



US011631940B2

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

(10) **Patent No.:** **US 11,631,940 B2**
(45) **Date of Patent:** **Apr. 18, 2023**

(54) **WAVEGUIDE SLOT ANTENNA**

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(73) Assignee: **NGK SPARK PLUG CO., LTD.**,
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patent is extended or adjusted under 35
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(21) Appl. No.: **17/055,001**

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(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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H01Q 13/10 (2006.01)

H01Q 13/22 (2006.01)

H01Q 21/00 (2006.01)

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

CPC **H01Q 13/10** (2013.01); **H01Q 13/22**
(2013.01); **H01Q 21/0043** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 13/10; H01Q 21/005; H01Q
21/0043

See application file for complete search history.

(56) **References Cited**

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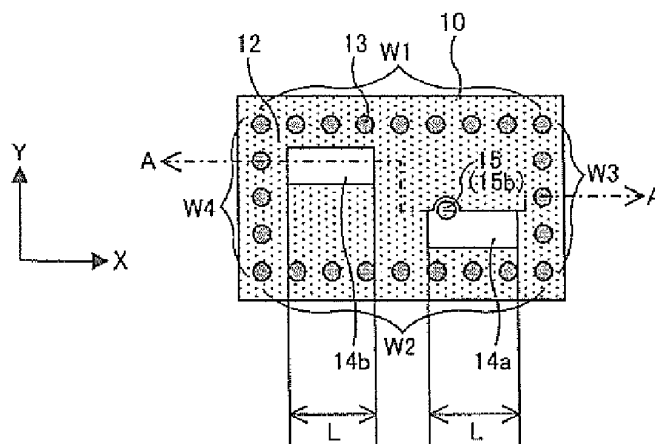
Primary Examiner — Ab Salam Alkassim, Jr.

(74) *Attorney, Agent, or Firm* — Stites & Harbison,
PLLC; Jeffrey A. Haeberlin

(57) **ABSTRACT**

A waveguide slot antenna is configured by a waveguide,
formed by a dielectric substrate, a first conductive layer
formed at a lower surface of the dielectric substrate, a
second conductive layer formed at an upper surface of the
dielectric substrate and provided with one or a plurality of
slots, and a pair of side wall parts electrically connecting the
first and second conductive layers and extending in a first
direction, being provided with a power feeding part. The one
or a plurality of slots include a first slot having a predeter-
mined slot length along the first direction. The waveguide
slot antenna has a structure in which, on a plan view from
a second direction, the power feeding part overlaps the first

(Continued)





US011631943B2

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

(10) **Patent No.:** **US 11,631,943 B2**
(45) **Date of Patent:** **Apr. 18, 2023**

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

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

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

(56) **References Cited**

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

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343/702

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

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 37 days.

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(21) Appl. No.: **17/523,073**

(22) Filed: **Nov. 10, 2021**

Primary Examiner — Andrea Lindgren Baltzell

(65) **Prior Publication Data**

US 2022/0166150 A1 May 26, 2022

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

(30) **Foreign Application Priority Data**

Nov. 25, 2020 (CN) 202011338097.9

(57) **ABSTRACT**

An antenna structure applied in a wireless communication device includes a frame, a first feed portion, a second feed portion, and a ground portion. The frame defines at least a first gap and a second gap. The first gap and the second gap collectively divide the frame into a first radiation portion and a second radiation portion. The first feed portion is electrically connected to the first radiation portion and a first signal feed point for feeding currents and signals to the first radiation portion. The second feed portion is electrically connected to the second radiation portion and a second signal feed point for feeding currents and signals to the second radiation portion. When the first radiation portion and the second radiation portion supply currents, respectively, the first radiation portion and the second radiation portion generate radiation signals in at least one same frequency band.

(51) **Int. Cl.**

H01Q 21/28 (2006.01)

H01Q 1/24 (2006.01)

H01Q 3/24 (2006.01)

H01Q 5/371 (2015.01)

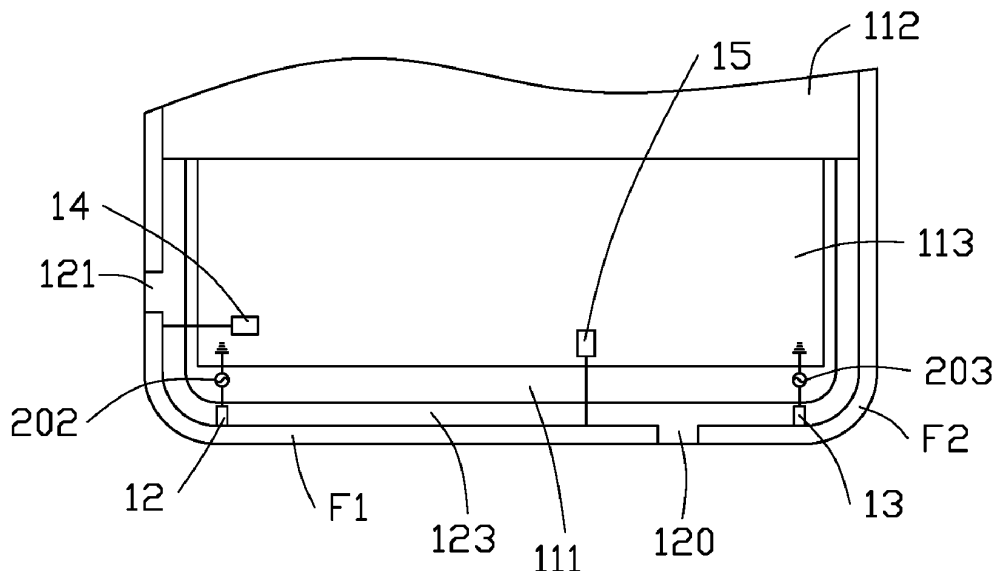
(52) **U.S. Cl.**

CPC **H01Q 21/28** (2013.01); **H01Q 1/241**
(2013.01); **H01Q 3/24** (2013.01); **H01Q 5/371**
(2015.01)

(58) **Field of Classification Search**

CPC H01Q 21/28; H01Q 5/37; H01Q 1/24;
H01Q 3/24

17 Claims, 13 Drawing Sheets





US011637361B2

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

(10) **Patent No.:** **US 11,637,361 B2**
(45) **Date of Patent:** **Apr. 25, 2023**

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

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

(72) Inventors: **Yung-Chin Chen**, New Taipei (TW);
Kun-Lin Sung, New Taipei (TW);
Yi-Chieh Lee, 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 318 days.

(21) Appl. No.: **17/106,347**

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

(65) **Prior Publication Data**

US 2021/0218130 A1 Jul. 15, 2021

(30) **Foreign Application Priority Data**

Jan. 14, 2020 (CN) 202010037127.6

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 13/10 (2006.01)

H01Q 5/378 (2015.01)

H01Q 1/48 (2006.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/378** (2015.01); **H01Q 13/10** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/48; H01Q 5/378; H01Q 13/10

See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Andrea Lindgren Baltzell

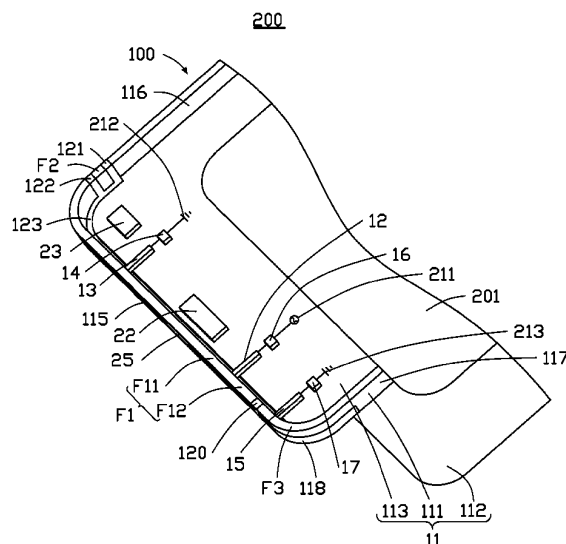
Assistant Examiner — Amal Patel

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

(57) **ABSTRACT**

An antenna structure includes a metal frame, a feeding portion, and a first ground portion. The metal frame is provided with a slot, a first gap, a second gap, and a third gap. The first gap, the second gap, and the third gap are coupled to the slot, and the slot, the first gap, the second gap, and the third gap divide the metal frame into a radiating portion and a first coupling portion. A portion of the metal frame between the first gap and the third gap form the radiating portion, and a portion of the metal frame between the second gap and the third gap form the first coupling portion. The feeding portion is electrically coupled to the radiating portion to feed an electric signal to the radiating portion. The first ground portion is electrically coupled to the radiating portion to provide ground to the radiating portion.

12 Claims, 7 Drawing Sheets





US011637375B2

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

(10) **Patent No.:** **US 11,637,375 B2**
(45) **Date of Patent:** **Apr. 25, 2023**

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

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

(72) Inventors: **Yarui Zhao**, Beijing (CN); **Mingming Zhou**, Beijing (CN); **Yuchuan Su**, 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 0 days.

(21) Appl. No.: **17/204,043**

(22) Filed: **Mar. 17, 2021**

(65) **Prior Publication Data**
US 2022/0037790 A1 Feb. 3, 2022

(30) **Foreign Application Priority Data**
Jul. 29, 2020 (CN) 202010746041.0

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0414** (2013.01); **H01Q 1/2291** (2013.01); **H01Q 9/0464** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 9/0414; H01Q 1/2291; H01Q 9/0464; H01Q 5/25; H01Q 5/371; H01Q 5/40; H01Q 9/04; H01Q 1/243; H01Q 1/36; H01Q 1/48

See application file for complete search history.

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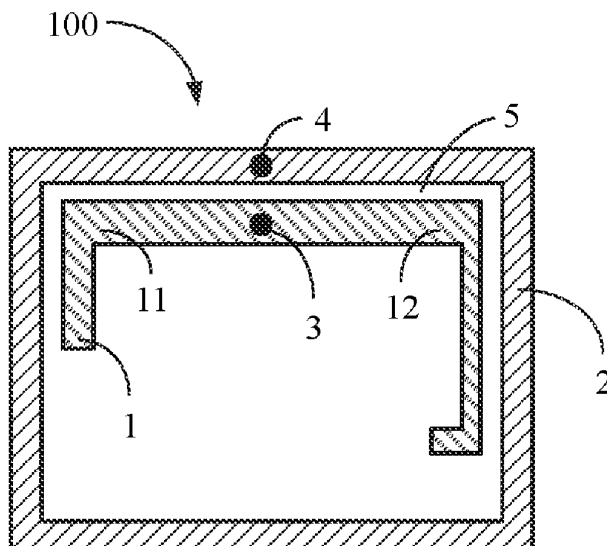
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Primary Examiner — Hai V Tran
Assistant Examiner — Michael M Bouizza
(74) *Attorney, Agent, or Firm* — Cozen O'Connor

(57) **ABSTRACT**

An antenna structure includes: a branching radiator, including a plurality of first radiation modes; a ring-shaped radiator surrounding the branching radiator, and including a plurality of second radiation modes; a feeding point and a grounding point, one of which is connected to the ring-shaped radiator, and the other is connected to the branching radiator; an antenna gap, which is provided between the branching radiator and the ring-shaped radiator. The ring-shaped radiator and the branching radiator are coupled through the antenna gap to form coupled radiation modes. A coupling among the first radiation modes, the second radiation modes and the coupled radiation modes broaden a radiation bandwidth of the antenna structure. The antenna structure may be incorporated in an electronic device.

16 Claims, 3 Drawing Sheets





US011641059B2

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

(10) **Patent No.:** **US 11,641,059 B2**
(45) **Date of Patent:** ***May 2, 2023**

(54) **WIRELESS COMMUNICATION
STRUCTURE, DISPLAY PANEL AND
WIRELESS COMMUNICATION DEVICE**

(56) **References Cited**

U.S. PATENT DOCUMENTS

(71) Applicant: **Yungu (Gu'an) Technology Co., Ltd.**,
Hebei (CN)

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(72) Inventors: **Huan-Chu Huang**, Taoyuan (CN);
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Langfang (CN)

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(73) Assignee: **Yungu (Gu'an) Technology Co., Ltd.**,
Hebei (CN)

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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.

This patent is subject to a terminal dis-
claimer.

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(21) Appl. No.: **17/889,976**

(22) Filed: **Aug. 17, 2022**

(65) **Prior Publication Data**

US 2022/0407228 A1 Dec. 22, 2022

Primary Examiner — Hai V Tran

Assistant Examiner — Michael M Bouizza

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

(51) **Int. Cl.**

H01Q 5/50 (2015.01)

H01Q 7/00 (2006.01)

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

CPC **H01Q 7/00** (2013.01); **H01Q 5/50**
(2015.01)

(58) **Field of Classification Search**

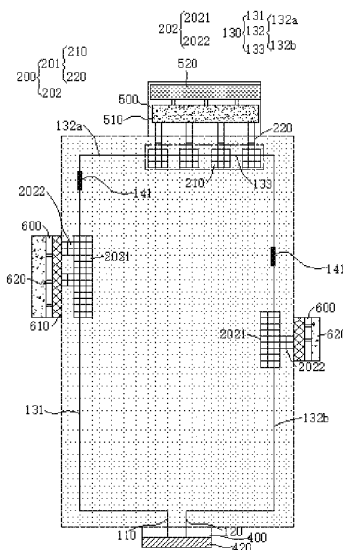
CPC H01Q 7/00; H01Q 5/50; H01Q 7/005;
H01Q 1/44; H01Q 1/2291; H01Q 1/36;
H01Q 1/243; H01Q 1/273; H01Q 1/38;
H01Q 1/50; H01Q 21/00; H01Q 7/06;
G06F 3/0416; G06F 3/046; H04B 1/40

See application file for complete search history.

(57) **ABSTRACT**

A wireless communication structure, a display panel and a
wireless communication device, the wireless communica-
tion structure includes: a loop structure including a first
connection end, a second connection end and a coil body, at
least a part of the coil body being connected between the first
connection end and the second connection end; an antenna
connected to the coil body. The antenna is connected to the
coil body of the loop structure, so that not only the loop
structure and the antenna can be arranged in a limited space,
but also a desired optical performance of the display screen
can be ensured.

15 Claims, 37 Drawing Sheets





US011641065B2

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

(10) **Patent No.:** **US 11,641,065 B2**
(45) **Date of Patent:** **May 2, 2023**

(54) **ANTENNA DEVICE**

(71) Applicants: **SAMSUNG**

ELECTRO-MECHANICS CO., LTD.,
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(72) Inventors: **Won Wook So,** Suwon-si (KR);
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Woncheol Lee, Suwon-si (KR);
Youngsik Hur, Suwon-si (KR); **Keum**
Cheol Hwang, Suwon-si (KR); **Nam**
Heung Kim, Suwon-si (KR);
Yong-Serk Kim, Suwon-si (KR)

(73) Assignees: **Samsung Electro-Mechanics Co., Ltd.,**
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(*) Notice: Subject to any disclaimer, the term of this
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(21) Appl. No.: **17/361,789**

(22) Filed: **Jun. 29, 2021**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
H01Q 21/06 (2006.01)
H01Q 5/307 (2015.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 21/065** (2013.01); **H01Q 5/307**
(2015.01); **H01Q 9/0414** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 21/065; H01Q 5/307; H01Q 9/0414
See application file for complete search history.

(56) **References Cited**

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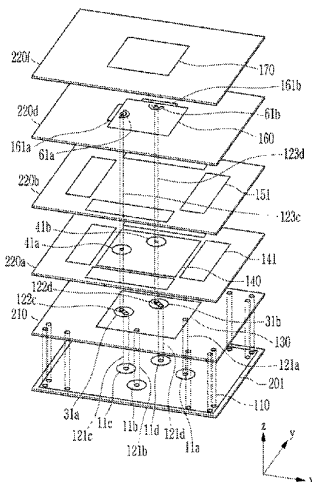
Primary Examiner — Dieu Hien T Duong

(74) *Attorney, Agent, or Firm* — NSIP Law

(57) **ABSTRACT**

An antenna device is provided. The antenna device includes
a first antenna patch configured to transmit and receive an
RF signal in a first frequency bandwidth and disposed a first
dielectric layer; a second antenna patch disposed on a
second dielectric layer and coupled to the first antenna
patch; a third antenna patch disposed on a third dielectric
layer and coupled to the second antenna patch; and a fourth
antenna patch configured to transmit and receive an RF
signal in the second frequency bandwidth, wherein the
second antenna patch includes a plurality of first sub-
antenna patches that do not overlap the first antenna patch,
and the third antenna patch includes a plurality of second
sub-antenna patches that overlap the first sub-antenna
patches.

20 Claims, 23 Drawing Sheets





US011646501B2

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

(10) **Patent No.:** **US 11,646,501 B2**
(45) **Date of Patent:** **May 9, 2023**

(54) **ELECTRONIC DEVICES HAVING
ANTENNAS WITH HYBRID SUBSTRATES**

(56)

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U.S. PATENT DOCUMENTS

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

(72) Inventors: **Jiangfeng Wu**, San Jose, CA (US);
Siwen Yong, Mountain View, CA (US);
Simon G. Begashaw, Santa Clara, CA
(US); **Yi Jiang**, Cupertino, CA (US);
Lijun Zhang, Los Gatos, CA (US)

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

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

J. J. Wang et al., Circuit Model of Microstrip Patch Antenna on Ceramic Land Grid Array Package for Antenna-Chip Codesign of Highly Integrated RF Transceivers, IEEE Transactions on Antennas and Propagation, Dec. 2005, pp. 3877-3883, vol. 53, No. 12.

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(21) Appl. No.: **17/338,481**

(22) Filed: **Jun. 3, 2021**

Primary Examiner — Thai Pham

(65) **Prior Publication Data**

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

(51) **Int. Cl.**

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H01Q 1/38 (2006.01)
H01Q 3/26 (2006.01)
H01Q 19/00 (2006.01)
H01Q 21/06 (2006.01)
H01Q 1/24 (2006.01)

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

CPC **H01Q 19/005** (2013.01); **H01Q 1/38**
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1/243 (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/22; H01Q 1/2283; H01Q 1/24;
H01Q 1/243; H01Q 1/38; H01Q 1/32;
H01Q 1/32617; H01Q 5/385; H01Q 9/04;
H01Q 9/0414; H01Q 19/005; H01Q
21/065

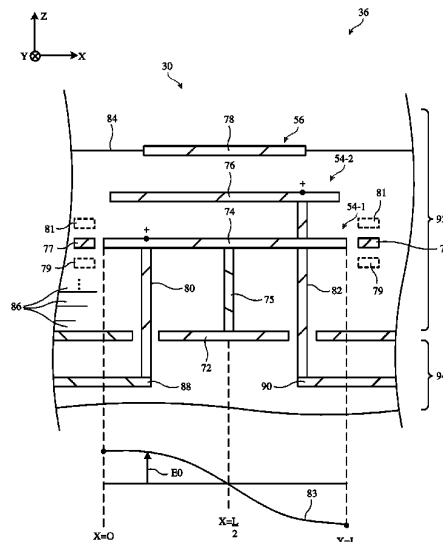
See application file for complete search history.

(57)

ABSTRACT

An electronic device may have an antenna embedded in a substrate. The substrate may have first layers, second layers on the first layers, and third layers on the second layers. The antenna may include a first patch on the first layers that radiates in a first band, a second patch on the second antenna layers that radiates in a second band, and a parasitic patch on the third layers. A short path may couple ground to a location on the first patch that allows the first patch to form a ground extension in the second band for the second patch without affecting performance of the first patch in the first band. The first layers may have a higher dielectric permittivity than the second and third layers to minimize the thickness of the substrate without requiring a separate dielectric loading layer over the substrate.

20 Claims, 9 Drawing Sheets





US011646503B2

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

(10) **Patent No.:** **US 11,646,503 B2**
(45) **Date of Patent:** **May 9, 2023**

(54) **ANTENNA APPARATUS**

21/08; H01Q 21/28; H01Q 21/0006;
H01Q 9/0435; H01Q 9/045; H01Q
9/0414; H01Q 9/0407

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

See application file for complete search history.

(72) Inventors: **Dae Ki Lim**, Suwon-si (KR); **Nam Ki Kim**, Suwon-si (KR); **Myeong Woo Han**, Suwon-si (KR); **Jeong Ki Ryoo**, Suwon-si (KR); **Ju Hyoung Park**, Suwon-si (KR); **Won Cheol Lee**, 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 191 days.

(21) Appl. No.: **16/661,084**

(22) Filed: **Oct. 23, 2019**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jun. 12, 2019 (KR) 10-2019-0069536

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H01Q 1/24 (2006.01)
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H01Q 21/00 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 21/065** (2013.01); **H01Q 1/243** (2013.01); **H01Q 21/0025** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/2283; H01Q 1/523;
H01Q 1/38; H01Q 1/48; H01Q 1/50;
H01Q 21/0025; H01Q 21/065; H01Q

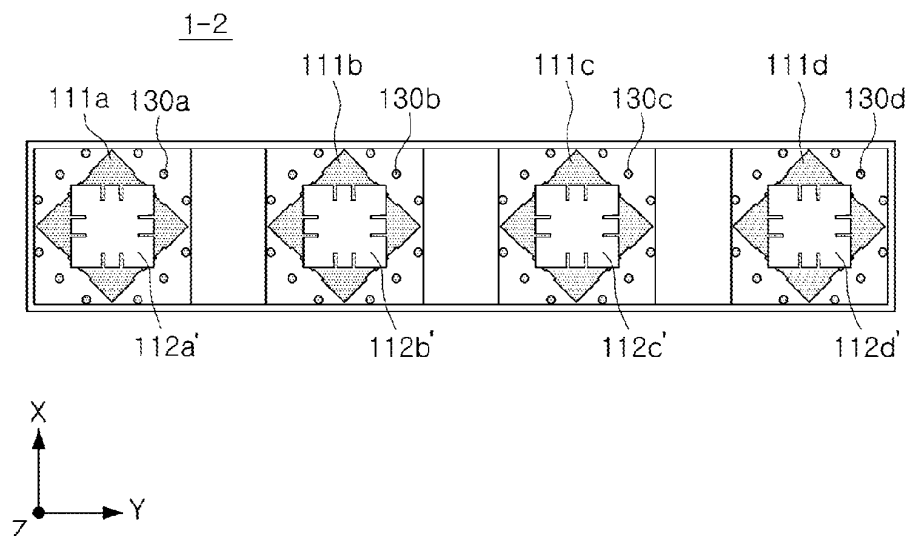
Primary Examiner — Awat M Salih

(74) *Attorney, Agent, or Firm* — NSIP Law

(57) **ABSTRACT**

An antenna apparatus may include: first patch antenna patterns arrayed in an N×1 structure, the first patch antenna patterns each having a polygonal shape having an oblique side with respect to an array direction of the N×1 structure; feed vias electrically connected to the first patch antenna patterns; and guide vias arrayed along the oblique side, wherein N is a natural number greater than or equal to 2.

16 Claims, 11 Drawing Sheets





US011652292B2

(12) **United States Patent**
Chang

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(54) **DUAL ANTENNA WITH A SHARED RADIATOR**

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USPC 324/600, 649, 658, 686
See application file for complete search history.

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(57) **ABSTRACT**

A dual antenna with a shared radiator includes a radiator unit, a first feed-in unit, a second feed-in unit, a sensing module and a ground unit. The first feed-in unit and the second feed-in unit are respectively coupled with the radiator unit. The sensing module is connected to a substantial center of the radiator unit and used for sensing a distance between the radiator unit and an external object through the radiator unit. The ground unit is connected to the sensing module. The first feed-in unit is used to send or receive a first radio frequency signal together with the radiator unit, and the second feed-in unit is used to send or receive a second radio frequency signal together with the radiator unit.

10 Claims, 7 Drawing Sheets

