



US011733744B2

(12) **United States Patent**
Fabrega Sanchez et al.

(10) **Patent No.:** **US 11,733,744 B2**
(45) **Date of Patent:** **Aug. 22, 2023**

(54) **DISPLAY-SIDE ANTENNA**

(71) Applicant: **QUALCOMM Incorporated**, San Diego, CA (US)

(72) Inventors: **Jorge Fabrega Sanchez**, San Diego, CA (US); **Mohammad Ali Tassoudji**, San Diego, CA (US); **Kevin Hsi-Huai Wang**, San Diego, CA (US); **Alberto Cicalini**, Tortona (IT); **Peter Lien**, Carlsbad, CA (US)

(73) Assignee: **QUALCOMM Incorporated**, San Diego, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 162 days.

(21) Appl. No.: **17/241,657**

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

(65) **Prior Publication Data**
US 2021/0333842 A1 Oct. 28, 2021

Related U.S. Application Data

(60) Provisional application No. 63/016,612, filed on Apr. 28, 2020.

(51) **Int. Cl.**
G06F 1/16 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/22 (2006.01)

(52) **U.S. Cl.**
CPC **G06F 1/1698** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 1/243** (2013.01)

(58) **Field of Classification Search**
CPC G06F 1/1698; H01Q 1/2266; H01Q 1/243
See application file for complete search history.

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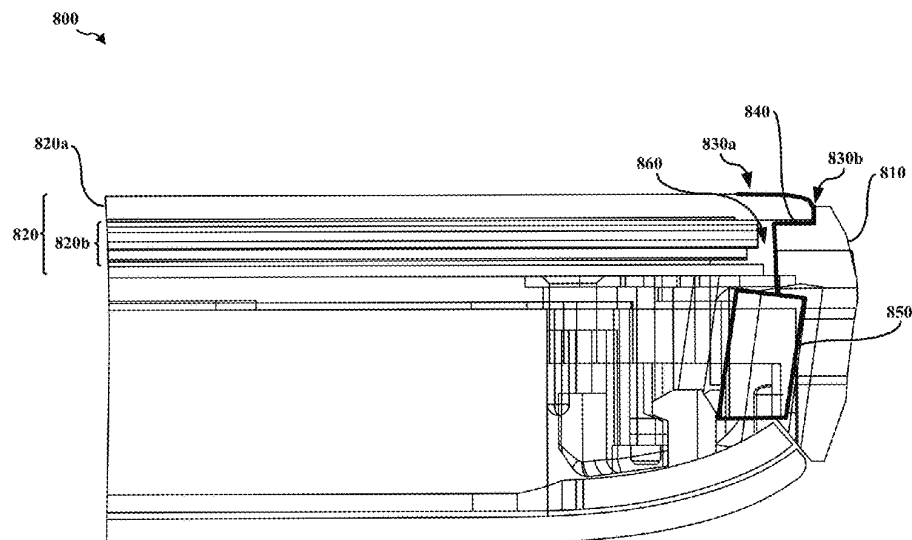
Primary Examiner — Junpeng Chen

(74) *Attorney, Agent, or Firm* — Arent Fox, LLP and Qualcomm, Incorporated

(57) **ABSTRACT**

Apparatus, methods, and computer-readable media for implementing a display-side antenna are disclosed herein. An example apparatus for wireless communication includes a housing and a display device supported by the housing. The example display device includes at least a glass cover and a panel positioned between the glass cover and an internal surface of the housing. The panel may be configured to output graphical content for presentation on the glass cover via pixels arranged within a visible area of the panel. The example apparatus also includes an antenna array. The antenna array may be configured to facilitate wireless communication at the apparatus. The antenna array may be positioned to overlap a portion of the visible area of the panel and configured to allow graphical content output by the panel to display on the glass cover at the overlapped portion of the visible area.

28 Claims, 15 Drawing Sheets





US011735809B2

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

(10) **Patent No.:** **US 11,735,809 B2**
(45) **Date of Patent:** **Aug. 22, 2023**

(54) **ANTENNA SYSTEM AND TERMINAL DEVICE**

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

(72) Inventors: **Hanyang Wang**, Reading (GB); **Lei Wang**, Shanghai (CN); **Yan Wang**,
Shenzhen (CN); **Jiaqing You**, Shanghai
(CN); **Dong Yu**, Shanghai (CN); **Liang Xue**, Shanghai (CN); **Chien-ming Lee**,
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 57 days.

(21) Appl. No.: **17/055,396**

(22) PCT Filed: **May 15, 2018**

(86) PCT No.: **PCT/CN2018/086932**

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(2) Date: **Nov. 13, 2020**

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PCT Pub. Date: **Nov. 21, 2019**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/44 (2006.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/38**
(2013.01); **H01Q 1/44** (2013.01); **H01Q 1/48**
(2013.01);

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(58) **Field of Classification Search**

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

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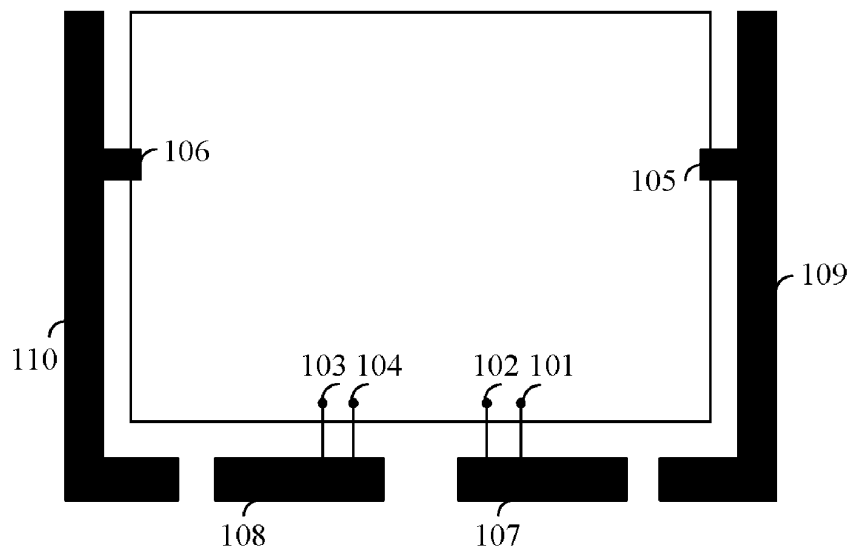
Primary Examiner — Ab Salam Alkassin, Jr.

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

(57) **ABSTRACT**

An antenna system and a terminal device, where the antenna system includes a first feed point, a first ground point, a second feed point, a second ground point, a third ground point, a fourth ground point, a first radiator, a second radiator, a first resonance structure, and a second resonance structure, where the first feed point is coupled to the first radiator, the second feed point is coupled to the second radiator, the first radiator is coupled to the first ground point, and the second radiator is coupled to the second ground point, the first resonance structure is electromagnetically coupled to the first radiator at a first distance from the first radiator, and the second resonance structure is electromagnetically coupled to the second radiator at a second distance from the second radiator.

20 Claims, 5 Drawing Sheets





US011735822B2

(12) **United States Patent**
Flores-Cuadras

(10) **Patent No.:** **US 11,735,822 B2**
(45) **Date of Patent:** **Aug. 22, 2023**

(54) **ANTENNA SYSTEM WITH SHORT CABLE**

(71) Applicant: **2J ANTENNAS USA,**
CORPORATION, Gilbert, AZ (US)

(72) Inventor: **Javier Ruben Flores-Cuadras**,
Chandler, AZ (US)

(73) Assignee: **2J ANTENNAS USA,**
CORPORATION, Gilbert, AZ (US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
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(21) Appl. No.: **17/738,320**

(22) Filed: **May 6, 2022**

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

(60) Provisional application No. 63/185,177, filed on May
6, 2021.

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

(52) **U.S. Cl.**
CPC **H01Q 9/0414** (2013.01); **H01Q 5/15**
(2015.01)

(58) **Field of Classification Search**

CPC H01Q 9/0414; H01Q 9/42; H01Q 5/15;
H01Q 5/371; H01Q 21/205; H01Q 21/28
See application file for complete search history.

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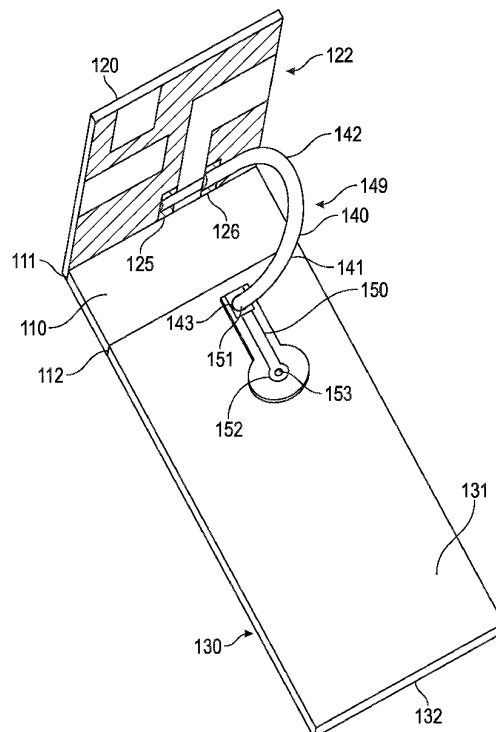
Primary Examiner — Hoang V Nguyen

(74) *Attorney, Agent, or Firm* — CP Law Group PC; Cy
Bates

(57) **ABSTRACT**

The disclosure concerns an antenna system having a clearance zone coupled to an antenna element, the clearance zone being further coupled to a ground plane. The antenna element and ground plane are electrically coupled by a short cable having a short cable routing. The short cable routing includes at least one bend wherein a portion of the short cable is disposed above the clearance zone. The short cable creates a bridging effect which reduces form factor while retaining lower frequency resonance.

20 Claims, 8 Drawing Sheets





US011736176B1

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

(10) **Patent No.:** **US 11,736,176 B1**
(45) **Date of Patent:** **Aug. 22, 2023**

(54) **GAIN PATTERN OVERLAP REDUCTION**

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(71) Applicant: **QUALCOMM Incorporated**, San
Diego, CA (US)

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(72) Inventors: **Lizhi Zheng**, San Diego, CA (US);
Guining Shi, San Diego, CA (US);
Allen Minh-Triet Tran, Rancho Santa
Fe, CA (US); **Mahmoud Shirazi**, San
Diego, CA (US)

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(73) Assignee: **QUALCOMM Incorporated**, San
Diego, 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.

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061625—ISA/EPO—dated Apr. 25, 2023.

(21) Appl. No.: **17/683,096**

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(22) Filed: **Feb. 28, 2022**

Primary Examiner — David B Lugo

(51) **Int. Cl.**
H04B 7/08 (2006.01)
H01Q 1/24 (2006.01)

(74) Attorney, Agent, or Firm — Sunstein LLP/Qualcomm

(52) **U.S. Cl.**
CPC **H04B 7/08** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 1/245** (2013.01)

(57) ABSTRACT

A wireless communication device includes: a first antenna configured to provide a first gain pattern at a millimeter-wave radio frequency and having a first boresight direction; a second antenna configured to provide a second gain pattern at the millimeter-wave radio frequency and having a second boresight direction that is different from the first boresight direction; and an electrically-conductive device; where the first antenna, in combination with the electrically-conductive device, is configured to provide a third gain pattern that has a first gain differential relative to the second gain pattern that is greater than a second gain differential between the first gain pattern and the second gain pattern over a range of angles relative to the wireless communication device.

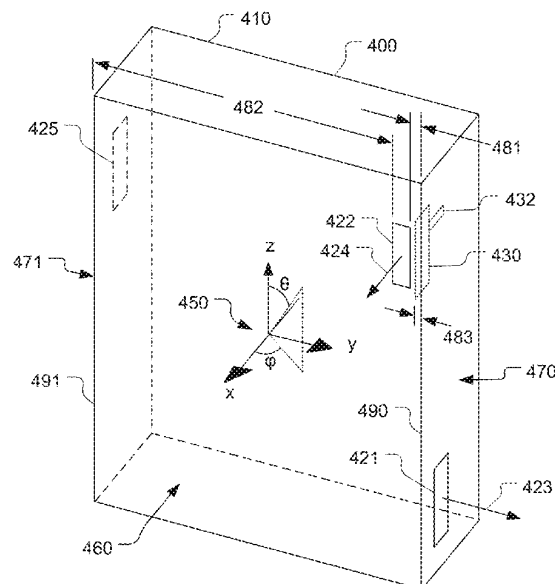
(58) **Field of Classification Search**
CPC H04B 7/08; H01Q 1/241; H01Q 1/242;
H01Q 1/243; H01Q 1/245
See application file for complete search history.

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18 Claims, 10 Drawing Sheets





US011740732B2

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

(10) **Patent No.:** **US 11,740,732 B2**
(45) **Date of Patent:** **Aug. 29, 2023**

(54) **ELECTRONIC DEVICE WITH DISPLAY PANEL**

(71) Applicant: **SAMSUNG**
ELECTRO-MECHANICS CO., LTD.,
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(72) Inventors: **Dooil Kim**, Suwon-si (KR); **Sungyoul Choi**, 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 0 days.

(21) Appl. No.: **17/472,968**

(22) Filed: **Sep. 13, 2021**

(65) **Prior Publication Data**
US 2022/0350456 A1 Nov. 3, 2022

(30) **Foreign Application Priority Data**
Apr. 29, 2021 (KR) 10-2021-0055930

(51) **Int. Cl.**
G06F 3/041 (2006.01)
G06F 3/16 (2006.01)
H01Q 9/04 (2006.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC **G06F 3/04164** (2019.05); **G06F 3/165**
(2013.01); **H01Q 1/243** (2013.01); **H01Q**
9/045 (2013.01); **G06F 2203/04112** (2013.01)

(58) **Field of Classification Search**

CPC G06F 1/1692; G06F 3/04164; G06F
2203/04112; H01Q 1/243; H01Q 9/0407;
H01Q 9/045

See application file for complete search history.

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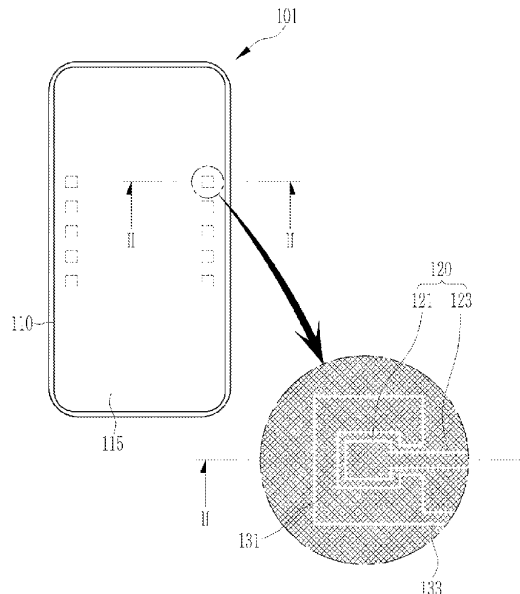
Primary Examiner — Priyank J Shah

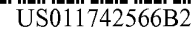
(74) *Attorney, Agent, or Firm* — NSIP Law

(57) **ABSTRACT**

An electronic device including: a display panel including a display screen to display an image; an antenna coupled to the display panel and disposed on the display screen; a touch sensor pattern separated from the antenna and disposed on the display screen; a first connecting member disposed outside the display screen of the display panel and mounted with a touch sensor driving circuit; and a second connecting member that connects the touch sensor driving circuit to the touch sensor pattern, and is at least partially more flexible than the first connecting member.

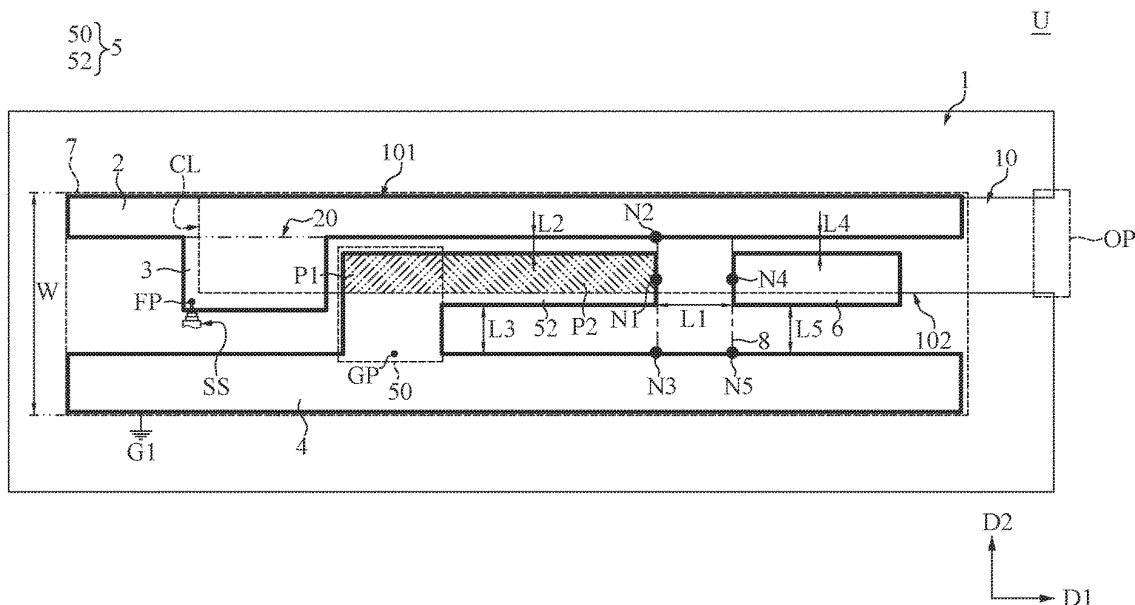
20 Claims, 8 Drawing Sheets





(10) **Patent No.:** US 11,742,566 B2
(45) **Date of Patent:** Aug. 29, 2023

- 9 Claims, 6 Drawing Sheets**





US011742587B2

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

(10) **Patent No.:** **US 11,742,587 B2**
(45) **Date of Patent:** **Aug. 29, 2023**

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

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

(72) Inventors: **Jungi Jeong**, Suwon-si (KR); **Chanju
Park**, Suwon-si (KR); **Junhwa Oh**,
Suwon-si (KR); **Sanghyuk Wi**,
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 22 days.

(21) Appl. No.: **17/581,044**

(22) Filed: **Jan. 21, 2022**

(65) **Prior Publication Data**
US 2022/0247087 A1 Aug. 4, 2022

(30) **Foreign Application Priority Data**
Feb. 2, 2021 (KR) 10-2021-0014957

(51) **Int. Cl.**
H01Q 21/06 (2006.01)
H01Q 1/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 21/0025** (2013.01); **H01Q 1/2283**
(2013.01); **H01Q 1/243** (2013.01); **H01Q**
21/064 (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/22; H01Q 1/2283; H01Q 1/243;
H01Q 1/38; H01Q 21/0025;
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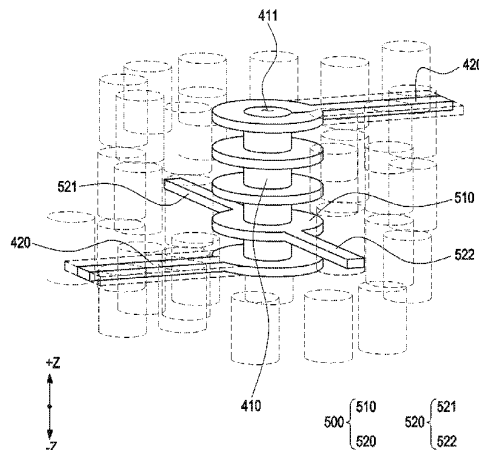
Primary Examiner — Jason Crawford

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

(57) **ABSTRACT**

The disclosure relates to a 5th generation (5G) or 6th generation (6G) communication system for supporting a higher data transfer rate beyond 4th generation (4G) communication such as long-term evolution (LTE). An antenna module is provided. The antenna module includes a communication circuit, an antenna unit comprising multiple antenna elements constituting a subarray, and a network unit disposed beneath the antenna unit in multiple layers, the network unit comprising at least one transmission line configured to be branched to positions of the multiple antenna elements, a via hole extending through the multi-layer, and a stub structure disposed on an area adjacent to the via hole. The open stub structure designed on a first layer forming a ground plane, among the multiple layers, may include a first via pad disposed to be adjacent to the via hole, a first open stub extending from the first via pad in a first direction, and a first slot part configured to surround the first via pad and the first open stub. The short stub structure designed on a second layer different from the first layer having the open stub structure designed thereon may include a second via pad disposed to be adjacent to the via hole, a

(Continued)





US011749878B2

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

(10) **Patent No.:** **US 11,749,878 B2**
(45) **Date of Patent:** **Sep. 5, 2023**

(54) **MOBILE DEVICE**

(71) Applicant: **Acer Incorporated**, New Taipei (TW)

(72) Inventors: **Kun-Sheng Chang**, New Taipei (TW);
Ching-Chi Lin, New Taipei (TW)

(73) Assignee: **ACER INCORPORATED**, 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 254 days.

(21) Appl. No.: **17/152,105**

(22) Filed: **Jan. 19, 2021**

(65) **Prior Publication Data**
US 2021/0367327 A1 Nov. 25, 2021

(30) **Foreign Application Priority Data**
May 21, 2020 (TW) 109116872

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)
H01Q 5/392 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/392** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 5/392;
H01Q 1/2291; H01Q 5/364; H01Q 5/378;
H01Q 9/42; H01Q 1/2266
See application file for complete search history.

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Primary Examiner — Hai V Tran

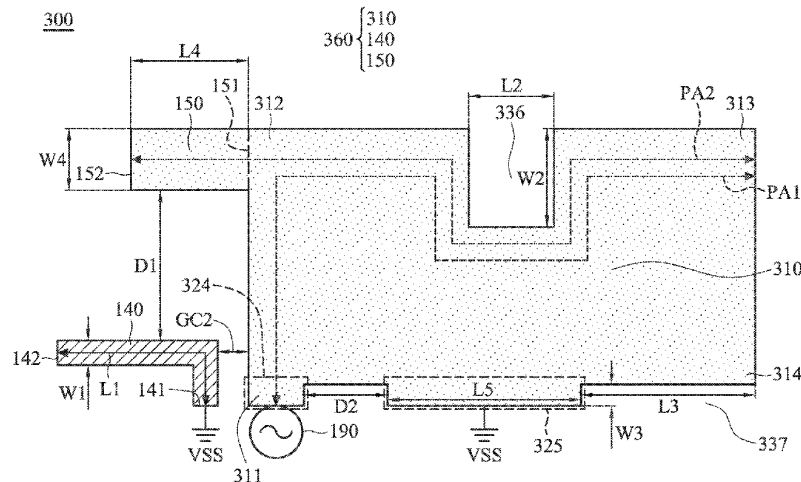
Assistant Examiner — Michael M Bouizza

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

(57) **ABSTRACT**

A mobile device includes a main radiation element, a parasitic radiation element, and an additional radiation element. The main radiation element has a first notch. The main radiation element includes a feeding region coupled to a signal source, and a grounding region coupled to a ground voltage. The parasitic radiation element is coupled to the ground voltage. The parasitic radiation element is adjacent to the feeding region of the main radiation element. The additional radiation element is coupled to the main radiation element. The additional radiation element and the parasitic radiation element substantially extend in the same direction. An antenna structure is formed by the main radiation element, the parasitic radiation element, and the additional radiation element.

13 Claims, 6 Drawing Sheets





US011749891B2

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

(10) **Patent No.:** **US 11,749,891 B2**
(45) **Date of Patent:** **Sep. 5, 2023**

(54) **ANTENNA STRUCTURE**

(56)

References Cited

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

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(72) Inventors: **Jian-De Li**, Hsinchu (TW); **Cheng-Da Yang**, Hsinchu (TW)

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(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 58 days.

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(21) Appl. No.: **17/404,023**

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

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(65) **Prior Publication Data**

US 2023/0028988 A1 Jan. 26, 2023

Primary Examiner — Henry Luong

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

(30) **Foreign Application Priority Data**

Jul. 23, 2021 (TW) 110127094

(57)

ABSTRACT

An antenna structure includes a feeding radiation element, a first radiation element, a second radiation element, a shorting element, a first tuner, and a second tuner. The feeding radiation element has a feeding point. The first radiation element is coupled to the feeding radiation element. The first radiation element is coupled through the first tuner to a ground voltage. The feeding radiation element is coupled through the shorting element to the ground voltage. The second radiation element is adjacent to the first radiation element, and is separated from the first radiation element. The second radiation element is coupled through the second tuner to the ground voltage. The feeding radiation element is disposed between the first tuner and the shorting element.

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 5/328 (2015.01)

H01Q 1/38 (2006.01)

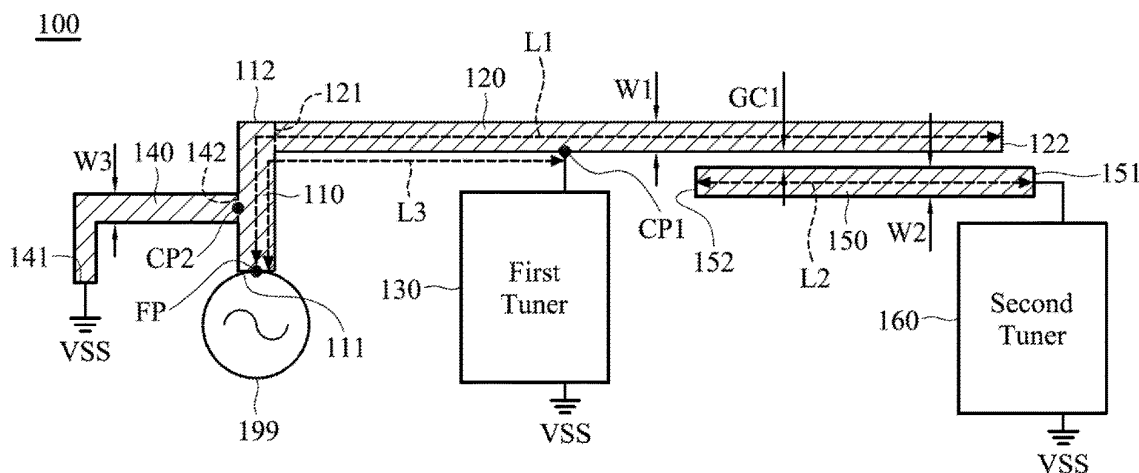
(52) **U.S. Cl.**

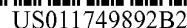
CPC **H01Q 5/328** (2015.01); **H01Q 1/24** (2013.01); **H01Q 1/38** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/328; H01Q 1/24-50; H01Q 1/243
See application file for complete search history.

17 Claims, 5 Drawing Sheets





(10) **Patent No.:** US 11,749,892 B2
(45) **Date of Patent:** Sep. 5, 2023

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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 antenna structure and an electronic device are provided. The antenna structure includes a first radiating member, a second radiating member, a grounding member, and a capacitance element. The first radiating member includes a first radiating part, a second radiating part, a feeding part, and a grounding part. The second radiating member is coupling to the first radiating member. The second radiating member includes a third radiating part and a main body part that are connected to each other. There is a first predetermined length between a feeding point of the feeding part and an open end of the second radiating part. There is an electrical length between a connection point where the main body part is electrically connected to the capacitance element and an open end of the third radiating part. The electrical length is greater than the first predetermined length.

- Mar. 10, 2021 (TW) 110108449

- (51) **Int. Cl.**
H01Q 5/328 (2015.01)
H01Q 5/371 (2015.01)
H01Q 5/385 (2015.01)
H01Q 9/26 (2006.01)
H04B 1/00 (2006.01)

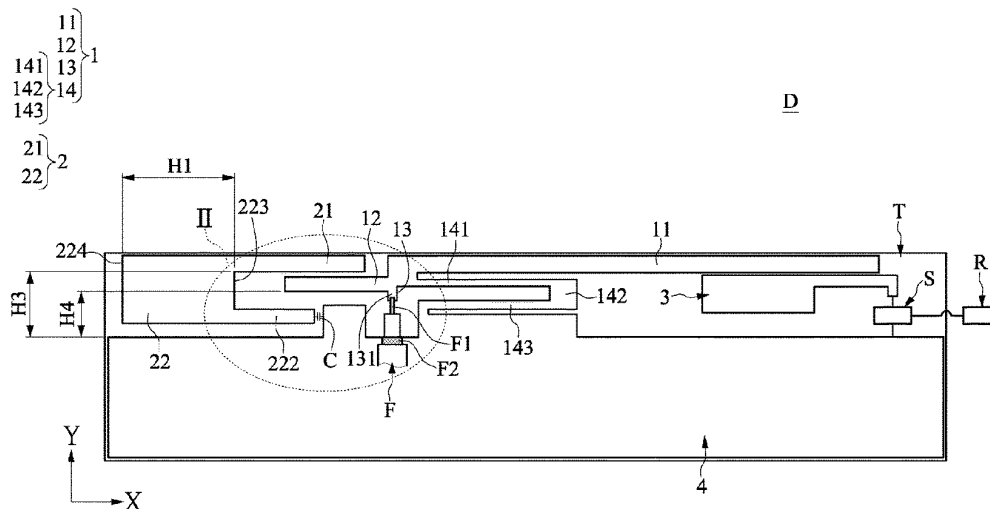
- (52) **U.S. Cl.**
CPC *H01Q 5/328* (2015.01); *H01Q 5/371*
(2015.01); *H01Q 5/385* (2015.01); *H01Q 9/26*
(2013.01); *H04B 1/006* (2013.01)

- (58) **Field of Classification Search**
CPC H01Q 5/328; H01Q 5/371; H01Q 5/385;
H01Q 9/26; H04B 1/006

- USPC 343/850

See application file for complete search history.

17 Claims, 11 Drawing Sheets





US011749901B2

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

(10) **Patent No.:** **US 11,749,901 B2**
(45) **Date of Patent:** **Sep. 5, 2023**

(54) **HYBRID ANTENNA STRUCTURE**

(56) **References Cited**

(71) Applicant: **Acer Incorporated**, New Taipei (TW)

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(72) Inventors: **Kun-Sheng Chang**, New Taipei (TW);
Ching-Chi Lin, New Taipei (TW)

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(73) Assignee: **ACER INCORPORATED**, New Taipei (TW)

(*) 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.: **17/700,112**

TW 201613173 A 4/2016
TW 202010177 A 3/2020
TW I734468 B 7/2021

(22) Filed: **Mar. 21, 2022**

(65) **Prior Publication Data**

US 2023/0096014 A1 Mar. 30, 2023

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Chinese language office action dated Jul. 6, 2022, issued in application No. TW 110135497.

(30) **Foreign Application Priority Data**

Sep. 24, 2021 (TW) 110135497

Primary Examiner — Thai Pham

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

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 1/44 (2006.01)
H01Q 19/02 (2006.01)
H01Q 21/28 (2006.01)
H01Q 1/36 (2006.01)

(57) **ABSTRACT**

A hybrid antenna structure includes a first metal element, a second metal element, a third metal element, a cable, and a proximity sensor. The first metal element has a feeding point. The second metal element is adjacent to and separate from the first metal element. A coupling gap is formed between the second metal element and the first metal element. The third metal element is coupled to a connection point on the second metal element. The proximity sensor is coupled through the cable to the third metal element. The second metal element and the third metal element are used as both a sensing pad and a radiation element.

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

CPC **H01Q 19/021** (2013.01); **H01Q 1/36** (2013.01); **H01Q 1/44** (2013.01); **H01Q 21/28** (2013.01); **H01Q 1/241** (2013.01)

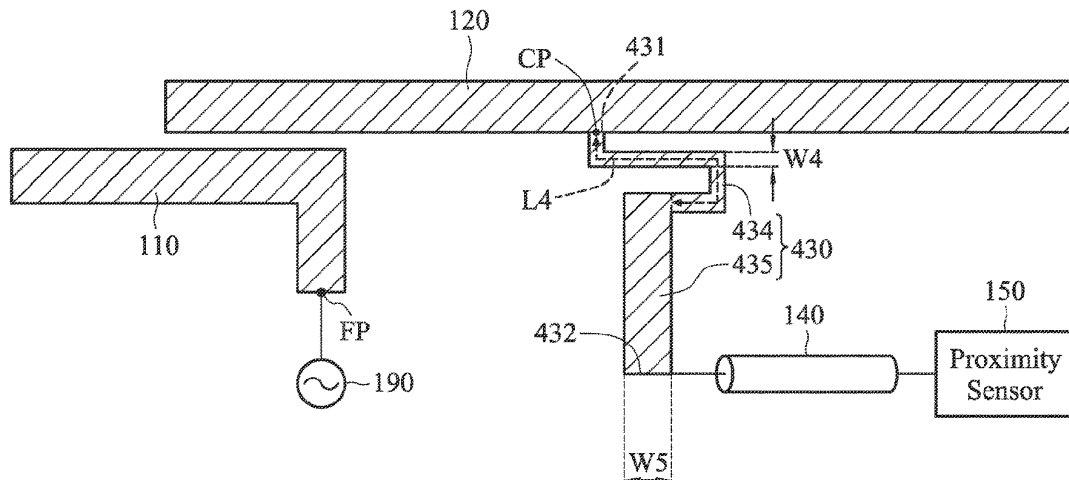
(58) **Field of Classification Search**

CPC H01Q 1/24; H01Q 1/241; H01Q 1/243; H01Q 1/36; H01Q 1/44; H01Q 5/307; H01Q 5/378; H01Q 5/392; H01Q 21/28

See application file for complete search history.

12 Claims, 5 Drawing Sheets

400





US011749903B2

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

(10) **Patent No.:** **US 11,749,903 B2**
(45) **Date of Patent:** ***Sep. 5, 2023**

(54) **ANTENNA STRUCTURE**

(71) Applicant: **COMPAL ELECTRONICS, INC.**,
Taipei (TW)

(72) Inventors: **Chun-Cheng Chan**, Taipei (TW);
Shih-Chia Liu, Taipei (TW); **Yen-Hao**
Yu, Taipei (TW); **Li-Chun Lee**, Taipei
(TW); **Jui-Hung Lai**, Taipei (TW);
Chih-Heng Lin, 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 86 days.

This patent is subject to a terminal dis-
claimer.

(21) Appl. No.: **17/374,954**

(22) Filed: **Jul. 13, 2021**

(65) **Prior Publication Data**
US 2021/0344119 A1 Nov. 4, 2021

Related U.S. Application Data

(63) Continuation-in-part of application No. 16/995,784,
filed on Aug. 17, 2020, now Pat. No. 11,588,244.
(Continued)

(51) **Int. Cl.**
H01Q 1/52 (2006.01)
H01Q 21/06 (2006.01)
H01Q 1/48 (2006.01)

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

(58) **Field of Classification Search**

CPC H01Q 21/06; H01Q 1/48; H01Q 21/28;
H01Q 1/521; H01Q 1/52; H01Q 1/36;
H01Q 1/50

See application file for complete search history.

(56) **References Cited**

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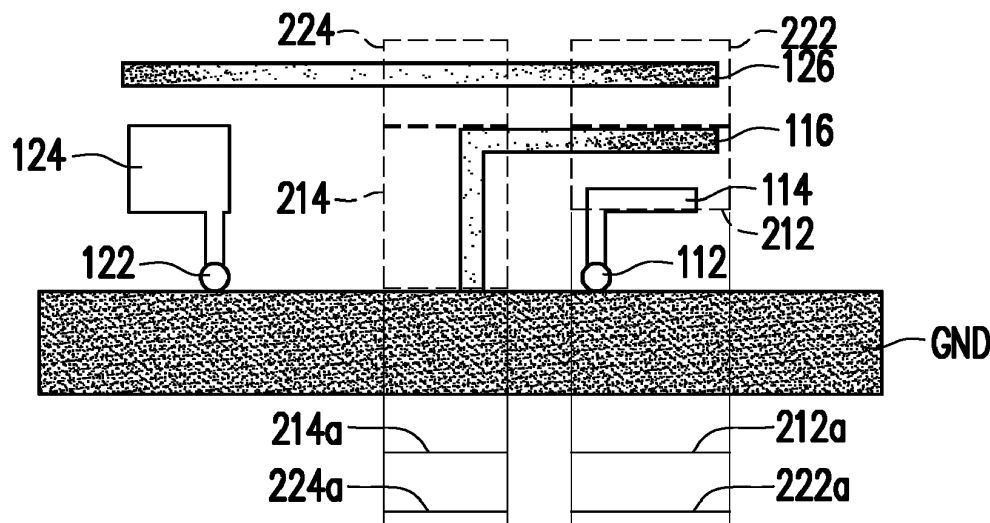
Primary Examiner — David E Lotter

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

(57) **ABSTRACT**

The disclosure provides an antenna structure including a ground plane, a first coupling antenna and a reference antenna. The first coupling antenna includes a first excitation source connected to the ground plane. The first excitation source is configured to excite a first resonant mode, and the first coupling antenna forms a first zero current area on the ground plane in response to the first resonant mode. The reference antenna includes a second excitation source connected to the ground plane. The second excitation source is configured to excite a second resonant mode, and the reference antenna forms a second zero current area on the ground plane in response to the second resonant mode. The first excitation source is located in the second zero current area, and the second excitation source is located in the first zero current area.

16 Claims, 9 Drawing Sheets





US011749907B2

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

(10) **Patent No.:** **US 11,749,907 B2**
(45) **Date of Patent:** **Sep. 5, 2023**

(54) **ANTENNA OF A TERMINAL DEVICE**

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

(72) Inventors: **Yijin Wang**, Dongguan (CN);
Huan-chu Huang, Dongguan (CN);
Xianjing Jian, 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 222 days.

(21) Appl. No.: **17/199,941**

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

(65) **Prior Publication Data**

US 2021/0203083 A1 Jul. 1, 2021

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2019/101703, filed on Aug. 21, 2019.

(30) **Foreign Application Priority Data**

Sep. 14, 2018 (CN) 201811076748.4

(51) **Int. Cl.**
H01Q 21/08 (2006.01)
H01Q 1/48 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 21/08** (2013.01); **H01Q 1/48** (2013.01); **H01Q 13/10** (2013.01); **H01Q 21/0006** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/22-48; H01Q 1/243; H01Q 1/273;
H01Q 13/10; H01Q 21/00; H01Q
21/06-08

See application file for complete search history.

(56) **References Cited**

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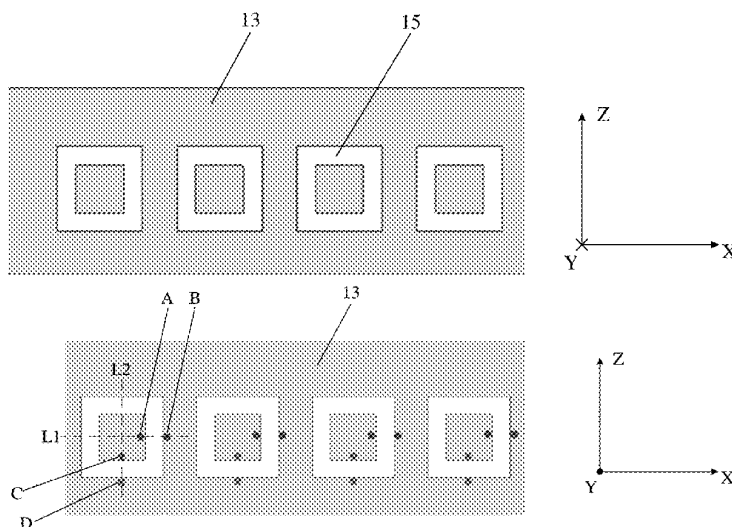
Primary Examiner — Hasan Islam

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

(57) **ABSTRACT**

An antenna of a terminal device, the antenna includes a metal frame, a side of the metal frame is provided with at least two slots, and the slots are ring-shaped slots. Portions of the metal frame at two sides of each slot of the at least two slots are provided with two groups of feed points, and each group of feed points includes an antenna feed point located on a portion of the metal frame at the inner side of the slot, and a ground feed point located on another portion of the metal frame at the outer side of the slot. The metal frame is electrically connected to a floor in the terminal device.

10 Claims, 3 Drawing Sheets





US011750301B1

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

(10) **Patent No.:** **US 11,750,301 B1**
(45) **Date of Patent:** **Sep. 5, 2023**

(54) **CERAMIC PIEZOELECTRIC UNDERWATER
DETECTION AND 5TH GENERATION
MOBILE PHONE ANTENNA**

(71) Applicant: **Anhui University**, Hefei (CN)

(72) Inventors: **Yingsong Li**, Hefei (CN); **Lulu Meng**,
Hefei (CN); **Zhixiang Huang**, Hefei
(CN)

(73) Assignee: **ANHUI UNIVERSITY**, Hefei (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.: **18/303,673**

(22) Filed: **Apr. 20, 2023**

(30) **Foreign Application Priority Data**

Sep. 22, 2022 (CN) 202211159749.1

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)
H04B 13/02 (2006.01)
H01Q 1/00 (2006.01)

(52) **U.S. Cl.**
CPC **H04B 13/02** (2013.01); **H01Q 1/002**
(2013.01); **H01Q 1/241** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 1/38; H01Q 1/04; H01Q 1/00; H01Q
1/002; H01Q 1/24; H04B 13/02; H03H
9/17; H03H 9/70; H03H 9/72
See application file for complete search history.

(56) **References Cited**

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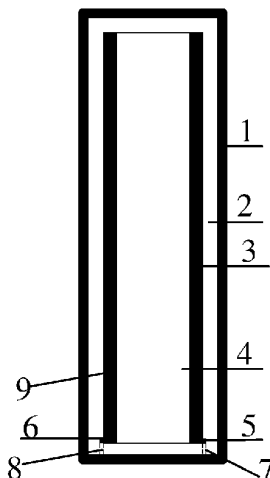
* cited by examiner

Primary Examiner — Tho G Phan

(57) **ABSTRACT**

Disclosed is a ceramic piezoelectric underwater detection and 5th generation (5G) mobile phone antenna, including: a ceramic cavity, a thin film, electrode feed holes and a coating, where the thin film is embedded inside the ceramic cavity; the electrode feed holes are drilled on both sides of the thin film at one end of a bottom of the ceramic cavity; the coating is coated outside the ceramic cavity for realizing omnidirectional radiation; the thin film drives the ceramic cavity to make the coating on an outer surface of the ceramic cavity generate radiation vibrations and generate electromagnetic wave radiation for communication and underwater detection.

5 Claims, 3 Drawing Sheets





US011757171B2

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

(10) **Patent No.:** **US 11,757,171 B2**
(45) **Date of Patent:** **Sep. 12, 2023**

(54) **MIMO ANTENNA SYSTEM, WIRELESS
DEVICE, AND WIRELESS
COMMUNICATION SYSTEM**

5/378 (2015.01); **H01Q 5/48** (2015.01); **H01Q
5/50** (2015.01); **H04B 7/0413** (2013.01)

(71) Applicant: **The Antenna Company International
N.V., Willemstad (CW)**

(58) **Field of Classification Search**

CPC **H01Q 1/2291**; **H01Q 1/48**; **H01Q 5/371**;
H01Q 5/378; **H01Q 5/48**; **H01Q 5/50**;
H01Q 5/42; **H01Q 21/28**; **H04B 7/0413**

(72) Inventors: **Diego Caratelli**, Eersel (NL); **Avraam
Loutridis**, Eindhoven (NL); **János
Sófalvi**, Eindhoven (NL)

See application file for complete search history.

(73) Assignee: **THE ANTENNA COMPANY
INTERNATIONAL N.V., Willemstad
(CW)**

(56) **References Cited**

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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 284 days.

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(21) Appl. No.: **16/825,082**

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(22) Filed: **Mar. 20, 2020**

Written Opinion and Search Report dated Jun. 1, 2019 correspond-
ing to Dutch application No. 2022792.

(65) **Prior Publication Data**

US 2020/0303807 A1 Sep. 24, 2020

(30) **Foreign Application Priority Data**

Mar. 22, 2019	(GR)	20190100143
Mar. 22, 2019	(NL)	2022792

Primary Examiner — Hai V Tran

Assistant Examiner — Michael M Bouizza

(74) Attorney, Agent, or Firm — Nath, Goldberg &
Meyer; Joshua B. Goldberg

(51) **Int. Cl.**

H01Q 1/22	(2006.01)
H01Q 1/48	(2006.01)
H01Q 5/371	(2015.01)
H01Q 5/378	(2015.01)
H01Q 5/48	(2015.01)
H01Q 5/50	(2015.01)
H04B 7/0413	(2017.01)

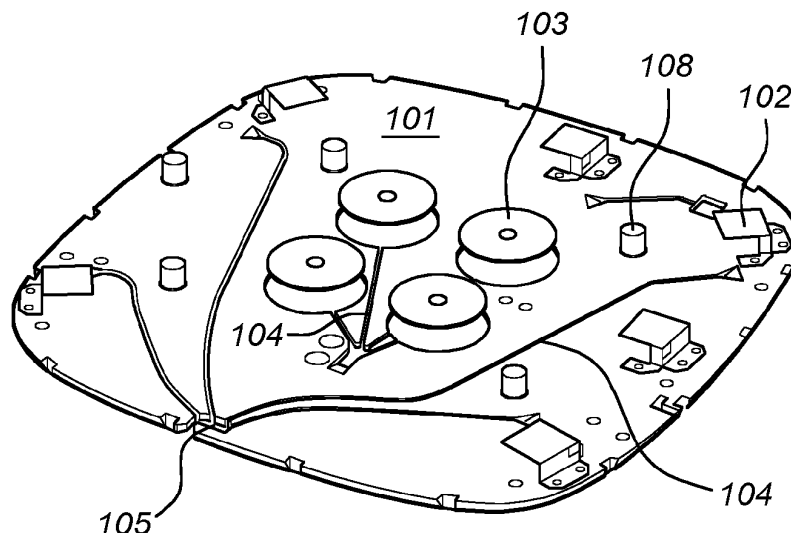
(57) **ABSTRACT**

The invention relates to a MIMO antenna system for IEEE 802.11 WiFi communication. The invention also relates to a wireless device, such as a wireless access point (AP), a router, a gateway, and/or a bridge, comprising at least one antenna system according to the invention. The invention further relates to a wireless communication system, comprising a plurality of antenna systems according to the invention, and, preferably, a plurality of wireless devices according to the invention.

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

CPC **H01Q 1/2291** (2013.01); **H01Q 1/48**
(2013.01); **H01Q 5/371** (2015.01); **H01Q**

20 Claims, 30 Drawing Sheets





US011757176B2

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

(10) **Patent No.:** **US 11,757,176 B2**
(45) **Date of Patent:** **Sep. 12, 2023**

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

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

(72) Inventors: **Shih Ming Chuang**, New Taipei (TW);
Lung-Fai Tuen, New Taipei (TW);
Pei-Cheng Hu, New Taipei (TW)

(73) Assignee: **WISTRON CORP.**, New Taipei (TW)

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

(21) Appl. No.: **17/521,547**

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

(65) **Prior Publication Data**

US 2023/0115428 A1 Apr. 13, 2023

(30) **Foreign Application Priority Data**

Oct. 7, 2021 (TW) 110137309

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/30 (2015.01)
H01Q 1/36 (2006.01)
H01Q 5/371 (2015.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/36** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01); **H01Q 9/045** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/241; H01Q 1/243;
H01Q 1/38; H01Q 5/31; H01Q 5/314;
H01Q 5/35; H01Q 1/48; H01Q 5/42;
H01Q 9/26; H01Q 9/42; H01Q 1/36;
H01Q 5/30

See application file for complete search history.

(56) **References Cited**

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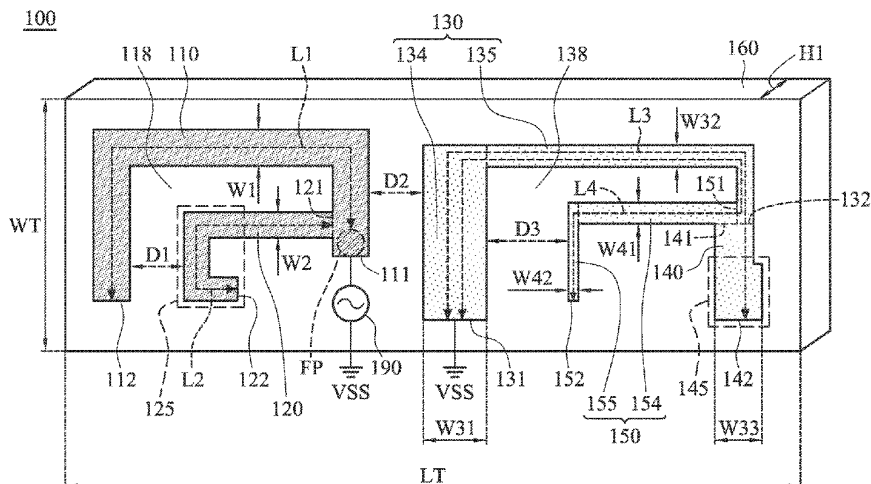
Primary Examiner — Thai Pham

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

(57) **ABSTRACT**

An antenna structure includes a first radiation element, a second radiation element, a third radiation element, a fourth radiation element, and a fifth radiation element. The first radiation element has a feeding point. The second radiation element is coupled to the feeding point. The second radiation element is at least partially surrounded by the first radiation element. The third radiation element is coupled to a ground voltage. The fourth radiation element is coupled to the third radiation element. The fifth radiation element is coupled to the third radiation element. The fifth radiation element is at least partially surrounded by the third radiation element and the fourth radiation element.

16 Claims, 4 Drawing Sheets





US011757179B2

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

(10) **Patent No.:** **US 11,757,179 B2**
(45) **Date of Patent:** **Sep. 12, 2023**

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

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

(72) Inventors: **Cheolhong Son**, Gyeonggi-do (KR);
Kyungjae Lee, Gyeonggi-do (KR);
Sangha Lee, Gyeonggi-do (KR);
Soonho Hwang, Gyeonggi-do (KR);
Sungjun Lee, Gyeonggi-do (KR);
Hyunjeong Lee, 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 357 days.

(21) Appl. No.: **17/090,459**

(22) Filed: **Nov. 5, 2020**

(65) **Prior Publication Data**
US 2021/0135351 A1 May 6, 2021

(30) **Foreign Application Priority Data**
Nov. 5, 2019 (KR) 10-2019-0140186

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)
H01Q 5/328 (2015.01)
H01Q 5/40 (2015.01)
H05K 1/18 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/48** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/328** (2015.01); **H01Q 5/40** (2015.01);

(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/48-50; H01Q 5/30-40; H01Q 5/307-328
See application file for complete search history.

(56) **References Cited**

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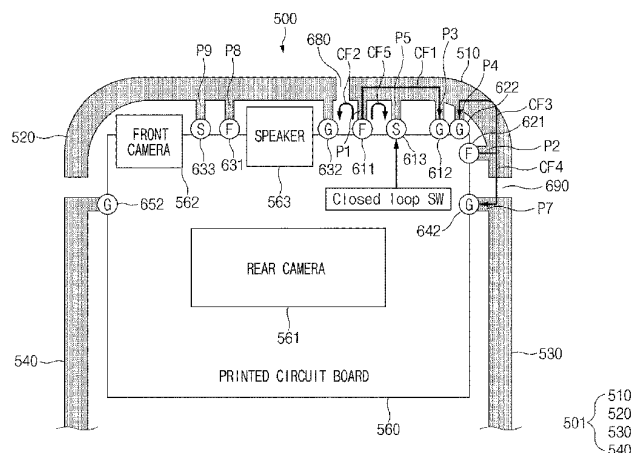
Primary Examiner — Hasan Islam

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

(57) **ABSTRACT**

An electronic device includes a housing including a front plate, a rear plate facing away from the front plate, and a side member surrounding a space between the front plate and the rear plate and connecting one side of the front plate to one side of the rear plate, an antenna structure including at least part of the conductive portion, and a printed circuit board disposed in the space and including at least one processor. At least part of the side member is a conductive portion. The conductive portion includes a first conductive pattern, a second conductive pattern disposed at least partially coupled to the first conductive pattern, and a third conductive pattern disposed at least partially coupled to the first conductive pattern and spaced apart from the second conductive pattern. The antenna structure includes a first feeding part electrically connected to a first location of the first conductive pattern, a second feeding part electrically connected to a second location of the first conductive pattern, wherein the second location is closer to the third conductive pattern than the first location, a first ground part electrically connected to a third location between the first location and the second

(Continued)





US011757186B1

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

(10) **Patent No.:** **US 11,757,186 B1**
(45) **Date of Patent:** **Sep. 12, 2023**

(54) **5G ULTRA-WIDEBAND DIPOLE ANTENNA**

(71) Applicant: **Airgain, Inc.**, San Diego, CA (US)

(72) Inventors: **Daniel Wang**, Sydney (AU); **Peisheng Qian**, Zhang Jia Gang (CN)

(73) Assignee: **Airgain, Inc.**, San Diego, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 66 days.

(21) Appl. No.: **17/359,779**

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

Related U.S. Application Data

(60) Provisional application No. 63/047,242, filed on Jul. 1, 2020.

(51) **Int. Cl.**
H01Q 5/335 (2015.01)
H01Q 21/00 (2006.01)
H01Q 9/30 (2006.01)
H01Q 1/24 (2006.01)
H01Q 21/06 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/335** (2015.01); **H01Q 1/243** (2013.01); **H01Q 9/30** (2013.01); **H01Q 21/0043** (2013.01); **H01Q 21/064** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/335; H01Q 1/243; H01Q 9/30; H01Q 21/0043; H01Q 21/064
See application file for complete search history.

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Primary Examiner — Hai V Tran

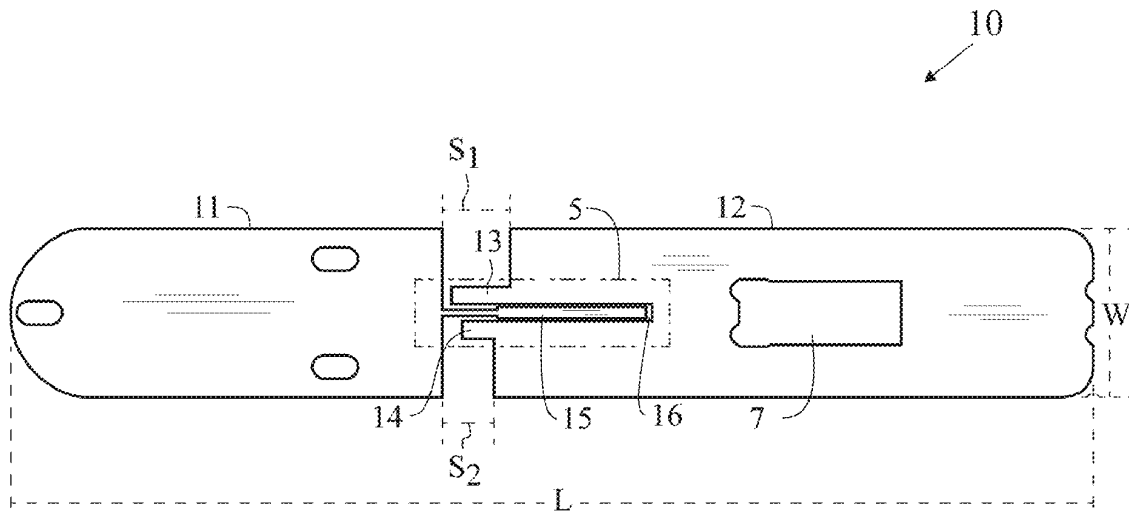
Assistant Examiner — Michael M Bouizza

(74) *Attorney, Agent, or Firm* — Clause Eight; Michael Catania

(57) **ABSTRACT**

An ultra-wide band dipole antenna assembly for transmitting or receiving electromagnetic signals is disclosed herein. The antenna assembly comprises a dipole antenna element and coplanar waveguide feeding network. The dipole antenna delivers the ultra-wide band matching through a pre-determined arrangement after the coplanar waveguide feeding network is applied.

20 Claims, 3 Drawing Sheets





US011757187B2

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

(10) **Patent No.:** **US 11,757,187 B2**
(45) **Date of Patent:** **Sep. 12, 2023**

(54) **WIDE BAND DIRECTIONAL ANTENNA**

(56)

References Cited

(71) Applicant: **SIRIO ANTENNE S.r.l.**, Volta
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U.S. PATENT DOCUMENTS

(72) Inventors: **Lorenzo Mezzadrelli**, Mantova (IT);
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(IT); **Luigi Corrà**, Marano Vicentino
(IT)

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(73) Assignee: **SIRIO ANTENNE S.R.L.**, Volta
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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.: **17/706,195**

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Patent Application No. 102021000008060.

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Primary Examiner — Dameon E Levi

Assistant Examiner — Leah Rosenberg

(30) **Foreign Application Priority Data**

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INGERSOLL, PLC; Timothy Klima

Mar. 31, 2021 (IT) 102021000008060

(57)

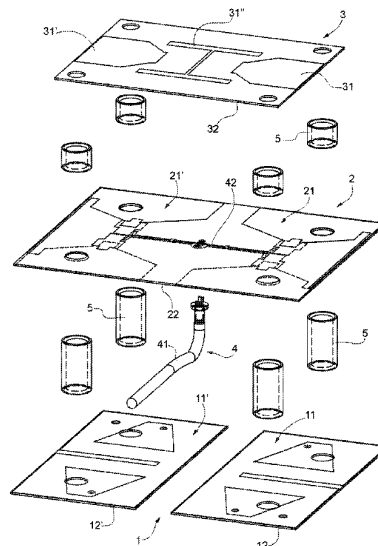
ABSTRACT

(51) **Int. Cl.**
H01Q 5/49 (2015.01)
H01Q 9/28 (2006.01)
H01Q 5/10 (2015.01)
H01Q 5/321 (2015.01)
(52) **U.S. Cl.**
CPC **H01Q 5/49** (2015.01); **H01Q 5/10**
(2015.01); **H01Q 5/321** (2015.01); **H01Q**
9/285 (2013.01)

A wide band directional antenna includes three elements which are partially aligned, electrically isolated from each other, of which a lower element includes at least one reflector circuit, a middle element comprises at least one dipole circuit connected to a transmission line, and an upper element includes a director circuit, wherein the dipole circuit includes at least one first pair of conductive elements, suitable for forming a minor dipole connected to the transmission line, and at least one second pair of electrically isolated conductive elements, excited with capacitive effect by the minor dipole, in such a way as to form a major dipole.

(58) **Field of Classification Search**
CPC H01Q 5/49; H01Q 9/0414; H01Q 9/285
See application file for complete search history.

18 Claims, 4 Drawing Sheets





US011757191B2

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

(10) **Patent No.:** **US 11,757,191 B2**
(45) **Date of Patent:** **Sep. 12, 2023**

(54) **DYNAMIC ANTENNA STRUCTURE TUNING MECHANISM**

(71) Applicant: **Dell Products L.P.**, Round Rock, TX (US)

(72) Inventors: **Ching-Cheng Hsu**, Shilin (TW); **I-Yu Chen**, Taipei (TW); **Shang-Chu Chien**, Taoyuan (TW)

(73) Assignee: **Dell Products L.P.**, Round Rock, TX (US)

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

(65) **Prior Publication Data**

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H01Q 21/28 (2006.01)
H01Q 7/00 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
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(58) **Field of Classification Search**

CPC H01Q 9/0442; H01Q 7/005; H01Q 9/0414; H01Q 9/0421; H01Q 21/28

See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Hai V Tran

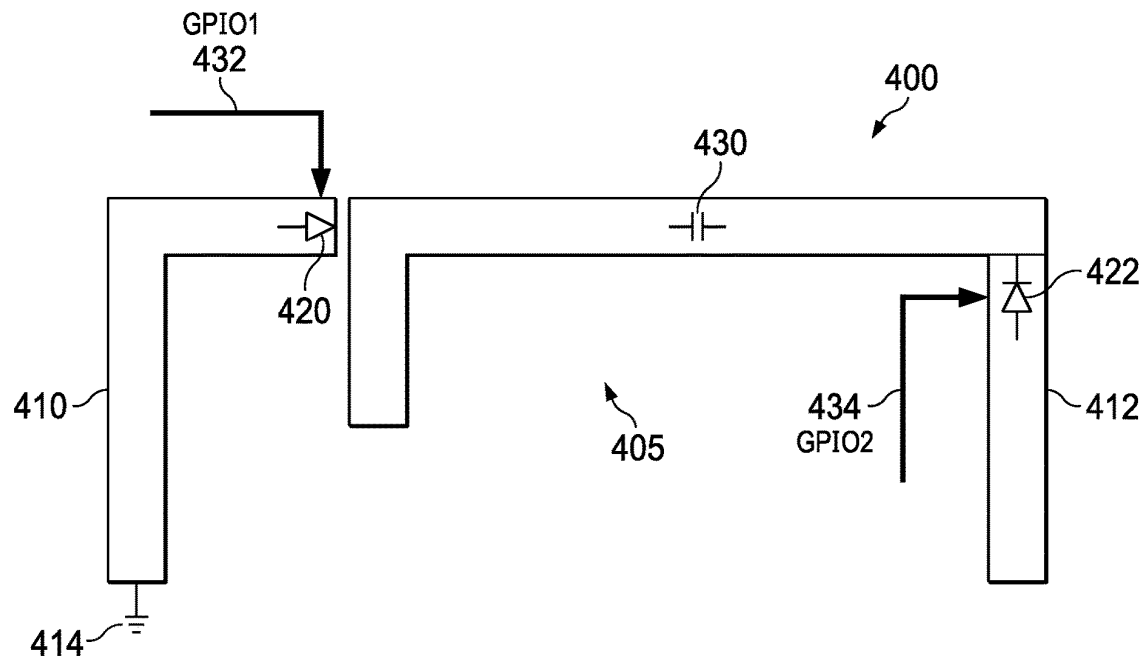
Assistant Examiner — Michael M Bouizza

(74) *Attorney, Agent, or Firm* — Terrile, Cannatti & Chambers; Stephen A. Terrile

(57) **ABSTRACT**

A dynamic antenna tuning system. The dynamic antenna tuning system includes: an antenna controller; and, a tunable antenna, the tunable antenna comprising a plurality of switches, the switches being controlled by the antenna controller to dynamically configure the antenna in one of a plurality of antenna geometry configurations.

10 Claims, 9 Drawing Sheets





US011757192B2

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

(10) **Patent No.:** **US 11,757,192 B2**
(45) **Date of Patent:** **Sep. 12, 2023**

(54) **ANTENNA DEVICE WITH PATCH INCLUDING A SLIT**

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

(72) Inventors: **Jungaun Lee**, Kariya (JP); **Sho Matsumoto**, Kariya (JP)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 12 days.

(21) Appl. No.: **17/409,881**

(22) Filed: **Aug. 24, 2021**

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(30) **Foreign Application Priority Data**
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H01Q 1/48 (2006.01)

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

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

(56) **References Cited**

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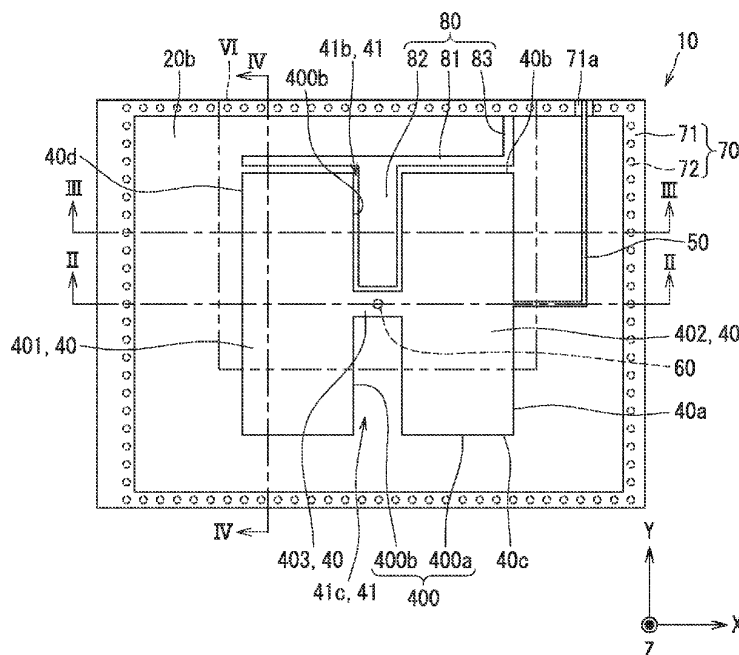
Primary Examiner — Wilson Lee

(74) Attorney, Agent, or Firm — POSZ LAW GROUP, PLC

(57) **ABSTRACT**

An antenna device includes a main board, a ground board, a patch, a power feeder, a short-circuit portion and an additional conductor. The main board is made of a dielectric material. The ground board is disposed at the main board and supplies a ground potential. The patch is disposed at the main board to face the ground board in a thickness direction of the main board. The power feeder is disposed at the main board and electrically connected to the patch. The short-circuit portion is a via conductor disposed at the main board, and is electrically connected to the patch and the ground board. The additional conductor is disposed at the main board such that a side surface of the additional conductor faces a side surface of the patch, and has a potential identical to the ground potential of the ground board.

9 Claims, 20 Drawing Sheets





US011758673B2

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

(10) **Patent No.:** **US 11,758,673 B2**
(45) **Date of Patent:** **Sep. 12, 2023**

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

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

(72) Inventors: **Shinho Yoon**, Suwon-si (KR);
Jonghyuck Lee, Suwon-si (KR); **Taeik Kim**,
Suwon-si (KR); **Haeyeon Kim**,
Suwon-si (KR); **Dongjun Oh**, Suwon-si
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(73) Assignee: **Samsung Electronics Co., Ltd.**,
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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
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(21) Appl. No.: **17/871,324**

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

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

(62) Division of application No. 16/742,191, filed on Jan.
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(30) **Foreign Application Priority Data**
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H01Q 1/22 (2006.01)
(Continued)

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CPC **H05K 5/0226** (2013.01); **H01Q 1/22**
(2013.01); **H01Q 1/36** (2013.01); **H01Q 1/50**
(2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/242; H01Q 1/243; H01Q 1/38;
H01Q 9/42; H01Q 13/10; H01Q 13/16;
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Primary Examiner — Jason Crawford

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

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a first housing structure including a conductive first side member, a second housing structure including a conductive second side member, a hinge structure rotatably connecting the first housing structure and the second housing structure, and a printed circuit board. The first side member or the second side member may include a first side face, a second side face, a third side face, a fourth side face, a first slit formed in the fourth side face, and a second slit formed in any one of the first side face, the second side face, and the third side face. At least a part of the second side face or the third side face between the first slit and the second slit may be made of a conductive material and electrically connected to the printed circuit board as a radiating conductor.

9 Claims, 14 Drawing Sheets

