



US008736496B2

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

(10) **Patent No.:** **US 8,736,496 B2**

(45) **Date of Patent:** ***May 27, 2014**

(54) **APPARATUS, METHODS AND COMPUTER PROGRAMS FOR WIRELESS COMMUNICATION**

(75) Inventors: **Bjarne Nielsen**, Copenhagen NV (DK);
Richard Breiter, Fredriksberg C (DK);
Jens Troelsen, Copenhagen NV (DK);
Alexandre Pinto, KBH S. (DK)

(73) Assignee: **Nokia Corporation**, Espoo (FI)

(*) 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.: **13/449,814**

(22) Filed: **Apr. 18, 2012**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. 12/157,549, filed on Jun. 10, 2008, which is a continuation-in-part of application No. 12/004,744, filed on Dec. 21, 2007, now Pat. No. 7,876,273.

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

(52) **U.S. Cl.**
USPC **343/702; 343/861**

(58) **Field of Classification Search**
USPC 343/702, 846, 850, 700 MS, 860-862
See application file for complete search history.

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Primary Examiner — Michael C Wimer

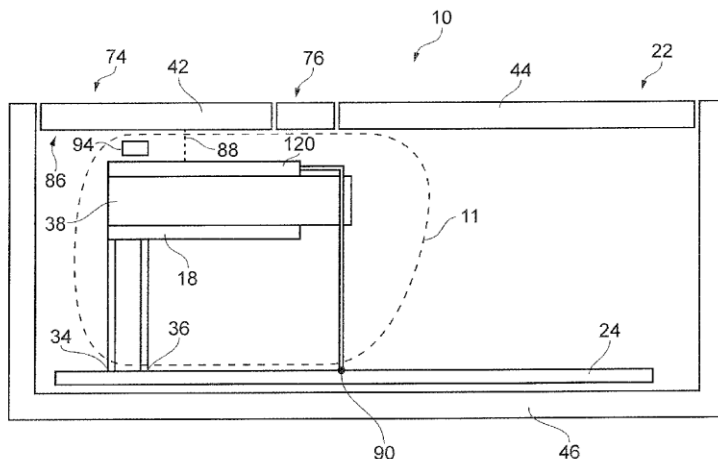
(74) *Attorney, Agent, or Firm* — Harrington & Smith

(57)

ABSTRACT

An apparatus including a cover defining an exterior surface of the apparatus and including a first conductive cover portion; an antenna, connected to a feed point and configured to operate in at least a first resonant frequency band; a first conductive member; a second conductive member; and wherein the first and second conductive members are configured to couple with the first conductive cover portion, the combination of the first and second conductive members and the first conductive cover portion are operable in a second resonant frequency band, different to the first resonant frequency band and are configured to be contactlessly fed by the antenna.

18 Claims, 9 Drawing Sheets





US008736509B2

(12) **United States Patent**
Shoji

(10) **Patent No.:** **US 8,736,509 B2**
(45) **Date of Patent:** **May 27, 2014**

(54) **MULTIBAND ANTENNA AND RADIO COMMUNICATION TERMINAL**

(75) Inventor: **Hideaki Shoji**, Chiba (JP)

(73) Assignees: **Sony Corporation**, Tokyo (JP); **Sony Mobile Communications Inc.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 261 days.

(21) Appl. No.: **12/473,682**

(22) Filed: **May 28, 2009**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jun. 25, 2008 (JP) 2008-166421

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

(52) **U.S. Cl.**
USPC **343/860**

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 9/42; H01Q 5/0003; H03H 7/38
USPC 343/860, 745, 749, 702, 861, 853
See application file for complete search history.

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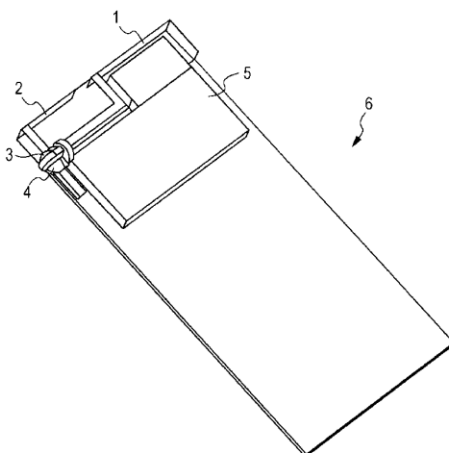
Primary Examiner — Huedung Mancuso

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

(57) **ABSTRACT**

A multiband antenna includes at least two antenna elements for use in a low frequency band and a high frequency band, a feeding point unit configured to be shared by both of the antenna elements for use in the low frequency band and the high frequency band and an impedance matching unit configured to be inserted into and connected to a position between an end of the antenna element for use in the high frequency band on the side of the feeding point unit and an open end thereof.

7 Claims, 6 Drawing Sheets





US008742991B2

(12) **United States Patent**
Soora

(10) **Patent No.:** **US 8,742,991 B2**
(45) **Date of Patent:** **Jun. 3, 2014**

(54) **HANDHELD ELECTRONIC DEVICES AND METHODS INVOLVING TUNABLE DIELECTRIC MATERIALS**

(75) Inventor: **Shruthi Soora**, Raleigh, NC (US)

(73) Assignee: **HTC Corporation**, Taoyuan, Taoyuan County (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 308 days.

(21) Appl. No.: **13/443,007**

(22) Filed: **Apr. 10, 2012**

(65) **Prior Publication Data**

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H01Q 1/24 (2006.01)

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

(56) **References Cited**

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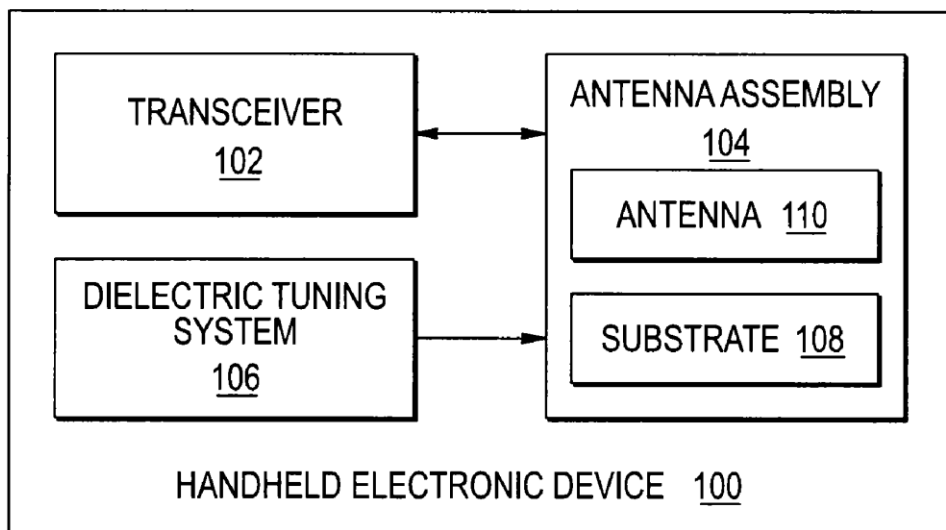
Primary Examiner — Hoanganh Le

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

(57) **ABSTRACT**

Handheld electronic devices and methods involving tunable dielectric materials are provided. In this regard, a representative device includes: a transceiver operative to selectively transmit and receive electrical signals; an antenna assembly electrically connected to the transceiver, the antenna assembly having anisotropic dielectric material operative to exhibit a change in dielectric constant responsive to an applied electrical signal; and a dielectric tuning system operative to automatically and selectively apply a first signal to the antenna assembly to change the dielectric constant of the anisotropic dielectric material to alter a resonant frequency and efficiency tuning of the antenna.

20 Claims, 4 Drawing Sheets





US008742992B2

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

(10) **Patent No.:** **US 8,742,992 B2**
(45) **Date of Patent:** **Jun. 3, 2014**

(54) **PLANAR INVERTED F ANTENNA**

(56) **References Cited**

(75) Inventors: **Manabu Kai**, Kawasaki (JP); **Teruhisa Ninomiya**, Kawasaki (JP); **Takahiro Koharagi**, Tokyo (JP); **Hiroaki Kawasumi**, Tokyo (JP); **Katsumi Kobayashi**, Tokyo (JP); **Takuji Furusawa**, Tokyo (JP); **Masaharu Nozawa**, Shizuoka (JP); **Masashi Kuwahara**, Fukushima (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 138 days.

(21) Appl. No.: **13/443,505**

(22) Filed: **Apr. 10, 2012**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Apr. 25, 2011 (JP) 2011-097005

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

(52) **U.S. Cl.**
CPC . **H01Q 1/38** (2013.01); **H01Q 1/243** (2013.01)
USPC **343/700 MS**; **343/702**

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

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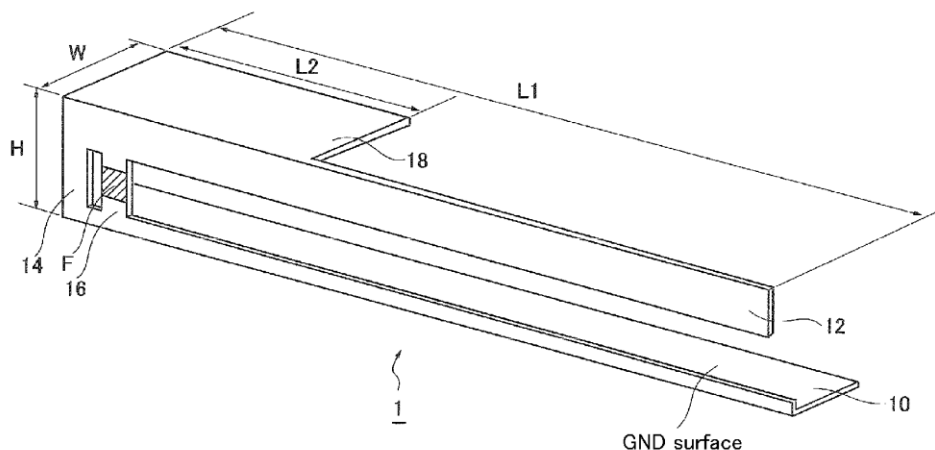
Primary Examiner — Hoanganh Le

(74) Attorney, Agent, or Firm — Myers Wolin, LLC

(57) **ABSTRACT**

In a planar inverted F antenna, a second radiation element is provided parallel to the GND surface and extending partially with respect to a first radiation element in a longitudinal direction, so as to substantially increase a width of the first radiation element in the vicinity of a power supply section.

8 Claims, 14 Drawing Sheets





US008742993B2

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

(10) **Patent No.:** **US 8,742,993 B2**
(45) **Date of Patent:** ***Jun. 3, 2014**

(54) **METAMATERIAL LOADED ANTENNA STRUCTURES**

(71) Applicant: **Tyco Electronics Services GmbH**,
Schaffhausen (CH)
(72) Inventors: **Cheng Jung Lee**, Santa Clara, CA (US);
Maha Achour, Encinitas, CA (US);
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(73) Assignee: **Tyco Electronics Services GmbH**,
Schaffhausen (CH)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
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This patent is subject to a terminal dis-
claimer.

(21) Appl. No.: **13/758,873**

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

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. 12/563,035, filed on
Sep. 18, 2009, now Pat. No. 8,368,595.

(60) Provisional application No. 61/098,735, filed on Sep.
19, 2008.

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

(52) **U.S. Cl.**
USPC **343/700 MS**; 343/828; 343/846

(58) **Field of Classification Search**
USPC 343/700 MS, 749, 846, 909, 828
See application file for complete search history.

(56) **References Cited**

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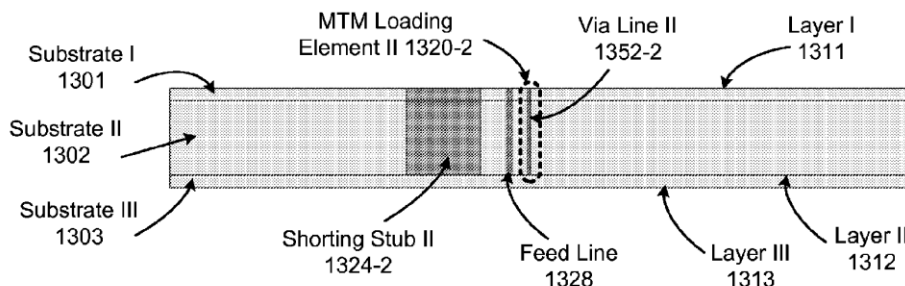
Primary Examiner — Michael C Wimer

(74) *Attorney, Agent, or Firm* — Schwegman Lundberg &
Woessner, P.A.

(57) **ABSTRACT**

Techniques and devices based on antenna structures with a
MTM loading element.

20 Claims, 19 Drawing Sheets





US008742996B2

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

(10) **Patent No.:** **US 8,742,996 B2**
(45) **Date of Patent:** ***Jun. 3, 2014**

(54) **MOBILE WIRELESS COMMUNICATIONS
DEVICE WITH SELECTIVE LOAD
SWITCHING FOR ANTENNAS AND
RELATED METHODS**

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

(72) Inventors: **Yihong Qi**, Waterloo (CA); **Ying Tong
Man**, Waterloo (CA); **Perry
Jarmuszewski**, Waterloo (CA)

(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.

This patent is subject to a terminal dis-
claimer.

(21) Appl. No.: **14/059,822**

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

(65) **Prior Publication Data**

US 2014/0045560 A1 Feb. 13, 2014

Related U.S. Application Data

(63) Continuation of application No. 13/899,138, filed on
May 21, 2013, now Pat. No. 8,599,077, which is a
continuation of application No. 13/609,855, filed on
Sep. 11, 2012, now Pat. No. 8,462,057, which is a
continuation of application No. 13/171,602, filed on
Jun. 29, 2011, now Pat. No. 8,310,401, which is a
continuation of application No. 12/115,646, filed on
May 6, 2008, now Pat. No. 7,973,725.

(60) Provisional application No. 61/032,563, filed on Feb.
29, 2008.

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

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

USPC **343/702**; 343/725; 343/876

(58) **Field of Classification Search**

USPC 343/702, 725, 876
See application file for complete search history.

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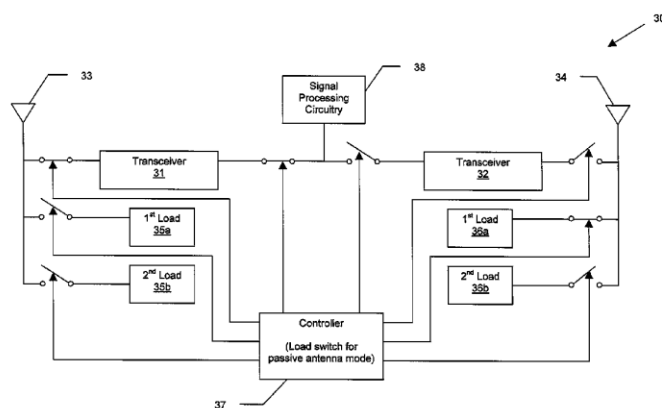
Primary Examiner — Tho G Phan

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

(57) **ABSTRACT**

A mobile wireless communications device may include a plurality of antennas, a plurality of wireless transceivers, and signal processing circuitry. The device may further include a controller for selectively switching the signal processing circuitry to a desired one of the wireless transceivers, and for selectively switching a desired one of the antennas to the desired one of the wireless transceivers. Moreover, the controller may also be for selectively connecting and disconnecting the at least one other one of the antennas to an unused one of the wireless transceivers.

20 Claims, 4 Drawing Sheets





US008742997B2

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

(10) **Patent No.:** **US 8,742,997 B2**
(45) **Date of Patent:** **Jun. 3, 2014**

(54) **TESTING SYSTEM WITH ELECTRICALLY COUPLED AND WIRELESSLY COUPLED PROBES**

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(75) Inventors: **Joshua G. Nickel**, San Jose, CA (US);
James L. McPeak, Fremont, CA (US);
Jr-Yi Shen, Sunnyvale, CA (US)

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

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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 349 days.

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(21) Appl. No.: **13/111,926**

(Continued)

(22) Filed: **May 19, 2011**

(65) **Prior Publication Data**

US 2012/0293379 A1 Nov. 22, 2012

Primary Examiner — Michael G. Lee
Assistant Examiner — Matthew Mikels

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

(51) **Int. Cl.**
G01R 29/10 (2006.01)

(52) **U.S. Cl.**
USPC **343/703; 343/700 R**

(58) **Field of Classification Search**
USPC 343/703; 324/76; 455/67
See application file for complete search history.

(57) **ABSTRACT**

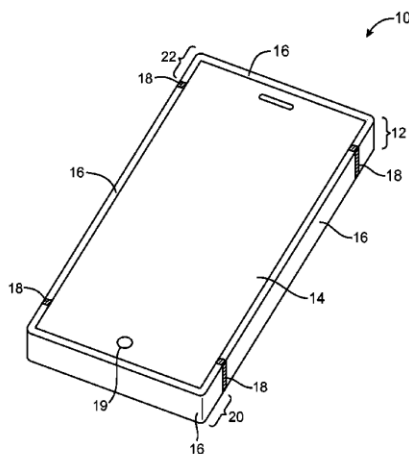
Conductive electronic device structures such as a conductive housing member that forms part of an antenna may be tested during manufacturing. A test system may be provided that has a pair of pins or other contacts. Test equipment such as a network analyzer may provide radio-frequency test signals in a range of frequencies. The radio-frequency test signals may be applied to the conductive housing member or other conductive structures under test using the test probe contacts. An antenna may be used to gather corresponding wireless radio-frequency signal data. Forward transfer coefficient data may be computed from the transmitted and received radio-frequency signals. The forward transfer coefficient data or other test data may be compared to reference data to determine whether the conductive electronic device structures contain a fault.

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11 Claims, 10 Drawing Sheets





US008742999B2

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

(10) **Patent No.:** **US 8,742,999 B2**

(45) **Date of Patent:** **Jun. 3, 2014**

(54) **ANTENNA APPARATUS FOR
SIMULTANEOUSLY TRANSMITTING
MULTIPLE RADIO SIGNALS WITH
DIFFERENT RADIATION
CHARACTERISTICS**

(75) Inventors: **Satoru Amari**, Osaka (JP); **Atsushi
Yamamoto**, Kyoto (JP); **Tsutomu
Sakata**, Osaka (JP)

(73) Assignee: **Panasonic Corporation**, Osaka (JP)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 216 days.

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(21) Appl. No.: **13/257,108**

(22) PCT Filed: **Dec. 20, 2010**

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§ 371 (c)(1),
(2), (4) Date: **Sep. 16, 2011**

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PCT Pub. Date: **Jul. 28, 2011**

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(30) **Foreign Application Priority Data**

Jan. 19, 2010 (JP) 2010-008654

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

(52) **U.S. Cl.**
CPC **H01Q 9/0407** (2013.01); **H01Q 9/0435**
(2013.01)

USPC **343/722; 343/700 MS**

(58) **Field of Classification Search**
CPC **H01Q 9/0407; H01Q 9/0435**
USPC **343/722, 700 MS, 702, 850, 852**
See application file for complete search history.

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(PCT) Application No. PCT/JP2010/007373.

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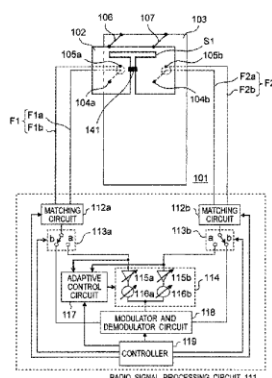
Primary Examiner — Hoanganh Le

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

(57) **ABSTRACT**

An antenna element has a slit including a first portion and a second portion, the first portion extending in a first direction so as to separate first and second feed points from each other, and the second portion extending in a second direction different from the first direction. The slit is configured to resonate at an isolation frequency to produce isolation between the first and second feed points, and configured to form a current path around the slit. A current distribution along the current path generated by exciting through the first feed point is different from a current distribution along the current path generated by exciting through the second feed point, thus providing different radiation characteristics by the different current distributions.

7 Claims, 21 Drawing Sheets





US008743010B2

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

(10) **Patent No.:** **US 8,743,010 B2**
(45) **Date of Patent:** **Jun. 3, 2014**

(54) **ANTENNA DEVICE**

(75) Inventors: **Masahiro Yanagi**, Tokyo (JP); **Shigemi Kurashima**, Tokyo (JP); **Hideaki Yoda**, Tokyo (JP)

(73) Assignee: **Fujitsu Component Limited**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 397 days.

(21) Appl. No.: **12/956,048**

(22) Filed: **Nov. 30, 2010**

(65) **Prior Publication Data**
US 2011/0205138 A1 Aug. 25, 2011

(30) **Foreign Application Priority Data**
Feb. 25, 2010 (JP) 2010-039657

(51) **Int. Cl.**
H01Q 1/48 (2006.01)
H01Q 9/42 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/04 (2006.01)

(52) **U.S. Cl.**
USPC **343/845**

(58) **Field of Classification Search**
USPC 343/845, 701, 866, 702, 906, 700 MS
See application file for complete search history.

(56) **References Cited**
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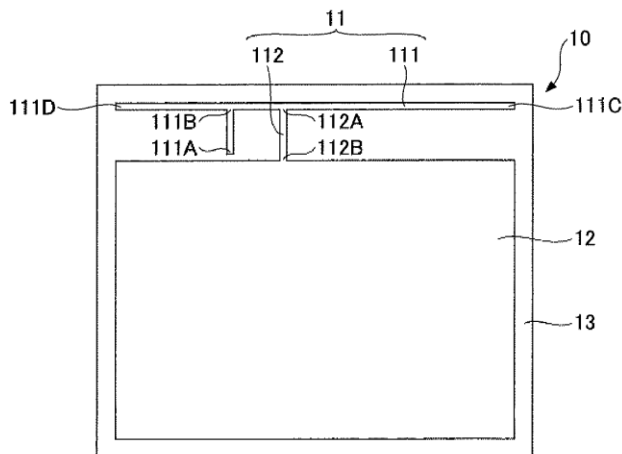
Primary Examiner — Huedung Mancuso

(74) *Attorney, Agent, or Firm* — IPUSA, PLLC

(57) **ABSTRACT**

An antenna device includes a T-shaped element having a first end part, a second end part, and a third end part, the first end part being a feeding point, the T-shaped element being bifurcated at an intermediate point; and a stub having one end connected between the intermediate point and the second end point and another end connected to ground, the stub forming a π -shaped configuration with the T-shaped element; wherein a length of a first line between the first end part and the second end part is longer than a length of a second line between the first end part and the third end part; and the length of the first line and the length of the second line correspond to a first resonance frequency and a second resonance frequency.

11 Claims, 15 Drawing Sheets





US008743011B2

(12) **United States Patent**
Kim

(10) **Patent No.:** **US 8,743,011 B2**
(45) **Date of Patent:** **Jun. 3, 2014**

(54) **INTERNAL ANTENNA SUPPORTING
WIDEBAND IMPEDANCE MATCHING**

(75) Inventor: **Byong-Nam Kim**, Kyeonggi-Do (KR)

(73) Assignee: **Ace Technologies Corporation**, Incheon
(KR)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 370 days.

(21) Appl. No.: **13/133,582**

(22) PCT Filed: **Mar. 30, 2009**

(86) PCT No.: **PCT/KR2009/001599**

§ 371 (c)(1),
(2), (4) Date: **Jun. 8, 2011**

(87) PCT Pub. No.: **WO2010/067924**

PCT Pub. Date: **Jun. 17, 2010**

(65) **Prior Publication Data**

US 2011/0241963 A1 Oct. 6, 2011

(30) **Foreign Application Priority Data**

Dec. 10, 2008 (KR) 10-2008-0125477

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

(52) **U.S. Cl.**
USPC **343/845**

(58) **Field of Classification Search**
USPC 343/845, 700, 700 MS
See application file for complete search history.

(56) **References Cited**

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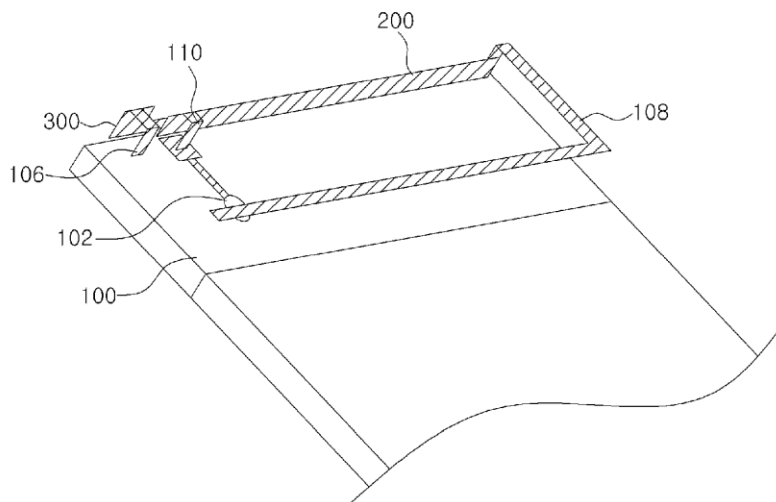
Primary Examiner — Seung Lee

(74) *Attorney, Agent, or Firm* — Edwards Wildman Palmer
LLP; Kongsik Kim; Stephen D. LeBarron

(57) **ABSTRACT**

An internal antenna providing impedance matching for a wide band is disclosed. The disclosed antenna may include: a substrate; an impedance matching/feeding unit comprising a feeding member, separated from the substrate at a designated distance, configured to receive RF signals, and of a designated length in a first direction, and a ground member, separated from the substrate at a designated distance, separated from the feeding member at a designated in a second direction perpendicular to the first direction, and of a designated length in the first direction; and a radiator extending from the ground member; wherein the impedance matching/feeding unit performs impedance matching by way of coupling between the feeding member and the ground member, and the radiator receives coupling feeding from the feeding member. The disclosed antenna has the advantages of overcoming the narrow band problem of a planar inverted-F antenna, and of allowing more efficient utilization of space in an internal antenna.

3 Claims, 9 Drawing Sheets





US008743012B2

(12) **United States Patent**
Kenoun

(10) **Patent No.:** **US 8,743,012 B2**
(45) **Date of Patent:** **Jun. 3, 2014**

(54) **BROAD-BAND, MULTI-BAND ANTENNA**

(75) Inventor: **Robert Kenoun**, Sunnyvale, 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 204 days.

(21) Appl. No.: **13/274,910**

(22) Filed: **Oct. 17, 2011**

(65) **Prior Publication Data**

US 2013/0093636 A1 Apr. 18, 2013

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

(52) **U.S. Cl.**
USPC **343/866**; 343/867; 343/741; 343/742

(58) **Field of Classification Search**
USPC 343/749, 725, 866, 867, 841, 842
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Dieu H. Duong

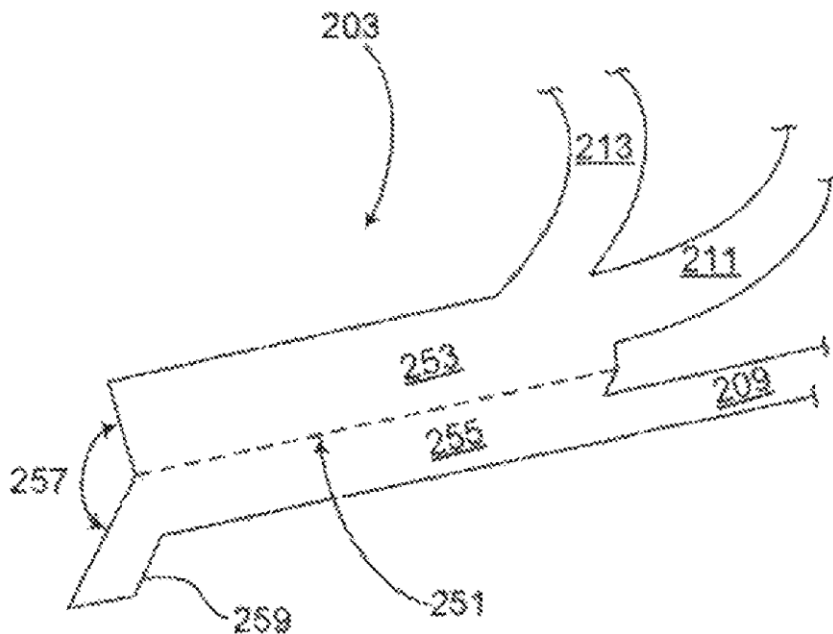
Assistant Examiner — Hai Tran

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

(57) **ABSTRACT**

A broad-band, multi-band antenna. The antenna includes a ground terminal and a feed terminal, an elongated inductor, a first inductive element electrically coupled between the ground terminal and a first extremity of the elongated inductor, a capacitive element in parallel connection with the first inductive element, and a second inductive element electrically coupled between a second extremity of the elongated inductor and the feed terminal.

10 Claims, 11 Drawing Sheets





US008743014B2

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

(10) **Patent No.:** **US 8,743,014 B2**
(45) **Date of Patent:** **Jun. 3, 2014**

(54) **ANTENNA DEVICE AND WIRELESS COMMUNICATION TERMINAL**

(75) Inventors: **Toshinori Kondo**, Osaka (JP); **Hiroyuki Takebe**, Osaka (JP); **Mikio Kuramoto**, Osaka (JP)

(73) Assignee: **Sharp Kabushiki Kaisha**, Osaka (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 293 days.

(21) Appl. No.: **13/057,995**

(22) PCT Filed: **May 26, 2010**

(86) PCT No.: **PCT/JP2010/058911**

§ 371 (c)(1),
(2), (4) Date: **Feb. 7, 2011**

(87) PCT Pub. No.: **WO2011/013438**

PCT Pub. Date: **Feb. 3, 2011**

(65) **Prior Publication Data**

US 2011/0134014 A1 Jun. 9, 2011

(30) **Foreign Application Priority Data**

Jul. 27, 2009 (JP) 2009-174619

(51) **Int. Cl.**
H01Q 3/24 (2006.01)

(52) **U.S. Cl.**
USPC **343/876**; 343/702; 343/777

(58) **Field of Classification Search**
CPC H01Q 3/24; H01Q 21/28; H01Q 1/243
USPC 343/876, 702, 777
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Dameon E Levi

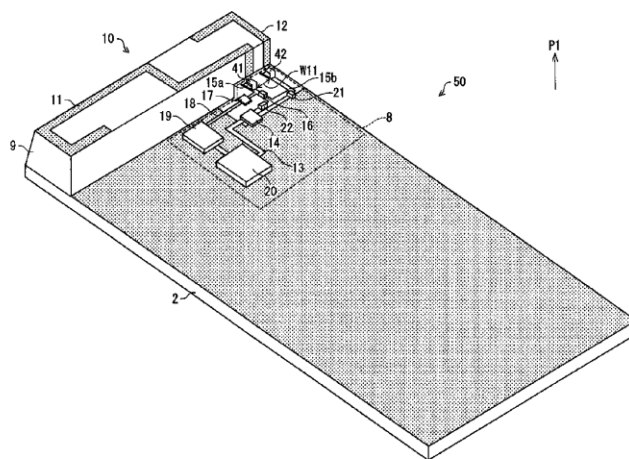
Assistant Examiner — Collin Dawkins

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

(57) **ABSTRACT**

At least three resonance frequencies are obtained by two antenna elements. The antenna device includes antenna elements (11) and (12), a wireless section (20) for supplying power to each of the antenna elements (11) and (12), a PIN diode (16) for electrically connecting and disconnecting the antenna element (11) and the wireless section (20) with/from each other, the antenna elements (11) and (12) being provided so as to be capacitively coupled to each other during the electrical disconnection between the antenna element (11) and the wireless section (20) which electrical disconnection is made by the PIN diode (16).

11 Claims, 29 Drawing Sheets





US008744381B2

(12) **United States Patent**
Wang

(10) **Patent No.:** **US 8,744,381 B2**
(45) **Date of Patent:** **Jun. 3, 2014**

(54) **ADJUSTMENT MODULE, ELECTRONIC DEVICE WITH THE ADJUSTMENT MODULE, AND ANTENNA PERFORMANCE ADJUSTING METHOD THEREOF**

(75) Inventor: **Yin-Tsai Wang**, Taipei (TW)

(73) Assignee: **Wistron Corporation**, 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 66 days.

(21) Appl. No.: **13/541,493**

(22) Filed: **Jul. 3, 2012**

(65) **Prior Publication Data**

US 2013/0088390 A1 Apr. 11, 2013

(30) **Foreign Application Priority Data**

Oct. 7, 2011 (TW) 100136527 A

(51) **Int. Cl.**
H04B 1/04 (2006.01)
H04Q 1/50 (2006.01)

(52) **U.S. Cl.**
USPC **455/121**; 343/861

(58) **Field of Classification Search**
USPC 455/80, 82, 121, 281, 120; 343/820, 343/822, 850, 852, 860, 861

See application file for complete search history.

(56) **References Cited**

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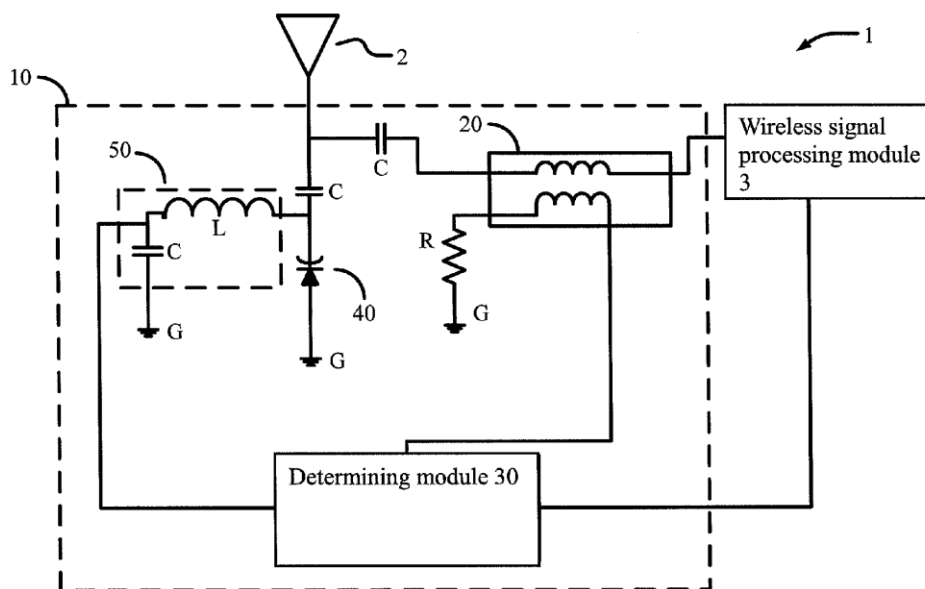
Primary Examiner — Sonny Trinh

(74) *Attorney, Agent, or Firm* — Muncy, Geissler, Olds & Lowe, P.C.

(57) **ABSTRACT**

An adjustment module, an electronic device with the adjustment module, and an antenna performance adjusting method thereof are disclosed. The adjustment module is used for adjusting an antenna module. The antenna module is disposed in the electronic device and used for radiating a wireless signal. The adjustment module includes a monitoring module, a determining module, and a capacitance adjusting unit. The monitoring module is used for detecting an alternating current signal waveform when the antenna module radiates the wireless signal. The determining module receives the alternating current signal waveform and is used for generating an adjusting voltage value when the alternating current signal waveform is a non-constant amplitude. The capacitance adjusting unit is used for changing a capacitance value according to the adjusting voltage value to adjust a resonance point coordinate of the antenna module.

14 Claims, 7 Drawing Sheets





US008749435B2

(12) **United States Patent**
Chiang

(10) **Patent No.:** **US 8,749,435 B2**
(45) **Date of Patent:** **Jun. 10, 2014**

(54) **ANTENNA STRUCTURE AND ELECTRONIC
DEVICE HAVING THE SAME**

(75) Inventor: **Chi-Ming Chiang**, Taoyuan County
(TW)

(73) Assignee: **Auden Techno Corp.**, Taoyuan County
(TW)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 611 days.

(21) Appl. No.: **13/043,450**

(22) Filed: **Mar. 8, 2011**

(65) **Prior Publication Data**

US 2012/0229348 A1 Sep. 13, 2012

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

(52) **U.S. Cl.**
USPC **343/700 MS; 343/702**

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

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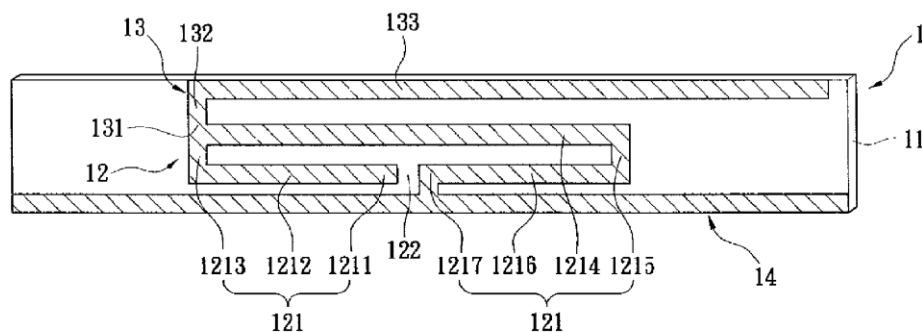
Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — Li & Cai Intellectual
Property (USA) Office

(57) **ABSTRACT**

An antenna structure is disclosed, which includes: a micro-
wave substrate; and a first circuit, a second circuit, and a
ground circuit disposed coplanarly on the microwave sub-
strate. The first circuit is an open loop structure with a dis-
continuous portion and has a pair of ends, namely a feed point
and a ground point, arranged respectively across the discon-
tinuous portion. The ground point is connected to the ground
circuit. The second circuit is disposed at the periphery of the
first circuit, where the second circuit is connected to a con-
necting point of the first circuit on one side thereof. Thereby,
the antenna structure reduces the SAR. In addition, an elec-
tronic device having an antenna structure is disclosed.

9 Claims, 8 Drawing Sheets





US008749437B2

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

(10) **Patent No.:** **US 8,749,437 B2**
(45) **Date of Patent:** **Jun. 10, 2014**

(54) **MOBILE COMMUNICATION TERMINAL**

(75) Inventors: **Jian Bai**, Huizhou (CN); **Yufei Tang**,
Huizhou (CN); **Xin Jin**, Huizhou (CN)

(73) Assignee: **Huizhou TCL Mobile Communication**
Co., Ltd, Huizhou, Guangdong (CN)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 438 days.

(21) Appl. No.: **13/203,881**

(22) PCT Filed: **Apr. 22, 2010**

(86) PCT No.: **PCT/CN2010/072037**

§ 371 (c)(1),
(2), (4) Date: **Aug. 30, 2011**

(87) PCT Pub. No.: **WO2011/003293**

PCT Pub. Date: **Jan. 13, 2011**

(65) **Prior Publication Data**

US 2011/0316749 A1 Dec. 29, 2011

(30) **Foreign Application Priority Data**

Jul. 7, 2009 (CN) 2009 1 0108490

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

(52) **U.S. CL.**

USPC **343/702**; 343/700 MS

(58) **Field of Classification Search**

USPC 343/700, 702, 767, 846, 848, 770
See application file for complete search history.

(56) **References Cited**

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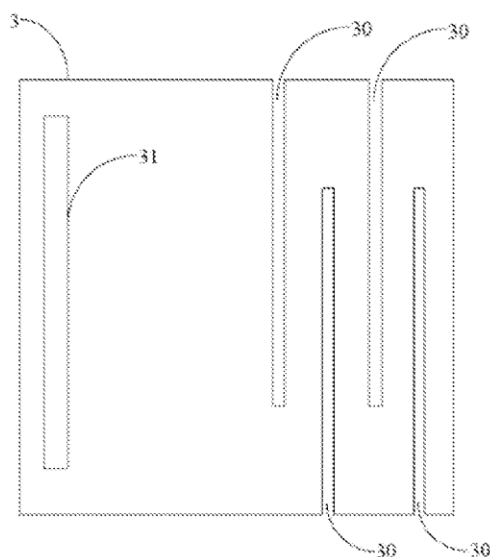
Primary Examiner — Tho G Phan

(74) *Attorney, Agent, or Firm* — Shimokaji & Associates
P.C.

(57) **ABSTRACT**

A mobile communication terminal comprises a motherboard and an internal antenna that is arranged at one end of the motherboard, and an isolation structure similar a hairline crack is formed at the other end of the motherboard far from the internal antenna. The mobile communication terminal provided by the present invention extends the main ground length of an antenna by means of an isolation structure on a motherboard, thereby increasing the antenna bandwidth so as to meet radio-frequency performance requirements.

18 Claims, 2 Drawing Sheets





US008749438B2

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

(10) **Patent No.:** **US 8,749,438 B2**
(45) **Date of Patent:** **Jun. 10, 2014**

(54) **MULTIBAND ANTENNA FOR A MOBILE DEVICE**

(75) Inventors: **Jatupum Jenwatanavet**, San Diego, CA (US); **Allen Minh-Triet Tran**, San Diego, CA (US); **Joe Chieu Le**, 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 297 days.

(21) Appl. No.: **13/229,647**

(22) Filed: **Sep. 9, 2011**

(65) **Prior Publication Data**

US 2012/0230377 A1 Sep. 13, 2012

Related U.S. Application Data

(63) Continuation-in-part of application No. 13/077,039, filed on Mar. 31, 2011.

(60) Provisional application No. 61/387,954, filed on Sep. 29, 2010.

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

(52) **U.S. Cl.**
CPC ... **H01Q 1/38** (2013.01); **H01Q 9/42** (2013.01)
USPC **343/702**; 343/700 MS

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

(56) **References Cited**

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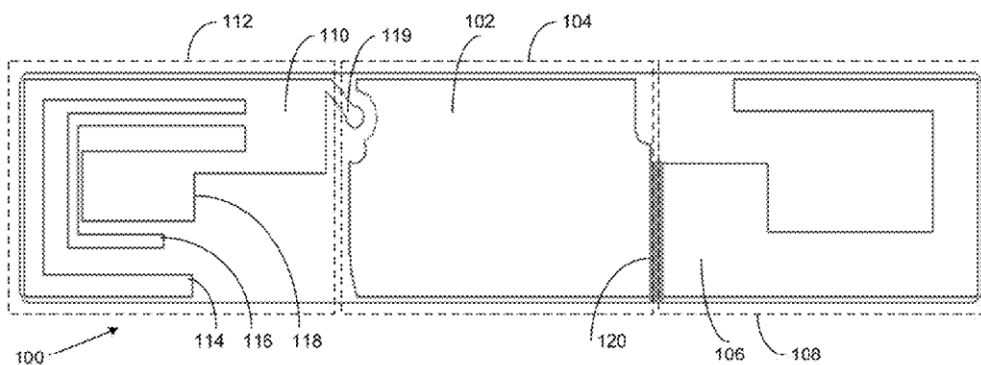
Primary Examiner — Hoanganh Le

(74) *Attorney, Agent, or Firm* — Silicon Valley Patent Group LLP

(57) **ABSTRACT**

A multiband antenna for a mobile device is disclosed. The multiband antenna includes a plurality of flexible antenna arms configured to communicate signals in multiple frequency bands, a flexible antenna counterpoise, a battery configured to provide power to the multiband antenna, and control logic configured to control communication of signals of the multiband antenna, where the plurality of flexible antenna arms, the flexible antenna counterpoise, the battery, and the control logic are bonded to a flexible insulation material. The multiband antenna further includes at least a portion of circuit schematics that connect the plurality of flexible antenna arms, the flexible antenna counterpoise, the battery and the control logic are placed and routed on the flexible insulation material.

32 Claims, 17 Drawing Sheets





US008749443B2

(12) **United States Patent**
Hashizume

(10) **Patent No.:** **US 8,749,443 B2**
(45) **Date of Patent:** **Jun. 10, 2014**

(54) **WIRELESS TERMINAL DEVICE**

(56) **References Cited**

(75) Inventor: **Takanori Hashizume**, Yokohama (JP)

U.S. PATENT DOCUMENTS

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 452 days.

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(21) Appl. No.: **13/142,122**

JP 9-270728 10/1997

(22) PCT Filed: **Dec. 25, 2009**

JP 2002-246822 8/2002

(86) PCT No.: **PCT/JP2009/071672**

JP 2003-273767 9/2003

§ 371 (c)(1),

(2), (4) Date: **Jun. 24, 2011**

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JP 2008-136189 6/2008

(87) PCT Pub. No.: **WO2010/074262**

WO WO 2006-006599 1/2006

PCT Pub. Date: **Jul. 1, 2010**

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(65) **Prior Publication Data**

US 2011/0260942 A1 Oct. 27, 2011

Primary Examiner — Thien M Le

(30) **Foreign Application Priority Data**

Dec. 25, 2008 (JP) 2008-331443

(57) **ABSTRACT**

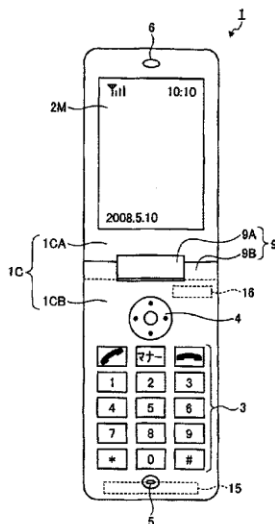
(51) **Int. Cl.**
H01Q 1/52 (2006.01)

(52) **U.S. Cl.**
USPC 343/853; 343/702

(58) **Field of Classification Search**
USPC 343/853, 702, 700 MS, 846, 900, 909
See application file for complete search history.

A first conduction part (12) coated with a conductive paint is formed on a back housing (1CAR) to be attached to one housing of a portable telephone unit at a position near a hinge mechanism (9) which connects the one housing to the other housing of the portable telephone unit. A GPS antenna is disposed on the hinge mechanism (9) side inside the other housing. The first conduction part (12) is in contact with a conductive connection terminal (21). A condenser element (22C) and a coil element (22L) are connected in parallel between the connection terminal (21) and a reference potential line (10G) of a first circuit board (10) disposed inside the aforementioned one housing.

12 Claims, 17 Drawing Sheets





US008749445B2

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

(10) **Patent No.:** **US 8,749,445 B2**
(45) **Date of Patent:** **Jun. 10, 2014**

(54) **VARIABLE CAPACITANCE DEVICE,
ANTENNA MODULE, AND
COMMUNICATION APPARATUS**

(75) Inventors: **Takehisa Ishida**, Tokyo (JP); **Nobuyuki Nagai**, Kanagawa (JP); **Yusaku Kato**, Tokyo (JP)

(73) Assignee: **Sony Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 166 days.

(21) Appl. No.: **13/253,545**

(22) Filed: **Oct. 5, 2011**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Oct. 15, 2010 (JP) 2010-232754

(51) **Int. Cl.**
H01G 5/01 (2006.01)
H01Q 1/50 (2006.01)

(52) **U.S. Cl.**
USPC **343/861**; 361/277

(58) **Field of Classification Search**
USPC 343/861
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Jerome Jackson, Jr.

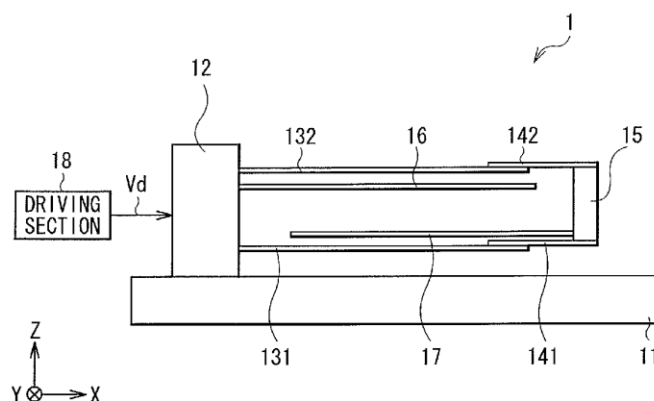
Assistant Examiner — Andrea Lindgren Baltzell

(74) *Attorney, Agent, or Firm* — K&L Gates LLP

(57) **ABSTRACT**

A variable capacitance device includes a fixing member, a fixed electrode having a first end side fixed by the fixing member, an actuator element having a first end side fixed by the fixing member directly or indirectly, a movable electrode provided to connect to the actuator element directly or indirectly and disposed to approximately face the fixed electrode, and a driving section deforming a second end side of the actuator element, to change a distance between the fixed electrode and the movable electrode.

14 Claims, 13 Drawing Sheets





US008749448B2

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

(10) **Patent No.:** **US 8,749,448 B2**
(45) **Date of Patent:** **Jun. 10, 2014**

(54) **MULTIBAND ANTENNA AND WIRELESS COMMUNICATION DEVICE EMPLOYING THE SAME**

(75) Inventors: **Tun-Yuan Tsou**, New Taipei (TW);
Yi-Chieh Lee, New Taipei (TW)

(73) Assignee: **Chi Mei Communication Systems, Inc.**, New Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 314 days.

(21) Appl. No.: **13/188,053**

(22) Filed: **Jul. 21, 2011**

(65) **Prior Publication Data**
US 2012/0274538 A1 Nov. 1, 2012

(30) **Foreign Application Priority Data**
Apr. 27, 2011 (TW) 100114621 A

(51) **Int. Cl.**
H01Q 5/01 (2006.01)
H01Q 9/04 (2006.01)
H01Q 5/00 (2006.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/0065** (2013.01); **H01Q 1/241** (2013.01); **H01Q 5/0058** (2013.01); **H01Q 5/0068** (2013.01)
USPC **343/876**

(58) **Field of Classification Search**
CPC ... H01Q 1/243; H01Q 5/0058; H01Q 5/0065; H01Q 5/0068
USPC 343/876, 702
See application file for complete search history.

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Primary Examiner — Robert Karacsony

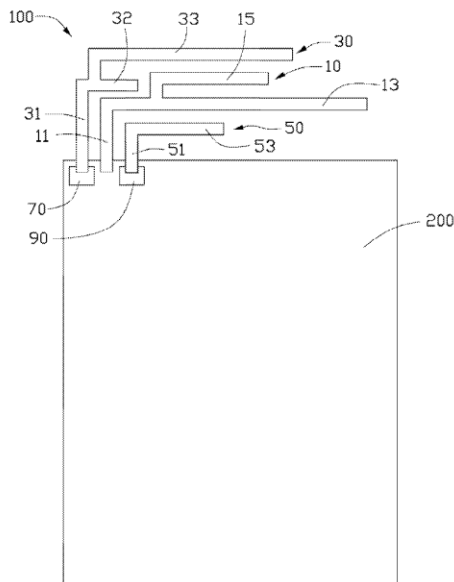
Assistant Examiner — Amal Patel

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

(57) **ABSTRACT**

A multiband antenna in a wireless communication device includes a main antenna, a first parasitic portion, a second parasitic portion, a first switch, and a second switch, the first switch is used to control functioning of the first parasitic portion. The second switch is used to control functioning of the second parasitic portion. Therefore, the main antenna can resonate alone or in combination with the functioning first parasitic portion and/or the functioning second parasitic portion, the multiband antenna has different operating frequency bands and different operating SAR.

10 Claims, 3 Drawing Sheets





US008750798B2

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

(10) **Patent No.:** **US 8,750,798 B2**
(45) **Date of Patent:** **Jun. 10, 2014**

(54) **MULTIPLE INPUT MULTIPLE OUTPUT
ANTENNA MODULE AND ASSOCIATED
METHOD**

(75) Inventors: **Qinjiang Rao**, Ottawa (CA); **James Paul Warden**, Irving, TX (US); **Mina Ayatollahi**, Waterloo (CA)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 168 days.

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(21) Appl. No.: **12/834,675**

(22) Filed: **Jul. 12, 2010**

(65) **Prior Publication Data**

US 2012/0009884 A1 Jan. 12, 2012

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

(52) **U.S. Cl.**
USPC **455/41.2**; 455/575.7; 455/41.1; 455/525;
455/90.3; 455/575.1; 455/550.1; 455/277.1;
455/63.1; 455/296; 343/850; 343/700; 343/702;
343/812; 343/722; 370/278; 370/328; 370/430

(58) **Field of Classification Search**
USPC 455/575.7, 41.1, 525, 90.3, 575.1,
455/550.1, 277.1, 63.1, 296, 41.2; 343/850,
343/700, 702, 812, 722; 370/278, 328, 430
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Edward Urban

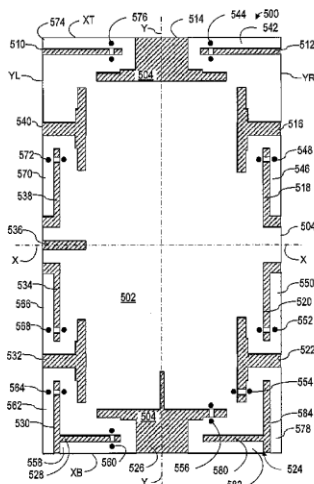
Assistant Examiner — Ganiyu A Hanidu

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

(57) **ABSTRACT**

A multiple input multiple output (MIMO) antenna module, comprising a first signal feed port coupled to a first antenna element disposed along a first edge of an antenna array board, a second signal feed port coupled to a second antenna element disposed on the antenna array board and a transceiver operable to be selectively coupled to either or both of the first and second signal feed ports.

10 Claims, 6 Drawing Sheets





US008750947B2

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

(10) **Patent No.:** **US 8,750,947 B2**
(45) **Date of Patent:** **Jun. 10, 2014**

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

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

(72) Inventors: **Chien-Chun Cheng**, Taoyuan (TW);
Yu-Che Lin, Taoyuan (TW);
Chung-Ting Hung, 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.

(21) Appl. No.: **13/749,780**

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

(65) **Prior Publication Data**

US 2013/0225234 A1 Aug. 29, 2013

Related U.S. Application Data

(60) Provisional application No. 61/602,843, filed on Feb. 24, 2012.

(51) **Int. Cl.**
H04M 1/00 (2006.01)
H01Q 1/24 (2006.01)
H01Q 5/00 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/00** (2013.01); **H01Q 5/001** (2013.01); **H01Q 5/0037** (2013.01); **H01Q 5/0068** (2013.01)
USPC **455/575.5**; 343/702; 343/700 MS

(58) **Field of Classification Search**

CPC H01Q 5/00; H01Q 5/001; H01Q 5/0037; H01Q 5/0068; H01Q 5/01
USPC 455/575.5; 343/702, 700 MS
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Duc M Nguyen

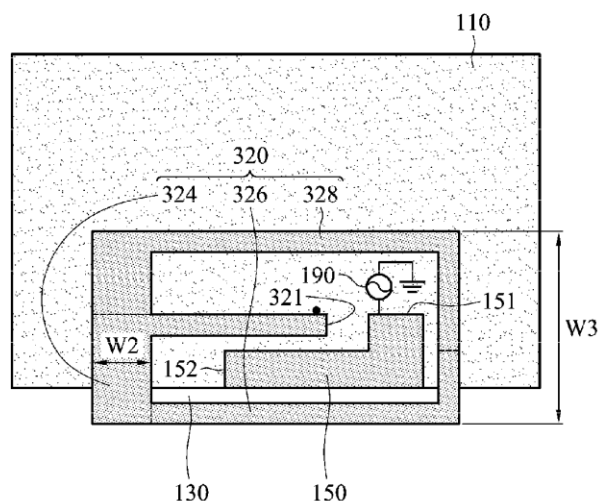
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**

A mobile device includes a ground plane, a grounding trace, and a feeding trace. The grounding trace defines a notch, and has a shorted end coupled to the ground plane. The feeding trace is disposed adjacent to the grounding trace, and has a feeding end and an open end. An antenna structure is formed by the grounding trace and the feeding trace. The feeding end of the feeding trace is coupled to a signal source. The open end of the feeding trace substantially extends into the notch of the grounding trace.

17 Claims, 6 Drawing Sheets

300





US008750949B2

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

(10) **Patent No.:** **US 8,750,949 B2**
(45) **Date of Patent:** **Jun. 10, 2014**

(54) **ENGAGEMENT FEATURES AND
ADJUSTMENT STRUCTURES FOR
ELECTRONIC DEVICES WITH INTEGRAL
ANTENNAS**

(75) Inventors: **Nicholas G. L. Merz**, San Francisco, CA
(US); **Dean F. Darnell**, 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 408 days.

(21) Appl. No.: **13/018,263**

(22) Filed: **Jan. 31, 2011**

(65) **Prior Publication Data**
US 2012/0178382 A1 Jul. 12, 2012

Related U.S. Application Data

(60) Provisional application No. 61/431,523, filed on Jan.
11, 2011.

(51) **Int. Cl.**
H04Q 1/24 (2006.01)

(52) **U.S. Cl.**
USPC **455/575.7**; 343/702

(58) **Field of Classification Search**
USPC 455/550.1, 575.1, 575.4, 90.1, 91, 107,
455/121, 269, 347, 351, 575.7;
343/700 MS, 702, 850, 860, 876
See application file for complete search history.

(56) **References Cited**

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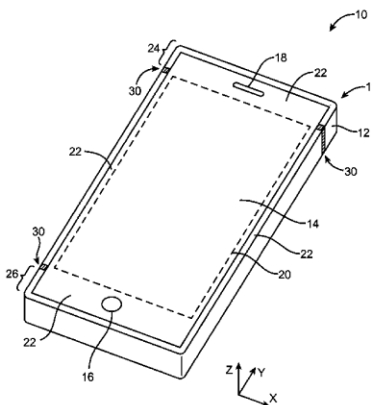
Primary Examiner — Thanh Le

(74) *Attorney, Agent, or Firm* — Treyz Law Group; G. Victor
Treyz; David C. Kellogg

(57) **ABSTRACT**

Electronic devices may be provided that contain wireless
communications circuitry. The wireless communications cir-
cuitry may include antenna structures that are formed from an
internal ground plane and a peripheral conductive housing
member. The internal ground plane and peripheral conductive
housing member may be separated by a gap. The internal
ground plane may be formed from sheet metal structures
having engagement features such as tabs bent upwards at an
angle. Plastic structures may be insert molded over the
engagement features. When the internal ground plane is
mounted in the electronic device, the plastic structures may
bridge the gap between the internal ground plane and the
peripheral conductive housing member. An adjustable struc-
ture such as a washer with a selectable thickness may be
mounted to the peripheral conductive housing member
opposing conductive structures across the gap. The thickness
may be adjusted to adjust antenna performance.

20 Claims, 9 Drawing Sheets





US008754814B2

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

(10) **Patent No.:** **US 8,754,814 B2**
(45) **Date of Patent:** **Jun. 17, 2014**

(54) **ANTENNA FOR MULTI MODE MIMO COMMUNICATION IN HANDHELD DEVICES**

(75) Inventors: **Qinjiang Rao**, Waterloo (CA); **Dong Wang**, Waterloo (CA)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 730 days.

(21) Appl. No.: **12/617,763**

(22) Filed: **Nov. 13, 2009**

(65) **Prior Publication Data**

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(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 1/38 (2006.01)

H01Q 21/30 (2006.01)

H01Q 9/42 (2006.01)

H01Q 5/00 (2006.01)

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

CPC **H01Q 21/30** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 9/42** (2013.01); **H01Q 5/0058** (2013.01)

USPC **343/702**; **343/700 MS**

(58) **Field of Classification Search**

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

(56) **References Cited**

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Primary Examiner — Robert Karacsony

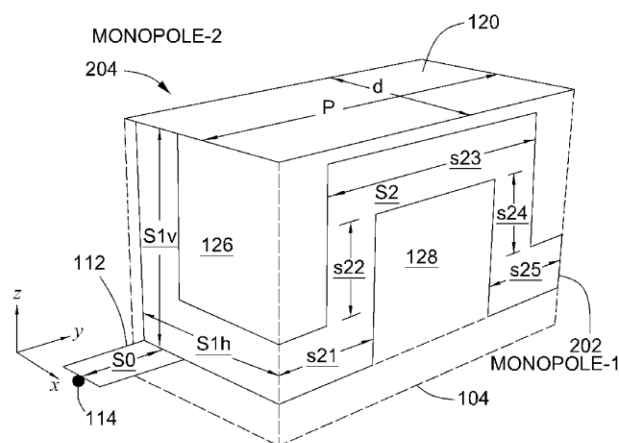
(74) *Attorney, Agent, or Firm* — Moffat & Co.

(57)

ABSTRACT

A multi-band antenna comprising a dielectric substrate, a ground plane formed on a first area of the dielectric substrate, a radiation part arranged in a second area of the dielectric substrate where the ground surface is not formed, a feed section formed of a metallic trace and having one end connected to the radiation part and an opposite end disposed near an edge of the ground plane for forming a feed point and the radiation part having a pair of monopole antenna elements formed of conductive metallic traces; a first monopole antenna element for radiating at a first resonant frequency, and a second monopole antenna element for radiating at a second resonant frequency and the conductive metallic traces being folded to form a three dimensional structure, with at least a portion of said first monopole spaced from a plane of the substrate and said second monopole.

17 Claims, 32 Drawing Sheets





US008754815B2

(12) **United States Patent**
Leem

(10) **Patent No.:** **US 8,754,815 B2**
(45) **Date of Patent:** **Jun. 17, 2014**

(54) **PORTABLE TERMINAL AND ANTENNA
DEVICE THEREOF**

(75) Inventor: **Ji-Hun Leem**, Gyeonggi-do (KR)

(73) Assignee: **LG Electronics Inc.**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 993 days.

(21) Appl. No.: **12/709,427**

(22) Filed: **Feb. 19, 2010**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

May 26, 2009 (KR) 10-2009-0046102
Jul. 30, 2009 (KR) 10-2009-0070255

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

(52) **U.S. Cl.**
USPC **343/702**; 343/846; 343/848

(58) **Field of Classification Search**
USPC 343/702, 846, 848
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Dameon Levi

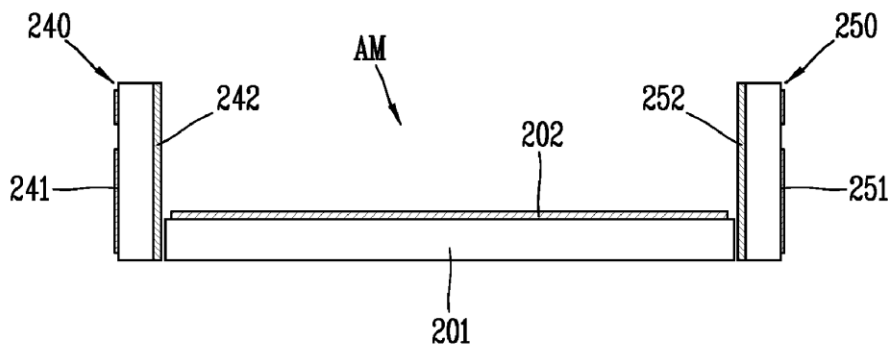
Assistant Examiner — Collin Dawkins

(74) *Attorney, Agent, or Firm* — Lee, Hong, Degerman,
Kang & Waimey

(57) **ABSTRACT**

A portable terminal includes a terminal body, a first antenna provided on a circuit board having a first ground that is used by the first antenna, and an antenna assembly integrated into the terminal body. The antenna assembly of the portable terminal includes at least one diversity antenna fed to the circuit board and formed on the circuit board having a ground that is independent from the first ground. The at least one diversity antenna is formed into an angled configuration with respect to the circuit board.

9 Claims, 20 Drawing Sheets





US008754820B2

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

(10) **Patent No.:** **US 8,754,820 B2**
(45) **Date of Patent:** ***Jun. 17, 2014**

(54) **ANTENNA APPARATUS PROVIDED WITH
ELECTROMAGNETIC COUPLING
ADJUSTER AND ANTENNA ELEMENT
EXCITED THROUGH MULTIPLE FEEDING
POINTS**

(75) Inventors: **Hiroshi Iwai**, Osaka (JP); **Atsushi
Yamamoto**, Kyoto (JP); **Tsutomu
Sakata**, Osaka (JP); **Satoru Amari**,
Osaka (JP)

(73) Assignee: **Panasonic Corporation**, Osaka (JP)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 1159 days.

This patent is subject to a terminal dis-
claimer.

(21) Appl. No.: **11/951,153**

(22) Filed: **Dec. 5, 2007**

(65) **Prior Publication Data**

US 2008/0143613 A1 Jun. 19, 2008

(30) **Foreign Application Priority Data**

Dec. 5, 2006 (JP) 2006-328198

(51) **Int. Cl.**
H01Q 21/00 (2006.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
USPC **343/725**; 343/702

(58) **Field of Classification Search**
USPC 343/702, 767, 850, 893, 770, 846, 725,
343/729

See application file for complete search history.

(56) **References Cited**

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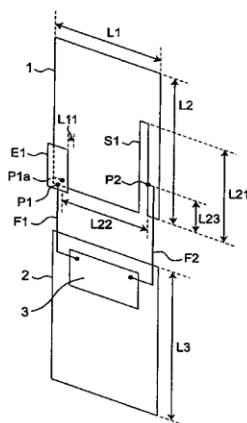
Primary Examiner — Robert Karacsony

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

(57) **ABSTRACT**

An antenna apparatus includes a first feeding point and a second feeding point provided at respective positions on an antenna element. The antenna element is excited through the first and second feeding points simultaneously so as to operate as a first antenna portion and a second antenna portion simultaneously, the first antenna portion and the second antenna portion correspond to the first and second feeding points, respectively. The antenna element further includes, between the first and second feeding points, an electromagnetic coupling adjuster for making an amount of isolation between the first and second antenna portions.

16 Claims, 36 Drawing Sheets





US008754821B2

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

(10) **Patent No.:** **US 8,754,821 B2**
(45) **Date of Patent:** **Jun. 17, 2014**

(54) **MULTI-BAND ANTENNA**

(75) Inventors: **Ying-Chih Wang**, Tao Yuan Hsien
(TW); **Ling-Chen Wei**, Tainan (TW);
Tsung-Ming Kuo, Tainan (TW)

(73) Assignee: **Quanta Computer Inc.**, Tao Yuan Hsien
(TW)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 446 days.

(21) Appl. No.: **13/151,032**

(22) Filed: **Jun. 1, 2011**

(65) **Prior Publication Data**

US 2012/0154230 A1 Jun. 21, 2012

(30) **Foreign Application Priority Data**

Dec. 20, 2010 (TW) 99144735 A

(51) **Int. Cl.**
H01Q 21/00 (2006.01)

(52) **U.S. Cl.**
USPC **343/725; 343/724**

(58) **Field of Classification Search**
USPC 343/725, 724, 908, 702, 895, 828
See application file for complete search history.

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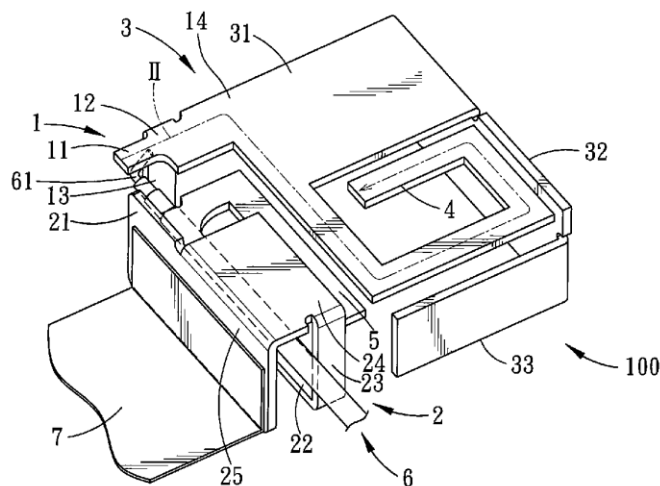
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(57) **ABSTRACT**

A multi-band antenna includes a feed-in section, a loop conductor, a first conductor arm, a second conductor arm, and a third conductor arm. The feed-in section includes a feed-in point for feeding of signals. The loop conductor extends from the feed-in section and has a grounding point disposed adjacent to the feed-in point. The first conductor arm is configured to resonate in a first frequency band and extends from the feed-in section. The second conductor arm is configured to resonate in a second frequency band and extends from the feed-in section. The third conductor arm is configured to resonate in a third frequency band and extends from the feed-in section. At least one of the loop conductor, the first conductor arm, the second conductor arm, and the third conductor arm is bent so as to be disposed in different planes.

11 Claims, 10 Drawing Sheets





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(12) **United States Patent**
Dou

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(45) **Date of Patent:** **Jun. 17, 2014**

(54) **TUNING ELEMENTS FOR SPECIFIC
ABSORPTION RATE REDUCTION**

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
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(51) **Int. Cl.**
H01Q 13/10 (2006.01)
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H01Q 19/00 (2006.01)

(52) **U.S. Cl.**
USPC **343/767; 343/702; 343/833**

(58) **Field of Classification Search**
USPC **343/702, 767, 770, 833**
See application file for complete search history.

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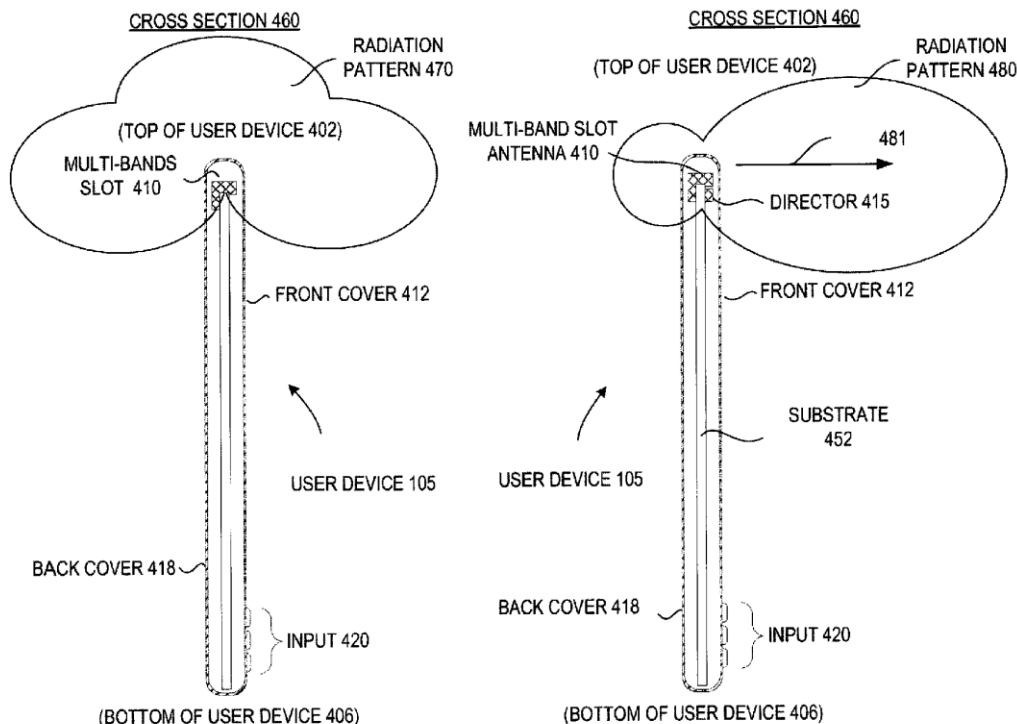
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(57) **ABSTRACT**

A user device having a multi-band slot antenna with multiple slot openings in conductive material and one or more tuning elements physically coupled to the multi-band slot antenna is described.

32 Claims, 12 Drawing Sheets





US008754826B2

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

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(54) **ANTENNA DEVICE AND RADIO COMMUNICATION APPARATUS**

USPC 333/17.3, 24 R, 32, 167, 172, 175, 262;
455/120, 121, 123, 125, 275, 276.1,
455/277.1, 290

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See application file for complete search history.

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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 268 days.

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(21) Appl. No.: **13/038,582**

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USPC **343/861**

(58) **Field of Classification Search**

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H04B 1/406; H04B 1/44; H04B 1/0053;
H04B 1/0057; H04B 1/006; H04B 1/0067;
H04B 1/005; H03F 1/56; H03F 3/60; H03F
2200/111; H03F 2200/423; H03F 2200/222;
H03F 2200/252; H03F 2200/255; H03F
2200/387; H03H 7/383; H03H 7/0115;
H03H 7/1758; H03H 7/1766; H03H 7/38;
H03H 7/465; H03H 7/0123; H03H 7/0153;
H03H 7/12; H03H 7/40; H01Q 1/521; H01Q
7/005

(57) **ABSTRACT**

An antenna device that includes an antenna having a single feed and a shunt circuit. The shunt circuit includes a first shunt matching circuit causing impedance, viewed from a main path connecting the antenna and a radio frequency circuit, to be substantially infinite with respect to all frequency ranges handled by the antenna, and a second shunt matching circuit providing a predetermined impedance characteristic with respect to a first subset of the frequency ranges handled by the antenna. Each of the first and second shunt matching circuits are selectively connected to the main path, and a selection controller of the antenna device controls selection of which of the first and second shunt matching circuits are connected to the main path.

6 Claims, 15 Drawing Sheets

