



US011537170B2

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

(10) **Patent No.:** **US 11,537,170 B2**
(45) **Date of Patent:** **Dec. 27, 2022**

(54) **ELECTRONIC DEVICE**

(56)

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(71) Applicant: **Dynabook Inc.**, Tokyo (JP)

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(72) Inventors: **Takehiro Hori**, Tokyo (JP); **Toshiyuki Hirota**, Tokyo (JP); **Shigeki Nishiyama**, Tokyo (JP); **Kazuhiro Nakamura**, Tokyo (JP); **Tomokazu Yuasa**, Tokyo (JP); **Shingo Koide**, Tokyo (JP)

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(73) Assignee: **DYNABOOK INC.**, Tokyo (JP)

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

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(21) Appl. No.: **17/539,651**

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CN 105938383 B 8/2017

(22) Filed: **Dec. 1, 2021**

(Continued)

(65) **Prior Publication Data**

US 2022/0308636 A1 Sep. 29, 2022

Primary Examiner — Adrian S Wilson

(74) *Attorney, Agent, or Firm* — Knobbe, Martens, Olson & Bear LLP

(30) **Foreign Application Priority Data**

Mar. 26, 2021 (JP) JP2021-054407

(57)

ABSTRACT

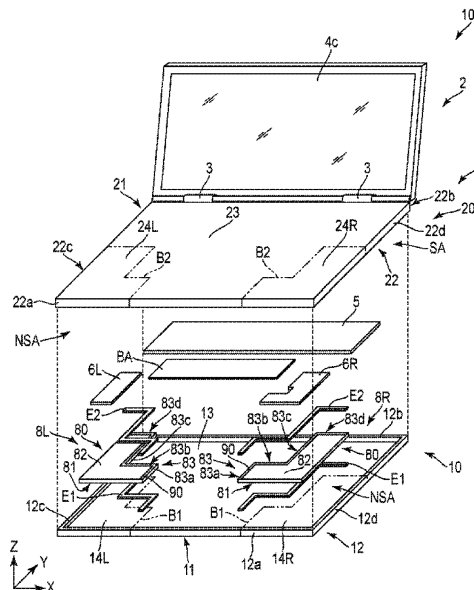
According to one embodiment, an electronic device includes a housing including a shield region, and a non-shield region formed of a dielectric, a part of the shield region is formed of a conductor, an antenna in the non-shield region, a vibration generating member including a casing formed of a dielectric, the vibration generating member being in the housing such that a surface of a part of the casing in the shield region and another part of the casing in the non-shield region, and an elastic support member which is sandwiched between the housing and the part of the casing, the elastic support member having a conductive property.

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

(52) **U.S. Cl.**
CPC **G06F 1/1658** (2013.01); **G06F 1/1688** (2013.01); **G06F 1/1698** (2013.01)

(58) **Field of Classification Search**
CPC G06F 1/1656; G06F 1/1658; G06F 1/1688; G06F 1/1698
See application file for complete search history.

8 Claims, 8 Drawing Sheets





US011539114B2

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

(10) **Patent No.:** **US 11,539,114 B2**
(45) **Date of Patent:** **Dec. 27, 2022**

(54) **ELECTRONIC DEVICE**

H01Q 1/48; H01Q 1/50; H01Q 9/0407;
H01Q 9/42; H01Q 5/371; H01Q 13/10;
H04M 1/0216; H04M 1/0268

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

See application file for complete search history.

(72) Inventors: **Cho-Kang Hsu**, New Taipei (TW);
Min-Hui Ho, New Taipei (TW)

(56) **References Cited**

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(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 84 days.

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TW 201427177 A 7/2014

(21) Appl. No.: **17/307,159**

(22) Filed: **May 4, 2021**

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(65) **Prior Publication Data**

US 2021/0359393 A1 Nov. 18, 2021

Primary Examiner — Hoang V Nguyen

(30) **Foreign Application Priority Data**

May 15, 2020 (CN) 202010414590.8

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

(57) **ABSTRACT**

An antenna for a foldable electronic device which functions equally well in both folded and unfolded states includes a rotating shaft and a housing. The overall housing is made of metallic material and includes a first housing and a second housing. The first housing connects to the second housing through the rotating shaft. The housing further defines at least one group of slots to form at least one slot antenna. The at least one slot antenna crosses the rotating shaft and extends to the first housing and/or the second housing. By setting at least one slot antenna to correspond to the rotating shaft, the foldable electronic device achieves high radiation performance whether the first and second housing are folded or unfolded.

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 13/10 (2006.01)
H04M 1/02 (2006.01)
H01Q 21/06 (2006.01)
H01Q 9/42 (2006.01)

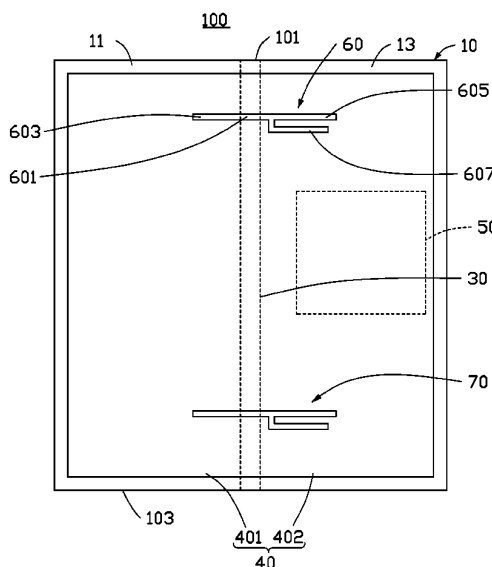
(52) **U.S. Cl.**

CPC **H01Q 1/243** (2013.01); **H01Q 9/42** (2013.01); **H01Q 13/10** (2013.01); **H01Q 21/064** (2013.01); **H04M 1/0216** (2013.01); **H04M 1/0268** (2013.01); **H04M 2250/16** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/242; H01Q 1/243; H01Q 1/36;

19 Claims, 8 Drawing Sheets





(10) **Patent No.:** US 11,539,123 B2
(45) **Date of Patent:** Dec. 27, 2022

- (58) **Field of Classification Search**
CPC H01Q 1/523; H01Q 1/521; H01Q 21/28;
H01Q 5/328; H01Q 5/385; H01Q 1/2266;
H01Q 9/42; H01Q 1/52
See application file for complete search history.

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- Primary Examiner* — Hoang V Nguyen

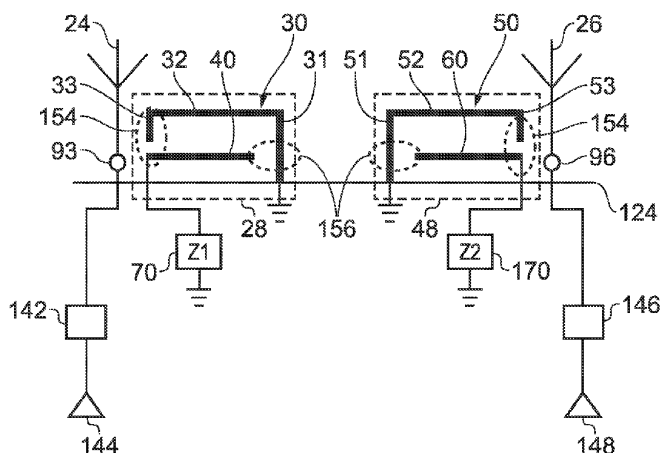
- (74) *Attorney, Agent, or Firm* — Shumaker & Sieffert, P.A.

- (57) **ABSTRACT**

- There is disclosed an antenna system comprising: i) first and second antennas, the second antenna being disposed laterally from the first along a longitudinal axis, and ii) an isolation structure disposed between the first and second antennas. The isolation structure comprises a first resonator element having a first arm with upper and lower ends, the first arm connected to ground at its lower end, and a lateral second arm connected to the upper end of the first arm. At least a portion of the first resonator element is disposed adjacent to a portion of the first antenna such that the first resonator element is strongly coupled to the first antenna.

- 29 Claims, 39 Drawing Sheets**

- (52) **U.S. Cl.**
CPC *H01Q 1/523* (2013.01); *H01Q 1/2266*
(2013.01); *H01Q 1/521* (2013.01); *H01Q*
5/328 (2015.01);





US011539133B2

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

(10) **Patent No.:** **US 11,539,133 B2**
(45) **Date of Patent:** **Dec. 27, 2022**

(54) **ANTENNA STRUCTURE**

(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 0 days.

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(21) Appl. No.: **17/367,495**

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(22) Filed: **Jul. 5, 2021**

Chinese language office action dated Sep. 29, 2021, issued in
application No. TW 110113907.

(65) **Prior Publication Data**

US 2022/0336948 A1 Oct. 20, 2022

Primary Examiner — Tho G Phan

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

(30) **Foreign Application Priority Data**

Apr. 19, 2021 (TW) 110113907

(57) **ABSTRACT**

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 5/314 (2015.01)
H01Q 9/26 (2006.01)
H01Q 5/42 (2015.01)

An antenna structure includes a first radiation element, a second radiation element, a third radiation element, a fourth radiation element, and a dielectric substrate. The first radiation element is coupled to a ground voltage. The first radiation element includes a variable-width portion. The second radiation element has a feeding point. The second radiation element is adjacent to the first radiation element. The third radiation element is coupled to the variable-width portion of the first radiation element. The fourth radiation element is coupled to the second radiation element. The dielectric substrate has a first surface and a second surface which are opposite to each other. The second radiation element and the fourth radiation element are disposed on the first surface of the dielectric substrate. The first radiation element and the third radiation element are disposed on the second surface of the dielectric substrate.

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

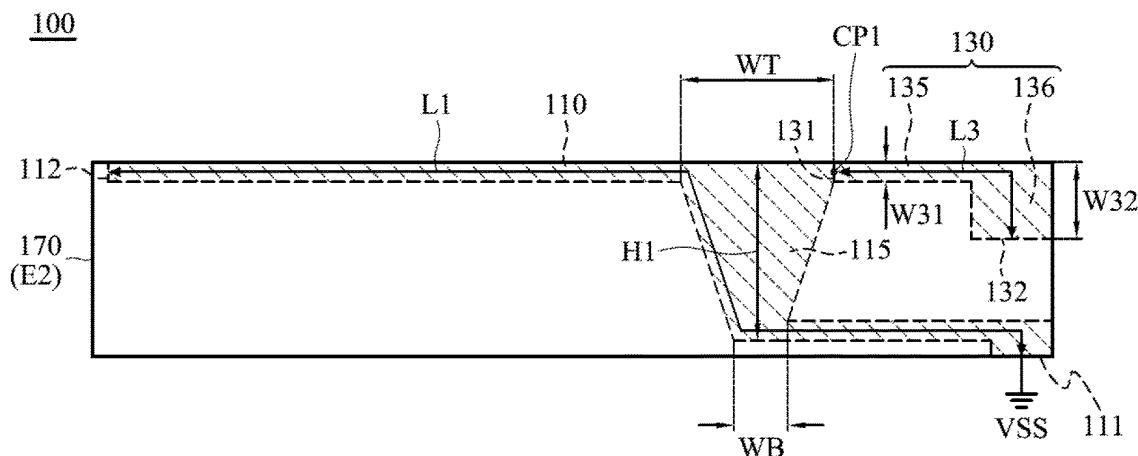
CPC **H01Q 5/314** (2015.01); **H01Q 5/42**
(2015.01); **H01Q 9/26** (2013.01)

(58) **Field of Classification Search**

CPC .. H01Q 1/24; H01Q 1/38; H01Q 5/31; H01Q
5/314; H01Q 1/48; H01Q 5/42; H01Q
9/26

See application file for complete search history.

13 Claims, 7 Drawing Sheets





US011539136B1

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

(10) **Patent No.:** **US 11,539,136 B1**
(45) **Date of Patent:** **Dec. 27, 2022**

(54) **ANTENNA DEVICE COMPRISING
RADIATOR FOR NARROWBAND AND
RADIATOR FOR WIDEBAND**

(71) Applicant: **KYOCERA AVX Components Gunpo
Co., Ltd., Gunpo-si (KR)**

(72) Inventors: **Sung Soo Nam, Suwon-si (KR);
Cheong Ho Ryu, Yongin-si (KR); Jin
Hyuk Jang, Suwon-si (KR); Hyung
Jin Kim, Gunpo-si (KR)**

(73) Assignee: **KYOCERA AVX Components Gunpo
Co., Ltd., Gunpo-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.: **17/830,089**

(22) Filed: **Jun. 1, 2022**

(30) **Foreign Application Priority Data**

Jun. 2, 2021 (KR) 10-2021-0071807

(51) **Int. Cl.**
H01Q 21/00 (2006.01)
H01Q 5/50 (2015.01)
H01Q 1/52 (2006.01)
H01Q 5/35 (2015.01)
H01Q 13/10 (2006.01)
H01Q 5/371 (2015.01)
H01Q 9/40 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/50** (2015.01); **H01Q 1/52**
(2013.01); **H01Q 5/35** (2015.01); **H01Q 5/371**
(2015.01); **H01Q 9/40** (2013.01); **H01Q 13/10**
(2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 5/50; H01Q 1/52; H01Q 5/35; H01Q
5/371; H01Q 9/40; H01Q 13/10
See application file for complete search history.

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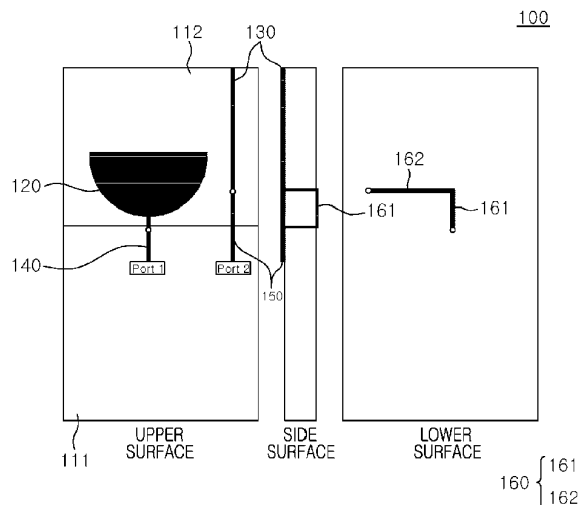
Primary Examiner — Dieu Hien T Duong

(74) *Attorney, Agent, or Firm* — Maier & Maier, PLLC

(57) **ABSTRACT**

The antenna device includes a substrate, a first radiator that
is in a plane shape, operates as a wideband antenna, and is
disposed on the dielectric region such that one end portion
faces the ground region and an opposite end portion faces
away from the ground region, a width of the opposite end
portion being wider than a width of the one end portion, a
second radiator that is in a line shape, operates as a narrow-
band antenna and at a lower frequency than the first radiator,
and is disposed adjacent to the first radiator on the dielectric
region such that one end portion faces the ground region and
an opposite end portion faces away from the ground region,
a first feeding line, a second feeding line, and a connecting
structure connected with the first radiator, the first feeding
line, the second radiator, and the second feeding line.

9 Claims, 11 Drawing Sheets





US011545733B2

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

(10) **Patent No.:** **US 11,545,733 B2**
(45) **Date of Patent:** **Jan. 3, 2023**

(54) **ANTENNA MODULE INCLUDING FLEXIBLE
PRINTED CIRCUIT BOARD AND
ELECTRONIC DEVICE INCLUDING THE
ANTENNA MODULE**

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

(72) Inventors: **Juneseok Lee**, Suwon-si (KR); **Junsig
Kum**, Suwon-si (KR); **Kwanghyun
Baek**, Suwon-si (KR); **Dohyuk Ha**,
Suwon-si (KR); **Jinsu Heo**, Suwon-si
(KR); **Youngju Lee**, Suwon-si (KR);
Jungyub Lee, Suwon-si (KR)

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

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 225 days.

(21) Appl. No.: **16/793,360**

(22) Filed: **Feb. 18, 2020**

(65) **Prior Publication Data**
US 2020/0266519 A1 Aug. 20, 2020

Related U.S. Application Data

(60) Provisional application No. 62/807,903, filed on Feb.
20, 2019.

Foreign Application Priority Data

Mar. 29, 2019 (KR) 10-2019-0036901

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

(52) **U.S. Cl.**
CPC **H01Q 1/2283** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 9/0435** (2013.01); **H01Q**
9/42 (2013.01); **H04B 7/0617** (2013.01);
H05K 1/189 (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/29; H01Q 21/28; H01Q 9/0457;
H01Q 21/24; H01Q 21/061-065;
(Continued)

(56) **References Cited**

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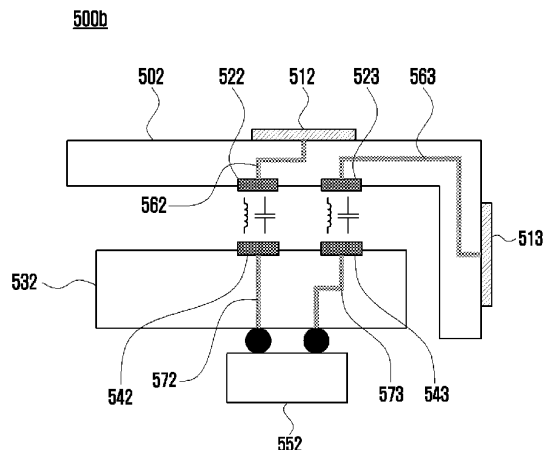
Primary Examiner — Ricardo I Magallanes

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

(57) **ABSTRACT**

The disclosure relates to a communication method and system for converging a 5th-Generation (5G) communication system for supporting higher data rates beyond a 4th-Generation (4G) system with a technology for Internet of Things (IoT). The disclosure may be applied to intelligent services based on the 5G communication technology and the IoT-related technology, such as smart home, smart building, smart city, smart car, connected car, health care, digital education, smart retail, security and safety services. An antenna module is provided. The antenna module includes a flexible printed circuit board (FPCB) including a first surface directed in a first direction and a second surface directed in a second direction that forms a predetermined first angle with respect to the first direction, a first antenna deployed on one surface of the first surface, and a second antenna deployed on one surface of the second surface.

18 Claims, 26 Drawing Sheets





US011545735B2

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

(10) **Patent No.:** **US 11,545,735 B2**
(45) **Date of Patent:** **Jan. 3, 2023**

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

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

(72) Inventors: **Cheng-Han Lee**, New Taipei (TW);
Yi-Wen Hsu, New Taipei (TW);
Wei-Xuan Ye, 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 37 days.

(21) Appl. No.: **17/144,326**

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

(65) **Prior Publication Data**

US 2021/0135339 A1 May 6, 2021

Related U.S. Application Data

(62) Division of application No. 15/647,281, filed on Jul. 12, 2017, now Pat. No. 10,923,801.

(Continued)

(30) **Foreign Application Priority Data**

Jun. 23, 2017 (CN) 201710488559.7

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/50 (2015.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/528** (2013.01); **H01Q 5/50** (2015.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**

CPC . H01Q 1/243-245; H01Q 5/321; H01Q 5/371
See application file for complete search history.

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Primary Examiner — Andrea Lindgren Baltzell

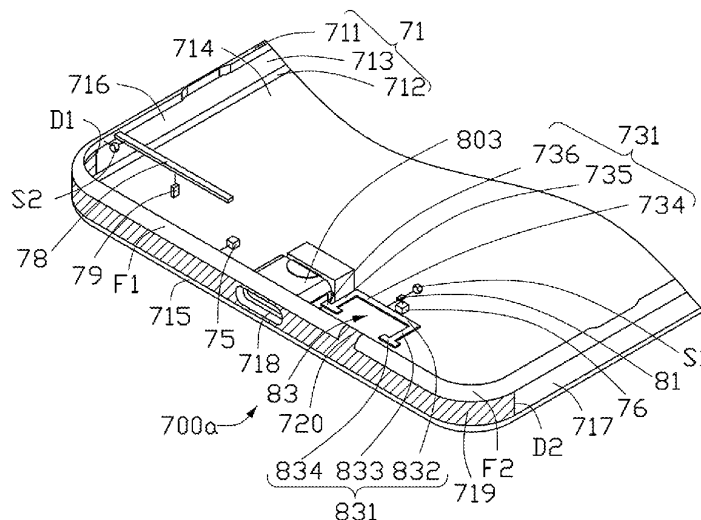
Assistant Examiner — Amal Patel

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

(57) **ABSTRACT**

An antenna structure includes a metal housing, a first feed source, and a first radiator. The metal housing includes a front frame, a backboard, and a side frame. The side frame defines a slot and the front frame defines a gap. The metal housing is divided into at least a long portion and a short portion by the slot and the gap. The first radiator is positioned in the housing and includes a first radiating portion and a second radiating portion. One end of the first radiating portion is electrically connected to the first feed source and another end of the first radiating portion is spaced apart from the long portion. One end of the second radiating portion is electrically connected to the first feed source and another end of the second radiating portion is spaced apart from the short portion.

30 Claims, 83 Drawing Sheets





US011545752B1

(12) **United States Patent**
Coutts

(10) **Patent No.:** **US 11,545,752 B1**
(45) **Date of Patent:** **Jan. 3, 2023**

(54) **VERTICAL COUPLING STRUCTURE FOR ANTENNA FEEDS**

(71) Applicant: **Amazon Technologies, Inc.**, Seattle, WA (US)

(72) Inventor: **Gordon Coutts**, Woodinville, WA (US)

(73) Assignee: **Amazon Technologies, Inc.**, Seattle, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1 day.

(21) Appl. No.: **17/369,782**

(22) Filed: **Jul. 7, 2021**

Related U.S. Application Data

(63) Continuation of application No. 16/845,689, filed on Apr. 10, 2020, now Pat. No. 11,088,453.

(51) **Int. Cl.**

H01L 35/00 (2006.01)

H01Q 9/04 (2006.01)

H05K 1/02 (2006.01)

H05K 1/14 (2006.01)

H05K 1/11 (2006.01)

H01Q 3/26 (2006.01)

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

CPC **H01Q 9/0457** (2013.01); **H01Q 9/0428** (2013.01); **H05K 1/0222** (2013.01); **H05K 1/115** (2013.01); **H05K 1/144** (2013.01); **H01Q 3/26** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/0457; H01Q 9/0428; H01Q 3/26; H05K 1/0222; H05K 1/115; H05K 1/144
See application file for complete search history.

(56) **References Cited**

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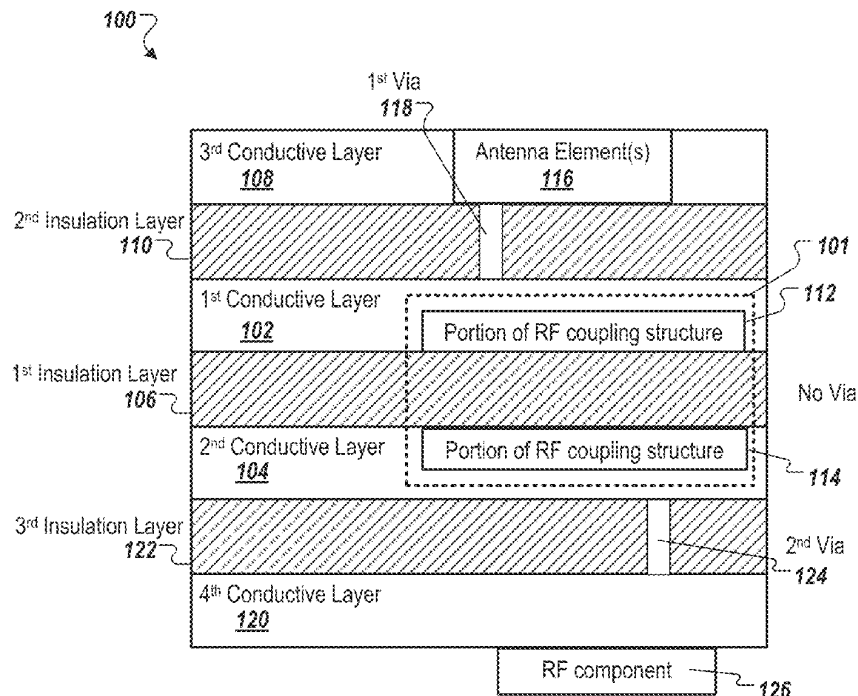
Primary Examiner — Binh B Tran

(74) Attorney, Agent, or Firm — Lowenstein Sandler LLP

(57) **ABSTRACT**

Technologies directed to coupling structures for antenna feeds of phased array antennas are described. One circuit board includes a first layer with a first portion of a RF coupling structure, a second layer with a second portion of the RF coupling structure, and a first insulation layer located between the first layer and the second layer. The RF coupling structure is configured to electromagnetically couple a first conductive trace on the first layer and a second conductive trace on the second layer at RF frequencies. The circuit board also includes an RF shielding structure coupled to a ground connection on the second layer and located in the first insulation layer. The RF shielding structure is configured to operate as a RF short circuit between the ground connection and a third conductive trace on the first layer at RF frequencies.

20 Claims, 12 Drawing Sheets





US011546459B2

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

(10) **Patent No.:** **US 11,546,459 B2**
(45) **Date of Patent:** **Jan. 3, 2023**

(54) **ELECTRONIC DEVICE AND METHOD FOR SWITCHING OF ANTENNA THEREOF**

(56) **References Cited**

U.S. PATENT DOCUMENTS

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

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(Continued)

(72) Inventors: **Hojin Jung**, Suwon-si (KR); **Yongyoun Kim**, Suwon-si (KR); **Myeongsu Oh**, Suwon-si (KR); **Duho Chu**, 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 0 days.

International Search Report dated Mar. 5, 2021, issued in International Application No. PCT/KR2020/017954.
(Continued)

(21) Appl. No.: **17/116,301**

Primary Examiner — Lester G Kincaid
Assistant Examiner — Maryam Soltanzadeh

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

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

(65) **Prior Publication Data**
US 2021/0185164 A1 Jun. 17, 2021

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a foldable housing, a communication circuit, a first transmission/reception circuit configured to transmit/receive a signal in a first frequency band, a first antenna electrically connected to the first transmission/reception circuit, and disposed on a portion of the first side member, a second transmission/reception circuit configured to transmit/receive a signal in a second frequency band different from the first frequency band, a second antenna electrically connected to the second transmission/reception circuit, and disposed on a portion of the first side member, a sensor configured to detect a contact of a user's body portion, and a processor. The processor may be configured to cause the first transmission/reception circuit to be electrically connected to the second antenna such that the signal in the first frequency band is transmitted/received through the second antenna when the contact of the user's body portion is detected by the sensor.

(30) **Foreign Application Priority Data**
Dec. 13, 2019 (KR) 10-2019-0166422
Aug. 4, 2020 (KR) 10-2020-0097130

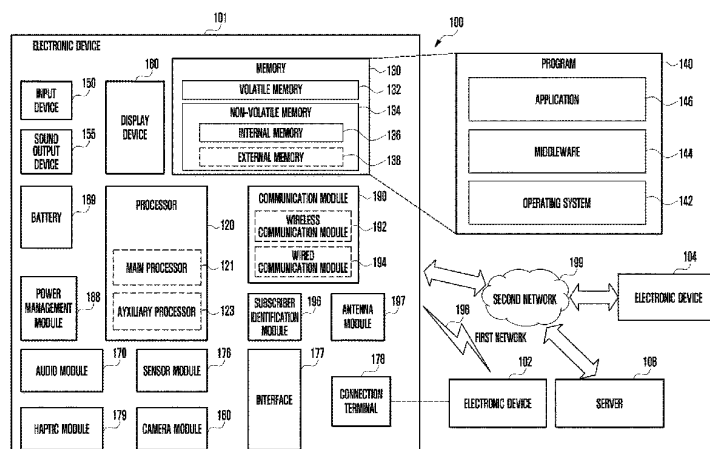
(51) **Int. Cl.**
H04M 1/7245 (2021.01)
H04M 1/02 (2006.01)

(52) **U.S. Cl.**
CPC **H04M 1/7245** (2021.01); **H04M 1/0216** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 3/24; H01Q 1/243; H04B 1/1009;
H04B 7/0834; H04B 7/0602;

(Continued)

20 Claims, 26 Drawing Sheets





US011552381B2

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

(10) **Patent No.:** US 11,552,381 B2
(45) **Date of Patent:** Jan. 10, 2023

(54) **ELECTRONIC DEVICE**

USPC 361/679
See application file for complete search history.

(71) Applicant: **Getac Technology Corporation**,
Hsinchu County (TW)

(56) **References Cited**

(72) Inventors: **Wan-Lin Hsu**, Taipei (TW); **Juei-Chi Chang**, Taipei (TW); **Ping-Chung Chen**, Taipei (TW); **Jia-Min Huang**, Taipei (TW)

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(73) Assignee: **GETAC TECHNOLOGY CORPORATION**, Hsinchu County (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 33 days.

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(21) Appl. No.: **17/182,513**

CN 101278438 B * 2/2013 G08B 7/066

(22) Filed: **Feb. 23, 2021**

Primary Examiner — Dameon E Levi

Assistant Examiner — Leah Rosenberg

(65) **Prior Publication Data**

US 2022/0271413 A1 Aug. 25, 2022

(74) *Attorney, Agent, or Firm* — Locke Lord LLP; Tim Tingkang Xia, Esq.

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 9/04 (2006.01)
H01Q 21/08 (2006.01)
H01Q 5/307 (2015.01)

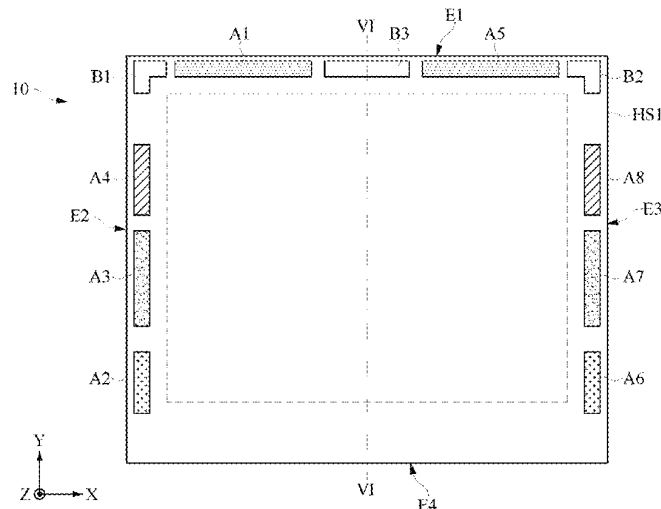
(57) **ABSTRACT**

The present invention discloses an antenna module and an electronic device. The antenna module is used in the electronic device. The electronic device includes a first housing. The antenna module includes a first antenna, a second antenna and a third antenna. The first antenna is disposed in the first housing and operates at a first frequency band. The second antenna is disposed in the first housing and operates at a second frequency band. The third antenna is disposed in the first housing and is located between the first antenna and the second antenna, and operates at a third frequency band. The first frequency band partially overlaps with the second frequency band, and the third frequency band does not overlap with the first frequency band and the second frequency band.

(52) **U.S. Cl.**
CPC **H01Q 1/2266** (2013.01); **H01Q 5/307** (2015.01); **H01Q 9/0407** (2013.01); **H01Q 21/08** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/2266; H01Q 1/243; H01Q 5/307; H01Q 1/241; H01Q 1/242; H01Q 5/20; H01Q 5/30; H01Q 9/0407; H01Q 21/08; H01Q 21/28; H01Q 21/20; G06F 1/1601; G06F 1/1616; G06F 1/1656; H04M 1/02; H04M 1/026; H04M 1/0214; H04M 1/0216; H04B 1/0064

17 Claims, 5 Drawing Sheets





US011552384B2

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

(10) **Patent No.:** **US 11,552,384 B2**
(45) **Date of Patent:** **Jan. 10, 2023**

(54) **ANTENNA**

(71) Applicant: **NOKIA SOLUTIONS AND NETWORKS OY**, Espoo (FI)

(72) Inventors: **Simon Svendsen**, Aalborg (DK);
Christian Rom, Aalborg (DK); **Poul Olesen**, Støvring (DK)

(73) Assignee: **NOKIA SOLUTIONS AND NETWORKS OY**, Espoo (FI)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 133 days.

(21) Appl. No.: **17/018,900**

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Sep. 12, 2019 (EP) 19196891

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)
H01Q 1/52 (2006.01)
H01Q 13/16 (2006.01)
H01Q 21/00 (2006.01)
H01Q 25/00 (2006.01)
G16Y 10/75 (2020.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/521** (2013.01); **H01Q 13/16** (2013.01); **H01Q 21/0025** (2013.01); **H01Q 25/00** (2013.01); **G16Y 10/75** (2020.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/48; H01Q 1/52;
H01Q 13/16; H01Q 21/00; H01Q 25/00
See application file for complete search history.

(56) **References Cited**

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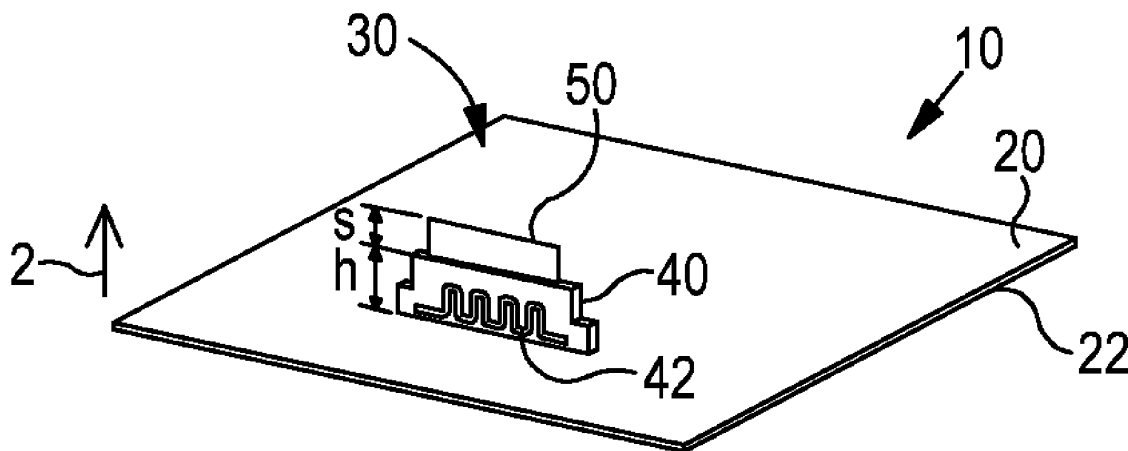
Primary Examiner — Andrea Lindgren Baltzell

(74) *Attorney, Agent, or Firm* — Alston & Bird LLP

(57) **ABSTRACT**

An apparatus is provided that includes a ground plane having a perimeter, at least one support positioned within the perimeter of the ground plane and extending outwardly from the ground plane and at least one multi-port antenna supported by the support at a distance from the ground plane. The multi-port antenna has a different radiation pattern associated with each port. The multi-port antenna operates with a first radiation pattern when a first port is used and operates with a second radiation pattern, different to the first radiation pattern, when a second port, different to the first port, is used. The at least one support defines a slot positioned between the multi-port antenna and the ground plane and/or the ground plane defines a slot.

20 Claims, 16 Drawing Sheets





US011552391B2

(12) **United States Patent**
Huang

(10) **Patent No.:** **US 11,552,391 B2**
(45) **Date of Patent:** **Jan. 10, 2023**

(54) **MOBILE DEVICE WITH
MULTIPLE-ANTENNA SYSTEM**

(71) Applicant: **Futurewei Technologies, Inc.**, Plano,
TX (US)

(72) Inventor: **Wei Huang**, San Diego, CA (US)

(73) Assignee: **Futurewei Technologies, Inc.**, Addison,
TX (US)

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

(21) Appl. No.: **15/868,958**

(22) Filed: **Jan. 11, 2018**

(65) **Prior Publication Data**
US 2018/0205146 A1 Jul. 19, 2018

Related U.S. Application Data
(60) Provisional application No. 62/446,173, filed on Jan.
13, 2017.

(51) **Int. Cl.**
H01Q 1/52 (2006.01)
H01Q 21/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/523** (2013.01); **H01Q 1/2258**
(2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48**
(2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 13/10; H01Q 21/064; H01Q 21/24;
H01Q 1/523; H01Q 1/2258; H01Q 1/243;
(Continued)

(56) **References Cited**

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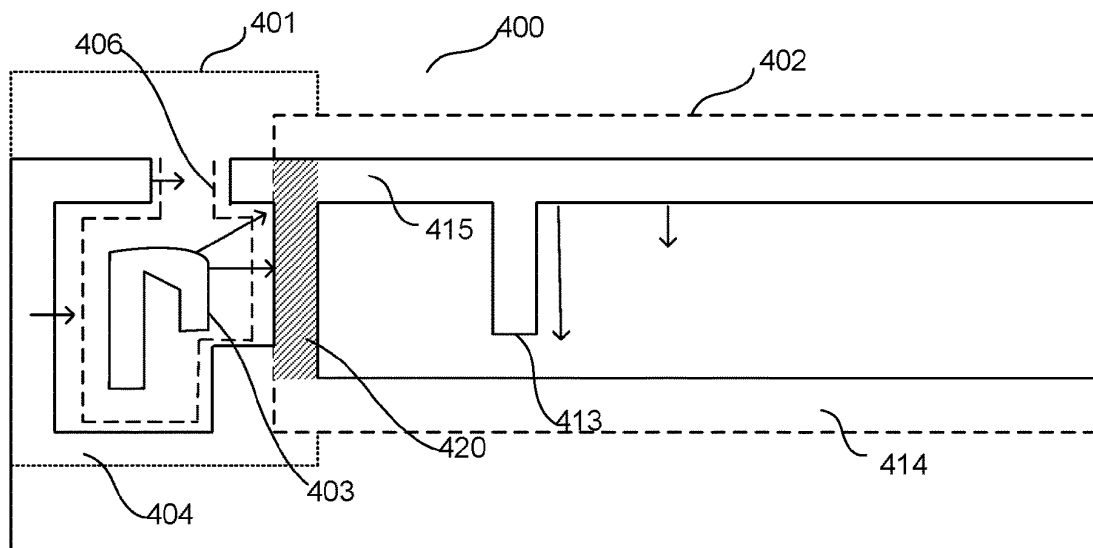
Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — Schwegman Lundberg &
Woessner, P.A.

(57) **ABSTRACT**

Embodiments provide mobile device comprising a body
frame; processing circuitry affixed to the body frame; a first
antenna and a second antenna arranged adjacent to each
other in the body frame, the first antenna and the second
antenna electrically coupled to the processing circuitry to
provide radiation, wherein the first antenna and the second
antenna share a common ground defined by the body frame,
wherein the first antenna is configured to provide radiation
of a first polarization, and wherein the second antenna is
configured to provide radiation of a second polarization
substantially orthogonal to the first polarization to provide a
signal isolation between the first antenna and the second
antenna.

17 Claims, 6 Drawing Sheets





US011552392B2

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

(10) **Patent No.:** **US 11,552,392 B2**
(45) **Date of Patent:** **Jan. 10, 2023**

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

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

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(72) Inventors: **Sangmin Jung**, Gyeonggi-do (KR);
Geunwoo Kim, Gyeonggi-do (KR)

FOREIGN PATENT DOCUMENTS

(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 481 days.

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International Search Report dated Jan. 3, 2020.

(21) Appl. No.: **16/571,544**

Primary Examiner — Dimary S Lopez Cruz

Assistant Examiner — Michael M Bouizza

(22) Filed: **Sep. 16, 2019**

(74) *Attorney, Agent, or Firm* — Cha & Reiter, LLC

(65) **Prior Publication Data**
US 2020/0144713 A1 May 7, 2020

(57) **ABSTRACT**

An electronic device comprises a plurality of antennas, wherein each of the plurality of antennas are spaced apart from each other, a first communication circuit electrically connected with the plurality of antennas, a plurality of array antennas comprising a first array antenna disposed adjacent to at least one of the plurality of antennas, and a second array antenna disposed adjacent to another antenna different from the at least one antenna of the plurality of antennas, a second communication circuit electrically connected with the first array antenna and the second array antenna, and at least one control circuit electrically connected with the first communication circuit and the second communication circuit, wherein the at least one control circuit is configured to obtain receive sensitivities of the plurality of antennas through the first communication circuit; activate at least one array antenna of the first array antenna and the second array antenna through the second communication circuit based at least on the receive sensitivities; and control the activated at least one array antenna to form at least one beam for communication with an external electronic device.

(30) **Foreign Application Priority Data**
Nov. 7, 2018 (KR) 10-2018-0135770

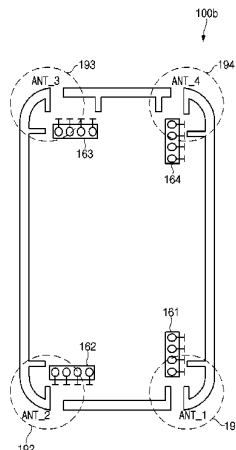
(51) **Int. Cl.**
H01Q 1/52 (2006.01)
H04W 76/10 (2018.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/523** (2013.01); **G06F 13/385**
(2013.01); **H04W 76/10** (2018.02); **H04W**
36/0072 (2013.01); **H04W 88/04** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/523; H01Q 1/243; H01Q 9/42;
H01Q 21/061; H01Q 25/00; G06F
13/385;

(Continued)

4 Claims, 11 Drawing Sheets





US011552397B2

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

(10) **Patent No.:** **US 11,552,397 B2**
(45) **Date of Patent:** ***Jan. 10, 2023**

(54) **HIGH GAIN AND LARGE BANDWIDTH ANTENNA INCORPORATING A BUILT-IN DIFFERENTIAL FEEDING SCHEME**

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

(72) Inventors: **Hamid Reza Memar Zadeh Tehran**,
Richardson, TX (US); **Gary Xu**, Allen,
TX (US); **Won Suk Choi**, Plano, TX
(US); **Jianzhong Zhang**, Plano, TX
(US)

(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.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **17/444,986**

(22) Filed: **Aug. 12, 2021**

(65) **Prior Publication Data**
US 2021/0376469 A1 Dec. 2, 2021

Related U.S. Application Data

(63) Continuation of application No. 17/195,401, filed on
Mar. 8, 2021, now Pat. No. 11,145,979, which is a
(Continued)

(51) **Int. Cl.**
H01Q 5/35 (2015.01)
H01Q 21/06 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/35** (2015.01); **H01Q 5/50**
(2015.01); **H01Q 9/045** (2013.01); **H01Q**
21/065 (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/523; H01Q 5/35; H01Q 5/50;
H01Q 9/045; H01Q 21/065; H01Q 21/24
See application file for complete search history.

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connection with European Application No. 19854647.5, 11 pages.
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Primary Examiner — Tung X Le

(57) **ABSTRACT**

An antenna and a base station including the antenna. The antenna includes a sub-array that includes first and second unit cells and a feed network. The first and second unit cells comprise first and second patches, respectively, having quadrilateral shapes. The feed network comprises a first transmission line terminating below first corners of the first and second patches, respectively; a second transmission line terminating below third corners of the first and second patches, respectively; a third transmission line terminating below a second corner of the first patch and a fourth corner of the second patch; and a fourth transmission line terminating below a fourth corner of the first patch and a second corner of the second patch. The first corners are opposite the third corners on the respective first and second patches and the second corners are opposite the fourth corners on the respective first and second patches.

20 Claims, 8 Drawing Sheets

