



US011101546B2

(12) **United States Patent**
Li

(10) **Patent No.:** **US 11,101,546 B2**

(45) **Date of Patent:** **Aug. 24, 2021**

(54) **ELECTRONICAL DEVICE**

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

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

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

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

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

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Mar. 30, 2018 (CN) 201810298316.1

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

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

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

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Primary Examiner — Dameon E Levi

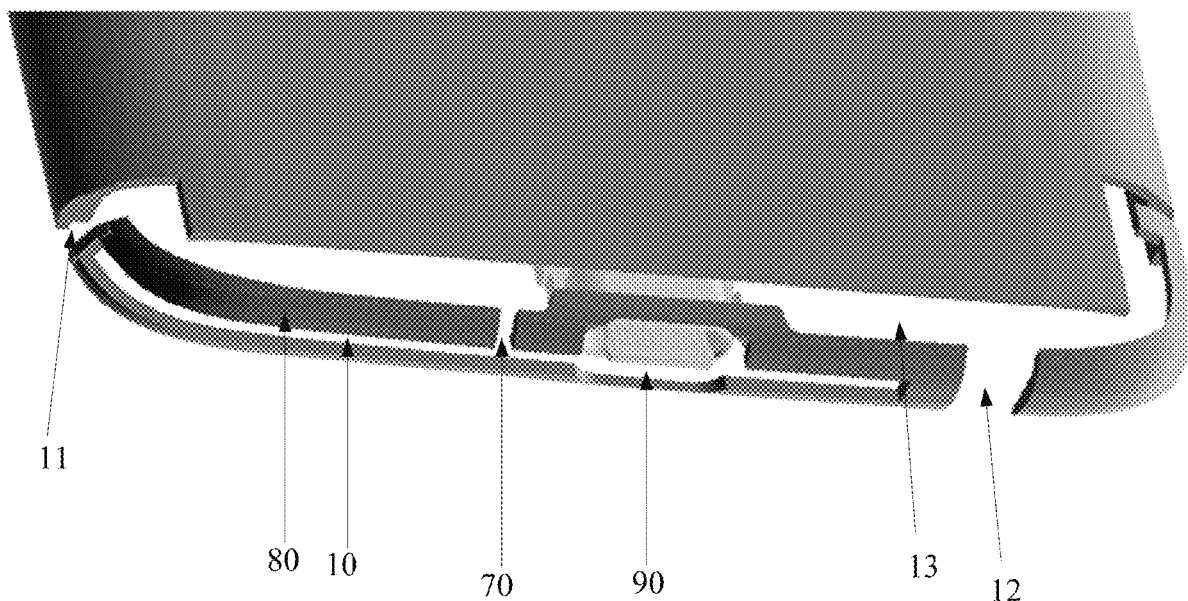
Assistant Examiner — David E Lotter

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

(57) **ABSTRACT**

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

16 Claims, 13 Drawing Sheets





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

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

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

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

(72) Inventors: **Yih-Shyang Her**, New Taipei (TW);
Yun-Jian Chang, New Taipei (TW);
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Wei-En Hsieh, New Taipei (TW)

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

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

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

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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

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

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

(56) **References Cited**

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Primary Examiner — Yuwen Pan

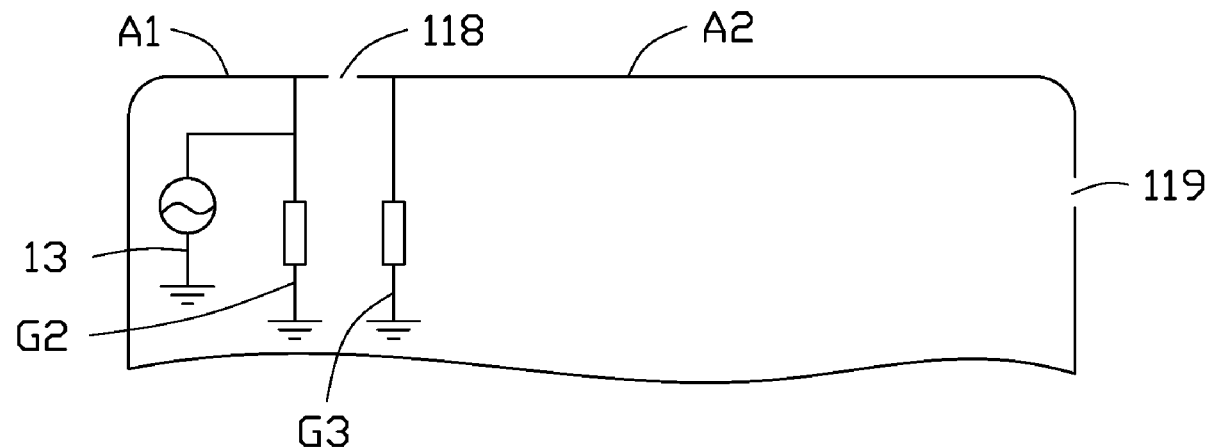
Assistant Examiner — Umair Ahsan

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

(57) **ABSTRACT**

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

18 Claims, 8 Drawing Sheets





US011101548B2

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

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

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

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

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

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

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
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(21) Appl. No.: **16/550,581**

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Aug. 31, 2018 (CN) 201811012451.1

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 1/22 (2006.01)

H04B 1/3827 (2015.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/2266**
(2013.01); **H04B 1/3833** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/244
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Seokjin Kim

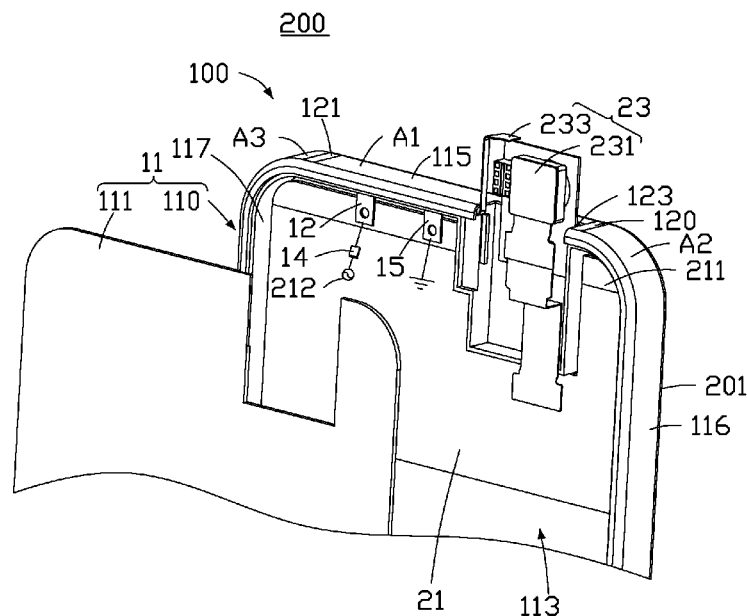
(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57)

ABSTRACT

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

20 Claims, 16 Drawing Sheets





US011101549B2

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

(10) **Patent No.:** **US 11,101,549 B2**

(45) **Date of Patent:** **Aug. 24, 2021**

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

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

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

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

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

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

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

(86) PCT No.: **PCT/KR2019/000842**

§ 371 (c)(1),

(2) Date: **Jul. 9, 2020**

(87) PCT Pub. No.: **WO2019/143211**

PCT Pub. Date: **Jul. 25, 2019**

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(30) **Foreign Application Priority Data**

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

(51) **Int. Cl.**

H01Q 1/52 (2006.01)

H01Q 21/00 (2006.01)

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

CPC **H01Q 1/246** (2013.01); **H01Q 1/42**
(2013.01); **H01Q 1/523** (2013.01); **H01Q**
21/0025 (2013.01); **H01Q 21/061** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/246; H01Q 1/52; H01Q 1/521;
H01Q 1/523; H01Q 21/0006;

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(56) **References Cited**

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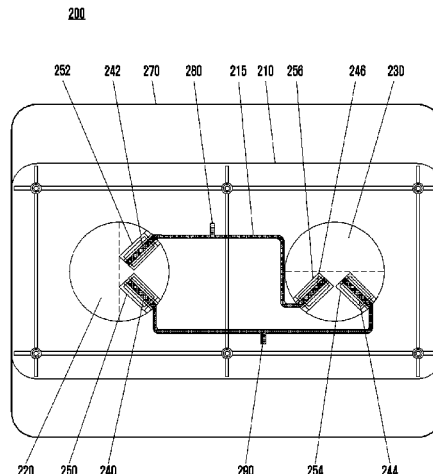
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Primary Examiner — Jason Crawford

(57) **ABSTRACT**

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

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US011101550B2

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

(10) **Patent No.:** **US 11,101,550 B2**

(45) **Date of Patent:** **Aug. 24, 2021**

(54) **BASE STATION ANTENNA**

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

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

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

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

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

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 15/14 (2006.01)
H01Q 21/00 (2006.01)
H01Q 21/26 (2006.01)
H01Q 19/10 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/246** (2013.01); **H01Q 15/14** (2013.01); **H01Q 19/10** (2013.01); **H01Q 21/00** (2013.01); **H01Q 21/26** (2013.01)

(58) **Field of Classification Search**

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

See application file for complete search history.

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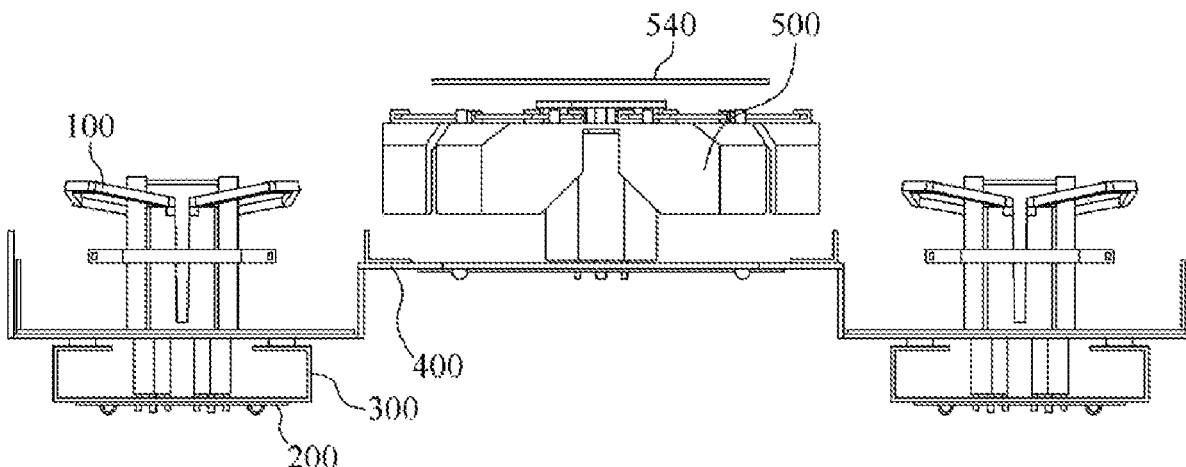
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Primary Examiner — Ricardo I Magallanes

(57) **ABSTRACT**

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

15 Claims, 10 Drawing Sheets





US011101556B2

(12) **United States Patent**
Shimura

(10) **Patent No.:** **US 11,101,556 B2**

(45) **Date of Patent:** **Aug. 24, 2021**

(54) **ANTENNA**

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

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

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

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
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(21) Appl. No.: **16/231,348**

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Dec. 28, 2017 (JP) JP2017-253435

(51) **Int. Cl.**

H01Q 1/36 (2006.01)

H01Q 1/38 (2006.01)

H01Q 9/42 (2006.01)

H01Q 21/06 (2006.01)

H01Q 1/22 (2006.01)

H01Q 5/378 (2015.01)

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

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

(58) **Field of Classification Search**

CPC H01Q 1/362; H01Q 1/38; H01Q 1/2291;

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

See application file for complete search history.

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Primary Examiner — Robert Karacsony

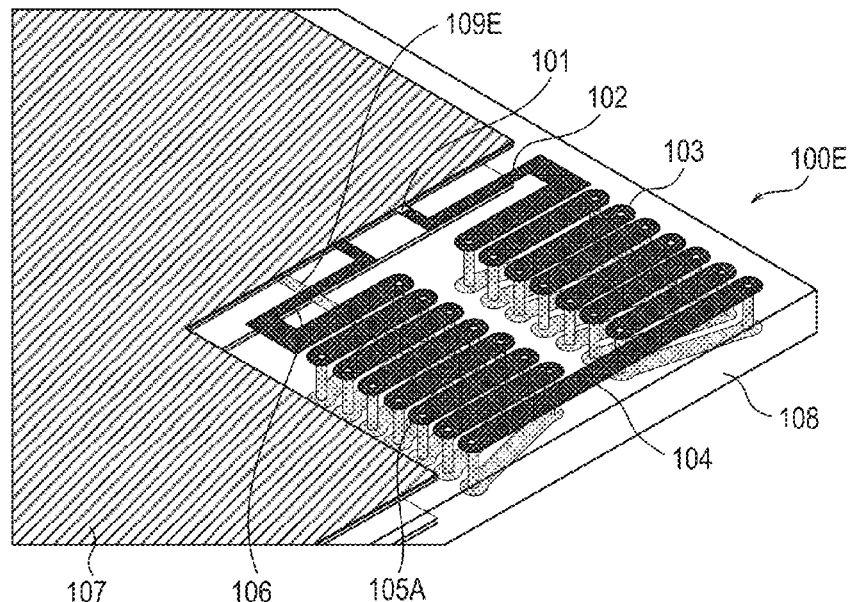
(74) Attorney, Agent, or Firm — Venable LLP

(57)

ABSTRACT

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

15 Claims, 17 Drawing Sheets



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

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

(54) **ANTENNA STRUCTURE**

(56) **References Cited**

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

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(73) Assignee: **WISTRON NEWEB CORPORATION**, Hsinchu Science Park (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 0 days.

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Primary Examiner — Jason Crawford

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

(21) Appl. No.: **16/853,794**

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(30) **Foreign Application Priority Data**

Jul. 12, 2019 (TW) 108124731

(51) **Int. Cl.**
H01Q 5/30 (2015.01)

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

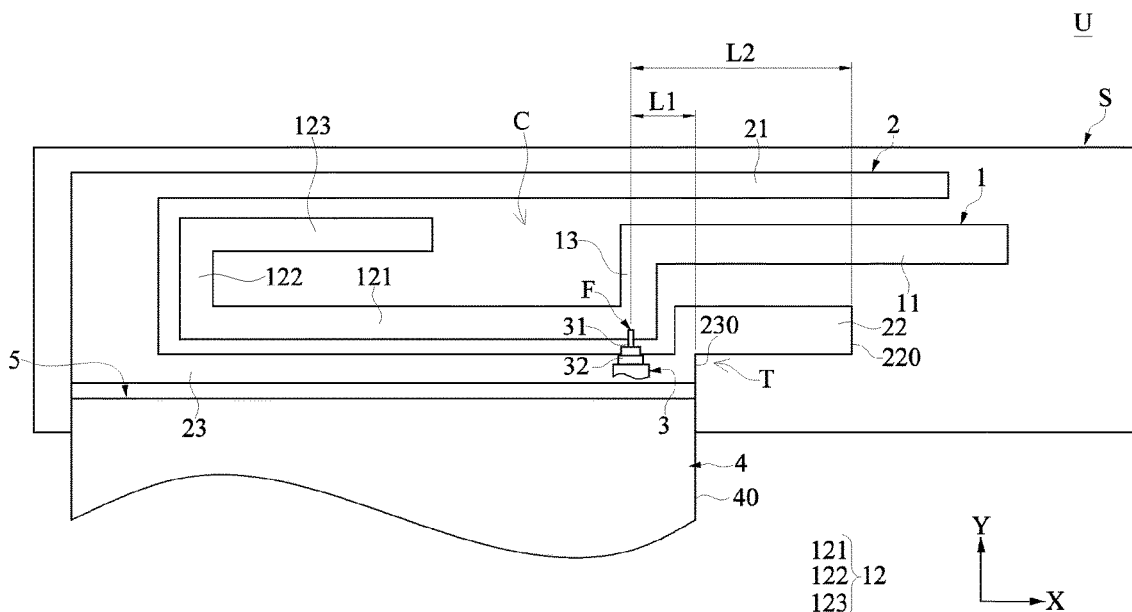
(58) **Field of Classification Search**
CPC H01Q 5/30; H01Q 5/328; H01Q 5/335;
H01Q 5/371; H01Q 5/378; H01Q 5/385;
H01Q 5/392; H01Q 5/50; H01Q
1/241–243

See application file for complete search history.

(57) **ABSTRACT**

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

14 Claims, 7 Drawing Sheets





US011101561B2

(12) **United States Patent**
Izawa

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

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

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

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

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

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

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

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

(65) **Prior Publication Data**

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Related U.S. Application Data

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

(30) **Foreign Application Priority Data**

Sep. 8, 2017 (JP) JP2017-173244

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

(Continued)

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

(58) **Field of Classification Search**
CPC H01Q 21/30; H01Q 5/371; H01Q 9/44; H01Q 9/16; H01Q 9/065; H01Q 1/36; H01Q 5/321; H01Q 5/335

See application file for complete search history.

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Primary Examiner — Graham P Smith

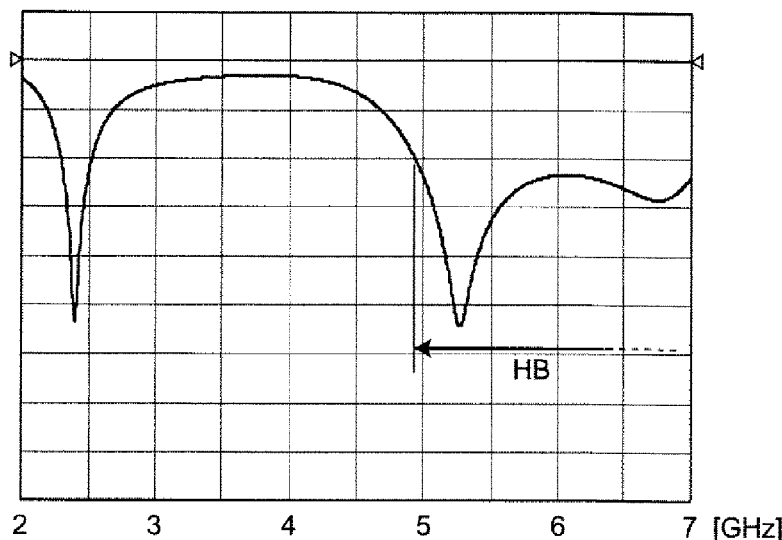
Assistant Examiner — Jae K Kim

(74) *Attorney, Agent, or Firm* — Pearne & Gordon LLP

(57) **ABSTRACT**

A dual band compatible antenna device includes a first branch electrode having a first electrode portion connected to a common electrode with a first adjustment element interposed between the first electrode portion and the common electrode and a second branch electrode having a second electrode portion connected to the common electrode with a second adjustment element interposed between the second electrode portion and the common electrode. The first electrode portion and the second electrode portion are provided on a line to have a length equal to or longer than $\frac{2}{3}$ of an electrical length of the first branch electrode and the second branch electrode.

10 Claims, 7 Drawing Sheets





US011101562B2

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

(10) **Patent No.:** **US 11,101,562 B2**

(45) **Date of Patent:** **Aug. 24, 2021**

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

(58) **Field of Classification Search**

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

See application file for complete search history.

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

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Primary Examiner — Thai Pham

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

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

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

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

(65) **Prior Publication Data**

US 2019/0386393 A1 Dec. 19, 2019

Related U.S. Application Data

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

(51) **Int. Cl.**

H01Q 21/06 (2006.01)

H01Q 21/24 (2006.01)

H01Q 5/28 (2015.01)

H01Q 5/42 (2015.01)

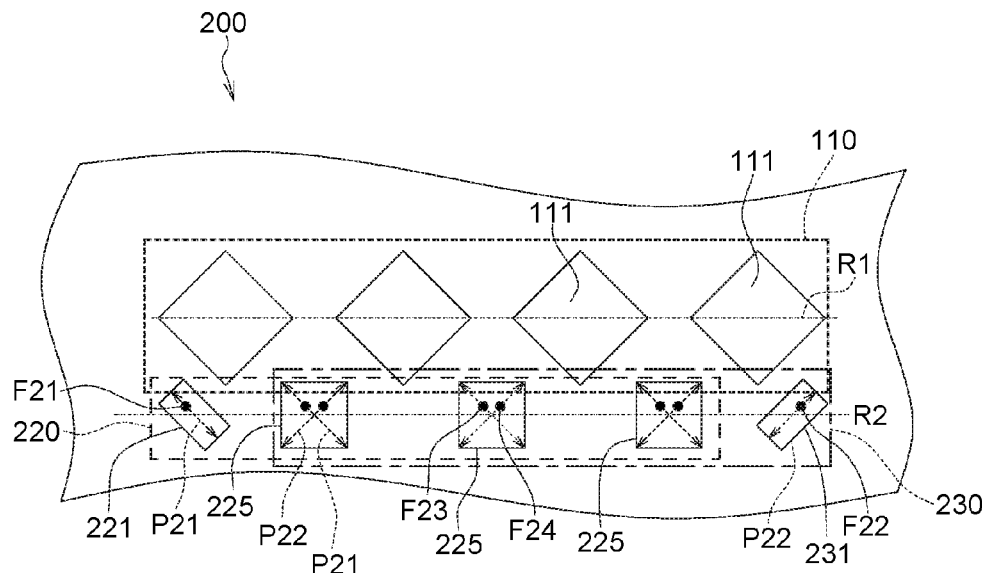
(52) **U.S. Cl.**

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

(57) **ABSTRACT**

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

13 Claims, 5 Drawing Sheets





(12) **United States Patent**
Oh

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

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

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

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

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(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 8 days.

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(Continued)

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

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

Primary Examiner — Joseph J Lauture

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

(65) **Prior Publication Data**

US 2020/0411989 A1 Dec. 31, 2020

(57) **ABSTRACT**

(30) **Foreign Application Priority Data**

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

(51) **Int. Cl.**

H01Q 7/00 (2006.01)

H01Q 1/24 (2006.01)

(Continued)

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

CPC **H01Q 7/00** (2013.01); **H01Q 1/24** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/243** (2013.01); **H02J 50/12** (2016.02); **H02J 50/90** (2016.02)

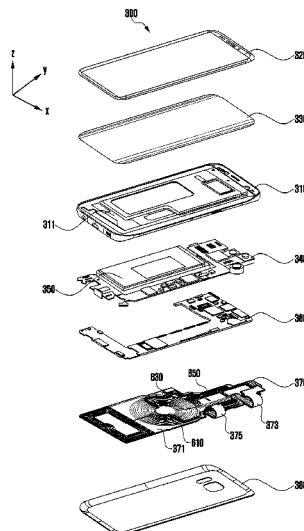
(58) **Field of Classification Search**

CPC .. H01Q 7/00; H01Q 1/24; H01Q 1/38; H01Q 1/243; H02J 50/90; H02J 50/12

See application file for complete search history.

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

20 Claims, 15 Drawing Sheets





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

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

(54) **ANTENNA STRUCTURE**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

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

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(73) Assignee: **QUANTA COMPUTER INC.**,
Taoyuan (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 37 days.

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

Primary Examiner — Hasan Islam

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

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

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

(65) **Prior Publication Data**

US 2021/0167521 A1 Jun. 3, 2021

(30) **Foreign Application Priority Data**

Nov. 28, 2019 (TW) 108143306

(51) **Int. Cl.**

H01Q 21/30 (2006.01)

H01Q 1/24 (2006.01)

(Continued)

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

CPC **H01Q 21/30** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48**
(2013.01)

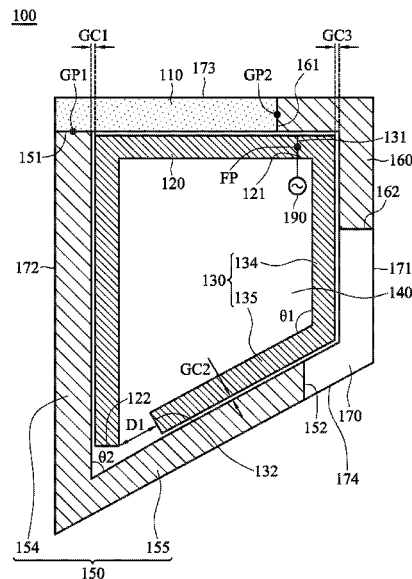
(58) **Field of Classification Search**

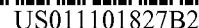
CPC .. H01Q 1/243; H01Q 21/30; H01Q 1/38–1/48
See application file for complete search history.

(57) **ABSTRACT**

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

9 Claims, 2 Drawing Sheets

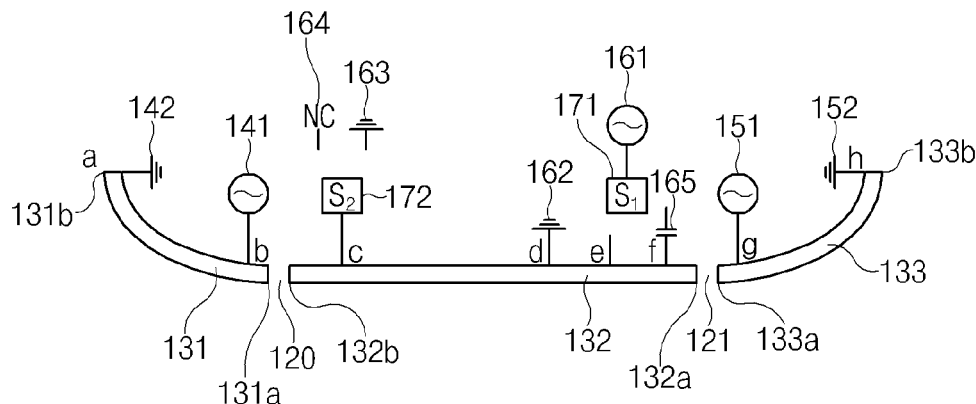




(45) **Date of Patent:** **Aug. 24, 2021**

- (Continued)

100





US011108129B2

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

(10) **Patent No.:** **US 11,108,129 B2**

(45) **Date of Patent:** **Aug. 31, 2021**

(54) **ANTENNA ASSEMBLY**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

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

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

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

FOREIGN PATENT DOCUMENTS

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

CN 203966214 6/2014

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

* cited by examiner

(65) **Prior Publication Data**

US 2019/0379104 A1 Dec. 12, 2019

Primary Examiner — Andrea Lindgren Baltzell

Assistant Examiner — Amal Patel

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

(51) **Int. Cl.**

H01Q 1/12 (2006.01)

H01Q 13/10 (2006.01)

H01Q 9/04 (2006.01)

H01Q 1/44 (2006.01)

(57) **ABSTRACT**

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

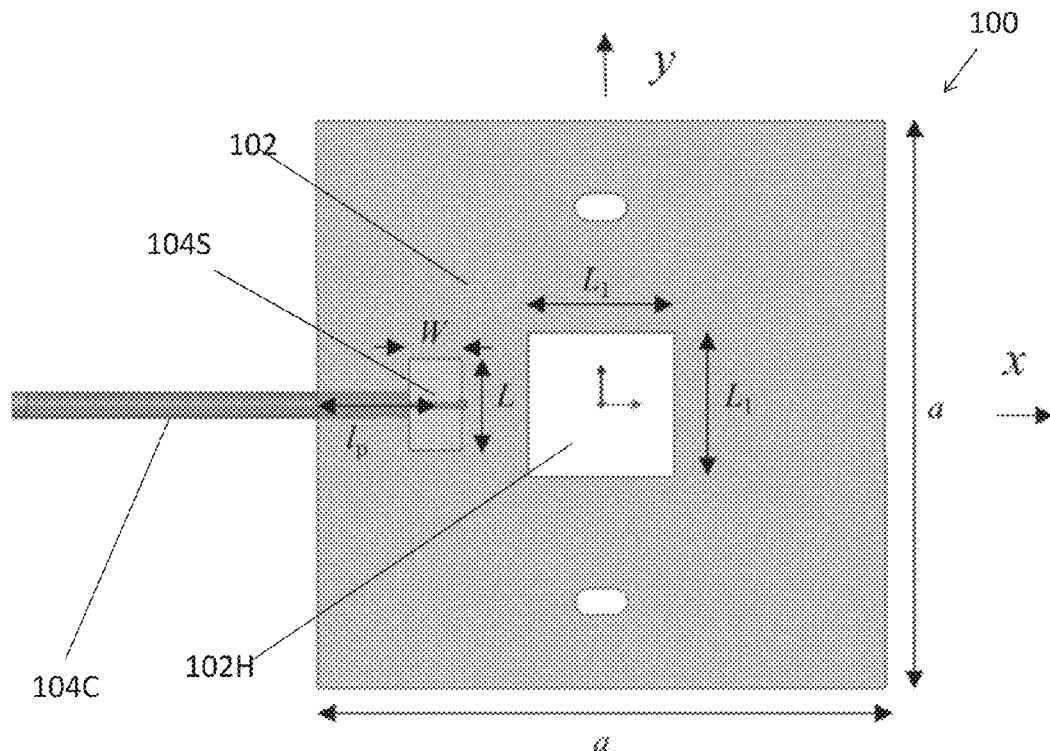
CPC **H01Q 1/1221** (2013.01); **H01Q 9/0485**
(2013.01); **H01Q 13/10** (2013.01); **H01Q 1/44**
(2013.01)

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

(58) **Field of Classification Search**

CPC H01Q 1/1221; H01Q 9/0485; H01Q 1/46
See application file for complete search history.

22 Claims, 11 Drawing Sheets



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

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

(54) **ELECTRONIC DEVICE SLOT ANTENNAS**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

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

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 11 days.

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WO 2019070253 A1 4/2019

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

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

Primary Examiner — Daniel D Chang

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

(51) **Int. Cl.**

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

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

CPC **H01Q 1/2266** (2013.01); **F16M 11/10**
(2013.01); **H01Q 13/10** (2013.01); **H05K**
1/0243 (2013.01); **H05K 1/189** (2013.01)

(58) **Field of Classification Search**

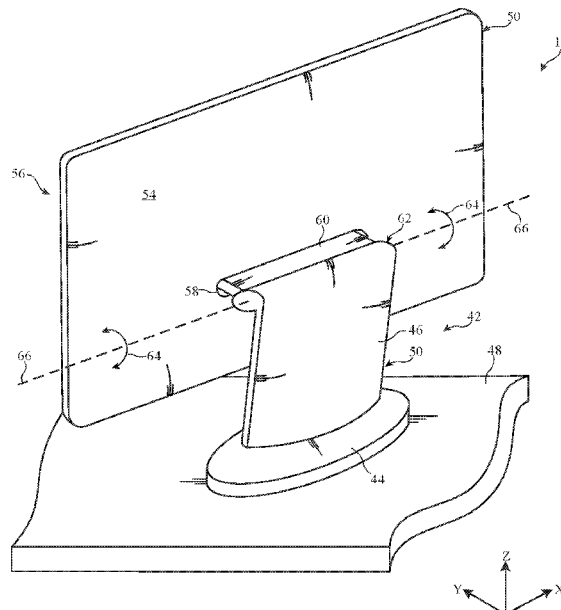
CPC H01Q 1/2266; H01Q 13/10; H05K 1/189;
H05K 1/0243; F16M 11/10; F16M
2200/00; F16M 2200/065; F16M
2200/08; F16L 3/1016

See application file for complete search history.

(57) **ABSTRACT**

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

20 Claims, 9 Drawing Sheets





US011108132B2

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

(10) **Patent No.:** **US 11,108,132 B2**

(45) **Date of Patent:** **Aug. 31, 2021**

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

(56) **References Cited**

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Patent Application No. 201810604313.6 (46 Pages).

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Primary Examiner — Daniel Munoz

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

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

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

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

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 189 days.

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

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

(65) **Prior Publication Data**

US 2019/0386377 A1 Dec. 19, 2019

(30) **Foreign Application Priority Data**

Jun. 13, 2018 (CN) 201810604313.6

(51) **Int. Cl.**

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

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

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

(58) **Field of Classification Search**

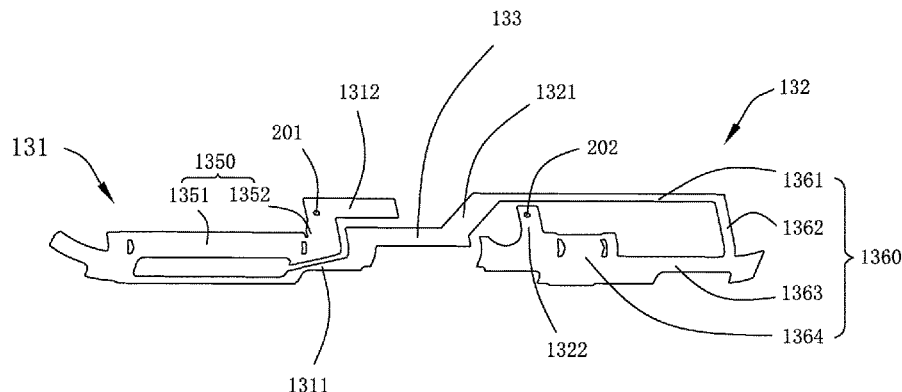
CPC H01Q 1/243; H01Q 5/364; H01Q 5/371
See application file for complete search history.

(57) **ABSTRACT**

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

6 Claims, 4 Drawing Sheets

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

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

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

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

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

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

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 127 days.

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

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

(65) **Prior Publication Data**

US 2020/0203806 A1 Jun. 25, 2020

(30) **Foreign Application Priority Data**

Dec. 24, 2018 (CN) 201811581133.7

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

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

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

(56) **References Cited**

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Primary Examiner — Dimary S Lopez Cruz

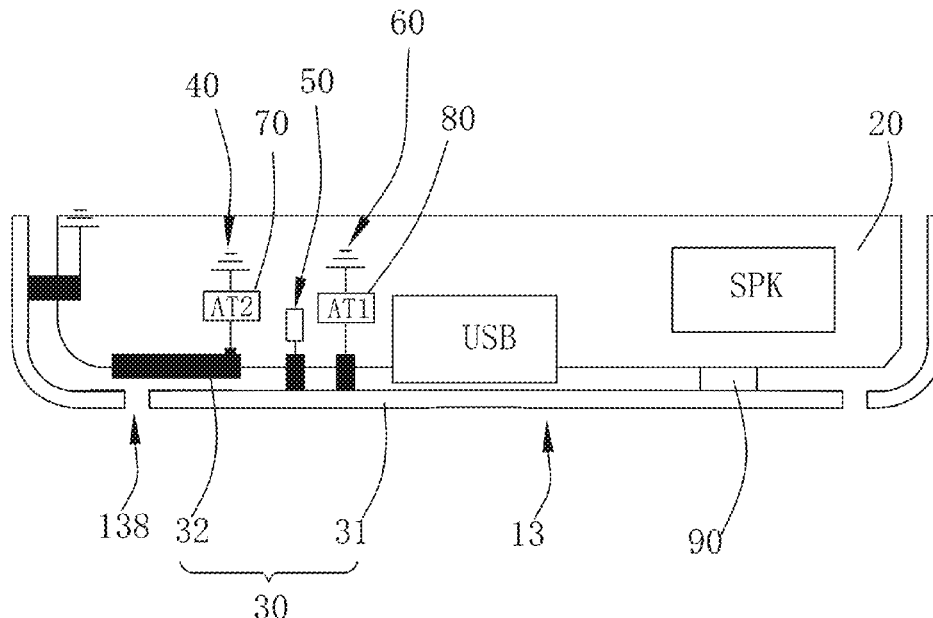
Assistant Examiner — Bamidele A Jegede

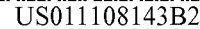
(74) *Attorney, Agent, or Firm* — W&G Law Group LLP

(57) **ABSTRACT**

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

16 Claims, 8 Drawing Sheets





(45) **Date of Patent:** Aug. 31, 2021

The schematic diagram illustrates a microelectronic device 100. The main cross-sectional view shows a substrate 104 with a dielectric layer 102. A central vertical stack includes a base contact pad 120, a conductive stem 122, and a top conductive cap 108. This cap is flanked by two insulating spacers 106. The total height of the device from the substrate to the top of the spacers is labeled H_D . The height of the central conductive portion above the base contact pad is labeled H_F . The width of the central conductive stem at its base is labeled d . An arrow w_1 points to the side surface of the central conductive stem. To the right, another conductive element 110 is shown, partially buried in the dielectric layer 102. It has a base contact pad 112 and a top conductive cap 104A. The distance between the central device and this second device is indicated by ϵ_r . A coordinate system is shown with the z -axis pointing upwards and the y -axis pointing to the right.

An inset provides a top-down view of the tapered conductive layer 110. It shows a trapezoidal shape with a bottom width w_S , a top width w_{ST} , and a height L_S .

(12) **United States Patent**
Chuang

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

(54) **ANTENNA STRUCTURE**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

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

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343/700 MS
2009/0079639 A1 * 3/2009 Hotta H01Q 1/243
343/702
2009/0135071 A1 * 5/2009 Huang H01Q 9/0421
343/700 MS

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

(Continued)

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

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

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

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

OTHER PUBLICATIONS

(65) **Prior Publication Data**

US 2021/0126355 A1 Apr. 29, 2021

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

Primary Examiner — Jason Crawford

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

(30) **Foreign Application Priority Data**

Oct. 23, 2019 (TW) 108138171

(57) **ABSTRACT**

(51) **Int. Cl.**

H01Q 19/24 (2006.01)

H01Q 1/24 (2006.01)

H01Q 1/38 (2006.01)

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

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

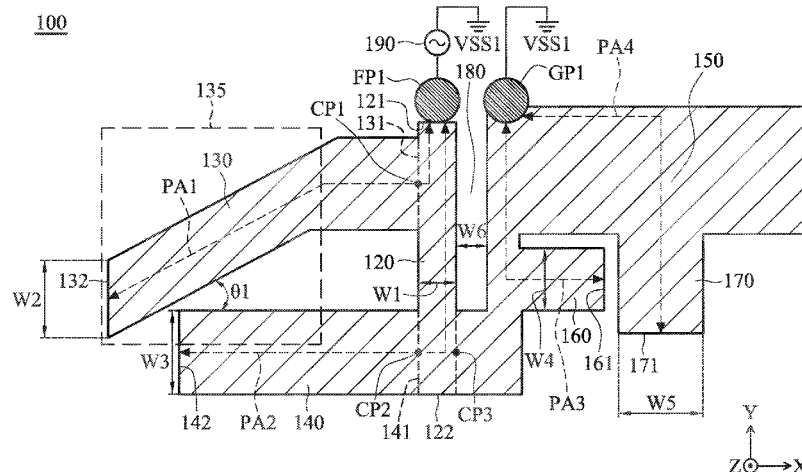
CPC **H01Q 1/38** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/245** (2013.01); **H01Q 19/24** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/36; H01Q 1/38; H01Q 1/243; H01Q 19/22; H01Q 19/24; H01Q 5/30; H01Q 5/307; H01Q 5/357; H01Q 5/364; H01Q 5/371

See application file for complete search history.

16 Claims, 5 Drawing Sheets





US011108164B2

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

(10) **Patent No.:** **US 11,108,164 B2**

(45) **Date of Patent:** **Aug. 31, 2021**

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

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

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

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

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

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

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

(65) **Prior Publication Data**

US 2020/0052416 A1 Feb. 13, 2020

(30) **Foreign Application Priority Data**

Aug. 12, 2018 (CN) 201810910596.7

(51) **Int. Cl.**

H01Q 21/06 (2006.01)

H01Q 1/22 (2006.01)

H01Q 1/24 (2006.01)

H01Q 23/00 (2006.01)

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

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

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/2283; H01Q 9/0407;
H01Q 9/0457; H01Q 21/065; H01Q
21/08; H01Q 23/00; H01Q 9/0435; H01Q
21/06; H01Q 1/38; H01Q 1/50
See application file for complete search history.

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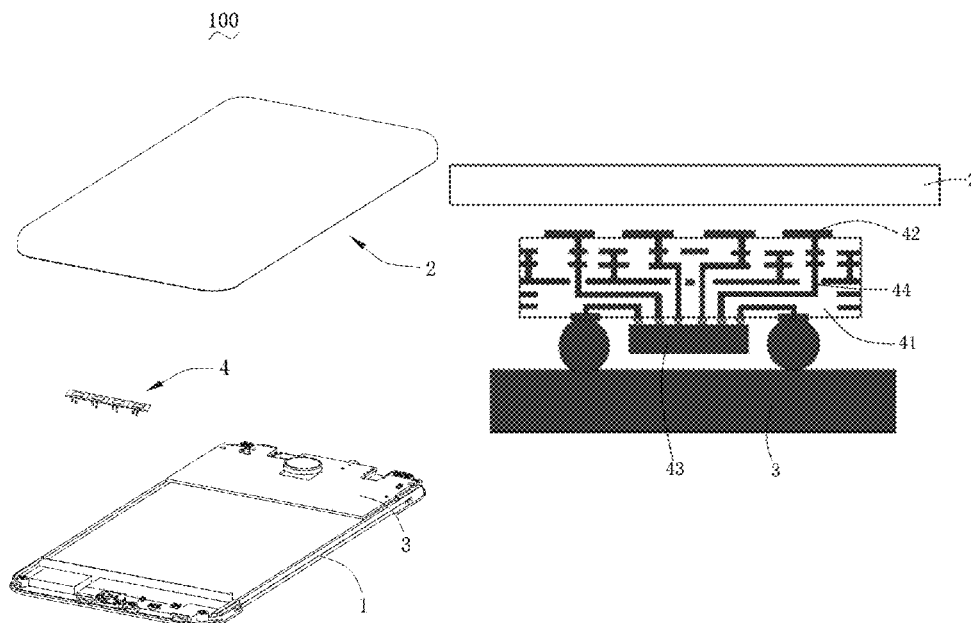
Primary Examiner — Haissa Philogene

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

(57) **ABSTRACT**

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

9 Claims, 9 Drawing Sheets





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

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

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

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

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

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

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

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

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

(65) **Prior Publication Data**
US 2020/0119429 A1 Apr. 16, 2020

(30) **Foreign Application Priority Data**
Oct. 16, 2018 (KR) 10-2018-0122922

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

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

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

(56) **References Cited**

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tional Application No. PCT/KR2019/013163.

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Primary Examiner — AB Salam Alkassim, Jr.

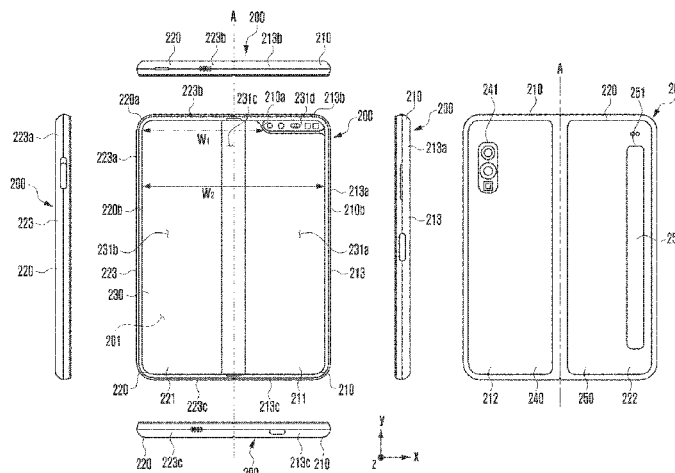
Assistant Examiner — David E Lotter

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

(57) **ABSTRACT**

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

8 Claims, 17 Drawing Sheets





US011114747B2

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

(10) **Patent No.:** **US 11,114,747 B2**

(45) **Date of Patent:** **Sep. 7, 2021**

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

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

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

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

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

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

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

(65) **Prior Publication Data**

US 2019/0386380 A1 Dec. 19, 2019

(30) **Foreign Application Priority Data**

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

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

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

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/38; H01Q 1/40;
H01Q 1/2283; H01Q 5/42; H01Q 9/065;
(Continued)

(56) **References Cited**

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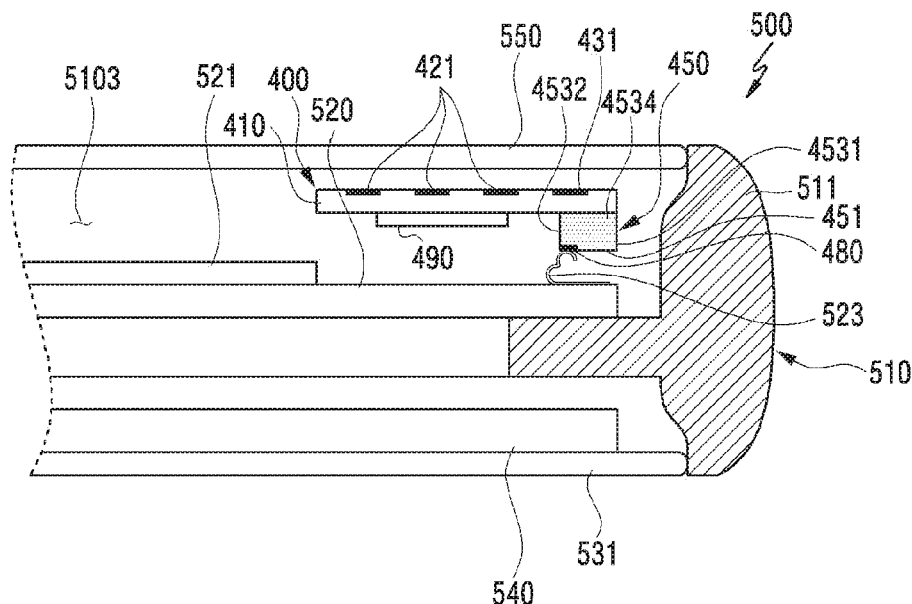
Primary Examiner — Robert Karacsony

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

(57) **ABSTRACT**

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

(Continued)



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

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

(54) **ANTENNA SYSTEM**

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

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

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

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

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

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

(65) **Prior Publication Data**

US 2021/0184345 A1 Jun. 17, 2021

(30) **Foreign Application Priority Data**

Dec. 13, 2019 (TW) 108145692

(51) **Int. Cl.**

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

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

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

(58) **Field of Classification Search**

CPC H01G 1/243; H01G 9/0421; H01G 13/106
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Graham P Smith

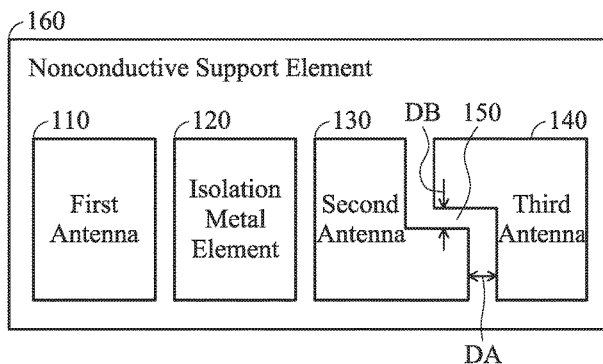
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

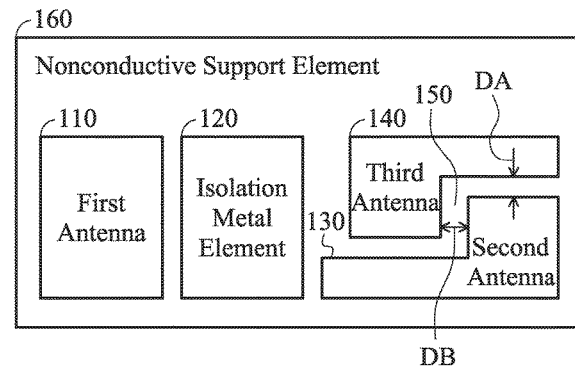
An antenna system includes a first antenna, a second antenna, a third antenna, an isolation metal element, and a nonconductive support element. The isolation metal element is disposed between the first antenna and the second antenna. The third antenna defines a notch region. The second antenna at least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

20 Claims, 9 Drawing Sheets

100



100





US011114766B1

(12) **United States Patent**
Hyman

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

(54) **TAPERED SLOT ANTENNA**

2017/0207546 A1 7/2017 Benzel et al.
2017/0256860 A1 9/2017 Liao
2018/0145420 A1 5/2018 Kushta

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

FOREIGN PATENT DOCUMENTS

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

GB 2508428 A 6/2014

(73) Assignee: **IXI Technology Holdings, Inc.**, Yorba Linda, CA (US)

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

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

(21) Appl. No.: **16/810,778**

* cited by examiner

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

Primary Examiner — Hasan Islam

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

(74) Attorney, Agent, or Firm — The Watson IP Group, PLC; Jovan N. Jovanovic

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

(57) **ABSTRACT**

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

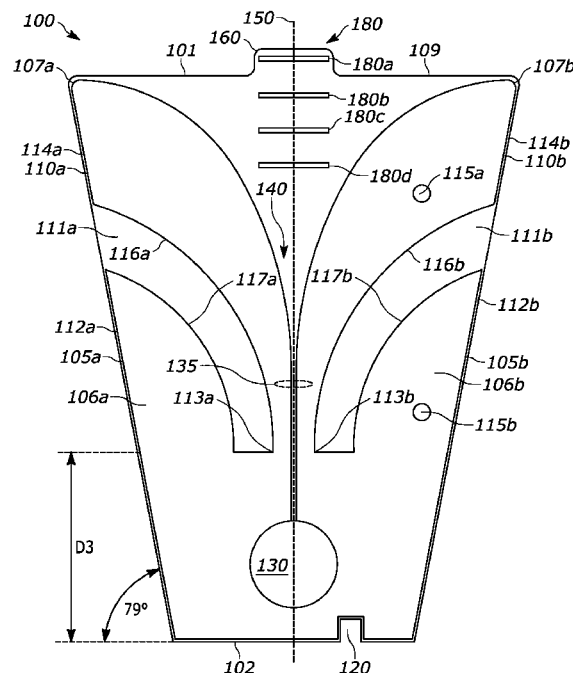
A tapered slot antenna includes a cavity, first and second antenna flanges, a tapered slot, and first and second current wings. The first and second antenna flanges can be disposed on a first half and a second half of the tapered slot antenna, respectively. The second antenna flange can be electrically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

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343/700 MS

16 Claims, 5 Drawing Sheets





US011114772B2

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

(10) **Patent No.:** **US 11,114,772 B2**

(45) **Date of Patent:** **Sep. 7, 2021**

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

(58) **Field of Classification Search**

CPC H01Q 25/005; H01Q 25/001; H01Q 21/26;
H01Q 9/16; H01Q 25/00

(Continued)

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

(56) **References Cited**

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

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

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

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

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

(65) **Prior Publication Data**

US 2019/0379141 A1 Dec. 12, 2019

Related U.S. Application Data

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

(30) **Foreign Application Priority Data**

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

(51) **Int. Cl.**

H01Q 21/26 (2006.01)

H01Q 25/00 (2006.01)

H01Q 9/16 (2006.01)

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

CPC **H01Q 25/005** (2013.01); **H01Q 9/16**
(2013.01); **H01Q 21/26** (2013.01); **H01Q**
25/00 (2013.01); **H01Q 25/001** (2013.01)

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24, 2018, and its English translation.

Primary Examiner — Hai V Tran

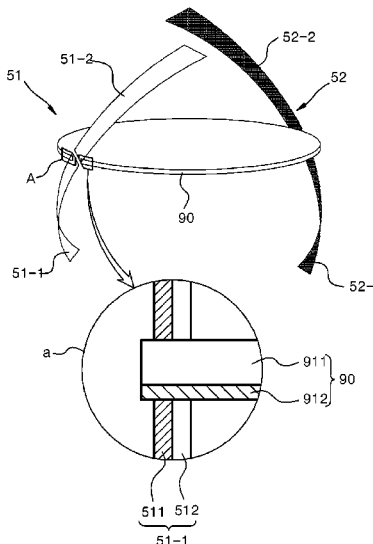
(74) *Attorney, Agent, or Firm* — Seung Ho Lee

(57)

ABSTRACT

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

11 Claims, 18 Drawing Sheets





US011115082B2

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

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

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

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

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

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

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

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

(56) **References Cited**

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

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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 242 days.

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(Continued)

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

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

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application No. 17824388.7-1202, 4 pages.

(86) PCT No.: **PCT/KR2017/003330**

(Continued)

§ 371 (c)(1),

(2) Date: **Jan. 7, 2019**

Primary Examiner — Jared Fureman
Assistant Examiner — Aqeel H Bukhari

(87) PCT Pub. No.: **WO2018/008832**

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

PCT Pub. Date: **Jan. 11, 2018**

(65) **Prior Publication Data**

US 2019/0229771 A1 Jul. 25, 2019

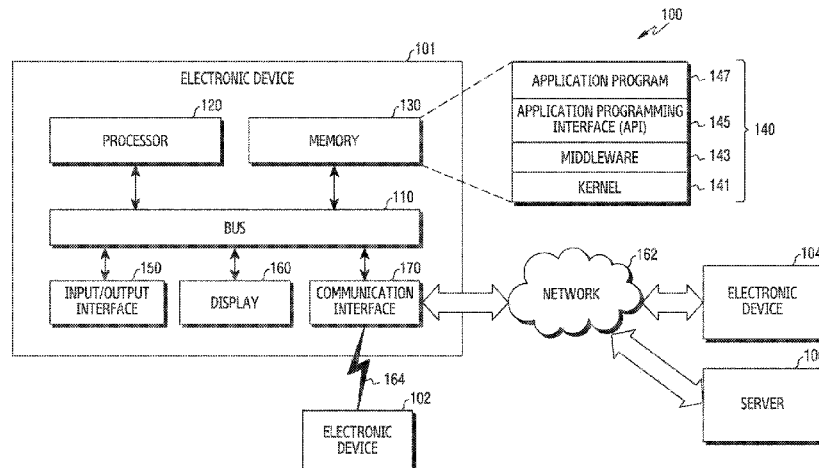
(57) **ABSTRACT**

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

(Continued)

(30) **Foreign Application Priority Data**

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





US011115508B1

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

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

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

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

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

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

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

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

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

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

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

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

(56) **References Cited**

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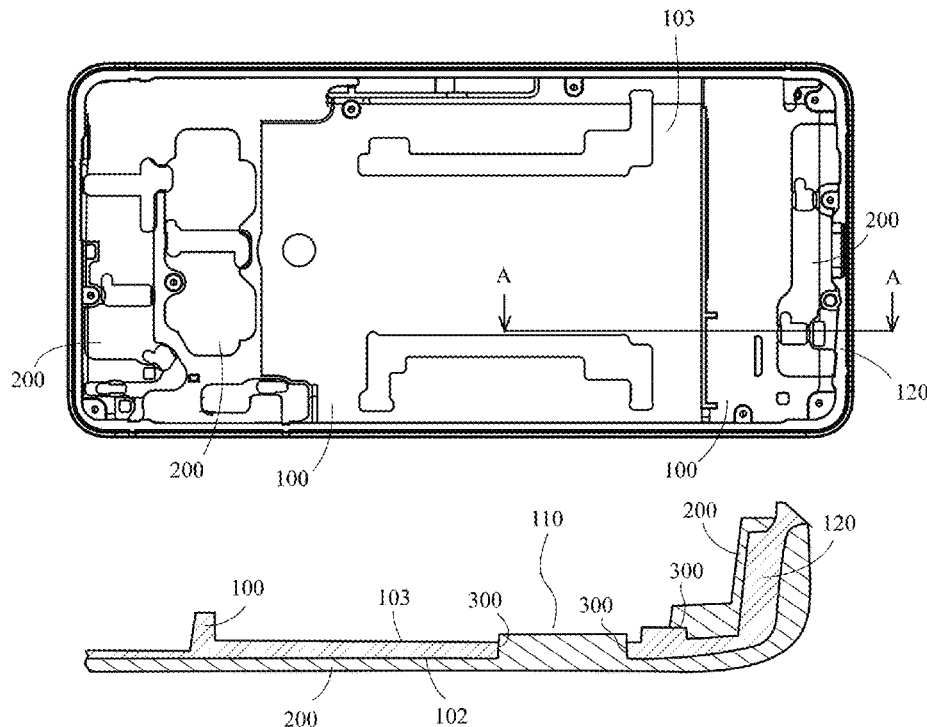
Primary Examiner — Kenneth T Lam

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

(57) **ABSTRACT**

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

8 Claims, 7 Drawing Sheets





US011115509B2

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

(10) **Patent No.:** **US 11,115,509 B2**

(45) **Date of Patent:** ***Sep. 7, 2021**

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

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

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

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

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

This patent is subject to a terminal dis-
claimer.

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

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

(65) **Prior Publication Data**

US 2021/0037123 A1 Feb. 4, 2021

Related U.S. Application Data

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

(30) **Foreign Application Priority Data**

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

(51) **Int. Cl.**

H04B 1/38 (2015.01)

H04M 1/02 (2006.01)

(Continued)

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

CPC **H04M 1/0218** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 5/385** (2015.01);
(Continued)

(58) **Field of Classification Search**

CPC H04M 1/0214; H04M 1/0216; H04M
1/0222; H04M 1/0274; H01Q 5/385;
H01Q 1/243

See application file for complete search history.

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Primary Examiner — Tuan Pham

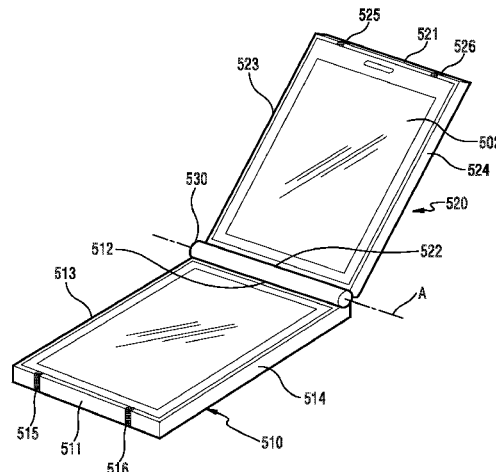
(74) *Attorney, Agent, or Firm* — The Farrell Law Firm,
P.C.

(57)

ABSTRACT

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

(Continued)





US011115511B1

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

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

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

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

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

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

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

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

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

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

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

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

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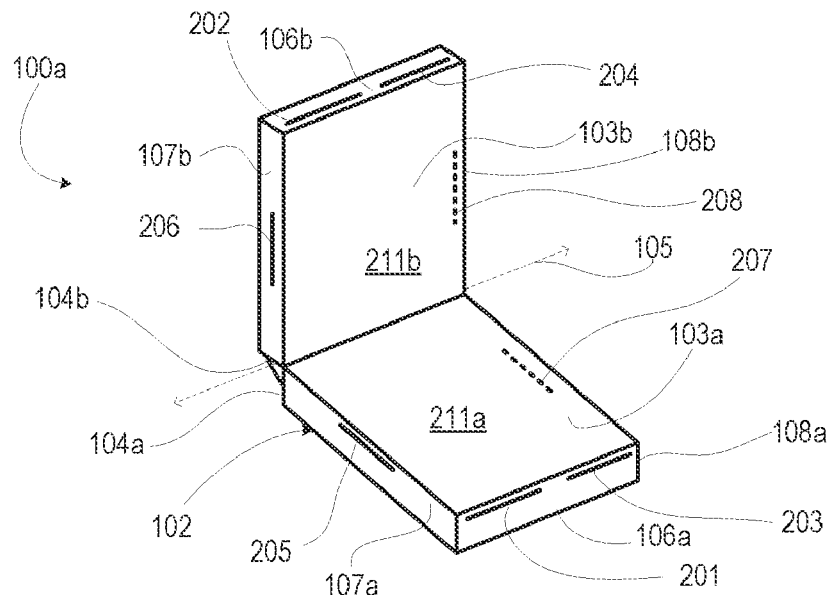
Primary Examiner — Hsinchun Liao

(74) *Attorney, Agent, or Firm* — Isidore PLLC

(57) **ABSTRACT**

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

20 Claims, 17 Drawing Sheets





US011121449B2

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

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

(54) **ELECTRONIC DEVICE**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

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

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(73) Assignee: **ACER INCORPORATED**, 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 47 days.

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

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(65) **Prior Publication Data**

US 2021/0075085 A1 Mar. 11, 2021

Primary Examiner — Graham P Smith

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

(30) **Foreign Application Priority Data**

Sep. 10, 2019 (TW) 108132544

(57) **ABSTRACT**

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

(51) **Int. Cl.**

H01Q 1/22 (2006.01)

H01Q 5/307 (2015.01)

H01Q 21/28 (2006.01)

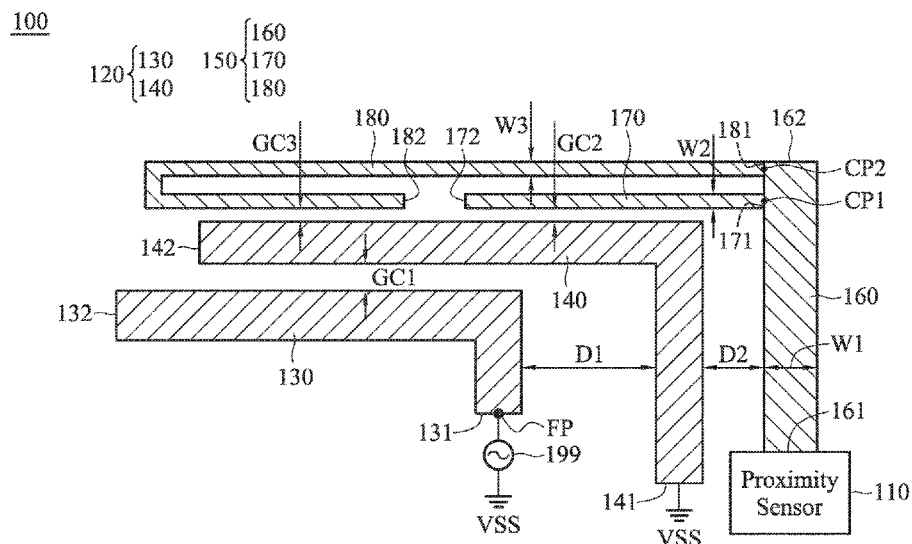
(52) **U.S. Cl.**

CPC **H01Q 1/22** (2013.01); **H01Q 5/307** (2015.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**

CPC H01G 1/22; H01G 5/307; H01G 21/28
See application file for complete search history.

16 Claims, 6 Drawing Sheets





(12) **United States Patent**
Zhang

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

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

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

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

(73) Assignee: **ZTE CORPORATION**, Shenzhen (CN)

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

(21) Appl. No.: **16/645,508**

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

(86) PCT No.: **PCT/CN2018/105223**

§ 371 (c)(1),

(2) Date: **Mar. 9, 2020**

(87) PCT Pub. No.: **WO2019/052466**

PCT Pub. Date: **Mar. 21, 2019**

(65) **Prior Publication Data**

US 2020/0287274 A1 Sep. 10, 2020

(30) **Foreign Application Priority Data**

Sep. 12, 2017 (CN) 201710817200.X

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 1/44 (2006.01)

(Continued)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/44** (2013.01); **H01Q 1/50** (2013.01); **H04M 1/0214** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/44; H01Q 1/50; H01Q 5/378; H01Q 5/328; H01Q 9/42; H01Q 1/24; H01Q 3/32; H04M 1/0214
See application file for complete search history.

(56) **References Cited**

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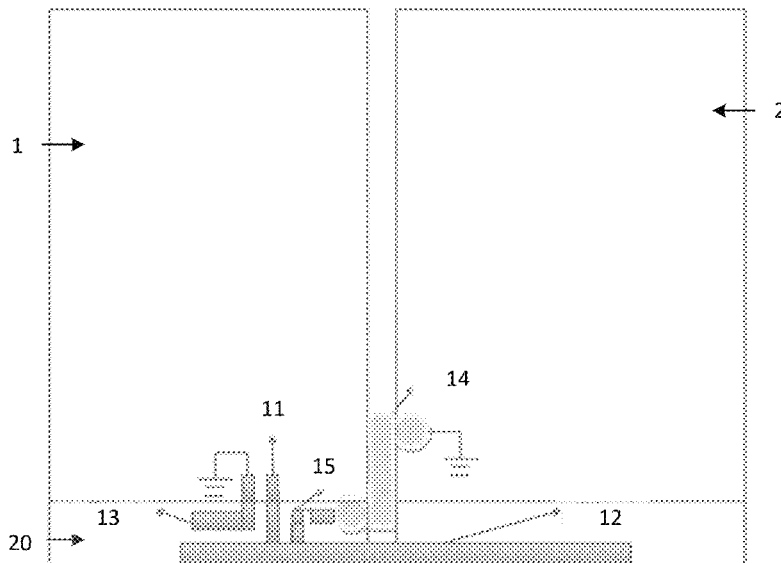
China Patent Office, First Office Action dated Oct. 10, 2020 for application No. CN201710817200.X.

Primary Examiner — Seung H Lee

(57) **ABSTRACT**

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

14 Claims, 4 Drawing Sheets





US011121458B2

(12) **United States Patent**
Lee

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

(54) **ANTENNA STRUCTURE**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

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

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343/866

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

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

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

TW 201112497 A 4/2011

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

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(65) **Prior Publication Data**

US 2020/0091595 A1 Mar. 19, 2020

Primary Examiner — Tung X Le

(30) **Foreign Application Priority Data**

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

Sep. 19, 2018 (TW) 107132949

(57) **ABSTRACT**

(51) **Int. Cl.**

H01Q 1/22 (2006.01)

H01Q 1/36 (2006.01)

H01Q 1/52 (2006.01)

H01Q 1/48 (2006.01)

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

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

CPC **H01Q 1/36** (2013.01); **H01Q 1/22** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/52** (2013.01)

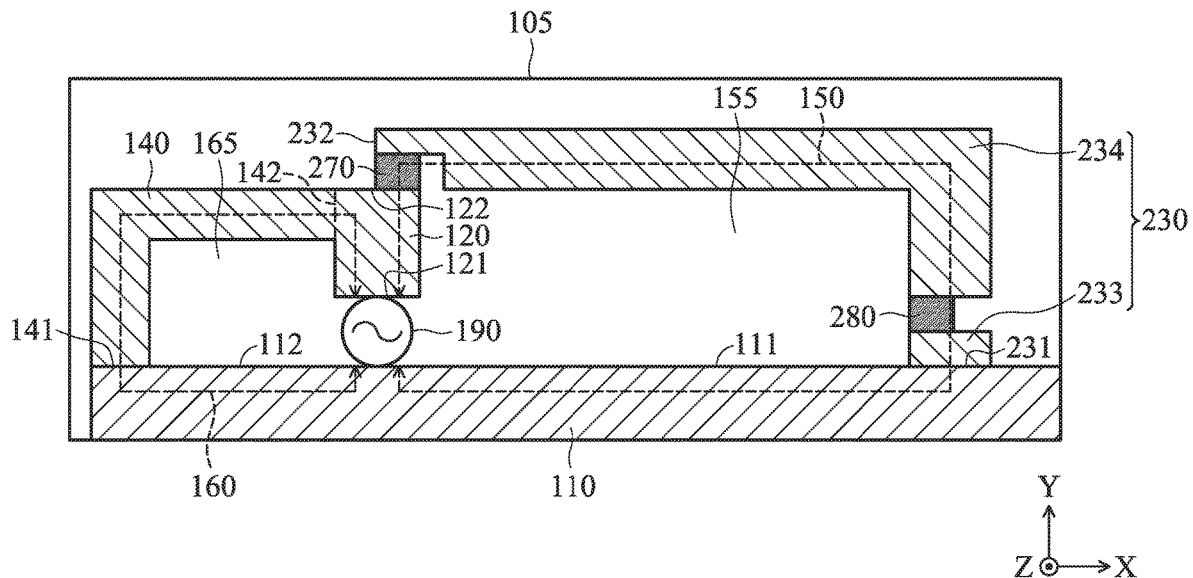
(58) **Field of Classification Search**

CPC .. H01Q 1/22; H01Q 1/36; H01Q 1/48; H01Q 1/52; H01Q 1/243; H01Q 5/33; H01Q 5/35; H01Q 5/321

See application file for complete search history.

19 Claims, 6 Drawing Sheets

200





US011121460B2

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

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

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

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

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

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

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

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

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

(65) **Prior Publication Data**

US 2020/0212560 A1 Jul. 2, 2020

(30) **Foreign Application Priority Data**

Dec. 29, 2018 (CN) 201811647572.3

(51) **Int. Cl.**

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

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

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

(58) **Field of Classification Search**

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

USPC 343/872

See application file for complete search history.

(56) **References Cited**

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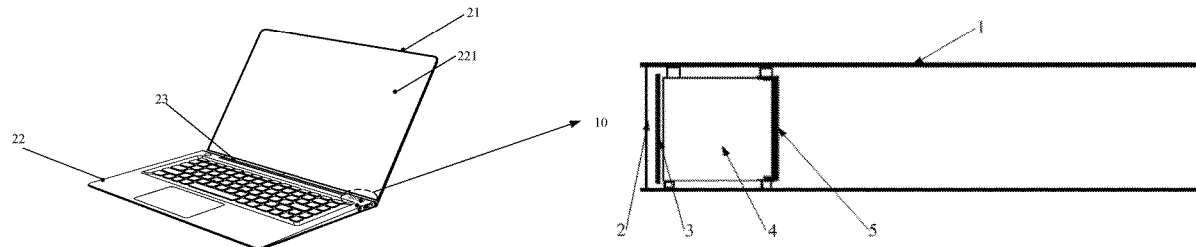
Primary Examiner — Jean B Jeanglaude

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

(57) **ABSTRACT**

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

20 Claims, 2 Drawing Sheets





US011121469B2

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

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

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

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

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

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

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

(21) Appl. No.: **16/584,067**

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

(65) **Prior Publication Data**

US 2021/0098882 A1 Apr. 1, 2021

(51) **Int. Cl.**

H01Q 21/06 (2006.01)
H01Q 9/04 (2006.01)
H01Q 21/22 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)

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

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

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 9/0414; H01Q 21/065
See application file for complete search history.

(56) **References Cited**

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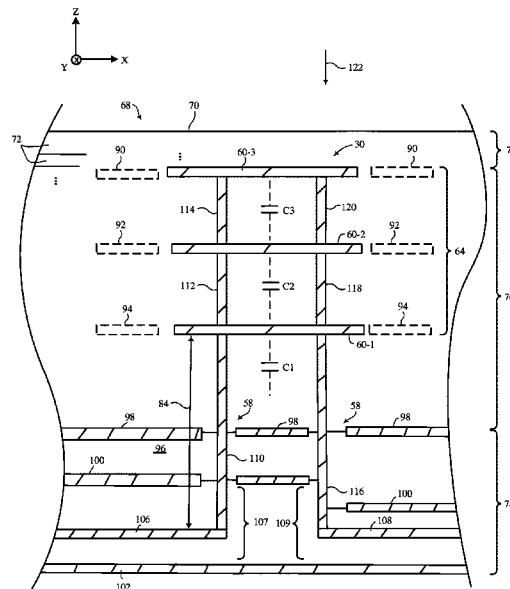
Primary Examiner — Hasan Islam

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

(57) **ABSTRACT**

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

20 Claims, 10 Drawing Sheets





US011121472B2

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

(10) **Patent No.:** **US 11,121,472 B2**
(45) **Date of Patent:** **Sep. 14, 2021**

(54) **FRONT-SHIELDED, COPLANAR
WAVEGUIDE, DIRECT-FED,
CAVITY-BACKED SLOT ANTENNA**

(56) **References Cited**

U.S. PATENT DOCUMENTS

(71) Applicant: **Motorola Mobility LLC**, Chicago, IL
(US)

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(72) Inventors: **Junsheng Zhao**, Vernon Hills, IL (US);
Eric Le Roy Krenz, Crystal Lake, IL
(US); **Hugh Smith**, Palatine, IL (US)

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

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

"Invitation to Pay Fees and Partial International Search Report",
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pages.

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(21) Appl. No.: **16/353,117**

Primary Examiner — Daniel D Chang

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

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

(65) **Prior Publication Data**

US 2020/0295465 A1 Sep. 17, 2020

(51) **Int. Cl.**
H01Q 13/18 (2006.01)
H01Q 1/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 13/18** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 1/40** (2013.01); **H01Q**
21/0037 (2013.01); **H01Q 1/2266** (2013.01)

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

(57) **ABSTRACT**

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

12 Claims, 18 Drawing Sheets

