US011101546B2

(12) **United States Patent**
Li

(10) **Patent No.: US 11,101,546 B2**
(45) **Date of Patent: Aug. 24, 2021**

(54) **ELECTRONICAL DEVICE**

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

(72) Inventor: **Shichao Li**, Beijing (CN)

(73) Assignee: **LENOVO (BEIJING) CO., LTD.**, Beijing (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 222 days.

(21) Appl. No.: **16/370,876**

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

(65) **Prior Publication Data**

US 2019/0305404 A1 Oct. 3, 2019

(30) **Foreign Application Priority Data**

Mar. 30, 2018 (CN) 201810298316.1

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

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

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/44; H01Q 7/00; H01Q 13/10; H01Q 1/48; H01Q 9/42; H01Q 5/328; H01Q 1/38; H04M 1/026
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

10,629,982	B2 *	4/2020	Kim	H04B 1/3888
2004/0222926	A1 *	11/2004	Kontogeorgakis	H01Q 1/243 343/702
2017/0346164	A1 *	11/2017	Kim	H01Q 13/10
2018/0076529	A1 *	3/2018	Minard	H01Q 13/18

FOREIGN PATENT DOCUMENTS

CN	204668449	U	9/2015
CN	106374192	A	2/2017
CN	107453040	A	12/2017
CN	207053566	U	2/2018

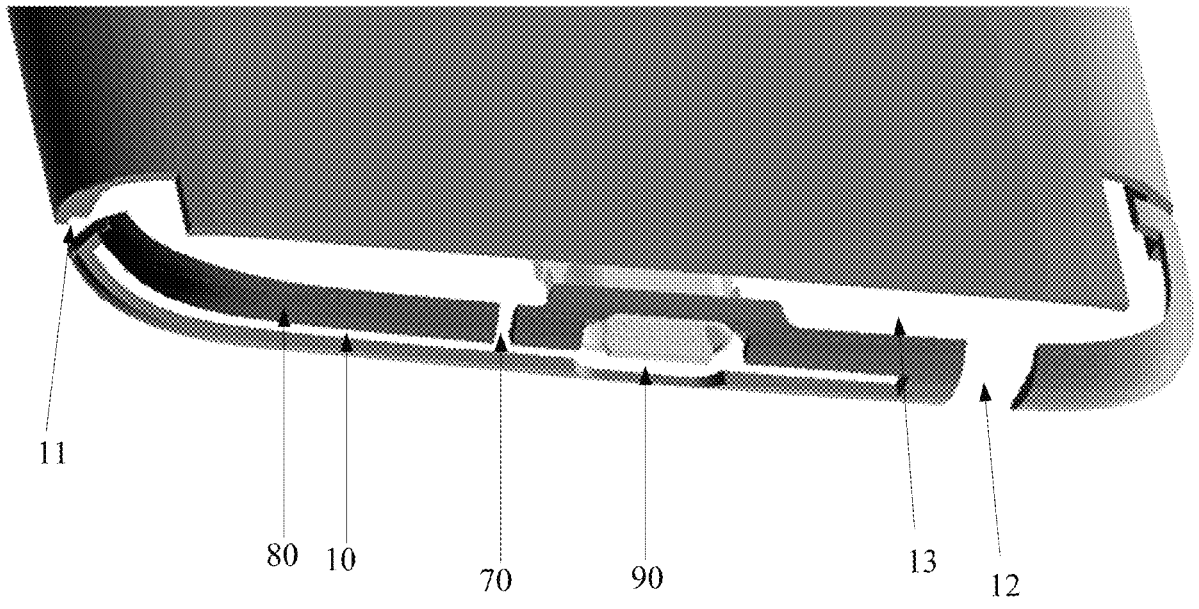
* cited by examiner

Primary Examiner — Dameon E Levi
Assistant Examiner — David E Lotter
(74) *Attorney, Agent, or Firm* — Anova Law Group, PLLC

(57) **ABSTRACT**

The present disclosure discloses an electronic device having a first slot disposed along a side surface of the electronic device; and a first metal portion disposed on the side surface corresponding to the first slot being used as a radiator of a first antenna of the electronic device.

16 Claims, 13 Drawing Sheets



US011101547B2

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

(10) **Patent No.: US 11,101,547 B2**
(45) **Date of Patent: Aug. 24, 2021**

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

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

(72) Inventors: **Yih-Shyang Her**, New Taipei (TW); **Yun-Jian Chang**, New Taipei (TW); **Chien-Hua Li**, New Taipei (TW); **Wei-En Hsieh**, 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 0 days.

(21) Appl. No.: **16/522,776**

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

(65) **Prior Publication Data**

US 2020/0036084 A1 Jan. 30, 2020

(30) **Foreign Application Priority Data**

Jul. 27, 2018 (CN) 201810846445.X

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)
H04M 1/02 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01); ***H04M 1/026*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/48; H04M 1/026
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,935,359	B2	4/2018	Kim et al.	
10,389,857	B2	8/2019	Sun et al.	
2016/0365623	A1*	12/2016	Kim	H01Q 9/42
2018/0026334	A1*	1/2018	Chen	H01Q 9/42 343/702
2018/0026337	A1	1/2018	Chen et al.	
2018/0026343	A1	1/2018	Lee et al.	
2018/0375971	A1*	12/2018	Sun	H01Q 1/243
2020/0058992	A1*	2/2020	Wu	H01Q 5/35

FOREIGN PATENT DOCUMENTS

CN	105514604	A	4/2016
CN	106252829	A	12/2016
CN	205960191	U	2/2017
CN	107681251	A	2/2018
WO	2017/101068	A1	6/2017
WO	2018/090295	A1	5/2018

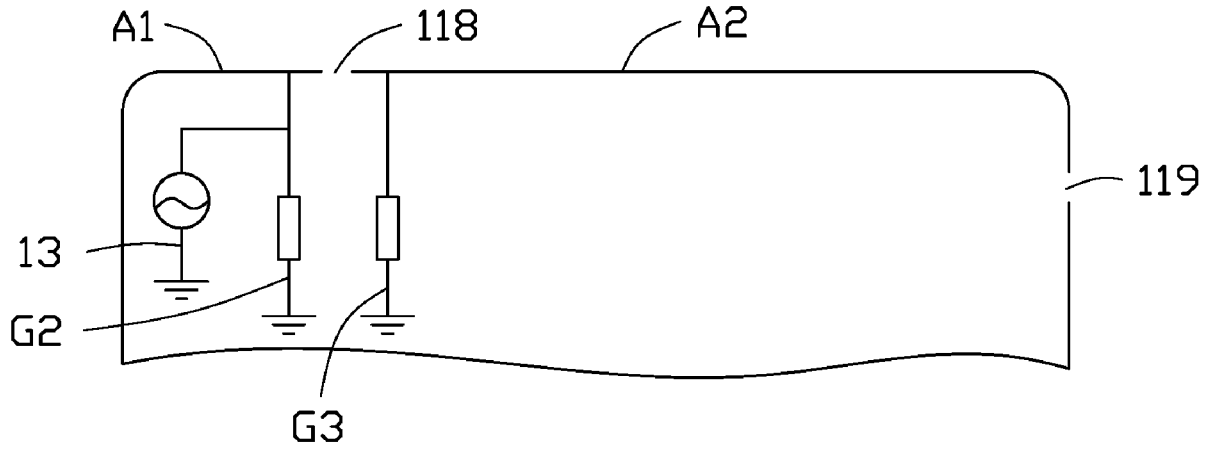
* cited by examiner

Primary Examiner — Yuwen Pan
Assistant Examiner — Umair Ahsan
(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

An antenna apparatus sited within a metal housing with improved frequency isolation between individual antennas includes the housing, a first ground portion, a first feed portion, and a second ground portion. A side frame of the housing defines at least one gap, the gap separates a first antenna and a second antenna. The first ground portion is formed by extending an end of the first antenna away from the gap. One end of the second ground portion is connected to the first feed portion, other end of the second ground portion is connected to ground. A first feed point feeds power and signal to the first antenna. A wireless communication device using the antenna apparatus is also provided.

18 Claims, 8 Drawing Sheets



US011101548B2

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

(10) **Patent No.: US 11,101,548 B2**
(45) **Date of Patent: Aug. 24, 2021**

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

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

(72) Inventors: **Yen-Hui Lin**, New Taipei (TW); **Wen-Yi Kuo**, New Taipei (TW); **Po-Ching Huang**, New Taipei (TW); **Chueh-Chuan Chen**, 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 0 days.

(21) Appl. No.: **16/550,581**

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

(65) **Prior Publication Data**

US 2020/0076060 A1 Mar. 5, 2020

(30) **Foreign Application Priority Data**

Aug. 31, 2018 (CN) 201811012451.1

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/22 (2006.01)
H04B 1/3827 (2015.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/2266*** (2013.01); ***H04B 1/3833*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/244
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2007/0080875 A1* 4/2007 Liao H01Q 1/243 343/702
2008/0074329 A1* 3/2008 Caballero H01Q 1/243 343/702
2012/0176279 A1 7/2012 Merz et al.
2017/0020012 A1 1/2017 Park et al.
2017/0214126 A1* 7/2017 Abreu H01Q 1/44
2018/0026348 A1 1/2018 Lee et al.
2018/0107913 A1* 4/2018 Shi H01Q 7/00
2019/0305403 A1* 10/2019 Wang H01Q 1/10
2019/0306292 A1* 10/2019 Hu H04M 1/0235
(Continued)

FOREIGN PATENT DOCUMENTS

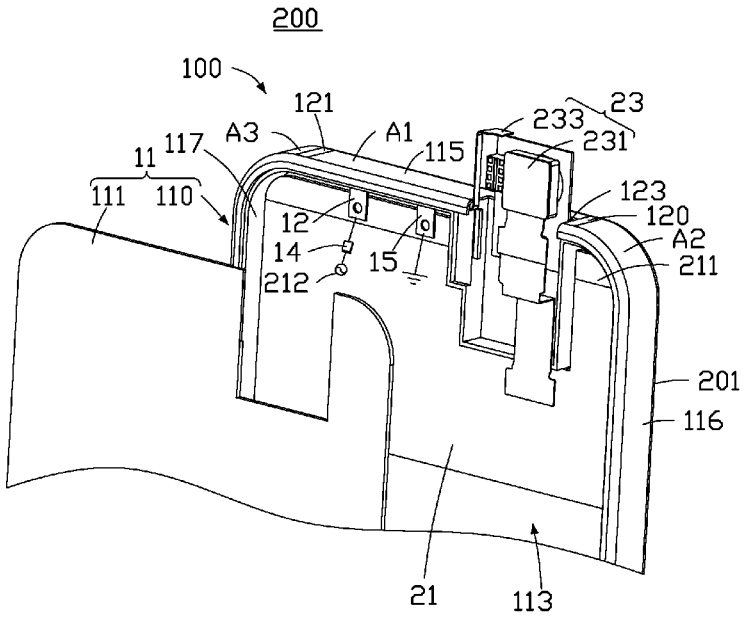
CN 102646862 B 1/2015
CN 106357845 A 1/2017
(Continued)

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

(57) **ABSTRACT**

An antenna of reduced size but of multiple functions according to manual adjustment includes a side frame made of metallic material, a feeding portion, and a moving module. The side frame defines first and second gaps each passing through the side frame to form at least one radiating portion. The feeding portion can feed current to either of the radiating portions. The metallic and movable moving module including an extending portion is movable relative to the side frame. In a first position, the extending portion is not connected to any radiating portion, and when moved to a second position, the extending portion is connected to one of the radiating portions.

20 Claims, 16 Drawing Sheets



US011101549B2

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

(10) **Patent No.: US 11,101,549 B2**
(45) **Date of Patent: Aug. 24, 2021**

(54) **ANTENNA MODULE INCLUDING INSULATOR, AND BASE STATION INCLUDING SAME ANTENNA MODULE**

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

(72) Inventors: **Kwanghyun Baek**, Suwon-si (KR); **Junsig Kum**, Suwon-si (KR); **Youngju Lee**, Suwon-si (KR); **Jungyub Lee**, Suwon-si (KR); **Yonghun Cheon**, Suwon-si (KR)

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

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

(21) Appl. No.: **15/733,363**

(22) PCT Filed: **Jan. 21, 2019**

(86) PCT No.: **PCT/KR2019/000842**
§ 371 (c)(1),
(2) Date: **Jul. 9, 2020**

(87) PCT Pub. No.: **WO2019/143211**
PCT Pub. Date: **Jul. 25, 2019**

(65) **Prior Publication Data**

US 2021/0098863 A1 Apr. 1, 2021

(30) **Foreign Application Priority Data**

Jan. 19, 2018 (KR) 10-2018-0007077

(51) **Int. Cl.**
H01Q 1/52 (2006.01)
H01Q 21/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/246*** (2013.01); ***H01Q 1/42*** (2013.01); ***H01Q 1/523*** (2013.01); ***H01Q 21/0025*** (2013.01); *H01Q 21/061* (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/246; H01Q 1/52; H01Q 1/521; H01Q 1/523; H01Q 21/0006;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

10,418,725 B2 9/2019 Yang et al.
10,965,031 B2 * 3/2021 Shin H01Q 9/045
(Continued)

FOREIGN PATENT DOCUMENTS

CN 201408837 Y 2/2010
CN 101673881 A 3/2010
(Continued)

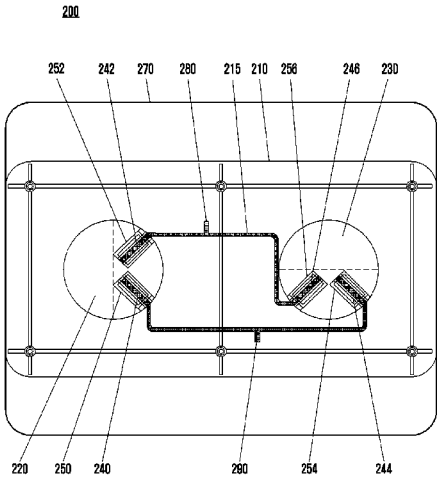
OTHER PUBLICATIONS

Supplementary European Search Report in connection with European Application No. 19741006.1 dated Oct. 28, 2020, 9 pages.
(Continued)

Primary Examiner — Jason Crawford

(57) **ABSTRACT**

The present invention relates to: a communication technique for converging an IoT technology with a 5G communication system for supporting a higher data transfer rate beyond the 4G system; and a system therefor. The present invention provides an antenna module including at least one antenna array, wherein the antenna array comprises: a first insulator having a shape of a plate and having a conductive pattern formed thereon to allow the flow of an electrical signal; a first radiator disposed such that the lower end surface thereof is spaced a predetermined first length apart from the upper end surface of the first insulator; a second radiator spaced a predetermined second length apart from the first radiator on
(Continued)



US011101550B2

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

(10) **Patent No.: US 11,101,550 B2**
(45) **Date of Patent: Aug. 24, 2021**

(54) **BASE STATION ANTENNA**

(71) Applicant: **ACE TECHNOLOGIES CORPORATION**, Incheon (KR)

(72) Inventors: **Yong Sang Lee**, Changnyeong-gun (KR); **Ho Yong Kim**, Incheon (KR); **Tack-Gyu Kim**, Incheon (KR); **Jae Hoon Tae**, Incheon (KR); **Bayanmunkh Enkhbayar**, Incheon (KR); **Kyu Hoon Lee**, Bucheon-si (KR)

(73) Assignee: **ACE TECHNOLOGIES CORPORATION**, Incheon (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 532 days.

(21) Appl. No.: **15/901,159**

(22) Filed: **Feb. 21, 2018**

(65) **Prior Publication Data**

US 2018/0254544 A1 Sep. 6, 2018

(30) **Foreign Application Priority Data**

Feb. 21, 2017 (KR) 10-2017-0022648
Mar. 21, 2017 (KR) 10-2017-0035223

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 15/14 (2006.01)
H01Q 21/00 (2006.01)
H01Q 21/26 (2006.01)
H01Q 19/10 (2006.01)

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

CPC ***H01Q 1/246*** (2013.01); ***H01Q 15/14*** (2013.01); ***H01Q 19/10*** (2013.01); ***H01Q 21/00*** (2013.01); ***H01Q 21/26*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 21/26; H01Q 15/14; H01Q 1/246; H01Q 19/18; H01Q 19/185; H01Q 21/06; H01Q 1/526

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,998,605 A * 8/1961 Orlando H01Q 19/185 343/848
5,838,282 A * 11/1998 Lalezari H01Q 21/26 343/727
2004/0140942 A1 * 7/2004 Gotti H01Q 13/10 343/810
2009/0096700 A1 * 4/2009 Chair H01Q 21/26 343/797
2010/0001921 A1 1/2010 Copeland
(Continued)

FOREIGN PATENT DOCUMENTS

CN 201233958 Y 5/2009
DE 60110869 T2 10/2005
(Continued)

OTHER PUBLICATIONS

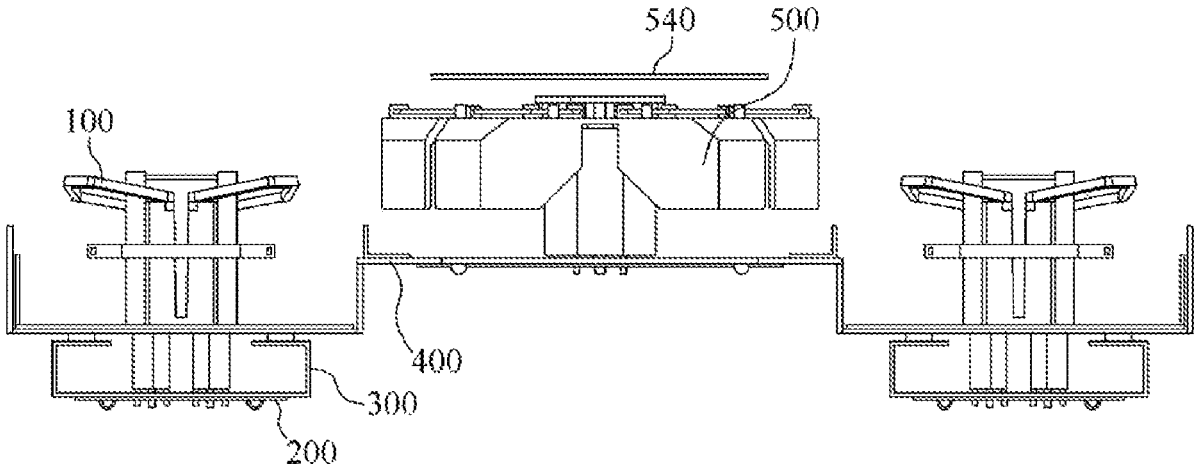
The Office Action from Intellectual Property India_ Application No. 201844005967, dated Nov. 2, 2020.

Primary Examiner — Ricardo I Magallanes

(57) **ABSTRACT**

A base station antenna is disclosed. The disclosed antenna includes: a reflector plate made of a metal material; a multiple number of radiators formed on the reflector plate and forming one or more arrays; and conductive rods positioned on both sides of each of the radiators, where the conductive rods are formed in parallel with the arrays formed by the radiators.

15 Claims, 10 Drawing Sheets



US011101556B2

(12) **United States Patent**
Shimura

(10) **Patent No.: US 11,101,556 B2**
(45) **Date of Patent: Aug. 24, 2021**

(54) **ANTENNA**

(71) Applicant: **CANON KABUSHIKI KAISHA**, Tokyo (JP)

(72) Inventor: **Hajime Shimura**, Yokohama (JP)

(73) Assignee: **CANON KABUSHIKI KAISHA**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 63 days.

(21) Appl. No.: **16/231,348**

(22) Filed: **Dec. 21, 2018**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Dec. 28, 2017 (JP) JP2017-253435

(51) **Int. Cl.**

H01Q 1/36	(2006.01)
H01Q 1/38	(2006.01)
H01Q 9/42	(2006.01)
H01Q 21/06	(2006.01)
H01Q 1/22	(2006.01)
H01Q 5/378	(2015.01)

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

CPC ***H01Q 1/362*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 5/378*** (2015.01); ***H01Q 9/42*** (2013.01); ***H01Q 21/061*** (2013.01); *H01Q 1/2291* (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/362; H01Q 1/38; H01Q 1/2291; H01Q 5/378; H01Q 7/00; H01Q 9/27; H01Q 9/42; H01Q 11/08; H01Q 21/061; H01Q 1/36; H01Q 1/2283; H01Q 1/243; H01Q 5/385; H01Q 5/392; H01Q 9/30; H01Q 9/38; H01Q 11/083

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,028,568	A *	2/2000	Asakura	H01Q 1/362 343/700 MS
6,765,536	B2 *	7/2004	Phillips	H01Q 1/362 343/702
6,897,812	B2 *	5/2005	Huang	H01Q 1/362 343/700 MS
8,175,067	B2	5/2012	Shimura	
8,547,947	B2	10/2013	Shimura	
8,699,431	B2	4/2014	Shimura	
8,804,683	B2	8/2014	Shimura	
8,976,772	B2	3/2015	Shimura	
9,287,621	B2	3/2016	Shimura	

(Continued)

FOREIGN PATENT DOCUMENTS

JP 9-69718 3/1997

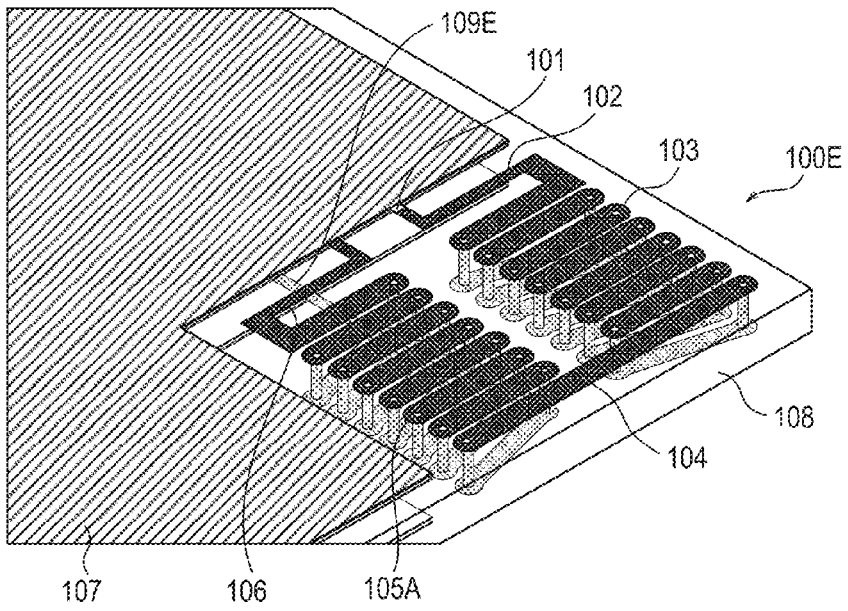
Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — Venable LLP

(57) **ABSTRACT**

An antenna includes: a feeding point; an antenna element unit having one end connected to the feeding point and the other end connected to the ground conductor; and a first conductive portion connected to the ground conductor. The antenna element unit has, between one end and the other end, a second conductor portion having a shape in which a plurality of bent parts are formed, and at least a part of the antenna element unit and at least a part of the first conductive portion are electromagnetically coupled with each other.

15 Claims, 17 Drawing Sheets



US011101560B2

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

(10) **Patent No.: US 11,101,560 B2**
(45) **Date of Patent: Aug. 24, 2021**

(54) **ANTENNA STRUCTURE**

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

(72) Inventors: **Chih-Feng Tai**, Hsinchu (TW); **Kuan-Hsun Lai**, Hsinchu (TW); **Kuei-Cheng Wang**, Hsinchu (TW)

(73) Assignee: **WISTRON NEWEB CORPORATION**, Hsinchu Science Park (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.: **16/853,794**

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jul. 12, 2019 (TW) 108124731

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H01Q 5/30 (2015.01)

(52) **U.S. Cl.**
CPC ***H01Q 5/30*** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 5/30; H01Q 5/328; H01Q 5/335; H01Q 5/371; H01Q 5/378; H01Q 5/385; H01Q 5/392; H01Q 5/50; H01Q 1/241–243
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,779,986 B2 * 7/2014 Fan ..... H01Q 9/42 343/700 MS
9,252,490 B2 2/2016 Wei
10,069,199 B2 * 9/2018 Chen H01Q 1/38
2012/0001815 A1 * 1/2012 Wong H01Q 9/0414 343/749

(Continued)

FOREIGN PATENT DOCUMENTS

CN 106299679 B 6/2019
TW 200905987 A 2/2009

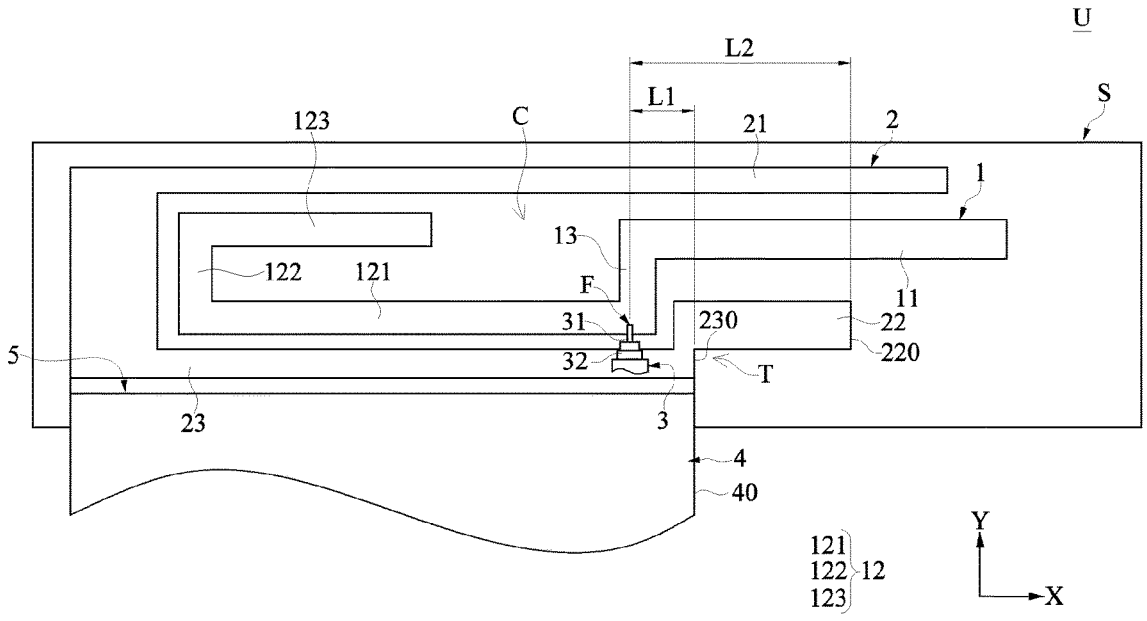
(Continued)

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

(57) **ABSTRACT**

An antenna structure is provided. The antenna structure includes a first radiation member, a second radiation member, and a feeding member. The first radiation member includes a first radiation portion, a second radiation portion, and a feeding portion electrically connected between the first radiation portion and the second radiation portion. The second radiation member includes a third radiation portion, a fourth radiation portion, and a grounding portion electrically connected between the third radiation portion and the fourth radiation portion. The third radiation portion and the first radiation portion are separate from and coupled to each other, the third radiation portion and the second radiation portion are separate from and coupled to each other, and the fourth radiation portion and the first radiation portion are separate from and coupled to each other. The feeding member is electrically connected between the feeding portion and the grounding portion.

14 Claims, 7 Drawing Sheets



US011101561B2

(12) **United States Patent**
Izawa

(10) **Patent No.: US 11,101,561 B2**
(45) **Date of Patent: Aug. 24, 2021**

(54) **DUAL BAND COMPATIBLE ANTENNA DEVICE**

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

(72) Inventor: **Masahiro Izawa**, Kyoto (JP)

(73) Assignee: **MURATA MANUFACTURING CO., LTD.**, Kyoto (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 57 days.

(21) Appl. No.: **16/810,959**

(22) Filed: **Mar. 6, 2020**

(65) **Prior Publication Data**

US 2020/0212570 A1 Jul. 2, 2020

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2018/028561, filed on Jul. 31, 2018.

(30) **Foreign Application Priority Data**

Sep. 8, 2017 (JP) JP2017-173244

(51) **Int. Cl.**
H01Q 5/321 (2015.01)
H01Q 1/36 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 5/321*** (2015.01); ***H01Q 1/36*** (2013.01); ***H01Q 5/371*** (2015.01); ***H01Q 9/065*** (2013.01); ***H01Q 9/16*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/30; H01Q 5/371; H01Q 9/44; H01Q 9/16; H01Q 9/065; H01Q 1/36; H01Q 5/321; H01Q 5/335
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,454,950 A * 7/1969 Grant H01Q 11/10 343/751
5,872,485 A * 2/1999 Ishikawa H01P 5/087 330/286

(Continued)

FOREIGN PATENT DOCUMENTS

JP 2001-156543 A 6/2001
JP 2003-505962 A 2/2003

(Continued)

OTHER PUBLICATIONS

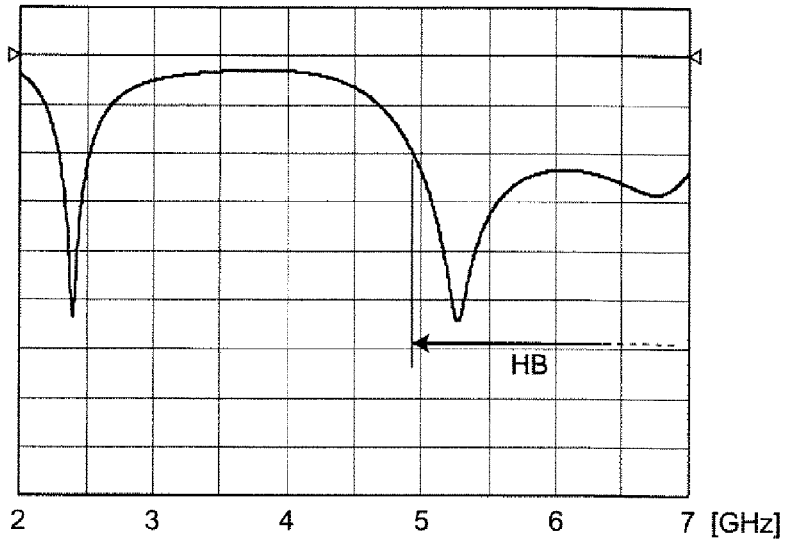
International Search Report for PCT/JP2018/028561 dated Oct. 9, 2018.
Written Opinion for PCT/JP2018/028561 dated Oct. 9, 2018.

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

(57) **ABSTRACT**

A dual band compatible antenna device includes a first branch electrode having a first electrode portion connected to a common electrode with a first adjustment element interposed between the first electrode portion and the common electrode and a second branch electrode having a second electrode portion connected to the common electrode with a second adjustment element interposed between the second electrode portion and the common electrode. The first electrode portion and the second electrode portion are provided on a line to have a length equal to or longer than ⅔ of an electrical length of the first branch electrode and the second branch electrode.

10 Claims, 7 Drawing Sheets



US011101562B2

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

(10) **Patent No.: US 11,101,562 B2**
(45) **Date of Patent: Aug. 24, 2021**

(54) **MULTI-BAND DUAL-POLARIZED ANTENNA STRUCTURE AND WIRELESS COMMUNICATION DEVICE USING THE SAME**

(71) Applicant: **MEDIATEK Inc.**, Hsin-Chu (TW)

(72) Inventors: **Chung-Hsin Chiang**, Hsin-Chu (TW); **Ching-Hsiang Wang**, Hsin-Chu (TW); **Yeh-Chun Kao**, Hsin-Chu (TW); **Shih-Huang Yeh**, Hsin-Chu (TW)

(73) Assignee: **MEDIATEK INC.**, Hsin-Chu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 111 days.

(21) Appl. No.: **16/408,582**

(22) Filed: **May 10, 2019**

(65) **Prior Publication Data**

US 2019/0386393 A1 Dec. 19, 2019

Related U.S. Application Data

(60) Provisional application No. 62/684,279, filed on Jun. 13, 2018.

(51) **Int. Cl.**

H01Q 21/06	(2006.01)
H01Q 21/24	(2006.01)
H01Q 5/28	(2015.01)
H01Q 5/42	(2015.01)

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

CPC ***H01Q 5/42*** (2015.01); ***H01Q 5/28*** (2015.01); ***H01Q 21/061*** (2013.01); ***H01Q 21/24*** (2013.01)

(58) **Field of Classification Search**

CPC .. H01Q 5/00; H01Q 5/28; H01Q 5/42; H01Q 21/061; H01Q 21/24; H01Q 1/2283; H01Q 1/2291; H01Q 1/24

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,937,206	B2 *	8/2005	Puente Baliarda	H01Q 1/246 343/700 MS
9,559,432	B2	1/2017	Sun et al.	
2007/0030208	A1 *	2/2007	Linehan	H01Q 21/061 343/757

(Continued)

FOREIGN PATENT DOCUMENTS

CN	104067442 A	9/2014
CN	104221218 A	12/2014

(Continued)

OTHER PUBLICATIONS

TIPO Office Action dated May 13, 2020 in Taiwan application (No. 108119468).

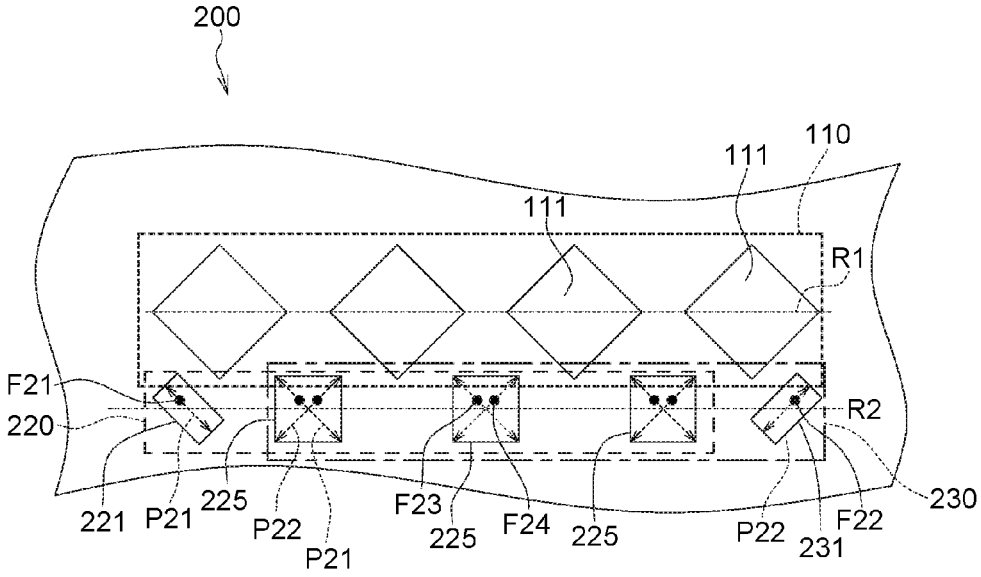
Primary Examiner — Thai Pham

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

(57) **ABSTRACT**

A multi-band dual-polarized antenna structure is provided. The multi-band dual-polarized antenna structure includes a first antenna array, a second antenna array and a third antenna array. The first antenna array is arranged in a first row and operating at a first frequency. The second antenna array is arranged in a second row, operates at a second frequency and has a first polarized direction. The third antenna array is arranged in the second row, operates at the second frequency and has a second polarized direction different from the first polarized direction.

13 Claims, 5 Drawing Sheets



US011101564B2

(12) **United States Patent**
Oh

(10) **Patent No.: US 11,101,564 B2**
(45) **Date of Patent: Aug. 24, 2021**

(54) **ELECTRONIC DEVICE INCLUDING ANTENNA STRUCTURE INSTALLABLE IN NARROW SPACE**

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

(72) Inventor: **Chanhee Oh**, Suwon-si (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 8 days.

(21) Appl. No.: **16/796,275**

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

(65) **Prior Publication Data**

US 2020/0411989 A1 Dec. 31, 2020

(30) **Foreign Application Priority Data**

Jun. 26, 2019 (KR) 10-2019-0076374

(51) **Int. Cl.**
H01Q 7/00 (2006.01)
H01Q 1/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 7/00*** (2013.01); ***H01Q 1/24*** (2013.01); ***H01Q 1/38*** (2013.01); *H01Q 1/243* (2013.01); *H02J 50/12* (2016.02); *H02J 50/90* (2016.02)

(58) **Field of Classification Search**
CPC .. H01Q 7/00; H01Q 1/24; H01Q 1/38; H01Q 1/243; H02J 50/90; H02J 50/12
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2015/0035709 A1 2/2015 Lim
2015/0333547 A1 11/2015 Na et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 108933330 A 12/2018
KR 10-2015-0131924 A 11/2015
(Continued)

OTHER PUBLICATIONS

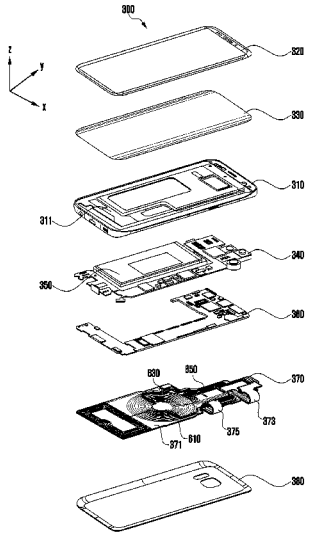
International Search Report dated May 29, 2020, issued in International Application No. PCT/KR2020/002523.
(Continued)

Primary Examiner — Joseph J Lauture
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An electronic device that includes an antenna structure installable in a narrow space is provided. The electronic device may include a first support member, a second support member, a printed circuit board (PCB), an antenna, and a first connector. The second support member is disposed in parallel with the first support member such that a lower surface thereof faces the first support member, and combined with the first support member through a plurality of fixing members. The PCB is disposed between the first and second support members and fixed by the plurality of fixing members. The antenna includes a flexible printed circuit board (FPCB), a short range communication antenna pattern formed on the FPCB, and a wireless charging coil formed on the FPCB. The first connector electrically connects the PCB and the antenna by passing through a lateral surface of the second support member such that the antenna covers an upper surface of the second support member and at least one of the plurality of fixing members is overlapped with the wireless charging coil of the antenna.

20 Claims, 15 Drawing Sheets



US011101574B2

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

(10) **Patent No.: US 11,101,574 B2**
(45) **Date of Patent: Aug. 24, 2021**

(54) **ANTENNA STRUCTURE**

(71) Applicant: **Quanta Computer Inc.**, Taoyuan (TW)

(72) Inventors: **Chin-Lung Tsai**, Taoyuan (TW); **Ying-Cong Deng**, Taoyuan (TW); **Chung-Hung Lo**, Taoyuan (TW); **Kuan-Hsien Lee**, Taoyuan (TW); **Yi-Ling Tseng**, Taoyuan (TW); **Chung-Ting Hung**, Taoyuan (TW)

(73) Assignee: **QUANTA COMPUTER INC.**, Taoyuan (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 37 days.

(21) Appl. No.: **16/747,213**

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

(65) **Prior Publication Data**

US 2021/0167521 A1 Jun. 3, 2021

(30) **Foreign Application Priority Data**

Nov. 28, 2019 (TW) 108143306

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

(52) **U.S. Cl.**
CPC ***H01Q 21/30*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 1/48*** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 1/243; H01Q 21/30; H01Q 1/38–1/48
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,907,853 B2 * 12/2014 Ying H01Q 1/243 343/702
2004/0108957 A1 * 6/2004 Umehara ..... H01Q 1/243 343/700 MS

(Continued)

FOREIGN PATENT DOCUMENTS

TW 200905987 A 2/2009

OTHER PUBLICATIONS

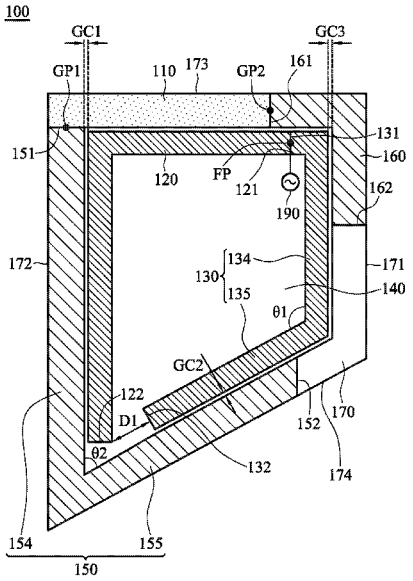
Chinese language office action dated Jul. 22, 2020, issued in application No. TW 108143306.

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

(57) **ABSTRACT**

An antenna structure includes a ground plane, a first radiation element, a second radiation element, a third radiation element, a fourth radiation element, and a dielectric substrate. The first radiation element has a feeding point. The second radiation element is coupled to the feeding point. The non-metal region is substantially surrounded by the first radiation element and the second radiation element. The third radiation element is coupled to a first shorting point on the ground plane. The third radiation element is adjacent to the first radiation element and the second radiation element. The fourth radiation element is coupled to a second shorting point on the ground plane. The fourth radiation element is adjacent to the second radiation element. The ground plane, the first radiation element, the second radiation element, the third radiation element, and the fourth radiation element are all disposed on the dielectric substrate.

9 Claims, 2 Drawing Sheets



US011101827B2

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

(10) **Patent No.: US 11,101,827 B2**
(45) **Date of Patent: Aug. 24, 2021**

(54) **ELECTRONIC DEVICE COMPRISING ANTENNA AND METHOD FOR TRANSMITTING OR RECEIVING SIGNAL**

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

(72) Inventors: **Yongyoun Kim**, Gyeonggi-do (KR); **Hyoseok Na**, Gyeonggi-do (KR); **Kyoungho Kim**, Gyeonggi-do (KR); **Jungsik Park**, Gyeonggi-do (KR); **Sunghyup Lee**, Gyeonggi-do (KR)

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

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

(21) Appl. No.: **16/766,975**

(22) PCT Filed: **Jan. 21, 2019**

(86) PCT No.: **PCT/KR2019/000834**
§ 371 (c)(1),
(2) Date: **May 26, 2020**

(87) PCT Pub. No.: **WO2019/143209**
PCT Pub. Date: **Jul. 25, 2019**

(65) **Prior Publication Data**

US 2020/0321988 A1 Oct. 8, 2020

(30) **Foreign Application Priority Data**

Jan. 22, 2018 (KR) 10-2018-0007778

(51) **Int. Cl.**
H04B 1/00 (2006.01)
H05K 5/02 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04B 1/0064*** (2013.01); ***H01Q 1/24*** (2013.01); ***H01Q 1/48*** (2013.01); ***H04B 1/40*** (2013.01); ***H05K 5/0217*** (2013.01)

(58) **Field of Classification Search**
CPC H04B 1/0064; H04B 1/40; H01Q 1/24; H01Q 1/48; H05K 5/0217
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,843,394 B2 11/2010 Egawa et al.
9,935,359 B2 4/2018 Kim et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 107317095 A 11/2017
JP 2006-166262 A 6/2006
(Continued)

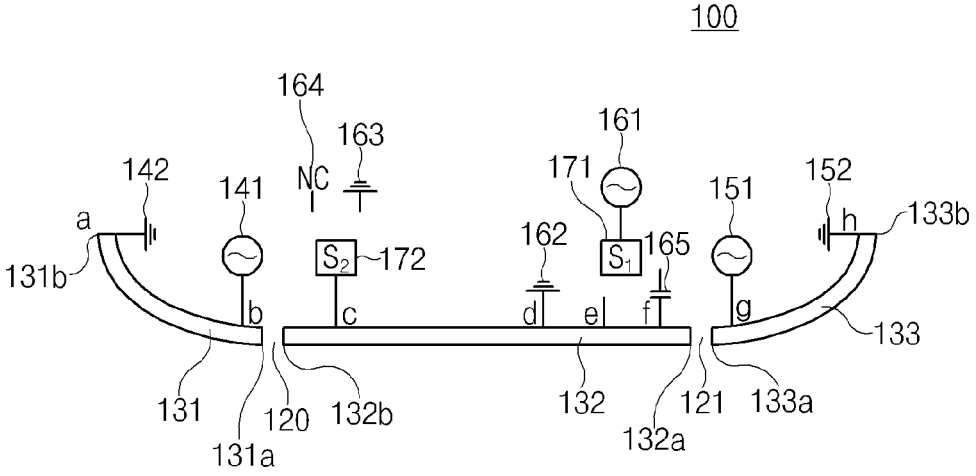
OTHER PUBLICATIONS

European Search Report dated Dec. 10, 2020.

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

(57) **ABSTRACT**

Disclosed is an electronic device which includes a housing that includes a first plate, a second plate facing away from the first plate, and a side member surrounding a space between the first plate and the second plate, wherein the side member includes a first conductive portion including a first end and being elongated, a second conductive portion including a second end and a third end and being elongated, the second end being adjacent to the first end, a third conductive portion including a fourth end adjacent to the third end and being elongated, a first insulating portion disposed between the first end and the second end to contact the first end and the second end, and a second insulating
(Continued)



US011108129B2

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

(10) **Patent No.: US 11,108,129 B2**
(45) **Date of Patent: Aug. 31, 2021**

(54) **ANTENNA ASSEMBLY**

(71) Applicant: **City University of Hong Kong**, Kowloon (HK)

(72) Inventors: **Kwok Wa Leung**, Kowloon Tong (HK); **Lei Guo**, Kowloon Tong (HK); **Kim Fung Tsang**, Kowloon Tong (HK)

(73) Assignee: **City University of Hong Kong**, Kowloon (HK)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 518 days.

(21) Appl. No.: **16/003,167**

(22) Filed: **Jun. 8, 2018**

(65) **Prior Publication Data**

US 2019/0379104 A1 Dec. 12, 2019

(51) **Int. Cl.**

H01Q 1/12	(2006.01)
H01Q 13/10	(2006.01)
H01Q 9/04	(2006.01)
H01Q 1/44	(2006.01)

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

CPC ***H01Q 1/1221*** (2013.01); ***H01Q 9/0485*** (2013.01); ***H01Q 13/10*** (2013.01); *H01Q 1/44* (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/1221; H01Q 9/0485; H01Q 1/46

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,987,061	B2	3/2015	Lee et al.	
9,123,995	B2	9/2015	Leung et al.	
2009/0153403	A1*	6/2009	Chang	H01Q 9/0492 343/700 MS
2013/0249757	A1*	9/2013	Leung	H01Q 9/0485 343/785
2014/0213199	A1	7/2014	Perten	
2015/0349427	A1*	12/2015	Camden	H04L 12/282 343/702

FOREIGN PATENT DOCUMENTS

CN	203966214	6/2014

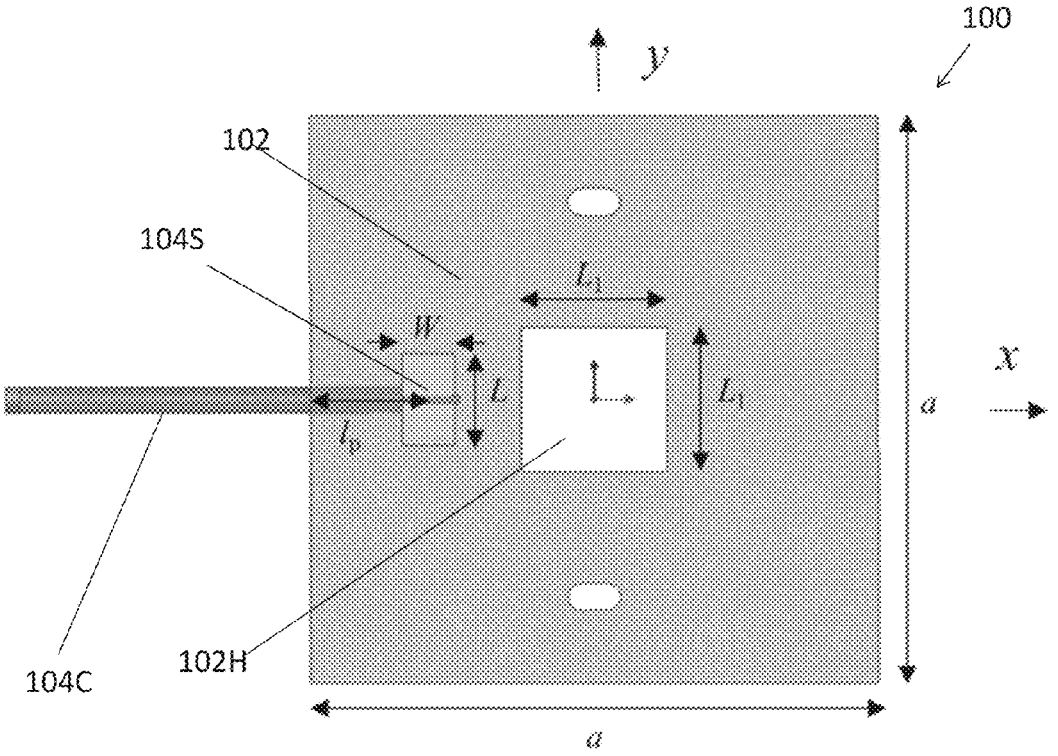
* cited by examiner

Primary Examiner — Andrea Lindgren Baltzell
Assistant Examiner — Amal Patel
(74) *Attorney, Agent, or Firm* — Renner Kenner Greive Bobak Taylor & Weber

(57) **ABSTRACT**

An antenna assembly, a wireless-communication-enabled device and an intelligent home or office appliance including such antenna assembly. The antenna assembly includes an antenna including an antenna body and a feeder, and at least one functional module arranged to operate with a function different from that provided by the antenna.

22 Claims, 11 Drawing Sheets



US011108130B1

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

(10) **Patent No.: US 11,108,130 B1**
(45) **Date of Patent: Aug. 31, 2021**

(54) **ELECTRONIC DEVICE SLOT ANTENNAS**

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

(72) Inventors: **Paul X. Wang**, Cupertino, CA (US); **Bradley J. Hamel**, San Carlos, CA (US); **Jerzy S. Guterman**, Sunnyvale, CA (US); **Joel D. Barrera**, San Jose, CA (US); **Nicholas A. Rundle**, San Jose, CA (US); **Nikolaos Chiotellis**, Campbell, CA (US); **Simon S. Lee**, 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 11 days.

(21) Appl. No.: **16/800,920**

(22) Filed: **Feb. 25, 2020**

(51) **Int. Cl.**

H01Q 1/22	(2006.01)
F16M 11/10	(2006.01)
H05K 1/18	(2006.01)
H05K 1/02	(2006.01)
H01Q 13/10	(2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/2266*** (2013.01); ***F16M 11/10*** (2013.01); ***H01Q 13/10*** (2013.01); ***H05K 1/0243*** (2013.01); ***H05K 1/189*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/2266; H01Q 13/10; H05K 1/189; H05K 1/0243; F16M 11/10; F16M 2200/00; F16M 2200/065; F16M 2200/08; F16L 3/1016
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,024,883	B2	5/2015	Mia	
9,917,347	B2 *	3/2018	Bologna	H01Q 1/2266
10,108,221	B1	10/2018	Gu et al.	
10,215,371	B1	2/2019	Lehman et al.	
10,278,300	B2	4/2019	Kim et al.	
2003/0213099	A1	11/2003	Mori	
2005/0002156	A1	1/2005	Hsu et al.	
2014/0240177	A1 *	8/2014	Wang	H01Q 1/2266 343/702
2017/0329364	A1 *	11/2017	Kim	F16M 11/22
2019/0309894	A1	10/2019	Hasegawa et al.	
2020/0303824	A1 *	9/2020	Barrera	H01Q 13/18

FOREIGN PATENT DOCUMENTS

WO 2019070253 A1 4/2019

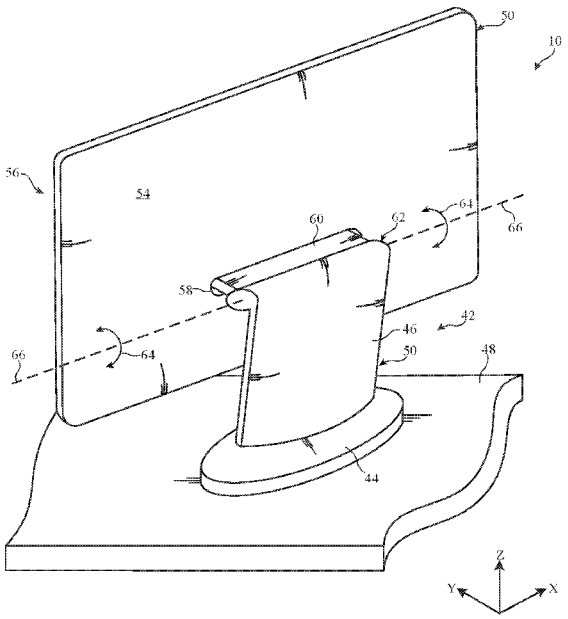
* cited by examiner

Primary Examiner — Daniel D Chang
(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; Michael H. Lyons

(57) **ABSTRACT**

An electronic device such as a desktop computer may have a housing with a conductive housing wall and a display mounted to the housing opposite the conductive housing wall. A conductive tongue may extend through an opening in the housing wall to secure the housing to a hinge barrel on a desktop stand. A slot antenna may be formed from a slot element in the conductive tongue. The antenna may be fed by a flexible printed circuit coupled across the slot element or by a feed printed circuit in the housing that is coupled to the conductive tongue by a conductive screw. A conductive sleeve may be placed over the conductive tongue. The stand may be replaced with a mounting bracket.

20 Claims, 9 Drawing Sheets



US011108132B2

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

(10) **Patent No.: US 11,108,132 B2**
(45) **Date of Patent: Aug. 31, 2021**

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

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

(72) Inventors: **Kai Dong**, Shenzhen (CN); **Dawei Shi**, 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 189 days.

(21) Appl. No.: **16/438,470**

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

(65) **Prior Publication Data**

US 2019/0386377 A1 Dec. 19, 2019

(30) **Foreign Application Priority Data**

Jun. 13, 2018 (CN) 201810604313.6

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 1/38	(2006.01)
H01Q 1/48	(2006.01)
H04M 1/02	(2006.01)
H04M 1/03	(2006.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 1/48*** (2013.01); ***H04M 1/0266*** (2013.01); ***H04M 1/03*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 5/364; H01Q 5/371

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2018/0159221	A1*	6/2018	Liou	H01Q 9/42
2018/0366812	A1*	12/2018	Kim	H01Q 13/106
2019/0109622	A1*	4/2019	Wang	H04B 7/0452

FOREIGN PATENT DOCUMENTS

CN	101719586 A1	6/2010
CN	108040310 A1	5/2018
CN	108110407 A1	6/2018

OTHER PUBLICATIONS

1st Office Action dated Dec. 19, 2019 by CNIPA in related Chinese Patent Application No. 201810604313.6 (46 Pages).

* cited by examiner

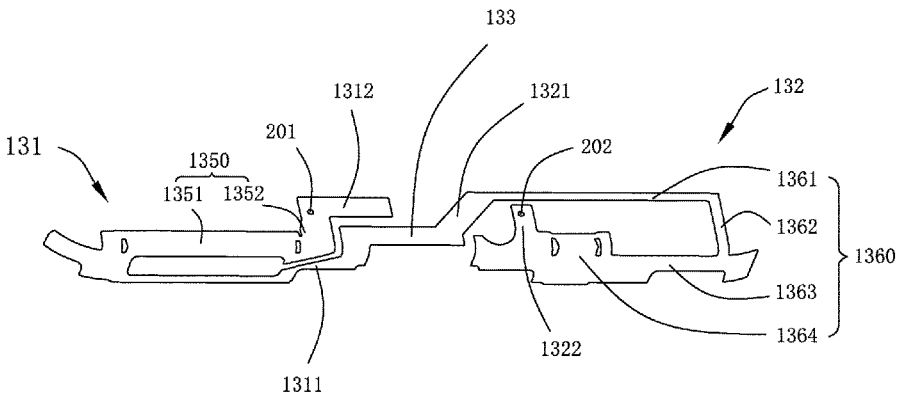
Primary Examiner — Daniel Munoz

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

(57) **ABSTRACT**

The present disclosure discloses an antenna system. The antenna system includes a circuit board having a feeding point, an RF switch, and a system ground. The antenna further includes a feeding portion electrically connected to the feeding point, a ground portion connected to the system ground by the RF switch, and a connecting portion connecting the feeding portion to the ground portion. The ground portion includes a first metal segment for connecting to the connecting portion, and a second metal segment; the feeding portion includes a third metal segment and a fourth segment. The RF switch electrically connects to the second metal segment, and the feeding point electrically connects to the fourth segment.

6 Claims, 4 Drawing Sheets



US011108133B2

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

(10) **Patent No.: US 11,108,133 B2**
(45) **Date of Patent: Aug. 31, 2021**

(54) **ANTENNA SYSTEM AND MOBILE TERMINAL IMPLEMENTED WITH THE ANTENNA SYSTEM**

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

(72) Inventors: **Jing Wu**, Shenzhen (CN); **Ke Hua**, Shenzhen (CN); **Haibing Chen**, 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 127 days.

(21) Appl. No.: **16/699,702**

(22) Filed: **Dec. 1, 2019**

(65) **Prior Publication Data**

US 2020/0203806 A1 Jun. 25, 2020

(30) **Foreign Application Priority Data**

Dec. 24, 2018 (CN) 201811581133.7

(51) **Int. Cl.**
H01Q 23/00 (2006.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 23/00*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/328; H01Q 1/243; H01Q 23/00; H01Q 9/0421; H01Q 5/378
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2003/0210206 A1* 11/2003 Phillips H01Q 1/50 343/895
2009/0224991 A1* 9/2009 Rowson H01Q 9/0421 343/747
2012/0009884 A1* 1/2012 Rao H01Q 21/30 455/73
2012/0146865 A1* 6/2012 Hayashi H01Q 9/42 343/750
2014/0218247 A1* 8/2014 Tefiku H01Q 1/243 343/752
2014/0266922 A1* 9/2014 Jin H01Q 5/314 343/702
2014/0292590 A1* 10/2014 Yoo H01Q 1/243 343/702

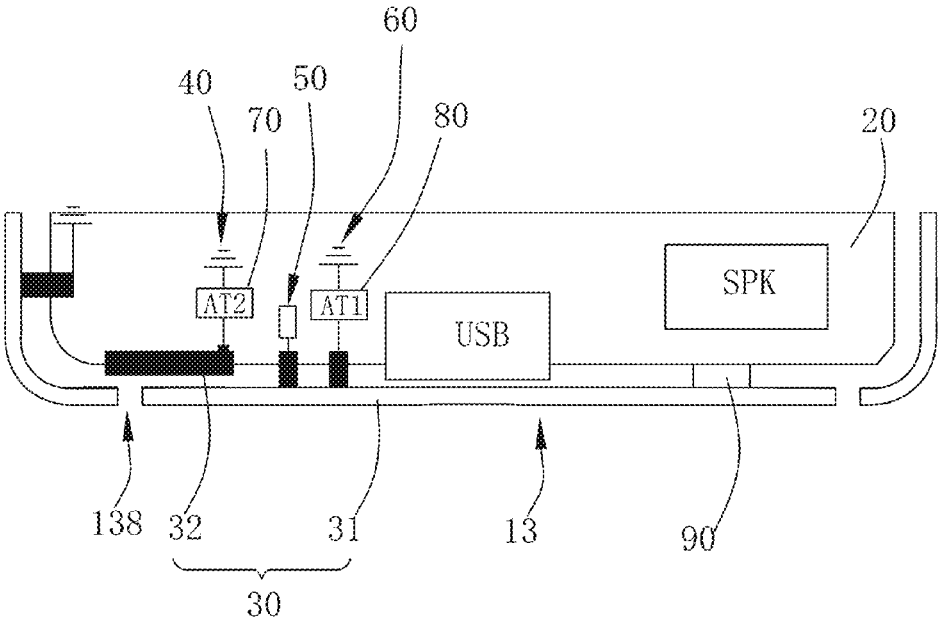
(Continued)

Primary Examiner — Dimary S Lopez Cruz
Assistant Examiner — Bamidele A Jegede
(74) *Attorney, Agent, or Firm* — W&G Law Group LLP

(57) **ABSTRACT**

An antenna system and a mobile terminal implemented with the antenna system are provided. The mobile terminal has a metal frame and a system grounding. The antenna system has at least a first antenna module, a second antenna module, a third antenna module and a fourth antenna module. The first antenna module has a radiating body and a parasitic element coupled to the radiating body. The radiating body is configured to generate a main harmonic, and the parasitic element is configured to generate a parasitic harmonic. The first antenna module further has a first tuning circuit and a second tuning circuit. The antenna system has at least four operation modes. The antenna system of the present invention may achieve carrier aggregation of different LTE frequencies, and may be used as a MIMO antenna system.

16 Claims, 8 Drawing Sheets



US011108143B2

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

(10) **Patent No.: US 11,108,143 B2**
(45) **Date of Patent: Aug. 31, 2021**

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

(71) Applicant: **City University of Hong Kong**, Kowloon (HK)

(72) Inventors: **Kwok Wa Leung**, Kowloon Tong (HK); **Li Ying Feng**, Tianjin (CN)

(73) Assignee: **City University of Hong Kong**, Kowloon (HK)

(*) 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.: **16/560,031**

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

(65) **Prior Publication Data**

US 2021/0066789 A1 Mar. 4, 2021

(51) **Int. Cl.**

H01Q 1/38	(2006.01)
H01Q 1/48	(2006.01)
H01Q 1/50	(2006.01)
H01Q 9/04	(2006.01)
H01Q 5/10	(2015.01)
H01Q 5/307	(2015.01)
H01Q 13/08	(2006.01)

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

CPC ***H01Q 1/38*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 1/50*** (2013.01); ***H01Q 5/10*** (2015.01); ***H01Q 5/307*** (2015.01); ***H01Q 9/0485*** (2013.01); ***H01Q 13/08*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/36; H01Q 5/10; H01Q 9/0485

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,546,333	A *	10/1985	Fukasawa	H01P 1/2056 333/202
4,626,865	A *	12/1986	Rammos	H01Q 1/38 343/786
6,445,345	B1 *	9/2002	Kamimoto	H01P 3/081 333/26
10,727,565	B2 *	7/2020	Kim	H01Q 1/2283
2008/0272963	A1 *	11/2008	Chang	H01Q 1/2291 343/700 MS
2019/0288399	A1 *	9/2019	Tanaka	H01Q 1/48

OTHER PUBLICATIONS

L. Y. Feng et al, "Dual-frequency folded-parallel-plate antenna with large frequency ratio," IEEE Trans. Antennas Propag., vol. 64, No. 1, pp. 304-245, Jan. 2016.

H. M. Chen et al, "A compact dual-band dielectric resonator antenna using a parasitic slot," IEEE Antennas Wireless Propag. Lett., vol. 8, pp. 173-176, Aug. 2009.

K. S. Fang et al, "Singly-fed dual-band circularly polarized dielectric resonator antenna," IEEE Antennas Wireless Propag. Lett., vol. 13, No. 6, pp. 995-998, 2014.

(Continued)

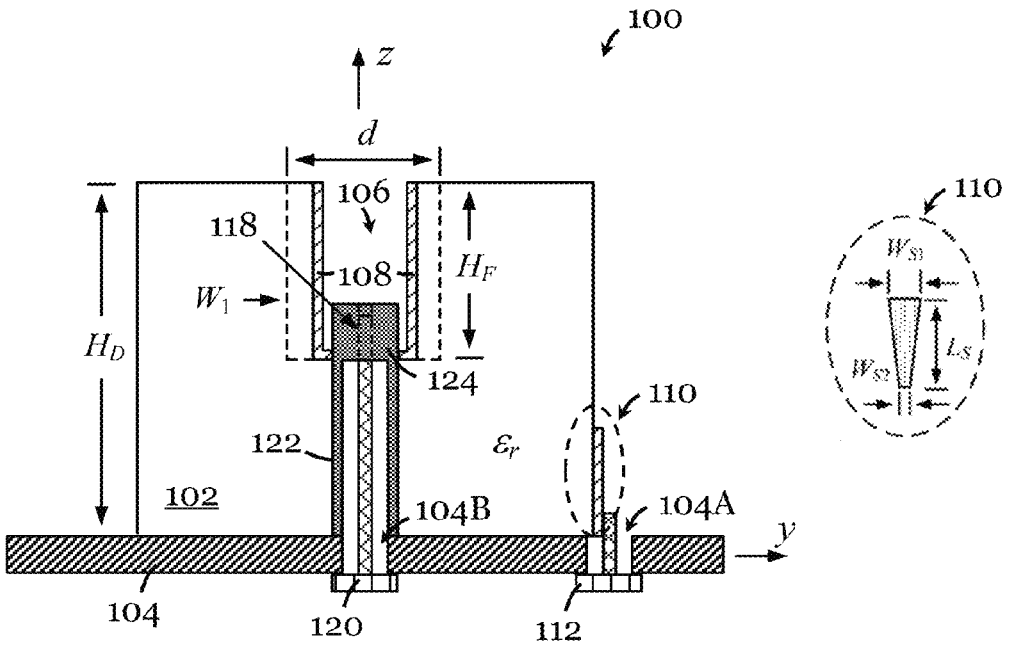
Primary Examiner — Wei (Victor) Y Chan

(74) *Attorney, Agent, or Firm* — Renner Kenner Greive Bobak Taylor & Weber

(57) **ABSTRACT**

An antenna including a dielectric block with a groove, and a conductor arranged in the groove. The antenna is arranged to be excited to operate as a dielectric resonator antenna and a Fabry-Perot resonator antenna.

25 Claims, 18 Drawing Sheets



US011108144B2

(12) **United States Patent**
Chuang

(10) **Patent No.: US 11,108,144 B2**
(45) **Date of Patent: Aug. 31, 2021**

(54) **ANTENNA STRUCTURE**

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

(72) Inventor: **Shih Ming Chuang**, New Taipei (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 86 days.

(21) Appl. No.: **16/689,752**

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

(65) **Prior Publication Data**

US 2021/0126355 A1 Apr. 29, 2021

(30) **Foreign Application Priority Data**

Oct. 23, 2019 (TW) 108138171

(51) **Int. Cl.**
H01Q 19/24 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/38*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/245*** (2013.01); ***H01Q 19/24*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/36; H01Q 1/38; H01Q 1/243; H01Q 19/22; H01Q 19/24; H01Q 5/30; H01Q 5/307; H01Q 5/357; H01Q 5/364; H01Q 5/371
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

10,418,697 B2 * 9/2019 Kashiwagi H01Q 21/30
2009/0073048 A1 * 3/2009 Kim ..... H01Q 9/30 343/700 MS
2009/0079639 A1 * 3/2009 Hotta H01Q 1/243 343/702
2009/0135071 A1 * 5/2009 Huang ..... H01Q 9/0421 343/700 MS

(Continued)

FOREIGN PATENT DOCUMENTS

CN 106033834 B 5/2019
TW M326236 U 1/2008

OTHER PUBLICATIONS

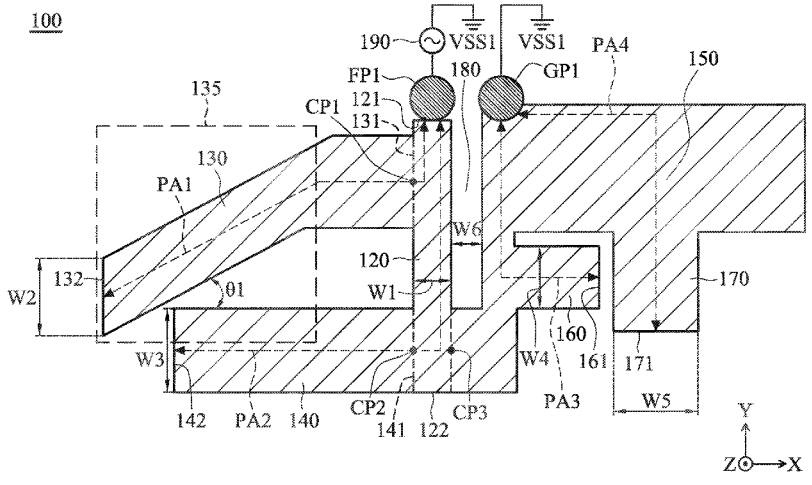
Chinese language office action dated May 22, 2020, issued in application No. TW 108138171.

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

(57) **ABSTRACT**

An antenna structure includes a feeding radiation element, a first radiation element, a second radiation element, and a third radiation element. The feeding radiation element has a feeding point. The first radiation element is coupled to a first connection point on the feeding radiation element. The first radiation element includes a bending portion. The second radiation element is coupled to a second connection point on the feeding radiation element, and is adjacent to the bending portion of the first radiation element. The second radiation element is not parallel to the first radiation element. The third radiation element has a grounding point, and is coupled to a third connection point on the feeding radiation element. The third radiation element includes a first protruding portion and a second protruding portion. The first protruding portion and the second protruding portion of the third radiation element extend in different directions.

16 Claims, 5 Drawing Sheets



US011108164B2

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

(10) **Patent No.: US 11,108,164 B2**
(45) **Date of Patent: Aug. 31, 2021**

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

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

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

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 72 days.

(21) Appl. No.: **16/524,095**

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

(65) **Prior Publication Data**

US 2020/0052416 A1 Feb. 13, 2020

(30) **Foreign Application Priority Data**

Aug. 12, 2018 (CN) 201810910596.7

(51) **Int. Cl.**

H01Q 21/06	(2006.01)
H01Q 1/22	(2006.01)
H01Q 1/24	(2006.01)
H01Q 23/00	(2006.01)

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

CPC ***H01Q 21/065*** (2013.01); ***H01Q 1/2283*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 23/00*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/2283; H01Q 9/0407; H01Q 9/0457; H01Q 21/065; H01Q 21/08; H01Q 23/00; H01Q 9/0435; H01Q 21/06; H01Q 1/38; H01Q 1/50

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,755,298	B2 *	9/2017	Choi	H01Q 1/48
10,305,189	B2 *	5/2019	Ueda	H01Q 9/0407
10,819,002	B2 *	10/2020	Zhu	H01Q 1/243
11,031,671	B2 *	6/2021	Xia	H01Q 9/0407
2019/0229402	A1 *	7/2019	Xia	H01Q 21/29
2020/0052373	A1 *	2/2020	Xia	H01Q 1/2283
2020/0052416	A1 *	2/2020	Yong	H01Q 21/065

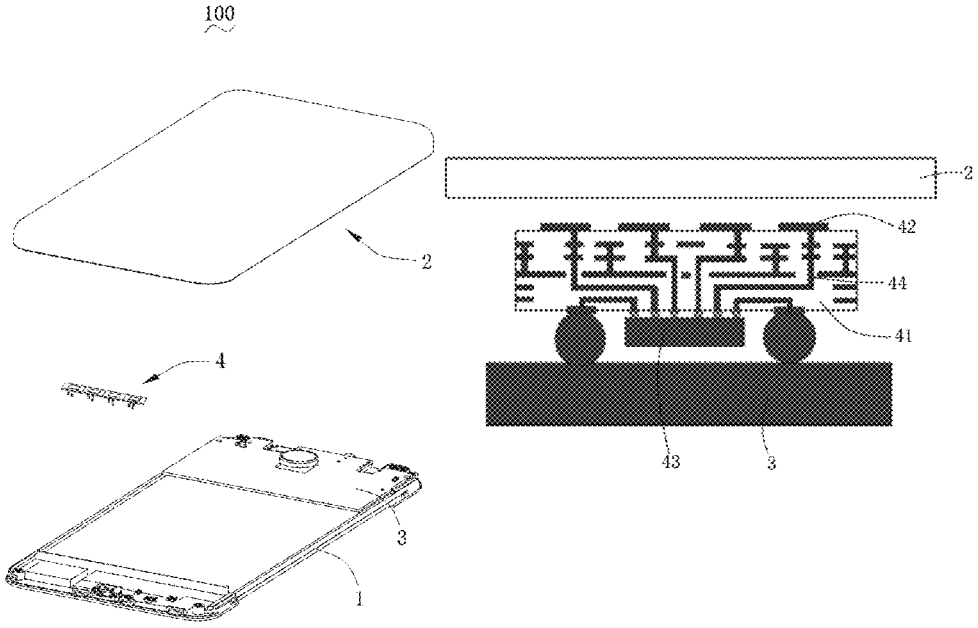
* cited by examiner

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

(57) **ABSTRACT**

An antenna module and a mobile terminal are provided. The antenna module is applied to a mobile terminal, and the mobile terminal includes a 3D glass back cover. The antenna module includes a patch antenna provided inside of the 3D glass back cover and spaced apart from the 3D glass back cover by a predetermined distance. The patch antenna is fed with power through a probe and operates in millimeter wave bands. The antenna module and the mobile terminal provided effectively improve the impedance bandwidth by changing a position of a feeding point.

9 Claims, 9 Drawing Sheets



US011114744B2

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

(10) **Patent No.: US 11,114,744 B2**
(45) **Date of Patent: Sep. 7, 2021**

(54) **ANTENNA HAVING SINGLE NON-CONDUCTIVE PORTION AND ELECTRONIC DEVICE INCLUDING THE SAME**

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

(72) Inventors: **Sungkoo Park**, Suwon-si (KR); **Hyungjoo Lee**, Suwon-si (KR); **Shinho Yoon**, Suwon-si (KR); **Himchan Yun**, Suwon-si (KR); **Soonho Hwang**, Suwon-si (KR); **Jaebong Chun**, Suwon-si (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 22 days.

(21) Appl. No.: **16/596,108**

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

(65) **Prior Publication Data**

US 2020/0119429 A1 Apr. 16, 2020

(30) **Foreign Application Priority Data**

Oct. 16, 2018 (KR) 10-2018-0122922

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

(52) **U.S. Cl.**
CPC ***H01Q 1/2266*** (2013.01); ***G06F 1/1616*** (2013.01); ***G06F 1/1626*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/2266; H01Q 1/38; H01Q 9/42; H01Q 9/30; H01Q 5/35; H01Q 5/335;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,541,962 B2 * 1/2017 Siddiqui E05D 1/00
9,813,532 B2 11/2017 Kim et al.
(Continued)

FOREIGN PATENT DOCUMENTS

EP 3 293 816 A1 3/2018
KR 10-2017-0073964 A 6/2017

OTHER PUBLICATIONS

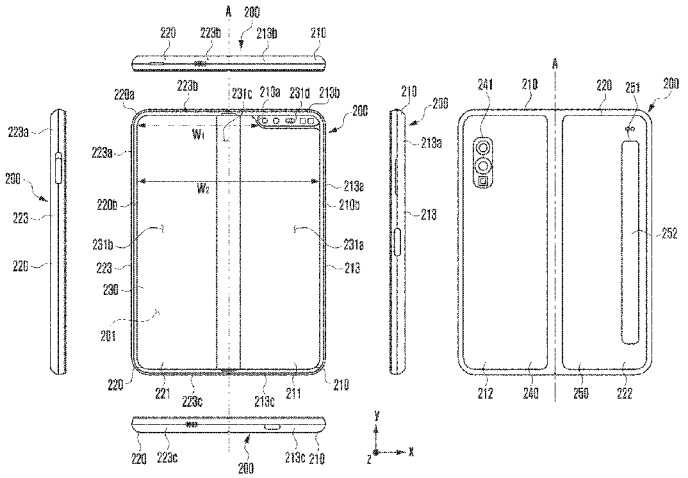
International Search Report dated Jan. 22, 2020, issued in International Application No. PCT/KR2019/013163.
(Continued)

Primary Examiner — AB Salam Alkassim, Jr.
Assistant Examiner — David E Lotter
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a foldable housing including, a hinge structure, a first housing structure including a first surface, a second surface, and a first side member, wherein the first side member encloses at least a portion of a space between the first surface and the second surface and includes a first conductive portion, a first non-conductive portion, and a second conductive portion, and a second housing structure including a third surface, a fourth surface, and a second side member, a printed circuit board, at least one wireless communication circuit including a first electrical path and a second electrical path, a first variable element including a first terminal, a second terminal, and a third terminal, and a second variable element including a fourth terminal, a fifth terminal, and a sixth terminal.

8 Claims, 17 Drawing Sheets



US011114747B2

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

(10) **Patent No.: US 11,114,747 B2**
(45) **Date of Patent: Sep. 7, 2021**

(54) **ANTENNA INCLUDING CONDUCTIVE PATTERN AND ELECTRONIC DEVICE INCLUDING THE SAME**

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

(72) Inventors: **Chungkyun Ham**, Suwon-si (KR); **Seunggil Jeon**, Suwon-si (KR); **Jaehun Jung**, Suwon-si (KR); **Youngsik Kim**, Suwon-si (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 141 days.

(21) Appl. No.: **16/441,376**

(22) Filed: **Jun. 14, 2019**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jun. 14, 2018 (KR) 10-2018-0068292

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/06 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 5/42*** (2015.01); ***H01Q 9/065*** (2013.01); ***H01Q 9/42*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 1/40; H01Q 1/2283; H01Q 5/42; H01Q 9/065;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,427,377 B2 4/2013 Wang
2009/0273531 A1 11/2009 Ishizuka et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 206271859 U 6/2017
EP 3 537 536 A1 9/2019
(Continued)

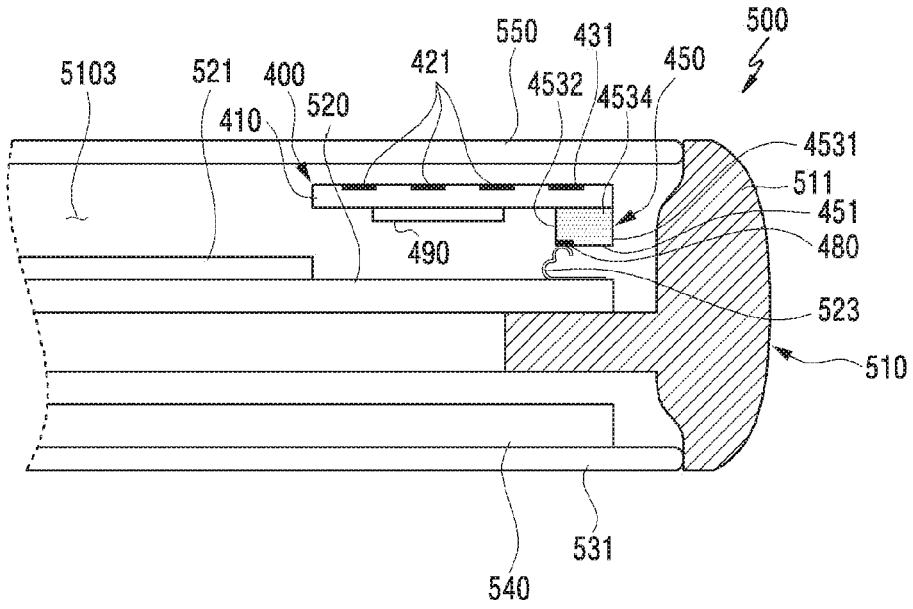
OTHER PUBLICATIONS

International Search Report with Written Opinion dated Sep. 26, 2019; International Appln. No. PCT/KR2019/007206.
(Continued)

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

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a housing including a first plate, a second plate facing away from the first plate, and a side member surrounding a space between the first plate and the second plate, a first PCB disposed in parallel with the first plate in the space between the first plate and the second plate, and including a first face facing the first plate and a second face facing the second plate, at least one conductive plate formed on the second face, a first conductive pattern embedded in the first PCB and disposed to be closer to a portion of the side member than the conductive plate when viewed from
(Continued)



US011114756B2

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

(10) **Patent No.: US 11,114,756 B2**
(45) **Date of Patent: Sep. 7, 2021**

(54) **ANTENNA SYSTEM**

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

(72) Inventors: **Shih Ming Chuang**, New Taipei (TW); **Jyun Nian Lin**, New Taipei (TW); **Chih-Ming Chen**, New Taipei (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 128 days.

(21) Appl. No.: **16/751,274**

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

(65) **Prior Publication Data**

US 2021/0184345 A1 Jun. 17, 2021

(30) **Foreign Application Priority Data**

Dec. 13, 2019 (TW) 108145692

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 1/52	(2006.01)
H01Q 21/30	(2006.01)
H01Q 9/04	(2006.01)
H01Q 21/28	(2006.01)
H01Q 13/10	(2006.01)

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

CPC ***H01Q 1/521*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 9/0421*** (2013.01); ***H01Q 13/106*** (2013.01); ***H01Q 21/28*** (2013.01); ***H01Q 21/30*** (2013.01)

(58) **Field of Classification Search**

CPC H01G 1/243; H01G 9/0421; H01G 13/106

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2017/0162948 A1 6/2017 Wong et al.
2020/0021021 A1 * 1/2020 Lin H01Q 5/20

FOREIGN PATENT DOCUMENTS

TW 201721974 A 6/2017

OTHER PUBLICATIONS

Chinese language office action dated Nov. 20, 2020, issued in application No. TW 108145692.

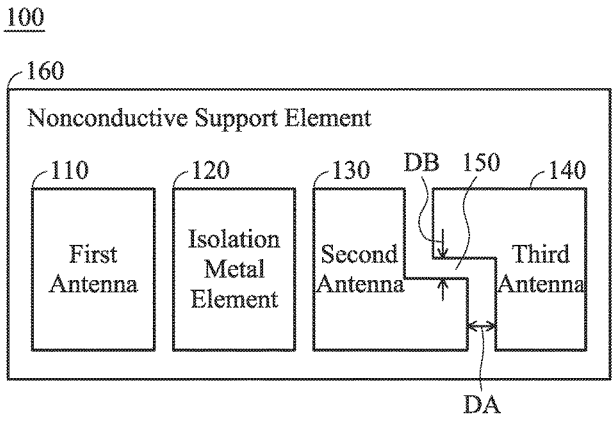
* cited by examiner

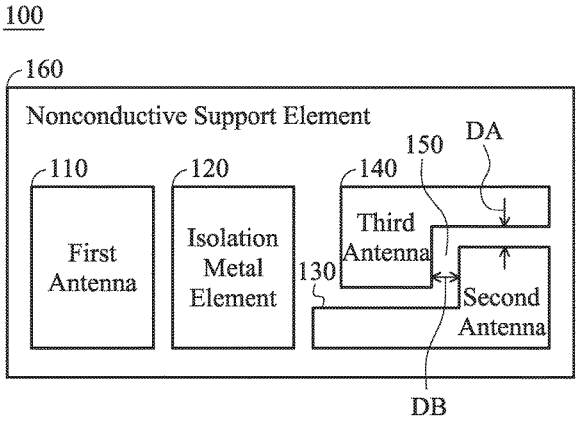
Primary Examiner — Graham P Smith
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

An antenna system includes a first antenna, a second antenna, a third antenna, an isolation metal element, and a nonconductive support element. The isolation metal element is disposed between the first antenna and the second antenna. The third antenna defines a notch region. The second antenna at least partially extends into the notch region. The distance between the third antenna and the second antenna is from 1 mm to 10 mm. The first antenna, the second antenna, the third antenna, and the isolation metal element are all disposed on the nonconductive support element.

20 Claims, 9 Drawing Sheets





US011114766B1

(12) **United States Patent**
Hyman

(10) **Patent No.: US 11,114,766 B1**
(45) **Date of Patent: Sep. 7, 2021**

(54) **TAPERED SLOT ANTENNA**

(71) Applicant: **IXI Technology Holdings, Inc.**, Yorba Linda, CA (US)

(72) Inventor: **Daniel Hyman**, Long Beach, CA (US)

(73) Assignee: **IXI Technology Holdings, Inc.**, Yorba Linda, 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.: **16/810,778**

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

(51) **Int. Cl.**
H01Q 13/08 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 13/085*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 13/08–13/18; H01Q 21/064
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,036,335	A *	7/1991	Jairam	H01Q 13/106 343/767
5,081,466	A *	1/1992	Bitter, Jr.	H01Q 13/085 343/767
5,748,153	A *	5/1998	McKinzie, III	H01Q 13/08 343/767
7,064,722	B1	6/2006	Neel	
7,557,755	B2 *	7/2009	Han	H01Q 1/38 343/700 MS
2017/0207546	A1	7/2017	Benzel et al.	
2017/0256860	A1	9/2017	Liao	
2018/0145420	A1	5/2018	Kushta	

FOREIGN PATENT DOCUMENTS

GB	2508428	A	6/2014

OTHER PUBLICATIONS

Amruta S. Dixit and Sumit Kumar, "A Survey of Performance Enhancement Techniques of Antipodal Vivaldi Antenna", IEEE Access,vol. 8, p. 45774-45796, pub. Feb. 28, 2020 (current version Mar. 16, 2020).

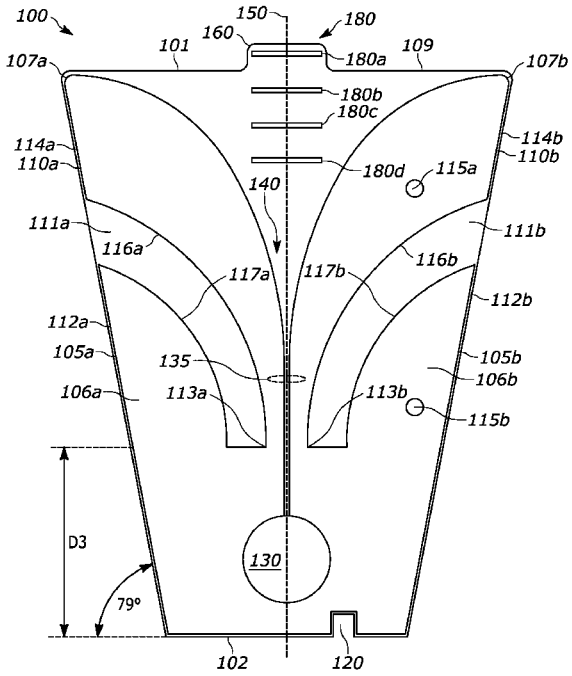
* cited by examiner

Primary Examiner — Hasan Islam
(74) *Attorney, Agent, or Firm* — The Watson IP Group, PLC; Jovan N. Jovanovic

(57) **ABSTRACT**

A tapered slot antenna includes a cavity, first and second antenna flanges, a tapered slot, and first and second current wings. The first and second antenna flanges can be disposed on a first half and a second half of the tapered slot antenna, respectively. The second antenna flange can be electrically coupled to the first antenna flange, the first and second antenna flanges tapering from a greater flange width proximate to a top of the tapered slot antenna to a lesser flange width proximate to the cavity. The first current wing can be disposed on the first half of the antenna and the second current wing can be disposed on the second side of the antenna. The first and second sidewalls can be disposed on the first and second halves of the tapered slot antenna, respectively, can taper from the top to a bottom of the tapered slot antenna.

16 Claims, 5 Drawing Sheets



US011114772B2

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

(10) **Patent No.: US 11,114,772 B2**
(45) **Date of Patent: Sep. 7, 2021**

(54) **DUAL POLARIZED OMNI-DIRECTIONAL ANTENNA AND BASE STATION INCLUDING SAME**

(71) Applicant: **KMW INC.**, Hwaseong-si (KR)

(72) Inventors: **Duk Yong Kim**, Yongin-si (KR); **Young Chan Moon**, Hwaseong-si (KR); **In Ho Kim**, Yongin-si (KR); **Oh Seog Choi**, Hwaseong-si (KR)

(73) Assignee: **KMW INC.**, Hwaseong-si (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 50 days.

(21) Appl. No.: **16/550,471**

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

(65) **Prior Publication Data**

US 2019/0379141 A1 Dec. 12, 2019

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2018/002426, filed on Feb. 28, 2018.

(30) **Foreign Application Priority Data**

Feb. 28, 2017 (KR) 10-2017-0026078

(51) **Int. Cl.**
H01Q 21/26 (2006.01)
H01Q 25/00 (2006.01)
H01Q 9/16 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 25/005*** (2013.01); ***H01Q 9/16*** (2013.01); ***H01Q 21/26*** (2013.01); ***H01Q 25/00*** (2013.01); ***H01Q 25/001*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 25/005; H01Q 25/001; H01Q 21/26; H01Q 9/16; H01Q 25/00
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,922,259 A 5/1990 Hall et al.
5,173,715 A * 12/1992 Rodal H01Q 21/205 343/795
(Continued)

FOREIGN PATENT DOCUMENTS

CN 2752984 Y 1/2006
CN 104092007 A 10/2014
(Continued)

OTHER PUBLICATIONS

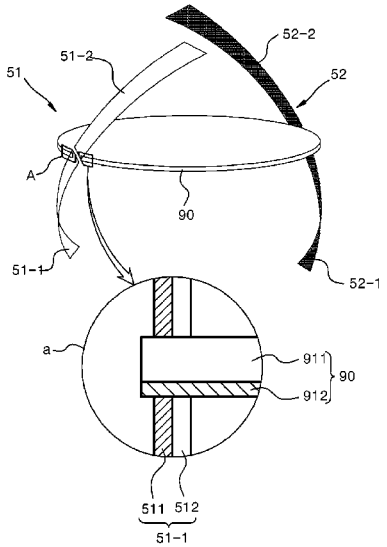
International Search Report for PCT/KR2018/002426, dated May 24, 2018, and its English translation.

Primary Examiner — Hai V Tran
(74) *Attorney, Agent, or Firm* — Seung Ho Lee

(57) **ABSTRACT**

The present disclosure includes, in a dual polarized omni-directional antenna and a base station including the same, a plurality of radiating elements disposed to be spaced apart in one direction by the dual polarized omni-directional antenna, and a feed line for providing a feed signal to the plurality of radiating elements, and the plurality of radiating elements include a first radiator for generating one polarization of dual polarization, and a second radiator for generating the other polarization of the dual polarization, respectively, the first radiator is prepared on a first surface, and the second radiator is prepared on a second surface, and a main lobe direction of the first radiator and a main lobe direction of the second radiator are different directions from each other.

11 Claims, 18 Drawing Sheets



US011115082B2

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

(10) **Patent No.: US 11,115,082 B2**
(45) **Date of Patent: Sep. 7, 2021**

(54) **WIRELESS POWER TRANSMISSION/RECEPTION DEVICE AND METHOD USED IN ELECTRONIC APPARATUS**

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

(72) Inventors: **Ju-Hyang Lee**, Gyeonggi-do (KR); **Keumsu Song**, Seoul (KR); **Dongzo Kim**, Gyeonggi-do (KR); **Yusu Kim**, Gyeonggi-do (KR); **Seho Park**, Gyeonggi-do (KR); **Jung-Oh Sung**, Gyeonggi-do (KR); **Mincheol Ha**, Gyeonggi-do (KR); **Changjong Son**, Gyeonggi-do (KR); **Seung-Nyun Kim**, Incheon (KR); **Yong Sang Yun**, Gyeonggi-do (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 242 days.

(21) Appl. No.: **16/315,940**

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

(86) PCT No.: **PCT/KR2017/003330**
§ 371 (c)(1),
(2) Date: **Jan. 7, 2019**

(87) PCT Pub. No.: **WO2018/008832**
PCT Pub. Date: **Jan. 11, 2018**

(65) **Prior Publication Data**

US 2019/0229771 A1 Jul. 25, 2019

(30) **Foreign Application Priority Data**

Jul. 7, 2016 (KR) 10-2016-0086211

(51) **Int. Cl.**
H04B 5/00 (2006.01)
H02J 50/12 (2016.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04B 5/0037*** (2013.01); ***H01Q 1/22*** (2013.01); ***H01Q 1/24*** (2013.01); ***H02H 9/04*** (2013.01);
(Continued)

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

2009/0146658 A1 6/2009 McDowell et al.
2010/0142509 A1 6/2010 Zhu et al.
(Continued)

FOREIGN PATENT DOCUMENTS

KR 1020070017804 2/2007
KR 1020140131428 11/2014
(Continued)

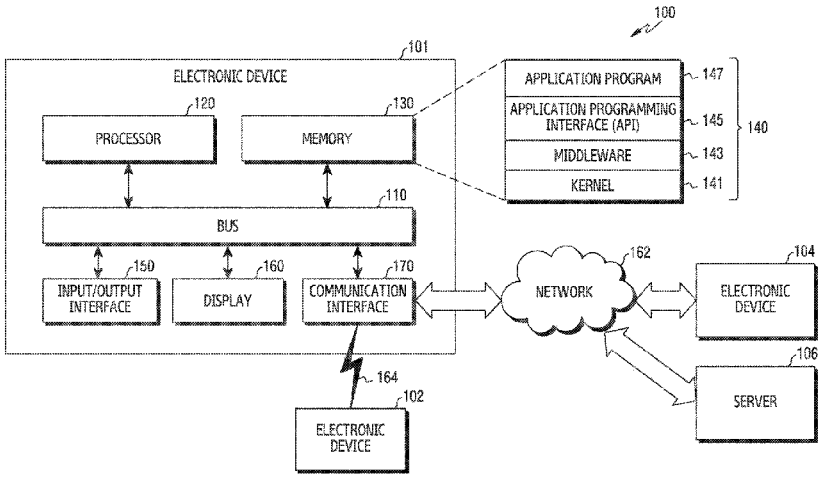
OTHER PUBLICATIONS

European Search Report dated Mar. 12, 2020 issued in counterpart application No. 17824388.7-1202, 4 pages.
(Continued)

Primary Examiner — Jared Fureman
Assistant Examiner — Aqeel H Bukhari
(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(57) **ABSTRACT**

According to one embodiment of the present invention, an electronic apparatus can comprises: at least one antenna; a first circuit for wirelessly receiving or transmitting power by using at least one part of the at least one antenna; a second circuit for performing at least one communication by using
(Continued)



US011115508B1

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

(10) **Patent No.: US 11,115,508 B1**
(45) **Date of Patent: Sep. 7, 2021**

(54) **WIRELESS COMMUNICATION DEVICE AND CASE ASSEMBLY**

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

(72) Inventors: **Chih-Kuang Wang**, Taoyuan (TW); **Chin Kai Sun**, Taoyuan (TW); **Chun-Lung Chu**, Taoyuan (TW); **Tung-Hsin Yeh**, Taoyuan (TW)

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

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

(21) Appl. No.: **16/897,438**

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

(51) **Int. Cl.**
H04M 1/02 (2006.01)

(52) **U.S. Cl.**
CPC ***H04M 1/0202*** (2013.01)

(58) **Field of Classification Search**
CPC H04M 1/0202
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,232,031	B1 *	1/2016	Shoval	H01Q 1/242
10,164,679	B1 *	12/2018	Rajagopalan	H04B 1/3827
2007/0155445	A1 *	7/2007	Cho	C25D 1/00 455/575.1
2008/0316117	A1 *	12/2008	Hill	H01Q 21/30 343/702
2011/0186345	A1 *	8/2011	Pakula	H05K 5/0086 174/520
2013/0017864	A1 *	1/2013	Allore	H04M 1/0202 455/566
2015/0050968	A1 *	2/2015	Jeon	C25D 11/26 455/575.1
2016/0233573	A1 *	8/2016	Son	H01Q 9/04
2018/0069588	A1 *	3/2018	Jiang	G06F 1/163
2018/0278730	A1 *	9/2018	Saeed	G06Q 20/322
2019/0260861	A1 *	8/2019	Wang	H04M 1/02

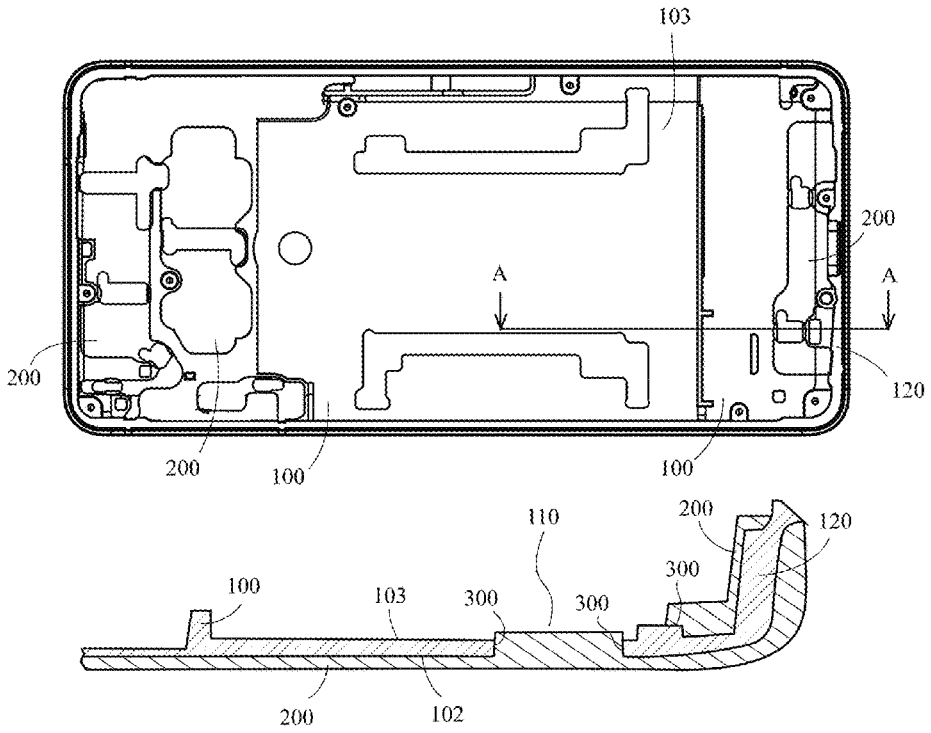
* cited by examiner

Primary Examiner — Kenneth T Lam
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

A case assembly and a wireless communication device are provided. The case assembly includes a metal case and a plastic cladding body. The metal case includes an inner side and an outer side, the inner side is opposite to the outer side, the metal case includes a hollow portion and an antenna portion, the hollow portion is adjacent to a side of the antenna portion. The plastic cladding body is disposed on the metal case, and completely covers the outer side of the metal case, partially covers the inner side of the metal case, and fills the hollow portion. The wireless communication device includes a case assembly and a radio frequency signal module. The radio frequency signal module is electrically connected to the antenna portion of the case assembly. Thus, the structural rigidity of the wireless communication device and its case assembly is kept, and the production cost is reduced.

8 Claims, 7 Drawing Sheets



US011115509B2

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

(10) **Patent No.: US 11,115,509 B2**
(45) **Date of Patent: *Sep. 7, 2021**

(54) **ELECTRONIC DEVICE WITH METAL FRAME ANTENNA**

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

(72) Inventors: **Jaehyung Kim**, Gyeonggi-do (KR); **Jinkyu Bang**, Gyeonggi-do (KR); **Jinu Kim**, Seoul (KR); **Donghwan Kim**, Gyeonggi-do (KR); **Taegyu Kim**, Gyeonggi-do (KR); **Kiyoung Chang**, Seoul (KR)

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

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

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **17/073,766**

(22) Filed: **Oct. 19, 2020**

(65) **Prior Publication Data**

US 2021/0037123 A1 Feb. 4, 2021

Related U.S. Application Data

(63) Continuation of application No. 16/126,534, filed on Sep. 10, 2018, now Pat. No. 10,812,636, which is a (Continued)

(30) **Foreign Application Priority Data**

Nov. 13, 2015 (KR) 10-2015-0159787

(51) **Int. Cl.**
H04B 1/38 (2015.01)
H04M 1/02 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04M 1/0218*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 5/385*** (2015.01);
(Continued)

(58) **Field of Classification Search**
CPC H04M 1/0214; H04M 1/0216; H04M 1/0222; H04M 1/0274; H01Q 5/385; H01Q 1/243
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,417,593 B1 8/2008 Hsiao et al.
8,090,419 B2 1/2012 Isoda et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 101248651 8/2008
CN 102037604 4/2011
(Continued)

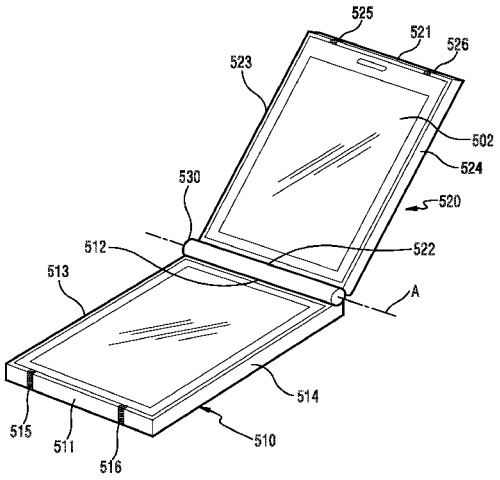
OTHER PUBLICATIONS

Australian Examination Report dated Sep. 20, 2018 issued in counterpart application No. 2016352502, 4 pages.
(Continued)

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

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a housing and a connection part. The housing includes a first housing portion that includes a first side face, and a second housing portion that includes a second side face. The connection part connects the first housing portion and the second housing portion. A first conductive member extends along at least a portion of the first side face, a first non-conductive member is disposed on the first side face, a second conductive member extends along at least a portion
(Continued)



US011115511B1

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

(10) **Patent No.: US 11,115,511 B1**
(45) **Date of Patent: Sep. 7, 2021**

(54) **COMMUNICATION DEVICE HAVING CONFIGURABLE HOUSING ASSEMBLY WITH MULTIPLE ANTENNAS**

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

(72) Inventors: **Kasra Ghaemi**, Chicago, IL (US); **Md Rashidul Islam**, Glen Ellyn, IL (US); **Junsheng Zhao**, Vernon Hills, IL (US); **Md Faisal Abedin**, Lisle, IL (US); **Mohammed R. Abdul-Gaffoor**, Palatine, IL (US)

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

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

(21) Appl. No.: **17/170,451**

(22) Filed: **Feb. 8, 2021**

(51) **Int. Cl.**
H04M 1/02 (2006.01)
H04B 7/06 (2006.01)

(52) **U.S. Cl.**
CPC ***H04M 1/0245*** (2013.01); ***H04B 7/0602*** (2013.01); ***H04M 1/0216*** (2013.01)

(58) **Field of Classification Search**
CPC H04M 1/0245
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,885,353 B2 4/2005 Kurihara
7,444,175 B2 10/2008 Ito et al.
9,312,888 B2 4/2016 Weissman et al.
10,523,292 B2 12/2019 Schwent et al.
10,587,329 B2 3/2020 Maldonado et al.
2005/0059444 A1* 3/2005 Martinez H01Q 1/40 455/575.7
2005/0128155 A1* 6/2005 Fukuda H01Q 1/38 343/745
2010/0022197 A1* 1/2010 Kato H04B 1/005 455/75
2011/0014879 A1* 1/2011 Alberth H01Q 1/242 455/75
2011/0169613 A1* 7/2011 Chen G01S 3/043 340/10.4
2012/0257508 A1* 10/2012 Reunamaki H04W 4/80 370/241
2015/0189619 A1* 7/2015 Kalliola H04W 4/023 455/456.1

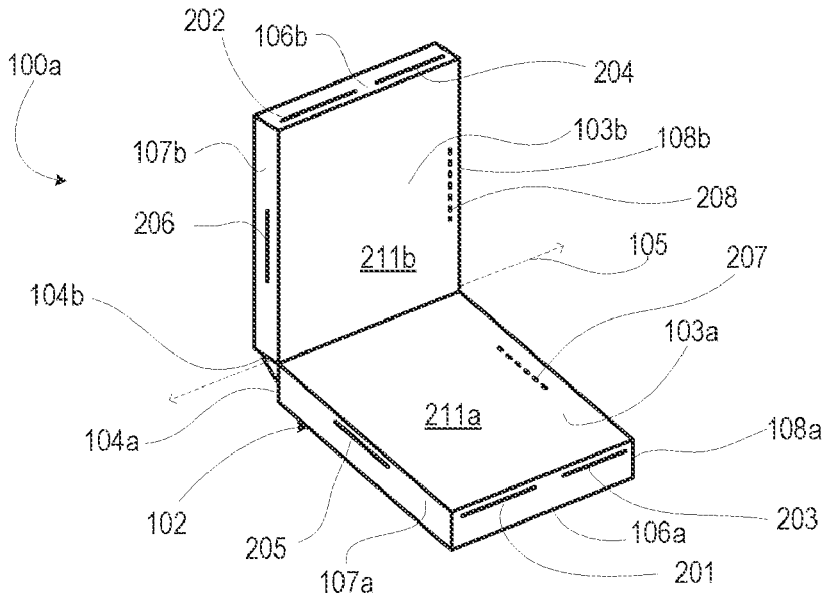
(Continued)

Primary Examiner — Hsinchun Liao
(74) *Attorney, Agent, or Firm* — Isidore PLLC

(57) **ABSTRACT**

A communication device, method and computer program product enable multiple independent communication connections via multiple antennas supported by a configurable housing assembly having first and second housing portions connected for movement between open and closed positions. In response to housing assembly being in an open position, a radio frequency (RF) front end of the communication device is configured to independently communicate in at least a low band via first and second antennas supported by a first housing portion and second and fourth antennas supported by a second housing portion. In response to the housing assembly being in the closed position that brings the first and second antennas into proximity and the third and fourth antennas into proximity, the RF front end is configured to communicate via a first antenna array of the first and the second antennas and via a second antenna array of the third and the fourth antennas.

20 Claims, 17 Drawing Sheets



US011121449B2

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

(10) **Patent No.: US 11,121,449 B2**
(45) **Date of Patent: Sep. 14, 2021**

(54) **ELECTRONIC DEVICE**

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

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

(73) Assignee: **ACER INCORPORATED**, New Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 47 days.

(21) Appl. No.: **16/710,609**

(22) Filed: **Dec. 11, 2019**

(65) **Prior Publication Data**

US 2021/0075085 A1 Mar. 11, 2021

(30) **Foreign Application Priority Data**

Sep. 10, 2019 (TW) 108132544

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 5/307 (2015.01)
H01Q 21/28 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/22*** (2013.01); ***H01Q 5/307*** (2015.01); ***H01Q 21/28*** (2013.01)

(58) **Field of Classification Search**
CPC H01G 1/22; H01G 5/307; H01G 21/28
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,948,002	B2	4/2018	Heikura et al.	
10,224,630	B2	3/2019	Iellci	
2004/0108957	A1	6/2004	Umehara et al.	
2019/0006735	A1 *	1/2019	Lee	H01Q 9/42

FOREIGN PATENT DOCUMENTS

CN	104737367	B	12/2018
TW	M532668	U	11/2016
TW	I604662	B	11/2017

OTHER PUBLICATIONS

Chinese language office action dated Apr. 22, 2020, issued in application No. TW 108132544.
European Search Report dated May 19, 2020, issued in application No. EP 19212171.3.

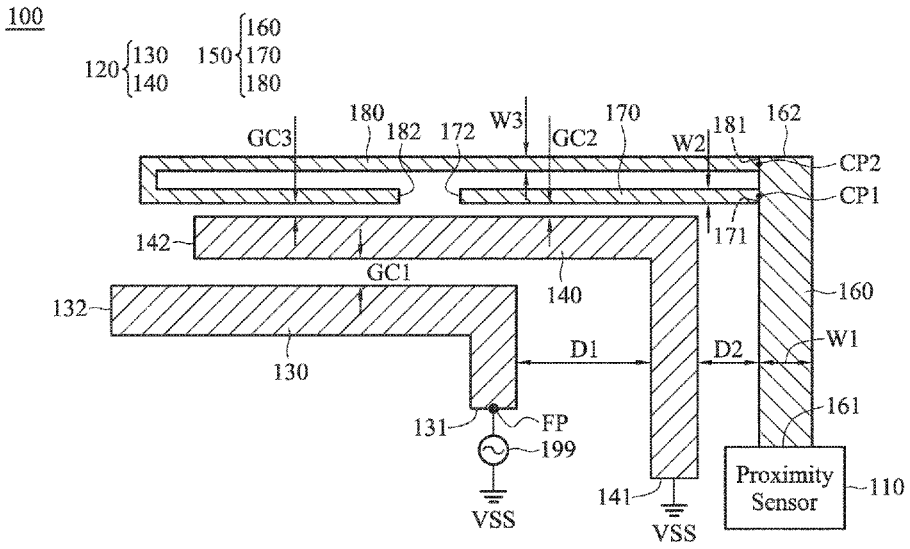
* cited by examiner

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

(57) **ABSTRACT**

An electronic device includes a proximity sensor, an antenna structure, and a sensing pad. The antenna structure includes a first radiation element and a second radiation element which are separate from and adjacent to each other. The first radiation element has a feeding point. The second radiation element is coupled to a ground voltage. The sensing pad is adjacent to the antenna structure. The sensing pad includes a main branch, a first branch, and a second branch. The main branch is coupled to the proximity sensor. The first branch and the second branch are coupled to the main branch. The second branch has a meandering shape. The antenna structure covers a first frequency band and a second frequency band. The resonant frequency of the sensing pad is neither within the first frequency band nor within the second frequency band.

16 Claims, 6 Drawing Sheets



US011121454B2

(12) **United States Patent**
Zhang

(10) **Patent No.: US 11,121,454 B2**
(45) **Date of Patent: Sep. 14, 2021**

(54) **ANTENNA FOR DEVICE AND FOLDABLE DEVICE**

(71) Applicant: **ZTE CORPORATION**, Guangdong (CN)

(72) Inventor: **Yan Zhang**, Guangdong (CN)

(73) Assignee: **ZTE CORPORATION**, 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.: **16/645,508**

(22) PCT Filed: **Sep. 12, 2018**

(86) PCT No.: **PCT/CN2018/105223**
§ 371 (c)(1),
(2) Date: **Mar. 9, 2020**

(87) PCT Pub. No.: **WO2019/052466**
PCT Pub. Date: **Mar. 21, 2019**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/44*** (2013.01); ***H01Q 1/50*** (2013.01); ***H04M 1/0214*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/44; H01Q 1/50; H01Q 5/378; H01Q 5/328; H01Q 9/42; H01Q 1/24; H01Q 3/32; H04M 1/0214
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,154,460 B2 4/2012 Sakata et al.
10,075,569 B2 * 9/2018 Kim H01Q 9/30
(Continued)

FOREIGN PATENT DOCUMENTS

CN 1918744 A 2/2007
CN 101459275 A 6/2009
(Continued)

OTHER PUBLICATIONS

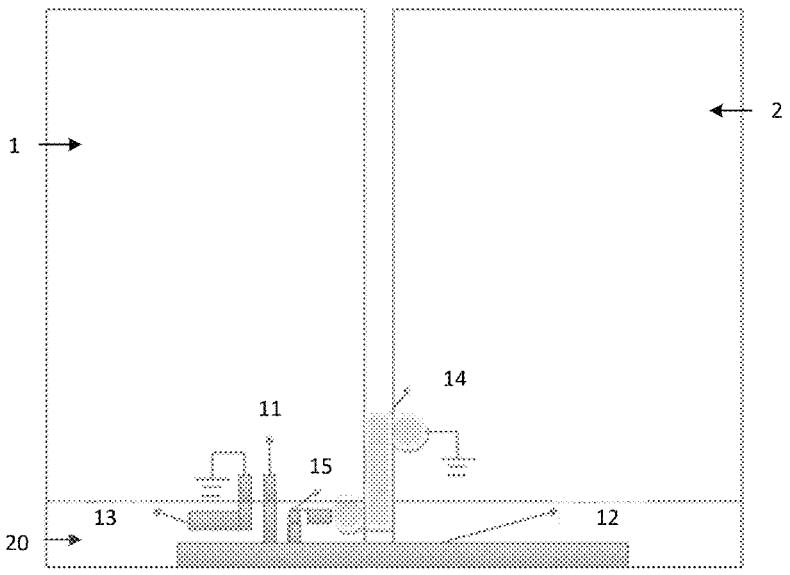
China Patent Office, First Office Action dated Oct. 10, 2020 for application No. CN201710817200.X.

Primary Examiner — Seung H Lee

(57) **ABSTRACT**

The present disclosure provides an antenna for an electronic device, and a foldable device. The electronic device includes a body provided with a mainboard, and a first screen. The antenna includes: a feed point disposed at a side where the body is located; a first antenna connected to the feed point and extending from the side where the body is located to a side where the first screen is located; a second antenna disposed at the side where the body is located; a rotating shaft connected between the body and the first screen; and a switch provided between the rotating shaft and the first antenna.

14 Claims, 4 Drawing Sheets



US011121458B2

(12) **United States Patent**
Lee

(10) **Patent No.: US 11,121,458 B2**
(45) **Date of Patent: Sep. 14, 2021**

(54) **ANTENNA STRUCTURE**

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

(72) Inventor: **Yun-Tsan Lee**, Hsinchu (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 87 days.

(21) Appl. No.: **16/562,682**

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

(65) **Prior Publication Data**

US 2020/0091595 A1 Mar. 19, 2020

(30) **Foreign Application Priority Data**

Sep. 19, 2018 (TW) 107132949

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 1/36 (2006.01)
H01Q 1/52 (2006.01)
H01Q 1/48 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/36*** (2013.01); ***H01Q 1/22*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 1/52*** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 1/22; H01Q 1/36; H01Q 1/48; H01Q 1/52; H01Q 1/243; H01Q 5/33; H01Q 5/35; H01Q 5/321
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

10,454,156 B1 * 10/2019 Yang H01Q 5/335
2011/0128200 A1 * 6/2011 Hossain H01Q 9/14 343/745
2012/0007782 A1 * 1/2012 Nishio ..... H01Q 5/371 343/700 MS
2014/0197993 A1 * 7/2014 Li ..... H01Q 1/48 343/700 MS
2015/0295314 A1 * 10/2015 Oh H01Q 21/0006 343/866

FOREIGN PATENT DOCUMENTS

TW 201112497 A 4/2011

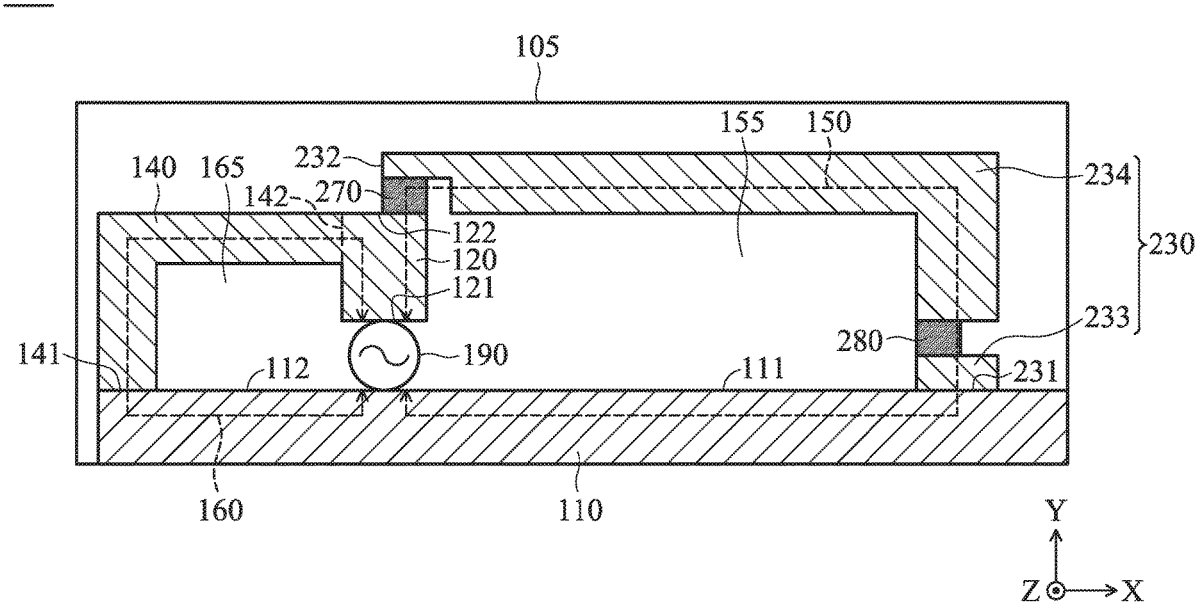
* cited by examiner

Primary Examiner — Tung X Le
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

An antenna structure includes a ground element, a feeding radiation element, a first radiation element, and a second radiation element. The feeding radiation element is coupled to a signal source. The first radiation element is coupled to the ground element. The first radiation element is adjacent to the feeding radiation element. The feeding radiation element is coupled through the second radiation element to the ground element. A first loop structure is formed by the feeding radiation element, the first radiation element, and the ground element. A second loop structure is formed by the feeding radiation element, the second radiation element, and the ground element. The second loop structure includes neither any branching portion nor any protruding portion.

19 Claims, 6 Drawing Sheets



US011121460B2

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

(10) **Patent No.: US 11,121,460 B2**
(45) **Date of Patent: Sep. 14, 2021**

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

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

(72) Inventors: **Dafei Mo**, Beijing (CN); **Xiaoren Cheng**, Beijing (CN); **Xiaozhun Shen**, Beijing (CN)

(73) Assignee: **LENOVO (BEIJING) CO., LTD.**, Beijing (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 80 days.

(21) Appl. No.: **16/727,897**

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

(65) **Prior Publication Data**

US 2020/0212560 A1 Jul. 2, 2020

(30) **Foreign Application Priority Data**

Dec. 29, 2018 (CN) 201811647572.3

(51) **Int. Cl.**

H01Q 13/00	(2006.01)
H01Q 1/52	(2006.01)
H01Q 1/42	(2006.01)
H01Q 1/02	(2006.01)

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

CPC ***H01Q 1/521*** (2013.01); ***H01Q 1/02*** (2013.01); ***H01Q 1/42*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/521; H01Q 1/42; H01Q 1/02; H01Q 1/2266; H01Q 13/18

USPC 343/872

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,624,788	B2 *	1/2014	Ayatollahi	H01Q 1/521 343/745
8,933,847	B2 *	1/2015	Yang	H01Q 1/243 343/702
10,418,693	B2 *	9/2019	Xu	H01Q 1/273
10,784,592	B2 *	9/2020	Martiskainen	H01Q 1/243
10,797,383	B2 *	10/2020	Xu	G04G 17/08
10,862,223	B2 *	12/2020	McGough	H01Q 1/521
2003/0151557	A1 *	8/2003	Johnson	H01Q 5/328 343/702
2008/0316117	A1 *	12/2008	Hill	H01Q 21/30 343/702

(Continued)

FOREIGN PATENT DOCUMENTS

CN	101958456 A	1/2011
CN	105938383 A	9/2016

(Continued)

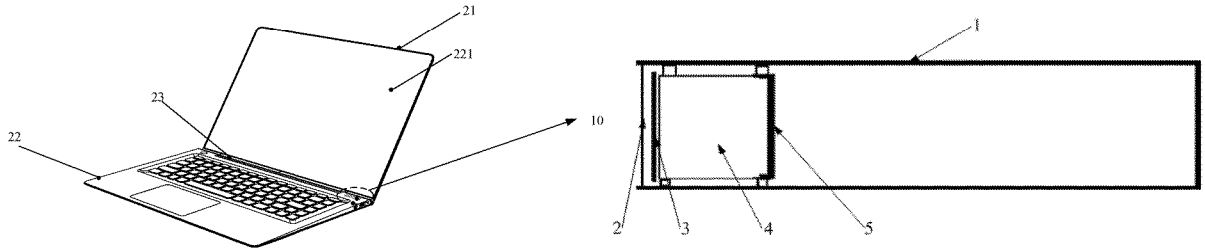
Primary Examiner — Jean B Jeanglaude

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

(57) **ABSTRACT**

An antenna assembly is provided for an electronic device. The electronic device has a housing, which includes a first portion and a second portion, the first portion is electrically conductive, and the second portion is non-conductive. The antenna assembly includes an antenna cavity, at least two antennas located in the antenna cavity, and at least one isolation structure. The antennas are used for radiating energy, the isolation structure is disposed between the two antennas and connected to the two antennas, and the isolation structure isolates induced currents of the two antennas to reduce interference at a same frequency or from adjacent frequency channels between the two antennas.

20 Claims, 2 Drawing Sheets



US011121469B2

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

(10) **Patent No.: US 11,121,469 B2**
(45) **Date of Patent: Sep. 14, 2021**

(54) **MILLIMETER WAVE ANTENNAS HAVING CONTINUOUSLY STACKED RADIATING ELEMENTS**

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

(72) Inventors: **Simone Paulotto**, Redwood City, CA (US); **Jennifer M. Edwards**, San Francisco, CA (US); **Harish Rajagopalan**, San Jose, CA (US); **Bilgehan Avser**, Mountain View, CA (US)

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(*) 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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(51) **Int. Cl.**

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H01Q 9/04	(2006.01)
H01Q 21/22	(2006.01)
H01Q 1/24	(2006.01)
H01Q 1/48	(2006.01)

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

CPC ***H01Q 9/0414*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 21/065*** (2013.01); ***H01Q 21/22*** (2013.01)

(58) **Field of Classification Search**

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

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,249,256 B1 6/2001 Luxon et al.
6,888,502 B2 5/2005 Beigel et al.
(Continued)

FOREIGN PATENT DOCUMENTS

EP 2797168 B1 4/2019
JP 2017085289 A 5/2017
KR 101014347 B1 2/2011

OTHER PUBLICATIONS

Bilgehan Avser et al., U.S. Appl. No. 16/146,705, filed Sep. 28, 2018.

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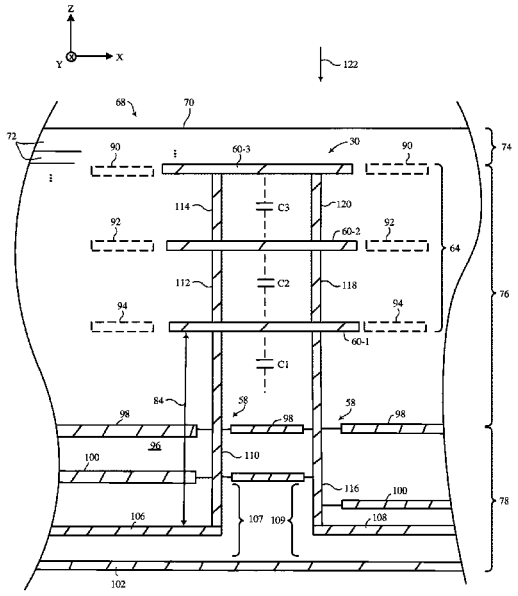
(57) **ABSTRACT**

An electronic device may be provided with a phased antenna array. The array may convey signals greater than 10 GHz and may be formed on a substrate having transmission line layers and antenna layers. An antenna in the array may have a radiating element that includes first, second, and third overlapping patch elements on the antenna layers. The antenna may be fed using a differential transmission line coupled to a differential feed on the first patch element. The differential transmission line may include first and second signal traces. A first via may couple the first signal trace to the first, second, and third patch elements. A second via may couple the second signal trace to the first, second, and third patch elements. The patch elements may introduce capacitances to the radiating element that help to compensate for inductances associated with the distance between the radiating element and the signal traces.

20 Claims, 10 Drawing Sheets



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

(10) **Patent No.: US 11,121,472 B2**
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(54) **FRONT-SHIELDED, COPLANAR WAVEGUIDE, DIRECT-FED, CAVITY-BACKED SLOT ANTENNA**

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(58) **Field of Classification Search**
CPC H01Q 13/18; H01Q 1/243; H01Q 21/0037; H01Q 1/40; H01Q 1/2266
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,245,222 A 1/1981 Eng et al.
4,590,478 A 5/1986 Powers et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 109066054 12/2018
CN 109066054 A 12/2018
(Continued)

OTHER PUBLICATIONS

"Invitation to Pay Fees and Partial International Search Report", Application No. PCT/US2019/064407, dated Mar. 11, 2020, 12 pages.
(Continued)

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(74) *Attorney, Agent, or Firm* — FIG. 1 Patents

(57) **ABSTRACT**

Front-shielded, coplanar waveguide, direct-fed, cavity-backed slot antennas are described. Various implementations form an antenna unit capable of millimeter waveform and/or microwave waveform transmissions. A bottom shielding structure of the antenna unit defines a cavity, where various implementations include one or more dampening structures within the cavity. Some implementations includes a slot antenna within the cavity defined by the bottom shielding structure, such as a coplanar waveguide (CPW) direct-fed slot antenna, to form a cavity-backed slot antenna. Some implementations connect a top shielding structure to the bottom shielding structure to encase the slot antenna. In one or more implementations, the top shielding structure includes aperture windows to allow waveforms within a frequency range from about between 600 Megahertz (MHz) to 72 Gigahertz (GHz) and radiated by the slot antenna to radiate outward from the antenna unit.

12 Claims, 18 Drawing Sheets