



US010483624B2

(12) **United States Patent**
Gu

(10) **Patent No.:** **US 10,483,624 B2**

(45) **Date of Patent:** **Nov. 19, 2019**

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

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

(72) Inventor: **Haichuan Gu**, 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.: **16/057,961**

(22) Filed: **Aug. 8, 2018**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Dec. 29, 2017 (CN) 2017 1 1475334

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 13/16 (2006.01)

H01Q 5/35 (2015.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 5/35**
(2015.01); **H01Q 13/16** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 5/35; H01Q 13/16
See application file for complete search history.

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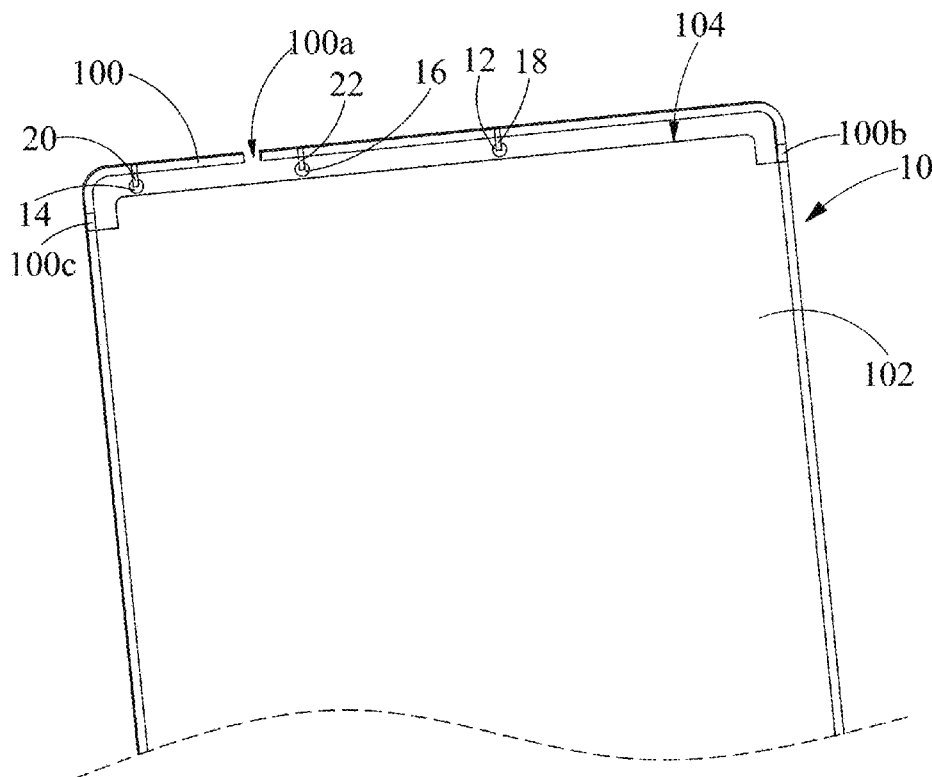
Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — IPro, PLLC; Na Xu

(57) **ABSTRACT**

The present disclosure relates to the field of antenna technologies and, in particular, to an antenna system and a mobile terminal. The antenna system includes: a metal rear cover, a first feeding point, and a system ground, wherein a U-shaped slot is arranged at a bottom of the metal rear cover, and the U-shaped slot divides the metal rear cover into a radiation portion and a grounding portion, the grounding portion is connected to the system ground, the radiation portion includes a first end and a second end, and both the first end and the second end are connected to the grounding portion, a break is defined at the radiation portion, and the radiation portion is electrically connected to the first feeding point, so as to form a main antenna.

18 Claims, 7 Drawing Sheets





US010483639B2

(12) **United States Patent**
Lee

(10) **Patent No.:** **US 10,483,639 B2**
(45) **Date of Patent:** **Nov. 19, 2019**

(54) **COMMUNICATION DEVICE AND ANTENNA ASSEMBLY THEREOF**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

(72) Inventor: **Cheng-Tse Lee**, Taipei (TW)

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(73) Assignee: **ASUSTEK COMPUTER INC.**, Taipei (TW)

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

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TW 201619755 A 6/2016
TW 201635636 A 10/2016

(21) Appl. No.: **16/018,471**

Primary Examiner — Dameon E Levi

Assistant Examiner — Hasan Z Islam

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

(74) *Attorney, Agent, or Firm* — Muncy, Geissler, Olds & Lowe, P.C.

(65) **Prior Publication Data**

US 2018/0375208 A1 Dec. 27, 2018

(57) **ABSTRACT**

(30) **Foreign Application Priority Data**

Jun. 27, 2017 (TW) 106121456 A

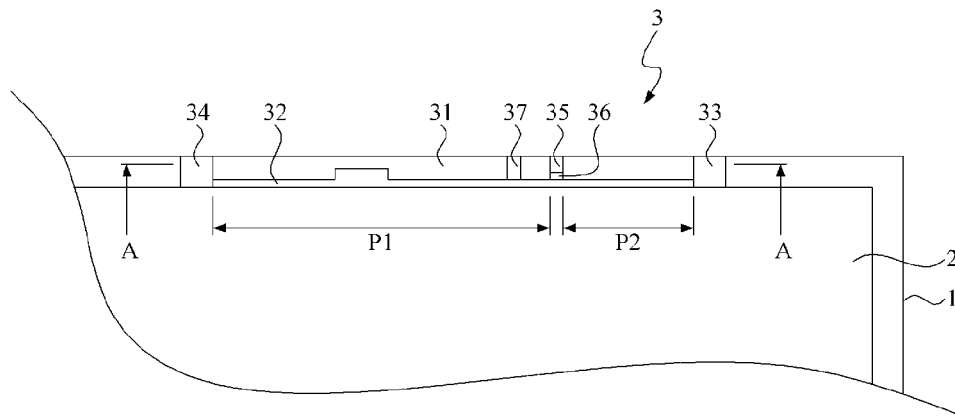
The invention discloses a communication device and an antenna assembly thereof. The communication device includes a metal rim, a device metal member, and an antenna assembly. The device metal member is disposed in the metal rim. The antenna assembly includes an insulating substrate, two electrical coupling portions, a feeding part, and a feeding signal source. The insulating substrate is disposed between the device metal member and the metal rim. The two electrical coupling portions are disposed at two opposite ends of the insulating substrate and electrically coupled to the device metal member and the metal rim. The feeding part is disposed on the insulating substrate and electrically coupled to the metal rim, so as to form a first slot section and a second slot section. The feed part is electrically coupled to the metal rim. The feeding signal source is disposed on the insulating substrate, located between the feeding part and the device metal member, and electrically coupled to the feeding part and the device metal member.

(51) **Int. Cl.**
H01Q 5/30 (2015.01)
H01Q 5/15 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/15** (2015.01); **H01Q 1/38** (2013.01); **H01Q 5/307** (2015.01); **H01Q 5/314** (2015.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 1/273; H01Q 5/30-5/50; H01Q 13/10
(Continued)

10 Claims, 13 Drawing Sheets





US010490881B2

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

(10) **Patent No.:** **US 10,490,881 B2**

(45) **Date of Patent:** **Nov. 26, 2019**

(54) **TUNING CIRCUITS FOR HYBRID ELECTRONIC DEVICE ANTENNAS**

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

(72) Inventors: **Umar Azad**, San Jose, CA (US);
Harish Rajagopalan, San Jose, CA (US);
Rodney A. Gomez Angulo, Sunnyvale, CA (US);
Pietro Romano, Mountain View, CA (US);
Mattia Pascolini, San Francisco, CA (US)

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

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 720 days.

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(Continued)

(21) Appl. No.: **15/066,419**

Primary Examiner — Daniel Munoz

(22) Filed: **Mar. 10, 2016**

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

(65) **Prior Publication Data**

US 2017/0264001 A1 Sep. 14, 2017

(57) **ABSTRACT**

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/04 (2006.01)
H01Q 5/328 (2015.01)

An electronic device may have hybrid antennas that include slot antenna resonating elements formed from slots in a ground plane and planar inverted-F antenna resonating elements. The planar inverted-F antenna resonating elements may each have a planar metal member that overlaps one of the slots. A return path and feed may be coupled in parallel between the planar metal member and the ground plane. Adjustable circuits such as tunable inductors may be used to tune the hybrid antennas. Adjustable circuits may bridge the slots in hybrid antennas and may be included in return paths that are coupled between the planar metal members of the planar inverted-F antenna resonating elements and the ground plane. A slot may be selectively divided to from two slots using switching circuitry.

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/328** (2015.01); **H01Q 9/0442** (2013.01)

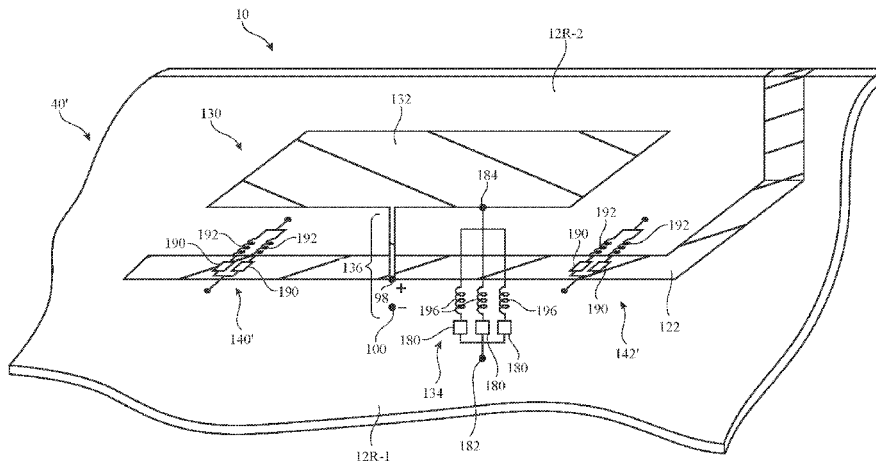
(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/243; H01Q 9/0442; H01Q 9/0407
See application file for complete search history.

(56) **References Cited**

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21 Claims, 9 Drawing Sheets



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

(10) **Patent No.:** **US 10,490,882 B2**
(45) **Date of Patent:** **Nov. 26, 2019**

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

(71) Applicants: **JianChun Mai**, Shenzhen (CN);
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(72) Inventors: **JianChun Mai**, Shenzhen (CN);
HuiYing Lu, 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 6 days.

(21) Appl. No.: **15/417,116**

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

(65) **Prior Publication Data**
US 2018/0115069 A1 Apr. 26, 2018

(30) **Foreign Application Priority Data**
Oct. 25, 2016 (CN) 2016 1 0938166

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/30 (2015.01)
H01Q 9/42 (2006.01)
H01Q 1/22 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/30** (2015.01); **H01Q 9/42** (2013.01); **H01Q 1/2291** (2013.01)

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

(56) **References Cited**

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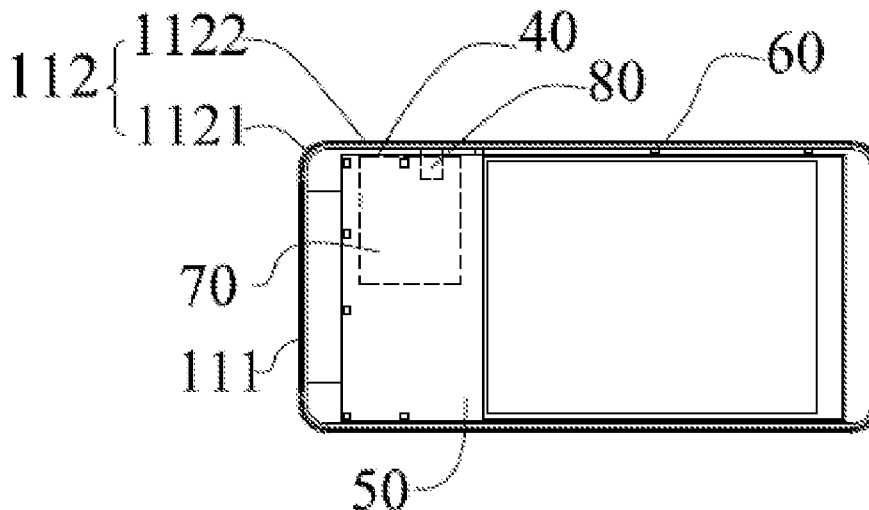
Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — IPPro, PLLC; Na Xu

(57) **ABSTRACT**

The present disclosure provides an antenna assembly, including a metal back cover with a completely closed metal edge frame, and a circuit board provided in the metal back cover, the metal edge frame is provided with a gap along a circumferential direction of the metal edge frame; the circuit board is provided with a matching circuit, a headroom region is provided between the matching circuit and the metal edge frame, the matching circuit includes a grounding point and a feeding point which are electrically connected with the metal edge frame, respectively; the matching circuit and the gap form a three-in-one antenna, which includes GPS antenna, WIFI-2.4G antenna and WIFI-5G antenna, respectively. In the antenna assembly provided by the present disclosure, even the gap is provided on the metal edge frame, the requirements on strength of the metal back cover can also be met, thereby guaranteeing resistance on knocking.

8 Claims, 3 Drawing Sheets





US010490883B2

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

(10) **Patent No.:** **US 10,490,883 B2**

(45) **Date of Patent:** **Nov. 26, 2019**

(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.

(21) Appl. No.: **15/599,247**

(22) Filed: **May 18, 2017**

(65) **Prior Publication Data**

US 2017/0256845 A1 Sep. 7, 2017

Related U.S. Application Data

(63) Continuation of application No. 13/672,464, filed on Nov. 8, 2012, now Pat. No. 9,716,307.

(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 1/24; H01Q 1/243;
H01Q 1/38; H01Q 13/103; H01Q 13/18;
H01Q 13/28; H01Q 5/22

See application file for complete search history.

(56) **References Cited**

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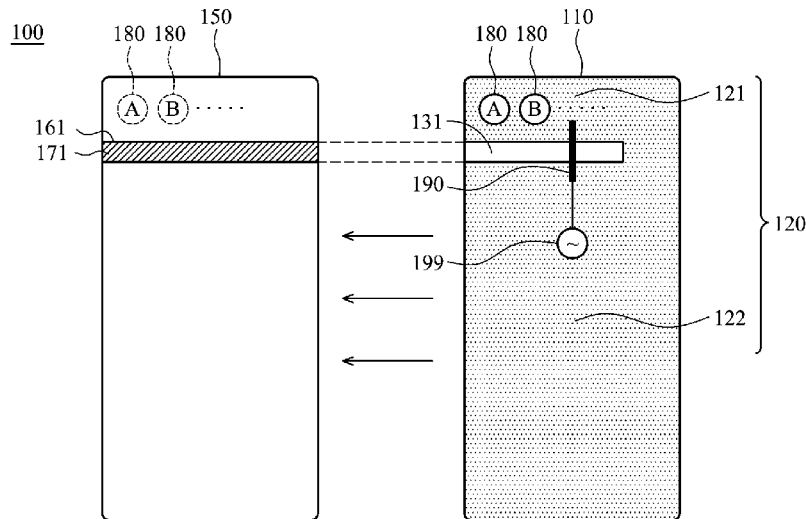
Primary Examiner — Tho G Phan

(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 nonconductive partition, at least one connection element, and a feeding element. The metal layer is disposed on the dielectric substrate, and includes an upper element and a main element, wherein a slot is formed between the upper element and the main element. The metal housing is substantially a hollow structure, and has a slit, wherein the slit is substantially aligned with the slot of the metal layer. The connection element couples the upper element of the metal layer to the metal housing. The feeding element is coupled to the upper element of the metal layer or coupled to the metal housing. An antenna structure is formed by the feeding element, the upper element of the metal layer, the connection element, and the metal housing.

41 Claims, 59 Drawing Sheets



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

(10) **Patent No.:** **US 10,490,885 B2**
(45) **Date of Patent:** **Nov. 26, 2019**

- (54) **ANTENNA DEVICE AND ELECTRONIC APPARATUS**
- (71) Applicant: **E Ink Holdings Inc.**, Hsinchu (TW)
- (72) Inventors: **Yu-Ming Lee**, Hsinchu (TW);
Chuen-Jen Liu, Hsinchu (TW)
- (73) Assignee: **E Ink Holdings Inc.**, 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.: **15/904,448**

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

(65) **Prior Publication Data**
US 2019/0058246 A1 Feb. 21, 2019

(30) **Foreign Application Priority Data**
Aug. 17, 2017 (CN) 2017 1 0705390

- (51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/30 (2015.01)
H01Q 13/10 (2006.01)
H01Q 9/04 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/364 (2015.01)
- (52) **U.S. Cl.**
CPC **H01Q 1/248** (2013.01); **H01Q 5/30** (2015.01); **H01Q 5/364** (2015.01); **H01Q 9/0457** (2013.01); **H01Q 9/42** (2013.01); **H01Q 13/10** (2013.01)

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

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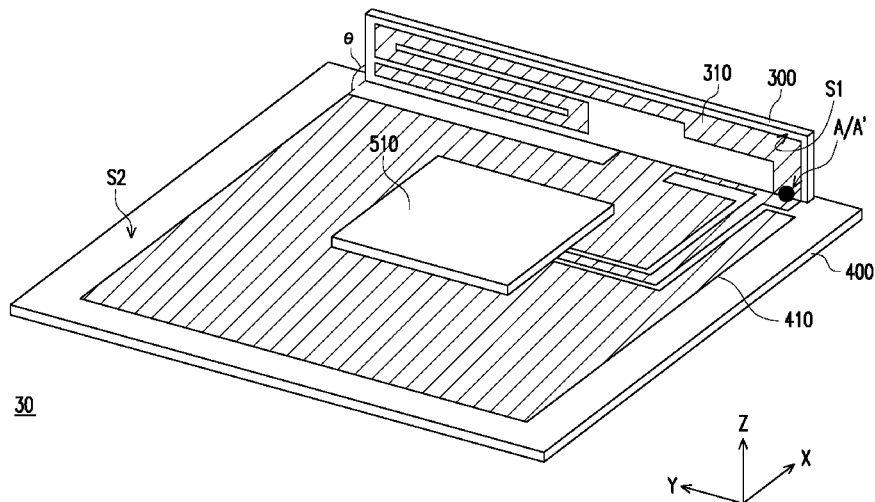
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Primary Examiner — Howard Williams
(74) *Attorney, Agent, or Firm* — JCIPRNET

(57) **ABSTRACT**

An antenna device including an antenna radiator and a feed line layer is provided. The antenna radiator is disposed on a first surface of a detachable substrate. The antenna radiator receives a microwave signal of at least one frequency band. The feed line layer is disposed on a second surface of a control circuit board. The feed line layer includes a signal feed line. The signal feed line is coupled to the antenna radiator through a connection point. The connection point is located on one side of the control circuit board. The detachable substrate and the control circuit board are arranged to have an angle between the first surface and the second surface. In addition, an electronic apparatus is also provided.

10 Claims, 4 Drawing Sheets





US010490902B2

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

(10) **Patent No.:** **US 10,490,902 B2**
(45) **Date of Patent:** **Nov. 26, 2019**

(54) **MOBILE DEVICE**

H01Q 1/2266; H01Q 1/2291; H01Q 1/243; H01Q 1/38; H01Q 1/48; H01Q 13/106; H01Q 21/28; H01Q 1/2258

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

See application file for complete search history.

(72) Inventors: **Ming-Ching Yen**, New Taipei (TW);
Kun-Sheng Chang, New Taipei (TW);
Chien-Wen Chen, New Taipei (TW);
Ching-Chi Lin, New Taipei (TW)

(56) **References Cited**

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

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343/725

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

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(21) Appl. No.: **15/886,026**

TW 201703350 A 1/2017

(22) Filed: **Feb. 1, 2018**

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(65) **Prior Publication Data**

US 2019/0006764 A1 Jan. 3, 2019

Chinese language office action dated Jun. 28, 2018, issued in application No. TW 106121976.

(30) **Foreign Application Priority Data**

Jun. 30, 2017 (TW) 106121976 A

Primary Examiner — Daniel Munoz

Assistant Examiner — Bamidele A Jegede

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

(51) **Int. Cl.**

H01Q 1/36 (2006.01)
H01Q 13/10 (2006.01)

(Continued)

(57) **ABSTRACT**

A mobile device includes a metal mechanism element, a ground plane, a feeding element, a parasitic element, and a dielectric substrate. The metal mechanism element has a slot. The ground plane is coupled to the metal mechanism element. The feeding element is coupled to a signal source. The feeding element extends across the slot. The parasitic element is coupled to the ground plane. The parasitic element extends across the slot. The ground plane, the feeding element, and the parasitic element are disposed on the dielectric substrate. An antenna structure is formed by the feeding element, the parasitic element, and the slot of the metal mechanism element.

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

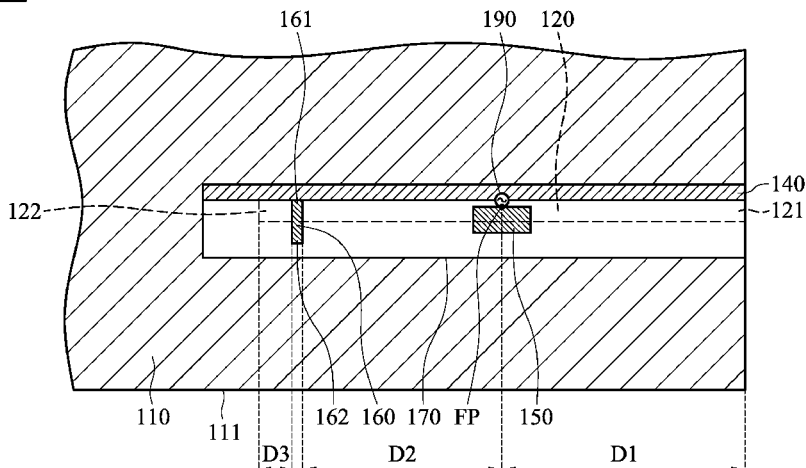
CPC **H01Q 13/10** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 1/2291** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/342** (2015.01); **H01Q 5/378** (2015.01); **H01Q 13/106** (2013.01); **H01Q 21/28** (2013.01); **H01Q 1/2258** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 13/10; H01Q 5/342; H01Q 5/378;

9 Claims, 8 Drawing Sheets

100



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

(10) **Patent No.:** **US 10,490,909 B2**
(45) **Date of Patent:** **Nov. 26, 2019**

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

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

(72) Inventors: **Dong-Ryul Shin**, Daegu (KR); **Min Sakong**, Gumi-si (KR); **Joon-Bo Park**, Busan (KR); **Byung-Chan Jang**, Gumi-si (KR); **Soo-Young Jang**, Daegu (KR); **Jin-Woo Jung**, 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.: **15/836,123**

(22) Filed: **Dec. 8, 2017**

(65) **Prior Publication Data**
US 2018/0102596 A1 Apr. 12, 2018

Related U.S. Application Data
(63) Continuation of application No. 14/878,468, filed on Oct. 8, 2015, now Pat. No. 9,871,304.

(30) **Foreign Application Priority Data**
Oct. 17, 2014 (KR) 10-2014-0140649

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

(52) **U.S. Cl.**
CPC **H01Q 21/30** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/364** (2015.01); **H01Q 13/10** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 21/30; H01Q 13/10; H01Q 5/364
See application file for complete search history.

(56) **References Cited**
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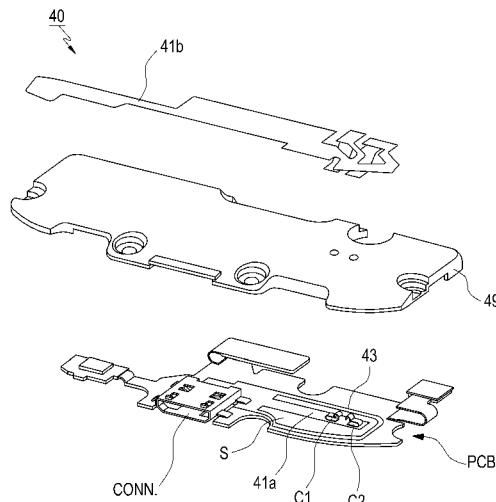
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Primary Examiner — Dieu Hien T Duong
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**
An antenna device and an electronic device including the same are provided. The antenna device includes a first radiator in which a slot is formed, a second radiator, at least a portion of which is disposed in the slot, and a feeder configured to feed the same electricity to the first radiator and the second radiator. The antenna device may have many resonance frequencies in the same installation space, allowing efficient use of the internal space of the electronic device. Moreover, the antenna device and the electronic device including the same may be implemented variously according to various embodiments.

10 Claims, 8 Drawing Sheets



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

(10) **Patent No.:** **US 10,498,010 B2**
(45) **Date of Patent:** **Dec. 3, 2019**

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

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

(72) Inventors: **Yen-Hui Lin**, New Taipei (TW);
Yun-Jian Chang, New Taipei (TW);
Jung-Chin 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 203 days.

(21) Appl. No.: **15/655,892**

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

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 62/364,880, filed on Jul. 21, 2016.

(30) **Foreign Application Priority Data**

Jun. 30, 2017 (CN) 2017 1 0526451

(51) **Int. Cl.**

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H01Q 1/52 (2006.01)

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

CPC **H01Q 1/242** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/521** (2013.01);

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(58) **Field of Classification Search**

CPC H01Q 1/242; H01Q 1/243; H01Q 5/35; H01Q 21/28; H01Q 9/42; H01Q 5/378;
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Primary Examiner — Jessica Han

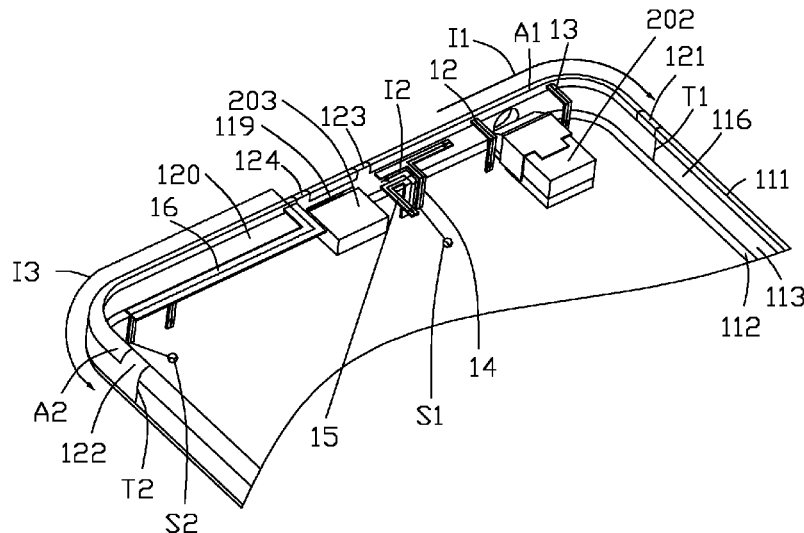
Assistant Examiner — Awat M Salih

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

(57) **ABSTRACT**

An antenna structure includes a metal housing, a first ground portion, a second ground portion, a first feed source, and a coupling portion. The metal housing includes a front frame, a backboard, and a side frame. The side frame defines a slot and the front frame defines a first groove and a first gap. The slot, the first groove, and the first gap separate a first antenna section from the metal housing. The first ground portion and the second ground portion are both electrically connected to the first antenna section and grounded. One end of the coupling portion is electrically connected to the first feed source. The coupling portion is spaced apart from the first antenna section and current from the first feed source is coupled to the first antenna section through the coupling portion.

33 Claims, 58 Drawing Sheets





US010498013B2

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

(10) **Patent No.:** **US 10,498,013 B2**
(45) **Date of Patent:** **Dec. 3, 2019**

(54) **ANTENNA ARRANGEMENT FOR AN ELECTRONIC DEVICE**

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

(72) Inventors: **Guozhong Ma**, Beijing (CN); **Anrong Zhang**, Beijing (CN); **Jie Zhang**, Beijing (CN); **Wei Wang**, Beijing (CN)

(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 0 days.

(21) Appl. No.: **15/751,149**

(22) PCT Filed: **Jul. 18, 2016**

(86) PCT No.: **PCT/US2016/042698**

§ 371 (c)(1),
(2) Date: **Feb. 7, 2018**

(87) PCT Pub. No.: **WO2017/027167**

PCT Pub. Date: **Feb. 16, 2017**

(65) **Prior Publication Data**

US 2018/0233807 A1 Aug. 16, 2018

(30) **Foreign Application Priority Data**

Aug. 7, 2015 (CN) 2015 1 0484994

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 1/48 (2006.01)

(Continued)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/521** (2013.01); **H01Q 1/523** (2013.01);

(Continued)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

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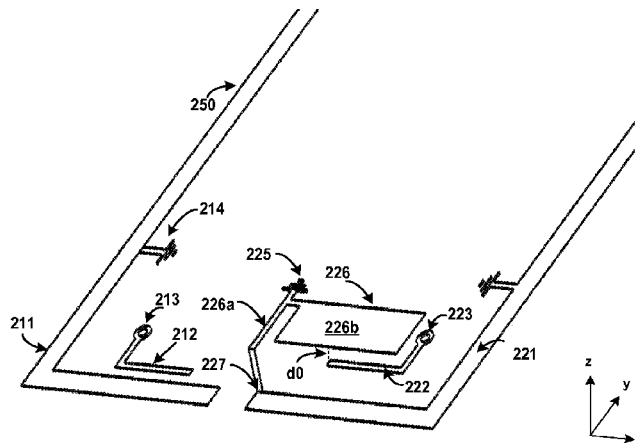
Primary Examiner — Trinh V Dinh

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

(57) **ABSTRACT**

The subject matter described herein relates to an antenna arrangement, an electronic device and a method for manufacturing the antenna arrangement. In one implementation, the antenna arrangement comprises a first antenna and a second antenna. The first antenna includes a first metal section connected to a first grounding point and a first initial radiator for feeding first radiations to the first metal section. The second antenna includes a second metal section connected to a second grounding point and a second initial radiator for feeding second radiations to the second metal section. The first and second metal sections are integral parts of a housing of the electronic device and separated by an opening. The second metal section is further connected to a third grounding point to provide isolation between the two

(Continued)





US010498031B2

(12) **United States Patent**
Gu

(10) **Patent No.:** **US 10,498,031 B2**
(45) **Date of Patent:** **Dec. 3, 2019**

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

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

(72) Inventor: **Haichuan Gu, 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 14 days.

(21) Appl. No.: **16/057,947**

(22) Filed: **Aug. 8, 2018**

(65) **Prior Publication Data**

US 2019/0207310 A1 Jul. 4, 2019

(30) **Foreign Application Priority Data**

Dec. 29, 2017 (CN) 2017 1 1478842

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 5/335 (2015.01)
H01Q 13/16 (2006.01)
H01Q 1/22 (2006.01)

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

CPC **H01Q 5/335** (2015.01); **H01Q 1/2291** (2013.01); **H01Q 1/243** (2013.01); **H01Q 13/16** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/335; H01Q 1/243; H01Q 1/2291; H01Q 13/16

See application file for complete search history.

(56) **References Cited**

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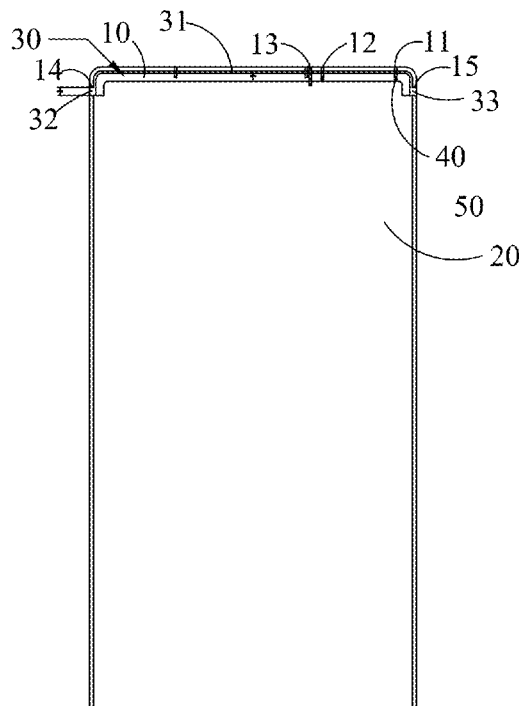
Primary Examiner — Hoang V Nguyen

(74) *Attorney, Agent, or Firm* — IPro, PLLC; Na Xu

(57) **ABSTRACT**

The antenna system includes: an upper frame, including a feeding point, a ground point, and a connection ground, wherein the ground point is arranged between the feeding point and the connection ground; system ground; feed source; matching network, including a first-order band elimination filter and a first capacitor that are connected in series; and first inductor. The upper frame is disposed at one side periphery of the system ground, and a clearance region is formed between the system ground and the upper frame. The feed source is connected to the feeding point through the matching network, the ground point is connected to the system ground through the first inductor, and the connection ground is connected to the system ground, so as to form a GPS antenna, a WIFI 2.4G antenna and a WIFI 5G antenna.

18 Claims, 6 Drawing Sheets





US010498032B2

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

(10) **Patent No.:** **US 10,498,032 B2**
(45) **Date of Patent:** **Dec. 3, 2019**

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

(71) Applicant: **Xiaomi Inc.**, Haidian District, Beijing (CN)

(72) Inventors: **Wei Kuang**, Beijing (CN); **Youquan Su**, Beijing (CN); **Wendong Liu**, Beijing (CN)

(73) Assignee: **XIAOMI INC.**, Beijing (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 385 days.

(21) Appl. No.: **15/385,076**

(22) Filed: **Dec. 20, 2016**

(65) **Prior Publication Data**

US 2017/0187112 A1 Jun. 29, 2017

(30) **Foreign Application Priority Data**

Dec. 26, 2015 (CN) 2015 1 0997796

(51) **Int. Cl.**
H01Q 5/35 (2015.01)
H01Q 1/48 (2006.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/35** (2015.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/35
See application file for complete search history.

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Extended European Search Report issued in corresponding EP Application No. 16205072.8, dated Apr. 28, 2017, 10 pages.

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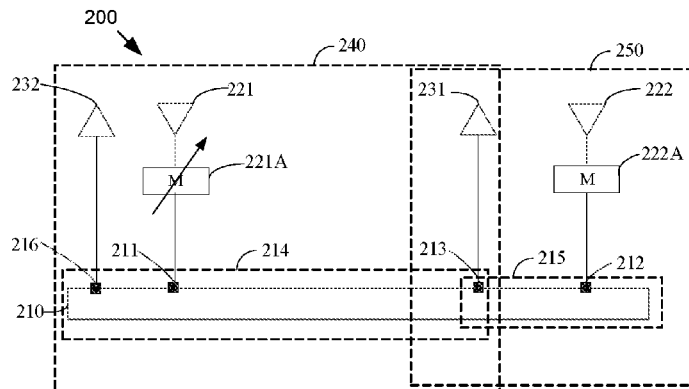
Primary Examiner — Jessica Han
Assistant Examiner — Amal Patel

(74) *Attorney, Agent, or Firm* — Arch & Lake LLP

(57) **ABSTRACT**

An antenna and an electronic device are disclosed, which relates to an antenna. The antenna component includes an antenna body, two feed circuits, and at least one ground circuit. The two feed circuits are connected to the antenna body through respective feed points. The at least one ground circuit is connected to the antenna body through respective one of ground points, and at least one of the ground points is located between the two feed points.

12 Claims, 5 Drawing Sheets





US010498041B1

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

(10) **Patent No.:** **US 10,498,041 B1**
(45) **Date of Patent:** **Dec. 3, 2019**

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

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

(72) Inventors: **Hsieh-Chih Lin**, New Taipei (TW);
Yu-Chia Chang, New Taipei (TW);
Wan Chu Wei, New Taipei (TW);
Jung-Chin Hsieh, New Taipei (TW);
Wen-Chieh Wu, New Taipei (TW)

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(73) Assignee: **Wistron Corp.**, New Taipei (TW)

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

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(21) Appl. No.: **16/162,310**

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

Primary Examiner — Omoniyi Obayanju

(30) **Foreign Application Priority Data**

Jul. 6, 2018 (TW) 107123470 A

(57) **ABSTRACT**

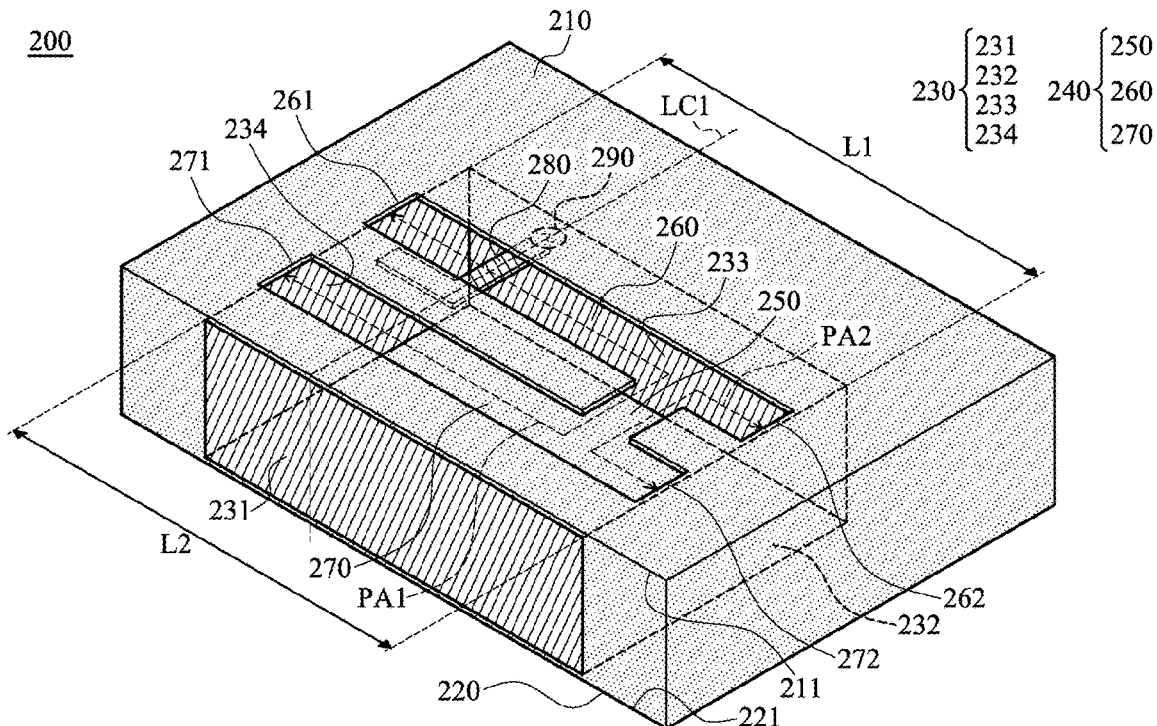
(51) **Int. Cl.**
H04W 4/00 (2018.01)
H01Q 13/16 (2006.01)
H04M 1/02 (2006.01)

A mobile device includes a host upper cover, a host lower cover, a metal cavity structure, an H-shaped slot antenna, and a feeding element. The metal cavity structure is coupled between the host upper cover and the host lower cover. The H-shaped slot antenna is formed on the host upper cover, the host lower cover, the metal cavity structure, the host upper cover and the metal cavity structure, or the host lower cover and the metal cavity structure. The feeding element is coupled to a signal source. The feeding element is configured to excite the H-shaped slot antenna.

(52) **U.S. Cl.**
CPC **H01Q 13/16** (2013.01); **H04M 1/026** (2013.01)

17 Claims, 22 Drawing Sheets

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





US010498046B2

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

(10) **Patent No.:** **US 10,498,046 B2**
(45) **Date of Patent:** **Dec. 3, 2019**

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

(58) **Field of Classification Search**
CPC H01Q 21/065; H01Q 21/28; H01Q 9/40
See application file for complete search history.

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

(56) **References Cited**

(72) Inventors: **Masao Teshima**, Tokyo (JP); **Akihiro Tsujimura**, Tokyo (JP)

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

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

(Continued)

(21) Appl. No.: **16/298,858**

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

JP	2005-322972	A	11/2005
JP	2010-074344	A	4/2010

(65) **Prior Publication Data**

US 2019/0207324 A1 Jul. 4, 2019

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Related U.S. Application Data

Primary Examiner — Dameon E Levi

Assistant Examiner — Ab Salam Alkassim, Jr.

(63) Continuation of application No. 15/019,018, filed on Feb. 9, 2016, now Pat. No. 10,270,186.

(74) *Attorney, Agent, or Firm* — Foley & Lardner LLP

(60) Provisional application No. 62/212,140, filed on Aug. 31, 2015.

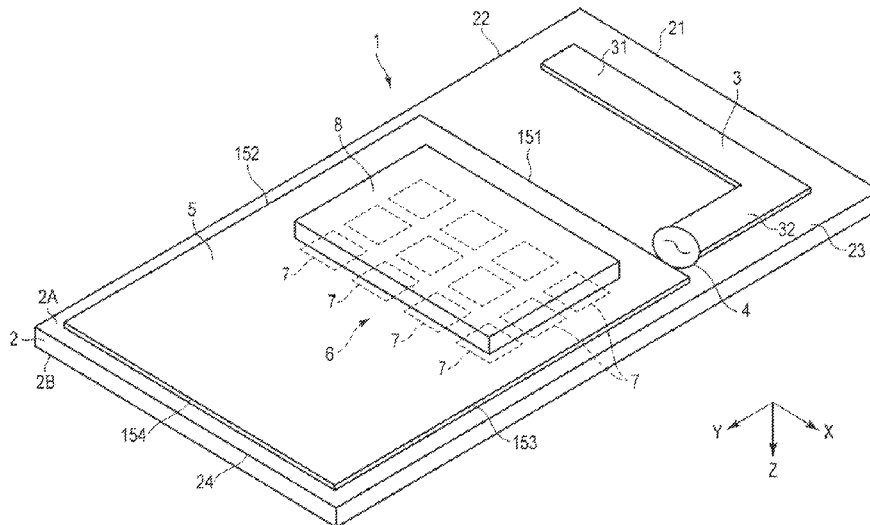
(57) **ABSTRACT**

(51) **Int. Cl.**
H01Q 21/28 (2006.01)
H01Q 1/24 (2006.01)
H01Q 3/24 (2006.01)
H01Q 9/42 (2006.01)
H01Q 21/06 (2006.01)

According to one embodiment, an antenna module includes a substrate, a first antenna, an array antenna, and a radio frequency (RF) module. The first antenna includes a first radiation element arranged on the substrate and a first ground plane arranged on the substrate. The array antenna includes a plurality of second radiation elements arranged on the substrate. The substrate includes a first surface and a second surface. The first ground plane is arranged on at least the first surface of the substrate. The plurality of second radiation elements are arranged on the second surface of the substrate and opposed to the first ground plane via the substrate.

(52) **U.S. Cl.**
 CPC **H01Q 21/28** (2013.01); **H01Q 1/243** (2013.01); **H01Q 3/24** (2013.01); **H01Q 9/42** (2013.01); **H01Q 21/065** (2013.01)

10 Claims, 14 Drawing Sheets





US010505262B2

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

(10) **Patent No.:** **US 10,505,262 B2**
(45) **Date of Patent:** **Dec. 10, 2019**

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

USPC 343/845, 700 MS
See application file for complete search history.

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

(56) **References Cited**

(72) Inventors: **Chien-Chang Liu**, New Taipei (TW);
Ting-Chih Tseng, New Taipei (TW);
Kun-Lin Sung, New Taipei (TW);
Hsi-Chieh Chen, New Taipei (TW);
Peng-Yu Lai, New Taipei (TW)

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2015/0200457 A1 *	7/2015	Chan	H01Q 9/40 343/700 MS

(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.

(Continued)

(21) Appl. No.: **15/835,401**

FOREIGN PATENT DOCUMENTS

(22) Filed: **Dec. 7, 2017**

CN	101414706 A	4/2009
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(65) **Prior Publication Data**

US 2018/0183139 A1 Jun. 28, 2018

(Continued)

Primary Examiner — Peguy Jean Pierre

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

(30) **Foreign Application Priority Data**

Dec. 23, 2016 (CN) 2016 1 1206378

(57) **ABSTRACT**

An antenna structure includes a first antenna with a first feed point feeding current, a first radiating portion, a second radiating portion, and a first ground point. The first radiating portion is electrically connected to the first feed point and receives radiation signals in a first frequency band. The second radiating portion is electrically connected to the first feed point and receives and sends radiation signals in a second frequency band. The first ground point is spaced apart from the first feed point and is electrically connected to the second radiating portion.

(51) **Int. Cl.**

H01Q 1/48	(2006.01)
H01Q 1/24	(2006.01)
H01Q 5/35	(2015.01)

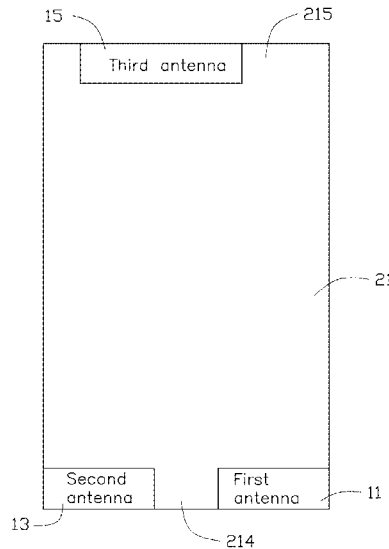
(52) **U.S. Cl.**

CPC **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/35** (2015.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 5/35; H01Q 5/731

20 Claims, 12 Drawing Sheets



(12) **United States Patent**
Anguera Pros et al.

(10) **Patent No.:** **US 10,505,272 B2**
(45) **Date of Patent:** **Dec. 10, 2019**

(54) **MULTI-STRUCTURE ANTENNA FOR MULTIBAND OPERATION**

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

(72) Inventors: **Jaume Anguera Pros**, Vinaros (ES); **Aurora Andujar Linares**, 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 0 days.

(21) Appl. No.: **16/433,744**

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

(65) **Prior Publication Data**

US 2019/0288386 A1 Sep. 19, 2019

Related U.S. Application Data

(63) Continuation of application No. 15/415,557, filed on Jan. 25, 2017, now Pat. No. 10,347,983.
(Continued)

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

(52) **U.S. Cl.**
CPC **H01Q 1/48** (2013.01); **H01Q 1/24** (2013.01); **H01Q 1/241** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01); **H01Q 5/50** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 1/48; H01Q 1/243; H01Q 1/241; H01Q 1/24; H01Q 5/371; H01Q 5/50
See application file for complete search history.

(56) **References Cited**

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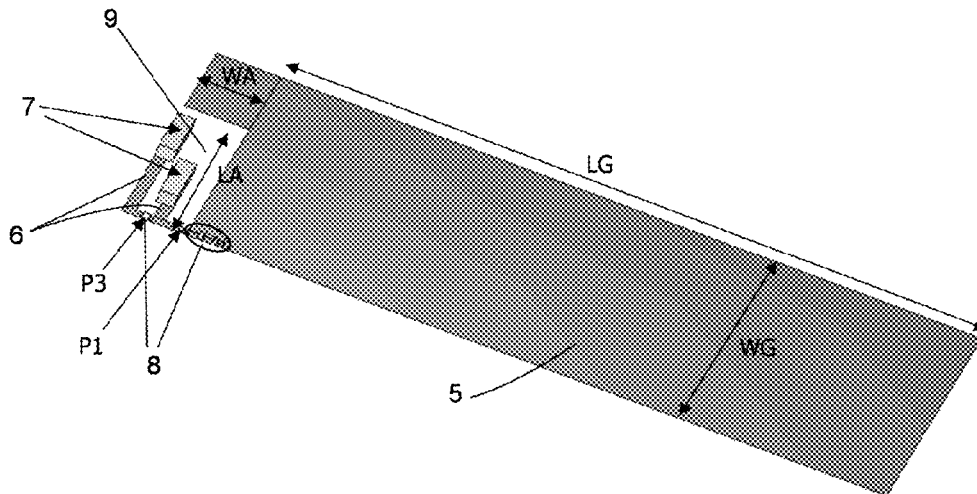
Primary Examiner — Hai V Tran

(74) *Attorney, Agent, or Firm* — Edell, Shapiro & Finnan, LLC.

(57) **ABSTRACT**

A wireless device operates in multiple frequency bands via a multi-structure arrangement that optimizes the electromagnetic performance at each frequency range of operation. The device includes a radiating system comprising a ground plane layer, a multi-structure antenna system that comprises at least two structural branches and at least a radiation booster, and a radiofrequency system. The radiofrequency system comprises an element inserted in the branch structure, connected at a point within the structure. The radiofrequency system may include an additional matching network that fine tunes the impedance of the device to match all the frequency ranges of operation.

16 Claims, 5 Drawing Sheets





US010511079B2

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

(10) **Patent No.:** **US 10,511,079 B2**

(45) **Date of Patent:** **Dec. 17, 2019**

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

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

(72) Inventors: **Chien-Yi Wu**, Taipei (TW); **Ya-Jyun Li**, Taipei (TW); **Yu-Yi Chu**, Taipei (TW); **Chao-Hsu Wu**, Taipei (TW); **Ching-Hsiang Ko**, Taipei (TW); **Chia-Chi Chang**, 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 138 days.

(21) Appl. No.: **15/895,870**

(22) Filed: **Feb. 13, 2018**

(65) **Prior Publication Data**
US 2018/0331415 A1 Nov. 15, 2018

Related U.S. Application Data
(60) Provisional application No. 62/503,676, filed on May 9, 2017.

(30) **Foreign Application Priority Data**
Jul. 3, 2017 (TW) 106122207 A

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 1/42 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/2258** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 1/243** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/2258; H01Q 1/2266; H01Q 1/48; H01Q 1/38; H01Q 1/243; H01Q 9/42; H01Q 13/085; H01Q 5/364; H01Q 1/42
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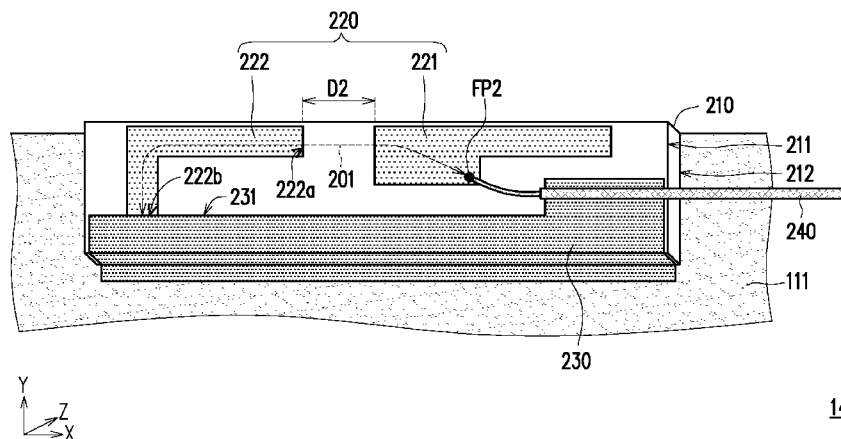
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Primary Examiner — Khai M Nguyen
(74) *Attorney, Agent, or Firm* — J. C. Patents

(57) **ABSTRACT**
An antenna structure including a conductive housing, a substrate, a ground element and a radiation element is provided. The conductive housing includes an open slot and a conductive segment adjacent to each other. The radiation element is disposed on a first surface of the substrate and is electrically connected to the ground element. A second surface of the substrate faces the open slot and the conductive segment. The ground element is electrically connected to the conductive housing. The radiation element has a feeding point and forms a first path. An orthogonal projection of the radiation element on the conductive housing is partially overlapping with the conductive segment such that the conductive housing and the radiation element form a
(Continued)



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

(10) **Patent No.:** **US 10,511,081 B2**
(45) **Date of Patent:** **Dec. 17, 2019**

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

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

(72) Inventors: **Yi-Ting Chen**, New Taipei (TW);
Yen-Jung Tseng, New Taipei (TW);
Tze-Hsuan 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 203 days.

(21) Appl. No.: **15/655,894**

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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H01Q 1/48 (2006.01)

(Continued)

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

CPC **H01Q 1/242** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/50** (2015.01); **H01Q 13/18** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC H01Q 1/242; H01Q 1/243; H01Q 9/42; H01Q 21/28; H01Q 5/371; H01Q 1/48;

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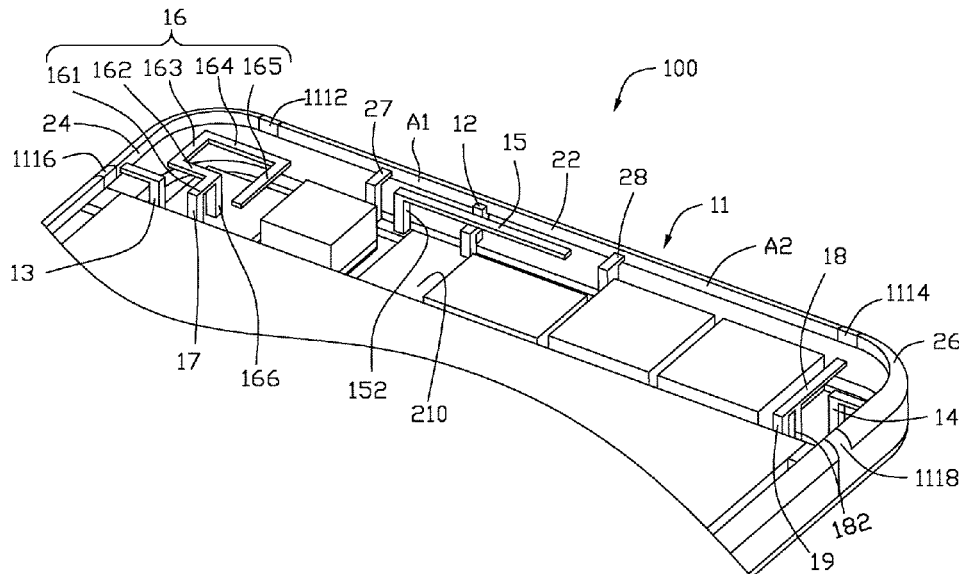
Assistant Examiner — Awat M Salih

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

(57) **ABSTRACT**

An antenna structure includes a metallic member, a first feed portion, a first ground portion and a second ground portion. The metallic member includes a front frame, a backboard, and a side frame. The side frame defines a slot. The front frame defines a first gap and a second gap communicating with the slot and extending across the front frame. A portion of the front frame between the first gap and the second gap forms a first radiating section. Current enters the first radiating section from the first feed portion and flows through the first radiating section and towards the first gap and the second gap to generate radiation signals in a first frequency band and a second frequency band. The frequencies of the first frequency band are higher than the frequencies of the second frequency band. A wireless communication device using the antenna structure is provided.

20 Claims, 26 Drawing Sheets



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

(10) **Patent No.:** **US 10,511,083 B2**
(45) **Date of Patent:** **Dec. 17, 2019**

(54) **ANTENNAS HAVING SYMMETRICAL SWITCHING ARCHITECTURE**

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

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(21) Appl. No.: **15/429,597**

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

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

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H01Q 1/24 (2006.01)
H01Q 19/02 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 9/30** (2013.01); **H01Q 19/021** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/329; H01Q 5/328
See application file for complete search history.

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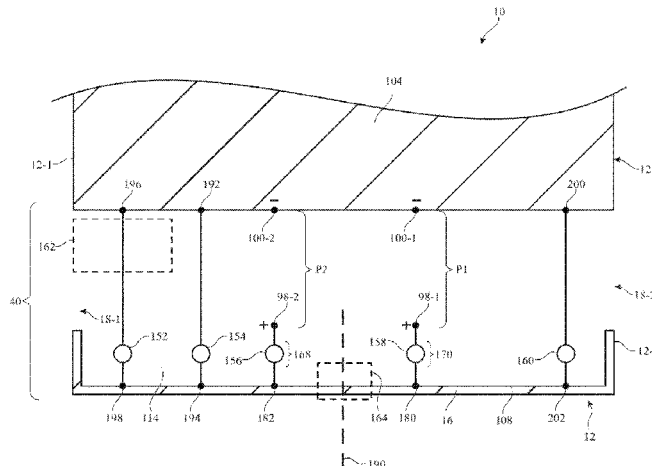
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Primary Examiner — Graham P Smith
(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; Tianyi He; Michael H. Lyons

(57) **ABSTRACT**

An electronic device may include wireless circuitry with antennas. An antenna resonating element arm for an antenna may be formed from conductive housing structures running along the edges of the device. The antenna may have first and second antenna feeds and multiple adjustable components that bridge a slot between the antenna resonating element and an antenna ground. Control circuitry may control the adjustable components and selectively activate one of the first and second feeds at a given time to place the antenna in first, second, or third operating modes. The control circuitry may determine which operating mode to use based on information indicative of the operating environment of the device. By switching between the operating modes, the control circuitry may shift current hot spots across the length of the resonating element arm to ensure

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

(10) **Patent No.:** **US 10,511,084 B2**
(45) **Date of Patent:** ***Dec. 17, 2019**

(54) **ANTENNA SYSTEM WITH ANTENNA SWAPPING AND ANTENNA TUNING**

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

(72) Inventors: **Ruben Caballero**, San Jose, CA (US); **Mattia Pascolini**, San Francisco, CA (US); **Mohit Narang**, Cupertino, CA (US); **Matt A. Mow**, Los Altos, CA (US); **Robert W. Schlub**, Cupertino, CA (US)

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

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This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/030,726**

(22) Filed: **Jul. 9, 2018**

(65) **Prior Publication Data**

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Related U.S. Application Data

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H01Q 1/24 (2006.01)
(Continued)

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

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/38; H01Q 21/28; H01Q 1/44

See application file for complete search history.

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Primary Examiner — Graham P Smith

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

(57) **ABSTRACT**

Electronic devices may be provided that contain wireless communications circuitry. The wireless communications circuitry may include radio-frequency transceiver circuitry and first and second antennas. An electronic device may include a housing. The first antenna may be located at an upper end of the housing and the second antenna may be located at a lower end of the housing. A peripheral conductive member may run around the edges of the housing and may be used in forming the first and second antennas. The radio-frequency transceiver circuitry may have a transmit-receive port and a receive port. Switching circuitry may connect the first antenna to the transmit-receive port and the second antenna to the receiver port or may connect the first antenna

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