US011043732B2

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

(10) **Patent No.: US 11,043,732 B2**
(45) **Date of Patent: Jun. 22, 2021**

(54) **ANTENNA STRUCTURE**

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

(72) Inventors: **Yun-Jian Chang**, New Taipei (TW); **Jung-Chin Lin**, New Taipei (TW); **Yen-Hui Lin**, 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 55 days.

(21) Appl. No.: **16/542,430**

(22) Filed: **Aug. 16, 2019**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Aug. 17, 2018 (CN) 201810942117.X

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 1/48	(2006.01)
H01Q 5/30	(2015.01)
H01Q 1/22	(2006.01)
H01Q 1/50	(2006.01)
H01Q 1/52	(2006.01)

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

CPC ***H01Q 1/24*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/30*** (2015.01)

(58) **Field of Classification Search**

CPC .. H01Q 1/22; H01Q 1/50; H01Q 1/52; H01Q 5/28; H01Q 5/328; H01Q 5/30; H01Q 1/24; H01Q 1/48

USPC ..... 343/702, 700 MS, 872, 767, 769, 795

See application file for complete search history.

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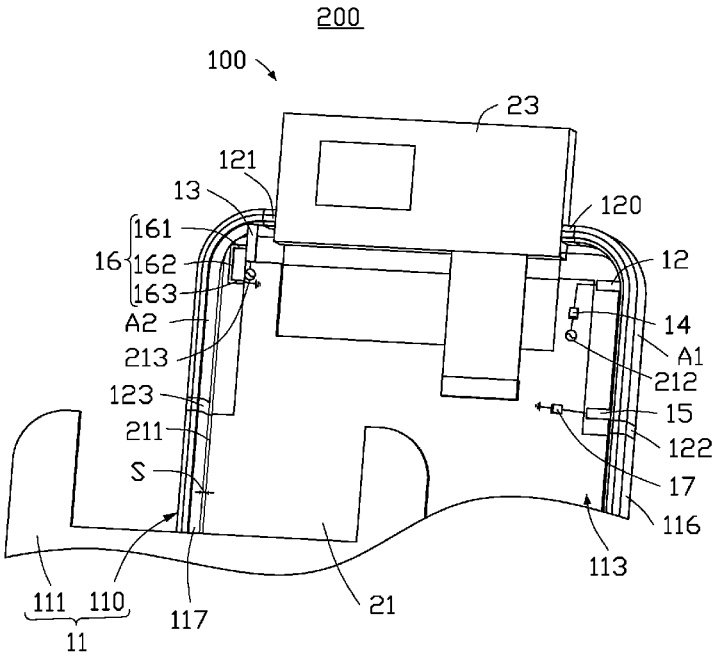
Primary Examiner — Wei (Victory) Y Chan
(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

An antenna structure includes a border frame, a first feed portion, and a second feed portion. The border frame includes an end portion, a first side portion, and a second side portion. The border frame defines a first gap, a second gap, a first slot, and a second slot. The first gap and the second gap are disposed in the end portion. The first slot is disposed in the first side portion. The second slot is disposed in the second side portion. The first gap, the second gap, the first slot, and the second slot divide the border frame into two radiating portions. The first feed portion and the second feed portion are electrically coupled to the two radiating portions and supply current to the two radiating portions respectively.

14 Claims, 14 Drawing Sheets



US011043754B2

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

(10) **Patent No.: US 11,043,754 B2**
(45) **Date of Patent: Jun. 22, 2021**

(54) **METHOD AND APPARATUS FOR MULTI-FEED MULTI-BAND MIMO ANTENNA SYSTEM**

(71) Applicant: **Airties Kablosuz Iletisim Sanayi Ve Dis Ticaret A.S.**, Istanbul (TR)

(72) Inventors: **Mehmet Ali Yesil**, Istanbul (TR); **Emre Aydin**, Istanbul (TR); **Ali Arsal**, Istanbul (TR)

(73) Assignee: **Airties Kablosuz Iletisim Sanayi Ve Dis Ticaret A.S.**, Istanbul (TR)

(*) 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.: **16/479,537**

(22) PCT Filed: **Jan. 25, 2018**

(86) PCT No.: **PCT/IB2018/000130**
§ 371 (c)(1),
(2) Date: **Jul. 19, 2019**

(87) PCT Pub. No.: **WO2018/138580**
PCT Pub. Date: **Aug. 2, 2018**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 62/450,359, filed on Jan. 25, 2017.

(51) **Int. Cl.**
H01Q 21/24 (2006.01)
H01Q 5/30 (2015.01)
H01Q 1/52 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 21/24*** (2013.01); ***H01Q 1/521*** (2013.01); ***H01Q 5/30*** (2015.01)

(58) **Field of Classification Search**
CPC .. H01Q 5/10; H01Q 5/20; H01Q 5/30; H01Q 5/378; H01Q 5/392; H01Q 5/50; H01Q 1/521; H01Q 9/04
See application file for complete search history.

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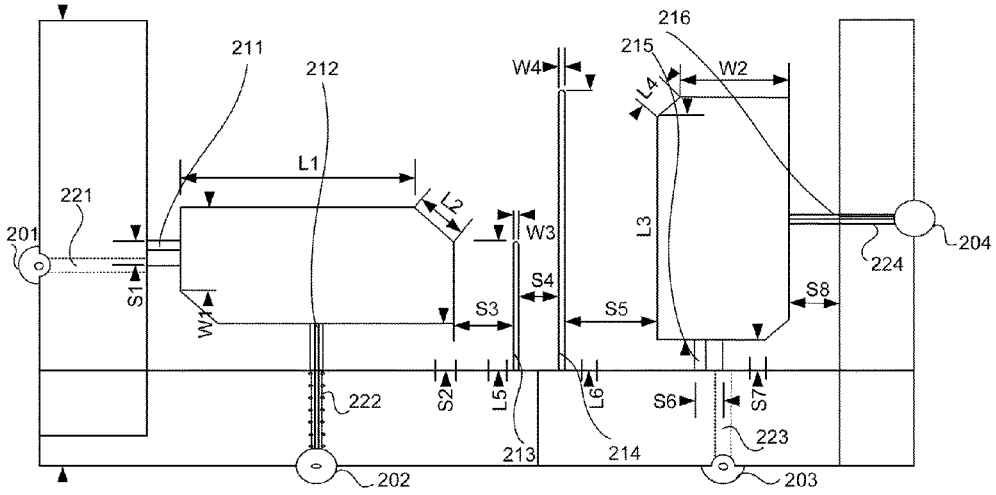
(Continued)

Primary Examiner — Jason Crawford
(74) *Attorney, Agent, or Firm* — Volpe Koenig

(57) **ABSTRACT**

According to aspects of the disclosure, a multi-feed multi-band MIMO antenna system comprises at least two antennas orthogonally positioned with respect to each other, which are operating over two different frequency ranges; at least two out-of-band resonators coupled with the two antennas respectively; and, at least two other in-band resonators coupled with the two antennas respectively and designed to decrease mutual coupling in the frequency ranges, where the first resonator filters out signals having the second frequency range leaking into a first antenna, while the second resonator filters out other signals having the first frequency range leaking into a second antenna.

14 Claims, 5 Drawing Sheets



US011047893B2

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

(10) **Patent No.: US 11,047,893 B2**
(45) **Date of Patent: Jun. 29, 2021**

(54) **ANTENNA FOR ELECTROMAGNETIC INTERFERENCE DETECTION AND PORTABLE ELECTRONIC DEVICE INCLUDING THE SAME**

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

(72) Inventors: **Jin-Chul Choi**, Yongin-si (KR); **Hyunwoo Kim**, 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 62 days.

(21) Appl. No.: **16/174,659**

(22) Filed: **Oct. 30, 2018**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Oct. 30, 2017 (KR) 10-2017-0142867

(51) **Int. Cl.**
G01R 29/12 (2006.01)
G01R 29/08 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***G01R 29/0814*** (2013.01); ***G01R 29/0892*** (2013.01); ***G01R 31/002*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC G01R 29/08; G01R 29/0807; G01R 29/0814; G01R 29/0878; G01R 29/0892;
(Continued)

(56) **References Cited**

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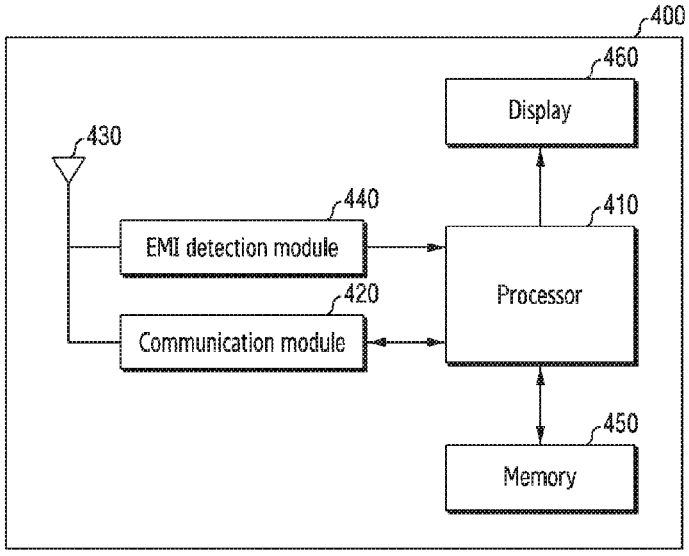
Primary Examiner — Thang X Le
(74) *Attorney, Agent, or Firm* — Nixon & Vanderhye P.C.

(57) **ABSTRACT**

According to an embodiment, an electronic device may include a display, a Printed Circuit Board (PCB), a communication module comprising communication circuitry disposed to the PCB, an Electro Magnetic Interference (EMI) detection module comprising EMI detecting circuitry disposed to the PCB, at least one antenna electrically coupled to the communication module and the EMI detection module, and a processor, wherein the processor is configured to: output an image using the display, control a communication configuration of the electronic device with an external electronic device using the communication module, detect an EMI signal using the antenna and the EMI detection module, and perform a designated operation based on at least the detected EMI signal.

18 Claims, 20 Drawing Sheets



US011050132B2

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

(10) **Patent No.: US 11,050,132 B2**
(45) **Date of Patent: Jun. 29, 2021**

(54) **CHIP-TYPE ANTENNA IMPROVED STRUCTURE**

(71) Applicant: **Power Wave Electronic Co ., Ltd.**, Taipei (TW)

(72) Inventors: **Wen-Jiao Liao**, Taipei (TW); **Yun-Chan Tsai**, Taipei (TW); **Shih-Hsun Hung**, Taipei (TW); **Shi-Hong Yang**, Taipei (TW)

(73) Assignee: **POWER WAVE ELECTRONIC CO., LTD.**, Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 105 days.

(21) Appl. No.: **16/690,775**

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

(65) **Prior Publication Data**

US 2021/0159583 A1 May 27, 2021

(51) **Int. Cl.**

H01Q 1/22	(2006.01)
H01Q 1/48	(2006.01)
H03H 7/01	(2006.01)
H03H 7/38	(2006.01)
H01Q 1/50	(2006.01)

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

CPC ***H01Q 1/22*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 1/50*** (2013.01); ***H03H 7/01*** (2013.01); ***H03H 7/38*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/22; H01Q 1/38; H01Q 1/243; H01Q 1/48–1/50; H03H 7/38

See application file for complete search history.

(56) **References Cited**

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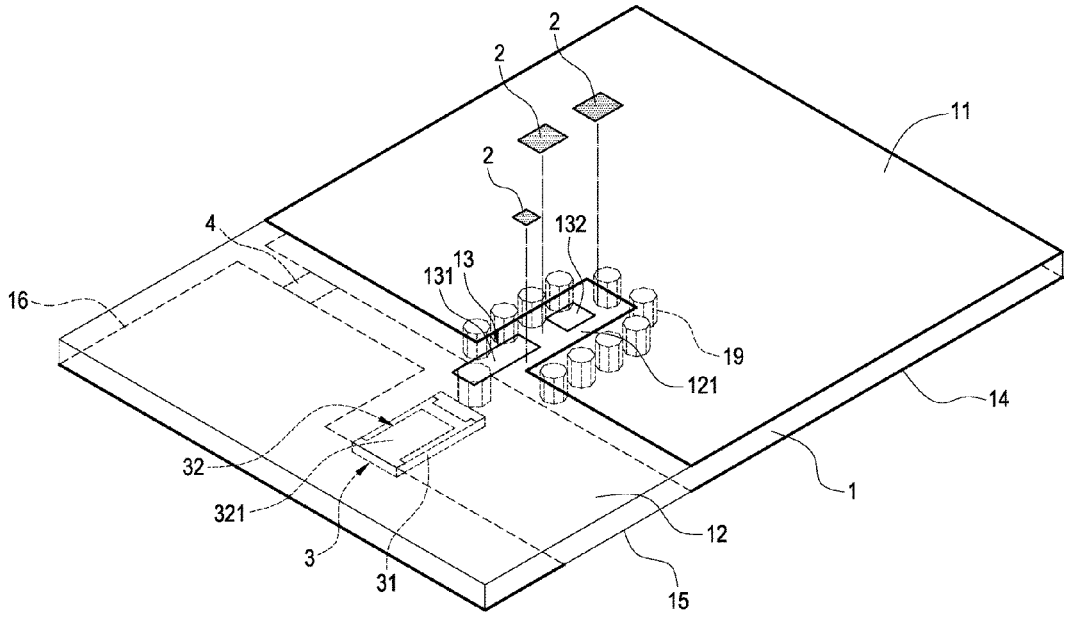
Primary Examiner — Hasan Islam

(74) *Attorney, Agent, or Firm* — Chun-Ming Shih; HDLS IPR Services

(57) **ABSTRACT**

A chip-type antenna structure includes a baseboard, a matching element, a radiation single body and a frequency-modulation element. The baseboard includes a first-ground surface, a first-clearance area and a signal-feed-in unit. A second-ground surface, a second-clearance area, a third-ground surface and a plurality of via holes through the baseboard and electrically connected to the first-ground surface and the second-ground surface are arranged on the other side of the baseboard. The matching element is electrically connected between the signal-feed-in unit and the first-ground surface. One side of the radiation single body is electrically connected to the signal-feed-in unit through the via holes. The other side of the radiation single body is electrically connected to the third-ground surface. The frequency-modulation element is electrically connected between the second-ground surface and the third-ground surface to adjust the frequency-modulation element to adjust a receiving-transmitting frequency of the chip-type antenna structure.

11 Claims, 5 Drawing Sheets



US011050136B2

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

(10) **Patent No.: US 11,050,136 B2**
(45) **Date of Patent: Jun. 29, 2021**

(54) **ELECTRONIC DEVICE COMPRISING ANTENNA**

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

(72) Inventors: **Sang Min Jung**, Gyeonggi-do (KR); **Yong Sang Yun**, 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 94 days.

(21) Appl. No.: **16/334,199**

(22) PCT Filed: **Jul. 28, 2017**

(86) PCT No.: **PCT/KR2017/008179**
§ 371 (c)(1),
(2) Date: **Mar. 18, 2019**

(87) PCT Pub. No.: **WO2018/052188**
PCT Pub. Date: **Mar. 22, 2018**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Sep. 19, 2016 (KR) 10-2016-0119045

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/307 (2015.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/24*** (2013.01); ***H01Q 5/307*** (2015.01)

(58) **Field of Classification Search**
CPC .. H01Q 1/24; H01Q 1/44; H01Q 1/48; H01Q 1/243; H01Q 5/307; H04M 1/02
See application file for complete search history.

(56) **References Cited**

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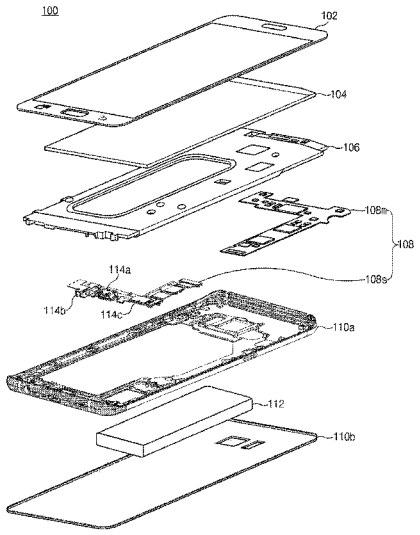
Primary Examiner — Awat M Salih
(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(57) **ABSTRACT**

An electronic device according to an embodiment of the disclosure includes a first antenna element that includes at least a portion of a housing, a metal component that is disposed adjacent to the first antenna element within the housing, a second antenna element that is disposed adjacent to the metal component, and a communication circuit that supplies a power to the first antenna element and the second antenna element. The communication circuit may indirectly supply a power to the metal component through at least one of the first antenna element and the second antenna element, and the communication circuit may transmit/receive a signal in a specified frequency band through an electrical path that is formed by the first antenna element, the second antenna element, and the metal component. Moreover, various embodiment found through the disclosure are possible.

13 Claims, 9 Drawing Sheets



US011050138B2

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

(10) **Patent No.: US 11,050,138 B2**
(45) **Date of Patent: Jun. 29, 2021**

(54) **COMBO SUB 6GHZ AND MMWAVE ANTENNA SYSTEM**

(71) Applicant: **Futurewei Technologies, Inc.**, Plano, TX (US)

(72) Inventors: **Wei Huang**, San Diego, CA (US); **Ping Shi**, San Diego, CA (US); **Xiaoyin He**, Plano, TX (US)

(73) Assignee: **Futurewei Technologies, Inc.**, Plano, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 170 days.

(21) Appl. No.: **16/034,240**

(22) Filed: **Jul. 12, 2018**

(65) **Prior Publication Data**

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(51) **Int. Cl.**

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H01Q 5/378	(2015.01)
H01Q 1/38	(2006.01)
H01Q 21/06	(2006.01)
H01Q 1/22	(2006.01)
H01Q 5/35	(2015.01)
H01Q 5/40	(2015.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/2291*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 5/35*** (2015.01); ***H01Q 5/378*** (2015.01); ***H01Q 5/40*** (2015.01); ***H01Q 21/065*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/2291; H01Q 1/38; H01Q 5/314; H01Q 5/321; H01Q 5/328; H01Q 5/335; H01Q 5/342; H01Q 5/35; H01Q 5/378; H01Q 21/065; H01Q 5/40; H01Q 5/50

See application file for complete search history.

(56) **References Cited**

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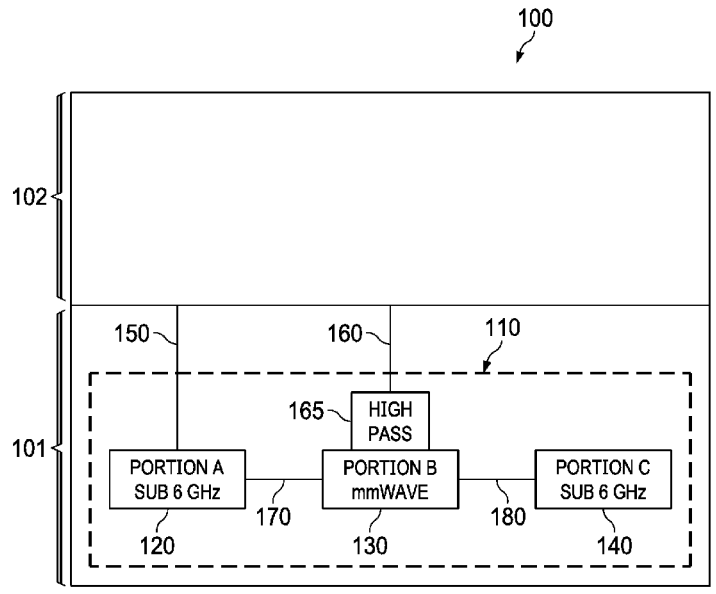
Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — Slater Matsil, LLP

(57) **ABSTRACT**

An embodiment antenna system includes a first antenna portion configured to transmit a first signal received from a first feed and a second antenna portion configured to transmit a second signal received from a second feed. The second antenna portion is capacitively coupled to the second feed and inductively coupled to the first antenna portion, and the second signal has a frequency greater than a frequency of the first signal.

32 Claims, 11 Drawing Sheets



US011050141B2

(12) **United States Patent**
Zhang

(10) **Patent No.: US 11,050,141 B2**
(45) **Date of Patent: Jun. 29, 2021**

(54) **VERTICALLY POLARIZED MIMO ANTENNA AND TERMINAL HAVING SAME**

(71) Applicant: **XI'AN ZHONGXING NEW SOFTWARE CO. LTD.**, Shaanxi (CN)

(72) Inventor: **Juxiang Zhang**, Shenzhen (CN)

(73) Assignee: **XI'AN ZHONGXING NEW SOFTWARE CO. LTD.**, Shaanxi (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.: **16/954,104**

(22) PCT Filed: **Sep. 10, 2018**

(86) PCT No.: **PCT/CN2018/104756**
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(87) PCT Pub. No.: **WO2019/114340**
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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
H04B 7/0413 (2017.01)
H01Q 1/24 (2006.01)
H01Q 1/36 (2006.01)
H01Q 1/38 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/36*** (2013.01); ***H01Q 1/38*** (2013.01); ***H04B 7/0413*** (2013.01)

(58) **Field of Classification Search**
CPC . H01Q 1/243; H01Q 1/36; H01Q 1/38; H04B 7/0413
USPC 455/575.7
See application file for complete search history.

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CN 208014897 U 10/2018
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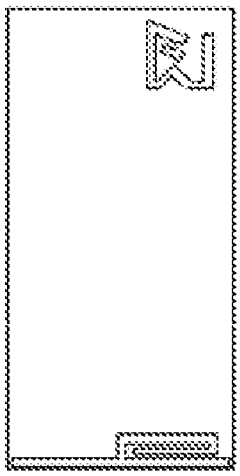
Primary Examiner — Ted M Wang
(74) *Attorney, Agent, or Firm* — Morgan, Lewis & Bockius LLP

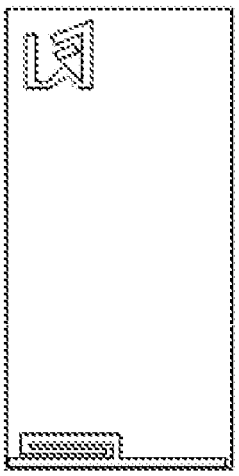
(57) **ABSTRACT**

Provided are a vertically polarized MIMO antenna and a terminal having an MIMO antenna. The antenna includes a primary antenna and a diversity antenna, where a radiation end of the diversity antenna is disposed vertically to a radiation end of the primary antenna. The terminal includes the above-mentioned antenna.

8 Claims, 12 Drawing Sheets



(a)



(b)

US011050148B2

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

(10) **Patent No.: US 11,050,148 B2**
(45) **Date of Patent: Jun. 29, 2021**

(54) **ANTENNA STRUCTURE**

(71) Applicant: **Quanta Computer Inc.**, Taoyuan (TW)

(72) Inventors: **Chung-Hung Lo**, Taoyuan (TW); **Yi-Ling Tseng**, Taoyuan (TW); **Chin-Lung Tsai**, Taoyuan (TW); **Ching-Hai Chiang**, Taoyuan (TW); **Kuan-Hsien Lee**, Taoyuan (TW); **Ying-Cong Deng**, Taoyuan (TW); **Chung-Ting Hung**, Taoyuan (TW)

(73) Assignee: **QUANTA COMPUTER INC.**, Taoyuan (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 30 days.

(21) Appl. No.: **16/661,319**

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jun. 28, 2019 (TW) 108122731

(51) **Int. Cl.**
H01Q 5/307 (2015.01)
H01Q 9/42 (2006.01)
H01Q 1/48 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 5/307*** (2015.01); ***H01Q 1/48*** (2013.01); ***H01Q 9/42*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/307; H01Q 5/314; H01Q 5/321; H01Q 5/378; H01Q 1/243; H01Q 9/42; H01Q 1/48
See application file for complete search history.

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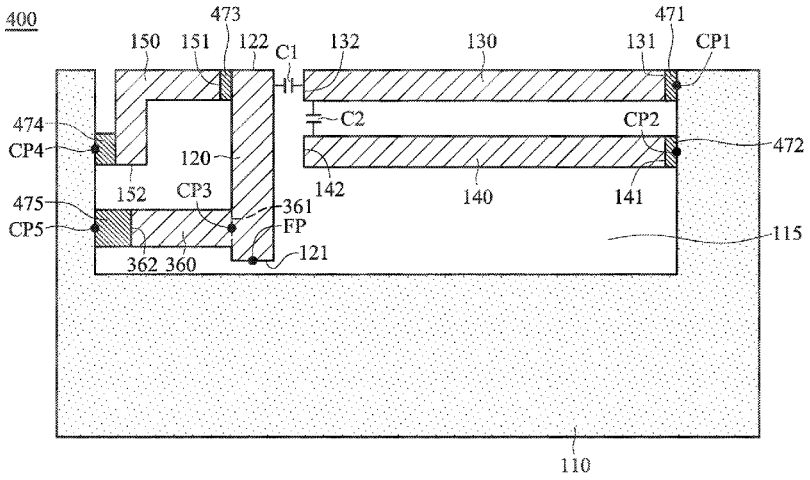
Primary Examiner — Dameon E Levi
Assistant Examiner — Jennifer F Hu
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

An antenna structure includes a ground element, a feeding radiation element, a first radiation element, a second radiation element, a third radiation element, a first capacitor, and a second capacitor. The ground element has a notch region. The feeding radiation element has a feeding point. The first radiation element is coupled to the ground element. The first capacitor is coupled between the feeding radiation element and the first radiation element. The second radiation element is coupled to the ground element. The second capacitor is coupled between the first radiation element and the second radiation element. The third radiation element is coupled to the feeding radiation element. The feeding radiation element, the first radiation element, the second radiation element, the third radiation element, the first capacitor, and the second capacitor are all disposed inside the notch region of the ground element.

4 Claims, 4 Drawing Sheets



US011050149B2

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

(10) **Patent No.: US 11,050,149 B2**
(45) **Date of Patent: Jun. 29, 2021**

(54) **DUAL-BAND ANTENNA**

(71) Applicants: **Wen-Jiao Liao**, Taipei (TW); **Jhin-Ciang Chen**, Taipei (TW); **Shih-Chia Liu**, Taipei (TW); **Liang-Che Chou**, Taipei (TW); **Yen-Hao Yu**, Taipei (TW); **Li-Chun Lee**, Taipei (TW)

(72) Inventors: **Wen-Jiao Liao**, Taipei (TW); **Jhin-Ciang Chen**, Taipei (TW); **Shih-Chia Liu**, Taipei (TW); **Liang-Che Chou**, Taipei (TW); **Yen-Hao Yu**, Taipei (TW); **Li-Chun Lee**, 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 49 days.

(21) Appl. No.: **16/683,172**

(22) Filed: **Nov. 13, 2019**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 62/767,518, filed on Nov. 15, 2018.

(51) **Int. Cl.**
H01Q 9/00 (2006.01)
H01Q 5/328 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 5/328*** (2015.01); ***H01Q 1/241*** (2013.01); ***H01Q 5/45*** (2015.01); ***H01Q 5/50*** (2015.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 9/16; H01Q 5/328; H01Q 5/45; H01Q 21/24; H01Q 1/242; H01Q 1/241; H01Q 5/50
(Continued)

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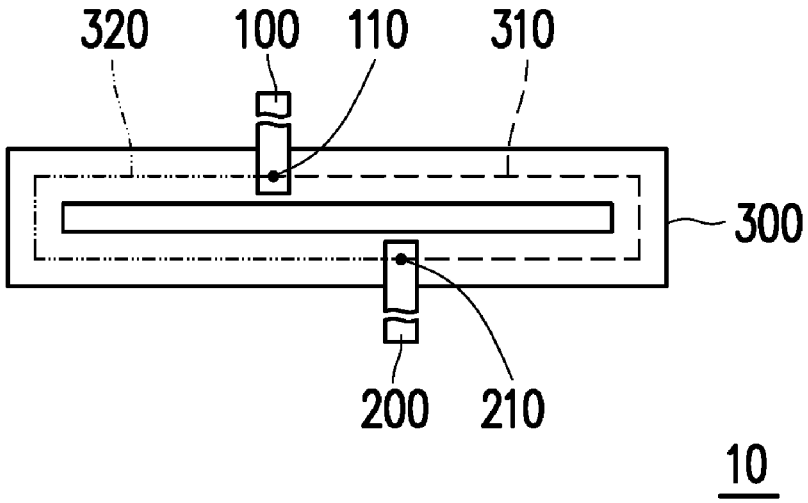
Primary Examiner — Joseph J Lauture
(74) *Attorney, Agent, or Firm* — JCIPRNET

(57) **ABSTRACT**

A dual-band antenna is provided. The dual-band antenna includes a first antenna, a second antenna, and a grounding component. The first antenna has a first feed point for transceiving a first signal. The second antenna has a second feed point. The grounding component is electrically coupled to the first feed point and the second feed point, wherein the grounding component forms a first path and a second path between the first feed point and the second feed point, wherein a first path length of the first path and a second path length of the second path are integer multiples of a first wavelength of the first signal.

10 Claims, 5 Drawing Sheets



US011050150B2

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

(10) **Patent No.: US 11,050,150 B2**
(45) **Date of Patent: Jun. 29, 2021**

(54) **ANTENNA APPARATUS AND ANTENNA MODULE**

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

(72) Inventors: **Nam Ki Kim**, Suwon-si (KR); **Jeong Ki Ryoo**, Suwon-si (KR); **Sang Hyun 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 110 days.

(21) Appl. No.: **16/171,844**

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

(65) **Prior Publication Data**

US 2019/0173176 A1 Jun. 6, 2019

(30) **Foreign Application Priority Data**

Dec. 1, 2017 (KR) 10-2017-0164105
Jun. 4, 2018 (KR) 10-2018-0064244

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 5/371 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 5/371*** (2015.01); ***H01Q 5/49*** (2015.01); ***H01Q 9/16*** (2013.01); ***H01Q 9/26*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01C 5/371; H01C 5/49; H01Q 21/065; H01Q 21/062; H01Q 21/29; H01Q 21/28;
(Continued)

(56) **References Cited**

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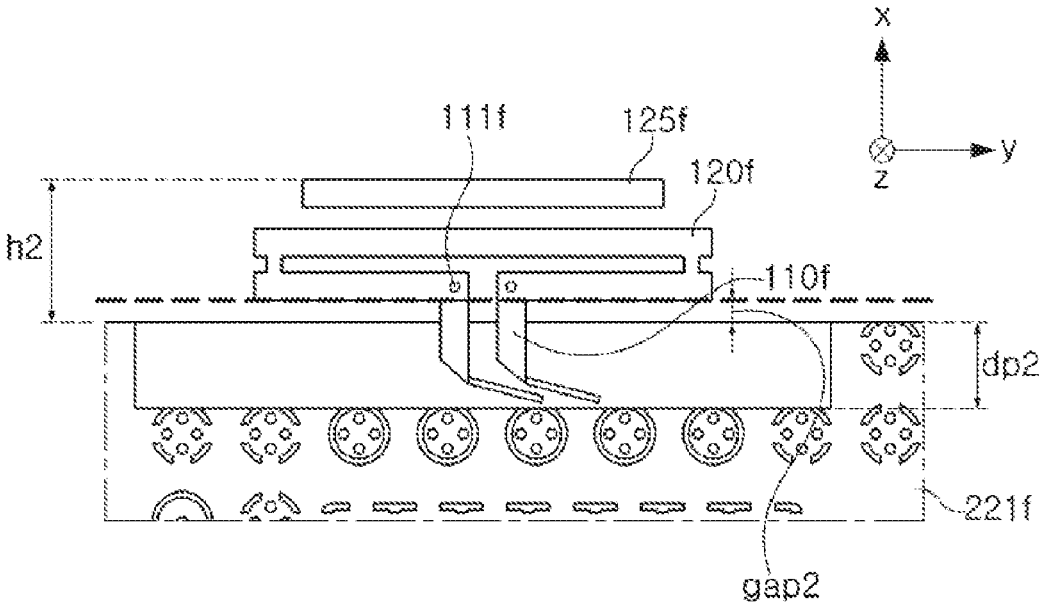
Primary Examiner — Awat M Salih
(74) *Attorney, Agent, or Firm* — NSIP Law

(57) **ABSTRACT**

An antenna apparatus includes: a first ground layer; a second ground layer disposed on a surface of the first ground layer; an antenna pattern spaced apart from the first and second ground layers in a direction of the surface, and configured to transmit and/or receive a radio frequency (RF) signal; and a feed line electrically connected to the antenna pattern and extending from the antenna pattern toward the first ground layer in the direction of the surface, wherein the first ground layer includes a first region recessed, relative to the second ground layer, in the direction of the surface.

15 Claims, 19 Drawing Sheets



US011050154B2

(12) **United States Patent**
Park

(10) **Patent No.: US 11,050,154 B2**
(45) **Date of Patent: Jun. 29, 2021**

(54) **CHIP ANTENNA**

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

(72) Inventor: **Ju Hyoung Park**, 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 174 days.

(21) Appl. No.: **16/441,541**

(22) Filed: **Jun. 14, 2019**

(65) **Prior Publication Data**

US 2020/0161768 A1 May 21, 2020

(30) **Foreign Application Priority Data**

Nov. 21, 2018 (KR) 10-2018-0144539

(51) **Int. Cl.**

H01Q 9/04	(2006.01)
H01Q 1/48	(2006.01)
H01Q 1/22	(2006.01)
H01Q 21/06	(2006.01)
H01Q 1/24	(2006.01)

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

CPC ***H01Q 9/0407*** (2013.01); ***H01Q 1/2283*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 21/065*** (2013.01); *H01Q 1/243* (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/2283; H01Q 1/243; H01Q 1/36; H01Q 1/38; H01Q 1/40; H01Q 9/16; H01Q 9/28; H01Q 9/285; H01Q 9/0407; H01Q 19/28; H01Q 19/30; H01Q 19/32; H01L 23/66; H01L 2223/66

See application file for complete search history.

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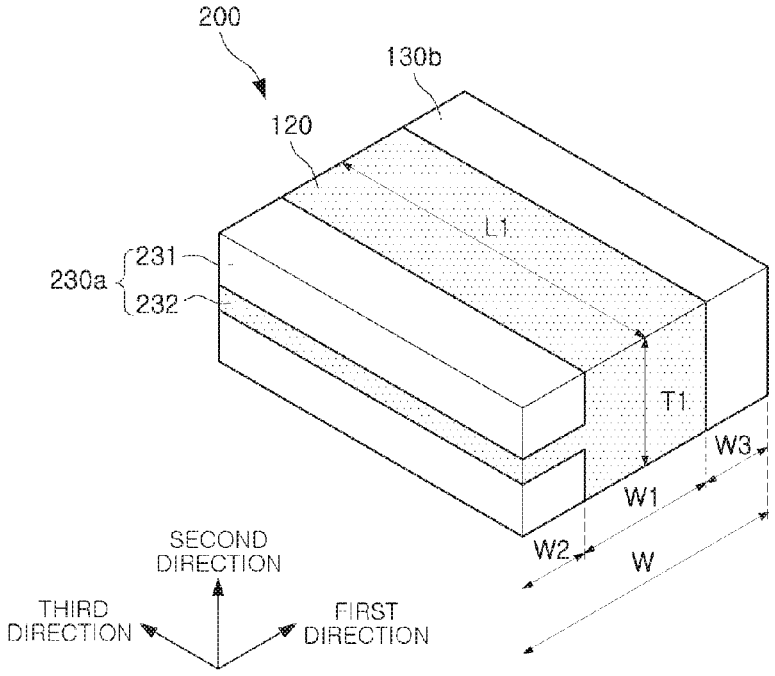
Primary Examiner — Robert Karacsony
(74) *Attorney, Agent, or Firm* — NSIP Law

(57) **ABSTRACT**

A chip antenna includes: a body portion; a radiating portion disposed on one surface of the body portion in a width direction; and a ground portion disposed on another surface of the body portion in a width direction, wherein the radiating portion includes a dielectric substance and a conductor, and the dielectric substance and the conductor are respectively disposed in different regions in a thickness direction.

16 Claims, 9 Drawing Sheets



US011050160B2

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

(10) **Patent No.: US 11,050,160 B2**
(45) **Date of Patent: Jun. 29, 2021**

(54) **PLANAR-SHAPED ANTENNA DEVICES, ANTENNA ARRAYS, AND FABRICATION**

(71) Applicant: **University of Massachusetts**, Boston, MA (US)

(72) Inventors: **Hualiang Zhang**, Arlington, MA (US); **Bowen Zheng**, Dracut, MA (US)

(73) Assignee: **University of Massachusetts**, Boston, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 425 days.

(21) Appl. No.: **15/953,739**

(22) Filed: **Apr. 16, 2018**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 62/486,133, filed on Apr. 17, 2017.

(51) **Int. Cl.**

H01Q 19/00	(2006.01)
H01Q 15/14	(2006.01)
H01Q 19/185	(2006.01)
H01P 1/203	(2006.01)
H01Q 5/42	(2015.01)
H01Q 21/06	(2006.01)

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

CPC ***H01Q 19/005*** (2013.01); ***H01Q 15/14*** (2013.01); ***H01Q 19/185*** (2013.01); *H01P 1/2039* (2013.01); *H01Q 5/42* (2015.01); *H01Q 21/064* (2013.01)

(58) **Field of Classification Search**

CPC H01Q 19/005; H01Q 19/10; H01Q 19/104; H01Q 19/108; H01Q 19/18; H01Q 19/185; H01Q 19/195; H01Q 15/14–23; H01Q 25/002; H01Q 25/005; H01Q 5/42; H01Q 21/0075; H01Q 21/064; H01Q 21/065; H01Q 13/10–18; H01Q 9/02; H01Q 9/04; H01Q 9/0407–0478; H01Q 1/246; H01Q 1/38; H01Q 1/52; H01Q 1/521; H01Q 1/523; H01Q 1/525; H01P 1/2039

See application file for complete search history.

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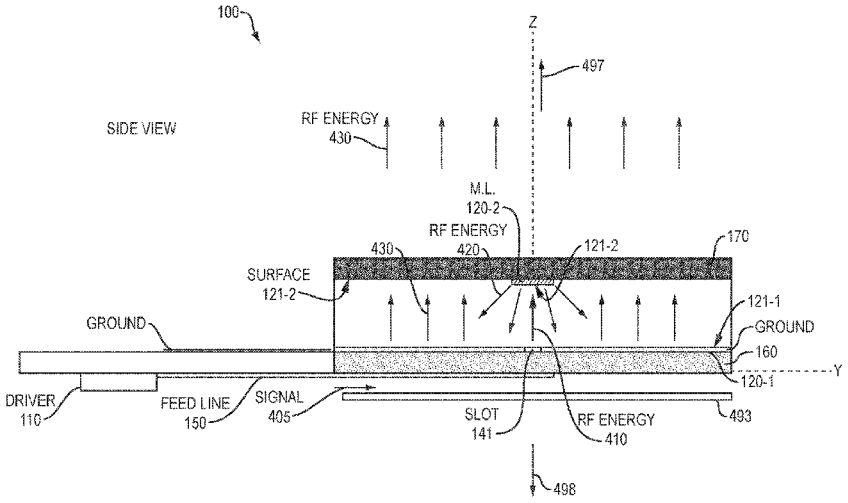
Primary Examiner — Dimary S Lopez Cruz
Assistant Examiner — Patrick R Holecek
(74) *Attorney, Agent, or Firm* — Armis IP Law, LLC

(57) **ABSTRACT**

An antenna device as described herein includes a first metal layer and a second metal layer. The second metal layer is spaced apart from the first metal layer. The first metal layer includes an opening through which to transmit RF (Radio Frequency) energy to the second metal layer. The second metal layer is operable to reflect the RF energy received through the opening back to a surface of the first metal layer. The first metal layer is operable to reflect the RF energy (received from the reflection off the second metal layer) in a direction past the second metal layer through a communication medium. The surface area of the first metal layer is sufficiently larger than a surface area of the second metal layer to reflect the RF energy past the second metal layer into the communication medium. This ensures that the antenna device operates in a reflective mode as opposed to a resonant mode, resulting in high gain.

34 Claims, 22 Drawing Sheets



US011050863B2

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

(10) **Patent No.: US 11,050,863 B2**
(45) **Date of Patent: Jun. 29, 2021**

(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.: **16/589,734**

(22) Filed: **Oct. 1, 2019**

(65) **Prior Publication Data**

US 2020/0036820 A1 Jan. 30, 2020

Related U.S. Application Data

(63) Continuation of application No. 15/991,568, filed on May 29, 2018, now Pat. No. 10,516,772, which is a (Continued)

(30) **Foreign Application Priority Data**

Aug. 13, 2015 (KR) 10-2015-0114638

(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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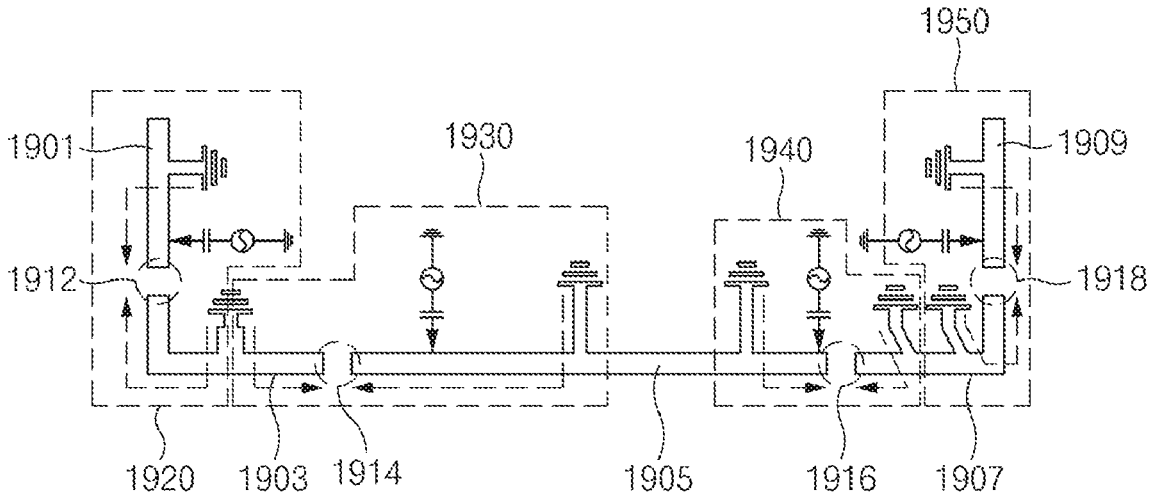
Primary Examiner — Tuan A Tran
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(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.

15 Claims, 42 Drawing Sheets



US011056767B2

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

(10) **Patent No.: US 11,056,767 B2**
(45) **Date of Patent: Jul. 6, 2021**

(54) **ELECTRONIC DEVICE INCLUDING ANTENNA USING HOUSING THEREOF**

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

(72) Inventors: **Sung Chul Park**, Seoul (KR); **Kyi Hyun Jang**, Seoul (KR); **Bum Jin Cho**, Gyeonggi-do (KR); **Kyung Kyun Kang**, Gyeonggi-do (KR); **Ji Ho Kim**, Gyeonggi-do (KR); **Gyu Bok Park**, Gyeonggi-do (KR); **Kyung Moon Seol**, Gyeonggi-do (KR); **Hyun Jeong 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 450 days.

(21) Appl. No.: **15/956,377**

(22) Filed: **Apr. 18, 2018**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Apr. 18, 2017 (KR) 10-2017-0049657

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 7/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 7/00*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/241; H01Q 1/242; H01Q 1/243; H01Q 1/44; H01Q 5/30; H01Q 5/307; H01Q 5/342; H01Q 7/00
See application file for complete search history.

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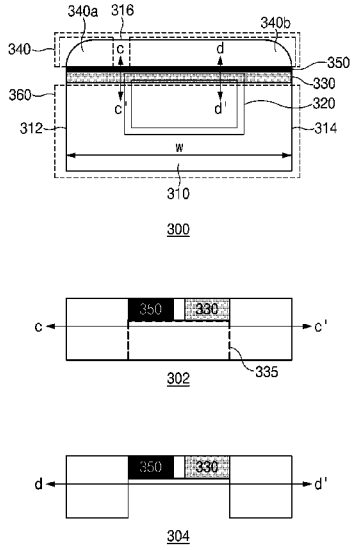
Primary Examiner — Dimary S Lopez Cruz
Assistant Examiner — Patrick R Holecek
(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(57) **ABSTRACT**

An electronic device includes a first antenna configured to transmit and receive a first signal of a first frequency band, and a housing in which the first antenna is accommodated, wherein the housing includes a first conductor having a first slit that at least partially overlaps the first antenna, wherein the first conductor is formed of a metal and at least a portion of the first slit is filled with a metal oxide. Additionally, the electronic device includes a second conductor configured to transmit and receive a second signal of a second frequency band, and a second slit formed between the first conductor and the second conductor, and wherein the second slit is filled with a material that has an external appearance that is different from that of the second conductor.

13 Claims, 10 Drawing Sheets



US011056768B2

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

(10) **Patent No.: US 11,056,768 B2**
(45) **Date of Patent: Jul. 6, 2021**

(54) **ELECTRONIC DEVICE COMPRISING ANTENNA**

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

(72) Inventors: **Hyeongtae Kim**, Gyeonggi-do (KR); **Seunggil Jeon**, 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 148 days.

(21) Appl. No.: **16/060,300**

(22) PCT Filed: **Nov. 14, 2016**

(86) PCT No.: **PCT/KR2016/013100**
§ 371 (c)(1),
(2) Date: **Jun. 7, 2018**

(87) PCT Pub. No.: **WO2017/099377**
PCT Pub. Date: **Jun. 15, 2017**

(65) **Prior Publication Data**

US 2018/0366813 A1 Dec. 20, 2018

(30) **Foreign Application Priority Data**

Dec. 7, 2015 (KR) 10-2015-0173203

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/2266*** (2013.01); ***H01Q 1/24*** (2013.01); ***H01Q 1/38*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/2226; H01Q 1/38; H01Q 1/24; H01Q 1/48; H01Q 9/04;
(Continued)

(56) **References Cited**

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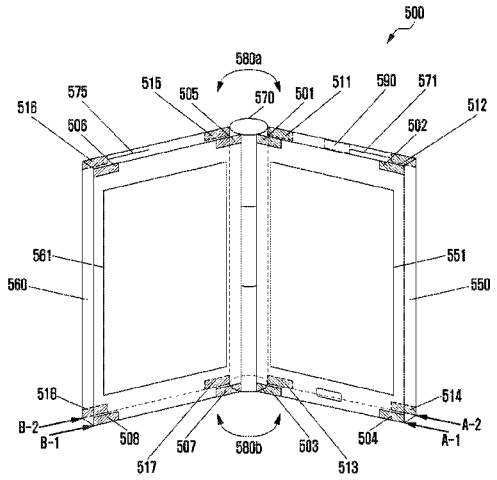
(Continued)

Primary Examiner — Awat M Salih
(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(57) **ABSTRACT**

According to various examples, an electronic device comprising: a housing, which is a foldable housing and includes a first housing part including a first surface and a second surface oppositely facing the first surface, a second housing part including a first surface facing the first surface of the first housing part when folded in a first direction, and a second surface facing the second surface of the first housing part when folded in a second direction, and a connection part connecting the first housing part and the second housing part; a communication circuit disposed inside the housing; a first antenna pattern disposed inside the first housing part; a second antenna pattern disposed inside the second housing part; a first display exposed to the first surface of the first housing part; a second display exposed to the first surface of
(Continued)



US011056769B2

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

(10) **Patent No.: US 11,056,769 B2**
(45) **Date of Patent: Jul. 6, 2021**

(54) **ELECTRONIC DEVICE COMPRISING ANTENNA**

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

(72) Inventors: **Seunggil Jeon**, Suwon-si (KR); **Kyungwoo Lee**, Suwon-si (KR); **Joohyun Ahn**, 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 0 days.

(21) Appl. No.: **16/661,033**

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

(65) **Prior Publication Data**

US 2020/0144699 A1 May 7, 2020

(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 1/48	(2006.01)
H01Q 9/04	(2006.01)
H01Q 5/50	(2015.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/50*** (2015.01); ***H01Q 9/0421*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/241; H01Q 1/243; H01Q 1/44; H01Q 1/48; H01Q 5/50; H01Q 5/335; H01Q 9/0421; H01Q 9/36; H01Q 9/42

See application file for complete search history.

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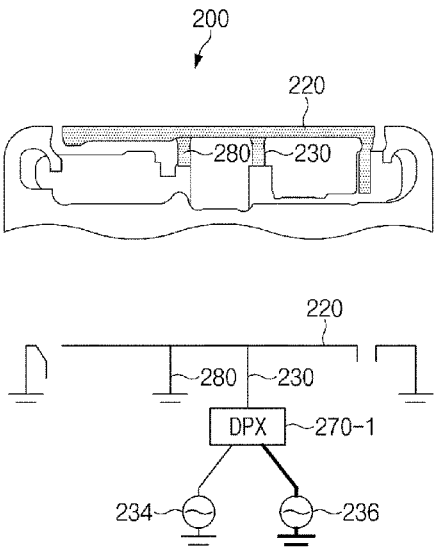
Primary Examiner — Hoang V Nguyen

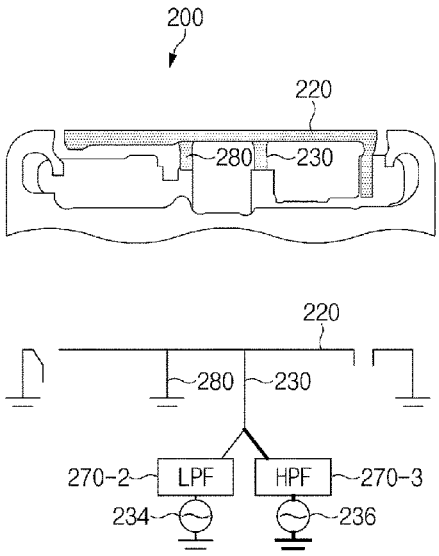
(74) *Attorney, Agent, or Firm* — Nixon & Vanderhye P.C.

(57) **ABSTRACT**

An electronic device may include a housing including a conductive area, a first conductive member comprising a conductive material in electrical contact with the conductive area, a first wireless communication circuit electrically connected to the conductive area, and a second wireless communication circuit electrically connected to the first conductive member. The first wireless communication circuit transmits and/or receives a first signal having a frequency of 6 GHz or less using the conductive area, and the second wireless communication circuit transmits and/or receives a second signal having a frequency of 20 GHz or more using at least part of the first conductive member and the conductive area.

17 Claims, 16 Drawing Sheets





US011056770B2

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

(10) **Patent No.: US 11,056,770 B2**
(45) **Date of Patent: Jul. 6, 2021**

(54) **MULTI-ANTENNA SYSTEM AND ELECTRONIC DEVICE THEREOF**

(71) Applicant: **ASUSTeK COMPUTER INC.**, Taipei (TW)

(72) Inventors: **Saou-Wen Su**, Taipei (TW); **Wei-Hsuan Chang**, Taipei (TW)

(73) Assignee: **ASUSTEK COMPUTER 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 49 days.

(21) Appl. No.: **16/708,593**

(22) Filed: **Dec. 10, 2019**

(65) **Prior Publication Data**

US 2020/0203808 A1 Jun. 25, 2020

(30) **Foreign Application Priority Data**

Dec. 19, 2018 (TW) 107146012

(51) **Int. Cl.**

H01Q 1/38	(2006.01)
H01Q 1/24	(2006.01)
H01Q 9/04	(2006.01)
H01Q 9/42	(2006.01)
H01Q 5/378	(2015.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 5/378*** (2015.01); ***H01Q 9/0421*** (2013.01); ***H01Q 9/42*** (2013.01)

(58) **Field of Classification Search**

CPC H01G 1/243; H01G 5/378; H01G 1/38; H01G 9/0421; H01G 9/42

See application file for complete search history.

(56) **References Cited**

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TW	201807881 A	3/2018

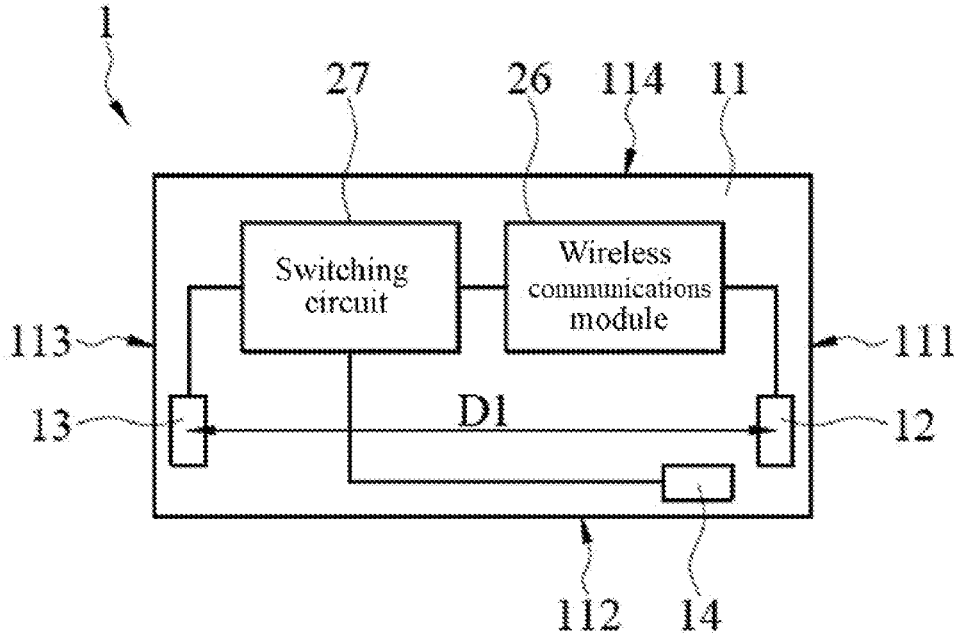
Primary Examiner — Graham P Smith

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

(57) **ABSTRACT**

A multi-antenna system includes a conductive plane with four adjacent sides, a main antenna unit disposed on any one of the four sides, a first secondary antenna unit disposed on any one of the four side, a second secondary antenna unit disposed on any one of the four sides of the conductive plane except the side on which the main antenna unit is disposed, a switching circuit disposed on the conductive plane and is selectively electrically connected to the first secondary antenna unit or the second secondary antenna unit and a wireless communications module disposed on the conductive plane and electrically connected to the switching circuit and the main antenna unit. The first secondary antenna unit is spaced apart from the main antenna unit by a spacing, where the spacing is greater than 0.5 times a wavelength distance of a low-frequency operating frequency of the multi-antenna system.

10 Claims, 6 Drawing Sheets



US011056771B2

(12) **United States Patent**
Jia

(10) **Patent No.: US 11,056,771 B2**
(45) **Date of Patent: Jul. 6, 2021**

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

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

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

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

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

(21) Appl. No.: **16/816,875**

(22) Filed: **Mar. 12, 2020**

(65) **Prior Publication Data**

US 2020/0313282 A1 Oct. 1, 2020

(30) **Foreign Application Priority Data**

Mar. 28, 2019 (CN) 201910244229.2

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

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/307*** (2015.01);
(Continued)

(58) **Field of Classification Search**
CPC .. H01Q 1/42; H01Q 5/00; H01Q 9/04; H01Q 9/0407; H01Q 9/045
See application file for complete search history.

(56) **References Cited**

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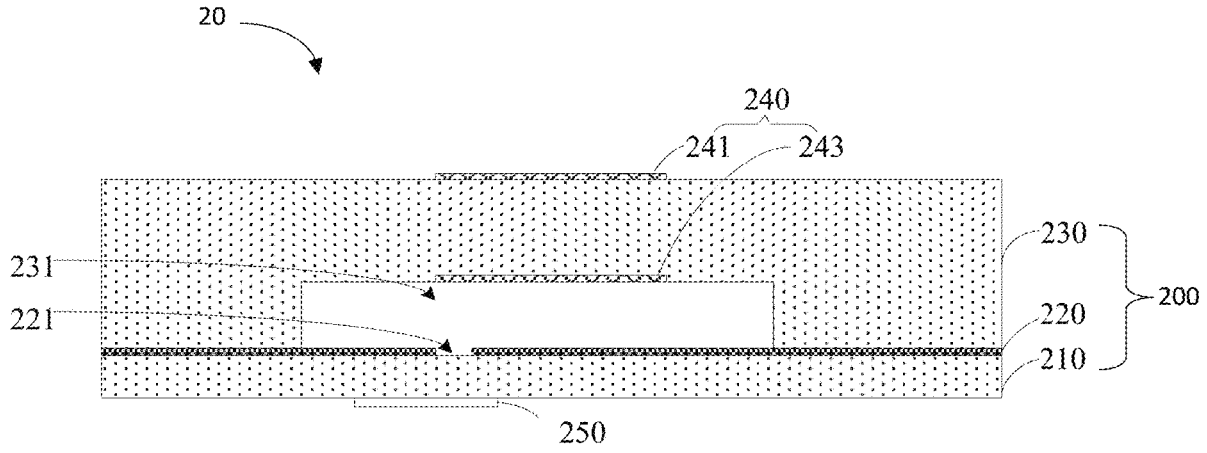
A Dual-Frequency Broad-Band Design of Coupled-Fed Stacked Microstrip Monopolar Patch Antenna for WLAN Applications.
(Continued)

Primary Examiner — Blane J Jackson

(57) **ABSTRACT**

The present disclosure relates to an antenna module and an electronic device. The antenna module includes: a first dielectric layer; a ground layer arranged on the first dielectric layer, and provided with at least one slot; a second dielectric layer arranged on the ground layer, and provided with an air chamber communicated with the at least one slot; a stacked patch antenna including a first radiation patch and a second radiation patch, the first radiation patch being attached to a side of the second dielectric layer facing away from the ground layer, and the second radiation patch being attached to a side of the second dielectric layer provided with the air chamber; and a feeding unit arranged to a side of the first dielectric layer facing away from the ground layer, and configured to feed the stacked patch antenna by the at least one slot.

20 Claims, 12 Drawing Sheets



US011056772B2

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

(10) **Patent No.: US 11,056,772 B2**
(45) **Date of Patent: Jul. 6, 2021**

(54) **ANTENNA SYSTEM WITH DECREASED SAR VALUE**

(71) Applicant: **AAC Technologies Pte. Ltd.**, Singapore (SG)

(72) Inventors: **Kai Dong**, Shenzhen (CN); **Dawei Shi**, Shenzhen (CN)

(73) Assignee: **AAC Technologies Pte. Ltd.**, Singapore (SG)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 55 days.

(21) Appl. No.: **16/439,723**

(22) Filed: **Jun. 13, 2019**

(65) **Prior Publication Data**

US 2019/0386382 A1 Dec. 19, 2019

(30) **Foreign Application Priority Data**

Jun. 13, 2018 (CN) 201810604287.7

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/50 (2006.01)
H04B 1/3827 (2015.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/245*** (2013.01); ***H01Q 1/50*** (2013.01); ***H04B 1/3838*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/245; H01Q 1/50; H04B 1/3838
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

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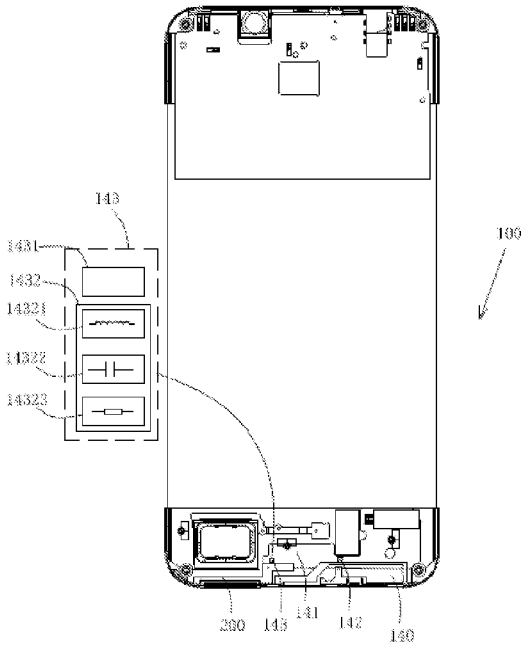
Primary Examiner — Robert Karacsony
(74) *Attorney, Agent, or Firm* — W&G Law Group LLP

(57) **ABSTRACT**

The present disclosure discloses an antenna system with decreased SAR. The antenna system includes a circuit board having a feeding point, an RF switch for making the antenna system work under a number of working modes with different frequency bands, and a system ground. The antenna further includes a radiation body including a feeding portion electrically connected to the feeding point, a ground portion connected to the system ground by the RF switch, and a connecting portion connecting the feeding portion to the ground portion. The ground portion includes a first metal segment for connecting to the connecting portion, and a second metal segment; the feeding portion includes a third metal segment and a fourth segment. The RF switch electrically connects to the second metal segment, and the feeding point electrically connects to the fourth segment. A method for decreasing the SAR value is also provide.

1 Claim, 2 Drawing Sheets



US011056781B2

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

(10) **Patent No.: US 11,056,781 B2**
(45) **Date of Patent: Jul. 6, 2021**

(54) **ANTENNA AND MOBILE TERMINAL**

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

(72) Inventors: **Ming Zhang**, Hangzhou (CN); **Daqing Liu**, Hangzhou (CN); **Huailin Wen**, Ottawa (CA)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 205 days.

(21) Appl. No.: **16/250,784**

(22) Filed: **Jan. 17, 2019**

(65) **Prior Publication Data**

US 2019/0157751 A1 May 23, 2019

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2017/090324, filed on Jun. 27, 2017.

(30) **Foreign Application Priority Data**

Jul. 20, 2016 (CN) 201610578153.3

(51) **Int. Cl.**
H01Q 1/52 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/52*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 1/521*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/48; H01Q 1/52; H01Q 1/521; H01Q 1/523; H01Q 25/00; H01Q 25/001; H01Q 25/004; H01Q 25/005; H01Q 21/205; H01Q 21/24; H01Q 21/29
See application file for complete search history.

(56) **References Cited**

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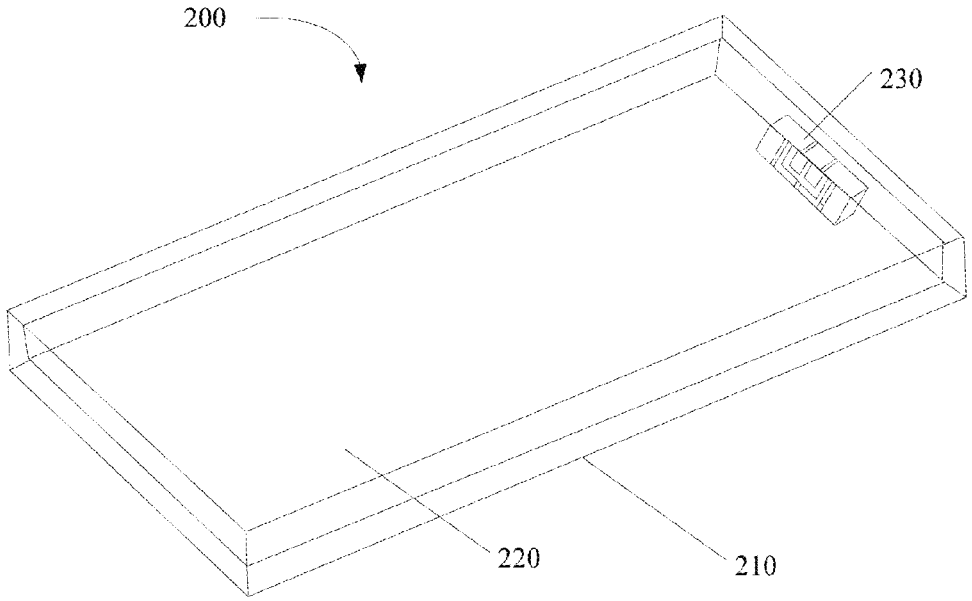
Primary Examiner — Dimary S Lopez Cruz
Assistant Examiner — Patrick R Holecek
(74) *Attorney, Agent, or Firm* — Womble Bond Dickinson (US) LLP

(57) **ABSTRACT**

The application disclose an antenna. The antenna includes a first radiating element, a second radiating element, a third radiating element, and a closed ring, where the first radiating element is connected to a first feed point, the second radiating element is connected to a second feed point, and the third radiating element is connected to a third feed point; the closed ring is configured to be disposed in a clearance area of a ground plate, and configured to connect to the ground plate; the first radiating element, the second radiating element, and the third radiating element are connected by using a microstrip, to form a radiator; the third radiating element is disposed between the first radiating element and the second radiating element.

10 Claims, 14 Drawing Sheets



US011056786B2

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

(10) **Patent No.: US 11,056,786 B2**
(45) **Date of Patent: Jul. 6, 2021**

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

(71) Applicant: **AAC Technologies Pte. Ltd.**, Singapore (SG)

(72) Inventors: **Yufei Zhu**, Shenzhen (CN); **Yongsheng Peng**, Shenzhen (CN)

(73) Assignee: **AAC Technologies Pte. Ltd.**, Singapore (SG)

(*) 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.: **16/524,084**

(22) Filed: **Jul. 28, 2019**

(65) **Prior Publication Data**

US 2020/0044339 A1 Feb. 6, 2020

(30) **Foreign Application Priority Data**

Aug. 3, 2018 (CN) 201810880128.X

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

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

(58) **Field of Classification Search**
CPC H01Q 5/30; H01Q 21/30; H01Q 1/243; H01Q 21/28; H01Q 1/22; H01Q 21/061
USPC 343/702
See application file for complete search history.

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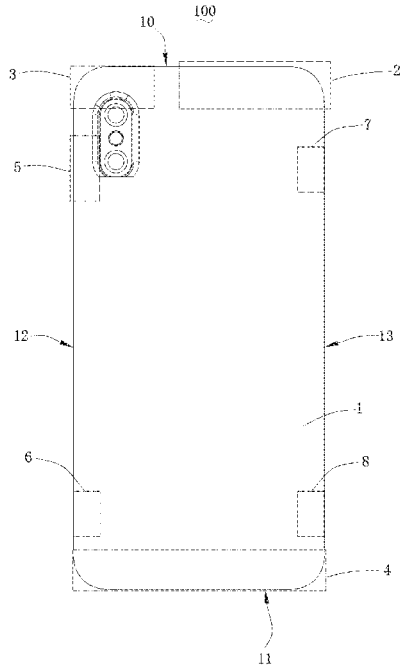
Primary Examiner — Don P Le
(74) *Attorney, Agent, or Firm* — W&G Law Group LLP

(57) **ABSTRACT**

The present disclosure provides an antenna system including a non-metallic housing. The non-metallic housing includes a top edge portion, a bottom edge portion provided correspondingly to the top edge portion, and a first long side edge portion and a second long side edge portion that connect the top edge portion with the bottom edge portion. The antenna system further includes seven antenna units provided on a periphery of the non-metallic housing. Compared with the related art, the antenna system provided by the present disclosure, by providing seven antenna units on the periphery of the non-metallic housing, achieves 3.3-3.6 GHz-4×4 MIMO, WIFI-2×2 MIMO, GPS, and 2G, 3G and 4G mobile communications.

6 Claims, 12 Drawing Sheets



US011056787B2

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

(10) **Patent No.: US 11,056,787 B2**
(45) **Date of Patent: Jul. 6, 2021**

(54) **HYBRID ANTENNA**

(71) Applicants: **SAMSUNG ELECTRONICS CO., LTD.**, Suwon-si (KR); **HONGIK UNIVERSITY INDUSTRY-ACADEMIA COOPERATION FOUNDATION**, Seoul (KR)

(72) Inventors: **Jae-Hyun Park**, Suwon-si (KR); **Jeong-Hae Lee**, Seoul (KR); **Young-Ho Ryu**, Yongin-si (KR); **Chang-Hyun Lee**, Incheon (KR); **Min-Seo Park**, Changwon-si (KR); **Sung-Bum Park**, Suwon-si (KR); **Kwi-Seob Um**, Seoul (KR); **Chong-Min Lee**, Seoul (KR)

(73) Assignees: **SAMSUNG ELECTRONICS CO., LTD.**, Suwon-si (KR); **HONGIK UNIVERSITY INDUSTRY-ACADEMIA COOPERATION FOUNDATION**, Seoul (KR)

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

(21) Appl. No.: **16/348,635**

(22) PCT Filed: **Feb. 10, 2017**

(86) PCT No.: **PCT/KR2017/001490**
§ 371 (c)(1),
(2) Date: **May 9, 2019**

(87) PCT Pub. No.: **WO2018/088634**
PCT Pub. Date: **May 17, 2018**

(65) **Prior Publication Data**

US 2019/0267712 A1 Aug. 29, 2019

(30) **Foreign Application Priority Data**

Nov. 14, 2016 (KR) 10-2016-0150938

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 5/335 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 5/335*** (2015.01); ***H01Q 1/24*** (2013.01); ***H01Q 1/364*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 13/08*** (2013.01); ***H02J 50/20*** (2016.02)

(58) **Field of Classification Search**
CPC H02J 50/005; H02J 50/20; H02J 50/23; H02J 50/27; H01Q 5/335; H01Q 13/08;
(Continued)

(56) **References Cited**

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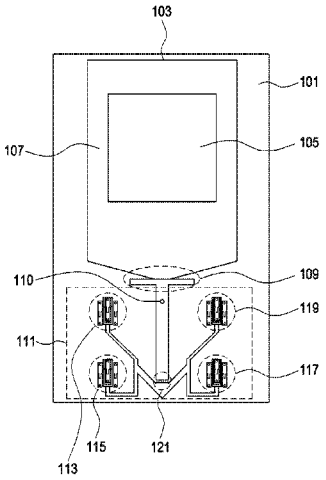
Primary Examiner — Seokjin Kim
(74) *Attorney, Agent, or Firm* — Nixon & Vanderhye, P.C.

(57) **ABSTRACT**

A hybrid antenna used for an electronic device is disclosed. A hybrid antenna comprises: a substrate comprising a first surface and a second surface and having an insulator; a first conductive member disposed on the first surface of the
(Continued)



US011056789B2

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

(10) **Patent No.: US 11,056,789 B2**
(45) **Date of Patent: Jul. 6, 2021**

(54) **DUAL-BAND CIRCULARLY POLARIZED ANTENNA STRUCTURE**

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

(72) Inventors: **Chien-Yi Wu**, Taipei (TW); **Chao-Hsu Wu**, Taipei (TW); **Shih-Keng Huang**, Taipei (TW); **Cheng-Hsiung Wu**, Taipei (TW); **Yi-Ru Yang**, Taipei (TW); **Ching-Hsiang Ko**, Taipei (TW); **Sheng-Chin Hsu**, 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 33 days.

(21) Appl. No.: **16/672,307**

(22) Filed: **Nov. 1, 2019**

(65) **Prior Publication Data**

US 2020/0203835 A1 Jun. 25, 2020

(30) **Foreign Application Priority Data**

Dec. 20, 2018 (TW) 107146271

(51) **Int. Cl.**

H01Q 9/27	(2006.01)
H01Q 1/28	(2006.01)
H01Q 9/04	(2006.01)
H01Q 1/38	(2006.01)
H01Q 21/24	(2006.01)
H01Q 1/48	(2006.01)
H01Q 5/10	(2015.01)

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

CPC ***H01Q 9/0407*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/10*** (2015.01); ***H01Q 9/27*** (2013.01); ***H01Q 21/24*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/0407; H01Q 1/38; H01Q 21/24; H01Q 1/48; H01Q 5/10; H01Q 9/27; H01Q 1/50; H01Q 5/20; H01Q 5/307

See application file for complete search history.

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(Continued)

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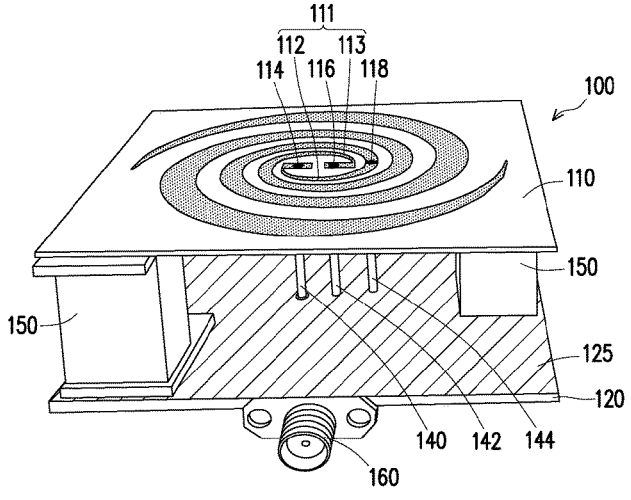
Primary Examiner — Vibol Tan

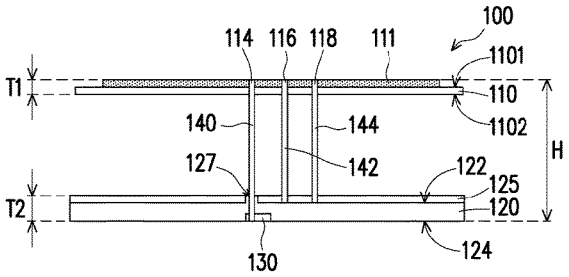
(74) *Attorney, Agent, or Firm* — J.C. Patents

(57) **ABSTRACT**

A dual-band circularly polarized antenna structure includes a microstrip line, an antenna unit and a ground. The antenna unit includes a first radiator and a second radiator. The first radiator has a feed-in portion and a first spiral pattern. The first spiral pattern spirals outwardly from a starting point close to the feed-in portion. The second radiator has a first grounding portion and a second spiral pattern. The second spiral pattern spirals outwardly from a starting point close to the first grounding portion in a manner non-overlapping with the first spiral pattern. One of the first and the second radiators has a second grounding portion. The microstrip line and the antenna unit are arranged apart. The feed-in portion of the first radiator of the antenna unit is coupled to the microstrip line. The first and the second grounding portions are coupled to the ground.

14 Claims, 17 Drawing Sheets





US011056790B2

(12) **United States Patent**
Xu

(10) **Patent No.: US 11,056,790 B2**
(45) **Date of Patent: Jul. 6, 2021**

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

(71) Applicant: **AAC Technologies Pte. Ltd.**, Singapore (SG)

(72) Inventor: **Xinying Xu**, Shenzhen (CN)

(73) Assignee: **AAC Technologies Pte. Ltd.**, Singapore (SG)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 29 days.

(21) Appl. No.: **16/524,082**

(22) Filed: **Jul. 28, 2019**

(65) **Prior Publication Data**

US 2020/0044348 A1 Feb. 6, 2020

(30) **Foreign Application Priority Data**

Aug. 3, 2018 (CN) 201821252395.4

(51) **Int. Cl.**

H01Q 9/04	(2006.01)
H01Q 1/24	(2006.01)
H01Q 5/50	(2015.01)
H01Q 5/328	(2015.01)

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

CPC ***H01Q 9/0414*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/245*** (2013.01); ***H01Q 5/328*** (2015.01); ***H01Q 5/50*** (2015.01)

(58) **Field of Classification Search**

CPC H01Q 9/0414; H01Q 1/245; H01Q 5/50; H01Q 5/328; H01Q 1/243; H01Q 21/28; H01Q 5/378; H01Q 9/42

USPC 343/702

See application file for complete search history.

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(Continued)

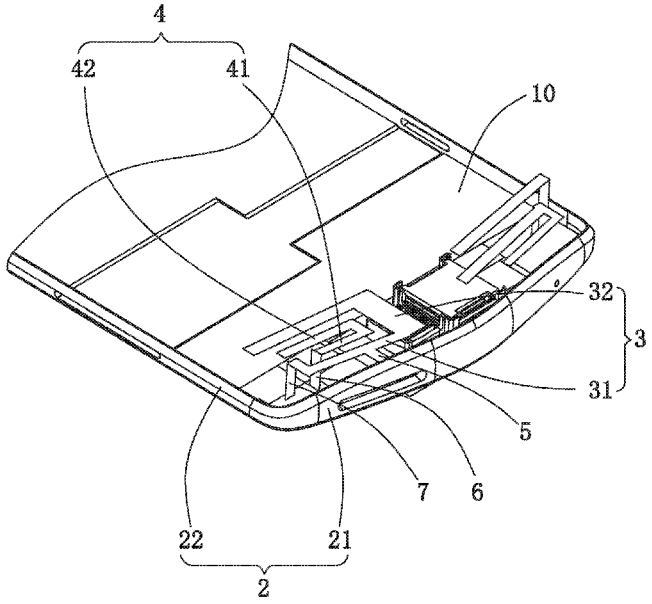
Primary Examiner — Don P Le

(74) *Attorney, Agent, or Firm* — W&G Law Group LLP

(57) **ABSTRACT**

The present disclosure provides an antenna system, including a mainboard having a system ground, a metal frame disposed around the mainboard and being closed-loop without any breakpoints, a first wire, a second wire, a third wire, a feed terminal, and a ground terminal. The system ground is electrically connected to the metal frame. The first wire is connected to the feed terminal and is opposite to and spaced apart from the metal frame, so that the first wire forms a first antenna unit. The second wire is connected to the ground terminal and is spaced apart from the first wire, and the second wire and the first wire are at least partially opposite, so that the second wire and the first wire are coupled with each other, to form a second antenna unit.

10 Claims, 6 Drawing Sheets



US011056791B2

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

(10) **Patent No.: US 11,056,791 B2**
(45) **Date of Patent: Jul. 6, 2021**

(54) **ARRAYS WITH FOLDABLE AND DEPLOYABLE CHARACTERISTICS**

(71) Applicants: **Constantinos L. Zekios**, Miami, FL (US); **Stavros Georgakopoulos**, Miami, FL (US); **Muhammad Hamza**, Miami, FL (US)

(72) Inventors: **Constantinos L. Zekios**, Miami, FL (US); **Stavros Georgakopoulos**, Miami, FL (US); **Muhammad Hamza**, Miami, FL (US)

(73) Assignee: **The Florida International University Board of Trustees**, Miami, FL (US)

(*) 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.: **16/680,673**

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

(65) **Prior Publication Data**

US 2021/0143551 A1 May 13, 2021

(51) **Int. Cl.**

H01Q 9/04	(2006.01)
H01Q 1/08	(2006.01)
H01Q 1/38	(2006.01)
H01Q 9/28	(2006.01)

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

CPC ***H01Q 9/0414*** (2013.01); ***H01Q 1/08*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 9/285*** (2013.01)

(58) **Field of Classification Search**

CPC .. H01Q 21/065; H01Q 21/0075; H01Q 1/243; H01Q 1/08; H01Q 1/38; H01Q 9/285

See application file for complete search history.

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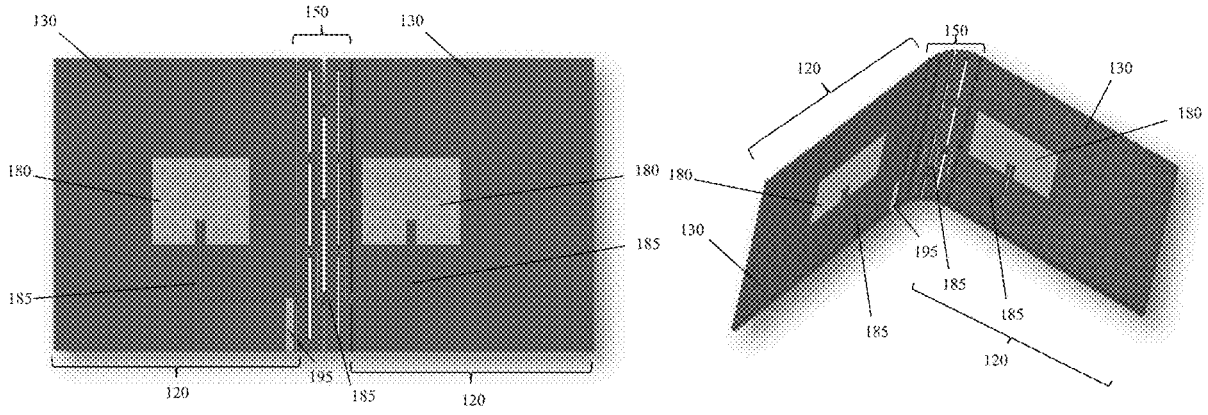
Primary Examiner — Dameon E Levi
Assistant Examiner — Jennifer F Hu
(74) *Attorney, Agent, or Firm* — Saliwanchik, Lloyd & Eisenschenk

(57) **ABSTRACT**

Antenna devices are provided, including tightly coupled arrays, transmitarrays, and reflectarrays. An antenna device can include a plurality of substrates each having an antenna element. The substrates can be provided in connected series or in an array. The substrates can be part of an origami array such that the entire array is foldable. The substrates can optionally be attached to a framework that can actuate the substrates to different configurations. By bending, folding, or otherwise repositioning the substrates/array, the electromagnetic characteristics of the antenna device can be easily reconfigured for the desired task.

14 Claims, 15 Drawing Sheets



US011056792B2

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

(10) **Patent No.: US 11,056,792 B2**
(45) **Date of Patent: Jul. 6, 2021**

(54) **ANTENNA-IN-PACKAGE SYSTEM AND MOBILE TERMINAL**

(71) Applicant: **AAC Technologies Pte. Ltd.**, Singapore (SG)

(72) Inventors: **Xiaoyue Xia**, Shenzhen (CN); **Chao Wang**, Shenzhen (CN)

(73) Assignee: **AAC Technologies Pte. Ltd.**, Singapore (SG)

(*) 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.: **16/705,227**

(22) Filed: **Dec. 6, 2019**

(65) **Prior Publication Data**

US 2020/0212579 A1 Jul. 2, 2020

(30) **Foreign Application Priority Data**

Dec. 29, 2018 (CN) 201811645892.5

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

(52) **U.S. Cl.**
CPC ***H01Q 9/0435*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 21/065*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0435; H01Q 1/243; H01Q 21/065; H01Q 5/35; H01Q 21/08; H01Q 1/22; H01Q 1/2266; H01Q 1/2283; H01Q 1/38; H01Q 1/50; H01Q 5/20
See application file for complete search history.

(56) **References Cited**

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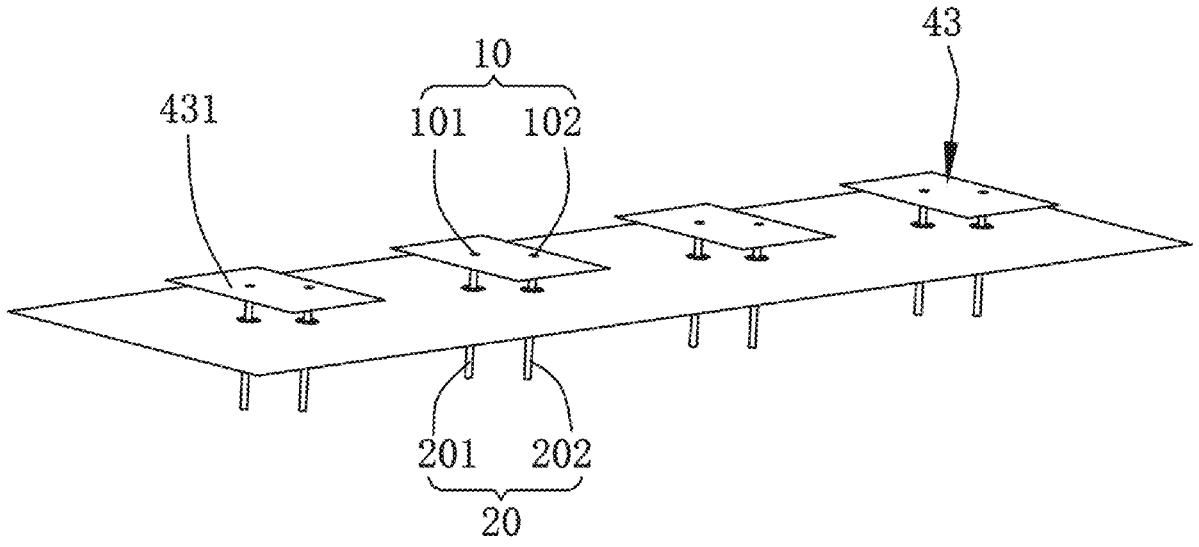
Primary Examiner — Daniel D Chang
(74) *Attorney, Agent, or Firm* — W&G Law Group LLP

(57) **ABSTRACT**

An antenna-in-package system and a mobile terminal are provided. The mobile terminal includes a main board. The antenna-in-package system includes a substrate, a metal antenna provided on a side of the substrate facing away from the main board, an integrated circuit chip provided on a side of the substrate close to the main board, and a circuit provided in the substrate and connecting the metal antenna to the integrated circuit chip. The circuit is connected to the main board. The metal antenna is a patch antenna simultaneously fed with power by two feeding points. The two feeding points are used to excite electromagnetic waves in different bands. The antenna-in-package system provided by the present disclosure achieves dual-band coverage of 28 GHz and 39 GHz, and a size is reduced to 18×5 mm, so that an occupied area is greatly reduced, and a gain reduction is small.

12 Claims, 9 Drawing Sheets



US011056793B2

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

(10) **Patent No.: US 11,056,793 B2**
(45) **Date of Patent: Jul. 6, 2021**

(54) **ANTENNA MODULE**

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

(72) Inventors: **Yasuyuki Hara**, Tokyo (JP); **Yuta Ashida**, Tokyo (JP)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 62 days.

(21) Appl. No.: **16/688,649**

(22) Filed: **Nov. 19, 2019**

(65) **Prior Publication Data**

US 2020/0161767 A1 May 21, 2020

(30) **Foreign Application Priority Data**

Nov. 20, 2018 (JP) JP2018-217000

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 9/04 (2006.01)
H01Q 1/48 (2006.01)

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

(58) **Field of Classification Search**
CPC H01Q 9/045; H01Q 1/48; H01Q 1/2283; H01Q 9/0457; H01Q 21/065; H01Q 9/041
See application file for complete search history.

(56) **References Cited**

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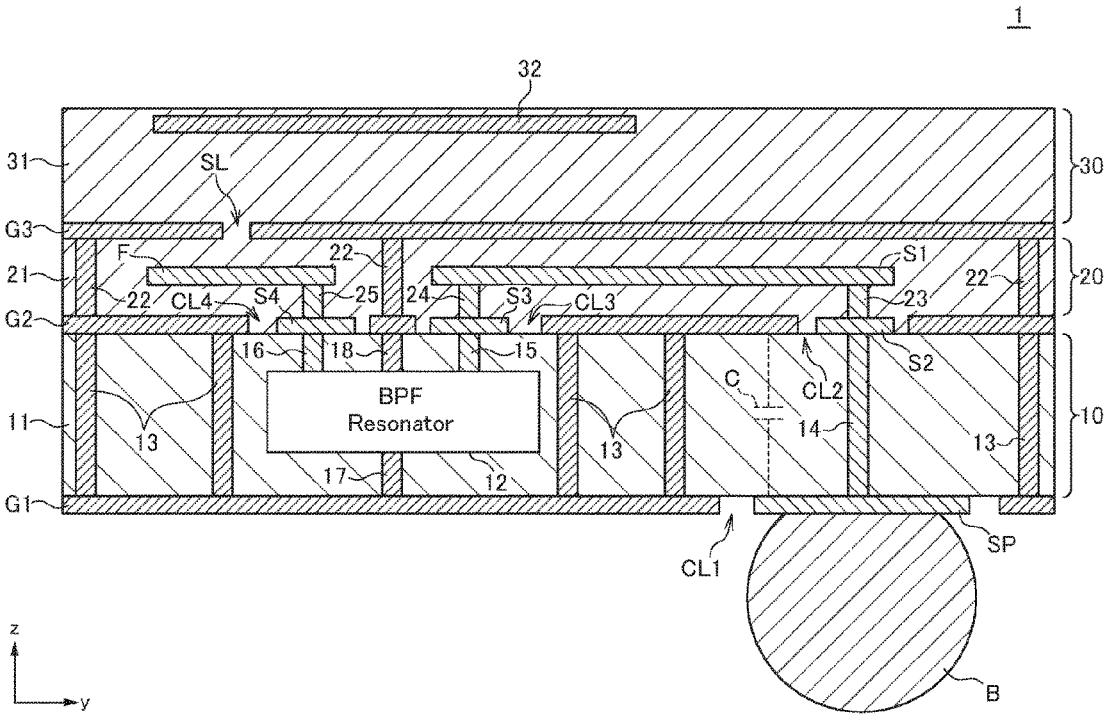
Primary Examiner — Dieu Hien T Duong
(74) *Attorney, Agent, or Firm* — McDermott Will & Emery LLP

(57) **ABSTRACT**

Disclosed herein is an antenna module that includes a circuit layer having a filter circuit, an antenna layer having a radiation conductor, a wiring layer having a connection wiring, a first ground pattern provided on a surface of the circuit layer, a second ground pattern provided between the circuit layer and the wiring layer, a third ground pattern provided between the wiring layer and the antenna layer, and a signal terminal provided on the surface of the circuit layer where the first ground pattern is cut away. The clearance region is located so as not to overlap the filter circuit as viewed in a lamination direction. The signal terminal is connected to the filter circuit through a pillar conductor penetrating the circuit layer and the connection wiring. The radiation conductor receives power through a feed pattern connected to the filter circuit.

18 Claims, 9 Drawing Sheets



US011056794B2

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

(10) **Patent No.: US 11,056,794 B2**
(45) **Date of Patent: Jul. 6, 2021**

(54) **DUAL-POLARIZED ANTENNA**

(71) Applicant: **KABUSHIKI KAISHA TOSHIBA**, Tokyo (JP)

(72) Inventors: **Koh Hashimoto**, Yokohama Kanagawa (JP); **Makoto Higaki**, Setagaya Tokyo (JP); **Manabu Mukai**, Yokohama Kanagawa (JP)

(73) Assignee: **KABUSHIKI KAISHA TOSHIBA**, Tokyo (JP)

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

(21) Appl. No.: **16/299,726**

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

(65) **Prior Publication Data**

US 2019/0207305 A1 Jul. 4, 2019

Related U.S. Application Data

(60) Division of application No. 15/730,173, filed on Oct. 11, 2017, which is a continuation of application No. 14/921,615, filed on Oct. 23, 2015, now abandoned.

(30) **Foreign Application Priority Data**

Jan. 6, 2015 (JP) 2015-000714

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

(52) **U.S. Cl.**
CPC ***H01Q 9/0457*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 9/0435*** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 9/0457; H01Q 9/0407; H01Q 9/0414; H01Q 9/0428; H01Q 9/0435;
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(56) **References Cited**

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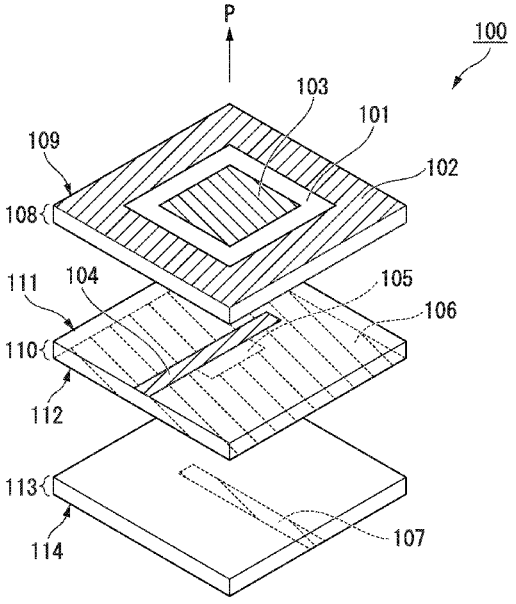
Primary Examiner — Robert Karacsony
(74) *Attorney, Agent, or Firm* — Holtz, Holtz & Volek PC

(57) **ABSTRACT**

A method for producing a dual-polarized antenna includes providing first, second and third dielectric substrates with first and second main surfaces. The method includes patterning a conductive film on the first main surface of the first dielectric substrate to form a first ground conductor having an opening and a metal patch as a radiation element, the patch aligned to the opening in a lamination direction, patterning a conductive film on the first main surface of the second dielectric substrate to form a first feed probe configured to excite the metal patch, patterning a conductive film on the second main surface of the second dielectric substrate to form a second ground conductor having a slot generally parallel to the first feed probe, and patterning a conductive film on the second main surface of the third dielectric substrate to form a second feed probe generally perpendicular to the slot.

9 Claims, 6 Drawing Sheets



US011056800B2

(12) **United States Patent**
Asrani

(10) **Patent No.: US 11,056,800 B2**
(45) **Date of Patent: Jul. 6, 2021**

(54) **ANTENNA ARRAYS INTEGRATED INTO AN ELECTROMAGNETIC TRANSPARENT METALLIC SURFACE**

(71) Applicant: **Google LLC**, Mountain View, CA (US)

(72) Inventor: **Vijay L. Asrani**, San Jose, CA (US)

(73) Assignee: **Google LLC**, Mountain View, CA (US)

(*) 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.: **16/161,906**

(22) Filed: **Oct. 16, 2018**

(65) **Prior Publication Data**

US 2020/0119454 A1 Apr. 16, 2020

(51) **Int. Cl.**

H04B 1/38	(2015.01)
H01Q 21/06	(2006.01)
H01Q 1/24	(2006.01)
H01Q 21/00	(2006.01)
H04M 1/02	(2006.01)

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

CPC ***H01Q 21/065*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 21/0087*** (2013.01); ***H04M 1/026*** (2013.01)

(58) **Field of Classification Search**

CPC .. H01Q 21/065; H01Q 1/243; H01Q 21/0087; H01Q 9/0435; H01Q 9/0407; H01Q 21/24; H01Q 1/38; H01Q 1/2283; H04M 1/026; H01L 2223/6677; H01L 23/66

USPC 455/73

See application file for complete search history.

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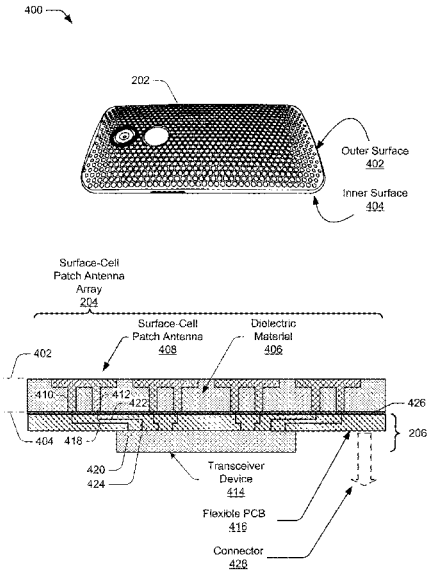
Primary Examiner — Mahendra R Patel

(74) *Attorney, Agent, or Firm* — Colby Nipper PLLC

(57) **ABSTRACT**

The present disclosure describes one or more aspects of surface-cell patch antenna arrays integrated as part of a user equipment housing. As part of integration, surface-cell patch antennas are formed from surface-cells that comprise an electromagnetic-transparent metallic surface proximate an outer surface of the housing. The surface-cell patch antennas, in turn, form a surface-cell patch antenna array. A transceiver module, disposed proximate an inner surface of the user equipment housing, includes a transceiver device and a flexible printed circuit board having traces that electrically couple the transceiver device to the surface-cell patch antenna array. The described aspects alleviate manufacturing and design challenges that are associated with use of patch array modules.

21 Claims, 10 Drawing Sheets



US011063339B2

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

(10) **Patent No.: US 11,063,339 B2**
(45) **Date of Patent: Jul. 13, 2021**

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

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

(72) Inventors: **Chien-Yi Wu**, Taipei (TW); **Cheng-Hsiung Wu**, Taipei (TW); **Chao-Hsu Wu**, Taipei (TW); **Ching-Hsiang Ko**, Taipei (TW); **Shih-Keng Huang**, Taipei (TW); **Yu-Yi Chu**, 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 6 days.

(21) Appl. No.: **16/502,209**

(22) Filed: **Jul. 3, 2019**

(65) **Prior Publication Data**

US 2020/0112080 A1 Apr. 9, 2020

(30) **Foreign Application Priority Data**

May 30, 2018 (TW) 107118548

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

(52) **U.S. Cl.**
CPC ***H01Q 1/2266*** (2013.01); ***H01Q 1/24*** (2013.01); ***H01Q 5/357*** (2015.01); ***H01Q 5/50*** (2015.01); ***H01Q 13/106*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/2266; H01Q 1/24; H01Q 1/48; H01Q 1/2258; H01Q 1/44; H01Q 1/36;
(Continued)

(56) **References Cited**

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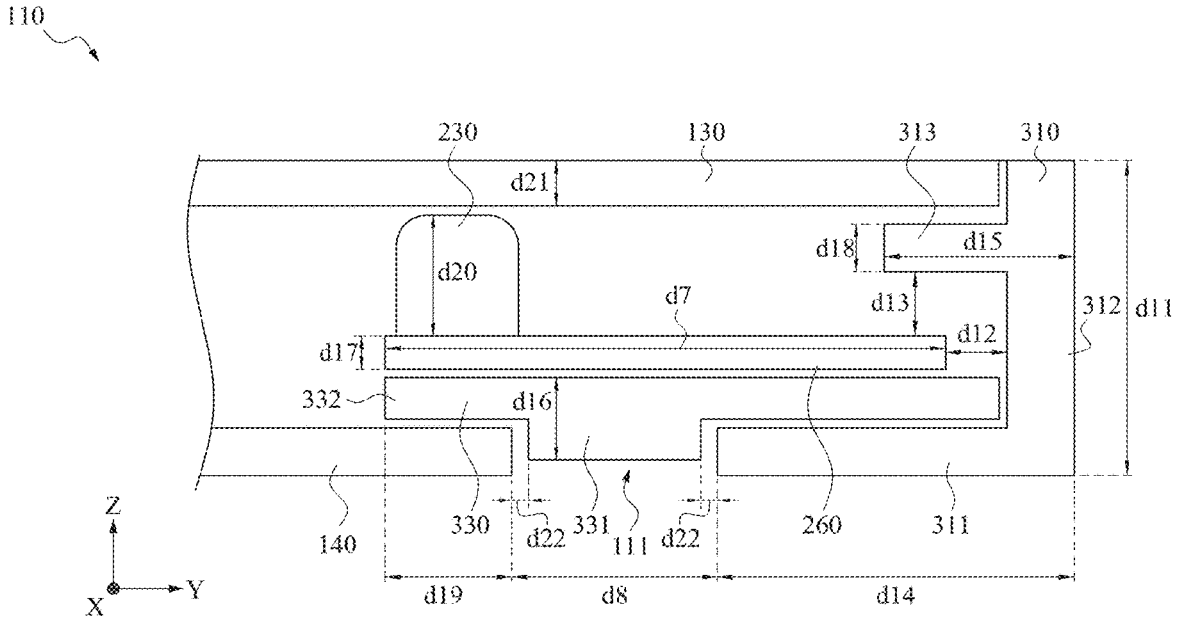
Primary Examiner — Awat M Salih
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

An antenna module includes a metal board, an inverted F metal plate and an antenna unit. A slot is provided between the inverted F metal plate and the metal board, the inverted F metal plate and the metal board are integrally formed, and the inverted F metal plate is disposed perpendicular to the metal board. The antenna unit is disposed corresponding to the slot and the inverted F metal plate, and includes a radiation part and a ground part. The radiation part is coupled to a signal feeding point and includes a first radiation body and a second radiation body. The first radiation body, the slot and the inverted F metal plate operate cooperatively to generate a wireless signal at a first operating frequency. The second radiation body, the slot and the inverted F metal plate operate cooperatively to generate a wireless signal at a second operating frequency.

10 Claims, 7 Drawing Sheets



US011063343B2

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

(10) **Patent No.: US 11,063,343 B2**
(45) **Date of Patent: *Jul. 13, 2021**

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

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

(72) Inventors: **Tiao-Hsing Tsai**, Taoyuan (TW); **Chien-Pin Chiu**, Taoyuan (TW); **Hsiao-Wei Wu**, Taoyuan (TW); **Ying-Chih Wang**, Taoyuan (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 33 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/719,271**

(22) Filed: **Dec. 18, 2019**

(65) **Prior Publication Data**

US 2020/0127368 A1 Apr. 23, 2020

Related U.S. Application Data

(63) Continuation of application No. 16/432,748, filed on Jun. 5, 2019, now Pat. No. 10,553,932, which is a (Continued)

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

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 5/335*** (2015.01); ***H01Q 5/378*** (2015.01); ***H01Q 9/42*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 13/103; H01Q 13/106; H01Q 5/335
(Continued)

(56) **References Cited**

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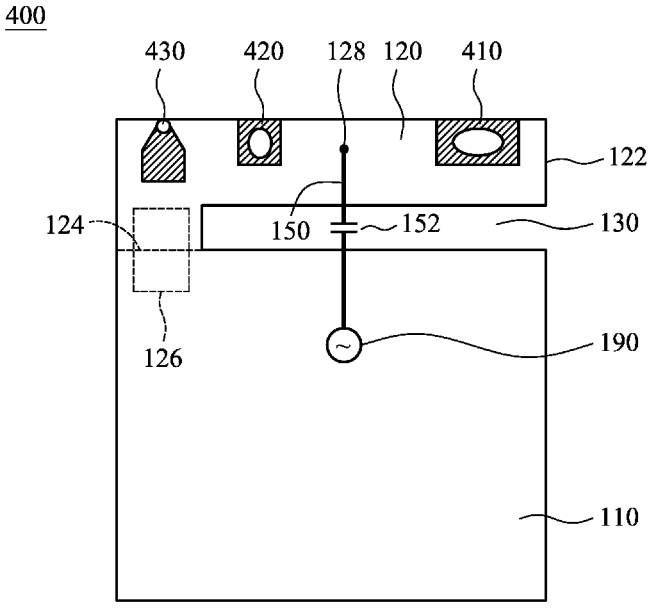
Primary Examiner — Daniel Munoz
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**

A mobile device including a ground plane, a grounding branch, wherein a slot is formed between the ground plane and the grounding branch, a connecting element, wherein the grounding branch is electrically coupled through the connecting element to the ground plane and a feeding element, extending across the slot, and electrically coupled between the grounding branch and a signal source, wherein an antenna structure is formed by the grounding branch and the feeding element.

10 Claims, 6 Drawing Sheets



US011063349B2

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

(10) **Patent No.: US 11,063,349 B2**
(45) **Date of Patent: Jul. 13, 2021**

(54) **MOBILE DEVICE**

(71) Applicant: **Quanta Computer Inc.**, Taoyuan (TW)

(72) Inventors: **Wen-Yuan Lo**, Taoyuan (TW); **Jui-Chun Jao**, Taoyuan (TW); **Kuo-Jung Tseng**, Taoyuan (TW)

(73) Assignee: **QUANTA COMPUTER INC.**, Taoyuan (TW)

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

(21) Appl. No.: **16/410,177**

(22) Filed: **May 13, 2019**

(65) **Prior Publication Data**

US 2020/0243962 A1 Jul. 30, 2020

(30) **Foreign Application Priority Data**

Jan. 24, 2019 (TW) ..... 108102627 A

(51) **Int. Cl.**

H01Q 1/22	(2006.01)
H01Q 1/48	(2006.01)
H01Q 5/10	(2015.01)
H01Q 1/12	(2006.01)
H01Q 1/24	(2006.01)

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

CPC ***H01Q 1/48*** (2013.01); ***H01Q 1/2266*** (2013.01); ***H01Q 5/10*** (2015.01); *H01Q 1/12* (2013.01); *H01Q 1/125* (2013.01); *H01Q 1/22* (2013.01); *H01Q 1/2283* (2013.01); *H01Q 1/243* (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/12; H01Q 1/125; H01Q 1/22; H01Q 1/2283; H01Q 1/243

See application file for complete search history.

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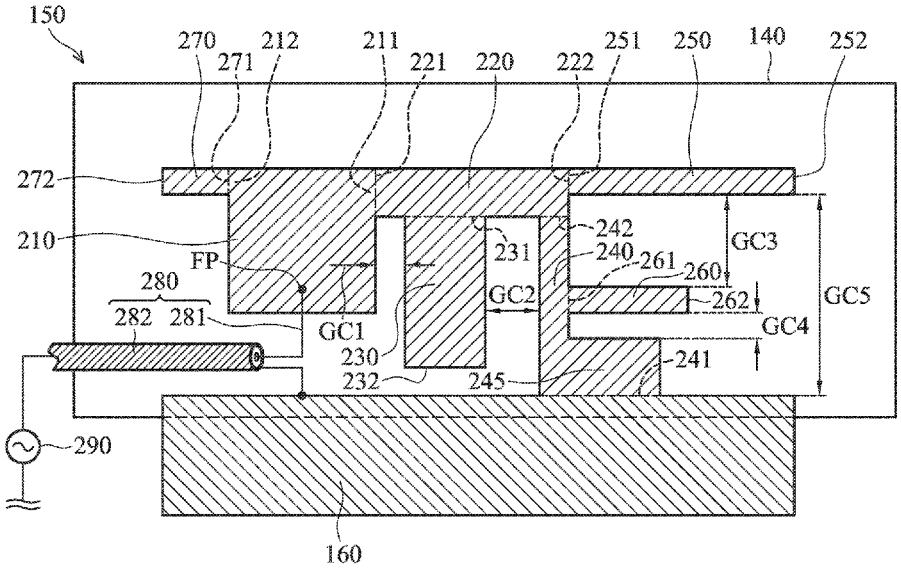
Primary Examiner — Thuy Vinh Tran

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

(57) **ABSTRACT**

A mobile device includes a metal back cover, an edge appearance element, a display device, a supporting element, an antenna structure, and a ground element. The edge appearance element is made of a nonconductive material. The edge appearance element is connected to the metal back cover. The display device is disposed opposite to the metal back cover. The antenna structure is disposed on the supporting element. The antenna structure is positioned between the edge appearance element and the display device. The ground element is coupled to the metal back cover. The electromagnetic waves of the antenna structure are transmitted through the edge appearance element, such that the mobile device supports wireless communication.

9 Claims, 5 Drawing Sheets



US011063350B2

(12) **United States Patent**
Zweers

(10) **Patent No.: US 11,063,350 B2**
(45) **Date of Patent: Jul. 13, 2021**

(54) **EDGE ENABLED VOID ANTENNA APPARATUS**

(71) Applicant: **Qorvo US, Inc.**, Greensboro, NC (US)

(72) Inventor: **Jan-Willem Zweers**, Nieuwleusen (NL)

(73) Assignee: **Qorvo US, Inc.**, Greensboro, NC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 44 days.

(21) Appl. No.: **16/246,642**

(22) Filed: **Jan. 14, 2019**

(65) **Prior Publication Data**

US 2020/0112089 A1 Apr. 9, 2020

Related U.S. Application Data

(60) Provisional application No. 62/740,803, filed on Oct. 3, 2018.

(51) **Int. Cl.**

H01Q 1/52	(2006.01)
H01Q 5/30	(2015.01)
H01Q 21/06	(2006.01)
H01Q 21/00	(2006.01)

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

CPC ***H01Q 1/521*** (2013.01); ***H01Q 5/30*** (2015.01); ***H01Q 21/0025*** (2013.01); ***H01Q 21/062*** (2013.01)

(58) **Field of Classification Search**

CPC .. H01Q 1/521; H01Q 21/0025; H01Q 21/062; H01Q 5/30

USPC 343/844

See application file for complete search history.

(56) **References Cited**

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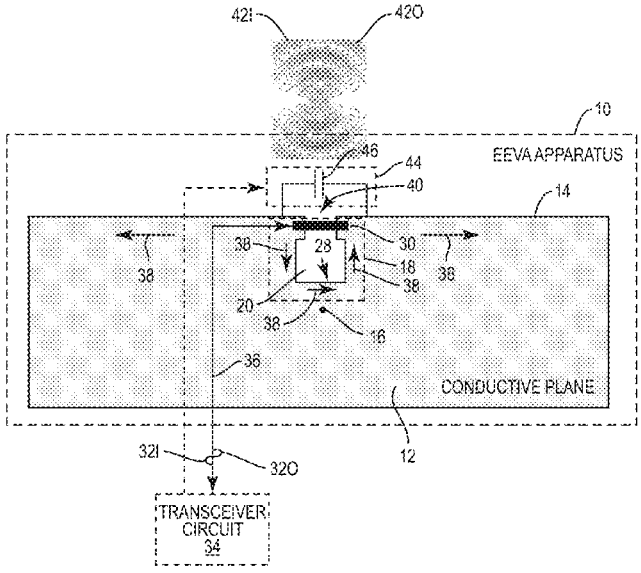
Primary Examiner — Don P Le

(74) *Attorney, Agent, or Firm* — Withrow & Terranova, P.L.L.C.

(57) **ABSTRACT**

An edge enabled void antenna (EEVA) apparatus is provided. The EEVA apparatus includes a conductive plane and a void is created on a geometric perimeter of the conductive plane to form an EEVA. A radio frequency (RF) port is coupled to the void to receive an RF signal. The RF signal excites the conductive plane to induce an electrical current along the geometric perimeter of the conductive plane. The void can cause the electrical current to increase and decrease on the geometric perimeter of the conductive plane, thus causing an electromagnetic wave corresponding to the RF signal being radiated from the EEVA. By forming the EEVA on the geometric perimeter of the conductive plane, it may be possible to enable a well-functioning antenna apparatus with a small effective footprint, thus allowing multiple EEVAs to be provided in a space confined wireless device with sufficient isolation for improved RF performance.

20 Claims, 6 Drawing Sheets



US011063354B2

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

(10) **Patent No.: US 11,063,354 B2**
(45) **Date of Patent: Jul. 13, 2021**

(54) **ANTENNA SYSTEM**

(71) Applicant: **Wistron NeWeb Corporation**, Hsinchu (TW)

(72) Inventors: **Cheng-Geng Jan**, Hsinchu (TW); **Chieh-Sheng Hsu**, Hsinchu (TW); **Tsun-Che Huang**, Hsinchu (TW)

(73) Assignee: **Wistron NeWeb Corporation**, Hsinchu (TW)

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

(21) Appl. No.: **16/558,178**

(22) Filed: **Sep. 2, 2019**

(65) **Prior Publication Data**

US 2020/0106174 A1 Apr. 2, 2020

(30) **Foreign Application Priority Data**

Sep. 27, 2018 (TW) 107133942

(51) **Int. Cl.**
H01Q 3/36 (2006.01)
H01Q 3/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 3/36*** (2013.01); ***H01Q 1/523*** (2013.01); ***H01Q 3/247*** (2013.01); ***H01Q 21/0025*** (2013.01); ***H04B 7/0413*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 3/36; H01Q 3/247; H01Q 21/0025; H01Q 1/523; H01Q 3/242; H01Q 1/246;
(Continued)

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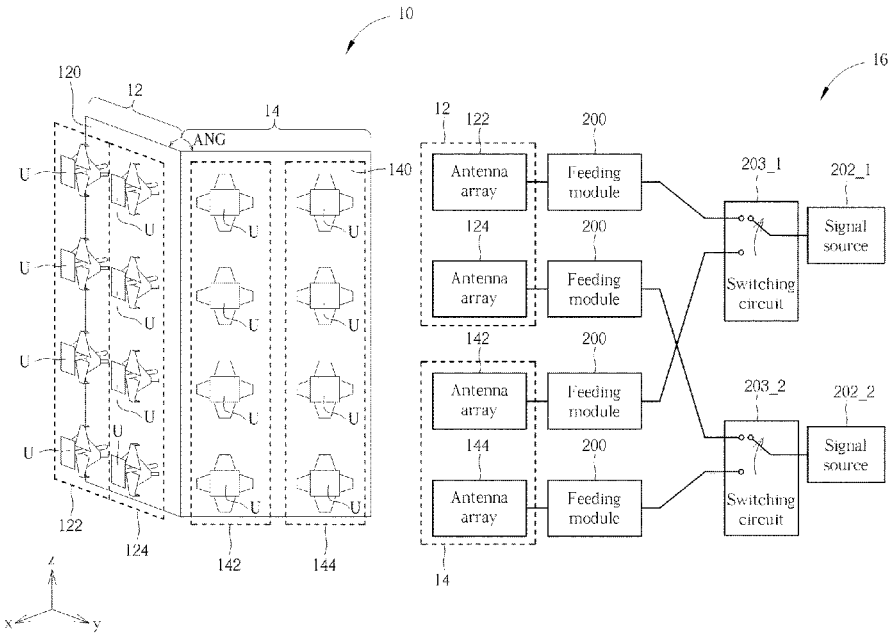
Primary Examiner — Renan Luque
(74) *Attorney, Agent, or Firm* — Winston Hsu

(57) **ABSTRACT**

An antenna system for receiving and transmitting wireless signals includes a first complex antenna including a first reflection element, a first antenna array and a second antenna array; a second complex antenna including a second reflection element, a third antenna array and a fourth antenna array, wherein the first reflection element and the second reflection element are fixed to form an included angle to each other; and a feeding device, coupled to the first complex antenna and the second complex antenna, for alternately outputting radio-frequency signals to the first complex antenna and the second complex antenna, to emit wireless signals via the first complex antenna and the second complex antenna, and switching phases of the radio-frequency signals outputted to the first complex antenna and the second complex antenna, to change characteristics of beam generated by the first complex antenna and the second complex antenna in a vertical plane.

6 Claims, 7 Drawing Sheets



US011063363B2

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

(10) **Patent No.: US 11,063,363 B2**
(45) **Date of Patent: Jul. 13, 2021**

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

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

(72) Inventors: **Ryo Komura**, Kyoto (JP); **Yoshiki Yamada**, Kyoto (JP)

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

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

(21) Appl. No.: **16/891,307**

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

(65) **Prior Publication Data**

US 2020/0295464 A1 Sep. 17, 2020

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2019/034889, filed on Sep. 5, 2019.

(30) **Foreign Application Priority Data**

Sep. 7, 2018 (JP) JP2018-167918

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 15/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 9/0457*** (2013.01); ***H01Q 5/371*** (2015.01); ***H01Q 15/24*** (2013.01); ***H01Q 19/028*** (2013.01); ***H01Q 21/065*** (2013.01); ***H01Q 23/00*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0457; H01Q 5/371; H01Q 15/24; H01Q 19/028; H01Q 21/065; H01Q 23/00;
(Continued)

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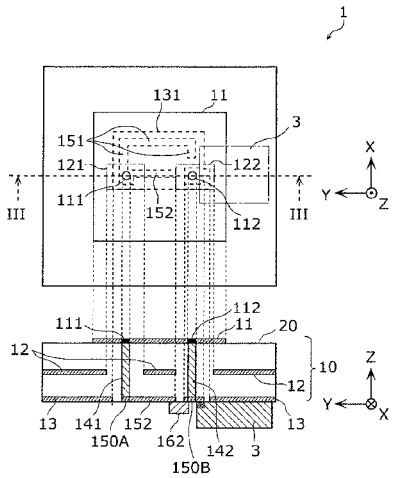
Primary Examiner — Dimary S Lopez Cruz
Assistant Examiner — Michael M Bouizza
(74) *Attorney, Agent, or Firm* — Pearne & Gordon LLP

(57) **ABSTRACT**

A patch antenna includes: a ground conductor pattern lying in a plane and set to ground potential; a feeding conductor pattern lying in a plane and disposed in a manner so as to face the ground conductor pattern, the feeding conductor pattern having feed points that are opposite to each other with respect to a center point of the feeding conductor pattern; feed lines that are connected in parallel between the feed points and are of different lengths; and a frequency selection circuits disposed on a path of at least one of the feed lines, the frequency selection circuits being configured to allow passage of radio-frequency signals in one frequency band and to attenuate radio-frequency signals in another frequency band.

13 Claims, 10 Drawing Sheets



US011063367B2

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

(10) **Patent No.: US 11,063,367 B2**
(45) **Date of Patent: Jul. 13, 2021**

(54) **DUAL BAND SLOT ANTENNA**

(71) Applicant: **HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P.**, Houston, TX (US)

(72) Inventors: **Ju-Hung Chen**, Taipei (TW); **Shih Huang Wu**, Houston, TX (US); **Hao Ming Chen**, Taipei (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 32 days.

(21) Appl. No.: **15/748,311**

(22) PCT Filed: **Nov. 10, 2015**

(86) PCT No.: **PCT/US2015/059808**
§ 371 (c)(1),
(2) Date: **Jan. 29, 2018**

(87) PCT Pub. No.: **WO2017/082863**
PCT Pub. Date: **May 18, 2017**

(65) **Prior Publication Data**

US 2018/0219297 A1 Aug. 2, 2018

(51) **Int. Cl.**
H01Q 13/10 (2006.01)
H01Q 5/364 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 13/10*** (2013.01); ***H01Q 5/342*** (2015.01); ***H01Q 5/364*** (2015.01); ***H01Q 7/00*** (2013.01); ***H01Q 9/0421*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 13/10; H01Q 9/0421; H01Q 5/342; H01Q 7/00; H01Q 5/364; H01Q 21/0062; H01Q 9/0407; H01Q 13/18; H01Q 21/0062; H01Q 13/103; H01Q 13/106; H01Q 13/16
See application file for complete search history.

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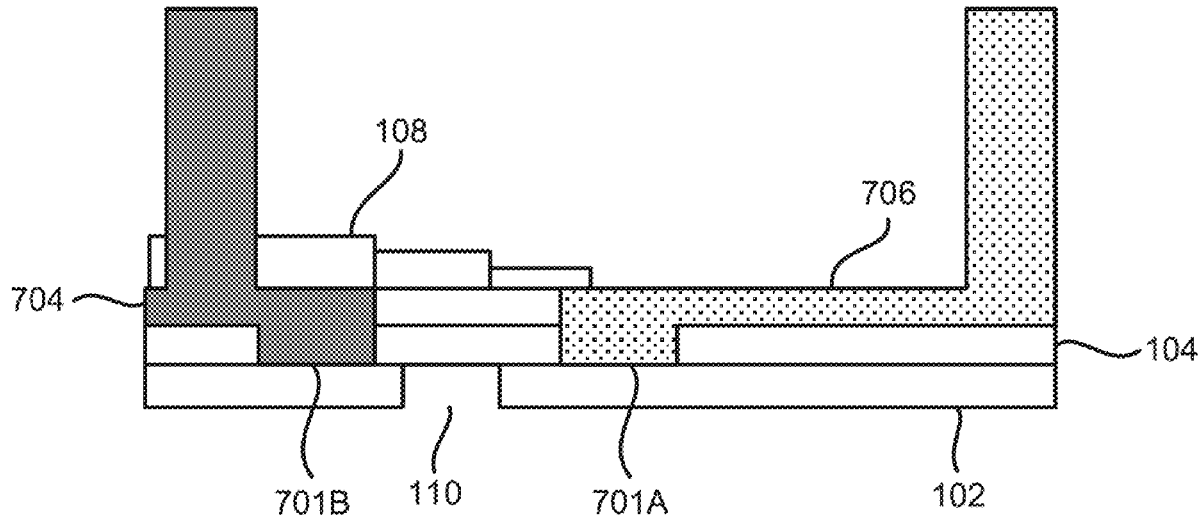
Primary Examiner — Dimary S Lopez Cruz
Assistant Examiner — Bamidele A Jegede
(74) *Attorney, Agent, or Firm* — HPI Patent Department

(57) **ABSTRACT**

Dual band slot antenna is described. The dual band slot antenna includes a ground plane having a slot, a conductive patch, a dielectric substrate disposed between the conductive patch and the ground plane, and a coaxial cable fastened on the conductive patch to form a first loop region and a second loop region of different sizes for dual band operation.

15 Claims, 9 Drawing Sheets



US011064061B2

(12) **United States Patent**
Zeng

(10) **Patent No.: US 11,064,061 B2**
(45) **Date of Patent: Jul. 13, 2021**

(54) **MOBILE TERMINAL SHELL FOR ENHANCING ANTENNA SLOT MECHANICAL PROPERTIES AND APPEARANCE**

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

(72) Inventor: **Yuanqing Zeng**, Dongguan (CN)

(73) Assignee: **GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP., LTD.**, Guangdong (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.: **16/620,844**

(22) PCT Filed: **Jun. 15, 2018**

(86) PCT No.: **PCT/CN2018/091489**
§ 371 (c)(1),
(2) Date: **Dec. 9, 2019**

(87) PCT Pub. No.: **WO2019/011104**
PCT Pub. Date: **Jan. 17, 2019**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jul. 13, 2017 (CN) 201710571118.3

(51) **Int. Cl.**
H04M 1/02 (2006.01)
B81C 1/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04M 1/0249*** (2013.01); ***B81C 1/0046*** (2013.01); ***H01Q 1/243*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H05K 5/0217; H05K 5/0243; H05K 5/04; B81C 1/0046; B82Y 30/00; H04B 1/3888
See application file for complete search history.

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Primary Examiner — Devan A Sandiford
(74) *Attorney, Agent, or Firm* — Ladas & Parry LLP

(57) **ABSTRACT**

The present application provides a mobile terminal shell, a preparation method, and a mobile terminal. The mobile terminal shell comprises: a substrate made of metal; an enhanced part provided on at least a part of the surface of one side of the substrate and made of a first material; an antenna slot provided on the substrate and filled with a second material, wherein the strength of the first material is higher than the strength of the second material.

19 Claims, 9 Drawing Sheets