

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

(10) **Patent No.:** **US 10,079,427 B2**
(45) **Date of Patent:** **Sep. 18, 2018**

(54) **ANTENNA WITH SLITLESS CLOSED FRAME AND WIRELESS COMMUNICATIONS DEVICE**

(58) **Field of Classification Search**
CPC H01Q 13/106; H01Q 13/10; H01Q 13/103
See application file for complete search history.

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

(56) **References Cited**

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(72) Inventors: **Jiaming Wang**, Shanghai (CN); **Rui Zhang**, Shanghai (CN); **Xiaoli Yang**, Shanghai (CN); **Meng Hou**, Shanghai (CN); **Xuefei Zhang**, Shenzhen (CN)

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

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 93 days.

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(21) Appl. No.: **15/118,276**

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(22) PCT Filed: **Jun. 30, 2014**

Foreign Communication From a Counterpart Application, Korean Application No. 10-2016-7020655, Korean Office Action dated Jul. 14, 2017, 6 pages.

(86) PCT No.: **PCT/CN2014/081224**

(Continued)

§ 371 (c)(1),

(2) Date: **Aug. 11, 2016**

Primary Examiner — Graham Smith

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

(87) PCT Pub. No.: **WO2016/000155**

(57) **ABSTRACT**

PCT Pub. Date: **Jan. 7, 2016**

An antenna apparatus and a wireless communications device, where the antenna apparatus includes a feeding part, a grounding part, and a closed frame, where the closed frame encircles a main body of the wireless communications device. The feeding part and the grounding part are electrically connected to the closed frame, and the closed frame, the feeding part, and the grounding part form a first current loop and a second current loop, where resonance is generated between the first current loop and the second current loop. There is no need to dispose a slit on the closed frame of the wireless communications device that uses a metal appearance, and a position of the feeding part of a radio frequency feeder is used, to mitigate impact, of a closed environment caused by not disposing the slit on the closed

(Continued)

(65) **Prior Publication Data**

US 2017/0005394 A1 Jan. 5, 2017

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

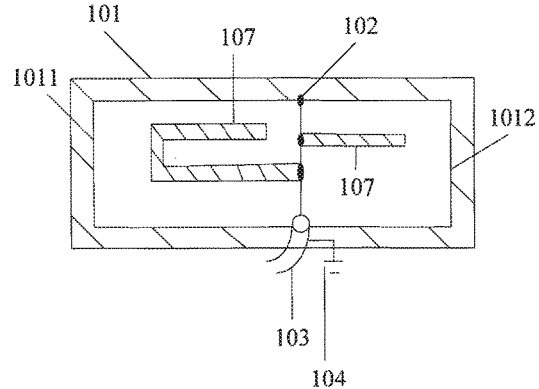
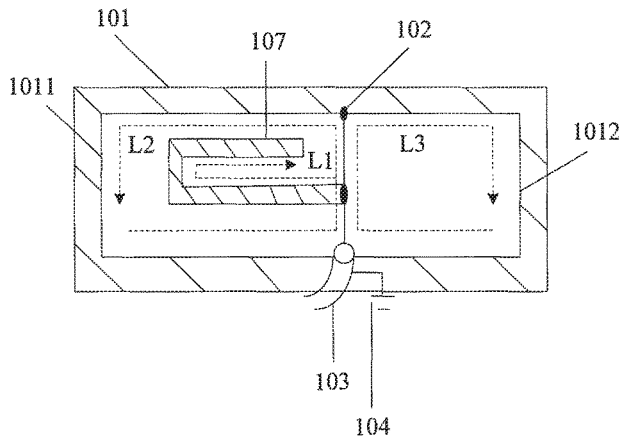
H01Q 1/48 (2006.01)

(Continued)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/357** (2015.01); **H01Q 5/371** (2015.01);

(Continued)





US010084234B2

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

(10) **Patent No.:** **US 10,084,234 B2**
(45) **Date of Patent:** **Sep. 25, 2018**

(54) **ELECTRONIC DEVICE**

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

(72) Inventors: **Shasha Hu**, Guangdong (CN); **Tianping Liang**, Guangdong (CN); **Liang Gu**, Guangdong (CN)

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

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

(21) Appl. No.: **15/965,549**

(22) Filed: **Apr. 27, 2018**

(65) **Prior Publication Data**
US 2018/0248253 A1 Aug. 30, 2018

Related U.S. Application Data

(63) Continuation of application No. 15/753,330, filed as application No. PCT/CN2016/085548 on Jun. 13, 2016.

(30) **Foreign Application Priority Data**

Mar. 18, 2016 (CN) 2016 1 0161287
Mar. 18, 2016 (CN) 2016 1 0161288
Apr. 20, 2016 (CN) 2016 1 0248724

(51) **Int. Cl.**
H01Q 5/321 (2015.01)
H01Q 1/44 (2006.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/321** (2015.01); **H01Q 1/243** (2013.01); **H01Q 1/44** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/22; H01Q 1/2208; H01Q 1/2216; H01Q 1/2225; H01Q 1/2258;
(Continued)

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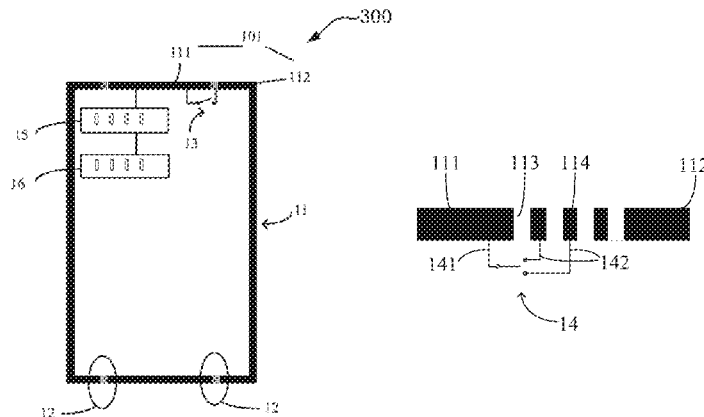
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Primary Examiner — Robert Karacsony
(74) *Attorney, Agent, or Firm* — Lathrop Gage L.L.P.

(57) **ABSTRACT**

The present disclosure provides an electronic device including a metal housing and at least one switch. The metal housing includes a peripheral frame provided with at least one micro seam band, the peripheral frame is partitioned by the at least one micro seam band to form at least one frame body, the micro seam band is formed by at least two micro seams, and a metal strip is provided between two adjacent micro seams. The switch includes a first end and a second end, the first end is electrically coupled to the frame body, and the second end is electrically coupled to the metal strip. The at least one frame body is an independent antenna. The switch includes a plurality of second ends coupled to different metal strips correspondingly, and a variety of low-frequency bandwidths of the antenna is expanded through different closed or open states of the switch.

16 Claims, 19 Drawing Sheets



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

(10) **Patent No.:** **US 10,084,235 B2**
(45) **Date of Patent:** ***Sep. 25, 2018**

(54) **FEEDING MATCHING APPARATUS OF MULTIBAND ANTENNA, MULTIBAND ANTENNA, AND RADIO COMMUNICATION DEVICE**

(58) **Field of Classification Search**
CPC H04B 1/18; H04B 1/0458; H04B 1/0057; H01Q 5/314; H01Q 5/335; H01Q 9/04;
(Continued)

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

(72) Inventors: **Yuanpeng Li**, Beijing (CN); **Hanyang Wang**, Reading (GB); **Yafang Yu**, Beijing (CN); **Meng Hou**, Shanghai (CN)

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(73) Assignee: **Huawei Device (Dongguan) Co., Ltd.**, Dongguan (CN)

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

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U.S. Appl. No. 14/143,367, filed Dec. 30, 2013.

Primary Examiner — Huedung Mancuso

(21) Appl. No.: **15/674,039**

(74) *Attorney, Agent, or Firm* — Leydig, Voit & Mayer, Ltd.

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

(65) **Prior Publication Data**

(57) **ABSTRACT**

US 2017/0338560 A1 Nov. 23, 2017

The present disclosure relates to the field of antenna technologies and discloses a feeding matching apparatus of a multiband antenna, a multiband antenna, and a radio communication device to improve a bandwidth and efficiency of a lower frequency band. The feeding matching apparatus of a multiband antenna includes: a grounding portion; a feeding portion connected to a signal source, where a signal of the signal source is input into the feeding portion; and two or more ground cable branches with different lengths, where one end of each ground cable branch is electrically connected to the feeding portion, the other end is electrically connected to the grounding portion, at least one ground cable branch is connected in series to a signal filtering component, and the signal filtering component is capable of preventing a signal lower than a frequency point corresponding to the signal filtering component from passing through it.

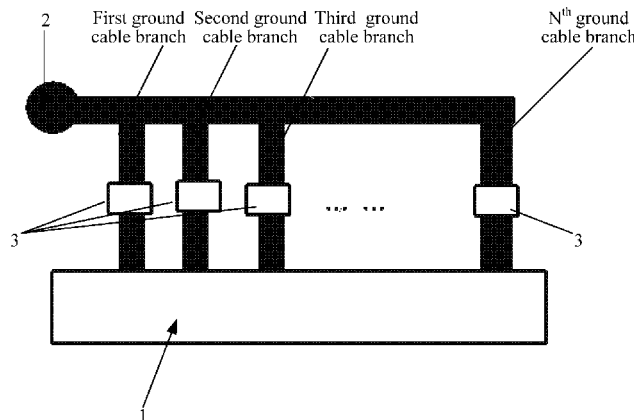
Related U.S. Application Data

(63) Continuation of application No. 15/229,829, filed on Aug. 5, 2016, now Pat. No. 9,761,942, which is a (Continued)

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 5/328 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/328** (2015.01); **H01Q 1/241** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/314** (2015.01);
(Continued)

20 Claims, 5 Drawing Sheets





US010084236B2

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

(10) **Patent No.:** **US 10,084,236 B2**

(45) **Date of Patent:** **Sep. 25, 2018**

(54) **TUNABLE ANTENNA AND TERMINAL**

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

(72) Inventors: **Bo Meng**, Shenzhen (CN); **Yi Fan**,
Shenzhen (CN); **Wanji An**, Shenzhen
(CN); **Hanyang Wang**, Shenzhen (CN);
Dongxing Tu, Shenzhen (CN); **Shuhui
Sun**, Shenzhen (CN)

(73) Assignee: **HUAWEI DEVICE (DONGGUAN)
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.: **15/038,132**

(22) PCT Filed: **Nov. 22, 2013**

(86) PCT No.: **PCT/CN2013/087702**

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(2) Date: **May 20, 2016**

(87) PCT Pub. No.: **WO2015/074251**

PCT Pub. Date: **May 28, 2015**

(65) **Prior Publication Data**

US 2016/0294060 A1 Oct. 6, 2016

(51) **Int. Cl.**

H01Q 7/00 (2006.01)

H01Q 5/328 (2015.01)

(Continued)

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

CPC **H01Q 7/005** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 5/328** (2015.01); **H01Q**
5/364 (2015.01); **H01Q 5/378** (2015.01);
H01Q 9/42 (2013.01)

(58) **Field of Classification Search**

CPC H01Q 7/005; H01Q 5/328; H01Q 5/364;
H01Q 5/371; H01Q 5/378; H01Q 5/385;
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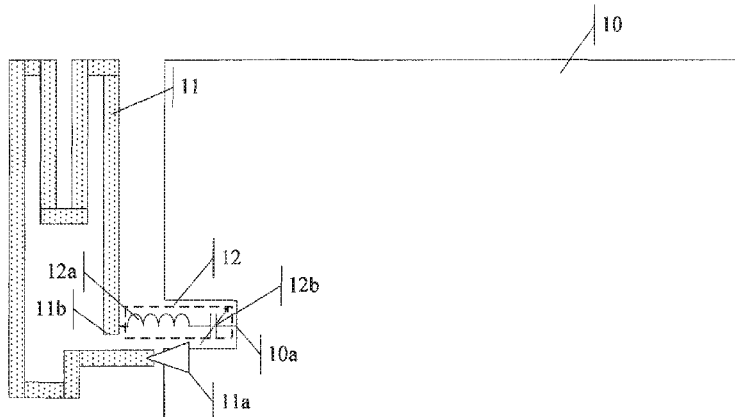
Primary Examiner — Robert Karacsony

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

(57) **ABSTRACT**

The present disclosure discloses a tunable antenna and a terminal. The tunable antenna includes a circuit board, an antenna body configured to transmit and receive a signal of a first frequency band and including a feed end and a ground pin, where the feed end is disposed on the circuit board, and an electrical tuning network, where a ground point disposed on the circuit board is connected to the ground pin of the antenna body by using the electrical tuning network, and the electrical tuning network includes an inductor and a first tunable capacitor with a tunable capacitance value, where a load value of the inductor is changed by tuning a first capacitance value of the first tunable capacitor, so that a first effective electrical length of the antenna body is changed.

14 Claims, 11 Drawing Sheets





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

(10) **Patent No.:** **US 10,090,581 B2**
(45) **Date of Patent:** **Oct. 2, 2018**

- (54) **MULTIPLE ANTENNA APPARATUS**
- (71) Applicant: **PEGATRON CORPORATION**, Taipei (TW)
- (72) Inventors: **Chien-Yi Wu**, Taipei (TW); **Chao-Hsu Wu**, Taipei (TW); **Yu-Yi Chu**, Taipei (TW); **Tse-Hsuan Wang**, Taipei (TW); **Shih-Keng Huang**, 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 0 days.

- (58) **Field of Classification Search**
CPC H04M 1/0202; H04M 1/026; H04B 1/04; H04B 1/3833; H04B 7/0404; H04B 7/0413
USPC 455/90.3, 552.1, 553.1, 575.1, 575.7; 343/845, 853
See application file for complete search history.

- (21) Appl. No.: **15/847,519**
- (22) Filed: **Dec. 19, 2017**
- (65) **Prior Publication Data**
US 2018/0191060 A1 Jul. 5, 2018

- (56) **References Cited**
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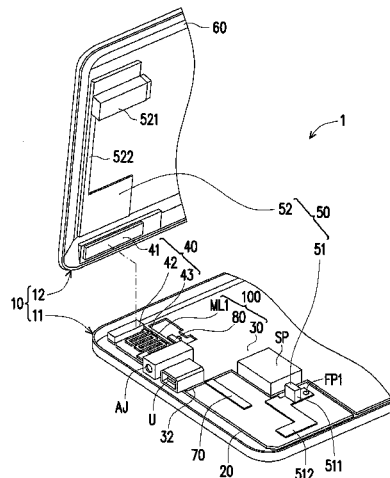
- (30) **Foreign Application Priority Data**
Jan. 5, 2017 (TW) 106100275 A

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"Office Action of Taiwan Counterpart Application", dated Apr. 19, 2018, p. 1-p. 7.
Primary Examiner — Quochien B Vuong
(74) *Attorney, Agent, or Firm* — J.C. Patents

- (51) **Int. Cl.**
H04M 1/00 (2006.01)
H01Q 1/24 (2006.01)
H01Q 13/10 (2006.01)
H01Q 5/35 (2015.01)
H01Q 1/48 (2006.01)
H04M 1/02 (2006.01)
H04B 1/401 (2015.01)
H04B 1/00 (2006.01)
- (52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/35** (2015.01); **H01Q 13/10** (2013.01); **H04M 1/0283** (2013.01); **H04B 1/0064** (2013.01); **H04B 1/401** (2013.01)

- (57) **ABSTRACT**
A multiple antenna apparatus is provided. A first feed antenna unit is shared for receiving and transmitting radio frequency (RF) signals corresponding to a bandwidth of a first resonance mode, so as to increase antenna configurable space of the multiple antenna apparatus, and thus a closed slot antenna formed by a wire, a ground plane and a radiation element is able to be configured in the multiple antenna apparatus to receive and transmit the RF signals corresponding to a second resonance mode.

15 Claims, 6 Drawing Sheets



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

(10) **Patent No.:** **US 10,090,907 B2**
(45) **Date of Patent:** **Oct. 2, 2018**

(54) **ANTENNA SWITCHING SYSTEM AND METHOD**

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

(72) Inventors: **Qiuliang Xu**, Shanghai (CN); **Liping Yang**, Shanghai (CN); **Changfeng Zhang**, Shanghai (CN); **Zhijun Chen**, Shanghai (CN)

(73) Assignee: **Huawei Device (Dongguan) 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.: **15/223,845**

(22) Filed: **Jul. 29, 2016**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. PCT/CN2014/072142, filed on Feb. 17, 2014.

(51) **Int. Cl.**
H01Q 5/378 (2015.01)
H04B 5/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H04B 7/0805** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 3/24** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H04B 1/005; H04B 5/00; H01Q 5/378
See application file for complete search history.

(56) **References Cited**

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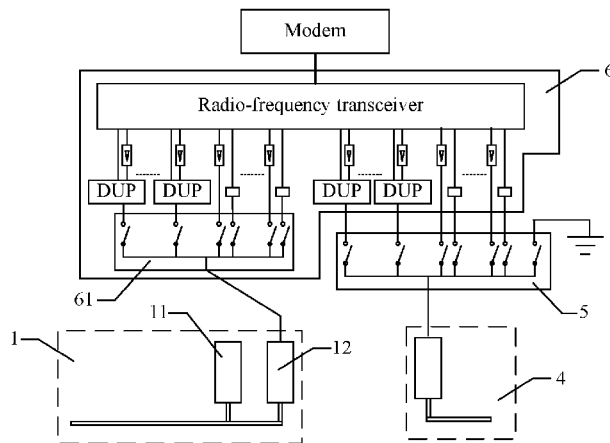
Primary Examiner — Cindy Trandai

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

(57) **ABSTRACT**

The present invention is applicable to the field of mobile terminals and provides an antenna switching system and method. The antenna switching system includes a radio-frequency transceiver circuit, a primary antenna, and a parasitic antenna, where the primary antenna is connected to the radio-frequency transceiver circuit, and further includes a switch circuit, configured to connect, when the parasitic antenna is used to receive or send a radio-frequency signal, the parasitic antenna and the radio-frequency transceiver circuit. If the parasitic antenna is grounded, the parasitic antenna may be configured to spread a spectrum. In addition, when carrier aggregation is needed, the parasitic antenna is connected to the radio-frequency transceiver circuit, so as to become an independent receive or transmit antenna.

20 Claims, 6 Drawing Sheets





US010096888B2

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

(10) **Patent No.:** **US 10,096,888 B2**
(45) **Date of Patent:** **Oct. 9, 2018**

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

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

(72) Inventors: **Jung-Ho Ahn**, Seoul (KR);
Seung-Hwan Kim, Seoul (KR);
Ho-Saeng Kim, Anyang-si (KR);
Joon-Ho Byun, Seongnam-si (KR)

(73) Assignee: **Samsung Electronics Co., Ltd.**,
Suwon-si (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 184 days.

(21) Appl. No.: **15/153,069**

(22) Filed: **May 12, 2016**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

May 27, 2015 (KR) 10-2015-0073582

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 1/42 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/378 (2015.01)
H01Q 1/48 (2006.01)
H01Q 9/04 (2006.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/42** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/378** (2015.01); **H01Q 9/0414** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/42; H01Q 9/42;
H01Q 1/48; H01Q 5/378

See application file for complete search history.

(56) **References Cited**

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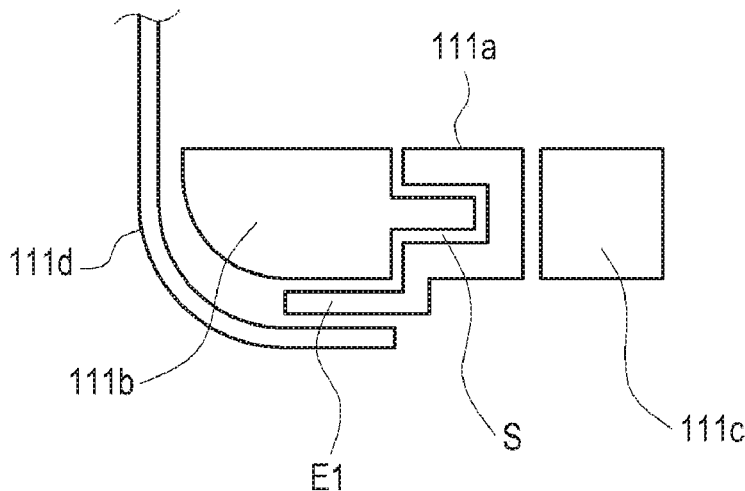
Primary Examiner — Dieu H Duong

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

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a front cover forming a front surface, a rear cover forming a rear surface, a sidewall at least partially enclosing a space formed between the front cover and the rear cover and at least partially formed of a conductive member, a display disposed in the space and including a screen region exposed through the front cover, a non-conductive structure disposed in adjacent to the sidewall or in contact with the sidewall in the space and including a first surface facing the front cover and a second surface facing the rear cover, a first antenna pattern overlapping the non-conductive structure and fed with electricity, a second antenna pattern overlapping the non-conductive structure and disposed adjacent to the first antenna pattern to form electromagnetic-field coupling with the first antenna pattern, and an integrated circuit chip feeding electricity to the first antenna pattern.

23 Claims, 11 Drawing Sheets





US010096889B2

(12) **United States Patent**
Yang

(10) **Patent No.:** **US 10,096,889 B2**

(45) **Date of Patent:** **Oct. 9, 2018**

(54) **MOBILE DEVICE**

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

(72) Inventor: **Chung-Wen Yang**, New Taipei (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 40 days.

(21) Appl. No.: **15/331,087**

(22) Filed: **Oct. 21, 2016**

(65) **Prior Publication Data**

US 2018/0062243 A1 Mar. 1, 2018

(30) **Foreign Application Priority Data**

Aug. 25, 2016 (TW) 105127217 A

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 1/48 (2006.01)

H01Q 1/36 (2006.01)

H01Q 1/22 (2006.01)

H01Q 5/385 (2015.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/2291** (2013.01); **H01Q 1/36** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/385** (2015.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 5/385
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Jessica Han

Assistant Examiner — Amal Patel

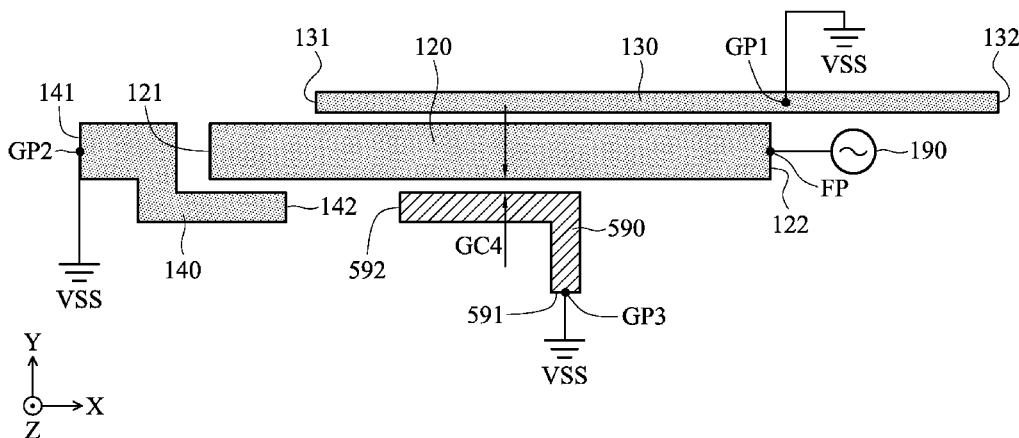
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

A mobile device includes an antenna structure. The antenna structure includes a main radiation element, a first parasitic element, and a second parasitic element. The main radiation element has a feeding point. The first parasitic element has a first grounding point. The first parasitic element is adjacent to the main radiation element, and the first grounding point is adjacent to the feeding point. The second parasitic element has a second grounding point. The second parasitic element is adjacent to an end of the main radiation element.

8 Claims, 7 Drawing Sheets

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(12) **United States Patent**
Wu

(10) **Patent No.:** **US 10,096,890 B2**
(45) **Date of Patent:** **Oct. 9, 2018**

(54) **ANTENNA MODULE**

(71) Applicant: **Jing Wu**, Shenzhen (CN)

(72) Inventor: **Jing Wu**, 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.: **15/417,118**

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

(65) **Prior Publication Data**
US 2017/0346161 A1 Nov. 30, 2017

(30) **Foreign Application Priority Data**
May 27, 2016 (CN) 2016 2 0498534 U

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/50 (2006.01)
H01Q 1/48 (2006.01)
H01Q 21/28 (2006.01)
H01Q 5/328 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/24** (2013.01); **H01Q 1/241** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/50** (2013.01); **H01Q 5/328** (2015.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/24; H01Q 1/241; H01Q 1/242; H01Q 1/243; H01Q 1/48; H01Q 1/50; H01Q 5/328; H01Q 21/28
See application file for complete search history.

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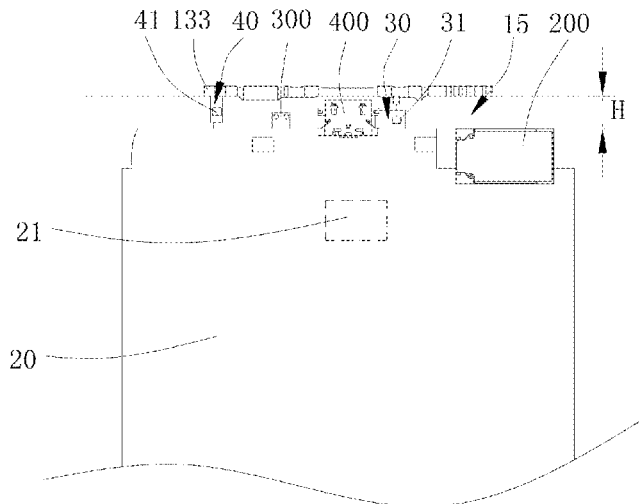
Primary Examiner — Hoang Nguyen

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

(57) **ABSTRACT**

The present disclosure provides an antenna module, including a metal housing having accommodating space and a circuit board accommodated in the accommodating space, the metal housing includes a metal back cover and a metal side wall, the metal side wall includes a side wall main body and a first radiator extending from an end of the side wall main body, a second radiator extending from another end of the side wall main body which is spaced with and arranged opposite to the first radiator, and a third radiator provided between the first radiator and the second radiator, a head-room region is formed between the third radiator and the circuit board. The present disclosure provides an antenna module having frequency bands of wireless signal and a good overall appearance.

9 Claims, 3 Drawing Sheets





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

(10) **Patent No.:** **US 10,103,423 B2**
(45) **Date of Patent:** **Oct. 16, 2018**

(54) **MODULAR STRUCTURAL AND FUNCTIONAL SUBASSEMBLIES**
(71) Applicant: **Apple Inc.**, Cupertino, CA (US)
(72) Inventors: **Daniel W. Jarvis**, Sunnyvale, CA (US); **Richard Hung Minh Dinh**, Santa Clara, CA (US); **Miguel C. Christophy**, San Francisco, CA (US); **Hao Xu**, Cupertino, CA (US); **Jayesh Nath**, Cupertino, CA (US); **Jared M. Kole**, San Jose, CA (US); **Mattia Pascolini**, Campbell, CA (US); **Ruben Caballero**, San Jose, CA (US); **Jennifer M. Edwards**, San Francisco, CA (US); **Peter I. Bevelacqua**, San Jose, CA (US); **Robert W. Schlub**, Cupertino, 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 1234 days.

(21) Appl. No.: **14/020,676**
(22) Filed: **Sep. 6, 2013**

(65) **Prior Publication Data**
US 2014/0361935 A1 Dec. 11, 2014

Related U.S. Application Data
(60) Provisional application No. 61/832,704, filed on Jun. 7, 2013.

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

(52) **U.S. Cl.**
CPC **H01Q 1/24** (2013.01); **G06F 1/1613** (2013.01); **G06F 1/1626** (2013.01);
(Continued)
(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/243; H04M 1/0249
See application file for complete search history.

(56) **References Cited**
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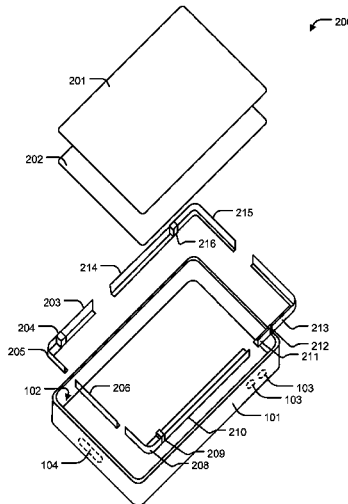
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Primary Examiner — Jessica Han
Assistant Examiner — Amal Patel
(74) *Attorney, Agent, or Firm* — Michael H. Lyons

(57) **ABSTRACT**
A housing for a personal electronic device is described herein. The housing may include at least one modular subassembly configured to be arranged within an internal cavity of the housing. The at least one modular subassembly is aligned with a feature external to the housing, is affixed to an interior surface of the internal cavity, and is configured to function both as an antenna and as an internal support member of the housing.

20 Claims, 8 Drawing Sheets



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

(10) **Patent No.:** **US 10,103,424 B2**
(45) **Date of Patent:** **Oct. 16, 2018**

(54) **ELECTRONIC DEVICE WITH MILLIMETER WAVE YAGI ANTENNAS**

(56) **References Cited**

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

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343/818

(72) Inventors: **Basim Noori**, San Jose, CA (US);
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Boon Wai Shiu, San Jose, CA (US);
Matthew A. Mow, Los Altos, CA (US);
Yuehui Ouyang, Sunnyvale, CA (US);
Mattia Pascolini, San Francisco, CA (US);
Ruben Caballero, San Jose, CA (US)

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

Grajek et al., "A 24-GHz High-Gain Yagi-Uda Antenna Array" IEEE Transactions on Antennas and Propagation, vol. 52, Issue: 5, May 10, 2004, DOI: 10.1109/TAP.2004.827543.

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 83 days.

(Continued)

(21) Appl. No.: **15/138,684**

Primary Examiner — Hoang Nguyen
(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.;
G. Victor Treyz; Joseph F. Guihan

(22) Filed: **Apr. 26, 2016**

(57) **ABSTRACT**

(65) **Prior Publication Data**
US 2017/0309991 A1 Oct. 26, 2017

An electronic device may be provided with wireless circuitry. The wireless circuitry may include one or more antennas. The antennas may include phased antenna arrays each of which includes multiple antenna elements. Phased antenna arrays may be formed from printed circuit board Yagi antennas or other antennas. A millimeter wave transceiver may use the antennas to transmit and receive wireless signals. The antennas may be mounted at the corners of an electronic device housing or elsewhere in an electronic device. An electronic device housing may be formed from metal and may have an opening filled with dielectric. The antennas may be aligned with portions of the dielectric. Printed circuit board antennas may have reflectors, radiators, and directors. The reflectors, radiators, and directors may be arranged to align radiation patterns for the antennas with the plastic-filled slots or other dielectric regions in the metal housing.

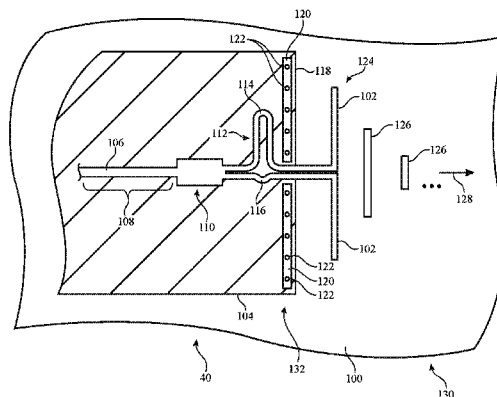
(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/49 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/2258** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 1/241** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/2258; H01Q 1/2266; H01Q 1/24; H01Q 1/241; H01Q 1/242; H01Q 1/243; H01Q 19/30

See application file for complete search history.

20 Claims, 9 Drawing Sheets





US010103427B1

(12) **United States Patent**
Yang

(10) **Patent No.:** **US 10,103,427 B1**
(45) **Date of Patent:** ***Oct. 16, 2018**

(54) **ANTENNA SYSTEM FOR A LARGE APPLIANCE**

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

(72) Inventor: **Simon Yang**, Carlsbad, CA (US)

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

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

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **15/904,332**

(22) Filed: **Feb. 24, 2018**

Related U.S. Application Data

(62) Division of application No. 15/482,790, filed on Apr. 9, 2017, now Pat. No. 9,912,043.

(60) Provisional application No. 62/441,221, filed on Dec. 31, 2016.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 21/00 (2006.01)
H01Q 5/30 (2015.01)
H04W 84/12 (2009.01)
H01Q 1/12 (2006.01)
H04N 5/64 (2006.01)
H04N 5/44 (2011.01)
H04B 7/0413 (2017.01)

(52) **U.S. Cl.**
CPC **H01Q 1/246** (2013.01); **H01Q 1/12** (2013.01); **H01Q 5/30** (2015.01); **H01Q 21/00** (2013.01); **H01Q 21/0043** (2013.01); **H04W**

84/12 (2013.01); **H04B 7/0413** (2013.01); **H04N 5/44** (2013.01); **H04N 5/64** (2013.01)

(58) **Field of Classification Search**
CPC **H01Q 5/30**; **H01Q 1/12**; **H01Q 21/00**; **H01Q 21/0043**; **H04W 84/12**
See application file for complete search history.

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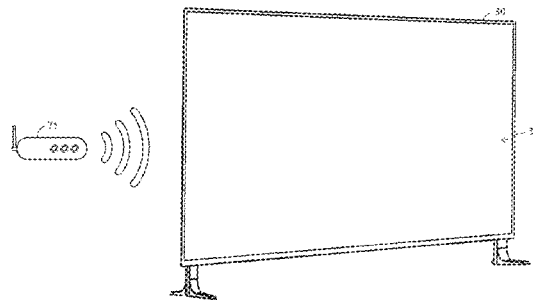
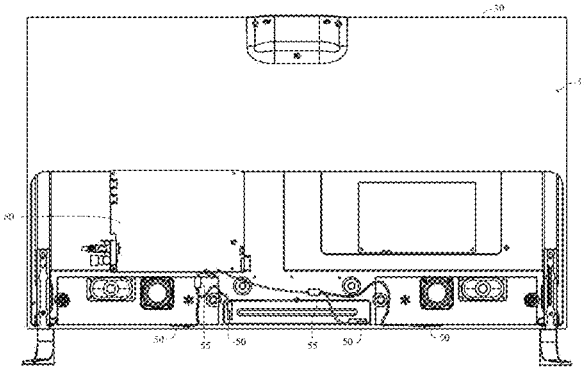
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Primary Examiner — Dieu H Duong
(74) *Attorney, Agent, or Firm* — Clause Eight IPS; Michael Catania

(57) **ABSTRACT**

An antenna system for a large appliance is disclosed herein. The antenna system comprises a large appliance having a front surface and a rear surface, a first antenna mounted on the rear surface, a second antenna mounted on the rear surface, a combiner in communication with the first antenna and the second antenna, a radio, a processor, and a wireless access point. The combiner selects the strongest signal of the first antenna and the second antenna to receive a wireless signal from the wireless access point.

6 Claims, 54 Drawing Sheets



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

(10) **Patent No.:** **US 10,103,435 B2**
(45) **Date of Patent:** **Oct. 16, 2018**

(54) **SYSTEMS AND METHODS FOR
TRANSLOOP IMPEDANCE MATCHING OF
AN ANTENNA**

13/106 (2013.01); H01Q 13/12 (2013.01);
H01Q 13/14 (2013.01); H01Q 13/16
(2013.01); H01Q 13/18 (2013.01); H05K
999/99 (2013.01)

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

(58) **Field of Classification Search**
CPC H01Q 1/2258; H01Q 1/243; H01Q 7/00;
H01Q 13/10
See application file for complete search history.

(72) Inventors: **Ching Wei Chang**, New Taipei (TW);
I-Yu Chen, Taipei (TW)

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

(56) **References Cited**

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 51 days.

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(Continued)

(21) Appl. No.: **15/346,784**

(22) Filed: **Nov. 9, 2016**

Primary Examiner — Dameon E Levi

(65) **Prior Publication Data**

US 2018/0131091 A1 May 10, 2018

Assistant Examiner — Ab Salam Alkassim, Jr.

(74) *Attorney, Agent, or Firm* — Jackson Walker LLP

(51) **Int. Cl.**

H01Q 5/335	(2015.01)
H01Q 1/36	(2006.01)
H01Q 7/00	(2006.01)
H01Q 1/38	(2006.01)
H01Q 1/22	(2006.01)
H01Q 13/14	(2006.01)
H01Q 13/16	(2006.01)
H01Q 13/12	(2006.01)
H01Q 13/10	(2006.01)
H01Q 13/18	(2006.01)

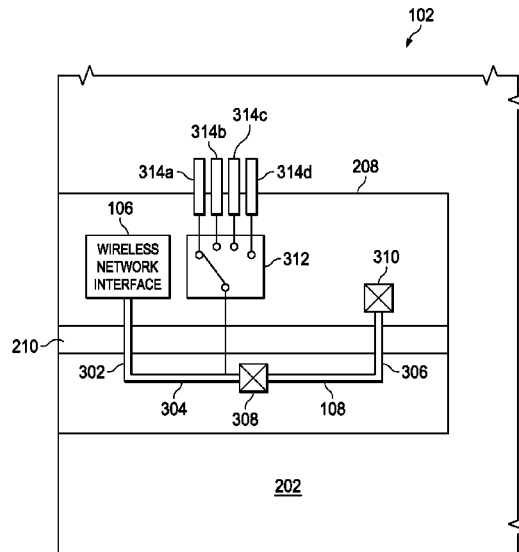
(57) **ABSTRACT**

In accordance with embodiments of the present disclosure, an information handling system may include an enclosure for housing information handling resources of the information handling system, the enclosure having an antenna slot formed therein and formed from a material substantially different from that in which the remainder of the enclosure is formed and a circuit board mechanically coupled to the enclosure and proximate to the antenna slot, the circuit board comprising an antenna electrically coupled at two or more locations to the enclosure so as to form a loop antenna and the antenna positioned such that the antenna at least partially overlaps the antenna slot.

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

CPC **H01Q 5/335** (2015.01); **H01Q 1/2258**
(2013.01); **H01Q 1/36** (2013.01); **H01Q 1/38**
(2013.01); **H01Q 7/00** (2013.01); **H01Q 13/10**
(2013.01); **H01Q 13/103** (2013.01); **H01Q**

14 Claims, 2 Drawing Sheets



(12) **United States Patent**
Huang

(10) **Patent No.:** **US 10,103,437 B2**
(45) **Date of Patent:** **Oct. 16, 2018**

(54) **MULTI-BAND ANTENNA**

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

(72) Inventor: **Chin-Ting Huang**, 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 78 days.

(21) Appl. No.: **15/331,920**

(22) Filed: **Oct. 24, 2016**

(65) **Prior Publication Data**
US 2017/0141469 A1 May 18, 2017

(30) **Foreign Application Priority Data**
Nov. 12, 2015 (TW) 104137367 A

(51) **Int. Cl.**
H01Q 5/50 (2015.01)
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/50 (2006.01)
H01Q 7/00 (2006.01)
H01Q 9/30 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/328 (2015.01)
H01Q 5/335 (2015.01)
H01Q 5/364 (2015.01)
H01Q 5/371 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 5/50** (2015.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/50** (2013.01); **H01Q 5/328** (2015.01); **H01Q**

5/335 (2015.01); **H01Q 5/364** (2015.01); **H01Q 5/371** (2015.01); **H01Q 7/00** (2013.01); **H01Q 9/30** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/50; H01Q 5/328; H01Q 5/335; H01Q 5/364; H01Q 5/371; H01Q 1/243; H01Q 1/38; H01Q 1/50; H01Q 9/30; H01Q 9/42; H01Q 7/00
See application file for complete search history.

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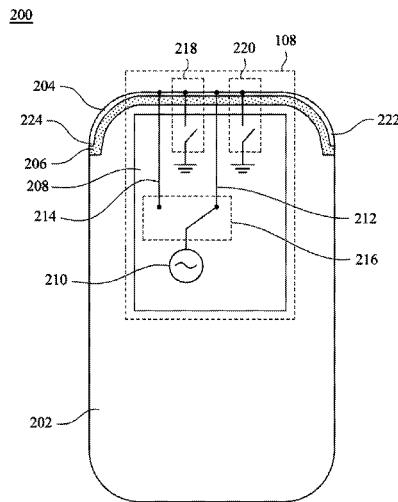
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Primary Examiner — Dameon E Levi
Assistant Examiner — David Lotter
(74) *Attorney, Agent, or Firm* — CKC & Partners Co., Ltd.

(57) **ABSTRACT**

A multi-band antenna includes a metal backing plate, a radiating conductor, a non-conductor and a connector. The non-conductor is interleaved between the metal backing plate and the radiating conductor. The connector is connected to the metal backing plate and the radiating conductor, and the connector is configured to adjust a connection path between the metal backing plate and the radiating conductor to adjust an antenna operation band.

10 Claims, 20 Drawing Sheets



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

(10) **Patent No.:** **US 10,103,449 B2**
(45) **Date of Patent:** **Oct. 16, 2018**

(54) **ANTENNA ARRAY**

(71) Applicant: **Industrial Technology Research Institute, Hsinchu (TW)**

(72) Inventors: **Kin-Lu Wong, Kaohsiung (TW); Jun-Yu Lu, Kaohsiung (TW); Wei-Yu Li, Yilan (TW)**

(73) Assignee: **INDUSTRIAL TECHNOLOGY RESEARCH INSTITUTE, Hsinchu (TW)**

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 387 days.

(21) Appl. No.: **14/984,590**

(22) Filed: **Dec. 30, 2015**

(65) **Prior Publication Data**

US 2017/0162948 A1 Jun. 8, 2017

(30) **Foreign Application Priority Data**

Dec. 8, 2015 (TW) 104141055 A

(51) **Int. Cl.**

H01Q 21/06 (2006.01)
H01Q 5/10 (2015.01)

(Continued)

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

CPC **H01Q 21/06** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/523** (2013.01); **H01Q 5/10** (2015.01)

(58) **Field of Classification Search**

CPC H01Q 1/24-1/243; H01Q 21/06; H01Q 5/10; H01Q 1/38; H01Q 1/523

See application file for complete search history.

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Primary Examiner — Dameon E Levi

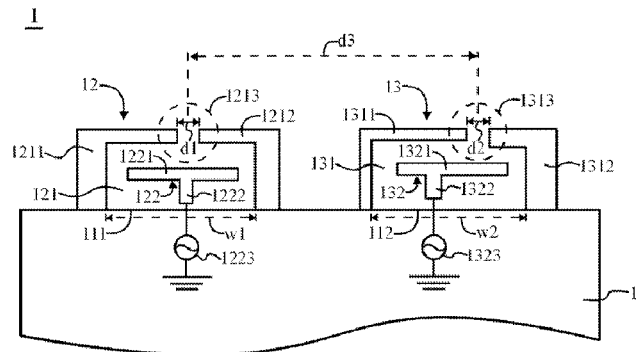
Assistant Examiner — Jennifer F Hu

(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**

An antenna array includes a ground conductor portion, a first antenna and a second antenna. The ground conductor portion has a first edge and a second edge. The first antenna has a first no-ground radiating area and a first feeding conductor portion. The second antenna has a second no-ground radiating area and a second feeding conductor portion. The first no-ground radiating area is formed and surrounded by a first grounding conductor structure, a second grounding conductor structure, and the first edge, and the first no-ground radiating area has a first breach. The second no-ground radiating area is formed and surrounded by a third grounding conductor structure, a fourth grounding conductor structure, and the second edge, and the second no-ground radiating area has a second breach. The first and second feeding conductor portions are respectively and electrically connected to a first signal source and a second signal source.

12 Claims, 10 Drawing Sheets





US010103451B2

(12) **United States Patent**
Dorsey

(10) **Patent No.:** **US 10,103,451 B2**

(45) **Date of Patent:** **Oct. 16, 2018**

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

(58) **Field of Classification Search**

CPC H01Q 5/30; H01Q 5/371; H01Q 1/48; H01Q 1/241; H01Q 1/242; H01Q 1/24
See application file for complete search history.

(71) Applicant: **Taoglas Group Holdings Limited**,
Wexford (IE)

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

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

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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 29 days.

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(21) Appl. No.: **15/351,263**

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

GB 2544415 A 5/2017

(65) **Prior Publication Data**

US 2017/0133767 A1 May 11, 2017

Primary Examiner — Hoang Nguyen

Related U.S. Application Data

(74) *Attorney, Agent, or Firm* — Shartsis Friese, LLP;
Cecily Anne O'Regan; Kevin J. Everett, Jr.

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

(57) **ABSTRACT**

(51) **Int. Cl.**

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

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.

(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)

22 Claims, 4 Drawing Sheets

