



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**

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(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)

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European Patent Application No. 19 20 0733, 14 pages.

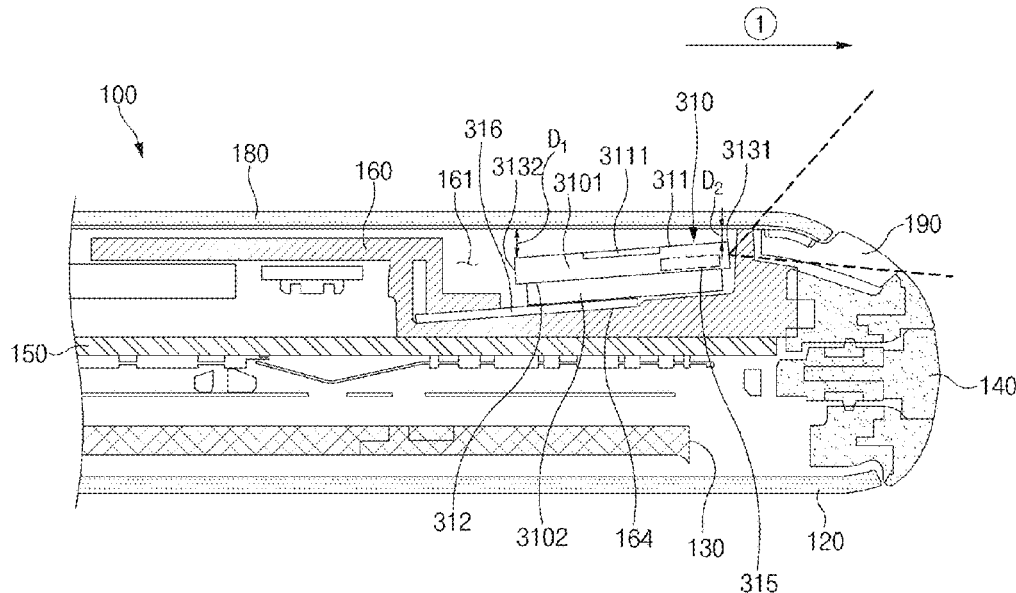
(Continued)

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**

(56) **References Cited**

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

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(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)

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KR 10-2019-0060283 A 6/2019

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

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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 52 days.

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

(Continued)

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

Primary Examiner — Nhan T Le

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

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

(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

(57) **ABSTRACT**

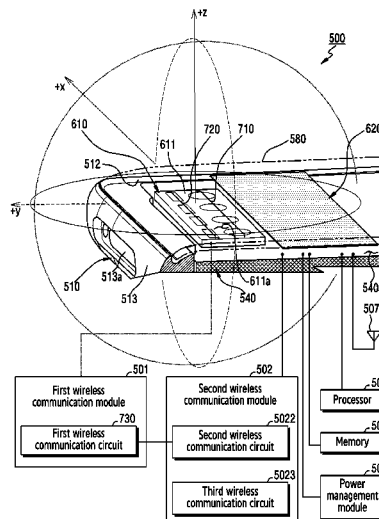
A portable communication device is provided. The portable communication device includes a display defining a front surface of the portable communication device, a plate defining a rear surface of the portable communication device and including a nonconductive material, the plate including a first surface 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.

(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.

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**

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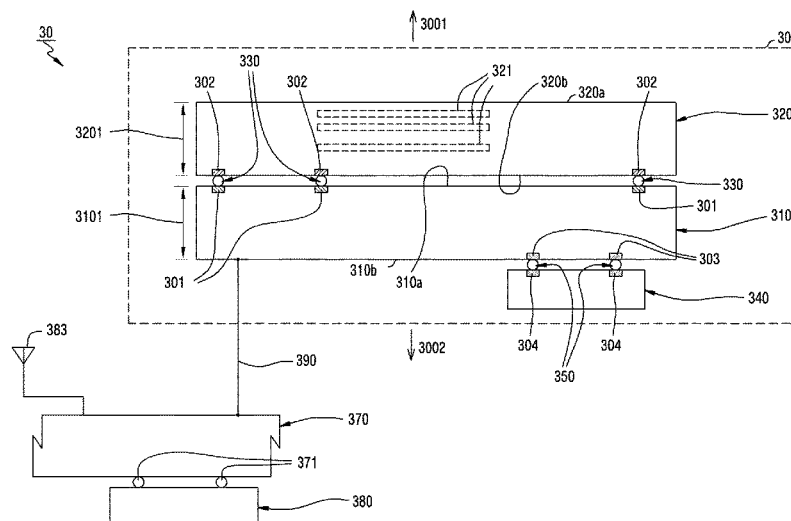
Primary Examiner — Andrea Lindgren Baltzell

(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**

(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)

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

(58) **Field of Classification Search**

CPC combination set(s) only.
See application file for complete search history.

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

(56) **References Cited**

(73) Assignee: **Ethertronics, Inc.**, San Diego, 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 212 days.

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

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

(65) **Prior Publication Data**

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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.

Primary Examiner — Zhitong Chen

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

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

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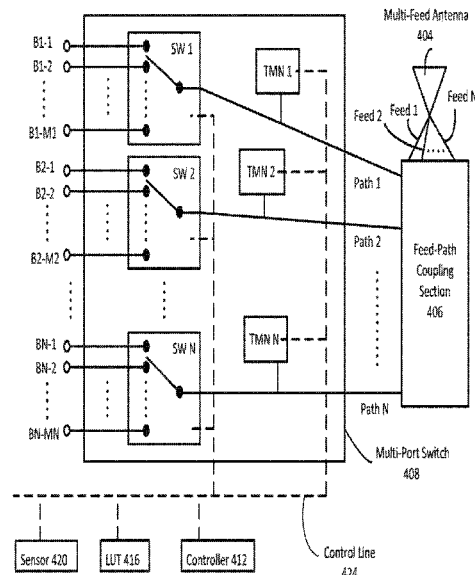
ABSTRACT

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.

(51) **Int. Cl.**

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

9 Claims, 21 Drawing Sheets



(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
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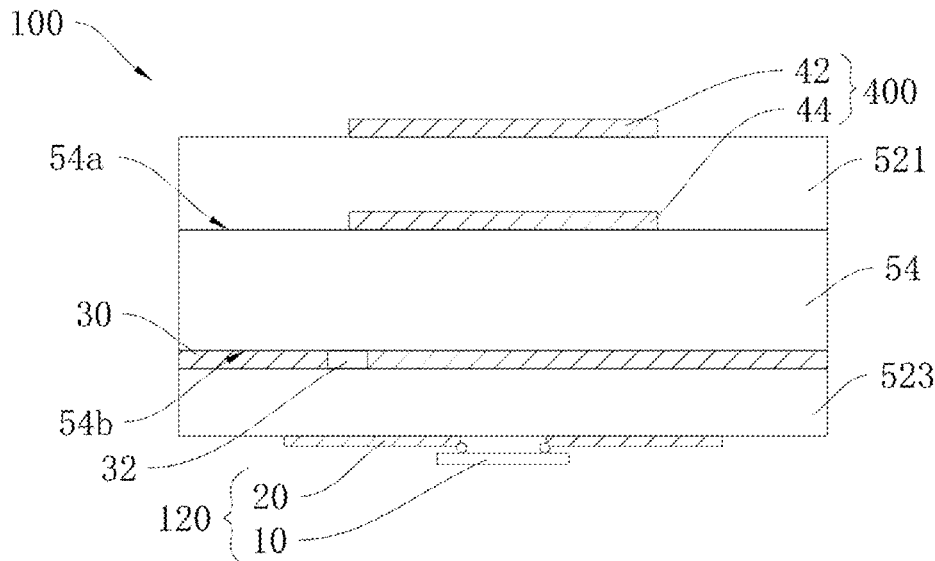
Primary Examiner — Peguy Jean Pierre

(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**

(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)

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

(56) **References Cited**

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(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.

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national 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.

(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.

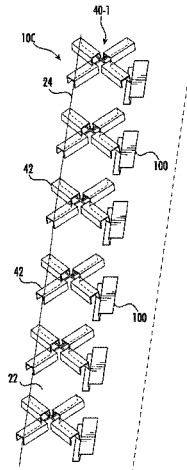
(51) **Int. Cl.**
H01Q 21/24 (2006.01)
H01Q 1/24 (2006.01)
(Continued)

(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)

(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.

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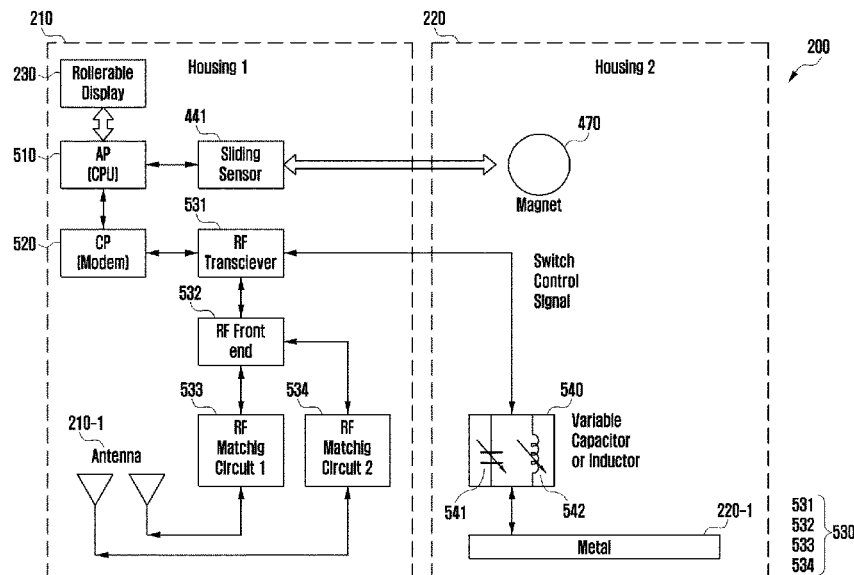
Primary Examiner — Nguyen T Vo

(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.

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Primary Examiner — Zachary Pape

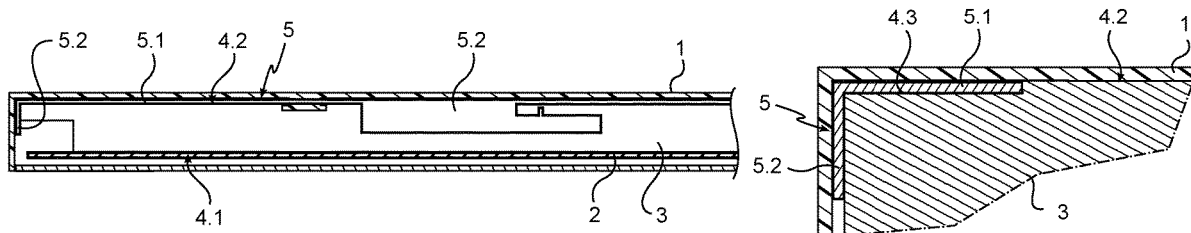
(74) *Attorney, Agent, or Firm* — Muncy, Geissler, Olds &
Lowe, P.C.

(57)

ABSTRACT

Electronic device including a housing enclosing an elec-
tronic 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





(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)

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10-2017-0072359.

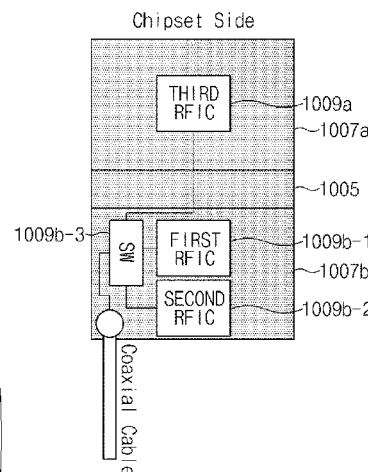
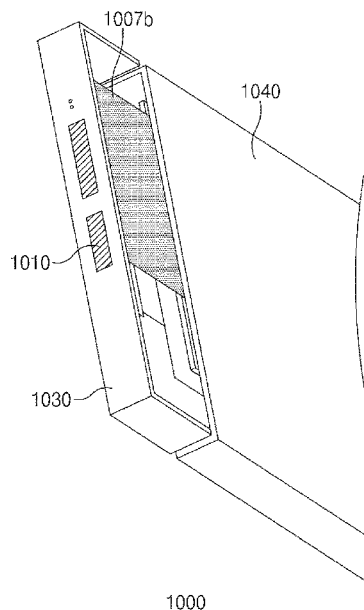
Primary Examiner — Awat M Salih

(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



(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**

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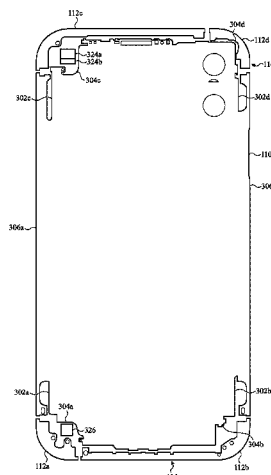
Primary Examiner — Graham P Smith

(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 dis-
claimer.

(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**

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10,644,389 B1 * 5/2020 Chueh H01Q 21/28

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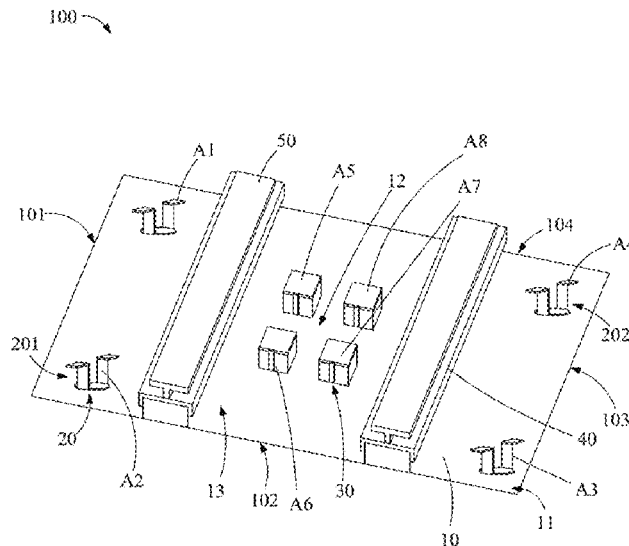
Primary Examiner — Tho G Phan

(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



(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**

(2013.01); *H01Q 5/10* (2015.01); *H01Q 5/328* (2015.01); *H01Q 5/371* (2015.01); *H01Q 5/378* (2015.01)

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

(58) **Field of Classification Search**

None

See application file for complete search history.

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

(56)

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U.S. PATENT DOCUMENTS

(73) Assignee: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)

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343/700 MS
2007/0268143 A1 * 11/2007 Copeland *H01Q 9/065*
340/572.7

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 354 days.

(Continued)

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

FOREIGN PATENT DOCUMENTS

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

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

(65) **Prior Publication Data**

Primary Examiner — Trinh V Dinh

US 2019/0181549 A1 Jun. 13, 2019

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

(30) **Foreign Application Priority Data**

(57)

ABSTRACT

Nov. 22, 2017 (CN) 201711175305.6

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.

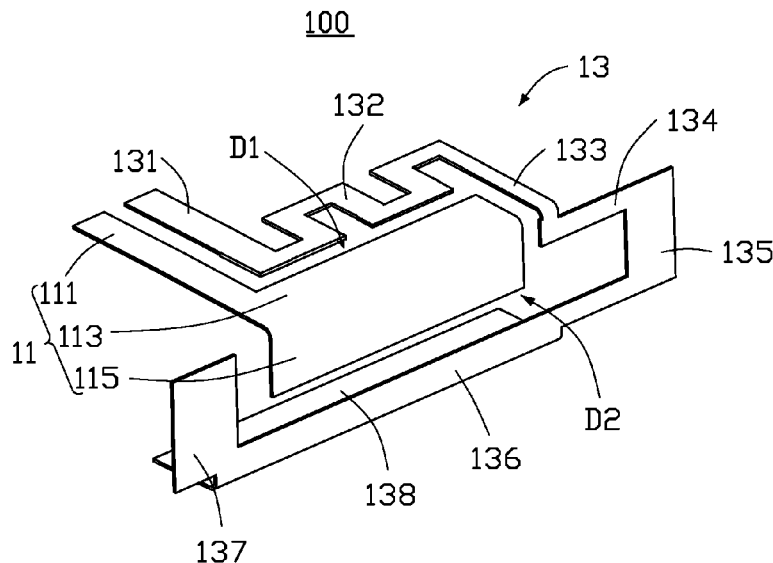
(51) **Int. Cl.**

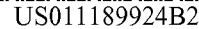
H01Q 1/24 (2006.01)
H01Q 5/30 (2015.01)
H01Q 5/10 (2015.01)
H01Q 5/328 (2015.01)
H01Q 1/38 (2006.01)
H01Q 1/36 (2006.01)
H01Q 5/371 (2015.01)
H01Q 5/378 (2015.01)

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

CPC *H01Q 5/30* (2015.01); *H01Q 1/243* (2013.01); *H01Q 1/36* (2013.01); *H01Q 1/38*

15 Claims, 10 Drawing Sheets





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

(54) ANTENNA STRUCTURE

H01Q 9/30 (2013.01); *H01Q 9/42* (2013.01);
H01Q 13/10 (2013.01); *H01Q 21/28* (2013.01)

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

(58) **Field of Classification Search**

None

See application file for complete search history.

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

(56) **References Cited**

(73) Assignee: **Chiun Mai Communication Systems, Inc., New Taipei (TW)**

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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 455 days.

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

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

CN	104064879	A	9/2014
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(65) **Prior Publication Data**

(Continued)

US 2019/0181553 A1 Jun. 13, 2019

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

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

Primary Examiner — Trinh V Dinh

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

(51) **Int. Cl.**

(57) **ABSTRACT**

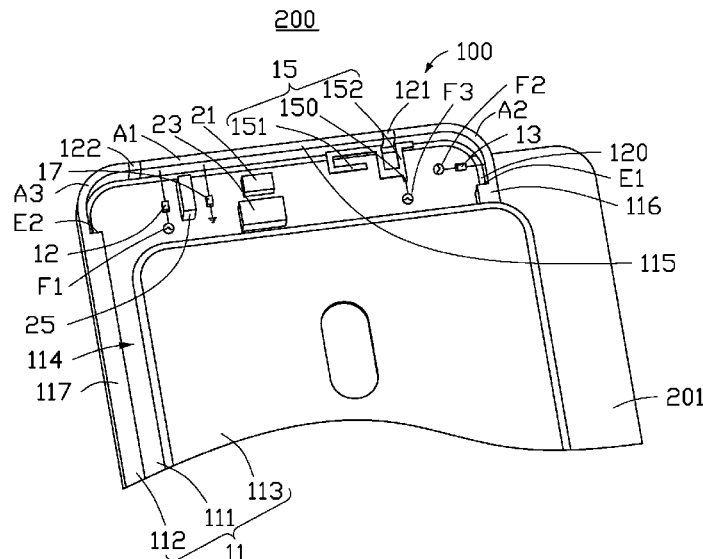
<i>H01Q 1/24</i>	(2006.01)
<i>H01Q 5/35</i>	(2015.01)
<i>H01Q 9/28</i>	(2006.01)
<i>H01Q 3/24</i>	(2006.01)
<i>H01Q 9/42</i>	(2006.01)
<i>H01Q 5/335</i>	(2015.01)
<i>H01Q 21/28</i>	(2006.01)
<i>H01Q 13/10</i>	(2006.01)
<i>H01Q 9/30</i>	(2006.01)

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.

(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);

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**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

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

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343/700 MS

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(Continued)

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

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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 28 days.

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

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

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bandwidth and stable radiation pattern", 2014 IEEE Antennas and
Propagation Society International Symposium (APSURSI), IEEE,
XP032645552, Jul. 6, 2014, pp. 1875-1876.

(65) **Prior Publication Data**

US 2020/0280132 A1 Sep. 3, 2020

(Continued)

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)

Primary Examiner — Tho G Phan

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

(30) **Foreign Application Priority Data**

Jan. 30, 2016 (CN) 201610071196.2

(57)

ABSTRACT

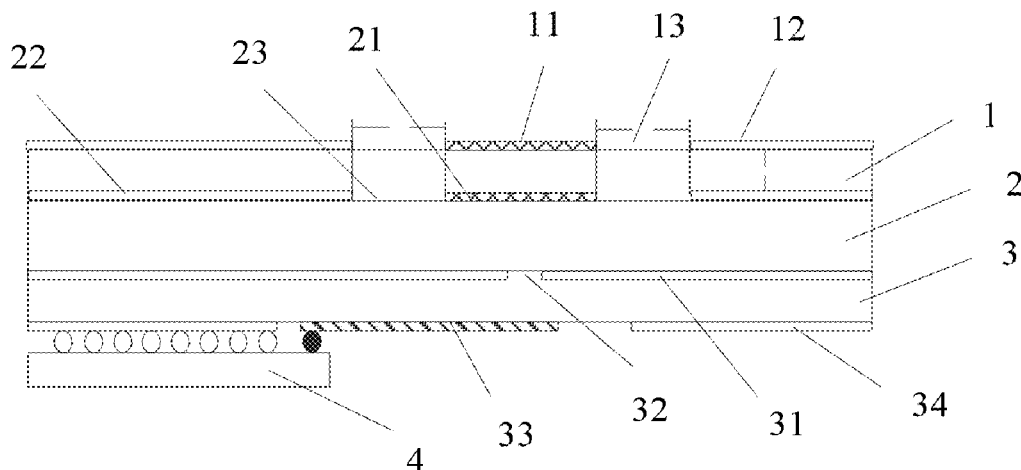
(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 9/04 (2006.01)
(Continued)

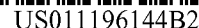
A patch antenna unit includes a first support layer, a sub-
strate, a second support layer, and an integrated circuit that
are stacked. One radiation patch is attached to the first
support layer, and one radiation patch is attached to the
second support layer. A ground layer is disposed on the
second 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.

(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)

20 Claims, 12 Drawing Sheets





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

(56) **References Cited**

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343/700 MS

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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

See application file for complete search history.



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**

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343/700 MS
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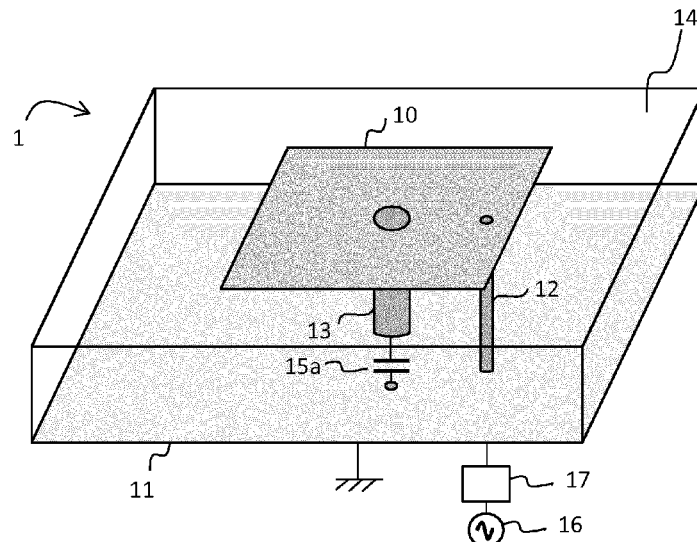
Primary Examiner — Jean B Jeanglaude

(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





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**

US 2021/0021047 A1 Jan. 21, 2021

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**

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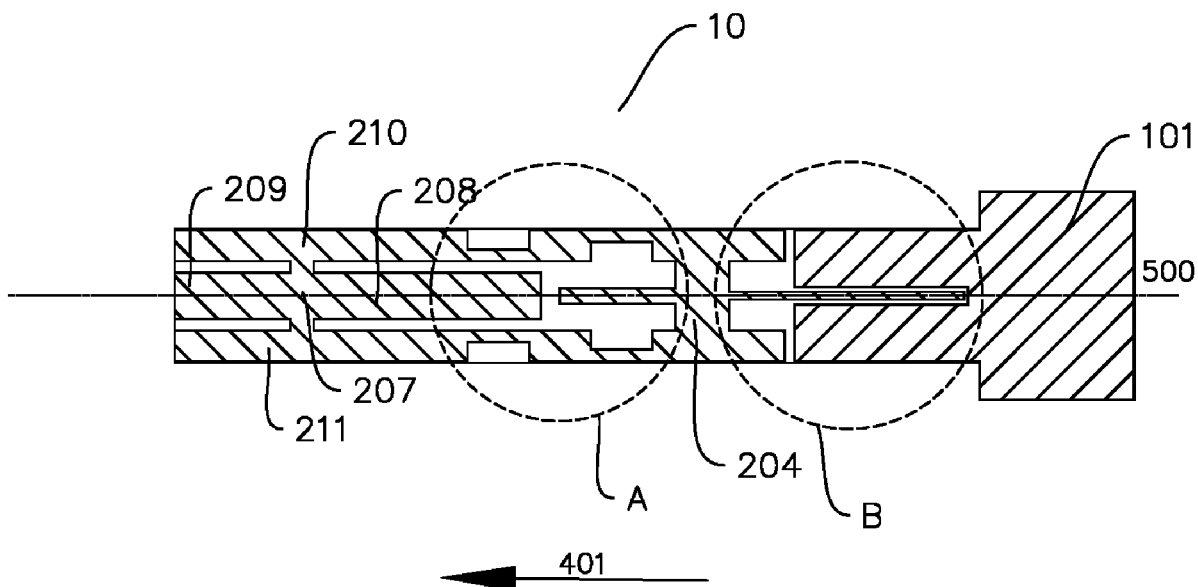
Primary Examiner — Peguy Jean Pierre

(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



(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**

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(30) **Foreign Application Priority Data**

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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.

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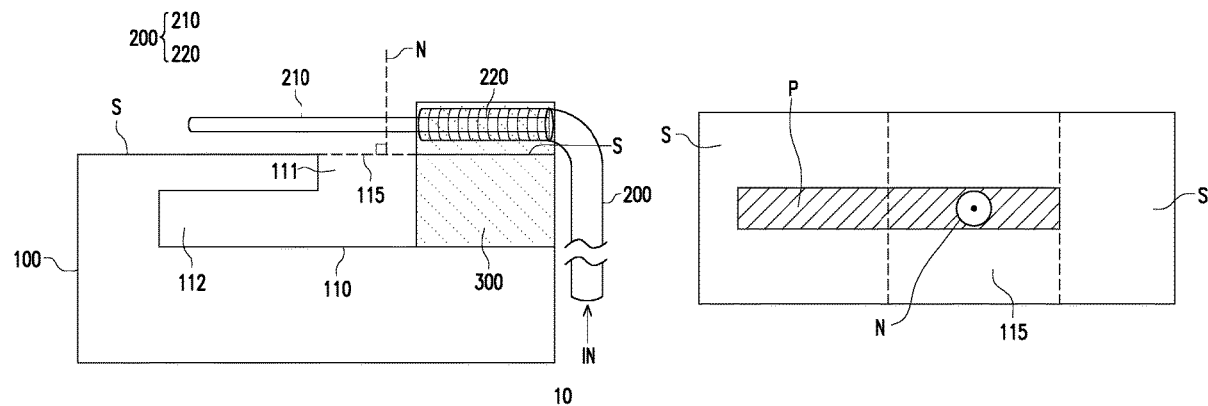
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(57) **ABSTRACT**

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.

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(54) **ANTENNA DEVICE**

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

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§ 371 (c)(1),

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(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.

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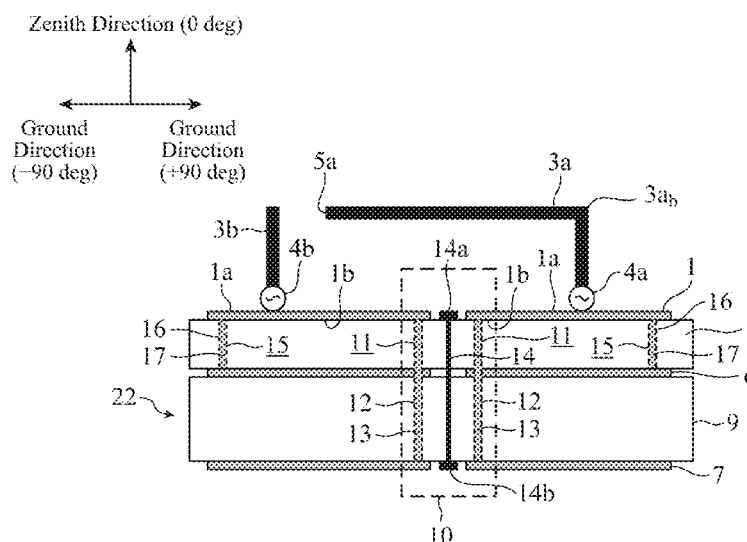
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(57) **ABSTRACT**

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 (3a), (3b), (3c), and (3d) 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**
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(54) **ELECTRONIC DEVICE INCLUDING ANTENNA**

(56) **References Cited**

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

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(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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H01Q 1/24 (2006.01)

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

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Primary Examiner — Dinh Nguyen

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(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

