



US009118104B2

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

(10) **Patent No.:** **US 9,118,104 B2**
(45) **Date of Patent:** **Aug. 25, 2015**

(54) **OVERSIZED ANTENNA FLEX**
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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 0 days.

(21) Appl. No.: **13/768,177**
(22) Filed: **Feb. 15, 2013**

(65) **Prior Publication Data**
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Related U.S. Application Data

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(51) **Int. Cl.**
H01P 11/00 (2006.01)
H01Q 1/00 (2006.01)
H01Q 1/12 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)
H01Q 15/00 (2006.01)

(52) **U.S. Cl.**
CPC . **H01Q 1/00** (2013.01); **H01Q 1/12** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 15/00** (2013.01); **Y10T 29/49002** (2015.01); **Y10T 29/49004** (2015.01); **Y10T 29/49016** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 15/00; H01Q 1/00
USPC 29/600, 601, 592.1, 593, 564.2-564.5; 343/700 MS
See application file for complete search history.

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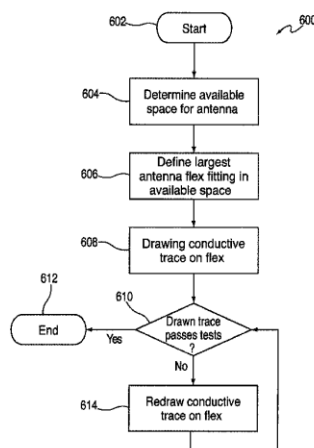
Primary Examiner — Minh Trinh

(74) *Attorney, Agent, or Firm* — Joseph F. Guihan

(57) **ABSTRACT**

This is directed to an antenna for use in an electronic device. The antenna can be constructed from a flex and printed trace, such that the flex is originally defined to be as large or nearly as large as possible to fit within portion of the electronic device dedicated to the antenna. This can allow the antenna trace to vary as the antenna is tuned without requiring a new flex having a different shape. In addition, this can allow the antenna design to be decoupled from the mechanical considerations related to mounting the antenna within the electronic device.

9 Claims, 4 Drawing Sheets





US009118109B2

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

(10) **Patent No.:** **US 9,118,109 B2**
(45) **Date of Patent:** **Aug. 25, 2015**

(54) **MULTIBAND ANTENNA WITH GROUNDED ELEMENT**

(75) Inventors: **Sung-Hoon Oh**, Cupertino, CA (US);
Thomas Liu, Sunnyvale, CA (US);
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(73) Assignee: **QUALCOMM INCORPORATED**, San Diego, CA (US)

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(21) Appl. No.: **12/971,444**

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(65) **Prior Publication Data**

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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)

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

(56) **References Cited**

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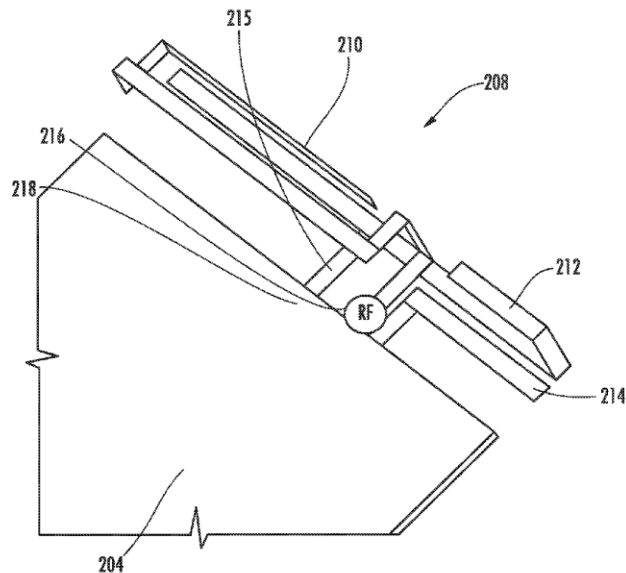
Primary Examiner — Graham Smith

(74) *Attorney, Agent, or Firm* — Kilpatrick Townsend & Stockton LLP

(57) **ABSTRACT**

Various embodiments of an antenna structure for mobile devices are described. In one or more embodiments a multi-band antenna includes a grounded parasitic element. In some embodiments, a high band arm is provided, and is fed off-center, so that the resonating arms are not symmetrical in length. In some embodiments, a coupled ground resonator is included to add a differential resonating mode. A ground leg may be included to offer facilitate impedance and inductance matching. The combination of these structures creates four distinct resonance modes for the high band, which creates a wide effective bandwidth for the disclosed antenna. Other embodiments are described and claimed.

22 Claims, 11 Drawing Sheets





US009118110B2

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

(10) **Patent No.:** **US 9,118,110 B2**
(45) **Date of Patent:** **Aug. 25, 2015**

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

(75) Inventors: **Kin-Lu Wong**, Kaohsiung (TW);
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(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 249 days.

(21) Appl. No.: **13/599,092**

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

(65) **Prior Publication Data**
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Jun. 22, 2012 (TW) 101122356 A

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
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H01Q 1/48 (2006.01)

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

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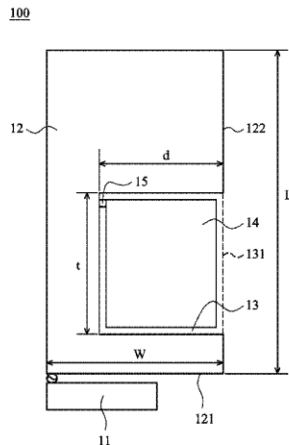
Primary Examiner — Hoang V Nguyen
Assistant Examiner — Hai Tran

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

(57) **ABSTRACT**

A communication device including an antenna element, a ground element and a battery element is provided. The ground element has a short edge as a first edge and a long edge as a second edge. The antenna element is close to the first edge or at a dented section of the first edge. There is a notch in the ground element, and an open edge of the notch is at the second edge. The length of the notch is at least 0.3 times the maximum length of the ground element, and the width of the notch is at least 0.4 times the maximum width of the ground element.

11 Claims, 6 Drawing Sheets





US009118117B2

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

(10) **Patent No.:** **US 9,118,117 B2**
(45) **Date of Patent:** **Aug. 25, 2015**

(54) **RECEIVING AND TRANSMITTING DEVICE FOR WIRELESS TRANSCEIVER**

(71) Applicant: **SOUTHERN TAIWAN UNIVERSITY OF SCIENCE AND TECHNOLOGY**, Tainan (TW)

(72) Inventors: **Wen-Shan Chen**, Tainan (TW); **Yuan-Chih Lin**, Tainan (TW); **Ke-Ming Lin**, Tainan (TW)

(73) Assignee: **Southern Taiwan University of Science and Technology**, Tainan (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 186 days.

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(65) **Prior Publication Data**
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H01Q 1/52 (2006.01)
H01Q 21/28 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/525** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/525; H01Q 21/28
USPC 343/702, 833, 834, 841
See application file for complete search history.

(56) **References Cited**

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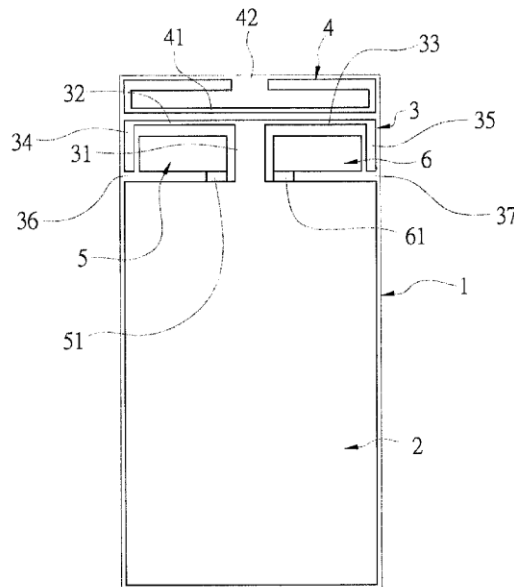
Primary Examiner — Michael C Wimer

(74) *Attorney, Agent, or Firm* — Rosenberg, Klein & Lee

(57) **ABSTRACT**

A receiving and transmitting device for wireless transceivers is revealed. The device has been developed from a high isolation MIMO (multiple-input multiple-output) antenna used for 2.45 GHz WLAN operation. The antenna is a dual-fed coupled monopole MIMO antenna that includes a dielectric substrate and a MIMO antenna. A grounding portion with two signal ends for feeding signals is disposed on the dielectric substrate. A T-shaped metal plate is extended from the grounding portion and located between two signal ends. A C-shaped parasitic element is arranged at the metal plate and there is a certain distance therebetween so as to adjust the isolation. The antenna is symmetrical for improving isolation and is suitable for USB dongles or small-sized wireless mobile devices.

8 Claims, 14 Drawing Sheets





US009119223B2

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

(10) **Patent No.:** **US 9,119,223 B2**
(45) **Date of Patent:** **Aug. 25, 2015**

- (54) **TWO ANTENNAS IN CLOSE PROXIMITY WITH SIGNAL ISOLATION**
- (71) Applicant: **Futurewei Technologies, Inc.**, Plano, TX (US)
- (72) Inventors: **Chulmin Han**, San Diego, CA (US); **Xiaomeng Su**, 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 312 days.

- (21) Appl. No.: **13/706,486**
- (22) Filed: **Dec. 6, 2012**

- (65) **Prior Publication Data**
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- (51) **Int. Cl.**
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H04W 88/06 (2009.01)
H01Q 1/48 (2006.01)
H01Q 1/52 (2006.01)
H01Q 9/42 (2006.01)
- (52) **U.S. Cl.**
CPC **H04W 88/06** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/521** (2013.01); **H01Q 9/42** (2013.01)
- (58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/48; H01Q 1/521; H01Q 9/42
USPC 343/702, 700 MS, 848
See application file for complete search history.

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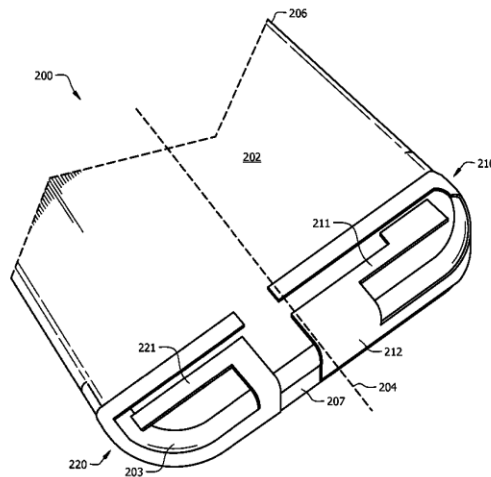
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Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.; Grant Rodolph; William H. Dietrich

- (57) **ABSTRACT**
Included is a mobile node (MN) comprising a first antenna configured to communicate with a wireless network, a second antenna configured to communicate with a wireless network, a first data line coupled to the first antenna, a second data line coupled to the second antenna, and a common ground trace coupled to the first data line and the second data line, wherein the first antenna and the second antenna are not directly connected to the common ground.

25 Claims, 9 Drawing Sheets





US009122446B2

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

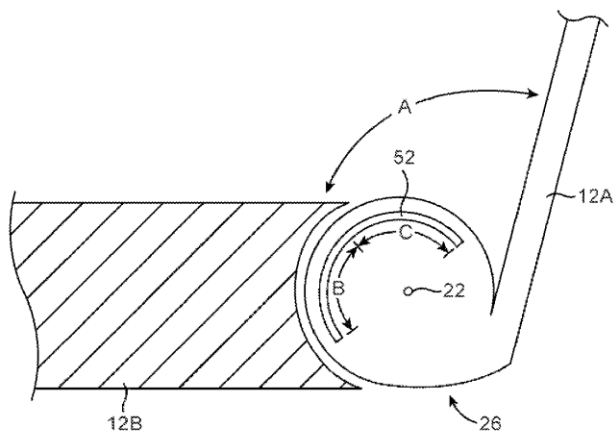
(10) **Patent No.:** **US 9,122,446 B2**
(45) **Date of Patent:** **Sep. 1, 2015**

- (54) **ANTENNA STRUCTURES IN ELECTRONIC DEVICES WITH HINGED ENCLOSURES**
- (75) Inventors: **James W. Jervis**, Santa Clara, CA (US); **Jayesh Nath**, Milpitas, CA (US); **Erdinc Irci**, Sunnyvale, CA (US); **Jerzy Guterman**, Mountain View, CA (US); **Mattia Pascolini**, Campbell, CA (US); **Robert W. Schlub**, Cupertino, CA (US)
- (73) Assignee: **Apple Inc.**, Cupertino, CA (US)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 50 days.
- (21) Appl. No.: **13/484,040**
- (22) Filed: **May 30, 2012**
- (65) **Prior Publication Data**
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- (51) **Int. Cl.**
G06F 1/16 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/42 (2006.01)
H04M 1/02 (2006.01)
- (52) **U.S. Cl.**
CPC **G06F 1/1616** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 1/2291** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/42** (2013.01); **H04M 1/0216** (2013.01)
- (58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/2266; H01Q 1/42; H01Q 1/38; G06F 1/1616; H04M 1/0216
USPC 343/702; 455/575.1-575.7
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* — Treyz Law Group; Joseph F. Guihan

(57) **ABSTRACT**
Electronic devices may include radio-frequency transceiver circuitry and antenna structures. The antenna structures may include antenna resonating elements, parasitic antenna resonating elements, and antenna ground structures. The antenna structures may include metal traces that are wrapped around an elongated plastic carrier. The plastic carrier may have metal traces that are coupled to a metal bracket using solder that protrudes through a hole in the metal bracket. A printed circuit board may be mounted between the metal bracket and a metal housing. The metal housing may have a protruding ridge portion that is gripped between prongs on the metal bracket. A cover may cover the metal traces on the elongated plastic carrier. The antenna structures may be mounted between hinge structures that couple upper and lower housing structures. The antenna structures may be configured to operate with comparable performance when the upper and lower housing structures are open and closed.

23 Claims, 13 Drawing Sheets





US009123986B2

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

(10) **Patent No.:** **US 9,123,986 B2**
(45) **Date of Patent:** **Sep. 1, 2015**

(54) **ANTENNA SYSTEM FOR INTERFERENCE SUPPRESSION**

(71) Applicant: **Ethertronics, Inc.**, San Diego, CA (US)

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

(73) Assignee: **ETHERTRONICS, INC.**, San Diego, CA (US)

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

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(22) Filed: **Feb. 9, 2015**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
H01Q 9/00 (2006.01)
H01Q 3/00 (2006.01)
H01Q 19/00 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 3/00** (2013.01); **H01Q 19/005** (2013.01)

(58) **Field of Classification Search**

USPC 343/700 MS, 745, 815, 834
See application file for complete search history.

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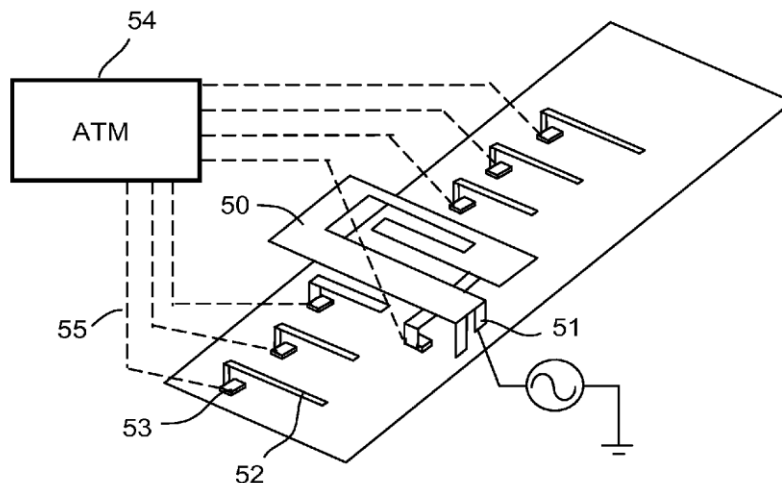
Primary Examiner — Tho G Phan

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

(57) **ABSTRACT**

An antenna system is capable of optimizing communication link quality with one or multiple transceivers while suppressing one or multiple interference sources. The antenna provides a low cost, physically small multi-element antenna system capable of being integrated into mobile devices and designed to form nulls in the radiation pattern to reduce interference from unwanted interferers. The antenna system operates in both line of sight and high multi-path environments by adjusting the radiation pattern and sampling the received signal strength to reduce signal levels from interferers while monitoring and optimizing receive signal strength from desired sources.

14 Claims, 14 Drawing Sheets





US009123989B2

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

(10) **Patent No.:** **US 9,123,989 B2**
(45) **Date of Patent:** **Sep. 1, 2015**

(54) **ANTENNA APPARATUS AND ANTENNA SWITCH CIRCUIT**

(75) Inventors: **Chih-Hsiang Peng**, Hsinchu (TW);
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(73) Assignee: **WISTRON NEWEB CORP.**, Hsinchu (TW)

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H01Q 1/22 (2006.01)

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(58) **Field of Classification Search**
CPC H01Q 1/2258; H01Q 3/24
USPC 455/73, 78, 562.1, 81; 342/175; 343/702, 876
See application file for complete search history.

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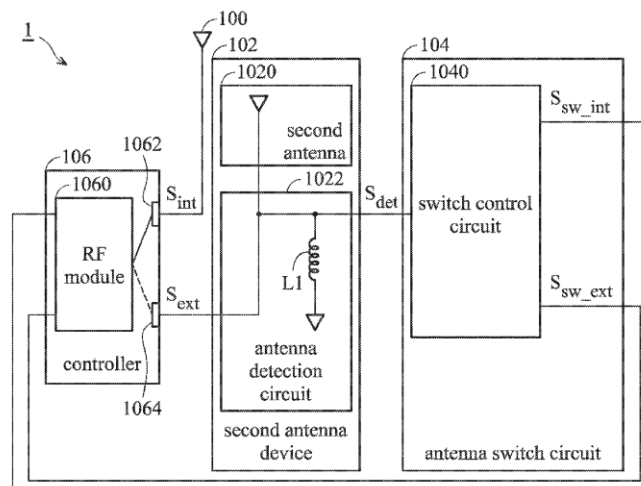
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Primary Examiner — Wesley Kim
Assistant Examiner — Raj Chakraborty
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

An antenna device and an antenna switch circuit are provided. The antenna device comprises a first antenna, an antenna detection circuit, a switch control circuit, and a controller. The first antenna is configured to transmit an RF signal. The antenna detection circuit comprises an inductor configured to detect a second antenna. The switch control circuit is coupled to the antenna detection circuit and configured to generate a first control signal indicative of the presence of the second antenna upon the detection thereof. The controller is coupled to the first antenna, the antenna detection circuit and the switch control circuit, and configured to receive the first control signal and connect to the second antenna when the first control signal indicates the presence of the second antenna.

8 Claims, 2 Drawing Sheets





US009123990B2

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

(10) **Patent No.:** **US 9,123,990 B2**
(45) **Date of Patent:** **Sep. 1, 2015**

(54) **MULTI-FEED ANTENNA APPARATUS AND METHODS**

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(75) Inventors: **Prasadh Ramachandran**, Oulu (FI);
Ari Raappana, Kello (FI); **Petteri Annamaa**, Oulunsalo (FI)

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(73) Assignee: **Pulse Finland OY**, Kempele (FI)

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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 24 days.

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(21) Appl. No.: **13/269,490**

(22) Filed: **Oct. 7, 2011**

(65) **Prior Publication Data**

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Primary Examiner — Hoang V Nguyen

Assistant Examiner — Patrick Holecsek

(74) *Attorney, Agent, or Firm* — Gazdzinski & Associates PC

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 7/00 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/40 (2015.01)

(57) **ABSTRACT**

A space efficient multi-feed antenna apparatus, and methods for use in a radio frequency communications device. In one embodiment, the antenna assembly comprises three (3) separate radiator structures disposed on a common antenna carrier. Each of the three antenna radiators is connected to separate feed ports of a radio frequency front end. In one variant, the first and the third radiators comprise quarter-wavelength planar inverted-L antennas (PILA), while the second radiator comprises a half-wavelength grounded loop-type antenna disposed in between the first and the third radiators. The PILA radiators are characterized by radiation patterns having maximum radiation axes that are substantially perpendicular to the antenna plane. The loop radiator is characterized by radiation pattern having axis of maximum radiation that is parallel to the antenna plane. The above configuration of radiating patterns advantageously isolates the first radiator structure from the third radiator structure in at least one frequency band.

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/40** (2015.01); **H01Q 7/00** (2013.01); **H01Q 9/42** (2013.01)

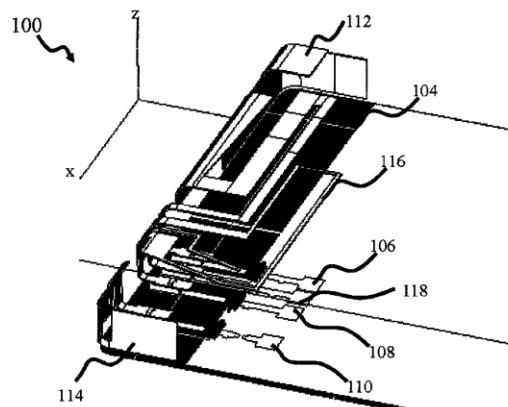
(58) **Field of Classification Search**
CPC H01Q 7/00; H01Q 1/243; H01Q 1/38; H01Q 21/28; H01Q 9/42; H01Q 5/0062; H01Q 13/10; H01Q 5/0058; H01Q 9/26; H01Q 5/00; H01Q 1/52
USPC 343/853, 858, 855, 700 MS, 702; 333/100, 124, 129
See application file for complete search history.

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16 Claims, 8 Drawing Sheets





US009123994B2

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

(10) **Patent No.:** **US 9,123,994 B2**
(45) **Date of Patent:** **Sep. 1, 2015**

(54) **ANTENNA STRUCTURE**
(75) Inventors: **Young-ju Lee**, Seoul (KR); **Byung-chul Kim**, Hwaseong-si (KR); **Jung-min Park**, Seoul (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 543 days.

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 1/243; H01Q 9/0414
USPC 343/702, 700 MS
See application file for complete search history.

(21) Appl. No.: **13/482,453**
(22) Filed: **May 29, 2012**
(65) **Prior Publication Data**
US 2012/0299783 A1 Nov. 29, 2012

(56) **References Cited**
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Related U.S. Application Data
(60) Provisional application No. 61/490,715, filed on May 27, 2011.

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(30) **Foreign Application Priority Data**
Oct. 31, 2011 (KR) 10-2011-0112501

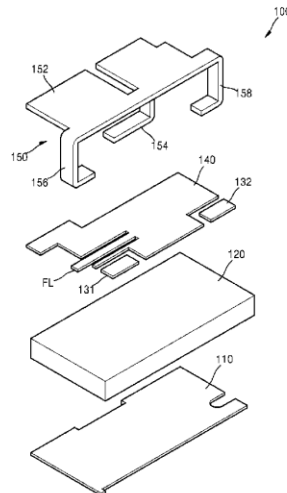
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(51) **Int. Cl.**
H01Q 1/36 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/52 (2006.01)
H01Q 9/04 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 1/36** (2013.01); **H01Q 1/2291** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/52** (2013.01); **H01Q 9/0414** (2013.01)

Primary Examiner — Dameon E Levi
Assistant Examiner — Hasan Islam
(74) *Attorney, Agent, or Firm* — Sughrue Mion, PLLC

(57) **ABSTRACT**
An antenna structure includes: a substrate; a ground layer disposed on a first surface of the substrate; a patch antenna unit which is disposed on a second surface of the substrate opposite to the first surface of the substrate, and is configured to receive a signal to be radiated; and a three-dimensional (3D) antenna unit which comprises a shorting leg that is shorted with the patch antenna unit, and is configured to radiate the signal received by the patch antenna unit.

21 Claims, 7 Drawing Sheets





US009124001B2

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

(10) **Patent No.:** **US 9,124,001 B2**
(45) **Date of Patent:** **Sep. 1, 2015**

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

- (71) Applicant: **Acer Incorporated**, New Taipei (TW)
- (72) Inventors: **Kin-Lu Wong**, New Taipei (TW);
Hsuan-Jui 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 183 days.

(21) Appl. No.: **13/963,375**

(22) Filed: **Aug. 9, 2013**

(65) **Prior Publication Data**
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(30) **Foreign Application Priority Data**
May 15, 2013 (TW) 102117169 A

- (51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/50 (2006.01)
H01Q 5/371 (2015.01)
- (52) **U.S. Cl.**
CPC **H01Q 1/50** (2013.01); **H01Q 5/371** (2015.01)
- (58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/50; H01Q 1/50
USPC 343/702, 700 MS, 860, 866
See application file for complete search history.

(56) **References Cited**

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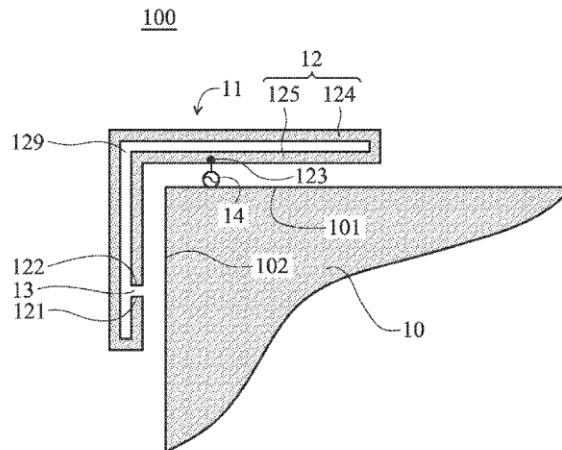
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Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

A communication device including a ground element and an antenna element is provided. The antenna element includes a metal element. The metal element has a plurality of bends and substantially forms a loop structure with a gap. The gap is between a first open end and a second open end of the metal element. The metal element extends along an edge of the ground element and does not overlap with the ground element. The antenna element has a feeding point. A first portion of the metal element is between the feeding point and the first open end, and a second portion of the metal element is between the feeding point and the second open end. The feeding point, the first open end, and the second open end are all facing or adjacent to the edge of the ground element.

8 Claims, 5 Drawing Sheets





US009124002B2

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

(10) **Patent No.:** **US 9,124,002 B2**
(45) **Date of Patent:** **Sep. 1, 2015**

- (54) **COMMUNICATION DEVICE**
- (71) Applicant: **Acer Incorporated**, New Taipei (TW)
- (72) Inventors: **Kin-Lu Wong**, Kaohsiung (TW);
Tseng-Wei Weng, Kaohsiung (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 134 days.

- (21) Appl. No.: **13/743,322**
- (22) Filed: **Jan. 16, 2013**
- (65) **Prior Publication Data**
US 2014/0139392 A1 May 22, 2014

- (30) **Foreign Application Priority Data**
Nov. 16, 2012 (TW) 101142877 A

- (51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/52 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/38 (2006.01)

- (52) **U.S. Cl.**
CPC **H01Q 1/523** (2013.01); **H01Q 1/521** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 1/2291** (2013.01); **H01Q 1/38** (2013.01)

- (58) **Field of Classification Search**
CPC H01Q 1/521; H01Q 1/243; H01Q 1/2266
USPC 343/841, 702, 893
See application file for complete search history.

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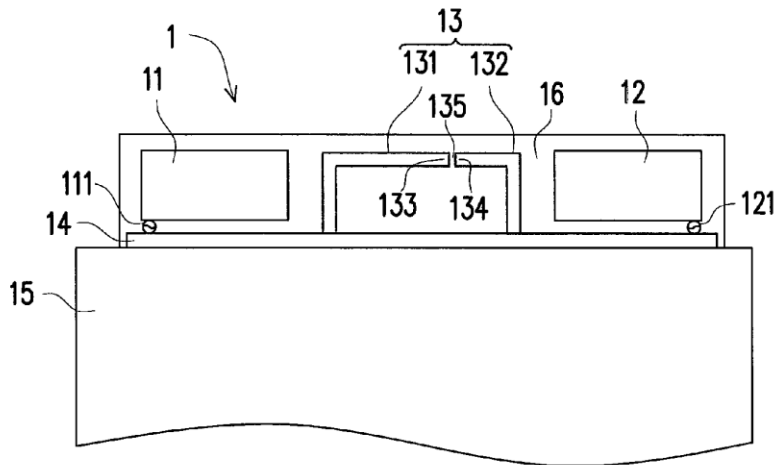
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Primary Examiner — Dieu H Duong
(74) *Attorney, Agent, or Firm* — Jianq Chyun IP Office

(57) **ABSTRACT**

A communication device including a first antenna, a second antenna, a ground element, and an isolation element is provided. The ground element is coupled to a conductive plane. The isolation element is disposed between the first antenna and the second antenna and includes a first portion and a second portion. A first end of the first portion and a first end of the second portion are respectively coupled to the ground element, and a second end of the first portion is spaced apart a coupling distance from a second end of the second portion.

12 Claims, 5 Drawing Sheets





US009124003B2

(12) **United States Patent**
Jenwatanavet

(10) **Patent No.:** **US 9,124,003 B2**
(45) **Date of Patent:** **Sep. 1, 2015**

- (54) **MULTIPLE ANTENNA SYSTEM**
- (71) Applicant: **QUALCOMM Incorporated**, San Diego, CA (US)
- (72) Inventor: **Jatupum Jenwatanavet**, San Diego, CA (US)
- (73) Assignee: **QUALCOMM Incorporated**, San Diego, CA (US)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 142 days.

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Primary Examiner — Tho G Phan

(74) *Attorney, Agent, or Firm* — The Marbury Law Group, PLLC

- (21) Appl. No.: **13/773,626**
- (22) Filed: **Feb. 21, 2013**

(65) **Prior Publication Data**
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- (51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/52 (2006.01)
H01Q 9/04 (2006.01)
H01Q 9/42 (2006.01)

- (52) **U.S. Cl.**
CPC *H01Q 1/525* (2013.01); *H01Q 1/521* (2013.01); *H01Q 9/0421* (2013.01); *H01Q 9/42* (2013.01)

- (58) **Field of Classification Search**
CPC H01Q 1/521; H01Q 1/525; H01Q 9/42
USPC 343/700 MS, 702, 825, 829, 846
See application file for complete search history.

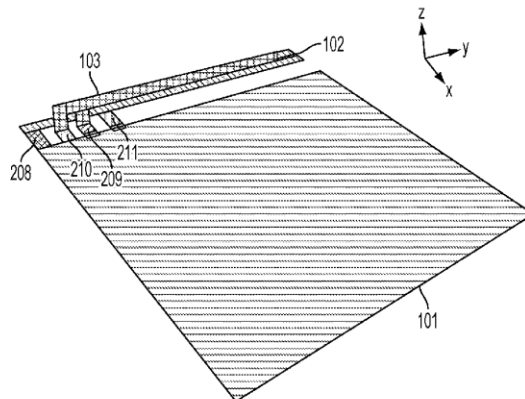
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(57) **ABSTRACT**

A multiple antenna module suitable for use in small sized mobile computing devices includes at least a first antenna extending beyond a lateral edge of and coplanar with a printed circuit board assembly and connected to the printed circuit board assembly via a first antenna ground contact and a first antenna feed contact. The multiple antenna module also includes a second antenna located proximate to the first antenna and configured in a plane perpendicular to the plane continuing the first antenna and the printed circuit board. The second antenna is connected to the printed circuit board assembly via a second antenna ground contact and a second antenna feed contact in which the second antenna ground contact and second antenna feed contact are connect to the printed circuit between the first antenna ground contact and the first antenna feed contact.

20 Claims, 17 Drawing Sheets





US009124007B2

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

(10) **Patent No.:** **US 9,124,007 B2**
(45) **Date of Patent:** **Sep. 1, 2015**

(54) **ANTENNA APPARATUS AND RADIO
TERMINAL APPARATUS**

(75) Inventors: **Takashi Yamagajo**, Kawasaki (JP);
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Shinsuke Shimahashi, Kawasaki (JP);
Kouji Soekawa, Kawasaki (JP)

(73) Assignee: **FUJITSU LIMITED**, Kawasaki (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1046 days.

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(22) Filed: **Dec. 7, 2010**

(65) **Prior Publication Data**

US 2011/0140973 A1 Jun. 16, 2011

(30) **Foreign Application Priority Data**

Dec. 11, 2009 (JP) 2009-281390

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 21/28 (2006.01)
H01Q 1/36 (2006.01)
H01Q 1/08 (2006.01)
H01Q 1/22 (2006.01)

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

CPC **H01Q 21/28** (2013.01); **H01Q 1/084**
(2013.01); **H01Q 1/2275** (2013.01); **H01Q 1/36**
(2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/04; H01Q 1/24; H01Q 1/243;
H01Q 1/36; H01Q 1/2275; H01Q 1/084;
H01Q 21/08

USPC 343/702, 841, 846, 895; 455/575.7
See application file for complete search history.

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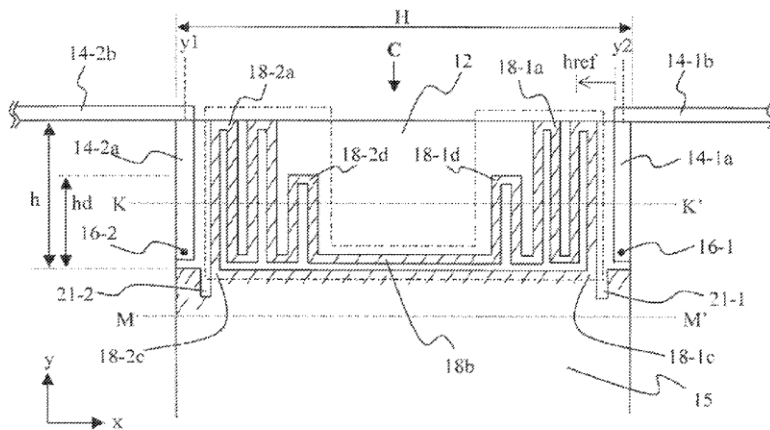
Primary Examiner — Michael C Wimer

(74) Attorney, Agent, or Firm — Fujitsu Patent Center

(57) **ABSTRACT**

An antenna apparatus including: a first and second antenna elements which transmit or receive radio signal; a ground pattern; and a wiring pattern which is provided on a line segment connecting the first and second antenna elements, and directly connected to the ground pattern, wherein a circumventing path is formed by the wiring pattern and a part of the ground pattern.

11 Claims, 25 Drawing Sheets





US009124241B2

(12) **United States Patent**
Lee

(10) **Patent No.:** **US 9,124,241 B2**
(45) **Date of Patent:** **Sep. 1, 2015**

(54) **IMPEDANCE MATCHING APPARATUS**

(75) Inventor: **Sang Hun Lee**, Seoul (KR)
(73) Assignee: **LG INNOTEK CO., LTD.**, Seoul (KR)
(*) 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.: **14/238,065**
(22) PCT Filed: **Aug. 3, 2012**
(86) PCT No.: **PCT/KR2012/006202**
§ 371 (c)(1),
(2), (4) Date: **Feb. 10, 2014**

(87) PCT Pub. No.: **WO2013/022237**
PCT Pub. Date: **Feb. 14, 2013**

(65) **Prior Publication Data**
US 2014/0167878 A1 Jun. 19, 2014

(30) **Foreign Application Priority Data**
Aug. 8, 2011 (KR) 10-2011-0078626

(51) **Int. Cl.**
H03H 7/38 (2006.01)
H03H 7/40 (2006.01)
H04B 1/04 (2006.01)
H04B 1/18 (2006.01)

(52) **U.S. Cl.**
CPC . **H03H 7/38** (2013.01); **H03H 7/40** (2013.01);
H04B 1/0458 (2013.01); **H04B 1/18** (2013.01)

(58) **Field of Classification Search**
CPC H04B 1/0458; H01Q 1/05
USPC 455/107, 123, 78, 115.1, 121; 333/124,
333/17.3
See application file for complete search history.

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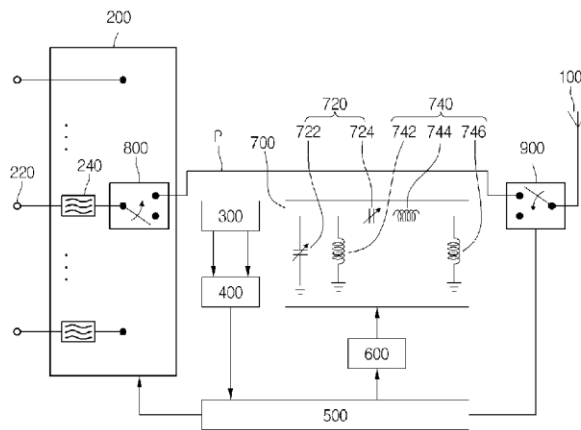
Primary Examiner — Dinh Le

(74) *Attorney, Agent, or Firm* — Saliwanchik, Lloyd & Eisenschenk

(57) **ABSTRACT**

Disclosed is an impedance matching apparatus performing impedance matching between a front-end module and an antenna. The impedance matching apparatus includes an RF front end providing a multi-band RF signal, a reflected power measuring module measuring a reflection coefficient for the RF input signal, a matching unit adjusting impedance so that the reflection coefficient is minimized, a first switch module provided in the RF front end to selectively switch the RF signal onto a bypass path, and a controller allowing the RF signal to be switched onto the bypass path if a specific frequency range is detected from the reflection coefficient.

15 Claims, 3 Drawing Sheets





US009130261B2

(12) **United States Patent
Chang**

(10) **Patent No.: US 9,130,261 B2**
(45) **Date of Patent: Sep. 8, 2015**

(54) **INVERTED-F ANTENNA**
(75) Inventor: **Jin-Su Chang**, Hsinchu County (TW)
(73) Assignee: **ARCADYAN TECHNOLOGY CORPORATION**, Hsinchu (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 168 days.

(21) Appl. No.: **13/277,294**
(22) Filed: **Oct. 20, 2011**

(65) **Prior Publication Data**
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(30) **Foreign Application Priority Data**
Jul. 5, 2011 (TW) 100123645 A

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

(52) **U.S. Cl.**
CPC **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**
USPC 343/700 MS, 702, 770, 718, 846
See application file for complete search history.

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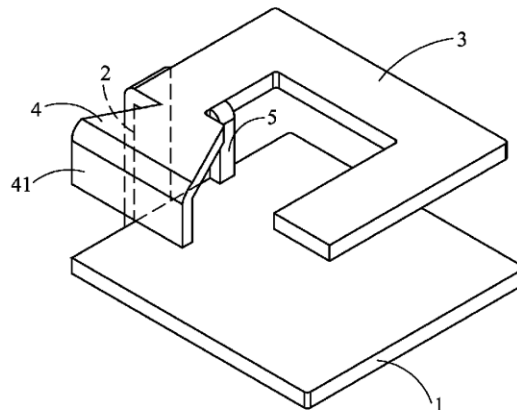
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Primary Examiner — Hoang V Nguyen
Assistant Examiner — Hai Tran
(74) *Attorney, Agent, or Firm* — WPAT, P.C.; Justin King

(57) **ABSTRACT**
An improved inverted-F antenna, adapted for wireless communication devices, is disclosed, which comprises: a ground plane; a pin, coupled to a side of the ground plane while extending vertically upward therefrom; a first radiation unit, connected to an end of the pin that is not connected to the ground plane while enabling the periphery of the same to align with the periphery of the ground plane. Moreover, the inverted-F antenna is further comprised of: a second radiation unit, connected to the end of the first radiation unit that is not connected to the pin while enabling the same to be enveloped within the periphery of the ground plane, and being shaped like a fan tapering toward the end thereof that is connected to the first radiation unit; and a feed point, disposed extendingly from an end of the first radiation unit for feeding electrical signals.

8 Claims, 3 Drawing Sheets





US009130263B2

(12) **United States Patent**
Kim

(10) **Patent No.:** **US 9,130,263 B2**
(45) **Date of Patent:** **Sep. 8, 2015**

(54) **COMMUNICATION TERMINAL AND ANTENNA APPARATUS THEREOF**

- (71) Applicant: **LG INNOTEK CO., LTD.**, Seoul (KR)
- (72) Inventor: **Chang Wook Kim**, Seoul (KR)
- (73) Assignee: **LG INNOTEK CO., LTD.**, Seoul (KR)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 12 days.

(21) Appl. No.: **14/046,569**

(22) Filed: **Oct. 4, 2013**

(65) **Prior Publication Data**

US 2014/0099903 A1 Apr. 10, 2014

(30) **Foreign Application Priority Data**

Oct. 4, 2012 (KR) 10-2012-0109789

- (51) **Int. Cl.**
H04B 1/38 (2006.01)
H01Q 9/04 (2006.01)
H04B 1/40 (2015.01)

- (52) **U.S. Cl.**
CPC **H01Q 9/0442** (2013.01); **H04B 1/40** (2013.01)

- (58) **Field of Classification Search**
CPC H04B 1/3838
USPC 455/575.5, 73
See application file for complete search history.

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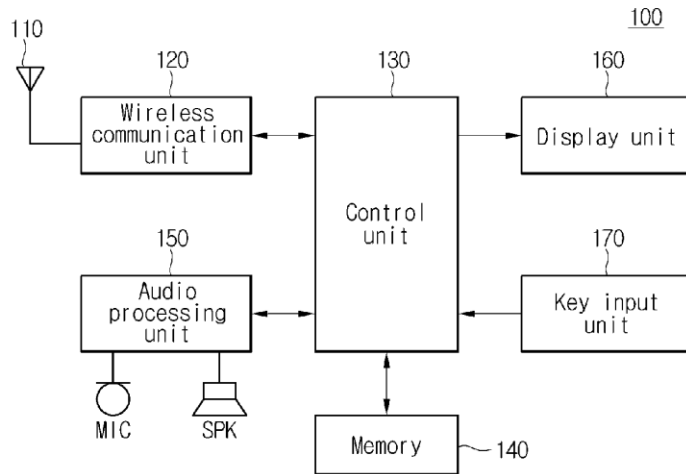
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Primary Examiner — April G Gonzales
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**

Disclosed are to a communication terminal and an antenna apparatus thereof. The antenna apparatus includes an antenna device including a feeding point to which a signal is applied; and at least one variable reactance device connected to the antenna device. The communication terminal determines a communication network to access to drive the antenna apparatus corresponding to the determined communication network, and accesses to the determined communication network through the antenna apparatus to communicate. Accordingly, a resonance frequency band of the antenna apparatus is expanded.

10 Claims, 6 Drawing Sheets





US009130267B2

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

(10) **Patent No.:** **US 9,130,267 B2**
(45) **Date of Patent:** **Sep. 8, 2015**

(54) **WIRELESS DEVICE INCLUDING A MULTIBAND ANTENNA SYSTEM**

(75) Inventors: **Jaume Anguera**, Castellon (ES); **Ivan Sanz**, Barcelona (ES); **Carles Puente**, Sant Cugat del Valles (ES); **Josep Mumbriu**, Barcelona (ES)

(73) Assignee: **Fractus, S.A.**, Barcelona (ES)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 969 days.

(21) Appl. No.: **12/593,290**

(22) PCT Filed: **Mar. 26, 2008**

(86) PCT No.: **PCT/EP2008/053526**

§ 371 (c)(1), (2), (4) Date: **Sep. 26, 2009**

(87) PCT Pub. No.: **WO2008/119699**

PCT Pub. Date: **Oct. 9, 2008**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 60/910,113, filed on Apr. 4, 2007.

(30) **Foreign Application Priority Data**

Mar. 30, 2007 (EP) 07105364

(51) **Int. Cl.**
H01Q 5/00 (2006.01)
H01Q 1/36 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/36** (2013.01); **H01Q 5/00** (2013.01); **H01Q 5/50** (2013.01); **H01Q 21/30** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/0093; H01Q 5/50; H01Q 21/30; H01Q 1/36
USPC 343/860, 745
See application file for complete search history.

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Primary Examiner — Robert Karacsony

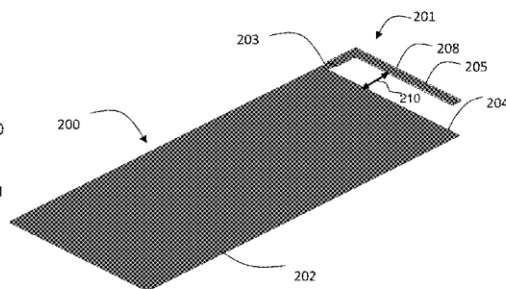
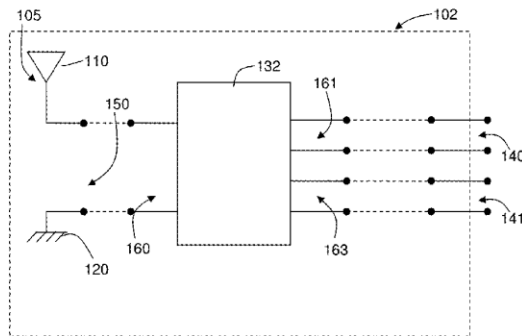
Assistant Examiner — Amal Patel

(74) *Attorney, Agent, or Firm* — Edell, Shapiro & Finnan, LLC

(57) **ABSTRACT**

A wireless handheld or portable device includes an antenna system operative in a first frequency region and a higher, second frequency region that includes an antenna structure, a matching and tuning system, and an external input/output port. The antenna structure includes at least one radiating element including a connection point, a ground plane layer including at least one connection point, and at least one internal input/output port. At least one radiating element of the antenna structure protrudes beyond the ground plane layer. The antenna structure features at any of its at least one internal input/output ports when disconnected from the matching and tuning system an input return loss curve having a minimum at a frequency outside the first frequency region of operation of the antenna system. The matching and tuning system provides impedance matching to the antenna system in the first and second regions of operation of the antenna system.

34 Claims, 30 Drawing Sheets





US009130269B2

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

(10) **Patent No.:** **US 9,130,269 B2**
(45) **Date of Patent:** **Sep. 8, 2015**

(54) **WIRELESS COMMUNICATION DEVICE HAVING METAL END PORTION OF HOUSING THEREOF**

(71) Applicants: **Chih-Yang Tsai**, New Taipei (TW);
Hao-Ying Chang, New Taipei (TW);
Chuan-Chou Chi, New Taipei (TW)

(72) Inventors: **Chih-Yang Tsai**, New Taipei (TW);
Hao-Ying Chang, New Taipei (TW);
Chuan-Chou Chi, New Taipei (TW)

(73) Assignee: **FIH (HONG KONG) Limited**,
Kowloon (HK)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 311 days.

(21) Appl. No.: **13/655,492**

(22) Filed: **Oct. 19, 2012**

(65) **Prior Publication Data**
US 2013/0154900 A1 Jun. 20, 2013

(30) **Foreign Application Priority Data**
Dec. 20, 2011 (TW) 100147564

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

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/371; H01Q 9/42
See application file for complete search history.

(56) **References Cited**
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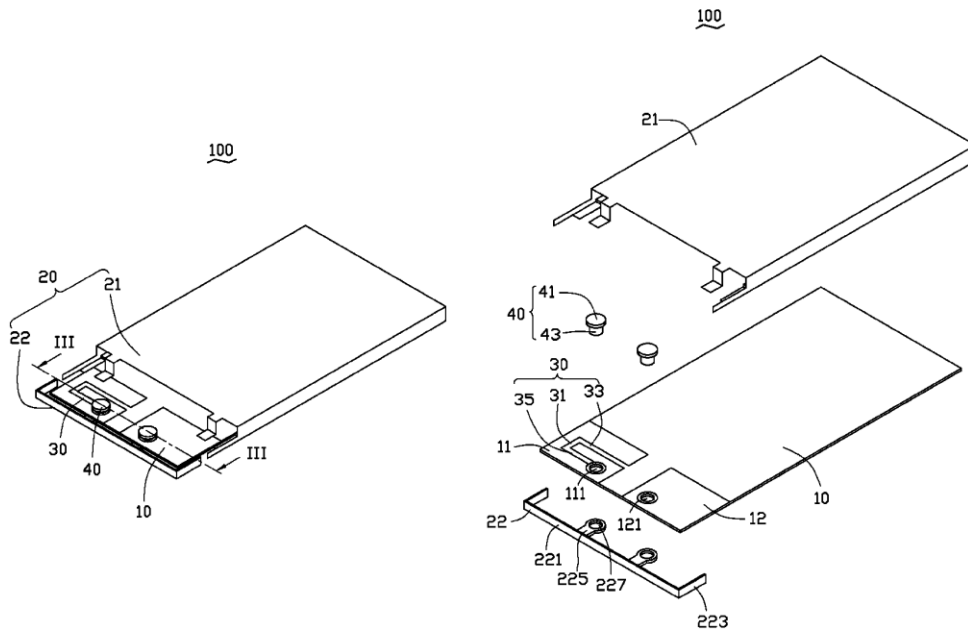
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Primary Examiner — Robert Karacsony
(74) *Attorney, Agent, or Firm* — Novak Druce Connolly Bove + Quigg LLP

(57) **ABSTRACT**

An exemplary wireless communication device includes a circuit board, a metal end portion, an antenna, and a connecting member. The antenna is positioned on the circuit board. The connecting member interconnects the circuit board and the end portion. The connecting member serves as a feeding point of the antenna. The end portion is a portion of a housing of the wireless communication device and further serves as a radiating portion of the antenna.

20 Claims, 4 Drawing Sheets





US009130275B2

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

(10) **Patent No.:** **US 9,130,275 B2**
(45) **Date of Patent:** **Sep. 8, 2015**

- (54) **OPEN-LOOP GPS ANTENNA**
- (71) Applicant: **ASKEY COMPUTER CORP.**, New Taipei (TW)
- (72) Inventors: **Chien-Sheng Liu**, Chiayi County (TW);
Yu-Chien Chan, New Taipei (TW);
Kuo-Chao Lo, Taoyuan County (TW);
Tzu-Hsuan Chou, Hsinchu County (TW)
- (73) Assignee: **ASKEY COMPUTER CORP.**, 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 261 days.
- (21) Appl. No.: **13/858,110**
- (22) Filed: **Apr. 8, 2013**
- (65) **Prior Publication Data**
US 2014/0139376 A1 May 22, 2014
- (30) **Foreign Application Priority Data**
Nov. 21, 2012 (TW) 101143486 A
- (51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 7/00 (2006.01)
H01Q 9/42 (2006.01)
- (52) **U.S. Cl.**
CPC . **H01Q 1/38** (2013.01); **H01Q 7/00** (2013.01);
H01Q 9/42 (2013.01)

(58) **Field of Classification Search**
USPC 343/700 MS, 702, 866
See application file for complete search history.

- (56) **References Cited**
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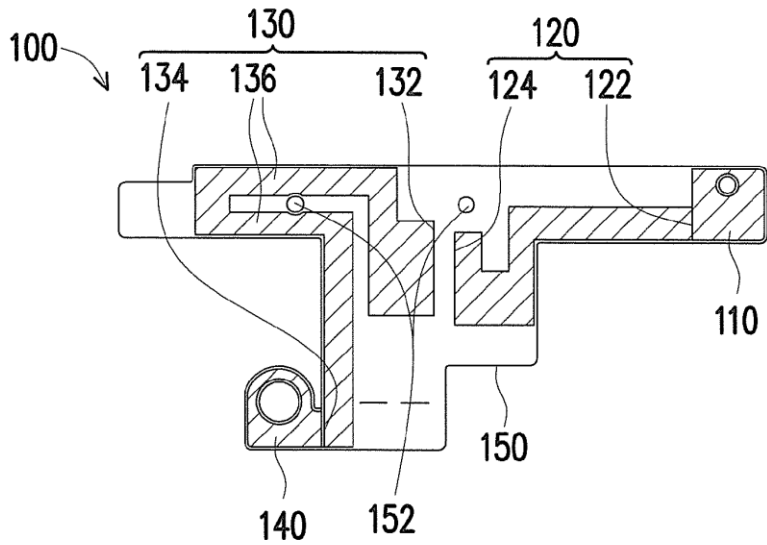
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Primary Examiner — Dieu H Duong
(74) *Attorney, Agent, or Firm* — Jianq Chyun IP Office

(57) **ABSTRACT**
An open-loop GPS antenna configured on an insulation object is provided. The open-loop GPS antenna includes a feed, a high frequency circuit, a low frequency circuit and a ground. The high frequency circuit includes a first end, connected to the feed, and a second end. The low frequency circuit includes a third end and a fourth end. The third end is disposed parallel to the second end so as to couple to the second end and generate a capacitance effect to transmit a signal. The fourth end is connected to the ground.

10 Claims, 4 Drawing Sheets





US009130279B1

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

(10) **Patent No.:** **US 9,130,279 B1**
(45) **Date of Patent:** **Sep. 8, 2015**

(54) **MULTI-FEED ANTENNA WITH INDEPENDENT TUNING CAPABILITY**

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/48; H01Q 5/0055
USPC 343/702, 700 MS, 728
See application file for complete search history.

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

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(72) Inventors: **Tzung-I Lee**, San Jose, CA (US); **In Chul Hyun**, San Jose, CA (US); **Cheol Su Kim**, San Jose, CA (US); **Jerry Weiming Kuo**, San Jose, CA (US)

Primary Examiner — Hoanganh Le

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

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 260 days.

(57) **ABSTRACT**

Antenna structures and methods of operating the same of a multi-feed antenna of an electronic device are described. A multi-feed antenna includes a first antenna element coupled to a first tuner circuit that is coupled a first radio frequency (RF) feed, and a second antenna element coupled to a second tuner circuit that is coupled to a second RF feed. The first tuner circuit is programmable to independently adjust a first impedance of the first antenna element and the second tuner circuit is programmable to independently adjust a second impedance of the second antenna element.

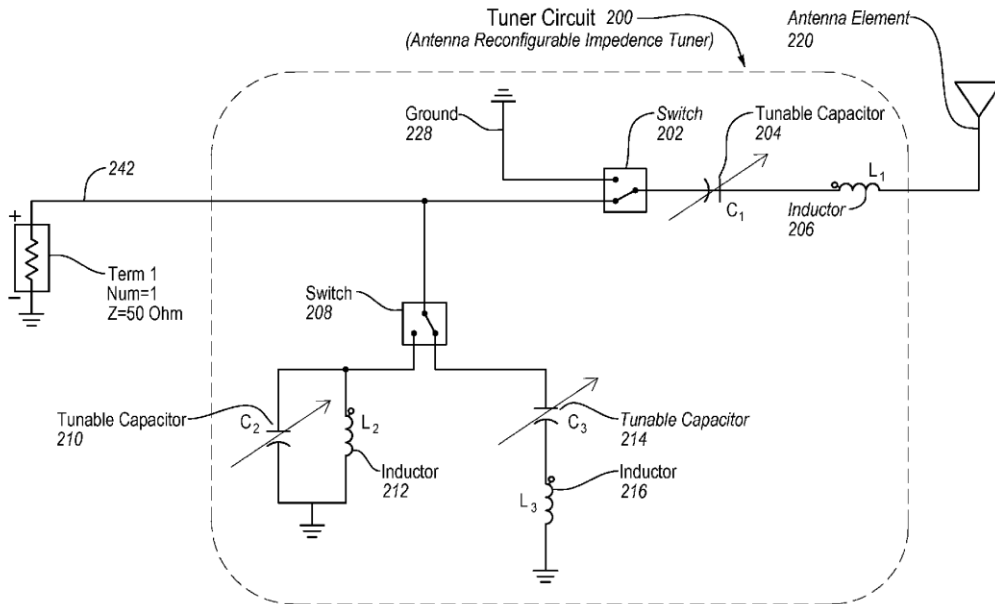
(21) Appl. No.: **13/789,455**

(22) Filed: **Mar. 7, 2013**

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 21/28 (2006.01)
H01Q 1/50 (2006.01)

(52) **U.S. Cl.**
CPC . **H01Q 21/28** (2013.01); **H01Q 1/50** (2013.01)

20 Claims, 13 Drawing Sheets





US009136581B2

(12) **United States Patent**
Sato

(10) **Patent No.:** **US 9,136,581 B2**
(45) **Date of Patent:** **Sep. 15, 2015**

(54) **WIRELESS TERMINAL APPARATUS**

(71) Applicant: **Koichi Sato**, Tachikawa (JP)

(72) Inventor: **Koichi Sato**, Tachikawa (JP)

(73) Assignee: **Kabushiki Kaisha Toshiba**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 188 days.

(21) Appl. No.: **13/719,684**

(22) Filed: **Dec. 19, 2012**

(65) **Prior Publication Data**

US 2013/0271329 A1 Oct. 17, 2013

(30) **Foreign Application Priority Data**

Apr. 13, 2012 (JP) 2012-091770

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 1/00 (2006.01)

H01Q 9/42 (2006.01)

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

CPC **H01Q 1/00** (2013.01); **H01Q 1/245** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/242; H01Q 1/243; H01Q 9/42

USPC 343/702, 720

See application file for complete search history.

(56) **References Cited**

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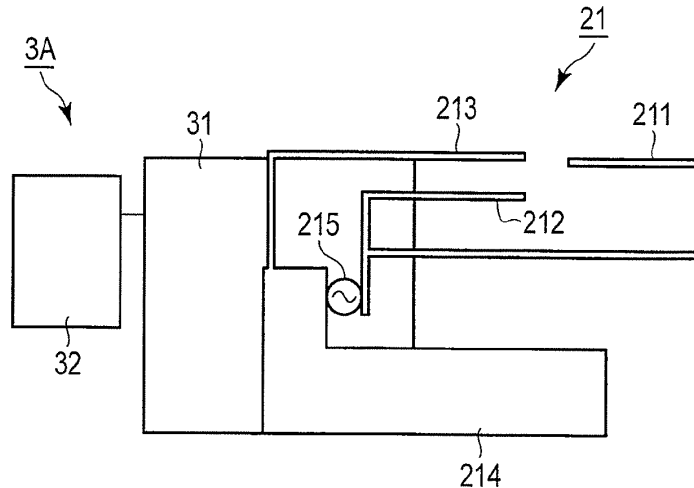
Primary Examiner — Hoang V Nguyen

(74) Attorney, Agent, or Firm — William W. Schaal; Rutan & Tucker, LLP

(57) **ABSTRACT**

According to one embodiment, a wireless terminal apparatus includes an antenna unit and a sensor unit in a housing. The sensor unit is disposed so that at least part of the sensor unit overlaps the antenna unit.

19 Claims, 4 Drawing Sheets





US009136584B2

(12) **United States Patent**
Wang

(10) **Patent No.:** **US 9,136,584 B2**
(45) **Date of Patent:** **Sep. 15, 2015**

(54) **ANTENNA SYSTEM**

- (71) Applicant: **Apple Inc.**, Cupertino, CA (US)
- (72) Inventor: **Shu-Li Wang**, Stafford, TX (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 0 days.

(21) Appl. No.: **13/858,865**
(22) Filed: **Apr. 8, 2013**

(65) **Prior Publication Data**
US 2013/0229322 A1 Sep. 5, 2013

Related U.S. Application Data

- (60) Continuation of application No. 12/764,788, filed on Apr. 21, 2010, now Pat. No. 8,427,377, which is a division of application No. 11/486,223, filed on Jul. 12, 2006, now Pat. No. 7,773,041.

- (51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/38 (2006.01)
H01Q 7/00 (2006.01)
H01Q 9/26 (2006.01)

- (52) **U.S. Cl.**
CPC *H01Q 1/22* (2013.01); *H01Q 1/243* (2013.01); *H01Q 1/38* (2013.01); *H01Q 7/00* (2013.01); *H01Q 9/265* (2013.01)

- (58) **Field of Classification Search**
USPC 343/702, 741, 742, 866, 867
See application file for complete search history.

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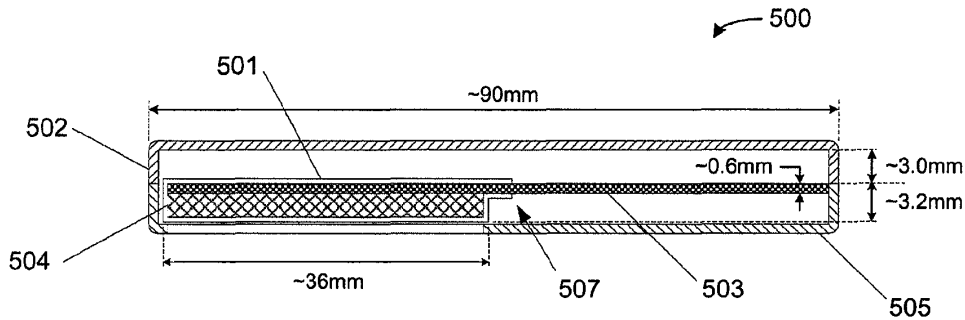
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Primary Examiner — Tan Ho
(74) *Attorney, Agent, or Firm* — Michael H. Lyons

(57) **ABSTRACT**

An antenna system includes a dielectrically-loaded loop element electromagnetically coupled to a planar element. The antenna system exhibits uniform, broadband radiation and reception patterns.

18 Claims, 12 Drawing Sheets





US009136585B2

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

(10) **Patent No.:** **US 9,136,585 B2**
(45) **Date of Patent:** **Sep. 15, 2015**

(54) **RADIO FREQUENCY IDENTIFICATION TAG**

(75) Inventors: **Lu-Chen Hwan**, Taipei (TW); **Po Ching Chen**, Hsinchu County (TW)

(73) Assignee: **Mutual-Pak Technology Co., Ltd.**,
Xinzhuang 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 0 days.

(21) Appl. No.: **13/401,584**

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

(65) **Prior Publication Data**
US 2013/0140368 A1 Jun. 6, 2013

(30) **Foreign Application Priority Data**
Dec. 1, 2011 (TW) 100144145 A

(51) **Int. Cl.**
G08B 13/14 (2006.01)
G06K 19/077 (2006.01)
H01Q 1/22 (2006.01)
H01Q 9/24 (2006.01)
H01Q 9/28 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/2225** (2013.01); **G06K 19/07754** (2013.01); **H01Q 9/24** (2013.01); **H01Q 9/285** (2013.01)

(58) **Field of Classification Search**
CPC G06K 7/0008; G06K 19/0723; G06K 19/077; G06K 19/07745; G06K 19/07749; G06K 19/07776; G06K 19/073; G06K 19/0772; G06K 19/07754
See application file for complete search history.

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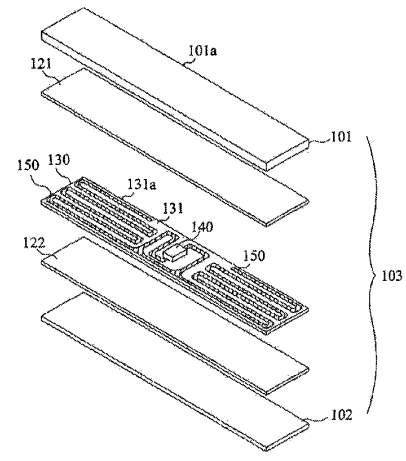
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Primary Examiner — Daniel Walsh
(74) *Attorney, Agent, or Firm* — Snell & Wilmer L.L.P.

(57) **ABSTRACT**
A radio frequency identification tag includes a housing shaped as a stripe defining a longitudinal side and an inlay shaped within the housing. The inlay includes a carrier board supporting a packaged chip and a wiring antenna in connection with the packaged chip. The wiring antenna is formed with an electrical joint directly and electrically connecting the packaged chip and an extension portion directly extending out of the electrical joint. The extension direction of the extension portion is substantially perpendicular to the longitudinal side.

11 Claims, 4 Drawing Sheets





US009136586B2

(12) **United States Patent**
Liu

(10) **Patent No.:** **US 9,136,586 B2**
(45) **Date of Patent:** **Sep. 15, 2015**

(54) **WIRELESS COMMUNICATION DEVICE**

(71) Applicant: **FIH (Hong Kong) Limited**, Kowloon (HK)

(72) Inventor: **Chi-Sheng Liu**, New Taipei (TW)

(73) Assignee: **FIH (Hong Kong) Limited**, Kowloon (HK)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 198 days.

(21) Appl. No.: **13/956,602**

(22) Filed: **Aug. 1, 2013**

(65) **Prior Publication Data**
US 2014/0062800 A1 Mar. 6, 2014

(30) **Foreign Application Priority Data**
Aug. 29, 2012 (TW) 101131436 A

(51) **Int. Cl.**
H01Q 9/00 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/24** (2013.01); **H01Q 1/243** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/24; H01Q 1/243; H01Q 9/42
USPC 343/700 MS, 702, 745
See application file for complete search history.

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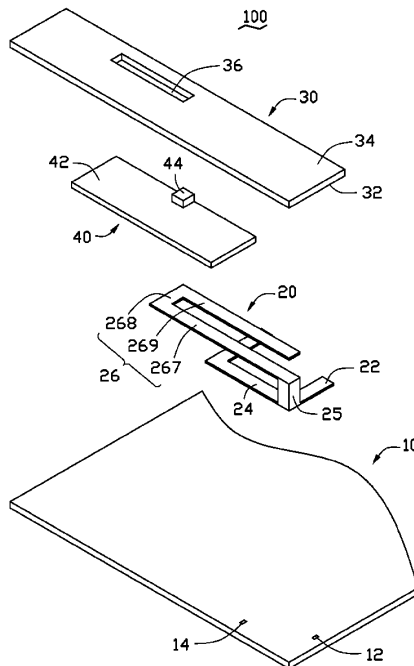
Primary Examiner — Tho G Phan

(74) *Attorney, Agent, or Firm* — Novak Druce Connolly Bove + Quigg LLP

(57) **ABSTRACT**

A wireless communication device includes a cover, an antenna, and an adjusting member. The adjusting member is slidably mounted to the cover and is made of non-conductive materials. The antenna includes a radiator, the radiator is mounted on the cover and is shielded by the adjusting member. The adjusting member slides relative to the cover to shield different areas of the radiator.

13 Claims, 3 Drawing Sheets





US009136590B2

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

(10) **Patent No.:** **US 9,136,590 B2**
(45) **Date of Patent:** **Sep. 15, 2015**

(54) **ELECTRONIC DEVICE PROVIDED WITH ANTENNA DEVICE**

USPC 343/702; 455/89, 90, 575.7
See application file for complete search history.

(71) Applicant: **Kabushiki Kaisha Toshiba**, Tokyo (JP)

(56) **References Cited**

(72) Inventors: **Hiroyuki Hotta**, Ome (JP); **Koichi Sato**, Tachikawa (JP); **Ippeï Kashiwagi**, Fuchu (JP)

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(73) Assignee: **Kabushiki Kaisha Toshiba**, Tokyo (JP)

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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 202 days.

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(Continued)

(21) Appl. No.: **14/015,682**

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(22) Filed: **Aug. 30, 2013**

International Search Report and Written Opinion from corresponding PCT/JP2013/057306 mailed May 28, 2013.

(Continued)

(65) **Prior Publication Data**

US 2014/0097993 A1 Apr. 10, 2014

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2013/057306, filed on Mar. 14, 2013.

Primary Examiner — Tho G Phan

(74) *Attorney, Agent, or Firm* — William W. Schaal; Rutan & Tucker, LLP

(30) **Foreign Application Priority Data**

Oct. 10, 2012 (JP) 2012-224931

(57) **ABSTRACT**

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/48 (2006.01)

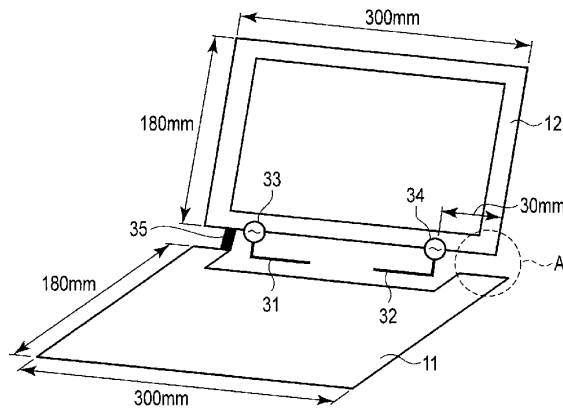
(Continued)

In an electronic device, a first housing for receiving a wireless circuit unit and a ground part, a second housing in which a ground part, a hinge mechanism which connects the first and second housings to each other to allow the first and second housings to be rotated, and first and second antennas which resonate for the same frequency band. The first and second antennas are provided in an intermediate portion of the hinge mechanism, and arranged side by side and apart from each other by a predetermined distance in a longitudinal direction of the mechanism. In the mechanism, one of end portions of the mechanism is made electrically conductive, and the other end portion is decreased in electrical conductivity.

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 1/48** (2013.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/2266; H01Q 1/48; H01Q 21/28; H01Q 9/42

4 Claims, 6 Drawing Sheets





US009136591B2

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

(10) **Patent No.:** **US 9,136,591 B2**
(45) **Date of Patent:** ***Sep. 15, 2015**

(54) **HANDHELD DEVICE**

(71) Applicant: **HTC CORPORATION**, Taoyuan (TW)

(72) Inventors: **Chien-Chih Chen**, Taoyuan (TW);
Chun-Wei Tseng, Taoyuan (TW);
Yen-Liang Kuo, Taoyuan (TW);
Wan-Ming Chen, Taoyuan (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 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/508,427**

(22) Filed: **Oct. 7, 2014**

(65) **Prior Publication Data**

US 2015/0022404 A1 Jan. 22, 2015

Related U.S. Application Data

(62) Division of application No. 13/041,858, filed on Mar. 7, 2011.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/364 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/0041** (2013.01); **H01Q 5/364** (2015.01); **H01Q 5/50** (2015.01); **H01Q 9/42** (2013.01); **H04B 1/006** (2013.01); **H04W 88/02** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/0055; H01Q 9/42; H01Q 9/0421
USPC 343/702, 876
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

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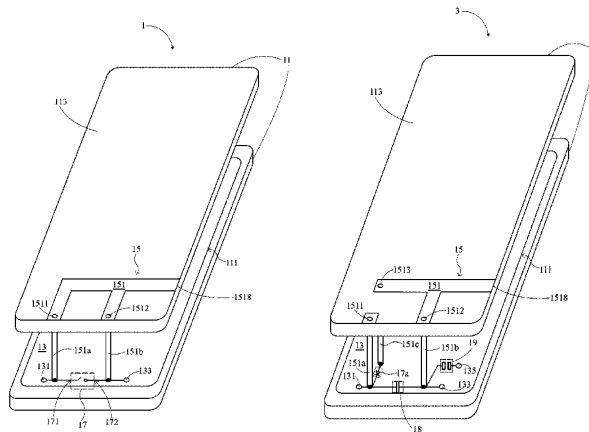
Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — Grossman, Tucker, Perreault & Pfleger, PLLC

(57) **ABSTRACT**

A handheld device is provided, wherein the handheld device comprises a housing, a circuit board, a planar antenna and a switch. The housing comprising an outer surface is configured to define a receiving space. The circuit board is disposed in the receiving space. The planar antenna comprises a metal layer, wherein the metal layer comprising a first connecting point and a second connecting point is patterned on the outer surface. The switch comprising a first electrode and a second electrode is configured to control the electrical connection between the first connecting point and the second connecting point, wherein the first electrode and the second electrode are electrically connected between the first connecting point and the second connecting point. The planar antenna operates at a first central band when the switch is turned on, and operates at a second central band when the switch is turned off.

5 Claims, 7 Drawing Sheets





US009136594B2

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

(10) **Patent No.:** **US 9,136,594 B2**
(45) **Date of Patent:** **Sep. 15, 2015**

(54) **COMPACT MULTI-BAND PLANAR
INVERTED F ANTENNA**

(75) Inventors: **Guining Shi**, San Diego, CA (US);
Allen M. Tran, San Diego, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 694 days.

(21) Appl. No.: **12/619,558**

(22) Filed: **Nov. 16, 2009**

(65) **Prior Publication Data**

US 2011/0043408 A1 Feb. 24, 2011

Related U.S. Application Data

(60) Provisional application No. 61/235,636, filed on Aug.
20, 2009.

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 1/48 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/48** (2013.01); **H01Q 9/0421**
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 9/42;
H01Q 21/30; H01Q 9/40; H01Q 5/0041;
H01Q 7/00; H01Q 5/0034; H01Q 5/0037;
H01Q 5/0051; H01Q 9/0421; H01Q 1/48
See application file for complete search history.

(56) **References Cited**

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IEEE Transactions on Antennas and Propagation, vol. 55, No. 11,
Nov. 2001, pp. 3300-3309.

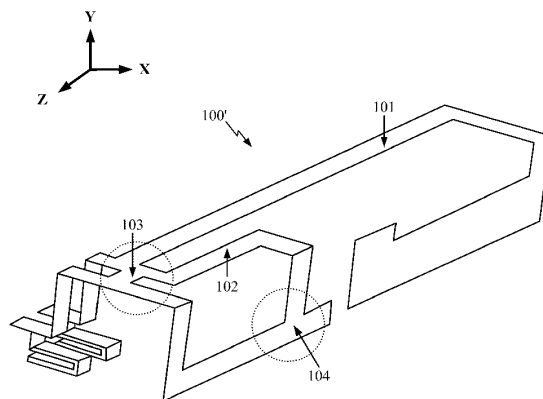
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Primary Examiner — Trinh Dinh
(74) *Attorney, Agent, or Firm* — James Gutierrez

(57) **ABSTRACT**

A simple, compact multi-band PIFA including two arm portions, where one arm portion is grounded at two points to form a loop, a ground plane, and a plastic carrier and housing. The antenna radiates a same signal from both arm portions, at different efficiencies according to the radiated frequency and the effective length of each arm. The antenna is made from a single standard metal sheet by cutting it and is assembled with the metal ground plane and the other plastic parts. In one embodiment, the antenna is folded into a 3D U-shape to reduce its size for use in mobile communication devices. In another embodiment, the antenna is a penta-band antenna with return loss of -6 B or better and measures 40x8x8 mm or smaller.

9 Claims, 8 Drawing Sheets





US009136595B2

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

(10) **Patent No.:** **US 9,136,595 B2**
(45) **Date of Patent:** **Sep. 15, 2015**

(54) **DIVERSITY ANTENNA MODULE AND ASSOCIATED METHOD FOR A USER EQUIPMENT (UE) DEVICE**

(75) Inventors: **Dong Wang**, Waterloo (CA); **Qinjiang Rao**, Kanata (CA); **James Warden**, Ft. Worth, TX (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 0 days.

(21) Appl. No.: **14/232,372**

(22) PCT Filed: **Jul. 15, 2011**

(86) PCT No.: **PCT/US2011/044119**

§ 371 (c)(1),
(2), (4) Date: **Jan. 13, 2014**

(87) PCT Pub. No.: **WO2013/012404**

PCT Pub. Date: **Jan. 24, 2013**

(65) **Prior Publication Data**

US 2014/0170992 A1 Jun. 19, 2014

(51) **Int. Cl.**
H04B 1/38 (2006.01)
H01Q 1/52 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)
H01Q 21/29 (2006.01)
H01Q 25/00 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/521** (2013.01); **H01Q 1/24** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 21/29** (2013.01); **H01Q 25/00** (2013.01); **H04B 1/38** (2013.01); **Y10T 29/49018** (2013.01)

(58) **Field of Classification Search**
USPC 455/73, 550.1, 552.1, 553.1, 575.1, 455/575.7, 90.1, 90.3, 101, 269, 277.1; 343/700, 843, 893, 700 MS
See application file for complete search history.

(56) **References Cited**

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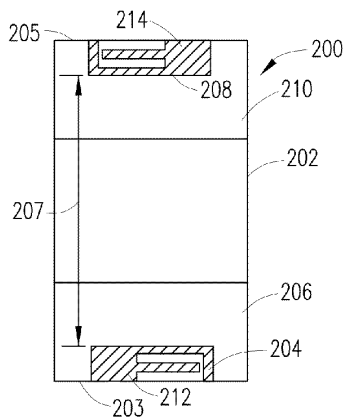
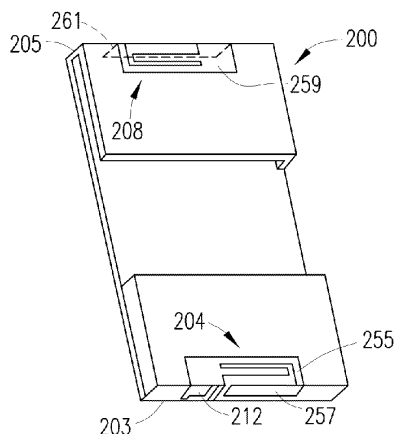
Primary Examiner — Thanh Le

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

(57) **ABSTRACT**

A diversity antenna module comprising a first radiating element adapted to operate with a first transceiver circuit operating in at least one band and a second radiating element adapted to operate with a second transceiver circuit operating in at least one band. The first radiating element is disposed along a first side of a substrate and the second radiating element is disposed along a second side of the substrate, wherein the first and second sides are substantially parallel to each other, the first and second radiating elements being spatially dispersed from each another by a distance.

23 Claims, 9 Drawing Sheets





US009136599B2

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

(10) **Patent No.:** **US 9,136,599 B2**
(45) **Date of Patent:** **Sep. 15, 2015**

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

(58) **Field of Classification Search**
CPC H01Q 5/01; H01Q 5/357; H01Q 5/378
USPC 343/700 MS, 702, 829, 846
See application file for complete search history.

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

(56) **References Cited**

(72) Inventors: **Wei-Cheng Su**, New Taipei (TW);
Yen-Hui Lin, New Taipei (TW)

U.S. PATENT DOCUMENTS

(73) Assignee: **Chiun Mai Communication Systems, Inc.**, New Taipei (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 159 days.

* cited by examiner

(21) Appl. No.: **14/014,586**

Primary Examiner — Tho G Phan

(22) Filed: **Aug. 30, 2013**

(74) *Attorney, Agent, or Firm* — Novak Druce Connolly Bove + Quigg LLP

(65) **Prior Publication Data**
US 2014/0111383 A1 Apr. 24, 2014

(57) **ABSTRACT**

(30) **Foreign Application Priority Data**

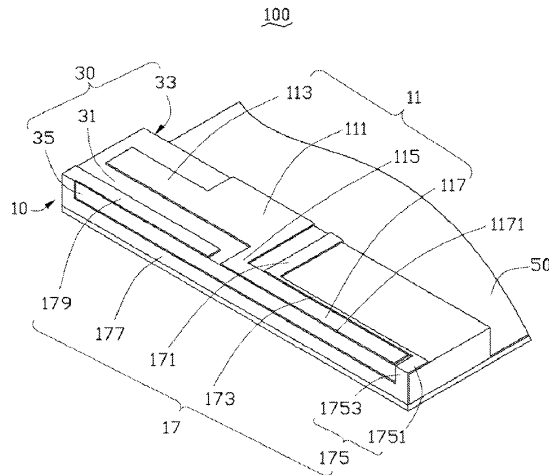
A broadband antenna for wireless communication device is disclosed. The broadband antenna includes a main radiator, a grounding unit, a feeding unit, and a resonating unit. The main radiator includes a main radiating portion, a first radiating arm extending from the main radiating portion, and a second radiating arm extending from the main radiating arm, the first radiating arm forms a first current path to generate a first high frequency mode; the second radiating arm forms a second current path to generate a second high frequency mode. The resonating unit is connected to the grounding unit, the resonating unit surrounds and is positioned separate from the second radiating arm, the resonating unit resonates with the main radiator to generate two different low frequency bands corresponding to two coupling currents.

Oct. 24, 2012 (TW) 101139311 A

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 5/01 (2006.01)
H01Q 5/357 (2015.01)
H01Q 5/378 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 5/01** (2013.01); **H01Q 5/357** (2015.01); **H01Q 5/378** (2015.01)

20 Claims, 3 Drawing Sheets





US009136601B2

(12) **United States Patent**
Yang

(10) **Patent No.:** **US 9,136,601 B2**
(45) **Date of Patent:** **Sep. 15, 2015**

(54) **TUNABLE MULTIBAND WAN ANTENNA FOR GLOBAL APPLICATIONS**

(71) Applicant: **Motorola Solutions, Inc.**, Schaumburg, IL (US)

(72) Inventor: **Guangli Yang**, Bellport, NY (US)

(73) Assignee: **MOTOROLA SOLUTIONS, INC.**, Schaumburg, IL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 325 days.

(21) Appl. No.: **13/904,413**

(22) Filed: **May 29, 2013**

(65) **Prior Publication Data**
US 2014/0354495 A1 Dec. 4, 2014

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/06 (2006.01)

(52) **U.S. Cl.**
CPC . **H01Q 9/06** (2013.01); **H01Q 1/243** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/06; H01Q 9/42; H01Q 1/243; H01Q 1/24; H01Q 1/241; H01Q 1/244
USPC 343/702, 750, 700 MS, 751
See application file for complete search history.

(56) **References Cited**

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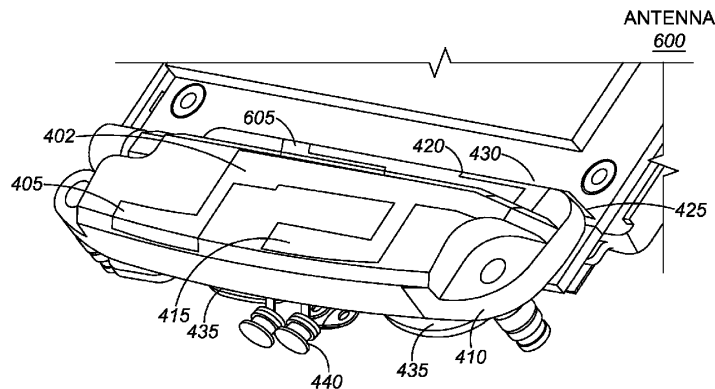
Primary Examiner — Hoanganh Le

(74) Attorney, Agent, or Firm — Barbara R. Doutre

(57) **ABSTRACT**

An electronic device includes an antenna for a transceiver to operate in a plurality of frequencies. The antenna includes a first portion that is coupled to an elongate element and is configured to enable the transceiver to operate in a first low-band frequency and a first high-band frequency. A second portion is also coupled to the elongate element. The second portion is configured to enable the transceiver to operate in a second high-band frequency. A third portion is coupled to the elongate element and is situated between the first and second portions. The third portion is configured to tune the first and the second high-band frequencies associated with the first and second portions. A tuning element is configured to tune the low-band frequency associated with the first portion such that the first and the second high-band frequencies are not significantly affected by tuning the tuning element.

20 Claims, 12 Drawing Sheets





US009136602B2

(12) **United States Patent**
Liu

(10) **Patent No.:** **US 9,136,602 B2**
(45) **Date of Patent:** **Sep. 15, 2015**

(54) **WIRELESS COMMUNICATION DEVICE**

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

(71) Applicant: **FIH (Hong Kong) Limited**, Kowloon (HK)

(56) **References Cited**

(72) Inventor: **Chi-Sheng Liu**, New Taipei (TW)

U.S. PATENT DOCUMENTS

(73) Assignee: **FIH (Hong Kong) Limited**, Kowloon (HK)

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7,176,840	B1 *	2/2007	Kelley	343/745

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 222 days.

* cited by examiner

(21) Appl. No.: **13/956,614**

Primary Examiner — Tho G Phan

(22) Filed: **Aug. 1, 2013**

(74) *Attorney, Agent, or Firm* — Novak Druce Connolly Bove + Quigg LLP

(65) **Prior Publication Data**

US 2014/0071007 A1 Mar. 13, 2014

(30) **Foreign Application Priority Data**

Sep. 10, 2012 (TW) 101132904 A

(57) **ABSTRACT**

A wireless communication device includes a cover, an antenna, and an adjusting member. The antenna includes a first radiator and a second radiator separate from the first radiator. The adjusting member is slidably mounted to the cover and is made of conductive materials. The adjusting member is positioned between and connecting the first radiator and the second radiator. The adjusting member is slid relative to the cover to change connection positions of the adjusting member relative to the first radiator and the second radiator.

(51) **Int. Cl.**

H01Q 9/06 (2006.01)
H01Q 9/04 (2006.01)
H01Q 9/14 (2006.01)

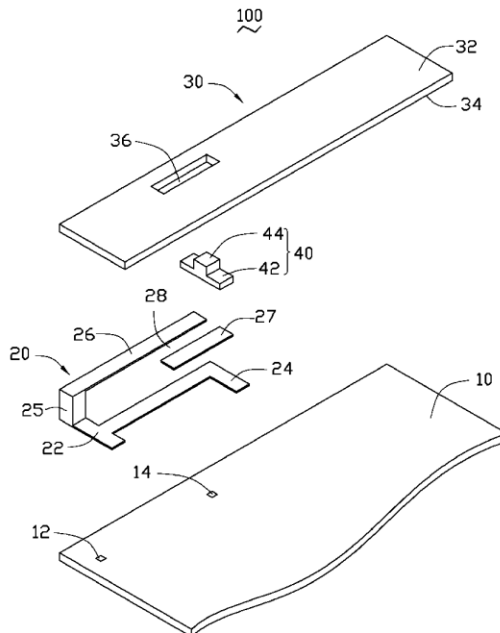
(52) **U.S. Cl.**

CPC **H01Q 9/06** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 9/14** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/06; H01Q 9/0421; H01Q 9/14

14 Claims, 3 Drawing Sheets





US009137349B2

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

(10) **Patent No.:** **US 9,137,349 B2**
(45) **Date of Patent:** **Sep. 15, 2015**

(54) **MULTI-ANTENNA MOBILE PHONE DATA CARD AND METHOD FOR REDUCING SPECIFIC ABSORPTION RATE**

(75) Inventors: **Pan Huang**, Shenzhen (CN); **Lu Zhang**, Shenzhen (CN); **Hui Jiang**, Shenzhen (CN)

(73) Assignee: **ZTE Corporation**, Shenzhen (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 42 days.

(21) Appl. No.: **14/129,444**

(22) PCT Filed: **Nov. 16, 2011**

(86) PCT No.: **PCT/CN2011/082283**
§ 371 (c)(1),
(2), (4) Date: **Dec. 26, 2013**

(87) PCT Pub. No.: **WO2012/151903**
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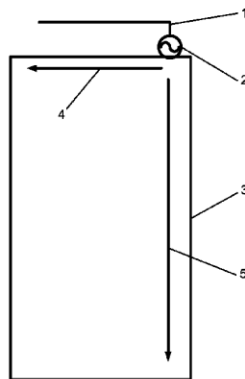
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(57) **ABSTRACT**

The present disclosure provides a multi-antenna mobile phone data card and method for reducing a specific absorption rate, where the data card includes: a radio frequency (RF) substrate, antennas configured to transmit and receive signals, and a feed source, connected between the RF substrate and the antennas, configured to excite the antennas, the RF substrate has a rectangular shape, and the feed source is arranged at a first corner of the RF substrate, a first hollow portion is arranged at a second corner which is adjacent to the first corner and is located on a short side of the RF substrate on which the first corner is located, the first hollow portion is provided with a first metal strip, the first metal strip has an end connected with the short side, and another end as a free end, a first electrical length formed from the feed source to the free end of the first metal strip is equal to a second electrical length formed from the feed source to another short side along a long side on which the first corner is located. According to the present disclosure, through the method of changing the shape of the RF substrate, the same electrical lengths is obtained from the feed source respectively to several edge points on the RF substrate, and thus reducing the current peak and the SAR value on the RF substrate and saving the structure space, thereby reducing the radiation hazard of the data card to the human body.

10 Claims, 5 Drawing Sheets





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(54) **ELECTRONIC DEVICE ASSEMBLIES**

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(57) **ABSTRACT**

An electronic device may have a conductive housing. A dielectric structure may be mounted in the conductive housing to form an antenna window. An electrical component such as a camera, light sensor, or other device may press against a conductive foam structure. A printed circuit may have conductive traces that form an antenna ground and antenna resonating element. The printed circuit may be wrapped around a support structure. The electrical component, the conductive foam structure, and the printed circuit wrapped around the support structure may be compressed between a display cover layer and the antenna window. A camera window may be attached to a camera window trim using multiple adhesives. The trim may have a curved exterior surface that matches a curved housing surface. A flexible printed circuit cable may have a folded portion. A band structure may surround the folded portion to form a service loop.

18 Claims, 20 Drawing Sheets

