



US007864116B2

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

(10) **Patent No.:** **US 7,864,116 B2**
(45) **Date of Patent:** **Jan. 4, 2011**

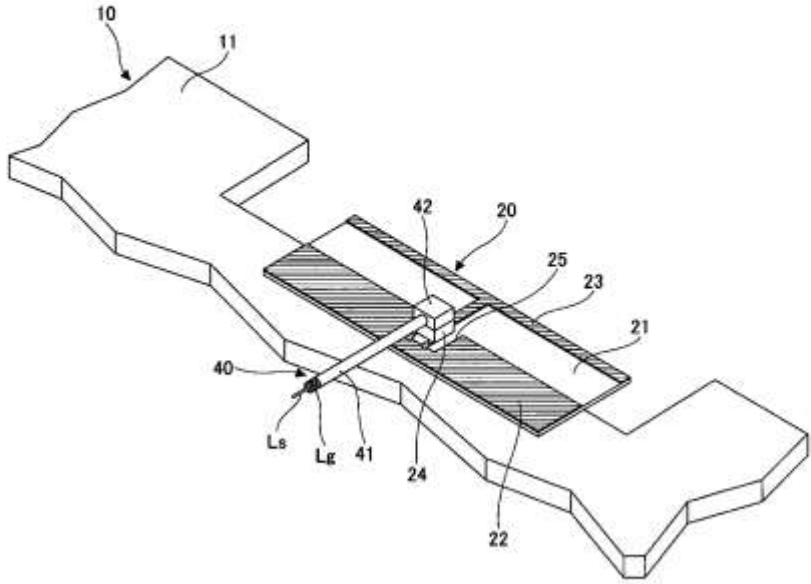
- (54) **MOUNTING STRUCTURE OF ANTENNA DEVICE**
- (75) Inventors: **Shigemi Kurashima**, Shinagawa (JP); **Masahiro Yanagi**, Shinagawa (JP); **Takashi Yuba**, Shinagawa (JP); **Satoshi Sakurai**, Shinagawa (JP); **Takashi Arita**, Shinagawa (JP)
- (73) Assignee: **Fujitsu Component Limited**, Tokyo (JP)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 88 days.
- (21) Appl. No.: **12/081,685**
- (22) Filed: **Apr. 18, 2008**
- (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; 343/702**
- (58) **Field of Classification Search** **343/878, 343/700 MS, 702, 749, 846, 858**
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*—Staas & Halsey LLP

(57) **ABSTRACT**

A mounting structure of an antenna device for mounting the antenna device composed of a ground part and an element part on an electronic apparatus is disclosed. The ground part is mounted on the electronic apparatus so as to be substantially overlapped with a conductive part of the electronic apparatus.

6 Claims, 9 Drawing Sheets





US007864120B2

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

(10) **Patent No.:** **US 7,864,120 B2**
(45) **Date of Patent:** **Jan. 4, 2011**

(54) **HIGH ISOLATION ANTENNA DESIGN FOR REDUCING FREQUENCY COEXISTENCE INTERFERENCE**

(75) Inventors: **Weiping Dou**, San Jose, CA (US); **Avi Kopelman**, Sunnyvale, CA (US)

(73) Assignee: **Palm, 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 617 days.

(21) Appl. No.: **11/756,455**

(22) Filed: **May 31, 2007**

(65) **Prior Publication Data**

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H01Q 1/24 (2006.01)

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

(58) **Field of Classification Search** 343/702,
343/821, 729, 876, 893

See application file for complete search history.

(56) **References Cited**

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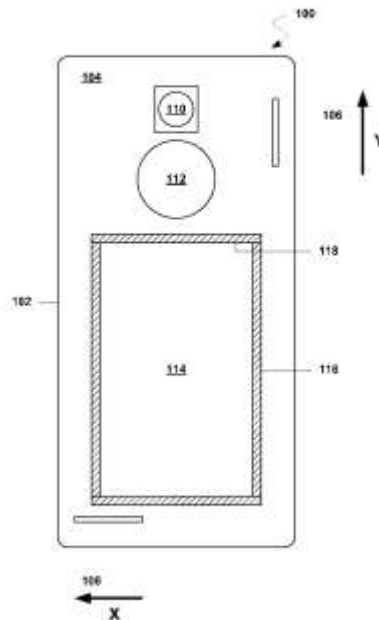
Primary Examiner—Huedung Mancuso

(74) *Attorney, Agent, or Firm*—Kacvinsky Daisak PLLC

(57) **ABSTRACT**

Various embodiments are directed to high isolation antenna design for reducing frequency coexistence interference. In one embodiment, a computing device may comprise a printed circuit board including a first internal antenna and a second internal antenna operating in a common frequency band. At least one of the first internal antenna and the second internal antenna may comprise a balanced antenna coupled to an unbalancing element to suppress surface current on the printed circuit board and reduce frequency coexistence interference between the first internal antenna and the second internal antenna. Other embodiments are described and claimed.

21 Claims, 3 Drawing Sheets





US007864121B2

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

(10) **Patent No.:** **US 7,864,121 B2**
(45) **Date of Patent:** **Jan. 4, 2011**

(54) **MIMO SELF-EXPANDABLE ANTENNA STRUCTURE**

(75) Inventors: **Peter Suprunov**, East Brunswick, NJ (US); **Victor Abramsky**, Edison, NJ (US)

(73) Assignee: **QUALCOMM Incorporated**, San Diego, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 587 days.

(21) Appl. No.: **11/774,504**

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

(65) **Prior Publication Data**

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H01Q 1/24 (2006.01)

(52) **U.S. Cl.** **343/702; 343/881**

(58) **Field of Classification Search** **343/702, 343/880, 881**

See application file for complete search history.

(56) **References Cited**

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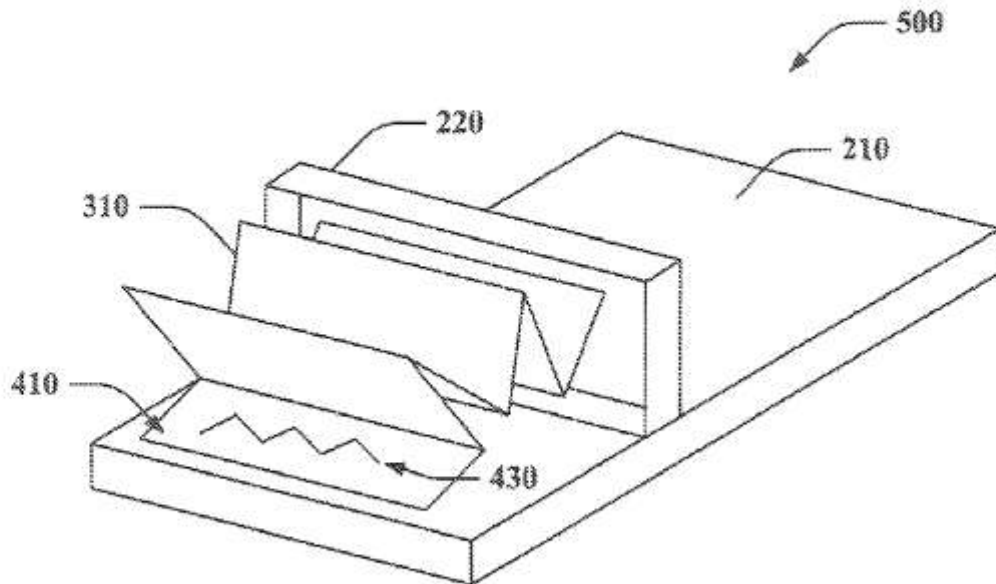
Primary Examiner—Tho G Phan

(74) *Attorney, Agent, or Firm*—Jiayu Xu

(57) **ABSTRACT**

Systems and methodologies are described that provide a low cost, compact and easily manufacturable multiple-input, multiple-output antenna structure suitable for portable radio equipment. Multiple antenna elements are printed on a folded flexible material. The flexible material expands when the antenna structure is deployed for operation and collapses when stowed.

46 Claims, 21 Drawing Sheets





US007864123B2

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

(10) **Patent No.:** **US 7,864,123 B2**
(45) **Date of Patent:** **Jan. 4, 2011**

(54) **HYBRID SLOT ANTENNAS FOR HANDHELD ELECTRONIC DEVICES**

2008/0231521 A1 9/2008 Anguera Pros et al.
2010/0007564 A1 1/2010 Hill et al.

(75) Inventors: **Robert J. Hill**, Salinas, CA (US); **Juan Zavala**, Watsonville, 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 334 days.

(21) Appl. No.: **11/897,033**

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

(65) **Prior Publication Data**

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H01Q 1/24 (2006.01)

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

(58) **Field of Classification Search** **343/702; 343/700 MS, 767**

See application file for complete search history.

(56) **References Cited**

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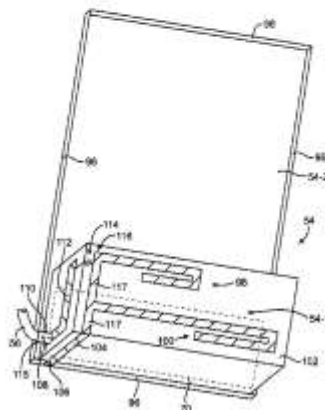
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Primary Examiner—Douglas W Owens
Assistant Examiner—Dieu Hien T Duong
(74) *Attorney, Agent, or Firm*—Treyz Law Group; G. Victor Treyz; David C. Kellogg

(57) **ABSTRACT**

Handheld electronic devices are provided that contain wireless communications circuitry. The wireless communications circuitry may include an antenna. The antenna may be formed from a ground plane having a dielectric-filled slot that defines a slot antenna structure and having a planar-inverted-F (PIFA) resonating element located above the opening. The slot antenna structure and the PIFA resonating element may both contribute to the performance of the antenna, so that the antenna exhibits the performance of a hybrid PIFA-slot antenna. The PIFA resonating element may contain multiple antenna resonating element branches. The branches may be configured to operate in different communications bands than the slot antenna structure.

22 Claims, 16 Drawing Sheets





US007864124B2

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

(10) **Patent No.:** **US 7,864,124 B2**
(45) **Date of Patent:** **Jan. 4, 2011**

(54) **MULTI-BAND ANTENNA FOR MOBILE PHONE**

(75) Inventors: **Suk-Chan Hong**, Gumi-si (KR);
Jae-Kyu Lee, Gumi-si (KR); **Jun-Chul Kang**, Gumi-si (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 197 days.

(21) Appl. No.: **12/136,929**

(22) Filed: **Jun. 11, 2008**

(65) **Prior Publication Data**
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(30) **Foreign Application Priority Data**
Jun. 11, 2007 (KR) 10-2007-0056677

(51) **Int. Cl.**
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(52) **U.S. Cl.** **343/702; 343/850**

(58) **Field of Classification Search** **343/700 MS, 343/702, 850, 853, 860**

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(56) **References Cited**

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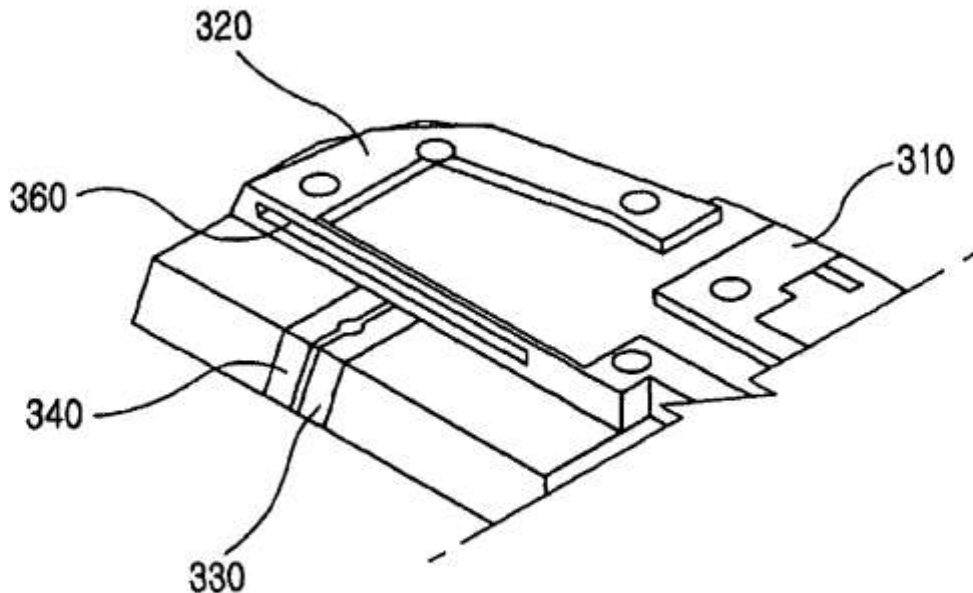
Primary Examiner—Hoang V Nguyen

(74) *Attorney, Agent, or Firm*—The Farrell Law Firm, LLP

(57) **ABSTRACT**

A mobile phone includes a multi-band antenna which is mutually connected in a dependent manner for operation according to a signal transmitted to and received from the mobile phone; and a resonance unit for generating resonance for multiple frequency bands as ends of the multi-band antenna are spaced apart at a predetermined interval, to improve mute performance, reduce SAR, and prevent a reduction in call performance due to an influence of a user's body and hand when holding the mobile phone to make a call.

6 Claims, 8 Drawing Sheets





US007868827B2

(12) **United States Patent**
Dijkstra

(10) **Patent No.:** **US 7,868,827 B2**
(45) **Date of Patent:** **Jan. 11, 2011**

(54) **COUPLING FOR PATCH ANTENNAS**

(75) Inventor: **Patrick Walter Joseph Dijkstra**, TJ
Driebruggen (NL)

(73) Assignee: **Stiching Noble House**, AC Lisse (NL)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 771 days.

(21) Appl. No.: **10/582,573**

(22) PCT Filed: **Dec. 10, 2004**

(86) PCT No.: **PCT/NL2004/000860**

§ 371 (c)(1),
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(30) **Foreign Application Priority Data**

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

See application file for complete search history.

(56) **References Cited**

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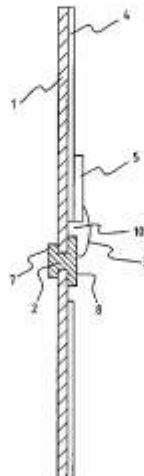
Primary Examiner—Hoang Anh T Le

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

(57) **ABSTRACT**

Device comprising a patch antenna, and coupling means for connecting the antenna to an electronic component, wherein the patch antenna is arranged on one side of an antenna plate, and the electronic component can be mounted on the other side of the antenna plate, wherein the coupling means comprise a metal passage through the antenna plate. This passage thus ensures the transmission of signals between the antenna and the electronic component. Such a passage is mechanically very robust and not susceptible to ageing, whereby this passage is suitable for automotive applications. This passage is generally not ideal, since it does not have the same characteristic impedance as the antenna and the electronic component, but the dimensions of the passage can be kept sufficiently small so that no disruption is encountered from this impedance mismatch.

15 Claims, 2 Drawing Sheets





US007868831B2

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

(10) **Patent No.:** **US 7,868,831 B2**
(45) **Date of Patent:** **Jan. 11, 2011**

(54) **COMPLEX ANTENNA**

(75) Inventors: **Chen-Ta Hung**, Tu-cheng (TW);
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Wen-Fong Su, Tu-cheng (TW)

(73) Assignee: **Hon Hai Precision Ind. Co., Ltd.**,
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 378 days.

(21) Appl. No.: **12/150,382**

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(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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

See application file for complete search history.

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Primary Examiner—Douglas W Owens

Assistant Examiner—Chuc D Tran

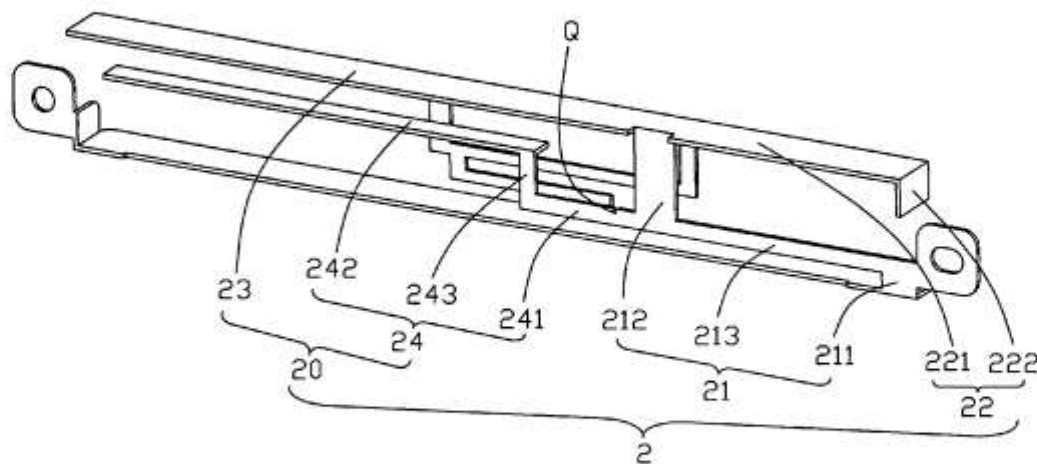
(74) *Attorney, Agent, or Firm*—Wei Te Chung; Andrew C. Cheng; Ming Chieh Chang

(57) **ABSTRACT**

A complex antenna includes a first antenna and a second antenna having a grounding element and an installing element sharing with the first antenna. The first antenna working in a WLAN (Wireless Local Area Network) comprises a first connecting element, a first radiating element and a second radiating element extending from the first connecting element in opposite direction. The second antenna working in a WWAN (Wireless Wide Area Network) comprises a second connecting element and at least three radiating elements extending from the second connecting element in different directions.

20 Claims, 9 Drawing Sheets

100





US007868836B2

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

(10) **Patent No.:** **US 7,868,836 B2**
(45) **Date of Patent:** **Jan. 11, 2011**

(54) **ANTENNA AND MOBILE TERMINAL**

(75) Inventors: **Orest Genrihovich Vendik**, St. Petersburg (RU); **Ivan Andreevich Pakhomov**, St. Petersburg (RU); **An Sun Hyun**, Seoul (KR); **Kang Jae Jung**, Seoul (KR); **Dong Ho Lee**, Seoul (KR)

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

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(21) Appl. No.: **11/747,100**

(22) Filed: **May 10, 2007**

(65) **Prior Publication Data**
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Related U.S. Application Data

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Dec. 28, 2006 (KR) 10-2006-0135938

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H01Q 21/00 (2006.01)

(52) **U.S. Cl.** **343/726; 343/853; 343/816; 343/866**

(58) **Field of Classification Search** 343/725, 343/726, 853, 866, 816
See application file for complete search history.

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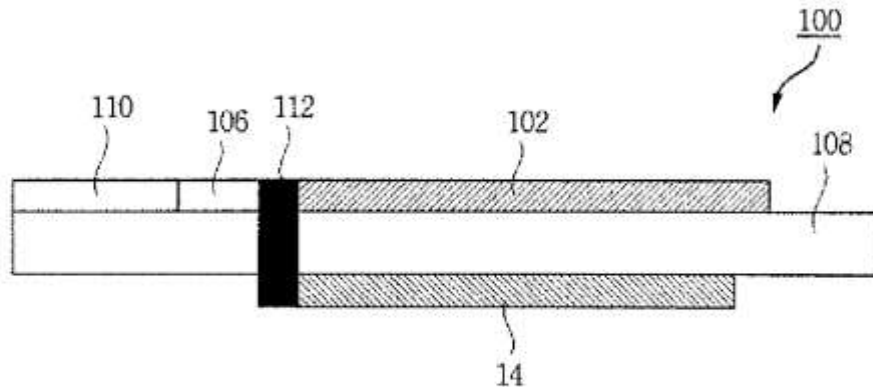
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Primary Examiner—Douglas W Owens
Assistant Examiner—Dieu Hien T Duong
(74) *Attorney, Agent, or Firm*—Lee, Hong, Degerman, Kang & Waimey

(57) **ABSTRACT**

An antenna for a mobile terminal includes a substrate, a dipole placed on the substrate, a loop placed on the substrate, and a matching circuit on the substrate. The matching circuit comprises at least one of a variable capacitor or a variable inductor. The radiation center of the loop substantially coincides with the radiation center of the dipole.

16 Claims, 19 Drawing Sheets





US007868838B2

(12) **United States Patent**
Tai

(10) **Patent No.:** **US 7,868,838 B2**
(45) **Date of Patent:** **Jan. 11, 2011**

- (54) **ULTRA WIDEBAND ANTENNA**
- (75) **Inventor:** Lung-Sheng Tai, Tu-cheng (TW)
- (73) **Assignee:** Hon Hai Precision Ind. Co., Ltd, 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 181 days.
- (21) **Appl. No.:** 12/150,612
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- (30) **Foreign Application Priority Data**
Apr. 30, 2007 (TW) 96115269 A
- (51) **Int. Cl.**
H01Q 1/36 (2006.01)
- (52) **U.S. Cl.** 343/729; 343/767; 343/828;
343/830
- (58) **Field of Classification Search** 343/700 MS,
343/702, 846, 729, 767, 825, 826, 829, 830
See application file for complete search history.

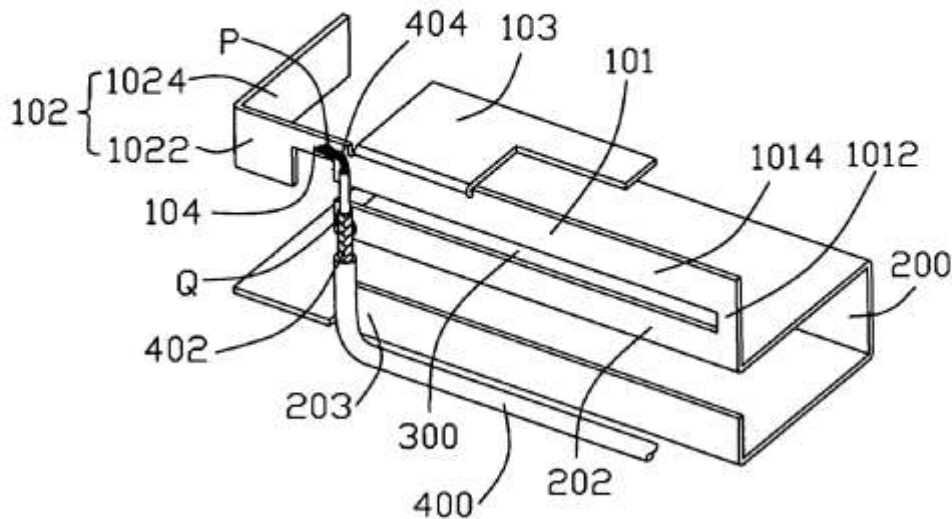
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Primary Examiner—Michael C Wimer
(74) *Attorney, Agent, or Firm*—Wei Te Chung; Andrew C. Cheng; Ming Chieh Chang

(57) **ABSTRACT**

A wideband antenna includes a ground element comprising an upper first side, a first metal sheet a short arm connecting to the first side of the grounding element and a long arm separated from the first side, a second metal sheet electrically connecting to the first metal sheet, a third metal sheet perpendicular to the second metal sheet, and a slot between the first side of the ground element and the long arm of the first metal sheet; wherein said slot, said second metal sheet and said third metal sheet work together to form an ultra wide resonant frequency.

11 Claims, 5 Drawing Sheets





US007868844B2

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

(10) **Patent No.:** **US 7,868,844 B2**
(45) **Date of Patent:** **Jan. 11, 2011**

(54) **ULTRA-WIDE BANDWIDTH ANTENNA**

(75) Inventors: **Tiao Hsing Tsai**, Yungho (TW); **Chao Hsu Wu**, Tao Yuan Shien (TW); **Chi Yin Fang**, Pingtung (TW)

(73) Assignee: **Quanta Computer Inc.** (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 464 days.

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(30) **Foreign Application Priority Data**
Jun. 21, 2007 (TW) 96122265 A

(51) **Int. Cl.**
H01Q 1/48 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)

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

(58) **Field of Classification Search** 343/700 MS, 343/702, 846, 793, 795, 830
See application file for complete search history.

(56) **References Cited**

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Primary Examiner—Jacob Y Choi

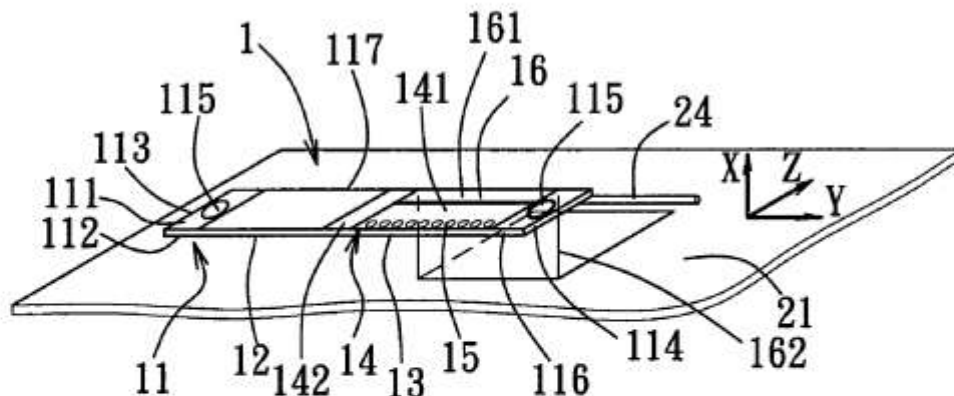
Assistant Examiner—Robert Karacsony

(74) *Attorney, Agent, or Firm*—Banner & Witcoff, Ltd.

(57) **ABSTRACT**

An ultra-wide bandwidth antenna includes a dielectric substrate, first and second conductive elements, and a third conductive element. The dielectric substrate has opposite first and second surfaces. The first conductive element is formed on the second surface of the dielectric substrate and has a feeding point. The second conductive element is formed on the second surface of the dielectric substrate, is spaced apart from the first conductive element, and has a grounding point. The third conductive element is formed on the first surface of the dielectric substrate, partially overlaps the first conductive element, and is coupled electrically to the second conductive element.

4 Claims, 7 Drawing Sheets





US007869842B2

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

(10) **Patent No.:** **US 7,869,842 B2**
(45) **Date of Patent:** **Jan. 11, 2011**

(54) **FOLDER TYPE PORTABLE TERMINAL WITH VARIABLE-TYPE GROUNDING UNIT**

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2006/0092081 A1* 5/2006 Kanazawa 343/702

(75) Inventors: **Jae-Ho Kim**, Suwon-si (KR); **Hun-Jong Jeong**, Suwon-si (KR)

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

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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 1132 days.

KR 10-2003-0027512 4/2003
KR 10-2004-0063235 7/2004

(21) Appl. No.: **11/489,343**

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(22) Filed: **Jul. 19, 2006**

Primary Examiner—Kamran Afshar

(65) **Prior Publication Data**

(74) *Attorney, Agent, or Firm*—The Farrell Law Firm, LLP

US 2007/0021158 A1 Jan. 25, 2007

(57) **ABSTRACT**

(30) **Foreign Application Priority Data**

Jul. 20, 2005 (KR) 10-2005-0065541

The present invention relates to a folder or hinge type portable terminal having a grounding unit. A main body has a main board. A folder opens and closes at an angle from the main body. At least one component of a hinge module is formed of a metallic material, and opens and closes the folder at an angle from the main body. A connecting means selectively contacts a grounding portion of the main board to the material components of the hinge module in response to the opening and closing operation of the folder, to provide optimal antenna radiation characteristic irrespective of the opening and closing operation of the folder.

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

(52) **U.S. Cl.** **455/575.3; 455/550.1; 455/575.1**

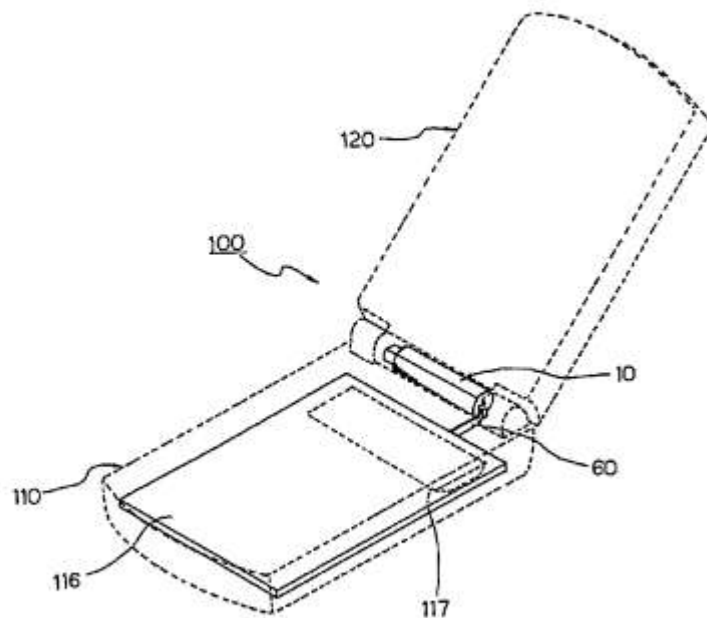
(58) **Field of Classification Search** 455/550.1, 455/575.1-575.7, 556.2; 343/702
See application file for complete search history.

(56) **References Cited**

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24 Claims, 9 Drawing Sheets





US007872605B2

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

(10) **Patent No.:** **US 7,872,605 B2**
(45) **Date of Patent:** **Jan. 18, 2011**

(54) **SLOTTED GROUND-PLANE USED AS A SLOT ANTENNA OR USED FOR A PIFA ANTENNA**

(75) Inventors: **Carles Puente Baliarda**, Barcelona (ES); **Jaime Anguera Pros**, Castellon (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 662 days.

(21) Appl. No.: **11/884,991**

(22) PCT Filed: **Mar. 15, 2006**

(86) PCT No.: **PCT/EP2006/060766**

§ 371 (c)(1),
(2), (4) Date: **Sep. 20, 2007**

(87) PCT Pub. No.: **WO2006/097496**

PCT Pub. Date: **Sep. 21, 2006**

(65) **Prior Publication Data**

US 2008/0316118 A1 Dec. 25, 2008

(30) **Foreign Application Priority Data**

Mar. 15, 2005 (EP) 05005540

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 13/10 (2006.01)
H01Q 1/48 (2006.01)

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

(58) **Field of Classification Search** 343/702,
343/700 MS, 767, 846

See application file for complete search history.

(56) **References Cited**

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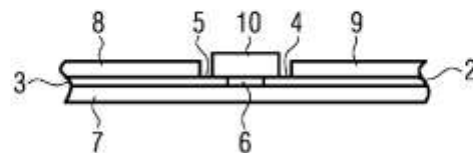
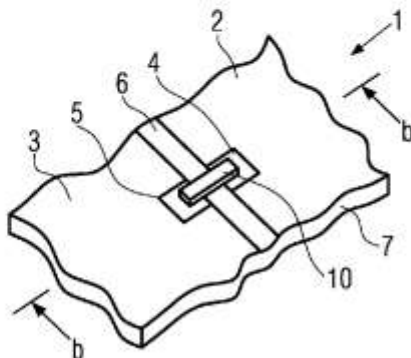
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Primary Examiner—Shih-Chao Chen
(74) *Attorney, Agent, or Firm*—Winstead PC

(57) **ABSTRACT**

A wireless device includes a ground plane with at least two portions. On each of the at least two portions at least one connecting means is provided. The two connecting means are connected with an electric component for connecting the at least two portions of the ground plane. The ground plane is partially covered with an insulating material and the connecting means are given by a part of the ground plane which is not covered by any insulating material.

42 Claims, 6 Drawing Sheets





US007872607B2

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

(10) **Patent No.:** **US 7,872,607 B2**
(45) **Date of Patent:** **Jan. 18, 2011**

(54) **DIVERSE SPECTRUM ANTENNA FOR HANDSETS AND OTHER DEVICES**

(75) Inventors: **Alireza Hormoz Mohammadian**, San Diego, CA (US); **Samir S. Soliman**, San Diego, CA (US)

(73) Assignee: **QUALCOMM, Incorporated**, San Diego, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 957 days.

(21) Appl. No.: **11/413,369**

(22) Filed: **Apr. 28, 2006**

(65) **Prior Publication Data**

US 2007/0176834 A1 Aug. 2, 2007

Related U.S. Application Data

(60) Provisional application No. 60/762,770, filed on Jan. 27, 2006.

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

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

(58) **Field of Classification Search** 343/700 MS, 343/702, 846, 767, 770

See application file for complete search history.

(56) **References Cited**

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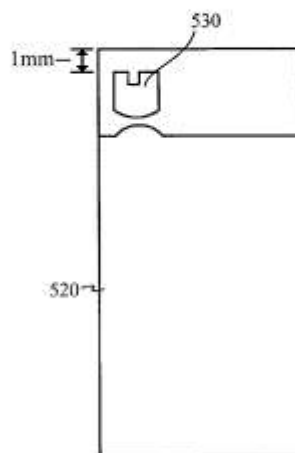
Primary Examiner—Hoang V Nguyen

(74) *Attorney, Agent, or Firm*—Jae Hee Choi; Ramin Mobarhan

(57) **ABSTRACT**

A system, apparatus and method for a diverse spectrum antenna is disclosed. The diverse spectrum antenna may comprise a circuit board having a ground plane and a chip antenna including a notch, wherein the chip antenna is mounted on the circuit board at a selected distance from the ground plane.

27 Claims, 6 Drawing Sheets





US007872612B2

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

(10) **Patent No.:** **US 7,872,612 B2**
(45) **Date of Patent:** **Jan. 18, 2011**

(54) **ANTENNA APPARATUS UTILIZING APERTURE OF TRANSMISSION LINE**

(75) Inventors: **Kanji Otsuka**, 2-1074-38, Kohan, Higashiyamato-shi, Tokyo 207-0002 (JP); **Tamotsu Usami**, 2-38-4, Nishi-machi, Kokubunji-shi, Tokyo 185-0035 (JP); **Yutaka Akiyama**, 120-12, Katakura-machi, Hachioji-shi, Tokyo 192-0914 (JP); **Chihiro Ueda**, 2-6-8, Higashi-ikou, Adachi-ku, Tokyo 121-0801 (JP)

(73) Assignees: **Kanji Otsuka**, Tokyo (JP); **Tamotsu Usami**, Tokyo (JP); **Yutaka Akiyama**, Tokyo (JP); **Renesas Electronics Corporation**, Tokyo (JP); **Kabushiki Kaisha Toshiba**, Tokyo (JP); **Fujitsu Microelectronics Limited**, Tokyo (JP); **Fuji Xerox Co., Ltd.**, Tokyo (JP); **Ibiden Co., Ltd.**, Gifu (JP); **Kyocera Corporation**, Kyoto (JP); **Chihiro Ueda**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 32 days.

(21) Appl. No.: **12/155,247**

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

(65) **Prior Publication Data**
US 2008/0316136 A1 Dec. 25, 2008

(30) **Foreign Application Priority Data**
May 30, 2007 (JP) 2007-143565

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

(52) **U.S. Cl.** **343/807; 343/772**

(58) **Field of Classification Search** **343/850, 343/767, 786, 777, 807**

See application file for complete search history.

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Primary Examiner—Jacob Y Choi

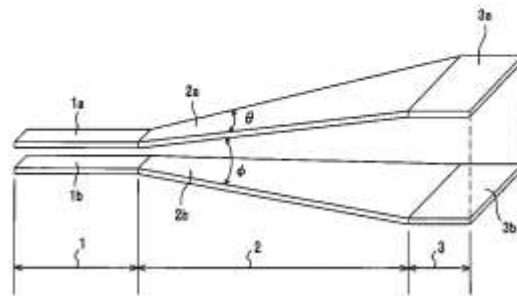
Assistant Examiner—Kyana R Robinson

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

(57) **ABSTRACT**

An antenna apparatus utilizing an aperture of transmission line, which is connected to a first transmission line having a predetermined characteristic impedance, includes a tapered line portion, and an aperture portion. The tapered line portion is connected to one end of the transmission line, and the tapered line portion includes a second transmission line including a pair of line conductors. The tapered line portion keeps a predetermined characteristic impedance constant and expands at least one of a width of the transmission line and an interval in a tapered shape at a predetermined taper angle. The aperture portion has a radiation aperture connected to one end of the tapered line portion. A size of one side of the aperture end plane of the aperture portion is set to be equal to or higher than a quarter wavelength of the minimum operating frequency of the antenna apparatus.

10 Claims, 28 Drawing Sheets





US007876272B2

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

(10) **Patent No.:** **US 7,876,272 B2**
(45) **Date of Patent:** **Jan. 25, 2011**

(54) **ANTENNA DESIGN FOR AN ATTACHED ACCESSORY**

(75) Inventors: **Weiping Dou**, San Jose, CA (US); **Avi Kopelman**, Sunnyvale, CA (US); **Yomi Matsuoka**, Cupertino, CA (US); **Mark Babella**, Salida, CA (US)

(73) Assignee: **Palm, 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 752 days.

(21) Appl. No.: **11/831,280**

(22) Filed: **Jul. 31, 2007**

(65) **Prior Publication Data**

US 2010/0026589 A1 Feb. 4, 2010

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

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

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

See application file for complete search history.

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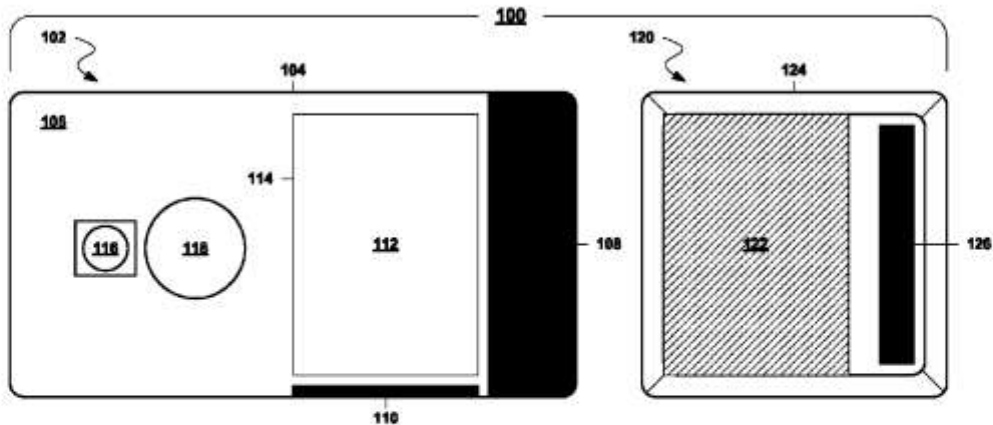
Primary Examiner—HoangAnh T Le

(74) *Attorney, Agent, or Firm*—Kacvinsky Daisak PLLC

(57) **ABSTRACT**

Various embodiments are directed to antenna designs that may improve the performance of a mobile computing device. Some embodiments are directed to a mobile computing device assembly comprising accessory incorporating a supplemental antenna designed to be adjacent to at least one internal antenna of a mobile computing device when the accessory is attached to the mobile computing device. The supplemental antenna and the internal antenna may cooperatively form an antenna system for the mobile computing device resulting in improved performance. In various implementations, the use of the supplemental antenna in conjunction with the internal antenna may enhance antenna performance and/or increase antenna efficiency. Other embodiments are described and claimed.

21 Claims, 3 Drawing Sheets





US007876274B2

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

(10) **Patent No.:** **US 7,876,274 B2**
(45) **Date of Patent:** **Jan. 25, 2011**

(54) **WIRELESS HANDHELD ELECTRONIC DEVICE**
(75) Inventors: **Phillip M. Hobson**, Menlo Park, CA (US); **Stephen P. Zadesky**, Portola Valley, CA (US); **Erik L. Wang**, Redwood City, CA (US); **Tang Yew Tan**, San Francisco, CA (US); **Richard Hung Minh Dinh**, San Jose, CA (US); **Adam D. Mittleman**, San Francisco, CA (US); **Kenneth A. Jenks**, Cupertino, CA (US); **Robert J. Hill**, Salinas, CA (US); **Robert W. Schlub**, Campbell, CA (US)

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Primary Examiner—Michael C Wimer

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

(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 224 days.

(21) Appl. No.: **12/142,552**

(22) Filed: **Jun. 19, 2008**

(65) **Prior Publication Data**
US 2008/0316121 A1 Dec. 25, 2008

Related U.S. Application Data
(60) Provisional application No. 60/936,796, filed on Jun. 21, 2007.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
(52) **U.S. Cl.** **343/702; 343/767; 455/575.7**
(58) **Field of Classification Search** **343/702; 343/741, 846, 905, 906, 767; 455/575.7**
See application file for complete search history.

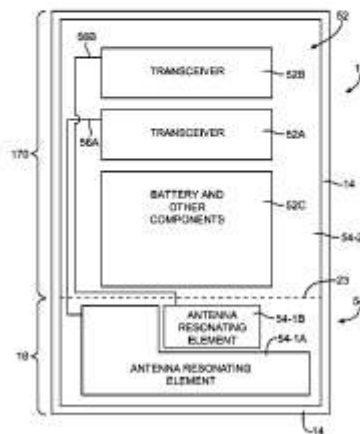
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4,894,663 A 1/1990 Urbish et al.

(57) **ABSTRACT**

A handheld electronic device may be provided that contains a conductive housing and other conductive elements. The conductive 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 components may be isolated from the antenna using isolation elements such as inductors and resistors.

17 Claims, 38 Drawing Sheets





US007876279B2

(12) **United States Patent**
Ma

(10) **Patent No.:** **US 7,876,279 B2**
(45) **Date of Patent:** **Jan. 25, 2011**

(54) **ANTENNA**
(75) Inventor: **Guozhong Ma**, Farnborough (GB)
(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 851 days.

(21) Appl. No.: **11/628,914**
(22) PCT Filed: **Jun. 27, 2005**
(86) PCT No.: **PCT/IB2005/001961**

§ 371 (c)(1),
(2), (4) Date: **Jul. 23, 2007**

(87) PCT Pub. No.: **WO2006/006061**
PCT Pub. Date: **Jan. 19, 2006**

(65) **Prior Publication Data**
US 2008/0042916 A1 Feb. 21, 2008

(30) **Foreign Application Priority Data**
Jun. 30, 2004 (GB) 0414575.1

(51) **Int. Cl.**
H01Q 13/10 (2006.01)
(52) **U.S. Cl.** 343/767
(58) **Field of Classification Search** 343/767,
343/700 MS, 702
See application file for complete search history.

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Primary Examiner—Huedung Mancuso
(74) *Attorney, Agent, or Firm*—Harrington & Smith

(57) **ABSTRACT**

An antenna having a plurality of resonant frequencies and including a feed point; a ground point; and an antenna track extending between the feed point and the ground point and including, in series, a first small loop, a large loop and a second small loop. In one embodiment, the extension of the antenna track through the first U-shaped small loop displaces the antenna track in a first direction, then the extension of the antenna track through the large U-shaped loop displaces the antenna track in a second direction opposite to the first direction and the extension of the antenna track through the second U-shaped small loop displaces the antenna track in the first direction. A bridge element may be used.

23 Claims, 3 Drawing Sheets

