US010873123B2

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

(10) **Patent No.: US 10,873,123 B2**
(45) **Date of Patent: Dec. 22, 2020**

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

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

(72) Inventors: **Chia-Ming Liang**, New Taipei (TW); **Jin-Bo Chen**, 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 0 days.

(21) Appl. No.: **16/523,113**

(22) Filed: **Jul. 26, 2019**

(65) **Prior Publication Data**

US 2020/0036085 A1 Jan. 30, 2020

(30) **Foreign Application Priority Data**

Jul. 27, 2018 (CN) 2018 1 0841074

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

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

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

(56) **References Cited**

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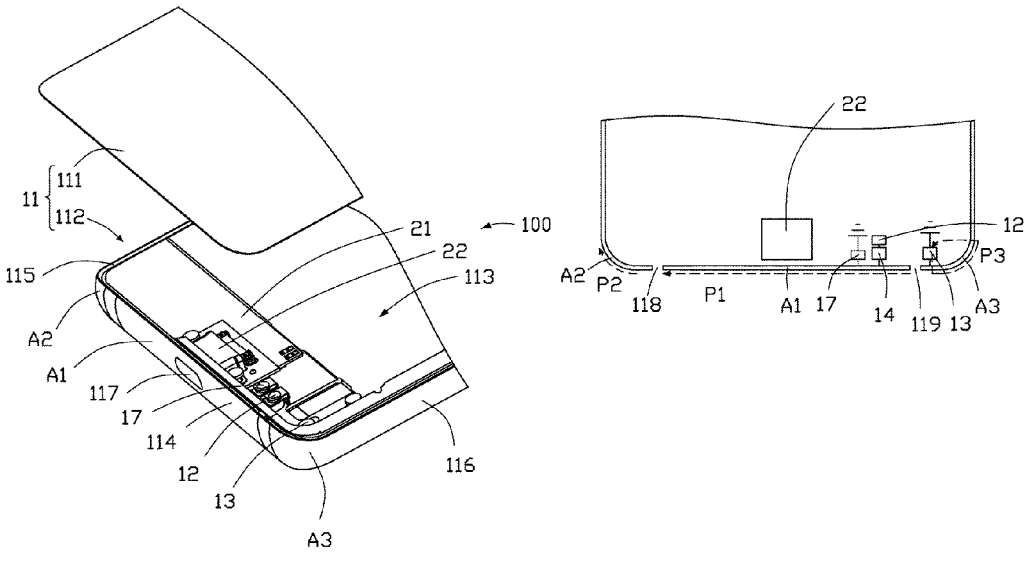
Primary Examiner — Anh Q Tran
(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

An antenna structure utilizing as radiating elements only the metal frame of an electronic device includes a metal frame, a feeding portion, and a ground point. The metal frame defines a first gap and a second gap. The metal frame forms a radiating portion, a first coupling portion, and a second coupling portion through the first gap and the second gap. When the feed supplies current, the current flows through the radiating portion and, being coupled to the first coupling portion and second coupling portion through the first and second gaps, first, second, and third operating modes at different frequencies can be invoked to generate wireless signals in first, second, and third LTE-A frequency bands.

16 Claims, 6 Drawing Sheets



US010873124B2

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

(10) **Patent No.: US 10,873,124 B2**
(45) **Date of Patent: Dec. 22, 2020**

(54) **MOBILE DEVICE**

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

(72) Inventors: **Ching-Wen Chen**, Hsinchu (TW); **Chia-Hao Chang**, Hsinchu (TW)

(73) Assignee: **WISTRON NEWEB CORP.**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 9 days.

(21) Appl. No.: **16/550,713**

(22) Filed: **Aug. 26, 2019**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Aug. 28, 2018 (TW) ..... 107129974 A

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 9/28	(2006.01)
H01Q 21/00	(2006.01)
H01Q 21/06	(2006.01)
H01Q 1/36	(2006.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/36*** (2013.01); ***H01Q 9/285*** (2013.01); ***H01Q 21/0068*** (2013.01); ***H01Q 21/064*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/36; H01Q 5/371; H01Q 5/364; H01Q 5/378; H01Q 9/285; H01Q 13/106; H01Q 21/0068; H01Q 21/064

See application file for complete search history.

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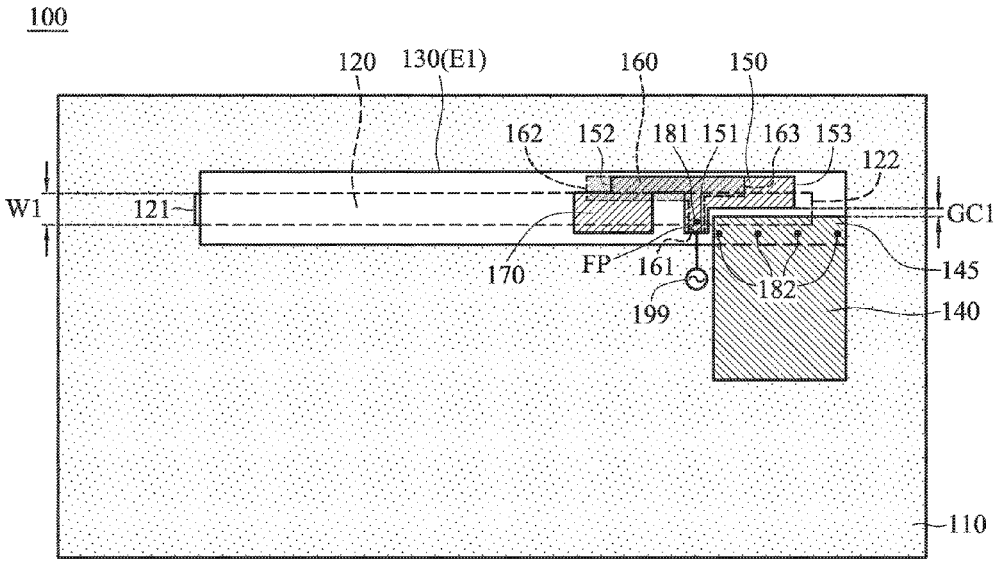
Primary Examiner — Seokjin Kim
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

A mobile device includes a metal back cover, a dielectric substrate, a grounding metal element, a first radiation element, and a second radiation element. The metal back cover has a slot. The dielectric substrate has a first surface and a second surface, and the second surface faces the slot. The grounding metal element extends onto the first surface of the dielectric substrate. The first radiation element has a feeding point, and is disposed on the first surface of the dielectric substrate. The first vertical projection of the first radiation element at least partially overlaps the slot. The second radiation element is disposed on the second surface of the dielectric substrate. The second vertical projection of the second radiation element at least partially overlaps the slot. An antenna structure is formed by the first radiation element, the second radiation element, and the slot of the metal back cover.

20 Claims, 10 Drawing Sheets



US010879581B2

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

(10) **Patent No.: US 10,879,581 B2**
(45) **Date of Patent: Dec. 29, 2020**

(54) **ELECTRONIC DEVICE**

(71) Applicant: **Lenovo (Beijing) Co., Ltd.**, Beijing (CN)

(72) Inventors: **Wenlei Wang**, Beijing (CN); **Zhaowei Hu**, Beijing (CN); **Xiaozhun Shen**, Beijing (CN); **Dafei Mo**, Beijing (CN)

(73) Assignee: **LENOVO (BEIJING) CO., LTD.**, Beijing (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 166 days.

(21) Appl. No.: **15/941,578**

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

(65) **Prior Publication Data**

US 2019/0006747 A1 Jan. 3, 2019

(30) **Foreign Application Priority Data**

Jun. 30, 2017 (CN) 2017 1 0524844

(51) **Int. Cl.**

H01Q 1/22	(2006.01)
H01Q 1/24	(2006.01)
H01Q 9/42	(2006.01)
H01Q 21/28	(2006.01)

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

CPC ***H01Q 1/2266*** (2013.01); ***H01Q 1/2291*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 9/42*** (2013.01); *H01Q 21/28* (2013.01)

(58) **Field of Classification Search**

CPC .. H01Q 1/2258; H01Q 1/2266; H01Q 1/2291; H01Q 1/24; H01Q 1/241; H01Q 1/243; H01Q 1/523; H01Q 5/321; H01Q 9/16; H01Q 9/42; H01Q 21/28; H01Q 21/30; H04M 1/0283; H04M 1/185

See application file for complete search history.

(56) **References Cited**

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CN	106450651	A	2/2017

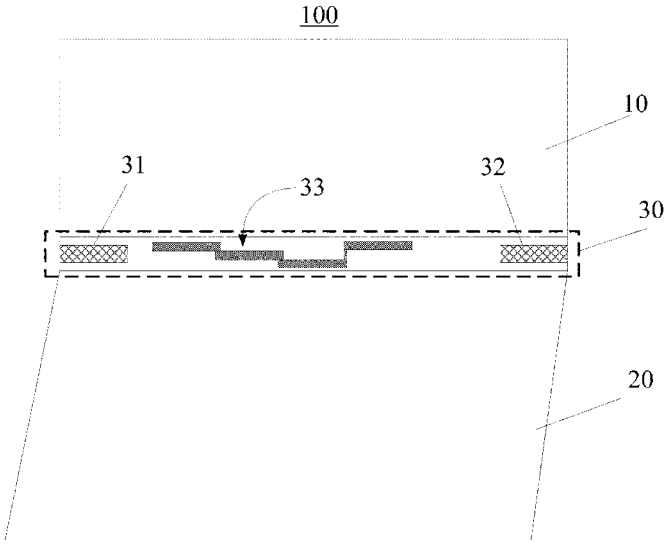
* cited by examiner

Primary Examiner — Dimary S Lopez-Cruz
Assistant Examiner — Patrick R Holecek
(74) *Attorney, Agent, or Firm* — Anova Law Group, PLLC

(57) **ABSTRACT**

An electronic device includes a first body, a second body, and a rotating shaft structure connected to the first body and the second body. The rotating shaft structure includes a first shaft and a second shaft arranged opposite to each other and fixedly connected to the first body and the second body. The rotating shaft structure further includes an antenna radiator including a plurality of metal shafts electrically coupled to each other and provided in an interspace between the first shaft and the second shaft.

11 Claims, 2 Drawing Sheets



US010879586B2

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

(10) **Patent No.: US 10,879,586 B2**
(45) **Date of Patent: Dec. 29, 2020**

(54) **UTILIZATION OF ANTENNA LOADING FOR IMPEDANCE MATCHING**

(71) Applicant: **Microsoft Technology Licensing, LLC**, Redmond, WA (US)

(72) Inventors: **Alireza Mahanfar**, Redmond, WA (US); **Javier Rodriguez De Luis**, Kirkland, WA (US); **Stanley Yu Tao Ng**, Bellevue, WA (US); **Benjamin J. Shewan**, Redmond, WA (US); **Kim Willi Schulze**, Seattle, WA (US)

(73) Assignee: **Microsoft Technology Licensing, LLC**, Redmond, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 350 days.

(21) Appl. No.: **15/151,312**

(22) Filed: **May 10, 2016**

(65) **Prior Publication Data**

US 2016/0254592 A1 Sep. 1, 2016

Related U.S. Application Data

(63) Continuation of application No. 13/745,609, filed on Jan. 18, 2013, now Pat. No. 9,356,343.

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

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/245*** (2013.01); ***H01Q 1/50*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/245; H01Q 1/50; H01Q 1/52
See application file for complete search history.

(56) **References Cited**

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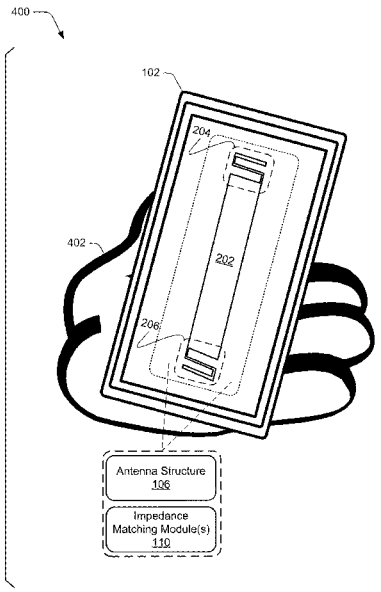
Primary Examiner — Hasan Z Islam
(74) *Attorney, Agent, or Firm* — Ray Quinney & Nebeker P.C; James Bullough

(57) **ABSTRACT**

Techniques for utilization of antenna loading for impedance matching are described. In at least some embodiments, a device (e.g., a smart phone) includes multiple antennas that are employed to send and receive wireless signals for the device. The device further includes impedance matching functionality communicatively connected to the antennas, and configured to perform impedance matching for one of the antennas based on loading (e.g., dielectric loading) of another of the antennas.

8 Claims, 9 Drawing Sheets



US010879587B2

(12) **United States Patent**
Andujar Linares et al.

(10) **Patent No.: US 10,879,587 B2**
(45) **Date of Patent: Dec. 29, 2020**

(54) **WIRELESS DEVICE INCLUDING A METAL FRAME ANTENNA SYSTEM BASED ON MULTIPLE ARMS**

(71) Applicant: **Fractus Antennas, S.L.**, Barcelona (ES)

(72) Inventors: **Aurora Andujar Linares**, Barcelona (ES); **Jaume Anguera Pros**, Vinaros (ES); **Carles Puente Baliarda**, Barcelona (ES)

(73) Assignee: **Fractus Antennas, S.L.**, Barcelona (ES)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 483 days.

(21) Appl. No.: **15/434,960**

(22) Filed: **Feb. 16, 2017**

(65) **Prior Publication Data**

US 2017/0237151 A1 Aug. 17, 2017

Related U.S. Application Data

(60) Provisional application No. 62/295,577, filed on Feb. 16, 2016.

(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 1/38*** (2013.01); ***H01Q 5/328*** (2015.01); ***H01Q 5/335*** (2015.01); ***H01Q 9/42*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 9/42; H01Q 5/335; H01Q 5/328; H01Q 1/243
See application file for complete search history.

(56) **References Cited**

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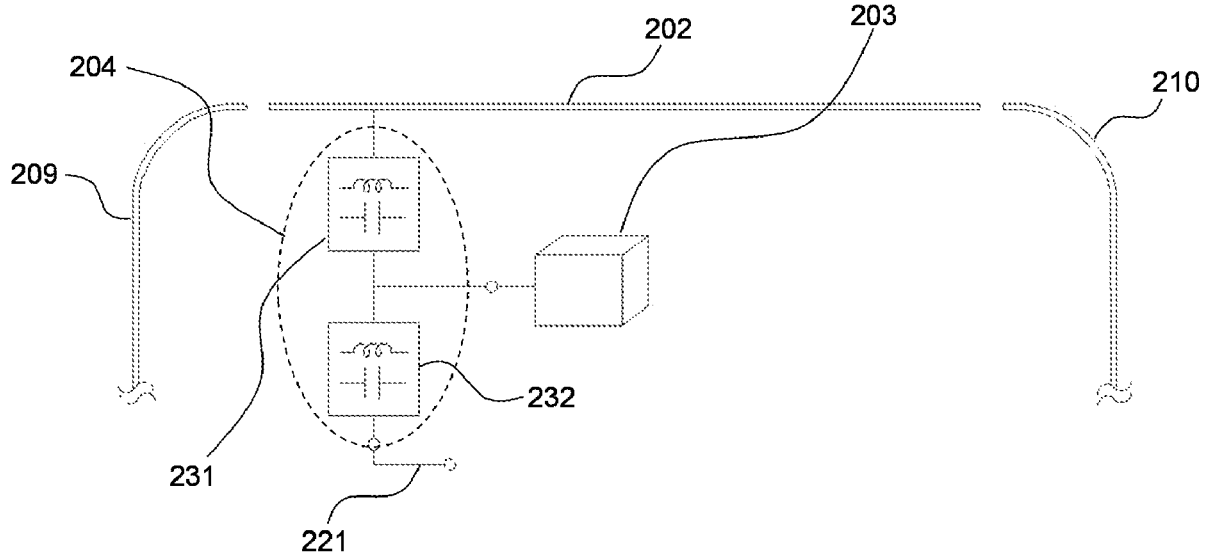
Primary Examiner — Graham P Smith
Assistant Examiner — Jae K Kim
(74) *Attorney, Agent, or Firm* — Edell, Shapiro & Finnan, LLC

(57) **ABSTRACT**

A metal frame antenna (MFA) system comprises multiple arms developed to cover multiple ranges of frequencies normally required in a wireless device such as a phone. The MFA system comprises a ground plane layer, a first electrical arm including a strip element at an edge of a phone spaced apart from an edge of the ground plane layer, a second electrical arm comprising a strip element and/or an antenna booster, a branching system connecting the first and second arms to a feeding system that is connected to the RF system of the phone.

20 Claims, 4 Drawing Sheets



US010879588B2

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

(10) **Patent No.: US 10,879,588 B2**
(45) **Date of Patent: Dec. 29, 2020**

(54) **MOBILE DEVICE AND MANUFACTURING METHOD THEREOF**

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

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

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 451 days.

(21) Appl. No.: **15/722,355**

(22) Filed: **Oct. 2, 2017**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 62/439,356, filed on Dec. 27, 2016.

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

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

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 9/42; H01Q 21/28; H01Q 9/04; H01Q 5/335; H01Q 1/521;
(Continued)

(56) **References Cited**

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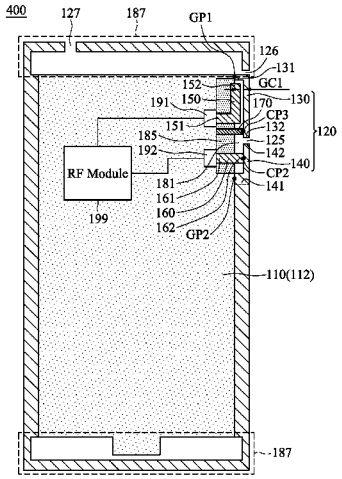
Primary Examiner — Dimary S Lopez Cruz
Assistant Examiner — Michael M Bouizza
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**

A mobile device includes a system circuit board, a metal frame, a first feeding element, a second feeding element, and an RF (Radio Frequency) module. The system circuit board includes a system ground plane. The metal frame includes a first portion and a second portion. The metal frame has a first cut point positioned between the first portion and the second portion. The first feeding element is directly or indirectly electrically connected to the first portion. A first antenna structure is formed by the first feeding element and the first portion. The second feeding element is directly or indirectly electrically connected to the second portion. A second antenna structure is formed by the second feeding element and the second portion. The RF module is electrically coupled to the first feeding element and the second feeding
(Continued)



US010879589B2

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

(10) **Patent No.: US 10,879,589 B2**
(45) **Date of Patent: Dec. 29, 2020**

(54) **ANTENNA AND ELECTRONIC DEVICE COMPRISING SAME**

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

(72) Inventors: **Jae-Ho Lim**, Gyeonggi-do (KR); **Kyung-Jong Lee**, Gyeonggi-do (KR); **Hosaeng Kim**, Gyeonggi-do (KR); **Seunghwan Kim**, Seoul (KR)

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

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

(21) Appl. No.: **16/095,618**

(22) PCT Filed: **Jan. 26, 2017**

(86) PCT No.: **PCT/KR2017/000984**
§ 371 (c)(1),
(2) Date: **Oct. 22, 2018**

(87) PCT Pub. No.: **WO2017/183802**
PCT Pub. Date: **Oct. 26, 2017**

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(30) **Foreign Application Priority Data**

Apr. 22, 2016 (KR) 10-2016-0049632

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

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 5/335*** (2015.01); ***H01Q 5/342*** (2015.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 3/24; H01Q 5/342; H04M 1/0216
See application file for complete search history.

(56) **References Cited**

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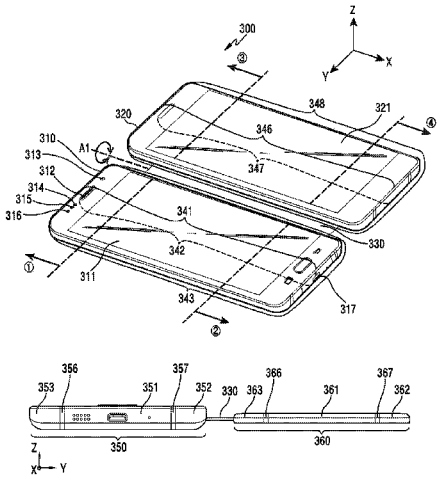
Primary Examiner — Ab Salam Alkassim, Jr.
(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(57) **ABSTRACT**

Provided is an electronic device that includes first and second housings, a display, a connecting member connecting the first and second housings, first and second conductive members, and a wireless communication circuit. The first housing includes a first side facing a first direction, a second side facing a second direction opposite to the first direction, and a first lateral side surrounding at least part of a space between the first side and the second side. The second housing includes a third side facing a third direction, a fourth side facing a fourth direction opposite to the third direction, and a second lateral side surrounding at least part of a space between the third side and the fourth side. The connecting member connects the first and second housings such that
(Continued)



US010879590B2

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

(10) **Patent No.: US 10,879,590 B2**
(45) **Date of Patent: Dec. 29, 2020**

(54) **ANTENNA AND MOBILE TERMINAL**

(71) Applicant: **Huawei Device Co., Ltd.**, Dongguan (CN)

(72) Inventors: **Jianming Li**, Taipei (TW); **Hanyang Wang**, Reading (GB)

(73) Assignee: **HUAWEI DEVICE 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 0 days.

(21) Appl. No.: **16/118,926**

(22) Filed: **Aug. 31, 2018**

(65) **Prior Publication Data**

US 2018/0366814 A1 Dec. 20, 2018

Related U.S. Application Data

(63) Continuation of application No. 15/118,323, filed as application No. PCT/CN2015/072407 on Feb. 6, 2015, now Pat. No. 10,069,193.

(30) **Foreign Application Priority Data**

Feb. 12, 2014 (CN) 2014 1 0049276

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

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/328*** (2015.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/48; H01Q 5/30; H01Q 5/328–371
See application file for complete search history.

(56) **References Cited**

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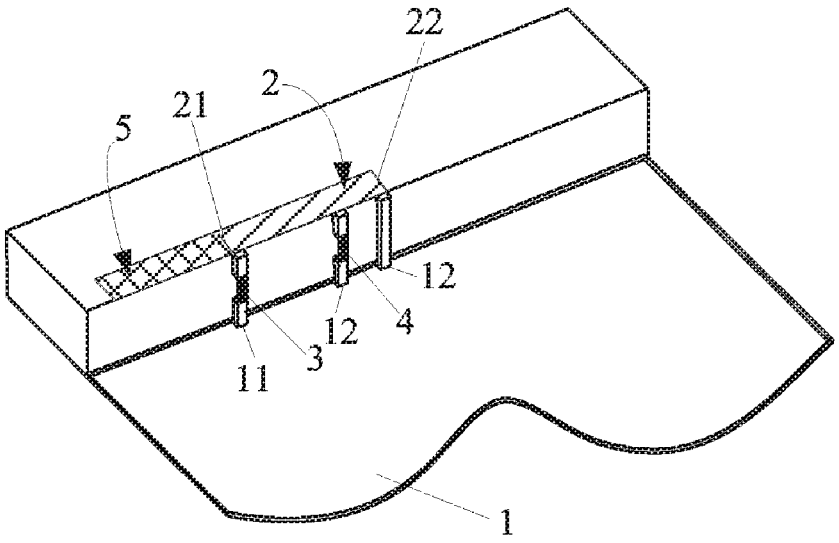
Primary Examiner — Hasan Z Islam
(74) *Attorney, Agent, or Firm* — Slater Matsil, LLP

(57) **ABSTRACT**

An antenna and a mobile terminal with the antenna including a first radiator and a first capacitor structure. A first end of the first radiator is electrically connected to a signal feed end of a printed circuit board by means of the first capacitor structure, and a second end of the first radiator is electrically connected to a ground end of the printed circuit board. The first radiator, the first capacitor structure, the signal feed end, and the ground end form a first antenna, configured to generate a first resonance frequency. An electrical length of the first radiator is less than or equal to one eighth of a wavelength corresponding to the first resonance frequency.

16 Claims, 10 Drawing Sheets



US010879591B2

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

(10) **Patent No.: US 10,879,591 B2**
(45) **Date of Patent: *Dec. 29, 2020**

(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); **Chao-Chiang Kuo**, Taoyuan (TW)

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

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

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/265,430**

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

(65) **Prior Publication Data**

US 2019/0165453 A1 May 30, 2019

Related U.S. Application Data

(60) Division of application No. 15/599,255, filed on May 18, 2017, now Pat. No. 10,516,202, which is a (Continued)

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 13/10 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 13/106*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 13/106; H01Q 13/10; H01Q 1/24; H01Q 1/243; H01Q 1/38; H01Q 1/22; H01Q 1/2266; H01Q 1/50
See application file for complete search history.

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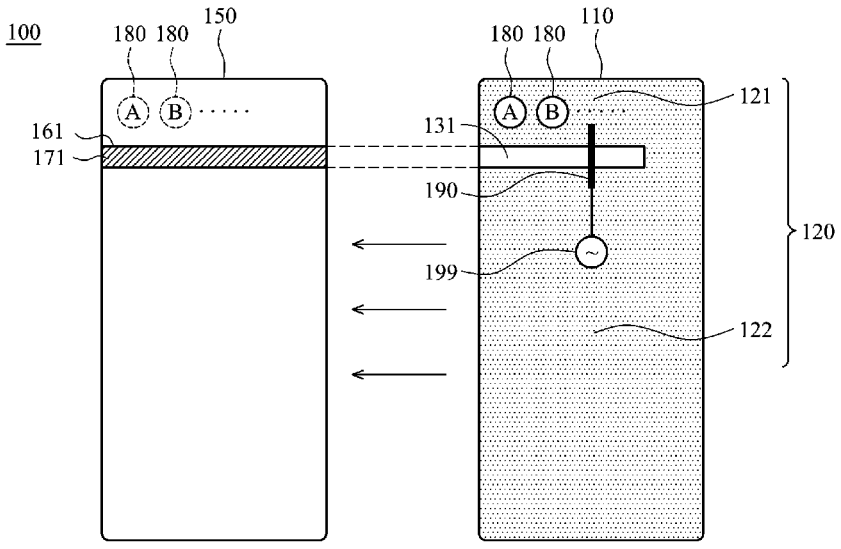
(Continued)

Primary Examiner — Tho G Phan
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch LLP

(57) **ABSTRACT**

A mobile device includes a dielectric substrate, a metal layer, a metal housing, a first nonconductive partition, a second nonconductive partition, a first connection element, and a second connection element. The dielectric substrate includes a first protruded portion. The metal layer lies on the dielectric substrate, and includes an upper element and a main element, wherein the upper element is separated from the main element by a first region. The metal housing is substantially a hollow structure, and has a first slit and a second slit, wherein a first projection of the first slit with respect to the dielectric substrate at least partially overlaps the first region, and a second projection of the second slit with respect to the dielectric substrate at least partially overlaps the first protruded portion. The mobile device is capable of operating in multiple bands.

66 Claims, 59 Drawing Sheets



US010879974B2

(12) **United States Patent**
Guo

(10) **Patent No.: US 10,879,974 B2**
(45) **Date of Patent: Dec. 29, 2020**

(54) **ELECTRONIC DEVICE AND ANTENNA COMPONENT THEREOF**

(71) Applicant: **Beijing Xiaomi Mobile Software Co., Ltd.**, Beijing (CN)

(72) Inventor: **Fang Guo**, Beijing (CN)

(73) Assignee: **Beijing Xiaomi Mobile Software Co., Ltd.**, Beijing (CN)

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

(21) Appl. No.: **16/412,799**

(22) Filed: **May 15, 2019**

(65) **Prior Publication Data**

US 2019/0372635 A1 Dec. 5, 2019

(30) **Foreign Application Priority Data**

May 29, 2018 (CN) 2018 1 0533925

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H04B 7/06 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04B 7/0602*** (2013.01); ***H01Q 1/364*** (2013.01); ***H01Q 1/38*** (2013.01); ***H04B 1/406*** (2013.01); ***H04W 84/12*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/241–1/243; H01Q 13/10; H04B 7/04–7/06
See application file for complete search history.

(56) **References Cited**

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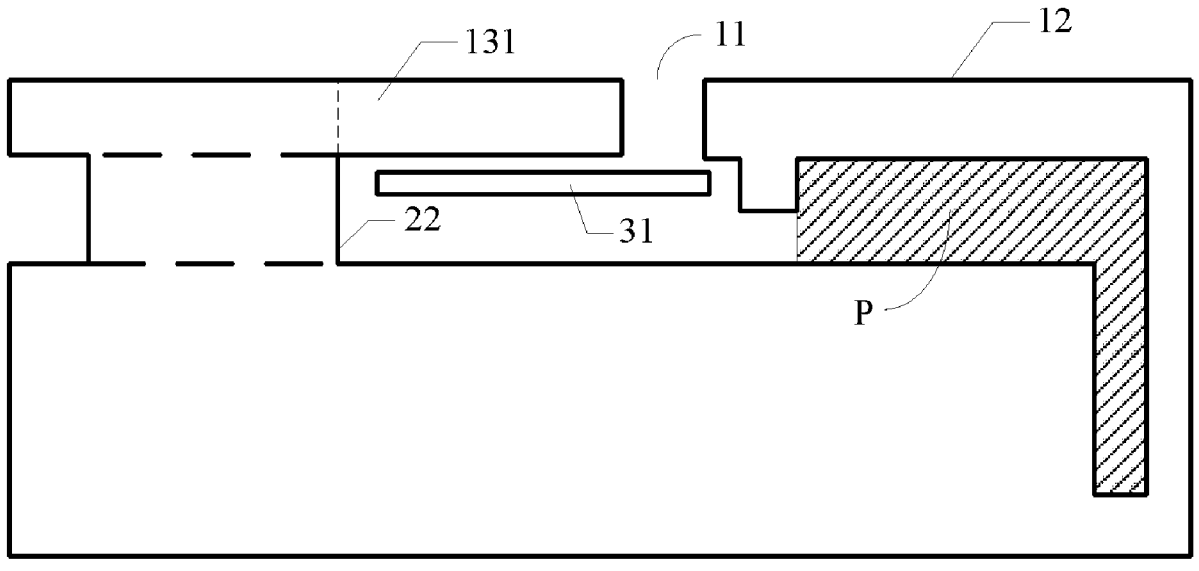
(Continued)

Primary Examiner — Hasan Z Islam
(74) *Attorney, Agent, or Firm* — Finnegan, Henderson, Farabow, Garrett & Dunner, L.L.P.

(57) **ABSTRACT**

The present disclosure relates to an electronic device and an antenna component thereof. The antenna component includes a conductive frame and a signal generation circuit. The conductive frame includes a first conductive frame section and a second conductive frame section, and a slit therebetween is configured to implement signal radiation of the antenna component. A feed point is provided on the first conductive frame section near the slit. The first conductive frame section includes an extension portion from the feed point to an end away from the silt. A groove is formed by the extension portion and a first ground element. The signal generation circuit is electronically connected to the feed point, and configured to generate an L5 band signal when a signal source is input to the signal generation circuit, such that the groove generates an L1 band signal.

15 Claims, 4 Drawing Sheets



US010886242B2

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

(10) **Patent No.: US 10,886,242 B2**
(45) **Date of Patent: Jan. 5, 2021**

(54) **ANTENNA MODULE**

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

(72) Inventors: **Doo Il Kim**, Suwon-si (KR); **Won Wook So**, Suwon-si (KR); **Young Sik Hur**, Suwon-si (KR); **Jung Chul Gong**, 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.: **16/430,959**

(22) Filed: **Jun. 4, 2019**

(65) **Prior Publication Data**

US 2020/0321293 A1 Oct. 8, 2020

(30) **Foreign Application Priority Data**

Apr. 4, 2019 (KR) 10-2019-0039437

(51) **Int. Cl.**
H01L 21/48 (2006.01)
H01L 21/56 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01L 23/66*** (2013.01); ***H01L 21/4853*** (2013.01); ***H01L 21/56*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC . H01L 23/66; H01L 23/3135; H01L 23/3185; H01L 23/49816; H01L 23/5386; H01L 23/5389; H01L 21/4853; H01L 21/56; H01L 24/05; H01L 24/16; H01L 24/17; H01L 25/0657; H01L 2224/04105; H01L 2224/12105; H01L 2224/16225;
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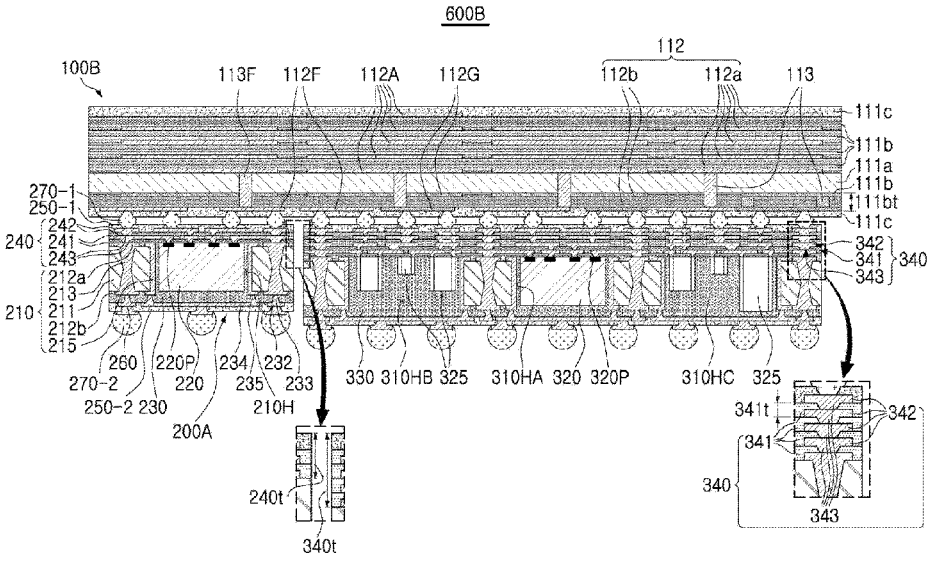
Primary Examiner — Tong-Ho Kim
(74) *Attorney, Agent, or Firm* — Morgan, Lewis & Bockius LLP

(57) **ABSTRACT**

An antenna module includes an antenna substrate, a first semiconductor package, disposed on the antenna substrate, including a first connection member including one or more first redistribution layers, electrically connected to the antenna substrate, and a first semiconductor chip disposed on the first connection member, and a second semiconductor package, disposed on the antenna substrate to be spaced apart from the first semiconductor package, including a second connection member including one or more second redistribution layers, electrically connected to the antenna substrate, and a second semiconductor chip disposed on the second connection member. The first semiconductor chip and the second semiconductor chip are different types of semiconductor chips.

14 Claims, 14 Drawing Sheets



US010886596B2

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

(10) **Patent No.: US 10,886,596 B2**
(45) **Date of Patent: Jan. 5, 2021**

(54) **WIRELESS COMMUNICATION DEVICE HAVING A TWO-PART ROTATABLE HOUSING WITH MULTIPLE ANTENNA CONDUCTORS**

(71) Applicant: **Motorola Mobility LLC**, Chicago, IL (US)

(72) Inventors: **Binbin Yang**, Chicago, IL (US); **Hariharan Muthukrishnan**, Chicago, IL (US); **Juan Martinez**, Barrington, IL (US); **Eric Krenz**, Crystal Lake, IL (US)

(73) Assignee: **Motorola Mobility LLC**, Chicago, IL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 21 days.

(21) Appl. No.: **16/296,698**

(22) Filed: **Mar. 8, 2019**

(65) **Prior Publication Data**

US 2020/0287272 A1 Sep. 10, 2020

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 1/22 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/2291*** (2013.01); ***H01Q 1/125*** (2013.01); ***H01Q 1/24*** (2013.01); *H01Q 1/2266* (2013.01); *H01Q 1/38* (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/2266; H01Q 1/38
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

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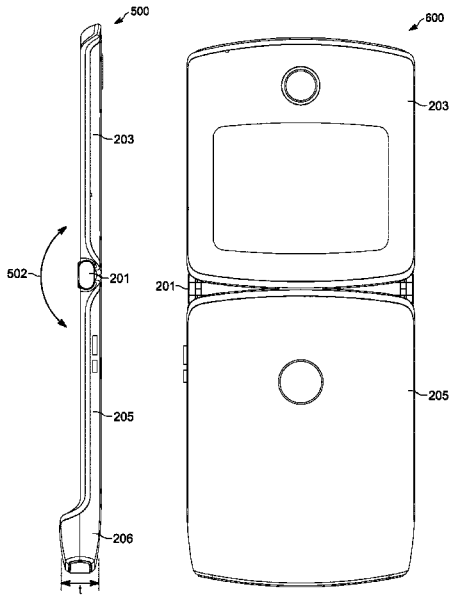
Primary Examiner — Thuy Vinh Tran
(74) *Attorney, Agent, or Firm* — Loppnow & Chapa

(57) **ABSTRACT**

The present application provides a handheld wireless communication device. The handheld wireless communication device includes a two part housing having an upper housing and a lower housing, the upper housing and the lower housing being rotatably coupled together via a hinge. The upper housing and the lower housing through a relative movement via the hinge can transition between an opened position and a closed position. The lower housing has a first conductor including one or more tuned structures and has a second conductor including one or more tuned structures, where each of the tuned structures of the first conductor and the second conductor are adapted for at least one of transmitting or receiving electromagnetic energy having a respective predefined range of frequencies in support of wireless communications. The first conductor and the second conductor in a spaced apart fashion relative to each other are located proximate a first side edge of the lower housing, where the first side edge is opposite a second side edge of the lower housing, where the second side edge of the lower housing is the side edge of the lower housing, which is most directly coupled to the upper housing via the hinge.

18 Claims, 6 Drawing Sheets



US010886597B2

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

(10) **Patent No.: US 10,886,597 B2**
(45) **Date of Patent: Jan. 5, 2021**

(54) **HOUSING, ANTENNA DEVICE AND MOBILE TERMINAL**

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

(72) Inventors: **Shasha Hu**, Dongguan (CN); **Ning Zhao**, Dongguan (CN); **Shengzhao Xiang**, 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 167 days.

(21) Appl. No.: **15/798,823**

(22) Filed: **Oct. 31, 2017**

(65) **Prior Publication Data**

US 2018/0069293 A1 Mar. 8, 2018

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2016/086566, filed on Jun. 21, 2016.

(30) **Foreign Application Priority Data**

Mar. 21, 2016 (CN) 2016 1 0163702
Apr. 29, 2016 (CN) 2016 1 0287114
Apr. 29, 2016 (CN) 2016 1 0287147

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

(52) **U.S. Cl.**
CPC ***H01Q 1/24*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/44*** (2013.01); ***H01Q 21/28*** (2013.01); ***H01Q 21/30*** (2013.01); ***H05K 5/04*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/243; H01Q 1/44; H01Q 21/28; H01Q 21/30; H05K 5/04
See application file for complete search history.

(56) **References Cited**

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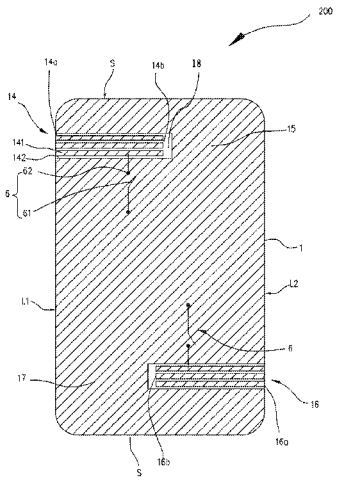
Primary Examiner — Dimary S Lopez Cruz
Assistant Examiner — Bamidele A Jegede
(74) *Attorney, Agent, or Firm* — Lathrop GPM LLP

(57) **ABSTRACT**

A housing is provided. The housing includes a first housing area, a second housing area, a slit strip and a connecting segment, the slit strip includes at least one slit, the first housing area and the second housing area are located at two sides of the slit strip, the connecting segment are located at an extending path of the slit strip, the connecting segment electrically conductively couples the first housing area and the second housing area. An antenna device and a mobile terminal are also provided by the present disclosure.

19 Claims, 9 Drawing Sheets



US010886600B2

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

(10) **Patent No.: US 10,886,600 B2**
(45) **Date of Patent: Jan. 5, 2021**

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

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

(72) Inventors: **Bum Jin Cho**, Gyeonggi-do (KR); **Jae Bong Chun**, Gyeonggi-do (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.: **16/004,665**

(22) Filed: **Jun. 11, 2018**

(65) **Prior Publication Data**

US 2018/0358687 A1 Dec. 13, 2018

(30) **Foreign Application Priority Data**

Jun. 12, 2017 (KR) 10-2017-0072888

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 7/00	(2006.01)
H01Q 13/10	(2006.01)
G06K 7/10	(2006.01)
H04B 5/00	(2006.01)
H01Q 1/22	(2006.01)
H01Q 1/44	(2006.01)

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

CPC ***H01Q 1/243*** (2013.01); ***G06K 7/10336*** (2013.01); ***H01Q 1/2208*** (2013.01); ***H01Q 1/44*** (2013.01); ***H01Q 7/00*** (2013.01); ***H01Q 13/106*** (2013.01); ***H04B 5/0081*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243–1/244; H04B 5/0081; G06K 7/10336

See application file for complete search history.

(56) **References Cited**

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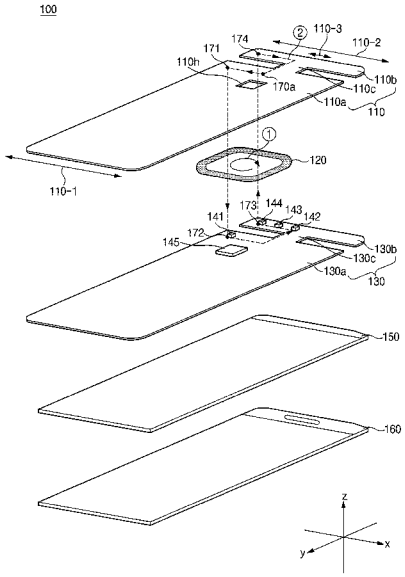
Chinese Search Report dated Oct. 29, 2020.

Primary Examiner — Graham P Smith
Assistant Examiner — Amal Patel
(74) *Attorney, Agent, or Firm* — Cha & Reiter, LLC.

(57) **ABSTRACT**

An electronic device includes a housing including a back cover and a cover glass facing away from the back cover, a coil type radiator disposed between the back cover and the cover glass, at least one printed circuit board (PCB) disposed between the radiator and the cover glass, a communication circuit disposed on the PCB and feeding to the radiator, a first connecting member, a second connecting member, and one or more elements.

8 Claims, 13 Drawing Sheets



US010886601B2

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

(10) **Patent No.: US 10,886,601 B2**
(45) **Date of Patent: Jan. 5, 2021**

(54) **ELECTRONIC DEVICE**

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

(72) Inventors: **Kenichi Ishizuka**, Nagaokakyo (JP); **Takeaki Tamayama**, Nagaokakyo (JP)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 89 days.

(21) Appl. No.: **16/258,869**

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

(65) **Prior Publication Data**

US 2019/0157746 A1 May 23, 2019

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2018/020746, filed on May 30, 2018.

(30) **Foreign Application Priority Data**

Jul. 6, 2017 (JP) 2017-132442

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 13/10 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 7/00*** (2013.01); ***H01Q 13/10*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 21/28; H01Q 13/10; H01Q 7/00; H01Q 1/48; H05K 7/20509; H04M 1/02; H04M 1/026
See application file for complete search history.

(56) **References Cited**

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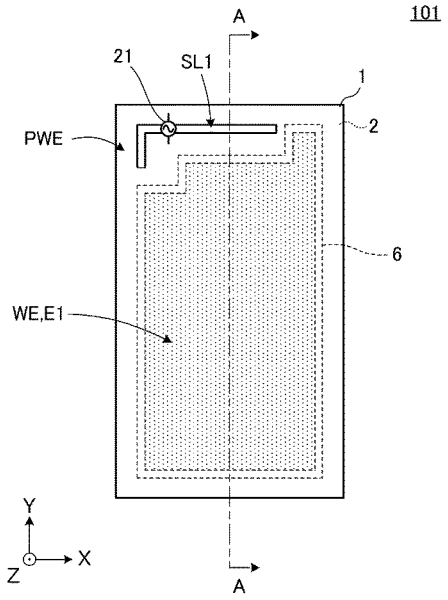
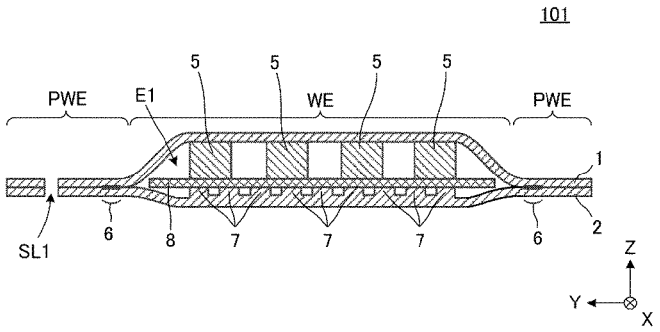
Primary Examiner — Dieu Hien T Duong
(74) *Attorney, Agent, or Firm* — Arent Fox LLP

(57) **ABSTRACT**

An electronic device includes an antenna, and a plate-shaped heat spreader including first and second metal layers that are stacked, a working fluid in an enclosed space interposed between the first and second metal layers, and a joint along which outer peripheral portions around the enclosed space are joined. The heat spreader includes an operational region in which the enclosed space is located and a quasi-operational region other than the enclosed space. The antenna is provided in the quasi-operational region in a plan view of the heat spreader.

19 Claims, 11 Drawing Sheets





US010886607B2

(12) **United States Patent**
Ayala Vazquez et al.

(10) **Patent No.: US 10,886,607 B2**
(45) **Date of Patent: *Jan. 5, 2021**

(54) **MULTIPLE-INPUT AND MULTIPLE-OUTPUT ANTENNA STRUCTURES**

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

(72) Inventors: **Enrique Ayala Vazquez**, Watsonville, CA (US); **Hongfei Hu**, Santa Clara, CA (US); **Mattia Pascolini**, San Francisco, CA (US); **Nanbo Jin**, Milpitas, CA (US); **Matthew A. Mow**, Los Altos, CA (US); **Erdinc Irci**, Sunnyvale, CA (US); **Erica J. Tong**, Pacifica, CA (US); **Han Wang**, Cupertino, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 429 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **15/657,001**

(22) Filed: **Jul. 21, 2017**

(65) **Prior Publication Data**

US 2019/0027822 A1 Jan. 24, 2019

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

(52) **U.S. Cl.**
CPC ***H01Q 1/523*** (2013.01); ***H01Q 1/242*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/42*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/523; H01Q 1/42; H01Q 1/44; H01Q 1/243; H01Q 1/242; H01Q 9/42;
(Continued)

(56) **References Cited**

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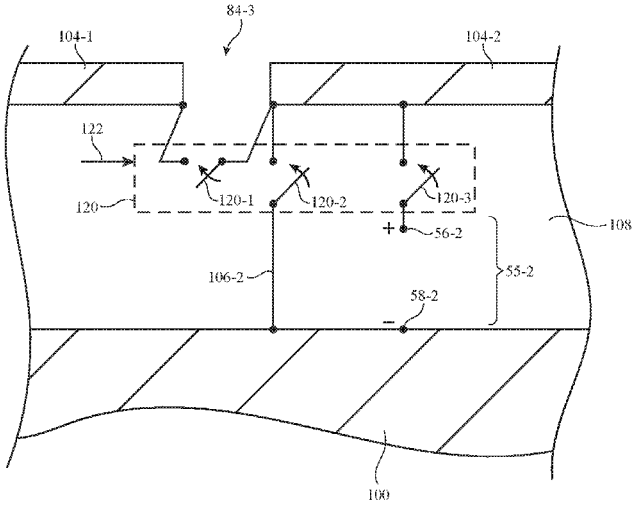
Ayala Vazquez et al., U.S. Appl. No. 15/655,660, filed Sep. 21, 2017.
(Continued)

Primary Examiner — Awat M Salih
(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; Michael H. Lyons; Matthew R. Williams

(57) **ABSTRACT**

An electronic device may include a housing and four antennas at respective corners of the housing. Cellular telephone transceiver circuitry may concurrently convey signals at one or more of the same frequencies over one or more of the four antennas using a multiple-input multiple-output (MIMO) scheme. In order to isolate adjacent antennas, dielectric-filled openings may be formed in conductive walls of the housing to divide the walls into segments that are used to form resonating element arms for the antennas. If desired, first and second antennas may include resonating element arms formed from a wall without any gaps. The first and second antennas may include adjacent return paths. A magnetic field associated with currents for the first antenna may cancel out with a magnetic field associated with currents for the second antenna at the adjacent return paths, thereby serving to electromagnetically isolate the first and second antennas.

20 Claims, 14 Drawing Sheets



US010886614B2

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

(10) **Patent No.: US 10,886,614 B2**
(45) **Date of Patent: Jan. 5, 2021**

(54) **ANTENNA STRUCTURE**

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

(72) Inventors: **Cheng-Han Lee**, New Taipei (TW); **Huo-Ying Chang**, 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 65 days.

(21) Appl. No.: **16/217,063**

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

(65) **Prior Publication Data**

US 2019/0181552 A1 Jun. 13, 2019

Related U.S. Application Data

(60) Provisional application No. 62/597,442, filed on Dec. 12, 2017, provisional application No. 62/614,364, filed on Jan. 6, 2018.

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 5/35	(2015.01)
H01Q 9/28	(2006.01)
H01Q 3/24	(2006.01)
H01Q 9/42	(2006.01)
H01Q 5/335	(2015.01)
H01Q 21/28	(2006.01)
H01Q 13/10	(2006.01)
H01Q 9/30	(2006.01)

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

CPC ***H01Q 5/35*** (2015.01); ***H01Q 1/243*** (2013.01); ***H01Q 3/247*** (2013.01); ***H01Q 5/335*** (2015.01); ***H01Q 9/285*** (2013.01); ***H01Q 9/30*** (2013.01); ***H01Q 9/42*** (2013.01); ***H01Q 13/10*** (2013.01); ***H01Q 21/28*** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

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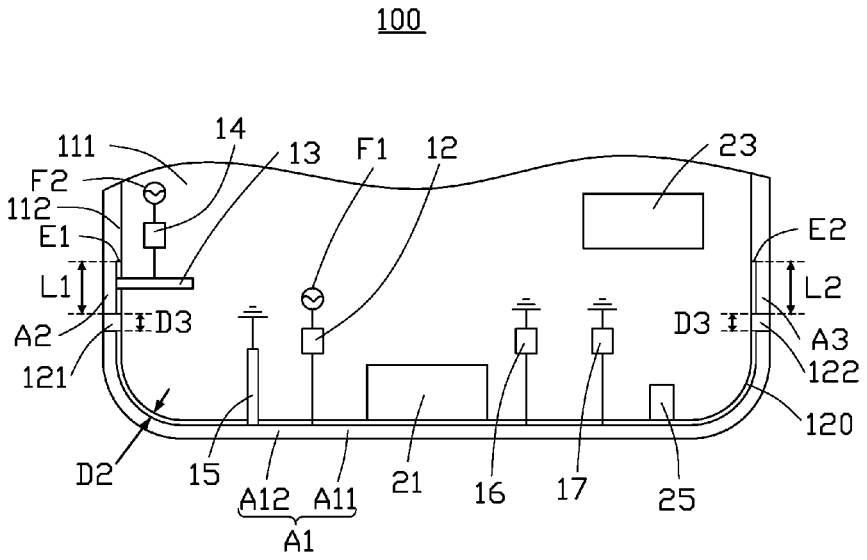
Primary Examiner — Trinh V Dinh

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

(57) **ABSTRACT**

An antenna structure includes a housing and a first feed source. The first feed source is electrically coupled to a first radiating portion of the housing and adapted to provide an electric current to the first radiating portion.

20 Claims, 19 Drawing Sheets



US010886617B2

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

(10) **Patent No.: US 10,886,617 B2**
(45) **Date of Patent: Jan. 5, 2021**

(54) **ELECTRONIC DEVICES WITH PROBE-FED DIELECTRIC RESONATOR ANTENNAS**

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

(72) Inventors: **Bilgehan Avser**, Mountain View, CA (US); **Harish Rajagopalan**, San Jose, CA (US); **Simone Paulotto**, Redwood City, CA (US); **Jennifer M. Edwards**, San Francisco, CA (US); **Mattia Pascolini**, San Francisco, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 42 days.

(21) Appl. No.: **16/289,459**

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

(65) **Prior Publication Data**

US 2020/0280131 A1 Sep. 3, 2020

(51) **Int. Cl.**

H01Q 9/04	(2006.01)
H01Q 5/40	(2015.01)
H01Q 1/24	(2006.01)
H01Q 3/26	(2006.01)

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

CPC ***H01Q 9/0407*** (2013.01); ***H01Q 1/241*** (2013.01); ***H01Q 3/267*** (2013.01); ***H01Q 3/2658*** (2013.01); ***H01Q 5/40*** (2015.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

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6,995,715	B2	2/2006	Ying et al.	
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7,605,763	B2	10/2009	Finn et al.	
8,493,272	B2	7/2013	Ollikainen et al.	
9,074,070	B2	7/2015	Yung et al.	
9,667,290	B2	5/2017	Ouyang et al.	
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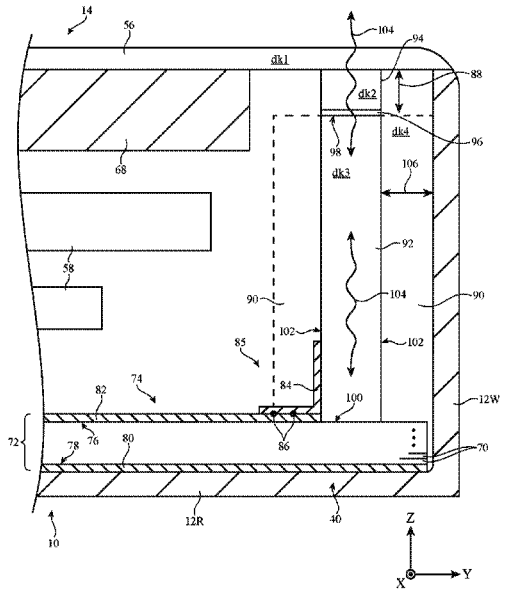
Primary Examiner — Crystal L Hammond

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

(57) **ABSTRACT**

An electronic device may be provided with a phased antenna array and a display cover layer. The phased antenna array may include a probe-fed dielectric resonator antenna. The antenna may include a dielectric resonating element mounted to a flexible printed circuit. A feed probe may be formed from a patch of conductive traces on a sidewall of the resonating element. The feed probe may excite resonant modes of the resonating element. The resonating element may convey corresponding radio-frequency signals through the display cover layer. An additional feed probe may be mounted to an orthogonal sidewall of the resonating element for covering additional polarizations. Probe-fed dielectric resonator antennas for covering different polarizations and frequencies may be interleaved across the phased antenna array.

20 Claims, 14 Drawing Sheets



US010886618B2

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

(10) **Patent No.: US 10,886,618 B2**
(45) **Date of Patent: Jan. 5, 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); **Ju Hyoung Park**, Suwon-si (KR); **Jeong Ki Ryoo**, Suwon-si (KR); **Myeong Woo Han**, Suwon-si (KR); **Dae Ki Lim**, 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 19 days.

(21) Appl. No.: **16/260,505**

(22) Filed: **Jan. 29, 2019**

(65) **Prior Publication Data**

US 2019/0305432 A1 Oct. 3, 2019

(30) **Foreign Application Priority Data**

Mar. 30, 2018 (KR) 10-2018-0037621
Jul. 9, 2018 (KR) 10-2018-0079286

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

(52) **U.S. Cl.**
CPC ***H01Q 9/0457*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 9/0464*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 21/065; H01Q 9/0464; H01Q 1/38; H01Q 9/0428; H01Q 1/42; H01Q 9/0435;
(Continued)

(56) **References Cited**

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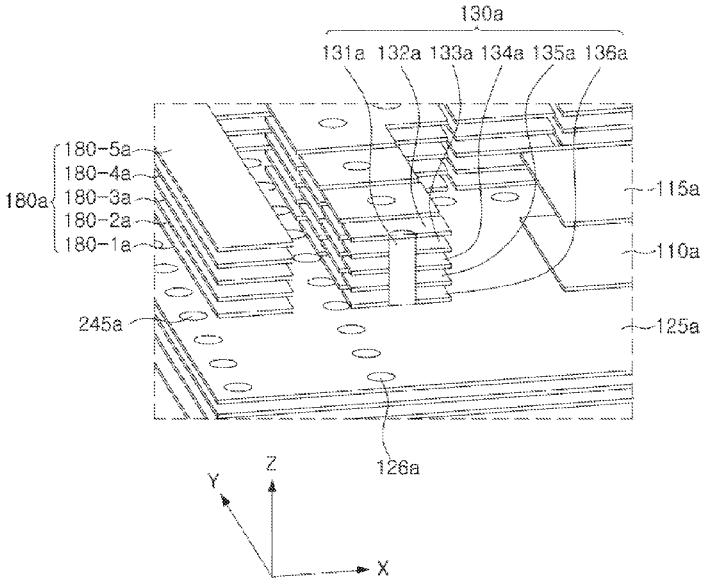
Primary Examiner — Wei (Victor) Y Chan
(74) *Attorney, Agent, or Firm* — NSIP Law

(57) **ABSTRACT**

An antenna apparatus includes a feed via, a patch antenna pattern which is electrically connected to a first end of the feed via, a plurality of first conductive array patterns, respectively disposed to be spaced apart from the patch antenna pattern and arranged to correspond to at least a portion of a side boundary of the patch antenna pattern, and a first conductive ring pattern spaced apart from the patch antenna pattern and the plurality of conductive array patterns and configured to surround the patch antenna pattern and the plurality of conductive array patterns.

14 Claims, 16 Drawing Sheets



US010886619B2

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

(10) **Patent No.: US 10,886,619 B2**
(45) **Date of Patent: Jan. 5, 2021**

(54) **ELECTRONIC DEVICES WITH DIELECTRIC RESONATOR ANTENNAS**

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

(72) Inventors: **Bilgehan Avser**, Mountain View, CA (US); **Harish Rajagopalan**, San Jose, CA (US); **Simone Paulotto**, Redwood City, CA (US); **Jennifer M. Edwards**, San Francisco, CA (US); **Hao Xu**, Cupertino, CA (US); **Rodney A. Gomez Angulo**, Santa Clara, CA (US); **Matthew D. Hill**, Cupertino, CA (US); **Mattia Pascolini**, San Francisco, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 42 days.

(21) Appl. No.: **16/289,433**

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

(65) **Prior Publication Data**

US 2020/0280133 A1 Sep. 3, 2020

(51) **Int. Cl.**

H01Q 9/04	(2006.01)
H01Q 1/24	(2006.01)
H01Q 21/00	(2006.01)

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

CPC ***H01Q 9/0485*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 21/0075*** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

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6,768,454	B2	7/2004	Kingsley et al.	
6,995,715	B2	2/2006	Ying et al.	
7,405,697	B2	7/2008	Ying	
7,605,763	B2	10/2009	Finn et al.	
8,493,272	B2	7/2013	Ollikainen et al.	
9,074,070	B2	7/2015	Yung et al.	
9,667,290	B2	5/2017	Ouyang et al.	
9,685,700	B2	6/2017	Komulainen et al.	

(Continued)

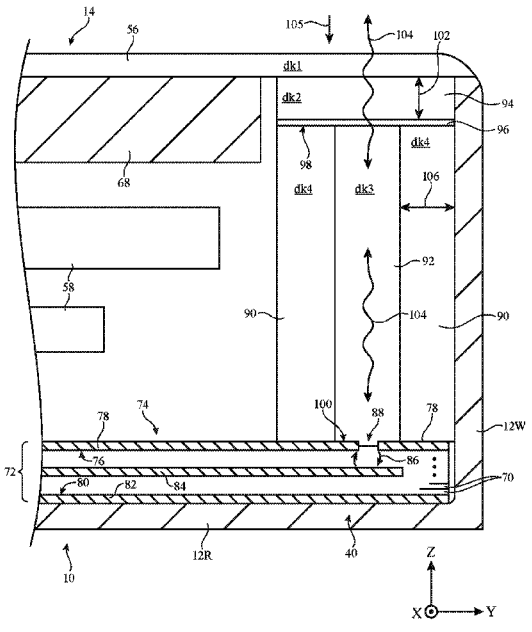
Primary Examiner — Crystal L Hammond

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

(57) **ABSTRACT**

An electronic device may be provided with a phased antenna array and a display cover layer. The phased antenna array may include a dielectric resonator antenna. The dielectric resonator antenna may include a dielectric resonating element embedded in a lower permittivity dielectric substrate. The substrate and the resonating element may be mounted to a flexible printed circuit. A slot may be formed in ground traces on the flexible printed circuit and aligned with the resonating element. The slot may excite resonant modes of the resonating element. The resonating element may convey corresponding radio-frequency signals through the cover layer. A dielectric matching layer may be interposed between the resonating element and the cover layer. If desired, the slot may radiate additional radio-frequency signals and the matching layer may have a tapered shape. Dielectric resonator antennas for covering different polarizations and frequencies may be interleaved across the array.

20 Claims, 17 Drawing Sheets



US010886621B2

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

(10) **Patent No.: US 10,886,621 B2**
(45) **Date of Patent: Jan. 5, 2021**

(54) **ANTENNA DEVICE**

(71) Applicant: **PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO., LTD.**, Osaka (JP)

(72) Inventors: **Yuki Tanaka**, Tokyo (JP); **Ryosuke Hasaba**, Kanagawa (JP); **Yoshio Koyanagi**, Kanagawa (JP); **Kazuki Kanai**, Kanagawa (JP)

(73) Assignee: **PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO., LTD.**, Osaka (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.: **16/298,076**

(22) Filed: **Mar. 11, 2019**

(65) **Prior Publication Data**

US 2019/0288399 A1 Sep. 19, 2019

(30) **Foreign Application Priority Data**

Mar. 14, 2018 (JP) 2018-046925

(51) **Int. Cl.**
H01Q 13/16 (2006.01)
H01Q 13/10 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 13/16*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 13/10*** (2013.01); ***H01Q 13/106*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 13/16; H01Q 1/48; H01Q 5/371; H01Q 7/00; H01Q 1/36; H01Q 1/38;
(Continued)

(56) **References Cited**

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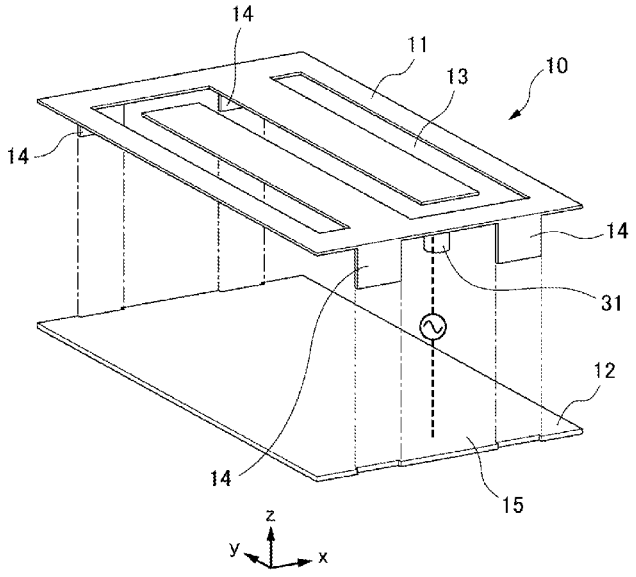
Primary Examiner — Vibol Tan
(74) *Attorney, Agent, or Firm* — Pearne & Gordon LLP

(57) **ABSTRACT**

An antenna device includes a substrate having a ground conductor, an antenna conductor disposed approximately parallel with the ground conductor with an air layer or a dielectric layer, plural short-circuiting conductors that connect the antenna conductor to the ground conductor, and a feed conductor disposed in a vicinity of one of the plural short-circuiting conductors and that feeds the antenna conductor with power. When a wavelength of frequency used in the antenna device is represented by λ, an outer circumferential length of the slot is approximately 1λ to 2λ and a width of the slot is 0.005λ to 0.05λ, an interval between the plural short-circuiting conductors is shorter than or equal to λ/2, and a distance between the antenna conductor and the ground conductor is 0.005λ to 0.05λ.

7 Claims, 9 Drawing Sheets



US010886633B2

(12) **United States Patent**
Dorsey

(10) **Patent No.: US 10,886,633 B2**
(45) **Date of Patent: Jan. 5, 2021**

(54) **FLEXIBLE POLYMER ANTENNA WITH MULTIPLE GROUND RESONATORS**

(71) Applicant: **Taoglas Group Holdings Limited**, San Diego, CA (US)

(72) Inventor: **Jason Philip Dorsey**, Oceanside, CA (US)

(73) Assignee: **TAOGLAS GROUP HOLDING LIMITED**, Enniscorthy (IE)

(*) 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.: **16/665,942**

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

(65) **Prior Publication Data**

US 2020/0235492 A1 Jul. 23, 2020

Related U.S. Application Data

(63) Continuation of application No. 16/140,977, filed on Sep. 25, 2018, now Pat. No. 10,461,439, which is a continuation of application No. 15/351,263, filed on Nov. 14, 2016, now Pat. No. 10,103,451.

(60) Provisional application No. 62/254,140, filed on Nov. 11, 2015.

(51) **Int. Cl.**

H01Q 21/20	(2006.01)
H01Q 1/48	(2006.01)
H01Q 1/24	(2006.01)
H01Q 1/38	(2006.01)
H01Q 5/371	(2015.01)
H01Q 5/30	(2015.01)
H01Q 1/36	(2006.01)

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

CPC ***H01Q 21/20*** (2013.01); ***H01Q 1/241*** (2013.01); ***H01Q 1/242*** (2013.01); ***H01Q 1/36*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/30*** (2015.01); ***H01Q 5/371*** (2015.01)

(58) **Field of Classification Search**

CPC H01Q 1/241; H01Q 1/242; H01Q 1/36; H01Q 1/38; H01Q 1/48; H01Q 5/10; H01Q 5/30; H01Q 5/307; H01Q 5/371; H01Q 9/04; H01Q 21/20

See application file for complete search history.

(56) **References Cited**

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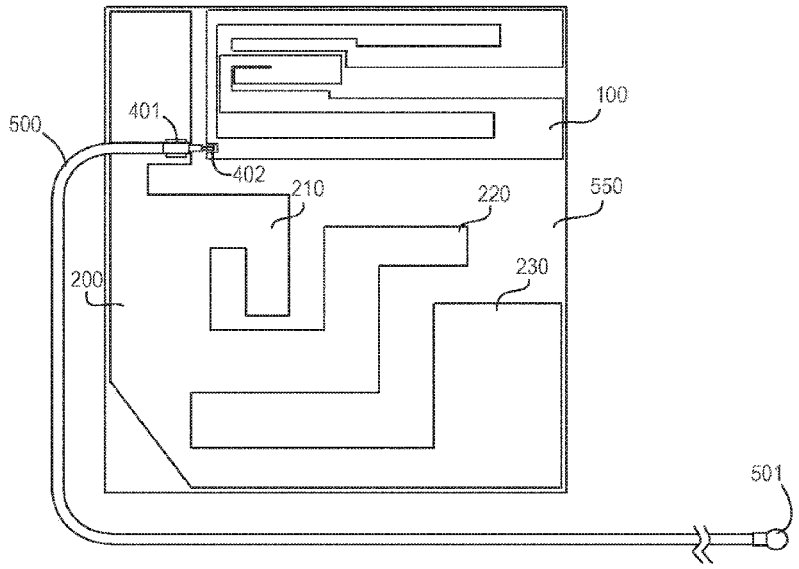
Primary Examiner — Hoang V Nguyen

(74) *Attorney, Agent, or Firm* — Garson & Gutierrez, PC

(57) **ABSTRACT**

The disclosure concerns an antenna assembly having a substrate with an antenna radiating element and a ground conductor disposed on the substrate, the ground conductor further characterized by a plurality of ground resonators, wherein a length associated with each of the ground resonators increases as the ground resonators are distanced from the antenna radiating element. Additionally, a coaxial cable is routed around the antenna assembly for configuring the coaxial cable as an additional ground resonator associated with the antenna assembly. The resulting antenna provides wide band performance between 700 MHz and 2700 MHz with improved efficiency compared with conventional antennas.

20 Claims, 4 Drawing Sheets



US010887434B2

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

(10) **Patent No.: US 10,887,434 B2**
(45) **Date of Patent: *Jan. 5, 2021**

(54) **MOBILE TERMINAL**

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

(72) Inventors: **Kyoungsun Hwang**, Seoul (KR); **Moonsoo Song**, Seoul (KR); **Yoonjae Won**, Seoul (KR); **Deuksu Choi**, Seoul (KR); **Chisang You**, Seoul (KR)

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

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

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/742,785**

(22) Filed: **Jan. 14, 2020**

(65) **Prior Publication Data**

US 2020/0153947 A1 May 14, 2020

Related U.S. Application Data

(63) Continuation of application No. 16/383,399, filed on Apr. 12, 2019, now Pat. No. 10,560,557, which is a (Continued)

(30) **Foreign Application Priority Data**

May 3, 2018 (KR) 10-2018-0051314

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

(52) **U.S. Cl.**
CPC ***H04M 1/0202*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 13/10*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H04M 1/0202; H01Q 1/243; H01Q 13/10; H01Q 5/35; H01Q 1/44; H04B 1/3833; H04W 88/02
See application file for complete search history.

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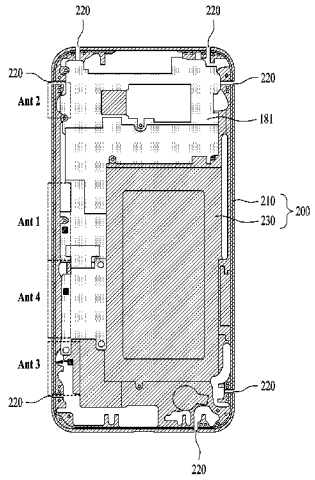
U.S. Appl. No. 16/383,399, Office Action dated Jun. 17, 2019, 34 pages.
(Continued)

Primary Examiner — Barry W Taylor
(74) *Attorney, Agent, or Firm* — Lee, Hong, Degerman, Kang & Waimey

(57) **ABSTRACT**

There is disclosed a mobile terminal including: a display; a middle frame including a supporting portion and a side portion provided around the supporting portion to define a lateral external appearance; a main board including a ground; a first wireless communication unit configured to transceive a first signal; a second wireless communication unit configured to transceive a second signal; and a rear case configured to cover a rear surface of the main board, wherein the side portion includes a plurality of conductive members of which ends are divided into slits, and the plurality of the conductive members includes a common antenna electrically connectable with the first wireless communication unit and the second wireless communication unit and configured to receive the first signal and the second signal; and an
(Continued)



US010892557B1

(12) **United States Patent**
Liu

(10) **Patent No.: US 10,892,557 B1**
(45) **Date of Patent: Jan. 12, 2021**

(54) **ANTENNA STRUCTURE AND INTELLIGENT HOUSEHOLD APPLIANCE USING THE SAME**

(71) Applicant: **AMBIT MICROSYSTEMS (SHANGHAI) LTD.**, Shanghai (CN)

(72) Inventor: **Yen-Yu Liu**, New Taipei (TW)

(73) Assignee: **AMBIT MICROSYSTEMS (SHANGHAI) LTD.**, Shanghai (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.: **16/445,346**

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

(51) **Int. Cl.**

H01Q 9/06	(2006.01)
H01Q 9/04	(2006.01)
H01Q 13/10	(2006.01)
H01Q 1/00	(2006.01)
H01Q 1/22	(2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 9/065*** (2013.01); ***H01Q 1/007*** (2013.01); ***H01Q 1/2208*** (2013.01); ***H01Q 9/0407*** (2013.01); ***H01Q 13/106*** (2013.01)

(58) **Field of Classification Search**
CPC H01G 9/065; H01G 1/007; H01G 1/2208; H01G 13/106; H01G 9/0407
See application file for complete search history.

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

(57) **ABSTRACT**

An antenna structure capable of operating in several modes includes first and second metal patches and a substrate (which can be an air-filled void) positioned between them. The second patch is substantially an isosceles trapezoidal patch. The second patch includes a first bottom edge, a second bottom edge parallel to and spaced from the first bottom edge, a first side edge, a second side edge, a first shorting wall, and a second short circuit patch. The first side edge and the second side edge are connected to the first bottom edge and the second bottom edge. The first shorting wall and the second shorting wall are formed between the first patch and the second patch. The second patch further defines a V-shaped slot.

20 Claims, 14 Drawing Sheets