



US011258163B2

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

(10) **Patent No.:** **US 11,258,163 B2**
(45) **Date of Patent:** **Feb. 22, 2022**

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

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

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

(73) Assignee: **APPLE INC.**, Cupertino, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 567 days.

(21) Appl. No.: **16/142,285**

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

(65) **Prior Publication Data**

US 2020/0076056 A1 Mar. 5, 2020

Related U.S. Application Data

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

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

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

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 5/30
See application file for complete search history.

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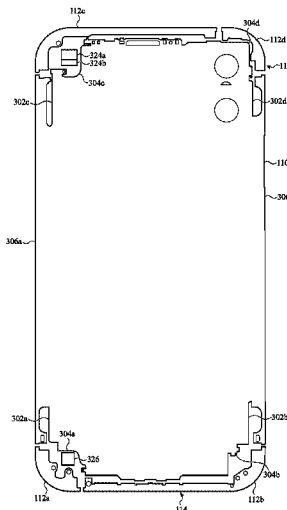
Primary Examiner — Graham P Smith

(74) *Attorney, Agent, or Firm* — Brownstein Hyatt Farber Schreck, LLP

(57) **ABSTRACT**

A device includes a display and a housing. The housing surrounds the display and has four corners defining portions of an exterior surface of the device. The housing includes a first housing segment defining at least part of a first corner of the four corners and configured to operate as an antenna; a second housing segment defining at least part of a second corner of the four corners; and a third housing segment defining at least part of a third corner of the four corners. The third corner forms part of the housing diagonally opposite the second corner. The housing further includes a non-conductive housing component that structurally couples the first housing segment to another portion of the housing.

20 Claims, 46 Drawing Sheets





US011258174B2

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

(10) **Patent No.:** **US 11,258,174 B2**
(45) **Date of Patent:** **Feb. 22, 2022**

(54) **ANTENNA RADIATOR INCLUDING PLURALITY OF LAYERS AND ELECTRONIC DEVICE INCLUDING THE SAME**

(56) **References Cited**

U.S. PATENT DOCUMENTS

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

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(72) Inventors: **Yoonjung Kim**, Gyeonggi-do (KR);
Jaedeok Lim, Gyeonggi-do (KR);
Gyuyeong Cho, Gyeonggi-do (KR);
Hyein Park, Gyeonggi-do (KR)

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

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(21) Appl. No.: **16/861,415**

Elliot, et al.; "E-textile Microstrip Patch Antennas for GPS"; Apr. 23, 2012; XP032200215.

(22) Filed: **Apr. 29, 2020**

(Continued)

(65) **Prior Publication Data**
US 2020/0350682 A1 Nov. 5, 2020

Primary Examiner — Graham P Smith

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

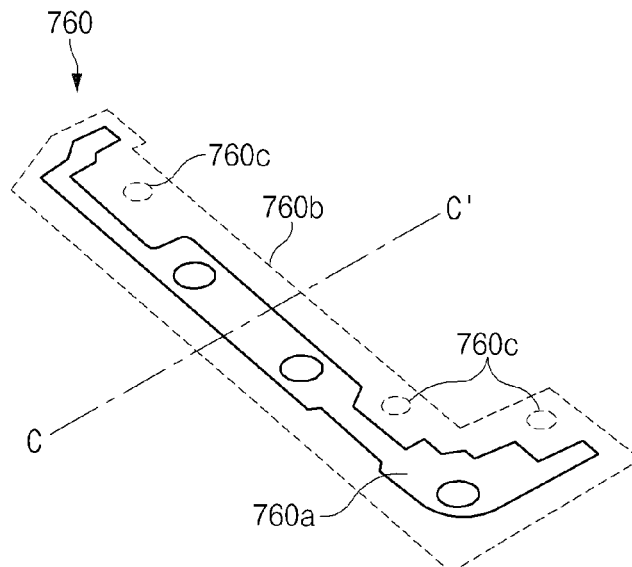
(30) **Foreign Application Priority Data**
Apr. 30, 2019 (KR) 10-2019-0050482

(57) **ABSTRACT**

Disclosed is an electronic device including a housing, a first plate positioned on a front surface of the housing, a second plate positioned on a rear surface of the housing, an antenna radiator interposed between the first plate and the second plate, and a wireless communication circuit connected to the antenna radiator and processing a signal in a specific frequency band. The antenna radiator includes at least one conductive fabric layer having a resistance characteristic suitable for transmitting or receiving the signal in the specific frequency band, and the at least one conductive fabric layer includes a fabric that is plated with at least one metal.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/04 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 9/0414** (2013.01); **H01Q 1/243** (2013.01)
(58) **Field of Classification Search**
CPC H01G 9/0414; H01G 1/243
See application file for complete search history.

20 Claims, 20 Drawing Sheets





US011258178B2

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

(10) **Patent No.:** **US 11,258,178 B2**

(45) **Date of Patent:** **Feb. 22, 2022**

(54) **ANTENNA AND METHOD OF ASSEMBLY OF SUCH ANTENNA**

(71) Applicant: **Nokia Shanghai Bell Co., Ltd.**,
Shanghai (CN)

(72) Inventors: **Thomas Julien**, Lannion (FR);
Jean-Pierre Harel, Lannion (FR); **Zied Charaabi**, Lannion (FR); **Patrick Lecam**, Lannion (FR); **Jerome Plet**, Lannion (FR)

(73) Assignee: **Nokia Shanghai Bell Co., Ltd.**,
Shanghai (CN)

(*) 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.: **16/652,446**

(22) PCT Filed: **Oct. 2, 2018**

(86) PCT No.: **PCT/IB2018/057626**

§ 371 (c)(1),

(2) Date: **Mar. 31, 2020**

(87) PCT Pub. No.: **WO2019/069216**

PCT Pub. Date: **Apr. 11, 2019**

(65) **Prior Publication Data**

US 2020/0235479 A1 Jul. 23, 2020

(30) **Foreign Application Priority Data**

Oct. 2, 2017 (EP) 17306315

(51) **Int. Cl.**

H01Q 9/04 (2006.01)

H01Q 21/08 (2006.01)

(Continued)

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

CPC **H01Q 9/0471** (2013.01); **H01Q 5/40** (2015.01); **H01Q 21/0075** (2013.01); **H01Q 21/08** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/1242; H01Q 1/246; H01Q 1/42; H01Q 5/10; H01Q 5/40; H01Q 9/0471; H01Q 21/0075; H01Q 21/28; H01Q 21/08

See application file for complete search history.

(56) **References Cited**

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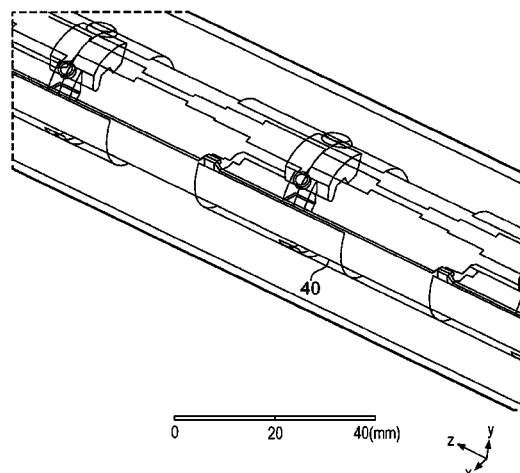
Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — Fay Sharpe LLP

(57) **ABSTRACT**

An antenna comprising: a longitudinal support member for supporting components of the antenna and a method of assembling such an antenna is disclosed. The components supported by the longitudinal member comprise: at least one signal feed probe configured to capacitively supply a signal to a corresponding at least one radiating patch; the at least one radiating patch mounted to at least partially wraparound the longitudinal support member; and signal supply circuitry for supplying a signal to the at least one signal feed. The signal supply circuitry is mounted on an outer surface of the inner longitudinal support member; and the longitudinal

(Continued)



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

(10) **Patent No.:** **US 11,258,184 B2**
(45) **Date of Patent:** **Feb. 22, 2022**

(54) **ANTENNA SYSTEM INCLUDING A
POLYMER COMPOSITION HAVING A LOW
DISSIPATION FACTOR**

USPC 343/702
See application file for complete search history.

(71) Applicant: **Ticona LLC**, Florence, KY (US)

(56) **References Cited**

(72) Inventors: **Young Shin Kim**, Cincinnati, OH (US);
Xinyu Zhao, Cincinnati, OH (US)

U.S. PATENT DOCUMENTS

(73) Assignee: **Ticona LLC**, Florence, KY (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 9 days.

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(21) Appl. No.: **16/995,870**

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

(65) **Prior Publication Data**

US 2021/0057827 A1 Feb. 25, 2021

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Polymer Composition for Use in an Antenna System.

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Related U.S. Application Data

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27, 2020, provisional application No. 63/038,959,
filed on Jun. 15, 2020, provisional application No.
63/024,557, filed on May 14, 2020, provisional
application No. 63/008,979, filed on Apr. 13, 2020,
provisional application No. 62/994,314, filed on Mar.
25, 2020, provisional application No. 62/972,195,
filed on Feb. 10, 2020, provisional application No.
62/951,039, filed on Dec. 20, 2019, provisional
(Continued)

Primary Examiner — Peguy Jean Pierre

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

(51) **Int. Cl.**

H01Q 1/38 (2006.01)

H01Q 21/00 (2006.01)

H01Q 21/06 (2006.01)

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

CPC **H01Q 21/0087** (2013.01); **H01Q 1/38**
(2013.01); **H01Q 21/0012** (2013.01); **H01Q**
21/065 (2013.01)

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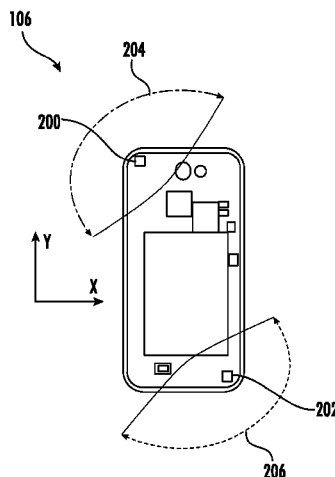
ABSTRACT

A 5G antenna system is disclosed that comprises a substrate
and at least one antenna element configured to transmit and
receive 5G radio frequency signals. The at least one antenna
element is coupled to the substrate. The substrate comprises
a polymer composition that comprises a polymer matrix
containing at least one polymer having a glass transition
temperature of about 30° C. or more and at least one laser
activatable additive wherein the polymer composition
exhibits a dissipation factor of about 0.1 or less, as deter-
mined at a frequency of 2 GHz.

(58) **Field of Classification Search**

CPC H01Q 21/0087; H01Q 1/38

36 Claims, 7 Drawing Sheets





US011264692B2

(12) **United States Patent**
Itou

(10) **Patent No.:** **US 11,264,692 B2**
(45) **Date of Patent:** **Mar. 1, 2022**

(54) **ANTENNA UNIT**

(71) Applicant: **Yazaki Corporation**, Tokyo (JP)

(72) Inventor: **Eita Itou**, Shizuoka (JP)

(73) Assignee: **YAZAKI CORPORATION**, Tokyo (JP)

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

(21) Appl. No.: **16/669,464**

(22) Filed: **Oct. 30, 2019**

(65) **Prior Publication Data**

US 2020/0144694 A1 May 7, 2020

(30) **Foreign Application Priority Data**

Nov. 2, 2018 (JP) JP2018-207132

(51) **Int. Cl.**

H01Q 1/38 (2006.01)

H01Q 1/12 (2006.01)

H01P 3/08 (2006.01)

H01Q 1/48 (2006.01)

H01Q 9/04 (2006.01)

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

CPC **H01Q 1/12** (2013.01); **H01P 3/081** (2013.01); **H01Q 1/48** (2013.01); **H01Q 9/045** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/12; H01Q 1/48; H01Q 9/045; H01Q 1/22; H01Q 9/0407; H01Q 1/38; H01Q 1/1221; H01Q 1/405; H01Q 1/42; H01Q 1/50; H01Q 1/32; H01Q 1/40; H01P 3/081

See application file for complete search history.

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Primary Examiner — Dieu Hien T Duong

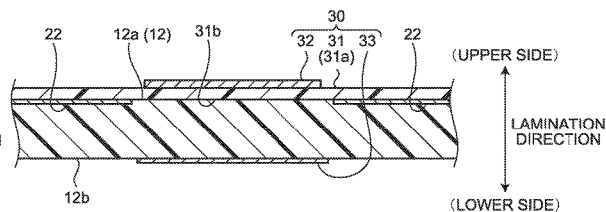
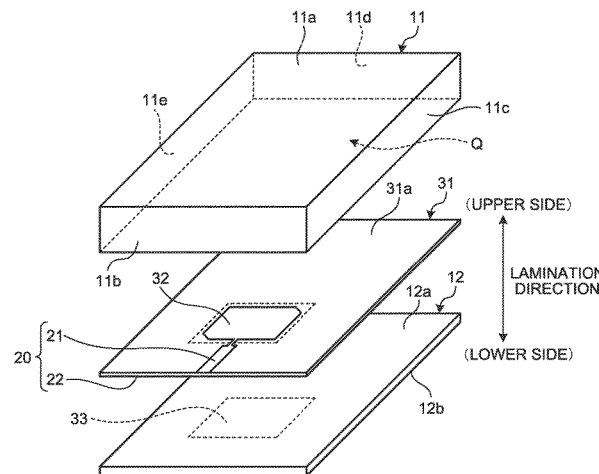
(74) *Attorney, Agent, or Firm* — Kenealy Vaidya LLP

(57)

ABSTRACT

An antenna unit includes a patch antenna and a case. The patch antenna includes a conductive antenna pattern and an antenna ground pattern that functions as ground of the antenna pattern and receives an electric wave. The case has dielectricity, the case being provided with the patch antenna. The antenna pattern is provided on an inner wall surface of a wall portion of the case. The antenna ground pattern is provided on an outer wall surface of a wall portion of the case and is positioned so as to face the antenna pattern.

2 Claims, 5 Drawing Sheets



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

(10) **Patent No.:** **US 11,264,699 B2**
(45) **Date of Patent:** **Mar. 1, 2022**

(54) **ANTENNA STRUCTURE AND MOBILE DEVICE**

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

(72) Inventors: **Cheng-Pang Chang**, Hsinchu (TW);
Shih-Hsien Tseng, Hsinchu (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 228 days.

(21) Appl. No.: **16/658,353**

(22) Filed: **Oct. 21, 2019**

(65) **Prior Publication Data**

US 2020/0185813 A1 Jun. 11, 2020

(30) **Foreign Application Priority Data**

Dec. 7, 2018 (TW) 107144086

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/48 (2006.01)
H01Q 9/42 (2006.01)
H01Q 9/40 (2006.01)

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

CPC **H01Q 1/2266** (2013.01); **H01Q 1/2291** (2013.01); **H01Q 1/48** (2013.01); **H01Q 9/40** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**

None
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Trinh V Dinh

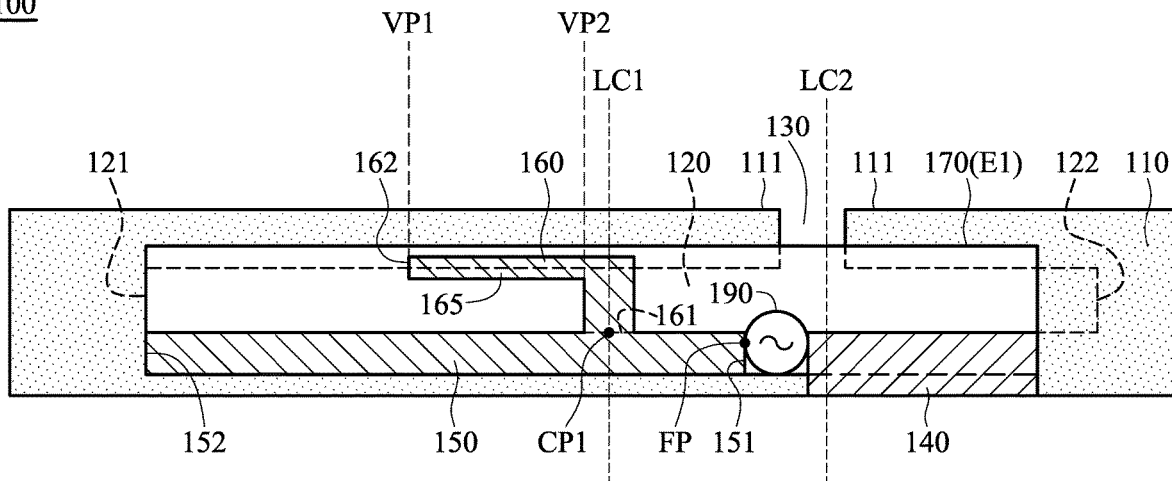
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

An antenna structure includes a metal mechanism element, a ground element, a first radiation element, a second radiation element, and a dielectric substrate. The metal mechanism element has a slot. A notch is formed on an edge of the metal mechanism element. The notch and the slot are connected to each other. The ground element is coupled to the metal mechanism element. The first radiation element has a feeding point. The second radiation element is coupled to the first radiation element and includes a first extension portion. The second radiation element extends across the slot. The first extension portion is parallel to the slot. A vertical projection of the first extension portion at least partially overlaps the slot. The dielectric substrate is adjacent to the metal mechanism element. The first radiation element and the second radiation element are disposed on the dielectric substrate.

20 Claims, 8 Drawing Sheets

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US011264718B2

(12) **United States Patent**
Yang

(10) **Patent No.:** **US 11,264,718 B2**
(45) **Date of Patent:** **Mar. 1, 2022**

(54) **EIGHT-FREQUENCY BAND ANTENNA**

(56) **References Cited**

(71) Applicant: **Taoglas Group Holdings Limited**, San Diego, CA (US)

U.S. PATENT DOCUMENTS

(72) Inventor: **Tsai Yi Yang**, Tainan (TW)

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(73) Assignee: **TAOGLAS GROUP HOLDINGS LIMITED**, Enniscorthy (IE)

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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.: **16/685,843**

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CN 1485950 3/2004

(22) Filed: **Nov. 15, 2019**

(Continued)

(65) **Prior Publication Data**

Primary Examiner — Dameon E Levi

Assistant Examiner — Jennifer F Hu

US 2020/0266541 A1 Aug. 20, 2020

(74) *Attorney, Agent, or Firm* — Garson & Gutierrez, PC

Related U.S. Application Data

(57) **ABSTRACT**

(63) Continuation of application No. 16/172,098, filed on Oct. 26, 2018, now Pat. No. 10,483,644, which is a continuation of application No. 14/948,237, filed on Nov. 20, 2015, now abandoned.

An eight-frequency band antenna includes a carrier, a high-frequency segment, a low-frequency segment, a printed circuit board (PCB) and an inductor. The high-frequency segment is arranged on left side of the carrier and the low-frequency segment is arranged on right side of the carrier. The radiator on the bottom face of the carrier electrically connects with the micro strip of the PCB and the ground line of the ground metal when the carrier is fixed to the PCB. Moreover, the low-frequency segment is corresponding to a metal face with smaller area such that the low-frequency segment is at a free space to enhance the frequency response of the low-frequency segment and the bandwidth of the high-frequency segment. The area and the volume of blind hole on the carrier can adjust the effective dielectric constant to adjust the resonant frequency and bandwidth of the antenna.

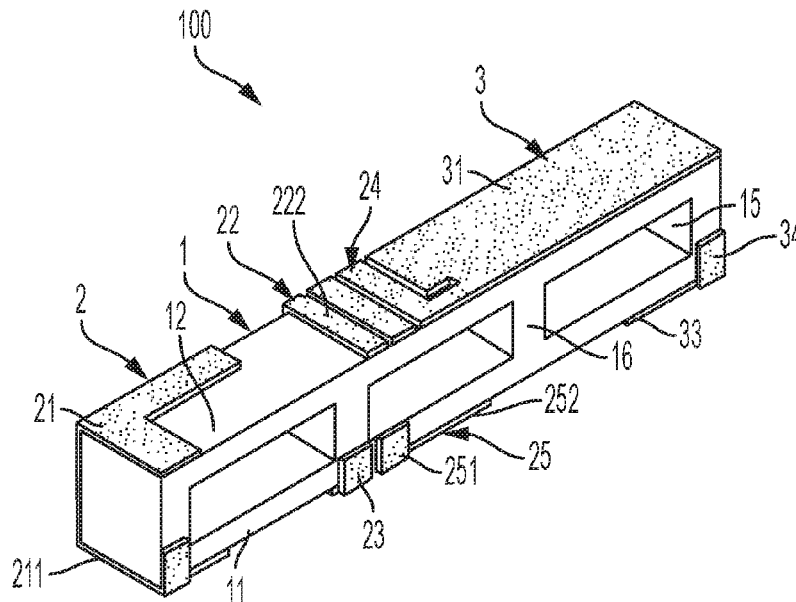
(51) **Int. Cl.**
H01Q 5/371 (2015.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/371** (2015.01); **H01Q 1/243** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/10; H01Q 5/30; H01Q 5/307;
H01Q 5/342; H01Q 5/357; H01Q 5/364;
H01Q 5/371; H01Q 1/48; H01Q 1/243;
H01Q 9/04; H01Q 1/38

See application file for complete search history.

14 Claims, 9 Drawing Sheets





US011264721B2

(12) **United States Patent**
Nguyen

(10) **Patent No.:** **US 11,264,721 B2**
(45) **Date of Patent:** **Mar. 1, 2022**

(54) **ANTENNA, CONFIGURATION METHOD OF ANTENNA AND WIRELESS COMMUNICATION DEVICE**

(56) **References Cited**

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(71) Applicant: **NEC CORPORATION**, Tokyo (JP)

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343/700 MS

(72) Inventor: **Tung Nguyen**, Tokyo (JP)

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343/700 MS

(73) Assignee: **NEC CORPORATION**, Tokyo (JP)

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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 72 days.

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(21) Appl. No.: **16/497,550**

(22) PCT Filed: **Feb. 7, 2018**

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(86) PCT No.: **PCT/JP2018/004123**

Notice of Reasons for Refusal dated Nov. 17, 2020 from the Japanese Patent Office in Application No. 2019-552297.

§ 371 (c)(1),

(2) Date: **Sep. 25, 2019**

(Continued)

(87) PCT Pub. No.: **WO2018/179870**

Primary Examiner — Tung X Le

PCT Pub. Date: **Oct. 4, 2018**

(74) *Attorney, Agent, or Firm* — Sughrue Mion, PLLC

(65) **Prior Publication Data**

US 2021/0111490 A1 Apr. 15, 2021

(30) **Foreign Application Priority Data**

Mar. 28, 2017 (JP) JP2017-063248

(57)

ABSTRACT

One end of a second feeding line is connected to a first feeding line configured to transmit a first polarization at a first position and the other end is connected to a patch at a second position. One end of a third feeding line is connected to the first feeding line and the other end is connected to the patch at a third position. One end of a fourth feeding line is connected to the patch at a fourth position and configured to transmit a second polarization, wavelengths of the first and second polarizations being the same as each other. The second and third feeding lines are configured to cause the first polarization at the second position to be in opposite phase to the first polarization at the third position. A distance between the second and fourth positions is equal to a distance between the third and fourth positions.

(51) **Int. Cl.**

H01Q 9/04 (2006.01)

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

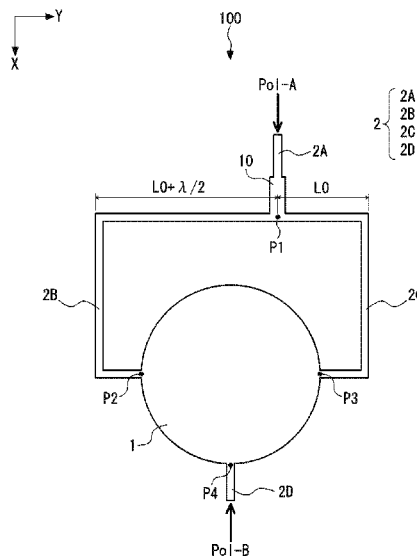
CPC **H01Q 9/045** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/523; H01Q 5/357; H01Q 9/045;
H01Q 9/0485; H01Q 21/065; H01Q
21/24

See application file for complete search history.

12 Claims, 15 Drawing Sheets





US011264722B2

(12) **United States Patent**
Etani

(10) **Patent No.:** **US 11,264,722 B2**
(45) **Date of Patent:** **Mar. 1, 2022**

(54) **ANTENNA**

(56) **References Cited**

(71) Applicant: **FURUNO ELECTRIC CO., LTD.**,
Hyogo (JP)

U.S. PATENT DOCUMENTS

(72) Inventor: **Soichiro Etani**, Minoh (JP)

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(73) Assignee: **FURUNO ELECTRIC CO., LTD.**,
Hyogo (JP)

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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 19 days.

CN 112602234 A * 4/2021 H01Q 5/385
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(21) Appl. No.: **17/070,944**

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(22) Filed: **Oct. 15, 2020**

“International Search Report (Form PCT/ISA/210)” of PCT/JP2019/
011325, dated May 7, 2019, with English translation thereof, pp.
1-2.

(65) **Prior Publication Data**

US 2021/0044025 A1 Feb. 11, 2021

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2019/011325,
filed on Mar. 19, 2019.

Primary Examiner — Graham P Smith

Assistant Examiner — Jae K Kim

(74) *Attorney, Agent, or Firm* — JCIPRNET

(30) **Foreign Application Priority Data**

Apr. 17, 2018 (JP) JP2018-079058

(57) **ABSTRACT**

An antenna is provided, including: a first substrate, having
has a first and a second surfaces parallel to each other and
having a dielectric; a second substrate, having a third and a
fourth surfaces parallel to each other, the third surface being
disposed to face and abut the second surface, having a
dielectric; a first radiation conductor, formed on the first
surface; a second radiation conductor, formed on the third
surface; and a power supply, supplying power to the first and
second radiation conductors. A position of the power supply
is disposed from centers of the first and second radiation
conductors by distance d. A distance between a position
where a reflection loss with respect to the second high-
frequency signal becomes the smallest and the centers is d0,
d/d0 is equal to or larger than 4/3.

(51) **Int. Cl.**

H01Q 13/08 (2006.01)

H01Q 13/24 (2006.01)

(Continued)

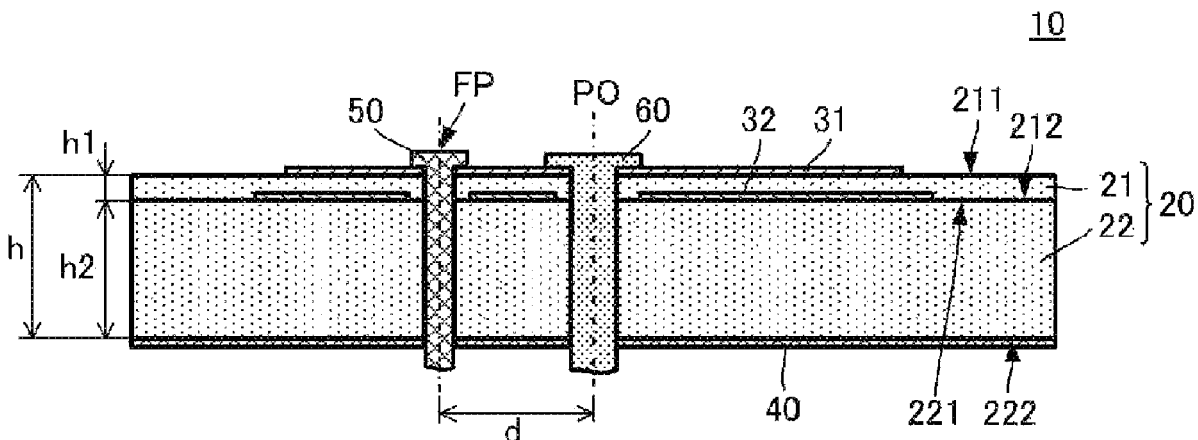
(52) **U.S. Cl.**

CPC **H01Q 13/08** (2013.01); **H01Q 1/38**
(2013.01); **H01Q 5/378** (2015.01); **H01Q**
13/24 (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/35; H01Q 9/045; H01Q 5/378;
H01Q 1/38; H01Q 13/08; H01Q 13/24
See application file for complete search history.

5 Claims, 5 Drawing Sheets





US011264723B2

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

(10) **Patent No.:** **US 11,264,723 B2**
(45) **Date of Patent:** **Mar. 1, 2022**

(54) **SLOT ANTENNAS**

(71) Applicant: **Hewlett-Packard Development Company, L.P.**, Spring, TX (US)

(72) Inventors: **Shih Huang Wu**, Spring, TX (US);
Kuan-Ting Wu, Taipei (TW)

(73) Assignee: **Hewlett-Packard Development Company, L.P.**, Spring, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 99 days.

(21) Appl. No.: **16/754,970**

(22) PCT Filed: **Nov. 15, 2017**

(86) PCT No.: **PCT/US2017/061656**

§ 371 (c)(1),

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

(87) PCT Pub. No.: **WO2019/098998**

PCT Pub. Date: **May 23, 2019**

(65) **Prior Publication Data**

US 2020/0303825 A1 Sep. 24, 2020

(51) **Int. Cl.**

H01Q 13/10 (2006.01)

H01Q 1/24 (2006.01)

H01Q 1/52 (2006.01)

H01Q 13/18 (2006.01)

H01Q 9/28 (2006.01)

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

CPC **H01Q 13/10** (2013.01); **H01Q 1/242** (2013.01); **H01Q 1/528** (2013.01); **H01Q 9/28** (2013.01); **H01Q 13/18** (2013.01)

(58) **Field of Classification Search**

CPC **H01Q 13/10**; **H01Q 13/18**; **H01Q 1/242**;
H01Q 9/28; **H01Q 1/528**

See application file for complete search history.

(56) **References Cited**

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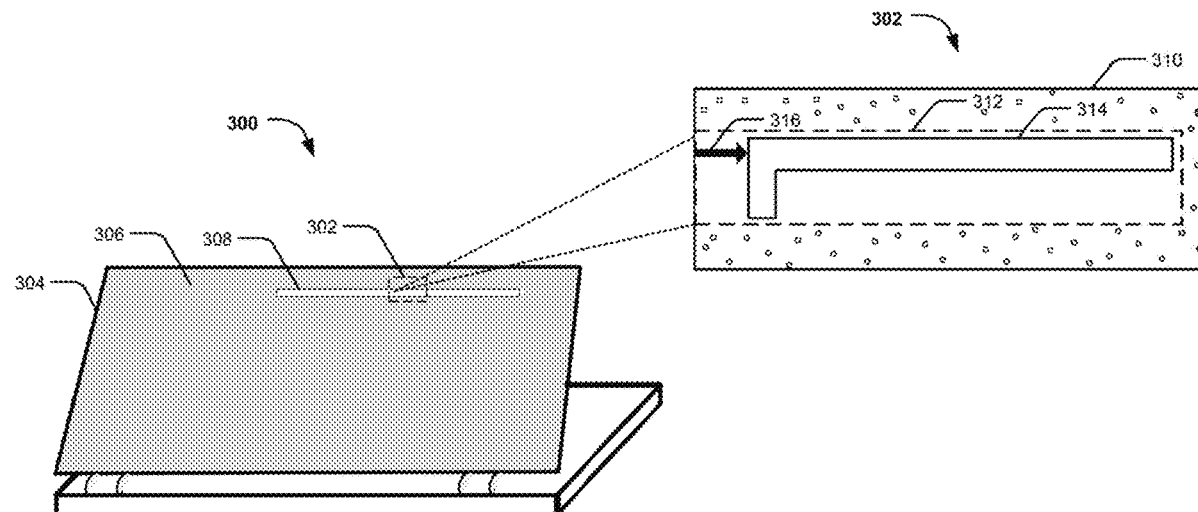
Primary Examiner — Joseph J Lauture

(74) *Attorney, Agent, or Firm* — HPI Patent Department

(57) **ABSTRACT**

Examples of slot antennas are described herein. In an example, the slot antenna includes a substrate and an antenna element disposed on the substrate to transmit and receive signals. The substrate is porous.

12 Claims, 4 Drawing Sheets





US011264730B2

(12) **United States Patent**
Thompson, Jr. et al.

(10) **Patent No.:** **US 11,264,730 B2**
(45) **Date of Patent:** **Mar. 1, 2022**

(54) **QUAD-PORT RADIATING ELEMENT**

(71) Applicant: **Amphenol Antenna Solutions, Inc.**,
Rockford, IL (US)

(72) Inventors: **James E. Thompson, Jr.**, Mooresville,
NC (US); **Mark W. Kishler**, Lenoir,
NC (US); **Jodie M. Bell**, Tallahassee, FL
(US); **Joshua W. Shehan**, Melbourne,
FL (US); **Kostyantyn Semonov**,
Denver, NC (US); **Ryan M. Nagel**,
Hickory, NC (US); **James C. Carson**,
Newton, NC (US)

(73) Assignee: **Amphenol Antenna Solutions, Inc.**,
Rockford, IL (US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 244 days.

(21) Appl. No.: **16/452,133**

(22) Filed: **Jun. 25, 2019**

(65) **Prior Publication Data**

US 2020/0006862 A1 Jan. 2, 2020

Related U.S. Application Data

(60) Provisional application No. 62/690,570, filed on Jun.
27, 2018.

(51) **Int. Cl.**

H01Q 21/06 (2006.01)

H01Q 21/00 (2006.01)

H01Q 9/30 (2006.01)

H04B 7/0413 (2017.01)

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

CPC **H01Q 21/061** (2013.01); **H01Q 9/30**
(2013.01); **H01Q 21/0006** (2013.01); **H01Q**
21/0031 (2013.01); **H04B 7/0413** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 21/26; H01Q 9/40
See application file for complete search history.

(56) **References Cited**

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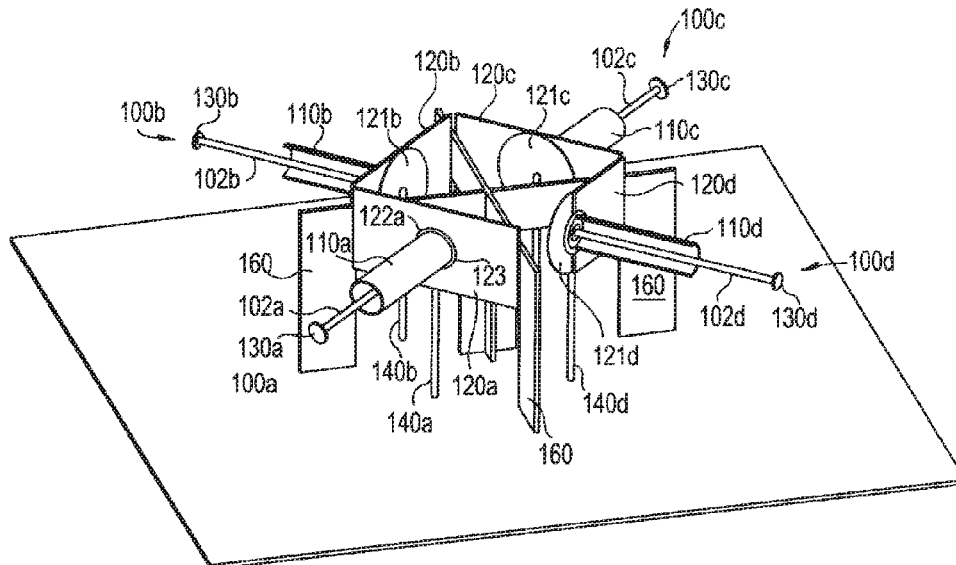
Primary Examiner — Ricardo I Magallanes

(74) *Attorney, Agent, or Firm* — Blank Rome LLP

(57) **ABSTRACT**

An Antenna Radiating Element provides 4 simultaneous
isolated radiation ports that can be used to increase the
orders of MIMO communication for wireless applications.
An antenna array that contains a plurality of the Quad-Port
Radiating Elements (QPRE). An antenna that contains mul-
tiple arrays of the QPRE in single-band or Multi-Band
configurations that produces 2× the available polarization
states without the need to increase the antenna aperture or
reduce the size of the antenna array.

7 Claims, 12 Drawing Sheets





US011264734B2

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

(10) **Patent No.:** **US 11,264,734 B2**
(45) **Date of Patent:** **Mar. 1, 2022**

(54) **ANTENNA AND ELECTRONIC DEVICE INCLUDING SAME**

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

(72) Inventors: **Sungyoung Lee**, Suwon-si (KR);
Sanghun Park, Suwon-si (KR);
Gunwoo Lee, Suwon-si (KR); **Jongjoo Je**, Suwon-si (KR)

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

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

(21) Appl. No.: **16/971,526**

(22) PCT Filed: **Jul. 31, 2020**

(86) PCT No.: **PCT/KR2020/010157**

§ 371 (c)(1),

(2) Date: **Aug. 20, 2020**

(87) PCT Pub. No.: **WO2021/025393**

PCT Pub. Date: **Feb. 11, 2021**

(65) **Prior Publication Data**

US 2021/0218128 A1 Jul. 15, 2021

(30) **Foreign Application Priority Data**

Aug. 2, 2019 (KR) 10-2019-0094589

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 1/42 (2006.01)

(Continued)

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

CPC **H01Q 21/08** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 21/062** (2013.01); **H01Q 21/065** (2013.01)

(58) **Field of Classification Search**

CPC **H01Q 1/24**; **H01Q 1/243**; **H01Q 5/307**;
H01Q 9/0407; **H01Q 1/12**; **H01Q 1/1221**;

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(56)

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Primary Examiner — Thai Pham

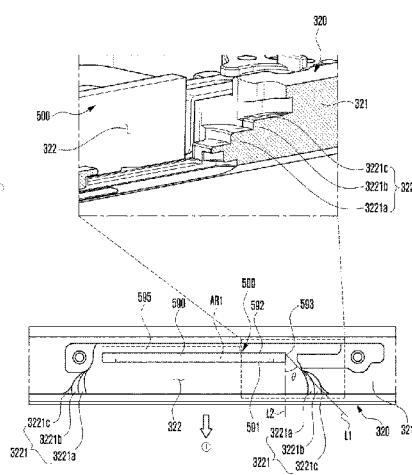
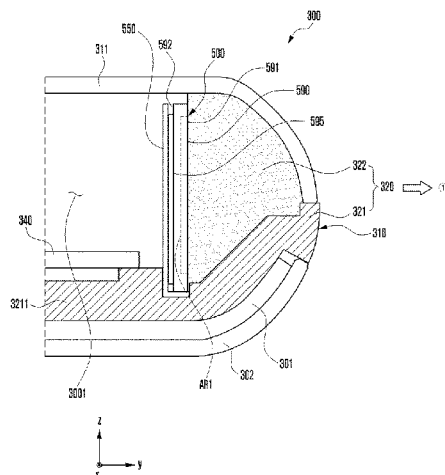
(74) Attorney, Agent, or Firm — Jefferson IP Law, LLP

(57)

ABSTRACT

According to various embodiments, an electronic device may include: a housing including a side member including a conductive member and a non-conductive member coupled with the conductive member; and at least one antenna structure disposed in an internal space of the housing and including a substrate disposed to face the side member, and at least one antenna element which is disposed on the substrate such that a beam pattern is formed through the non-conductive member in a direction in which the side member faces, wherein: when the side member is viewed from the outside, a boundary region between the conductive member and the non-conductive member is disposed in a region not overlapping the substrate; in the boundary region, the conductive member includes at least one concave part formed to at least partially receive the non-conductive member; and the at least one concave part includes two or more stepped parts which gradually get higher or lower as

(Continued)





US011271285B2

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

(10) **Patent No.:** **US 11,271,285 B2**
(45) **Date of Patent:** **Mar. 8, 2022**

(54) **ANTENNA STRUCTURE**

(71) Applicant: **Shenzhen Next Generation Communications Limited**, Shenzhen (CN)

(72) Inventors: **Jia Chen**, Shenzhen (CN); **Kuo-Cheng Chen**, New Taipei (TW); **Jian-Wei Chang**, New Taipei (TW); **Zhen-Chang Tang**, Shenzhen (CN); **Bo Peng**, Shenzhen (CN); **Wei-Yu Ye**, Shenzhen (CN); **Chun-Sheng Wu**, New Taipei (TW)

(73) Assignee: **Mobile Drive Netherlands B.V.**, Amsterdam (NL)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 88 days.

(21) Appl. No.: **16/568,981**

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

(65) **Prior Publication Data**

US 2020/0091589 A1 Mar. 19, 2020

(30) **Foreign Application Priority Data**

Sep. 13, 2018 (CN) 201811070579.3

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 5/30 (2015.01)

H01Q 5/10 (2015.01)

H01Q 21/30 (2006.01)

H01Q 13/10 (2006.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 5/10** (2015.01); **H01Q 5/30** (2015.01); **H01Q 13/10** (2013.01); **H01Q 21/30** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 5/30; H01Q 5/10; H01Q 13/10; H01Q 1/241; H01Q 1/242; H01Q 1/38; H01Q 13/22; H01Q 15/167; H01Q 21/30

See application file for complete search history.

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Primary Examiner — Andrea Lindgren Baltzell

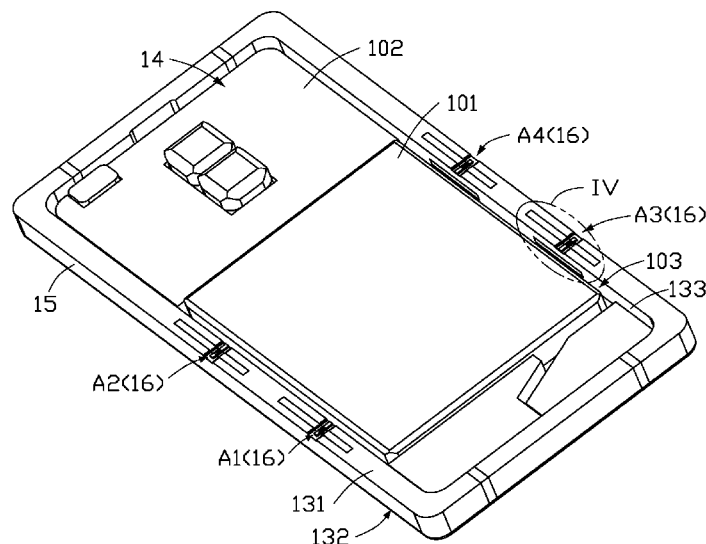
Assistant Examiner — Yonchan J Kim

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

(57) **ABSTRACT**

An antenna structure includes a metal frame. The metal frame includes a first surface, a second surface, and a third surface. The third surface is located between the first surface and the second surface. The metal frame includes at least one antenna. The at least one antenna includes a first gap, a second gap, and a feed portion. The first gap is disposed between the first surface and the second surface. The second gap is disposed in the third surface. The feed portion is mounted on the first surface and spans the first gap. When the feed portion supplies an electric current, the electric current is coupled to the first gap and the second gap.

20 Claims, 6 Drawing Sheets





US011271287B2

(12) **United States Patent**
Andujar Linares et al.

(10) **Patent No.:** **US 11,271,287 B2**

(45) **Date of Patent:** ***Mar. 8, 2022**

(54) **WIRELESS DEVICE AND ANTENNA
SYSTEM WITH EXTENDED BANDWIDTH**

(71) Applicant: **Fractus Antennas, S.L.**, Barcelona
(ES)

(72) Inventors: **Aurora Andujar Linares**, Barcelona
(ES); **Jaume Anguera Pros**, Vinaros
(ES); **Carles Puente Baliarda**,
Barcelona (ES)

(73) Assignee: **IGNION, S.L.**, Barcelona (ES)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 6 days.

This patent is subject to a terminal dis-
claimer.

(21) Appl. No.: **16/733,842**

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

(65) **Prior Publication Data**

US 2020/0144700 A1 May 7, 2020

Related U.S. Application Data

(63) Continuation of application No. 15/621,792, filed on
Jun. 13, 2017, now Pat. No. 10,601,110.
(Continued)

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/36 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/36**
(2013.01); **H01Q 5/335** (2015.01); **H01Q**
5/371 (2015.01);
(Continued)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/36; H01Q 5/335;
H01Q 5/371; H01Q 5/40; H01Q 9/0421;
H01Q 9/42

See application file for complete search history.

(56) **References Cited**

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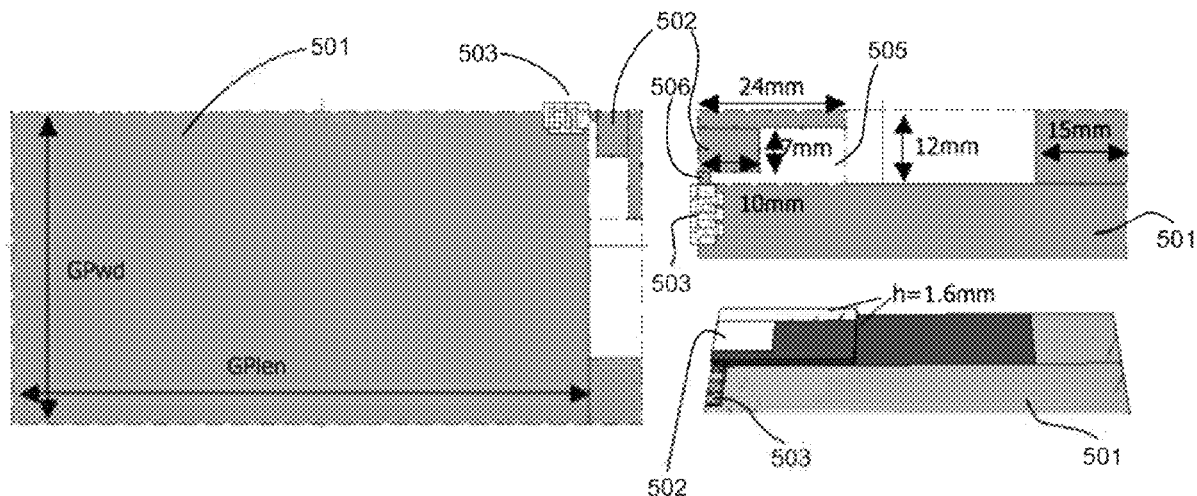
Primary Examiner — Hoang V Nguyen

(74) *Attorney, Agent, or Firm* — Edell, Shapiro & Finnan,
LLC

(57) **ABSTRACT**

An apparatus comprises an antenna element operable in
multiple frequency bands and configured to be connected to
a ground plane and to a radiofrequency system to provide
impedance matching at the multiple frequency bands, where
the radiofrequency system comprising at least a matching
network. A maximum length of the antenna element is
shorter than $L/12$ but longer than $L/22$, where L is the
free-space wavelength corresponding to a lowest frequency
related to a lowest frequency region of operation of the
antenna element. A contour of the antenna element has a
complexity factor $F12$ less than 1.25.

15 Claims, 3 Drawing Sheets





US011271288B2

(12) **United States Patent**
Ke

(10) **Patent No.:** **US 11,271,288 B2**
(45) **Date of Patent:** **Mar. 8, 2022**

(54) **METAL MIDDLE FRAME,
MILLIMETER-WAVE ANTENNA
STRUCTURE, AND MOBILE TERMINAL**

(71) Applicant: **BEIJING XIAOMI MOBILE
SOFTWARE CO., LTD.**, Beijing (CN)

(72) Inventor: **Changqing Ke**, Beijing (CN)

(73) Assignee: **BEIJING XIAOMI MOBILE
SOFTWARE 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 56 days.

(21) Appl. No.: **16/818,492**

(22) Filed: **Mar. 13, 2020**

(65) **Prior Publication Data**

US 2021/0135336 A1 May 6, 2021

(30) **Foreign Application Priority Data**

Oct. 30, 2019 (CN) 201911043880.X

(51) **Int. Cl.**

H04Q 1/24 (2006.01)

H04M 1/02 (2006.01)

H01Q 1/42 (2006.01)

H01Q 1/24 (2006.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/421**
(2013.01); **H04M 1/026** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 13/16; H01Q 1/243; H01Q 1/421;
H01Q 21/064; H01Q 21/08; H01Q 21/28;
H04M 1/026

USPC 455/453, 575.1, 575.5, 575.7; 342/702
See application file for complete search history.

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Primary Examiner — Tan H Trinh

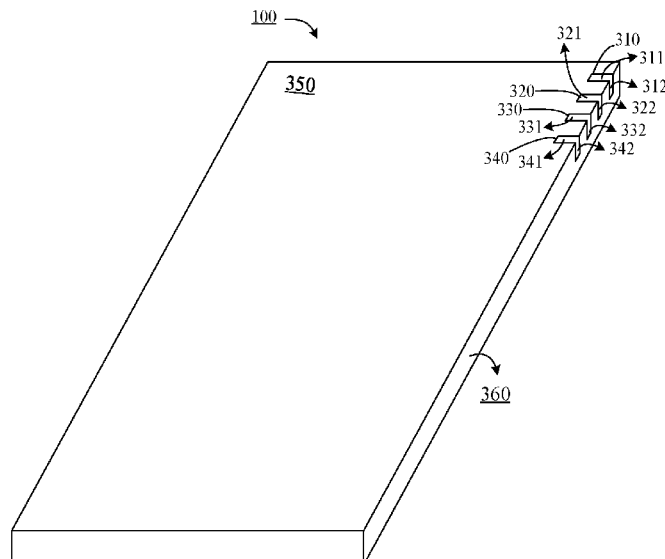
(74) *Attorney, Agent, or Firm* — Syncoda LLC; Feng Ma

(57)

ABSTRACT

A frame body of the metal middle frame includes a first side and a second side, which are jointed at a side edge of the first side and second side; an L-shaped slit is arranged on the frame body, and includes a first slit edge and a second slit edge which are jointed at an end point of the first slit edge and the second slit edge, the first slit edge is arranged on the first side, and the second slit edge is arranged on the second side; and a millimeter-wave antenna is arranged in the L-shaped slit, and the millimeter-wave antenna is configured to perform millimeter-wave radiation through the first slit edge and the second slit edge.

20 Claims, 5 Drawing Sheets





US011271303B2

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

(10) **Patent No.:** **US 11,271,303 B2**
(45) **Date of Patent:** **Mar. 8, 2022**

(54) **ANTENNA, SMART WINDOW, AND METHOD OF FABRICATING ANTENNA**

(71) Applicant: **BOE Technology Group Co., Ltd.**,
Beijing (CN)

(72) Inventors: **Yuan Yao**, Beijing (CN); **Lei Wang**,
Beijing (CN); **Tuo Sun**, Beijing (CN)

(73) Assignees: **BOE Technology Group Co., Ltd.**,
Beijing (CN); **Beijing University of
Posts and Telecommunications**,
Beijing (CN)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 36 days.

(21) Appl. No.: **16/756,111**

(22) PCT Filed: **May 24, 2019**

(86) PCT No.: **PCT/CN2019/088324**

§ 371 (c)(1),

(2) Date: **Apr. 14, 2020**

(87) PCT Pub. No.: **WO2020/140368**

PCT Pub. Date: **Jul. 9, 2020**

(65) **Prior Publication Data**

US 2021/0226325 A1 Jul. 22, 2021

(30) **Foreign Application Priority Data**

Jan. 3, 2019 (CN) 201910004275.5

Jan. 3, 2019 (CN) 201910004663.3

(51) **Int. Cl.**

H01Q 1/38 (2006.01)

H01Q 5/35 (2015.01)

(Continued)

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

CPC **H01Q 5/35** (2015.01); **H01Q 1/36**
(2013.01); **H01Q 1/38** (2013.01); **H01Q 21/26**
(2013.01)

(58) **Field of Classification Search**

CPC .. **H01Q 1/36**; **H01Q 1/38**; **H01Q 5/25**; **H01Q**
5/35; **H01Q 9/065**; **H01Q 9/28**
See application file for complete search history.

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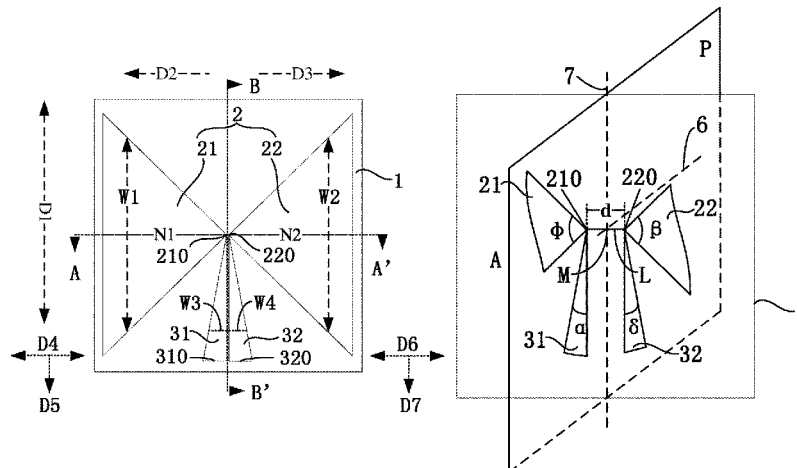
Primary Examiner — Thien M Le

(74) Attorney, Agent, or Firm — Intellectual Valley Law,
P.C.

(57) **ABSTRACT**

An antenna is provided. The antenna includes a substantially transparent base substrate; a first pattern having a first feed point and a second pattern having a second feed point spaced apart from each other; a first feed line electrically connected to the first pattern through the first feed point; and a second feed line electrically connected to the second pattern through the second feed point. A first width along a first direction, of the first pattern, gradually increases along a second direction. A second width along the first direction, of the second pattern, gradually increases along a third direction substan-

(Continued)





US011271310B2

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

(10) **Patent No.:** **US 11,271,310 B2**
(45) **Date of Patent:** **Mar. 8, 2022**

(54) **ANTENNA DEVICE**

(71) Applicant: **DENSO CORPORATION**, Kariya (JP)

(72) Inventors: **Yuuji Kakuya**, Nisshin (JP); **Hidenori Akita**, Kariya (JP); **Masakazu Ikeda**, Nisshin (JP); **Kenichirou Sanji**, Nisshin (JP); **Hiroyuki Izumi**, Kariya (JP)

(73) Assignee: **DENSO CORPORATION**, Kariya (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.

(21) Appl. No.: **16/840,484**

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

(65) **Prior Publication Data**

US 2020/0328516 A1 Oct. 15, 2020

(30) **Foreign Application Priority Data**

Apr. 10, 2019 (JP) JP2019-075085

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/48 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0407** (2013.01); **H01Q 1/48** (2013.01)

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

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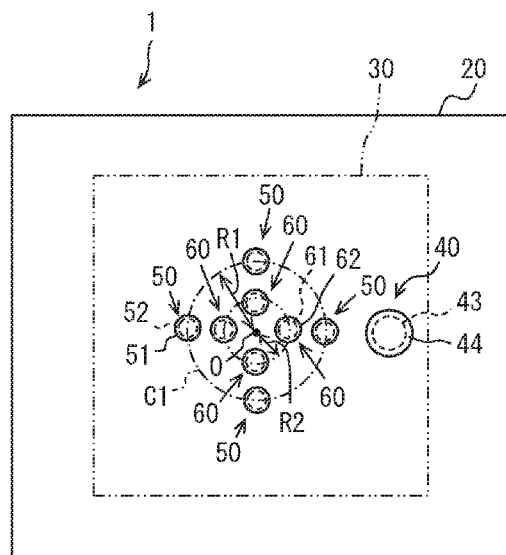
Primary Examiner — Crystal L Hammond

(74) *Attorney, Agent, or Firm* — Hamess, Dickey & Pierce, P.L.C.

(57) **ABSTRACT**

An antenna device includes a ground plate that is a conductive member having a plate shape, a patch section that is a conductive member having a plate shape and is disposed in parallel with the ground plate with a predetermined interval so as to face the ground plate, a plurality of first short-circuit vias each having an axial center disposed on a circumference of a via arrangement circle located in a center portion of the patch section and each having a first end connected with the patch section and a second end connected with the ground plate, and at least one second short-circuit via having an axial center disposed at a position different from the circumference of the via arrangement circle and having a first end connected with the patch section and a second end connected with the ground plate.

3 Claims, 5 Drawing Sheets





US011271311B2

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

(10) **Patent No.:** **US 11,271,311 B2**
(45) **Date of Patent:** ***Mar. 8, 2022**

(54) **COMPACT WIDEBAND INTEGRATED
THREE-BROADSIDE-MODE PATCH
ANTENNA**

(71) Applicant: **The Hong Kong University of Science
and Technology**, Hong Kong (CN)

(72) Inventors: **Chi Yuk Chiu**, Hong Kong (CN); **Ross
David Murch**, Hong Kong (CN)

(73) Assignee: **THE HONG KONG UNIVERSITY
OF SCIENCE AND TECHNOLOGY**,
Hong Kong (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.

This patent is subject to a terminal dis-
claimer.

(21) Appl. No.: **17/064,266**

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

(65) **Prior Publication Data**

US 2021/0021041 A1 Jan. 21, 2021

Related U.S. Application Data

(63) Continuation-in-part of application No. 16/220,916,
filed on Dec. 14, 2018, now Pat. No. 10,854,977.

(60) Provisional application No. 62/973,720, filed on Oct.
22, 2019, provisional application No. 62/708,755,
filed on Dec. 21, 2017.

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 21/06 (2006.01)
H01Q 5/50 (2015.01)
H01Q 5/15 (2015.01)

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

CPC **H01Q 9/0407** (2013.01); **H01Q 5/15**
(2015.01); **H01Q 5/50** (2015.01); **H01Q**
21/065 (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/0407; H01Q 5/15; H01Q 5/50;
H01Q 21/065; H01Q 21/24; H01Q 21/28
See application file for complete search history.

(56) **References Cited**

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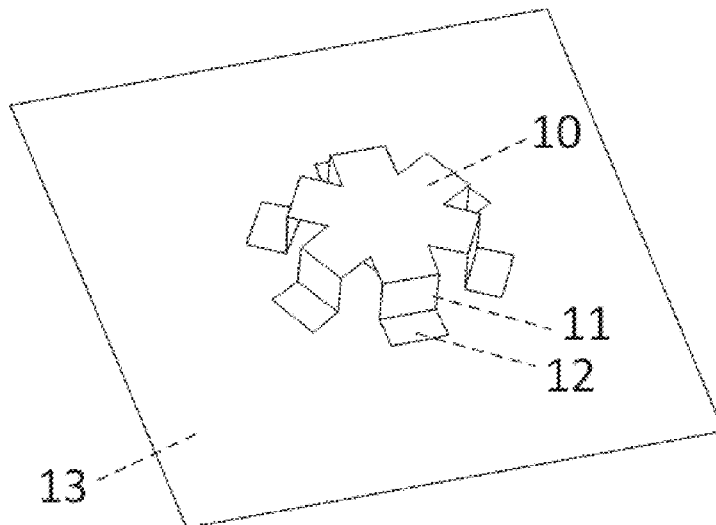
Primary Examiner — Hoang V Nguyen

(74) *Attorney, Agent, or Firm* — Leydig, Voit & Mayer,
Ltd.

(57) **ABSTRACT**

A three-broadside-mode patch antenna includes: a rotation-
ally symmetric radiator; a patch, wherein the patch is
separated from the rotationally symmetric radiator by a
dielectric and configured to capacitively feed the rotationally
symmetric radiator; and three antenna probes, connected to
the patch, configured to provide three antenna ports corre-
sponding to three respective broadside radiation polariza-
tions.

21 Claims, 27 Drawing Sheets





US011271314B2

(12) **United States Patent**
Ishizuka

(10) **Patent No.:** **US 11,271,314 B2**
(45) **Date of Patent:** **Mar. 8, 2022**

(54) **ANTENNA COUPLING ELEMENT,
ANTENNA DEVICE, AND ELECTRONIC
DEVICE**

(71) Applicant: **Murata Manufacturing Co., Ltd.,**
Nagaokakyo (JP)
(72) Inventor: **Kenichi Ishizuka**, Nagaokakyo (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 10 days.

(21) Appl. No.: **16/744,226**

(22) Filed: **Jan. 16, 2020**

(65) **Prior Publication Data**
US 2020/0153099 A1 May 14, 2020

Related U.S. Application Data
(63) Continuation of application No.
PCT/JP2018/021580, filed on Jun. 5, 2018.

(30) **Foreign Application Priority Data**
Jul. 21, 2017 (JP) JP2017-141549

(51) **Int. Cl.**
H01Q 5/30 (2015.01)
H01Q 9/04 (2006.01)
H01Q 1/48 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/045** (2013.01); **H01Q 1/48**
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/48–1/50; H01Q 5/30–5/392
See application file for complete search history.

(56) **References Cited**

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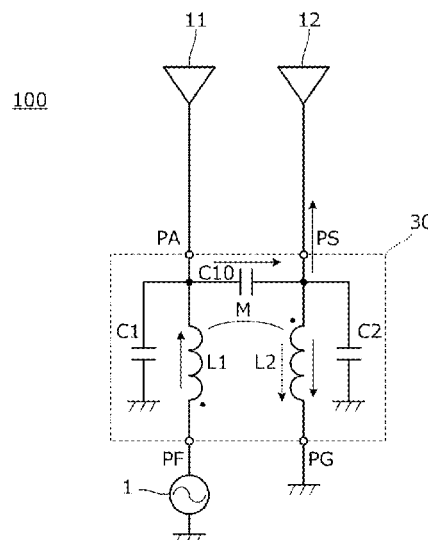
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Primary Examiner — Hasan Islam
(74) *Attorney, Agent, or Firm* — Keating & Bennett, LLP

(57) **ABSTRACT**

An antenna device includes first and second radiating elements, and an antenna coupling element. The antenna coupling element includes a primary coil electrically connected between the first radiating element and a feed circuit and a secondary coil inductively coupled to the primary coil and electrically connected between the second radiating element and a ground. A capacitor is provided between the primary coil and the secondary coil, thus causing current to flow from the primary coil to the secondary coil or the second radiating element via the capacitor even at an anti-resonant frequency of the first radiating element.

17 Claims, 6 Drawing Sheets





US011271315B2

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

(10) **Patent No.:** **US 11,271,315 B2**
(45) **Date of Patent:** **Mar. 8, 2022**

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

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

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333/133

(72) Inventors: **Kengo Onaka**, Kyoto (JP); **Yoshiki Yamada**, Kyoto (JP); **Keiichi Hirose**, Kyoto (JP); **Hirotsugu Mori**, Kyoto (JP)

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

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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 57 days.

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(21) Appl. No.: **16/818,339**

(22) Filed: **Mar. 13, 2020**

(65) **Prior Publication Data**

US 2020/0220270 A1 Jul. 9, 2020

Primary Examiner — Dieu Hien T Duong

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

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2018/028180, filed on Jul. 27, 2018.

(30) **Foreign Application Priority Data**

Sep. 14, 2017 (JP) JP2017-176596

(51) **Int. Cl.**

H01Q 1/38 (2006.01)

H01Q 9/04 (2006.01)

(Continued)

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

CPC **H01Q 9/045** (2013.01); **H01Q 1/2208** (2013.01); **H01Q 1/422** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/045; H01Q 1/2208; H01Q 1/422; H01Q 1/241

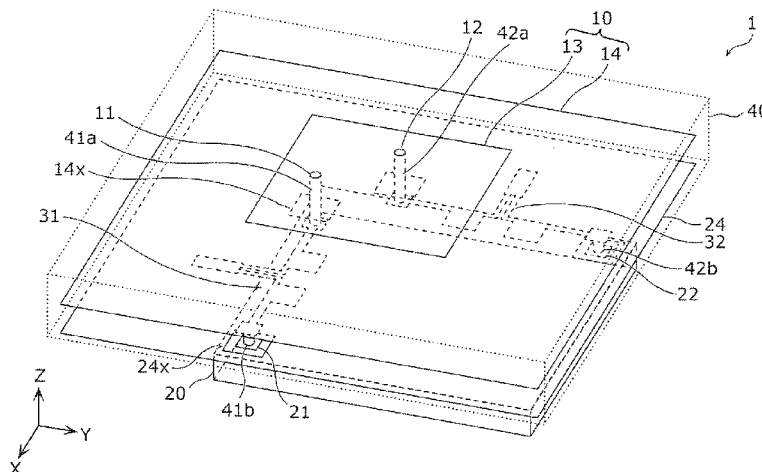
See application file for complete search history.

(57)

ABSTRACT

An antenna module includes a multilayer substrate having a first main surface and a second main surface opposing to each other, a patch antenna formed on a side of the first main surface of the multilayer substrate and configured with a radiation electrode and a ground electrode, an RFIC formed on a side of the second main surface of the multilayer substrate, a first filter, and a second filter different from the first filter, wherein the patch antenna has a first feed point and a second feed point provided at different positions in the radiation electrode, the first feed point is electrically connected to the RFIC via the first filter, the second feed point is electrically connected to the RFIC via the second filter, and the first filter and the second filter are formed in the multilayer substrate.

20 Claims, 10 Drawing Sheets





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

(10) **Patent No.:** **US 11,271,322 B2**
(45) **Date of Patent:** **Mar. 8, 2022**

(54) **SUBSTRATE INTEGRATED WAVEGUIDE
FED ANTENNA**

21/062; H01Q 5/378; H01Q 13/106;
H01Q 19/108; H01Q 19/005; H01Q
5/392; H01Q 21/0037; H01Q 9/16

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

See application file for complete search history.

(56) **References Cited**

(72) Inventors: **Chi Hou Chan,** Kowloon (HK);
Manting Wang, Kowloon (HK)

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

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
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(21) Appl. No.: **16/889,089**

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(22) Filed: **Jun. 1, 2020**

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ering 57-71 GHz Band for 5G Applications—Zhu et al. (Year:
2017).*

(65) **Prior Publication Data**

US 2021/0376483 A1 Dec. 2, 2021

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(51) **Int. Cl.**

H01Q 21/00 (2006.01)
H01Q 9/06 (2006.01)
H01Q 5/30 (2015.01)
H01Q 21/06 (2006.01)
H01Q 9/16 (2006.01)
H01Q 9/28 (2006.01)
H01Q 5/378 (2015.01)
H01Q 5/392 (2015.01)

Primary Examiner — Vibol Tan

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

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

CPC **H01Q 21/0037** (2013.01); **H01Q 5/378**
(2015.01); **H01Q 5/392** (2015.01); **H01Q**
9/065 (2013.01); **H01Q 9/16** (2013.01); **H01Q**
9/285 (2013.01); **H01Q 21/062** (2013.01)

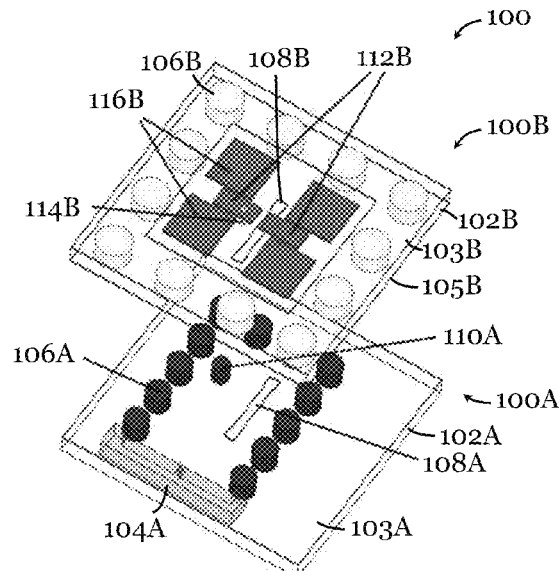
(57) **ABSTRACT**

A substrate integrated waveguide fed antenna. The antenna
includes an electric dipole, a parasitic patch arrangement
operably coupled with the electric dipole, and a feed struc-
ture. The feed structure includes a substrate integrated
waveguide operably coupled with the electric dipole for
exciting the electric dipole. A slotted conductive surface
with a slot is arranged between the electric dipole and the
feed structure for operably coupling the feed structure with
the electric dipole.

(58) **Field of Classification Search**

CPC H01Q 9/285; H01Q 21/065; H01Q 9/065;
H01Q 13/10; H01Q 21/0075; H01Q

33 Claims, 25 Drawing Sheets
(2 of 25 Drawing Sheet(s) Filed in Color)



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

(10) **Patent No.:** **US 11,271,326 B2**
(45) **Date of Patent:** **Mar. 8, 2022**

(54) **ANTENNA SYSTEM**

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

(72) Inventors: **Ying-Sheng Fang**, New Taipei (TW);
Po-Tsang Lin, New Taipei (TW);
Chia-Wei Su, New Taipei (TW);
Pei-Cheng Hu, 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 30 days.

(21) Appl. No.: **16/281,336**

(22) Filed: **Feb. 21, 2019**

(65) **Prior Publication Data**

US 2020/0235491 A1 Jul. 23, 2020

(30) **Foreign Application Priority Data**

Jan. 22, 2019 (TW) 108102350

(51) **Int. Cl.**

H01Q 21/08 (2006.01)
H01Q 9/06 (2006.01)
H01Q 1/48 (2006.01)
H01Q 21/00 (2006.01)

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

CPC **H01Q 21/08** (2013.01); **H01Q 1/48** (2013.01); **H01Q 9/06** (2013.01); **H01Q 21/0006** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 21/00; H01Q 21/06
USPC 343/848, 893
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Amy Cohen Johnson

Assistant Examiner — James H Cho

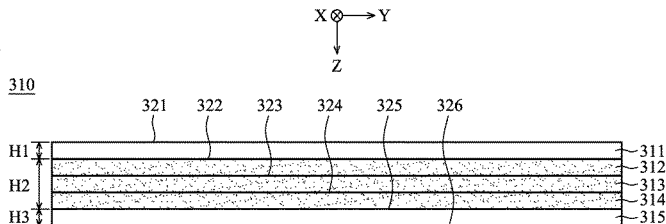
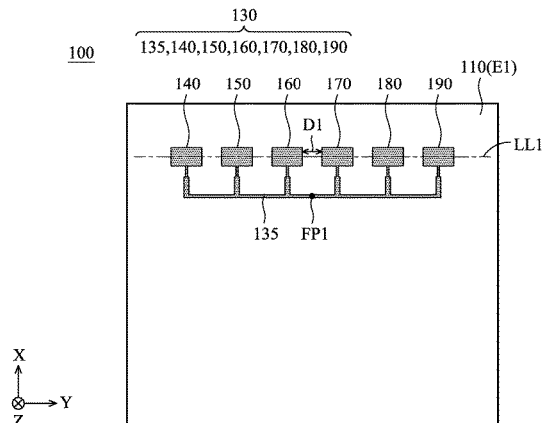
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57)

ABSTRACT

An antenna system includes a dielectric substrate, a ground plane, and a first antenna array. The ground plane is disposed on a second surface of the dielectric substrate. The first antenna array is disposed on a first surface of the dielectric substrate. The first antenna array includes a first transmission line, a first antenna element, a second antenna element, a third antenna element, a fourth antenna element, a fifth antenna element, and a sixth antenna element. The first transmission line has a first feeding point and is coupled to the first antenna element, the second antenna element, the third antenna element, the fourth antenna element, the fifth antenna element, and the sixth antenna element. The first antenna element, the second antenna element, the third antenna element, the fourth antenna element, the fifth antenna element, and the sixth antenna element are all substantially arranged in a first straight line.

15 Claims, 8 Drawing Sheets





US011276916B2

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

(10) **Patent No.:** **US 11,276,916 B2**
(45) **Date of Patent:** **Mar. 15, 2022**

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

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

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(72) Inventors: **Dongyeon Kim**, Suwon-si (KR);
Ahmed Hussain, Suwon-si (KR);
Seongjin Park, Suwon-si (KR);
Sehyun Park, Suwon-si (KR); **Sumin Yun**, Suwon-si (KR); **Woomin Jang**,
Suwon-si (KR); **Myunghun Jeong**,
Suwon-si (KR); **Jehun Jong**, Suwon-si
(KR); **Jaehoon Jo**, 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.

Primary Examiner — Pablo N Tran

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

(21) Appl. No.: **16/750,541**

(57) **ABSTRACT**

(22) Filed: **Jan. 23, 2020**

(65) **Prior Publication Data**

US 2020/0243948 A1 Jul. 30, 2020

(30) **Foreign Application Priority Data**

Jan. 25, 2019 (KR) 10-2019-0009581

(51) **Int. Cl.**

H01Q 13/10 (2006.01)

H01Q 9/04 (2006.01)

(Continued)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/38**
(2013.01); **H01Q 9/0407** (2013.01)

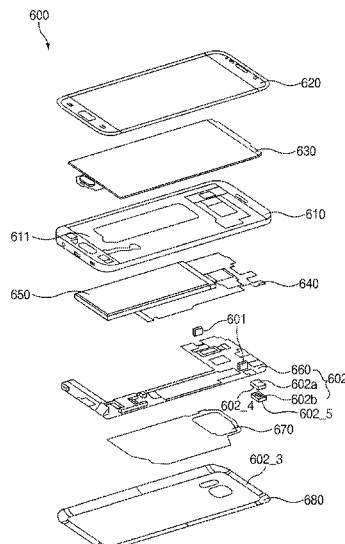
(58) **Field of Classification Search**

None

See application file for complete search history.

An electronic device is provided. The electronic device includes a housing, a display exposed through at least part of the first plate, an antenna structure body disposed inside the housing and including a first surface facing the non-conductive portion and a second surface facing away from the first surface, a spacer structure coupled to the first surface or integrally formed with the antenna structure body to protrude from the first surface without overlapping with the conductive pattern when viewed from above the first surface, and a wireless communication circuit electrically connected to the conductive pattern and configured to transmit or receive a signal. At least part of the first plate, the second plate, or the side member includes a non-conductive portion. The antenna structure body includes at least one conductive pattern disposed between the first surface and the second surface or on the first surface.

19 Claims, 12 Drawing Sheets





US011276923B2

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

(10) **Patent No.:** **US 11,276,923 B2**
(45) **Date of Patent:** **Mar. 15, 2022**

(54) **MULTI-BAND ANTENNA ARRANGEMENT**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

(72) Inventors: **Jiangcheng Chen**, Oulu (FI); **Markus Berg**, Kiiminki (FI)

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

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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 127 days.

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(21) Appl. No.: **16/863,634**

(22) Filed: **Apr. 30, 2020**

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(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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May 2, 2019 (EP) 19172157

Primary Examiner — Thanh C Le

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

(51) **Int. Cl.**

H01Q 1/52 (2006.01)

H01Q 5/10 (2015.01)

H01Q 1/24 (2006.01)

H01Q 9/28 (2006.01)

(57) **ABSTRACT**

A multi-layer antenna arrangement is provided that includes a first layer having a conductive radiating element configured to have multiple overlapping resonant modes that define a first frequency range. The multi-layer antenna arrangement also includes a second layer having at least a portion of a ground plane for the conductive radiating element. The multi-layer antenna arrangement additionally includes a third layer, between the first layer and the second layer, that has a conductive resonator configured to provide a stop band within the first frequency range.

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

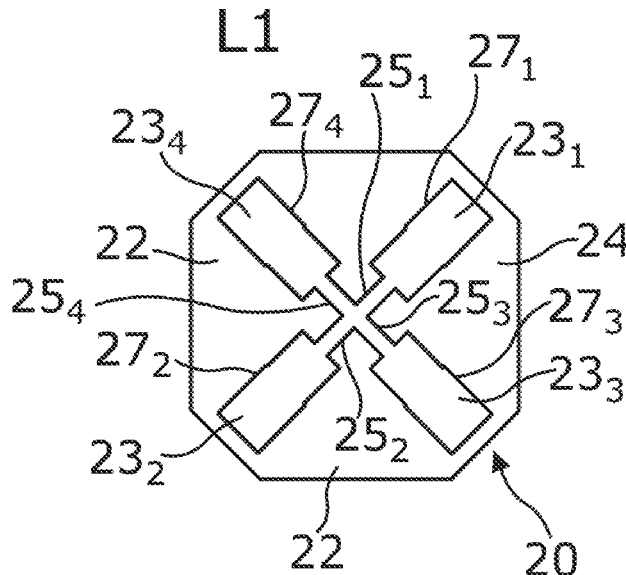
CPC **H01Q 1/52** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/246** (2013.01); **H01Q 5/10** (2015.01); **H01Q 9/285** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/38; H01Q 1/52; H01Q 1/243; H01Q 1/246; H01Q 5/345; H01Q 9/0442; H01Q 9/284; H01Q 5/10; H01Q 13/106

See application file for complete search history.

16 Claims, 6 Drawing Sheets





US011276925B2

(12) **United States Patent**
Ramasamy

(10) **Patent No.:** **US 11,276,925 B2**
(45) **Date of Patent:** **Mar. 15, 2022**

(54) **SYSTEM AND METHOD FOR
ESTABLISHING AND OPERATING PLURAL
ANTENNA SYSTEMS IN PROXIMITY**

(56) **References Cited**

U.S. PATENT DOCUMENTS

(71) Applicant: **Dell Products, LP**, Round Rock, TX
(US)

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

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(21) Appl. No.: **15/884,644**

CN 106935964 A 7/2017

(22) Filed: **Jan. 31, 2018**

Primary Examiner — Dimary S Lopez Cruz

Assistant Examiner — Bamidele A Jegede

(65) **Prior Publication Data**

US 2019/0237865 A1 Aug. 1, 2019

(74) *Attorney, Agent, or Firm* — Prol Intellectual Property
Law, PLLC; H. Kenneth Prol

(57) **ABSTRACT**

An information handling system comprising a processor, a memory, and a wireless adapter with a first and second antenna feed operatively connected to the wireless adapter for communicating on a plurality of wireless links and disposed on a circuit board having a trench through one or more metallic layers with a perimeter edge dimension extending from an outer edge of the circuit board into the circuit board where the first antenna feed mounted adjacent to a first side of the trench of the circuit board and operatively connected to a first antenna and the second antenna feed mounted adjacent to a second side of the trench of the circuit board opposite to the first side and the second antenna feed operatively connected to a second antenna.

(51) **Int. Cl.**

H01Q 1/52 (2006.01)
H01Q 5/35 (2015.01)
H01Q 1/22 (2006.01)
H01Q 21/00 (2006.01)
H01Q 1/02 (2006.01)

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

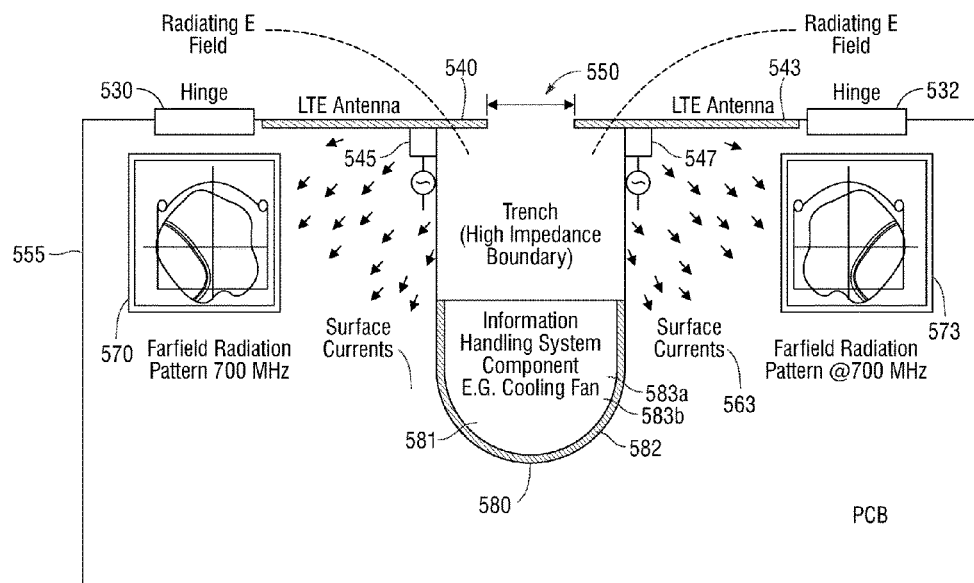
CPC **H01Q 1/523** (2013.01); **H01Q 1/02**
(2013.01); **H01Q 1/2266** (2013.01); **H01Q**
5/35 (2015.01); **H01Q 21/0025** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/523; H01Q 5/35; H01Q 1/02; H01Q
1/2266; H01Q 21/0025

See application file for complete search history.

20 Claims, 9 Drawing Sheets





US011276930B2

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

(10) **Patent No.:** **US 11,276,930 B2**

(45) **Date of Patent:** **Mar. 15, 2022**

(54) **ANTENNA AND MOBILE TERMINAL**

(71) Applicant: **Huawei Technologies Co., Ltd.**,
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(72) Inventors: **Dawei Zhou**, Beijing (CN); **Yuanpeng Li**, Beijing (CN); **Tiezhu Liang**, Beijing (CN); **Gonglei Zhang**, Beijing (CN)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 88 days.

(21) Appl. No.: **16/620,359**

(22) PCT Filed: **Dec. 27, 2018**

(86) PCT No.: **PCT/CN2018/124150**

§ 371 (c)(1),

(2) Date: **Dec. 6, 2019**

(87) PCT Pub. No.: **WO2019/227914**

PCT Pub. Date: **Dec. 5, 2019**

(65) **Prior Publication Data**

US 2020/0106177 A1 Apr. 2, 2020

(30) **Foreign Application Priority Data**

Jun. 1, 2018 (CN) 201810554555.9

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 1/48 (2006.01)

H01Q 5/10 (2015.01)

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

CPC **H01Q 5/10** (2015.01); **H01Q 1/24** (2013.01); **H01Q 1/48** (2013.01)

(58) **Field of Classification Search**

CPC .. **H01Q 5/10**; **H01Q 1/24**; **H01Q 1/48**; **H01Q 9/04**; **H01Q 5/335**; **H01Q 1/243**; **H01Q 5/364**; **H01Q 1/44**; **H01Q 5/378**
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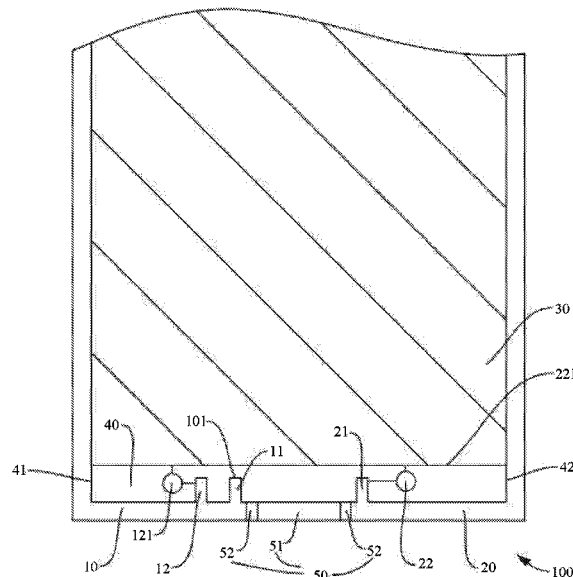
Primary Examiner — Hai V Tran

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

(57) **ABSTRACT**

An antenna disposed on a mobile terminal, where the mobile terminal includes a radiation portion and a circuit board, the circuit board includes a lateral side and a grounding layer, and an insulating slot divides the radiation portion into a feed stub and a parasitic stub. A gap is encompassed by the circuit board and the radiation portion. There is a first branch that extends from the feed stub to the gap for feeding the antenna, and there is a second branch that extends from the parasitic stub to the gap and that is electrically connected to a grounding portion. The antenna excites a current loop winding around the gap on the grounding portion, the feed stub, and the parasitic stub.

20 Claims, 13 Drawing Sheets





US011276934B2

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

(10) **Patent No.:** **US 11,276,934 B2**

(45) **Date of Patent:** **Mar. 15, 2022**

(54) **ANTENNA**

USPC 343/731–737, 772–786, 825–831
See application file for complete search history.

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(56) **References Cited**

(72) Inventors: **Kwok Wa Leung,** Kowloon Tong
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Nan Yang, Kowloon Tong (HK)

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

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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.

(21) Appl. No.: **16/002,261**

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

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(65) **Prior Publication Data**

US 2019/0379123 A1 Dec. 12, 2019

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(51) **Int. Cl.**

H01Q 9/34	(2006.01)
H01Q 9/04	(2006.01)
H01Q 1/22	(2006.01)
H01Q 21/00	(2006.01)
H01Q 13/10	(2006.01)
H01Q 1/48	(2006.01)

Primary Examiner — Binh B Tran

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

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

CPC **H01Q 9/0485** (2013.01); **H01Q 1/22**
(2013.01); **H01Q 1/48** (2013.01); **H01Q 13/10**
(2013.01); **H01Q 21/0068** (2013.01)

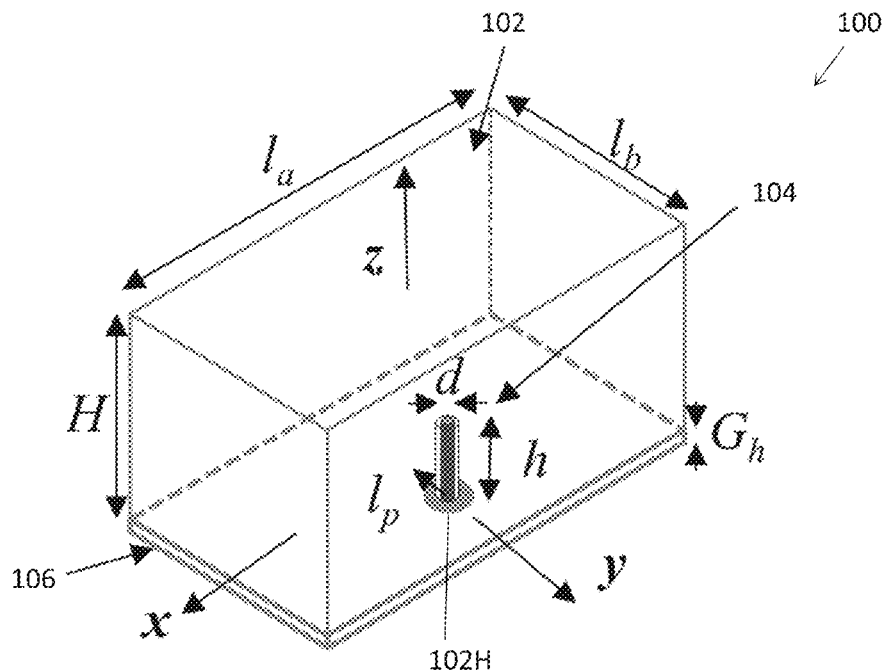
(57) **ABSTRACT**

An antenna and an antenna array, the antenna including a dielectric resonator fed by a feeder connected to a ground plane, wherein the dielectric resonator is arranged to emit an electromagnetic radiation along a wave propagation axis upon an electric excitation input to the feeder, and wherein the electromagnetic radiation is equivalent to a combination of a plurality of electromagnetic wave components.

(58) **Field of Classification Search**

CPC H01Q 11/105; H01Q 13/02; H01Q 13/06;
H01Q 13/04; H01Q 3/2664; H01Q 3/28;
H01Q 13/24; H01Q 9/30; H01Q 9/38

18 Claims, 11 Drawing Sheets





US011276938B2

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

(10) **Patent No.:** **US 11,276,938 B2**
(45) **Date of Patent:** **Mar. 15, 2022**

(54) **SINGLE LAYER ANTENNA**

(56) **References Cited**

(71) Applicant: **Semtech Corporation**, Camarillo, CA (US)

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343/700 MS

(72) Inventors: **Paul James Garrity**, Rockwall, TX (US); **Ross Elliot Teggatz**, The Colony, TX (US); **Antony Eugene Brinlee**, Plano, TX (US)

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(73) Assignee: **SEMTECH CORPORATION**, Camarillo, 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 220 days.

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

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(65) **Prior Publication Data**

US 2019/0214735 A1 Jul. 11, 2019

Primary Examiner — Hasan Islam

(74) *Attorney, Agent, or Firm* — Jackson Walker LLP; Christopher J. Rourke

Related U.S. Application Data

(60) Provisional application No. 62/616,323, filed on Jan. 11, 2018.

(51) **Int. Cl.**

H01Q 1/48 (2006.01)

H01Q 13/10 (2006.01)

(Continued)

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

CPC **H01Q 13/10** (2013.01); **G06K 19/07786** (2013.01); **H01Q 1/2225** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/38; H01Q 1/48; H01Q 13/106

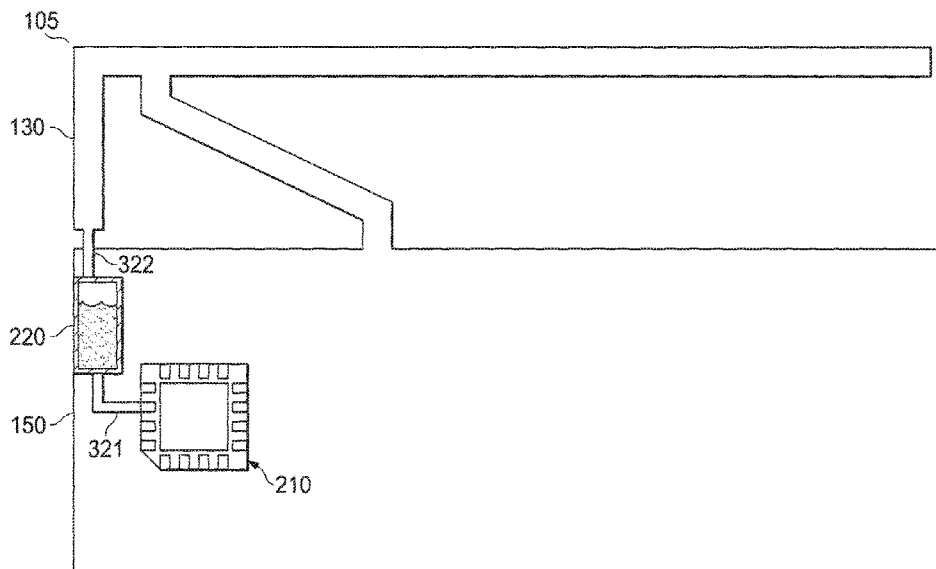
See application file for complete search history.

(57)

ABSTRACT

An antenna is disclosed that includes a ground plane extending in a first direction on a substrate and a radiating element occupying a same plane as the ground plane on the substrate, and coupled to the ground plane, the radiating element comprising a first portion with a first end and a second end extending in a substantially parallel direction to the ground plane, a feed line coupled to the first end of the first portion of the radiating element and extending in a substantially perpendicular direction from the first portion of the radiating element and a second portion having a third end and a fourth end, wherein the third end is coupled to the ground plane and the fourth end is coupled to the radiating element at a point between the first end and the second end.

20 Claims, 4 Drawing Sheets





US011276942B2

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

(10) **Patent No.:** **US 11,276,942 B2**
(45) **Date of Patent:** **Mar. 15, 2022**

(54) **HIGHLY-INTEGRATED MULTI-ANTENNA ARRAY**

FOREIGN PATENT DOCUMENTS

(71) Applicant: **INDUSTRIAL TECHNOLOGY RESEARCH INSTITUTE**, Hsinchu (TW)

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(72) Inventors: **Kin-Lu Wong**, Kaohsiung (TW); **Wei-Yu Li**, Yilan (TW); **Wei Chung**, Hengshan Township (TW)

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(73) Assignee: **INDUSTRIAL TECHNOLOGY RESEARCH INSTITUTE**, Hsinchu (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.

Primary Examiner — Jason Crawford

(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(21) Appl. No.: **16/728,926**

(22) Filed: **Dec. 27, 2019**

(57) **ABSTRACT**

(65) **Prior Publication Data**

US 2021/0203080 A1 Jul. 1, 2021

(51) **Int. Cl.**
H01Q 21/06 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 21/064** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/0043; H01Q 21/005; H01Q 21/0062; H01Q 21/0064; H01Q 13/085; H01Q 13/10; H01Q 13/106; H01Q 19/13
See application file for complete search history.

A highly-integrated multi-antenna array comprising a first conductor layer, a second conductor layer, a plurality of conjoined conducting structures, a plurality of slot antennas, and a conjoined slot structure is provided. The first conductor layer and the second conductor layer are spaced apart by a first interval, and are electrically connected by the conjoined conducting structures. Each slot antenna has a radiating slot structure and a signal coupling line, which partially overlap or cross each other. All radiating slot structures are formed at the second conductor layer. Each signal coupling line is spaced apart from the second conductor layer by a coupling interval and has a signal feeding point. Each slot antenna is excited to generate at least one resonant mode covering at least one identical first communication band. The conjoined slot structure is formed at the second conductor layer and connects with all radiating slot structures.

(56) **References Cited**

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12 Claims, 6 Drawing Sheets

