



US009325059B2

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

(10) **Patent No.:** **US 9,325,059 B2**
(45) **Date of Patent:** ***Apr. 26, 2016**

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

(75) Inventors: **Kin-Lu Wong**, New Taipei (TW);
Po-Wei Lin, New Taipei (TW)

(73) Assignee: **ACER INCORPORATED**, Xizhi Dist.,
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 167 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/409,128**

(22) Filed: **Mar. 1, 2012**

(65) **Prior Publication Data**

US 2013/0099979 A1 Apr. 25, 2013

(30) **Foreign Application Priority Data**

Oct. 20, 2011 (TW) 100138154 A

(51) **Int. Cl.**

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H01Q 1/24 (2006.01)

H01Q 9/42 (2006.01)

H01Q 13/10 (2006.01)

H01Q 5/40 (2015.01)

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

CPC **H01Q 1/38** (2013.01); **H01Q 1/243**

(2013.01); **H01Q 5/40** (2015.01); **H01Q 9/42**

(2013.01); **H01Q 13/10** (2013.01)

(58) **Field of Classification Search**

USPC 343/700 MS, 702, 767, 833, 834, 846

See application file for complete search history.

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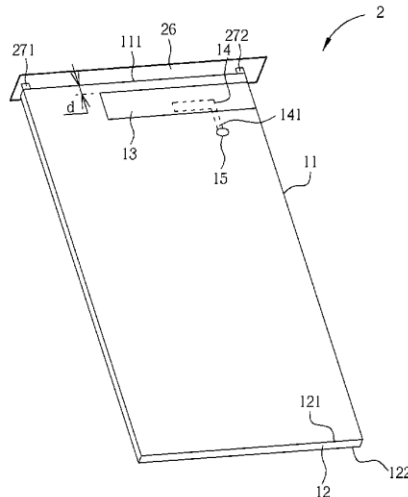
Primary Examiner — Graham Smith

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

(57) **ABSTRACT**

A communication device has an antenna structure including a substrate, a ground element, an open slot and a radiating metal portion. The ground element is disposed on a first surface of the substrate. The open slot is formed on the ground element and substantially parallel with an edge of the ground element, wherein the open slot at least generates a first resonant mode, and a distance between the open slot and the edge of the ground element is shorter than 0.05 wavelength of a center frequency of the first resonant mode. The radiating metal portion is disposed on a second surface of the substrate, wherein the open slot at least partially covers the radiating metal portion, the radiating metal portion at least generates a second resonant mode, and a feed point of the radiating metal portion is electrically coupled to a signal source on the substrate.

9 Claims, 6 Drawing Sheets





US009325064B2

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

(10) **Patent No.:** **US 9,325,064 B2**
(45) **Date of Patent:** **Apr. 26, 2016**

- (54) **MOBILE TERMINAL**
- (75) Inventors: **Kenichiro Kodama**, Saitama (JP); **Aiko Yoshida**, Kanagawa (JP); **Akihiro Bungo**, Tokyo (JP)
- (73) Assignees: **Sony Corporation**, Tokyo (JP); **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 635 days.

- (21) Appl. No.: **13/544,418**
- (22) Filed: **Jul. 9, 2012**

- (65) **Prior Publication Data**
US 2013/0176189 A1 Jul. 11, 2013

- Related U.S. Application Data**
- (60) Provisional application No. 61/524,916, filed on Aug. 18, 2011.

- (51) **Int. Cl.**
H01Q 3/24 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/52 (2006.01)
H01Q 21/28 (2006.01)
H01Q 21/00 (2006.01)

- (52) **U.S. Cl.**
CPC **H01Q 3/24** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/52** (2013.01); **H01Q 1/521** (2013.01); **H01Q 21/0006** (2013.01); **H01Q 21/28** (2013.01)

- (58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/52; H01Q 3/24
USPC 343/702, 876
See application file for complete search history.

- (56) **References Cited**
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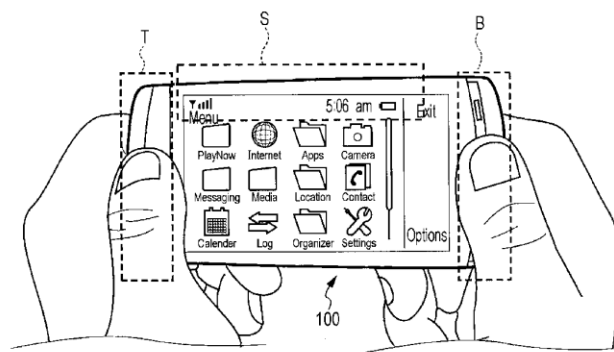
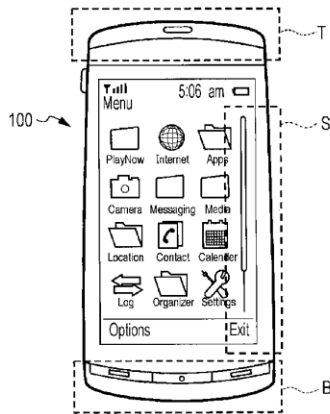
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Primary Examiner — Dieu H Duong
(74) *Attorney, Agent, or Firm* — Oblon, McClelland, Maier & Neustadt, L.L.P.

- (57) **ABSTRACT**
A mobile terminal that includes a first antenna element disposed in proximity to a first side of the mobile terminal, a second antenna element disposed in proximity to a second side of the mobile terminal, and a third antenna element disposed in proximity to a third side of the mobile terminal. The mobile terminal further including a switching mechanism that switches between a first connection mode in which the first and second antenna elements are feed elements and the third antenna element is a parasitic element, and a second connection mode in which the first and third antenna elements are feed elements, and a control unit that controls the switching mechanism to switch between the first connection mode and the second connection mode in accordance with a predetermined condition.

20 Claims, 12 Drawing Sheets





US009325066B2

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

(10) **Patent No.:** **US 9,325,066 B2**
(45) **Date of Patent:** **Apr. 26, 2016**

(54) **COMMUNICATION DEVICE AND METHOD FOR DESIGNING ANTENNA ELEMENT THEREOF**

(58) **Field of Classification Search**
CPC H01Q 5/0027; H01Q 5/378; H01Q 1/3781
USPC 343/700, 843; 235/492
See application file for complete search history.

(71) Applicants: **INDUSTRIAL TECHNOLOGY RESEARCH INSTITUTE**, Hsinchu (TW); **NATIONAL SUN YAT-SEN UNIVERSITY**, Kaohsiung (TW)

(56) **References Cited**
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(72) Inventors: **Kin-Lu Wong**, Kaohsiung (TW); **Hsuan-Jui Chang**, Taichung (TW); **Wei-Yu Li**, Yilan (TW); **Chun-Yih Wu**, Taipei (TW)

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(73) Assignees: **INDUSTRIAL TECHNOLOGY RESEARCH INSTITUTE**, Hsinchu (TW); **NATIONAL SUN YAT-SEN UNIVERSITY**, Kaohsiung (TW)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 280 days.

Primary Examiner — Michael C Wimer
Assistant Examiner — Bamidele A Jegede
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(21) Appl. No.: **13/906,483**

(22) Filed: **May 31, 2013**

(65) **Prior Publication Data**
US 2014/0085159 A1 Mar. 27, 2014

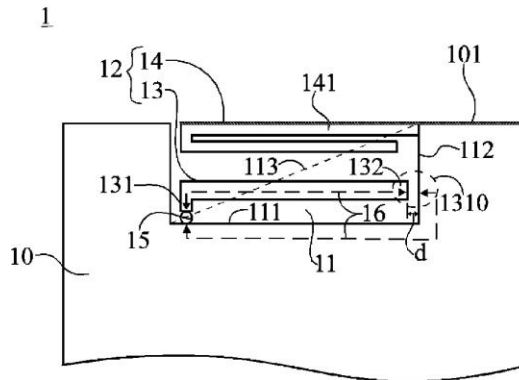
(57) **ABSTRACT**
A communication device including a ground plane and an antenna element is provided. An edge of the ground plane is embedded with a notch, which has at least a first edge and a second edge. The antenna element, disposed at the notch, has at least a first operating frequency band and a second operating frequency band. The antenna element includes a first conductive portion and a second conductive portion. The first conductive portion has a starting terminal, electrically coupled to the first edge of the notch through a signal source, as a feeding terminal of the antenna element. A capacitive coupling portion is formed between an end terminal of the first conductive portion and the ground plane. The second conductive portion has a shorting terminal electrically coupled or connected to the second edge of the notch.

(30) **Foreign Application Priority Data**
Sep. 27, 2012 (TW) 101135565 A

(51) **Int. Cl.**
H01Q 5/00 (2015.01)
H01Q 1/24 (2006.01)
(Continued)

14 Claims, 7 Drawing Sheets

(52) **U.S. Cl.**
CPC **H01Q 5/0027** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/328** (2015.01); **H01Q 5/378** (2015.01); **H01Q 9/42** (2013.01); **Y10T 29/49016** (2015.01)





US009325067B2

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

(10) **Patent No.:** **US 9,325,067 B2**
(45) **Date of Patent:** **Apr. 26, 2016**

(54) **TUNABLE MULTIBAND MULTIPORT ANTENNAS AND METHOD**

H01Q 5/314; H01Q 3/321; H01Q 3/328; H01Q 3/335

See application file for complete search history.

(71) Applicant: **BlackBerry Limited**, Waterloo (CA)

(56) **References Cited**

(72) Inventors: **Shirook M. Ali**, Milton (CA); **Mark E. Pecen**, Waterloo (CA); **James Paul Warden**, Fort Worth, TX (US)

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(73) Assignee: **BlackBerry Limited**, Waterloo, Ontario (CA)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 128 days.

(21) Appl. No.: **13/973,876**

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(22) Filed: **Aug. 22, 2013**

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(65) **Prior Publication Data**

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(51) **Int. Cl.**
H01Q 1/36 (2006.01)
H01Q 5/00 (2015.01)
H01Q 5/35 (2015.01)
H01Q 9/14 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/321 (2015.01)
H01Q 5/335 (2015.01)
H01Q 1/24 (2006.01)

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Primary Examiner — Amal Patel

(74) *Attorney, Agent, or Firm* — Fish & Richardson P.C.

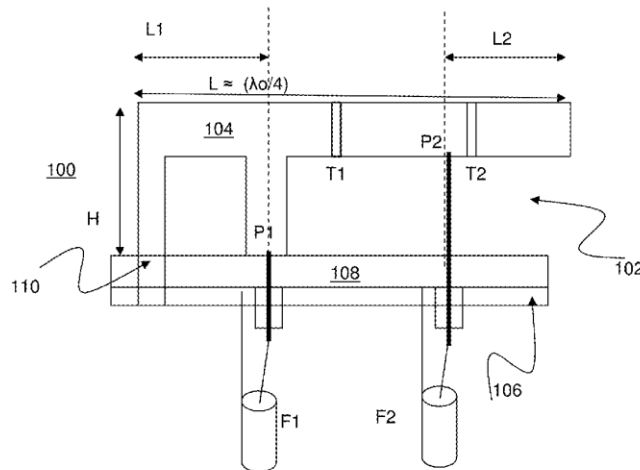
(52) **U.S. Cl.**
 CPC . **H01Q 5/35** (2015.01); **H01Q 1/36** (2013.01);
H01Q 5/321 (2015.01); **H01Q 5/335** (2015.01);
H01Q 9/145 (2013.01); **H01Q 9/42** (2013.01);
H01Q 1/241 (2013.01); **Y10T 29/49016**
 (2015.01)

(57) **ABSTRACT**

An antenna, comprising a plurality of feed points and tuning elements for tuning a resonant frequency at each feed point independently of the others of the plurality of feed points. The tuning elements are placed on the configured radiating element such that for a given feed point its tuning element is placed on the configured radiating element where a current distribution of the other feed points is a minimum.

(58) **Field of Classification Search**
CPC H01Q 1/36; H01Q 1/241; H01Q 5/35;

18 Claims, 9 Drawing Sheets





US009325068B2

(12) **United States Patent
Chang**

(10) **Patent No.:** US 9,325,068 B2
(45) **Date of Patent:** Apr. 26, 2016

- (54) **BROADBAND ANTENNA DEVICE**
- (71) Applicant: **Arcadyan Technology Corporation**,
Hsinchu (TW)
- (72) Inventor: **Jin Su Chang**, Hsinchu (TW)
- (73) Assignee: **ARCADYAN TECHNOLOGY
CORPORATION**, Hsinchu (TW)
- (*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 339 days.
- (21) Appl. No.: **13/948,623**
- (22) Filed: **Jul. 23, 2013**

USPC 343/843, 702, 700 MS, 846
See application file for complete search history.

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Primary Examiner — Huedung Mancuso
(74) *Attorney, Agent, or Firm* — Gottlieb, Rackman & Reisman, P.C.

- (65) **Prior Publication Data**
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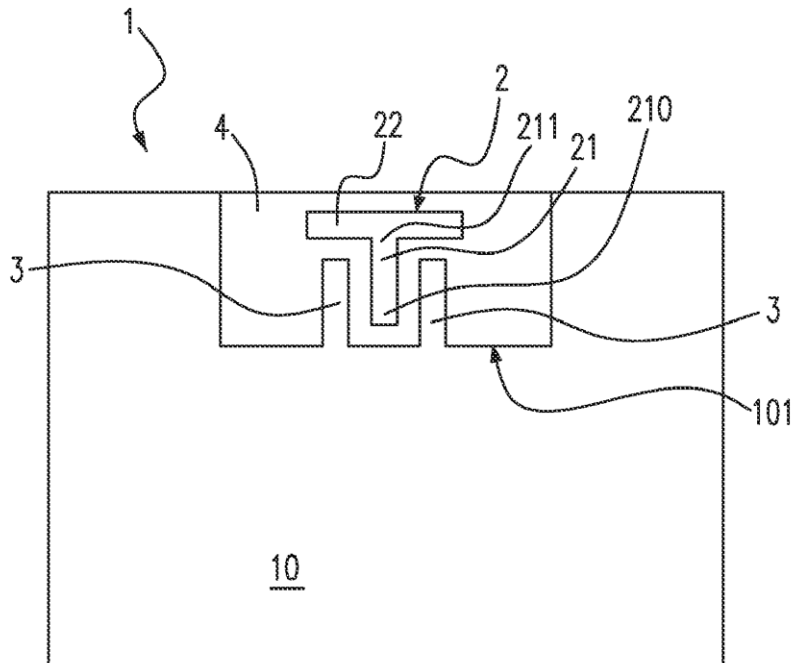
- (30) **Foreign Application Priority Data**
Mar. 28, 2013 (TW) 102111267 A

- (51) **Int. Cl.**
H01Q 11/00 (2006.01)
H01Q 5/371 (2015.01)
- (52) **U.S. Cl.**
CPC *H01Q 5/371* (2015.01)
- (58) **Field of Classification Search**
CPC H01Q 11/00; H01Q 1/24; H01Q 1/38

(57) **ABSTRACT**

An antenna device is provided. The antenna device comprises a first radiation portion and a second radiation portion. The first radiation portion includes a first end and a second end. The second radiation portion is connected to the first end at a connecting part and includes a first arm and a second arm. The first arm and the second arm have different lengths and extend from the connecting part.

17 Claims, 4 Drawing Sheets





US009325070B1

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

(10) **Patent No.:** **US 9,325,070 B1**
(45) **Date of Patent:** **Apr. 26, 2016**

(54) **DUAL-LOOP-SLOT ANTENNA**

(71) Applicant: **AMAZON TECHNOLOGIES, INC.**,
Reno, NV (US)

(72) Inventors: **Khaled Ahmad Obeidat**, Santa Clara,
CA (US); **Mark Corbridge**, Los Gatos,
CA (US); **Ming Zheng**, Cupertino, CA
(US); **Joseph Christopher Modro**, Palo
Alto, CA (US)

(73) Assignee: **Amazon Technologies, Inc.**, Reno, NV
(US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 283 days.

(21) Appl. No.: **13/925,467**

(22) Filed: **Jun. 24, 2013**

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

(52) **U.S. Cl.**
CPC **H01Q 9/0407** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 13/10; H01Q 13/106
USPC 343/702, 767
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Dameon E Levi

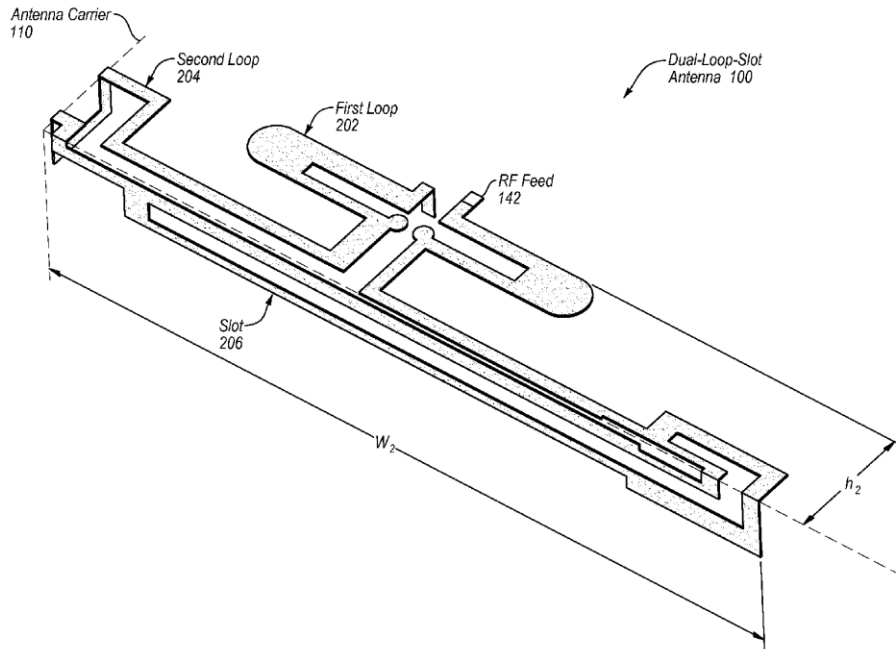
Assistant Examiner — Collin Dawkins

(74) *Attorney, Agent, or Firm* — Lowenstein Sandler LLP

(57) **ABSTRACT**

Antenna structures and methods of operating the same of a dual-loop-slot antenna of an electronic device are described. One dual-loop-slot antenna includes a first loop antenna coupled to a radio frequency (RF) feed and a ground plane, a second loop coupled to the RF feed and the ground plane. At least a portion of the second loop antenna is formed by the first loop antenna. The dual-loop-slot antenna also includes a slot antenna formed at least in part by a portion of at least one of the first loop antenna or the second loop antenna.

20 Claims, 10 Drawing Sheets





US009325072B2

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

(10) **Patent No.:** **US 9,325,072 B2**
(45) **Date of Patent:** **Apr. 26, 2016**

(54) **TOUCH SCREEN PANEL ANTENNA OF MOBILE TERMINAL**

(75) Inventors: **Kyung Jin Oh**, Hwaseong-si (KR); **Oh Hyuck Kwon**, Suwon-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 1197 days.

(21) Appl. No.: **12/977,620**

(22) Filed: **Dec. 23, 2010**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Dec. 28, 2009 (KR) 10-2009-0131636

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/40 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC ... **H01Q 9/40** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/38
USPC 343/702
See application file for complete search history.

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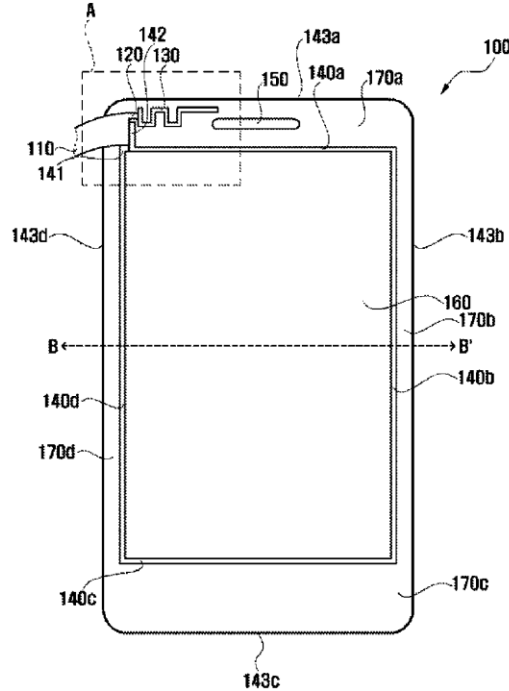
Primary Examiner — Graham Smith

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

(57) **ABSTRACT**

A touch screen panel (TSP) antenna of a mobile terminal is provided. The TSP antenna includes an ITO film stacked in a TSP, an upper electrode line, a lower electrode line, a left electrode line, and a right electrode line formed at an upper or lower surface of the ITO film, an external surface, and an antenna pattern formed in at least one of an upper surface, a lower surface, a left surface, and a right surface of the external surface.

11 Claims, 6 Drawing Sheets





US009325076B2

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

(10) **Patent No.:** **US 9,325,076 B2**
(45) **Date of Patent:** **Apr. 26, 2016**

- (54) **ANTENNA FOR WIRELESS DEVICE**
- (75) Inventors: **Bruce Foster Bishop**, Aptos, CA (US);
Yong Kwon Park, Capitola, CA (US);
Junwon Kim, Capitola, CA (US)
- (73) Assignee: **Tyco Electronics Corporation**, Berwyn, PA (US)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 485 days.

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- (21) Appl. No.: **13/445,602**
- (22) Filed: **Apr. 12, 2012**

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- (51) **Int. Cl.**
H01Q 9/00 (2006.01)
H01Q 15/00 (2006.01)
- (52) **U.S. Cl.**
CPC **H01Q 15/0086** (2013.01)
- (58) **Field of Classification Search**
USPC 343/702, 700 MS, 745, 909
See application file for complete search history.

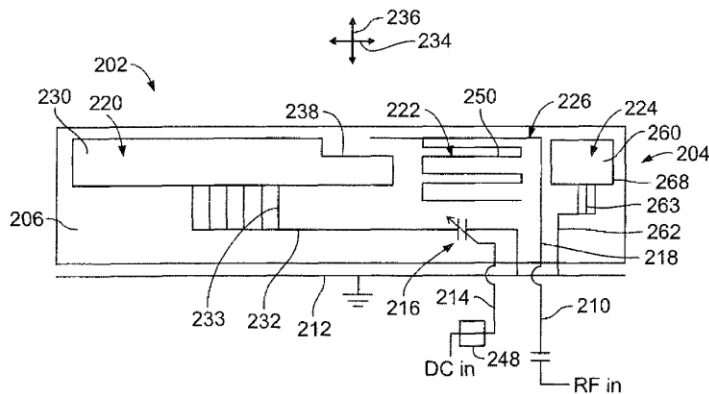
Primary Examiner — Hoang V Nguyen
Assistant Examiner — Hai Tran

(57) **ABSTRACT**

An antenna for a wireless device includes a low band left-handed (LBLH) mode element and a low band right-handed (LBRH) mode element both operable in a low frequency bandwidth and a high band left-handed (HBLH) mode element and a high band right-handed (HBRH) mode element both operable in a high frequency bandwidth. The LBLH mode element is capacitively coupled to a feed of the antenna and is inductively coupled to a ground of the antenna. The LBRH mode element is electrically coupled to the feed of the antenna. The HBLH mode element is capacitively coupled to the feed of the antenna and is inductively coupled to the ground of the antenna. The HBRH mode element is electrically coupled to the feed of the antenna. At least one tuning element is operatively coupled to at least one of the mode elements.

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23 Claims, 9 Drawing Sheets





US009325080B2

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

(10) **Patent No.:** **US 9,325,080 B2**
(45) **Date of Patent:** **Apr. 26, 2016**

(54) **ELECTRONIC DEVICE WITH SHARED ANTENNA STRUCTURES AND BALUN**

USPC 343/702, 700 MS, 745, 767
See application file for complete search history.

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

(56) **References Cited**

(72) Inventors: **Yuehui Ouyang**, Sunnyvale, CA (US); **Dean F. Darnell**, Durham, NC (US); **Enrique Ayala Vazquez**, Watsonville, CA (US); **Erica J. Tong**, Pacifica, CA (US); **Hongfei Hu**, Santa Clara, CA (US); **Matthew A. Mow**, Los Altos, CA (US); **Mattia Pascolini**, San Mateo, CA (US); **Ming-Ju Tsai**, Cupertino, CA (US); **Nanbo Jin**, Sunnyvale, CA (US); **Robert W. Schlub**, Cupertino, CA (US)

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

Primary Examiner — Linh Nguyen

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 131 days.

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

(21) Appl. No.: **14/195,130**

(57) **ABSTRACT**

(22) Filed: **Mar. 3, 2014**

(65) **Prior Publication Data**

US 2015/0249292 A1 Sep. 3, 2015

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 21/30 (2006.01)
H01Q 1/48 (2006.01)
H01Q 9/42 (2006.01)

(Continued)

An electronic device may be provided with shared antenna structures that can be used to form both a near-field communications antenna such as a loop antenna and a non-near-field communications antenna such as an inverted-F antenna. The antenna structures may include conductive structures such as metal traces on printed circuits or other dielectric substrates, internal metal housing structures, or other conductive electronic device housing structures. A main resonating element arm may be separated from an antenna ground by an opening. A non-near-field communications antenna return path and antenna feed path may span the opening. A balun may have first and second electromagnetically coupled inductors. The second inductor may have terminals coupled across differential signal terminals in a near-field communications transceiver. The first inductor may form part of the near-field communications loop antenna.

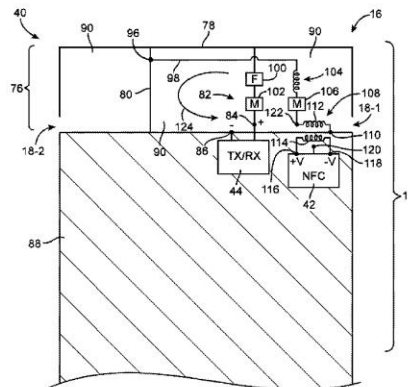
(52) **U.S. Cl.**

CPC **H01Q 21/30** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/35** (2015.01); **H01Q 5/371** (2015.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 9/0421; H01Q 21/30; H01Q 5/335; H01Q 5/371; H01Q 5/50; H01Q 1/2283; H01Q 21/29

21 Claims, 9 Drawing Sheets





US009325354B2

(12) **United States Patent**
Manteghi

(10) **Patent No.:** **US 9,325,354 B2**
(45) **Date of Patent:** **Apr. 26, 2016**

(54) **WIDEBAND FREQUENCY SHIFT MODULATION USING TRANSIENT STATE OF ANTENNA**

(71) Applicant: **VIRGINIA TECH INTELLECTUAL PROPERTIES, INC.**, Blacksburg, VA (US)

(72) Inventor: **Majid Manteghi**, Santa Clara, CA (US)

(73) Assignee: **Intel Corporation**, Santa Clara, 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.: **14/547,772**

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

(65) **Prior Publication Data**
US 2015/0139278 A1 May 21, 2015

Related U.S. Application Data

(60) Provisional application No. 61/906,652, filed on Nov. 20, 2013.

(51) **Int. Cl.**
H04B 1/00 (2006.01)
H04B 1/04 (2006.01)
H01Q 3/44 (2006.01)
H01Q 5/00 (2015.01)
H01Q 9/04 (2006.01)
H01Q 5/25 (2015.01)

(52) **U.S. Cl.**
CPC .. **H04B 1/04** (2013.01); **H01Q 3/44** (2013.01);
H01Q 5/00 (2013.01); **H01Q 5/25** (2015.01);
H01Q 9/0421 (2013.01)

(58) **Field of Classification Search**
CPC H04B 1/707; H04B 1/04; H01Q 5/00; H01Q 3/44
USPC 375/146
See application file for complete search history.

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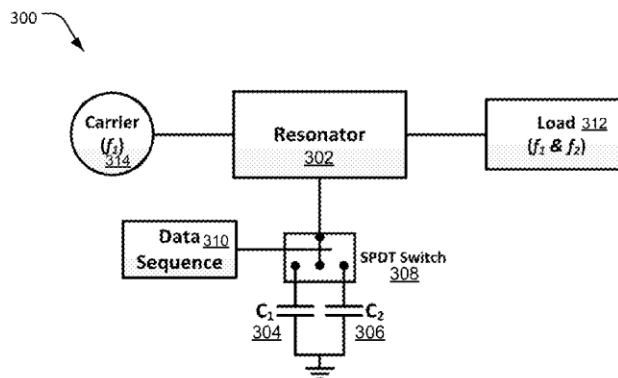
Primary Examiner — Erin File

(74) Attorney, Agent, or Firm — Forefront IP Lawgroup, PLLC

(57) **ABSTRACT**

Described herein are architectures, platforms and methods for implementing modulating a radiating signal of a high Q antenna in order to transmit from one frequency to one or more different frequencies which may be in the same narrow band frequency spectrum or in a wide band frequency spectrum.

1 Claim, 6 Drawing Sheets





US009331379B2

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

(10) **Patent No.:** **US 9,331,379 B2**
(45) **Date of Patent:** ***May 3, 2016**

(54) **MOBILE DEVICE AND MANUFACTURING METHOD THEREOF**
(75) Inventors: **Chien-Pin Chiu**, Taoyuan County (TW); **Hsiao-Wei Wu**, Taoyuan County (TW); **Tiao-Hsing Tsai**, Taoyuan County (TW); **Ying-Chih Wang**, Taoyuan County (TW)

(73) Assignee: **HTC Corporation**, Taoyuan (TW)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 115 days.
This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/442,644**

(22) Filed: **Apr. 9, 2012**

(65) **Prior Publication Data**
US 2013/0207846 A1 Aug. 15, 2013

Related U.S. Application Data
(63) Continuation-in-part of application No. 13/396,122, filed on Feb. 14, 2012.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/06 (2006.01)
H01Q 13/10 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/371 (2015.01)
(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01); **H01Q 9/42** (2013.01); **Y10T 29/49016** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 21/30; H01Q 5/0058; H01Q 5/357; H01Q 5/371; H01Q 1/243
USPC 343/700 MS, 721
See application file for complete search history.

(56) **References Cited**

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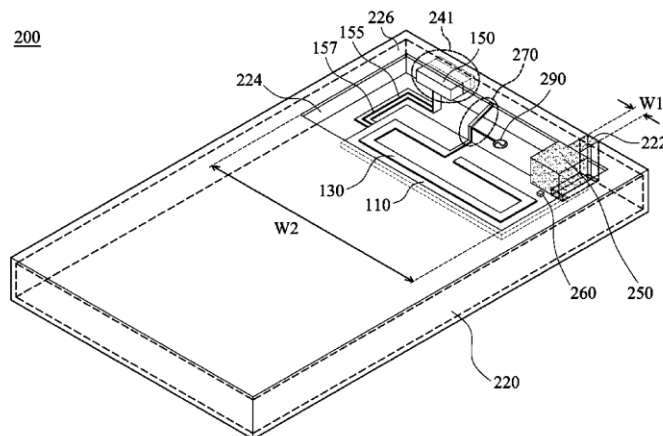
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Primary Examiner — Dameon E Levi
Assistant Examiner — Ricardo Magallanes
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**
A mobile device includes a substrate, a ground element, and a radiation branch. The ground element includes a ground branch, wherein an edge of the ground element has a notch extending into the interior of the ground element so as to form a slot region, and the ground branch partially surrounds the slot region. The radiation branch is substantially inside the slot region, and is coupled to the ground branch of the ground element. The ground branch and the radiation branch form an antenna structure.

10 Claims, 9 Drawing Sheets





US009331380B2

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

(10) **Patent No.:** **US 9,331,380 B2**
(45) **Date of Patent:** **May 3, 2016**

(54) **TUNABLE ANTENNA AND WIRELESS COMMUNICATION DEVICE EMPLOYING SAME**

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/371; H01Q 5/378
USPC 343/700 MS, 702
See application file for complete search history.

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

(56) **References Cited**

(72) Inventors: **Cho-Kang Hsu**, New Taipei (TW);
Tze-Hsuan Chang, New Taipei (TW)

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

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343/833

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 237 days.

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(21) Appl. No.: **14/068,240**

Primary Examiner — Dieu H Duong
(74) *Attorney, Agent, or Firm* — Novak Druce Connolly Bove + Quigg LLP

(22) Filed: **Oct. 31, 2013**

(65) **Prior Publication Data**

US 2014/0313084 A1 Oct. 23, 2014

(30) **Foreign Application Priority Data**

Apr. 23, 2013 (TW) 102114282 A

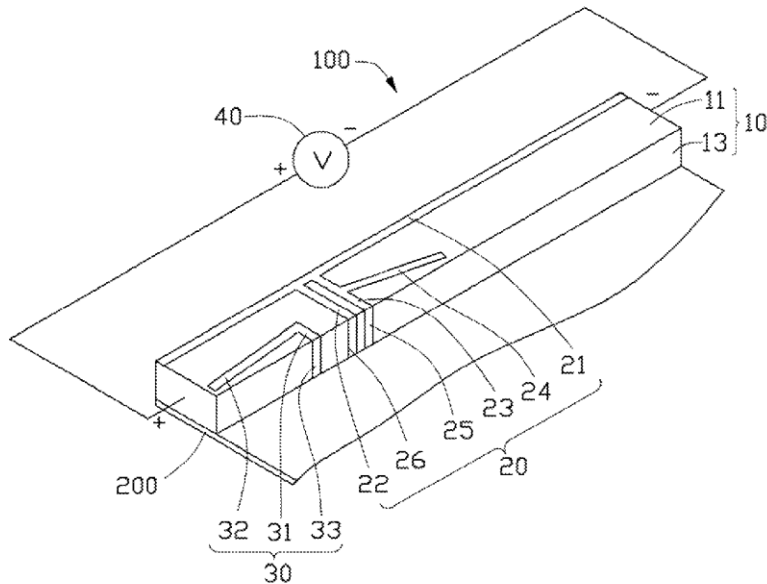
(57) **ABSTRACT**

A tunable antenna including a dielectric substrate, a main antenna, and a resonating antenna is disclosed. The dielectric substrate is made of dielectric constant-tunable material. The main antenna is positioned on the dielectric substrate, the main antenna includes a feeding arm and a first grounding arm. The main antenna generates a low-frequency mode and at least one high-frequency mode. The resonating antenna is positioned on the dielectric substrate. The resonating antenna resonates with the main antenna to generate another high-frequency mode. The central frequencies of the low-frequency mode and the high-frequency modes of the tunable antenna are adjusted by adjusting a dielectric constant of the dielectric substrate.

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 1/24 (2006.01)
H01Q 5/371 (2015.01)
H01Q 5/378 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01); **H01Q 5/378** (2015.01)

16 Claims, 2 Drawing Sheets





US009331383B2

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

(10) **Patent No.:** **US 9,331,383 B2**
(45) **Date of Patent:** **May 3, 2016**

(54) **ANTENNA STRUCTURE AND THE MANUFACTURING METHOD THEREFOR**

(71) Applicant: **ARCADYAN TECHNOLOGY CORPORATION**, Hsinchu (TW)
(72) Inventors: **Jian-Jhih Du**, Hsinchu (TW); **Chih-Yung Huang**, Hsinchu (TW); **Kuo-Chang Lo**, Hsinchu (TW)
(73) Assignee: **ARCADYAN TECHNOLOGY CORPORATION**, Hsinchu (TW)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 328 days.

(21) Appl. No.: **13/950,727**

(22) Filed: **Jul. 25, 2013**

(65) **Prior Publication Data**
US 2014/0285380 A1 Sep. 25, 2014

(30) **Foreign Application Priority Data**
Mar. 21, 2013 (TW) 102110130 A

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01P 11/00 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/40 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/38** (2013.01); **H01P 11/001** (2013.01); **H01Q 1/243** (2013.01); **H01Q 9/40** (2013.01); **H01Q 9/42** (2013.01); **Y10T 29/49016** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 1/243; H01Q 1/40; H01Q 1/42; H01P 11/001
See application file for complete search history.

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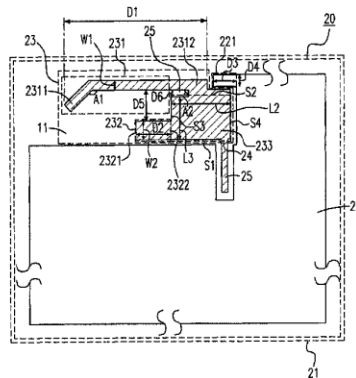
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Primary Examiner — Trinh Dinh
(74) *Attorney, Agent, or Firm* — Allen, Dyer, Doppelt, Milbrath & Gilchrist, P.A.

(57) **ABSTRACT**

An antenna structure is provided. The antenna structure includes a radiating portion having an approximately quadrangular body, wherein the quadrangular body has a first side, a second side opposite to the first side, a third side, and a fourth side opposite to the third side; and a ground portion surrounding an entire length of the first side, an entire length of the fourth side, and at most a half of a length of the second side.

8 Claims, 5 Drawing Sheets





US009331387B2

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

(10) **Patent No.:** **US 9,331,387 B2**
(45) **Date of Patent:** ***May 3, 2016**

- (54) **WIDEBAND ANTENNA**
- (71) Applicant: **MediaTek Inc.**, Hsin-Chu (TW)
- (72) Inventors: **Wei Yu Chen**, New Taipei (TW);
Shih-Wei Hsieh, Taipei (TW)
- (73) Assignee: **MEDIATEK INC.**, Hsin-Chu (TW)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 267 days.

This patent is subject to a terminal disclaimer.

- (21) Appl. No.: **14/079,287**
- (22) Filed: **Nov. 13, 2013**
- (65) **Prior Publication Data**
US 2014/0062796 A1 Mar. 6, 2014

Related U.S. Application Data

- (63) Continuation-in-part of application No. 13/290,406, filed on Nov. 7, 2011, now Pat. No. 8,610,628.
- (51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 5/01 (2006.01)
H01Q 1/24 (2006.01)
H01Q 5/378 (2015.01)
- (52) **U.S. Cl.**
CPC **H01Q 5/01** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/378** (2015.01)
- (58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 1/243
USPC 343/702, 700 MS
See application file for complete search history.

- (56) **References Cited**
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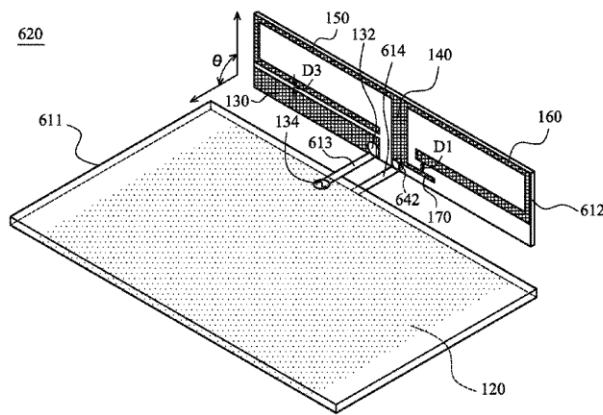
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Primary Examiner — Hoanganh Le
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

- (57) **ABSTRACT**
A wideband antenna includes a first substrate, a second substrate, a ground plane, an exciting element, a connection element, a first branch, a second branch, and a coupling branch. The ground plane is disposed on the first substrate. The exciting element is disposed on the second substrate and has a feed point coupled to a signal source. The connection element is disposed on the second substrate and coupled to the ground plane. The first branch is disposed on the second substrate and coupled to the connection element. The second branch is disposed on the second substrate and coupled to the connection element. The coupling element is disposed on the second substrate and coupled to the connection element. The distance between the coupling element and the second branch is smaller than 5 mm.

20 Claims, 13 Drawing Sheets





US009331391B2

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

(10) **Patent No.:** **US 9,331,391 B2**
(45) **Date of Patent:** **May 3, 2016**

- (54) **MOBILE DEVICE**
- (75) Inventors: **Chih-Ling Chien**, Taoyuan County (TW); **Chien-Hsin Huang**, Taoyuan County (TW); **Hsiao-Wei Wu**, Taoyuan County (TW); **Wen-Hsiung Shih**, Taoyuan County (TW)
- (73) Assignee: **HTC Corporation**, Taoyuan (TW)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 171 days.
- (21) Appl. No.: **13/396,122**
- (22) Filed: **Feb. 14, 2012**
- (65) **Prior Publication Data**
US 2013/0207855 A1 Aug. 15, 2013
- (51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/06 (2006.01)
H01Q 13/10 (2006.01)
H01Q 9/42 (2006.01)
H01Q 21/30 (2006.01)
- (52) **U.S. Cl.**
CPC **H01Q 9/42** (2013.01); **H01Q 13/10** (2013.01); **H01Q 21/30** (2013.01); **H01Q 1/243** (2013.01)
- (58) **Field of Classification Search**
CPC H01Q 21/30; H01Q 5/0058; H01Q 5/357; H01Q 5/371; H01Q 1/243
USPC 343/700 MS, 721
See application file for complete search history.
- (56) **References Cited**
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Primary Examiner — Dameon E Levi

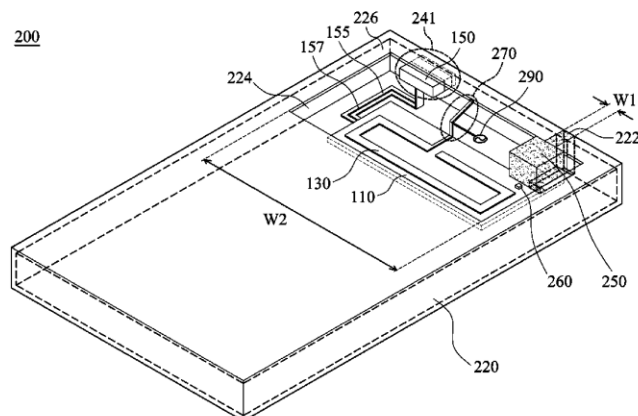
Assistant Examiner — Ricardo Magallanes

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

(57) **ABSTRACT**

A mobile device includes a substrate, a ground element, and a radiation branch. The ground element includes a ground branch, wherein an edge of the ground element has a notch extending into an interior of the ground element so as to form a slot region, and the ground branch partially surrounds the slot region. The radiation branch is substantially inside the slot region, and is coupled to the ground branch of the ground element. The ground branch and the radiation branch form an antenna structure.

17 Claims, 8 Drawing Sheets





US009331397B2

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

(10) **Patent No.:** **US 9,331,397 B2**
(45) **Date of Patent:** **May 3, 2016**

(54) **TUNABLE ANTENNA WITH SLOT-BASED PARASITIC ELEMENT**

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)
(72) Inventors: **Nanbo Jin**, Sunnyvale, CA (US); **Yuehui Ouyang**, Sunnyvale, CA (US); **Yijun Zhou**, Sunnyvale, CA (US); **Enrique Ayala Vazquez**, Watsonville, CA (US); **Anand Lakshmanan**, San Jose, CA (US); **Robert W. Schlub**, Cupertino, CA (US); **Mattia Pascolini**, Campbell, CA (US); **Matthew A. Mow**, Los Altos, 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 191 days.

(21) Appl. No.: **13/846,471**

(22) Filed: **Mar. 18, 2013**

(65) **Prior Publication Data**
US 2014/0266922 A1 Sep. 18, 2014

(51) **Int. Cl.**
H01Q 21/28 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/06 (2006.01)
H01Q 5/10 (2015.01)
(52) **U.S. Cl.**
CPC **H01Q 21/28** (2013.01); **H01Q 1/24** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/10** (2015.01); **H01Q 9/06** (2013.01)

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

(56) **References Cited**

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Primary Examiner — Dameon E Levi

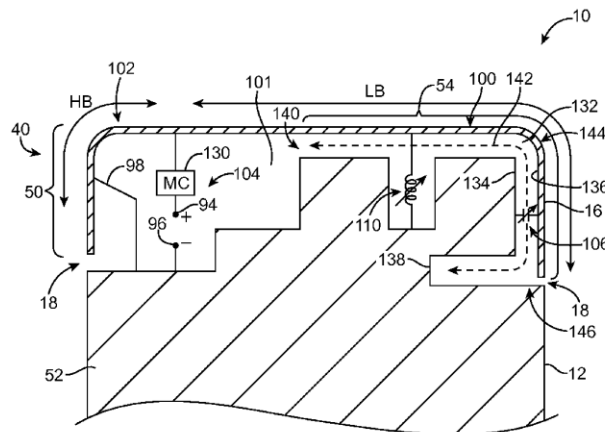
Assistant Examiner — Walter Davis

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

(57) **ABSTRACT**

Electronic devices may be provided that contain wireless communications circuitry. The wireless communications circuitry may include radio-frequency transceiver circuitry and antenna structures. The antenna structures may form a dual arm inverted-F antenna. The antenna may have a resonating element formed from portions of a peripheral conductive electronic device housing member and may have an antenna ground that is separated from the antenna resonating element by a gap. A short circuit path may bridge the gap. An antenna feed may be coupled across the gap in parallel with the short circuit path. Low band tuning may be provided using an adjustable inductor that bridges the gap. The antenna may have a slot-based parasitic antenna resonating element with a slot formed between portions of the peripheral conductive electronic device housing member and the antenna ground. An adjustable capacitor may bridge the slot to provide high band tuning.

25 Claims, 8 Drawing Sheets





US009337527B2

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

(10) **Patent No.:** **US 9,337,527 B2**
(45) **Date of Patent:** **May 10, 2016**

(54) **MOBILE TELECOMMUNICATION TERMINAL**

USPC 343/702
See application file for complete search history.

(75) Inventors: **Wei Yu**, Waterloo (CA); **Wen Li**, Waterloo (CA)

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(73) Assignee: **Wen Li**, Waterloo, Ontario (CA)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 900 days.

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(21) Appl. No.: **12/736,339**

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(22) PCT Filed: **Mar. 31, 2008**

Primary Examiner — Dameon E Levi

(86) PCT No.: **PCT/CN2008/000642**

Assistant Examiner — Collin Dawkins

§ 371 (c)(1),
(2), (4) Date: **Sep. 30, 2010**

(74) *Attorney, Agent, or Firm* — Steptoe & Johnson LLP

(87) PCT Pub. No.: **WO2009/121205**

PCT Pub. Date: **Oct. 8, 2009**

(57) **ABSTRACT**

(65) **Prior Publication Data**

US 2011/0018779 A1 Jan. 27, 2011

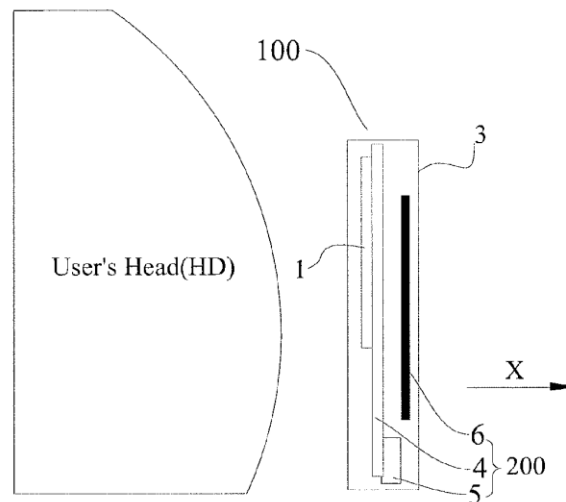
A mobile communication terminal comprises a shell, and a backfire antenna which includes a main board disposed in the shell and having a transmitting circuit and a receiving circuit on the main board; a main antenna element coupled to the transmitting circuit and the receiving circuit on the main board; and a backfire resonator located at a side of the shell deviated from a user's head, and coupled to the main board and the main antenna element, in which the backfire resonator is fed by the main board from a position on the main board deviated from a center of the main board. The mobile communication terminal according to embodiment of the present disclosure may cause most electromagnetic waves to radiate towards a direction deviated from the user, thus reducing radiation and harm thereof to the user, strengthening the signal received by the base station, and improving the communication quality.

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

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/245** (2013.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 9/0421

8 Claims, 11 Drawing Sheets





US009337528B2

(12) **United States Patent**
Hammond

(10) **Patent No.:** **US 9,337,528 B2**
(45) **Date of Patent:** **May 10, 2016**

(54) **MOBILE WIRELESS COMMUNICATIONS DEVICE INCLUDING ELECTRICALLY CONDUCTIVE PORTABLE HOUSING SECTIONS DEFINING AN ANTENNA**

(75) Inventor: **Robert Ralph Bryan Hammond**,
Ottawa (CA)

(73) Assignee: **BlackBerry Limited**, Waterloo (CA)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 310 days.

(21) Appl. No.: **13/360,197**

(22) Filed: **Jan. 27, 2012**

(65) **Prior Publication Data**

US 2013/0194138 A1 Aug. 1, 2013

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 13/10 (2006.01)
H01Q 1/00 (2006.01)
H01Q 1/44 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/44** (2013.01); **H01Q 13/10** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/243; H01Q 5/0058; H01Q 1/44
USPC 343/702
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Dameon E Levi

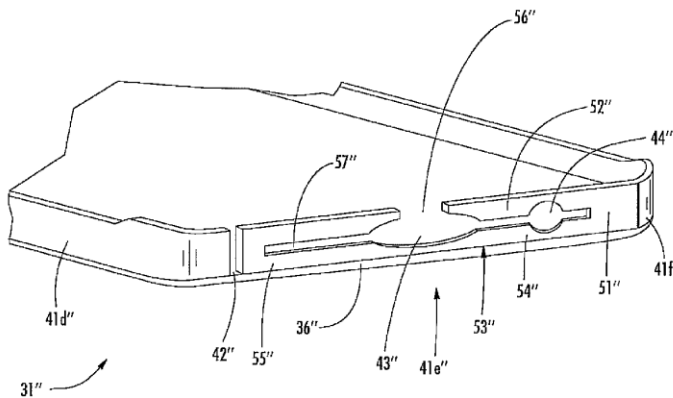
Assistant Examiner — Ricardo Magallanes

(74) *Attorney, Agent, or Firm* — Jenna L. Wilson; Dimock Stratton LLP

(57) **ABSTRACT**

A mobile wireless communications device may include a portable housing including electrically conductive sections defining a perimeter of the portable housing and configured to function as an antenna. One of the electrically conductive sections may include a base, a first electrically conductive arm extending from the base, and a second electrically conductive arm having a proximal portion parallel and spaced apart from the first electrically conductive arm. A printed circuit board (PCB) may be carried by the portable housing. The mobile wireless communications device may also include wireless transceiver circuitry carried by the PCB and coupled to the antenna.

20 Claims, 6 Drawing Sheets





US009337529B2

(12) **United States Patent**
Cui

(10) **Patent No.:** **US 9,337,529 B2**
(45) **Date of Patent:** **May 10, 2016**

(54) **PORTABLE TERMINAL**

(71) Applicants: **Beijing Lenovo Software Ltd.**, Haidian District, Beijing (CN); **Lenovo (Beijing) Co., Ltd.**, Beijing (CN)

(72) Inventor: **Bin Cui**, Beijing (CN)

(73) Assignees: **BEIJING LENOVO SOFTWARE LTD.**, Haidian District, Beijing (CN); **LENOVO (BEIJING) CO., LTD.**, Haidian District, Beijing (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 229 days.

(21) Appl. No.: **14/090,325**

(22) Filed: **Nov. 26, 2013**

(65) **Prior Publication Data**
US 2014/0145886 A1 May 29, 2014

(30) **Foreign Application Priority Data**
Nov. 27, 2012 (CN) 2012 1 0492560

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

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

(58) **Field of Classification Search**
USPC 343/702, 767, 770
See application file for complete search history.

(56) **References Cited**

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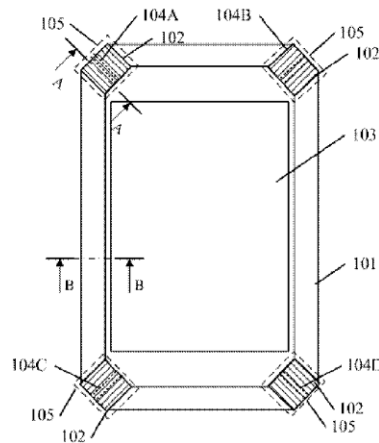
Primary Examiner — Tan Ho
(74) *Attorney, Agent, or Firm* — Brinks Gilson & Lione; G. Peter Nichols

(57) **ABSTRACT**

A portable terminal is described where the portable terminal includes a first frame body and a second frame body. The first frame body is used for an antenna unit of the portable terminal and a gap is set in a first partial area of the first frame body with the first partial area with a gap being set is covered by the second frame body.

13 Claims, 3 Drawing Sheets

— 100





US009337532B2

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

(10) **Patent No.:** **US 9,337,532 B2**
(45) **Date of Patent:** **May 10, 2016**

- (54) **MULTI LAYER 3D ANTENNA CARRIER ARRANGEMENT FOR ELECTRONIC DEVICES**
- (71) Applicant: **Futurewei Technologies, Inc.**, Plano, TX (US)
- (72) Inventors: **Kiran Vanjani**, San Diego, CA (US); **Jorge Fabrega Sanchez**, San Diego, CA (US); **Hui Vicki Tan**, San Diego, CA (US)
- (73) Assignee: **Futurewei Technologies, Inc.**, Plano, TX (US)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 510 days.

- (21) Appl. No.: **13/622,134**
- (22) Filed: **Sep. 18, 2012**

(65) **Prior Publication Data**
US 2014/0078017 A1 Mar. 20, 2014

- (51) **Int. Cl.**
H01Q 1/12 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/24 (2006.01)
H01Q 5/371 (2015.01)
H01Q 9/04 (2006.01)
- (52) **U.S. Cl.**
CPC **H01Q 1/38** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01); **H01Q 9/0414** (2013.01); **H01Q 9/0471** (2013.01)
- (58) **Field of Classification Search**
USPC 343/700 MS, 702, 878
See application file for complete search history.

- (56) **References Cited**
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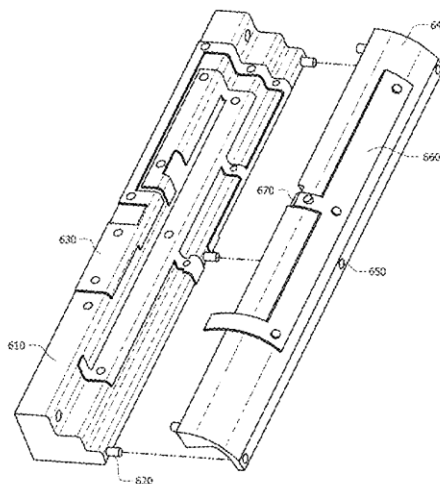
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Primary Examiner — Tan Ho
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.; Grant Rodolph; Adam J. Stegge

(57) **ABSTRACT**

An antenna comprising a plurality of carrier blocks, wherein each carrier block is coupled to at least one other carrier block, and a plurality of radiators, wherein each radiator is connected to at least one carrier block. Further, an antenna comprising a plurality of carrier blocks, wherein each carrier block is coupled with at least one other carrier block, and a radiator connected to at least two of the plurality of carrier blocks.

35 Claims, 24 Drawing Sheets





US009337537B2

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

(10) **Patent No.:** **US 9,337,537 B2**
(45) **Date of Patent:** **May 10, 2016**

(54) **ANTENNA WITH TUNABLE HIGH BAND PARASITIC ELEMENT**

(56) **References Cited**

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)
(72) Inventors: **Hongfei Hu**, Santa Clara, CA (US); **Mattia Pascolini**, San Mateo, CA (US); **Enrique Ayala Vazquez**, Watsonville, CA (US); **Matthew A. Mow**, Los Altos, CA (US); **Dean F. Darnell**, San Jose, CA (US); **Ming-Ju Tsai**, Cupertino, CA (US); **Robert W. Schlub**, Cupertino, CA (US); **Nanbo Jin**, Sunnyvale, CA (US); **Yuehui Ouyang**, Sunnyvale, CA (US); **Liang Han**, Sunnyvale, CA (US); **David Pratt**, Gilroy, CA (US)

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(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 428 days.

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

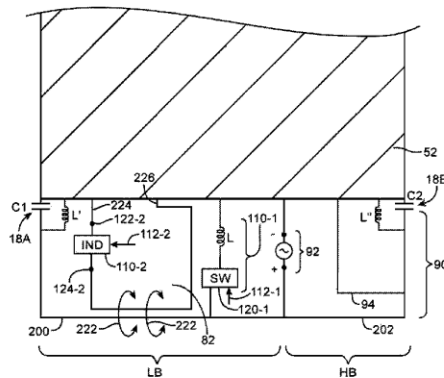
(21) Appl. No.: **13/890,013**
(22) Filed: **May 8, 2013**
(65) **Prior Publication Data**
US 2014/0333496 A1 Nov. 13, 2014

(57) **ABSTRACT**

Electronic devices may be provided that include radio-frequency transceiver circuitry and antennas. An antenna may be formed from an antenna resonating element and an antenna ground. The antenna resonating element may have a shorter portion that resonates at higher communications band frequencies and a longer portion that resonates at lower communications band frequencies. The resonating element may be formed from a peripheral conductive electronic device housing structure that is separated from the antenna ground by an opening. A parasitic monopole antenna resonating element or parasitic loop antenna resonating element may be located in the opening. Antenna tuning in the higher communications band may be implemented using an adjustable inductor in the parasitic element. Antenna tuning in the lower communications band may be implemented using an adjustable inductor that couples the antenna resonating element to the antenna ground.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/00 (2015.01)
(Continued)
(52) **U.S. Cl.**
CPC **H01Q 5/0024** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/30** (2015.01); **H01Q 5/321** (2015.01); **H01Q 5/378** (2015.01); **H01Q 9/0421** (2013.01)
(58) **Field of Classification Search**
USPC 343/700 MS, 702, 745, 833
See application file for complete search history.

17 Claims, 9 Drawing Sheets





US009337539B1

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

(10) **Patent No.:** **US 9,337,539 B1**
(45) **Date of Patent:** **May 10, 2016**

- (54) **COMBINED ANTENNA ELEMENT WITH MULTIPLE MATCHED FEEDS FOR MULTIPLE COMPONENT CARRIER AGGREGATION**
- (71) Applicant: **Amazon Technologies, Inc.**, Seattle, WA (US)
- (72) Inventors: **Peruvemba Ranganathan Sai Ananthanarayanan**, Sunnyvale, CA (US); **In Chul Hyun**, San Jose, CA (US)
- (73) Assignee: **Amazon Technologies, Inc.**, Seattle, WA (US)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.
- (21) Appl. No.: **14/562,605**
- (22) Filed: **Dec. 5, 2014**
- (51) **Int. Cl.**
H01Q 21/30 (2006.01)
H01Q 5/335 (2015.01)
H01Q 21/00 (2006.01)
H04B 1/40 (2015.01)
- (52) **U.S. Cl.**
CPC **H01Q 5/335** (2015.01); **H01Q 21/0006** (2013.01); **H01Q 21/30** (2013.01); **H04B 1/40** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/30; H04B 1/40
See application file for complete search history.

(56) **References Cited**

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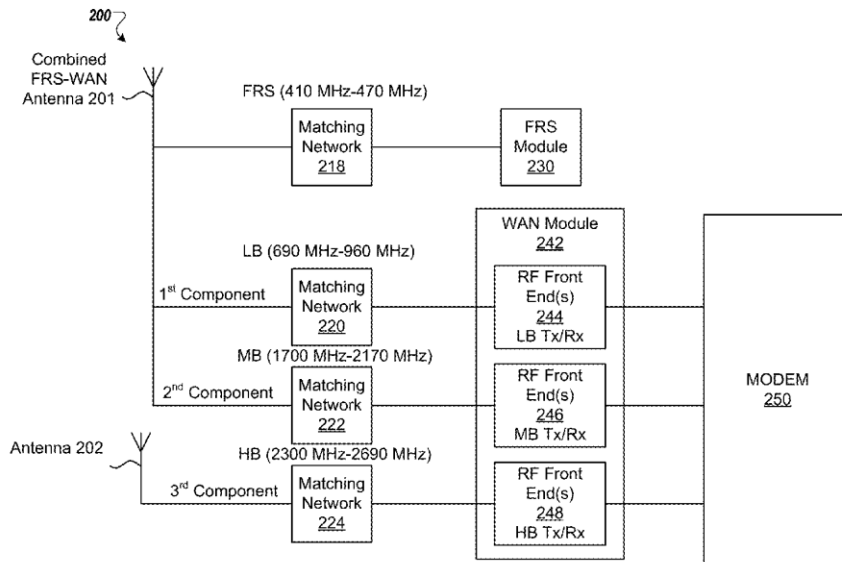
Primary Examiner — David Bilodeau

(74) *Attorney, Agent, or Firm* — Lowenstein Sandler LLP

(57) **ABSTRACT**

Antenna structures and methods of operating the same of an electronic device are described. One apparatus includes an antenna element and three matching circuits coupled to the antenna element. The first RF module is operable to cause the antenna element to radiate or receive electromagnetic energy in a first frequency range. The second RF module is operable to cause the antenna element to radiate or receive electromagnetic energy in a second frequency range and a third frequency range. The impedance matching circuits are operable to match an impedance of the antenna element to an impedance of the first RF module to radiate or receive in the first frequency ranges and to match impedances of the antenna element to impedances of the second RF module to radiate or receive the electromagnetic energy in the second and third frequency ranges.

20 Claims, 12 Drawing Sheets





US009337543B2

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

(10) **Patent No.:** **US 9,337,543 B2**
(45) **Date of Patent:** **May 10, 2016**

- (54) **ANTENNA DEVICE AND MOBILE TERMINAL HAVING THE SAME**
- (71) Applicant: **LG ELECTRONICS INC.**, Seoul (KR)
- (72) Inventors: **Byungwoon Jung**, Seoul (KR); **Jaewoo Lee**, Seoul (KR); **Daeyong Kwak**, Seoul (KR); **Hanphil Rhyu**, Seoul (KR); **Sungjung Rho**, Seoul (KR)
- (73) Assignee: **LG Electronics Inc.**, Seoul (KR)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 247 days.

- (21) Appl. No.: **13/922,276**
- (22) Filed: **Jun. 20, 2013**
- (65) **Prior Publication Data**
US 2013/0342411 A1 Dec. 26, 2013
- (30) **Foreign Application Priority Data**
Jun. 21, 2012 (KR) 10-2012-0066744
Nov. 22, 2012 (KR) 10-2012-0133296

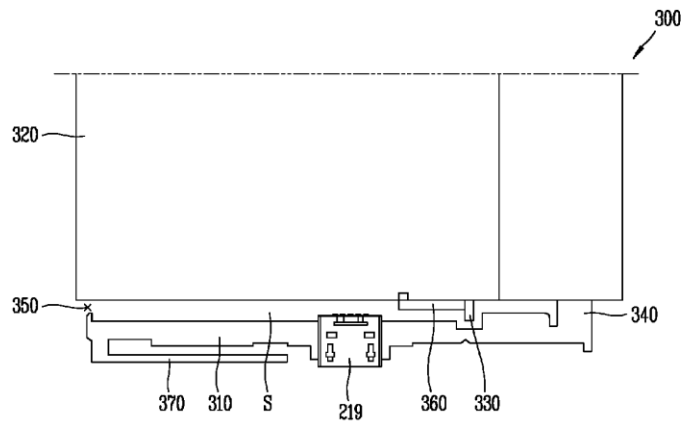
- (51) **Int. Cl.**
H01Q 13/10 (2006.01)
H01Q 1/24 (2006.01)
H01Q 21/28 (2006.01)
H01Q 5/307 (2015.01)
- (52) **U.S. Cl.**
CPC **H01Q 13/106** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/307** (2015.01); **H01Q 13/10** (2013.01); **H01Q 21/28** (2013.01)
- (58) **Field of Classification Search**
CPC H01Q 13/10; H01Q 13/085; H01Q 1/38; H01Q 9/0407
USPC 343/767, 702, 867
See application file for complete search history.

- (56) **References Cited**
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Primary Examiner — Dameon E Levi
Assistant Examiner — Collin Dawkins
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

- (57) **ABSTRACT**
A mobile terminal comprises: a terminal body having an upper part and a lower part; and an antenna device disposed on the upper part or the lower part of the terminal body, and configured to transmit and receive radio signals, wherein the antenna device comprises: a first member and a second member which form a slot of which one side is open; a feeding portion having one end connected to one of the first member and the second member such that the antenna device resonates in a first frequency band, and forming an electric field in the slot; and a feeding extension portion extending from the feeding portion such that the antenna device resonates in a second frequency band.

17 Claims, 17 Drawing Sheets





US009337547B2

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

(10) **Patent No.:** **US 9,337,547 B2**
(45) **Date of Patent:** **May 10, 2016**

(54) **INTERNAL ANTENNA HAVING WIDEBAND CHARACTERISTIC**

(2013.01); **H01Q 1/38** (2013.01); **H01Q 1/521** (2013.01); **H01Q 5/25** (2015.01); **H01Q 5/371** (2015.01); **H01Q 5/378** (2015.01); **H01Q 5/40** (2015.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01)

(71) Applicant: **LS Mtron Ltd.**, Anyang-si (KR)

(72) Inventors: **Tae-Hyung Kim**, Gunpo-Si (KR); **Ki-Hyun Kong**, Gunpo-Si (KR); **Suk-Ki Koo**, Gwangmyeong-Si (KR); **Byung-Je Lee**, Seoul (KR); **Hyun-Ho Wi**, Seoul (KR); **Byeong-Kwan Kim**, Seoul (KR)

(58) **Field of Classification Search**
CPC H01Q 21/0075; H01Q 1/243; H01Q 1/38
USPC 343/702, 700 MS, 844, 846
See application file for complete search history.

(73) Assignee: **LS MTRON LTD.**, Anyang-Si, Gyeonggi-Do (KR)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 273 days.

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(22) Filed: **Jul. 26, 2013**

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(65) **Prior Publication Data**

US 2014/0028519 A1 Jan. 30, 2014

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(30) **Foreign Application Priority Data**

Jul. 27, 2012 (KR) 10-2012-0082510

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Primary Examiner — Hoanganh Le

(74) *Attorney, Agent, or Firm* — LRK Patent Law Firm

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 21/00 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/52 (2006.01)
H01Q 9/42 (2006.01)
H01Q 21/28 (2006.01)
H01Q 5/25 (2015.01)
H01Q 5/371 (2015.01)
H01Q 5/378 (2015.01)
H01Q 5/40 (2015.01)

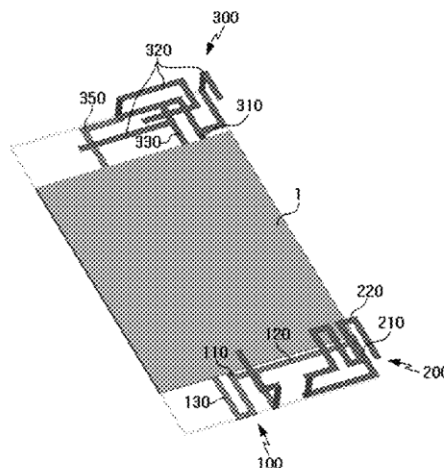
(57) **ABSTRACT**

An internal antenna having a wideband characteristic includes a printed circuit board, a first antenna unit fed with electricity from a feeding unit of the printed circuit board, and a second antenna unit spaced apart from the first antenna unit by a predetermined distance and indirectly fed with electricity by means of coupling to the first antenna unit, wherein the second antenna unit is indirectly fed with electricity with a phase difference from the first antenna unit due to an electric distance from a feeding point of the first antenna unit.

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

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

13 Claims, 10 Drawing Sheets





US009337990B2

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

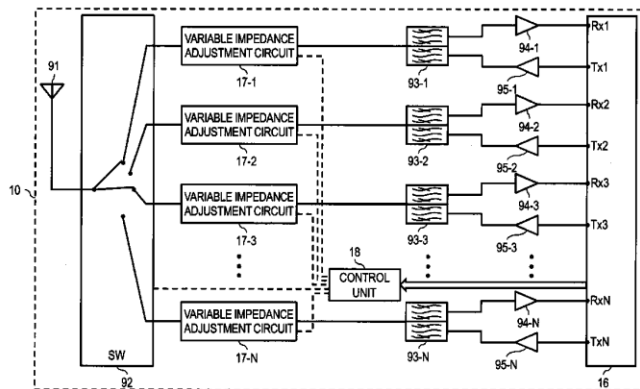
(10) **Patent No.:** **US 9,337,990 B2**
(45) **Date of Patent:** **May 10, 2016**

- (54) **FRONT-END CIRCUIT AND IMPEDANCE ADJUSTMENT METHOD**
- (71) Applicant: **NTT DOCOMO, INC.**, Tokyo (JP)
- (72) Inventors: **Shoichi Narahashi**, Tokyo (JP); **Hiroshi Okazaki**, Tokyo (JP); **Kunihiro Kawai**, Tokyo (JP); **Yuta Takagi**, Tokyo (JP); **Takayuki Furuta**, Tokyo (JP)
- (73) Assignee: **NTT DOCOMO, 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 25 days.
- (21) Appl. No.: **14/359,240**
- (22) PCT Filed: **Jul. 9, 2013**
- (86) PCT No.: **PCT/JP2013/068703**
- § 371 (c)(1),
(2) Date: **May 19, 2014**
- (87) PCT Pub. No.: **WO2014/010575**
PCT Pub. Date: **Jan. 16, 2014**
- (65) **Prior Publication Data**
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- (30) **Foreign Application Priority Data**
Jul. 11, 2012 (JP) 2012-155246
- (51) **Int. Cl.**
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H04B 1/525 (2015.01)
(Continued)
- (52) **U.S. Cl.**
CPC **H04L 5/1461** (2013.01); **H04B 1/006** (2013.01); **H04B 1/525** (2013.01); **H04W 24/08** (2013.01)
- (58) **Field of Classification Search**
CPC H04B 1/525; H04B 1/006; H04W 24/08; H04L 5/1461
USPC 370/242-252
See application file for complete search history.

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Primary Examiner — Bob Phunkulh
Assistant Examiner — Kyaw Z Soe
(74) *Attorney, Agent, or Firm* — Oblon, McClelland, Maier & Neustadt, L.L.P.

(57) **ABSTRACT**
A front-end circuit includes an RFIC, an antenna, N duplexers, N variable impedance adjustment circuits, a switch for selecting any two of the N variable impedance adjustment circuits, and a control unit which receives a control signal from the RFIC, where $2 \leq N$. The control unit executes switching operations of the N variable impedance adjustment circuits and the switch in accordance with control information. The control signal indicates to 1) control the switch to select two variable impedance adjustment circuits corresponding to a p-th frequency band and a q-th frequency band respectively, 2) control a variable impedance adjustment circuit corresponding to the p-th frequency band to increase input impedance in the q-th frequency band as viewed from the antenna side and 3) control a variable impedance adjustment circuit corresponding to the q-th frequency band to increase input impedance in the p-th frequency band as viewed from the side.

3 Claims, 9 Drawing Sheets





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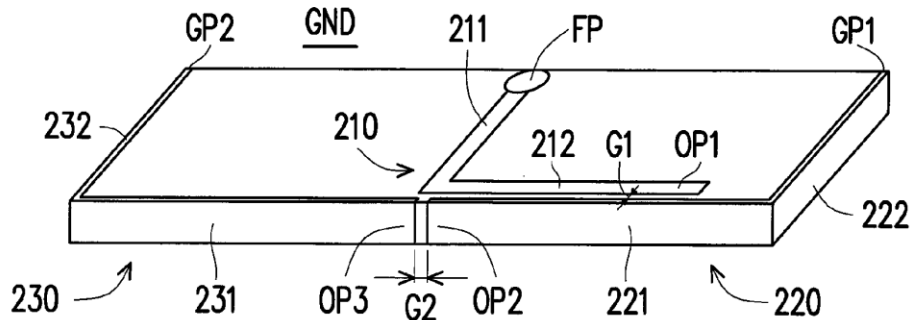
(12) **United States Patent**
Chou et al.

(10) **Patent No.:** **US 9,343,801 B2**
(45) **Date of Patent:** **May 17, 2016**

- (54) **ELECTRONIC DEVICE**
- (71) Applicant: **Acer Incorporated**, New Taipei (TW)
- (72) Inventors: **Ming-Yu Chou**, New Taipei (TW);
Ching-Chi Lin, New Taipei (TW);
Kun-Sheng Chang, 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 74 days.
- (21) Appl. No.: **14/501,047**
- (22) Filed: **Sep. 30, 2014**
- (65) **Prior Publication Data**
US 2016/0028150 A1 Jan. 28, 2016
- (30) **Foreign Application Priority Data**
Jul. 22, 2014 (TW) 103125085 A
- (51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/48 (2006.01)
H01Q 5/10 (2015.01)
- (52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/10** (2015.01)
- (58) **Field of Classification Search**
USPC 343/700 MS, 702
See application file for complete search history.

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343/702
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- Primary Examiner* — Tan Ho
- (74) *Attorney, Agent, or Firm* — Jianq Chyun IP Office

- (57) **ABSTRACT**
An electronic device having a radiation part and a metallic frame is provided. The radiation part is L-shaped, and includes a feeding branch and an open branch. The metallic frame includes a first metallic part and a second metallic part. The first metallic part is L-shaped, wherein a first side of the first metallic part is near the open branch of the radiation part, and a first gap exists therebetween. The second metallic part is L-shaped, wherein an open terminal of a first side of the second metallic part is aligned with an open terminal of the first side of the first metallic part, and a second gap exists therebetween. The radiation part and the metallic frame forms an antenna to transceive a plurality of radio frequency signals.
- 6 Claims, 3 Drawing Sheets**





US009343802B2

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

(10) **Patent No.:** **US 9,343,802 B2**
(45) **Date of Patent:** **May 17, 2016**

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

(71) Applicant: **KING SLIDE TECHNOLOGY CO., LTD.**, Kaohsiung (TW)

(72) Inventors: **Hsin-Cheng Su**, Kaohsiung (TW);
Chun-Ta Liu, Kaohsiung (TW);
Shu-Chen Lin, Kaohsiung (TW)

(73) Assignee: **KING SLIDE TECHNOLOGY CO., LTD.**, Kaohsiung Science Park, Lu Zhu Dist., Kaohsiung (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 98 days.

(21) Appl. No.: **14/515,494**

(22) Filed: **Oct. 15, 2014**

(65) **Prior Publication Data**

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

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

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

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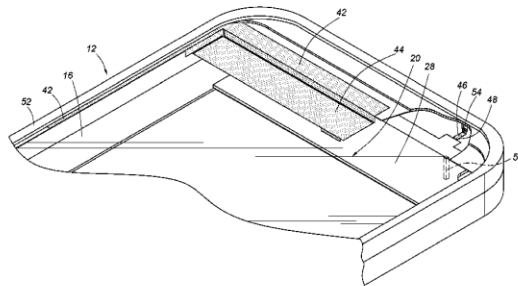
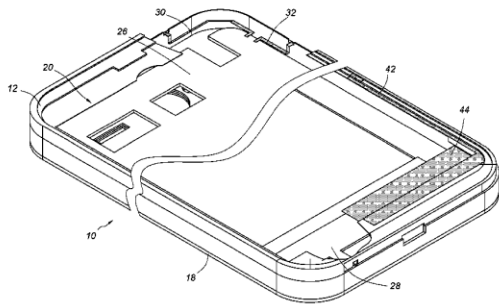
Primary Examiner — Trinh Dinh

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

(57) **ABSTRACT**

An antenna of a communication device includes a metal frame, a metal back cover and a printed circuit board. The printed circuit board includes a first circuit block and a second circuit block electrically connected to the first circuit block. A first conductor is connected between a first part of the metal frame and a signal terminal of the first circuit block. A second conductor is connected between a second part of the metal frame and a ground terminal of the first circuit block. A third conductor is connected to a third part of the metal frame. A fourth conductor is connected to a ground terminal of the second circuit block, and at least one coupling gap is defined between the third conductor and the fourth conductor. A signal terminal of the second circuit block is electrically connected to a fourth part of the metal frame.

5 Claims, 10 Drawing Sheets





US009343804B2

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

(10) **Patent No.:** **US 9,343,804 B2**
(45) **Date of Patent:** **May 17, 2016**

(54) **ANTENNA APPARATUS FOR PORTABLE TERMINAL**

USPC 343/702, 872, 909
See application file for complete search history.

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

(56) **References Cited**

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(72) Inventors: **Jun-Hwa Oh**, Seoul (KR); **Joon-Ho Byun**, Gyeonggi-do (KR); **Jae-Hee Kim**, Gyeonggi-do (KR); **Bum-Jin Cho**, Gyeonggi-do (KR); **Sang-Jin Eom**, Gyeonggi-do (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 251 days.

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(22) Filed: **Mar. 8, 2013**

(65) **Prior Publication Data**

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Primary Examiner — Hoanganh Le
(74) *Attorney, Agent, or Firm* — Cha & Reiter, LLC

(30) **Foreign Application Priority Data**

Mar. 12, 2012 (KR) 10-2012-0025126

(57) **ABSTRACT**

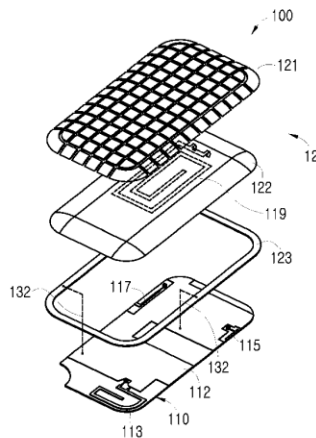
(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/42 (2006.01)
H01Q 1/44 (2006.01)
H01Q 5/378 (2015.01)

An antenna apparatus for a portable terminal is provided. The portable terminal includes a printed circuit board (PCB) having a ground surface and RF components to process a wireless signal received through at least one antenna element. A housing forms an external appearance of the portable terminal, and has a non-conductive member with a plurality of metal fragments attached thereto. At least one of the metal fragments is electrically connected to the ground surface. The metal fragments may enhance the texture and durability of the housing. Preferably, the shapes, sizes and distances separating the metal fragments are designed to minimally impact, or improve, the antenna performance provided by the at least one antenna element.

(52) **U.S. Cl.**
CPC **H01Q 1/42** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/44** (2013.01); **H01Q 5/378** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/42; H01Q 5/0062; H01Q 1/44

18 Claims, 18 Drawing Sheets





US009343812B2

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

(10) **Patent No.:** **US 9,343,812 B2**
(45) **Date of Patent:** **May 17, 2016**

(54) **COMMUNICATION DEVICE AND ANTENNA ELEMENT THEREIN**

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

(72) Inventors: **Kin-Lu Wong**, New Taipei (TW);
Meng-Ting Chen, 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 287 days.

(21) Appl. No.: **14/060,869**

(22) Filed: **Oct. 23, 2013**

(65) **Prior Publication Data**

US 2015/0035712 A1 Feb. 5, 2015

(30) **Foreign Application Priority Data**

Jul. 30, 2013 (TW) 102127223 A

(51) **Int. Cl.**
H01Q 9/00 (2006.01)
H01Q 7/00 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/321 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 7/00** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/321** (2015.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 7/00; H01Q 5/321; H01Q 9/42; H01Q 1/243
USPC 343/741, 749, 846, 702
See application file for complete search history.

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Primary Examiner — Dameon E Levi

Assistant Examiner — Hasan Islam

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

(57) **ABSTRACT**

A communication device includes a ground element and an antenna element. The antenna element includes a loop metal element and a branch metal element. The loop metal element is adjacent to an edge of the ground element. The loop metal element has a feeding end and a grounding end. The grounding end is coupled to the ground element. The feeding end is coupled through a capacitive element and a first inductive element to a signal source. A closed region is enclosed by the loop metal element and the edge of the ground element. The branch metal element is coupled through a second inductive element to a connection point on the loop metal element. The connection point is at the front-half portion of the loop metal element. The front-half portion includes the feeding end. The branch metal element substantially extends along an outer periphery of the loop metal element.

8 Claims, 5 Drawing Sheets

