



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**

H04B 1/40; H04B 1/03; H04B 1/08;
H04M 1/02; H04M 1/03; H01Q 1/243;
H01Q 5/314; H04W 88/06

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

See application file for complete search history.

(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**

US 2020/0203805 A1 Jun. 25, 2020

(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;

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,608,314 B1 *	3/2017	Kwon	.....	H01Q 5/307
10,177,443 B2 *	1/2019	Xue	.....	H01Q 1/48
2015/0022403 A1 *	1/2015	Lin	.....	H01Q 1/44
				343/702
2015/0155614 A1 *	6/2015	Youn	.....	G06F 1/1656
				343/702
2016/0315651 A1 *	10/2016	Hong	.....	H01Q 9/42
2017/0244151 A1 *	8/2017	Han	.....	H01Q 5/30
2018/0183137 A1 *	6/2018	Tsai	.....	H01Q 21/28
2018/0248252 A1 *	8/2018	Hu	.....	H01Q 1/243
2018/0331416 A1 *	11/2018	Yu	.....	H01Q 9/42
2018/0366812 A1 *	12/2018	Kim	.....	H01Q 13/106
2019/0081694 A1 *	3/2019	Zhou	.....	H05K 1/189
2020/0044311 A1 *	2/2020	Gu	.....	H01Q 1/243

(Continued)

Primary Examiner — Andrew Wendell

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

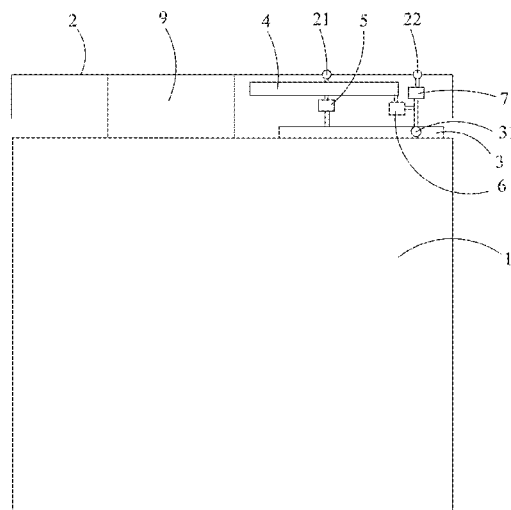
(57)

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

100





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**

U.S. PATENT DOCUMENTS

8,633,859 B2* 1/2014 Chou H01Q 5/378
343/700 MS
2005/0057404 A1* 3/2005 Demicco H01Q 1/088
343/702

2010/0304792 A1* 12/2010 Li H04B 1/3877
455/566
2015/0042533 A1* 2/2015 Cheng H01Q 1/36
343/817
2015/0263416 A1* 9/2015 Okano H01Q 5/371
343/702
2018/0115054 A1* 4/2018 Wu H01Q 5/35
2018/0375196 A1* 12/2018 Han H01Q 5/328

FOREIGN PATENT DOCUMENTS

CN 209329141 B1 8/2019

OTHER PUBLICATIONS

PCT search report dated Jan. 8, 2020 by SIPO in related PCT Patent
Application No. PCT/CN2019/113303 (4 Pages).

* cited by examiner

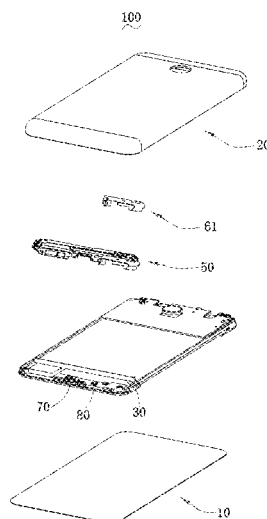
Primary Examiner — Hsinchun Liao

(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





(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**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS
8,477,074 B2 7/2013 Fukuchi
2007/0035454 A1* 2/2007 Zarnowitz H01Q 1/244
343/702

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

(Continued)

(73) Assignee: **GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP., LTD.**, Guangdong (CN)

FOREIGN PATENT DOCUMENTS
CN 2465338 Y 12/2001
CN 2874800 Y 2/2007
(Continued)

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

OTHER PUBLICATIONS

International search report in the international application No. PCT/CN2019/084271, dated Jun. 28, 2019 (4 pages).

(Continued)

(21) Appl. No.: **16/387,067**

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

Primary Examiner — Seokjin Kim

(74) *Attorney, Agent, or Firm* — Ladas & Parry, LLP

(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)

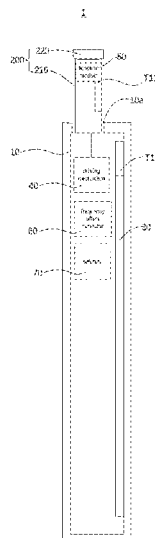
(52) **U.S. Cl.**
CPC **H01Q 1/244** (2013.01); **H01Q 5/307** (2015.01); **H04B 7/0404** (2013.01);
(Continued)

(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)

(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





(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**

US 2019/0379112 A1 Dec. 12, 2019

(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**

U.S. PATENT DOCUMENTS

7,061,434 B2	6/2006	Aoyama et al.	
7,421,245 B2	9/2008	Lieffort et al.	
8,022,886 B2	9/2011	Kai et al.	
9,190,732 B2 *	11/2015	Fujii	H01Q 1/38
9,558,440 B2	1/2017	Ikemoto et al.	
2011/0148728 A1 *	6/2011	Yoshioka	H01Q 1/40
			343/787
2016/0181698 A1 *	6/2016	Goto	H01Q 5/35
			343/870

FOREIGN PATENT DOCUMENTS

JP	2003258530 A	9/2003
JP	2004304783 A	10/2004
JP	3654235 B2	6/2005
JP	2007523563 A	8/2007
JP	4561932 B2	10/2010
JP	2011066628 A	3/2011
JP	4806373 B2	11/2011

* cited by examiner

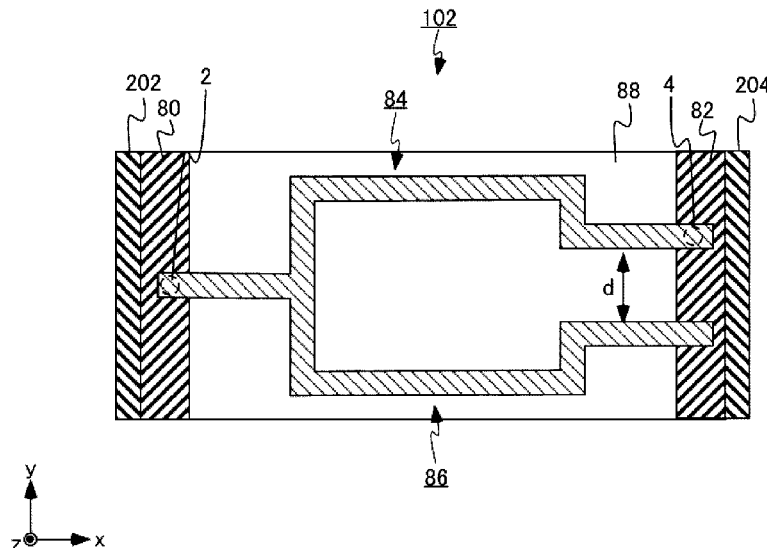
Primary Examiner — Anh Q Tran

(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.

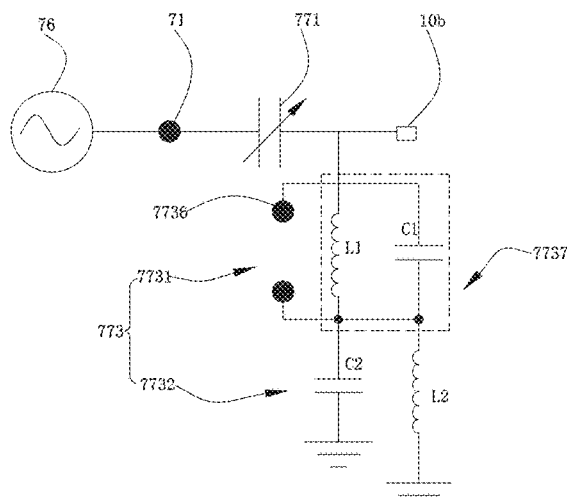
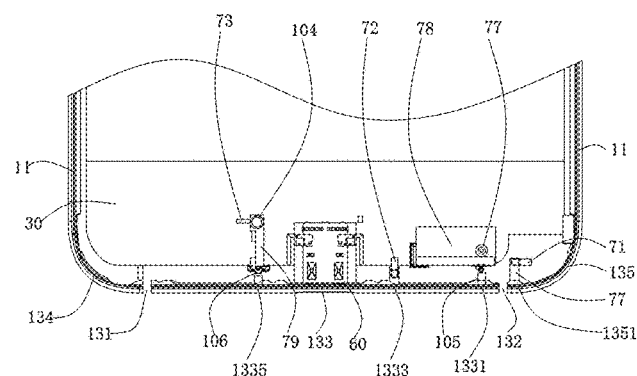
(56) **References Cited**
U.S. PATENT DOCUMENTS

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





(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.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2011/0109525 A1 5/2011 Takemura et al.
2015/0123852 A1* 5/2015 Yamagajo H01Q 1/2216 343/700 MS

(Continued)

FOREIGN PATENT DOCUMENTS

CN 104638341 A 5/2015
JP 2011-103630 5/2011

(Continued)

OTHER PUBLICATIONS

International Search Report dated Jul. 4, 2017 in PCT/JP2017/015201 filed Apr. 13, 2017 (with English Translation).

(Continued)

Primary Examiner — Hai V Tran

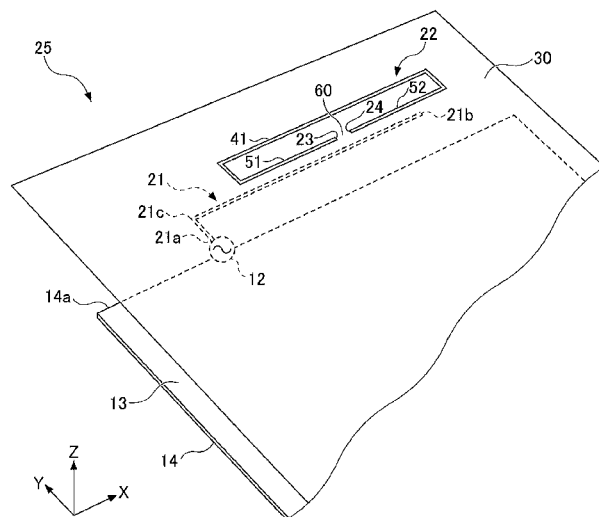
Assistant Examiner — Michael M Bouizza

(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



(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**

Aug. 3, 2018 (CN) 201810878294.6

(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**

U.S. PATENT DOCUMENTS

10,431,872 B1 *	10/2019	Kim	.....	H01Q 1/243
2018/0026333 A1 *	1/2018	Lee	.....	H01Q 13/18
				343/702
2018/0026335 A1 *	1/2018	Lee	.....	H01Q 13/18
				343/702
2018/0026344 A1 *	1/2018	Lee	.....	H01Q 1/2291
				343/702
2018/0026350 A1 *	1/2018	Hung	.....	H01Q 1/243
				455/575.7
2018/0026353 A1 *	1/2018	Tseng	.....	H01Q 13/10
				455/575.7
2018/0026360 A1 *	1/2018	Lee	.....	H01Q 5/371
				343/872
2018/0026370 A1 *	1/2018	Lee	.....	H01Q 1/243
				343/810
2018/0062244 A1 *	3/2018	Huang	.....	H01Q 1/243
				(Continued)

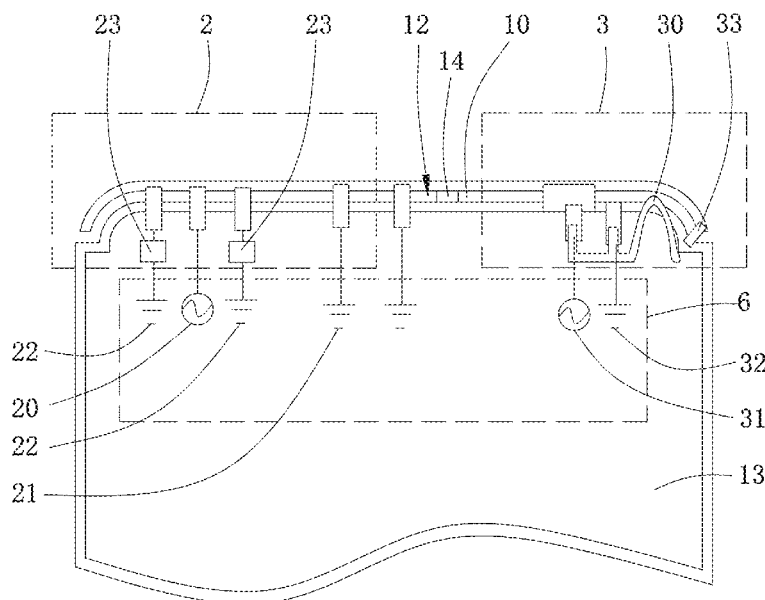
Primary Examiner — Crystal L Hammond

(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.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,933,330 A * 8/1999 Beutler H04M 1/0262
361/814

6,903,927 B2 6/2005 Anlauff

8,102,321 B2 * 1/2012 Chiang H01Q 9/16
343/702

(Continued)

OTHER PUBLICATIONS

Su, S., Two-Patch-PIFA System with Comparable Polarization
Radiation for Tablet-computer Applications with Complete, Metal
Back Cover, Sep. 23, 2013 < <http://onlinelibrary.wiley.com/doi/10.1002/mop.27996/abstract> >.

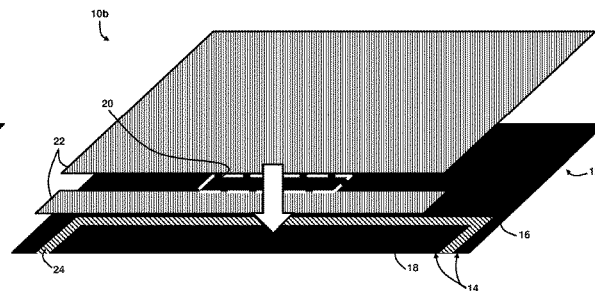
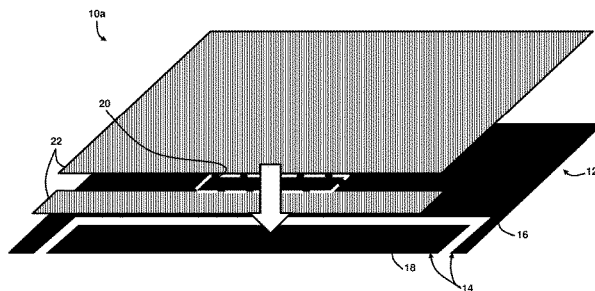
Primary Examiner — Haissa Philogene

(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 posi-
tioned 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.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,215,454 B1 * 4/2001 Tran H01Q 1/243 343/702
6,980,173 B2 * 12/2005 Man H01Q 1/243 343/700 MS
7,764,246 B2 * 7/2010 Yu H01Q 1/52 343/702
8,531,342 B2 * 9/2013 Sung H01Q 1/243 343/702
9,455,488 B2 * 9/2016 Chirila H01Q 1/2208
2009/0256758 A1 * 10/2009 Schlub H01Q 5/40 343/702
2016/0156098 A1 * 6/2016 Kim H01Q 1/243 343/841

* cited by examiner

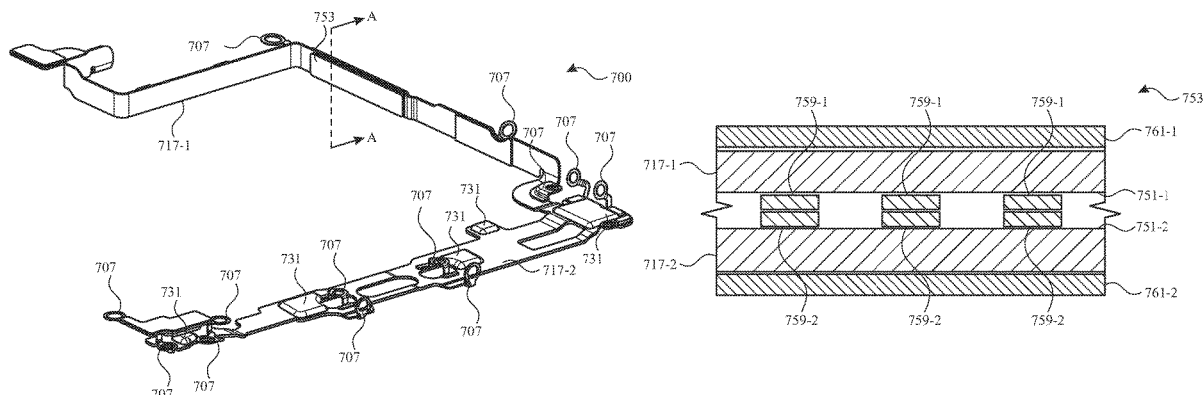
Primary Examiner — Tung X Le

(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



(12) **United States Patent**
Hovmoller

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

(54) **PCB ANTENNA**

USPC 343/702, 846
See application file for complete search history.

(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

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,079,079 B2 * 7/2006 Jo H01Q 1/243
343/700 MS
7,825,863 B2 * 11/2010 Martiskainen H01Q 1/243
343/700 MS
7,990,320 B2 * 8/2011 Pros H01Q 1/243
343/700 MS
9,379,432 B2 * 6/2016 Ishikawa H01Q 21/28
9,455,492 B2 * 9/2016 Jiang H01Q 1/243
2002/0145567 A1 10/2002 Spiegel et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CN 201489565 U 5/2010
CN 103928757 A 7/2014

(Continued)

OTHER PUBLICATIONS

European Search Report dated Dec. 16, 2016 in European Application 16175439.5 filed Jun. 21, 2016 (with Written Opinion).

(Continued)

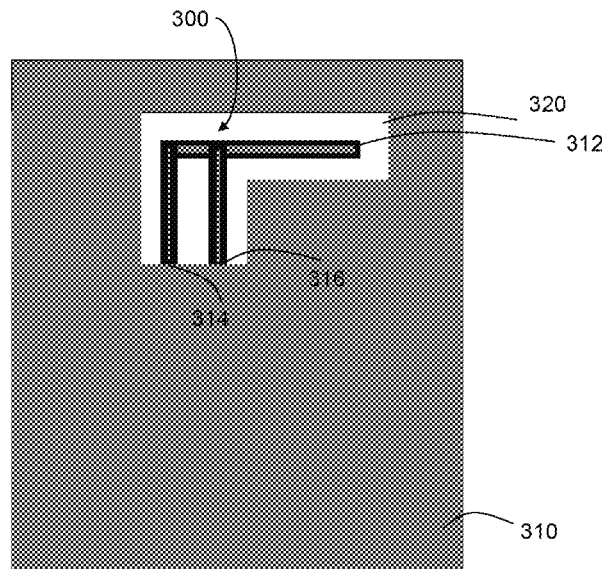
Primary Examiner — Hasan Z Islam

(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



(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**

U.S. PATENT DOCUMENTS

9,563,838 B2 2/2017 Ban et al.
2012/0038519 A1* 2/2012 Su H01Q 21/28 343/702

(Continued)

FOREIGN PATENT DOCUMENTS

CN 202817173 3/2013
JP H06169216 6/1994

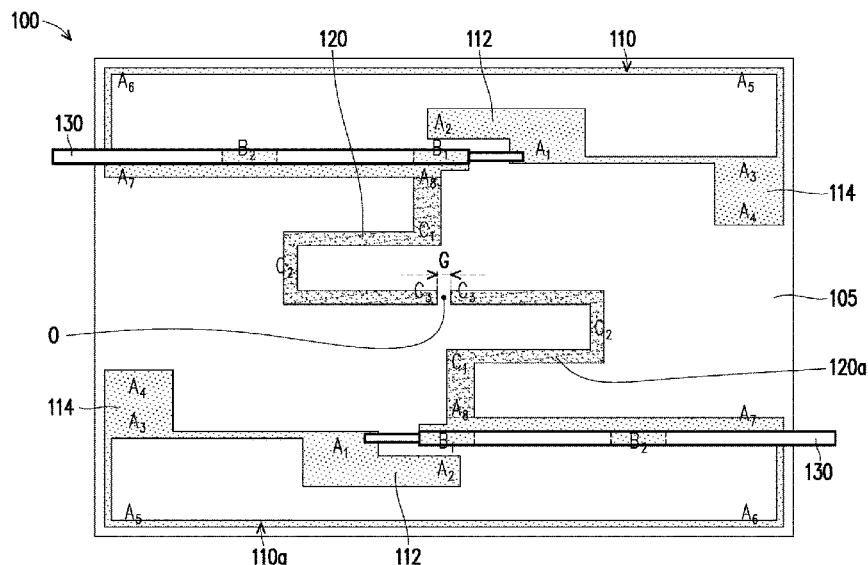
Primary Examiner — Raymond R Chai

(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.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2016/0181701 A1* 6/2016 Sangaran **H01Q 5/371**
343/837

FOREIGN PATENT DOCUMENTS

CN	102751573	10/2012
CN	204616107	9/2015
CN	106711582	5/2017
CN	106935964	7/2017
TW	201806245	2/2018

* cited by examiner

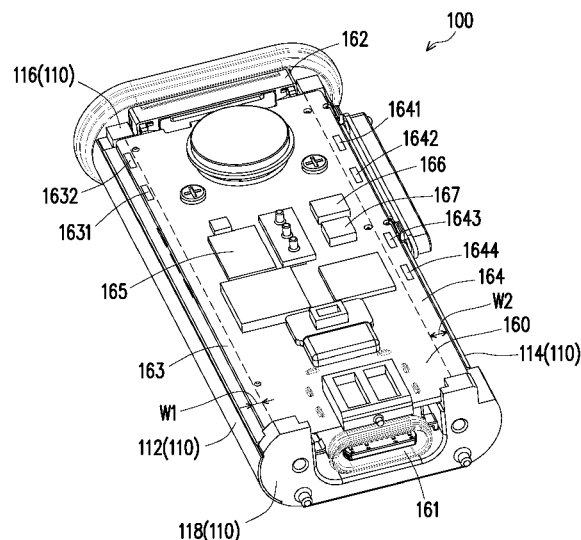
Primary Examiner — Andrea Lindgren Baltzell

(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**

U.S. PATENT DOCUMENTS

6,054,962 A * 4/2000 Ha H01Q 5/321 343/722
7,079,079 B2 * 7/2006 Jo H01Q 1/243 343/700 MS

(Continued)

FOREIGN PATENT DOCUMENTS

JP 2005-136912 A 5/2005
JP 2008-245132 A 10/2008

(Continued)

OTHER PUBLICATIONS

International Search Report for corresponding International Application No. PCT/JP2016/004512 dated Dec. 27, 2016.

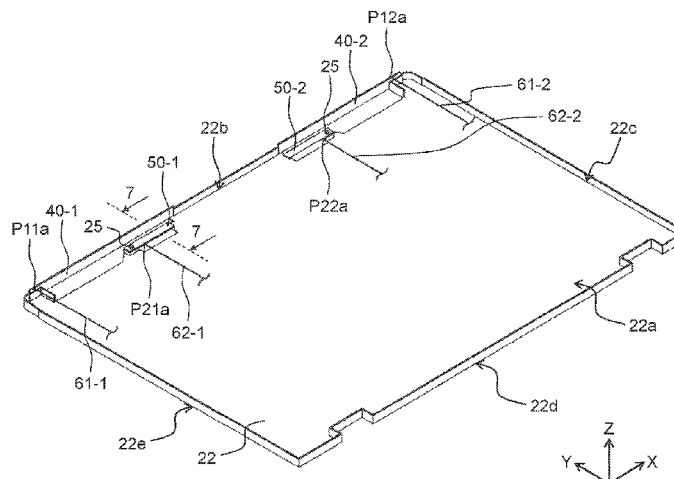
Primary Examiner — Hasan Z Islam

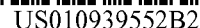
(74) *Attorney, Agent, or Firm* — Renner, Otto, Boisselle & Sklar, LLP

(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





(45) **Date of Patent:** Mar. 2, 2021

[illegible]

(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)

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,766,859 B2 7/2014 Merz et al.
2013/0016013 A1* 1/2013 Wong H01Q 1/38
343/700 MS

(Continued)

FOREIGN PATENT DOCUMENTS

CN 105281020 A 1/2016
CN 105762515 A 7/2016
CN 205960191 U 2/2017

Primary Examiner — Dimary S Lopez Cruz

Assistant Examiner — Bamidele A Jegede

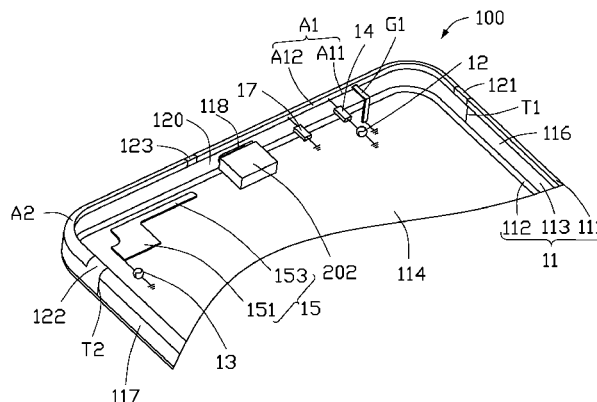
(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(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

200



(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**

US 2020/0076059 A1 Mar. 5, 2020

(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

U.S. PATENT DOCUMENTS

9,337,539 B1 * 5/2016 Ananthanarayanan H01Q 5/335
2018/0062270 A1 3/2018 Liang et al.
2018/0358699 A1 * 12/2018 Li H01Q 11/14
2019/0260112 A1 * 8/2019 Azad H01Q 1/243
2020/0212543 A1 * 7/2020 Zhu H01Q 5/307

FOREIGN PATENT DOCUMENTS

CN 107799909 3/2018

* cited by examiner

Primary Examiner — Jany Richardson

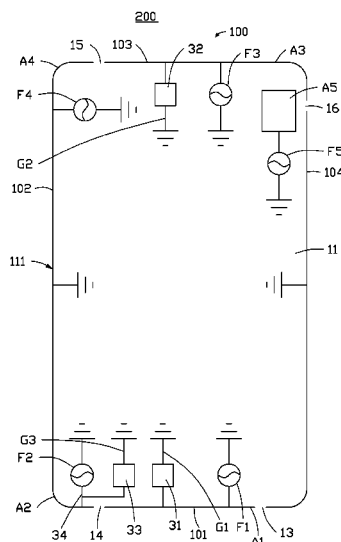
(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(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** 8,188,925 B2 5/2012 DeJean
8,466,839 B2 * 6/2013 Schlub H01Q 5/378
343/702
(71) Applicant: **Apple Inc.**, Cupertino, CA (US) 8,816,935 B2 8/2014 Liu et al.
9,564,683 B2 * 2/2017 Won H01Q 21/30
10,312,571 B2 6/2019 Edwards et al.
(72) Inventors: **Salih Yarga**, Sunnyvale, CA (US); 2008/0100513 A1 5/2008 Deng et al.
Jingni Zhong, Campbell, CA (US); 2016/0064812 A1 * 3/2016 Han H01Q 1/52
Bilgehan Ayser, Mountain View, CA 343/702
(US); **Mattia Pascolini**, San Francisco, CA (US) 2016/0204520 A1 7/2016 Dong et al.
(Continued)

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

FOREIGN PATENT DOCUMENTS

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

CN 105122541 A 12/2015
CN 105144474 A 12/2015
(Continued)

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

Primary Examiner — Jason Crawford

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

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

(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.

(57) **ABSTRACT**

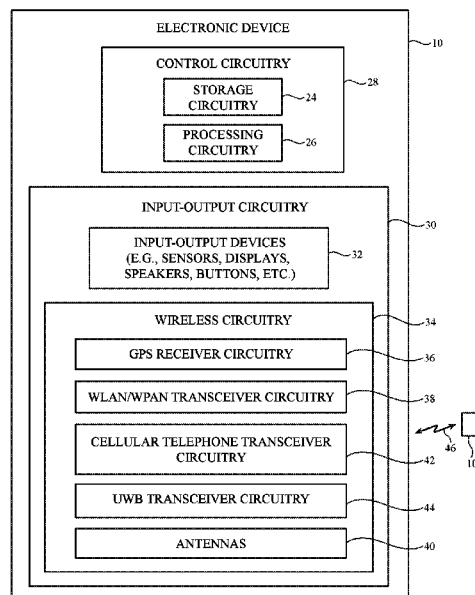
An electronic device may be provided with an antenna having a resonating element. The resonating element may have first and second arms extending from opposing sides of a feed. The first arm may have a fundamental mode that radiates in a first communications band such as a 5.0 GHz wireless local area 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.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,765,542 B2 7/2004 McCarthy et al.
7,542,002 B1 6/2009 Andersson
7,925,319 B2 4/2011 Kenoun et al.

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**

U.S. PATENT DOCUMENTS

7,046,199 B2 * 5/2006 Montgomery H01Q 1/36
343/700 MS
2004/0217910 A1 11/2004 Montgomery et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 104300209 A 1/2015
WO WO 2005/064745 A1 7/2005

OTHER PUBLICATIONS

PCT International Search Report for PCT Counterpart Application
No. PCT/SG2017/050165, 4 pgs. (dated Jun. 18, 2017).

(Continued)

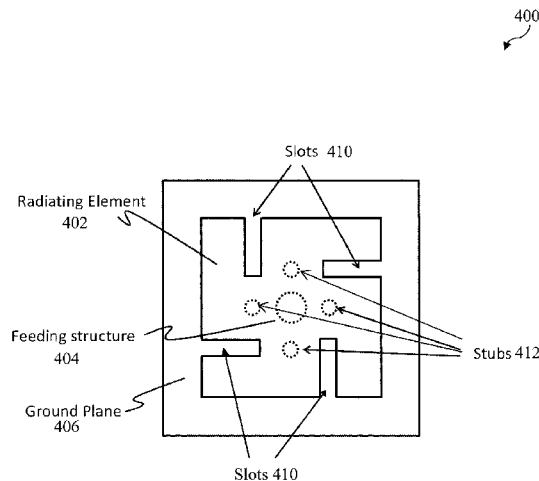
Primary Examiner — Hoang V Nguyen

(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



(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**

U.S. PATENT DOCUMENTS

9,673,526 B1 *	6/2017	Jensen	.....	H01Q 9/0414
10,020,560 B1 *	7/2018	Chou	.....	H01Q 1/1214
2006/0001574 A1 *	1/2006	Petros	.....	H01Q 9/0407
				343/702
2007/0052587 A1 *	3/2007	Cheng	.....	H01Q 9/0457
				343/700 MS
2007/0268188 A1 *	11/2007	Guha	.....	H01Q 9/0414
				343/700 MS
2012/0268347 A1 *	10/2012	Tatarnikov	.....	H01Q 9/0407
				343/893

FOREIGN PATENT DOCUMENTS

JP	2008-172697 A	7/2008
WO	2007/060782 A1	5/2007

* cited by examiner

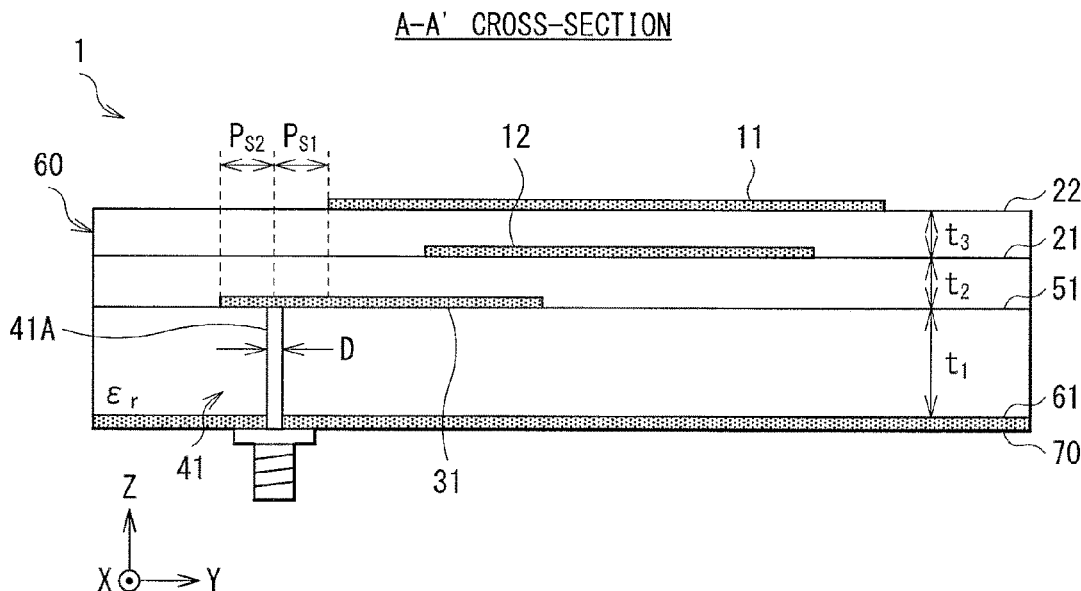
Primary Examiner — Thai Pham

(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**

US 2020/0243984 A1 Jul. 30, 2020

(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**

U.S. PATENT DOCUMENTS

9,331,396 B2 * 5/2016 Tran H01Q 21/24

9,496,614 B2 * 11/2016 Bringuier H01Q 21/30

(Continued)

FOREIGN PATENT DOCUMENTS

CN 104638356 A 5/2015

CN 104701623 A 6/2015

(Continued)

OTHER PUBLICATIONS

Jun. 25, 2019 Office Action issued in Chinese Patent Application
No. 201810035964.8.

(Continued)

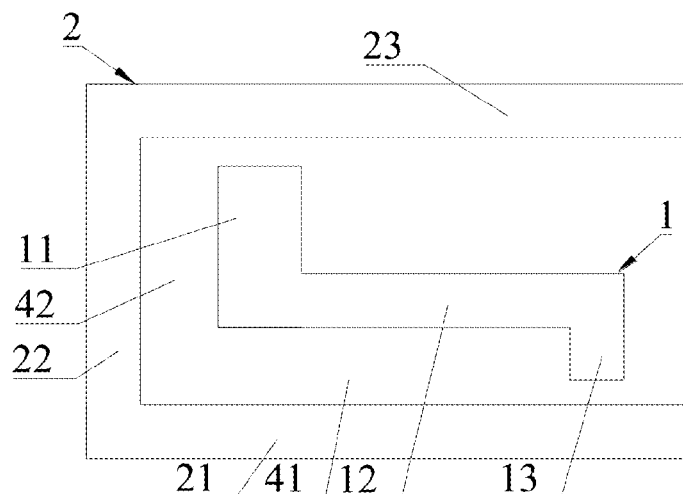
Primary Examiner — Hasan Z Islam

(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**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

(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)

9,413,058 B1 8/2016 Kuo et al.
9,509,042 B1 11/2016 Zheng et al.
(Continued)

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

FOREIGN PATENT DOCUMENTS

CN 203536554 U 4/2014
CN 204538197 U 8/2015
(Continued)

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

OTHER PUBLICATIONS

Dong, "A Study of Miniaturized Broadband and Multi-band Antennas for Mobile Handsets," Mar. 2014, pp. 1-55, with English translation.

(21) Appl. No.: **16/480,978**

Primary Examiner — Anh Q Tran

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

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

(86) PCT No.: **PCT/KR2017/000952**

§ 371 (c)(1),

(2) Date: **Jul. 25, 2019**

(57) **ABSTRACT**

(87) PCT Pub. No.: **WO2018/139692**

PCT Pub. Date: **Aug. 2, 2018**

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.

(65) **Prior Publication Data**

US 2020/0007184 A1 Jan. 2, 2020

(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.

12 Claims, 12 Drawing Sheets

