



US011563275B2

(12) **United States Patent**  
**Wei**

(10) **Patent No.:** **US 11,563,275 B2**  
(45) **Date of Patent:** **Jan. 24, 2023**

- (54) **ANTENNA STRUCTURE**
- (71) Applicant: **Wistron NeWeb Corp.**, Hsinchu (TW)
- (72) Inventor: **Shih-Chiang Wei**, 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 171 days.

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*Primary Examiner* — Ricardo I Magallanes  
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

- (21) Appl. No.: **17/010,219**
- (22) Filed: **Sep. 2, 2020**
- (65) **Prior Publication Data**  
US 2021/0249776 A1 Aug. 12, 2021

- (30) **Foreign Application Priority Data**  
Feb. 6, 2020 (TW) ..... 109103648

- (51) **Int. Cl.**  
**H01Q 13/10** (2006.01)  
**H01Q 1/48** (2006.01)
- (52) **U.S. Cl.**  
CPC ..... **H01Q 13/106** (2013.01); **H01Q 1/48** (2013.01)

- (58) **Field of Classification Search**  
CPC ..... H01Q 5/364; H01Q 5/357; H01Q 13/106;  
H01Q 5/328; H01Q 5/335; H01Q 5/392  
See application file for complete search history.

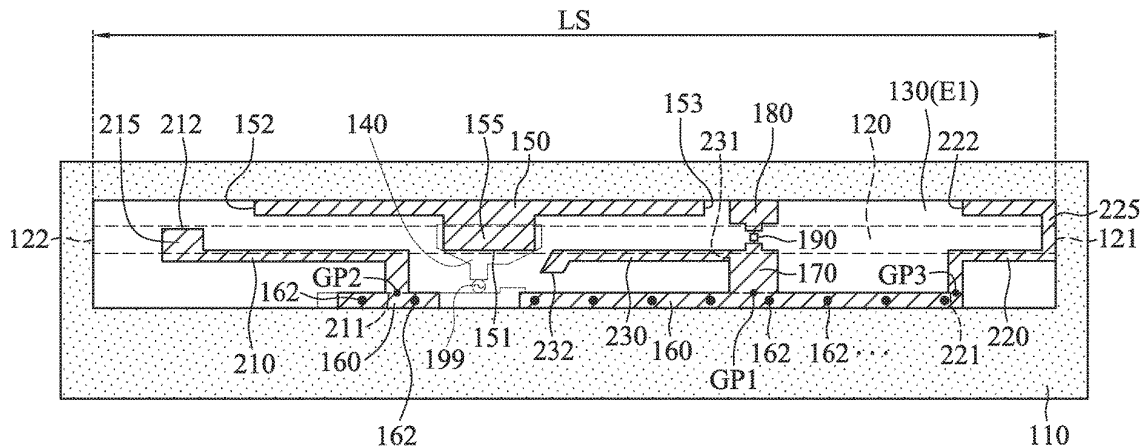
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343/702

(57) **ABSTRACT**

An antenna structure includes a metal mechanism element, a dielectric substrate, a feeding radiation element, a coupling radiation element, a ground plane, a first shorting element, a second shorting element, and a circuit element. The metal mechanism element has a slot. The dielectric substrate has a first surface and a second surface which are opposite to each other. The feeding radiation element extends across the slot. The coupling radiation element is adjacent to the feeding radiation element. The first shorting element is coupled to a first grounding point on the ground plane. The second shorting element is coupled to the metal mechanism element. The circuit element is coupled between the first shorting element and the second shorting element. The coupling radiation element is disposed on the first surface of the dielectric substrate. The feeding radiation element is disposed on the second surface of the dielectric substrate.

**18 Claims, 7 Drawing Sheets**

100





US011569561B2

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

(10) **Patent No.:** **US 11,569,561 B2**  
(45) **Date of Patent:** **Jan. 31, 2023**

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

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

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

(56) **References Cited**

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

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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.

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(21) Appl. No.: **17/394,909**

*Primary Examiner* — David E Lotter

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

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

(65) **Prior Publication Data**

US 2021/0367322 A1 Nov. 25, 2021

**Related U.S. Application Data**

(62) Division of application No. 16/596,108, filed on Oct. 8, 2019, now Pat. No. 11,114,744.

(57) **ABSTRACT**

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

(30) **Foreign Application Priority Data**

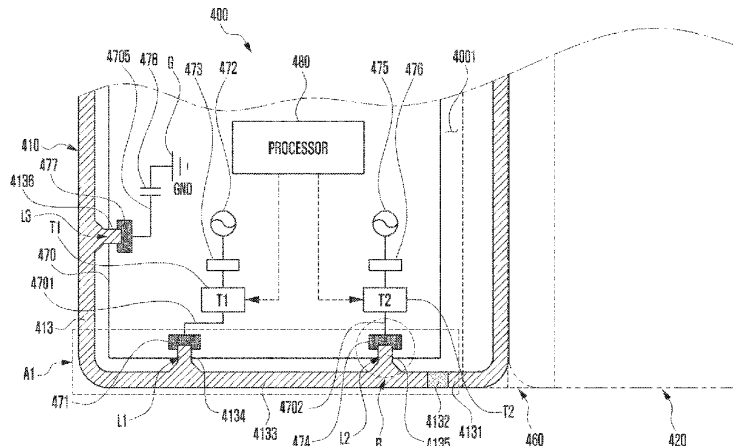
Oct. 16, 2018 (KR) ..... 10-2018-0122922

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

(Continued)

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

**12 Claims, 17 Drawing Sheets**







US011569581B2

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

(10) **Patent No.:** **US 11,569,581 B2**  
(45) **Date of Patent:** **Jan. 31, 2023**

(54) **TRANSMISSION STRUCTURE WITH DUAL-FREQUENCY ANTENNA**

(56) **References Cited**

(71) Applicant: **Arcadyan Technology Corporation**,  
Hsinchu (TW)

U.S. PATENT DOCUMENTS

(72) Inventors: **Chih-Yung Huang**, Taichung (TW);  
**Kuo-Chang Lo**, Miaoli County (TW)

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(73) Assignee: **ARCADYAN TECHNOLOGY CORPORATION**

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

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(21) Appl. No.: **17/465,660**

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cation No. 21198340.8, dated Feb. 17, 2022, 9 pages.

(22) Filed: **Sep. 2, 2021**

(Continued)

(65) **Prior Publication Data**

US 2022/0094062 A1 Mar. 24, 2022

*Primary Examiner* — Ab Salam Alkassim, Jr.

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

(30) **Foreign Application Priority Data**

Sep. 23, 2020 (TW) ..... 109132891

(57) **ABSTRACT**

A transmission structure with a dual-frequency antenna is provided. The transmission structure includes a substrate, a first radiator and a second radiator. The first radiator has a first electrical connection portion. The first radiator extends from the first electrical connection portion in a first direction and a second direction, wherein the first direction is opposite to the second direction. The second radiator has a second electrical connection portion adjacent to the first electrical connection portion. The second electrical connection portion has a first side and a second side, wherein the first side is closer to the first electrical connection portion than the second side, the second electrical connection portion forms a ground area between the first side and the second side, and the length of the ground area is greater than a first set value.

(51) **Int. Cl.**

**H01Q 9/28** (2006.01)  
**H01Q 1/38** (2006.01)  
**H01Q 5/371** (2015.01)

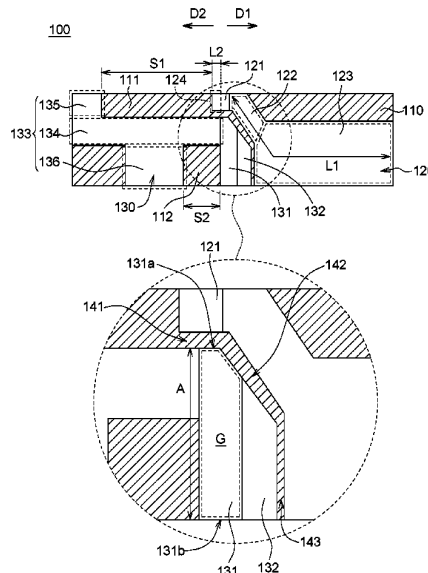
(52) **U.S. Cl.**

CPC ..... **H01Q 9/285** (2013.01); **H01Q 1/38**  
(2013.01); **H01Q 5/371** (2015.01)

(58) **Field of Classification Search**

CPC ..... H01Q 9/285; H01Q 9/28; H01Q 9/065  
See application file for complete search history.

**9 Claims, 3 Drawing Sheets**





US011569585B2

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

(10) **Patent No.:** **US 11,569,585 B2**  
(45) **Date of Patent:** **Jan. 31, 2023**

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

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(71) Applicant: **Industrial Technology Research  
Institute, Hsinchu (TW)**

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(72) Inventors: **Wei-Yu Li**, Yilan County (TW); **Wei  
Chung**, Hsinchu County (TW); **Kin-Lu  
Wong**, Kaohsiung (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  
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U.S.C. 154(b) by 273 days.

(Continued)

(21) Appl. No.: **17/137,362**

*Primary Examiner* — Ricardo I Magallanes

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

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

(65) **Prior Publication Data**

US 2022/0209420 A1 Jun. 30, 2022

(51) **Int. Cl.**  
**H01Q 21/06** (2006.01)  
**H01Q 9/42** (2006.01)  
**H01Q 1/48** (2006.01)

(57) **ABSTRACT**

A highly integrated pattern-variable multi-antenna array,  
including a ground conductor structure, a first antenna array,  
a second antenna array, and an array conjoined grounding  
structure, is provided. A first inverted L-shaped resonant  
structure has a first feeding point, and the others respectively  
have a first switch and are electrically connected or coupled  
to the ground conductor structure. A second inverted  
L-shaped resonant structure has a second feeding point, and  
the others respectively have a second switch and are elec-  
trically connected or coupled to the ground conductor struc-  
ture. The first and second antenna arrays respectively gener-  
ate first and second resonance modes. The second and first  
resonance modes cover at least one same first communica-  
tion frequency band. The array conjoined grounding struc-  
ture electrically connects an adjacent first inverted L-shaped  
resonant structure, one of the second inverted L-shaped  
resonant structures, and has an array conjoined capacitive  
structure electrically connecting the ground conductor struc-  
ture.

(52) **U.S. Cl.**  
CPC ..... **H01Q 21/06** (2013.01); **H01Q 1/48**  
(2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 21/06; H01Q 21/28; H01Q 1/50;  
H01Q 21/062; H01Q 21/29; H01Q  
5/385-392; H01Q 5/321; H01Q 5/378  
See application file for complete search history.

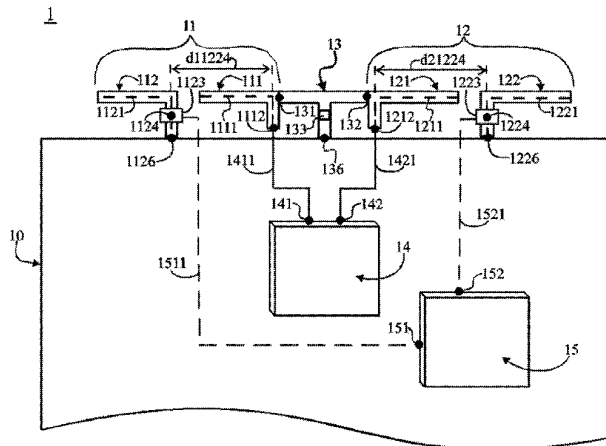
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**31 Claims, 23 Drawing Sheets**





US011569586B2

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

(10) **Patent No.:** **US 11,569,586 B2**  
(45) **Date of Patent:** **Jan. 31, 2023**

(54) **ANTENNA**

(71) Applicant: **SAMSUNG ELECTRO-MECHANICS CO., LTD.**, Suwon-si (KR)

(72) Inventors: **Sangik Cho**, Suwon-si (KR); **Ju Ho Kim**, Suwon-si (KR)

(73) Assignee: **SAMSUNG ELECTRO-MECHANICS 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 238 days.

(21) Appl. No.: **16/919,609**

(22) Filed: **Jul. 2, 2020**

(65) **Prior Publication Data**  
US 2021/0320426 A1 Oct. 14, 2021

(30) **Foreign Application Priority Data**  
Apr. 14, 2020 (KR) ..... 10-2020-0045141

(51) **Int. Cl.**  
**H01Q 21/06** (2006.01)  
**H01Q 9/04** (2006.01)  
**H01Q 1/24** (2006.01)  
**H01Q 1/38** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 21/065** (2013.01); **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.

(56) **References Cited**

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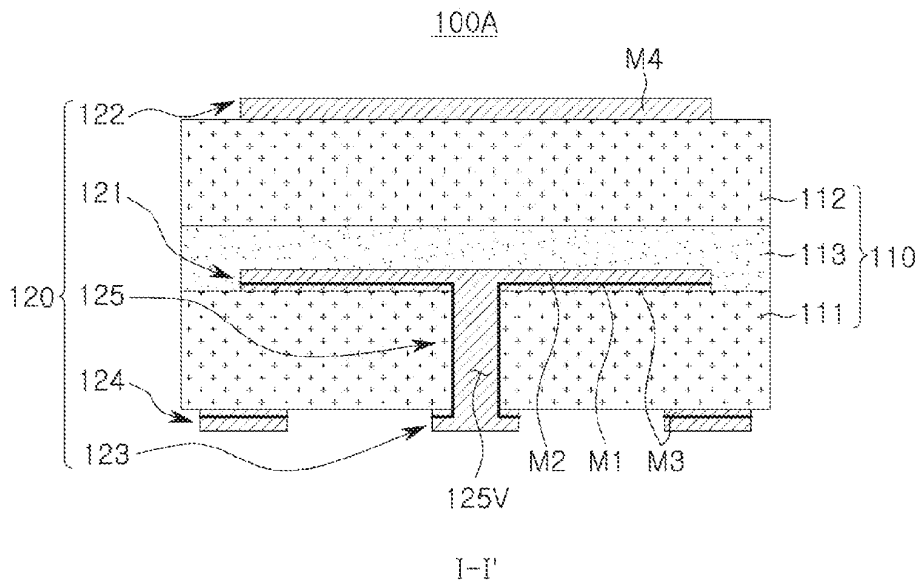
*Primary Examiner* — Crystal L Hammond

(74) *Attorney, Agent, or Firm* — Morgan, Lewis & Bockius LLP

(57) **ABSTRACT**

A antenna may include a first dielectric layer having a first surface and a second surface opposing the first surface; a second dielectric layer having a third surface, and a fourth surface opposing the third surface; an adhesive layer disposed between the second surface and the third surface and connecting the first dielectric layer to the second dielectric layer; a patch pattern disposed on the second surface and embedded in the adhesive layer; and a coupling pattern disposed on the fourth surface and having at least a portion overlapping the patch pattern on a plane. Each of the first dielectric layer and the second dielectric layer may include an organic binder and an inorganic filler.

**20 Claims, 9 Drawing Sheets**





US011570286B2

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

(10) **Patent No.:** **US 11,570,286 B2**  
(45) **Date of Patent:** **Jan. 31, 2023**

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

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

(72) Inventors: **Hyung Joo Lee**, Seongnam-si (KR); **Gyu Sub Kim**, Seoul (KR); **Dong Yeon Kim**, Suwon-si (KR); **Chae Up Yoo**, Seoul (KR)

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

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

(21) Appl. No.: **17/323,472**

(22) Filed: **May 18, 2021**

(65) **Prior Publication Data**

US 2021/0274027 A1 Sep. 2, 2021

**Related U.S. Application Data**

(63) Continuation of application No. 16/589,734, filed on Oct. 1, 2019, now Pat. No. 11,050,863, which is a (Continued)

(51) **Int. Cl.**  
**H04B 1/44** (2006.01)  
**H04M 1/02** (2006.01)  
(Continued)

(52) **U.S. Cl.**  
CPC ..... **H04M 1/0202** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01);  
(Continued)

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

(56) **References Cited**

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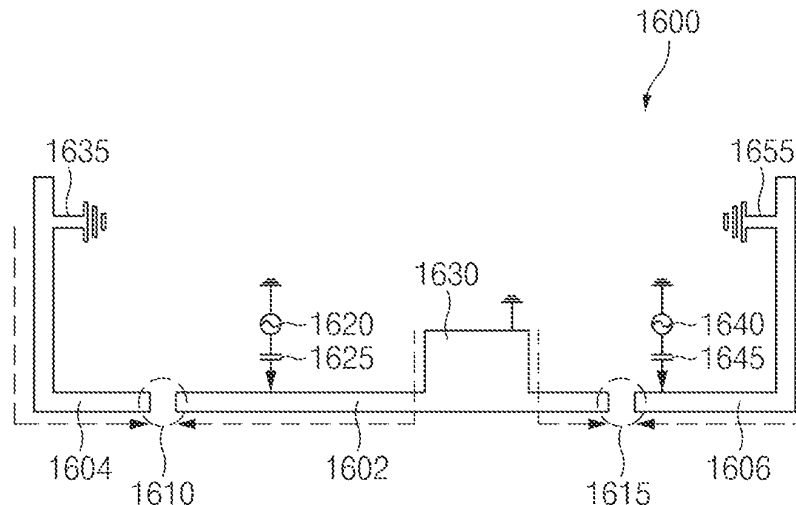
*Primary Examiner* — Tuan A Tran

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

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a housing including a first surface, a second surface disposed facing an opposite side of the first surface, and a side surface configured to surround at least a portion of a space between the first surface and the second surface, a first elongated metal member configured to form a first portion of the side surface and including a first end and a second end, at least one communication circuit electrically connected to a first point of the first elongated metal member through a capacitive element, at least one ground member disposed in an interior of the housing, and a first conductive member configured to electrically connect a second point of the first elongated metal member to the ground member. The second point of the first elongated metal member is disposed closer to the second end than to the first point.

**20 Claims, 42 Drawing Sheets**





US011574881B2

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

(10) **Patent No.:** **US 11,574,881 B2**  
(45) **Date of Patent:** **Feb. 7, 2023**

(54) **SEMICONDUCTOR PACKAGE STRUCTURE WITH ANTENNA**

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

(72) Inventors: **Nai-Wei Liu**, Hsin-Chu (TW); **Yen-Yao Chi**, Hsin-Chu (TW); **Yeh-Chun Kao**, Hsin-Chu (TW); **Shih-Huang Yeh**, Hsin-Chu (TW); **Tzu-Hung Lin**, Hsin-Chu (TW); **Wen-Sung Hsu**, Hsin-Chu (TW)

(73) Assignee: **MediaTek Inc.**, Hsin-Chu (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.: **17/361,285**

(22) Filed: **Jun. 28, 2021**

(65) **Prior Publication Data**

US 2021/0327835 A1 Oct. 21, 2021

**Related U.S. Application Data**

(62) Division of application No. 16/452,395, filed on Jun. 25, 2019, now Pat. No. 11,081,453.  
(Continued)

(51) **Int. Cl.**  
**H01L 23/66** (2006.01)  
**H01L 23/31** (2006.01)  
(Continued)

(52) **U.S. Cl.**  
CPC ..... **H01L 23/66** (2013.01); **H01L 23/3128** (2013.01); **H01L 23/3135** (2013.01);  
(Continued)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/2283; H01Q 9/0407; H01Q 9/16; H01L 2223/667; H01L 23/28-3192; H01L 23/66  
See application file for complete search history.

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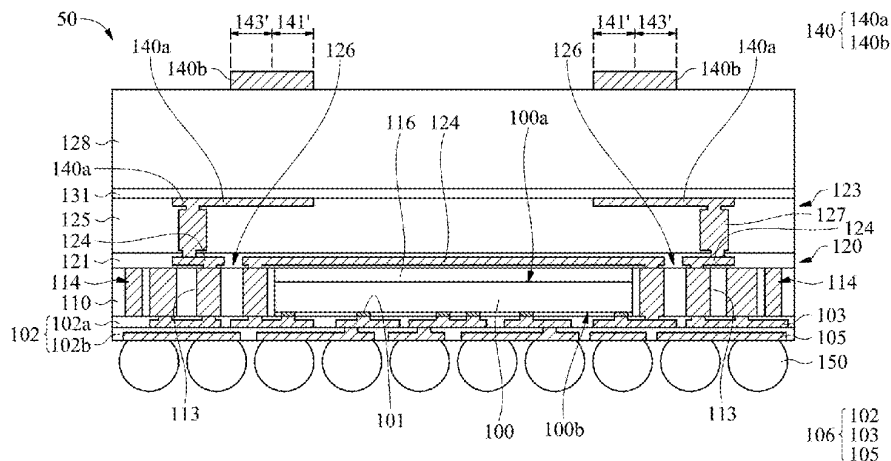
*Primary Examiner* — Victoria K. Hall

(74) *Attorney, Agent, or Firm* — Wolf, Greenfield & Sacks, P.C.

(57) **ABSTRACT**

A semiconductor package structure is provided. The semiconductor package structure includes a first redistribution layer (RDL) structure formed on a non-active surface of a semiconductor die. A second RDL structure is formed on and electrically coupled to an active surface of the semiconductor die. A ground layer is formed in the first RDL structure. A first molding compound layer is formed on the first RDL structure. A first antenna includes a first antenna element formed in the second RDL structure and a second antenna element formed on the first molding compound layer. Each of the first antenna element and the second antenna element has a first portion overlapping the semiconductor die as viewed from a top-view perspective.

**13 Claims, 8 Drawing Sheets**







US011575193B2

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

(10) **Patent No.:** **US 11,575,193 B2**  
(45) **Date of Patent:** **Feb. 7, 2023**

(54) **ELECTRONIC DEVICE WITH SLOT ANTENNA**

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

(72) Inventors: **Yuhui Wang**, Wuhan (CN); **Kemeng Wang**, Wuhan (CN); **Chungwen Yang**, Dongguan (CN); **He Xiang**, Wuhan (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 125 days.

(21) Appl. No.: **17/050,559**

(22) PCT Filed: **Apr. 28, 2018**

(86) PCT No.: **PCT/CN2018/085036**

§ 371 (c)(1),

(2) Date: **Oct. 26, 2020**

(87) PCT Pub. No.: **WO2019/205120**

PCT Pub. Date: **Oct. 31, 2019**

(65) **Prior Publication Data**

US 2021/0242567 A1 Aug. 5, 2021

(51) **Int. Cl.**

**H01Q 1/22** (2006.01)

**H01Q 1/24** (2006.01)

**H01Q 1/48** (2006.01)

**H01Q 13/16** (2006.01)

**G06F 3/02** (2006.01)

**G06F 3/0354** (2013.01)

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

CPC ..... **H01Q 1/2266** (2013.01); **G06F 3/0202** (2013.01); **G06F 3/03547** (2013.01); **H01Q 1/245** (2013.01); **H01Q 1/48** (2013.01); **H01Q 13/16** (2013.01)

(58) **Field of Classification Search**

CPC ..... H01Q 1/2266; H01Q 1/245; H01Q 1/48; H01Q 13/16; H01Q 13/103; G06F 3/0202; G06F 3/03547

See application file for complete search history.

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*Primary Examiner* — Dimary S Lopez Cruz

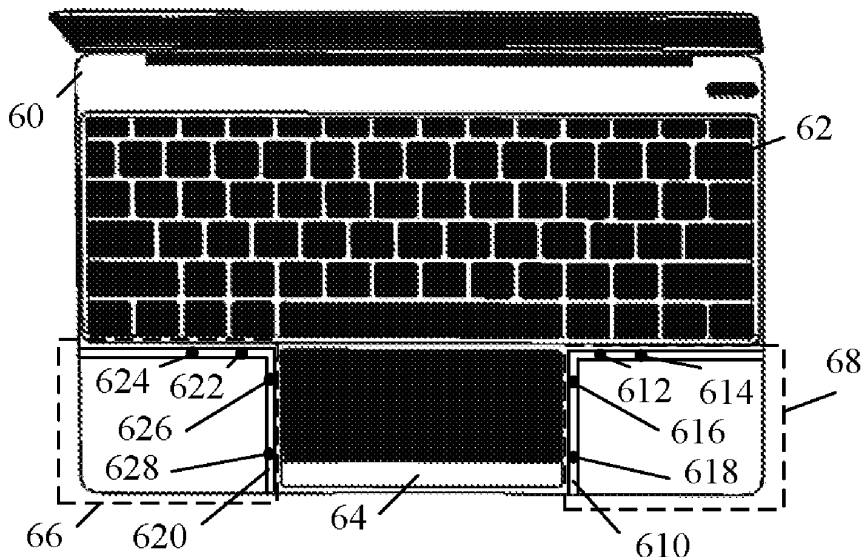
*Assistant Examiner* — Michael M Bouizza

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

(57) **ABSTRACT**

An electronic device with a slot antenna comprises a surface C, which includes a keyboard area for inputting using a keyboard, a touch area for inputting using a touchpad, and a palm rest. The palm rest is made of a metal material, and a radiating slot is disposed in the palm rest to form the slot antenna.

**18 Claims, 5 Drawing Sheets**





US011575206B2

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

(10) **Patent No.:** **US 11,575,206 B2**  
(45) **Date of Patent:** **Feb. 7, 2023**

(54) **SELF-FILTERING WIDEBAND MILLIMETER WAVE ANTENNA**

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

(72) Inventors: **Haotao Hu**, Hong Kong (HK); **Chi Hou Chan**, Hong Kong (HK)

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

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

(21) Appl. No.: **17/351,281**

(22) Filed: **Jun. 18, 2021**

(65) **Prior Publication Data**

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(60) Provisional application No. 63/041,169, filed on Jun. 19, 2020.

(51) **Int. Cl.**  
**H01Q 9/04** (2006.01)  
**H01Q 21/06** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 9/0457** (2013.01); **H01Q 21/065** (2013.01)

(58) **Field of Classification Search**  
CPC .... H01Q 9/0457; H01Q 21/065; H01Q 13/10; H01Q 19/005; H01Q 5/378  
See application file for complete search history.

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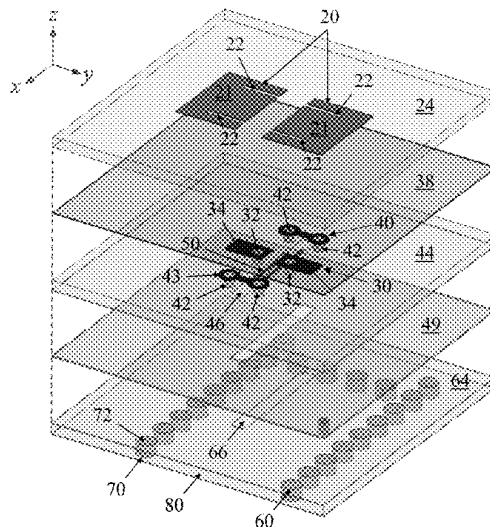
*Primary Examiner* — Jason Crawford

(74) *Attorney, Agent, or Firm* — Idea Intellectual Limited; Margaret A. Burke; Sam T. Yip

(57) **ABSTRACT**

The present invention provides a self-filtering millimeter-wave wideband multilayer planar antenna. The antenna includes a first layer having a slot feed. A second layer includes at least a pair of probes fed by the slot feed from the first layer. A third layer includes at least two substantially planar radiating patches each patch respectively coupled to one of the probes on the second layer. The radiating patches are arranged to radiate a millimeter-wavelength electromagnetic wave when the slot feed receives excitation energy and transmits the energy to the radiating patch through the respective probe. The self-filtering antenna does not require a resonant cavity structure coupled to the radiating patches. Antenna arrays of arbitrary numbers of antenna elements may be constructed from the self-filtering antenna. Such arrays are particularly suitable for 5G mm-wave backhaul communications.

**9 Claims, 14 Drawing Sheets**





US011581628B2

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

(10) **Patent No.:** **US 11,581,628 B2**  
(45) **Date of Patent:** **Feb. 14, 2023**

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

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

(72) Inventors: **Chien-Yi Wu**, Taipei (TW); **Shih-Keng Huang**, Taipei (TW); **Chao-Hsu Wu**, Taipei (TW); **Yi-Ru Yang**, Taipei (TW); **Ching-Hsiang Ko**, Taipei (TW); **Cheng-Hsiung Wu**, Taipei (TW); **Ming-Huang Chen**, Taipei (TW)

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

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 130 days.

(21) Appl. No.: **17/077,958**

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

(65) **Prior Publication Data**  
US 2021/0151858 A1 May 20, 2021

(30) **Foreign Application Priority Data**  
Nov. 18, 2019 (TW) ..... 108141751

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

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01); **H01Q 9/0457** (2013.01); **H01Q 13/10** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/243; H01Q 9/40; H01Q 9/0457; H01Q 1/2266; H01Q 1/48; H01Q 5/371; H01Q 13/10; H01Q 9/42  
See application file for complete search history.

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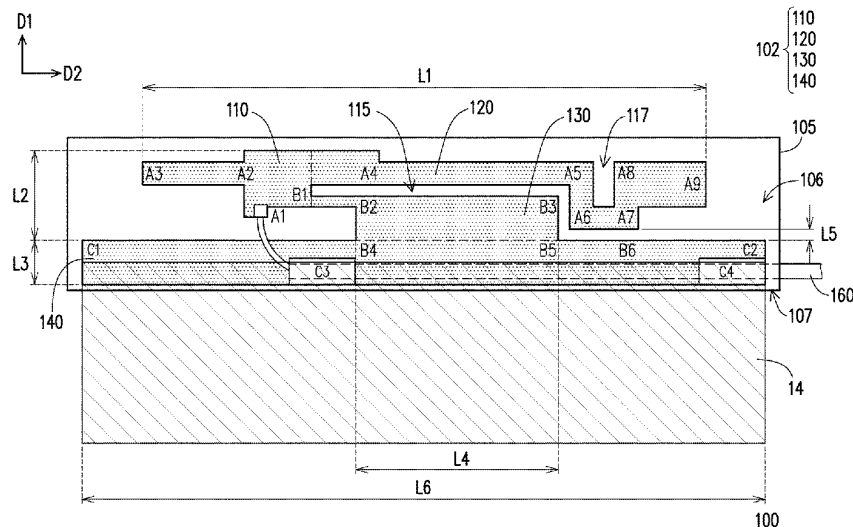
“Search Report of Europe Counterpart Application”, dated Apr. 13, 2021, pp. 1-15.

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*Primary Examiner* — Graham P Smith  
(74) *Attorney, Agent, or Firm* — J.C. Patents

(57) **ABSTRACT**  
An antenna structure includes a first radiator, a second radiator, an antenna ground, and a conductor. The first radiator for resonating at a high frequency band includes a feeding end. The second radiator is connected to the first radiator and resonates at a low frequency band with a part of the first radiator. The antenna ground is located on one side of the first radiator and the second radiator. The conductor is located between the second radiator and the antenna ground in a first direction and connected to the first radiator and the antenna ground. A slit having at least one bending portion is formed among the second radiator, and the conductor and the antenna ground. An electronic device is further provided.

**18 Claims, 17 Drawing Sheets**





US011581647B2

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

(10) **Patent No.:** **US 11,581,647 B2**  
(45) **Date of Patent:** **Feb. 14, 2023**

(54) **ANTENNA STRUCTURE**

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

(72) Inventors: **Yun-Tsan Lee**, Hsinchu (TW);  
**Chia-Hao Chang**, 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 311 days.

(21) Appl. No.: **17/022,391**

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Apr. 24, 2020 (TW) ..... 109113707

(51) **Int. Cl.**

**H01Q 5/371** (2015.01)  
**H01Q 1/48** (2006.01)  
**H01Q 1/24** (2006.01)  
**H01Q 5/364** (2015.01)  
**H01Q 13/10** (2006.01)

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

CPC ..... **H01Q 5/371** (2015.01); **H01Q 1/48** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/364** (2015.01); **H01Q 13/10** (2013.01)

(58) **Field of Classification Search**

CPC ..... H01Q 5/371; H01Q 13/106; H01Q 13/16-18; H01Q 13/10; H01Q 5/357; H01Q 5/364; H01Q 5/385  
See application file for complete search history.

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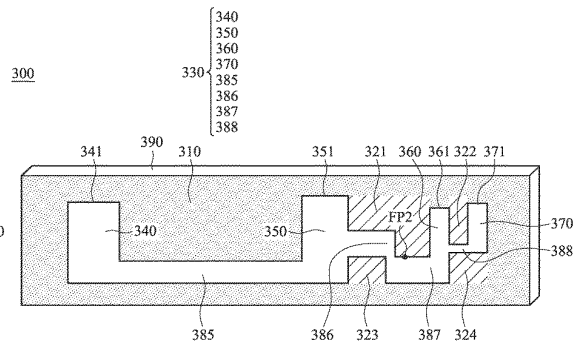
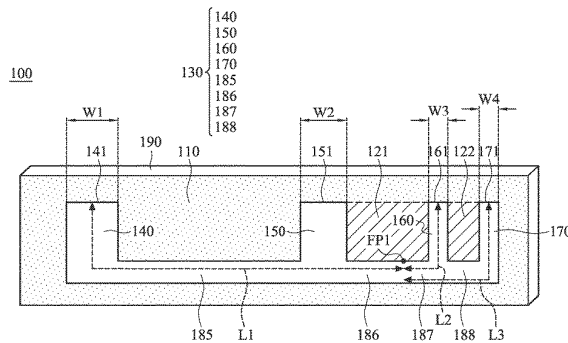
*Primary Examiner* — Ricardo I Magallanes

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

(57) **ABSTRACT**

An antenna structure includes a ground metal element, a first metal element, and a second metal element. The ground metal element has a slot. A feeding point is positioned at the first metal element. The first metal element and the second metal element are coupled to the ground metal element. The first metal element and the second metal element extend into the interior of the slot. The slot includes a first branch portion, a second branch portion, a third branch portion, and a fourth branch portion. The first metal element is disposed between the second branch portion and the third branch portion of the slot. The second metal element is disposed between the third branch portion and the fourth branch portion of the slot.

**20 Claims, 6 Drawing Sheets**





US011581659B2

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

(10) **Patent No.:** **US 11,581,659 B2**  
(45) **Date of Patent:** **Feb. 14, 2023**

(54) **ANTENNA DEVICE**  
(71) Applicant: **Yokowo Co., Ltd.**, Tokyo (JP)  
(72) Inventors: **Takeshi Sampo**, Tomioka (JP);  
**Takayuki Sone**, Tomioka (JP)  
(73) Assignee: **YOKOWO CO., LTD.**, 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.: **17/163,691**

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

(65) **Prior Publication Data**  
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**Related U.S. Application Data**  
(63) Continuation of application No. PCT/JP2019/029899, filed on Jul. 30, 2019.

(30) **Foreign Application Priority Data**  
Jul. 31, 2018 (JP) ..... JP2018-143828

(51) **Int. Cl.**  
**H01Q 21/24** (2006.01)  
**H01Q 9/16** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 21/24** (2013.01); **H01Q 9/16** (2013.01)

(58) **Field of Classification Search**  
CPC .. H01Q 9/16; H01Q 9/26; H01Q 9/28; H01Q 9/285; H01Q 21/24; H01Q 21/26;  
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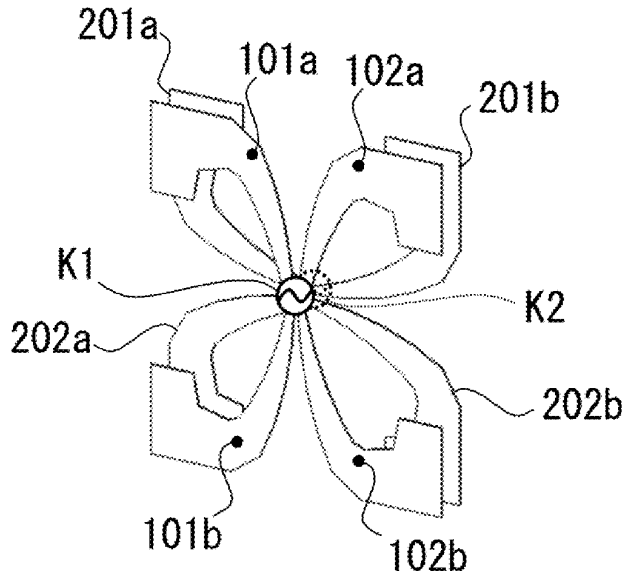
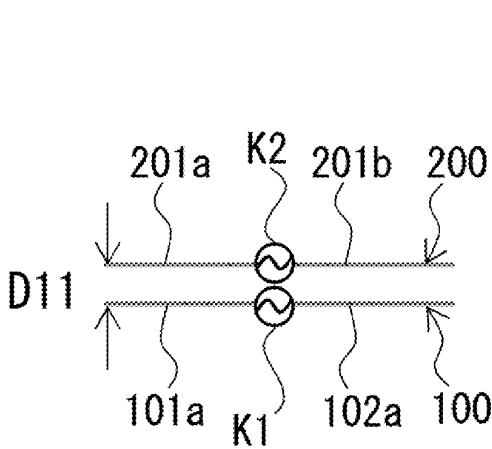
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*Primary Examiner* — Thai Pham  
(74) *Attorney, Agent, or Firm* — Xsensus LLP

(57) **ABSTRACT**  
An antenna device includes: a pair of first elements that are arranged on a first plane; and a pair of second elements that are arranged on a second plane parallel to the first plane such that a polarized wave direction of the pair of second elements is orthogonal to that of the pair of first elements. Each element of the pair of first elements and the pair of second elements includes a portion that acts as a self-similarity antenna or an antenna that acts based on similar operating principle to the self-similarity antenna. In one embodiment, each element of the pair of first elements and the pair of second elements includes two arms that extend in a direction away from each other from a proximal end portion to which a feed point is connectable.

**22 Claims, 46 Drawing Sheets**





US011581662B2

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

(10) **Patent No.:** **US 11,581,662 B2**  
(45) **Date of Patent:** **Feb. 14, 2023**

(54) **ELECTRONIC DEVICE INCLUDING ANTENNA**

- (71) Applicant: **Samsung Electronics Co., Ltd.**, Gyeonggi-do (KR)
- (72) Inventors: **Yonghyun Yoon**, Gyeonggi-do (KR); **Mincheol Seo**, Gyeonggi-do (KR); **Seho Kim**, Gyeonggi-do (KR); **Minkyung Lee**, Gyeonggi-do (KR); **Jongheon Lee**, Gyeonggi-do (KR); **Sooyoung Jang**, Gyeonggi-do (KR); **Hyuntae Jung**, Gyeonggi-do (KR); **Kyunggu Kim**, Gyeonggi-do (KR); **Jinwoo Jung**, Gyeonggi-do (KR)

- (73) Assignee: **Samsung Electronics Co., Ltd**
- (\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.
- (21) Appl. No.: **16/986,793**
- (22) Filed: **Aug. 6, 2020**

(65) **Prior Publication Data**  
US 2021/0044029 A1 Feb. 11, 2021

(30) **Foreign Application Priority Data**  
Aug. 7, 2019 (KR) ..... 10-2019-0096134

(51) **Int. Cl.**  
**H01Q 21/28** (2006.01)  
**H01Q 5/335** (2015.01)  
 (Continued)

(52) **U.S. Cl.**  
 CPC ..... **H01Q 21/28** (2013.01); **H01Q 1/02** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/335** (2015.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/243; H01Q 5/30; H01Q 5/335; H01Q 5/378; H01Q 5/385; H01Q 5/392; H01Q 9/30

See application file for complete search history.

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*Primary Examiner* — Ricardo I Magallanes  
(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(57) **ABSTRACT**

An electronic device includes a housing including a front plate and a rear plate disposed opposite the front plate, and a display disposed in a space between the front plate and the rear plate, and disposed at least partially along the front plate. The electronic device further includes a first antenna structure disposed in the space and configured to transmit or receive a first signal in a first frequency band, wherein the first antenna structure includes at least one first conductive pattern. The electronic device also includes a second antenna structure disposed in the space without being overlapped with the first conductive pattern when viewed from above the rear plate, and configured to transmit or receive a second signal in a second frequency band different from the first frequency band. In addition, the electronic device includes a conductive sheet disposed in the space and on the rear plate. The conductive sheet is physically separated from the first conductive pattern, and at least partially overlapped with the first conductive pattern when viewed from above the rear plate.

**18 Claims, 33 Drawing Sheets**

