



US008191230B2

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

(10) **Patent No.:** **US 8,191,230 B2**
(45) **Date of Patent:** **Jun. 5, 2012**

(54) **METHOD FOR MAKING RADIO FREQUENCY (RF) ANTENNA CONTAINING ELEMENT**

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(73) Assignee: **Avery Dennison Corporation**, Pasadena, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 109 days.

(21) Appl. No.: **12/426,307**

(22) Filed: **Apr. 20, 2009**

(65) **Prior Publication Data**
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Related U.S. Application Data
(62) Division of application No. 11/338,590, filed on Jan. 24, 2006.

(51) **Int. Cl.**
H01Q 1/12 (2006.01)
(52) **U.S. Cl.** **29/600; 343/700 MS**
(58) **Field of Classification Search** 29/600, 29/564.2-564.4; 235/487-488, 492; 340/572.2-572.7; 343/700 MS, 886; 156/238, 156/247, 268
See application file for complete search history.

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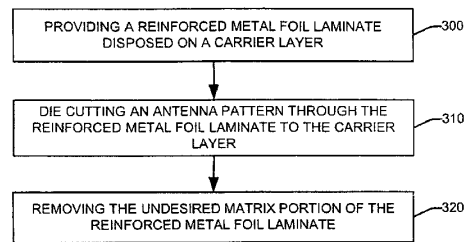
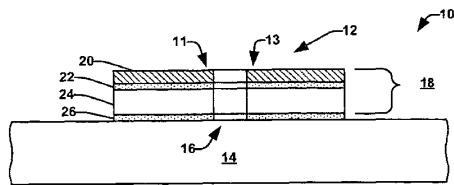
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Primary Examiner — Minh Trinh
(74) *Attorney, Agent, or Firm* — Avery Dennison Corporation

(57) **ABSTRACT**
Methods of making a radio frequency (RF) antenna containing element are provided. The methods comprise providing a metal foil laminate bonded to a carrier layer. The metal foil laminate can have a metal foil layer bonded to a reinforcement layer. The methods further comprise cutting an antenna pattern through the metal foil laminate to the carrier layer, and removing an undesired matrix portion of the reinforced metal foil laminate to provide a metal foil laminate antenna disposed on the carrier layer.

13 Claims, 5 Drawing Sheets





US008193988B2

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

(10) **Patent No.:** **US 8,193,988 B2**
(45) **Date of Patent:** **Jun. 5, 2012**

(54) **VERSATILE ANTENNA SYSTEM**

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Corinne Nicolas, La Chapelle des
Fougeretz (FR)

(73) Assignee: **Thomson Licensing**,
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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 213 days.

(21) Appl. No.: **11/919,770**

(22) PCT Filed: **May 3, 2006**

(86) PCT No.: **PCT/FR2006/050409**
§ 371 (c)(1),
(2), (4) Date: **Nov. 1, 2007**

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(65) **Prior Publication Data**
US 2009/0085821 A1 Apr. 2, 2009

(30) **Foreign Application Priority Data**
May 3, 2005 (FR) 05 51166

(51) **Int. Cl.**
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(52) **U.S. Cl.** **343/700 MS; 343/893**
(58) **Field of Classification Search** **343/700 MS,**
343/767, 795, 819, 893
See application file for complete search history.

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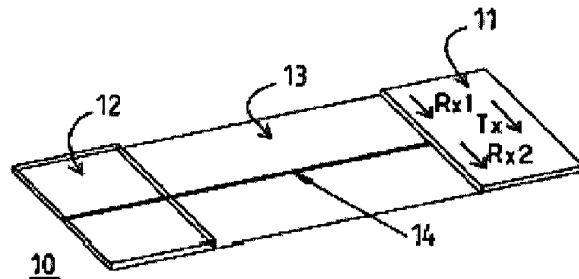
Primary Examiner — Kyana R McCain

(74) *Attorney, Agent, or Firm* — Tutunjian & Bitetto, P.C.

(57) **ABSTRACT**

The present invention relates to an antenna system designed
to be used in a wireless link, having polarization directions,
respectively for reception and emission, identical to the polar-
ization directions, respectively for emission and reception,
presented by a similar system placed in a geometric configura-
tion of use that is different from that of the said first system.
The invention enables identical devices to be implemented in
separate items of equipment and in distinct positions while
enabling the antenna pair to function correctly.

13 Claims, 4 Drawing Sheets





US008193989B2

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

(10) **Patent No.:** **US 8,193,989 B2**
(45) **Date of Patent:** **Jun. 5, 2012**

- (54) **ANTENNA APPARATUS**
- (75) Inventors: **Seiken Fujita**, Saitama (JP); **Hisamatsu Nakano**, Kodaira (JP); **Iichi Wako**, Saitama (JP); **Ken Tanaka**, Saitama (JP); **Toshihito Umegaki**, Inagi (JP)
- (73) Assignees: **Hitachi Kokusai Electric Inc.**, Tokyo (JP); **Yagi Antenna Inc.**, Saitama-Shi (JP)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 555 days.

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(21) Appl. No.: **12/354,227**

(22) Filed: **Jan. 15, 2009**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. PCT/JP2007/066480, filed on Aug. 24, 2007.

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- (51) **Int. Cl.**
H01Q 1/38 (2006.01)
- (52) **U.S. Cl.** **343/700 MS; 343/846**
- (58) **Field of Classification Search** **343/700 MS, 343/829, 833, 834, 846**
See application file for complete search history.

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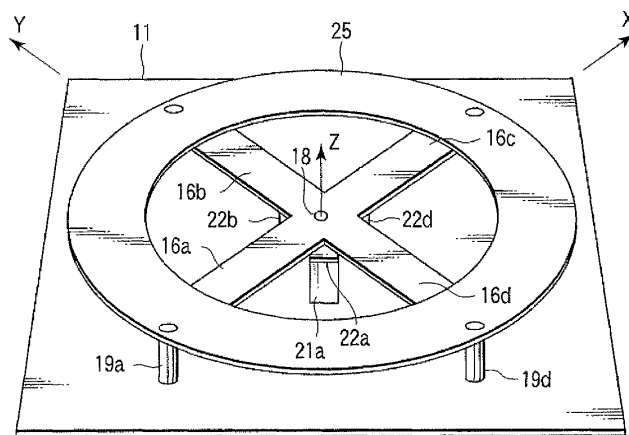
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Primary Examiner — Tho G Phan
(74) *Attorney, Agent, or Firm* — Bacon & Thomas, PLLC

(57) **ABSTRACT**

An aspect of an antenna apparatus according to the present invention is provided with a conductor plate, radiating elements disposed to face the conductor plate and partially short-circuited to the conductor plate, a feeding terminal provided on the conductor plate, and a feeding path connecting the feeding terminal and a feeding portion of the radiating elements to each other.

12 Claims, 54 Drawing Sheets





US008193990B2

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

(10) **Patent No.:** **US 8,193,990 B2**
(45) **Date of Patent:** **Jun. 5, 2012**

(54) **MICROSTRIP ARRAY ANTENNA**
(75) Inventors: **Kento Nakabayashi**, Anjo (JP); **Kunio Sakakibara**, Nagoya (JP)
(73) Assignees: **Denso Corporation**, Kariya (JP); **National University Corporation Nagoya Institute of Technology**, Nagoya (JP)

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(21) Appl. No.: **12/462,112**

(22) Filed: **Jul. 29, 2009**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jul. 31, 2008 (JP) 2008-198297

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

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

(58) **Field of Classification Search** **343/700 MS, 343/846, 850, 853, 824**
See application file for complete search history.

(56) **References Cited**

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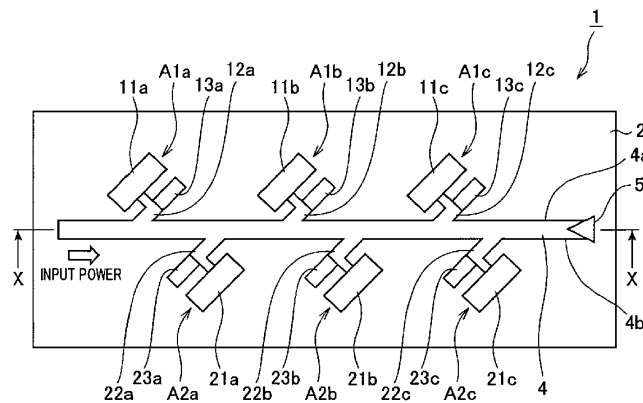
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(74) *Attorney, Agent, or Firm* — Harness, Dickey & Pierce, PLC

(57) **ABSTRACT**

The microstrip array antenna includes a dielectric substrate formed with a conductive ground plate at a back surface thereof, and strip conductors formed on a front surface of the dielectric substrate. The strip conductors includes a linear main feeding strip line, and a plurality of array elements connected to the main feeding strip line, the array elements being disposed at least one of both sides of the main feeding strip line at a predetermined interval along a longitudinal direction of the main feeding strip line. Each of the array elements includes a sub-feeding strip line connected to the main feeding strip line, a rectangular radiating antenna element connected to a terminal end of the sub-feeding strip line, and a stub connected to the sub-feeding strip line. The stub is disposed between the main feeding strip line and the radiating antenna element.

19 Claims, 11 Drawing Sheets





US008193991B2

(12) **United States Patent**
Rofougaran

(10) **Patent No.:** **US 8,193,991 B2**
(45) **Date of Patent:** **Jun. 5, 2012**

(54) **INTEGRATED CIRCUIT MEMS ANTENNA STRUCTURE**

(75) Inventor: **Ahmadreza (Reza) Rofougaran,**
Newport Coast, CA (US)

(73) Assignee: **Broadcom Corporation,** Irvine, CA
(US)

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

(21) Appl. No.: **12/763,161**

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

(65) **Prior Publication Data**

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Related U.S. Application Data

(62) Division of application No. 11/648,828, filed on Dec. 29, 2006.

(51) **Int. Cl.**
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(52) **U.S. Cl.** **343/700 MS; 343/767; 343/772; 343/909; 343/793; 343/773**

(58) **Field of Classification Search** **343/700 MS, 343/767, 909, 773, 753, 772, 793**
See application file for complete search history.

(56) **References Cited**

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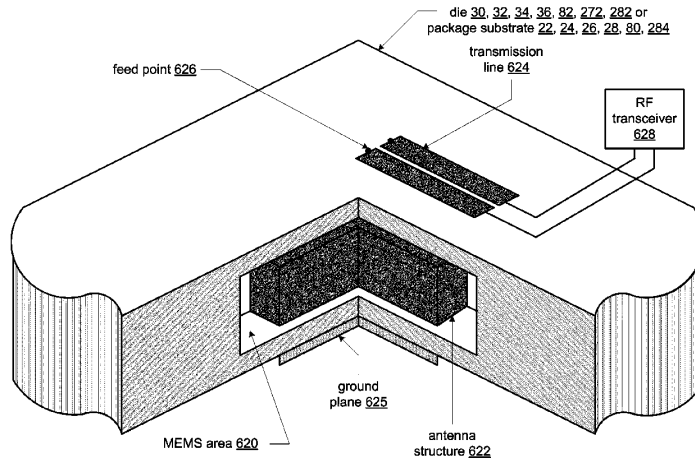
Primary Examiner — Dieu H Duong

(74) *Attorney, Agent, or Firm* — Garlick & Markison; Holly L. Rudnick

(57) **ABSTRACT**

An integrated circuit (IC) antenna structure includes a micro-electromechanical (MEM) area, a feed point, and a transmission line. The micro-electromechanical (MEM) area includes a three-dimensional shape, wherein the three dimensional-shape provides an antenna structure. The feed point is coupled to provide an outbound radio frequency (RF) signal to the antenna structure for transmission and to receive an inbound RF signal from the antenna structure. The transmission line electrically coupled to the feed point.

20 Claims, 38 Drawing Sheets





US008193992B2

(12) **United States Patent**
Ikonen

(10) **Patent No.:** **US 8,193,992 B2**
(45) **Date of Patent:** **Jun. 5, 2012**

(54) **RADIO COMMUNICATION APPARATUS AND AN ASSOCIATED METHOD**

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(75) Inventor: **Pekka Martti Tapio Ikonen**, Helsinki (FI)

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

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1048 days.

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(21) Appl. No.: **11/998,696**

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(22) Filed: **Nov. 30, 2007**

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(65) **Prior Publication Data**

Primary Examiner — Dieu H Duong

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

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

(57) **ABSTRACT**

(52) **U.S. Cl.** 343/702; 343/787; 343/700 MS

An apparatus including: a conductive antenna; a conductive object; a connection having a complex electrical impedance between the antenna and the conductive object; and an element having a complex magnetic permeability located adjacent the conductive antenna, wherein, when the conductive antenna is energized, the connection and the element substantially reduce a phase difference between an electric current flowing in the conductive antenna and an induced electric current flowing in the conductive object. Methods and other apparatus are described and claimed.

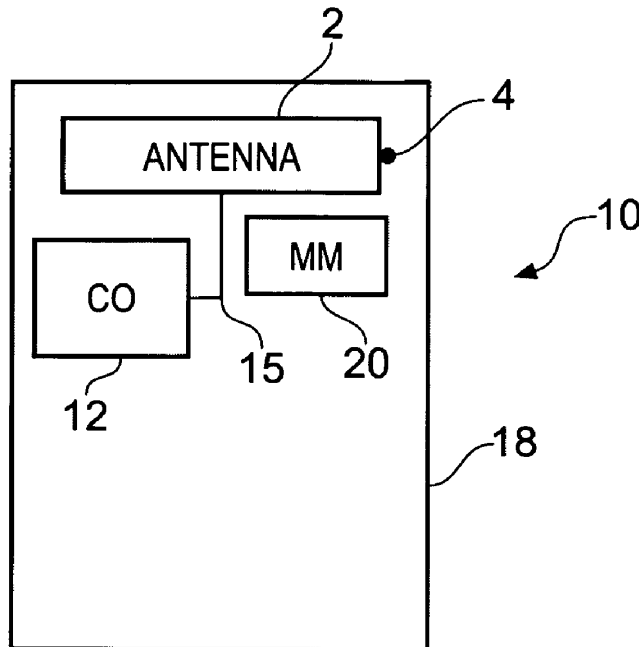
(58) **Field of Classification Search** 343/787, 343/793, 795, 700 MS, 702
See application file for complete search history.

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31 Claims, 3 Drawing Sheets





US008193993B2

(12) **United States Patent**
Maddaleno

(10) **Patent No.:** **US 8,193,993 B2**
(45) **Date of Patent:** **Jun. 5, 2012**

(54) **ANTENNA SUB-ASSEMBLY FOR ELECTRONIC DEVICE**
(75) Inventor: **Marco Maddaleno**, Turin (IT)
(73) Assignee: **Motorola Mobility, Inc.**, Libertyville, IL (US)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 272 days.

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(22) Filed: **May 11, 2009**

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

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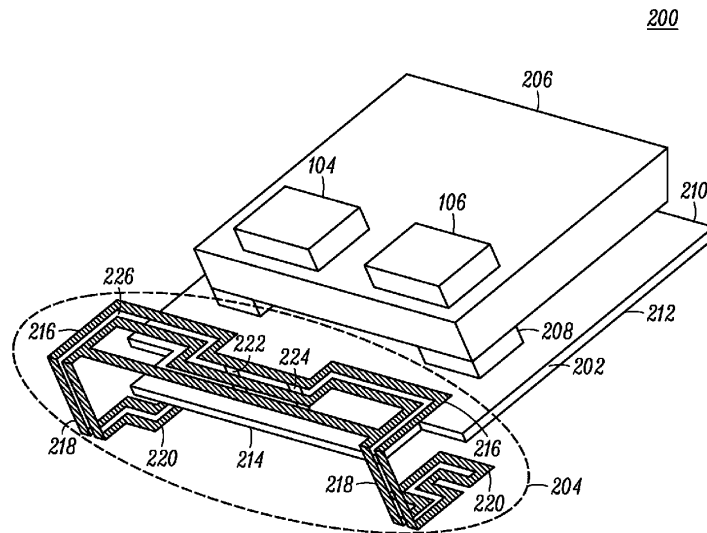
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Primary Examiner — Tan Ho

(57) **ABSTRACT**

A portable electronic device (100) having an antenna sub-assembly (204) including a conductor with a first portion (216) along a first surface of a circuit board, a second portion (218) connected to the first portion along an edge of the circuit board, and a third portion (220) connected to the second portion. The third portion is along a second surface of the circuit board. A feed leg (222) couples to the conductor to radio circuitry.

16 Claims, 5 Drawing Sheets





US008193996B2

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

(10) **Patent No.:** **US 8,193,996 B2**
(45) **Date of Patent:** **Jun. 5, 2012**

- (54) **ANTENNA RADOME**
- (75) Inventors: **Chun-Yih Wu**, Taichung (TW);
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Ken-Huang Lin, Kaohsiung (TW);
Kun-Hsien Lin, Tainan County (TW);
Yu-Feng Yeh, Taipei (TW)
- (73) Assignees: **Industrial Technology Research Institute**, Hsinchu (TW); **National Sun Yat-Sen University**, Kaohsiung (TW)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 531 days.

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- (30) **Foreign Application Priority Data**
Jun. 23, 2008 (TW) 97123319 A

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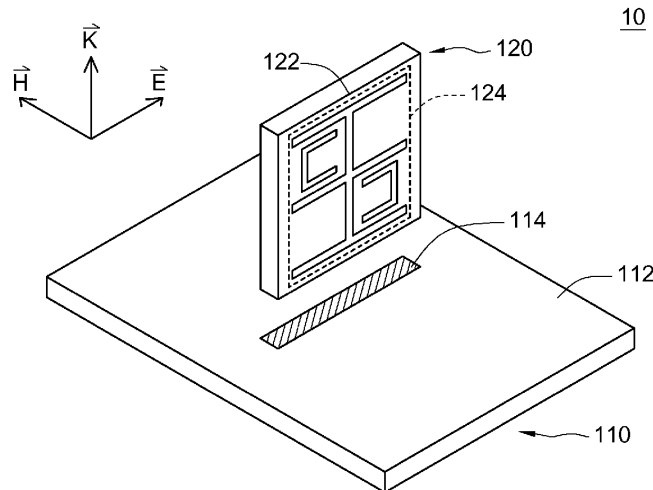
- (51) **Int. Cl.**
H01Q 1/42 (2006.01)
- (52) **U.S. Cl.** **343/872**; 343/909; 343/700 MS
- (58) **Field of Classification Search** 343/909,
343/872, 873, 700 MS
See application file for complete search history.

Primary Examiner — Dieu H Duong
 (74) *Attorney, Agent, or Firm* — Thomas|Kayden

- (56) **References Cited**
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2006/0044189 A1* 3/2006 Livingston et al. 343/700 MS
2006/0125681 A1* 6/2006 Smith et al. 342/120

(57) **ABSTRACT**
 An antenna radome is provided. The antenna radome comprises an antenna radome substrate and a unit cell. The unit cell is formed on a surface of the antenna radome substrate, and the unit cell is perpendicular to a magnetic field direction of an antenna. The unit cell comprises a plurality of conductors.

19 Claims, 6 Drawing Sheets



10



US008193997B2

(12) **United States Patent**
Webb

(10) **Patent No.:** **US 8,193,997 B2**
(45) **Date of Patent:** **Jun. 5, 2012**

(54) **DIRECTIONAL PLANAR LOG-SPIRAL SLOT ANTENNA**

(75) Inventor: **Spencer Webb**, Pelham, NH (US)

(73) Assignee: **Antennasys, Inc.**, Pelham, NH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 445 days.

(21) Appl. No.: **12/544,838**

(22) Filed: **Aug. 20, 2009**

(65) **Prior Publication Data**

US 2011/0043414 A1 Feb. 24, 2011

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

(52) **U.S. Cl.** **343/895**; 343/767; 343/792.5

(58) **Field of Classification Search** 343/767,
343/792.5, 895

See application file for complete search history.

(56) **References Cited**

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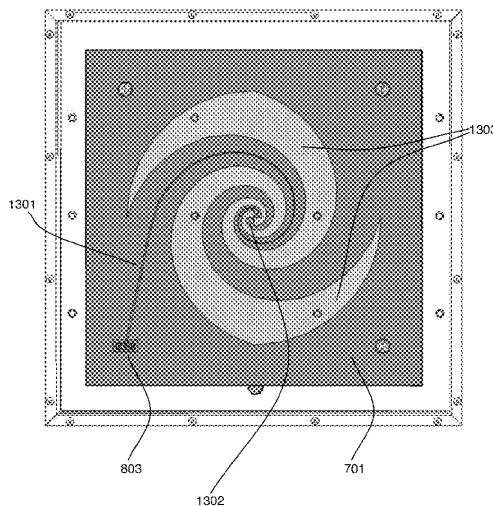
Primary Examiner — Tho G Phan

(74) *Attorney, Agent, or Firm* — ARC IP Law, PC; Joseph J. Mayo

(57) **ABSTRACT**

Directional wide band antenna that may be utilized to enhance cell phone coverage within a building, or for signals intelligence collection (SIGINT). Includes a log-spiral slot antenna with feed-point configured to transfer energy to/from the antenna. Includes an energy absorbent backing and an energy absorbent siding coupled with the log-spiral slot antenna. Includes a cavity behind the log-spiral slot antenna and in front of the energy absorbent backing. Includes a cable connector coupled to a tapered microstrip line coupled to the feed-point wherein the tapered microstrip line is configured to transform the input impedance to the antenna impedance. Housed in a container configured to hold the above listed components. Energy absorbent siding, cavity and energy absorbent backing greatly reduces back lobes. Another embodiment has log-spiral shaped slots at an outer portion of the log-spiral slot antenna overlap with the energy absorbent siding and wherein the feed-point overlaps the cavity.

20 Claims, 64 Drawing Sheets





US008193998B2

(12) **United States Patent**
Puente Baliarda et al.

(10) **Patent No.:** **US 8,193,998 B2**
(45) **Date of Patent:** **Jun. 5, 2012**

- (54) **ANTENNA CONTACTING ASSEMBLY**
- (75) Inventors: **Carles Puente Baliarda**, Barcelona (ES); **Eloy Hinojo**, Barcelona (ES)
- (73) Assignee: **Fractus, S.A.**, Barcelona (ES)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 728 days.

- (21) Appl. No.: **11/886,980**
- (22) PCT Filed: **Apr. 12, 2006**
- (86) PCT No.: **PCT/EP2006/061564**
§ 371 (c)(1),
(2), (4) Date: **Mar. 13, 2009**
- (87) PCT Pub. No.: **WO2007/098810**
PCT Pub. Date: **Sep. 7, 2007**

(65) **Prior Publication Data**
US 2009/0213029 A1 Aug. 27, 2009

Related U.S. Application Data
(60) Provisional application No. 60/678,571, filed on May 6, 2005.

(30) **Foreign Application Priority Data**
Apr. 14, 2005 (EP) 05102942

- (51) **Int. Cl.**
H01Q 1/50 (2006.01)
- (52) **U.S. Cl.** **343/906; 343/702**
- (58) **Field of Classification Search** **343/700 MS, 343/702, 906; 439/66, 862**
See application file for complete search history.

- (56) **References Cited**
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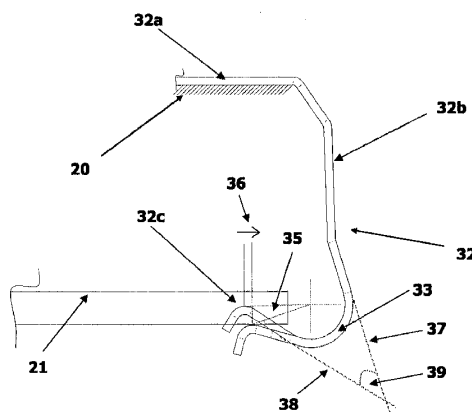
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Primary Examiner — Tan Ho
(74) *Attorney, Agent, or Firm* — Winstead PC

(57) **ABSTRACT**

This invention refers to an antenna contacting assembly which allows electrical connection of an antenna element to the RF module of a wireless device when very little space is available on the side of the PCB underneath the antenna element. The antenna contacting assembly provides electrical contact between a first conducting surface and a second conducting surface by engaging in traction mode said first conducting surface with said second conducting surface. Further the invention refers to an antenna system provided with such antenna contacting assembly and the corresponding wireless device with an antenna system provided with such antenna contacting assembly.

24 Claims, 12 Drawing Sheets





US008194416B2

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

(10) **Patent No.:** **US 8,194,416 B2**
(45) **Date of Patent:** **Jun. 5, 2012**

(54) **MULTILAYER PRINTED CIRCUIT BOARD HAVING ELECTROMAGNETIC WAVE REDUCTION MEMBER**

(75) Inventors: **Hark Byeong Park**, Suwon-si (KR); **Byong Su Seol**, Yongin-si (KR); **Hyung Geun Kim**, Yongin-si (KR); **Hyun Ho Park**, Daedeok-gu (KR); **Jong Sung Lee**, Seoul (KR); **Hyung Seok Lee**, Suwon-si (KR); **Young Jun Moon**, 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 1012 days.

(21) Appl. No.: **11/970,051**

(22) Filed: **Jan. 7, 2008**

(65) **Prior Publication Data**
US 2008/0198567 A1 Aug. 21, 2008

(30) **Foreign Application Priority Data**
Feb. 16, 2007 (KR) 10-2007-0016854

(51) **Int. Cl.**
H05K 9/00 (2006.01)
(52) **U.S. Cl.** **361/818**
(58) **Field of Classification Search** 361/818,
361/780, 793, 794; 174/255
See application file for complete search history.

(56) **References Cited**
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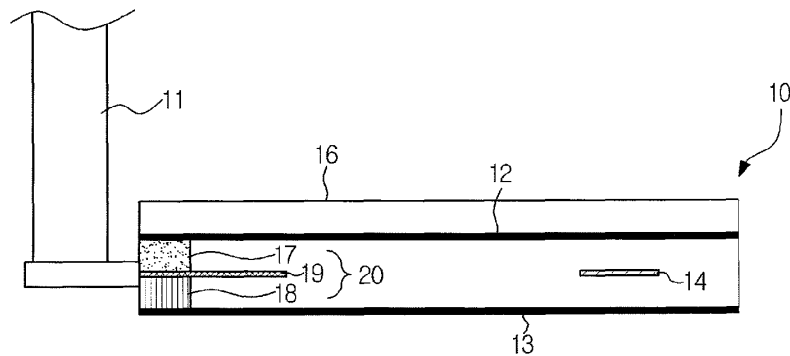
Primary Examiner — Jeremy Norris
Assistant Examiner — Tremesha S Willis

(74) *Attorney, Agent, or Firm* — Stanzione & Kim, LLP

(57) **ABSTRACT**

Disclosed is a multilayer printed circuit board. The multilayer printed circuit board includes a power source surface to provide power to each component disposed on the power source surface, a ground surface having a reference voltage, a strip line which passes through the power source surface and/or the ground surface so as to transmit signals between components, an antenna installed in proximity to a sectional region of the power source surface and the ground surface, and an electromagnetic wave reduction member which is provided between the power source surface and the ground surface to effectively reduce an electromagnetic wave generated from the strip line.

17 Claims, 5 Drawing Sheets





US008195236B2

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

(10) **Patent No.:** **US 8,195,236 B2**
(45) **Date of Patent:** **Jun. 5, 2012**

(54) **RETROFIT CONTACTLESS SMART SIM FUNCTIONALITY IN MOBILE COMMUNICATORS**

(75) Inventors: **Nehemya Itay**, Beit Hillel (IL); **Yaacov Haroosh**, Migdal HaEmek (IL); **Oded Bashan**, Rosh Pina (IL)

(73) Assignee: **On Track Innovations Ltd.**, Rosh Pina (IL)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 171 days.

(21) Appl. No.: **12/816,669**

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

(65) **Prior Publication Data**
US 2011/0312382 A1 Dec. 22, 2011

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

(52) **U.S. Cl.** **455/558**

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

(56) **References Cited**

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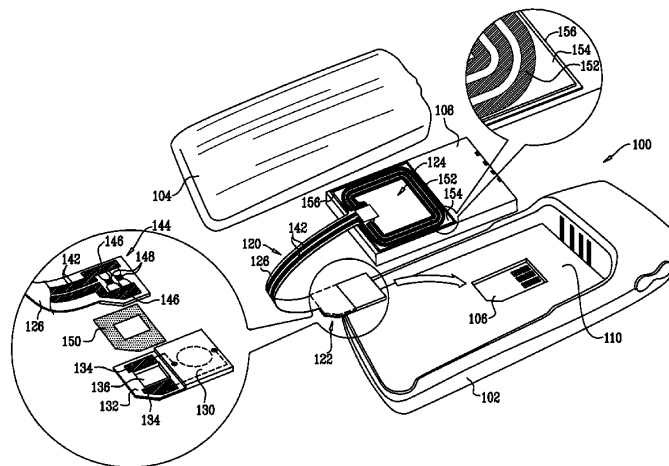
Primary Examiner — Ajit Patel

(74) Attorney, Agent, or Firm — Sughrue Mion, PLLC

(57) **ABSTRACT**

A mobile communicator including a main housing portion, defining a SIM card socket, a battery located at a battery location defined by the main housing portion, a cover over the battery and a retrofit contactless smart SIM functionality assembly, having a SIM card shaped portion which is mounted in the SIM card socket, a contactless smart card antenna portion located between the battery and the cover and an antenna tail portion which interconnects the contactless smart card antenna portion with the SIM card shaped portion, the antenna tail portion being attached and electrically connected to the SIM card shaped portion by means of an electrically conductive adhesive.

22 Claims, 2 Drawing Sheets





US008199056B2

(12) **United States Patent**
Pohjonen

(10) **Patent No.:** **US 8,199,056 B2**
(45) **Date of Patent:** **Jun. 12, 2012**

- (54) **ANTENNA ARRANGEMENT**
- (75) Inventor: **Helena Pohjonen**, Espoo (FI)
- (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 659 days.
- (21) Appl. No.: **11/992,792**
- (22) PCT Filed: **Oct. 13, 2005**
- (86) PCT No.: **PCT/IB2005/003180**
§ 371 (c)(1),
(2), (4) Date: **Jun. 23, 2009**
- (87) PCT Pub. No.: **WO2007/042856**
PCT Pub. Date: **Apr. 19, 2007**
- (65) **Prior Publication Data**
US 2009/0309795 A1 Dec. 17, 2009
- (51) **Int. Cl.**
H01Q 1/38 (2006.01)
- (52) **U.S. Cl.** **343/700 MS; 343/722**
- (58) **Field of Classification Search** **343/700 MS, 343/722, 846, 850, 893**
See application file for complete search history.

(56) **References Cited**

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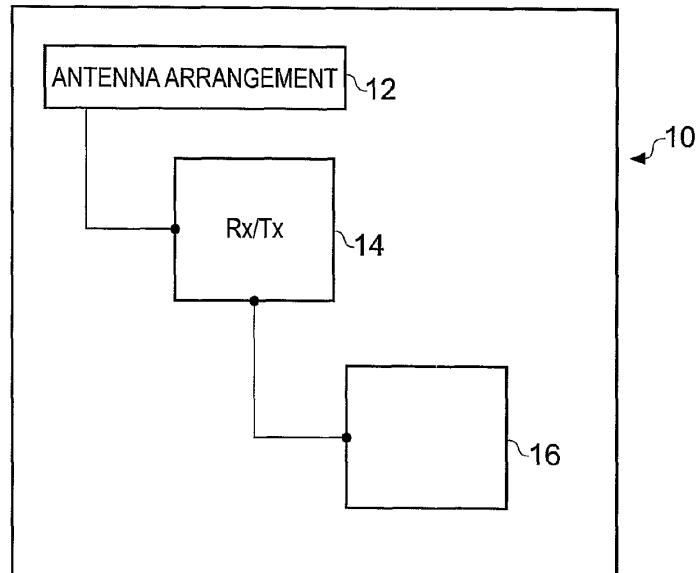
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Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — Harrington & Smith

(57) **ABSTRACT**

An antenna arrangement including a first antenna element having one or more surfaces; and a laminate attenuator, positioned adjacent a portion of at least one surface of the first antenna element, wherein the laminate attenuator is arranged or attenuating predetermined radio frequency electromagnetic waves.

20 Claims, 5 Drawing Sheets





US008199058B2

(12) **United States Patent**
Johnson

(10) **Patent No.:** **US 8,199,058 B2**
(45) **Date of Patent:** **Jun. 12, 2012**

(54) **ANTENNA SYSTEM WITH PIFA-FED CONDUCTOR**

(76) Inventor: **Greg F. Johnson**, Aptos, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 349 days.

(21) Appl. No.: **12/576,779**

(22) Filed: **Oct. 9, 2009**

(65) **Prior Publication Data**
US 2010/0090904 A1 Apr. 15, 2010

Related U.S. Application Data

(60) Provisional application No. 61/104,242, filed on Oct. 9, 2008.

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

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

(58) **Field of Classification Search** **343/700 MS, 343/702**

See application file for complete search history.

(56) **References Cited**

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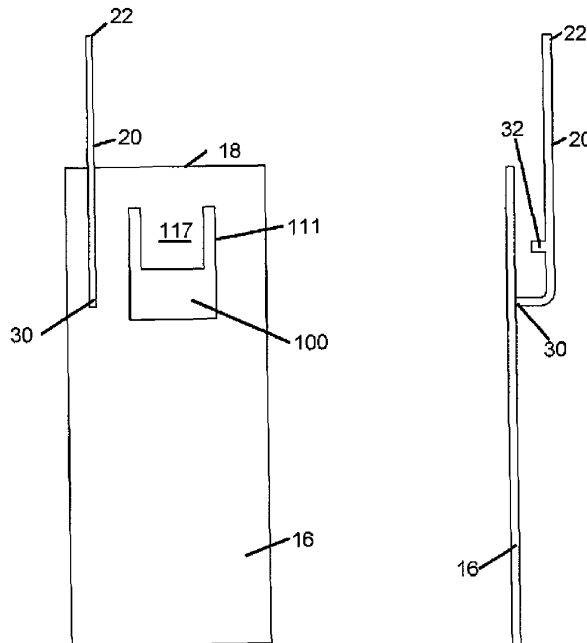
Primary Examiner — Dieu H Duong

(74) *Attorney, Agent, or Firm* — Briggs and Morgan, P.A.;
John F. Klos

(57) **ABSTRACT**

A high efficiency antenna for the 824-960 MHz and/or 1710-2170 MHz frequency ranges including world cellular and ISM bands, for use primarily on wireless communications devices such as handsets. An antenna system may be integrated within a handset as a "pull-out" whip or as an internal antenna. The antenna uses an oriented PIFA-fed resonator working in conjunction with a ground plane conductor, which can be realized as the ground traces of the PCB printed circuit board and/or an extension of the ground plane of a wireless communication device. The antenna system when installed on a handset as a pull-out whip, requires approximately one-half the extended length of current pull-out antennas, thus improving the device's aesthetic and mechanical durability.

18 Claims, 7 Drawing Sheets





US008199065B2

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

(10) **Patent No.:** **US 8,199,065 B2**
(45) **Date of Patent:** **Jun. 12, 2012**

(54) **H-J ANTENNA**

(75) Inventors: **Aviv Shachar**, Ramat-Gan (IL); **Yiu K. Chan**, Vernon Hills, IL (US); **Motti Elkobi**, Natanya (IL)

(73) Assignee: **Motorola Solutions, Inc.**, Schaumburg, IL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1196 days.

(21) Appl. No.: **11/965,780**

(22) Filed: **Dec. 28, 2007**

(65) **Prior Publication Data**

US 2011/0181485 A1 Jul. 28, 2011

(51) **Int. Cl.**
H01Q 21/30 (2006.01)

(52) **U.S. Cl.** **343/848**; 343/893; 343/702

(58) **Field of Classification Search** 343/702, 343/700 MS, 848, 893

See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Jacob Y Choi

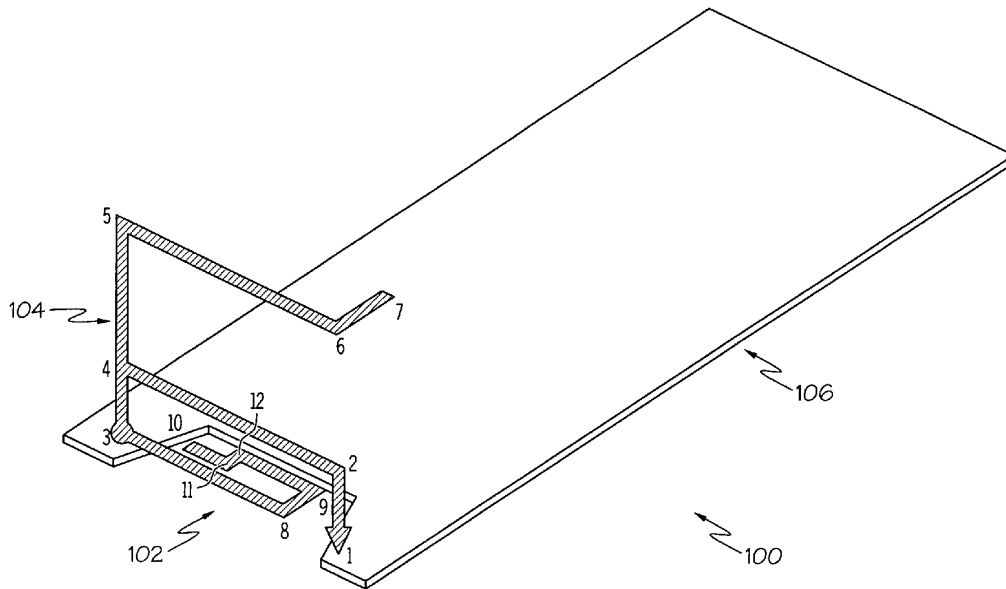
Assistant Examiner — Amal Patel

(74) *Attorney, Agent, or Firm* — Jeffrey K. Jacobs; Anthony P. Curtis; Daniel R. Bestor

(57) **ABSTRACT**

A dual-band antenna includes a first antenna element having a generally “J” shaped element, and a second antenna element having a generally “h” shaped element. The first antenna element and the second antenna element share a common feed point and each antenna element is oriented substantially perpendicular to the other. The first antenna element and the second antenna element, in one implementation, are adapted to efficiently operate the dual-band antenna at approximately 1575 MHz and approximately 850 MHz, respectively.

11 Claims, 12 Drawing Sheets





US008199066B2

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

(10) **Patent No.:** **US 8,199,066 B2**
(45) **Date of Patent:** **Jun. 12, 2012**

(54) **MAGNETIC ANTENNA AND ANTENNA DEVICE**

(75) Inventors: **Hiroyuki Kubo**, Ishikawa-ken (JP);
Hiromitsu Ito, Ishikawa-ken (JP);
Kuniaki Yosui, Ishikawa-ken (JP)

(73) Assignee: **Murata Manufacturing Co., Ltd.** (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 345 days.

(21) Appl. No.: **12/646,468**

(22) Filed: **Dec. 23, 2009**

(65) **Prior Publication Data**
US 2010/0156729 A1 Jun. 24, 2010

(30) **Foreign Application Priority Data**
Dec. 24, 2008 (JP) 2008-327416

(51) **Int. Cl.**
H01Q 1/36 (2006.01)
(52) **U.S. Cl.** **343/895; 343/702; 343/788**
(58) **Field of Classification Search** **343/702, 343/787, 788, 895**
See application file for complete search history.

(56) **References Cited**
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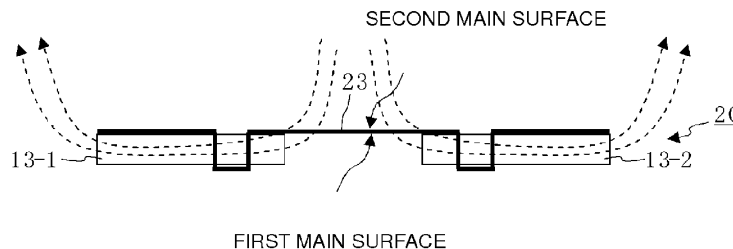
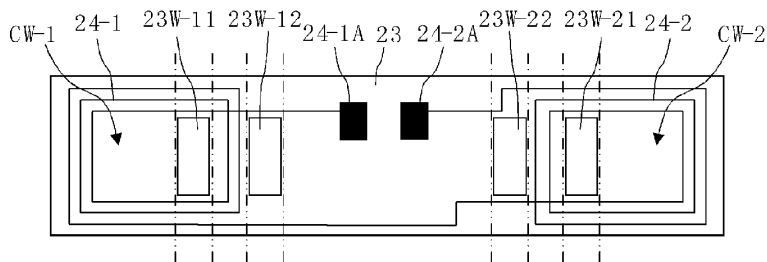
Primary Examiner — Tan Ho

(74) *Attorney, Agent, or Firm* — Studebaker & Brackett PC; Tim L. Brackett, Jr.; John F. Guay

(57) **ABSTRACT**

There is provided a magnetic antenna and an antenna device that increase the packaging density of a portion where the magnetic antenna is mounted in an electronic apparatus, and suppresses degradation of antenna performance. A flexible substrate has first and second substantially spiral-shaped coil conductors formed thereon. Conductor-opening-side through holes are formed in the respective conductor openings of the coil conductors, and non-coil-conductor-forming-area through holes are formed in areas in which the coil conductors are not formed. First and second magnetic cores are arranged so as to extend through the respective conductor-opening-side through holes from a first main surface of the flexible substrate and to extend through the respective non-coil-conductor-forming-area through holes in a direction from a second main surface side to the first main surface of the flexible substrate.

11 Claims, 6 Drawing Sheets





US008199855B2

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

(10) **Patent No.:** **US 8,199,855 B2**
(45) **Date of Patent:** **Jun. 12, 2012**

(54) **ANTENNA DIVERSITY**

(75) Inventors: **James Digby Yarlet Collier**, Suffolk (GB); **Steven Mark Singer**, Cambridge (GB)

(73) Assignee: **Cambridge Silicon Radio Limited**, Cambridge (GB)

(*) 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.: **12/088,077**

(22) PCT Filed: **Sep. 4, 2006**

(86) PCT No.: **PCT/GB2006/003272**
§ 371 (c)(1),
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(65) **Prior Publication Data**
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(30) **Foreign Application Priority Data**
Sep. 26, 2005 (GB) 0519582.1

(51) **Int. Cl.**
H03K 9/00 (2006.01)
H04L 27/00 (2006.01)

(52) **U.S. Cl.** **375/316; 375/267; 375/347; 455/277.1; 455/277.2**

(58) **Field of Classification Search** **375/267, 375/316, 347; 455/277.1, 277.2**
See application file for complete search history.

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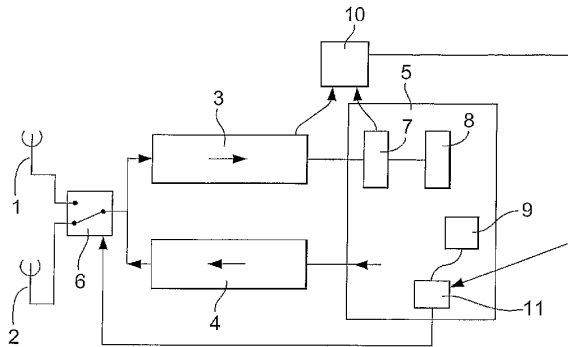
Primary Examiner — Curtis Odom

(74) *Attorney, Agent, or Firm* — Greenberg Traurig, LLP

(57) **ABSTRACT**

A communication device for receiving a signal in the form of a series of bursts, each burst being at one of a plurality of different available transmission modes, the communication device comprising: two antennas; a receiver unit coupled to the antennas for preferentially receiving signals from a selected one of the antennas; and an antenna selection unit for selecting for each received burst with which of the antennas the receiver unit is to preferentially receive signals.

22 Claims, 5 Drawing Sheets





US008200301B2

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

(10) **Patent No.:** **US 8,200,301 B2**
(45) **Date of Patent:** **Jun. 12, 2012**

- (54) **MOBILE WIRELESS COMMUNICATION APPARATUS HAVING A PLURALITY OF ANTENNA ELEMENTS**
- (75) Inventors: **Atsushi Yamamoto**, Kyoto (JP); **Hiroshi Iwai**, Osaka (JP); **Tsutomu Sakata**, Osaka (JP); **Yoshio Koyanagi**, Ishikawa (JP); **Toshiteru Hayashi**, Kanagawa (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 450 days.
- (21) Appl. No.: **12/516,611**
- (22) PCT Filed: **Sep. 30, 2008**
- (86) PCT No.: **PCT/JP2008/002753**
§ 371 (c)(1), (2), (4) Date: **Jul. 14, 2009**
- (87) PCT Pub. No.: **WO2009/044541**
PCT Pub. Date: **Apr. 9, 2009**
- (65) **Prior Publication Data**
US 2010/0056234 A1 Mar. 4, 2010
- (30) **Foreign Application Priority Data**
Oct. 2, 2007 (JP) 2007-258655
- (51) **Int. Cl.**
H04M 1/00 (2006.01)
- (52) **U.S. Cl.** **455/575.7; 455/575.5; 370/339**
- (58) **Field of Classification Search** **455/575.1-575.8**
See application file for complete search history.

(56) **References Cited**

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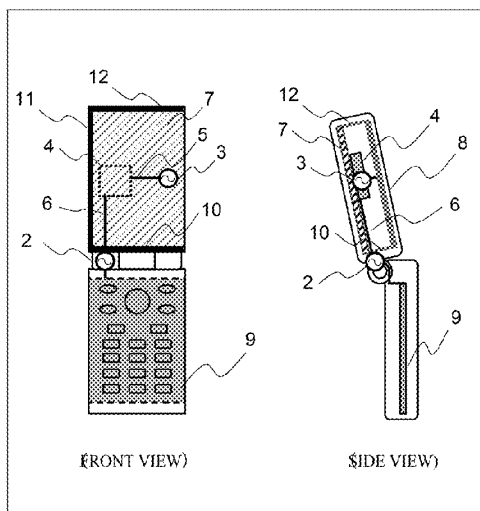
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Primary Examiner — Rafael Pérez-Gutiérrez
Assistant Examiner — Keith Fang
(74) *Attorney, Agent, or Firm* — Wenderoth, Lind & Ponack, L.L.P.

(57) **ABSTRACT**

A housing antenna is small enough in size so as to be accommodated in a mobile device. The antenna has a number of feeding points that allow the antenna to operate as a number of antennal elements. The antenna is capable of realizing high-speed communication by increasing communication capacity.

24 Claims, 20 Drawing Sheets





US008200302B2

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

(10) **Patent No.:** **US 8,200,302 B2**
(45) **Date of Patent:** **Jun. 12, 2012**

- (54) **MOBILE WIRELESS COMMUNICATION APPARATUS HAVING A PLURALITY OF ANTENNA ELEMENTS**
- (75) Inventors: **Atsushi Yamamoto**, Kyoto (JP); **Hiroshi Iwai**, Osaka (JP); **Tsutomu Sakata**, Osaka (JP); **Yoshio Koyanagi**, Ishikawa (JP); **Toshiteru Hayashi**, Kanagawa (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 448 days.
- (21) Appl. No.: **12/517,316**
- (22) PCT Filed: **Sep. 30, 2008**
- (86) PCT No.: **PCT/JP2008/002752**
§ 371 (c)(1),
(2), (4) Date: **Jul. 16, 2009**
- (87) PCT Pub. No.: **WO2009/044540**
PCT Pub. Date: **Apr. 9, 2009**
- (65) **Prior Publication Data**
US 2010/0069017 A1 Mar. 18, 2010
- (30) **Foreign Application Priority Data**
Oct. 2, 2007 (JP) 2007-258654
- (51) **Int. Cl.**
H04M 1/00 (2006.01)
- (52) **U.S. Cl.** **455/575.7; 455/575.5; 370/339**
- (58) **Field of Classification Search** **455/575.1-575.8**
See application file for complete search history.

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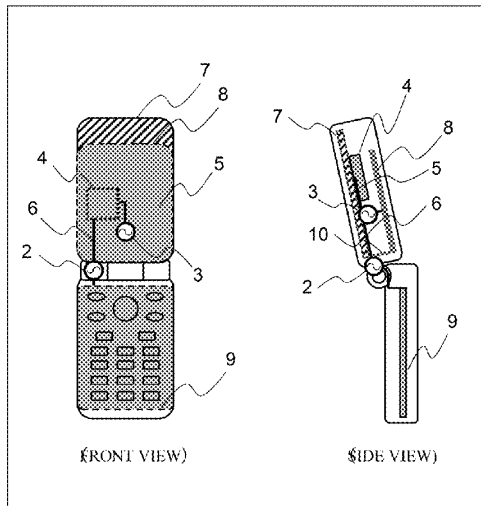
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- Primary Examiner* — Rafael Pérez-Gutiérrez
- Assistant Examiner* — Keith Fang
- (74) *Attorney, Agent, or Firm* — Wenderoth, Lind & Ponack, L.L.P.

- (57) **ABSTRACT**
- A housing antenna is small enough in size so as to be accommodated in a mobile device. The antenna has a number of feeding points that allow the antenna to operate as a number of antenna elements. The antenna is capable of realizing high speed communication by increasing communication capacity.
- 17 Claims, 23 Drawing Sheets**





US008200303B2

(12) **United States Patent**
Morishita

(10) **Patent No.:** **US 8,200,303 B2**
(45) **Date of Patent:** **Jun. 12, 2012**

(54) **PORTABLE TERMINAL ANTENNA
ARRANGEMENT TO SUPPRESS
DETERIORATION OF ANTENNA
SENSITIVITY**

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JP	2008-177730	A	7/2008

(75) Inventor: **Katsuji Morishita**, Kanagawa (JP)
(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 0 days.

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(21) Appl. No.: **13/265,397**
(22) PCT Filed: **Apr. 23, 2010**
(86) PCT No.: **PCT/JP2010/057221**
§ 371 (c)(1),
(2), (4) Date: **Oct. 20, 2011**

Primary Examiner — Vladimir Magloire
(74) *Attorney, Agent, or Firm* — Hoffmann & Baron, LLP

(87) PCT Pub. No.: **WO2010/123092**
PCT Pub. Date: **Oct. 28, 2010**

(57) **ABSTRACT**

Provided is a portable terminal which is provided with a first case, a second case, and a connecting section which connects together the first case and the second case, and has less deterioration of antenna sensitivity. The portable terminal has the first case (2), the second case (3), the connecting section (4), a first circuit section (32) disposed in the first case (2), a first conductive section (31) disposed in the first case (2), a second conductive section (33) disposed in the second case (3), a third conductive section (34) disposed in the connecting section (4), and a first electronic component (61) disposed adjacent to the first conductive section (31) in the length direction of the first case (2) in the first case (2). The first length (X1), which is obtained from the sum of the path length of the signals in the band of a first frequency (f1) in the first conductive section (31) and the path length of the signals in the band of the first frequency (f1) in the first electronic component (61), is substantially the same as the second length (X2), which is obtained from the sum of the path length of the signals in the band of the first frequency (f1) in the second conductive section (33) and the path length of the signals in the band of the first frequency (f1) in the third conductive section (34).

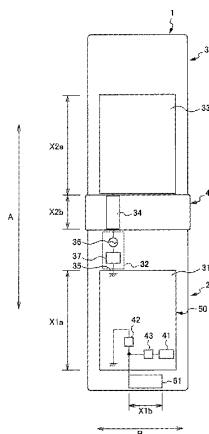
(65) **Prior Publication Data**
US 2012/0040726 A1 Feb. 16, 2012

(30) **Foreign Application Priority Data**
Apr. 24, 2009 (JP) 2009-107183

(51) **Int. Cl.**
H04M 1/00 (2006.01)
(52) **U.S. Cl.** **455/575.7; 455/550.1; 455/575.3; 343/893**
(58) **Field of Classification Search** **455/575.5, 455/575.3, 575.1, 575.7; 343/893**
See application file for complete search history.

(56) **References Cited**
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10 Claims, 7 Drawing Sheets





US008201746B2

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

(10) **Patent No.:** **US 8,201,746 B2**
(45) **Date of Patent:** **Jun. 19, 2012**

(54) **ON-CHIP ANTENNA AND A METHOD OF FABRICATING THE SAME**

(75) Inventors: **Li Hui Guo**, Singapore (SG); **Hong Yu Li**, Singapore (SG); **Min Tang**, Singapore (SG)

(73) Assignee: **Agency for Science, Technology and Research**, Singapore (SG)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 880 days.

(21) Appl. No.: **12/161,958**

(22) PCT Filed: **Jan. 24, 2007**

(86) PCT No.: **PCT/SG2007/000019**

§ 371 (c)(1),
(2), (4) Date: **Nov. 21, 2008**

(87) PCT Pub. No.: **WO2007/086809**

PCT Pub. Date: **Aug. 2, 2007**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 60/761,571, filed on Jan. 24, 2006.

(51) **Int. Cl.**
G06K 19/06 (2006.01)

(52) **U.S. Cl.** **235/492; 235/487**

(58) **Field of Classification Search** **235/492, 235/487, 380, 382, 375**

See application file for complete search history.

(56) **References Cited**

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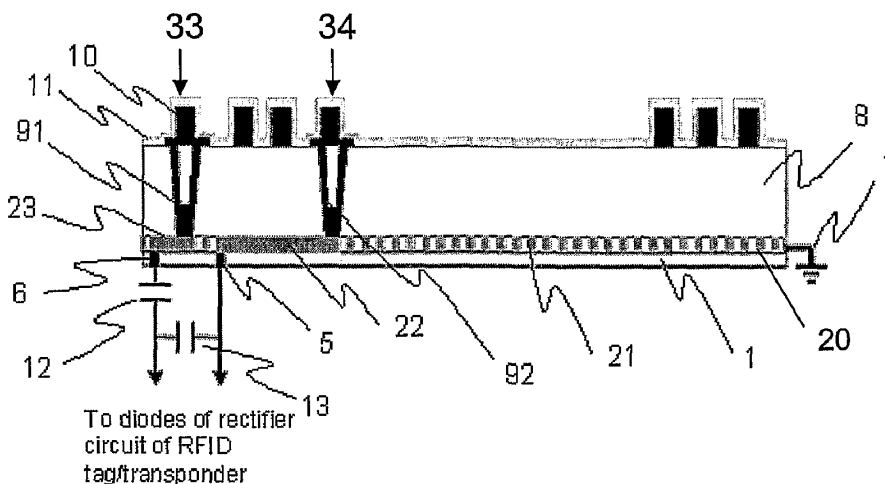
Primary Examiner — Karl D Frech

(74) Attorney, Agent, or Firm — K. David Crockett, Esq.; Niky Economy Syrengelas, Esq.; Crockett & Crockett, PC

(57) **ABSTRACT**

An on-chip antenna fabricated on a chip for wireless communication is disclosed. The on-chip antenna includes a first dielectric layer arranged on a surface of the chip of the radio frequency identification tag, a grounded shielding layer arranged on the first dielectric layer, a second dielectric layer arranged on the grounded shielding layer, and a planar antenna arranged on the second dielectric layer above the grounded shielding layer. A radio frequency identification tag with an on-chip antenna and a method of fabricating an on-chip antenna on a chip for wireless communication are also disclosed.

44 Claims, 3 Drawing Sheets





US008201748B2

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

(10) **Patent No.:** **US 8,201,748 B2**
(45) **Date of Patent:** **Jun. 19, 2012**

(54) **PACKAGED RFID IC WITH INTEGRATED ANTENNA**

(75) Inventors: **Ronald L. Koepp**, Seattle, WA (US);
Ronald A. Oliver, Seattle, WA (US);
Jay Fassett, Edmonds, WA (US);
Christopher J. Diorio, Shoreline, WA (US)

(73) Assignee: **Impinj, Inc.**, Seattle, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 96 days.

(21) Appl. No.: **12/767,220**

(22) Filed: **Apr. 26, 2010**

(65) **Prior Publication Data**
US 2010/0270382 A1 Oct. 28, 2010

Related U.S. Application Data

(60) Provisional application No. 61/173,107, filed on Apr. 27, 2009.

(51) **Int. Cl.**
G06K 5/00 (2006.01)

(52) **U.S. Cl.** **235/492**; 235/472.02; 235/487

(58) **Field of Classification Search** 235/492, 235/487, 462.46, 472.02; 343/895
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Daniel StCyr

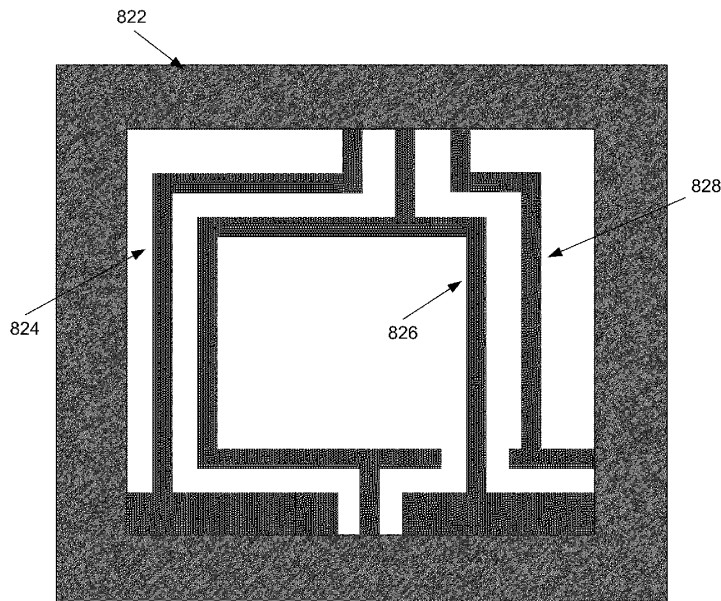
(74) *Attorney, Agent, or Firm* — Turk IP Law, LLC

(57) **ABSTRACT**

A precursor for a Radio Frequency Identification (RFID) tag includes a conductive lead frame with at least three segments, an RFID Integrated Circuit (IC) with at least two antenna terminals, and at least two jumpers. The RFID IC is mounted on at least one of the segments. The antenna terminals are electrically coupled to at least two of the segments, and the jumpers electrically couple the segments such that the coupled segments form a two-turn coil between the antenna terminals of the RFID IC.

20 Claims, 15 Drawing Sheets

800



EXAMPLE LEADFRAME FOR
2-LOOP RFID PRECURSOR



US008203489B2

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

(10) **Patent No.:** **US 8,203,489 B2**
(45) **Date of Patent:** **Jun. 19, 2012**

(54) **DUAL-BAND ANTENNA**

(75) Inventors: **Chia-Tien Li**, Hsichih (TW); **Li-Jean Yen**, Hsichih (TW)

(73) Assignee: **Wistron Neweb Corp.**, Taipei Hsien (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 344 days.

(21) Appl. No.: **12/579,041**

(22) Filed: **Oct. 14, 2009**

(65) **Prior Publication Data**

US 2010/0271264 A1 Oct. 28, 2010

(30) **Foreign Application Priority Data**

Apr. 22, 2009 (TW) 98206683 U

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

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

(58) **Field of Classification Search** **343/700 MS, 343/702**

See application file for complete search history.

(56) **References Cited**

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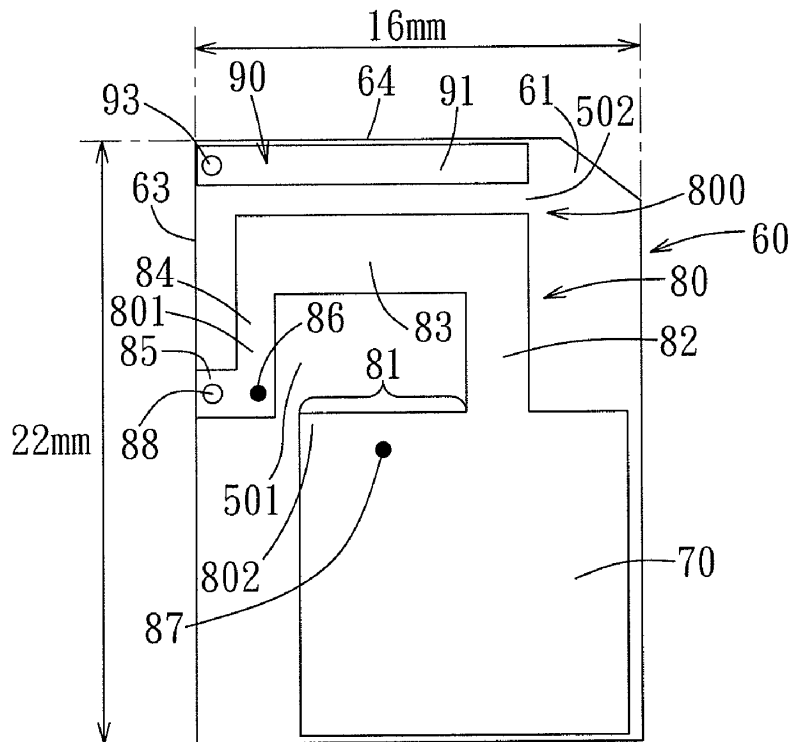
Primary Examiner — Dieu H Duong

(74) *Attorney, Agent, or Firm* — Merchant & Gould P.C.

(57) **ABSTRACT**

A dual-band antenna includes a ground plane, a loop antenna, and a monopole antenna. The loop antenna is connected to the ground plane, and has a radiator that forms a loop. The radiator has a first end and a second end adjacent to the first end, and is capable of resonating at a first frequency band. The monopole antenna has one end connected to the first end of the radiator of the loop antenna, and is capable of resonating at a second frequency band. A feed point is disposed at a connection between the first end of the radiator of the loop antenna and the monopole antenna. A ground point is disposed at the radiator of the loop antenna proximate to the second end of the radiator.

6 Claims, 5 Drawing Sheets





US008203490B2

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

(10) **Patent No.:** **US 8,203,490 B2**
(45) **Date of Patent:** **Jun. 19, 2012**

(54) **MULTI-BAND ANTENNA APPARATUS**

(56) **References Cited**

(75) Inventors: **Yong Soo Kwak**, Suwon-si (KR); **Bum Jin Cho**, Hwaseong-si (KR); **Joon Ho Byun**, Yongin-si (KR); **Seong Tae Jeong**, Yongin-si (KR); **Austin Kim**, Seongnam-si (KR); **Sung Koo Park**, Suwon-si (KR)

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

Primary Examiner — Tho G Phan

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 337 days.

(57) **ABSTRACT**

A multi-band antenna apparatus using a multiple frequency band is provided. The apparatus includes a substrate body formed in a flat plate structure having a preset thickness and in which at least one dielectric plate is stacked, a power supply line, disposed at the substrate body and connected to an external power source, for forming an electromagnetic field when power is supplied from the external power source, a radiation line, separated from the power supply line using the dielectric plate as the boundary in the substrate body, for forming an overlapping area overlapped with the power supply line along one axis through at least a portion, and for resonating in a frequency band determined according to the overlapping area when the electromagnetic field is formed, and a ground plate disposed in at least one an upper ground area and a lower ground area of the substrate body, for grounding the radiation line by contacting with the radiation line.

(21) Appl. No.: **12/755,780**

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

(65) **Prior Publication Data**
US 2010/0265152 A1 Oct. 21, 2010

(30) **Foreign Application Priority Data**
Apr. 15, 2009 (KR) 10-2009-0032766

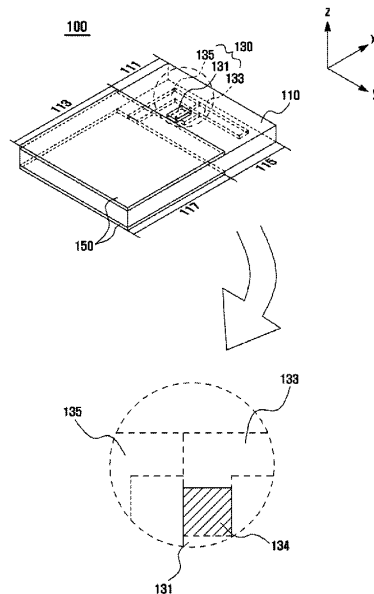
(51) **Int. Cl.**
H01Q 1/38 (2006.01)

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

(58) **Field of Classification Search** 343/700 MS, 343/846, 848

See application file for complete search history.

20 Claims, 12 Drawing Sheets





US008203491B2

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

(10) **Patent No.:** **US 8,203,491 B2**
(45) **Date of Patent:** **Jun. 19, 2012**

(54) **HOUSING, WIRELESS COMMUNICATION DEVICE USING THE HOUSING, AND MANUFACTURING METHOD THEREOF**

(75) Inventors: **Fu-Keng Yang**, Taipei Hsien (TW); **Bing Zhang**, Shenzhen (CN); **Yi-Ping Zeng**, Shenzhen (CN); **Jian-Jun Zhan**, Shenzhen (CN)

(73) Assignees: **Shenzhen Futaihong Precision Industry Co., Ltd.**, ShenZhen, Guangdong Province (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 580 days.

(21) Appl. No.: **12/354,081**

(22) Filed: **Jan. 15, 2009**

(65) **Prior Publication Data**

US 2009/0189818 A1 Jul. 30, 2009

(30) **Foreign Application Priority Data**

Jan. 30, 2008 (CN) 2008 1 0300274

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

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

(58) **Field of Classification Search** **343/700 MS, 343/702, 841, 846, 872, 906**

See application file for complete search history.

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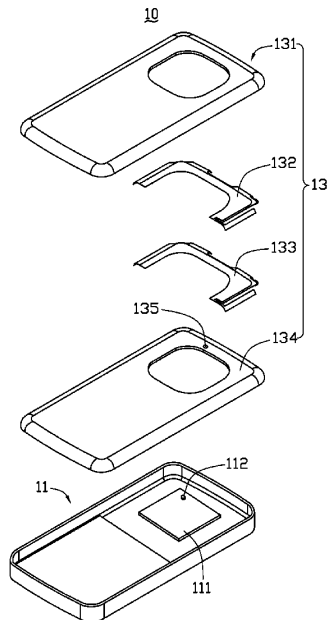
Primary Examiner — Tan Ho

(74) *Attorney, Agent, or Firm* — Altis Law Group, Inc.

(57) **ABSTRACT**

A housing for a wireless communication device includes a decorative film having an antenna pattern formed thereon, a protective coating covering the antenna pattern, and a substrate moldingly attached to the decorative film and the protective coating. The antenna pattern is a conductive ink coating. The antenna pattern and the protective coating are sandwiched between the decorative film and the substrate.

6 Claims, 2 Drawing Sheets





US008203493B2

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

(10) **Patent No.:** **US 8,203,493 B2**
(45) **Date of Patent:** **Jun. 19, 2012**

(54) **PORTABLE WIRELESS DEVICE**
(75) Inventors: **Kenichi Sato**, Miyagi (JP); **Daigo Imano**, Miyagi (JP); **Hironori Kikuchi**, Miyagi (JP); **Yasuhiro Katajima**, Kanagawa (JP); **Tatsuya Sano**, Miyagi (JP); **Nobuhiro Iwai**, Kanagawa (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 234 days.

(21) Appl. No.: **12/812,452**
(22) PCT Filed: **Dec. 26, 2008**
(86) PCT No.: **PCT/JP2008/003998**
§ 371 (c)(1),
(2), (4) Date: **Jul. 9, 2010**
(87) PCT Pub. No.: **WO2009/090721**

PCT Pub. Date: **Jul. 23, 2009**

(65) **Prior Publication Data**
US 2010/0277377 A1 Nov. 4, 2010

(30) **Foreign Application Priority Data**
Jan. 15, 2008 (JP) 2008-006314

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/42 (2006.01)
(52) **U.S. Cl.** **343/702; 343/872**
(58) **Field of Classification Search** None
See application file for complete search history.

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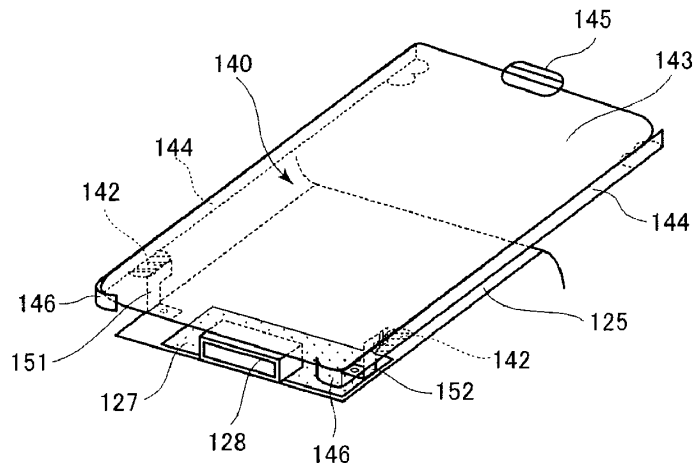
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Primary Examiner — Trinh Dinh
(74) *Attorney, Agent, or Firm* — Seed IP Law Group PLLC

(57) **ABSTRACT**
Provided is a portable communication device, specifically a portable wireless device which is thin while maintaining excellent reception sensitivity even when the device is laid on a metal top panel. As such device (100), a foldable portable cellular phone (100) is provided with a battery box (117) opened on the side of a rear surface (115), and a circuit board (121) having an antenna power feed point (124) is arranged inside a lower case (114). The battery box (117) is covered with a battery cover section (140) removably attached to the lower case (114). The battery cover section (140) is formed of a member having conductivity, and attached to the lower case (114) by having contact point members (151, 152) in between for carrying a current to a reinforcing conductive plate (125) which is to be a GND layer of the circuit board (121). The battery cover section (140) attached to the lower case (114) is electrically connected to the reinforcing conductive plate (125) by making the battery cover section abut to contact point members (151, 152).

15 Claims, 8 Drawing Sheets





US008203499B2

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

(10) **Patent No.:** **US 8,203,499 B2**
(45) **Date of Patent:** **Jun. 19, 2012**

(54) **CONFORMABLE ANTENNA**

(75) Inventors: **Randell Cozzolino**, Phoenix, AZ (US);
Gary Wannagot, Gilbert, AZ (US); **Snir Azulay**, Tiberias (IL)

(73) Assignee: **Galtronics Corporation Ltd.**, Tiberias (IL)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 277 days.

(21) Appl. No.: **12/468,579**

(22) Filed: **May 19, 2009**

(65) **Prior Publication Data**
US 2009/0284432 A1 Nov. 19, 2009

Related U.S. Application Data
(60) Provisional application No. 61/128,284, filed on May 19, 2008.

(51) **Int. Cl.**
H01Q 9/16 (2006.01)
H01P 11/00 (2006.01)

(52) **U.S. Cl.** **343/821**; 29/601

(58) **Field of Classification Search** 343/821,
343/850, 865, 856; 29/601
See application file for complete search history.

(56) **References Cited**

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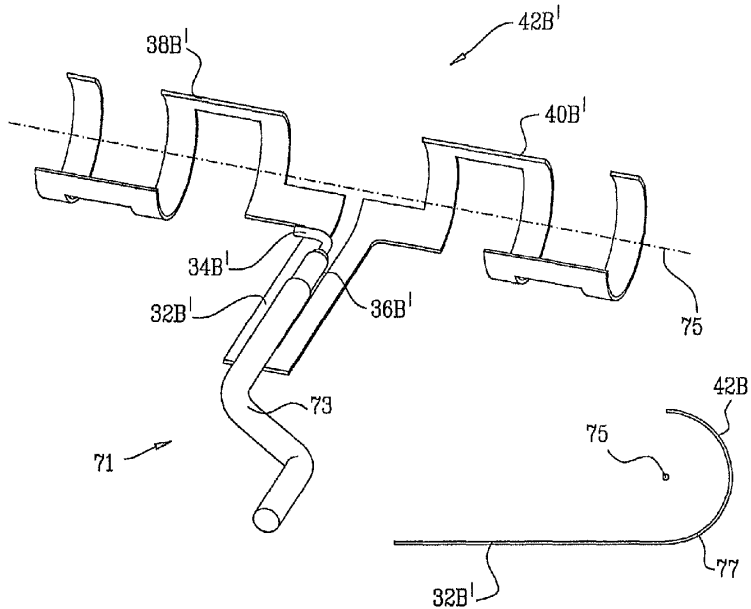
Primary Examiner — Huedung Mancuso

(74) *Attorney, Agent, or Firm* — Sughrue Mion, PLLC

(57) **ABSTRACT**

A polymorphic antenna, including a metallic template configurable in at least first and second possible different three-dimensional shapes, the antenna, when configured in the at least first and second different three-dimensional shapes, having a common antenna feed point, a common balun coupled to the common antenna feed point; and a common dipole coupled to the common antenna feed point and to the common balun. The antenna operates in a common frequency band when configured in either of the at least first and second different three-dimensional shapes when fed via the common antenna feed point.

23 Claims, 16 Drawing Sheets





US008203500B2

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

(10) **Patent No.:** **US 8,203,500 B2**
(45) **Date of Patent:** **Jun. 19, 2012**

(54) **COMPACT CIRCULARLY POLARIZED
OMNI-DIRECTIONAL ANTENNA**

(75) Inventors: **Royden M. Honda**, Post Falls, ID (US);
Robert J. Conley, Liberty Lake, WA
(US)

(73) Assignee: **LHC2 Inc**, Liberty Lake, WA (US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 336 days.

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(21) Appl. No.: **12/692,556**

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

(65) **Prior Publication Data**

US 2010/0188308 A1 Jul. 29, 2010

Related U.S. Application Data

(60) Provisional application No. 61/147,058, filed on Jan.
23, 2009.

(51) **Int. Cl.**
H01Q 21/08 (2006.01)

(52) **U.S. Cl.** **343/824**; 343/853; 343/895

(58) **Field of Classification Search** 343/700 MS,
343/824, 850, 853, 857, 858, 895
See application file for complete search history.

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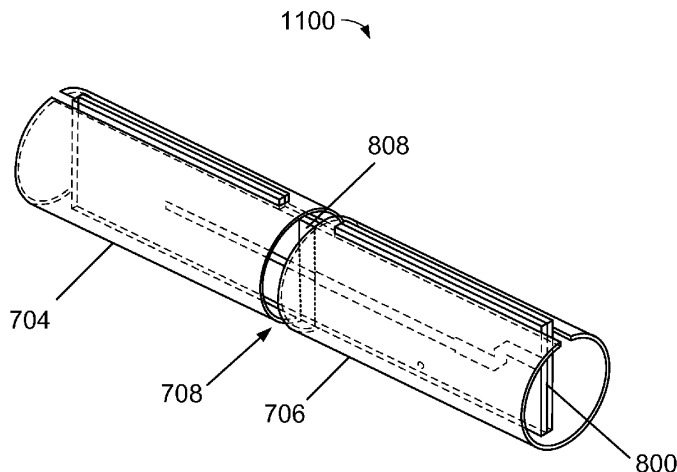
Primary Examiner — Hoanganh Le

(74) *Attorney, Agent, or Firm* — Lee & Hayes, PLLC

(57) **ABSTRACT**

Antennas that can transceive signals in an elliptically-polarized, omni-directional manner are described. In an example embodiment, an antenna comprises two elements proximally located to each other at a predetermined distance, such that two orthogonally-polarized omni-directional electromagnetic waves are transceived. In a further example, the two elements are supported by an internal printed circuit, the printed circuit including conductors configured to supply a feed to the elements, which may be contained within a radome. Alternate embodiments comprise a plurality of elements of varying lengths.

19 Claims, 22 Drawing Sheets





US008207894B2

(12) **United States Patent**
Betts-LaCroix

(10) **Patent No.:** **US 8,207,894 B2**
(45) **Date of Patent:** **Jun. 26, 2012**

(54) **MULTILAYER COMPACT ANTENNA**

(56) **References Cited**

(75) Inventor: **Jonathan Betts-LaCroix**, San Francisco, CA (US)

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(73) Assignee: **Google Inc.**, Mountain View, 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 472 days.

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Primary Examiner — Hoang V Nguyen

(74) Attorney, Agent, or Firm — Morris & Kamlay LLP

(21) Appl. No.: **12/554,813**

(22) Filed: **Sep. 4, 2009**

(57) **ABSTRACT**

(65) **Prior Publication Data**

US 2010/0141360 A1 Jun. 10, 2010

An antenna is provided. The antenna includes a dielectric material including a plurality of layers defined a first set of electrodes of a first polarity and a second set of electrodes of a second polarity, wherein the first set of electrodes and second set of electrodes alternate in position to form the plurality of layers; a first interconnect coupled to the first set of electrodes, the first interconnect coupled to a ground; a second interconnect coupled to the second set of electrodes, the second interconnect coupled to a voltage source, wherein a voltage is applied to the second interconnect to generate an electric field.

Related U.S. Application Data

(60) Provisional application No. 61/096,064, filed on Sep. 11, 2008.

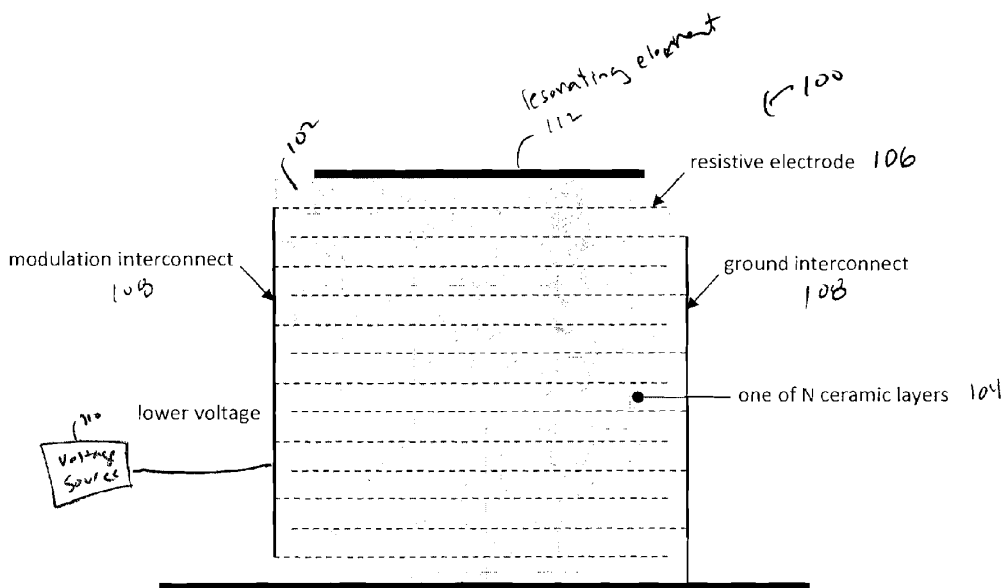
(51) **Int. Cl.**
H01Q 1/38 (2006.01)

(52) **U.S. Cl.** **343/700 MS; 343/702; 343/745**

(58) **Field of Classification Search** **343/700 MS, 343/702, 745**

See application file for complete search history.

12 Claims, 2 Drawing Sheets





US008207895B2

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

(10) **Patent No.:** **US 8,207,895 B2**
(45) **Date of Patent:** **Jun. 26, 2012**

(54) **SHORTED MONOPOLE ANTENNA**

(56) **References Cited**

(75) Inventors: **Kin-Lu Wong**, Tapei Hsien (TW);
Shu-Chuan Chen, Tapei Hsien (TW)

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(73) Assignee: **Acer Inc.**, Taipei Hsien (TW)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 432 days.

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(21) Appl. No.: **12/605,493**

Primary Examiner — Tho G Phan

(22) Filed: **Oct. 26, 2009**

(74) *Attorney, Agent, or Firm* — Alan Kamrath; Kamrath IP Lawfirm, PA

(65) **Prior Publication Data**

US 2011/0018783 A1 Jan. 27, 2011

ABSTRACT

The present invention discloses a shorted monopole antenna comprising a radiating portion comprising a first metal portion and a second metal portion and is located on the dielectric substrate, without overlapping with the ground plane. The first metal portion comprises a coupling section formed by bending the front portion of the first metal portion into two adjacent sections with a coupling gap. A first end of the feeding portion is electrically connected to the first metal portion. A second end of the feeding portion is the antenna's feeding point. The shorting portion is disposed on the dielectric substrate, without overlapping with the ground plane. A first end of the capacitive element is electrically connected to the antenna's feeding point. A second end of the capacitive element is electrically connected to a source.

(30) **Foreign Application Priority Data**

Jul. 24, 2009 (TW) 98125107 A

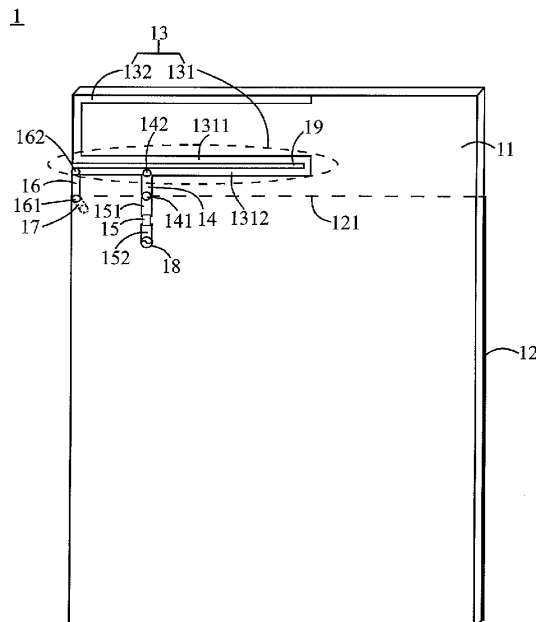
(51) **Int. Cl.**
H01Q 1/12 (2006.01)

(52) **U.S. Cl.** **343/700 MS; 343/702; 343/848**

(58) **Field of Classification Search** **343/700 MS, 343/702, 829, 846, 848**

See application file for complete search history.

9 Claims, 4 Drawing Sheets





US008207896B2

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

(10) **Patent No.:** **US 8,207,896 B2**
(45) **Date of Patent:** ***Jun. 26, 2012**

(54) **MULTIPLE-BAND ANTENNA WITH PATCH AND SLOT STRUCTURES**

(75) Inventors: **Geyi Wen**, Waterloo (CA); **Perry Jarmuszewski**, Waterloo (CA); **Adam D. Stevenson**, Waterloo (CA)

(73) Assignee: **Research In Motion 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.: **13/038,540**

(22) Filed: **Mar. 2, 2011**

(65) **Prior Publication Data**

US 2011/0151949 A1 Jun. 23, 2011

Related U.S. Application Data

(63) Continuation of application No. 12/331,518, filed on Dec. 10, 2008, now Pat. No. 7,916,087, which is a continuation of application No. 11/838,751, filed on Aug. 14, 2007, now Pat. No. 7,466,271, which is a continuation of application No. 11/456,025, filed on Jul. 6, 2006, now Pat. No. 7,283,097, which is a continuation of application No. 10/723,840, filed on Nov. 26, 2003, now Pat. No. 7,224,312.

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

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

(58) **Field of Classification Search** **343/700 MS, 343/702, 725, 745, 770**

See application file for complete search history.

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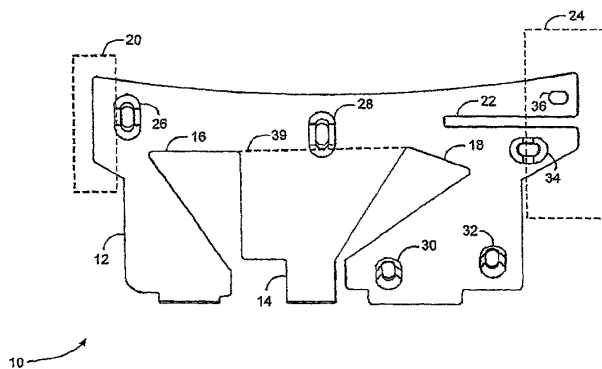
Primary Examiner — Tan Ho

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

(57) **ABSTRACT**

A multiple-band antenna having first and second operating frequency bands is provided. The antenna includes a first patch structure associated primarily with the first operating frequency band, a second patch structure electrically coupled to the first patch structure and associated primarily with the second operating frequency band, a first slot structure disposed between a first portion of the first patch structure and the second patch structure and associated primarily with the first operating frequency band, and a second slot structure disposed between a second portion of the first patch structure and the second patch structure and associated primarily with the second operating frequency band. A mounting structure for the multiple-band antenna is also provided. The mounting structure includes a first surface and a second surface opposite to and overlapping the first surface. The first and second patch structures are mounted to the first surface, and a feeding point and ground point, respectively connected to the first and second patch structures, are mounted to the second surface.

27 Claims, 7 Drawing Sheets





US008207897B2

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

(10) **Patent No.:** **US 8,207,897 B2**
(45) **Date of Patent:** **Jun. 26, 2012**

(54) **RADIO DEVICE AND SLOT ANTENNA WHICH FACILITATES OPERATION OF A USER INTERFACE ELEMENT**

(58) **Field of Classification Search** 343/700 MS, 343/702, 767
See application file for complete search history.

(75) Inventors: **Graham R. Alvey**, Skokie, IL (US); **Paul R. Steuer**, Hawthorn Woods, IL (US); **James A. Van Bosch**, Crystal Lake, IL (US); **Louis J. Vannatta**, Crystal Lake, IL (US)

(56) **References Cited**

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(73) Assignee: **Motorola Mobility, Inc.**, Libertyville, IL (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 588 days.

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Primary Examiner — Dieu H Duong

(21) Appl. No.: **12/338,637**

(74) *Attorney, Agent, or Firm* — Patents on Demand, P.A.; Scott M. Garrett

(22) Filed: **Dec. 18, 2008**

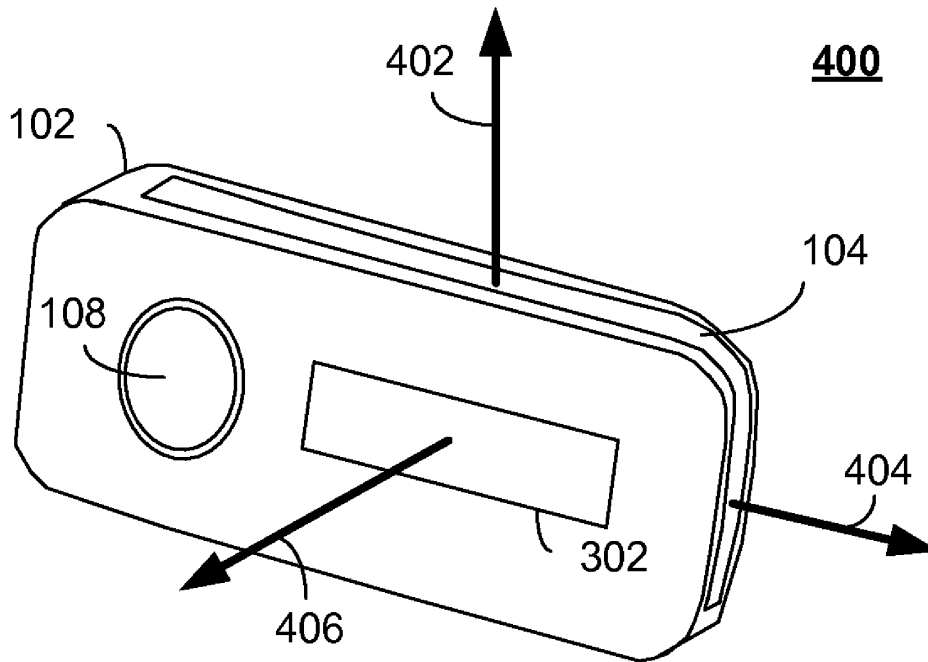
(65) **Prior Publication Data**
US 2010/0156728 A1 Jun. 24, 2010

(57) **ABSTRACT**

A portable communication device (100, 800, 900) has an antenna element (102, 1206). The antenna element forms a slot (104, 1208) which is used as a slot antenna. The device is configured such that the slot facilitates operation of a user interface element through the slot.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
(52) **U.S. Cl.** **343/702; 343/767**

20 Claims, 8 Drawing Sheets





US008207899B2

(12) **United States Patent**
Ishimiya

(10) **Patent No.:** **US 8,207,899 B2**
(45) **Date of Patent:** ***Jun. 26, 2012**

(54) **FOLDED DIPOLE ANTENNA DEVICE AND MOBILE RADIO TERMINAL**

(75) Inventor: **Katsunori Ishimiya**, Tokyo (JP)

(73) Assignee: **Sony Mobile Communications Japan, 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 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/585,270**

(22) Filed: **Sep. 10, 2009**

(65) **Prior Publication Data**

US 2010/0066628 A1 Mar. 18, 2010

Related U.S. Application Data

(63) Continuation of application No. 11/588,289, filed on Oct. 27, 2006, now Pat. No. 7,605,764.

(30) **Foreign Application Priority Data**

Nov. 18, 2005 (JP) 2005-333783

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/26 (2006.01)

(52) **U.S. Cl.** **343/702; 343/803**

(58) **Field of Classification Search** **343/702, 343/741, 803, 804, 846**

See application file for complete search history.

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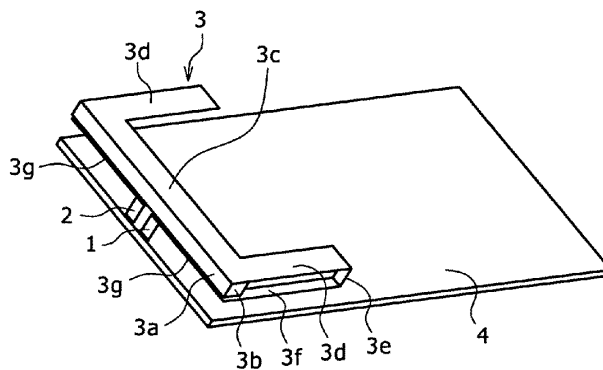
Primary Examiner — Michael C Wimer

(74) *Attorney, Agent, or Firm* — Rader Fishman & Grauer, PLLC

(57) **ABSTRACT**

Disclosed is a folded dipole antenna device which is of an unbalanced feed type and includes an antenna element of approximately plate-like loop structure, connected to an antenna feed point and an antenna ground provided on a base plate. In the folded dipole antenna device, the antenna element of loop structure includes a pair of first element sections which extend approximately parallel to the base plate, a second element section formed by merging element sections that are folded back from both ends of the first element sections and extend approximately parallel to the first element sections, and a third element section which extends from a folded top part of the second element section toward the first element sections and an end part thereof is close to the first element sections.

9 Claims, 11 Drawing Sheets





US008207903B2

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

(10) **Patent No.:** **US 8,207,903 B2**
(45) **Date of Patent:** **Jun. 26, 2012**

(54) **ANTENNA**

(75) Inventors: **Yi-Fong Lu**, Taipei (TW); **Yi-Cheng Lin**, Taipei (TW); **Kuo-Fong Hung**, Taipei (TW)

(73) Assignee: **National Taiwan University**, Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 547 days.

(21) Appl. No.: **12/259,978**

(22) Filed: **Oct. 28, 2008**

(65) **Prior Publication Data**
US 2009/0256765 A1 Oct. 15, 2009

(30) **Foreign Application Priority Data**
Apr. 9, 2008 (TW) 97112781 A

(51) **Int. Cl.**
H01Q 13/00 (2006.01)
H01Q 9/04 (2006.01)

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

(58) **Field of Classification Search** **343/700 MS, 343/767, 768, 770, 771**

See application file for complete search history.

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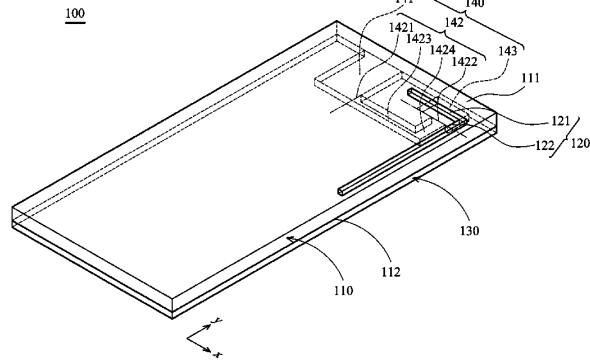
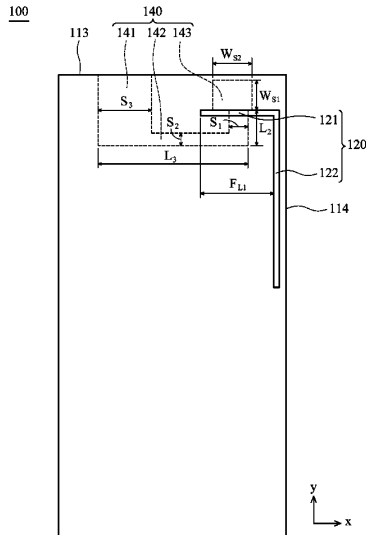
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Primary Examiner — Jacob Y Choi
Assistant Examiner — Hasan Islam

(57) **ABSTRACT**

An antenna is provided. The antenna includes a substrate, a feed conductor, a ground layer and a radiation slot. The substrate includes a first surface and a second surface, wherein the first surface is opposite to the second surface. The feed conductor is formed on the first surface. The ground layer is formed on the second surface. The radiation slot is formed on the ground layer, including a first radiation portion, a second radiation portion and a third radiation portion, wherein the second radiation portion connects the first radiation portion and the third radiation portion, the radiation slot is U shaped, and the feed conductor corresponds to a location between the second radiation portion and the third radiation portion.

8 Claims, 5 Drawing Sheets





US008207904B2

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

(10) **Patent No.:** **US 8,207,904 B2**
(45) **Date of Patent:** **Jun. 26, 2012**

(54) **HIGH GAIN MULTIPLE PLANAR REFLECTOR ULTRA-WIDE BAND (UWB) ANTENNA STRUCTURE**

(75) Inventors: **Bo Pan**, Irvine, CA (US); **Frederic Battaglia**, Irvine, CA (US); **KuangYu Li**, Irvine, CA (US); **Ran-Hong Yan**, Irvine, CA (US); **Kuan Leok Sun**, Irvine, CA (US)

(73) Assignee: **Realtek Semiconductor Corp.**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 404 days.

(21) Appl. No.: **12/488,509**

(22) Filed: **Jun. 19, 2009**

(65) **Prior Publication Data**
US 2010/0321270 A1 Dec. 23, 2010

(51) **Int. Cl.**
H01Q 9/28 (2006.01)
(52) **U.S. Cl.** **343/795; 343/818**
(58) **Field of Classification Search** **343/795, 343/818, 819, 821**
See application file for complete search history.

(56) **References Cited**

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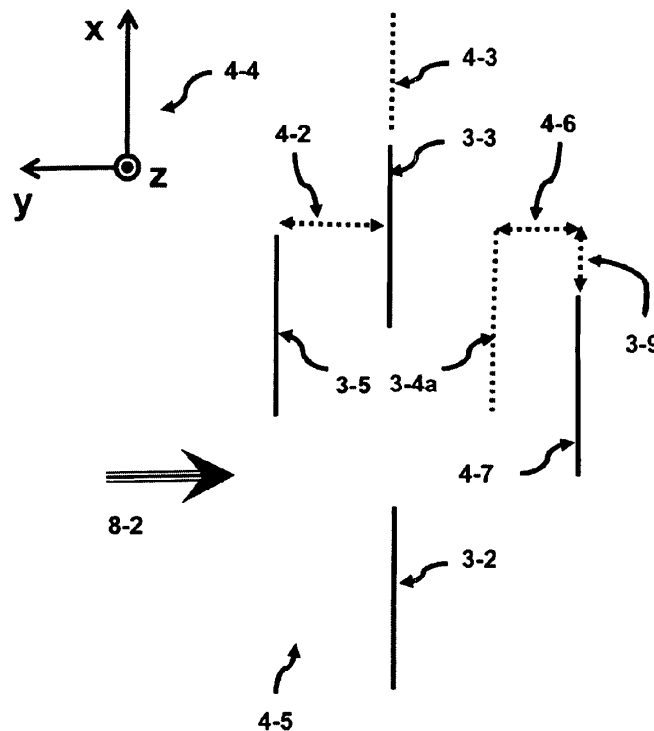
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(74) *Attorney, Agent, or Firm* — Thomas, Kayden, Horstemeyer & Risley, LLP

(57) **ABSTRACT**

Multiple out-of-plane planar reflectors can be used to build a receive/transmit high-gain directional antenna. The driver portion and the first reflector of the antenna are formed within a metal layer of a PWB. A plurality of sets of reflector plates can be placed on the PWB, on a non-conductive low-dielectric constant material coating both opposing planar surfaces of the PWB, or on the opposing sidewalls of the product housing unit. The metal layer in the PWB is placed between the reflector plates. The plates can have either a parallel or non-parallel orientation to each other. This greatly increase the received power and thus increases the operating range of a low-power UWB system, as well as significantly improves wireless data transmission throughput. This antenna is applicable for USB communications systems.

16 Claims, 12 Drawing Sheets





US008207906B2

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

(10) **Patent No.:** **US 8,207,906 B2**
(45) **Date of Patent:** **Jun. 26, 2012**

- (54) **ANTENNA INSERT**
- (75) Inventors: **Victor M. Tiscareno**, Issaquah, WA (US); **John G. Tang**, San Carlos, CA (US); **Stephen P. Zadesky**, Portola Valley, 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 629 days.

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- (21) Appl. No.: **11/970,504**
- (22) Filed: **Jan. 7, 2008**

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- (65) **Prior Publication Data**
US 2008/0165066 A1 Jul. 10, 2008

Related U.S. Application Data

- (60) Provisional application No. 60/884,014, filed on Jan. 8, 2007.

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Primary Examiner — Huedung Mancuso

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

- (51) **Int. Cl.**
H01Q 1/50 (2006.01)
- (52) **U.S. Cl.** **343/906**
- (58) **Field of Classification Search** 455/89-90;
343/702, 700 MS, 841, 895, 905-906
See application file for complete search history.

(57) **ABSTRACT**

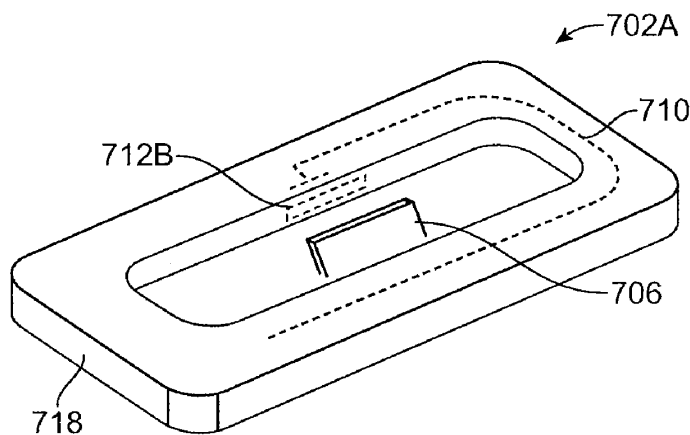
Circuits, methods, and apparatus for adapters and docking stations that include one or more of the following: reradiating antennas to enhance wireless signal integrity, inductive charging circuits, and wireless or optical data links. The adapters may be inserts for use in a docking station, adapters for a cable connection, or other type of device. One example provides an adapter that includes a reradiating antenna. In other examples, passive coupling is used to charge a rechargeable battery in the handheld device. Other examples include wireless or optical circuits for faster data transmission.

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13 Claims, 15 Drawing Sheets





US008208870B2

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

(10) **Patent No.:** **US 8,208,870 B2**
(45) **Date of Patent:** **Jun. 26, 2012**

(54) **HAND-HELD WIRELESS COMMUNICATION DEVICE WITH CERAMIC SCREWS**

(75) Inventors: **I-Cheng Chuang**, Shindian (TW);
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(73) Assignee: **HTC Corporation**, 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 1226 days.

(21) Appl. No.: **11/345,496**

(22) Filed: **Feb. 2, 2006**

(65) **Prior Publication Data**
US 2006/0234788 A1 Oct. 19, 2006

(30) **Foreign Application Priority Data**
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(51) **Int. Cl.**
H04M 1/00 (2006.01)
(52) **U.S. Cl.** **455/90.3**; 455/575.5; 455/575.1;
455/296; 343/702; 343/700; 343/895; 333/235;
333/193

(58) **Field of Classification Search** 455/90.3,
455/575.1, 575.3, 575.5, 575.8, 575.2, 550.1;
343/895, 702, 700; 361/814
See application file for complete search history.

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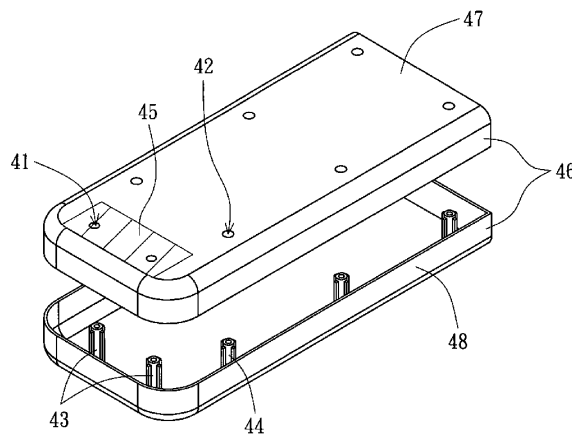
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Assistant Examiner — Ganiyu Hanidu
(74) *Attorney, Agent, or Firm* — Rabin & Berdo, P.C.

(57) **ABSTRACT**

A wireless communication device having an antenna area includes at least a first component, a second component and a connector. The connector is made of ceramic material and is disposed in the antenna area for fixing and connecting the first component and the second component so as to avoid interference with the antenna. Adopting the ceramic connectors enables the wireless communication device to have the advantages of good locking performance, good antennal transmission efficiency and elegant appearance simultaneously and to provide an electrostatic shielding function.

20 Claims, 3 Drawing Sheets





US008208980B2

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

(10) **Patent No.:** **US 8,208,980 B2**
(45) **Date of Patent:** **Jun. 26, 2012**

(54) **RADIATION REDIRECTING EXTERNAL CASE FOR PORTABLE COMMUNICATION DEVICE AND ANTENNA EMBEDDED IN BATTERY OF PORTABLE COMMUNICATION DEVICE**

(75) Inventors: **Alfred Y. Wong**, Los Angeles, CA (US); **Robert Moreno**, Acton, CA (US); **Karl Richard Shields**, North Hills, CA (US); **Rong Wang**, Sherman Oaks, CA (US)

(73) Assignee: **Pong Research Corporation**, Leesbug, VA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 259 days.

(21) Appl. No.: **12/614,132**

(22) Filed: **Nov. 6, 2009**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 61/112,141, filed on Nov. 6, 2008, provisional application No. 61/158,551, filed on Mar. 9, 2009.

(51) **Int. Cl.**
H04Q 7/32 (2006.01)

(52) **U.S. Cl.** **455/575.5**; 455/575.1; 455/550.1; 455/67.11; 455/90.3; 455/553.1; 343/702

(58) **Field of Classification Search** 455/575.5, 455/575.1, 550.1, 552.1, 553.1, 422.1, 403, 455/445, 67.11, 426.1, 426.2, 41.1, 41.2, 455/90.3; 343/702

See application file for complete search history.

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Primary Examiner — Keith Ferguson

(57) **ABSTRACT**

An advanced antenna or set of antennae for a wireless device is provided by embedding the antennae into the battery case or generally the largest surface area of a wireless phone. The antenna connections are made through the battery's connections to the wireless device. The antenna design can be compact and located in any area of the battery. The antenna design can be thin and flat, located at the back surface of the battery or the large rear surface of a wireless phone, facing away from the user. An RF shielding device can be embedded into the battery and configured in relation to the antenna such that the RF field intensity and the consequent specific absorption rate for the user is lowered while the outgoing signals of the wireless device remain fully adequate for the function of the wireless device. This feature is preserved for a multi-band operation because a digital phase shifter is used between two radiating antennae. An external case is used as a complement to the wireless phone to provide additional antennae, power and capability.

20 Claims, 13 Drawing Sheets

