



US007710330B2

(12) **United States Patent**
Huang

(10) **Patent No.:** **US 7,710,330 B2**

(45) **Date of Patent:** **May 4, 2010**

(54) **DUAL-BAND INVERTED-F ANTENNA**

2003/0206136 A1 * 11/2003 Chen 343/702

(75) Inventor: **Chien-Lin Huang**, Jhongli (TW)

(73) Assignee: **Smart Approach Co., Ltd.**, Hsinchu (TW)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 126 days.

Primary Examiner—Hoang V Nguyen

(74) Attorney, Agent, or Firm—Workman Nydegger

(21) Appl. No.: **12/055,176**

(57) **ABSTRACT**

(22) Filed: **Mar. 25, 2008**

(65) **Prior Publication Data**

US 2009/0243936 A1 Oct. 1, 2009

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

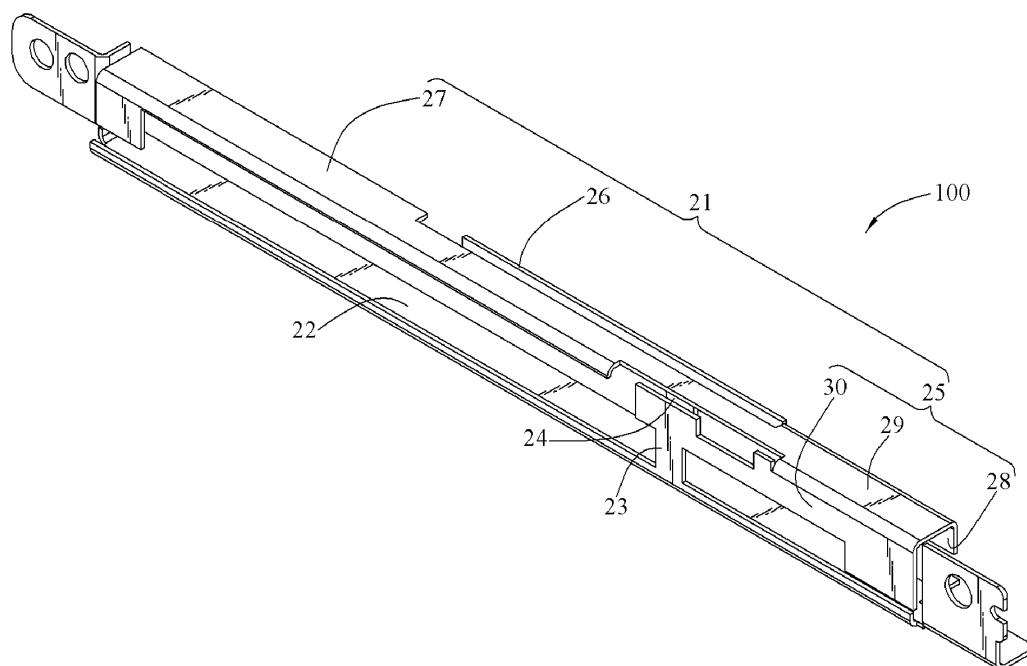
A dual-band inverted-F antenna including a radiation element, a ground element, a conductive pin, and a signal feed-in portion is described. The radiation element includes a loop portion, a first radiation portion, and a second radiation portion. After being fed in through the signal feed-in portion, a first band signal and a second band signal are wirelessly transmitted/received by the first radiation portion and the second radiation portion respectively in one aspect, and transmitted to the conductive pin through the loop portion and finally to the ground element in another aspect. The loop portion is directly short-grounding, such that the bandwidths of the first and the second band signals in operation are increased, thereby improving the overall radiation efficiency.

(56) **References Cited**

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7,489,278 B2 * 2/2009 Huang 343/702

5 Claims, 6 Drawing Sheets



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US007710332B2

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

(10) **Patent No.:** **US 7,710,332 B2**
(45) **Date of Patent:** **May 4, 2010**

(54) **MOBILE COMMUNICATIONS DEVICE WITH A COMPACT-SIZED THREE-DIMENSIONAL ANTENNA**

(75) Inventors: **Min-Che Chen**, Taoyuan (TW);
Ching-Sung Wang, Taoyuan (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 40 days.

(21) Appl. No.: **11/889,974**

(22) Filed: **Aug. 17, 2007**

(65) **Prior Publication Data**

US 2009/0046023 A1 Feb. 19, 2009

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

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

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

See application file for complete search history.

(56) **References Cited**

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2007/0152894	A1 *	7/2007	Sanz et al.	343/702

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Primary Examiner—Rexford N Barnie

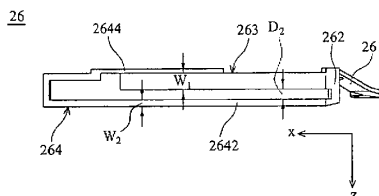
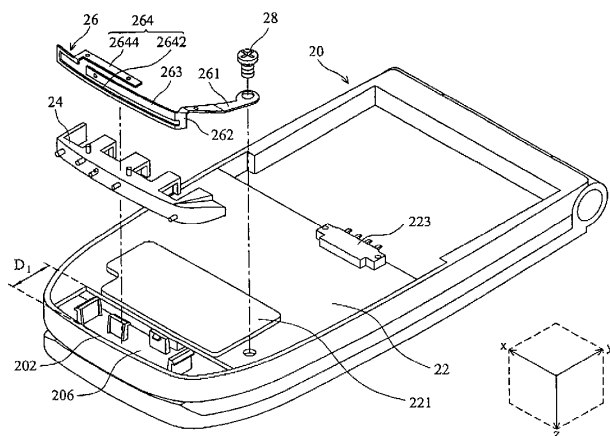
Assistant Examiner—Thienvu V Tran

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

(57) **ABSTRACT**

A mobile communications device includes a circuit board and a monopole antenna. The monopole antenna includes a feed part electrically connected to the circuit board and directed away from the circuit board at an acute angle, a connecting part extending from the feed part in a direction substantially perpendicular to the circuit board, a first radiating part extending from the connecting part, and a second radiating part also extending from the connecting part.

22 Claims, 4 Drawing Sheets



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US007710338B2

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

(10) **Patent No.:** **US 7,710,338 B2**
(45) **Date of Patent:** **May 4, 2010**

(54) **SLOT ANTENNA APPARATUS ELIMINATING UNSTABLE RADIATION DUE TO GROUNDING STRUCTURE**

FOREIGN PATENT DOCUMENTS

JP 2004-336328 11/2004
JP 4050307 12/2007

(75) Inventors: **Tomoyasu Fujishima**, Kanagawa (JP);
Hiroshi Kanno, Osaka (JP)

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(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 222 days.

L. Zhu et al., "A Novel Broadband Microstrip-Fed Wide Slot Antenna With Double Rejection Zeros," IEEE Antennas and Wireless Propagation Letters, vol. 2, 2003, pp. 194-196.
T. Fukazawa et al., "Impedance Measurement of the Antenna on the Portable Telephone using Fiber-Optics," Proceeding of the 2003 IEICE General Conference, the Institute of Electronics, Information and Communication Engineers (IEICE), B-1-206, 2003, p. 206 (with English translation).

(21) Appl. No.: **12/113,407**

* cited by examiner

(22) Filed: **May 1, 2008**

(65) **Prior Publication Data**

US 2009/0066596 A1 Mar. 12, 2009

Primary Examiner—Douglas W Owens

Assistant Examiner—Dieu Hien T Duong

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

(30) **Foreign Application Priority Data**

May 8, 2007 (JP) 2007-123205

(57) **ABSTRACT**

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

(52) **U.S. Cl.** **343/767**; 343/770; 343/700 MS;
343/859

(58) **Field of Classification Search** 343/767,
343/770, 700 MS, 850, 859

See application file for complete search history.

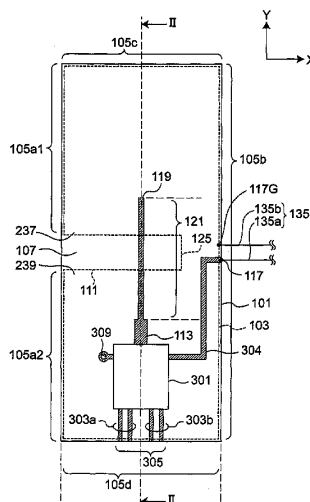
A slot antenna apparatus includes a grounding conductor having an outer edge including a first portion and a second portion, a one-end-opened slot formed in the grounding conductor along a radiation direction such that an open end is provided at a center of the first portion, a first feed line intersecting with the slot to feed radio-frequency signals, a second feed line connected to an external circuit, and a signal processing circuit including active elements and connected between the first and second feed lines and connected to the grounding conductor. The grounding conductor is configured to be symmetric about an axis parallel to the radiation direction and passing through the slot, and is provided with a grounding terminal on the axis of symmetry at the second portion. The grounding terminal is to be connected to a ground of the external circuit.

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5 Claims, 26 Drawing Sheets



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US007710343B2

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

(10) **Patent No.:** **US 7,710,343 B2**
(45) **Date of Patent:** **May 4, 2010**

(54) **COMPACT 3-PORT ORTHOGONALLY
POLARIZED MIMO ANTENNAS**

2006/0261905 A1 * 11/2006 Ham et al. 331/107 SL

(75) Inventors: **Chi Yuk Chiu**, Hong Kong (CN); **Jie
Bang Yan**, Hong Kong (CN); **Ross
David Murch**, Hong Kong (CN)

(73) Assignee: **Hong Kong Technologies Group
Limited**, Apia (WS)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 12 days.

(21) Appl. No.: **11/873,071**

(22) Filed: **Oct. 16, 2007**

(65) **Prior Publication Data**

US 2009/0096699 A1 Apr. 16, 2009

(51) **Int. Cl.**
H01Q 21/26 (2006.01)
H01Q 9/28 (2006.01)

(52) **U.S. Cl.** **343/797**; 343/795

(58) **Field of Classification Search** 343/797,
343/795

See application file for complete search history.

(56) **References Cited**

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27, 2007.

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Primary Examiner—Rexford N Barnie

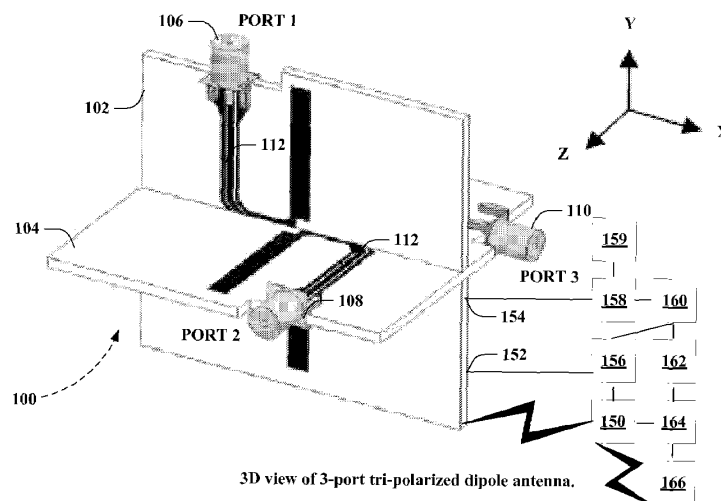
Assistant Examiner—Matthew C Tabler

(74) *Attorney, Agent, or Firm*—Turocy & Watson, LLP

(57) **ABSTRACT**

Generalized non-limiting embodiments include employing a
dipole antenna and/or a half slot antenna. Each of the anten-
nas constitutes three mutually perpendicular radiating ele-
ments to achieve good isolation and low antenna signal cor-
relation between the three ports. In one generalized non-
limiting embodiment the antennas are fabricated on FR-4
epoxy boards. Experimental results show that the antennas
resonate a reasonable frequency and have a desired mutual
coupling. In addition experimental results for the diversity
performance and the MIMO channel capacity are also pro-
vided for these antennas and these results show that the herein
described antennas offer good diversity gain and the channel
capacity can be increased by as much as three times by using
these antennas over conventional antennas.

20 Claims, 10 Drawing Sheets



3D view of 3-port tri-polarized dipole antenna.



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US007714786B2

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

(10) **Patent No.:** **US 7,714,786 B2**
(45) **Date of Patent:** **May 11, 2010**

(54) **ANTENNA DEVICE**

(75) Inventors: **Min-Che Chen**, Tao Yuan (TW);
Kuo-Cheng Chen, Tao Yuan (TW);
Ching-Sung Wang, Tao Yuan (TW)

(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 0 days.

(21) Appl. No.: **11/969,227**

(22) Filed: **Jan. 4, 2008**

(65) **Prior Publication Data**
US 2009/0135067 A1 May 28, 2009

(30) **Foreign Application Priority Data**
Nov. 22, 2007 (TW) 96144308 A

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 1/24 (2006.01)
(52) **U.S. Cl.** **343/700 MS; 343/702**
(58) **Field of Classification Search** **343/845-849,**
343/700 MS, 702
See application file for complete search history.

(56) **References Cited**
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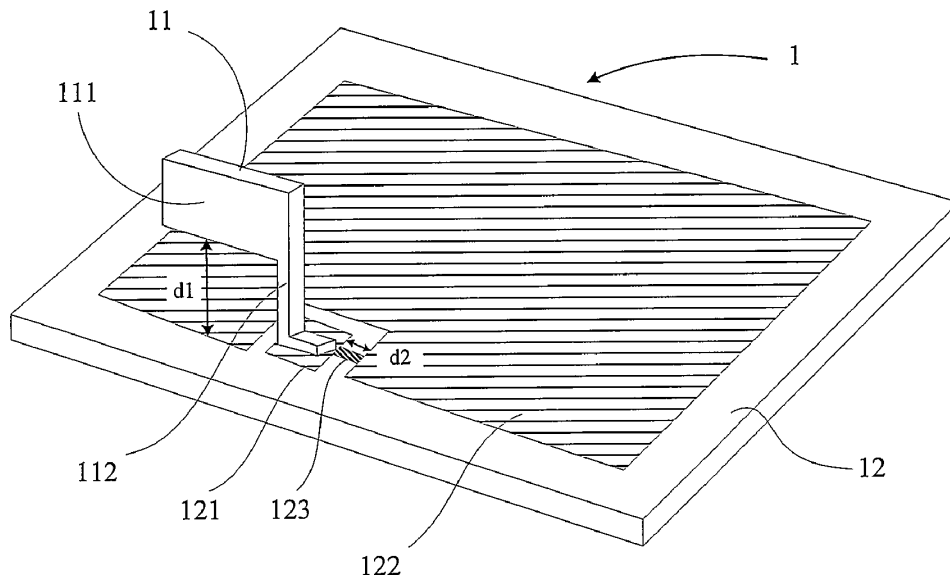
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Primary Examiner—Vibol Tan
Assistant Examiner—Jany Tran
(74) *Attorney, Agent, or Firm*—Jianq Chyun IP Office

(57) **ABSTRACT**

An antenna device including a ground plane, a circuit board, an antenna, and a conductive wire is provided. The circuit board includes a signal feed point, and the antenna includes a radiation portion and a feed portion extending externally from the radiation portion. The feed portion is electrically connected to the signal feed point, and the conductive wire is disposed on the circuit board and electrically connected to the ground plane and the signal feed point. The conductive wire is, for example, a printed trace formed on the circuit board.

25 Claims, 3 Drawing Sheets



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US007714788B2

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

(10) **Patent No.:** **US 7,714,788 B2**
(45) **Date of Patent:** **May 11, 2010**

(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 339 days.

(21) Appl. No.: **11/674,055**

(22) Filed: **Feb. 12, 2007**

(65) **Prior Publication Data**

US 2008/0007458 A1 Jan. 10, 2008

(30) **Foreign Application Priority Data**

Jul. 4, 2006 (TW) 95124300 A

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 1/38 (2006.01)

(52) **U.S. Cl.** **343/702; 373/700 MS; 373/770; 373/860**

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

(56) **References Cited**

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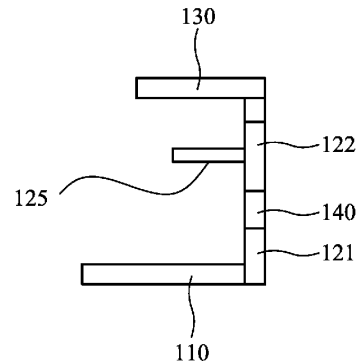
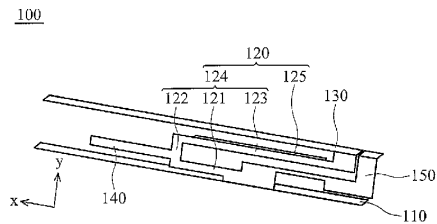
Primary Examiner—Trinh V Dinh

(74) *Attorney, Agent, or Firm*—Quintero Law Office

(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.

8 Claims, 5 Drawing Sheets



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US007714789B2

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

(10) **Patent No.:** **US 7,714,789 B2**
(45) **Date of Patent:** **May 11, 2010**

(54) **ANTENNA HAVING A DIVERSITY EFFECT**

(75) Inventors: **Tiao-Hsing Tsai**, Taipei Shien (TW);
Chih-Wei Liao, Yilan Shien (TW);
Chao-Hsu Wu, Tao Yuan Shien (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 66 days.

(21) Appl. No.: **12/197,885**

(22) Filed: **Aug. 25, 2008**

(65) **Prior Publication Data**

US 2009/0256754 A1 Oct. 15, 2009

(30) **Foreign Application Priority Data**

Apr. 10, 2008 (TW) 97112992 A

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

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

(58) **Field of Classification Search** 343/700 MS,
343/702, 893, 895, 818

See application file for complete search history.

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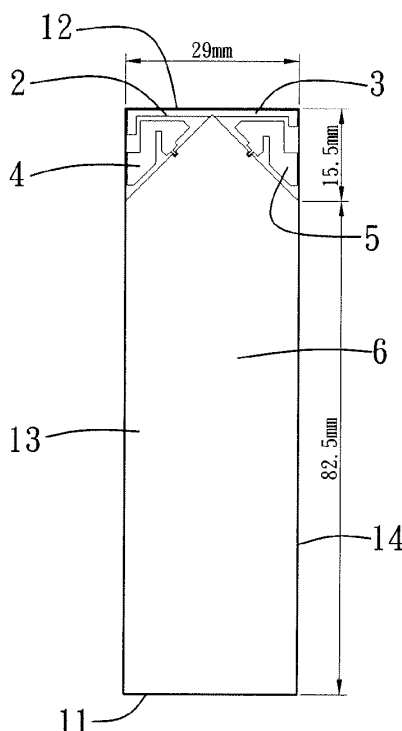
Primary Examiner—Huedung Mancuso

(74) *Attorney, Agent, or Firm*—Stephen A. Bent; Foley & Lardner LLP

(57) **ABSTRACT**

An antenna includes a dielectric substrate, a grounding plane, first and second grounding elements, and first and second radiating elements. The grounding plane is formed on the dielectric substrate and is disposed between the first and second radiating elements. The first and second grounding elements extend from the grounding plane away from each other. The first and second radiating elements are coupled electromagnetically to the first and second grounding elements, respectively.

20 Claims, 18 Drawing Sheets



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US007714795B2

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

(10) **Patent No.:** **US 7,714,795 B2**
(45) **Date of Patent:** **May 11, 2010**

(54) **MULTI-BAND ANTENNA APPARATUS
DISPOSED ON A THREE-DIMENSIONAL
SUBSTRATE, AND ASSOCIATED
METHODOLOGY, FOR A RADIO DEVICE**

(75) Inventors: **Geyi Wen**, Waterloo (CA); **Qinjiang Rao**, Waterloo (CA); **Mark Pecan**, Waterloo (CA)

(73) Assignee: **Research in Motion Limited**, Waterloo (CA)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 176 days.

(21) Appl. No.: **11/843,840**

(22) Filed: **Aug. 23, 2007**

(65) **Prior Publication Data**

US 2009/0051615 A1 Feb. 26, 2009

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

(52) **U.S. Cl.** **343/860**; 343/700 MS;
343/702; 343/895

(58) **Field of Classification Search** 343/745,
343/749, 791, 860, 895, 900, 700 MS, 702,
343/750, 793, 795, 806, 850, 852
See application file for complete search history.

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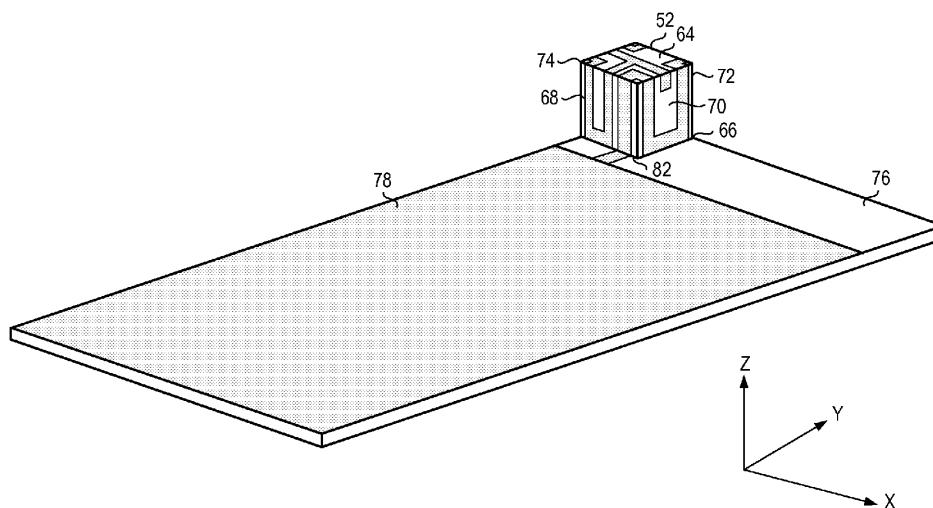
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Primary Examiner—Douglas W Owens
Assistant Examiner—Chuc D Tran

(57) **ABSTRACT**

Antenna apparatus, and an associated methodology, for a multi-frequency-band-capable radio device, such as a quad-band mobile station. The antenna apparatus is formed from a three-dimensional rectilinear non-conductive dielectric antenna substrate, such as cube. An elongated radiation element is disposed over multiple surfaces of the antenna substrate. A T-shaped impedance matching element located at the end of the radiation element permits the antenna input impedance to be matched to a communications device. The length of the radiation element is selected to be substantially equal to a quarter wavelength of the lowest frequency band at which the antenna operates.

43 Claims, 10 Drawing Sheets



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US00D615534S

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

(10) **Patent No.:** **US D615,534 S**

(45) **Date of Patent:** **** May 11, 2010**

(54) **MULTI-BAND ANTENNA**

(75) Inventors: **Yung-Chih Tsai**, Taipei (TW);
Jia-Hung Su, Taipei (TW); **Kai Shih**,
Taipei (TW)

(73) Assignee: **Cheng Uei Precision Industry Co.,
Ltd.**, Taipei (TW)

(**) Term: **14 Years**

(21) Appl. No.: **29/351,119**

(22) Filed: **Nov. 30, 2009**

(51) **LOC (9) CL.** **14-03**

(52) **U.S. CL.** **D14/230**

(58) **Field of Classification Search** D14/138,
D14/230–238, 299, 358; D12/42, 43; 343/700 MS,
343/700 R–705, 711–713, 741, 748, 767,
343/795, 819, 840, 846, 866, 871–908; 455/90.2,
455/90.3, 91, 128, 269, 344, 347, 562.1;
333/193, 195

See application file for complete search history.

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D608,354 S * 1/2010 Yang et al. D14/230
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Primary Examiner—T. Chase Nelson

Assistant Examiner—John Windmuller

(57) **CLAIM**

The ornamental design for multi-band antenna, as shown and described.

DESCRIPTION

FIG. 1 is a perspective view of multi-band antenna showing our new design;

FIG. 2 is a front elevational view thereof;

FIG. 3 is a rear elevational view thereof;

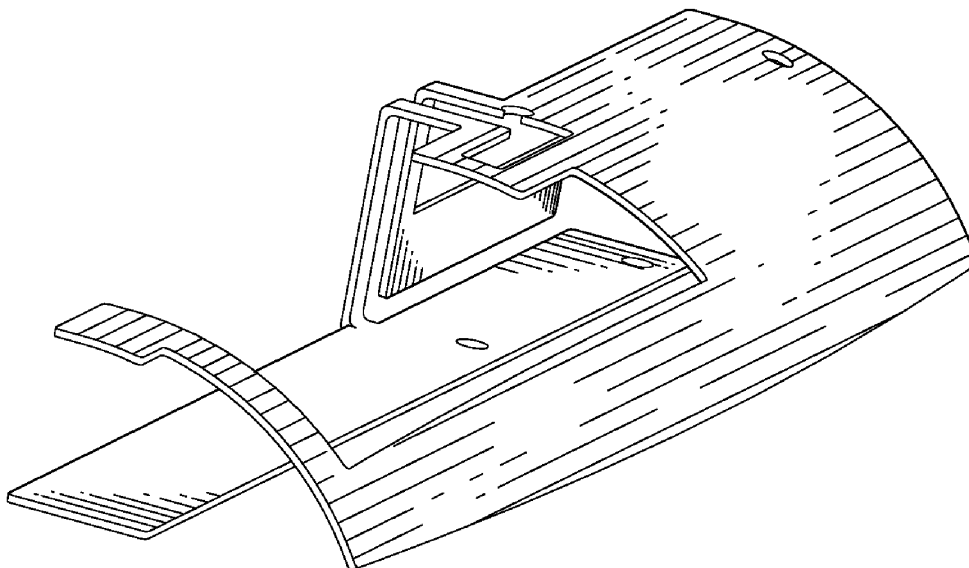
FIG. 4 is a left side elevational view thereof;

FIG. 5 is a right side elevational view thereof;

FIG. 6 is a top plan view thereof; and,

FIG. 7 is a bottom plan view thereof.

1 Claim, 7 Drawing Sheets



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US007719470B2

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

(10) **Patent No.:** **US 7,719,470 B2**
(45) **Date of Patent:** **May 18, 2010**

(54) **MULTI-BAND ANTENNA, AND ASSOCIATED METHODOLOGY, FOR A RADIO COMMUNICATION DEVICE**

(75) Inventors: **Dong Wang**, Waterloo (CA); **Geyi Wen**, Waterloo (CA); **Qinjiang Rao**, Waterloo (CA); **Mark Pecan**, Waterloo (CA)

(73) Assignee: **Research In Motion Limited**, Waterloo (CA)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 320 days.

(21) Appl. No.: **11/843,802**

(22) Filed: **Aug. 23, 2007**

(65) **Prior Publication Data**

US 2009/0051595 A1 Feb. 26, 2009

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

(52) **U.S. Cl.** **343/700 MS; 343/702; 343/767; 343/846**

(58) **Field of Classification Search** **343/700 MS, 343/702, 722, 767, 846, 895**
See application file for complete search history.

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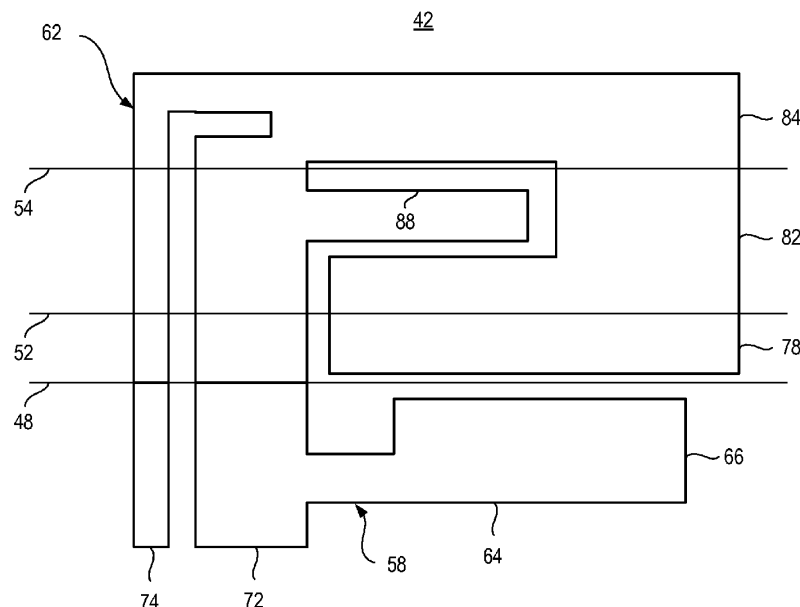
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Primary Examiner—Douglas W Owens
Assistant Examiner—Chuc D Tran

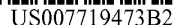
(57) **ABSTRACT**

An antenna, and an associated methodology, for a portable radio device, such as a mobile station capable of operation at a plurality of frequency bands spread across a wide range of frequencies. The antenna includes a first antenna patch and a second antenna patch. The first antenna patch comprises an L-shaped patch disposed upon a substrate. A second antenna patch forms a folded patch formed of three contiguous portions, folded about fold lines in a manner to cause the second antenna patch to include a first contiguous portion that extends upwardly beyond the first antenna patch at an angle perpendicular thereto. Second and third contiguous portions are formed by folding additional portions of the second antenna patch about additional fold lines.

32 Claims, 7 Drawing Sheets



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(10) **Patent No.:** US 7,719,473 B2
(45) **Date of Patent:** May 18, 2010

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US007724192B2

(12) **United States Patent**
Liu

(10) **Patent No.:** **US 7,724,192 B2**
(45) **Date of Patent:** **May 25, 2010**

(54) **PORTABLE COMMUNICATION DEVICE
WITH SLOT-COUPLED ANTENNA MODULE**

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
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(21) Appl. No.: **11/802,027**

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(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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

(52) **U.S. Cl.** **343/700 MS; 343/829;**
343/846

(58) **Field of Classification Search** **343/700 MS,**
343/705, 767, 789, 829, 830, 846, 848, 872
See application file for complete search history.

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Primary Examiner—Douglas W Owens

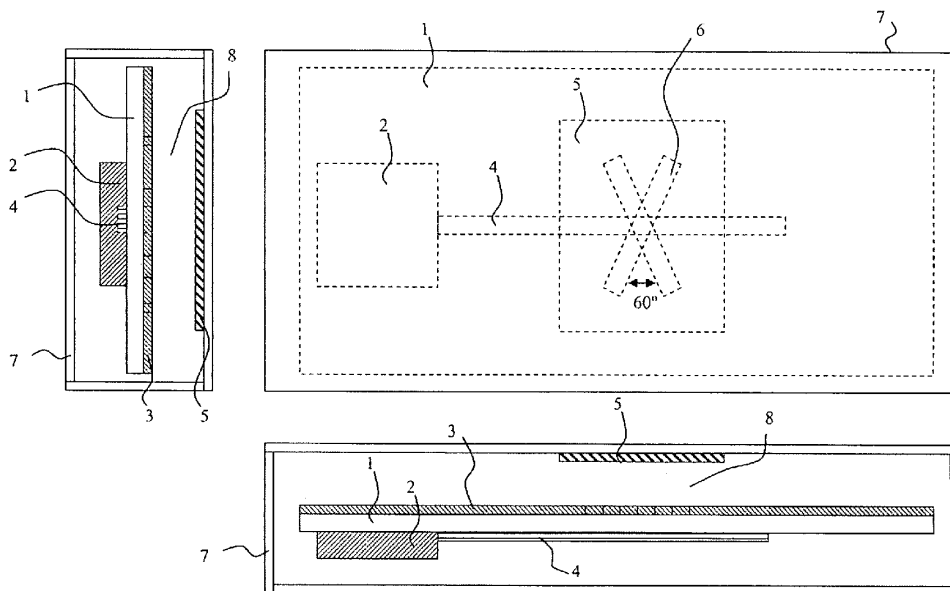
Assistant Examiner—Chuc D Tran

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

(57) **ABSTRACT**

The present invention discloses a portable communication device with slot-coupled antenna module the slot-coupled antenna module comprises: a dielectric substrate, radio module, ground plane, air substrate, and patch radiator. The radio module contains a feed line and stub that are coupled on the surface of the dielectric substrate and extending along the long side of the dielectric substrate in parallel. The ground plane with slot-coupled structure is coupled on the other surface of the dielectric substrate, the feed line and stub pass through the intersect portion of the coupled slots. The air gap is therefore formed between the ground plane and the patch radiator, and the patch radiator is substantially parallel with the ground plane and locating substantially on the position of the coupled slots.

18 Claims, 14 Drawing Sheets



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US007724195B2

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

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(54) **ANTENNA APPARATUS**

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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 447 days.

(21) Appl. No.: **11/492,074**

(22) Filed: **Jul. 25, 2006**

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H01Q 1/24 (2006.01)

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

(58) **Field of Classification Search** **343/702; 343/906**

See application file for complete search history.

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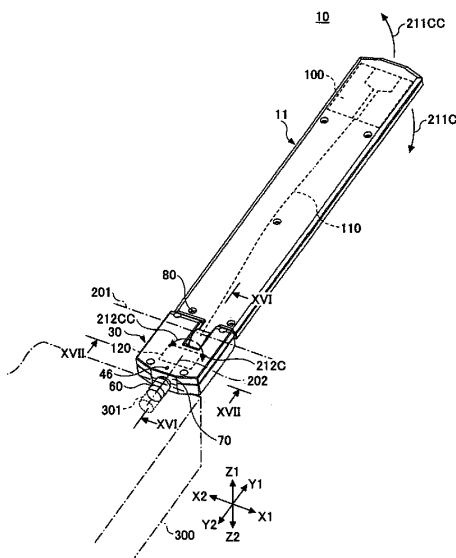
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(74) *Attorney, Agent, or Firm*—Staas & Halsey LLP

(57) **ABSTRACT**

An antenna apparatus includes an antenna case housing an antenna; a connector to be connected to a device which connector is electrically connected to the antenna; and an antenna case supporting mechanism which supports the antenna case and enables changing a position of the antenna case at least to a horizontal position and a vertical position.

9 Claims, 19 Drawing Sheets



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US007724196B2

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

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(45) **Date of Patent:** **May 25, 2010**

(54) **FOLDED DIPOLE MULTI-BAND ANTENNA**

(56) **References Cited**

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patent is extended or adjusted under 35
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(65) **Prior Publication Data**

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

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

343/803, 767, 741, 700 MS, 729, 725

See application file for complete search history.

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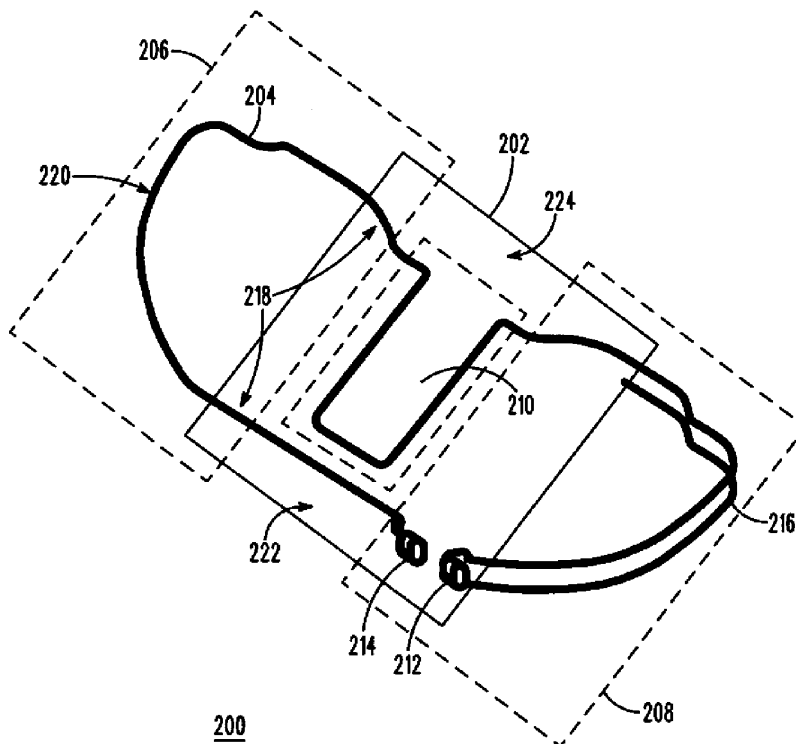
Primary Examiner—Huedung Mancuso

(74) *Attorney, Agent, or Firm*—Gregory L. Mayback; Scott
B. Smiley; Mayback & Hoffman

(57) **ABSTRACT**

A loop antenna includes a ground plane and a conductive element with a first C-shaped element portion having an open end and a closed end, with only the open end extending directly above a first portion of the ground plane, a second C-shaped element portion having an open end and a closed end, with only the open end extending directly above a second portion of the ground plane, and a transmission line element disposed between the first C-shaped element portion and the second C-shaped element portion and positioned directly above a third portion of the ground plane.

20 Claims, 7 Drawing Sheets



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