

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

(10) **Patent No.:** US 10,263,319 B2
(45) **Date of Patent:** Apr. 16, 2019

(54) **ANTENNA WITH SWAPPABLE RADIATION DIRECTION AND COMMUNICATION DEVICE THEREOF**

(2013.01); **H01Q 7/005** (2013.01); **H01Q 9/04** (2013.01); **H01Q 9/0442** (2013.01); **H01Q 21/29** (2013.01)

(71) Applicant: **MEDIATEK INC.**, Hsin-Chu (TW)

(58) **Field of Classification Search**

(72) Inventors: **Chung-Yu Hung**, Taipei (TW);
Chen-Fang Tai, New Taipei (TW);
Wun-Jian Lin, Kaohsiung (TW);
Shih-Huang Yeh, Hsinchu (TW)

CPC H01Q 1/2266; H01Q 1/245; H01Q 3/24;
H01Q 7/00; H01Q 9/04; H01Q 9/0442;
H01Q 1/243; H01Q 21/29; H01Q 5/328;
H01Q 7/005

See application file for complete search history.

(73) Assignee: **MEDIATEK INC.**, Hsin-Chu (TW)

(56) **References Cited**

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 120 days.

U.S. PATENT DOCUMENTS

6,980,154 B2 * 12/2005 Vance H01Q 1/243
343/700 MS
7,916,089 B2 * 3/2011 Schlub H01Q 1/243
343/702

(21) Appl. No.: **15/394,713**

(Continued)

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

FOREIGN PATENT DOCUMENTS

(65) **Prior Publication Data**

US 2017/0279185 A1 Sep. 28, 2017

TW 201338272 A 9/2013
TW 201541713 A 11/2015

Primary Examiner — Tho G Phan

(74) *Attorney, Agent, or Firm* — Winston Hsu

Related U.S. Application Data

(60) Provisional application No. 62/311,951, filed on Mar. 23, 2016.

(57) **ABSTRACT**

An antenna with swappable and selective radiation direction includes a first arm, a second arm electrically connected to the first arm, a third arm is electrically connected to the first arm, a first impedance tuning circuit coupled to the second arm for connecting the second arm to a ground or a first matching component according to a control signal, and a second impedance tuning circuit coupled to the third arm for connecting the third arm to the ground or a second matching component according to the control signal. By tuning impedance of the antenna, the antenna operates in a first mode corresponding to a first radiation direction or a second mode corresponding to a second radiation direction.

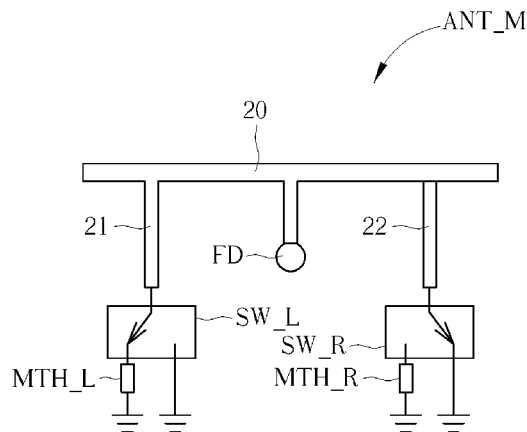
(51) **Int. Cl.**

H01Q 3/24 (2006.01)
H01Q 9/04 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/22 (2006.01)
H01Q 7/00 (2006.01)
H01Q 21/29 (2006.01)
H01Q 5/328 (2015.01)

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

CPC **H01Q 1/245** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 1/243** (2013.01); **H01Q 3/24** (2013.01); **H01Q 5/328** (2015.01); **H01Q 7/00**

4 Claims, 8 Drawing Sheets



Mode 1



US010263323B2

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

(10) **Patent No.:** **US 10,263,323 B2**
(45) **Date of Patent:** **Apr. 16, 2019**

(54) **ANTENNA STRUCTURE WITH SELF SUPPORTING FEATURE**

(71) Applicant: **THOMSON LICENSING**, Issy de Moulineaux (FR)
(72) Inventors: **Henri Girard**, Carmel, IN (US); **Joseph Lee Carpenter**, Noblesville, IN (US)
(73) Assignee: **INTERDIGITAL CE PATENT HOLDINGS**, Paris (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 117 days.

(21) Appl. No.: **15/312,763**
(22) PCT Filed: **May 28, 2015**
(86) PCT No.: **PCT/US2015/032810**
§ 371 (c)(1),
(2) Date: **Nov. 21, 2016**
(87) PCT Pub. No.: **WO2015/184052**
PCT Pub. Date: **Dec. 3, 2015**

(65) **Prior Publication Data**
US 2017/0194702 A1 Jul. 6, 2017

Related U.S. Application Data
(60) Provisional application No. 62/004,934, filed on May 30, 2014.

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 9/42 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01); **H01Q 9/0414** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 1/48; H01Q 9/0414
See application file for complete search history.

(56) **References Cited**
U.S. PATENT DOCUMENTS
6,744,409 B2 6/2004 Ellis et al.
2003/0201943 A1 10/2003 Kadambi et al.
(Continued)

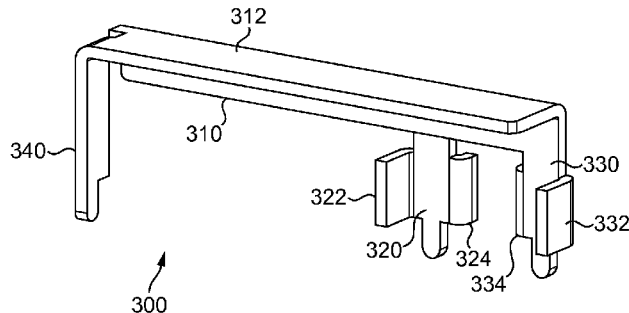
FOREIGN PATENT DOCUMENTS
CA 2644946 11/2007
EP 1569298 8/2006
WO WO2007126897 11/2007

OTHER PUBLICATIONS
Hong et al.: Design of an internal monopole Antenna for GSM900/DCS1800/US-PCS/S-DMB. IEEE Transactions on Antennas and Propagation, vol. 56, No. 5, May 2008.
(Continued)

Primary Examiner — Dameon E Levi
Assistant Examiner — David E Lotter
(74) *Attorney, Agent, or Firm* — Tutunjian & Bitetto, P.C.

(57) **ABSTRACT**
An antenna including a first conductive element having a first length and including a first connecting interface to connect, at a first end, the antenna structure to an electrical circuit, a second conductive element having a second length, the second conductive element connecting, at a first end, to a second end of the first conductive element, and a third conductive element having a third length and connecting at a first end to a second end of the second conductive element and oriented at an angle that is orthogonal to the orientation axis for the first conductive element and the second conductive element. The antenna can be placed by machine without the antenna moving or tilting in any direction prior attaching to a printed circuit board.

37 Claims, 3 Drawing Sheets





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

(10) **Patent No.:** **US 10,263,324 B2**
(45) **Date of Patent:** **Apr. 16, 2019**

(54) **IMPEDANCE CONVERSION ELEMENT AND COMMUNICATION DEVICE**

- (71) Applicant: **Murata Manufacturing Co., Ltd.**, Nagaokakyo-shi, Kyoto-fu (JP)
- (72) Inventors: **Hisashi Akiyama**, Nagaokakyo (JP); **Kenichi Ishizuka**, Nagaokakyo (JP)
- (73) Assignee: **MURATA MANUFACTURING CO., LTD.**, Kyoto (JP)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

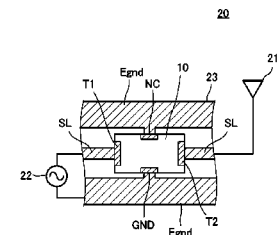
(21) Appl. No.: **15/662,325**
(22) Filed: **Jul. 28, 2017**

(65) **Prior Publication Data**
US 2017/0324158 A1 Nov. 9, 2017

Related U.S. Application Data
(63) Continuation of application No. PCT/JP2016/055969, filed on Feb. 29, 2016.

(30) **Foreign Application Priority Data**
Mar. 11, 2015 (JP) 2015-048099

- (51) **Int. Cl.**
H01Q 1/50 (2006.01)
H01Q 7/00 (2006.01)
(Continued)
- (52) **U.S. Cl.**
CPC **H01Q 1/50** (2013.01); **H01Q 5/50** (2015.01); **H01Q 7/00** (2013.01); **H01Q 1/243** (2013.01); **H03H 7/38** (2013.01)
- (58) **Field of Classification Search**
CPC .. H01Q 7/06; H01Q 1/50; H01Q 5/50; H01Q 7/00; H01Q 1/243; H04B 1/0053; H03H 7/38



(56) **References Cited**

U.S. PATENT DOCUMENTS

- 8,991,713 B2 3/2015 Dokai et al.
- 2012/0127049 A1* 5/2012 Kato H01P 1/20345 343/749

(Continued)

FOREIGN PATENT DOCUMENTS

- JP 2012-085250 A 4/2012
- WO 2012/096365 A1 7/2012

(Continued)

OTHER PUBLICATIONS

Official Communication issued in International Patent Application No. PCT/JP2016/055969, dated May 17, 2016.

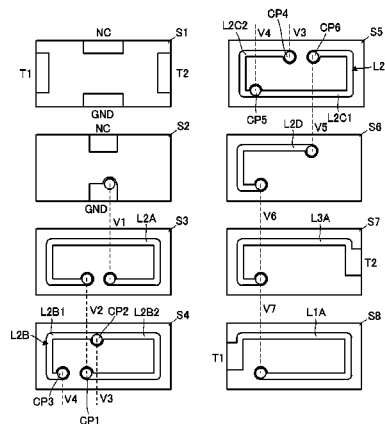
Primary Examiner — Hai V Tran

(74) *Attorney, Agent, or Firm* — Keating & Bennett, LLP

(57) **ABSTRACT**

A first end of a first conductor pattern of a first coil conductor is connected to a power supply terminal, and a second end of the first conductor pattern is connected to an antenna terminal. A second conductor pattern includes second coil conductors. A first end of the second conductor pattern is connected to the antenna terminal and the second end of the second conductor pattern is connected to a ground terminal. The second conductor pattern magnetically couples with the first conductor pattern. The second end of the first conductor pattern and the first end of the second conductor pattern are connected to the antenna terminal via a routing pattern that extends to magnetically couple with at least either the first conductor pattern or the second conductor pattern.

19 Claims, 7 Drawing Sheets





US010263326B2

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

(10) **Patent No.:** **US 10,263,326 B2**
(45) **Date of Patent:** **Apr. 16, 2019**

(54) **REPEATER WITH MULTIMODE ANTENNA**

(71) Applicant: **ETHERTRONICS, INC.**, San Diego, CA (US)

(72) Inventors: **Abhishek Singh**, San Diego, CA (US); **Sebastian Rowson**, San Diego, CA (US); **Laurent Desclos**, San Diego, CA (US); **Jeffrey Shamblin**, San Marcos, CA (US)

(73) Assignee: **ETHERTRONICS, INC.**, 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.

(21) Appl. No.: **15/917,101**

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

(65) **Prior Publication Data**
US 2018/0198200 A1 Jul. 12, 2018

Related U.S. Application Data

(63) Continuation of application No. 15/242,514, filed on Aug. 20, 2016, now Pat. No. 9,917,359, which is a continuation-in-part of application No. 14/965,881, filed on Dec. 10, 2015, now Pat. No. 9,748,637, which is a continuation-in-part of application No. 14/144,461, filed on Dec. 30, 2013, now Pat. No. 9,240,634, which is a continuation of application No. 13/726,477, filed on Dec. 24, 2012, now Pat. No. 8,648,755, which is a continuation of application No. 13/029,564, filed on Feb. 17, 2011, now Pat. No. 8,362,962, which is a continuation of application No. 12/043,090, filed on Mar. 5, 2008, now Pat. No. 7,911,402.

(51) **Int. Cl.**
H01Q 1/52 (2006.01)
H01Q 9/04 (2006.01)
H04B 7/15 (2006.01)
H04W 52/52 (2009.01)
H01Q 1/24 (2006.01)
H01Q 3/00 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/521** (2013.01); **H01Q 1/243** (2013.01); **H01Q 3/00** (2013.01); **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 1/52; H01Q 1/521; H01Q 3/00; H01Q 21/22; H01Q 3/34; H01Q 9/0421; H04B 7/15; H04B 7/155; H04B 1/5571; H04W 52/52
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,236,102	A	3/1941	Kilster
2,318,516	A	5/1943	Newbold
2,433,804	A	12/1947	Wolff
2,761,134	A	8/1956	Tewsbury et al.
2,938,208	A	5/1960	Engel et al.
3,419,869	A	12/1968	Altmayer
3,971,031	A	7/1976	Burke
5,165,109	A	11/1992	Han et al.

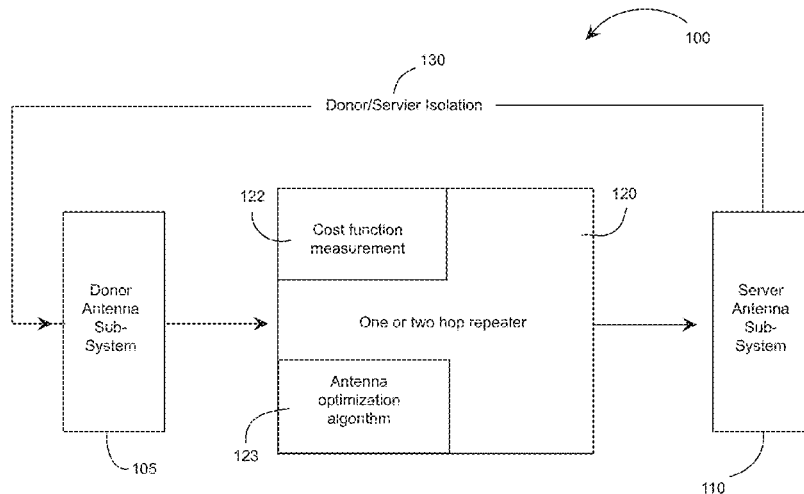
(Continued)

Primary Examiner — Tho G Phan
(74) *Attorney, Agent, or Firm* — Dority & Manning, P.A.

(57) **ABSTRACT**

The disclosure concerns an antenna subsystem that can be used in various repeater systems to optimize gain of the repeater by increasing isolation between donor and server antennas, wherein at least one of the donor and server antennas is an active multi-mode antenna.

4 Claims, 5 Drawing Sheets



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

(10) **Patent No.:** **US 10,263,327 B1**
(45) **Date of Patent:** **Apr. 16, 2019**

(54) **ANTI-INTERFERENCE MICROWAVE ANTENNA**

(71) Applicant: **Gaodi Zou**, Shenzhen (CN)

(72) Inventors: **Gaodi Zou**, Shenzhen (CN); **Xin Zou**, Shenzhen (CN)

(73) Assignee: **Gaodi Zou**, Baoan, Shenzhen (CN)

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

(21) Appl. No.: **16/127,196**

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

Related U.S. Application Data

(63) Continuation of application No. 16/035,689, filed on Jul. 15, 2018.

Foreign Application Priority Data

Jun. 11, 2018 (CN) 2018 1 0595979

(51) **Int. Cl.**
H01Q 1/52 (2006.01)
H01Q 5/30 (2015.01)
H01Q 5/328 (2015.01)
H01Q 9/16 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/521** (2013.01); **H01Q 5/328** (2015.01); **H01Q 9/16** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/328; H01Q 9/16; H01Q 1/521; H01Q 9/0407; H01Q 9/0414; H01Q 9/0421; H01Q 9/0428; H01Q 9/0435; H01Q 9/0478; H01Q 9/045

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,126,828 A *	11/1978	Kumagai	H03G 3/3052
			455/207
4,386,357 A *	5/1983	Patton	H01Q 9/0442
			343/700 MS
5,003,318 A *	3/1991	Berneking	H01Q 9/0414
			343/700 MS
7,129,899 B2 *	10/2006	Jecko	H01Q 9/0421
			343/702
2003/0146878 A1 *	8/2003	Mikkola	H01Q 1/243
			343/702
2004/0070539 A1 *	4/2004	Shikata	H01Q 1/27
			343/700 MS
2004/0164916 A1 *	8/2004	Jecko	H01Q 9/0421
			343/767

(Continued)

Primary Examiner — Dameon E Levi

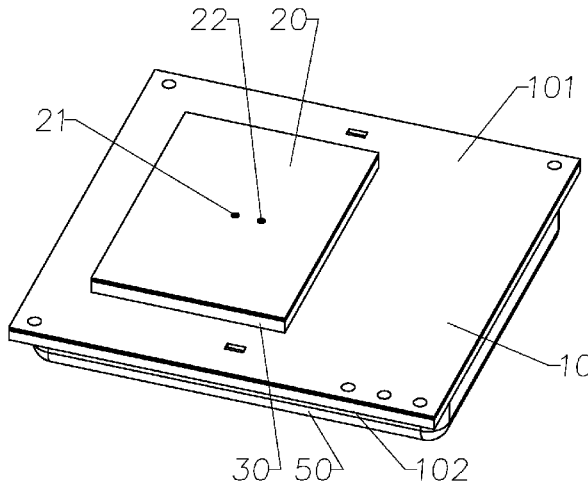
Assistant Examiner — Jennifer F Hu

(74) *Attorney, Agent, or Firm* — Raymond Y. Chan; David and Raymond Patent Firm

(57) **ABSTRACT**

An anti-interference microwave antenna includes a reference ground and at least a radiating source spacedly disposed at the reference ground to define a radiating clearance between the radiating source and the reference ground, wherein the radiating source is electrically connected to the reference ground to ground the radiating source so as to narrow a bandwidth of the antenna. When a electromagnetic excitation signal is received at a feed point of the radiating source, the bandwidth of the antenna is narrowed down to prevent any interference of the electromagnetic wave signal received or generated by the antenna in response to nearby electromagnetic radiation frequency or stray radiation frequency of the adjacent frequency bands.

5 Claims, 9 Drawing Sheets





US01026333B2

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

(10) **Patent No.:** **US 10,263,333 B2**
(45) **Date of Patent:** ***Apr. 16, 2019**

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

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

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

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **15/753,330**

(22) PCT Filed: **Jun. 13, 2016**

(86) PCT No.: **PCT/CN2016/085548**
§ 371 (c)(1),
(2) Date: **Feb. 18, 2018**

(87) PCT Pub. No.: **WO2017/156900**
PCT Pub. Date: **Sep. 21, 2017**

(65) **Prior Publication Data**
US 2018/0248252 A1 Aug. 30, 2018

(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)
H05K 5/04 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/321** (2015.01); **H01Q 1/243** (2013.01); **H01Q 1/36** (2013.01); **H01Q 1/44** (2013.01); **H05K 5/04** (2013.01); **H01Q 1/50** (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

10,084,234 B2 * 9/2018 Hu H01Q 5/321
2012/0009983 A1 * 1/2012 Mow H01Q 1/243
455/575.7

(Continued)

FOREIGN PATENT DOCUMENTS

CA 2953629 A1 10/2015
CN 102142855 A 8/2011

(Continued)

OTHER PUBLICATIONS

European Patent Application No. 16894062.5, Extended Search and Opinion dated Aug. 18, 2018, 8 pages.

(Continued)

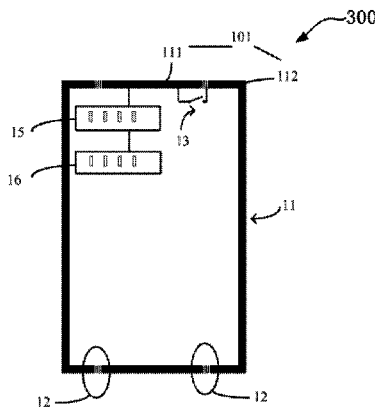
Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — Lathrop Gage LLP

(57) **ABSTRACT**

The present disclosure provides a metal housing; the metal housing includes a first edge and a second edge arranged opposite to each other, and a third edge and a fourth edge arranged opposite to each other. The third edge and the fourth edge are connected between the first edge and the

(Continued)





US010263334B2

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

(10) **Patent No.:** **US 10,263,334 B2**
(45) **Date of Patent:** **Apr. 16, 2019**

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

(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.: **15/973,201**

(22) Filed: **May 7, 2018**

(65) **Prior Publication Data**
US 2018/0254542 A1 Sep. 6, 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 1/24 (2006.01)
H01Q 5/321 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/321** (2015.01); **H01Q 1/243** (2013.01); **H01Q 1/36** (2013.01); **H01Q 1/44** (2013.01); **H05K 5/04** (2013.01); **H01Q 1/50** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/321; H01Q 1/36; H01Q 1/243; H01Q 1/44; H01Q 1/50
See application file for complete search history.

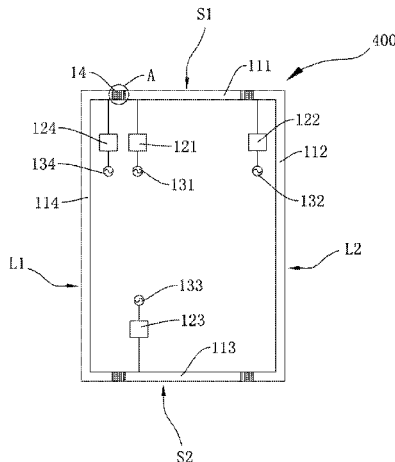
(56) **References Cited**
U.S. PATENT DOCUMENTS
10,084,234 B2 9/2018 Hu et al.
2012/0009983 A1 1/2012 Mow et al.
(Continued)

FOREIGN PATENT DOCUMENTS
CA 2953629 A1 10/2015
CN 102142855 A 8/2011
(Continued)

OTHER PUBLICATIONS
Chinese Patent Application No. 201610161287.5 First Office Action dated May 17, 2017, 4 pages.
(Continued)

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

(57) **ABSTRACT**
The present disclosure provides an antenna device including: a peripheral frame made of a signal shielding material and provided with at least two micro seam bands which partition the peripheral frame into at least two frame bodies, the frame bodies including a first antenna, the micro seam band having at least one micro seam; a first matching circuit electrically coupled to the first antenna; and a first radio-frequency receiving and emitting circuit electrically coupled to the first matching circuit. The frame bodies further includes a second antenna including a second matching
(Continued)





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

(10) **Patent No.:** **US 10,263,335 B2**
(45) **Date of Patent:** **Apr. 16, 2019**

(54) **ELECTRONIC DEVICE ANTENNAS HAVING SHARED STRUCTURES FOR NEAR-FIELD COMMUNICATIONS AND NON-NEAR FIELD COMMUNICATIONS**

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

(72) Inventors: **Yijun Zhou**, Mountain View, CA (US);
Yiren Wang, Santa Clara, CA (US);
Jennifer M. Edwards, San Francisco, CA (US); **Hao Xu**, Cupertino, CA (US);
Mattia Pascolini, San Francisco, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 65 days.

(21) Appl. No.: **15/700,565**

(22) Filed: **Sep. 11, 2017**

(65) **Prior Publication Data**

US 2019/0081398 A1 Mar. 14, 2019

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

(52) **U.S. Cl.**
CPC **H01Q 5/328** (2015.01); **H01Q 9/0421** (2013.01); **H01Q 1/241** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/32; H01Q 9/04; H01Q 1/24
USPC 343/722
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,344,959 B2	1/2013	Autti et al.	
9,537,983 B2	1/2017	Lee et al.	
2014/0139380 A1	5/2014	Ouyang et al.	
2015/0303568 A1*	10/2015	Yarga	H01Q 5/321 343/720
2016/0197401 A1*	7/2016	Ouyang	H01Q 21/30 343/724

* cited by examiner

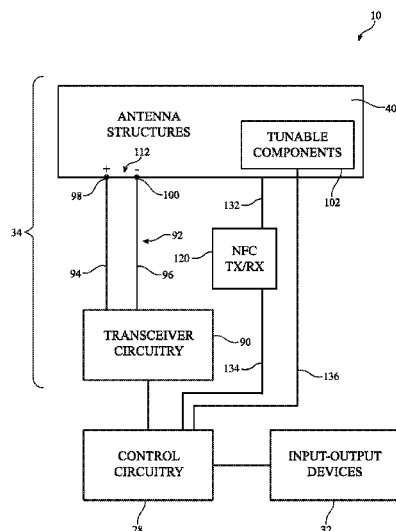
Primary Examiner — Andrea Lindgren Baltzell

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

(57) **ABSTRACT**

An electronic device may be provided with wireless circuitry. The wireless circuitry may include antenna structures such as an antenna resonating element arm and an antenna ground. A split return path may be coupled between the antenna resonating element arm and the antenna ground. The antenna structures may form one or more inverted-F antennas when operated at non-near-field communications frequencies. The antenna structures may be coupled to near-field communications transceiver circuitry using a conductive path. When operated at near-field communications frequencies, near-field communications signals may be conveyed using the conductive path, the antenna resonating element arm, the return path, and the antenna ground. A capacitor may be coupled between the conductive path and an antenna ground. The capacitor may short non-near-field communications signals to the antenna ground and block near-field communications signals from passing from the conductive path to the antenna ground.

20 Claims, 7 Drawing Sheets



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

(10) **Patent No.:** **US 10,263,336 B1**
(45) **Date of Patent:** **Apr. 16, 2019**

(54) **MULTI-BAND MULTI-ANTENNA ARRAY**

FOREIGN PATENT DOCUMENTS

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

CN 103229356A A 7/2013
CN 104393398B B 5/2017

(Continued)

(72) Inventors: **Kin-Lu Wong, Hsinchu (TW); Wei-Yu Li, Hsinchu (TW); Chih-Yu Tsai, Hsinchu (TW)**

OTHER PUBLICATIONS

(73) Assignee: **Industrial Technology Research Institute, Hsinchu (TW)**

Ding, Y., "A Novel Dual-Band Printed Diversity Antenna for Mobile Terminals" IEEE Transactions on Antennas and Propagation, Jul. 2007, pp. 2088-2096, US.

(Continued)

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

Primary Examiner — Andrea Lindgren Baltzell

(21) Appl. No.: **15/855,601**

(74) *Attorney, Agent, or Firm* — Mintz Levin Cohn Ferris Glovsky and Popeo, P.C.; Peter F. Corless; Steven M. Jensen

(22) Filed: **Dec. 27, 2017**

(30) **Foreign Application Priority Data**

Dec. 8, 2017 (TW) 106143155 A

(57) **ABSTRACT**

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

A multi-band multi-antenna array includes a ground conductor plane and a dual antenna array. The ground conductor plane includes a first edge and separates a first side space and a second side space. The dual antenna array has a maximum array length extending along the first edge and includes a first antenna and a second antenna. The first antenna includes a first resonant loop and a first radiating conductor line exciting the first antenna generating a first resonant mode and a second resonant mode, respectively, wherein frequencies of the first resonant mode are lower than frequencies of the second resonant mode. The second antenna includes a second resonant loop and a second radiating conductor line exciting the first antenna generating a third resonant mode and a fourth resonant mode, respectively, wherein frequencies of the third resonant mode are lower than frequencies of the fourth resonant mode.

(52) **U.S. Cl.**
CPC **H01Q 5/35** (2015.01); **H01Q 1/48** (2013.01); **H01Q 7/00** (2013.01); **H01Q 9/0457** (2013.01); **H01Q 21/065** (2013.01); **H01Q 1/243** (2013.01)

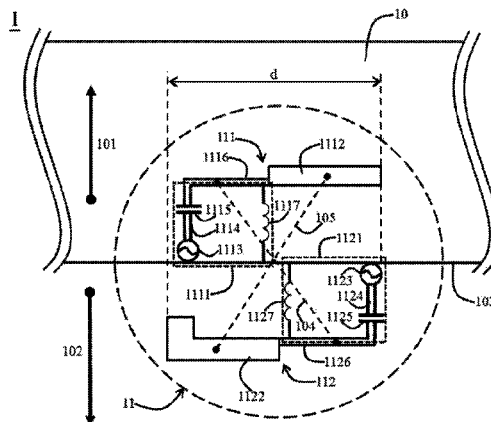
(58) **Field of Classification Search**
CPC .. H01Q 5/35; H01Q 1/48; H01Q 7/00; H01Q 9/04; H01Q 21/06; H01Q 1/24
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

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

15 Claims, 13 Drawing Sheets



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

(10) **Patent No.:** **US 10,270,165 B2**
(45) **Date of Patent:** **Apr. 23, 2019**

(54) **ANTENNA DEVICE**

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

(72) Inventors: **Makoto Higaki**, Setagaya Tokyo (JP);
Seiya Kishimoto, Shinagawa Tokyo (JP);
Makoto Sano, Kawasaki Kanagawa (JP)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 52 days.

(21) Appl. No.: **15/444,694**

(22) Filed: **Feb. 28, 2017**

(65) **Prior Publication Data**

US 2018/0006369 A1 Jan. 4, 2018

(30) **Foreign Application Priority Data**

Jul. 1, 2016 (JP) 2016-131786

(51) **Int. Cl.**

H01Q 3/24 (2006.01)
H01Q 1/48 (2006.01)
H01Q 1/50 (2006.01)
H01Q 9/42 (2006.01)

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

CPC **H01Q 3/24** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/50** (2013.01); **H01Q 3/247** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**

CPC .. H01Q 3/24; H01Q 1/48; H01Q 1/50; H01Q 3/247; H01Q 9/42
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2017/0084985 A1* 3/2017 Ku H01Q 1/243

FOREIGN PATENT DOCUMENTS

JP	2003168916 A	6/2003
JP	2003283225 A	10/2003
JP	2004064282 A	2/2004
JP	2004147040 A	5/2004
JP	2006319772 A	11/2006

* cited by examiner

Primary Examiner — Dameon E Levi

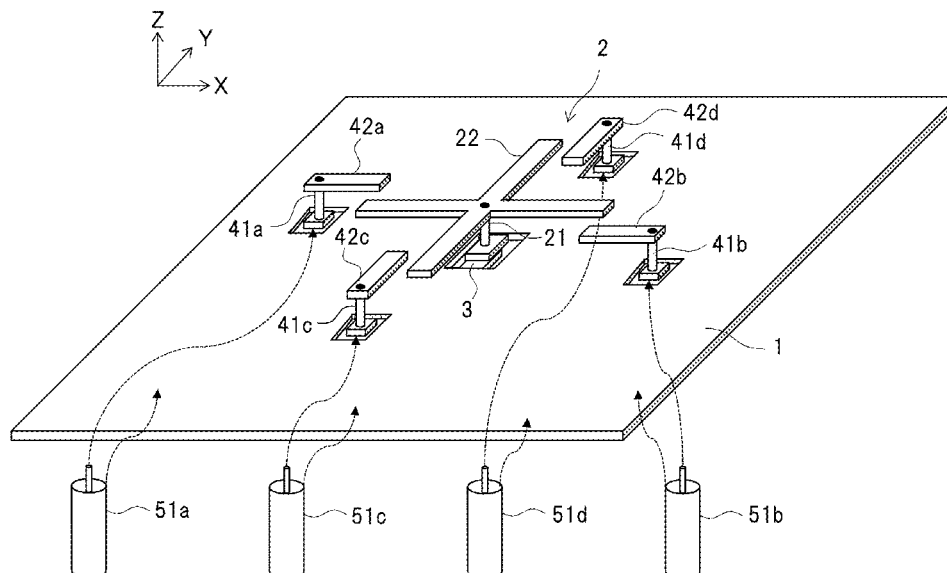
Assistant Examiner — David E Lotter

(74) *Attorney, Agent, or Firm* — Holtz, Holtz & Volek PC

(57) **ABSTRACT**

The antenna device in one embodiment of the present invention includes a conductor ground plate, a first antenna portion, a switch, and a plurality of second antenna portions. The above described switch is connected between the above described conductor ground plate and the above described first antenna portion. The above described plurality of second antenna portions are arranged at positions at which the second antenna portions can be capacitively coupled to the above described first antenna portion.

8 Claims, 8 Drawing Sheets



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

(10) **Patent No.:** **US 10,270,170 B2**
(45) **Date of Patent:** **Apr. 23, 2019**

(54) **COMPOUND LOOP ANTENNA SYSTEM WITH ISOLATION FREQUENCY AGILITY**

(71) Applicant: **DOCKON AG**, Zurich (CH)
(72) Inventors: **Matthew Robert Foster**, San Diego, CA (US); **Jonathan Neil Bringuier**, Carlsbad, CA (US); **Ryan James Orsi**, San Diego, CA (US); **Forrest James Brown**, San Diego, CA (US); **Alexandre Dupuy**, San Diego, CA (US)

(73) Assignee: **QuantalRF AG**

(*) 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.: **15/351,300**

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

(65) **Prior Publication Data**
US 2017/0062932 A1 Mar. 2, 2017

Related U.S. Application Data
(63) Continuation-in-part of application No. 14/253,678, filed on Apr. 15, 2014, now Pat. No. 9,496,614.

(51) **Int. Cl.**
H01Q 7/00 (2006.01)
H01Q 1/48 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 7/00** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/525** (2013.01); **H01Q 5/371** (2015.01)

(58) **Field of Classification Search**
USPC 343/700 MS, 702, 729, 867
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,987,421 A 1/1991 Sunahara et al.
5,952,982 A 9/1999 Jorgenson et al.
(Continued)

FOREIGN PATENT DOCUMENTS

EP 1753080 A1 2/2007
WO WO 2009/118565 10/2009

OTHER PUBLICATIONS

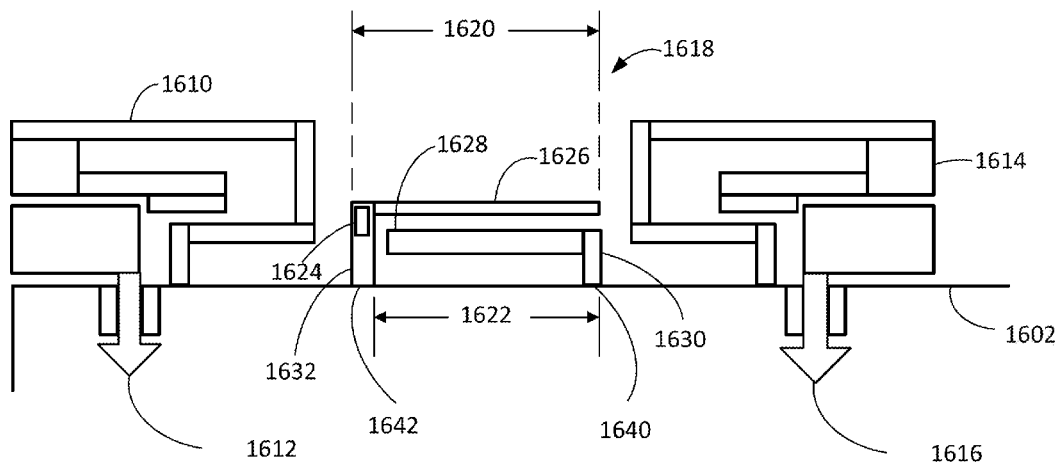
International Patent Application No. PCT/US2014/69627; Int'l Preliminary Report on Patentability; dated Dec. 11, 2015; 19 pages.
(Continued)

Primary Examiner — Hai V Tran
(74) *Attorney, Agent, or Firm* — Cooley LLP

(57) **ABSTRACT**

An antenna system is provided, including a first antenna, a second antenna, a ground plane, and a resonant isolator located proximate to the first antenna and the second antenna. The resonant isolator is coupled to the ground plane at or proximate to one current null point created by a first antenna and at or proximate to a second current null point created by a second antenna, and is configured to isolate the first antenna from the second antenna at a resonance. In some cases, the resonant isolator may include at least two conductive portions that may be substantially parallel to one another. The resonant isolator may also include an active tuning element that may change the resonance at which the resonant isolator de-couples the two antennas. In some cases, each of the antennas may be a capacitively-coupled compound loop antenna.

17 Claims, 21 Drawing Sheets



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

(10) **Patent No.:** **US 10,270,171 B2**
(45) **Date of Patent:** **Apr. 23, 2019**

(54) **ELECTRONIC DEVICE AND ANTENNA**

(71) Applicant: **SONY MOBILE COMMUNICATIONS INC.**,
Shinagawa-ku (JP)

(72) Inventors: **Check Chin Yong**, Tokyo (JP); **Tatsuya Nagae**, Tokyo (JP)

(73) Assignee: **SONY MOBILE COMMUNICATIONS INC.**, Tokyo (JP)

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

(21) Appl. No.: **15/344,176**

(22) Filed: **Nov. 4, 2016**

(65) **Prior Publication Data**

US 2017/0141470 A1 May 18, 2017

(30) **Foreign Application Priority Data**

Nov. 13, 2015 (JP) 2015-223130

(51) **Int. Cl.**

H01Q 7/06 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/38 (2006.01)
H04B 5/00 (2006.01)
H01Q 1/24 (2006.01)

(Continued)

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

CPC **H01Q 7/06** (2013.01); **H01Q 1/2291** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/248** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/20** (2015.01); **H01Q 5/314** (2015.01); **H01Q 9/0421** (2013.01); **H01Q 7/00** (2013.01); **H01Q 21/28** (2013.01); **H04B 5/0031** (2013.01); **H04B 5/0037** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 7/06; H01Q 1/38; H01Q 1/2291; H01Q 1/248; H01Q 5/35; H01Q 5/314; H01Q 5/20; H01Q 21/28; H01Q 9/0421; H01Q 7/00; H01Q 1/243; H04B 5/0031; H04B 5/0037

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,661,446 B2* 5/2017 Konanur H01Q 7/00
2010/0222010 A1 9/2010 Ozaki et al.
(Continued)

FOREIGN PATENT DOCUMENTS

JP 2014-96612 5/2014

OTHER PUBLICATIONS

Extended European Search Report dated Mar. 21, 2017 in Patent Application No. 16197267.4.

Primary Examiner — Jessica Han

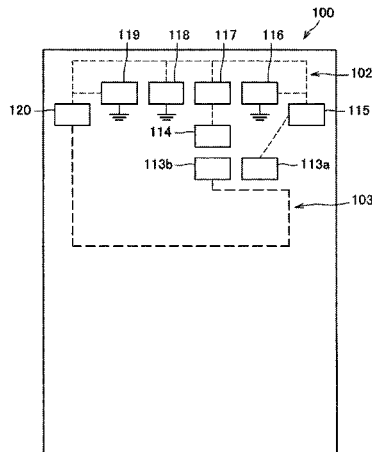
Assistant Examiner — Michael M Bouizza

(74) *Attorney, Agent, or Firm* — Xsensus LLP

(57) **ABSTRACT**

There is provided an electronic device including: a first antenna for wireless communication; a second antenna for near-field communication that forms a loop by being used together with the first antenna, at least a part of the second antenna being positioned at a back surface of a display region of a display; and a first filter that is provided in the first antenna or the second antenna, passes a signal of a frequency band used in the near-field communication to the first antenna, and blocks inflow of the signal of the frequency band used in the wireless communication into the second antenna.

19 Claims, 33 Drawing Sheets



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

(10) **Patent No.:** **US 10,270,186 B2**
(45) **Date of Patent:** **Apr. 23, 2019**

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

- (71) Applicant: **KABUSHIKI KAISHA TOSHIBA**,
Minato-ku, Tokyo (JP)
- (72) Inventors: **Masao Teshima**, Tokyo (JP); **Akihiro Tsujimura**, Tokyo (JP)
- (73) Assignee: **KABUSHIKI KAISHA TOSHIBA**,
Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 417 days.

(21) Appl. No.: **15/019,018**
(22) Filed: **Feb. 9, 2016**

(65) **Prior Publication Data**
US 2017/0062953 A1 Mar. 2, 2017

Related U.S. Application Data
(60) Provisional application No. 62/212,140, filed on Aug. 31, 2015.

(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)

(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)

(58) **Field of Classification Search**
CPC H01Q 3/24; H01Q 21/065; H01Q 21/28; H01Q 1/243
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,529,166 B2 *	3/2003	Kanamaluru	H01Q 25/00 343/700 MS
6,768,476 B2 *	7/2004	Lilly	H01Q 1/243 343/700 MS
6,795,020 B2 *	9/2004	Sreenivas	H01Q 1/38 343/700 MS
7,760,154 B2 *	7/2010	Sekine	H01Q 1/38 343/795

(Continued)

FOREIGN PATENT DOCUMENTS

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

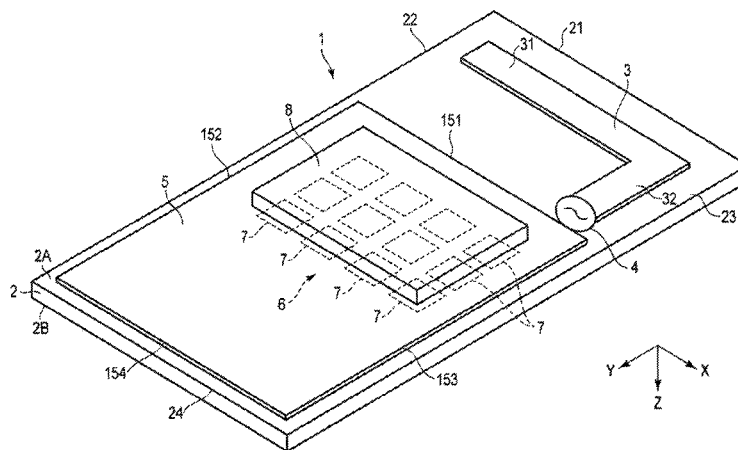
(Continued)

Primary Examiner — Dameon E Levi
Assistant Examiner — Ab Salam Alkassim, Jr.
(74) *Attorney, Agent, or Firm* — Foley & Lardner LLP

(57) **ABSTRACT**

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.

10 Claims, 14 Drawing Sheets





US010276924B2

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

(10) **Patent No.:** **US 10,276,924 B2**
(45) **Date of Patent:** **Apr. 30, 2019**

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

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

(72) Inventors: **Cheng-Han Lee**, New Taipei (TW);
Yi-Wen Hsu, New Taipei (TW);
Wei-Xuan Ye, New Taipei (TW)

(73) Assignee: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)

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

(21) Appl. No.: **15/647,282**

(22) Filed: **Jul. 12, 2017**

(65) **Prior Publication Data**

US 2018/0026346 A1 Jan. 25, 2018

Related U.S. Application Data

(60) Provisional application No. 62/364,303, filed on Jul. 19, 2016.

(30) **Foreign Application Priority Data**

Jun. 29, 2017 (CN) 2017 1 0518152

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 5/10 (2015.01)
H01Q 9/42 (2006.01)
H01Q 13/10 (2006.01)

(Continued)

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

CPC **H01Q 1/243** (2013.01); **H01Q 5/10** (2015.01); **H01Q 5/371** (2015.01); **H01Q 9/42** (2013.01); **H01Q 13/10** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 5/10; H01Q 5/371; H01Q 13/10; H01Q 9/0421; H01Q 9/42; H01Q 1/36; H01Q 1/48; H01Q 9/0485; H01Q 9/0414; H01Q 9/0457; H01Q 9/14;

(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,650,294 B2 * 11/2003 Ying H01Q 1/243 343/700 MS

2014/0347227 A1 11/2014 Iellici et al.
2015/0123871 A1 5/2015 Chang et al.

(Continued)

FOREIGN PATENT DOCUMENTS

WO WO2013135043 * 9/2013 H01Q 1/243

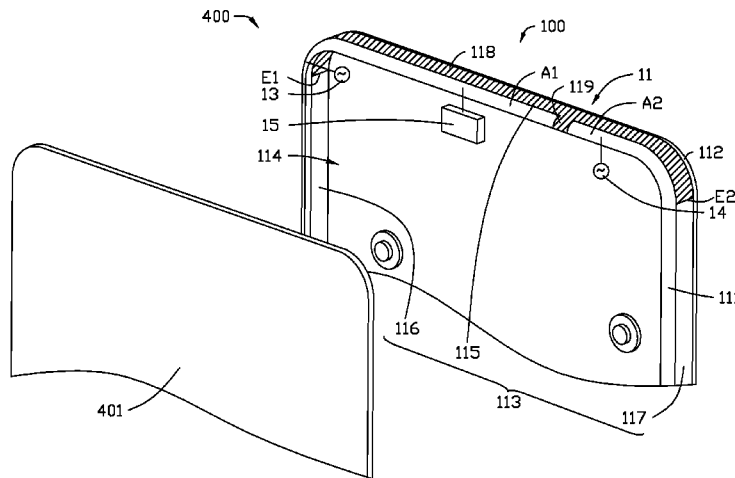
Primary Examiner — Jianxun Yang

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

(57) **ABSTRACT**

An antenna structure includes a metal housing, a first feed source, and a first radiator. 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 gap. The metal housing is divided into at least a long portion and a short portion by the slot and the gap. The radiator is positioned in the housing and includes a first radiating portion and a second radiating portion. One end of the first radiating portion is electrically connected to the first feed source and another end of the first radiating portion is spaced apart from the long portion. One end of the second radiating portion is electrically connected to the first feed source and another end of the second radiating portion is spaced apart from the short portion.

24 Claims, 83 Drawing Sheets





US010276938B2

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

(10) **Patent No.:** **US 10,276,938 B2**
(45) **Date of Patent:** **Apr. 30, 2019**

- (54) **MOBILE TERMINAL DEVICE**
- (71) Applicants: **Chan Yun Ghit**, Shenzhen (CN); **Ng Guan Hong**, Shenzhen (CN); **Tay Yew Siow**, Shenzhen (CN); **Tan Yew Choon**, Shenzhen (CN)
- (72) Inventors: **Chan Yun Ghit**, Shenzhen (CN); **Ng Guan Hong**, Shenzhen (CN); **Tay Yew Siow**, Shenzhen (CN); **Tan Yew Choon**, 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 460 days.

- (21) Appl. No.: **15/062,057**
- (22) Filed: **Mar. 5, 2016**
- (65) **Prior Publication Data**
US 2017/0033437 A1 Feb. 2, 2017

- (30) **Foreign Application Priority Data**
Jul. 31, 2015 (CN) 2015 1 0463929

- (51) **Int. Cl.**
H01Q 1/02 (2006.01)
H01Q 9/04 (2006.01)
H01Q 1/24 (2006.01)
- (52) **U.S. Cl.**
CPC **H01Q 9/0421** (2013.01); **H01Q 1/243** (2013.01)

- (58) **Field of Classification Search**
CPC H01Q 9/0421
USPC 343/702
See application file for complete search history.

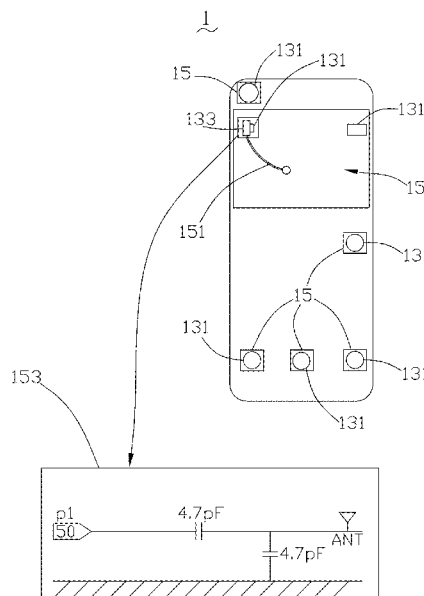
- (56) **References Cited**
U.S. PATENT DOCUMENTS
2009/0153412 A1* 6/2009 Chiang H01Q 1/52
343/702
2009/0231215 A1* 9/2009 Taura H01Q 1/243
343/702
2016/0093955 A1* 3/2016 Ayala Vazquez H01Q 9/0442
343/702

* cited by examiner

Primary Examiner — Dameon E Levi
Assistant Examiner — David E Lotter
(74) *Attorney, Agent, or Firm* — Na Xu; IPro, PLLC

- (57) **ABSTRACT**
A mobile terminal device is disclosed. The mobile terminal device includes a metal rear cover; a metal frame forming an accommodation space with the metal rear cover; a printed circuit board assembly; and an antenna module inside the accommodation space and electrically connected with the printed circuit board assembly. The antenna module includes a grounding terminal and a feeding point disposed on the printed circuit board assembly. The metal rear cover includes a first metal part, a second metal part, a third metal part and the two coupled gap. The first metal part and the third metal part are connected to both ends of the second metal part.

8 Claims, 5 Drawing Sheets





US010276943B2

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

(10) **Patent No.:** **US 10,276,943 B2**

(45) **Date of Patent:** **Apr. 30, 2019**

(54) **ANTENNA DEVICE INCLUDING PATCH ARRAY ANTENNA AND CONDUCTIVE METAL MEMBER**

(58) **Field of Classification Search**

CPC H01Q 1/48; H01Q 13/28; H01Q 9/0407; H01Q 21/065; H01Q 21/08

USPC 343/789
See application file for complete search history.

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

(56) **References Cited**

(72) Inventors: **Kazunari Kawahata**, Kyoto (JP);
Ryukun Mizunuma, Kyoto (JP)

U.S. PATENT DOCUMENTS

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

7,215,298 B1 * 5/2007 Fraschilla H01Q 1/08
342/174
2008/0054317 A1 * 3/2008 Kim H01L 27/14621
257/290
2008/0136713 A1 * 6/2008 Fu H01Q 21/065
343/700 MS
2009/0213012 A1 * 8/2009 Jiang H01Q 1/38
343/700 MS
2014/0225782 A1 * 8/2014 Sanford H01Q 21/0087
343/700 MS

(*) 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.: **15/703,267**

FOREIGN PATENT DOCUMENTS

(22) Filed: **Sep. 13, 2017**

JP H07-273536 A 10/1995
JP 2010-161612 A 7/2010
WO 00/48269 A1 8/2000

(65) **Prior Publication Data**

US 2018/0076530 A1 Mar. 15, 2018

Primary Examiner — Lam T Mai

(30) **Foreign Application Priority Data**

Sep. 14, 2016 (JP) 2016-179318

(74) *Attorney, Agent, or Firm* — Pearne & Gordon LLP

(57) **ABSTRACT**

(51) **Int. Cl.**

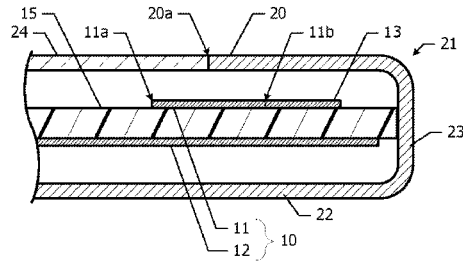
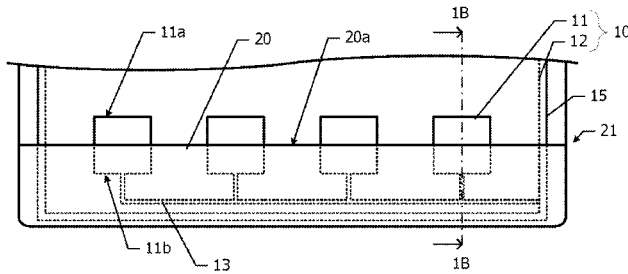
H01Q 13/28 (2006.01)
H01Q 21/06 (2006.01)
H01Q 1/48 (2006.01)
H01Q 9/04 (2006.01)
H01Q 19/10 (2006.01)
H01Q 21/08 (2006.01)

A patch array antenna includes a ground plane and a plurality of radiation elements that are disposed being distanced from the ground plane. A conductive metal member is disposed above a surface on which the plurality of radiation elements are disposed. The metal member overlaps with part of a region of each of the plurality of radiation elements in a direction orthogonal to an array direction of the patch array antenna and does not overlap with the other part of the region, and continuously extends from the radiation element at one end to the radiation element at the other end in the array direction.

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

CPC **H01Q 13/28** (2013.01); **H01Q 1/48** (2013.01); **H01Q 9/0407** (2013.01); **H01Q 19/10** (2013.01); **H01Q 21/065** (2013.01); **H01Q 21/08** (2013.01)

12 Claims, 6 Drawing Sheets



(12) **United States Patent**
Karlsson

(10) **Patent No.:** **US 10,283,840 B2**
(45) **Date of Patent:** **May 7, 2019**

(54) **MULTI-BAND WLAN ANTENNA DEVICE**

(71) Applicant: **InCoax Networks AB**, Gävle (SE)

(72) Inventor: **Carl Karlsson**, Sandviken (SE)

(73) Assignee: **INCOAX NETWORKS AB**, Gävle (SE)

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

(21) Appl. No.: **15/341,500**

(22) Filed: **Nov. 2, 2016**

(65) **Prior Publication Data**

US 2017/0324146 A1 Nov. 9, 2017

(30) **Foreign Application Priority Data**

Apr. 18, 2016 (SE) 1630092

(51) **Int. Cl.**

H01Q 1/22 (2006.01)
H01Q 1/36 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/48 (2006.01)
H01Q 1/52 (2006.01)

(Continued)

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

CPC **H01Q 1/2291** (2013.01); **H01Q 1/36** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/371** (2015.01); **H01Q 5/50** (2015.01); **H01Q 9/42** (2013.01); **H01Q 21/24** (2013.01); **H01Q 21/28** (2013.01); **H01Q 1/521** (2013.01); **H01Q 5/35** (2015.01)

(58) **Field of Classification Search**

CPC H01Q 1/2291; H01Q 1/48; H01Q 1/38; H01Q 1/521; H01Q 1/52
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2006/0181464 A1* 8/2006 Erkocevic H01Q 1/243 343/702
2011/0134897 A1* 6/2011 Montemurro H04M 1/72536 370/338

(Continued)

FOREIGN PATENT DOCUMENTS

DE 202014103657 U1 7/2015
EP 1083624 B1 2/2006
EP 2790268 A1 10/2014

OTHER PUBLICATIONS

International-Type Search Report for Swedish Patent Application No. SE 1630092-3 dated Nov. 2, 2016.

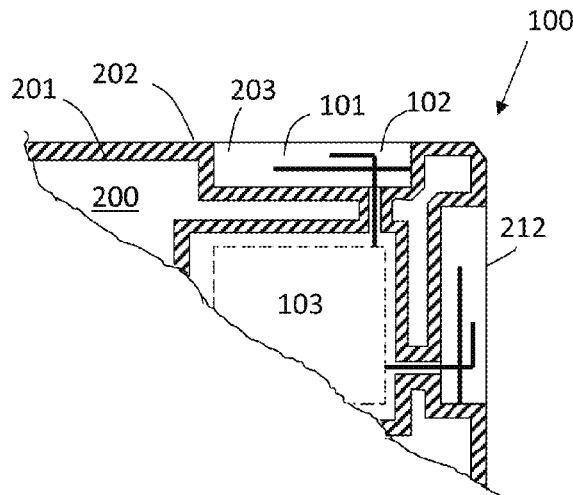
(Continued)

Primary Examiner — Ricardo I Magallanes
(74) *Attorney, Agent, or Firm* — Moore & Van Allen PLLC; Henry B. Ward, III

(57) **ABSTRACT**

A multi-band WLAN antenna device, comprising a layer of conductive material forming a planar ground plane, having a first side edge in which a first cutout is formed, having an indented cutout edge and first and second connecting edges. A first antenna structure is formed in the cutout, comprising a first member projecting from the first connecting edge and extending parallel to the indented cutout edge. The antenna structure also includes a second member having a first part projecting from a feed point at the indented cutout edge, extending through the first member, and a second part connected to the first part and extending parallel to the first member away from the first connecting edge.

19 Claims, 3 Drawing Sheets





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

(10) **Patent No.:** **US 10,283,847 B2**
(45) **Date of Patent:** **May 7, 2019**

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

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

(72) Inventors: **Kuan-Hung Li**, Hsinchu (TW);
Cheng-Da Yang, Hsinchu (TW);
Shang-Ching Tseng, Hsinchu (TW);
Yu-Yu Chiang, Hsinchu (TW)

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

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

(21) Appl. No.: **15/854,045**

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

(65) **Prior Publication Data**

US 2019/0027810 A1 Jan. 24, 2019

(30) **Foreign Application Priority Data**

Jul. 24, 2017 (TW) 106124727 A

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/44 (2006.01)
H01Q 1/48 (2006.01)
H01Q 21/30 (2006.01)
H01Q 5/392 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/245** (2013.01); **H01Q 1/44** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/392** (2015.01); **H01Q 21/30** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/44; H01Q 1/48; H01Q 21/30

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2003/0122721 A1* 7/2003 Sievenpiper H01Q 9/14 343/767
2013/0271333 A1* 10/2013 Taura H01Q 13/10 343/767
2017/0033467 A1 2/2017 Huang et al.
2017/0207542 A1* 7/2017 Tseng H01Q 13/10
2018/0219297 A1* 8/2018 Chen H01Q 7/00

FOREIGN PATENT DOCUMENTS

TW 201703350 A 1/2017

* cited by examiner

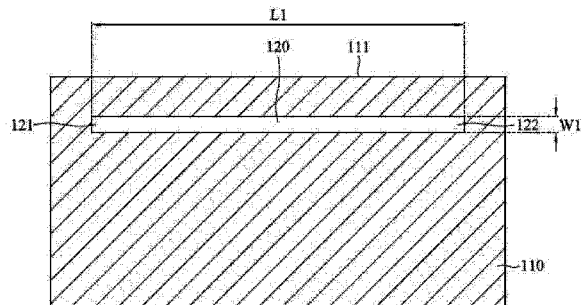
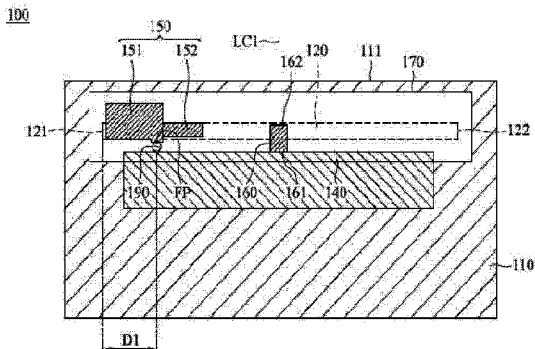
Primary Examiner — Dieu Hien T Duong

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

(57) **ABSTRACT**

An antenna device includes a metal mechanism element, a ground plane, a feeding element, a grounding extension element, and a dielectric substrate. The metal mechanism element has a slot. The feeding element has a feeding point coupled to a signal source. The feeding element extends across the slot. The grounding extension element is coupled to the ground plane. A vertical projection of the grounding extension element at least partially overlaps the slot. An antenna structure is formed by the feeding element, the grounding extension element, and the slot of the metal mechanism element. The antenna structure is capable of covering a low-frequency band and a high-frequency band. The distance between the feeding point and one end of the slot is less than or equal to 0.1 wavelength of a central frequency of the low-frequency band.

10 Claims, 10 Drawing Sheets





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

(10) **Patent No.:** **US 10,283,858 B2**
(45) **Date of Patent:** **May 7, 2019**

(54) **ANTENNA FOR TERMINAL**
(71) Applicant: **Beijing Xiaomi Mobile Software Co., Ltd.**, Beijing (CN)
(72) Inventors: **Zonglin Xue**, Beijing (CN); **Linchuan Wang**, Beijing (CN); **Xiaofeng Xiong**, Beijing (CN)
(73) Assignee: **Beijing Xiaomi Mobile Software Co., Ltd.**, Beijing (CN)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 37 days.

(56) **References Cited**
U.S. PATENT DOCUMENTS
9,203,141 B1 12/2015 Su et al.
2007/0285321 A1* 12/2007 Chung H01Q 1/38 343/702

(Continued)
FOREIGN PATENT DOCUMENTS
CN 103236583 A 8/2013
CN 103326124 A 9/2013
(Continued)

OTHER PUBLICATIONS
Supplementary European Search Report in European application No. 17165010.4, dated Aug. 22, 2017, 9 pages.
(Continued)

(21) Appl. No.: **15/473,211**
(22) Filed: **Mar. 29, 2017**
(65) **Prior Publication Data**
US 2017/0294709 A1 Oct. 12, 2017

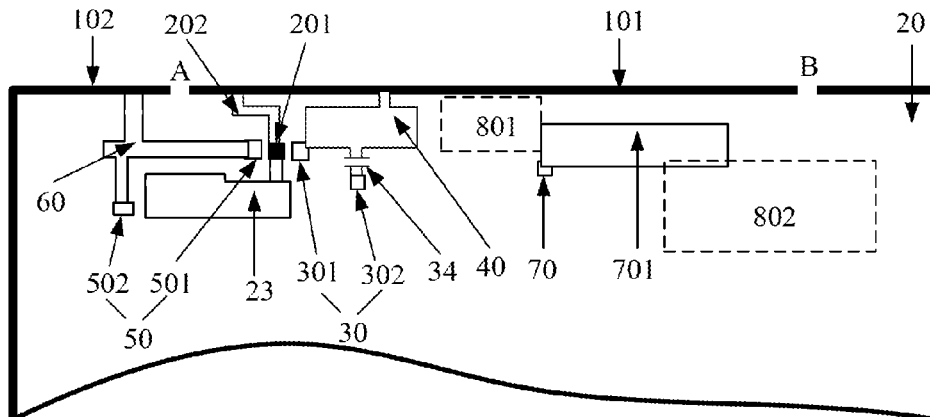
Primary Examiner — Linh V Nguyen
(74) *Attorney, Agent, or Firm* — Arch & Lake LLP

(30) **Foreign Application Priority Data**
Apr. 8, 2016 (CN) 2016 1 0214832

(57) **ABSTRACT**
An antenna for a terminal includes: a metal frame surrounding four sides of the terminal, a circuit board positioned within the metal frame and at least two radiation units arranged on the circuit board. The metal frame includes a bottom frame and a side frame defined by two breaking joints disposed on a side of the metal frame. A signal feed point is arranged on the circuit board, the signal feed point is connected with the bottom frame through a first radiation unit. At least two first grounding points are also arranged on the circuit board, the at least two first grounding points are positioned on one side of the signal feed point, the at least two first grounding points are connected with the bottom frame through a second radiation unit, and the bottom frame is configured to generate low-frequency resonance.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)
(Continued)
(52) **U.S. Cl.**
CPC **H01Q 1/48** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/328** (2015.01);
(Continued)
(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 13/10; H01Q 9/0421; H01Q 9/42; H01Q 5/307; H01Q 13/106; H01Q 21/29; H01Q 5/00; H01Q 5/321
(Continued)

18 Claims, 2 Drawing Sheets





US010283864B2

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

(10) **Patent No.:** **US 10,283,864 B2**
(45) **Date of Patent:** **May 7, 2019**

(54) **ANTENNA AND TERMINAL**
(71) Applicant: **Huawei Device Co., Ltd.**, Dongguan (CN)
(72) Inventors: **Jianming Li**, Taipei (TW); **Hanyang Wang**, Shenzhen (CN); **Kun Feng**, Shanghai (CN); **Xiaoju Zhang**, 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.: **15/186,123**

(22) Filed: **Jun. 17, 2016**

(65) **Prior Publication Data**
US 2016/0301134 A1 Oct. 13, 2016

Related U.S. Application Data
(63) Continuation of application No. PCT/CN2013/090144, filed on Dec. 20, 2013.

(51) **Int. Cl.**
H01Q 5/328 (2015.01)
H01Q 1/48 (2006.01)
H01Q 9/04 (2006.01)
H01Q 5/335 (2015.01)
(52) **U.S. Cl.**
CPC **H01Q 5/328** (2015.01); **H01Q 1/48** (2013.01); **H01Q 5/335** (2015.01); **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/328; H01Q 5/335; H01Q 1/48; H01Q 9/0421
See application file for complete search history.

(56) **References Cited**
U.S. PATENT DOCUMENTS
8,570,227 B1 10/2013 Mileski
8,629,813 B2 1/2014 Milosavljevic
2004/0075614 A1 4/2004 Dakeya et al.
2006/0017621 A1 1/2006 Okawara et al.
2007/0285335 A1 12/2007 Bungo et al.
2009/0278755 A1 11/2009 Shoji
(Continued)

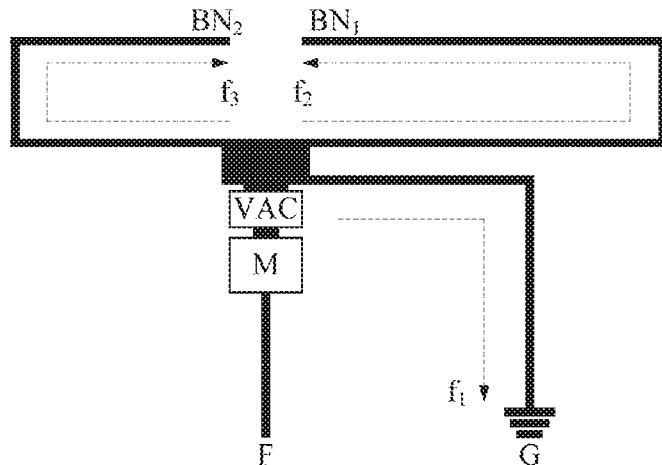
FOREIGN PATENT DOCUMENTS
CN 201060933 Y 5/2008
CN 101212230 A 7/2008
(Continued)

OTHER PUBLICATIONS
Wong, Kin-Liu et al., 4G/Multiband Handheld Device Ground Antennas, Asia-Pacific Microwave Conference Proceedings, 2013, 3 pages.
(Continued)

Primary Examiner — Hai V Tran
Assistant Examiner — Michael M Bouizza
(74) *Attorney, Agent, or Firm* — Slater Matsil, LLP

(57) **ABSTRACT**
The present invention discloses an antenna and a terminal, which can extend antenna bandwidth. The antenna includes a capacitor component and at least one radiator, where one end of each radiator of the at least one radiator is connected to form a first node, the first node is connected to one end of the capacitor component to form a second node, and the second node is grounded; and the other end of the capacitor component receives a feed signal.

20 Claims, 4 Drawing Sheets





US010283865B2

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

(10) **Patent No.:** **US 10,283,865 B2**
(45) **Date of Patent:** **May 7, 2019**

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

(71) Applicant: **Samsung Electronics Co., Ltd.**,
Gyeonggi-do (KR)
(72) Inventors: **Hyun Seock Roh**, Gyeonggi-do (KR);
Sang Bong Sung, Gyeonggi-do (KR);
Seong Yong An, Gyeonggi-do (KR); **Se**
Woong Kim, Gyeongsangnam-do (KR);
Ji Ho Kim, Gyeonggi-do (KR); **Gyu**
Bok Park, Gyeonggi-do (KR); **Kyung**
Moon Seol, Seoul (KR); **Shin Ho**
Yoon, Gyeonggi-do (KR)

(73) Assignee: **Samsung Electronics Co., Ltd** (KR)
(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 304 days.

(21) Appl. No.: **15/165,415**

(22) Filed: **May 26, 2016**

(65) **Prior Publication Data**
US 2016/0352015 A1 Dec. 1, 2016

(30) **Foreign Application Priority Data**
May 27, 2015 (KR) 10-2015-0074261

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/50 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/50** (2015.01); **H01Q 1/243**
(2013.01); **H01Q 1/48** (2013.01); **H01Q 5/307**
(2015.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/00; H01Q 21/28;
H01Q 9/30; H01Q 3/24
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,891,506 B2 5/2005 Jarmuszewski et al.
7,183,984 B2 2/2007 Jarmuszewski et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 1663072 8/2005
CN 101496224 7/2009
(Continued)

OTHER PUBLICATIONS

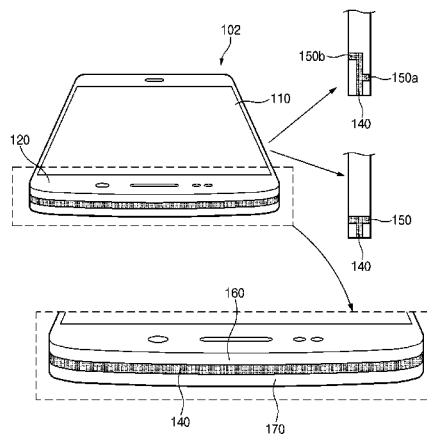
European Search Report dated Nov. 4, 2016 issued in counterpart
application No. 16171650.1-1811, 10 pages.
(Continued)

Primary Examiner — Joseph J Lauture
(74) *Attorney, Agent, or Firm* — The Farrell Law Firm,
P.C.

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a housing including a first surface, a second surface facing the first surface, and side surfaces surrounding a space between the first surface and the second surface, a first conductive member and a second conductive member forming at least part of the side surfaces, being parallel to the first surface, and extending parallel to each other, a first nonconductive member disposed between the first conductive member and the second conductive member to electrically isolate the first conductive member and the second conductive member from each other, and a communication circuit that performs wireless communication by using the first conductive member and the second conductive member as radiators.

16 Claims, 18 Drawing Sheets



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

(10) **Patent No.:** **US 10,283,867 B2**
(45) **Date of Patent:** **May 7, 2019**

(54) **SQUARE SHAPED MULTI-SLOTTED 2.45 GHZ WEARABLE ANTENNA**
(71) Applicant: **COMSATS Institute of Information Technology, Wah (PK)**
(72) Inventors: **Muhammad Toaha Raza Khan, Wah (PK); Nadia Nawaz Qadri, Wah (PK); Hassan Iftikhar, Wah (PK)**
(73) Assignee: **COMSATS Institute of Information Technology (PK)**
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 144 days.

(52) **U.S. Cl.**
CPC **H01Q 9/0407** (2013.01); **H01Q 1/245** (2013.01); **H01Q 1/273** (2013.01)
(58) **Field of Classification Search**
CPC H01G 1/38; H01G 9/0407
See application file for complete search history.

(56) **References Cited**
U.S. PATENT DOCUMENTS
2011/0006950 A1* 1/2011 Park H01Q 9/0407 343/700 MS
2016/0079676 A1* 3/2016 Chuang H01Q 9/0407 343/770

* cited by examiner
Primary Examiner — Graham P Smith
(74) *Attorney, Agent, or Firm* — H.C. Park & Associates, PLC

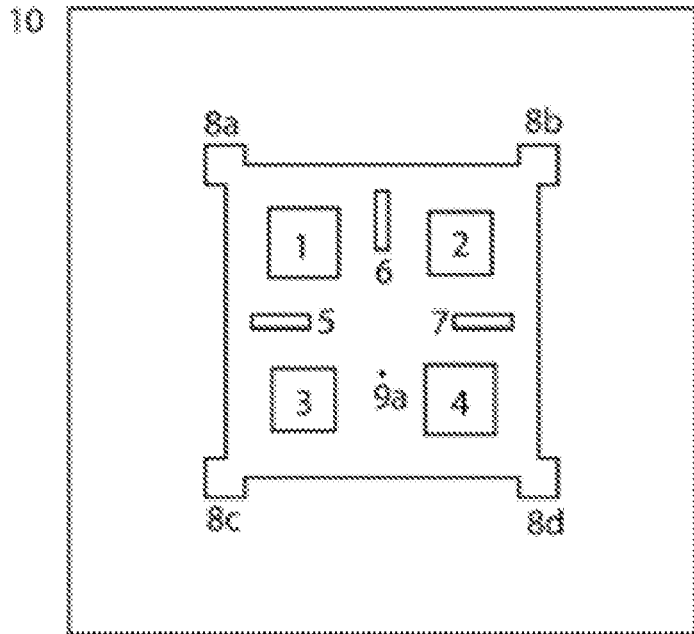
(21) Appl. No.: **15/626,536**
(22) Filed: **Jun. 19, 2017**
(65) **Prior Publication Data**
US 2017/0365927 A1 Dec. 21, 2017

(30) **Foreign Application Priority Data**
Jun. 20, 2016 (PK) 370/2016

(51) **Int. Cl.**
H01Q 1/32 (2006.01)
H01Q 9/04 (2006.01)
H01Q 1/27 (2006.01)
H01Q 1/24 (2006.01)

(57) **ABSTRACT**
A microstrip antenna including: a substrate; a radiating slotted patch; a square plate; and a coaxial feed, wherein the coaxial feed further comprises an inner central conducting pin; wherein the substrate is sandwiched between the radiating slotted patch and the square plate, and wherein the coaxial feed is connected to the square plate, and the inner central conducting pin of coaxial feed passes through the substrate and is connected to the radiating slotted patch.

18 Claims, 2 Drawing Sheets





US010283869B2

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

(10) **Patent No.:** **US 10,283,869 B2**

(45) **Date of Patent:** **May 7, 2019**

(54) **MIMO ANTENNA AND WIRELESS DEVICE**

(71) Applicant: **AGC Inc.**, Tokyo (JP)

(72) Inventors: **Ryuta Sonoda**, Tokyo (JP); **Koji Ikawa**, Tokyo (JP); **Toshiki Sayama**, Tokyo (JP)

(73) Assignee: **AGC Inc.**, Tokyo (JP)

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

(21) Appl. No.: **14/790,472**

(22) Filed: **Jul. 2, 2015**

(65) **Prior Publication Data**

US 2015/0303577 A1 Oct. 22, 2015

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2014/050356, filed on Jan. 10, 2014.

(30) **Foreign Application Priority Data**

Jan. 10, 2013 (JP) 2013-002988

(51) **Int. Cl.**

- H01Q 9/06** (2006.01)
- H01Q 21/00** (2006.01)
- H01Q 21/24** (2006.01)
- H01Q 21/28** (2006.01)
- H01Q 1/12** (2006.01)
- H01Q 9/28** (2006.01)

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

CPC **H01Q 9/065** (2013.01); **H01Q 1/1271** (2013.01); **H01Q 1/1285** (2013.01); **H01Q**

9/285 (2013.01); **H01Q 21/00** (2013.01); **H01Q 21/24** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**

CPC **H01Q 9/065**; **H01Q 9/285**; **H01Q 1/1271**; **H01Q 1/1285**; **H01Q 21/00**; **H01Q 21/24**; **H01Q 21/28**

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,106,256 B2 9/2006 Watanabe et al.
7,176,837 B2 2/2007 Sonoda et al.

(Continued)

FOREIGN PATENT DOCUMENTS

EP 2 053 692 A2 4/2009
EP 2 053 692 A3 4/2009

(Continued)

OTHER PUBLICATIONS

International Search Report dated Apr. 8, 2014 in PCT/JP2014/050356, filed Jan. 10, 2014.

(Continued)

Primary Examiner — Jessica Han

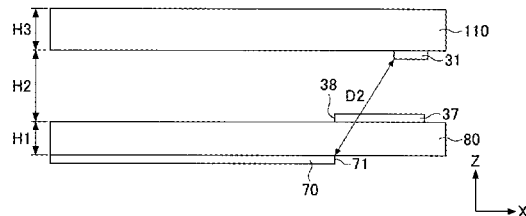
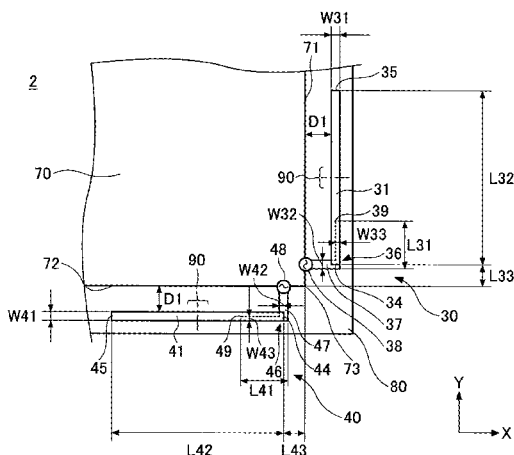
Assistant Examiner — Michael M Bouizza

(74) *Attorney, Agent, or Firm* — Oblon, McClelland, Maier & Neustadt L.L.P.

(57) **ABSTRACT**

A MIMO antenna is provided that includes a ground plane, and a plurality of dipole antenna elements that are arranged in the vicinity of the ground plane. Each of the plurality of dipole antenna elements includes a radiating element including a conductor portion extending along an outer edge portion of the ground plane, and a feeding portion that feeds the radiating element.

20 Claims, 16 Drawing Sheets



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

(10) **Patent No.:** **US 10,283,870 B2**
(45) **Date of Patent:** **May 7, 2019**

(54) **TUNABLE ANTENNA**

(71) Applicant: **Kyocera Corporation**, Kyoto-shi,
Kyoto (JP)

(72) Inventors: **Mitsuhiro Nishizono**, Hachioji (JP);
Daisuke Togashi, Yokohama (JP);
Kouhei Sugawara, Yokohama (JP)

(73) Assignee: **KYOCERA CORPORATION**, Kyoto
(JP)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 125 days.

(21) Appl. No.: **15/163,671**

(22) Filed: **May 25, 2016**

(65) **Prior Publication Data**
US 2016/0352017 A1 Dec. 1, 2016

(30) **Foreign Application Priority Data**
May 26, 2015 (JP) 2015-106461

(51) **Int. Cl.**
H01Q 9/30 (2006.01)
H01Q 9/32 (2006.01)
H01Q 5/328 (2015.01)
H01Q 5/357 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 9/32** (2013.01); **H01Q 5/328**
(2015.01); **H01Q 5/357** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 9/0442; H01Q 9/32; H01Q 9/40;
H01Q 5/30; H01Q 5/314; H01Q 5/328
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,079,079 B2 *	7/2006	Jo	H01Q 1/243 343/700 MS
7,420,511 B2	9/2008	Oshiyama et al.	
9,548,535 B1 *	1/2017	Kuo	H01Q 3/34
2006/0097918 A1	5/2006	Oshiyama et al.	
2007/0176836 A1 *	8/2007	Abramov	H01Q 1/2291 343/702

(Continued)

FOREIGN PATENT DOCUMENTS

JP	2000-114860 A	4/2000
JP	2001-136019 A	5/2001

(Continued)

OTHER PUBLICATIONS

Office Action in JP Application No. 2015-106461, dated Feb. 7,
2017, for which an explanation of relevance is attached.

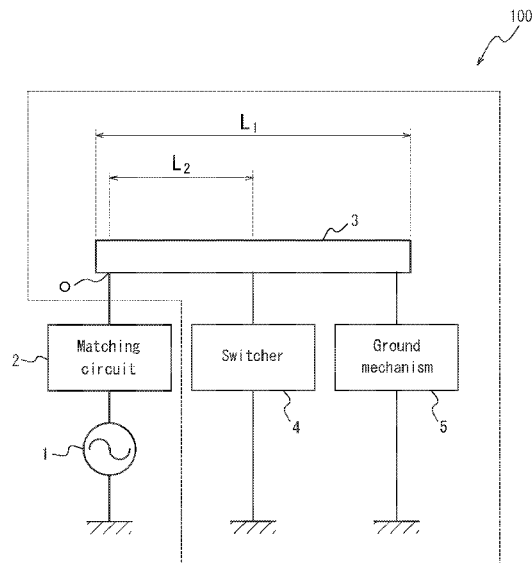
Primary Examiner — Dameon E Levi
Assistant Examiner — Hasan Z Islam

(74) *Attorney, Agent, or Firm* — Hauptman Ham, LLP

(57) **ABSTRACT**

A tunable antenna includes an antenna element having a feed point at one end thereof, a feed line being connected to the feed point, and a switcher that switches the resonance frequency of the antenna element. The switcher is connected to the antenna element at a position that is at a distance other than $(\lambda_m/4) \times n$ from the one end towards another end of the antenna element, where λ_m represents the wavelength corresponding to any resonance frequency of the antenna element, and n is a positive, odd number.

1 Claim, 9 Drawing Sheets





US010290441B2

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

(10) **Patent No.:** **US 10,290,441 B2**

(45) **Date of Patent:** **May 14, 2019**

(54) **BUTTON STRUCTURES FOR ELECTRONIC DEVICES**

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

(72) Inventors: **Trent Weber**, Saratoga, CA (US);
Michael B. Wittenberg, Sunnyvale, CA (US);
Michelle Yu, Oakland, CA (US);
Scott A. Myers, Palo Alto, CA (US);
Kurt Stiehl, Los Gatos, 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 199 days.

(21) Appl. No.: **14/016,190**

(22) Filed: **Sep. 2, 2013**

(65) **Prior Publication Data**

US 2014/0001022 A1 Jan. 2, 2014

Related U.S. Application Data

(62) Division of application No. 12/794,651, filed on Jun. 4, 2010, now Pat. No. 8,526,161.

(Continued)

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01H 13/14 (2006.01)

(Continued)

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

CPC **H01H 13/14** (2013.01); **H01H 9/02** (2013.01); **H01H 13/04** (2013.01); **H01H 13/70** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC H01Q 1/24

(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,550,466 A 12/1970 Ham
3,609,256 A 9/1971 Di Veto

(Continued)

FOREIGN PATENT DOCUMENTS

CN 2503678 7/2002
CN 2927534 7/2007

(Continued)

OTHER PUBLICATIONS

Author Unknown, "How Stuff Works: Battery Pictures," HowStuffWorks, Inc., [www.http://electronics.howstuffworks.com/battery-pictures1.htm](http://electronics.howstuffworks.com/battery-pictures1.htm), at least as early as Dec. 9, 2009.

(Continued)

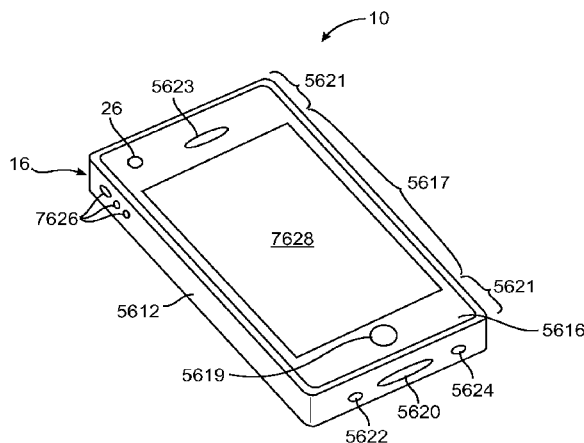
Primary Examiner — Huedung X Mancuso

(74) *Attorney, Agent, or Firm* — Morgan, Lewis & Bockius LLP

(57) **ABSTRACT**

An electronic device may have buttons, a display, and a vibrator unit. Buttons may be included in electronic devices such as glass buttons, metal buttons, buttons that are assembled on printed circuit boards, and buttons that are partly formed from antenna structures. Button coatings may be used to improve the sliding performance of metal-on-metal buttons. A layer of polymer may be interposed between a button plate and a housing structure. A glass button member may have an underside on which a layer of patterned ink is formed. Elastomeric members may be used to reduce button rattle. Portions of a button may be provided with conductive features that form portions of an antenna.

19 Claims, 45 Drawing Sheets



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

(10) **Patent No.:** **US 10,290,922 B2**
(45) **Date of Patent:** **May 14, 2019**

(54) **ELECTRONIC DEVICE**

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

(72) Inventors: **Jianming Li**, Taipei (TW); **Kun Feng**, Shanghai (CN); **Xuefei Zhang**, Shenzhen (CN); **Hanyang Wang**, Reading (GB)

(73) Assignee: **HUAWEI DEVICE CO., LTD.**, Dongguan (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 8 days.

(21) Appl. No.: **15/124,449**

(22) PCT Filed: **Mar. 4, 2015**

(86) PCT No.: **PCT/CN2015/073649**
§ 371 (c)(1),
(2) Date: **Sep. 8, 2016**

(87) PCT Pub. No.: **WO2015/139558**
PCT Pub. Date: **Sep. 24, 2015**

(65) **Prior Publication Data**
US 2017/0025740 A1 Jan. 26, 2017

(30) **Foreign Application Priority Data**
Mar. 21, 2014 (CN) 2014 1 0109571

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

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/50** (2013.01); **H01Q 5/328** (2015.01); **H01Q 5/335** (2015.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 9/42; H01Q 5/328; H01Q 5/335; H01Q 1/48; H01Q 1/50
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2003/0025637 A1* 2/2003 Mendolia H01Q 9/0421 343/702
2004/0041734 A1 3/2004 Shiotsu et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 102956954 A 3/2013
CN 103296385 A 9/2013
(Continued)

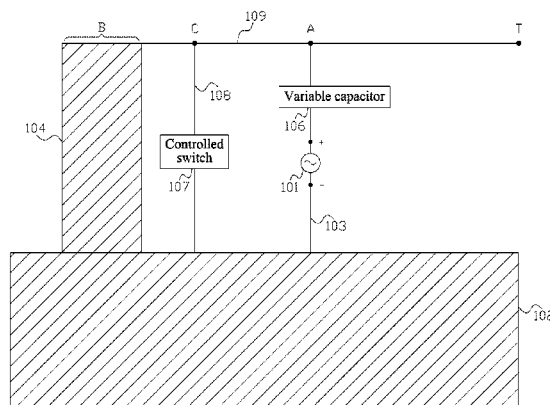
OTHER PUBLICATIONS

International Search Report (including English translation) issued in corresponding International Application No. PCT/CN2015/073649, dated Jun. 12, 2015, 6 pages.
(Continued)

Primary Examiner — Dieu Hien T Duong
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

(57) **ABSTRACT**

An electronic device is disclosed, where the electronic device is provided with a metal frame, the electronic device further includes an antenna feeding point, an antenna ground, a feeding branch, a grounding branch, an antenna resonance arm, a variable capacitor, and a control circuit. The antenna resonance arm is a part of the metal frame after segmentation, the antenna feeding point is disposed on the feeding branch, a first connection portion and a second connection portion are disposed on the antenna resonance arm, the feeding branch is disposed between the second connection portion and the antenna ground, the grounding branch is disposed between the first connection portion and the antenna ground, the variable capacitor is disposed on the feeding branch, the variable capacitor is disposed between
(Continued)





US010290923B2

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

(10) **Patent No.:** **US 10,290,923 B2**

(45) **Date of Patent:** **May 14, 2019**

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

USPC 343/702, 904; 455/41.1
See application file for complete search history.

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

(56) **References Cited**

(72) Inventors: **Dong-Uk Choi**, Gyeonggi-do (KR);
Sang-Pil Lee, Gyeonggi-do (KR);
Jangje Park, Gyeonggi-do (KR); **Jinu Kim**, Seoul (KR); **Bumjin Cho**,
Gyeonggi-do (KR); **Inyong Hwang**,
Gyeonggi-do (KR)

U.S. PATENT DOCUMENTS

2012/0214412 A1* 8/2012 Schlub G01B 7/023
455/41.1
2013/0100030 A1* 4/2013 Los G06F 3/023
345/169
2013/0267284 A1* 10/2013 Ryu H04W 88/06
455/575.7

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

FOREIGN PATENT DOCUMENTS

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 140 days.

KR 10-0720939 5/2007

* cited by examiner

(21) Appl. No.: **15/217,411**

Primary Examiner — Hai V Tran

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

(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(65) **Prior Publication Data**

US 2017/0033442 A1 Feb. 2, 2017

(57) **ABSTRACT**

(30) **Foreign Application Priority Data**

Jul. 31, 2015 (KR) 10-2015-0109186

An electronic device is provided. The electronic device includes a housing including a window that forms a first side of the electronic device, and a second side that is disposed opposite to the first side, a touch sensor disposed adjacent to the window and configured to generate a capacitance, an input circuit operably connected to the touch sensor and configured to detect an input based on a variation in the capacitance, an antenna radiator at least one of partially disposed inside the housing and a part of the housing, a ground operably disposed between the first side and the second side, a communication circuit operably connected to the antenna radiator and the ground, and an antenna matching circuit operably connected to the touch sensor and the input circuit.

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
G06F 3/044 (2006.01)
H01Q 1/38 (2006.01)
H04W 88/06 (2009.01)

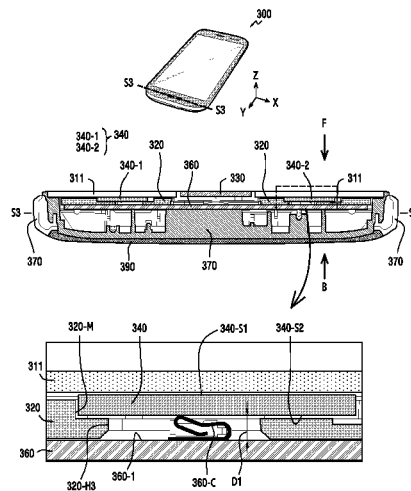
(52) **U.S. Cl.**

CPC **H01Q 1/243** (2013.01); **G06F 3/044** (2013.01); **H01Q 1/24** (2013.01); **H01Q 1/38** (2013.01); **H04W 88/06** (2013.01)

(58) **Field of Classification Search**

CPC H04W 88/06; H01Q 1/243; H01Q 1/48; H01Q 5/001; H01Q 1/24; H01Q 1/38; G06F 3/044

16 Claims, 20 Drawing Sheets



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

(10) **Patent No.:** **US 10,290,924 B2**
(45) **Date of Patent:** **May 14, 2019**

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

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/36; H01Q 1/48;
H01Q 9/42; H01Q 13/106; H01Q 19/26
See application file for complete search history.

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

(56) **References Cited**

(72) Inventors: **Ming-Yu Chou**, New Taipei (TW);
Yu-Kai Tseng, New Taipei (TW);
Kuo-Lun Huang, New Taipei (TW)

U.S. PATENT DOCUMENTS

(73) Assignee: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)

9,337,528 B2 * 5/2016 Hammond H01Q 1/243
2013/0285870 A1 * 10/2013 Hotta H01Q 1/243
343/843
2017/0040668 A1 * 2/2017 Ayala Vazquez H01Q 9/42
2017/0117620 A1 * 4/2017 Lapushin H01Q 1/38
2017/0194709 A1 * 7/2017 Jansson H01Q 7/00

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 130 days.

FOREIGN PATENT DOCUMENTS

(21) Appl. No.: **15/399,749**

TW 1274439 2/2007
TW M463914 U 10/2013

(22) Filed: **Jan. 6, 2017**

* cited by examiner

(65) **Prior Publication Data**

US 2017/0244154 A1 Aug. 24, 2017

Primary Examiner — Dameon E Levi

Assistant Examiner — David E Lotter

(30) **Foreign Application Priority Data**

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

Feb. 19, 2016 (CN) 2016 1 0093269
May 19, 2016 (CN) 2016 1 0339153

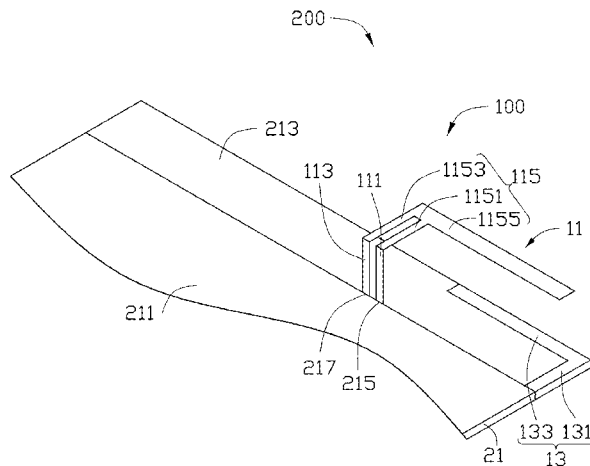
(57) **ABSTRACT**

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 1/24 (2006.01)
H01Q 13/10 (2006.01)
H01Q 1/48 (2006.01)
H01Q 1/36 (2006.01)
H01Q 9/42 (2006.01)
H01Q 19/26 (2006.01)

An antenna structure includes a metallic frame and a stub antenna. The metallic frame defines a slot and two gaps. The two gaps are positioned at two ends of the slot and are substantially perpendicular to the slot. The metallic frame is divided into a first portion and a second portion by the slot and the two gaps. A portion of the metallic frame surrounded by the slot and the two gaps forms the first portion. The first portion serves as a radiator of the antenna structure and is grounded through the second portion. The stub antenna is positioned at an interior of the metallic frame and is spaced from the radiator.

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/36** (2013.01); **H01Q 1/48** (2013.01); **H01Q 9/42** (2013.01); **H01Q 13/106** (2013.01); **H01Q 19/26** (2013.01)

19 Claims, 9 Drawing Sheets



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

(10) **Patent No.:** **US 10,290,925 B2**
(45) **Date of Patent:** **May 14, 2019**

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

H01Q 5/35 (2015.01)
H01Q 5/378 (2015.01)
(52) **U.S. Cl.**
CPC *H01Q 1/243* (2013.01); *H01Q 5/10* (2015.01); *H01Q 5/35* (2015.01); *H01Q 5/371* (2015.01); *H01Q 9/42* (2013.01); *H01Q 13/10* (2013.01); *H01Q 5/378* (2015.01)
(58) **Field of Classification Search**
CPC H01Q 1/242; H01Q 1/243
See application file for complete search history.

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

(72) Inventors: **Kuo-Lun Huang**, New Taipei (TW);
Ming-Yu Chou, New Taipei (TW);
Yu-Kai Tseng, 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 13 days.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,813,532 B2 * 11/2017 Kim H04M 1/026
10,038,234 B2 * 7/2018 Tseng H01Q 9/42
2011/0183633 A1 * 7/2011 Ohba H01Q 1/243
455/77

(21) Appl. No.: **15/653,668**

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

(65) **Prior Publication Data**

US 2018/0062244 A1 Mar. 1, 2018

Related U.S. Application Data

(60) Provisional application No. 62/382,762, filed on Sep. 1, 2016, provisional application No. 62/364,881, filed on Jul. 21, 2016.

(30) **Foreign Application Priority Data**

Jun. 23, 2017 (CN) 2017 1 0487851

(51) **Int. Cl.**

H01Q 1/00 (2006.01)
H01Q 1/24 (2006.01)
H01Q 5/10 (2015.01)
H01Q 5/371 (2015.01)
H01Q 13/10 (2006.01)
H01Q 9/42 (2006.01)

(Continued)

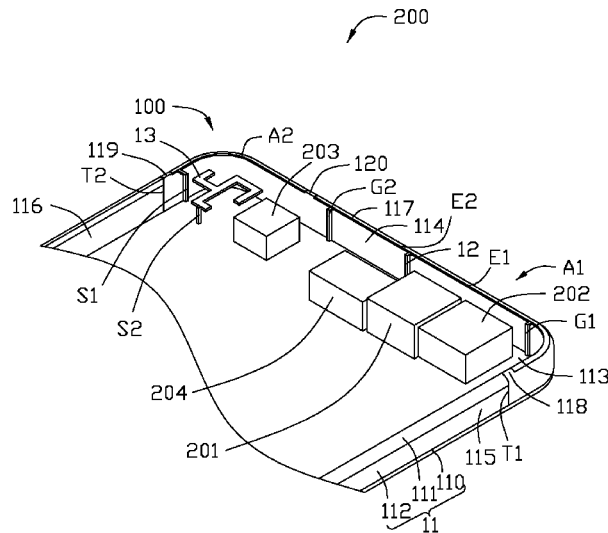
Primary Examiner — Wen W Huang

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

(57) **ABSTRACT**

An antenna structure which is switchable between low, middle, and high frequencies includes a metal housing, a feed portion, a resonance portion, and a connecting 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 gap and a second gap. The slot, the first gap, and the second gap separate a continuous antenna portion from the metal housing. The feed portion is electrically connected to the antenna portion for feeding current to the antenna portion. One end of the resonance portion is electrically connected to a first location of the antenna portion and another end grounded. One end of the connecting portion is electrically connected to a second location of the antenna portion and another end is electrically connected to the resonance portion.

27 Claims, 27 Drawing Sheets



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

(10) **Patent No.:** **US 10,290,940 B2**
(45) **Date of Patent:** **May 14, 2019**

(54) **BROADBAND SWITCHABLE ANTENNA**

USPC 343/772, 846, 724, 876
See application file for complete search history.

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

(56) **References Cited**

(72) Inventors: **Wee Kian Toh**, San Diego, CA (US);
Ping Shi, San Diego, CA (US)

U.S. PATENT DOCUMENTS

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

7,420,513 B2 * 9/2008 Tsutsumi H01Q 9/0428
343/700 MS
8,217,841 B2 * 7/2012 Hossain H01Q 1/243
343/700 MS

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 122 days.

(Continued)

(21) Appl. No.: **14/219,292**

OTHER PUBLICATIONS

(22) Filed: **Mar. 19, 2014**

Komulainen, M. et al, "A Frequency Tuning Method for a Planar Inverted-F Antenna," IEEE Transactions on Antennas and Propagation, vol. 56, No. 4, Apr. 2008, pp. 944-950.

(65) **Prior Publication Data**

(Continued)

US 2015/0270613 A1 Sep. 24, 2015

(51) **Int. Cl.**

Primary Examiner — Dameon E Levi

Assistant Examiner — Ab Salam Alkassim, Jr.

H01Q 9/04 (2006.01)
H01Q 5/30 (2015.01)
H01Q 5/328 (2015.01)
H01Q 5/357 (2015.01)
H01Q 5/307 (2015.01)
H01Q 5/364 (2015.01)
H01Q 5/371 (2015.01)

(74) *Attorney, Agent, or Firm* — Jinghua Karen Tang

(Continued)

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

(57) **ABSTRACT**

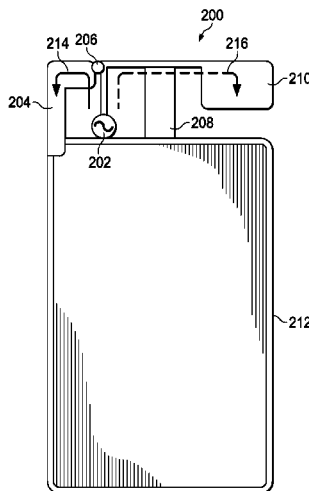
CPC **H01Q 5/30** (2015.01); **H01Q 1/243** (2013.01); **H01Q 5/307** (2015.01); **H01Q 5/314** (2015.01); **H01Q 5/328** (2015.01); **H01Q 5/357** (2015.01); **H01Q 5/364** (2015.01); **H01Q 5/371** (2015.01); **H01Q 9/0421** (2013.01); **H01Q 9/0442** (2013.01); **H01Q 9/42** (2013.01)

System and method embodiments are provided for a broadband switchable antenna. The embodiments enable an easily tunable, temporally switchable antenna with good low- and high-band performance with controlled high impedance loci that easily coexists with other wireless device components. In an embodiment, a broadband switchable antenna includes an antenna feed; a high-band antenna arm comprising a first end electrically coupled to an antenna feed and a second end electrically coupled to ground; a switch coupled to the antenna feed at a position proximate to the first end of the high-band antenna arm; and a low-band antenna arm comprising a first end electrically coupled to the switch, wherein the antenna is configured to operate in a high-band mode when the switch is open and to operate in a low-band mode when the switch is closed.

(58) **Field of Classification Search**

CPC H01Q 5/328; H01Q 5/364; H01Q 5/314; H01Q 5/307; H01Q 5/357; H01Q 5/371; H01Q 9/0442

19 Claims, 12 Drawing Sheets





US010290941B2

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

(10) **Patent No.:** **US 10,290,941 B2**
(45) **Date of Patent:** **May 14, 2019**

(54) **ELECTRONIC DEVICE HAVING MULTIBAND ANTENNA WITH EMBEDDED FILTER**

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)
(72) Inventors: **Erdinc Irci**, Santa Clara, CA (US); **Carlo Di Nallo**, San Carlos, CA (US); **Jayesh Nath**, Milpitas, CA (US); **Zheyu Wang**, Cupertino, CA (US); **Eduardo Da Costa Bras Lima**, Sunnyvale, CA (US); **Hongfei Hu**, Santa Clara, CA (US); **Mario Martinis**, Cupertino, CA (US); **Mattia Pascolini**, San Francisco, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 364 days.

(21) Appl. No.: **15/008,130**

(22) Filed: **Jan. 27, 2016**

(65) **Prior Publication Data**
US 2017/0214136 A1 Jul. 27, 2017

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/10 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/321** (2015.01); **H01Q 1/243** (2013.01); **H01Q 5/10** (2015.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243-1/244; H01Q 5/321
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,436,365 B1 * 10/2008 Tan H01Q 1/243 343/702
9,190,713 B2 * 11/2015 Eom H01Q 1/243
(Continued)

FOREIGN PATENT DOCUMENTS

CN 101501926 A 8/2009
CN 202977704 U 6/2013
(Continued)

OTHER PUBLICATIONS

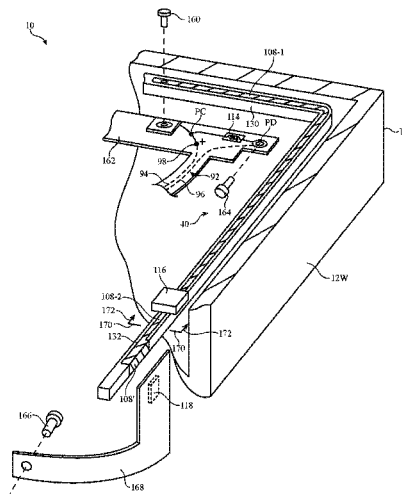
Chaudhary, G. et al., "Dual-Band Bandpass Filter with Independently Tunable Centre Frequencies and Bandwidths", IEEE Transactions on Microwave Theory and Techniques, vol. 61, No. 1, Jan. 2013.

Primary Examiner — Jessica Han
Assistant Examiner — Amal Patel
(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; G. Victor Treyz; David K. Cole

(57) **ABSTRACT**

An electronic device may have a display in a housing with a metal wall. An antenna may have an antenna ground formed from the wall and an antenna resonating element. Transceiver circuitry may be coupled to an antenna feed that extends between the antenna resonating element and the antenna ground. A return path may extend between the antenna resonating element and the antenna ground in parallel with the feed. The antenna resonating element may have segments that are coupled by a frequency dependent filter. At a first frequency, the filter may have a low impedance so that the antenna resonating element has a first effective length. At a second frequency that is greater than the first frequency, the filter may have a high impedance so that the antenna resonating element has a second effective length that is shorter than the first effective length.

20 Claims, 12 Drawing Sheets





US010290946B2

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

(10) **Patent No.:** **US 10,290,946 B2**
(45) **Date of Patent:** **May 14, 2019**

(54) **HYBRID ELECTRONIC DEVICE ANTENNAS HAVING PARASITIC RESONATING ELEMENTS**

(56) **References Cited**

U.S. PATENT DOCUMENTS

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

4,016,490 A 4/1977 Weckenmann et al.
4,614,937 A 9/1986 Poujois
(Continued)

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

FOREIGN PATENT DOCUMENTS

CN 1343380 4/2002
CN 1543010 11/2004
(Continued)

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

OTHER PUBLICATIONS

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 201 days.

Myllmaki et al., "Capacitive recognition of the user's hand grip position in mobile handsets", Progress in Electromagnetics Research B, vol. 22, 2010, pp. 203-220.

(Continued)

(21) Appl. No.: **15/274,328**

Primary Examiner — Jessica Han

(22) Filed: **Sep. 23, 2016**

Assistant Examiner — Patrick R Holecek

(65) **Prior Publication Data**

US 2018/0090847 A1 Mar. 29, 2018

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

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 5/30 (2015.01)

(Continued)

(57) **ABSTRACT**

An electronic device may have a hybrid antenna that includes a slot resonating element formed from a slot in a ground plane and a planar resonating element formed over the slot. A parasitic element may be disposed over the planar element. A switch may couple the parasitic element to the ground. A tunable circuit may couple the planar element to the ground. The switch and tunable circuit may be placed in different tuning states. In a first state, the tunable circuit and switch form open circuits. In a second state, the tunable circuit may an open circuit and the switch is closed. In a third state, the tunable circuit forms a return path and the switch forms an open circuit. This may allow the antenna to operate with satisfactory efficiency in low, mid, and high bands despite volume constraints imposed on the antenna.

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

CPC **H01Q 13/10** (2013.01); **H01Q 1/241** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/328** (2015.01); **H01Q 5/385** (2015.01); **H01Q 9/0414** (2013.01); **H01Q 9/285** (2013.01); **H01Q 13/16** (2013.01); **H01Q 13/18** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/30; H01Q 5/307; H01Q 5/314; H01Q 5/328; H01Q 5/342; H01Q 5/357;
(Continued)

20 Claims, 10 Drawing Sheets

