US011183747B2

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

(10) **Patent No.: US 11,183,747 B2**
(45) **Date of Patent: Nov. 23, 2021**

(54) **ELECTRONIC DEVICE INCLUDING ANTENNA MODULE**

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

(72) Inventors: **Heecheul Moon**, Suwon-si (KR); **Sangyoup Seok**, Suwon-si (KR); **Kwonho Son**, Suwon-si (KR)

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

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

(21) Appl. No.: **16/591,552**

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

(65) **Prior Publication Data**

US 2020/0106167 A1 Apr. 2, 2020

(30) **Foreign Application Priority Data**

Oct. 2, 2018 (KR) 10-2018-0117623

(51) **Int. Cl.**
H04M 1/02 (2006.01)
H04B 1/40 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 9/16*** (2013.01); ***H01Q 23/00*** (2013.01); ***H04M 1/026*** (2013.01)

(58) **Field of Classification Search**
CPC ... H04B 1/08; H04B 1/03; H04B 1/40; H04B 1/04; H04B 1/16; H04M 1/03;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,128,515 A 10/2000 Kabler et al.
6,326,919 B1 12/2001 Diximus et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 108376828 A 8/2018
EP 3703346 A1 9/2020
(Continued)

OTHER PUBLICATIONS

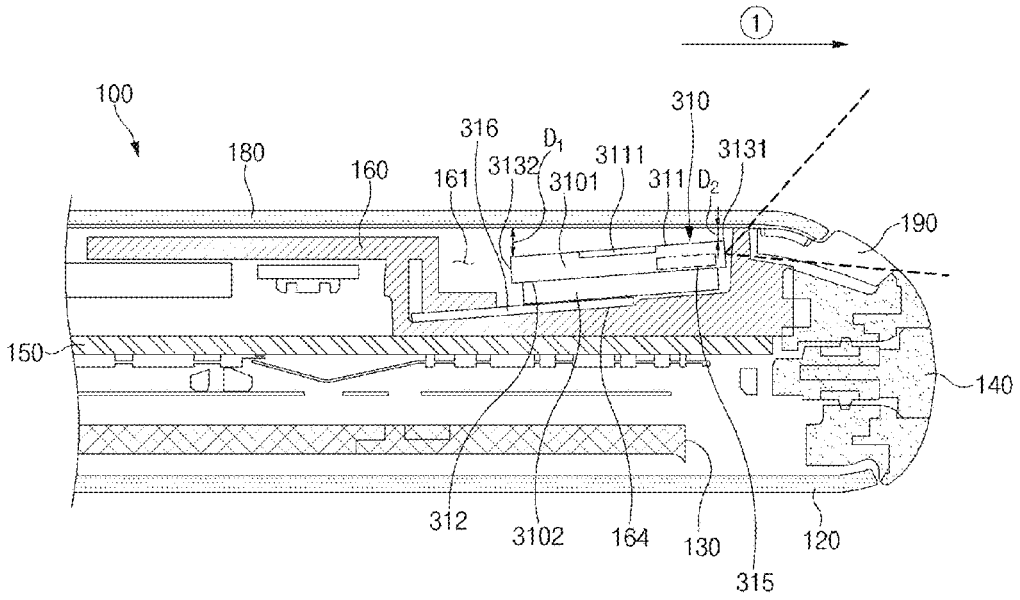
European Search Report dated Nov. 20, 2019 in connection with European Patent Application No. 19 20 0733, 14 pages.
(Continued)

Primary Examiner — Andrew Wendell

(57) **ABSTRACT**

An electronic device includes a housing that includes a front plate facing a first direction, a back plate facing a second direction opposite to the first direction, and a side member surrounding a space between the front plate and the back plate and at least a portion of which is formed of a metal material. A display is viewable through the front plate, and an antenna module is positioned in the space and includes a first surface facing a third direction different from the first direction and the second direction, a second surface facing a fourth direction different from the third direction, and at least one conductive element extended in a fifth direction, which is perpendicular to the third direction and the fourth direction and faces a first portion of the side member, adjacent to the side member, and between the first surface and the second surface.

20 Claims, 18 Drawing Sheets



US011183748B2

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

(10) **Patent No.: US 11,183,748 B2**
(45) **Date of Patent: Nov. 23, 2021**

(54) **ELECTRONIC DEVICE INCLUDING ANTENNA MODULE**

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

(72) Inventors: **Sungcheol Yoo**, Suwon-si (KR); **Chihwei Lee**, Suwon-si (KR); **Jungmin Park**, Suwon-si (KR); **Chonghwa Seo**, Suwon-si (KR); **Jongwon Lee**, Suwon-si (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 52 days.

(21) Appl. No.: **16/924,863**

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

(65) **Prior Publication Data**

US 2021/0013588 A1 Jan. 14, 2021

(30) **Foreign Application Priority Data**

Jul. 9, 2019 (KR) 10-2019-0082719
Mar. 4, 2020 (KR) 10-2020-0027269

(51) **Int. Cl.**
H04M 1/00 (2006.01)
H01Q 1/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 7/00*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 7/00; H01Q 1/241; H01Q 9/04; H01Q 13/10; H01Q 19/005; H01Q 21/00; H01Q 5/48
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,379,433 B2 6/2016 Ying
2014/0112511 A1 4/2014 Corbin et al.
(Continued)

FOREIGN PATENT DOCUMENTS

EP 3490059 A1 5/2019
KR 10-2019-0020349 a 3/2019
KR 10-2019-0060283 A 6/2019

OTHER PUBLICATIONS

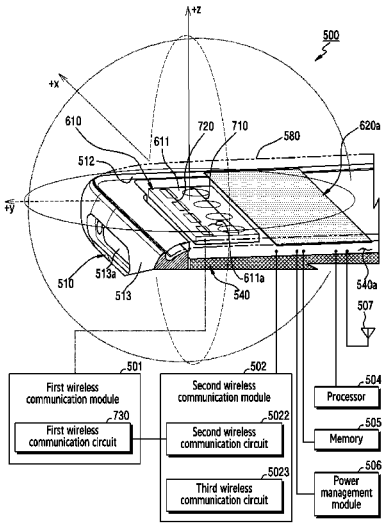
Extended European Search Report dated Dec. 2, 2020, issued in a counterpart European Application No. 20184922.1-1205.
(Continued)

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

(57) **ABSTRACT**

A portable communication device is provided. The portable communication device includes a display defining a front surface of the portable communication device, a plate defining a rear surface of the portable communication device and including a nonconductive material, the plate including a first surface facing an outside of the portable communication device and a second surface facing an inside of the portable communication device, a first antenna module attached to a first area of the second surface or disposed adjacent to the first area, a second antenna module attached to a second area of the second surface or disposed adjacent to the second area, and a conductive member disposed in or attached to a third area between the first area and the second area, wherein the conductive member at least partially interrupts some electric waves, among electric waves radiated from the first antenna module, that travel towards the second antenna module through the plate.

17 Claims, 33 Drawing Sheets



US011183753B2

(12) **United States Patent**
Hong

(10) **Patent No.: US 11,183,753 B2**
(45) **Date of Patent: Nov. 23, 2021**

(54) **ANTENNA MODULE HAVING PLURALITY OF PRINTED CIRCUIT BOARDS LAMINATED THEREIN, AND ELECTRONIC DEVICE COMPRISING SAME**

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

(72) Inventor: **Eunseok Hong**, 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.: **17/330,854**

(22) Filed: **May 26, 2021**

(65) **Prior Publication Data**

US 2021/0280964 A1 Sep. 9, 2021

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2020/001233, filed on Jan. 23, 2020.

(30) **Foreign Application Priority Data**

Jan. 24, 2019 (KR) 10-2019-0009284

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 1/24 (2006.01)
H01Q 7/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/38*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 7/00*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 1/243; H01Q 7/00
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,279,131 B2 10/2012 Puzella et al.
8,854,277 B2 * 10/2014 De Graauw H01Q 23/00 343/904
(Continued)

FOREIGN PATENT DOCUMENTS

JP 2008-283676 A 11/2008
JP 6336107 B2 6/2018
(Continued)

OTHER PUBLICATIONS

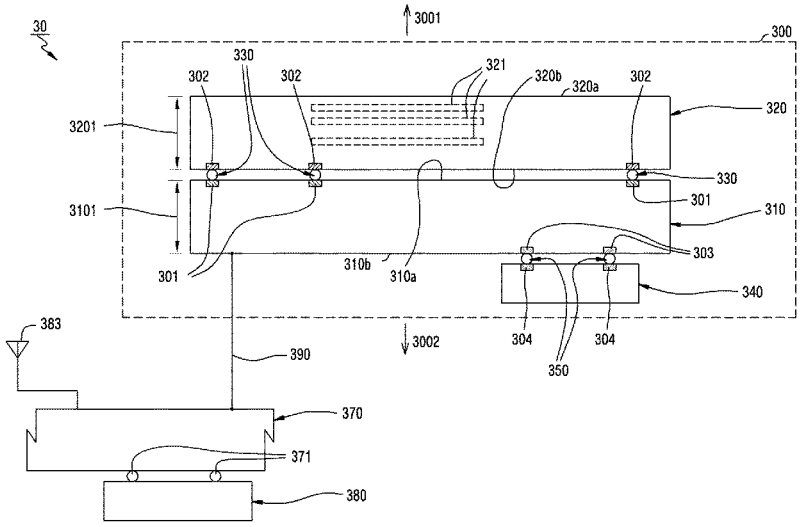
International Search Report dated May 14, 2020, issued in International Application No. PCT/KR2020/001233.

Primary Examiner — Andrea Lindgren Baltzell
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

According to an embodiment of the present invention, an electronic device may comprise: a first printed circuit board which includes a first surface facing a first direction and a second surface facing a second direction opposite to the first direction; a second printed circuit board which includes a third surface facing the first direction and a fourth surface facing the second direction and includes at least one first antenna; a first wireless communication circuit which is electrically connected to at least one connection terminal formed on the first printed circuit board and transmits and receives a signal of a first frequency band through the at least one first antenna; and a conductive bonding member which is disposed between the first surface and the fourth surface and electrically connects the at least one first antenna and the first wireless communication circuit. Various other embodiments may be included.

30 Claims, 25 Drawing Sheets



US011183759B2

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

(10) **Patent No.: US 11,183,759 B2**
(45) **Date of Patent: Nov. 23, 2021**

(54) **MULTI-BAND COMMUNICATION SYSTEM WITH ISOLATION AND IMPEDANCE MATCHING PROVISION**

(71) Applicant: **Ethertronics, Inc.**, San Diego, CA (US)

(72) Inventors: **Alexandre Dupuy**, San Diego, CA (US); **Laurent Desclos**, San Diego, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 212 days.

(21) Appl. No.: **16/136,821**

(22) Filed: **Sep. 20, 2018**

(65) **Prior Publication Data**

US 2019/0036218 A1 Jan. 31, 2019

Related U.S. Application Data

(63) Continuation of application No. 15/354,736, filed on Nov. 17, 2016, now Pat. No. 10,096,900, which is a continuation of application No. 13/854,495, filed on Apr. 1, 2013, now abandoned, which is a continuation of application No. 13/717,519, filed on Dec. 17, 2012, now Pat. No. 9,263,793.

(60) Provisional application No. 61/636,558, filed on Apr. 20, 2012, provisional application No. 61/649,369, filed on May 21, 2012.

(51) **Int. Cl.**

H01Q 5/335	(2015.01)
H01Q 21/30	(2006.01)
H01Q 5/378	(2015.01)
H01Q 21/28	(2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 5/335*** (2015.01); ***H01Q 5/378*** (2015.01); ***H01Q 21/28*** (2013.01); ***H01Q 21/30*** (2013.01)

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,034,773	B1 *	4/2006	Saunders	H01Q 3/2605 343/895
8,325,097	B2	12/2012	McKinzie et al.	
8,447,255	B2	5/2013	Asokan	
9,041,617	B2 *	5/2015	Sorensen	H01Q 7/005 343/850

(Continued)

OTHER PUBLICATIONS

Agilent Technologies, LTE-Advanced Physical Layer Design and Test Challenges: Carrier Aggregation (2012).

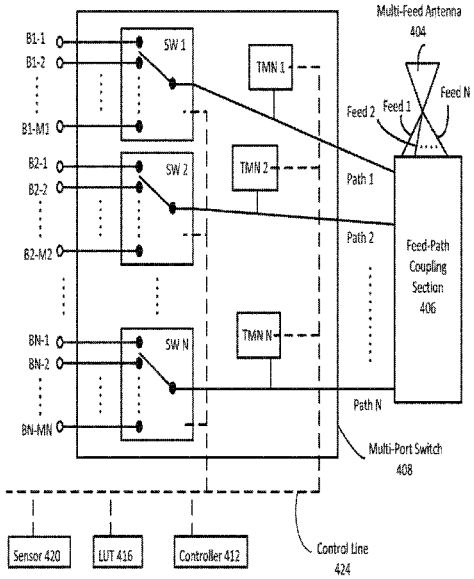
(Continued)

Primary Examiner — Zhitong Chen
(74) *Attorney, Agent, or Firm* — Dority & Manning, P.A.

(57) **ABSTRACT**

A communication system is provided, including one or more antennas coupled to multiple RF paths, one or more matching blocks, each block including multiple matching networks, a look-up table including characterization data according to frequency bands and conditions, and a controller configured to control the multiple matching networks by referring to the look-up table to provide optimum impedance for a frequency band selected and a condition detected during a time interval. The matching block may further include switches and adjustment circuits.

9 Claims, 21 Drawing Sheets



US011183766B2

(12) **United States Patent**
Jia

(10) **Patent No.: US 11,183,766 B2**
(45) **Date of Patent: Nov. 23, 2021**

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

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

(72) Inventor: **Yuhu Jia**, Guangdong (CN)

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

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

(21) Appl. No.: **16/833,216**

(22) Filed: **Mar. 27, 2020**

(65) **Prior Publication Data**

US 2020/0335869 A1 Oct. 22, 2020

(30) **Foreign Application Priority Data**

Apr. 19, 2019 (CN) 201910316178.X

(51) **Int. Cl.**
H01Q 3/36 (2006.01)
H01Q 9/04 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 9/045*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 5/30*** (2015.01); ***H01Q 9/0414*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/045; H01Q 5/30
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,636,726 B1 * 10/2003 Erhage H01Q 3/36 342/159
2007/0052587 A1 3/2007 Cheng
(Continued)

FOREIGN PATENT DOCUMENTS

CN 102280699 12/2011
CN 203760674 8/2014
(Continued)

OTHER PUBLICATIONS

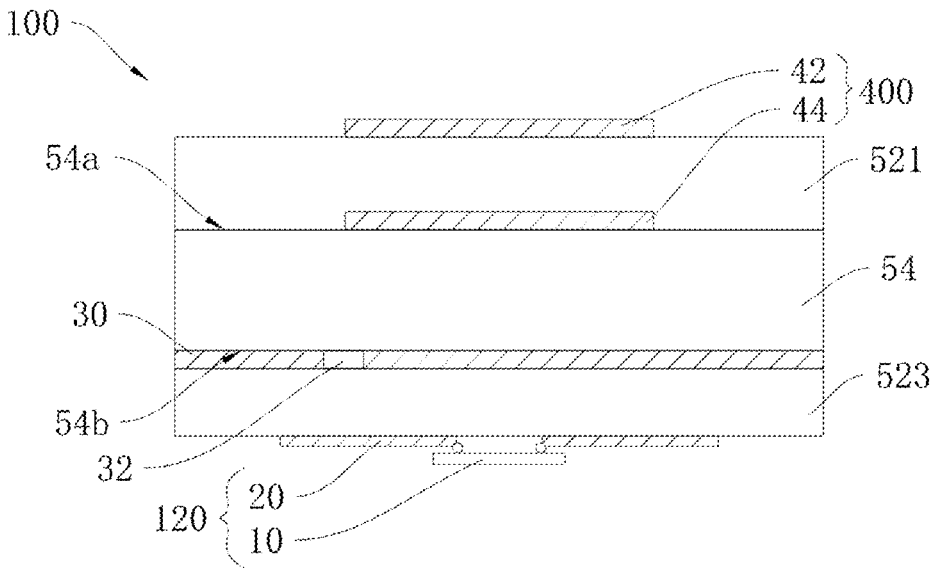
PCT, International Search Report for Application No. PCT/CN2020/082117, dated Jun. 30, 2020.
(Continued)

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

(57) **ABSTRACT**

An antenna module is provided. The antenna module includes a dielectric substrate, a first insulating layer, a stacked patch antenna, a ground layer, a second insulating layer, and a feeding structure. The dielectric substrate includes a first surface and a second surface opposite the first surface. The first insulating layer is disposed on the first surface of the dielectric substrate. The stacked patch antenna includes a first antenna radiator disposed on a side of the first insulating layer away from the dielectric substrate and a second antenna radiator disposed between the first insulating layer and the dielectric substrate. A projection of the first antenna radiator on the dielectric substrate at least partially overlaps with a projection of the second antenna radiator on the dielectric substrate. The ground layer is disposed on the second surface of the dielectric substrate, and the ground layer defines at least one slot.

19 Claims, 10 Drawing Sheets



US011183775B2

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

(10) **Patent No.: US 11,183,775 B2**
(45) **Date of Patent: Nov. 23, 2021**

(54) **BASE STATION ANTENNAS HAVING PARASITIC ASSEMBLIES FOR IMPROVING CROSS-POLARIZATION DISCRIMINATION PERFORMANCE**

(71) Applicant: **CommScope Technologies LLC**, Hickory, NC (US)

(72) Inventors: **Yunzhe Li**, Suzhou (CN); **YueMin Li**, Suzhou (CN); **Peter J. Bisiules**, La Grange Park, IL (US); **Xiaohua Tian**, Suzhou (CN); **Junfeng Yu**, Suzhou (CN); **Dongmin Wang**, Suzhou (CN); **Xiaoan Fu**, Suzhou (CN); **Haidan Tang**, Suzhou (CN)

(73) Assignee: **CommScope Technologies LLC**, Hickory, NC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 30 days.

(21) Appl. No.: **16/823,450**

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

(65) **Prior Publication Data**

US 2020/0303836 A1 Sep. 24, 2020

Related U.S. Application Data

(60) Provisional application No. 62/821,622, filed on Mar. 21, 2019.

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

(52) **U.S. Cl.**
CPC ***H01Q 21/245*** (2013.01); ***H01Q 1/24*** (2013.01); ***H01Q 1/246*** (2013.01); ***H01Q 21/24*** (2013.01); ***H01Q 21/26*** (2013.01); *H01Q 1/521* (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/245; H01Q 1/246; H01Q 21/26; H01Q 1/521; H01Q 21/24; H01Q 1/24
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,681,770 A * 8/1972 Alford H01Q 1/521 343/815
4,499,474 A 2/1985 Muhs, Jr. et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 101662068 3/2010
EP 0895303 A1 2/1999
(Continued)

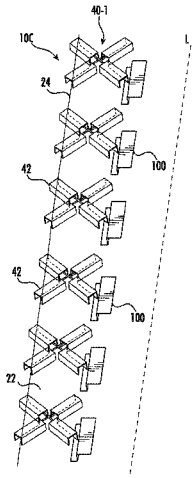
OTHER PUBLICATIONS

International Search Report and the Written Opinion of the International Searching Authority corresponding to International Patent Application No. PCT/US2020/022962 (20 pages) (dated Aug. 19, 2020).

Primary Examiner — Hai V Tran
(74) *Attorney, Agent, or Firm* — Myers Bigel, P.A.

(57) **ABSTRACT**

Base station antennas include a reflector, a first array of cross-polarized radiating elements that are mounted to extend forwardly from the reflector, and a parasitic assembly. The parasitic assembly includes a base that is mounted on the reflector, a horizontal component shaping element, and a forwardly projecting member that projects forwardly from the base that is coupled between the base and the horizontal component shaping element. The horizontal component shaping element may extend substantially parallel to a plane defined by the reflector and may include a proximate side that is directly connected to the forwardly projecting member and a distal side that is opposite the proximate side.
(Continued)



US011184987B1

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

(10) **Patent No.: US 11,184,987 B1**
(45) **Date of Patent: Nov. 23, 2021**

(54) **ELECTRONIC DEVICE AND METHOD FOR INCREASING ANTENNA EFFICIENCY**

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

(72) Inventors: **Hojin Jung**, Gyeonggi-do (KR); **Moonsun Kim**, Gyeonggi-do (KR); **Wonho 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.: **17/130,176**

(22) Filed: **Dec. 22, 2020**

(30) **Foreign Application Priority Data**

Aug. 13, 2020 (KR) 10-2020-0101867

(51) **Int. Cl.**

H05K 5/02	(2006.01)
H05K 5/00	(2006.01)
H04B 1/00	(2006.01)
G01D 5/12	(2006.01)
H04M 1/02	(2006.01)

(52) **U.S. Cl.**
CPC ***H05K 5/0217*** (2013.01); ***G01D 5/12*** (2013.01); ***H04B 1/0053*** (2013.01); ***H05K 5/0017*** (2013.01); *H04M 1/0268* (2013.01)

(58) **Field of Classification Search**
CPC H05K 5/0217; H05K 5/0017; G01D 5/12; H04B 1/0053; H04M 1/0268
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,578,147	B2 *	2/2017	Peng	H04M 1/185
2011/0117973	A1 *	5/2011	Asrani	H04W 52/245 455/571
2011/0148719	A1 *	6/2011	Okajima	H01Q 1/243 343/702
2014/0210685	A1	7/2014	Chang et al.	

(Continued)

FOREIGN PATENT DOCUMENTS

KR	10-2014-0105886 A	9/2014
KR	10-2017-0050270 A	5/2017

(Continued)

OTHER PUBLICATIONS

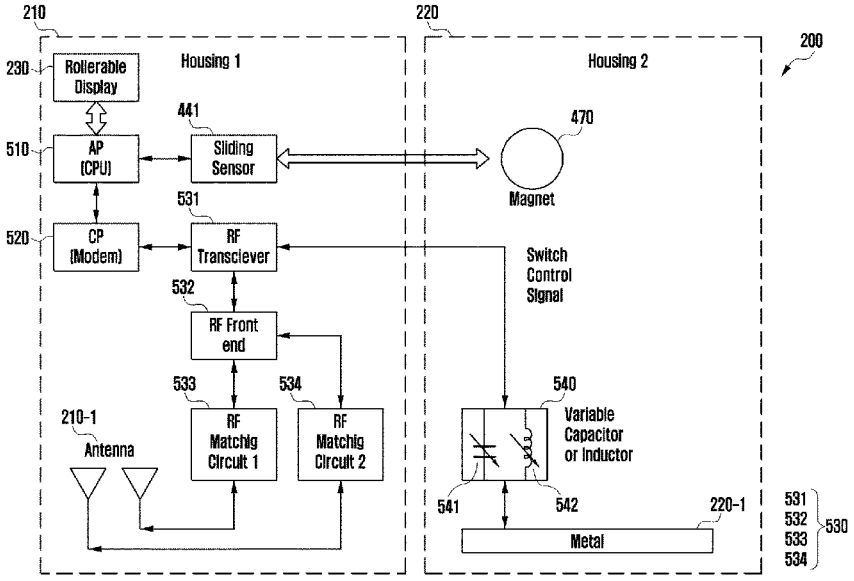
Korean Search Report dated Jan. 25, 2021.
International Search Report dated May 6, 2021.

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

(57) **ABSTRACT**

Certain embodiments of the disclosure relate to a device and a method for increasing the efficiency of an antenna of an electronic device that includes a rollable display. The electronic device may include: a processor; a first housing, in which the processor is disposed, including a first conductive portion; a second housing configured to slide in a first direction from the first housing and including a second conductive portion; a rollable display, at least a portion of which is exposed in a slide-out manner according to movement of the second housing; and a variable element disposed in the second housing and is electrically connected to the second conductive portion. The processor may adjust an electrical characteristic of the variable element in response to sliding of the second housing. The disclosure may further include various other embodiments.

19 Claims, 14 Drawing Sheets



US011184998B2

(12) **United States Patent**
Dejardin

(10) **Patent No.: US 11,184,998 B2**
(45) **Date of Patent: Nov. 23, 2021**

(54) **ELECTRONIC DEVICE PROVIDED WITH AN ANTENNA INTEGRATED INTO A HEATSINK**

(71) Applicant: **SAGEMCOM BROADBAND SAS**, Rueil Malmaison (FR)

(72) Inventor: **Romain Dejardin**, Rueil Malmaison (FR)

(73) Assignee: **SAGEMCOM BROADBAND SAS**, Rueil Malmaison (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 661 days.

(21) Appl. No.: **15/531,305**

(22) PCT Filed: **Nov. 27, 2015**

(86) PCT No.: **PCT/EP2015/077983**
§ 371 (c)(1),
(2) Date: **May 26, 2017**

(87) PCT Pub. No.: **WO2016/087335**
PCT Pub. Date: **Jun. 9, 2016**

(65) **Prior Publication Data**

US 2017/0346152 A1 Nov. 30, 2017

(30) **Foreign Application Priority Data**

Dec. 3, 2014 (FR) 1461882

(51) **Int. Cl.**
H05K 7/20 (2006.01)
H01Q 1/44 (2006.01)
H01Q 1/02 (2006.01)

(52) **U.S. Cl.**
CPC ***H05K 7/2039*** (2013.01); ***H01Q 1/02*** (2013.01); ***H01Q 1/44*** (2013.01); *H05K 7/20509* (2013.01)

(58) **Field of Classification Search**
CPC H05K 7/2039; H05K 7/20509; H01Q 1/02; H01Q 1/44; G06F 1/20; G06F 1/203
USPC 361/704, 709–711, 719; 165/80.2, 185; 257/713
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,681,501 B2 * 3/2014 Govindasamy G06F 1/203 174/16.3
2013/0009320 A1 * 1/2013 Yoo H01L 23/49827 257/774
2013/0208427 A1 * 8/2013 Lin H01L 23/40 361/720
2014/0139400 A1 5/2014 Voss et al.

FOREIGN PATENT DOCUMENTS

DE 202009001821 U1 4/2009

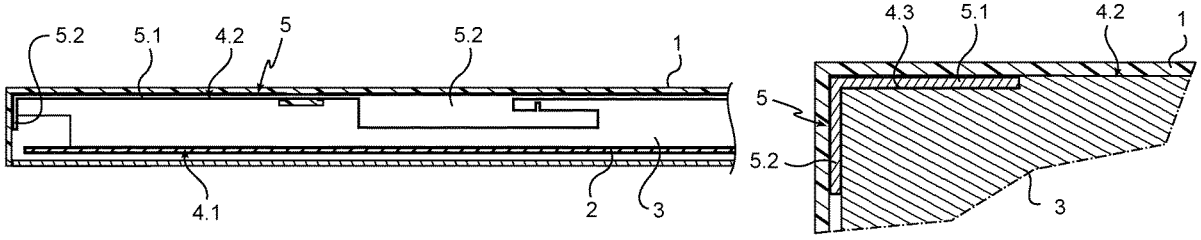
* cited by examiner

Primary Examiner — Zachary Pape
(74) *Attorney, Agent, or Firm* — Muncy, Geissler, Olds & Lowe, P.C.

(57) **ABSTRACT**

Electronic device including a housing enclosing an electronic board and a heatsink having a first face applied against the electronic board and, opposite, a second face making contact with the housing, an antenna being electrically connected to the electronic board and extending flatly between the heatsink and the housing while making contact with the heatsink and the housing.

9 Claims, 1 Drawing Sheet



US011189906B2

(12) **United States Patent**
Park

(10) **Patent No.: US 11,189,906 B2**
(45) **Date of Patent: Nov. 30, 2021**

(54) **ELECTRONIC DEVICE COMPRISING ANTENNA**

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

(72) Inventor: **Sung Chul Park**, Seoul (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 289 days.

(21) Appl. No.: **16/003,599**

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

(65) **Prior Publication Data**

US 2018/0358686 A1 Dec. 13, 2018

(30) **Foreign Application Priority Data**

Jun. 9, 2017 (KR) 10-2017-0072359

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

(52) **U.S. Cl.**
CPC ***H01Q 1/2283*** (2013.01); ***H01Q 1/02*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 3/40*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/2283; H01Q 1/243; H01Q 1/02; H01Q 13/106; H01Q 3/40; H01Q 21/08;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,896,487 B2 11/2014 Chiang et al.
2011/0006953 A1* 1/2011 Chiang G06F 1/1616 343/702
(Continued)

FOREIGN PATENT DOCUMENTS

JP 2015-213285 11/2015
KR 10-2011-0005212 A 1/2011
(Continued)

OTHER PUBLICATIONS

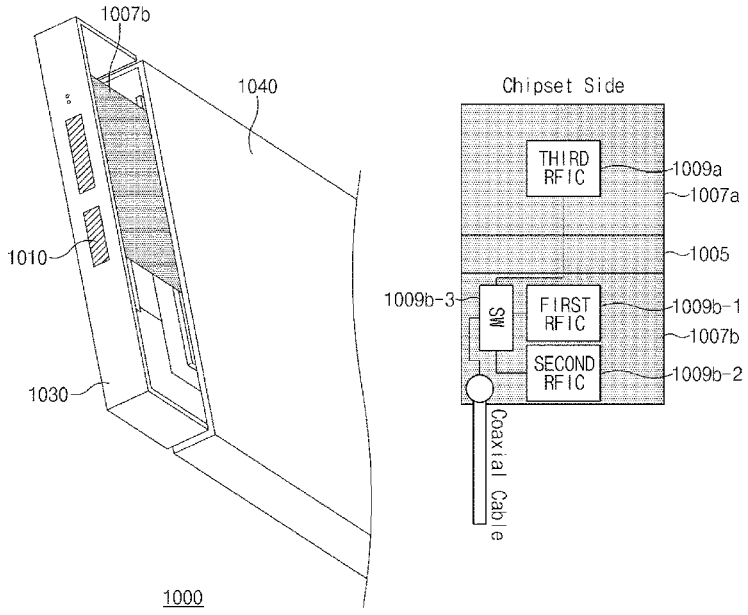
Korean Office Action dated Aug. 18, 2021 for KR Application No. 10-2017-0072359.

Primary Examiner — Awat M Salih
(74) *Attorney, Agent, or Firm* — Nixon & Vanderhye P.C.

(57) **ABSTRACT**

An electronic device includes a housing including a first plate, a second plate opposite to the first plate, and a side member surrounding a space between the first plate and the second plate, and including at least part of a conductive material, a flexible printed circuit board (FPCB) attached on an inner surface of the housing, a first antenna element which is included in the FPCB and in which a slot is formed, and a first radio frequency integrated circuit (RFIC) for the first antenna element. An opening is formed in the side member or the second plate of the housing. The FPCB is attached the inner surface of the housing such that at least part in which the slot of the first antenna element is formed is exposed through the opening. At least part of the opening is filled with an insulating material.

6 Claims, 18 Drawing Sheets



US011189909B2

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

(10) **Patent No.: US 11,189,909 B2**
(45) **Date of Patent: Nov. 30, 2021**

(54) **HOUSING AND ANTENNA ARCHITECTURE FOR MOBILE DEVICE**

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

(72) Inventors: **Paul U. Leutheuser**, Saratoga, CA (US); **Martin J. Auclair**, Campbell, CA (US); **Kevin M. Froese**, San Francisco, CA (US); **Christopher J. Durning**, Cupertino, CA (US); **Jun Ham**, Cupertino, CA (US); **Lucy E. Browning**, San Francisco, CA (US); **Sawyer I. Cohen**, Menlo Park, CA (US); **Richard Hung Minh Dinh**, Cupertino, CA (US); **Donald J. Parr**, Mountain View, 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 545 days.

(21) Appl. No.: **16/142,352**

(22) Filed: **Sep. 26, 2018**

(65) **Prior Publication Data**

US 2020/0076057 A1 Mar. 5, 2020

Related U.S. Application Data

(60) Provisional application No. 62/725,237, filed on Aug. 30, 2018.

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

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 5/30*** (2015.01); ***H01Q 13/10*** (2013.01); ***H04M 1/0249*** (2013.01); *H04M 1/0283* (2013.01)

(58) **Field of Classification Search**
CPC H01G 1/243; H01G 5/30; H01G 13/10; H04M 1/0249; H04M 1/0283
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,106,839 A 8/1978 Cooper
4,256,412 A 3/1981 Tybus et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 101087500 12/2007
CN 102159045 8/2011
(Continued)

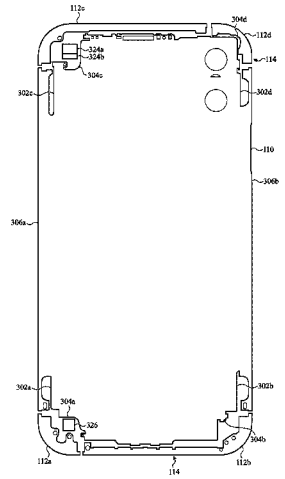
OTHER PUBLICATIONS

Author Unknown, "Improved Touchscreen Products," Research Disclosure, Kenneth Mason Publications, Hampshire, UK, GB, vol. 428, No. 53, Dec. 1, 1999.
(Continued)

Primary Examiner — Graham P Smith
(74) *Attorney, Agent, or Firm* — Brownstein Hyatt Farber Schreck, LLP

(57) **ABSTRACT**

A device includes a display and a housing. The housing at least partially surrounds the display. The housing includes a first housing segment defining at least a first portion of an exterior surface of the device and a first interlock feature having an interlock surface that is offset with respect to an end surface of the first housing segment. The first interlock feature has a first opening formed in the interlock surface. The housing further includes a second housing segment defining at least a second portion of the exterior surface of the device and a second interlock feature having a second opening aligned with the first opening, and a non-conductive
(Continued)



US011189916B2

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

(10) **Patent No.: US 11,189,916 B2**
(45) **Date of Patent: *Nov. 30, 2021**

(54) **DOUBLE-FREQUENCY ANTENNA STRUCTURE WITH HIGH ISOLATION**

(71) Applicant: **NANNING FUGUI PRECISION INDUSTRIAL CO., LTD.**, Nanning (CN)

(72) Inventors: **Yu-Chih Chueh**, New Taipei (TW); **Mao-Chang Chuang**, New Taipei (TW)

(73) Assignee: **NANNING FUGUI PRECISION INDUSTRIAL CO., LTD.**, Nanning (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 44 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/815,166**

(22) Filed: **Mar. 11, 2020**

(65) **Prior Publication Data**

US 2020/0212555 A1 Jul. 2, 2020

Related U.S. Application Data

(63) Continuation of application No. 16/175,863, filed on Oct. 31, 2018, now Pat. No. 10,644,389.

(51) **Int. Cl.**

H01Q 1/38	(2006.01)
H01Q 1/48	(2006.01)
H01Q 21/06	(2006.01)
H01Q 21/28	(2006.01)

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

CPC ***H01Q 1/38*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 21/065*** (2013.01); ***H01Q 21/28*** (2013.01)

(58) **Field of Classification Search**

CPC .. H01Q 1/38; H01Q 1/42; H01Q 1/48; H01Q 21/24; H01Q 21/245; H01Q 21/28; H01Q 21/30; H01Q 21/06; H01Q 21/065; H01Q 5/364; H01Q 7/00; H01Q 9/265

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,273,158	A *	9/1966	Fouts	H01Q 21/24 343/792
6,650,299	B2 *	11/2003	Zhang	H01Q 13/10 343/770
9,806,423	B2 *	10/2017	Panther	H01Q 5/10
10,454,184	B2 *	10/2019	Boutayeb	H01Q 21/005
10,644,389	B1 *	5/2020	Chueh	H01Q 21/28

FOREIGN PATENT DOCUMENTS

CN	203910978 U	10/2014
CN	206506026 U	9/2017
CN	206619691 U	11/2017
TW	201712950 A	4/2017

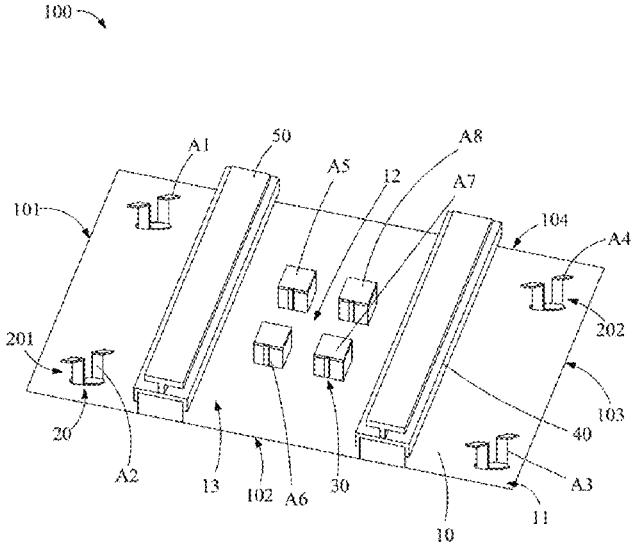
* cited by examiner

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

(57) **ABSTRACT**

A double-frequency antenna structure with a high degree of electrical isolation between long distance and short distance antennas includes a dielectric substrate having at least two corners and a center area. A first set of antenna arrays is positioned at the corners. A second set of antenna arrays is positioned at the center area. At least one first folded isolation plate is mounted on the dielectric substrate, and positioned between the first set of antenna arrays and the second set of antenna arrays. At least one second folded isolation plate each is mounted on one first folded isolation plate.

18 Claims, 8 Drawing Sheets



US011189923B2

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

(10) **Patent No.: US 11,189,923 B2**
(45) **Date of Patent: Nov. 30, 2021**

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

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

(72) Inventors: **Wei-En Hsieh**, New Taipei (TW); **Chien-Hua Li**, New Taipei (TW); **Yih-Shyang Her**, New Taipe (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 354 days.

(21) Appl. No.: **16/183,721**

(22) Filed: **Nov. 7, 2018**

(65) **Prior Publication Data**

US 2019/0181549 A1 Jun. 13, 2019

(30) **Foreign Application Priority Data**

Nov. 22, 2017 (CN) 201711175305.6

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 5/30	(2015.01)
H01Q 5/10	(2015.01)
H01Q 5/328	(2015.01)
H01Q 1/38	(2006.01)
H01Q 1/36	(2006.01)
H01Q 5/371	(2015.01)
H01Q 5/378	(2015.01)

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

CPC ***H01Q 5/30*** (2015.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/36*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 5/10*** (2015.01); ***H01Q 5/328*** (2015.01); ***H01Q 5/371*** (2015.01); ***H01Q 5/378*** (2015.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,537,218	B2 *	1/2017	Lin	H01Q 21/28
2003/0052824	A1 *	3/2003	Ollikainen	H01Q 5/371 343/700 MS
2007/0268143	A1 *	11/2007	Copeland	H01Q 9/065 340/572.7

(Continued)

FOREIGN PATENT DOCUMENTS

CN	105633581 A	6/2016
TW	201501415 A	1/2015

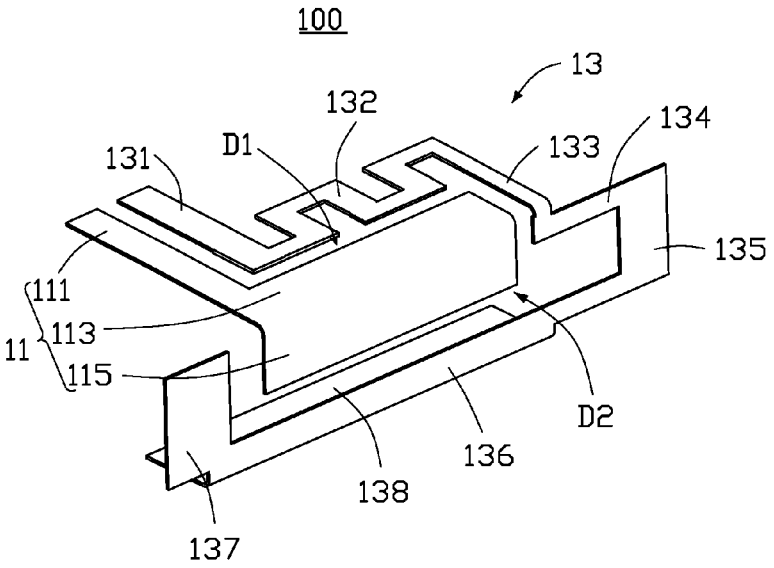
Primary Examiner — Trinh V Dinh

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

(57) **ABSTRACT**

An antenna structure includes a radiating portion and a coupling portion. The radiating portion is electrically connected to a feed point for feeding current. The coupling portion is electrically connected to a ground point to be grounded. The coupling portion is spaced apart from the radiating portion. The radiating portion excites a first resonant mode for generating radiation signals in a first frequency band. The current flowing through the radiating portion is coupled to the coupling portion, and the coupling portion excites a second resonant mode and a third resonant mode for generating radiation signals in a second frequency band and a third frequency band. Frequencies of the first frequency band are higher than frequencies of the second frequency band. Frequencies of the third frequency band are higher than frequencies of the first frequency band.

15 Claims, 10 Drawing Sheets



US011189924B2

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

(10) **Patent No.: US 11,189,924 B2**
(45) **Date of Patent: Nov. 30, 2021**

(54) **ANTENNA STRUCTURE**

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

(72) Inventors: **Cheng-Han Lee**, New Taipei (TW); **Min-Hui Ho**, 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 455 days.

(21) Appl. No.: **16/217,065**

(22) Filed: **Dec. 12, 2018**

(65) **Prior Publication Data**

US 2019/0181553 A1 Jun. 13, 2019

Related U.S. Application Data

(60) Provisional application No. 62/597,442, filed on Dec. 12, 2017, provisional application No. 62/614,364, filed on Jan. 6, 2018.

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 5/35	(2015.01)
H01Q 9/28	(2006.01)
H01Q 3/24	(2006.01)
H01Q 9/42	(2006.01)
H01Q 5/335	(2015.01)
H01Q 21/28	(2006.01)
H01Q 13/10	(2006.01)
H01Q 9/30	(2006.01)

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

CPC ***H01Q 5/35*** (2015.01); ***H01Q 1/243*** (2013.01); ***H01Q 3/247*** (2013.01); ***H01Q 5/335*** (2015.01); ***H01Q 9/285*** (2013.01); ***H01Q 9/30*** (2013.01); ***H01Q 9/42*** (2013.01); ***H01Q 13/10*** (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

9,559,433	B2 *	1/2017	Zhou	H01Q 1/243
9,806,400	B2	10/2017	Tseng et al.	
10,886,614	B2 *	1/2021	Lee	H01Q 13/10

(Continued)

FOREIGN PATENT DOCUMENTS

CN	104064879	A	9/2014
CN	104752822	A	7/2015

(Continued)

OTHER PUBLICATIONS

CN107317095A and English translation, 13 pages, no date.*

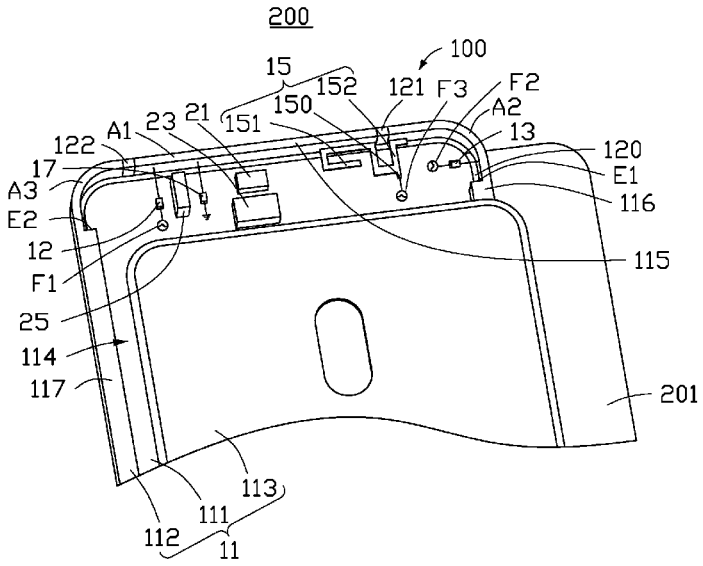
Primary Examiner — Trinh V Dinh

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

(57) **ABSTRACT**

An antenna structure includes a housing, a first feed source, a second feed source, a third feed source, and a radiating body. The first feed source is electrically coupled to a first radiating portion of the housing and adapted to provide an electric current to the first radiating portion. The second feed source is electrically coupled to the second radiating portion and adapted to provide an electric current to the second radiating portion. The radiating body is mounted within the housing and electrically coupled to the third feed source. The third feed source provides an electric current to the radiating body.

20 Claims, 23 Drawing Sheets



US011189927B2

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

(10) **Patent No.: US 11,189,927 B2**
(45) **Date of Patent: Nov. 30, 2021**

(54) **PATCH ANTENNA UNIT AND ANTENNA**

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

(72) Inventors: **Liangsheng Liu**, Shenzhen (CN); **Xinhong Li**, Hsinchu (CN); **HuiLi Fu**, Shenzhen (CN)

(73) Assignee: **HUAWEI TECHNOLOGIES CO., LTD.**, Shenzhen (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 28 days.

(21) Appl. No.: **16/872,920**

(22) Filed: **May 12, 2020**

(65) **Prior Publication Data**

US 2020/0280132 A1 Sep. 3, 2020

Related U.S. Application Data

(63) Continuation of application No. 16/049,104, filed on Jul. 30, 2018, now Pat. No. 10,727,595, which is a (Continued)

(30) **Foreign Application Priority Data**

Jan. 30, 2016 (CN) 201610071196.2

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

(52) **U.S. Cl.**
CPC ***H01Q 9/0414*** (2013.01); ***H01Q 1/2283*** (2013.01); ***H01Q 1/48*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/22; H01Q 1/2283; H01Q 1/48; H01Q 21/00; H01Q 21/0075; H01Q 21/06;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,847,625 A * 7/1989 Dietrich ..... H01Q 9/0457 343/700 MS
5,043,738 A 8/1991 Shapiro et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 101064381 A 10/2007
CN 101141023 A 3/2008
(Continued)

OTHER PUBLICATIONS

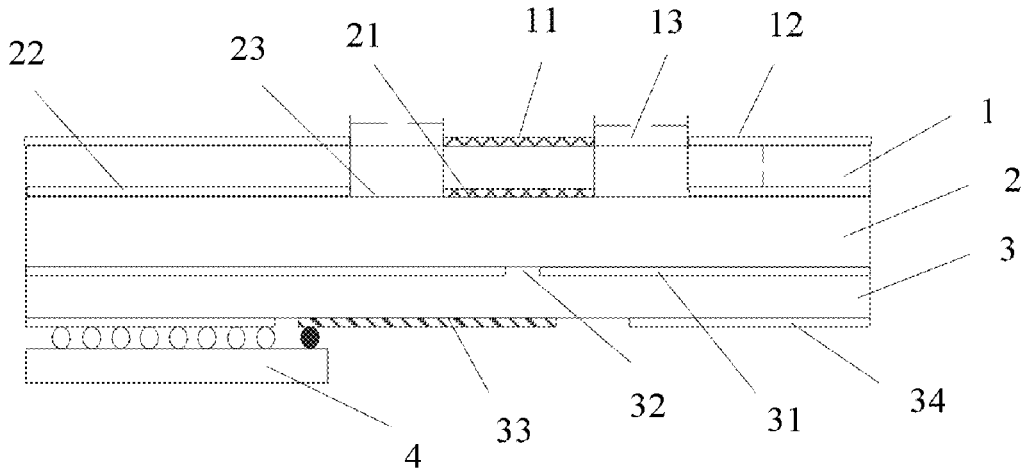
Ueda et al., "Small and low profile stacked patch antenna with wide bandwidth and stable radiation pattern", 2014 IEEE Antennas and Propagation Society International Symposium (APSURSI), IEEE, XP032645552, Jul. 6, 2014, pp. 1875-1876.
(Continued)

Primary Examiner — Tho G Phan
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

(57) **ABSTRACT**

A patch antenna unit includes a first support layer, a substrate, a second support layer, and an integrated circuit that are stacked. One radiation patch is attached to the first support layer, and one radiation patch is attached to the second support layer. A ground layer is disposed on the second support layer, a coupling slot is disposed on the ground layer, and a feeder corresponding to the coupling slot is disposed on the second support layer. The integrated circuit is connected to the first ground layer and the feeder. In the foregoing specific technical solution, a four-layer substrate is used for fabrication.

20 Claims, 12 Drawing Sheets



US011196144B2

(12) **United States Patent**
Hsu

(10) **Patent No.: US 11,196,144 B2**
(45) **Date of Patent: Dec. 7, 2021**

(54) **ANTENNA ASSEMBLY AND WIRELESS COMMUNICATION DEVICE EMPLOYING SAME**

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

(72) Inventor: **Yi-Wen Hsu**, 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 265 days.

(21) Appl. No.: **16/502,128**

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

(65) **Prior Publication Data**

US 2020/0014094 A1 Jan. 9, 2020

(30) **Foreign Application Priority Data**

Jul. 4, 2018 (CN) 201810725796.5

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 1/48	(2006.01)
H01Q 21/30	(2006.01)
H01Q 1/52	(2006.01)
H01Q 7/00	(2006.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 1/521*** (2013.01); ***H01Q 7/00*** (2013.01); ***H01Q 21/30*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/48; H01Q 1/243; H01Q 1/521; H01Q 1/36; H01Q 1/50; H01Q 21/30; H01Q 5/371; H01Q 9/42

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2006/0170600	A1*	8/2006	Korva	H01Q 1/244 343/702
2011/0043408	A1*	2/2011	Shi	H01Q 1/48 343/700 MS
2014/0320349	A1*	10/2014	Lee	H01Q 5/392 343/700 MS
2015/0002340	A1*	1/2015	Liou	H01Q 9/42 343/700 MS
2016/0134017	A1	5/2016	Lin	

FOREIGN PATENT DOCUMENTS

CN 105633581 A 6/2016

* cited by examiner

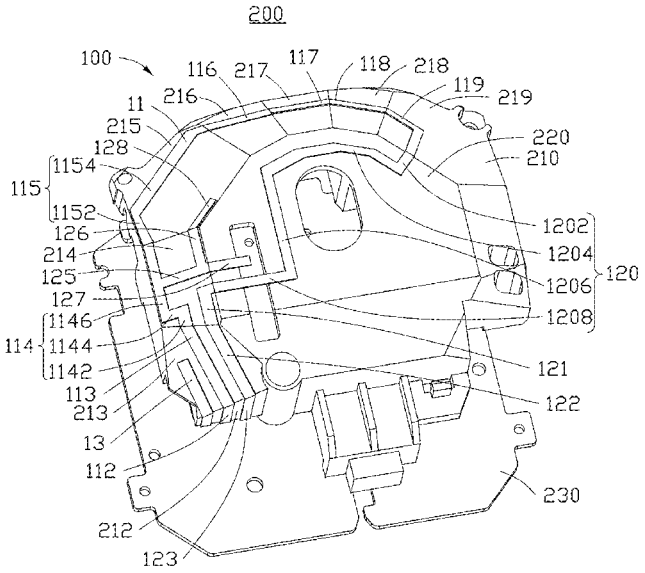
Primary Examiner — Awat M Salih

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

(57) **ABSTRACT**

An antenna assembly of reduced size but with optimized radiation and reception capabilities through slanted connections between the parts includes a feed portion, a first ground portion, a second ground portion, a first radiating portion, and a second radiating portion. The first radiating portion is a loop antenna on at least three surfaces of a carrier, and is connected between the feed portion and the first ground portion on opposite ends. The first radiating portion feeds in electric current through the feed portion. The second radiating portion is spaced from the first radiating portion, the second radiating portion is arranged on at least two surfaces of the carrier. The second radiating portion is connected between the second ground portion, the second radiating portion couples electric current from the first radiating portion. A wireless communication device employing the antenna assembly is also provided.

20 Claims, 10 Drawing Sheets



US011196162B2

(12) **United States Patent**
Jouanlanne

(10) **Patent No.: US 11,196,162 B2**
(45) **Date of Patent: Dec. 7, 2021**

(54) **PATCH ANTENNA HAVING TWO DIFFERENT RADIATION MODES WITH TWO SEPARATE WORKING FREQUENCIES, DEVICE USING SUCH AN ANTENNA**

(71) Applicant: **SIGFOX**, Labege (FR)

(72) Inventor: **Cyril Jouanlanne**, Toulouse (FR)

(73) Assignee: **SigFox**

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 34 days.

(21) Appl. No.: **16/635,831**

(22) PCT Filed: **Aug. 17, 2018**

(86) PCT No.: **PCT/EP2018/072288**
§ 371 (c)(1),
(2) Date: **Jan. 31, 2020**

(87) PCT Pub. No.: **WO2019/034760**
PCT Pub. Date: **Feb. 21, 2019**

(65) **Prior Publication Data**

US 2020/0227829 A1 Jul. 16, 2020

(30) **Foreign Application Priority Data**

Aug. 18, 2017 (FR) 1757731

(51) **Int. Cl.**
H03M 1/38 (2006.01)
H01Q 5/335 (2015.01)
H01Q 5/328 (2015.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 5/335*** (2015.01); ***H01Q 5/328*** (2015.01); ***H01Q 9/0407*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/335; H01Q 5/328; H01Q 9/0407; H01Q 5/314; H01Q 9/0421; H01Q 1/3275
USPC ..... 343/700 M
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,720,935 B2 * 4/2004 Lamensdorf ..... H01Q 1/362 343/700 MS
8,354,972 B2 * 1/2013 Borja H01Q 5/378 343/797
8,952,857 B2 * 2/2015 Diaz H01Q 13/0225 343/772
2003/0114118 A1 * 6/2003 Fukushima H01Q 1/48 455/82
2003/0117325 A1 * 6/2003 Jo H01Q 1/243 343/702

(Continued)

FOREIGN PATENT DOCUMENTS

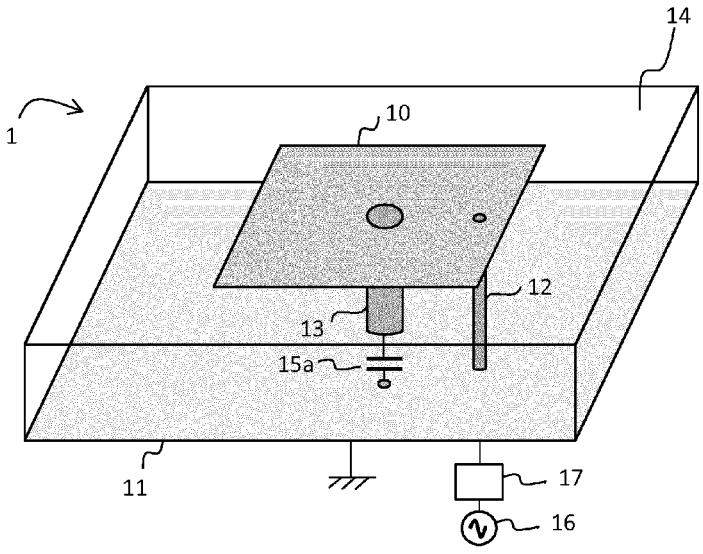
WO 03041216 5/2003

Primary Examiner — Jean B Jeanglaude
(74) *Attorney, Agent, or Firm* — Perman & Green, LLP

(57) **ABSTRACT**

An antenna including a ground plane, a metal plate arranged facing the ground plane, and a supply wire for connecting the plate to a generator or a receiver, such that the antenna has a first resonance frequency in a patch antenna mode. The antenna further includes a ground wire connecting the plate to the ground plane, and a capacitive element arranged in series with the ground wire between the supply wire and the ground plane, such that the antenna also has a second resonance frequency in a wire-plate antenna mode.

13 Claims, 6 Drawing Sheets



US011196163B2

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

(10) **Patent No.: US 11,196,163 B2**
(45) **Date of Patent: Dec. 7, 2021**

(54) **ANTENNA STRUCTURE**

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

(72) Inventors: **Cheng-Han Lee**, New Taipei (TW); **Huo-Ying Chang**, 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 261 days.

(21) Appl. No.: **16/217,068**

(22) Filed: **Dec. 12, 2018**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 62/597,442, filed on Dec. 12, 2017, provisional application No. 62/614,364, filed on Jan. 6, 2018.

(51) **Int. Cl.**

H01Q 5/35	(2015.01)
H01Q 9/28	(2006.01)
H01Q 3/24	(2006.01)
H01Q 9/42	(2006.01)
H01Q 5/335	(2015.01)
H01Q 21/28	(2006.01)
H01Q 1/24	(2006.01)
H01Q 13/10	(2006.01)
H01Q 9/30	(2006.01)

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

CPC ***H01Q 5/35*** (2015.01); ***H01Q 1/243*** (2013.01); ***H01Q 3/247*** (2013.01); ***H01Q 5/335*** (2015.01); ***H01Q 9/285*** (2013.01); ***H01Q 9/30*** (2013.01); ***H01Q 9/42*** (2013.01); ***H01Q 13/10*** (2013.01); ***H01Q 21/28*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/35; H01Q 5/335; H01Q 1/243; H01Q 3/247; H01Q 9/285; H01Q 9/30; H01Q 9/42; H01Q 13/10; H01Q 21/28

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2012/0009983	A1 *	1/2012	Mow	H04B 1/40 455/575.7
2015/0372372	A1	12/2015	Lee et al.	
2018/0034135	A1 *	2/2018	Kwak	H01Q 9/42
2018/0358699	A1	12/2018	Li et al.	
2019/0036210	A1 *	1/2019	Kim	H01Q 5/35

FOREIGN PATENT DOCUMENTS

CN	104300215	A	1/2015
CN	107317095	A *	11/2017
CN	107317095	A	11/2017
WO	2017/092003	A1	6/2017

* cited by examiner

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Assistant Examiner — Noel Maldonado
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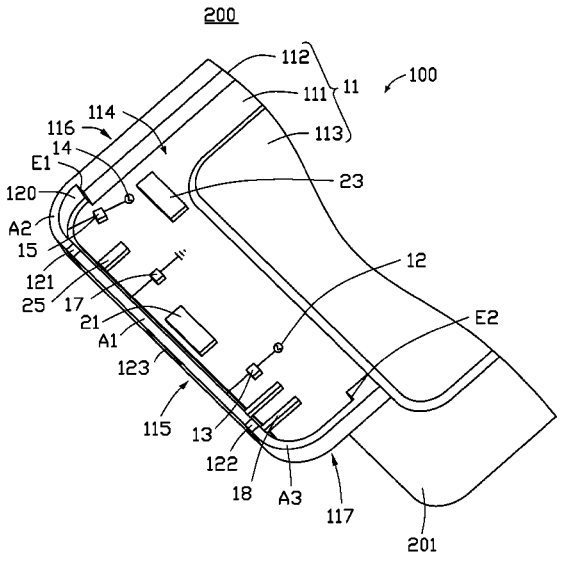
(57) **ABSTRACT**

An antenna structure includes a housing, a first feed source, and a second feed source. The first feed source is electrically coupled to a first radiating portion of the housing and adapted to provide an electric current to the first radiating portion. The second feed source is electrically coupled to one of a second radiating portion or a third radiating portion of the housing. The other one of the second radiating portion or the third radiating portion is electrically coupled to the first radiating portion.

20 Claims, 24 Drawing Sheets



US011196169B2

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

(10) **Patent No.: US 11,196,169 B2**
(45) **Date of Patent: Dec. 7, 2021**

(54) **PRINTED CIRCUIT BOARD ANTENNA**

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

(72) Inventors: **Yachuan Shen**, Shenzhen (CN); **Lei Zheng**, Shenzhen (CN); **Yongsheng Peng**, Shenzhen (CN); **Hongjun 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 0 days.

(21) Appl. No.: **16/945,945**

(22) Filed: **Aug. 3, 2020**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. PCT/CN2019/093502, filed on Jun. 28, 2019.

(51) **Int. Cl.**

H01Q 1/38	(2006.01)
H01Q 13/10	(2006.01)
H01Q 21/30	(2006.01)
H01Q 1/24	(2006.01)

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

CPC ***H01Q 13/10*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 21/30*** (2013.01); *H01Q 1/241* (2013.01)

(58) **Field of Classification Search**

CPC H01Q 13/10; H01Q 1/38; H01Q 21/30
USPC 343/767
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2020/0350672 A1* 11/2020 Chen H01Q 9/285
2020/0366003 A1* 11/2020 Kim H01Q 21/28

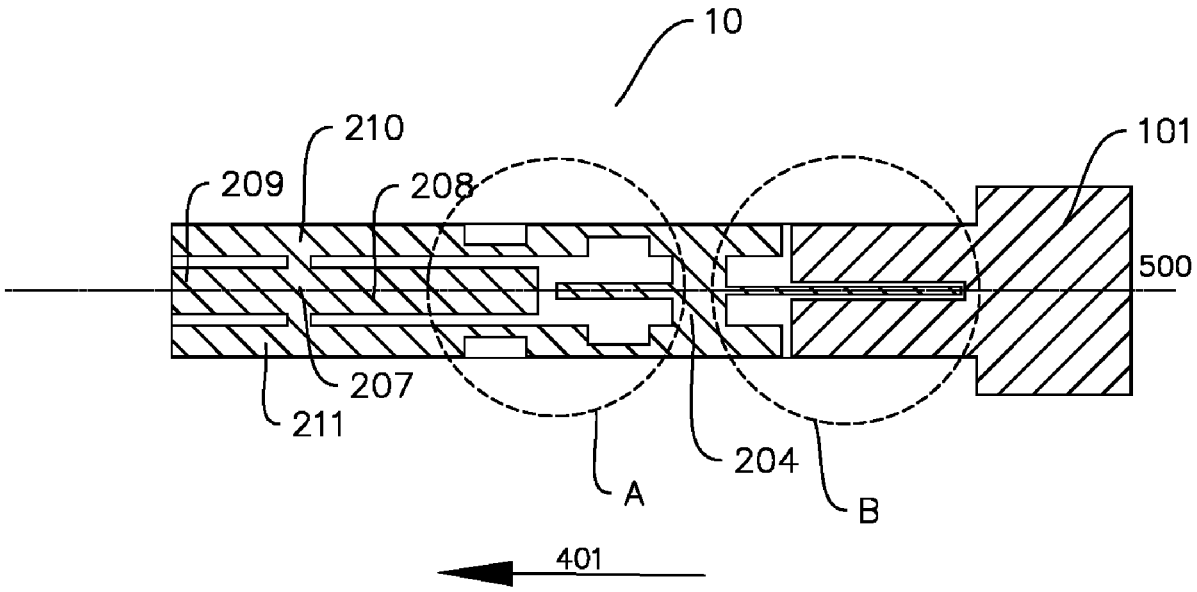
* cited by examiner

Primary Examiner — Peguy Jean Pierre
(74) *Attorney, Agent, or Firm* — W&G Law Group

(57) **ABSTRACT**

Provided is a PCB antenna, including PCB substrate, first and second radiating portions, the first radiating portion includes first radiator, second and third radiators extending therefrom to form feeding groove; the second radiating portion includes fourth radiator, fifth and sixth radiators extending therefrom, seventh radiator, eighth and ninth radiators extending therefrom, and tenth and eleventh radiators symmetrically arranged, the fifth radiator extends to the feeding groove; the sixth radiator extends in opposite direction of the fifth radiator; the seventh radiator extends in the direction of the sixth radiator and forms second slot therewith; the eighth radiator extends in opposite direction of the seventh radiator; third slot is formed between the tenth radiator and the second radiator, fourth slot is formed between the eleventh radiator and the third radiator. The PCB antenna provided can enhance medium and high frequency resonance and provide full-band omnidirectional antenna design under 4G demand.

12 Claims, 9 Drawing Sheets



US011196170B2

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

(10) **Patent No.: US 11,196,170 B2**
(45) **Date of Patent: Dec. 7, 2021**

(54) **ANTENNA DEVICE**

(71) Applicants: **Chun-Cheng Chan**, Taipei (TW); **Shih-Chia Liu**, Taipei (TW); **Li-Chun Lee**, Taipei (TW); **Chao-Lin Wu**, Taipei (TW); **Jui-Hung Lai**, Taipei (TW); **Yen-Hao Yu**, Taipei (TW)

(72) Inventors: **Chun-Cheng Chan**, Taipei (TW); **Shih-Chia Liu**, Taipei (TW); **Li-Chun Lee**, Taipei (TW); **Chao-Lin Wu**, Taipei (TW); **Jui-Hung Lai**, Taipei (TW); **Yen-Hao Yu**, Taipei (TW)

(73) Assignee: **COMPAL ELECTRONICS, INC.**, Taipei (TW)

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

(21) Appl. No.: **16/739,114**

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

(65) **Prior Publication Data**

US 2021/0083394 A1 Mar. 18, 2021

(30) **Foreign Application Priority Data**

Sep. 16, 2019 (TW) 108133152

(51) **Int. Cl.**
H01Q 13/16 (2006.01)
H01Q 5/10 (2015.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 13/16*** (2013.01); ***H01Q 1/24*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 5/10*** (2015.01)

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,223,082	B2 *	7/2012	Chiang	H01Q 1/2266 343/767
8,373,601	B2 *	2/2013	Wu	H01Q 5/371 343/700 MS
10,511,079	B2 *	12/2019	Wu	H01Q 1/2258
10,804,612	B2 *	10/2020	Wu	G06F 1/1616
2011/0316760	A1 *	12/2011	Wu	H01Q 9/42 343/905

FOREIGN PATENT DOCUMENTS

TW 201902032 1/2019

OTHER PUBLICATIONS

"Office Action of Taiwan Counterpart Application", dated Jun. 17, 2020, p. 1-p. 5.

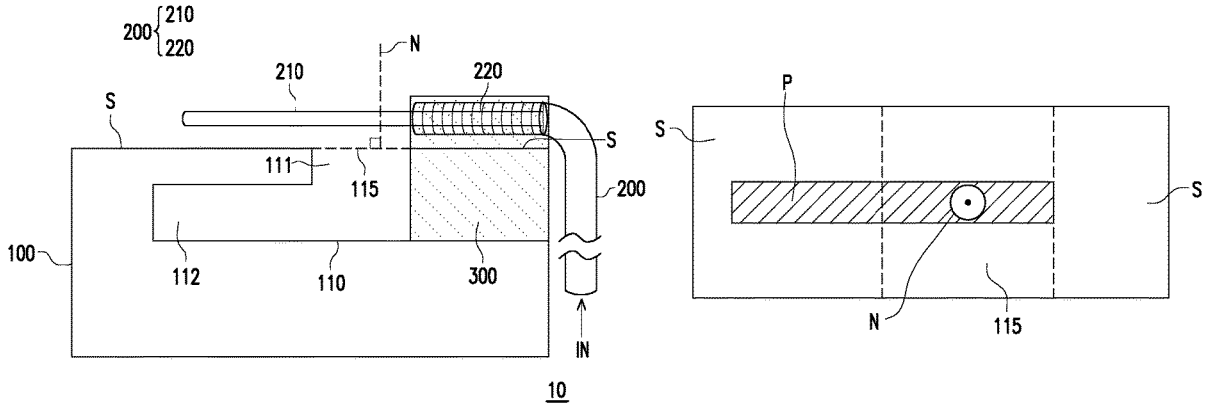
* cited by examiner

Primary Examiner — Vibol Tan
(74) *Attorney, Agent, or Firm* — JCIPRNET

(57) **ABSTRACT**

An antenna device is provided in the disclosure. The antenna device includes a metal component, a signal cable, and a grounding component. The metal component includes a slot. The slot includes an open end and a closed end, and the open end forms an opening at a side of the metal component. The signal cable includes a signal portion and a grounding portion. The signal cable is disposed such that a projection of the signal portion is partially overlapped with the opening. The grounding portion is electrically connected to the metal component through the grounding component.

9 Claims, 3 Drawing Sheets



US011196175B2

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

(10) **Patent No.: US 11,196,175 B2**
(45) **Date of Patent: Dec. 7, 2021**

(54) **ANTENNA DEVICE**

(71) Applicant: **MITSUBISHI ELECTRIC CORPORATION**, Tokyo (JP)

(72) Inventors: **Hiroaki Sakamoto**, Tokyo (JP); **Takashi Yanagi**, Tokyo (JP); **Yusuke Kitsukawa**, Tokyo (JP); **Moriyasu Miyazaki**, Tokyo (JP); **Takuma Kadoya**, Tokyo (JP); **Yuichi Hagito**, Tokyo (JP)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 15 days.

(21) Appl. No.: **16/646,030**

(22) PCT Filed: **Sep. 29, 2017**

(86) PCT No.: **PCT/JP2017/035396**
§ 371 (c)(1),
(2) Date: **Mar. 10, 2020**

(87) PCT Pub. No.: **WO2019/064470**
PCT Pub. Date: **Apr. 4, 2019**

(65) **Prior Publication Data**

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

(52) **U.S. Cl.**
CPC ***H01Q 21/0006*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 9/42*** (2013.01); ***H01Q 21/24*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/38–1/48; H01Q 9/0407; H01Q 9/42; H01Q 21/00; H01Q 21/24
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,497,164 A * 3/1996 Croq ..... H01Q 9/0414 343/700 MS
6,320,542 B1 * 11/2001 Yamamoto ..... H01Q 1/38 343/700 MS
(Continued)

FOREIGN PATENT DOCUMENTS

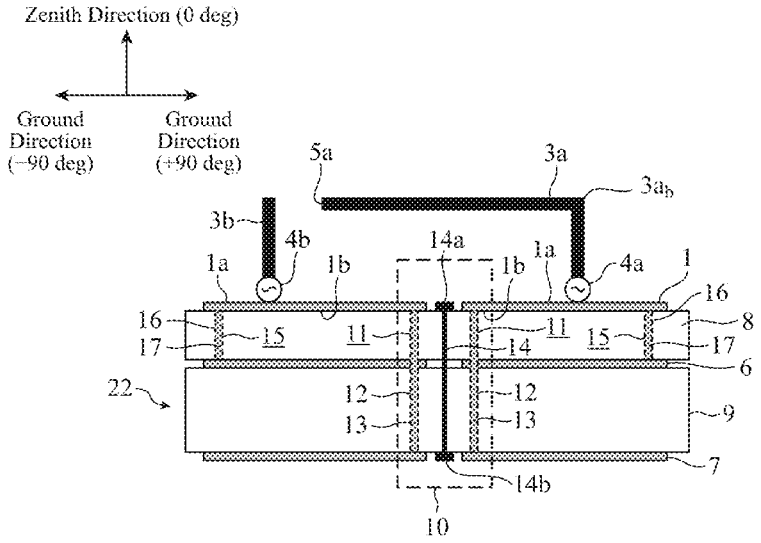
JP 2000-77930 A 3/2000
JP 2014-135707 A 7/2014

Primary Examiner — Hasan Islam
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**

Included are: a coaxial line (**10**) provided so as to pass through a second ground conductor (**6**), a first dielectric substrate (**8**), and a second dielectric substrate (**9**), the coaxial line (**10**) including an outer conductor (**11**) allowing a first ground conductor (**1**), a second ground conductor (**6**), and a third ground conductor (**7**) to be conductive thereamong; and a conductive member (**15**) provided so as to pass through the first dielectric substrate (**8**), the conductive member (**15**) allowing the first ground conductor (**1**) and the second ground conductor (**6**) to be conductive therebetween. An interface circuit (**18**) combines a plurality of signals having mutually different phases output from each of plurality of element antennas (**3***a*), (**3***b*), (**3***c*), and (**3***d*) and outputs the combined signal to the coaxial line (**10**).

12 Claims, 9 Drawing Sheets



US011196847B2

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

(10) **Patent No.: US 11,196,847 B2**
(45) **Date of Patent: Dec. 7, 2021**

(54) **ELECTRONIC DEVICE INCLUDING ANTENNA**

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

(72) Inventors: **Seyoung Jang**, Suwon-si (KR); **Chulwoo Park**, Suwon-si (KR); **Dongil Son**, Suwon-si (KR); **Hyeongju Lee**, Suwon-si (KR)

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

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

(21) Appl. No.: **16/296,701**

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

(65) **Prior Publication Data**

US 2019/0281146 A1 Sep. 12, 2019

(30) **Foreign Application Priority Data**

Mar. 9, 2018 (KR) 10-2018-0028195

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

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

(58) **Field of Classification Search**
CPC H04M 1/026; H01Q 1/243; H01Q 1/244; H01Q 1/245
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,896,488	B2	11/2014	Ayala Vazquez et al.	
9,153,856	B2	10/2015	Rappoport et al.	
9,293,806	B2	3/2016	Kwong et al.	
9,653,778	B2	5/2017	Kwong et al.	
10,084,241	B1 *	9/2018	Jenwatanavet	H01Q 1/243
10,084,490	B2	9/2018	Ouyang et al.	
10,116,065	B2	10/2018	Pan	
10,297,900	B2	5/2019	Lee et al.	
10,305,172	B2	5/2019	Noori et al.	

(Continued)

FOREIGN PATENT DOCUMENTS

DE	2020 17002063 U1	8/2017
KR	10-2011-0092104	8/2011

(Continued)

OTHER PUBLICATIONS

International Search Report and Written Opinion dated Jul. 4, 2019 in counterpart International Patent Application No. PCT/KR2019/002704.

(Continued)

Primary Examiner — Dinh Nguyen
(74) *Attorney, Agent, or Firm* — Nixon & Vanderhye P.C.

(57) **ABSTRACT**

An electronic device includes a housing including a first plate including a glass plate, a second plate facing the first plate, and a side surface surrounding a space between the first plate and the second plate, a display positioned inside the space and exposed through a first area of the first plate, an antenna structure at least partially overlapping a second area of the first plate when viewed from above the first plate and which is connected to the second area, and a processor.

13 Claims, 40 Drawing Sheets