



US007880678B2

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

(10) **Patent No.:** **US 7,880,678 B2**

(45) **Date of Patent:** **Feb. 1, 2011**

(54) **REMOVABLE ANTENNAS FOR
ELECTRONIC DEVICES**

(75) Inventors: **Brett William Degner**, Menlo Park, CA (US); **Chris Ligtenberg**, San Carlos, CA (US); **Bartley K. Andre**, Menlo Park, CA (US); **Douglas Blake Kough**, San Jose, CA (US)

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

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

Primary Examiner—HoangAnh T Le

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(21) Appl. No.: **12/061,176**

(57) **ABSTRACT**

(22) Filed: **Apr. 2, 2008**

(65) **Prior Publication Data**

US 2009/0251372 A1 Oct. 8, 2009

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

(52) **U.S. Cl.** **343/702; 343/906**

(58) **Field of Classification Search** **342/702, 342/906, 882**

See application file for complete search history.

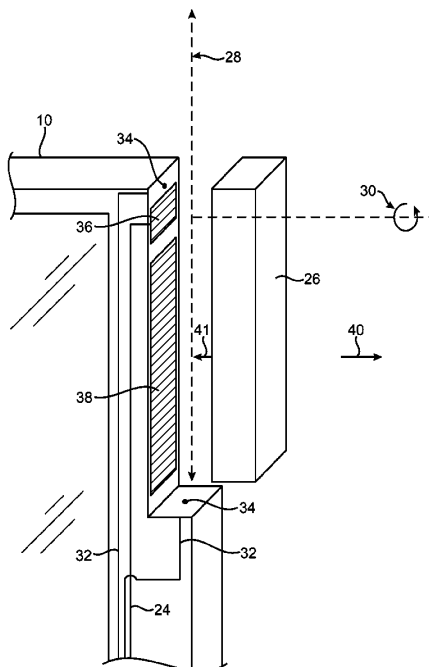
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A removable antenna is provided for an electronic device such as a laptop computer. An antenna resonating element is mounted within the antenna. Magnetic coupling structures are used to magnetically attach the antenna to the electronic device. The magnetic coupling structures couple the antenna resonating element to circuitry in the electronic device. The electronic device may have an antenna receptacle that holds the antenna in a stowed position and allows the antenna to extend to an extended position. A user may extend the antenna by sliding the antenna or by rotating the antenna to its extended position. The coupling structures may allow the antenna to break away from the electronic device without damage.

20 Claims, 21 Drawing Sheets



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

(10) **Patent No.:** **US 7,880,680 B2**

(45) **Date of Patent:** **Feb. 1, 2011**

(54) **TAG DEVICE, ANTENNA, AND PORTABLE CARD**

(75) Inventors: **Takashi Yamagajo**, Kawasaki (JP);
Toru Maniwa, Kawasaki (JP); **Manabu Kai**, 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 836 days.

(21) Appl. No.: **11/822,528**

(22) Filed: **Jul. 6, 2007**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. PCT/JP2005/000091, filed on Jan. 7, 2005.

(51) **Int. Cl.**
H01Q 7/00 (2006.01)
H01Q 11/12 (2006.01)
G06K 19/00 (2006.01)

(52) **U.S. Cl.** **343/718**; 343/744; 343/873;
340/572.7

(58) **Field of Classification Search** 343/718,
343/743, 744, 866, 867, 873; 340/572.7,
340/572.8; 235/491, 492
See application file for complete search history.

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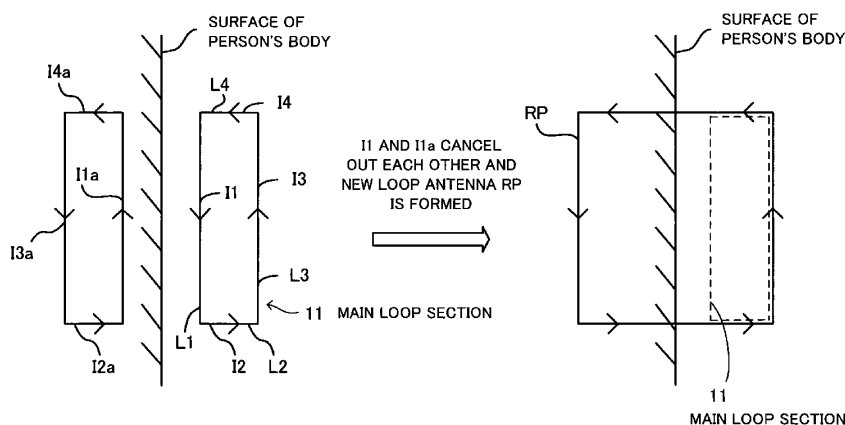
Primary Examiner—Michael C Wimer

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

(57) **ABSTRACT**

A tag device that performs high-quality radio communication without radio wave radiation or receiving characteristics being deteriorated near a person's body and without hindering communication by another IC tag. A main loop section sends and receives radio waves. The main loop section is a metal foil and has the shape of a long thin loop. The area of the main loop section is smaller than the area of a dielectric substrate. The main loop section covers part of surfaces of the dielectric substrate and part of sides of the dielectric substrate so as to put the dielectric substrate inside the loop. The main loop section is mounted in a horizontal direction of the dielectric substrate. Each of capacitive load sections is a metal foil and has a load corresponding to a capacitance component. The capacitive load sections are located at both end portions of the main loop section which covers part of the front side of the dielectric substrate and are located at both end portions of the main loop section which covers part of the reverse side of the dielectric substrate. A control unit is connected to the main loop section and controls information via the radio waves.

23 Claims, 16 Drawing Sheets



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US007880681B2

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

(10) **Patent No.:** **US 7,880,681 B2**
(45) **Date of Patent:** **Feb. 1, 2011**

(54) **ANTENNA WITH DUAL BAND LUMPED
ELEMENT IMPEDANCE MATCHING**

(75) Inventors: **Mark L. Rentz**, Torrance, CA (US);
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(US)

(73) Assignee: **Navcom Technology, Inc.**, Torrance, CA
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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 319 days.

(21) Appl. No.: **12/037,908**

(22) Filed: **Feb. 26, 2008**

(65) **Prior Publication Data**

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

(52) **U.S. Cl.** **343/722; 343/852; 343/860**

(58) **Field of Classification Search** **343/722,**
343/852, 860
See application file for complete search history.

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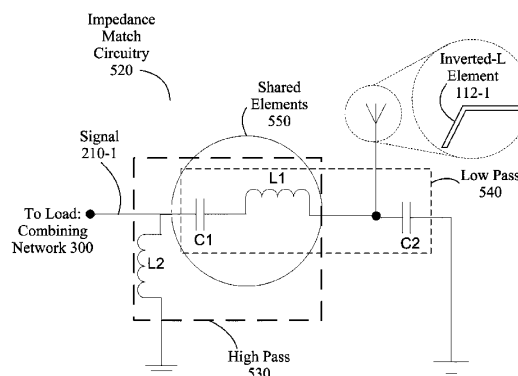
Primary Examiner—Tho G Phan

(74) *Attorney, Agent, or Firm*—Morgan, Lewis & Bockius
LLP

(57) **ABSTRACT**

An antenna includes a first antenna element and a second antenna element. The first antenna element and the second antenna element are both configured to receive signals in a first band of frequencies and in a second band of frequencies. Frequencies in the second band of frequencies are greater than frequencies in the first band of frequencies. A first impedance matching circuit, coupled to the first antenna element, includes a first plurality of filters having a first shared component. A second impedance matching circuit, coupled to the second antenna element, includes a second plurality of filters having a second shared component. A feed network circuit is coupled to the first impedance matching circuit and to the second impedance matching circuit and has a combined output corresponding to the signals received by the first antenna element and a second antenna element.

23 Claims, 14 Drawing Sheets



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US007880683B2

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

(10) **Patent No.:** **US 7,880,683 B2**

(45) **Date of Patent:** ***Feb. 1, 2011**

(54) **ANTENNAS WITH POLARIZATION DIVERSITY**

(75) Inventors: **Victor Shtrom**, Sunnyvale, CA (US);
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(73) Assignee: **Ruckus Wireless, Inc.**, Sunnyvale, CA (US)

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

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/396,439**

(22) Filed: **Mar. 2, 2009**

(65) **Prior Publication Data**
US 2010/0053010 A1 Mar. 4, 2010

Related U.S. Application Data

(63) Continuation of application No. 11/646,136, filed on Dec. 26, 2006, now Pat. No. 7,498,996, which is a continuation-in-part of application No. 11/041,145, filed on Jan. 21, 2005, now Pat. No. 7,362,280.

(60) Provisional application No. 60/602,711, filed on Aug. 18, 2004, provisional application No. 60/603,157, filed on Aug. 18, 2004, provisional application No. 60/753,442, filed on Dec. 23, 2005.

(51) **Int. Cl.**
H01Q 9/28 (2006.01)
H01Q 21/00 (2006.01)

(52) **U.S. Cl.** **343/795; 343/893**

(58) **Field of Classification Search** 343/700 MS,
343/702, 795, 818, 876, 893
See application file for complete search history.

(56) **References Cited**

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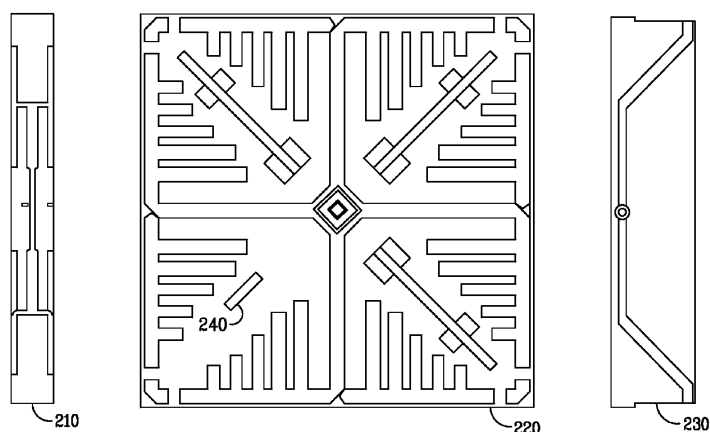
Primary Examiner—Shih-Chao Chen

(74) *Attorney, Agent, or Firm*—Carr & Ferrell LLP

(57) **ABSTRACT**

A horizontally polarized antenna array allows for the efficient distribution of RF energy into a communications environment through selectable antenna elements and redirectors that create a particular radiation pattern such as a substantially omnidirectional radiation pattern. In conjunction with a vertically polarized array, a particular high-gain wireless environment may be created such that one environment does not interfere with other nearby wireless environments and avoids interference created by those other environments. Lower gain patterns may also be created by using particular configurations of a horizontal and/or vertical antenna array. In a preferred embodiment, the antenna systems disclosed herein are utilized in a multiple-input, multiple-output (MIMO) wireless environment.

19 Claims, 14 Drawing Sheets



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US007884767B2

(12) **United States Patent**
Itsuji

(10) **Patent No.:** **US 7,884,767 B2**
(45) **Date of Patent:** **Feb. 8, 2011**

(54) **ANTENNA DEVICE**

(75) Inventor: **Takeaki Itsuji**, Hiratsuka (JP)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 86 days.

(21) Appl. No.: **12/496,617**

(22) Filed: **Jul. 1, 2009**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. 12/023,863, filed on Jan. 31, 2008, now Pat. No. 7,570,216.

(30) **Foreign Application Priority Data**

Feb. 1, 2007 (JP) 2007-023596

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

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

(58) **Field of Classification Search** **343/700 MS, 343/825, 828, 829, 846**
See application file for complete search history.

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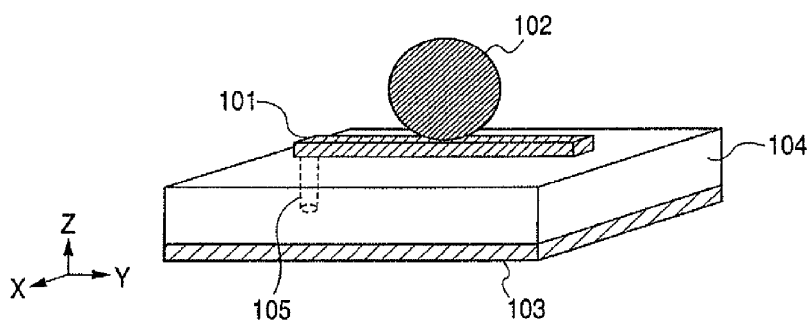
Primary Examiner—Hoang Anh T Le

(74) *Attorney, Agent, or Firm*—Fitzpatrick, Cella, Harper & Scinto

(57) **ABSTRACT**

An antenna device for operating in a predetermined frequency band has a resonator section, a semiconductor section and an antenna section. The resonator section includes a first conductor section, a dielectric section, and a second conductor section for specifying a reference potential against each section which is arranged so as to oppose the first conductor section through the dielectric section. A semiconductor section is arranged so as to be sandwiched between the first conductor section and the second conductor section. The antenna section uses the second conductor section as a grounding conductor, is substantially spherical, makes at least its surface electroconductive, and is arranged on the first conductor section.

6 Claims, 5 Drawing Sheets



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US007884771B2

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

(10) **Patent No.:** **US 7,884,771 B2**
(45) **Date of Patent:** **Feb. 8, 2011**

(54) **ANTENNA**

(75) Inventors: **Kuan-Hsueh Tseng**, Taipei (TW);
Yi-Ling Chiu, Taipei (TW); **Chia-Tien Li**, Taipei (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 0 days.

(21) Appl. No.: **12/614,302**

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

(65) **Prior Publication Data**
US 2010/0053016 A1 Mar. 4, 2010

Related U.S. Application Data
(63) Continuation of application No. 11/674,055, filed on Feb. 12, 2007, now Pat. No. 7,714,788.

(30) **Foreign Application Priority Data**
Jul. 4, 2006 (TW) 95124300 A

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

(52) **U.S. Cl.** **343/702; 343/700 MS; 343/850; 343/846; 343/820**

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

(56) **References Cited**

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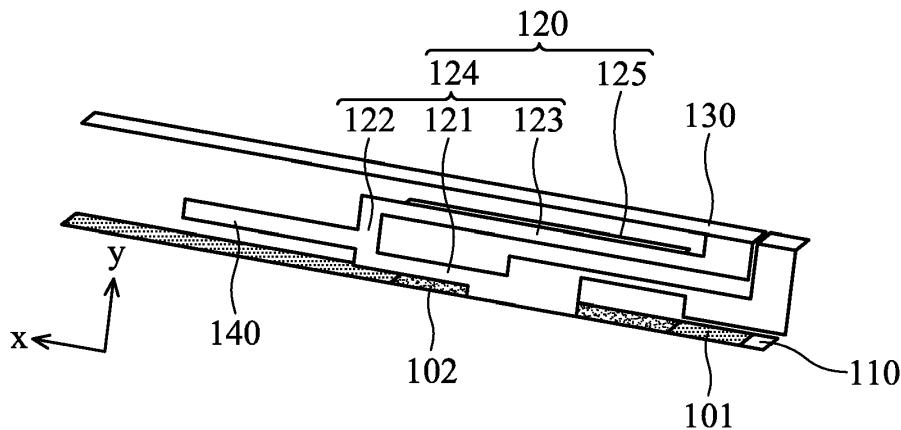
Primary Examiner—Trinh V Dinh

(57) **ABSTRACT**

An antenna comprises a ground element, a transmission element, a conductive element and a coupling element. The conductive element connects the ground element and the transmission element. The coupling element extends from the conductive element substantially parallel to the transmission element, wherein the coupling element is located on a first plane, the transmission element is located on a second plane, and the second plane is parallel to the first plane.

6 Claims, 5 Drawing Sheets

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US007884774B2

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

(10) **Patent No.:** **US 7,884,774 B2**

(45) **Date of Patent:** **Feb. 8, 2011**

(54) **PLANAR ANTENNA**

(75) Inventors: **Chi-Cheng Huang**, Taoyuan County
(TW); **Chia-Bin Yang**, Taoyuan County
(TW)

(73) Assignee: **Delta Networks, Inc.**, 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 101 days.

(21) Appl. No.: **11/945,711**

(22) Filed: **Nov. 27, 2007**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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

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(58) **Field of Classification Search** 343/700 MS,
343/895, 795, 803, 817–821, 725–727
See application file for complete search history.

(56) **References Cited**

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Primary Examiner—James H. Cho

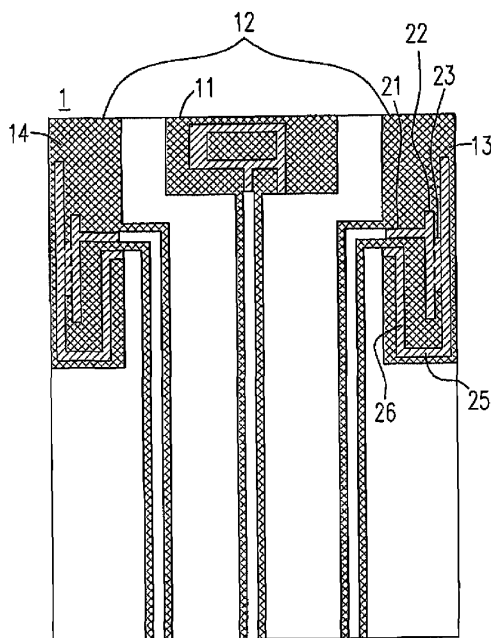
Assistant Examiner—Christopher Lo

(74) *Attorney, Agent, or Firm*—Volpe and Koenig, PC

(57) **ABSTRACT**

The present invention provides a wireless transmit/receive unit, comprising a feeding connecting line, a first radiating line, a second radiating line, a third radiating line and a fourth radiating line, wherein the third radiating line is longer than the first radiating line and the first radiating line is longer than the second radiating line that provides different current paths for getting a broader bandwidth. The first, second and third radiating lines are connected parallel for enhancing an antenna pattern being perpendicular thereto, and form a series capacity between the first and the third radiating lines. The fourth radiating line vertically connects between the third radiating line and a grounding line for forming a grounding capacity. The printed antenna can be reduced in size by the effect of the two capacities. The wireless transmit/receive unit can provide a better isolation with others by the direction enforced pattern and the reduced size.

9 Claims, 9 Drawing Sheets



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US007889136B2

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

(10) **Patent No.:** **US 7,889,136 B2**
(45) **Date of Patent:** **Feb. 15, 2011**

(54) **MICRO-STRIP ANTENNA WITH L-SHAPED BAND-STOP FILTER**

(75) Inventors: **Shau-Gang Mao**, Taipei (TW);
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Min-Shou Wu, Taoyuan County (TW);
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Jen-Chun Yeh, Taichung (TW);
Wei-Kung Deng, Taipei (TW)

(73) Assignee: **RichWave Technology Corp.**, NeiHu District, Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 523 days.

(21) Appl. No.: **12/129,704**

(22) Filed: **May 30, 2008**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jun. 28, 2007 (TW) 96123490 A

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

(52) **U.S. Cl.** **343/700 MS; 343/750; 343/753**

(58) **Field of Classification Search** **343/700 MS; 343/850, 853, 756, 909**
See application file for complete search history.

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Primary Examiner—Douglas W Owens

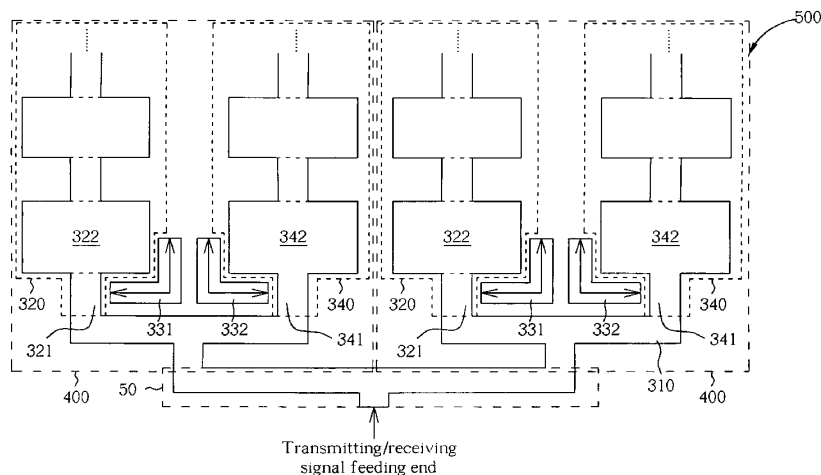
Assistant Examiner—Dieu Hien T Duong

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

(57) **ABSTRACT**

A micro-strip antenna includes an L-shaped coupler, a set of micro-strip antennas, and an L-shaped band-stop filter. The set of micro-strip antennas includes at least one rectangular micro-strip antenna unit and a micro-strip line. The rectangular micro-strip antenna unit is coupled to the micro-strip line. The micro-strip line is coupled to the first end of the coupler. The band-stop filter is disposed along a corner of the rectangular micro-strip antenna unit, and is disposed between the antenna unit and the coupler without being physically connected to the antenna unit and the coupler. The width, length, and position of the L-shaped band-stop filter can be determined for the specific band-stop frequency and to optimize its coupling extent with the L-shaped coupler.

17 Claims, 8 Drawing Sheets



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US007889138B2

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

(10) **Patent No.:** **US 7,889,138 B2**

(45) **Date of Patent:** **Feb. 15, 2011**

(54) **ELECTROMAGNETIC WAVE RECEPTION
AND DECODING SYSTEM PROVIDED WITH
A COMPACT ANTENNA**

(75) Inventors: **Jean-Francois Pintos**, Bourgbarre (FR);
Jean-Luc Robert, Betton (FR); **Philippe
Minard**, Saint Medard sur Ille (FR); **Ali
Louzir**, Rennes (FR)

(73) Assignee: **Thomson Licensing**, Boulogne-Billcourt
(FR)

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patent is extended or adjusted under 35
U.S.C. 154(b) by 747 days.

(21) Appl. No.: **10/593,222**

(22) PCT Filed: **Mar. 15, 2005**

(86) PCT No.: **PCT/EP2005/051175**

§ 371 (c)(1),

(2), (4) Date: **Sep. 18, 2006**

(87) PCT Pub. No.: **WO2005/093903**

PCT Pub. Date: **Oct. 6, 2005**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Mar. 22, 2004 (FR) 04 02955

(51) **Int. Cl.**

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

(58) **Field of Classification Search** 343/829,
343/846, 848, 882, 702, 726, 728, 845, 825,
343/826, 830, 831, 700 MS

See application file for complete search history.

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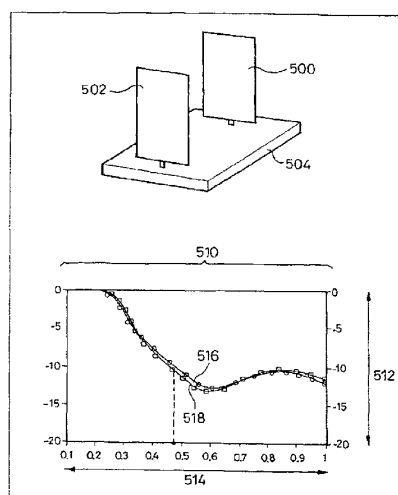
Primary Examiner—HoangAnh T Le

(74) *Attorney, Agent, or Firm*—Robert D. Shedd; Joseph J.
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(57) **ABSTRACT**

The invention relates to a data transmission system compris-
ing an antenna provided with a monopole radiating element
held in place by an earth plane provided with a conducting
surface. According to the invention, the radiating element is
located facing the surface of the earth plane so as to interact
with the latter in order to improve its performance.

8 Claims, 17 Drawing Sheets



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US007889139B2

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

(10) **Patent No.:** **US 7,889,139 B2**
(45) **Date of Patent:** **Feb. 15, 2011**

(54) **HANDHELD ELECTRONIC DEVICE WITH
CABLE GROUNDING**

(75) Inventors: **Phillip M. Hobson**, Menlo Park, CA
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CA (US); **Tang Yew Tan**, San Francisco,
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(73) Assignee: **Apple Inc.**, Cupertino, CA (US)

Hobson et al. U.S. Appl. No. 60/883,587, filed Jan. 5, 2007.

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 536 days.

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Primary Examiner—Douglas W Owens

Assistant Examiner—Chuc D Tran

(74) *Attorney, Agent, or Firm*—Treyz Law Group; G. Victor
Treyz; Nancy Y. Ru

(21) Appl. No.: **11/821,329**

(22) Filed: **Jun. 21, 2007**

(57) **ABSTRACT**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 9/04 (2006.01)

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

(58) **Field of Classification Search** 343/702,
343/709, 700 MS, 833, 836; 439/92, 881;
174/75, 78, 756

See application file for complete search history.

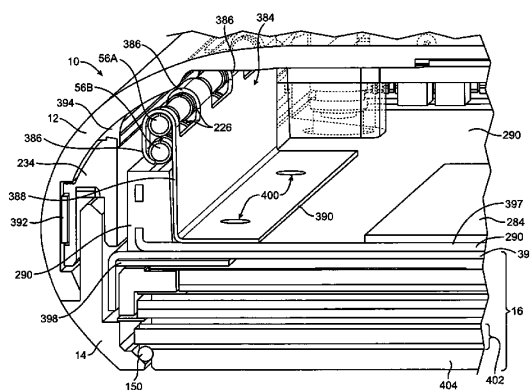
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A handheld electronic device may be provided that contains a
conductive housing and other conductive elements. The con-
ductive elements may form an antenna ground plane. One or
more antennas for the handheld electronic device may be
formed from the ground plane and one or more associated
antenna resonating elements. Transceiver circuitry may be
connected to the resonating elements by transmission lines
such as coaxial cables. Ferrules may be crimped to the coaxial
cables. A bracket with extending members may be crimped
over the ferrules to ground the coaxial cables to the housing
and other conductive elements in the ground plane. The
ground plane may contain an antenna slot. A dock connector
and flex circuit may overlap the slot in a way that does not
affect the resonant frequency of the slot. Electrical compo-
nents may be isolated from the antenna using isolation ele-
ments such as inductors and resistors.

3 Claims, 38 Drawing Sheets





US007889140B2

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

(10) **Patent No.:** **US 7,889,140 B2**

(45) **Date of Patent:** **Feb. 15, 2011**

(54) **ULTRA-WIDE BAND ANTENNA AND
PLUG-AND-PLAY DEVICE USING THE SAME**

(75) Inventors: **Kin-Lu Wong**, Kaohsiung (TW);
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(TW); **Jui-Hung Chou**, Taichung (TW)

(73) Assignees: **Lite-On Technology Corporation**,
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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 223 days.

(21) Appl. No.: **11/878,963**

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Mar. 27, 2007 (TW) 96110648 A

(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,**
343/767, 702

See application file for complete search history.

(56) **References Cited**

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Primary Examiner—Jacob Y Choi

Assistant Examiner—Kyana R Robinson

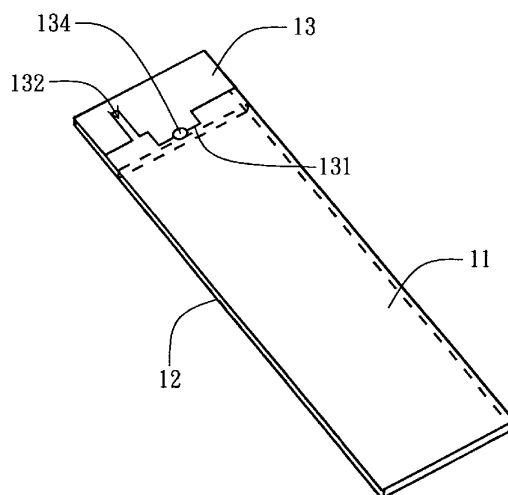
(74) *Attorney, Agent, or Firm*—Bacon & Thomas, PLLC

(57) **ABSTRACT**

An ultra-wide band (UWB) antenna and a plug-and-play (PnP) device using the same are provided. A dielectric substrate of the PnP device has a ground plane. The UWB antenna includes a radiating metal plate and a feeding portion. The radiating metal plate is in a non-ground region of the dielectric substrate and has at least a slit cut. An opening of the slit cut is at the edge of the radiating metal plate facing the ground plane. The feeding portion is also at the edge of the radiating metal plate facing the ground plane for feeding a signal to the antenna.

8 Claims, 9 Drawing Sheets

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US007893877B2

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

(10) **Patent No.:** **US 7,893,877 B2**

(45) **Date of Patent:** **Feb. 22, 2011**

(54) **ANTENNA FOR WWAN AND INTEGRATED
ANTENNA FOR WWAN, GPS AND WLAN**

(75) Inventors: **Chi-Yueh Wang**, Kaohsiung (TW);
Cheng-Han Lee, Kaohsiung (TW);
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(73) Assignee: **Yageo Corporation**, Kaohsiung (TW)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
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(21) Appl. No.: **11/589,236**

(22) Filed: **Oct. 30, 2006**

(65) **Prior Publication Data**

US 2007/0096999 A1 May 3, 2007

(30) **Foreign Application Priority Data**

Oct. 31, 2005 (TW) 94138184 A

(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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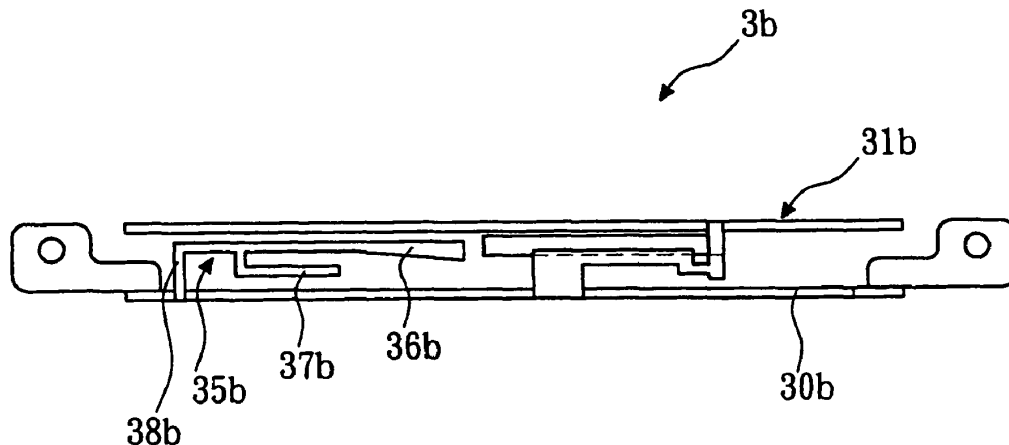
Primary Examiner—Tan Ho

(74) *Attorney, Agent, or Firm*—Volentine & Whitt, P.L.L.C.

(57) **ABSTRACT**

An integrated antenna for WWAN, GPS, and WLAN includes a ground metal plane, a WWAN antenna, and a WLAN antenna. The WWAN antenna is connected to the ground metal plane and includes first and second radiating metal strips which induce a first resonance mode and a second resonance mode respectively. The WLAN antenna is connected to the ground metal plane and includes third and fourth radiating metal strips which induce a third resonance mode and a fourth resonance mode respectively. The integrated antenna can be used in WWAN and WLAN at the same time. The ground metal plane of the integrated antenna does not need to connect to a ground end of a wireless electronic device, and is used for grounding. Therefore, the integrated antenna can be mounted on any part of a wireless electronic device, and can have stable electrical characteristics.

32 Claims, 14 Drawing Sheets



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US007893879B2

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

(10) **Patent No.:** **US 7,893,879 B2**
(45) **Date of Patent:** **Feb. 22, 2011**

(54) **ANTENNA APPARATUS**

(75) Inventors: **Junichi Noro**, Akita (JP); **Akira Yoneya**, Akita (JP); **Isao Fukae**, Tokyo (JP); **Tomohiro Shinkawa**, Tokyo (JP); **Kazunari Saito**, Akita (JP); **Akira Miyoshi**, Tokyo (JP); **Satoshi Kohno**, Akita (JP)

(73) Assignee: **Mitsumi Electric Co., Ltd.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 693 days.

(21) Appl. No.: **11/858,253**

(22) Filed: **Sep. 20, 2007**

(65) **Prior Publication Data**
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(30) **Foreign Application Priority Data**
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Sep. 21, 2006 (JP) P2006-255933
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(51) **Int. Cl.**
H01Q 1/38 (2006.01)
(52) **U.S. Cl.** **343/700 MS; 343/846; 343/848**
(58) **Field of Classification Search** **343/700 MS, 343/846, 848**
See application file for complete search history.

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Primary Examiner—Douglas W Owens

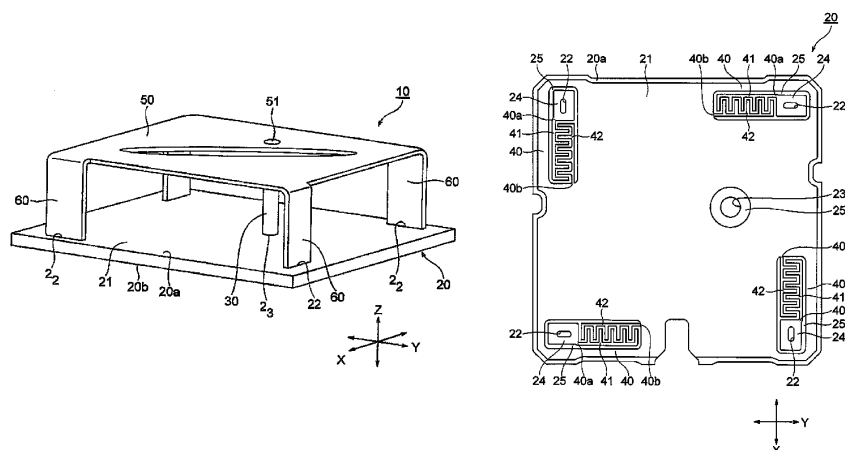
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(57) **ABSTRACT**

An antenna apparatus includes: a circuit board that has a main surface and a rear surface opposite to each other; an antenna element that is formed of a metal plate and is arranged at a predetermined distance from the main surface of the circuit board; a plurality of legs that extend from the antenna element toward the circuit board; a ground conductor that is formed on the main surface or the rear surface of the circuit board; a feeding pin that supplies power from the circuit board to the antenna element; and a plurality of comb-shaped capacitor patterns that are formed on one of or both the main surface and the rear surface of the circuit board and are electrically connected between the plurality of legs and the ground conductor.

6 Claims, 13 Drawing Sheets



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