



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)

(56)

References Cited

U.S. PATENT DOCUMENTS

2012/0009983 A1* 1/2012 Mow H01Q 1/243
455/575.7

FOREIGN PATENT DOCUMENTS

CN 104584324 A 4/2015
CN 104953292 A 9/2015

OTHER PUBLICATIONS

Chinese Patent Application No. 201610161288.X First Office Action dated May 17, 2017, 4 pages.

(Continued)

Primary Examiner — Robert Karacsony

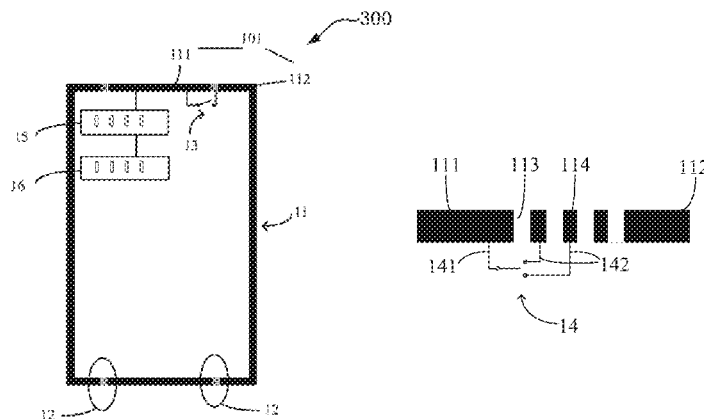
(74) *Attorney, Agent, or Firm* — Lathrop Gage L.L.P.

(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





US010084235B2

(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**

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

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

This patent is subject to a terminal disclaimer.

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

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

(65) **Prior Publication Data**

US 2017/0338560 A1 Nov. 23, 2017

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)

(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)

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,413,410 B2 * 8/2016 You H04B 15/00
2005/0184909 A1 8/2005 Tchistiakov et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 102318138 A 1/2012
CN 202435391 U 9/2012

OTHER PUBLICATIONS

U.S. Appl. No. 15/229,829, filed Aug. 5, 2016.
U.S. Appl. No. 14/143,367, filed Dec. 30, 2013.

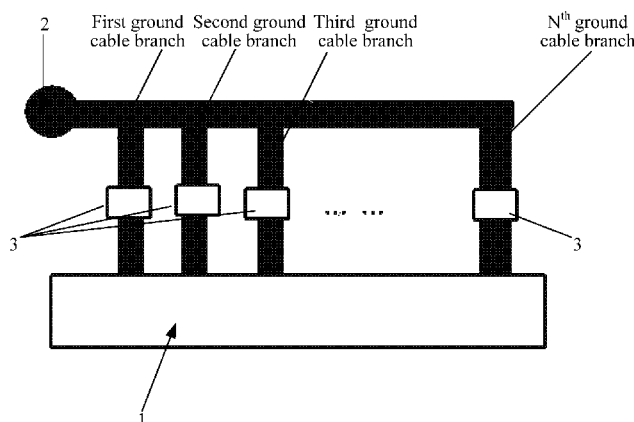
Primary Examiner — Huedung Mancuso

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

(57) **ABSTRACT**

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.

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**

§ 371 (c)(1),

(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**;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,095,292 A 3/1992 Masterton
5,874,926 A 2/1999 Tsuru et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 1492538 A 4/2004
CN 102067624 A 5/2011
(Continued)

OTHER PUBLICATIONS

Partial English Translation and Abstract of Dutch Patent Application
No. DE3246365, dated Nov. 7, 2016, 7 pages.

(Continued)

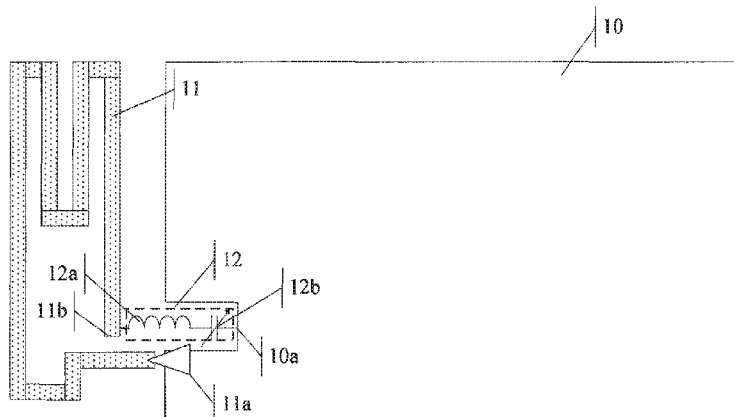
Primary Examiner — Robert Karacsony

(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





US010090581B2

(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.

(21) Appl. No.: **15/847,519**

(22) Filed: **Dec. 19, 2017**

(65) **Prior Publication Data**

US 2018/0191060 A1 Jul. 5, 2018

(30) **Foreign Application Priority Data**

Jan. 5, 2017 (TW) 106100275 A

(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)

(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.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,936,307 B2 * 5/2011 Pang H01Q 1/243 343/702
9,455,499 B2 * 9/2016 Wong H01Q 5/35 (Continued)

FOREIGN PATENT DOCUMENTS

CN 103904414 7/2014
TW 201427181 7/2014
(Continued)

OTHER PUBLICATIONS

“Office Action of Taiwan Counterpart Application”, dated Apr. 19, 2018, p. 1-p. 7.

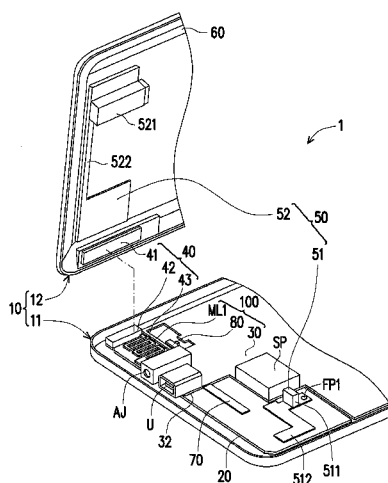
Primary Examiner — Quochien B Vuong

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

(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





US010090907B2

(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**

US 2016/0337025 A1 Nov. 17, 2016

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**

U.S. PATENT DOCUMENTS

5,479,176 A * 12/1995 Zavrel, Jr. H01Q 3/242
342/374
5,854,986 A * 12/1998 Dorren H01Q 1/246
455/103

(Continued)

FOREIGN PATENT DOCUMENTS

CN 101309087 A 11/2008
CN 101582539 A 11/2009

(Continued)

OTHER PUBLICATIONS

3GPP TS 36.306 V11.3.0 (Mar. 2013); 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio access capabilities (Release 11); 27 pages.

(Continued)

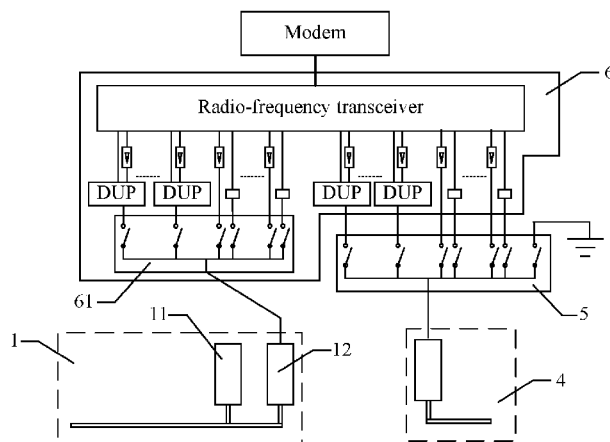
Primary Examiner — Cindy Trandai

(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



(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**

US 2016/0351998 A1 Dec. 1, 2016

(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**

U.S. PATENT DOCUMENTS

2002/0084943 A1	7/2002	Tsai et al.	
2007/0257842 A1	11/2007	Tseng	
2011/0163937 A1	7/2011	Jung et al.	
2012/0026064 A1	2/2012	Lee et al.	
2012/0105287 A1	5/2012	Jung et al.	
2013/0176178 A1*	7/2013	Chen	H01Q 1/243 343/702
2014/0125535 A1	5/2014	Ramachandran et al.	

(Continued)

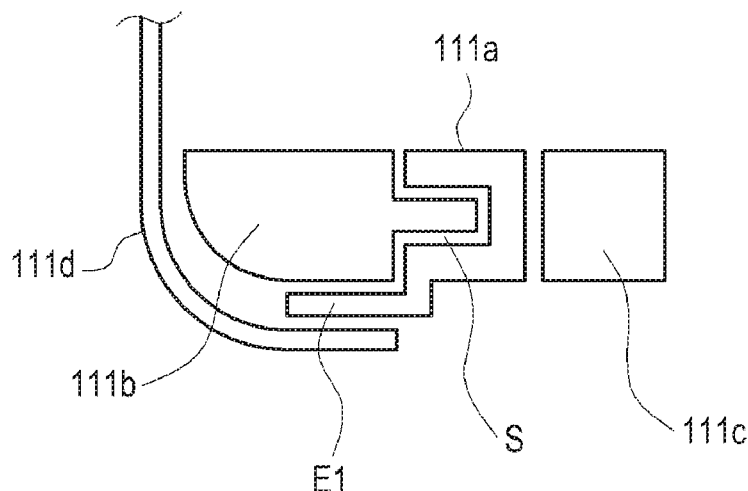
Primary Examiner — Dieu H Duong

(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



(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**

U.S. PATENT DOCUMENTS

8,436,774 B2* 5/2013 Wong H01Q 1/243
343/700 MS
2007/0285321 A1 12/2007 Chung et al.
2014/0256388 A1 9/2014 Lin et al.
2015/0070239 A1* 3/2015 Hung H01Q 1/48
343/848
2015/0123871 A1* 5/2015 Chang H01Q 1/243
343/872
2015/0255854 A1 9/2015 Lin et al.
(Continued)

FOREIGN PATENT DOCUMENTS

TW 200729612 A 8/2007
TW 201324942 A1 6/2013
TW 201401646 A 1/2014

OTHER PUBLICATIONS

Chinese language office action dated Nov. 20, 2017, issued in application No. TW 105127217.

(Continued)

Primary Examiner — Jessica Han

Assistant Examiner — Amal Patel

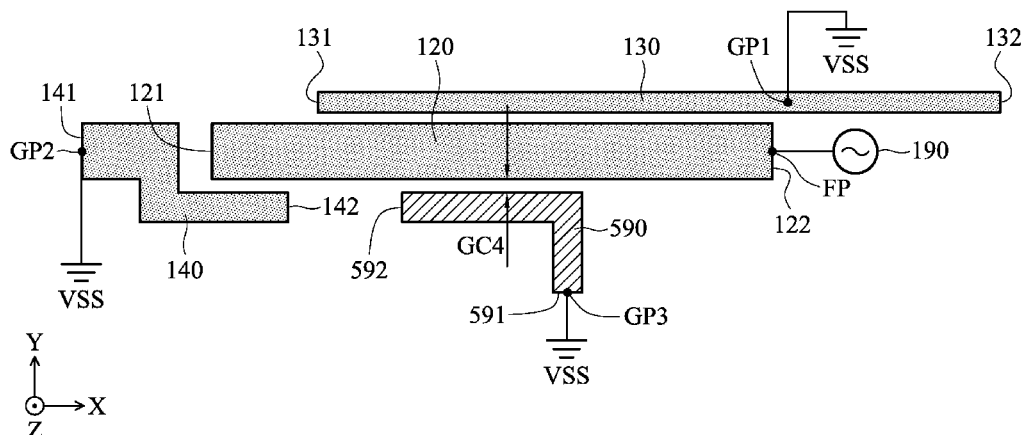
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(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

610



(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.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2004/0160370 A1* 8/2004 Ghosh G06F 1/1616
343/702
2014/0218244 A1* 8/2014 Chang H01Q 13/10
343/702

FOREIGN PATENT DOCUMENTS

CN 104103888 * 10/2014 H01Q 1/24
* cited by examiner

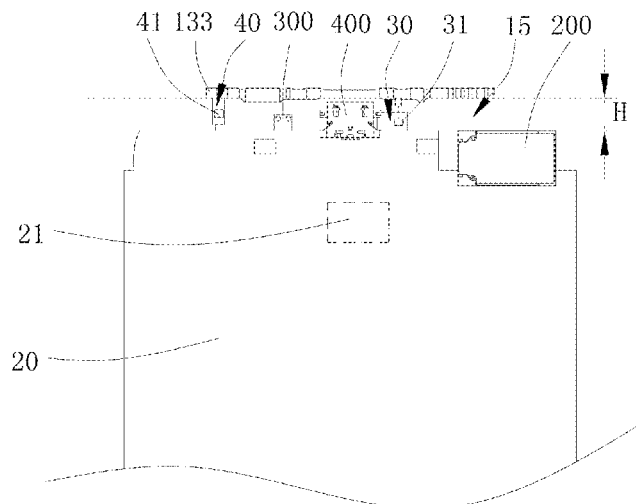
Primary Examiner — Hoang Nguyen

(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





US010103423B2

(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**

U.S. PATENT DOCUMENTS

4,047,182 A 9/1977 Faren
5,673,054 A 9/1997 Hama et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 1539146 10/2004
CN 101867629 10/2010
(Continued)

OTHER PUBLICATIONS

PCT Application No. PCT/US2014/041086—International Search
Report and Written Opinion dated Sep. 24, 2014.

(Continued)

Primary Examiner — Jessica Han

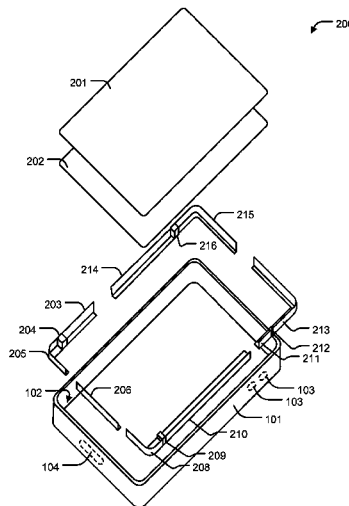
Assistant Examiner — Amal Patel

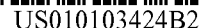
(74) *Attorney, Agent, or Firm* — Michael H. Lyons

(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





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

- (56)
- References Cited**

- U.S. PATENT DOCUMENTS

- | | | | | |
|--------------|------|---------|---------------|-------------|
| 9,196,968 | B2 * | 11/2015 | Ko | H01Q 19/30 |
| 2007/0103377 | A1 * | 5/2007 | Abramov | G06F 1/1616 |
| | | | | 343/818 |

(Continued)

FOREIGN PATENT DOCUMENTS

- | | | | |
|----|-----------|---|--------|
| CN | 101809814 | A | 8/2010 |
| CN | 101958456 | A | 1/2011 |

(Continued)

- ## OTHER PUBLICATIONS

- 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.

(Continued)

- Primary Examiner — Hoang Nguyen

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

- (65) **Prior Publication Data**

- US 2017/0309991 A1 Oct. 26, 2017

- (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)

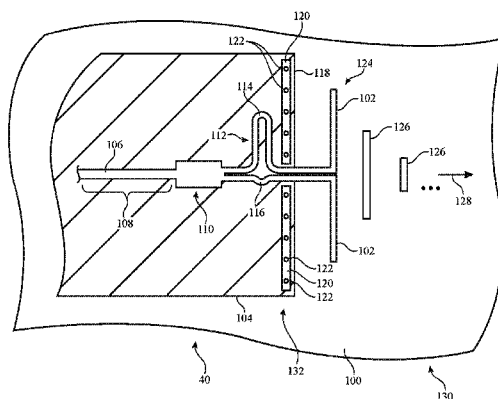
- (58) **Field of Classification Search**
CPC H01Q 1/2258; H01Q 1/2266; H01Q 1/24;
H01Q 1/241; H01Q 1/242; H01Q 1/243;
H01Q 19/30

See application file for complete search history.

- (57) **ABSTRACT**

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.

20 Claims, 9 Drawing Sheets





(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.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,496,932 B1 * 11/2016 Prendergast H04B 7/0417
9,912,043 B1 * 3/2018 Yang H01Q 1/246
2007/0182643 A1 * 8/2007 Li H01Q 1/2291
343/702
2009/0207082 A1 * 8/2009 Raghuraman H01Q 1/242
343/702
2009/0237321 A1 * 9/2009 Lin H01Q 1/246
343/893
2009/0256777 A1 * 10/2009 Nagai H01Q 9/0407
343/893
2011/0007225 A1 * 1/2011 Kitaguchi H04N 5/64
348/731
2014/0375513 A1 * 12/2014 Kang H01Q 1/526
343/720

(Continued)

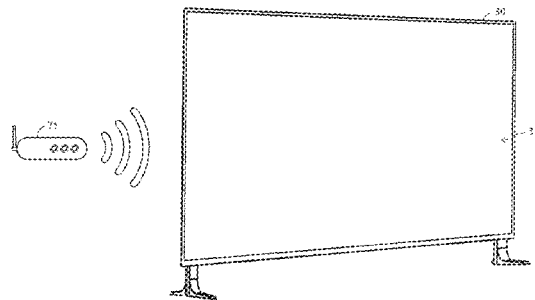
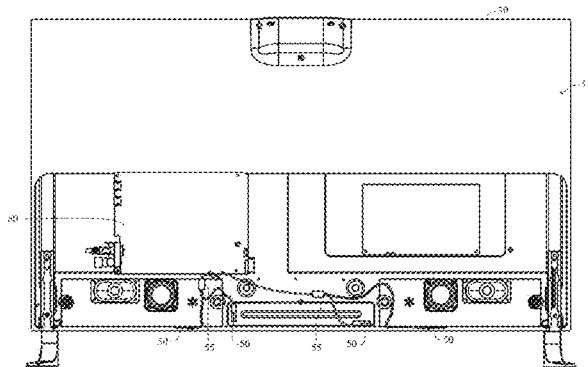
Primary Examiner — Dieu H Duong

(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
TRANSLLOOP 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)

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

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

8,106,836 B2 * 1/2012 Hill H01Q 1/243
343/700 MS
9,105,966 B1 * 8/2015 Dou H01Q 1/243
9,203,141 B1 * 12/2015 Su H01Q 7/00
9,325,070 B1 * 4/2016 Obeidat H01Q 9/0407
9,431,693 B2 * 8/2016 Kwak H01Q 1/243
9,728,858 B2 * 8/2017 Zhu H01Q 13/10
9,882,264 B2 * 1/2018 Gummalla H01Q 1/2258

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

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

(Continued)

(65) **Prior Publication Data**

US 2018/0131091 A1 May 10, 2018

Primary Examiner — Dameon E Levi

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)

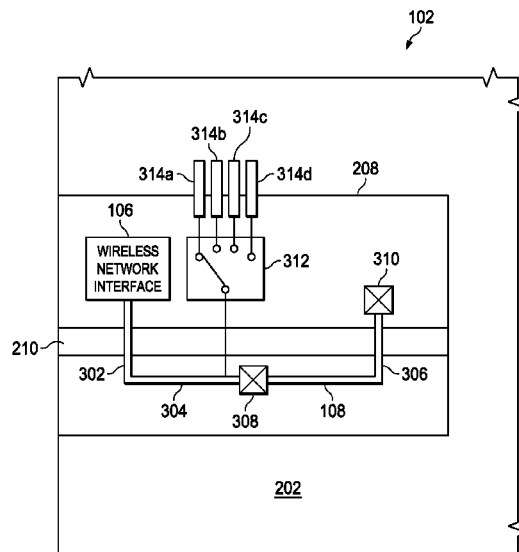
(52) **U.S. Cl.**

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**

(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.

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.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,331,397 B2 * 5/2016 Jin H01Q 21/28
2007/0182638 A1 8/2007 Rowell
2015/0057054 A1 * 2/2015 Su H01Q 1/243
455/575.7
2015/0236426 A1 * 8/2015 Zhu H01Q 13/10
343/702

FOREIGN PATENT DOCUMENTS

CN 104064865 A 9/2014

* cited by examiner

Primary Examiner — Dameon E Levi

Assistant Examiner — David Lotter

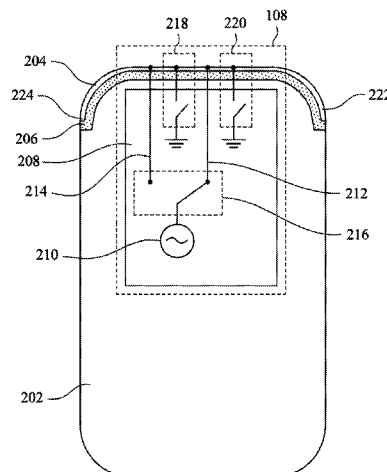
(74) *Attorney, Agent, or Firm* — CKC & Partners Co., Ltd.

(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

200



(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**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

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

4,460,899 A 7/1984 Schmidt et al.
5,952,983 A 9/1999 Dearnley et al.
(Continued)

FOREIGN PATENT DOCUMENTS

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

CN 101316008 A 12/2008
CN 102683807 A 9/2012
(Continued)

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

OTHER PUBLICATIONS

Extended European Search Report, dated May 10, 2017, for European Application No. 15202618.3.

(Continued)

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

Primary Examiner — Dameon E Levi

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

Assistant Examiner — Jennifer F Hu

(65) **Prior Publication Data**

US 2017/0162948 A1 Jun. 8, 2017

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

(30) **Foreign Application Priority Data**

Dec. 8, 2015 (TW) 104141055 A

(57) **ABSTRACT**

(51) **Int. Cl.**

H01Q 21/06 (2006.01)

H01Q 5/10 (2015.01)

(Continued)

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.

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

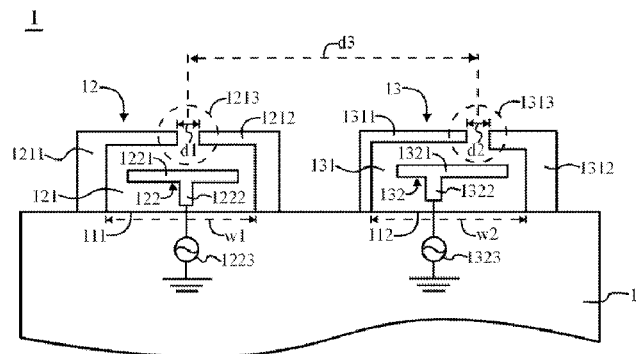
CPC **H01Q 21/06** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/523** (2013.01); **H01Q 5/10** (2015.01)

(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.

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**

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

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

(73) Assignee: **TAOGLAS GROUP HOLDINGS
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 29 days.

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

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

(65) **Prior Publication Data**

US 2017/0133767 A1 May 11, 2017

Related U.S. Application Data

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

(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)

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,501,991 B2 * 3/2009 Yeap H01Q 1/38
343/700 MS
9,755,302 B2 9/2017 Flores-Cuadras et al.
2005/0237244 A1 10/2005 Annabi et al.
2006/0214867 A1 9/2006 Chen
2007/0046557 A1 3/2007 Chen et al.
2007/0159398 A1 7/2007 Tsai et al.
2010/0090913 A1 4/2010 Liu

(Continued)

FOREIGN PATENT DOCUMENTS

GB 2544415 A 5/2017

Primary Examiner — Hoang Nguyen

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

(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.

22 Claims, 4 Drawing Sheets

