



US008760239B2

(12) **United States Patent**
Schmidhammer

(10) **Patent No.:** **US 8,760,239 B2**
(45) **Date of Patent:** **Jun. 24, 2014**

(54) **IMPEDANCE MATCHING CIRCUIT FOR MATCHING PLANAR ANTENNAS**

(75) Inventor: **Edgar Schmidhammer**, Stein an der Traun (DE)

(73) Assignee: **Qualcomm Technologies, 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 518 days.

(21) Appl. No.: **13/120,260**

(22) PCT Filed: **Oct. 6, 2009**

(86) PCT No.: **PCT/EP2009/062981**

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

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PCT Pub. Date: **Apr. 15, 2010**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Oct. 8, 2008 (DE) 10 2008 050 743

(51) **Int. Cl.**
H03H 7/38 (2006.01)

(52) **U.S. Cl.**
CPC **H03H 7/38** (2013.01)
USPC **333/32**

(58) **Field of Classification Search**
USPC 333/32, 167, 174, 175, 176
See application file for complete search history.

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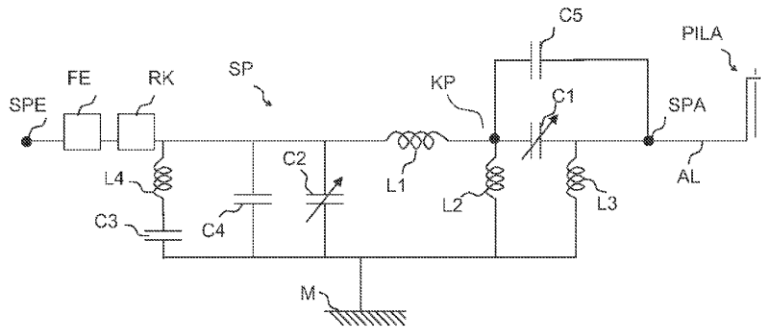
Primary Examiner — Stephen Jones

(74) Attorney, Agent, or Firm — Smith Risley Tempel Santos LLC

(57) **ABSTRACT**

A circuit includes a signal path having a node between a signal path input and a signal path output. A first inductive element is connected between the signal path input and the node and a first capacitive element whose capacitance is variably adjustable is connected between the node and the signal path output. A second variable-capacitance capacitive element is connected between the signal path input and ground. A second inductive element is connected between the node and ground, and a third inductive element is connected between the signal path output and ground.

25 Claims, 1 Drawing Sheet





US008760348B2

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

(10) **Patent No.:** **US 8,760,348 B2**
(45) **Date of Patent:** **Jun. 24, 2014**

(54) **MULTI-BAND ANTENNA**

(75) Inventors: **Yi-Feng Huang**, New Taipei (TW);
Jia-Hung Su, New Taipei (TW); **Kai Shih**, New Taipei (TW)

(73) Assignee: **Cheng Uei Precision Industry Co., Ltd.**, 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 213 days.

(21) Appl. No.: **13/489,448**

(22) Filed: **Jun. 5, 2012**

(65) **Prior Publication Data**

US 2013/0321213 A1 Dec. 5, 2013

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

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

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 9/42; H01Q 5/0051
USPC 343/700 MS, 702, 848
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Tan Ho

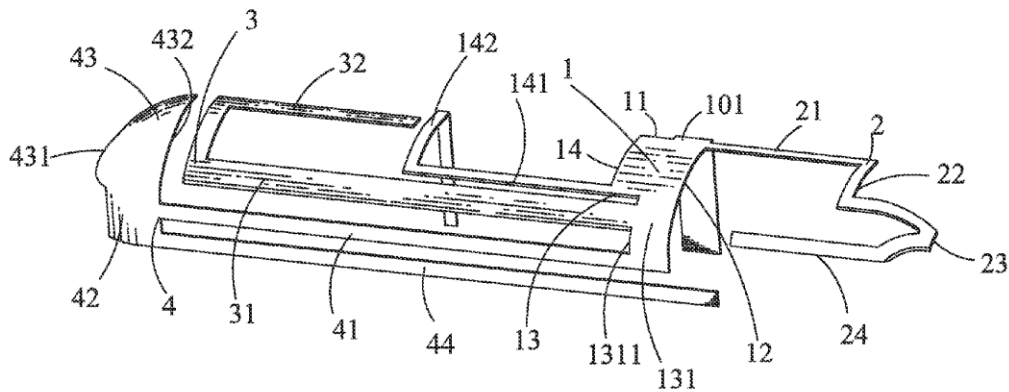
(74) *Attorney, Agent, or Firm* — Cheng-Ju Chiang

(57) **ABSTRACT**

A multi-band antenna includes a base plate of which a feeding portion, a connection section and a ground portion are connected with rear, front and left edges of the base plate respectively, a first radiating element connected with a right edge of the base plate and coplanar with the base plate, a second radiating element coplanar with the base plate and the connection section and connected with an upper portion of a left rim of the connection section with a free end thereof adjacent to the ground portion, and a third radiating element connected with a lower end of the left rim of the connection section. Wherein the second radiating element is apart located between the ground portion and the third radiating element.

6 Claims, 1 Drawing Sheet

100





US008760357B2

(12) **United States Patent**
Kim

(10) **Patent No.:** **US 8,760,357 B2**
(45) **Date of Patent:** **Jun. 24, 2014**

(54) **WIDEBAND SINGLE RESONANCE ANTENNA**

(75) Inventor: **Sung-Min Kim**, Gyeonggi-do (KR)

(73) Assignee: **KT Corporation**, Gyeonggi-do (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 121 days.

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(21) Appl. No.: **13/325,118**

(22) Filed: **Dec. 14, 2011**

(65) **Prior Publication Data**

US 2012/0154243 A1 Jun. 21, 2012

(30) **Foreign Application Priority Data**

Dec. 17, 2010 (KR) 10-2010-0129831

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

(52) **U.S. Cl.**
USPC **343/860**; 343/700 MS

(58) **Field of Classification Search**
USPC 343/860
See application file for complete search history.

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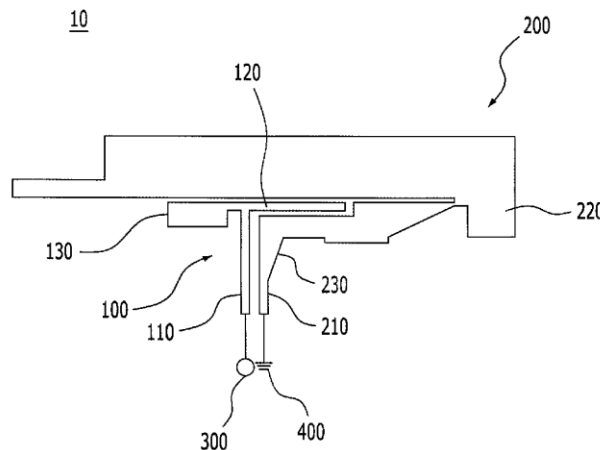
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Primary Examiner — Jerome Jackson, Jr.
Assistant Examiner — Andrea Lindgren Baltzel
(74) *Attorney, Agent, or Firm* — IP Legal Services, LLC

(57) **ABSTRACT**

Wideband single resonance antenna. An antenna may include a first conductor unit and a second conductor unit. The first conductor unit may be configured to have one end electrically coupled to a power. The second conductor unit may be configured to have one end electrically coupled to a ground, to surround at least one side of the first conductor unit, and to be electrically separated from the first conductor unit.

20 Claims, 2 Drawing Sheets





US008760360B2

(12) **United States Patent**
Kuo

(10) **Patent No.:** **US 8,760,360 B2**
(45) **Date of Patent:** **Jun. 24, 2014**

- (54) **SWITCHING MULTI-MODE ANTENNA**
- (75) Inventor: **Jerry W. Kuo**, San Jose, CA (US)
- (73) Assignee: **Amazon Technologies, Inc.**, Reno, NV (US)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 118 days.

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- (21) Appl. No.: **13/421,870**
- (22) Filed: **Mar. 16, 2012**

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International Search Report and Written Opinion for International Application No. PCT/US2013/031331, Sep. 17, 2013, 16 pages.

- (65) **Prior Publication Data**
US 2013/0241797 A1 Sep. 19, 2013

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Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — Lowenstein Sandler LLP

- (51) **Int. Cl.**
H01Q 3/24 (2006.01)
- (52) **U.S. Cl.**
USPC **343/876; 343/850**
- (58) **Field of Classification Search**
USPC 343/876, 853; 455/553.1, 552.1, 101, 455/41.2, 183.2
See application file for complete search history.

(57) **ABSTRACT**

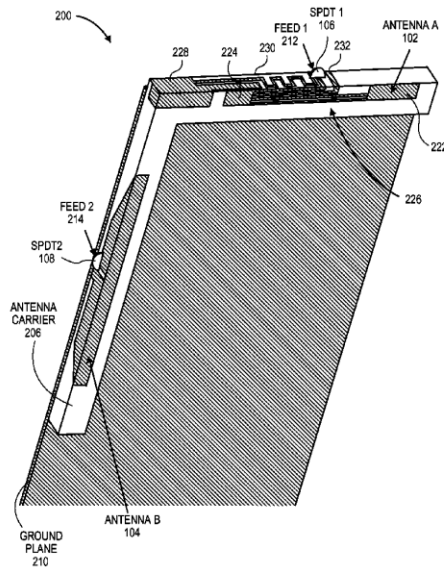
Methods and apparatus of a switching multi-mode antenna of a user device are described. A switching multi-mode antenna is coupled to receive an RF input from one of at least two radio frequency (RF) feeds via a switch. The switching multi-mode antenna includes multiple antenna structures to communicate information in multiple frequency bands. A first antenna structure is configured to transmit first information in one of the frequency bands and a second antenna structure is configured to receive second information in the same one of the frequency bands.

- (56) **References Cited**

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33 Claims, 14 Drawing Sheets





US008761847B2

(12) **United States Patent**
Ayatollahi

(10) **Patent No.:** **US 8,761,847 B2**
(45) **Date of Patent:** ***Jun. 24, 2014**

(54) **MOBILE WIRELESS COMMUNICATIONS DEVICE HAVING AN ANTENNA ASSEMBLY WITH CORNER COUPLED RECTANGULAR BASE CONDUCTOR PORTIONS AND RELATED METHODS**

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Primary Examiner — Erika A Washington

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

(71) Applicant: **Research in Motion Limited**, Waterloo (CA)

(72) Inventor: **Mina Ayatollahi**, 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 disclaimer.

(21) Appl. No.: **13/869,278**

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

(65) **Prior Publication Data**

US 2013/0237295 A1 Sep. 12, 2013

Related U.S. Application Data

(63) Continuation of application No. 13/114,476, filed on May 24, 2011, now Pat. No. 8,457,699.

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

(52) **U.S. Cl.**
USPC **455/575.7; 455/575.1; 343/700 MS**

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

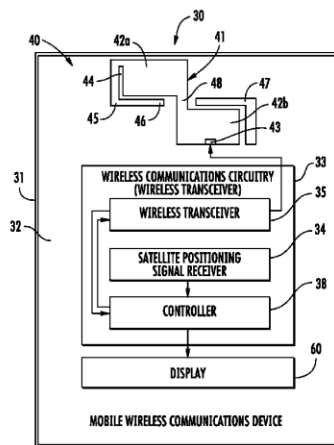
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(57) **ABSTRACT**

A mobile wireless communications device may include a portable housing, a substrate carried by the portable housing, and wireless communications circuitry carried by the substrate. The mobile wireless communications device may also include at least one antenna assembly carried by the substrate and coupled to the wireless communications circuitry. The at least one antenna assembly may include an electrically conductive base conductor having a first rectangular base portion and a second rectangular base portion offset therefrom. The first and second base portions may be coupled at respective diagonally opposing corners thereof and having an antenna feed defined along an outer portion of one of the first and second rectangular base portions. The at least one antenna assembly may include at least one electrically conductive arm extending along at least one side of one of the first and second rectangular base portions and spaced apart therefrom.

19 Claims, 8 Drawing Sheets





US008766855B2

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

(10) **Patent No.:** **US 8,766,855 B2**
(45) **Date of Patent:** **Jul. 1, 2014**

(54) **MICROSTRIP-FED SLOT ANTENNA**

(75) Inventors: **Behzad Biglarbegian**, North York (CA);
Mohammad-Reza Nezhad-Ahmadi,
Waterloo (CA); **Safieddin**
Safavi-Naeini, Waterloo (CA)

(73) Assignee: **Semiconductor Components**
Industries, LLC, Phoenix, AZ (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.: **13/177,756**

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

(65) **Prior Publication Data**

US 2012/0075154 A1 Mar. 29, 2012

Related U.S. Application Data

(60) Provisional application No. 61/362,827, filed on Jul. 9,
2010.

(51) **Int. Cl.**
H01Q 13/08 (2006.01)

(52) **U.S. Cl.**
USPC **343/700 MS; 343/767; 343/770**

(58) **Field of Classification Search**

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

(56) **References Cited**

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Primary Examiner — Jerome Jackson, Jr.

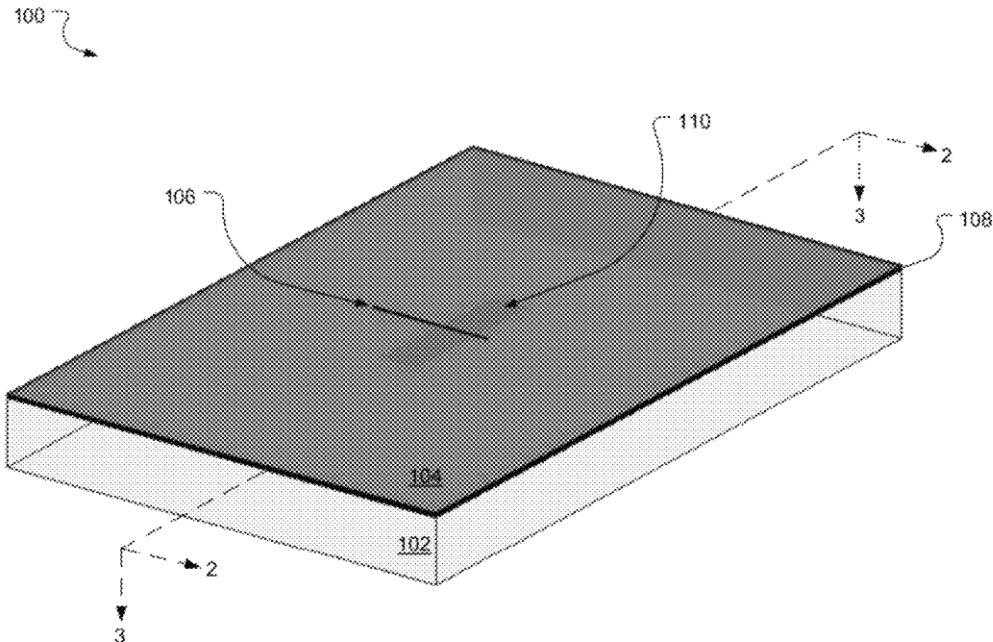
Assistant Examiner — Michael Bouizza

(74) *Attorney, Agent, or Firm* — Noon Intellectual Property
Law, P.C.

(57) **ABSTRACT**

A microstrip-fed antenna is disclosed having a first dielectric
substrate and a second dielectric substrate. The second dielec-
tric substrate is disposed on the first dielectric substrate and
the first dielectric substrate has a relative permittivity greater
than or equal to the second dielectric substrate. The antenna
further includes a microstrip line formed in the second dielec-
tric substrate and a metal layer formed in the second dielec-
tric substrate. The metal layer is positioned between the micros-
trip line and the first dielectric substrate and includes a slot.

20 Claims, 13 Drawing Sheets





US008766856B2

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

(10) **Patent No.:** **US 8,766,856 B2**
(45) **Date of Patent:** **Jul. 1, 2014**

(54) **WIDEBAND ANTENNA**

USPC 343/700 MS, 702, 866; 455/90
See application file for complete search history.

(73) Inventors: **Chih-Sen Hsieh**, Hsinchu (TW);
Jen-Min Shau, Hsinchu (TW); **Hsiao-Yi Lin**, Hsinchu (TW)

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(73) Assignee: **Wistron NeWeb Corporation**, Hsinchu Science Park, 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 293 days.

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(21) Appl. No.: **13/210,378**

Primary Examiner — Huedung Mancuso

(22) Filed: **Aug. 16, 2011**

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

(65) **Prior Publication Data**

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(57) **ABSTRACT**

(30) **Foreign Application Priority Data**

May 25, 2011 (TW) 100118328 A

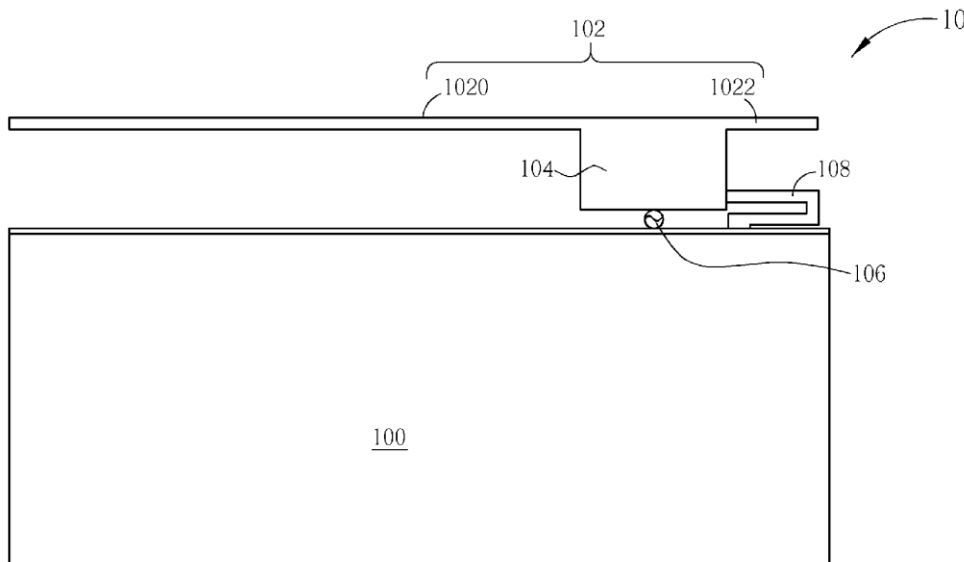
A wideband antenna includes a grounding element electrically connected to a ground, a radiating element, a matching adjustment element electrically connected to the radiating element, a feed-in element electrically connected between the matching adjustment element and the grounding element for receiving feed-in signals, and a shorting element electrically connected between the matching adjustment element and the grounding element. A width of the matching adjustment element is related to a bandwidth of the wideband antenna.

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

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

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 9/0407; H01Q 9/0421; H01Q 1/243; H01Q 5/0003

4 Claims, 7 Drawing Sheets





US008766858B2

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

(10) **Patent No.:** **US 8,766,858 B2**
(45) **Date of Patent:** **Jul. 1, 2014**

- (54) **ANTENNAS MOUNTED UNDER DIELECTRIC PLATES**
- (75) Inventors: **Qingxiang Li**, Mountain View, CA (US); **Robert W. Schlub**, Cupertino, CA (US); **Fletcher R. Rothkopf**, Los Altos, CA (US); **Adam D. Mittleman**, San Francisco, CA (US); **Yi Jiang**, Sunnyvale, CA (US); **Emily McMilin**, Mountain View, CA (US); **Lijun Zhang**, San Jose, CA (US)

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- (73) Assignee: **Apple Inc.**, Cupertino, CA (US)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 816 days.

(21) Appl. No.: **12/870,766**

(22) Filed: **Aug. 27, 2010**

(65) **Prior Publication Data**

US 2012/0050114 A1 Mar. 1, 2012

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

- (52) **U.S. Cl.**
CPC **H01Q 1/24** (2013.01)
USPC **343/702; 343/718**

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

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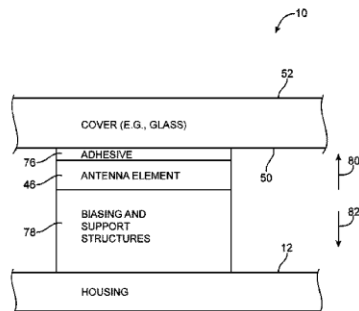
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Primary Examiner — Dameon E Levi
Assistant Examiner — Ricardo Magallanes
 (74) *Attorney, Agent, or Firm* — Treyz Law Group; G. Victor Treyz; Kendall P. Woodruff

(57) **ABSTRACT**

Electronic devices are provided that contain wireless communications circuitry. The wireless communications circuitry may include radio-frequency transceiver circuitry and antenna structures. The antenna structures may include antennas such as inverted-F antennas that contain antenna resonating elements and antenna ground elements. Antenna resonating elements may be formed from patterned conductive traces on substrates such as flex circuit substrates. Antenna ground elements may be formed from conductive device structures such as metal housing walls. Support and biasing structures such as dielectric support members and layer of foam may be used to support and bias antenna resonating elements against planar device structures. The planar device structures against which the antenna resonating elements are biased may be planar dielectric members such as transparent layers of display cover glass or other planar structures. Adhesive may be interposed between the planar structures and the antenna resonating elements.

18 Claims, 17 Drawing Sheets





US008766859B2

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

(10) **Patent No.:** **US 8,766,859 B2**
(45) **Date of Patent:** **Jul. 1, 2014**

(54) **ANTENNA STRUCTURES WITH ELECTRICAL CONNECTIONS TO DEVICE HOUSING MEMBERS**
(75) Inventors: **Nicholas G. L. Merz**, San Francisco, CA (US); **Scott A. Myers**, San Francisco, CA (US); **Dean F. Darnell**, San Jose, CA (US); **Robert W. Schlub**, Cupertino, CA (US); **Edward Siahhan**, San Francisco, CA (US)

(73) Assignee: **Apple Inc.**, Cupertino, CA (US)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 514 days.

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(22) Filed: **Feb. 9, 2011**
(65) **Prior Publication Data**
US 2012/0176754 A1 Jul. 12, 2012

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(63) Continuation-in-part of application No. 13/018,142, filed on Jan. 31, 2011.
(60) Provisional application No. 61/431,520, filed on Jan. 11, 2011.
(51) **Int. Cl.**
H01Q 1/24 (2006.01)
(52) **U.S. Cl.**
USPC **343/702; 343/906**
(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/243; H01Q 9/0421
USPC 343/702.7 MS, 846, 848, 906
See application file for complete search history.

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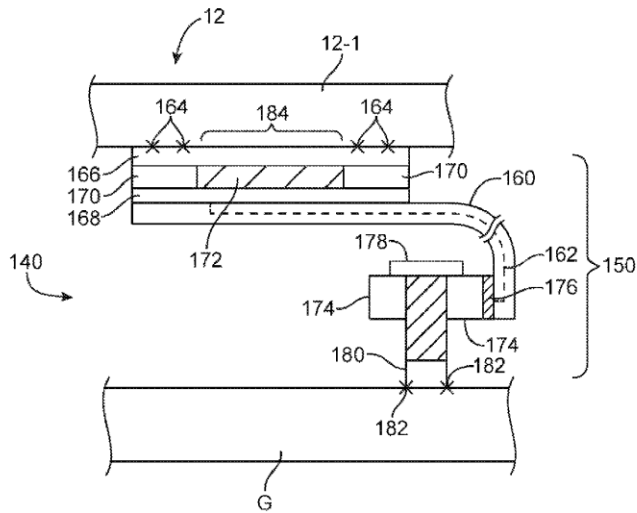
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Primary Examiner — Hoanganh Le
(74) *Attorney, Agent, or Firm* — Treyz Law Group; G. Victor Treyz; Michael H. Lyons

(57) **ABSTRACT**
Electronic devices may be provided that contain wireless communications circuitry. The wireless communications circuitry may include antenna structures that are formed from an internal ground plane and a peripheral conductive housing member. A conductive path may be formed that connects the peripheral conductive housing member and the internal ground plane. The conductive path may include a flex circuit. The flex circuit can include a solder flow barrier to constrain flow of solder. A metal structure may be welded to the peripheral conductive housing member. A solder pad and other traces in the flex circuit may be soldered to the metal structure at one end of the conductive path. At the other end of the conductive path, the flex circuit may be attached to the ground plane using a bracket, screw, and screw boss.

16 Claims, 12 Drawing Sheets





US008766860B2

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

(10) **Patent No.:** **US 8,766,860 B2**
(45) **Date of Patent:** **Jul. 1, 2014**

(54) **HOUSING COMBINATION OF ELECTRONIC DEVICE AND METHOD**

(75) Inventors: **Qi-Yuan Li**, Shenzhen (CN); **Yong Yan**, Shenzhen (CN); **Yong-Fa Fan**, Shenzhen (CN); **Xue-Li Zhang**, Shenzhen (CN); **Zhao-Yi Wu**, Shenzhen (CN); **Li Liu**, Shenzhen (CN)

(73) Assignees: **Shenzhen Futaihong Precision Industry Co., Ltd.**, Shenzhen (CN); **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 307 days.

(21) Appl. No.: **13/220,873**

(22) Filed: **Aug. 30, 2011**

(65) **Prior Publication Data**

US 2012/0249378 A1 Oct. 4, 2012

(30) **Foreign Application Priority Data**

Mar. 31, 2011 (CN) 201110080079

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

(52) **U.S. Cl.**
USPC **343/702**; 343/873; 343/872

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

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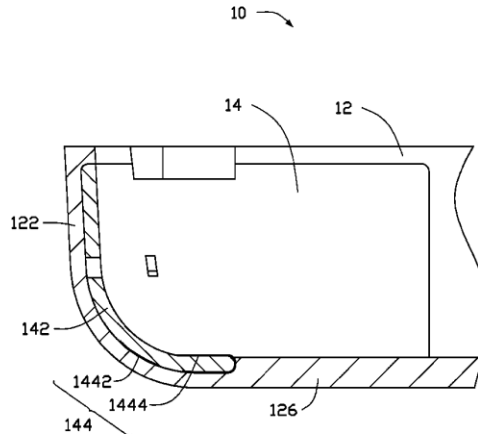
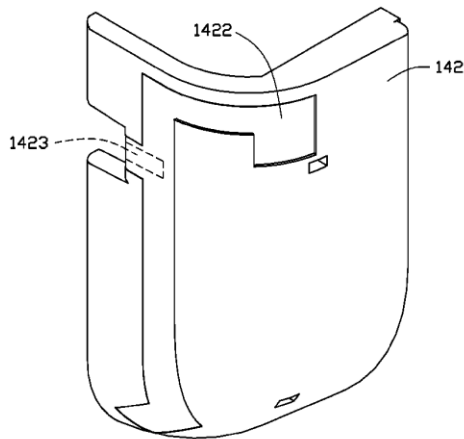
Primary Examiner — Trinh Dinh

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

(57) **ABSTRACT**

A housing combination includes a housing, and at least two antenna modules embedded at corners of the housing. Each antenna module includes an antenna carrier and an antenna radiator. The antenna carrier defines a first receiving groove and a second receiving groove opposite to each other. The antenna radiator includes a main portion and a conductive contact. The main portion is received in the first receiving groove, and the conductive contact is received in the second receiving groove. The main portion is embedded in the housing, and the conductive contact is exposed from the housing.

2 Claims, 6 Drawing Sheets





US008766867B2

(12) **United States Patent**
Ying

(10) **Patent No.:** **US 8,766,867 B2**
(45) **Date of Patent:** **Jul. 1, 2014**

(54) **COMPACT ANTENNA FOR MULTIPLE
INPUT MULTIPLE OUTPUT
COMMUNICATIONS INCLUDING ISOLATED
ANTENNA ELEMENTS**

FOREIGN PATENT DOCUMENTS

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(75) Inventor: **Zhinong Ying**, Lund (SE)

Ke, Shyh-Yeong, Broadband Proximity-coupled Microstrip Antennas with an H-shaped Slot in the Ground Plane, 2002, IEEE, pp. 530-533.*

(73) Assignees: **Sony Corporation**, Tokyo (JP); **Sony Mobile Communications AB**, Lund (SE)

European Search Report Corresponding to European Application No. 11188966.3; Dated: Mar. 26, 2012; 7 pages.

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 335 days.

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(21) Appl. No.: **12/969,764**

Chaff et al., "Broadband Microstrip Patch Antenna Fed by a Novel Coupling Device", *PIERS Online*, vol. 3, No. 7, Mar. 2007, pp. 1064-1066.

(22) Filed: **Dec. 16, 2010**

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(65) **Prior Publication Data**

US 2012/0154237 A1 Jun. 21, 2012

Primary Examiner — Douglas W Owens

Assistant Examiner — Jae Kim

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

(74) *Attorney, Agent, or Firm* — Myers Bigel Sibley & Sajovec, P.A.

(52) **U.S. Cl.**
USPC **343/833**; 343/700 MS

(57) **ABSTRACT**

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

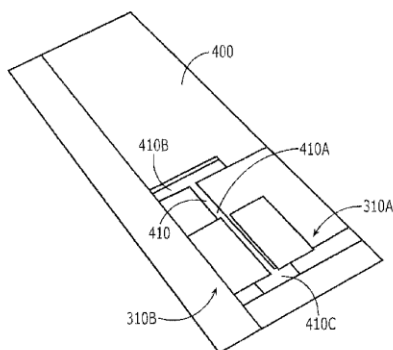
An antenna for MIMO communications includes a ground plane having a planar surface, a first feeding patch spaced apart from and parallel to the ground plane, and a first parasitic patch spaced apart from and parallel to the first feeding patch. The antenna further includes a second feeding patch spaced apart from and parallel to the ground plane and disposed adjacent the first feeding patch, and a second parasitic patch spaced apart from and parallel to the second feeding patch. The first parasitic patch may be capacitively coupled to the first feeding patch, and the second parasitic patch may be capacitively coupled to the second feeding patch. The ground plane may include an isolation notch therein arranged between the first and second feeding patches.

(56) **References Cited**

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13 Claims, 5 Drawing Sheets





US008766869B2

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

(10) **Patent No.:** **US 8,766,869 B2**
(45) **Date of Patent:** **Jul. 1, 2014**

- (54) **ANTENNA APPARATUS**
- (75) Inventors: **Yuuji Kakuya**, Okazaki (JP); **Akira Takaoka**, Okazaki (JP); **Hidenori Wada**, Anjo (JP); **Kouji Yamashita**, Kariya (JP)
- (73) Assignees: **DENSO CORPORATION**, Kariya (JP); **Nippon Soken, Inc.**, Nishio (JP)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 952 days.
- (21) Appl. No.: **12/798,228**
- (22) Filed: **Mar. 30, 2010**
- (65) **Prior Publication Data**
US 2010/0245192 A1 Sep. 30, 2010
- (30) **Foreign Application Priority Data**
Mar. 31, 2009 (JP) 2009-86703
- (51) **Int. Cl.**
H01Q 7/00 (2006.01)
- (52) **U.S. Cl.**
USPC **343/866**; 343/726; 343/728
- (58) **Field of Classification Search**
USPC 343/726, 728, 866, 702, 846
See application file for complete search history.

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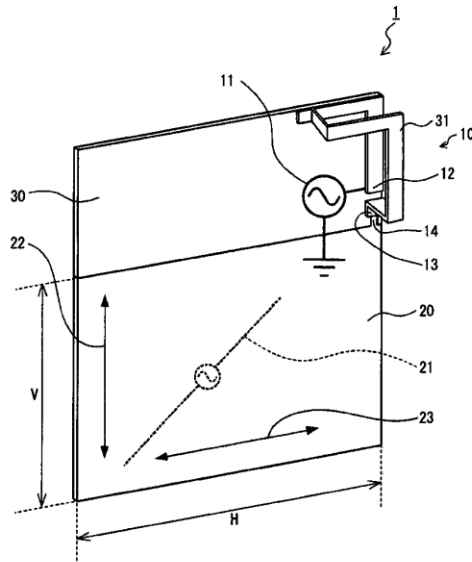
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- Primary Examiner* — Jacob Y Choi
Assistant Examiner — Kyana R Robinson
- (74) *Attorney, Agent, or Firm* — Harness, Dickey & Pierce, PLC

- (57) **ABSTRACT**
- An antenna apparatus includes: a ground substrate; and a loop antenna having first and second polarized wave surfaces, which are perpendicular to the substrate. The substrate provides an antenna, which is excited and vibrated together with the loop antenna. The antenna has a first polarized wave component in parallel to the first polarized wave surface and a second polarized wave component in parallel to the second polarized wave surface. A polarized wave ratio between the first polarized wave component and the second polarized wave component in the substrate is substantially equal to a polarized wave ratio between the first polarized wave surface and the second polarized wave surface in the loop antenna.
- 6 Claims, 3 Drawing Sheets**





US008766870B2

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

(10) **Patent No.:** **US 8,766,870 B2**
(45) **Date of Patent:** **Jul. 1, 2014**

(54) **MULTIPLE FREQUENCY BAND ANTENNA AND ANTENNA SYSTEM USING THE SAME**

(75) Inventors: **Chang-won Jung**, Hwaseong-si (KR);
Young-eil Kim, Suwon-si (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1172 days.

(21) Appl. No.: **12/144,153**

(22) Filed: **Jun. 23, 2008**

(65) **Prior Publication Data**
US 2009/0079647 A1 Mar. 26, 2009

(30) **Foreign Application Priority Data**
Sep. 21, 2007 (KR) 10-2007-0096952

(51) **Int. Cl.**
H01Q 3/24 (2006.01)
H01Q 1/38 (2006.01)
H01Q 5/00 (2006.01)
H01Q 13/00 (2006.01)

(52) **U.S. Cl.**
USPC **343/876**; 343/700 MS; 343/767

(58) **Field of Classification Search**
USPC 343/700 MS, 767, 795, 820, 821, 876
See application file for complete search history.

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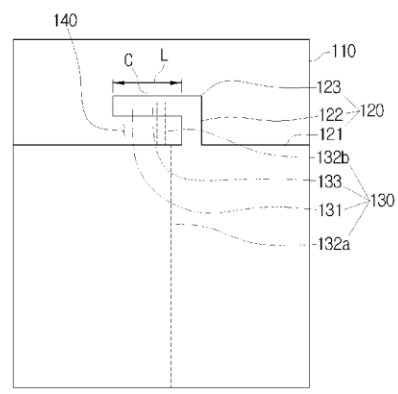
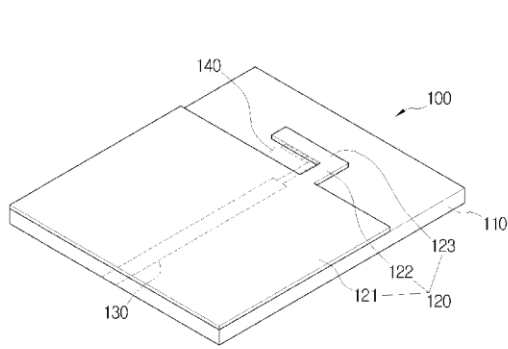
Korean Office Action issued Oct. 30, 2013 in counterpart Korean Application No. KR 10-2007-0096952 (9 pages, in Korean, with English language translation).

Primary Examiner — Robert Karacsony
(74) *Attorney, Agent, or Firm* — NSIP Law

(57) **ABSTRACT**

A multiple frequency band antenna is provided that includes a radiating unit having a slot formed on a first surface of the substrate that is closed at one end and open at the other end, and a feed unit formed on a second surface of the substrate to pass through an area on the second surface that corresponds with the same area on first surface between the center and the closed side of the slot. The feeding unit comprises at least one switch which adjusts the size of an area for feeding power to the antenna. The radiating unit is resonated in a plurality of frequency bands when the switch is turned off, and the radiating unit is resonated in a single frequency band which is different from the plurality of frequency bands when the switch is turned on. Consequently, an antenna is implemented for use in multiple frequency bands.

25 Claims, 6 Drawing Sheets





US008766871B2

(12) **United States Patent**
Hamabe

(10) **Patent No.:** **US 8,766,871 B2**
(45) **Date of Patent:** **Jul. 1, 2014**

(54) **ANTENNA APPARATUS AND DISPLAY APPARATUS**

(75) Inventor: **Taichi Hamabe**, Hyogo (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 155 days.

(21) Appl. No.: **13/520,040**

(22) PCT Filed: **Jul. 5, 2011**

(86) PCT No.: **PCT/JP2011/003823**

§ 371 (c)(1),
(2), (4) Date: **Jun. 29, 2012**

(87) PCT Pub. No.: **WO2012/004977**

PCT Pub. Date: **Jan. 12, 2012**

(65) **Prior Publication Data**

US 2012/0280887 A1 Nov. 8, 2012

(30) **Foreign Application Priority Data**

Jul. 6, 2010 (JP) 2010-153603

(51) **Int. Cl.**
H01Q 9/42 (2006.01)
H01Q 21/06 (2006.01)
H01Q 21/00 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/42** (2013.01); **H01Q 21/06**
(2013.01); **H01Q 21/00** (2013.01)
USPC **343/893**; **343/702**

(58) **Field of Classification Search**
CPC H01Q 9/42; H01Q 21/06; H01Q 21/00
USPC 343/702, 893, 700 MS
See application file for complete search history.

(56) **References Cited**

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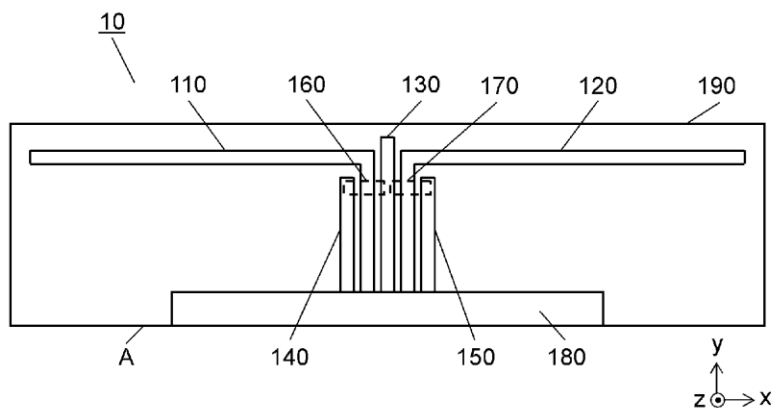
Primary Examiner — Hoanganh Le

(74) *Attorney, Agent, or Firm* — McDermott Will & Emery LLP

(57) **ABSTRACT**

Provided is an antenna device, including insulating base substrate (190), first monopole antenna (110), and second monopole antenna (120), the antennas being disposed on insulating base substrate (190), wherein first monopole antenna (110) and second monopole antenna (120) have: first portions extended in a same direction from power feeding ends connected to first power feeding section (180); and second portions extended from the first portions separately to left and right sides, and first passive element (130) is disposed between the first portion of first monopole antenna (110) and the first portion of second monopole antenna (120).

4 Claims, 6 Drawing Sheets





US008768420B2

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

(10) **Patent No.:** **US 8,768,420 B2**
(45) **Date of Patent:** **Jul. 1, 2014**

(54) **MOBILE TERMINAL**

(75) Inventors: **Hiromichi Suzuki**, Hamura (JP); **Isao Ohba**, Hachioji (JP)

(73) Assignee: **Fujitsu Mobile Communications 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 751 days.

(21) Appl. No.: **12/206,913**

(22) Filed: **Sep. 9, 2008**

(65) **Prior Publication Data**
US 2009/0069062 A1 Mar. 12, 2009

(30) **Foreign Application Priority Data**
Sep. 12, 2007 (JP) 2007-236857

(51) **Int. Cl.**
H04W 88/02 (2009.01)

(52) **U.S. Cl.**
USPC **455/575.1**

(58) **Field of Classification Search**
USPC 455/575.1-575.7, 550.1, 556.1, 455/90.1-90.3; 343/700-703

See application file for complete search history.

(56) **References Cited**

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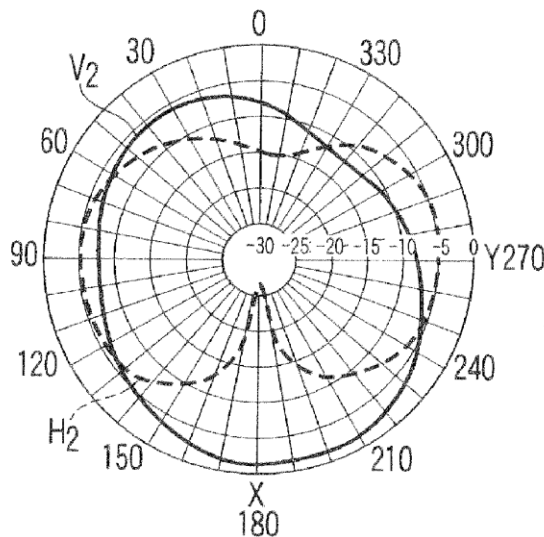
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Primary Examiner — Diane Mizrahi
(74) *Attorney, Agent, or Firm* — Maschoff Brennan

(57) **ABSTRACT**

A mobile terminal includes a first antenna configured to receive power from the first circuit board housed in the first housing, a second antenna configured to receive power from the second circuit board housed in the second housing, a first signal cable configured to electrically connect the first circuit board to the second circuit board and transmit a signal between the first circuit board and the second circuit board, and a second signal cable configured to electrically connect the first circuit board to the second circuit board and bypasses a board current flowing through the first signal cable from the first circuit board to the second antenna during operation of the second antenna.

16 Claims, 4 Drawing Sheets



(b) Radiation pattern of second antenna with portrait screen (embodiment)



US008768421B2

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

(10) **Patent No.:** **US 8,768,421 B2**
(45) **Date of Patent:** **Jul. 1, 2014**

(54) **ELECTRONIC DEVICE AND ANTENNA RECEPTION TUNING METHOD THEREOF**

(71) Applicants: **Kuo-Chiang Hung**, Taipei (TW);
Cheng-Wen Wang, Taipei (TW);
Chieh-Tsao Hwang, Taipei (TW);
Chang-Chih Chen, Taipei (TW);
Shih-Chia Liu, Taipei (TW)

(72) Inventors: **Kuo-Chiang Hung**, Taipei (TW);
Cheng-Wen Wang, Taipei (TW);
Chieh-Tsao Hwang, Taipei (TW);
Chang-Chih Chen, Taipei (TW);
Shih-Chia Liu, Taipei (TW)

(73) Assignee: **Compal Electronics, Inc.**, Taipei (TW)

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

(21) Appl. No.: **13/672,669**

(22) Filed: **Nov. 8, 2012**

(65) **Prior Publication Data**
US 2014/0051375 A1 Feb. 20, 2014

(30) **Foreign Application Priority Data**
Aug. 15, 2012 (TW) 101129555 A

(51) **Int. Cl.**
H04M 1/00 (2006.01)
H01Q 1/50 (2006.01)
H01Q 9/42 (2006.01)
H01Q 1/22 (2006.01)
H04B 1/16 (2006.01)

(52) **U.S. Cl.**
CPC .. **H04B 1/16** (2013.01); **H01Q 1/50** (2013.01);
H01Q 9/42 (2013.01); **H01Q 1/2266** (2013.01)
USPC **455/575.1**; 455/575.3; 455/575.7

(58) **Field of Classification Search**
USPC 455/78, 80, 550.1, 575.1, 575.3, 575.4,
455/575.5, 269, 575.6, 90.1
See application file for complete search history.

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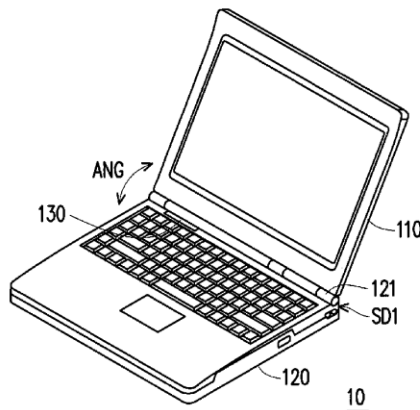
Primary Examiner — Thanh Le

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

(57) **ABSTRACT**

An electronic device and an antenna reception tuning method thereof are provided. The electronic device includes a first main body, a second main body, a sensing unit, and a processing unit. The second main body, including an antenna and a matching unit, is disposed on the first main body through a hinge and adapted for being opened or closed relative to the first main body. The sensing unit is disposed on the electronic device, adapted for detecting a distance between the first main body and the second main body, and generates a control signal according to the distance, wherein the distance includes an angle and an open/close state between the first and the second main bodies. The processing unit is electrically connected to the sensing unit and the matching unit, and adjusts the matching unit according to the received control signal.

20 Claims, 3 Drawing Sheets





US008773313B2

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

(10) **Patent No.:** **US 8,773,313 B2**
(45) **Date of Patent:** **Jul. 8, 2014**

- (54) **NON-PLANAR METAMATERIAL ANTENNA STRUCTURES**
- (71) Applicant: **Tyco Electronics Services GmbH**, Schaffhausen (CH)
- (72) Inventors: **Nan Xu**, San Diego, CA (US); **Sunil Kumar Rajgopal**, San Diego, CA (US); **Norberto Lopez**, San Diego, CA (US); **Vaneet Pathak**, Palo Alto, CA (US); **Ajay Gummalla**, Sunnysvale, CA (US); **Gregory Poilasne**, El Cajon, CA (US); **Maha Achour**, Encinitas, CA (US)
- (73) Assignee: **Tyco Electronics Services GmbH** (CH)
- (*) 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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Primary Examiner — Tan Ho

- (21) Appl. No.: **13/663,351**
- (22) Filed: **Oct. 29, 2012**
- (65) **Prior Publication Data**
US 2013/0050029 A1 Feb. 28, 2013
- Related U.S. Application Data**
- (63) Continuation of application No. 12/465,571, filed on May 13, 2009, now Pat. No. 8,299,967.
- (60) Provisional application No. 61/056,790, filed on May 28, 2008.

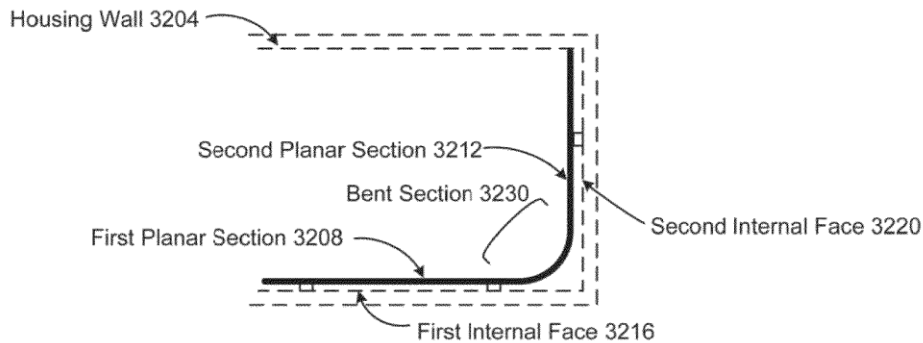
(57) **ABSTRACT**

Antennas for wireless communications based on metamaterial (MTM) structures to arrange one or more antenna sections of an MTM antenna away from one or more other antenna sections of the same MTM antenna so that the antenna sections of the MTM antenna are spatially distributed in a non-planar configuration to provide a compact structure adapted to fit to an allocated space or volume of a wireless communication device, such as a portable wireless communication device.

- (51) **Int. Cl.**
H01Q 1/38 (2006.01)
- (52) **U.S. Cl.**
USPC **343/700 MS**; 343/702
- (58) **Field of Classification Search**
USPC 343/700 MS, 702, 848
See application file for complete search history.

20 Claims, 31 Drawing Sheets

- (56) **References Cited**
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US008773314B2

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

(10) **Patent No.:** **US 8,773,314 B2**
(45) **Date of Patent:** **Jul. 8, 2014**

(54) **ANTENNA PATTERN FRAME, CASE OF ELECTRONIC DEVICE AND MOULD FOR MANUFACTURING THE SAME**

(75) Inventors: **Ha Ryong Hong**, Gyeonggi-do (KR); **Sung Eun Cho**, Gyeonggi-do (KR); **Duk Woo Lee**, Gyeonggi-do (KR); **Dae Kyu Lee**, Gyeonggi-do (KR); **Chan Gwang An**, Gyeonggi-do (KR); **Jae Suk Sung**, Gyeonggi-do (KR); **Ki Won Chang**, Gyeonggi-do (KR); **Chang Mok Han**, Chungcheongnam-do (KR); **Sang Woo Bae**, Gyeonggi-do (KR)

(73) Assignee: **Samsung Electro-Mechanics Co., Ltd.**, Gyeonggi-Do (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 581 days.

(21) Appl. No.: **13/022,117**

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

(65) **Prior Publication Data**
US 2011/0205127 A1 Aug. 25, 2011

(30) **Foreign Application Priority Data**
Feb. 25, 2010 (KR) 10-2010-0017246

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 1/40 (2006.01)
B29C 45/14 (2006.01)

(52) **U.S. Cl.**
USPC 343/702; 343/873; 425/116

(58) **Field of Classification Search**
USPC 343/702, 873; 425/116
See application file for complete search history.

(56) **References Cited**

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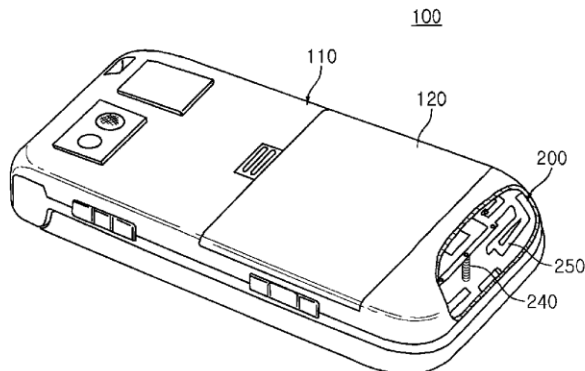
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Primary Examiner — Jerome Jackson, Jr.
Assistant Examiner — Andrea Lindgren Baltzel
(74) *Attorney, Agent, or Firm* — McDermott Will & Emery LLP

(57) **ABSTRACT**
There is provided an antenna pattern frame, including: a radiator that includes an antenna pattern part transmitting and receiving signals and a connection terminal part transmitting and receiving the signals to and from a circuit substrate of an electronic device; and a radiator frame that embeds the antenna pattern part in a case of the electronic device and supports the radiator, the radiator being manufactured by injection molding, wherein the radiator frame forms a guide boss inserted into a manufacturing mould for injection-molding the case of the electronic device in which the radiator is embedded.

11 Claims, 12 Drawing Sheets





US008773317B2

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

(10) **Patent No.:** **US 8,773,317 B2**
(45) **Date of Patent:** **Jul. 8, 2014**

(54) **ANTENNA APPARATUS INCLUDING MULTIPLE ANTENNA PORTIONS ON ONE ANTENNA ELEMENT OPERABLE AT MULTIPLE FREQUENCIES**

(75) Inventors: **Tsutomu Sakata**, Osaka (JP); **Atsushi Yamamoto**, Kyoto (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 596 days.

(21) Appl. No.: **13/063,317**

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

(86) PCT No.: **PCT/JP2010/003514**

§ 371 (c)(1),
(2), (4) Date: **Apr. 6, 2011**

(87) PCT Pub. No.: **WO2011/004541**

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

(65) **Prior Publication Data**

US 2011/0187615 A1 Aug. 4, 2011

(30) **Foreign Application Priority Data**

Jul. 10, 2009 (JP) 2009-163422

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

(52) **U.S. Cl.**
USPC **343/722**

(58) **Field of Classification Search**
USPC 343/722
See application file for complete search history.

(56) **References Cited**

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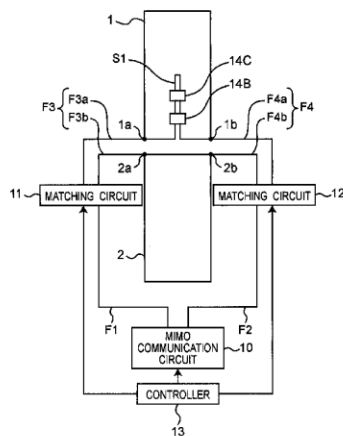
Primary Examiner — Kristy A Haupt

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

(57) **ABSTRACT**

An antenna apparatus includes a slit provided on an antenna element between first and second feed ports; and a series resonant circuit provided at a location along the slit, with a distance from an opening of the slit. When the antenna apparatus operates at a first isolation frequency identical to a resonance frequency of the series resonant circuit, the series resonant circuit is short-circuited, and only a section of the slit from its opening to the series resonant circuit resonates, thus providing isolation between the feed ports at the first isolation frequency. When the antenna apparatus operates at a second isolation frequency lower than the first isolation frequency, the series resonant circuit is open, and the entire slit resonates, thus providing isolation between the feed ports at the second isolation frequency.

9 Claims, 9 Drawing Sheets





US008773320B2

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

(10) **Patent No.:** **US 8,773,320 B2**
(45) **Date of Patent:** **Jul. 8, 2014**

(54) **PLANAR CRLH ANTENNA**

(75) Inventors: **Wee Sang Park**, Pohang-si (KR); **Jae Woo Ko**, Uiwang-si (KR); **Joon Hyun Baek**, Seoul (KR); **Dae Woong Woo**, Daegu (KR)

(73) Assignees: **Samsung Electronics Co., Ltd.**, Suwon-si (KR); **Postech Academy-Industry Foundation**, Pohang-si (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 470 days.

(21) Appl. No.: **13/132,130**

(22) PCT Filed: **Dec. 1, 2009**

(86) PCT No.: **PCT/KR2009/007107**

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

(87) PCT Pub. No.: **WO2010/064826**

PCT Pub. Date: **Jun. 10, 2010**

(65) **Prior Publication Data**

US 2011/0234465 A1 Sep. 29, 2011

(30) **Foreign Application Priority Data**

Dec. 2, 2008 (KR) 10-2008-0120977
Feb. 25, 2009 (KR) 10-2009-0015923

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

(52) **U.S. Cl.**
USPC 343/767; 343/722

(58) **Field of Classification Search**

USPC 343/767, 722, 770, 846
See application file for complete search history.

(56) **References Cited**

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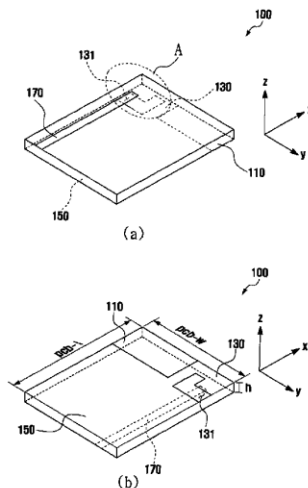
Primary Examiner — Thien M Le

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

(57) **ABSTRACT**

The present invention relates to a planar composite right/left handed (CRLH) antenna, comprising: a substrate body which is made of dielectric materials, and which has a planer structure; a radiation line which is disposed on one side of the substrate body, and which is bent to form a slot for exposing a predetermined width of the substrate body through both ends thereof, and which resonates at a predetermined frequency band when fed; and a feeder line which is disposed on the outer side of the substrate body, which extends across the slot, and which feeds electric power to the radiation line. The planar CRLH antenna of the present invention is small in size, and expands a radiation area, thereby expanding an available frequency band, or using a dual frequency band.

15 Claims, 28 Drawing Sheets





US008773321B2

(12) **United States Patent**
Konishi

(10) **Patent No.:** **US 8,773,321 B2**
(45) **Date of Patent:** **Jul. 8, 2014**

(54) **ANTENNA UNIT AND ELECTRONIC APPARATUS**

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2002/0022459 A1 2/2002 Kobayashi
2004/0061509 A1 4/2004 Tsuchihashi et al.
2005/0099344 A1 5/2005 Okubo et al.

(75) Inventor: **Michihiro Konishi**, 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 126 days.

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JP 2005-142785 6/2005

(21) Appl. No.: **13/137,986**

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

International Search Report mailed on Jun. 30, 2009 in corresponding PCT Application No. PCT/JP2009/056250.

(65) **Prior Publication Data**

US 2012/0013518 A1 Jan. 19, 2012

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Related U.S. Application Data

(63) Continuation of application No. PCT/JP2009/056250, filed on Mar. 27, 2009.

Primary Examiner — Robert Karacsony

Assistant Examiner — Amal Patel

(74) *Attorney, Agent, or Firm* — Staas & Halsey LLP

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 13/18 (2006.01)

(57) **ABSTRACT**

(52) **U.S. Cl.**
CPC **H01Q 1/2266** (2013.01); **H01Q 13/18** (2013.01)
USPC **343/789**; 343/702

An antenna unit includes a housing, a substrate, and an antenna. The housing includes a bottom wall, first and second side walls extending upward from the corresponding side edges of the bottom wall, a rear wall extending upward from the rear edge of the bottom wall, and an upper wall extending from the upper edge of the first side wall toward the second side wall leaving a gap between an edge of the upper wall and the second side wall. The substrate is fixed to the upper wall, and a part of the substrate projects from the edge of the upper wall to a position that is closer to the second side wall than is the edge of the upper wall. The antenna is fixed to the part of the substrate projecting from the edge of the upper wall such that a radio-wave emitting aperture of the antenna faces forward.

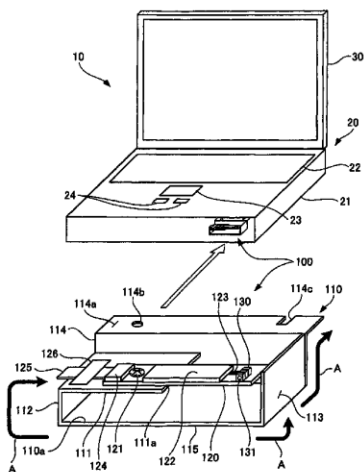
(58) **Field of Classification Search**
CPC H01Q 1/2266; H01Q 1/2258; H01Q 13/18
USPC 343/789, 702
See application file for complete search history.

(56) **References Cited**

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9 Claims, 7 Drawing Sheets





US008779985B2

(12) **United States Patent**
Oh

(10) **Patent No.:** **US 8,779,985 B2**
(45) **Date of Patent:** **Jul. 15, 2014**

(54) **DUAL RADIATOR MONOPOLE ANTENNA**

(75) Inventor: **Sung Hoon Oh**, 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 300 days.

(21) Appl. No.: **13/212,316**

(22) Filed: **Aug. 18, 2011**

(65) **Prior Publication Data**

US 2013/0044030 A1 Feb. 21, 2013

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

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

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 9/0407; H01Q 9/0421; H01Q 1/243; H01Q 5/0003
USPC 343/702, 700 MS, 720, 843
See application file for complete search history.

(56) **References Cited**

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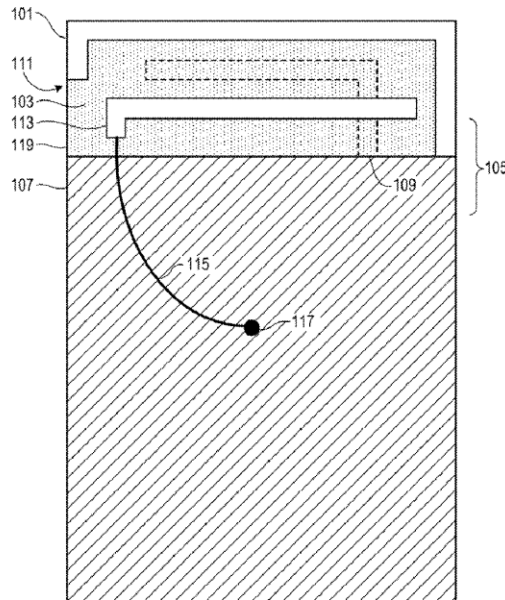
Primary Examiner — Huedung Mancuso

(74) *Attorney, Agent, or Firm* — Mahamedi Paradise LLP

(57) **ABSTRACT**

A dual radiator monopole antenna. An elongated low-band ground-coupled arm is disposed on a first surface of a printed circuit board. This arm is electrically connected to and spaced apart from a ground plane. An elongated high-band ground-coupled arm is disposed on a second surface of the printed circuit board, and like the low-band arm is electrically connected to and spaced apart from the ground plane. The high-band arm is oriented parallel to, and laterally displaced from, the low-band ground-coupled arm. An elongated feed arm is disposed on the first surface of the printed circuit board, oriented parallel the ground-coupled arms and laterally displaced from them. A conductor in electrical feed connection with the feed arm extends from the feed arm across a portion of the ground plane.

20 Claims, 8 Drawing Sheets





US008779986B2

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

(10) **Patent No.:** **US 8,779,986 B2**
(45) **Date of Patent:** **Jul. 15, 2014**

(54) **WIDEBAND ANTENNA**

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

(75) Inventors: **Wen-Chuan Fan**, Hsinchu (TW);
Yi-Feng Wu, Hsinchu (TW); **Wei-Hung Ruan**, Hsinchu (TW)

(56) **References Cited**

(73) Assignee: **Wistron NeWeb Corporation**, Hsinchu Science Park, 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 202 days.

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(21) Appl. No.: **13/253,990**

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(22) Filed: **Oct. 6, 2011**

Primary Examiner — Hoang V Nguyen

(65) **Prior Publication Data**

Assistant Examiner — Patrick Holecek

US 2013/0021209 A1 Jan. 24, 2013

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

(30) **Foreign Application Priority Data**

(57) **ABSTRACT**

Jul. 20, 2011 (TW) 100125591 A

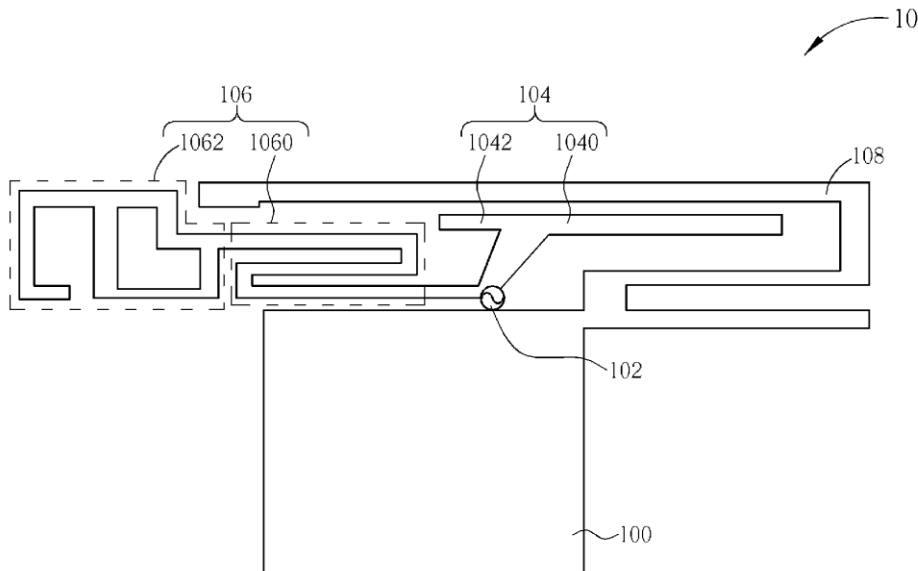
A wideband antenna includes a grounding element; a feed-in terminal; a first radiating unit, electrically connected to the feed-in terminal and extending from the feed-in terminal toward a first direction; a second radiating unit, electrically connected to the feed-in terminal, extending from the feed-in terminal toward a second direction, and including a meander-shaped element; and a third radiating unit, electrically connected to the grounding element, extending from the grounding element toward the first radiating unit and the second radiating unit, and having one segment parallel to the meander-shaped element, for coupling the meander-shaped element.

(51) **Int. Cl.**
H01Q 5/00 (2006.01)
H01Q 9/40 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/42** (2013.01); **H01Q 5/0058** (2013.01)
USPC **343/700 MS**

(58) **Field of Classification Search**
CPC H01Q 5/00; H01Q 5/0024; H01Q 5/0027;
H01Q 5/0062; H01Q 5/0065; H01Q 5/0068;
H01Q 5/0072

7 Claims, 9 Drawing Sheets





US008779987B2

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

(10) **Patent No.:** **US 8,779,987 B2**
(45) **Date of Patent:** **Jul. 15, 2014**

(54) **MULTIPLY RESONANT ANTENNA DEVICE AND ELECTRONIC DEVICE INCLUDING SUCH ANTENNA DEVICE**

FOREIGN PATENT DOCUMENTS

(75) Inventors: **Natsumi Endo**, Sagamihara (JP); **Hiroyuki Hotta**, Hamura (JP); **Koichi Sato**, Tachikawa (JP)

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(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 346 days.

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(21) Appl. No.: **13/279,890**

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(22) Filed: **Oct. 24, 2011**

(65) **Prior Publication Data**

US 2012/0194390 A1 Aug. 2, 2012

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

(30) **Foreign Application Priority Data**

Feb. 1, 2011 (JP) 2011-019881

(57) **ABSTRACT**

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

According to one embodiment, a multiply resonant antenna device according to the embodiment includes a first antenna element formed from a monopole element, a second antenna element formed from a parasitic element placed at a position where it can be current-coupled to the first antenna element, and a third antenna element formed from a folded monopole element. The length of the first antenna element is set to nearly a 1/4 of wavelength corresponding to the first resonant frequency. The length of the second antenna element is set to nearly a 1/4 of wavelength corresponding to the second resonant frequency. The electrical length of the third antenna element from the feed point to a ground point through a folding end is set to nearly a 1/2 of wavelength corresponding to the third resonant frequency higher than the first and second resonant frequencies.

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

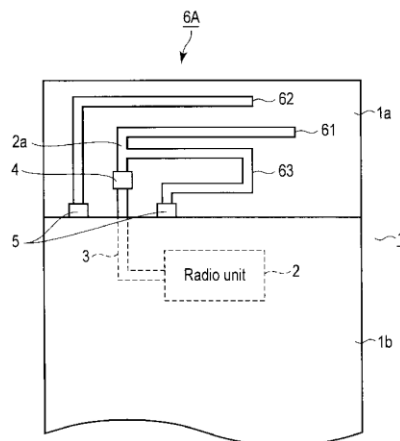
(58) **Field of Classification Search**
USPC 343/700 MS, 702, 843, 846
See application file for complete search history.

(56) **References Cited**

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18 Claims, 20 Drawing Sheets





US008779988B2

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

(10) **Patent No.:** **US 8,779,988 B2**
(45) **Date of Patent:** **Jul. 15, 2014**

(54) **SURFACE MOUNT DEVICE**
MULTIPLE-BAND ANTENNA MODULE

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(75) Inventors: **Tsai-Yi Yang**, Tainan (TW);
Chia-Tsung Wu, Tainan (TW)

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(73) Assignees: **Cirocomm Technology Corp.**, Tainan
(TW); **Taoglas Group Holdings**
Limited, Wexford (IE)

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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 219 days.

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(21) Appl. No.: **13/351,211**

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(22) Filed: **Jan. 16, 2012**

(65) **Prior Publication Data**

US 2012/0182186 A1 Jul. 19, 2012

Primary Examiner — Dameon E Levi

Assistant Examiner — Ricardo Magallanes

(74) *Attorney, Agent, or Firm* — Chun-Ming Shih; HDLS
IPR Services

(30) **Foreign Application Priority Data**

Jan. 18, 2011 (TW) 100101869 A

(57) **ABSTRACT**

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

A surface mount device multiple-band antenna module includes a substrate and a carrier. The substrate has a first grounding metal surface and a first micro-strip line on a side thereof. The first grounding metal surface has a second micro-strip line connected thereto. There is a space between the first micro-strip line and the second micro-strip line. The substrate has a second grounding metal surface on the other side thereof. The carrier is made of ceramic material with high dielectric constant, which has a first radiative metal portion, a second radiative metal portion and a third radiative metal portion. The carrier is electrically connected with the substrate. The joint of the first radiative metal portion and the second radiative metal portion is electrically connected to the first micro-strip line. The third radiative metal portion is electrically connected to the second micro-strip line. Thus, the multiple-band antenna module is obtained.

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/0058**
(2013.01); **H01Q 9/42** (2013.01)
USPC **343/700 MS**; 343/702

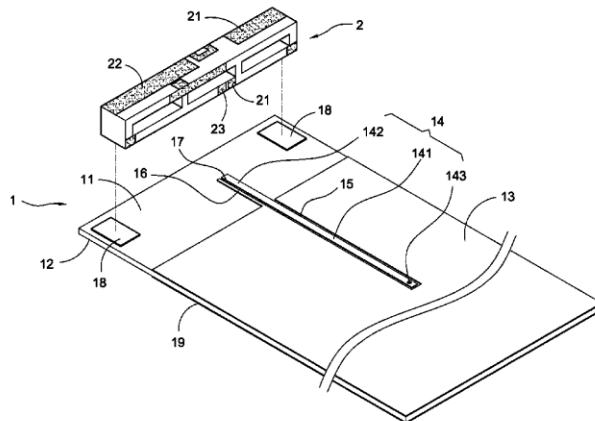
(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/0058; H01Q 5/0055
USPC 343/852, 700 MS
See application file for complete search history.

(56) **References Cited**

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7 Claims, 10 Drawing Sheets





US008779989B2

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

(10) **Patent No.:** **US 8,779,989 B2**
(45) **Date of Patent:** **Jul. 15, 2014**

(54) **WIDEBAND ANTENNA**

(75) Inventors: **Kuo-Lun Huang**, Hsinchu (TW); **Yu-Yu Chiang**, Hsinchu (TW); **Shang-Ching Tseng**, Hsinchu (TW)

(73) Assignee: **Wistron NeWeb Corporation**, Hsinchu Science Park, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 170 days.

(21) Appl. No.: **13/462,783**

(22) Filed: **May 2, 2012**

(65) **Prior Publication Data**
US 2013/0207861 A1 Aug. 15, 2013

(30) **Foreign Application Priority Data**
Feb. 10, 2012 (TW) 101104315 A

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

(52) **U.S. Cl.**
USPC **343/700 MS; 343/848**

(58) **Field of Classification Search**
CPC H01Q 13/10; H01Q 9/42; H01Q 1/2266
See application file for complete search history.

(56) **References Cited**

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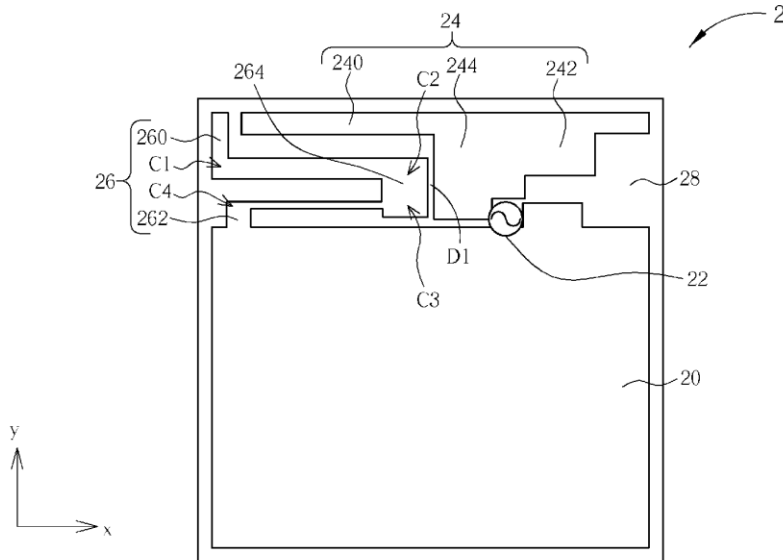
Primary Examiner — Trinh Dinh

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

(57) **ABSTRACT**

A wideband antenna includes a grounding unit electrically connected to a ground, a feed-in source for transmitting and receiving radio frequency signals, a first radiating body including a first radiating unit extending along a first direction, a second radiating unit extending along a second direction opposite to the first direction, and a conducting unit extending along a third direction, and a second radiating body including a short-circuit unit electrically connected to the grounding unit, a third radiating unit including a branch to generate a coupling connection effect with the conducting unit via a first distance, wherein an average perpendicular distance between the second radiating body and the grounding unit is smaller than an average perpendicular distance between the first radiating body and the grounding unit.

24 Claims, 9 Drawing Sheets





US00877990B2

(12) **United States Patent**
Odagiri

(10) **Patent No.:** **US 8,779,990 B2**
(45) **Date of Patent:** **Jul. 15, 2014**

(54) **ANTENNA AND WIRELESS COMMUNICATION APPARATUS USING SAME**

(75) Inventor: **Kazuya Odagiri**, Tokyo (JP)

(73) Assignees: **Sony Corporation**, Tokyo (JP); **Sony Computer Entertainment 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 462 days.

(21) Appl. No.: **12/295,871**

(22) PCT Filed: **Apr. 5, 2007**

(86) PCT No.: **PCT/JP2007/000370**
§ 371 (c)(1),
(2), (4) Date: **Jan. 9, 2009**

(87) PCT Pub. No.: **WO2007/125643**
PCT Pub. Date: **Nov. 8, 2007**

(65) **Prior Publication Data**
US 2010/0045539 A1 Feb. 25, 2010

(30) **Foreign Application Priority Data**
Apr. 5, 2006 (JP) 2006-103881

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/30 (2006.01)
H01Q 9/38 (2006.01)
H01Q 19/00 (2006.01)
H01Q 19/10 (2006.01)
H01Q 1/48 (2006.01)
H01Q 1/38 (2006.01)

(52) **U.S. Cl.**
USPC **343/702**; 343/828; 343/829; 343/833;
343/834; 343/846; 343/700 MS

(58) **Field of Classification Search**
USPC 343/702, 828, 829, 833, 834, 846,
343/700 MS
See application file for complete search history.

(56) **References Cited**
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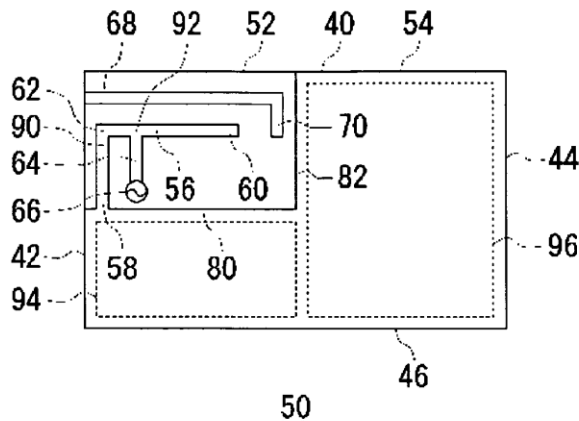
Primary Examiner — Dameon E Levi
Assistant Examiner — Graham Smith

(74) *Attorney, Agent, or Firm* — Katten Muchin Rosenman LLP

(57) **ABSTRACT**

An antenna which is laid out efficiently while ensuring a predetermined antenna directivity. An antenna area is formed on a corner of a substrate. An antenna conductor is formed in the antenna area, and is shaped so that a bend is formed between its ground end and its open end. A first ground area is formed on the substrate near the ground end of the antenna conductor, and is connected to the ground end. A second ground area is formed on the substrate near the open end of the antenna conductor. A feed unit feeds electricity to the antenna conductor.

9 Claims, 7 Drawing Sheets





US008779991B2

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

(10) **Patent No.:** **US 8,779,991 B2**
(45) **Date of Patent:** **Jul. 15, 2014**

(54) **ANTENNA ASSEMBLY WITH ELECTRICALLY EXTENDED GROUND PLANE ARRANGEMENT AND ASSOCIATED METHOD**

(75) Inventors: **Shirook M. Ali**, Waterloo (CA); **James Paul Warden**, Irving, TX (US); **Kelce Steven Wilson**, Irving, TX (US)

(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 344 days.

(21) Appl. No.: **12/765,581**

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

(65) **Prior Publication Data**

US 2011/0260929 A1 Oct. 27, 2011

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

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

(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/38; H01Q 9/0421; H01Q 1/244; H01Q 1/242
USPC 343/702, 700 MS, 788, 866
See application file for complete search history.

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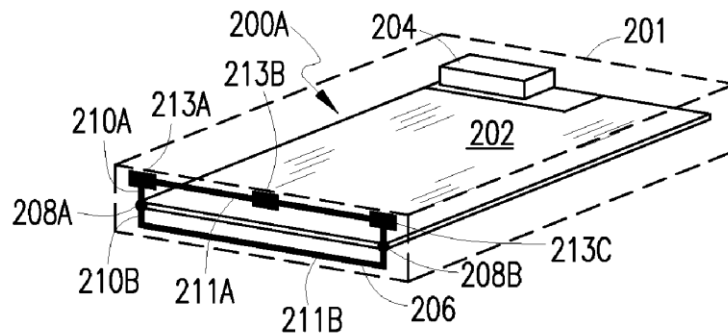
Primary Examiner — Huedung Mancuso

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

(57) **ABSTRACT**

Antenna assembly having an electrically or virtually extended ground plane, adapted for use in a mobile communications device, for example. The antenna assembly comprises at least one radiation element having an operating frequency and a ground plane coupled to the radiation element. At least one conductive member is electrically coupled to the ground plane at one or more connection points such that the conductive member forms a loop with the ground plane having a minimum distance therefrom that is less than a predetermined fraction of one wavelength of the operating frequency.

18 Claims, 6 Drawing Sheets





US00877992B2

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

(10) **Patent No.:** **US 8,779,992 B2**
(45) **Date of Patent:** **Jul. 15, 2014**

(54) **WIRELESS COMMUNICATION APPARATUS AND PLANAR ANTENNA THEREOF**

(75) Inventors: **Sy-Been Wang**, Hsinchu County (TW);
Kuo-Chang Lo, Miaoli County (TW);
Shih-Chieh Cheng, Tainan County (TW)

(73) Assignee: **Arcadyan Technology Corporation**,
Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 263 days.

(21) Appl. No.: **13/175,821**

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

(65) **Prior Publication Data**
US 2012/0001820 A1 Jan. 5, 2012

(30) **Foreign Application Priority Data**
Jul. 2, 2010 (TW) 99121911 A

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

(52) **U.S. Cl.**
USPC 343/702; 343/700 MS; 343/846

(58) **Field of Classification Search**
USPC 343/845, 846
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Michael C Wimer

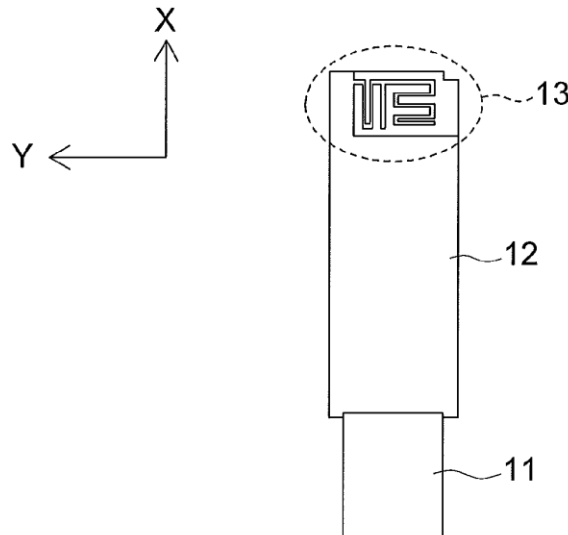
Assistant Examiner — Michael Bouizza

(74) *Attorney, Agent, or Firm* — Rabin & Berdo, P.C.

(57) **ABSTRACT**

A wireless communication apparatus and a planar antenna thereof are provided. The wireless communication apparatus comprises a connecting port, a printed circuit board, and a planar antenna. The printed circuit board is connected to the connecting port, and the planar antenna is formed on the printed circuit board. The planar antenna comprises a radiation portion, a shorting portion, and a feeding portion. The feeding portion is connected to the radiation portion and the shorting portion, and the radiation portion and the shorting portion are in a bent shape so that the radiation portion, the shorting portion and the feeding portion are distributed in a rectangular region.

13 Claims, 6 Drawing Sheets





US00877999B2

(12) **United States Patent**
Gummalla

(10) **Patent No.:** **US 8,779,999 B2**
(45) **Date of Patent:** **Jul. 15, 2014**

- (54) **ANTENNAS FOR COMPUTERS WITH CONDUCTIVE CHASSIS**
- (75) Inventor: **Ajay Chandra Venkata Gummalla**, Sunnyvale, CA (US)
- (73) Assignee: **Google Inc.**, Mountain View, CA (US)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 146 days.

(21) Appl. No.: **13/269,572**
(22) Filed: **Oct. 8, 2011**

(65) **Prior Publication Data**
US 2013/0082884 A1 Apr. 4, 2013

Related U.S. Application Data
(60) Provisional application No. 61/541,740, filed on Sep. 30, 2011.

(51) **Int. Cl.**
H01Q 13/10 (2006.01)
H01Q 5/00 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 13/10** (2013.01); **H01Q 5/0062** (2013.01); **H01Q 5/0024** (2013.01); **H01Q 1/24** (2013.01)
USPC **343/767**; 343/702

(58) **Field of Classification Search**
CPC . H01Q 5/0024; H01Q 5/0027; H01Q 5/0044; H01Q 5/0051; H01Q 5/0062; H01Q 5/0065; H01Q 13/10; H01Q 1/24; H01Q 1/241; H01Q 1/242
USPC 343/767, 702
See application file for complete search history.

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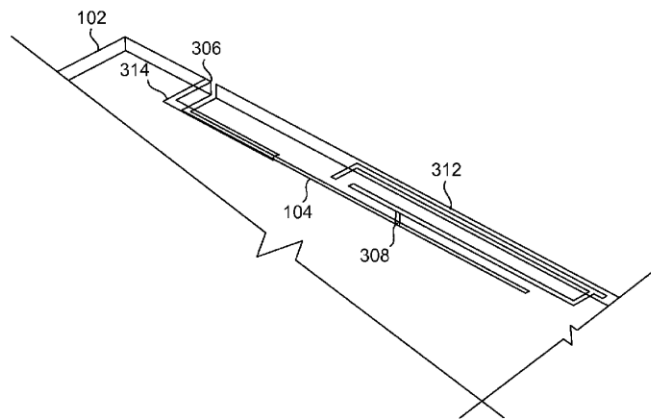
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Primary Examiner — Dameon E Levi
Assistant Examiner — Jennifer F Hu
(74) *Attorney, Agent, or Firm* — Brake Hughes Bellermann LLP

(57) **ABSTRACT**
According to one general aspect, an apparatus may include an electrically conductive frame and a slot antenna. The slot antenna may be formed, at least in part, by the electrically conductive frame, wherein the slot antenna includes a slot opening and is configured to provide at least a first frequency resonance. The width of the slot opening may be equal to or less than $\frac{1}{200}^{th}$ of the wavelength of the first resonant frequency.

20 Claims, 6 Drawing Sheets





US008780001B2

(12) **United States Patent**
Lee

(10) **Patent No.:** **US 8,780,001 B2**
(45) **Date of Patent:** **Jul. 15, 2014**

(54) **ASYMMETRICAL DIPOLE ANTENNA**
(75) Inventor: **Chang-Jung Lee**, Taoyuan County (TW)
(73) Assignee: **Accton Technology Corporation**,
Hsinchu (TW)
(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 283 days.

(21) Appl. No.: **13/347,157**
(22) Filed: **Jan. 10, 2012**

(65) **Prior Publication Data**
US 2012/0176289 A1 Jul. 12, 2012

(30) **Foreign Application Priority Data**
Jan. 10, 2011 (TW) 100100823 A

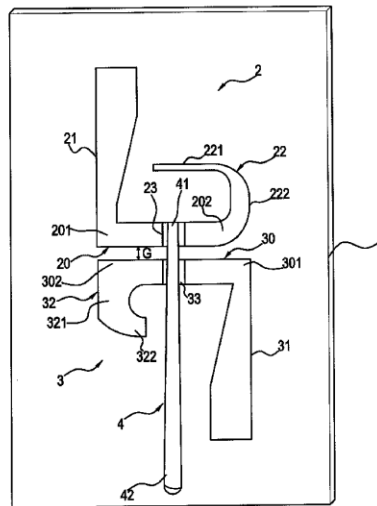
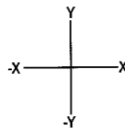
(51) **Int. Cl.**
H01Q 19/10 (2006.01)
(52) **U.S. Cl.**
USPC **343/818**
(58) **Field of Classification Search**
USPC 343/818, 807, 821, 830, 793-797
See application file for complete search history.

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

(57) **ABSTRACT**
An asymmetrical dipole antenna is provided. A radiation
module and a ground module are formed by a metallic con-
ductor and arranged at an interval on a substrate of the
antenna, and the radiation module and the ground module,
respectively, have a radiation base and a ground base. Two
radiation arms and two ground arms are formed by extending
from two ends of the two respective bases in opposite direc-
tions. The two radiation arms are orthogonal to the radiation
base, and the second radiation arm is bent and extended
toward the first radiation arm to form an arc opened toward
the first radiation arm. The two ground arms are orthogonal to
the ground base, and a hook is formed by extending and
bending the second ground arm toward the first ground arm.
A feeder unit connects the feed point and the ground point of
the two bases.

9 Claims, 7 Drawing Sheets





US008780002B2

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

(10) **Patent No.:** **US 8,780,002 B2**
(45) **Date of Patent:** **Jul. 15, 2014**

(54) **MULTIPLE-INPUT MULTIPLE-OUTPUT (MIMO) MULTI-BAND ANTENNAS WITH A CONDUCTIVE NEUTRALIZATION LINE FOR SIGNAL DECOUPLING**

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(75) Inventors: **Mikael Håkansson**, Skåne (SE);
Zhinong Ying, Skåne (SE)

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(73) Assignees: **Sony Corporation**, Tokyo (JP); **Sony Mobile Communications AB**, Lund (SE)

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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 382 days.

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(21) Appl. No.: **12/837,018**

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(22) Filed: **Jul. 15, 2010**

(Continued)

(65) **Prior Publication Data**

US 2012/0013519 A1 Jan. 19, 2012

Primary Examiner — Jacob Y Choi

Assistant Examiner — Jae Kim

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

(74) *Attorney, Agent, or Firm* — Myers Bigel Sibley & Sajovec, PA

(52) **U.S. Cl.**
USPC **343/835**; 343/700 MS; 343/834;
343/836; 343/837; 343/893

(57) **ABSTRACT**

A MIMO antenna includes first and second radiating elements and a conductive neutralization line. Each of the first and second radiating elements includes a straight portion connected to a serpentine portion. The straight and serpentine portions are configured to resonate in at least two spaced apart RF frequency ranges in response to the straight portion being electrically excited through a RF feed. The conductive neutralization line conducts resonant currents between the first and second radiating elements and has a conductive length that is configured to phase shift the conducted resonant currents to cause at least partial cancellation of currents in the first and second radiating elements which are generated by wireless RF signals received by the first and second radiating elements from each other.

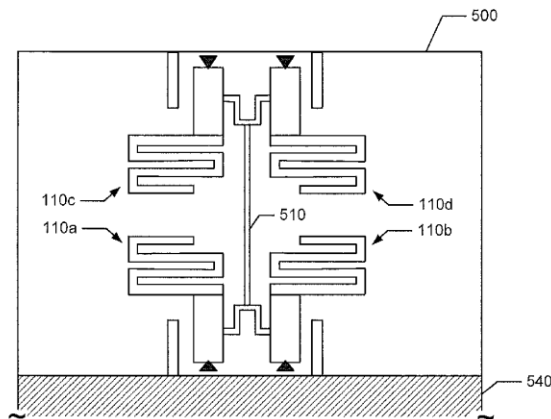
(58) **Field of Classification Search**
CPC H01Q 1/521; H01Q 1/38; H01Q 21/28;
H01Q 1/243; H01Q 1/36
USPC 343/700 MS
See application file for complete search history.

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19 Claims, 4 Drawing Sheets





US008780007B2

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

(10) **Patent No.:** **US 8,780,007 B2**
(45) **Date of Patent:** **Jul. 15, 2014**

(54) **HANDHELD DEVICE AND PLANAR ANTENNA THEREOF**

(75) Inventors: **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 322 days.

(21) Appl. No.: **13/106,934**

(22) Filed: **May 13, 2011**

(65) **Prior Publication Data**

US 2012/0287014 A1 Nov. 15, 2012

(51) **Int. Cl.**
H01Q 3/24 (2006.01)
H01Q 9/04 (2006.01)
H01Q 5/00 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/14 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 9/0442** (2013.01); **H01Q 5/0034** (2013.01); **H01Q 9/145** (2013.01)
USPC **343/876**

(58) **Field of Classification Search**
USPC 343/876, 702
See application file for complete search history.

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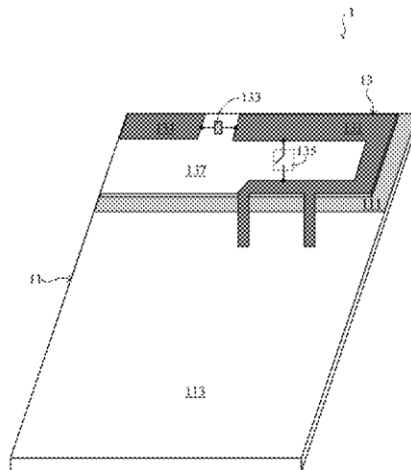
Primary Examiner — Seung Lee

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

(57) **ABSTRACT**

A handheld device and a planar antenna thereof are provided. The planar antenna comprises a radiator, a screening element and a switch. The screening element is configured to make the planar antenna operating in a first high-frequency (HF) current path and a first low-frequency (LF) current path, and the switch is configured to make the planar antenna operating in a second HF current path and a second LF current path. The planar antenna operates at a first HF central frequency corresponding to the first HF current path and a first LF central frequency corresponding to the first LF current path when the switch is turned off, and operates at a second HF central frequency corresponding to the second HF current path and a second LF central frequency corresponding to the second LF current path when the switch is turned on.

12 Claims, 7 Drawing Sheets





US008781420B2

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

(10) **Patent No.:** **US 8,781,420 B2**
(45) **Date of Patent:** **Jul. 15, 2014**

(54) **ADJUSTABLE WIRELESS CIRCUITRY WITH ANTENNA-BASED PROXIMITY DETECTOR**

(75) Inventors: **Robert W. Schlub**, Cupertino, CA (US);
Ruben Caballero, San Jose, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 597 days.

(21) Appl. No.: **12/759,243**

(22) Filed: **Apr. 13, 2010**

(65) **Prior Publication Data**

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

(52) **U.S. Cl.**
USPC **455/127.2**; 455/115.1

(58) **Field of Classification Search**
USPC 455/101, 115.1, 121, 127.1, 269, 272, 455/273, 276.1, 277.1, 277.2, 278.1, 296
See application file for complete search history.

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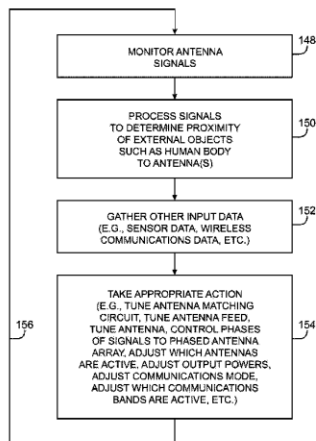
Primary Examiner — Blane J Jackson

(74) Attorney, Agent, or Firm — Treyz Law Group; G. Victor Treyz; Chih-Yun Wu

(57) **ABSTRACT**

An electronic device such as a portable electronic device has wireless communications circuitry. Antennas in the electronic device may be used in transmitting radio-frequency antenna signals. A coupler and antenna signal phase and magnitude measurement circuitry may be used to determine when external objects are in the vicinity of the antenna by making antenna impedance measurements. In-band and out-of-band phase and magnitude signal measurements may be made in determining whether external objects are present. Additional sensors such as motion sensors, light and heat sensors, acoustic and electrical sensors may produce data that can be combined with the proximity data gathered using the antenna-based proximity sensor. In response to detecting that an external object such as a user's body is within a given distance of the antenna, the electronic device may reduce transmit powers, switch antennas, steer a phased antenna array, switch communications protocols, or take other actions.

16 Claims, 9 Drawing Sheets





US008786497B2

(12) **United States Patent**
Sharawi

(10) **Patent No.:** **US 8,786,497 B2**
(45) **Date of Patent:** **Jul. 22, 2014**

(54) **HIGH ISOLATION MULTIBAND MIMO ANTENNA SYSTEM**

(56) **References Cited**

(75) Inventor: **Mohammad S. Sharawi**, Dhahran (SA)

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(73) Assignee: **King Fahd University of Petroleum and Minerals**, Dhahran (SA)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 847 days.

(21) Appl. No.: **12/958,330**

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(22) Filed: **Dec. 1, 2010**

Primary Examiner — Michael C Wimer
(74) *Attorney, Agent, or Firm* — Richard C. Litman

(65) **Prior Publication Data**

US 2012/0139793 A1 Jun. 7, 2012

(57) **ABSTRACT**

The high isolation multiband MIMO antenna system is a multi-band dual and quad antenna for multiple-input-multiple-output (MIMO) antenna systems. Element and ground plane geometries that can cover a wide range of frequency bands (780 MHz-5850 MHz) are based on the varying some simple geometrical lengths and widths of the elements and ground planes. The MIMO antenna systems can be used for next generation cellular and wireless MIMO communication systems. Several isolation enhancement schemes increase the isolation between adjacent antenna elements. Any combination of the isolation and MIMO antenna system geometries can be created to support different wireless system standards. The novel MIMO antenna systems are disposed within a dielectric substrate area of 50x100 mm².

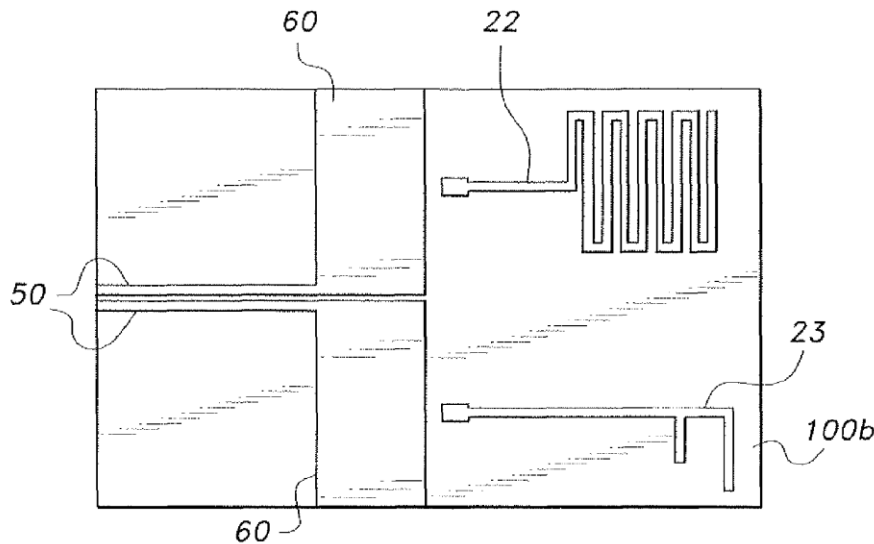
(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 5/01 (2006.01)
H01Q 21/30 (2006.01)

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

(58) **Field of Classification Search**
USPC 343/700 MS, 702, 828, 829, 841, 846, 343/895

See application file for complete search history.

15 Claims, 11 Drawing Sheets





US008786499B2

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

(10) **Patent No.:** **US 8,786,499 B2**
(45) **Date of Patent:** **Jul. 22, 2014**

(54) **MULTIBAND ANTENNA SYSTEM AND METHODS**

(75) Inventors: **Pertti Nissinen**, Kempele (FI); **Antti Leskelä**, Oulu (FI); **Jari Perunka**, Tupos (FI); **Zlatoljub Milosavljevic**, Kempele (FI); **Petteri Annamaa**, Oulunsalo (FI); **Kimmo Koskiniemi**, Oulu (FI)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1813 days.

(21) Appl. No.: **12/083,129**

(22) PCT Filed: **Sep. 20, 2006**

(86) PCT No.: **PCT/FI2006/050403**

§ 371 (c)(1),
(2), (4) Date: **May 17, 2010**

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PCT Pub. Date: **Apr. 12, 2007**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Oct. 3, 2005 (FI) 20055527

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H01Q 21/00 (2006.01)

(52) **U.S. Cl.**
USPC **343/702**; 343/700 MS; 343/853;
343/893

(58) **Field of Classification Search**
None
See application file for complete search history.

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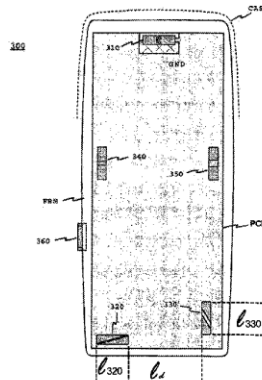
Primary Examiner — Trinh Dinh

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

(57) **ABSTRACT**

An antenna system internal to the device especially intended for small-sized mobile stations, the system having separate operating bands. The system is implemented as decentralized in a way that the device (300) has a plurality of separate antennas (310-360). Each antenna is based on (a) radiating element(s) on the surface of a dielectric substrate. The substrate can be, for example, a piece of ceramics or a part of the outer casing of the device. The antennas are located at suitable places in the device. The operating band of an individual antenna covers the frequency range used by one radio system, the frequency ranges close to each other and is used by two different radio systems or only the transmitting or receiving band of the frequency range used by a radio system. If the device has a shared transmitter and a shared receiver for the radio systems using frequency ranges close to each other, there can anyway be a separate antenna for each system or the antenna can also be shared. The antennas can be made very small, because a relatively small bandwidth is sufficient for an individual antenna, when there is a plurality of antennas. A good matching of the antenna is achieved on the whole width of each radio system, because the matching of a separate antenna having a relatively narrow band is easier to arrange than that of a combined multi-band antenna. No switches are needed in the structure for choosing a sub-band, which contributes to good efficiency for its part.

19 Claims, 5 Drawing Sheets





US008786500B2

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

(10) **Patent No.:** **US 8,786,500 B2**
(45) **Date of Patent:** **Jul. 22, 2014**

- (54) **BUILT-IN ANTENNA AND METHOD FOR IMPROVING ANTENNA EFFICIENCY**
- (75) Inventors: **Sang-Jin Eom**, Suwon-si (KR); **Jin-Kyu Bang**, Suwon-si (KR); **Ho-Saeng Kim**, Anyang-si (KR); **Yong-Jin Kim**, Seoul (KR); **Jin-U Kim**, 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 343 days.
- (21) Appl. No.: **13/204,032**
- (22) Filed: **Aug. 5, 2011**
- (65) **Prior Publication Data**
US 2012/0044114 A1 Feb. 23, 2012
- (30) **Foreign Application Priority Data**
Aug. 17, 2010 (KR) 10-2010-0079223
- (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 MS, 702, 846
See application file for complete search history.

- (56) **References Cited**
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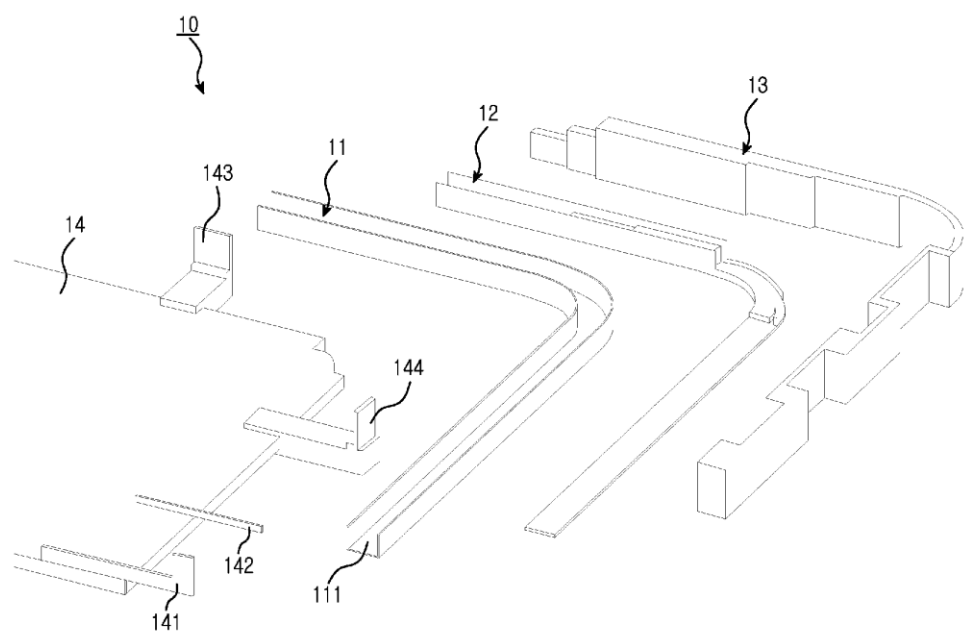
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Primary Examiner — Tho G Phan
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

A built-in antenna of a portable terminal and a method of forming the same are provided. The built-in antenna includes a first conductor having a specific length and used for a ground, a second conductor disposed with a specific distance in parallel to the first conductor to couple with the first conductor and used for power feeding, and a separating element disposed between the first conductor and the second conductor to separate the first and second conductors. Accordingly, the built-in antenna may exhibit a smooth radiation property even if a metal construction is used in a device and thus may implement robustness improvement of the device and make the device slim and have an attractive outer appearance. In addition, a method of improving antenna efficiency may prevent deterioration of the radiation property of the antenna radiator of the related art by using simple processing, and the metal construction may be used as a radiator.

16 Claims, 20 Drawing Sheets





US008786507B2

(12) **United States Patent**
Ayatollahi

(10) **Patent No.:** **US 8,786,507 B2**
(45) **Date of Patent:** **Jul. 22, 2014**

(54) **ANTENNA ASSEMBLY UTILIZING METAL-DIELECTRIC STRUCTURES**

(75) Inventor: **Mina Ayatollahi**, 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 448 days.

(21) Appl. No.: **13/095,338**

(22) Filed: **Apr. 27, 2011**

(65) **Prior Publication Data**

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H01Q 13/10 (2006.01)

(52) **U.S. Cl.**
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(58) **Field of Classification Search**
USPC 343/770, 725; 455/550.1, 575.1
See application file for complete search history.

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Primary Examiner — Allyson Trail

(74) *Attorney, Agent, or Firm* — Quarles & Brady LLP

(57) **ABSTRACT**

An antenna assembly for a wireless communication device includes a substrate of dielectric material that has opposing first and second surfaces. A ground plane formed by a layer of electrically conductive material on the first surface. An antenna with a physical length is disposed on the substrate. At least one metal-dielectric structure is disposed on the substrate. The metal-dielectric structures resonate so as to interact with the antenna and thereby alter the effective electrical length of the antenna. That interaction causes the antenna to function as though it had a greater physical length. In one embodiment, that interaction enables an antenna, that is shorter than one-fourth the wavelength of a radio frequency signal applied thereto, to function as through the physical length of the antenna was one-fourth that wavelength.

23 Claims, 4 Drawing Sheets

