



US009065165B2

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

(10) **Patent No.:** **US 9,065,165 B2**
(45) **Date of Patent:** **Jun. 23, 2015**

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

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(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 198 days.

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(30) **Foreign Application Priority Data**

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H01Q 1/50 (2006.01)
H01Q 7/00 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC . **H01Q 7/00** (2013.01); **H01Q 1/50** (2013.01);
H01Q 1/243 (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 9/42; H01Q 1/50;
H01Q 7/00; H01Q 5/0037
USPC 343/700 MS, 702, 866, 876, 848, 860
See application file for complete search history.

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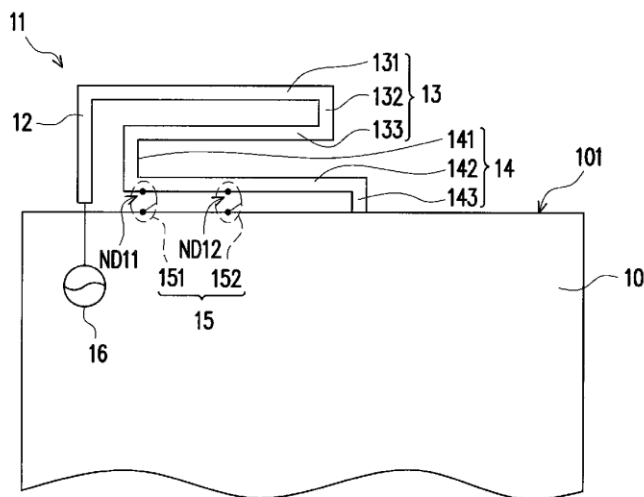
Primary Examiner — Tan Ho

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(57) **ABSTRACT**

A communication device including a ground element, an antenna element and a switching unit is provided. The antenna element is substantially a loop antenna and includes a first part, a second part and a third part. The second part includes (N-1) bends for forming N connection sections. The third part includes (P-1) bends for forming P ground sections. The N connection sections are connected in series between a first end of a first ground section and the first part. A second end of an i^{th} ground section is electrically connected to a first end of an $(i+1)^{th}$ ground section, i is an integer and $1 \leq i \leq (P-1)$. A second end of a P^{th} ground section is electrically connected to the ground element, and a $(P-1)^{th}$ ground section includes at least one ground point. The switching unit is electrically connected between the at least one ground point and the ground element.

10 Claims, 6 Drawing Sheets



100



US009065168B2

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

(10) **Patent No.:** **US 9,065,168 B2**
(45) **Date of Patent:** **Jun. 23, 2015**

- (54) **ANTENNA APPARATUS FOR PORTABLE TERMINAL**
- (75) Inventors: **Jae-Bong Chun**, Gyeonggi-do (KR);
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(30) **Foreign Application Priority Data**
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(51) **Int. Cl.**
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H01Q 9/04 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/48 (2006.01)
H01Q 5/378 (2015.01)

(52) **U.S. Cl.**
 CPC **H01Q 9/0421** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/378** (2015.01)

(58) **Field of Classification Search**
USPC 343/702, 700 MS, 848, 720
See application file for complete search history.

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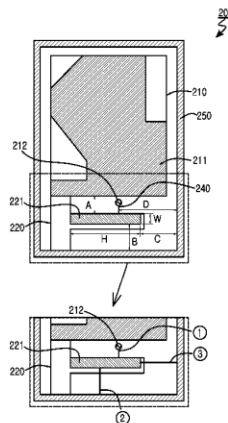
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Primary Examiner — Hoang V Nguyen
Assistant Examiner — Hai Tran
(74) *Attorney, Agent, or Firm* — Cha & Reiter, LLC

(57) **ABSTRACT**

An antenna apparatus for a portable terminal which is light, thin, compact, and small. The antenna apparatus preferably includes a main board equipped with a power feeding part for feeding power and a ground surface for grounding the main board and at least one sub-board, each sub-board which has a ground surface and electrically communicates with the main board, wherein the ground surface of each sub-board receives power from the power feeding part of the main board and resonates.

18 Claims, 13 Drawing Sheets





US009065175B2

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

(10) **Patent No.:** **US 9,065,175 B2**
(45) **Date of Patent:** **Jun. 23, 2015**

(54) **ANTENNA STRUCTURES AND ELECTRICAL COMPONENTS WITH GROUNDING**

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

(72) Inventors: **Sean S. Corbin**, San Jose, CA (US); **Taylor H. Gilbert**, Sunnyvale, CA (US); **Rodney A. Gomez Angulo**, Sunnyvale, CA (US); **Yi Jiang**, Sunnyvale, CA (US); **Conor P. Lenahan**, Cupertino, CA (US); **Qingxiang Li**, Mountain View, CA (US); **Stephen R. McClure**, San Francisco, CA (US); **Robert W. Schlub**, Cupertino, CA (US); **Salih Yarga**, Sunnyvale, CA (US); **Jiang Zhu**, Sunnyvale, CA (US)

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

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H01Q 1/48 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)
H05K 1/02 (2006.01)
H05K 1/18 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H05K 1/0215** (2013.01); **H05K 1/189** (2013.01); **H05K 2201/0281** (2013.01); **H05K 2201/10409** (2013.01); **H04N 5/2257** (2013.01)

(58) **Field of Classification Search**
CPC F16M 13/022; F16M 11/10; F16M 2200/041; H01Q 1/243; H01Q 1/42; G06F

1/1626; G06F 1/1633; G06F 1/1656; G06F 1/1686; G06F 1/1688; G06F 1/1698; H04B 1/3816; H04M 1/026; H04R 1/02; H04R 1/101
USPC 348/158, 373-374; 343/700, 767, 785, 343/845
See application file for complete search history.

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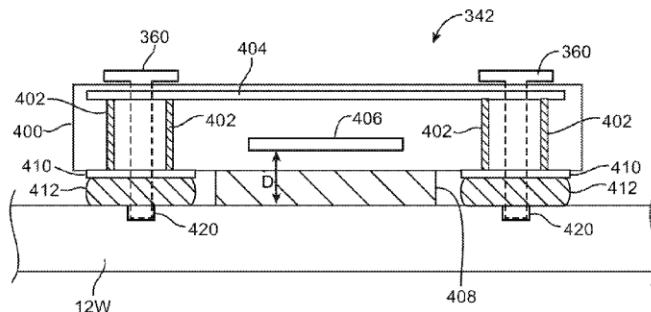
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(74) Attorney, Agent, or Firm — Treyz Law Group; G. Victor Treyz; Michael H. Lyons

(57) **ABSTRACT**

An electronic device may have a conductive housing with an antenna window. Antenna structures may be mounted adjacent to the antenna window. The antenna structures may have a dielectric carrier. Patterned metal antenna traces may be formed on the surface of the dielectric carrier. A proximity sensor may be formed from a flexible printed circuit mounted on the dielectric carrier. The flexible printed circuit may have a tail that contains a transmission line for feeding the antenna structures. The transmission line may include a positive signal conductor that is maintained at a desired distance from the conductive housing using a polymer sheet. A portion of the antenna structures may protrude between a microphone and a camera module. Plastic camera module housing structures may have an inner surface coated with a shielding metal. A U-shaped conductive fabric layer may be used as a grounding structure.

23 Claims, 10 Drawing Sheets





US009065496B2

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

(10) **Patent No.:** **US 9,065,496 B2**
(45) **Date of Patent:** **Jun. 23, 2015**

(54) **METHOD AND SYSTEM FOR SWITCHED COMBINED DIVERSITY WITH A MODAL ANTENNA**

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

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

(73) Assignee: **Ethertronics, Inc.**, San Diego, CA (US)

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(21) Appl. No.: **14/337,062**

(22) Filed: **Jul. 21, 2014**

(65) **Prior Publication Data**

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Related U.S. Application Data

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(51) **Int. Cl.**
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H04B 7/04 (2006.01)
H04B 7/08 (2006.01)
H04B 7/10 (2006.01)

(52) **U.S. Cl.**
CPC **H04B 7/04** (2013.01); **H04B 7/0825** (2013.01); **H04B 7/0854** (2013.01); **H04B 7/0857** (2013.01); **H04B 7/0871** (2013.01); **H04B 7/10** (2013.01)

(58) **Field of Classification Search**
CPC .. H04B 7/0825; H04B 7/0854; H04B 7/0857; H04B 7/0871
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See application file for complete search history.

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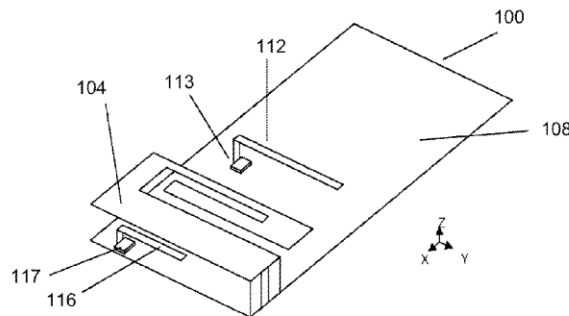
Primary Examiner — Tho G Phan

(74) *Attorney, Agent, or Firm* — Coastal Patent Law Group, P.C.

(57) **ABSTRACT**

A system and method for diversity implementation are provided, where diversity gains are obtained by using a hybrid of the switching technique and the combining technique in conjunction with the use of a modal antenna. The antenna system includes multiple antennas including at least one modal antenna that has multiple modes, and a processor for selecting one or more modes from the multiple modes associated with each of the at least one modal antenna, combining modes to form one or more combinations of modes, the modes in each of the one or more combinations including one of the one or more selected modes associated with each of the at least one modal antenna, and selecting one of the one or more combinations that optimizes correlation and/or a quality metric for diversity.

23 Claims, 8 Drawing Sheets





US009065891B2

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

(10) **Patent No.:** **US 9,065,891 B2**
(45) **Date of Patent:** **Jun. 23, 2015**

(54) **RADIO COMMUNICATION APPARATUS AND CURRENT REDUCING METHOD**

(75) Inventors: **Masanori Sakurai**, Tokyo (JP); **Naoki Kobayashi**, Tokyo (JP); **Noriaki Ando**, Tokyo (JP); **Hiroshi Toyao**, Tokyo (JP); **Masaharu Imazato**, Tokyo (JP)

(73) Assignee: **Lenovo Innovations Limited**, Quarry Bay (HK)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 376 days.

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(22) PCT Filed: **Mar. 25, 2011**
(86) PCT No.: **PCT/JP2011/001760**

§ 371 (c)(1),
(2), (4) Date: **Jul. 31, 2012**

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PCT Pub. Date: **Oct. 6, 2011**

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Mar. 31, 2010 (JP) 2010-081473

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H01Q 19/06 (2006.01)
H01Q 19/10 (2006.01)
H04M 1/02 (2006.01)
H01Q 15/00 (2006.01)

(52) **U.S. Cl.**
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(58) **Field of Classification Search**
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USPC 361/749
See application file for complete search history.

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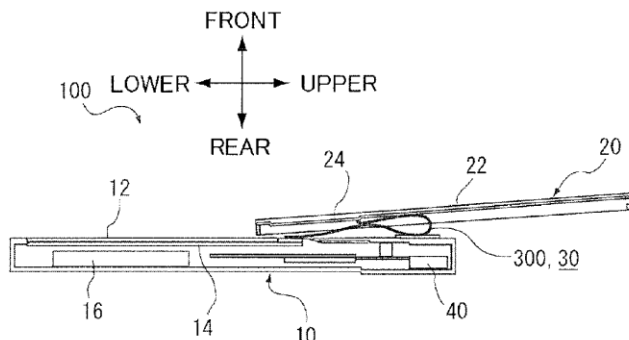
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Primary Examiner — Dameon E Levi
Assistant Examiner — Ricardo Magallanes

(57) **ABSTRACT**

A radio communication apparatus includes: a first casing; a second casing; a connection section that connects the first and second casings to each other to be movable; and an antenna device that operates at a predetermined communication frequency. In the radio communication apparatus, first and second states are switched between by relatively moving the first and second casings. The first state is a state in which the first and second casings are opened or closed with respect to one another, and a first conductor (122) installed from the connection section to the first casing and a second conductor (240) installed from the connection section to the second casing are separated and faced each other. In the first state, the first conductor (122) and the second conductor (240) are electrically connected to each other at the communication frequency. The second state is a state in which the first and second casings are closed or opened with respect to one another.

19 Claims, 33 Drawing Sheets





US009070965B2

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

(10) **Patent No.:** **US 9,070,965 B2**
(45) **Date of Patent:** ***Jun. 30, 2015**

(54) **HYBRID METAMATERIAL ANTENNA STRUCTURES**

(75) Inventors: **Maha Achour**, Encinitas, CA (US);
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(73) Assignee: **Tyco Electronics Services GmbH** (CH)

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This patent is subject to a terminal disclaimer.

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(22) Filed: **Mar. 4, 2011**

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Related U.S. Application Data

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(51) **Int. Cl.**

H01Q 9/04 (2006.01)
H01Q 1/00 (2006.01)
H01Q 5/00 (2015.01)
H01Q 1/38 (2006.01)
H01Q 15/00 (2006.01)

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CPC **H01Q 5/0024** (2013.01); **H01Q 1/38** (2013.01); **H01Q 9/0428** (2013.01); **H01Q 15/006** (2013.01)

(58) **Field of Classification Search**

USPC 343/700 MS, 702, 725, 893
See application file for complete search history.

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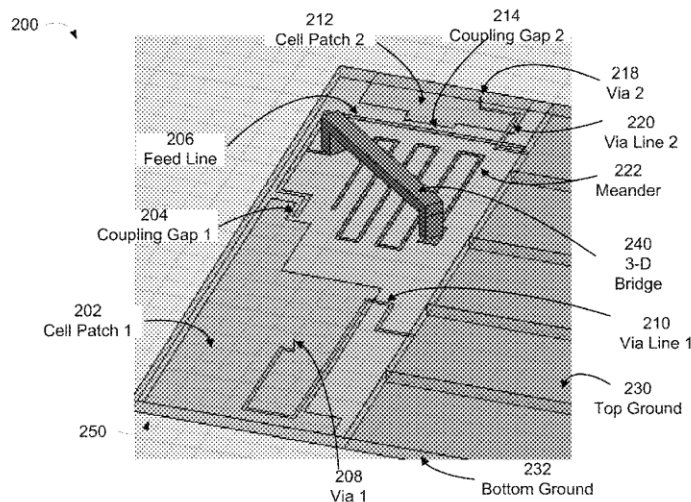
Primary Examiner — Robert Karacsony

Assistant Examiner — Patrick Holecek

(57) **ABSTRACT**

A wireless device having a CRLH antenna structure incorporates a meander line at the feed and adds a three dimensional conductive structure to shift a meander mode resonance frequency.

17 Claims, 5 Drawing Sheets





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

(10) **Patent No.:** US 9,070,966 B2
(45) **Date of Patent:** Jun. 30, 2015

- (54) **MULTI-BAND, WIDE-BAND ANTENNAS**
- (75) Inventors: **Kok Jiunn Ng**, Penang (MY); **Kean Meng Lim**, Kedah (MY)
- (73) Assignee: **Laird Technologies, Inc.**, Earth City, MO (US)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 350 days.
- (21) Appl. No.: **13/877,715**
- (22) PCT Filed: **Oct. 5, 2010**
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- § 371 (c)(1), (2), (4) Date: **Apr. 4, 2013**
- (87) PCT Pub. No.: **WO2012/047085**
- PCT Pub. Date: **Apr. 12, 2012**

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Primary Examiner — Dieu H Duong

(74) Attorney, Agent, or Firm — Harness, Dickey & Pierce, P.L.C.

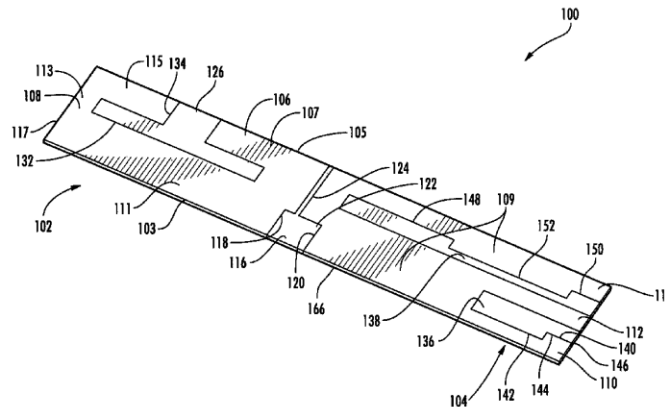
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- H01Q 5/02** (2006.01)
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- (52) **U.S. Cl.**
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- (58) **Field of Classification Search**
- USPC 343/793, 795, 822, 700 MS
- See application file for complete search history.

(57) **ABSTRACT**

Disclosed herein are various exemplary embodiments of multi-band, wide-band antennas. In exemplary embodiments, the antenna generally includes an upper portion and a lower portion. The upper portion includes two or more upper radiating elements and one or more slots disposed between the two or more upper radiating elements. The lower portion includes three or more lower radiating elements and one or more slots disposed between the three or more lower radiating elements. A gap is between the upper and lower portions such that the upper radiating elements are separated and spaced apart from the lower radiating elements. The antenna may be configured such that coupling of the gap and the upper and lower radiating elements enable multi-band, wide-band operation of the antenna within at least a first frequency range and a second frequency range, with the upper radiating elements operable as a radiating portion of the antenna, the lower radiating elements operable as a ground portion, and the gap operable for impedance matching.

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20 Claims, 18 Drawing Sheets





US009070968B2

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

(10) **Patent No.:** **US 9,070,968 B2**
(45) **Date of Patent:** **Jun. 30, 2015**

(54) **METHODS FOR CHARACTERIZING TUNABLE RADIO-FREQUENCY ELEMENTS IN WIRELESS ELECTRONIC DEVICES**

(75) Inventors: **Matthew A. Mow**, Los Altos, CA (US); **Rocco V. Dragone, Jr.**, Mountain View, CA (US); **Thomas E. Biedka**, San Jose, CA (US); **Robert W. Schlub**, Cupertino, CA (US); **Ruben Caballero**, San Jose, 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 619 days.

(21) Appl. No.: **13/437,804**

(22) Filed: **Apr. 2, 2012**

(65) **Prior Publication Data**
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(51) **Int. Cl.**
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H01Q 5/328 (2015.01)
G01R 29/10 (2006.01)
H04B 17/10 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0421** (2013.01); **G01R 29/10** (2013.01); **H01Q 5/328** (2015.01); **H04B 17/103** (2015.01)

(58) **Field of Classification Search**
USPC 455/67.11
See application file for complete search history.

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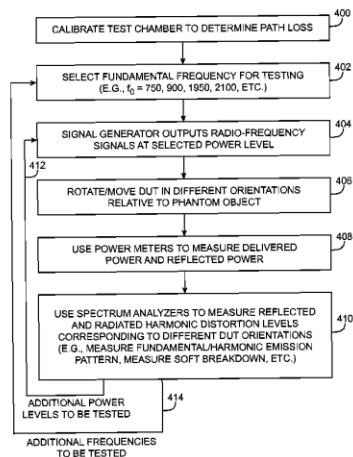
Primary Examiner — Ajibola Akinyemi

(74) Attorney, Agent, or Firm — Treyz Law Group; Jason Tsai; Joseph F. Guihan

(57) **ABSTRACT**

A wireless electronic device may contain an antenna tuning element for tuning the device's operating frequency range. The antenna tuning element may include radio-frequency switches, continuously/semi-continuously adjustable components such as tunable resistors, inductors, and capacitors, etc. A test system may be used to measure the radio-frequency characteristics associated with the tuning element assembled with an electronic device. The test system may include a test host, a test chamber, a signal generator, power meters, and radio-frequency testers. The electronic device under test (DUT) may be placed in the test chamber. The signal generator may generate radio-frequency test signals for energizing the antenna tuning element. The power meters and radio-frequency testers may be used to measure conducted and radiated signals emitted from the DUT while the DUT is placed in different desired orientations. A phantom object is optionally placed in the vicinity of the DUT to simulate actual user scenario.

19 Claims, 9 Drawing Sheets





US009070969B2

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

(10) **Patent No.:** **US 9,070,969 B2**
(45) **Date of Patent:** **Jun. 30, 2015**

(54) **TUNABLE ANTENNA SYSTEMS**
(75) Inventors: **Matt A. Mow**, Los Altos, CA (US);
Robert W. Schlub, Cupertino, CA (US);
Mattia Pascolini, Campbell, CA (US);
Robert J. Hill, Salinas, CA (US);
Ruben Caballero, San Jose, 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 284 days.

(21) Appl. No.: **12/831,180**

(22) Filed: **Jul. 6, 2010**

(65) **Prior Publication Data**
US 2012/0009983 A1 Jan. 12, 2012

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/04 (2006.01)
H01Q 1/48 (2006.01)
H01Q 7/00 (2006.01)
H01Q 9/14 (2006.01)
H01Q 13/10 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0442** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 7/005** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 9/145** (2013.01); **H01Q 13/103** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/48; H01Q 7/005; H01Q 6/0421; H01Q 9/0442; H01Q 9/145; H01Q 13/103
USPC 343/700 MS, 702, 741, 743-748, 823, 343/861; 455/575.7, 193.1, 193.2, 193.3
See application file for complete search history.

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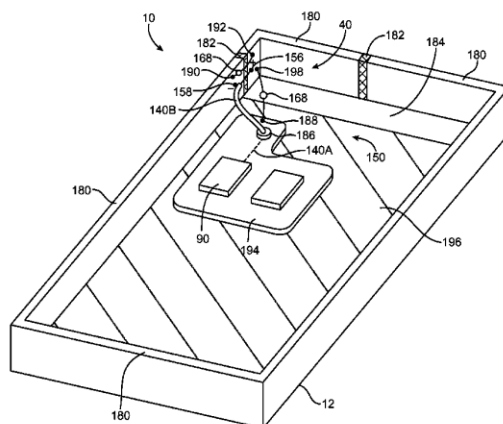
Primary Examiner — Michael C Wimer

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

(57) **ABSTRACT**

An electronic device has wireless communications circuitry including an adjustable antenna system coupled to a radio-frequency transceiver. The adjustable antenna system may include one or more adjustable electrical components that are controlled by storage and processing circuitry in the electronic device. The adjustable electrical components may include switches and components that can be adjusted between numerous different states. The adjustable electrical components may be coupled between antenna system components such as transmission line elements, matching network elements, antenna elements and antenna feeds. By adjusting the adjustable electrical components, the storage and processing circuitry can tune the adjustable antenna system to ensure that the adjustable antenna system covers communications bands of interest.

20 Claims, 21 Drawing Sheets





US009070975B2

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

(10) **Patent No.:** **US 9,070,975 B2**
(45) **Date of Patent:** **Jun. 30, 2015**

(54) **ANTENNAS WITH MULTIPLE FEED CIRCUITS**

(75) Inventors: **Brian Collins**, Stow-cum-Quy (GB);
Marc Harper, Stow-cum-Quy (GB)

(73) Assignee: **Microsoft Technology Licensing, LLC**,
Redmond, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 497 days.

(21) Appl. No.: **13/388,126**

(22) PCT Filed: **Aug. 12, 2010**

(86) PCT No.: **PCT/GB2010/051335**

§ 371 (c)(1),
(2), (4) Date: **Jan. 31, 2012**

(87) PCT Pub. No.: **WO2011/021027**

PCT Pub. Date: **Feb. 24, 2011**

(65) **Prior Publication Data**

US 2012/0133571 A1 May 31, 2012

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

(52) **U.S. Cl.**
CPC **H01Q 1/242** (2013.01); **H01Q 7/00**
(2013.01); **H01Q 9/145** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 7/00; H01Q 9/145; H01Q 1/242
See application file for complete search history.

(56) **References Cited**

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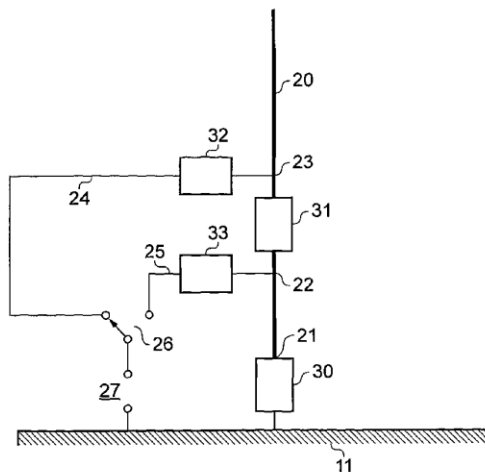
Primary Examiner — Trinh Dinh

(74) *Attorney, Agent, or Firm* — Ladislav Kusnyer; Judy Yee; Mickey Minhas

(57) **ABSTRACT**

There is disclosed an antenna arrangement comprising an electrically conductive radiating element having first and second ends, an electrically conductive ground plane or ground member, and an input terminal. The radiating element has a plurality of separate feed points at different locations between its first and second ends, and the input terminal is provided with a switch. Each feed point is electrically connected to the switch by way of a separate electrical pathway, the switch being configured to allow the separate feed points to be connected individually or in predetermined combinations to the input terminal by selecting between a plurality of selectable contacts. At least one of the electrical pathways includes a capacitive circuit component connected in series, and at least one other of the electrical pathways includes an inductive circuit component connected in series. The antenna arrangement allows for a high degree of customization and improved matching, and enables good multi-band performance.

11 Claims, 7 Drawing Sheets





US009070976B2

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

(10) **Patent No.:** **US 9,070,976 B2**
(45) **Date of Patent:** **Jun. 30, 2015**

- (54) **ANTENNA APPARATUS FOR RADIO-BASED ELECTRONIC DEVICES**
- (75) Inventors: **Dietmar Gapski**, Bocholt (DE); **Oliver Spiess**, Bocholt (DE)
- (73) Assignee: **Gigaset Communications GmbH**, München (DE)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1032 days.

- (21) Appl. No.: **12/808,950**
- (22) PCT Filed: **Dec. 1, 2008**
- (86) PCT No.: **PCT/EP2008/066504**
§ 371 (c)(1), (2), (4) Date: **Jul. 7, 2010**
- (87) PCT Pub. No.: **WO2009/080445**
PCT Pub. Date: **Jul. 2, 2009**
- (65) **Prior Publication Data**
US 2011/0199268 A1 Aug. 18, 2011

- (30) **Foreign Application Priority Data**
Dec. 21, 2007 (DE) 10 2007 062 051

- (51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/36 (2006.01)
(Continued)

- (52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 9/36** (2013.01); **H01Q 9/40** (2013.01); **H01Q 9/42** (2013.01)

- (58) **Field of Classification Search**
CPC H01Q 9/30
USPC 343/702, 700 MS, 789
See application file for complete search history.

(56) **References Cited**
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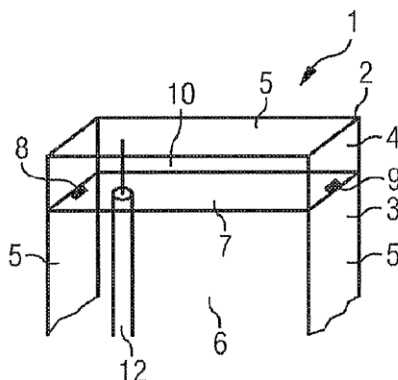
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Primary Examiner — Hoang V Nguyen
Assistant Examiner — Hai Tran
(74) *Attorney, Agent, or Firm* — Harness, Dickey & Pierce, P.L.C.

(57) **ABSTRACT**

An antenna apparatus is proposed, which can be operated outside in the vicinity around the antenna apparatus despite a shielding effect of an electrically conducting frame or electrically conducting housing. In the process, the electrically conducting frame or electrically conducting housing encloses a housing volume inside the housing, within said volume an electrically conducting connection being produced from a first to a second location of the electrically conducting frame or the electrically conducting housing. The first and the second locations are selected such that a radio resonance chamber is separated by a parallel radio resonance at a working frequency of the electronic device inside the enclosed housing volume by means of the electrically conducting connection.

10 Claims, 2 Drawing Sheets





US009070980B2

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

(10) **Patent No.:** **US 9,070,980 B2**
(45) **Date of Patent:** **Jun. 30, 2015**

(54) **SMALL ANTENNA APPARATUS OPERABLE IN MULTIPLE BANDS INCLUDING LOW-BAND FREQUENCY AND HIGH-BAND FREQUENCY AND INCREASING BANDWIDTH INCLUDING HIGH-BAND FREQUENCY**

(75) Inventors: **Kenichi Asanuma**, Kyoto (JP); **Atsushi Yamamoto**, Kyoto (JP); **Tsutomu Sakata**, Osaka (JP)

(73) Assignee: **PANASONIC INTELLECTUAL PROPERTY CORPORATION OF AMERICA**, Torrance, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 220 days.

(21) Appl. No.: **13/883,871**

(22) PCT Filed: **Aug. 31, 2012**

(86) PCT No.: **PCT/JP2012/005537**

§ 371 (c)(1),
(2), (4) Date: **May 7, 2013**

(87) PCT Pub. No.: **WO2013/051188**

PCT Pub. Date: **Apr. 11, 2013**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Oct. 6, 2011 (JP) 2011-221692

(51) **Int. Cl.**
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H01Q 1/52 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC . **H01Q 1/52** (2013.01); **H01Q 7/00** (2013.01);
H01Q 9/30 (2013.01); **H01Q 5/321** (2015.01)

(58) **Field of Classification Search**
USPC 343/749, 866, 867, 788
See application file for complete search history.

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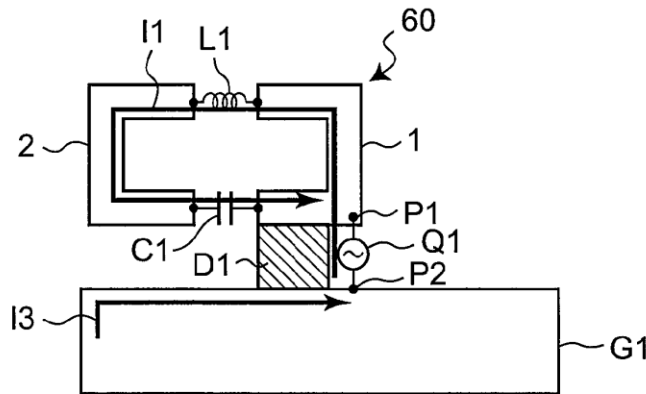
Primary Examiner — Tan Ho

(74) *Attorney, Agent, or Firm* — Wenderoth, Lind & Ponack, L.L.P.

(57) **ABSTRACT**

A radiator is provided with a looped radiation conductor, a capacitor, an inductor, a feed point on the radiation conductor, and a dielectric block provided in a portion where the radiation conductor and the ground conductor are close to each other. At a low-band resonance frequency, a current flows through a path extending along an inner perimeter of the loop of the radiation conductor and including the inductor and the capacitor. At a high-band resonance frequency, a current flows through a path including a section extending along an outer perimeter of the loop of the radiation conductor, including the capacitor but not including the inductor, and extending between the feed point and the inductor, and a parallel resonant circuit is formed from: a capacitance between the radiation conductor and the ground conductor through which the dielectric block is provided; and an inductance of the radiation conductor.

15 Claims, 41 Drawing Sheets





US009070985B2

(12) **United States Patent**
Wang

(10) **Patent No.:** **US 9,070,985 B2**

(45) **Date of Patent:** **Jun. 30, 2015**

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

USPC 343/725, 767, 770, 729
See application file for complete search history.

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

(56) **References Cited**

(72) Inventor: **Chuan-Chun Wang**, Taipei Hsien (TW)

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(73) Assignee: **ACER INCORPORATED**, Taipei Hsien (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 201 days.

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(21) Appl. No.: **13/731,287**

Primary Examiner — Robert Karacsony

(22) Filed: **Dec. 31, 2012**

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Sep. 7, 2012 (TW) 101132656 A

(57) **ABSTRACT**

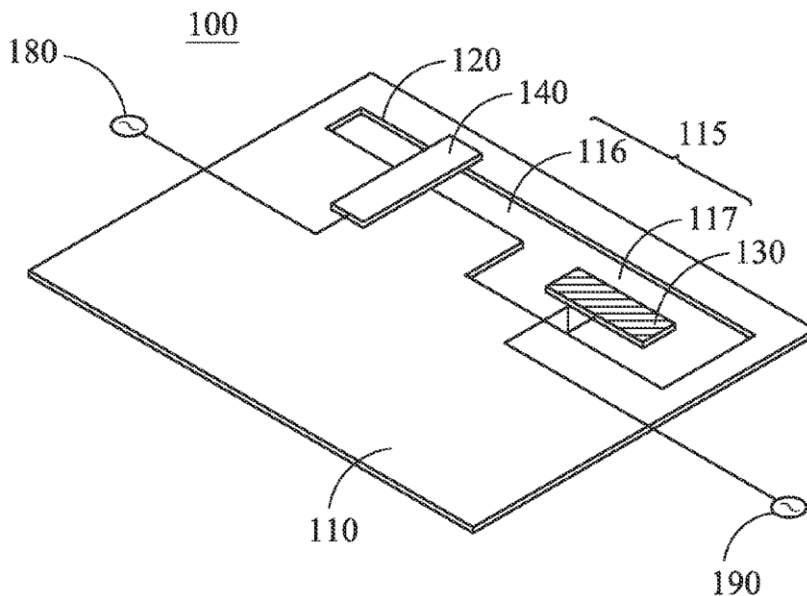
A mobile device includes a metal body element, a feeding element, and a second antenna. The metal body element is substantially a planar structure and has a slot, wherein a first antenna is formed by the slot of the metal body element. The feeding element extends across the slot of the metal body element, and is coupled to a first signal source. The second antenna is substantially located inside the slot of the metal body element, and is coupled to a second signal source. The slot is used as a portion of a resonant structure of the second antenna in order to reduce a total size of the first antenna and the second antenna.

(51) **Int. Cl.**
H01Q 21/28 (2006.01)
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H01Q 13/10 (2006.01)

(52) **U.S. Cl.**
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(58) **Field of Classification Search**
CPC H01Q 13/10; H01Q 13/106; H01Q 21/28

10 Claims, 6 Drawing Sheets





US009077066B1

(12) **United States Patent**
Lee

(10) **Patent No.:** **US 9,077,066 B1**
(45) **Date of Patent:** **Jul. 7, 2015**

(54) **WIDEBAND TAPERED ANTENNA WITH PARASITIC GROUNDING ELEMENT**

(56) **References Cited**

(75) Inventor: **Tzung-I Lee**, San Jose, 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 203 days.

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(21) Appl. No.: **13/419,629**
(22) Filed: **Mar. 14, 2012**

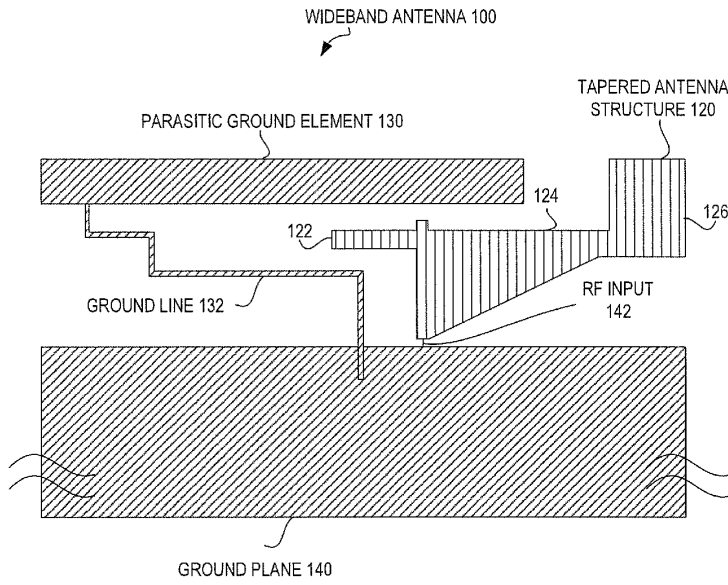
* cited by examiner
Primary Examiner — Robert Karacsony
Assistant Examiner — Daniel J Munoz
(74) *Attorney, Agent, or Firm* — Lowenstein Sandler LLP

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/38 (2006.01)
H01Q 5/00 (2006.01)
H01Q 5/378 (2015.01)
H01Q 19/00 (2006.01)

(57) **ABSTRACT**
Methods and systems for extending a bandwidth of a wideband antenna of a user device are described. A wideband antenna includes a parasitic element coupled to ground and a single radio frequency (RF) input coupled to an antenna structure at a first point. The antenna structure comprises a tapered side that tapers away from the first point to create an increasingly larger gap between the antenna structure and ground. The antenna structure is configured to operate as a feeding structure to the parasitic element, the parasitic element not being conductively connected to the antenna structure.

(52) **U.S. Cl.**
CPC **H01Q 9/0407** (2013.01); **H01Q 19/005** (2013.01); **H01Q 5/378** (2013.01); **H01Q 9/0471** (2013.01)
(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 1/243; H01Q 9/0407; H01Q 19/005; H01Q 9/0471
USPC 343/700 MS, 828, 829, 845
See application file for complete search history.

29 Claims, 10 Drawing Sheets





US009077068B2

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

(10) **Patent No.:** **US 9,077,068 B2**
(45) **Date of Patent:** **Jul. 7, 2015**

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

(75) Inventors: **Kin-Lu Wong**, Kaohsiung (TW);
Tsung-Ju Wu, Kaohsiung (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 296 days.

(21) Appl. No.: **13/599,059**

(22) Filed: **Aug. 30, 2012**

(65) **Prior Publication Data**

US 2013/0342425 A1 Dec. 26, 2013

(30) **Foreign Application Priority Data**

Jun. 22, 2012 (TW) 101122355 A

(51) **Int. Cl.**

H01Q 7/00 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/48 (2006.01)
H01Q 1/52 (2006.01)
H01Q 9/42 (2006.01)
H01Q 21/28 (2006.01)
H01Q 21/30 (2006.01)
H01Q 5/20 (2015.01)

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

CPC **H01Q 1/2266** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/521** (2013.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01); **H01Q 21/30** (2013.01); **H01Q 5/20** (2015.01)

(58) **Field of Classification Search**

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

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Primary Examiner — Hoang V Nguyen

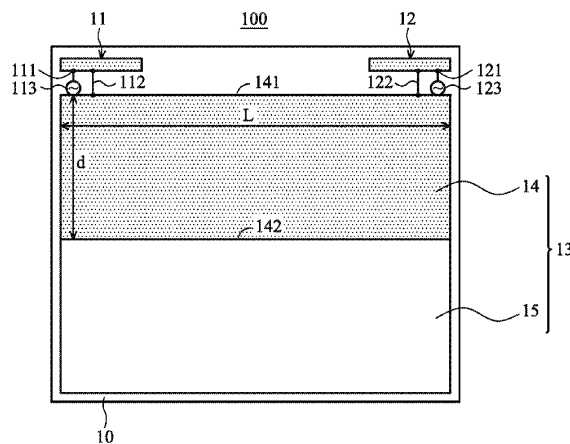
Assistant Examiner — Hai Tran

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

(57) **ABSTRACT**

A communication device including a supporting plate and an antenna system is provided. The supporting plate includes a conductive plate and a non-conductive plate. The conductive plate has a first edge and a second edge. The antenna system includes at least two antennas, which are both disposed at the first edge of the conductive plate and operate in at least a first band. A distance between the first edge and the second edge of the conductive plate is about 0.25 wavelength of the lowest frequency in the first band, and the distance is smaller than a length of the first edge.

12 Claims, 4 Drawing Sheets





US009077069B2

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

(10) **Patent No.:** **US 9,077,069 B2**
(45) **Date of Patent:** **Jul. 7, 2015**

- (54) **METHOD AND APPARATUS FOR TUNABLE ANTENNA AND GROUND PLANE FOR HANDSET APPLICATIONS**
- (71) Applicant: **BlackBerry Limited**, Waterloo (CA)
- (72) Inventors: **Shirook M. Ali**, Milton, CA (US);
Kasra Payandehjoo, Montreal, CA (US)
- (73) Assignee: **BlackBerry Limited**, Waterloo, Ontario (CA)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 263 days.

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Primary Examiner — Hoang V Nguyen

(74) Attorney, Agent, or Firm — Conley Rose, P.C.; J. Robert Brown, Jr.

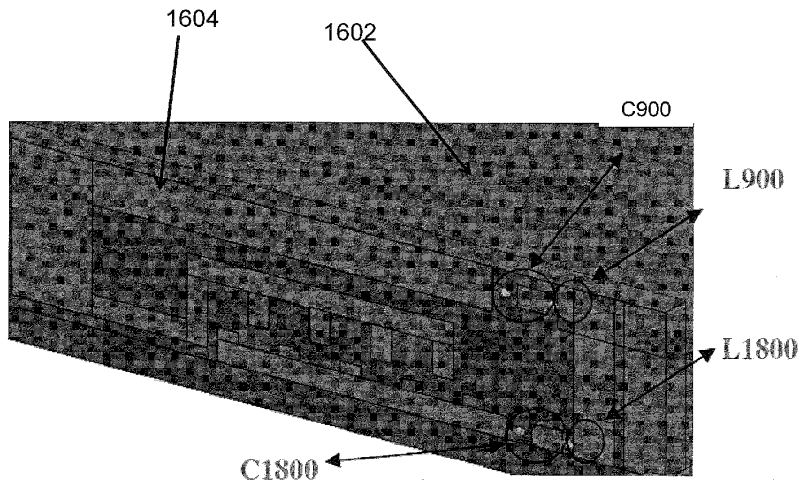
- (21) Appl. No.: **13/647,959**
- (22) Filed: **Oct. 9, 2012**
- (65) **Prior Publication Data**
US 2014/0098000 A1 Apr. 10, 2014
- (51) **Int. Cl.**
H01Q 1/24 (2006.01)
- (52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01)
- (58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/242; H01Q 1/241; H01Q 1/24; H01Q 1/50
USPC 343/702, 872, 848, 767, 861
See application file for complete search history.

(57) **ABSTRACT**

An embodiment is directed to a device comprising an antenna, a chassis configured to be electrically coupled to the antenna and comprising a slot loaded with at least one tunable component, wherein: the slot is aligned along a longitudinal edge of the chassis, the slot is formed in an area of the chassis based on an identification of currents in the area, and the antenna and chassis are electrically connected at a location based on the area.

23 Claims, 18 Drawing Sheets

- (56) **References Cited**
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US009077077B2

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

(10) **Patent No.:** **US 9,077,077 B2**
(45) **Date of Patent:** **Jul. 7, 2015**

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

(75) Inventors: **Kin-Lu Wong**, Kaohsiung (TW);
Ting-Wei Kang, Kaohsiung (TW);
Shih-Wei Hsieh, Taipei (TW); **Wei Yu Chen**, New Taipei (TW)

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(73) Assignees: **MEDIATEK SINGAPORE PTE. LTD.**, Singapore (SG); **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 235 days.

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(22) Filed: **Jul. 13, 2011**

(65) **Prior Publication Data**

Primary Examiner — Hoang V Nguyen

Assistant Examiner — Hai Tran

US 2013/0016013 A1 Jan. 17, 2013

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

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/04 (2006.01)
H01Q 19/00 (2006.01)

(57) **ABSTRACT**

A mobile communication device for operating in LTE and WWAN bands is provided in the invention. The mobile communication device includes a system circuit board and an antenna. The system circuit board includes a system ground plane. The antenna includes: an antenna substrate, substantially parallel to the system ground plane; a first radiation element, disposed on the antenna substrate; a second radiation element, disposed on the antenna substrate; an antenna ground plane, disposed on the antenna substrate, and coupled to the system ground plane; and a transmission line, disposed on the antenna substrate, coupled to the first and second radiation elements, and having a feed point. The mobile communication device is further configured to accommodate a data transmission component.

(52) **U.S. Cl.**
CPC **H01Q 1/38** (2013.01); **H01Q 1/243** (2013.01); **H01Q 9/04** (2013.01); **H01Q 19/005** (2013.01)

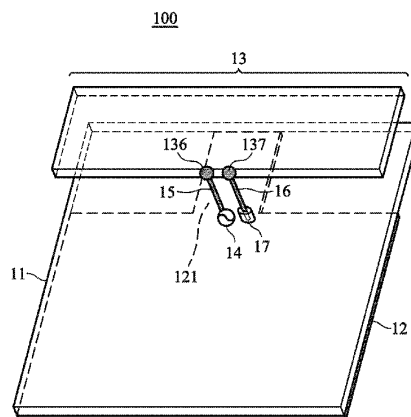
(58) **Field of Classification Search**
USPC 343/700 MS, 702
See application file for complete search history.

(56) **References Cited**

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27 Claims, 15 Drawing Sheets





US009077078B2

(12) **United States Patent**
Rodriguez De Luis et al.

(10) **Patent No.:** **US 9,077,078 B2**
(45) **Date of Patent:** **Jul. 7, 2015**

(54) **RECONFIGURABLE MONOPOLE ANTENNA FOR WIRELESS COMMUNICATIONS**

(71) Applicant: **Microsoft Corporation**, Redmond, WA (US)

(72) Inventors: **Javier Rodriguez De Luis**, Redmond, WA (US); **Alireza Mahanfar**, Bellevue, WA (US); **Benjamin Shewan**, Redmond, WA (US)

(73) Assignee: **Microsoft Technology Licensing, LLC**, Redmond, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 239 days.

(21) Appl. No.: **13/707,439**

(22) Filed: **Dec. 6, 2012**

(65) **Prior Publication Data**

US 2014/015982 A1 Jun. 12, 2014

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/50 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/10 (2015.01)
H01Q 5/35 (2015.01)
H01Q 5/378 (2015.01)

(52) **U.S. Cl.**
CPC . **H01Q 1/50** (2013.01); **H01Q 9/42** (2013.01);
H01Q 5/10 (2015.01); **H01Q 5/35** (2015.01);
H01Q 5/378 (2015.01)

(58) **Field of Classification Search**
CPC H01Q 5/10; H01Q 1/50; H01Q 5/35;
H01Q 9/42; H01Q 5/378
USPC 343/702, 700 MS, 846
See application file for complete search history.

(56) **References Cited**

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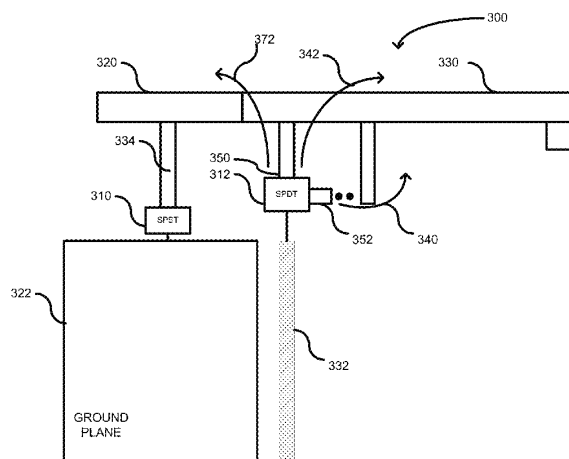
Primary Examiner — Hoanganh Le

(74) *Attorney, Agent, or Firm* — Ladislav Kusnyer; Judy Yee; Micky Minhas

(57) **ABSTRACT**

A reconfigurable monopole antenna is described which includes a radiator element coupled to a feed point through at least two different current paths. The current paths are of different lengths to accommodate different frequency bands. To change the current paths, a feed-point switch is positioned at the antenna feed point for selectively supplying current along either a first current path or a second current path. The current paths share a majority of the radiator element so that separate radiator elements need not be used.

15 Claims, 6 Drawing Sheets





US009077079B2

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

(10) **Patent No.:** **US 9,077,079 B2**
(45) **Date of Patent:** **Jul. 7, 2015**

- (54) **ELECTRONIC DEVICE**
- (71) Applicants: **Yun-Lung Ke**, Taipei (TW); **Wen-Feng Tsai**, Taipei (TW); **Cheng-Chi Chen**, Taipei (TW); **Huang-Wei Chen**, Taipei (TW)
- (72) Inventors: **Yun-Lung Ke**, Taipei (TW); **Wen-Feng Tsai**, Taipei (TW); **Cheng-Chi Chen**, Taipei (TW); **Huang-Wei Chen**, Taipei (TW)
- (73) Assignee: **COMPAL ELECTRONICS, INC.**, Taipei (TW)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 165 days.
- (21) Appl. No.: **13/633,141**
- (22) Filed: **Oct. 2, 2012**
- (65) **Prior Publication Data**
US 2014/0062797 A1 Mar. 6, 2014
- (30) **Foreign Application Priority Data**
Aug. 28, 2012 (TW) 101131227 A
- (51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)

- H01Q 1/52** (2006.01)
- H01Q 1/22** (2006.01)
- H01Q 21/28** (2006.01)
- (52) **U.S. Cl.**
CPC **H01Q 1/521** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 21/28** (2013.01)
- (58) **Field of Classification Search**
USPC 343/702, 700 MS
See application file for complete search history.
- (56) **References Cited**

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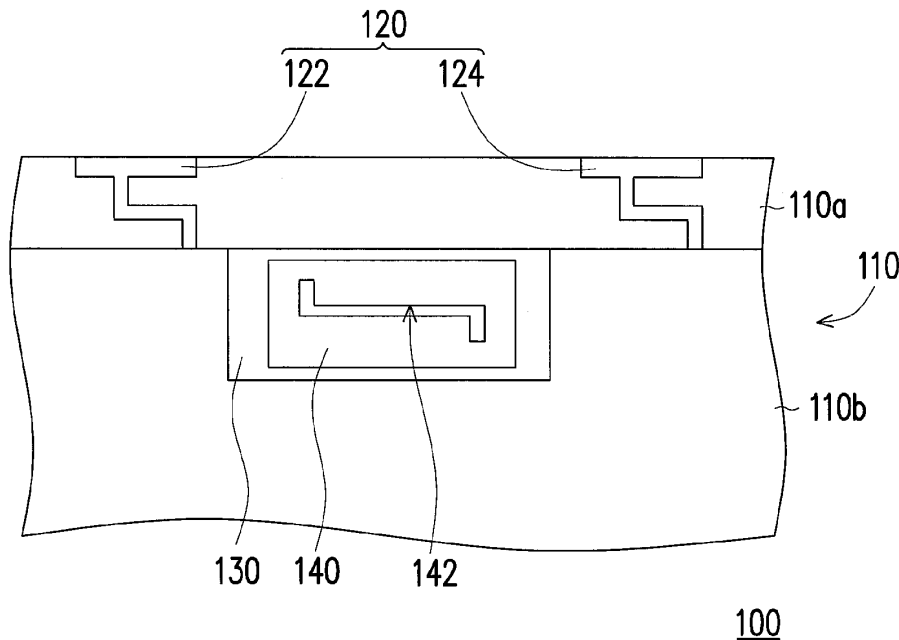
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Primary Examiner — Graham Smith
(74) *Attorney, Agent, or Firm* — Jianq Chyun IP Office

(57) **ABSTRACT**

An electronic device including a shell, an antenna unit, an insulating layer and an isolating conductor is provided. The material of the shell includes conductive material. The antenna unit is disposed on the shell and includes a first antenna and a second antenna. The first antenna and the second antenna are grounded to the shell. The insulating layer is disposed on the shell and located between a ground plane of the first antenna and a ground plane of the second antenna. The isolating conductor is disposed on the insulating layer and has a slot.

7 Claims, 1 Drawing Sheet



100



US009077081B2

(12) **United States Patent**
Wakabayashi

(10) **Patent No.:** **US 9,077,081 B2**
(45) **Date of Patent:** **Jul. 7, 2015**

(54) **MULTI-ANTENNA DEVICE AND COMMUNICATION APPARATUS**

(71) Applicant: **Funai Electric Co., Ltd.**, Daito, Osaka (JP)
(72) Inventor: **Naoyuki Wakabayashi**, Osaka (JP)
(73) Assignee: **FUNAI ELECTRIC CO., LTD.**, Osaka (JP)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 172 days.

(21) Appl. No.: **13/685,091**
(22) Filed: **Nov. 26, 2012**

(65) **Prior Publication Data**
US 2013/0162496 A1 Jun. 27, 2013

(30) **Foreign Application Priority Data**
Dec. 26, 2011 (JP) 2011-282843

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 21/00 (2006.01)
H01Q 9/30 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 21/00** (2013.01); **H01Q 21/0006** (2013.01); **H01Q 1/38** (2013.01); **H01Q 9/30** (2013.01)

(58) **Field of Classification Search**
USPC 343/700 MS, 702, 850, 853
See application file for complete search history.

(56) **References Cited**

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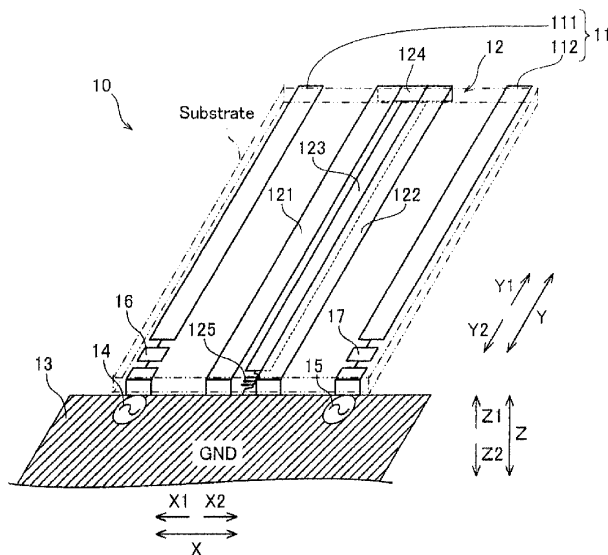
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Primary Examiner — Dieu H Duong
(74) *Attorney, Agent, or Firm* — Global IP Counselors, LLP

(57) **ABSTRACT**

A multi-antenna device includes a feeding element and a passive element. The feeding element has first and second antenna elements. The passive element is disposed between the first and second antenna elements. The passive element has a first portion that is grounded at one end, a second portion that is grounded at one end and a third portion that is grounded at one end via a serially connected member with inductance. The third portion is connected at the other end to the other ends of the first and second portions.

10 Claims, 11 Drawing Sheets





US009077084B2

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

(10) **Patent No.:** **US 9,077,084 B2**
(45) **Date of Patent:** **Jul. 7, 2015**

(54) **MULTI-BAND MULTI-ANTENNA SYSTEM AND COMMUNICATION DEVICE THEREOF**

(75) Inventors: **Wei-Yu Li**, Yilan County (TW); **Wei-Ji Chen**, Tainan (TW); **Chun-Yih Wu**, Taipei (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 238 days.

(21) Appl. No.: **13/528,853**

(22) Filed: **Jun. 21, 2012**

(65) **Prior Publication Data**
US 2013/0257674 A1 Oct. 3, 2013

(30) **Foreign Application Priority Data**
Apr. 3, 2012 (TW) 10111861 A

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

(52) **U.S. Cl.**
CPC **H01Q 21/28** (2013.01); **H01Q 9/42** (2013.01); **H01Q 5/321** (2015.01); **H01Q 5/378** (2015.01); **H01Q 5/40** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 3/26; H01Q 3/2617; H01Q 9/0407; H01Q 5/321; H01Q 5/378; H01Q 5/40; H01Q 9/42; H01Q 21/28
USPC 343/700 MS, 846, 853
See application file for complete search history.

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Primary Examiner — Robert Karacsony

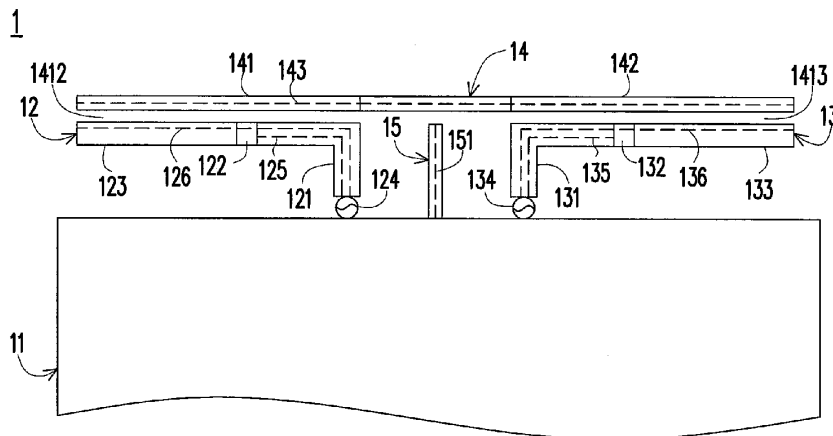
Assistant Examiner — Daniel J Munoz

(74) *Attorney, Agent, or Firm* — Jianq Chyun IP Office

(57) **ABSTRACT**

A multi-band multi-antenna system and a communication device thereof are provided. The multi-band multi-antenna system includes at least one ground, two antenna units, a coupling conductor line and a grounding conductor line. Both of the two antenna units have at least one conductor portion, a low-pass filtering portion and an extending conductor portion. Each antenna unit generates at least one higher and lower operating bands. The low-pass filtering portion is electrically coupled between the conductor portion and the extending conductor portion, and effectively decreases dependent relationship between the higher and lower operating bands. The coupling conductor line is disposed nearby the two antenna units and has a first coupling portion and a second coupling portion. The grounding conductor line is disposed between the two antenna units and connected to the ground.

21 Claims, 11 Drawing Sheets





US009077085B2

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

(10) **Patent No.:** **US 9,077,085 B2**
(45) **Date of Patent:** **Jul. 7, 2015**

(54) **COMMUNICATION DEVICE AND ANTENNA SYSTEM WITH HIGH ISOLATION**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

(72) Inventors: **Kin-Lu Wong**, Taipei Hsien (TW);
Wun-Jian Lin, Taipei Hsien (TW)

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(73) Assignee: **ACER INCORPORATED**, Hsichih, Taipei Hsien (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 271 days.

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(21) Appl. No.: **13/777,587**

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

(Continued)

(65) **Prior Publication Data**
US 2014/0078018 A1 Mar. 20, 2014

Primary Examiner — Tho G Phan
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

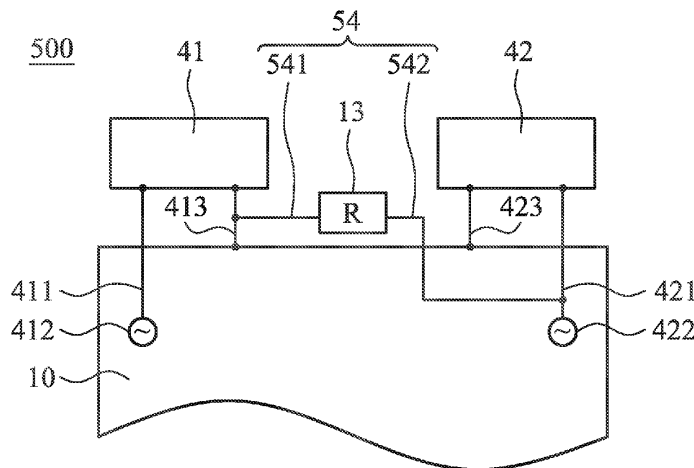
(30) **Foreign Application Priority Data**
Sep. 14, 2012 (TW) 101133609 A

(57) **ABSTRACT**

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 21/28 (2006.01)
H01Q 1/52 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 21/28** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/523** (2013.01)
(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/523
USPC 343/700 MS, 702, 725
See application file for complete search history.

A communication device including a ground element and an antenna system is provided. The antenna system is adjacent to the ground element. The antenna system includes at least a first antenna, a second antenna, a connection element, and a resistive element. The second antenna is adjacent to the first antenna. The connection element includes a first portion and a second portion, wherein the first portion is coupled to the first antenna, and the second portion is coupled to the second antenna. The resistive element is coupled between the first portion and the second portion of the connection element. The connection element and the resistive element increase the isolation between the first antenna and the second antenna.

7 Claims, 5 Drawing Sheets





US009077087B2

(12) **United States Patent**
Rowell

(10) **Patent No.:** **US 9,077,087 B2**
(45) **Date of Patent:** **Jul. 7, 2015**

(54) **ANTENNAS USING OVER-COUPLING FOR WIDE-BAND OPERATION**

(71) Applicant: **Hong Kong Applied Science and Technology Research Institute Co., Ltd.**, Shatin, New Territories (CN)

(72) Inventor: **Corbett Ray Rowell**, TaiPo (CN)

(73) Assignee: **Hong Kong Science and Technology Research Institute Co., Ltd.**, Shatin (HK)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 282 days.

(21) Appl. No.: **13/774,621**

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

(65) **Prior Publication Data**
US 2014/0240189 A1 Aug. 28, 2014

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 21/30 (2006.01)
H01Q 5/40 (2015.01)

(52) **U.S. Cl.**
CPC . **H01Q 21/30** (2013.01); **H01Q 5/40** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 21/30; H01Q 5/0072
USPC 343/700 MS, 702
See application file for complete search history.

(56) **References Cited**
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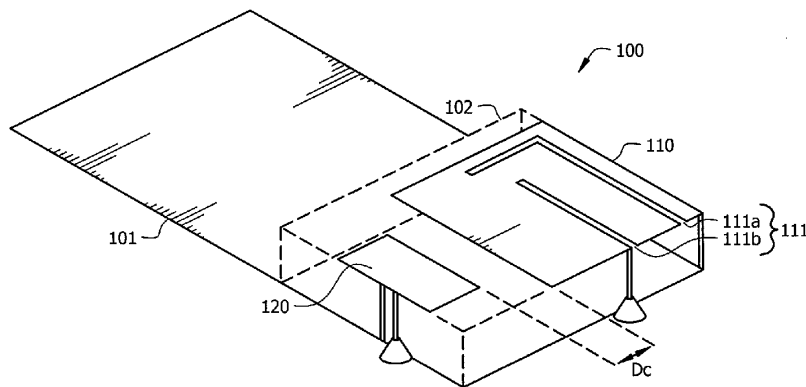
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Primary Examiner — Tho G Phan
(74) *Attorney, Agent, or Firm* — Norton Rose Fulbright US LLP

(57) **ABSTRACT**

Systems and methods in which antenna system configurations use over-coupling between a plurality of antenna elements for effectively providing wide-band operation are shown. Such over-coupling comprises a multiple antenna element configuration in which adaptation to one antenna element (e.g., an influencing antenna element) results in substantial operational frequency band adaptation to a second antenna element (e.g., a respondent antenna element). Over-coupling results in a frequency split at the second antenna, whereby the resonate frequency of the antenna element is split into a plurality of frequency bands. By implementing such frequency splitting with respect to otherwise narrow band antenna elements, the over-coupled antenna system may be made to effectively provide wide-band operation.

37 Claims, 4 Drawing Sheets





US009083080B2

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

(10) **Patent No.:** **US 9,083,080 B2**
(45) **Date of Patent:** **Jul. 14, 2015**

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

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/50; H01Q 9/42
USPC 343/700 MS, 702, 725, 729, 853, 876
See application file for complete search history.

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

(72) Inventors: **Chung-Hung Chen**, Hsinchu (TW);
Yi-Hung Chiu, Hsinchu (TW);
Chia-Hao Chang, Hsinchu (TW);
Chih-Sen Hsieh, Hsinchu (TW)

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(57) **ABSTRACT**

An antenna structure is provided, including a first radiator, a second radiator, a second coupling portion and a switch Circuit. The first radiator includes a feed portion and a first radiator body. The second radiator includes a first coupling portion, a second radiator body and a ground portion. The first coupling portion is connected to a first end portion of the second radiator body. The ground portion is connected to the second radiator body. At least a portion of the first radiator body is located between the first coupling portion and the second coupling portion. When the antenna structure is in a first mode, the switch circuit forms an electric path between the second radiator and the second coupling portion, and when the antenna structure is in a second mode, the switch circuit removes the electric path between the second radiator and the second coupling portion.

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