



US011901625B2

(12) **United States Patent**
Jia

(10) **Patent No.:** **US 11,901,625 B2**
(45) **Date of Patent:** **Feb. 13, 2024**

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

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

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

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 194 days.

(21) Appl. No.: **17/577,980**

(22) Filed: **Jan. 18, 2022**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. PCT/CN2020/115516, filed on Sep. 16, 2020.

(30) **Foreign Application Priority Data**

Sep. 30, 2019 (CN) 201910948454.4

(51) **Int. Cl.**
H01Q 15/00 (2006.01)
H01Q 1/24 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 15/0026** (2013.01); **H01Q 1/42** (2013.01); **H01Q 1/44** (2013.01); **H01Q 1/241** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 15/0026; H01Q 1/42; H01Q 1/44; H01Q 1/241; H01Q 1/425; H01Q 1/243;
(Continued)

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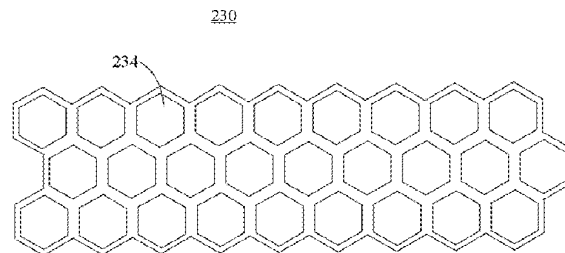
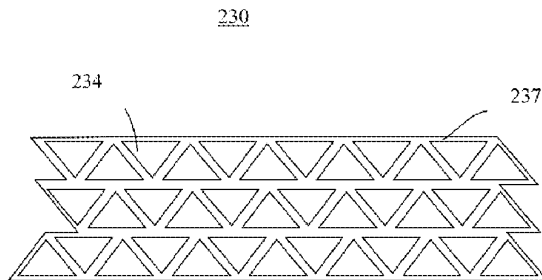
Primary Examiner — Vibol Tan

(74) *Attorney, Agent, or Firm* — Young Basile Hanlon & MacFarlane, P.C.

(57) **ABSTRACT**

An antenna apparatus and an electronic device are provided. The antenna apparatus includes an antenna module and an antenna radome. The antenna module is configured to receive and emit a radio frequency (RF) signal of a preset frequency band toward a preset direction range. The antenna radome is spaced apart from the antenna module, and located within the preset direction range. The antenna radome includes a substrate and a resonant structure carried on the substrate. The substrate is configured to allow a RF signal of a first preset frequency band to pass through, the resonant structure is configured to adjust a passband width of the substrate to the RF signal, to make the antenna radome allow a RF signal of a second frequency band to pass through. A bandwidth of the second frequency band is greater than that of the first frequency band.

20 Claims, 11 Drawing Sheets





US011901647B2

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

(10) **Patent No.:** **US 11,901,647 B2**
(45) **Date of Patent:** **Feb. 13, 2024**

(54) **ANTENNA DEVICE**

(71) Applicant: **Sony Group Corporation**, Tokyo (JP)

(72) Inventors: **Yoshiaki Hiraoka**, Tokyo (JP);
Yuichiro Suzuki, Tokyo (JP);
Takayoshi Ito, Tokyo (JP); **Tomihiko Omuro**, Tokyo (JP); **Toru Ozone**, Tokyo (JP); **Jin Sato**, Tokyo (JP)

(73) Assignee: **SONY GROUP 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 369 days.

(21) Appl. No.: **17/298,949**

(22) PCT Filed: **Dec. 13, 2018**

(86) PCT No.: **PCT/JP2018/045876**

§ 371 (c)(1),

(2) Date: **Jun. 2, 2021**

(87) PCT Pub. No.: **WO2020/121481**

PCT Pub. Date: **Jun. 18, 2020**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
H01Q 5/35 (2015.01)
H01Q 9/42 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/35** (2015.01); **H01Q 1/22** (2013.01); **H01Q 1/2291** (2013.01); **H01Q 1/24** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC H01Q 5/35; H01Q 1/2291; H01Q 1/243;
H01Q 9/42; H01Q 13/10; H01Q 1/48;
H01Q 1/22; H01Q 1/24

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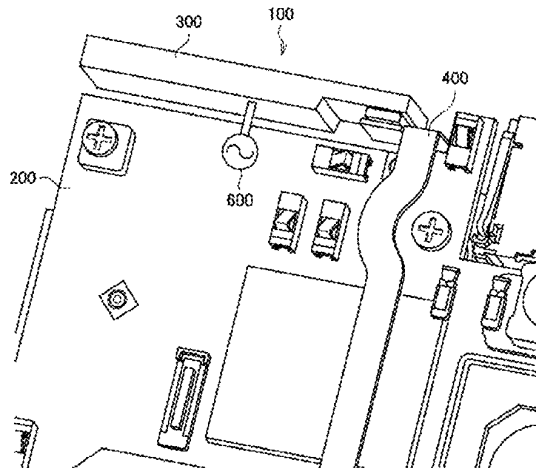
Primary Examiner — Hai V Tran

(74) *Attorney, Agent, or Firm* — XSENSUS LLP

(57) **ABSTRACT**

To optimize space efficiency in mounting a plurality of antennas compatible with different frequencies. According to the present disclosure, provided is an antenna device including a first antenna that operates at a first frequency, and a second antenna that is provided adjacent to the first antenna, operates at a second frequency lower than the first frequency, and has a ground potential connected to a grounding wire provided at the first antenna.

18 Claims, 6 Drawing Sheets





US011909130B2

(12) **United States Patent**
Li

(10) **Patent No.:** **US 11,909,130 B2**
(45) **Date of Patent:** **Feb. 20, 2024**

(54) **ANTENNA STRUCTURE AND COMMUNICATIONS TERMINAL**

(71) Applicant: **VIVO MOBILE COMMUNICATION CO., LTD.**, Guangdong (CN)

(72) Inventor: **Rihui Li**, Dongguan (CN)

(73) Assignee: **VIVO MOBILE COMMUNICATION CO., LTD.**, Dongguan (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 357 days.

(21) Appl. No.: **17/345,193**

(22) Filed: **Jun. 11, 2021**

(65) **Prior Publication Data**
US 2021/0305703 A1 Sep. 30, 2021

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2019/117441, filed on Nov. 12, 2019.

(30) **Foreign Application Priority Data**
Dec. 12, 2018 (CN) 201811521132.3

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

(52) **U.S. Cl.**
CPC **H01Q 9/0442** (2013.01); **H01Q 5/328** (2015.01); **H01Q 9/0414** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/241; H01Q 1/243; H01Q 5/10; H01Q 5/328; H01Q 5/335;
(Continued)

(56) **References Cited**

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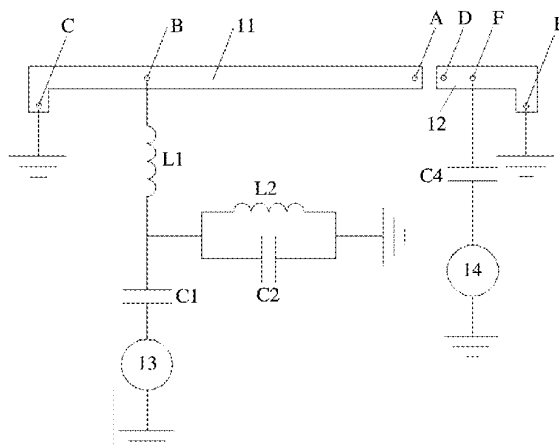
Primary Examiner — Thai Pham

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

(57) **ABSTRACT**

An antenna structure includes a first antenna radiator, a second antenna radiator, and a first impedance matching circuit. The first antenna radiator and the second antenna radiator are disposed in a laminated or opposite manner, and a gap exists between the first antenna radiator and the second antenna radiator. The length of the first antenna radiator is greater than that of the second antenna radiator, and the resonant frequency band of the first antenna radiator is smaller than that of the second antenna radiator. The first end of the first antenna radiator is grounded, a first feeding point is provided on the first antenna radiator. The first end of the second antenna radiator is grounded, a second feeding point is provided on the second antenna radiator, and the second feeding point is connected to a second signal source.

20 Claims, 4 Drawing Sheets





US011916282B2

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

(10) **Patent No.:** **US 11,916,282 B2**
(45) **Date of Patent:** **Feb. 27, 2024**

(54) **COUPLING ANTENNA APPARATUS AND ELECTRONIC DEVICE**

(71) Applicant: **HUAWEI TECHNOLOGIES CO., LTD.**, Guangdong (CN)

(72) Inventors: **Pengfei Wu**, Shanghai (CN);
Chien-Ming Lee, Shenzhen (CN);
Dong Yu, Shanghai (CN); **Chih Yu Tsai**, Taiwan (CN); **Chih-Hua Chang**, Taiwan (CN); **Arun Sowpati**, Shenzhen (CN)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 394 days.

(21) Appl. No.: **17/290,904**

(22) PCT Filed: **Nov. 5, 2019**

(86) PCT No.: **PCT/CN2019/115493**

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(2) Date: **May 3, 2021**

(87) PCT Pub. No.: **WO2020/093985**

PCT Pub. Date: **May 14, 2020**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Nov. 6, 2018 (CN) 201811312284.2

Nov. 15, 2018 (CN) 201811362920.2

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 5/35 (2015.01)

(Continued)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/22** (2013.01); **H01Q 1/242** (2013.01); **H01Q 1/244** (2013.01); **H01Q 5/357** (2015.01); **H01Q 13/10** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 5/357; H01Q 13/10; H01Q 5/328; H01Q 7/00; H01Q 1/48; (Continued)

(56) **References Cited**

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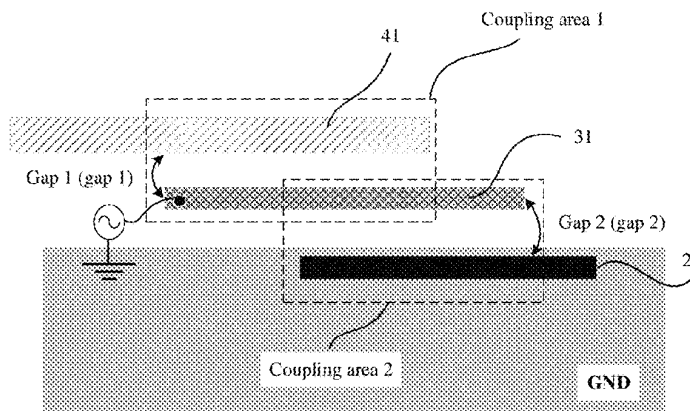
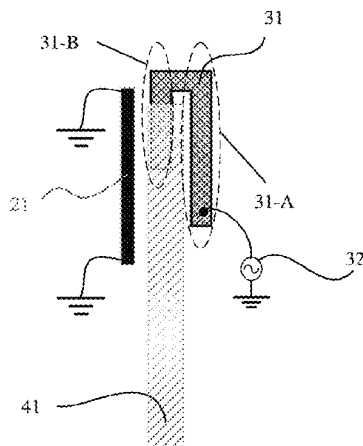
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Primary Examiner — Vibol Tan

(57) **ABSTRACT**

An antenna apparatus includes a feeding antenna inside an electronic device and one or more antenna elements, such as a floating metal antenna, disposed on a rear cover of the electronic device. The floating metal antenna and a feeding antenna inside the electronic device may form a coupling antenna structure. The feeding antenna may be an antenna fastened on an antenna support (which may be referred to as a support antenna). The feeding antenna may alternatively be a slot antenna formed by slitting on a metal middle frame of the electronic device. The antenna apparatus may be

(Continued)





US011916283B2

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

(10) **Patent No.:** **US 11,916,283 B2**
(45) **Date of Patent:** **Feb. 27, 2024**

(54) **COMPACTED ANTENNA MODULE WITH
IMPROVED PERFORMANCE FOR
ELECTRONIC DEVICE**

(71) Applicant: **Samsung Display Co., Ltd.**, Yongin-Si
(KR)

(72) Inventors: **Sangrook Yoon**, Hwaseong-si (KR);
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(73) Assignee: **Samsung Display Co., Ltd.**, Yongin-Si
(KR)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 193 days.

(21) Appl. No.: **17/463,036**

(22) Filed: **Aug. 31, 2021**

(65) **Prior Publication Data**

US 2022/0190466 A1 Jun. 16, 2022

(30) **Foreign Application Priority Data**

Dec. 16, 2020 (KR) 10-2020-0176478

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

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **G06F 3/0443**
(2019.05); **H01Q 9/065** (2013.01); **H04M**
1/0268 (2013.01); **H04M 1/0277** (2013.01)

(58) **Field of Classification Search**
CPC H05K 1/00; H05K 5/0017; H05K 5/0018;
H05K 5/0247; H01Q 1/243; H01Q 1/364
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Yuwen Pan

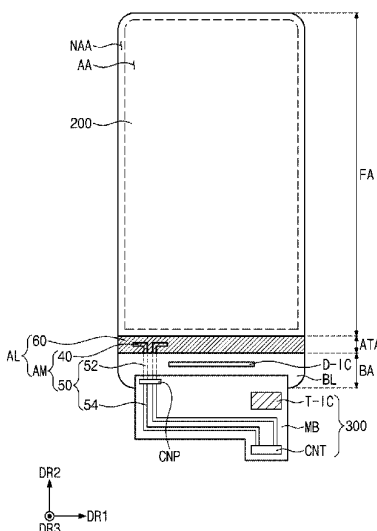
Assistant Examiner — Angelica Perez

(74) *Attorney, Agent, or Firm* — Innovation Counsel LLP

(57) **ABSTRACT**

An electronic device includes a base layer including a flat region and a bendable region extending from the flat region, a display module disposed on the base layer and overlapping the flat region, a window disposed on the display module and having a display region and a non-display region adjacent to the display region, and an antenna layer overlapping the non-display region of the window and disposed on one side of the display module, wherein the antenna layer includes an antenna module and an insulating layer surrounding the antenna module.

20 Claims, 10 Drawing Sheets





US011916286B2

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

(10) **Patent No.:** **US 11,916,286 B2**
(45) **Date of Patent:** **Feb. 27, 2024**

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

(71) Applicant: **WISTRON NEWEB
CORPORATION**, Hsinchu (TW)

(72) Inventors: **Shih-Chiang Wei**, Hsinchu (TW);
Hsieh-Chih Lin, Hsinchu (TW)

(73) Assignee: **WISTRON NEWEB
CORPORATION**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
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(21) Appl. No.: **17/348,838**

(22) Filed: **Jun. 16, 2021**

(65) **Prior Publication Data**
US 2022/0285833 A1 Sep. 8, 2022

(30) **Foreign Application Priority Data**
Mar. 8, 2021 (TW) 110108128

(51) **Int. Cl.**
H01Q 1/48 (2006.01)
H01Q 1/50 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/48** (2013.01); **H01Q 1/50**
(2013.01); **H05K 9/0067** (2013.01); **H01Q**
1/241 (2013.01); **H01Q 1/38** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/48; H01Q 1/38; H01Q 1/243;
H01Q 1/50; H01Q 1/241; H01Q 5/378;
(Continued)

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Primary Examiner — Dimary S Lopez Cruz

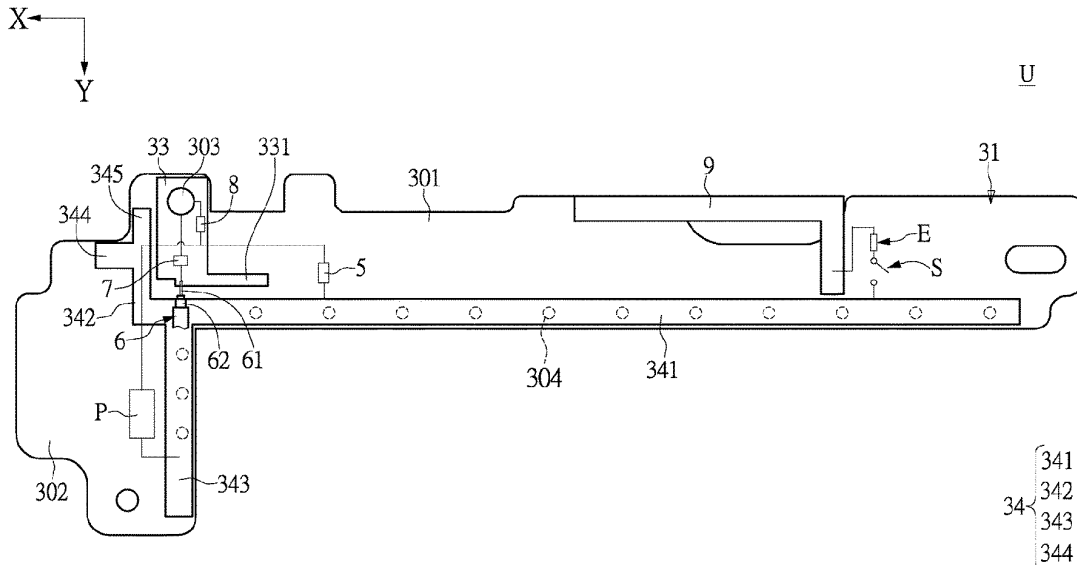
Assistant Examiner — Brandon Sean Woods

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

(57) **ABSTRACT**

An electronic device and an antenna feeding device are provided. The electronic device includes a metal housing, a radiation element, a substrate, a grounding element and an electrostatic protection element. The antenna feeding device includes a substrate, a grounding element, and an electrostatic protection element. The radiation element is arranged along the edge of the electronic device, and the radiation element and the metal housing are separated from each other. The substrate is arranged on the metal housing. The substrate includes a feeding portion and a grounding portion, and the feeding portion is coupled to the radiating element. The grounding portion is coupled to the metal housing. The grounding element is electrically connected to the metal housing, and the grounding element is coupled to the grounding portion. The electrostatic protection element is electrically connected between the feeding portion and the grounding portion.

18 Claims, 7 Drawing Sheets





US011916293B2

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

(10) **Patent No.:** **US 11,916,293 B2**
(45) **Date of Patent:** **Feb. 27, 2024**

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

(71) Applicant: **DELTA ELECTRONICS, INC.**,
Taoyuan (TW)
(72) Inventors: **Chieh-Tsao Hwang**, Taoyuan (TW);
Siang-Rong Hsu, Taoyuan (TW);
Yen-Ting Chen, Taoyuan (TW)

(73) Assignee: **DELTA ELECTRONICS, INC.**,
Taoyuan (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 18 days.

(21) Appl. No.: **17/450,556**

(22) Filed: **Oct. 11, 2021**

(65) **Prior Publication Data**
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(30) **Foreign Application Priority Data**
Apr. 16, 2021 (CN) 202110411522.0

(51) **Int. Cl.**
H01Q 13/10 (2006.01)
H01Q 1/48 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 13/10** (2013.01); **H01Q 1/48** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 13/10; H01Q 13/106; H01Q 21/08; H01Q 1/38
See application file for complete search history.

(56) **References Cited**

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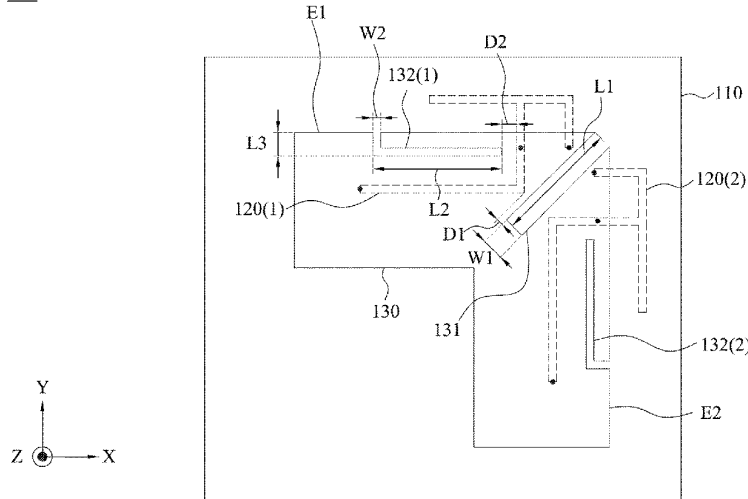
Primary Examiner — Ricardo I Magallanes
(74) *Attorney, Agent, or Firm* — CKC & Partners Co., LLC

(57) **ABSTRACT**

An antenna structure is provided, which includes a substrate, an antenna unit and a metal ground. The substrate includes a first surface and a second surface; the antenna unit disposed on the first surface includes a radiation part, a feeding part and a feeding line, where the feeding line includes a first transmission line and a second transmission line that are perpendicular to each other and connected to each other, and the first transmission line is connected to the radiation part via the feeding part; and the metal ground disposed on the second surface has an edge which is perpendicular to projection of the radiation part to the metal ground; and a resonance slot is disposed on the metal ground, and its position corresponds between projection of the second transmission line to the metal ground and the edge.

4 Claims, 7 Drawing Sheets

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US011916294B2

(12) **United States Patent**
Yoshikawa

(10) **Patent No.:** **US 11,916,294 B2**
(45) **Date of Patent:** **Feb. 27, 2024**

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

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/521; H01Q 5/35;
H01Q 21/065; H01Q 5/371; H01Q 5/378;

(Continued)

(71) Applicant: **KYOCERA CORPORATION**, Kyoto
(JP)

(56) **References Cited**

(72) Inventor: **Hiromichi Yoshikawa**, Yokohama (JP)

U.S. PATENT DOCUMENTS

(73) Assignee: **KYOCERA CORPORATION**, 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 400 days.

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(21) Appl. No.: **17/286,820**

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JP 2017504274 A 2/2017

(22) PCT Filed: **Oct. 25, 2019**

Primary Examiner — Linh V Nguyen

(86) PCT No.: **PCT/JP2019/042059**

(74) Attorney, Agent, or Firm — HAUPTMAN HAM,
LLP

§ 371 (c)(1),

(2) Date: **Apr. 20, 2021**

(57) **ABSTRACT**

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(65) **Prior Publication Data**

US 2021/0359418 A1 Nov. 18, 2021

(30) **Foreign Application Priority Data**

Oct. 31, 2018 (JP) 2018-206004

(51) **Int. Cl.**

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H01Q 1/52 (2006.01)

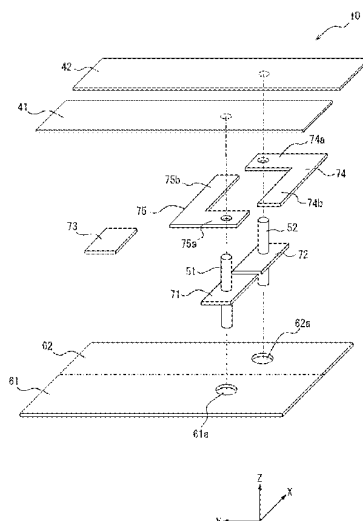
H01Q 21/06 (2006.01)

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

CPC **H01Q 13/18** (2013.01); **H01Q 1/52**
(2013.01); **H01Q 21/06** (2013.01)

In an antenna, a first antenna element includes a first radiation conductor and a first feeder line. A second antenna element includes a second radiation conductor and a second feeder line. A second feeder line is coupled to the first feeder line such that a first component, which is a capacitance component or an inductance component, is dominant. A first coupler couples the first and second feeder lines such that a second component different from the first component is dominant. The first and second radiation conductors are arranged at interval of $\frac{1}{2}$ or less of resonance wavelength. The second feeder line is coupled to the first radiation conductor such that a third component, which is the capacitance component or the inductance component, is dominant. The first coupling portion couples the first radiation conductor and the second feeder line such that a fourth component different from the third component is dominant.

20 Claims, 14 Drawing Sheets





US011923597B2

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

(10) **Patent No.:** **US 11,923,597 B2**
(45) **Date of Patent:** **Mar. 5, 2024**

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

H01Q 5/364; H01Q 5/371; H01Q 5/378;
H01Q 5/385; H01Q 5/392; H01Q 9/42;
H01Q 21/28; H01Q 21/30

(71) Applicant: **WISTRON NEWEB CORPORATION**, Hsinchu (TW)

See application file for complete search history.

(72) Inventors: **Meng-Kai Wu**, Hsinchu (TW);
Hong-Jun Jian, Hsinchu (TW)

(73) Assignee: **WISTRON NEWEB CORPORATION**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 17 days.

(21) Appl. No.: **17/834,002**

(22) Filed: **Jun. 7, 2022**

(65) **Prior Publication Data**
US 2023/0216177 A1 Jul. 6, 2023

(30) **Foreign Application Priority Data**
Jan. 3, 2022 (TW) 111100008

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 1/38 (2006.01)
H01Q 5/371 (2015.01)
H01Q 5/392 (2015.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/2266** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/371** (2015.01); **H01Q 5/392** (2015.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 1/2291; H01Q 1/2258; H01Q 1/2266;
H01Q 1/243; H01Q 1/38; H01Q 5/357;

(56) **References Cited**

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343/700 MS

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Primary Examiner — Robert Karacsony

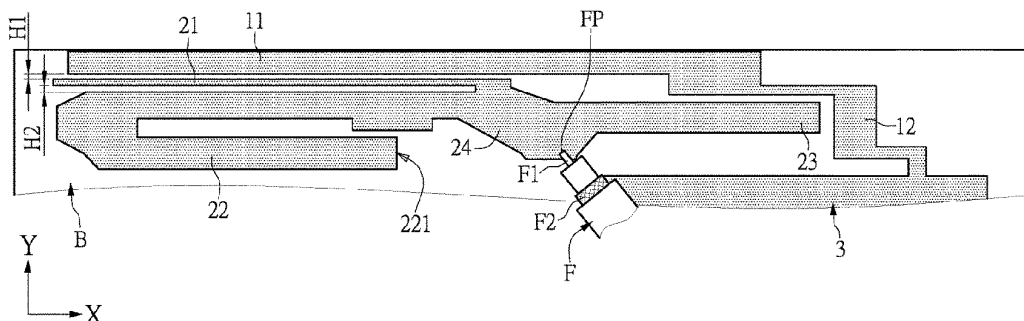
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes an antenna structure and a housing. The antenna structure includes a first radiating element, a grounding element, and a second radiating element. The first radiating element includes a first radiating portion and a grounding portion. Two ends of the grounding portion are respectively connected with the first radiating portion and the grounding element. The first radiating portion, the grounding portion and the grounding element form a surrounding structure. The second radiating element includes a second radiating portion, a third radiating portion, a fourth radiating portion, and a feeding portion connected between the second radiating portion, the third radiating portion and the fourth radiating portion. The second radiating portion and the first radiating portion are separated from each other and couple to each other.

12 Claims, 6 Drawing Sheets

$$\begin{matrix} \left. \begin{matrix} 11 \\ 12 \\ 13 \end{matrix} \right\} 1 & \left. \begin{matrix} 21 \\ 22 \\ 23 \\ 24 \end{matrix} \right\} 2 & \left. \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \end{matrix} \right\} A \end{matrix}$$





US011923599B2

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

(10) **Patent No.:** **US 11,923,599 B2**
(45) **Date of Patent:** ***Mar. 5, 2024**

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

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

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

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 114 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **17/408,755**

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

(65) **Prior Publication Data**

US 2022/0069468 A1 Mar. 3, 2022

(30) **Foreign Application Priority Data**

Aug. 28, 2020 (CN) 202010888026.X

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 1/44 (2006.01)

H01Q 5/20 (2015.01)

H01Q 5/35 (2015.01)

H01Q 5/50 (2015.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/44** (2013.01); **H01Q 5/20** (2015.01); **H01Q 5/35** (2015.01); **H01Q 5/50** (2015.01)

(58) **Field of Classification Search**

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

(56) **References Cited**

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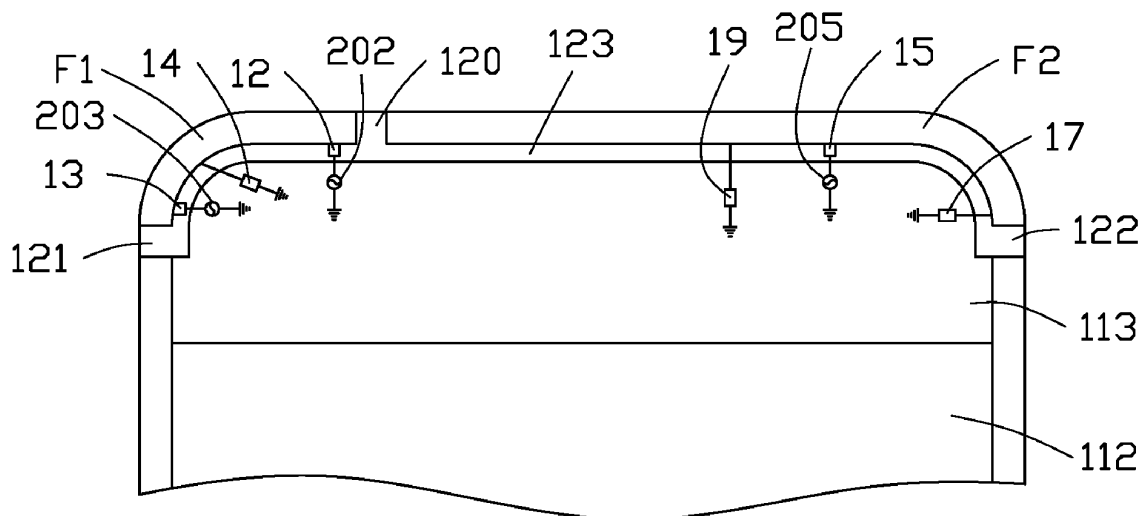
Primary Examiner — Ab Salam Alkassim, Jr.

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

(57) **ABSTRACT**

An antenna structure applied in a wireless communication device includes a metal frame, a first feed portion, a second feed portion, and a ground portion. The metal frame defines a first gap and a second gap. A portion of the metal frame positioned between the first gap and the second gap forms the first radiation portion. The first feed portion is electrically connected to the first radiation portion and a first signal feed point for feeding current and signals to the first radiation portion. The second feed portion is positioned apart from the first feed portion, electrically connected to the first radiation portion and a second signal feed point for feeding current and signal to the first radiation portion. The ground portion is positioned between the first feed portion and the second feed portion and is connected to the first radiation portion for grounding the first radiation portion.

13 Claims, 13 Drawing Sheets





US011923610B2

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

(10) **Patent No.:** **US 11,923,610 B2**
(45) **Date of Patent:** **Mar. 5, 2024**

(54) **ANTENNA ARRAY**

(71) Applicants: **Samsung Electronics Co., Ltd.**,
Suwon-si (KR); **HONGIK**
UNIVERSITY
INDUSTRY-ACADEMIA
COOPERATION FOUNDATION,
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(72) Inventors: **Jae-Hyun Park**, Suwon-si (KR);
Jeong-Hae Lee, Seoul (KR); **Min-Seo**
Park, Changwon-si (KR); **Young-Ho**
Ryu, Yongin-si (KR); **Sung-Bum Park**,
Suwon-si (KR); **Kwi-Seob Um**, Seoul
(KR); **Chong-Min Lee**, Seoul (KR);
Chang-Hyun Lee, Incheon (KR)

(73) Assignees: **Samsung Electronics Co., Ltd.**,
Suwon-si (KR); **HONGIK**
UNIVERSITY
INDUSTRY-ACADEMIA
COOPERATION FOUNDATION,
Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 1395 days.

(21) Appl. No.: **16/331,858**

(22) PCT Filed: **May 24, 2017**

(86) PCT No.: **PCT/KR2017/005417**

§ 371 (c)(1),
(2) Date: **Sep. 12, 2019**

(87) PCT Pub. No.: **WO2018/048061**

PCT Pub. Date: **Mar. 15, 2018**

(65) **Prior Publication Data**

US 2023/0198164 A1 Jun. 22, 2023

(30) **Foreign Application Priority Data**

Sep. 9, 2016 (KR) 10-2016-0116207

(51) **Int. Cl.**
H01Q 1/52 (2006.01)
H01Q 1/48 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 21/065** (2013.01); **H01Q 1/48**
(2013.01); **H01Q 1/523** (2013.01); **H01Q**
9/0421 (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/38–48; H01Q 1/521–523; H01Q
9/0407–0421; H01Q 21/065
See application file for complete search history.

(56) **References Cited**

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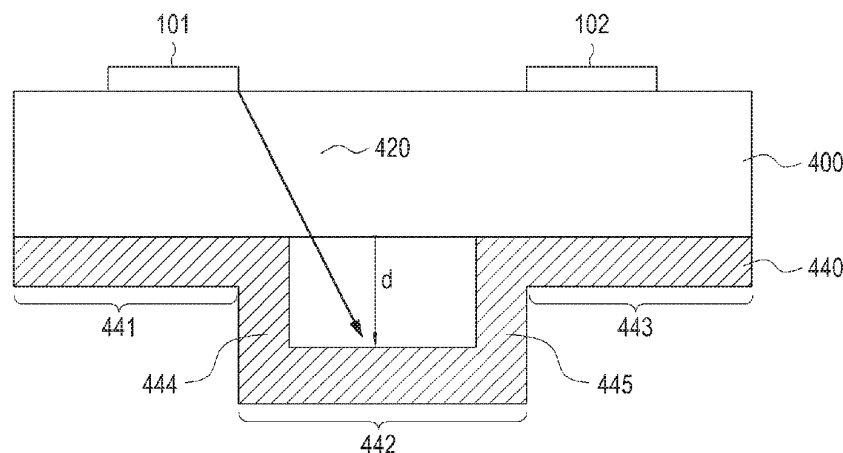
Primary Examiner — Hasan Islam

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

(57) **ABSTRACT**

In various embodiments, an antenna array may comprise a
dielectric; a first patch antenna disposed on a first region of
the dielectric; a second patch antenna disposed on a second
region of the dielectric; and a ground layer including a first
sub-ground layer in contact with a lower portion of the first
region of the dielectric, a third sub-ground layer in contact
with a lower portion of the second region of the dielectric,

(Continued)





US011923622B2

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

(10) **Patent No.:** **US 11,923,622 B2**
(45) **Date of Patent:** **Mar. 5, 2024**

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

(71) Applicant: **Nokia Solutions and Networks Oy**,
Espoo (FI)

(72) Inventors: **Fei Gao**, Shanghai (CN); **Chaojun Xu**,
Shanghai (CN); **Gang Shen**, Shanghai
(CN)

(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 542 days.

(21) Appl. No.: **17/264,349**

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

(86) PCT No.: **PCT/CN2018/098382**

§ 371 (c)(1),

(2) Date: **Jan. 29, 2021**

(87) PCT Pub. No.: **WO2020/024232**

PCT Pub. Date: **Feb. 6, 2020**

(65) **Prior Publication Data**

US 2021/0296775 A1 Sep. 23, 2021

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 5/385 (2015.01)
H01Q 7/00 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 7/00** (2013.01); **H01Q 1/38**
(2013.01); **H01Q 5/385** (2015.01)

(58) **Field of Classification Search**

CPC H01Q 7/00; H01Q 5/385; H01Q 1/38

USPC 343/865

See application file for complete search history.

(56) **References Cited**

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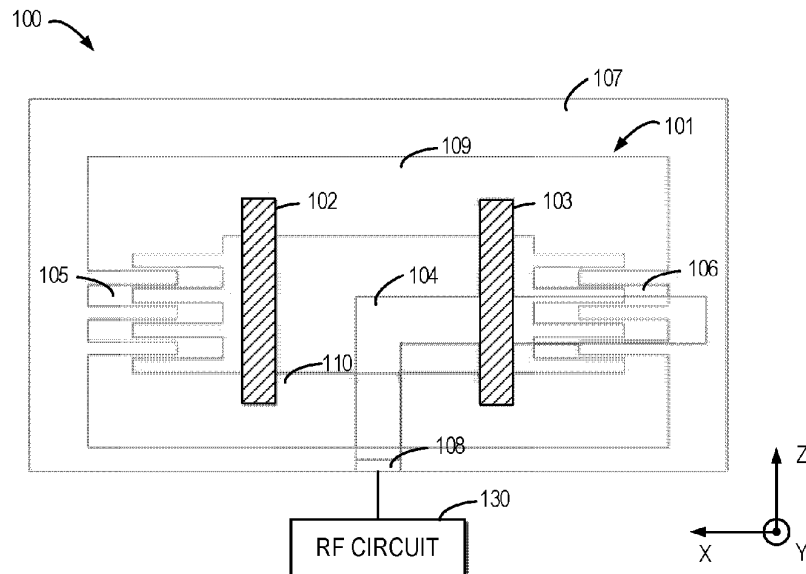
Primary Examiner — Peguy Jean Pierre

(74) *Attorney, Agent, or Firm* — Harrington & Smith

(57) **ABSTRACT**

In accordance with some embodiments, there is provided an apparatus. The apparatus includes a conductive loop; a first conductive member electromagnetically coupled to the conductive loop and galvanically coupled to a radio frequency circuit; a second conductive member arranged across and electromagnetically coupled to the conductive loop; and a third conductive member arranged across and electromagnetically coupled to the conductive loop, the third conductive member being spaced apart from the second conductive member and electromagnetically coupled to the first conductive member.

15 Claims, 6 Drawing Sheets





US011923625B2

(12) **United States Patent**
Kim

(10) **Patent No.:** **US 11,923,625 B2**
(45) **Date of Patent:** **Mar. 5, 2024**

(54) **PATCH ANTENNA AND ARRAY ANTENNA
COMPRISING SAME**

- (71) Applicant: **ATCODI CO., LTD**, Seoul (KR)
(72) Inventor: **Jeong Pyo Kim**, Suwon-si (KR)
(73) Assignee: **ATCODI CO., LTD**, Seoul (KR)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 258 days.

(56) **References Cited**

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Primary Examiner — Ricardo I Magallanes

Assistant Examiner — Jordan E. DeWitt

(74) *Attorney, Agent, or Firm* — LRK PATENT LAW FIRM

- (21) Appl. No.: **17/610,373**
(22) PCT Filed: **Jun. 10, 2019**

- (86) PCT No.: **PCT/KR2019/006923**
§ 371 (c)(1),
(2) Date: **Nov. 10, 2021**

- (87) PCT Pub. No.: **WO2020/251064**
PCT Pub. Date: **Dec. 17, 2020**

- (65) **Prior Publication Data**
US 2022/0224012 A1 Jul. 14, 2022

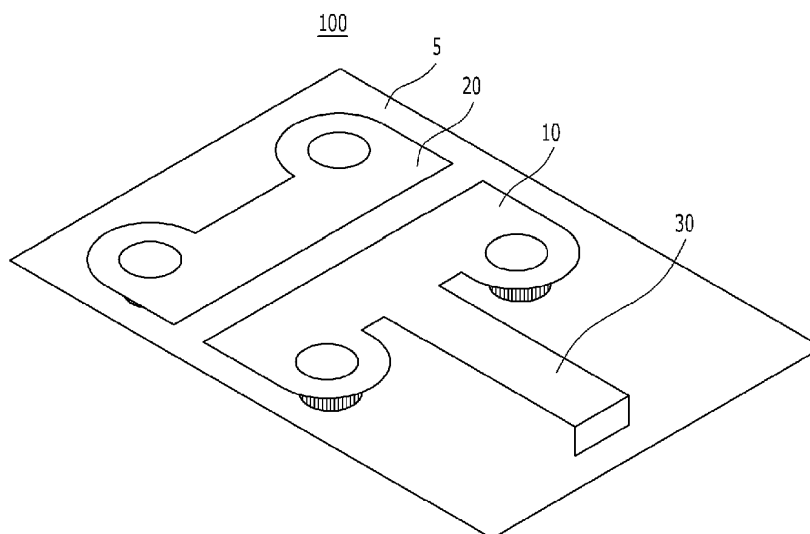
- (51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 21/08 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 9/045** (2013.01); **H01Q 21/08**
(2013.01)

- (58) **Field of Classification Search**
CPC H01Q 9/045; H01Q 21/08
See application file for complete search history.

(57) **ABSTRACT**

A patch antenna includes: a substrate; a first radiator disposed on the substrate and having a first shape; a second radiator disposed on the substrate while being spaced a predetermined distance apart from the first radiator, and having a second shape; and a power feeder which supplies a power feed signal to the first radiator, wherein the first radiator includes a first outer edge portion straightly formed in the horizontal direction and second outer edge portions vertically formed from both ends of the first outer edge portion.

12 Claims, 7 Drawing Sheets





US011923626B2

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

(10) **Patent No.:** **US 11,923,626 B2**
(45) **Date of Patent:** **Mar. 5, 2024**

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

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

(72) Inventors: **Le Chang**, Shenzhen (CN); **Yafang Yu**,
Shenzhen (CN); **Kunpeng Wei**,
Shenzhen (CN); **Dawei Zhou**, Shenzhen
(CN); **Dong Yu**, Shanghai (CN);
Hanyang Wang, Reading (GB)

(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 264 days.

(21) Appl. No.: **17/610,972**

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

(86) PCT No.: **PCT/CN2020/078006**

§ 371 (c)(1),

(2) Date: **Nov. 12, 2021**

(87) PCT Pub. No.: **WO2020/228399**

PCT Pub. Date: **Nov. 19, 2020**

(65) **Prior Publication Data**

US 2022/0239004 A1 Jul. 28, 2022

(30) **Foreign Application Priority Data**

May 13, 2019 (CN) 201910401967.3

(51) **Int. Cl.**

H01Q 9/40 (2006.01)

H01Q 1/48 (2006.01)

(Continued)

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

CPC **H01Q 9/40** (2013.01); **H01Q 1/48**
(2013.01); **H01Q 9/20** (2013.01); **H01Q 13/10**
(2013.01)

(58) **Field of Classification Search**

CPC .. **H01Q 9/40**; **H01Q 1/48**; **H01Q 9/20**; **H01Q**
13/10

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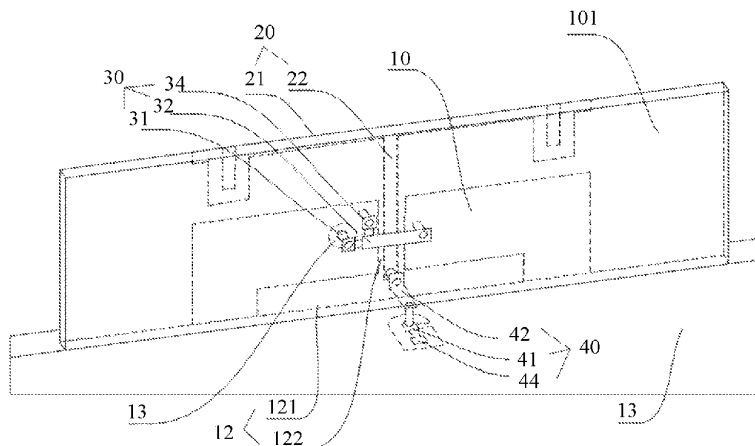
Primary Examiner — Hai V Tran

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

(57) **ABSTRACT**

An antenna apparatus includes a grounding plate, a mono-
pole, a first feeding component, and a second feeding
component. A slot on the grounding plate includes a first slot
and a second slot that interpenetrate each other, the second
slot extends from the first slot to an edge of the grounding
plate. The monopole includes a first stub and a second stub
extending from the first stub to the second slot, the second

(Continued)





US011923886B2

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

(10) **Patent No.:** **US 11,923,886 B2**
(45) **Date of Patent:** **Mar. 5, 2024**

(54) **ANTENNA DEVICE AND METHOD FOR CONFIGURING THE SAME**

(71) Applicants: **Jhih-Ciang Chen**, Taipei (TW); **Shih-Chia Liu**, Taipei (TW); **Yen-Hao Yu**, Taipei (TW); **Li-Chun Lee**, Taipei (TW); **Yan-Ming Lin**, Taipei (TW); **Jui-Hung Lai**, Taipei (TW)

(72) Inventors: **Jhih-Ciang Chen**, Taipei (TW); **Shih-Chia Liu**, Taipei (TW); **Yen-Hao Yu**, Taipei (TW); **Li-Chun Lee**, Taipei (TW); **Yan-Ming Lin**, Taipei (TW); **Jui-Hung Lai**, Taipei (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 384 days.

(21) Appl. No.: **17/458,552**

(22) Filed: **Aug. 27, 2021**

(65) **Prior Publication Data**
US 2022/0263531 A1 Aug. 18, 2022

Related U.S. Application Data

(60) Provisional application No. 63/121,208, filed on Dec. 3, 2020.

(51) **Int. Cl.**
H01Q 1/48 (2006.01)
H01Q 9/42 (2006.01)
H04B 1/3827 (2015.01)

(52) **U.S. Cl.**
CPC **H04B 1/3838** (2013.01); **H01Q 1/48** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**

CPC H04B 1/3838; H01Q 1/48; H01Q 9/42
See application file for complete search history.

(56) **References Cited**

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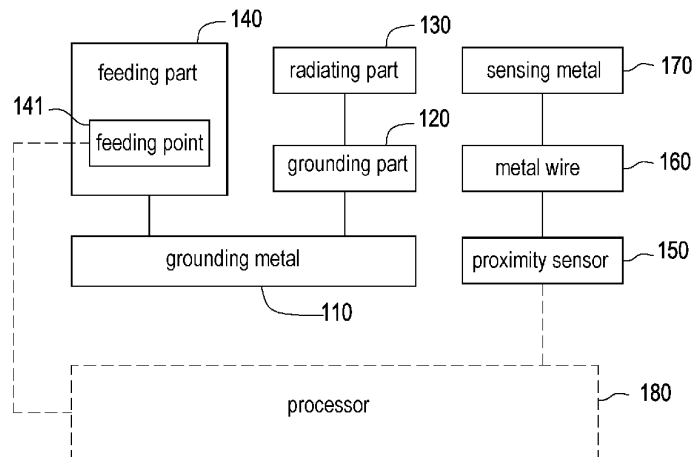
Primary Examiner — Hai V Nguyen

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

(57) **ABSTRACT**

An antenna device and a method for configuring the same are provided. The antenna device includes a grounding metal, a grounding part, a radiating part, a feeding part, a proximity sensor, and a sensing metal. The radiating part is electrically connected to the grounding metal through the grounding part. The feeding part is coupled to the grounding metal through a feeding point. The sensing metal is electrically connected to the proximity sensor. The sensing metal is separated from the radiating part at a distance. The distance is less than or equal to one thousandth of a wavelength corresponding to an operating frequency of the antenna device.

22 Claims, 6 Drawing Sheets





US011929546B2

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

(10) **Patent No.:** **US 11,929,546 B2**
(45) **Date of Patent:** **Mar. 12, 2024**

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

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 9/0407; H01Q 9/16;
H05K 1/142; H05K 5/0017; H05K
5/0226;

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

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(72) Inventors: **Jaehyung Kim**, Gyeonggi-do (KR);
Jinkyu Bang, Gyeonggi-do (KR);
Jaebong Chun, Gyeonggi-do (KR)

(56) **References Cited**

U.S. PATENT DOCUMENTS

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

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343/788

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 599 days.

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(21) Appl. No.: **17/259,445**

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KR 20010006237 1/2001

(22) PCT Filed: **Jul. 11, 2019**

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(86) PCT No.: **PCT/KR2019/008557**

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§ 371 (c)(1),

(2) Date: **Jan. 11, 2021**

KR Notice of Patent Grant dated Dec. 22, 2022 issued in counterpart
application No. 10-2018-0080509, 4 pages.

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(87) PCT Pub. No.: **WO2020/013625**

PCT Pub. Date: **Jan. 16, 2020**

Primary Examiner — Jacob R Crum

(65) **Prior Publication Data**

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

US 2021/0280961 A1 Sep. 9, 2021

(57)

ABSTRACT

(30) **Foreign Application Priority Data**

Jul. 11, 2018 (KR) 10-2018-0080509

(51) **Int. Cl.**

H05K 1/14 (2006.01)

H01Q 1/24 (2006.01)

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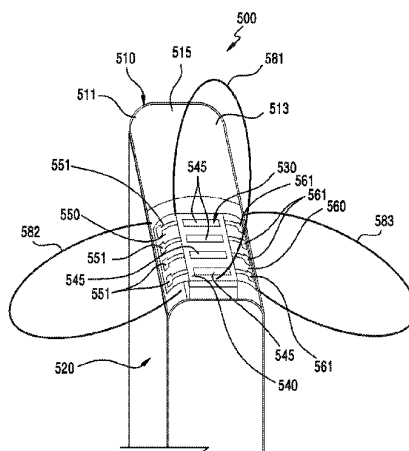
(52) **U.S. Cl.**

CPC **H01Q 1/243** (2013.01); **H01Q 9/0407**
(2013.01); **H01Q 9/16** (2013.01); **H05K 1/142**
(2013.01);

(Continued)

An electronic device comprising an array antenna according
to various embodiments of the present invention may com-
prise: a housing comprising a first plate, a second plate
facing away from the first plate, and a side member sur-
rounding the space between the first plate and the second
plate; a display visible through a part of the first plate; a first
printed circuit board comprising a first surface facing the
side member, a second surface facing away from the first
surface, a first edge adjacent close to the first plate, and a
second edge closer to the second plate than the first edge, the
first printed circuit board comprising one or more conduc-
tive plates on the first surface; a second printed circuit board

(Continued)





US011929547B2

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

(10) **Patent No.:** **US 11,929,547 B2**
(45) **Date of Patent:** **Mar. 12, 2024**

(54) **MOBILE DEVICE**

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

(72) Inventors: **Tiao-Hsing Tsai**, Taoyuan (TW);
Chien-Pin Chiu, Taoyuan (TW);
Hsiao-Wei Wu, Taoyuan (TW);
Li-Yuan Fang, Taoyuan (TW);
Shen-Fu Tzeng, Taoyuan (TW);
Yi-Hsiang Kung, Taoyuan (TW)

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

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

(21) Appl. No.: **18/297,325**

(22) Filed: **Apr. 7, 2023**

(65) **Prior Publication Data**
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Related U.S. Application Data

(63) Continuation of application No. 17/038,963, filed on Sep. 30, 2020, now Pat. No. 11,664,583, which is a (Continued)

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/335 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/335** (2015.01); **H01Q 9/04** (2013.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01); **H04M 1/026** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/335; H01Q 9/04; H01Q 9/42; H01Q 21/28; H01Q 5/307; H01Q 5/328; H01Q 13/10; H04M 1/026
See application file for complete search history.

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Primary Examiner — Hai V Tran

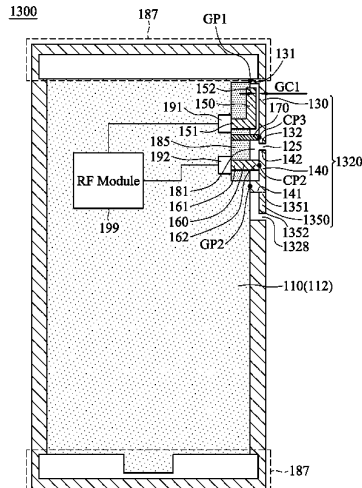
Assistant Examiner — Michael M Bouizza

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

(57) **ABSTRACT**

A mobile device includes a system circuit board, a metal frame, one or more other antenna elements, a display device, a first feeding element, and an RF (Radio Frequency) module. The system circuit board includes a system ground plane. The metal frame at least includes a first portion and a second portion. The metal frame at least has a first cut point positioned between the first portion and the second portion. The metal frame further has a second cut point for separating the other antenna elements from the first portion. The first cut point is arranged to be close to a middle region of the display device. The first feeding element is directly or indirectly electrically connected to the first portion. A first antenna structure is formed by the first feeding element and the first portion.

44 Claims, 14 Drawing Sheets





US011929557B2

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

(10) **Patent No.:** **US 11,929,557 B2**
(45) **Date of Patent:** **Mar. 12, 2024**

(54) **ANTENNA MODULE AND
COMMUNICATION DEVICE EQUIPPED
WITH THE SAME**

(71) Applicant: **Murata Manufacturing Co., Ltd.**,
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(72) Inventors: **Keisei Takayama**, Nagaokakyo (JP);
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(73) Assignee: **MURATA MANUFACTURING CO.,
LTD.**, Nagaokakyo (JP)

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

(21) Appl. No.: **17/847,254**

(22) Filed: **Jun. 23, 2022**

(65) **Prior Publication Data**
US 2022/0328983 A1 Oct. 13, 2022

Related U.S. Application Data

(63) Continuation of application No.
PCT/JP2020/039810, filed on Oct. 23, 2020.

(30) **Foreign Application Priority Data**

Dec. 26, 2019 (JP) 2019-236703

(51) **Int. Cl.**
H01Q 21/30 (2006.01)
H01Q 21/00 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 21/30** (2013.01); **H01Q 21/0025**
(2013.01); **H01Q 21/065** (2013.01); **H04M**
1/026 (2013.01)

(58) **Field of Classification Search**
CPC .. **H01Q 21/30**; **H01Q 21/0025**; **H01Q 21/065**;
H04M 1/026

See application file for complete search history.

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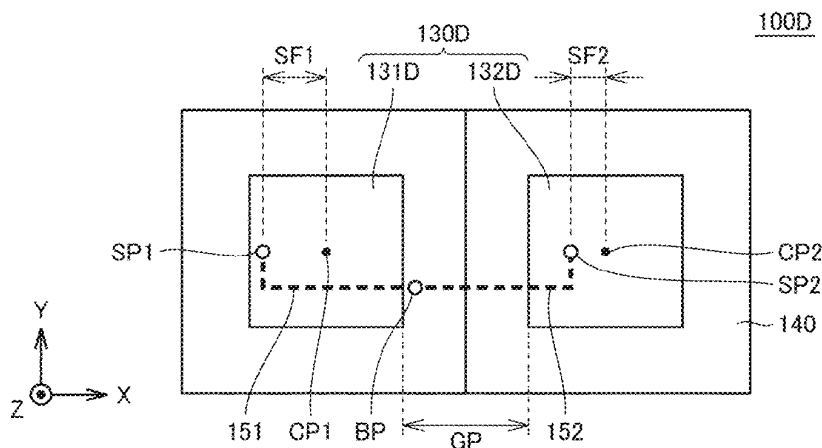
Primary Examiner — Jimmy T Vu

(74) *Attorney, Agent, or Firm* — XSENSUS LLP

(57) **ABSTRACT**

An antenna module radiates radio waves upon receiving a radio-frequency signal output from an RFIC. The antenna module includes flat radiating elements that radiate radio waves in a first polarization direction, feed conductors that each supply a radio-frequency signal from the RFIC to an associated one of the radiating elements, and a ground electrode disposed opposite the radiating elements. As viewed from the RFIC, frequency characteristics of an impedance of the radiating element are different from frequency characteristics of an impedance of the radiating element. Under a condition a frequency band in which a return loss is less than or equal to a predetermined value is defined as an operable band width in each of the radiating elements, the operable band width of the radiating element partially overlaps the operable band width of the radiating element.

20 Claims, 47 Drawing Sheets





US011929560B2

(12) **United States Patent**
Komura

(10) **Patent No.:** **US 11,929,560 B2**
(45) **Date of Patent:** **Mar. 12, 2024**

(54) **ANTENNA DEVICE AND RADIO COMMUNICATION DEVICE INCLUDING THE SAME**

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

(72) Inventor: **Ryo Komura**, Kyoto (JP)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 7 days.

(21) Appl. No.: **17/657,174**

(22) Filed: **Mar. 30, 2022**

(65) **Prior Publication Data**

US 2022/0224008 A1 Jul. 14, 2022

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2020/033117, filed on Sep. 1, 2020.

(30) **Foreign Application Priority Data**

Oct. 3, 2019 (JP) 2019-182742

(51) **Int. Cl.**
H01Q 5/00 (2015.01)
H01Q 1/38 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/321** (2015.01); **H01Q 1/38** (2013.01); **H01Q 5/20** (2015.01); **H01Q 9/0414** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/321; H01Q 5/20; H01Q 9/285; H01Q 1/48; H01Q 1/08; H01Q 1/38;
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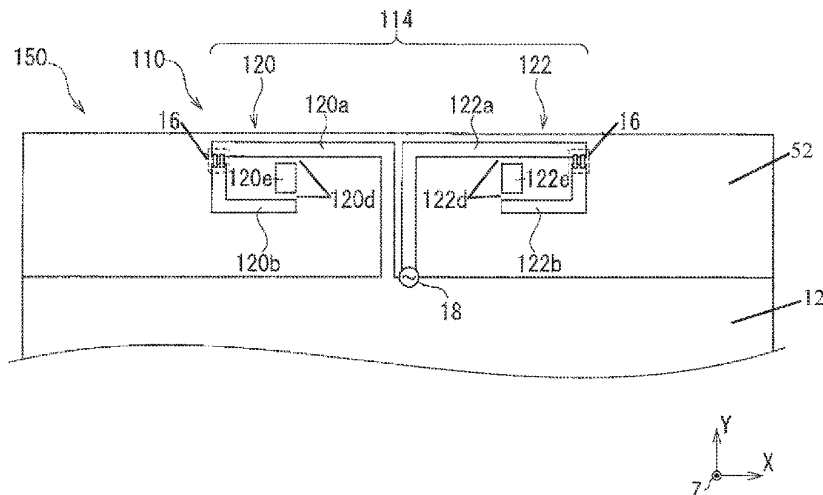
Primary Examiner — Vibol Tan

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

(57) **ABSTRACT**

A dual-band antenna device allowed to perform communication at a first frequency in a predetermined frequency band and at a second frequency in a frequency band higher than the predetermined frequency band includes: a ground conductor; a folded antenna conductor including a first linear part and a second linear part that are caused to face each other at a distance by folding; an LC resonant circuit that is included in the folded antenna conductor, that lets the first frequency pass, and that lets the second frequency attenuate; and a feeding point between the ground conductor and the folded antenna conductor. A narrow gap part is provided between the first linear part and the second linear part of the folded antenna conductor, the narrow gap part measuring a distance shorter than a distance measured in a different portion between the first linear part and the second linear part.

16 Claims, 5 Drawing Sheets





US011929561B2

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

(10) **Patent No.:** **US 11,929,561 B2**
(45) **Date of Patent:** **Mar. 12, 2024**

(54) **ANTENNA MODULE**

(56)

References Cited

(71) Applicant: **PEGATRON CORPORATION**, Taipei (TW)

U.S. PATENT DOCUMENTS

(72) Inventors: **I-Shu Lee**, Taipei (TW); **Chih-Hung Cho**, Taipei (TW); **Hau Yuen Tan**, Taipei (TW); **Po-Sheng Chen**, Taipei (TW); **Chao-Hsu Wu**, Taipei (TW); **Yi Chen**, Taipei (TW); **Hung-Ming Yu**, Taipei (TW); **Chih-Chien Hsieh**, Taipei (TW)

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(73) Assignee: **PEGATRON CORPORATION**, Taipei (TW)

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TW	I715313	1/2021

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 120 days.

Primary Examiner — Hai V Tran

Assistant Examiner — Michael M Bouizza

(74) *Attorney, Agent, or Firm* — J.C. PATENTS

(21) Appl. No.: **17/857,676**

(22) Filed: **Jul. 5, 2022**

(65) **Prior Publication Data**
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(30) **Foreign Application Priority Data**
Aug. 6, 2021 (TW) 110129175

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/371 (2015.01)
H01Q 9/04 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 5/371** (2015.01); **H01Q 1/241** (2013.01); **H01Q 9/0421** (2013.01)

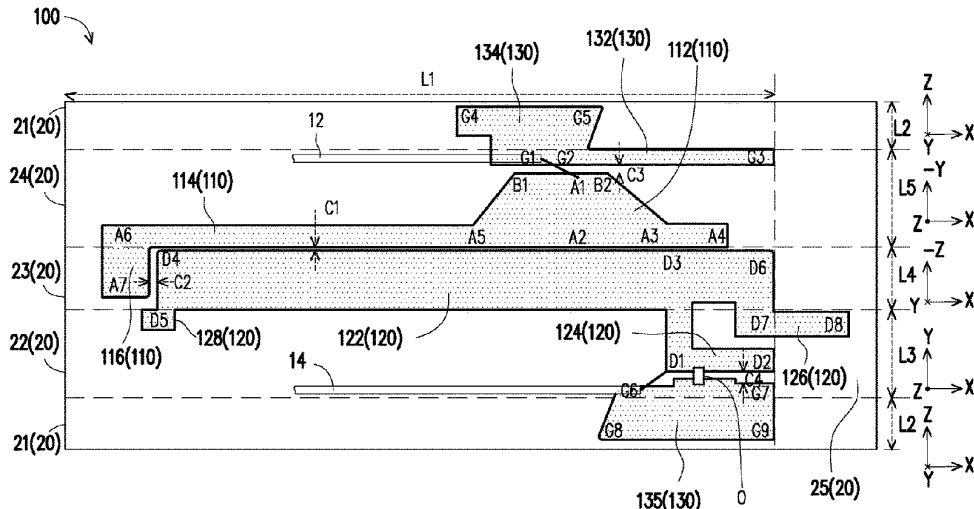
(58) **Field of Classification Search**
CPC H01Q 5/371; H01Q 1/241; H01Q 9/0421;
H01Q 1/2266; H01Q 5/40; H01Q 9/40;
H01Q 9/42; H01Q 21/28; H01Q 1/48
See application file for complete search history.

(57)

ABSTRACT

An antenna module includes a first antenna radiator including a feeding terminal, a second antenna radiator, a first ground radiator, a second ground radiator and a capacitive element. The second antenna radiator is disposed on one side of the first antenna radiator, and a first gap is formed between a main portion of the second antenna radiator and the first antenna radiator. The first ground radiator is disposed on another side of the first antenna radiator, and a second gap is formed between the first antenna radiator and the first ground radiator. The second ground radiator is disposed between the second antenna radiator and the first ground radiator, and a third gap is formed between the second ground radiator and a first branch of the second antenna radiator. The capacitive element is disposed on the third gap and connects the second antenna radiator and the second ground radiator.

10 Claims, 7 Drawing Sheets





US011929564B2

(12) **United States Patent**
Woo

(10) **Patent No.:** **US 11,929,564 B2**
(45) **Date of Patent:** **Mar. 12, 2024**

(54) **ELECTRONIC DEVICE COMPRISING 5G ANTENNA**

(71) Applicant: **LG ELECTRONICS INC.**, Seoul (KR)

(72) Inventor: **Seungmin Woo**, Seoul (KR)

(73) Assignee: **LG ELECTRONICS INC.**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 138 days.

(21) Appl. No.: **17/773,008**

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

(86) PCT No.: **PCT/KR2019/014421**

§ 371 (c)(1),

(2) Date: **Apr. 28, 2022**

(87) PCT Pub. No.: **WO2021/085669**

PCT Pub. Date: **May 6, 2021**

(65) **Prior Publication Data**

US 2022/0407233 A1 Dec. 22, 2022

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

(52) **U.S. Cl.**
CPC **H01Q 9/065** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 1/48** (2013.01); **H01Q 5/385**
(2015.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 9/065; H01Q 1/243; H01Q 1/48;
H01Q 5/385; H01Q 21/062; H01Q 23/00;
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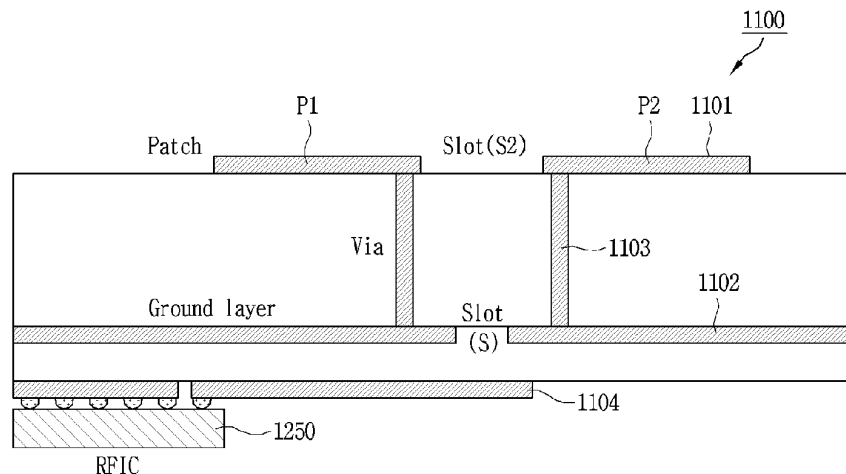
Primary Examiner — Fitwi Y Hailegiorgis

(74) *Attorney, Agent, or Firm* — LEE, HONG,
DEGERMAN, KANG & WAIMEY

(57) **ABSTRACT**

Provided is an electronic device comprising an antenna for 5G communication according to the present invention. The electronic device comprises an array antenna which is implemented as a multi-layer substrate inside the electronic device and includes multiple antenna elements. Each of the multiple antenna elements of the array antenna may comprise: a patch antenna disposed on a specific layer of the multi-layer substrate and including a first patch and a second patch which are spaced a predetermined distance apart from each other; and a ground layer disposed under the patch antenna and having a slot. Meanwhile, the first patch and the second patch may be connected to the ground layer through multiple vias, and the multiple vias may be arranged in the longitudinal direction of the slot while being adjacent to the slot.

20 Claims, 25 Drawing Sheets





US011929768B2

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

(10) **Patent No.:** **US 11,929,768 B2**
(45) **Date of Patent:** **Mar. 12, 2024**

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

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

(72) Inventors: **Yoondo Lee**, Suwon-si (KR); **Sigwan Kim**, Suwon-si (KR); **Hyelee Song**, Suwon-si (KR); **Dongryul Shin**, Suwon-si (KR); **Dongmin Shin**, Suwon-si (KR); **Yoonjae Lee**, Suwon-si (KR); **Handug Lee**, Suwon-si (KR); **Woosik Cho**, Suwon-si (KR); **Weonjai Choi**, Suwon-si (KR); **Taewook Ham**, Suwon-si (KR); **Kyunggu Kim**, Suwon-si (KR); **Hongpyo Bae**, Suwon-si (KR); **Jinwoo Jung**, Suwon-si (KR); **Youngjun Cho**, 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 763 days.

(21) Appl. No.: **16/976,907**

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

(86) PCT No.: **PCT/KR2020/010158**

§ 371 (c)(1),
(2) Date: **Aug. 31, 2020**

(87) PCT Pub. No.: **WO2021/025394**

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

(65) **Prior Publication Data**
US 2023/0155610 A1 May 18, 2023

(30) **Foreign Application Priority Data**
Aug. 6, 2019 (KR) 10-2019-0095741

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

(52) **U.S. Cl.**
CPC **H04B 1/0064** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/50** (2015.01); **H01Q 21/08** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H04B 1/0064; H01Q 5/50; H01Q 1/243; H01Q 1/08; H05K 1/0243; H05K 1/0277; H05K 7/1427; H05K 2201/10098
See application file for complete search history.

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Primary Examiner — Moustapha Diaby

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

(57) **ABSTRACT**

In embodiments, an electronic device may include a housing having an inner space, a printed circuit board (PCB) disposed in the inner space of the housing, a first antenna structure disposed at a position spaced apart from the PCB, and transmitting and/or receiving a radio signal in a first
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