US007898483B2

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

(10) **Patent No.: US 7,898,483 B2**
(45) **Date of Patent: Mar. 1, 2011**

(54) **DIGITAL TV ANTENNA**

(75) Inventors: **Yen-Yu Chen**, Chung Ho (TW); **Yung-Da Lin**, Chung Ho (TW); **Kuo-Ying Su**, Chung Ho (TW)

(73) Assignee: **Avermedia Technology, Inc.**, Chung Ho, 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 375 days.

(21) Appl. No.: **12/254,120**

(22) Filed: **Oct. 20, 2008**

(65) **Prior Publication Data**

US 2010/0026581 A1 Feb. 4, 2010

(30) **Foreign Application Priority Data**

Jul. 31, 2008 (TW) ..... 97129120 A

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

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

(58) **Field of Classification Search** ..... 343/828, 343/848, 770, 786, 711, 772, 791, 792.5, 343/771, 795, 895, 713, 767, 702, 700 MS; 174/2, 33, 36; 333/204, 247, 238; 361/118, 361/302, 816
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,768,400	B2 *	8/2010	Lawrence et al.	340/572.1
2004/0246180	A1	12/2004	Okado	
2007/0046544	A1 *	3/2007	Murofushi et al.	343/700 MS
2008/0143607	A1 *	6/2008	Jung et al.	343/700 MS
2008/0246668	A1 *	10/2008	Qi et al.	343/702
2009/0121943	A1 *	5/2009	Tinsley et al.	343/700 MS

FOREIGN PATENT DOCUMENTS

FR	2888675	1/2007
WO	WO 9930385	6/1999

OTHER PUBLICATIONS

English language translation of abstract of FR 2888675.

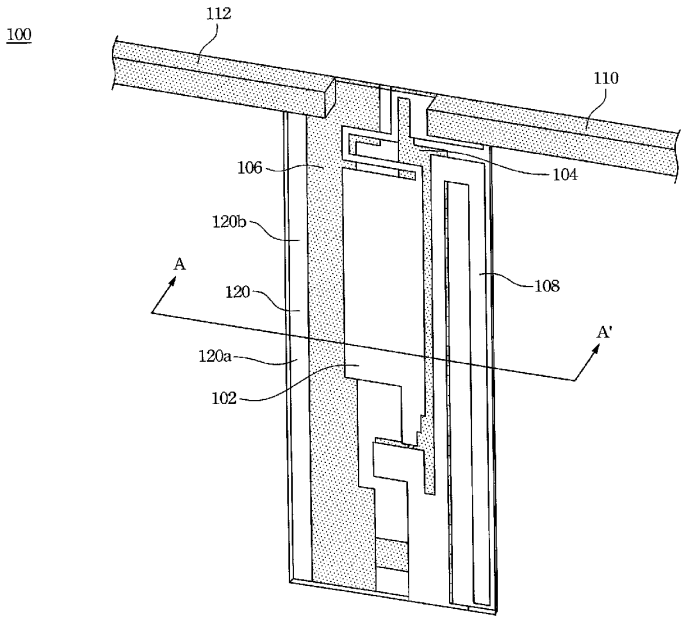
* cited by examiner

Primary Examiner — Douglas W Owens
Assistant Examiner — Jae K Kim
(74) *Attorney, Agent, or Firm* — Thomas, Kayden, Horstemeyer & Risley, LLP

(57) **ABSTRACT**

A digital TV antenna includes a grounding plane, a first radiation conductor, a second radiation conductor and a third radiation conductor. The grounding plane and the first radiation conductor are located in the first surface of a substrate. The second radiation conductor and the third radiation conductor are located in the second surface opposite to the first surface. Partial second radiation conductor covers the first radiation conductor to form an overlapping region. Partial third radiation conductor covers the first radiation conductor to form an overlapping region.

20 Claims, 5 Drawing Sheets



US007898485B2

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

(10) **Patent No.: US 7,898,485 B2**
(45) **Date of Patent: Mar. 1, 2011**

(54) **HANDHELD ELECTRONIC DEVICES WITH ISOLATED ANTENNAS**

(75) Inventors: **Robert W. Schlub**, Campbell, CA (US); **Robert J. Hill**, Salinas, CA (US); **Juan Zavala**, Watsonville, CA (US); **Ruben Caballero**, San Jose, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 21 days.

(21) Appl. No.: **12/504,443**

(22) Filed: **Jul. 16, 2009**

(65) **Prior Publication Data**

US 2009/0278753 A1 Nov. 12, 2009

Related U.S. Application Data

(62) Division of application No. 11/650,071, filed on Jan. 4, 2007, now Pat. No. 7,595,759.

(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, 725, 767, 846

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,947,987	A *	8/1960	Dodington	343/705
4,641,366	A *	2/1987	Yokoyama et al.	455/73
6,384,696	B1	5/2002	Miller et al.	
6,624,789	B1 *	9/2003	Kangasvieri et al.	343/702
6,670,923	B1	12/2003	Kadambi et al.	
6,741,214	B1	5/2004	Kadambi et al.	
6,747,601	B2	6/2004	Boyle	
6,856,294	B2	2/2005	Kadambi et al.	
6,980,154	B2	12/2005	Vance et al.	
7,027,838	B2	4/2006	Zhou et al.	
7,116,276	B2	10/2006	Lee	
7,119,747	B2	10/2006	Lin et al.	
7,202,826	B2 *	4/2007	Grant et al.	343/713
7,289,068	B2 *	10/2007	Fujio et al.	343/700 MS
7,403,164	B2	7/2008	Sanz et al.	
7,535,422	B2 *	5/2009	Liu et al.	343/702
2003/0107518	A1	6/2003	Li et al.	
2003/0119457	A1	6/2003	Standke	
2004/0017318	A1	1/2004	Annabi et al.	
2004/0137950	A1	7/2004	Bolin et al.	

(Continued)

FOREIGN PATENT DOCUMENTS

EP	1 315 238 A	7/2003

(Continued)

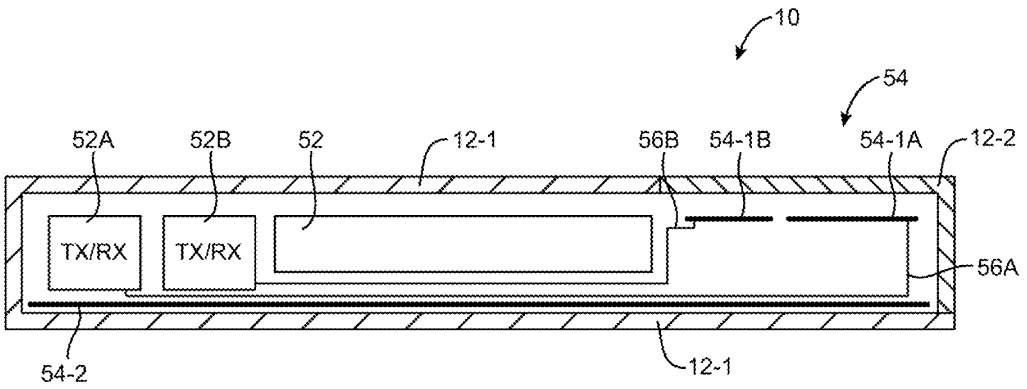
Primary Examiner — Tho G Phan

(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 having at least first and second antennas. An antenna isolation element reduces signal interference between the antennas, so that the antennas may be used in close proximity to each other. A planar ground element may be used as a ground by the first and second antennas. The first antenna may be formed using a hybrid planar-inverted-F and slot arrangement in which a planar resonating element is located above a rectangular slot in the planar ground element. The second antenna may be formed from an L-shaped strip. The planar resonating element of the first antenna may have first and second arms. The first arm may resonate at a common frequency with the second antenna and may serve as the isolation element. The second arm may resonate at approximately the same frequency as the slot portion of the hybrid antenna.

10 Claims, 12 Drawing Sheets



US007898488B2

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

(10) **Patent No.: US 7,898,488 B2**
(45) **Date of Patent: Mar. 1, 2011**

(54) **ANTENNA APPARATUS**

(75) Inventors: **Nobuyasu Takemura**, Tokyo (JP); **Masataka Ohtsuka**, Tokyo (JP)

(73) Assignee: **Mitsubishi Electric Corporation**, Tokyo (JP)

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

(21) Appl. No.: **11/970,636**

(22) Filed: **Jan. 8, 2008**

(65) **Prior Publication Data**

US 2008/0169991 A1 Jul. 17, 2008

(30) **Foreign Application Priority Data**

Jan. 12, 2007 (JP) 2007-004706

(51) **Int. Cl.**
H01Q 11/12 (2006.01)

(52) **U.S. Cl.** **343/741**

(58) **Field of Classification Search** 343/741, 343/742, 702

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,402,134 A * 3/1995 Miller et al. 343/742
6,486,844 B2 * 11/2002 Thursby et al. 343/744
7,286,098 B2 * 10/2007 Ogino et al. 343/833
2002/0024472 A1 * 2/2002 Thursby et al. 343/741
2007/0177414 A1 * 8/2007 Funato et al. 365/36

FOREIGN PATENT DOCUMENTS

JP 09-148838 A 6/1997
JP 2003-008326 A 1/2003

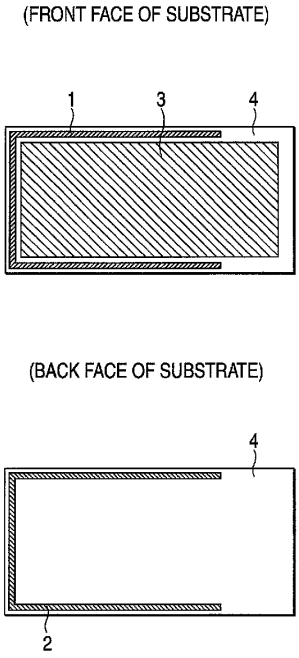
* cited by examiner

Primary Examiner—Huedung Mancuso
(74) *Attorney, Agent, or Firm*—Sughrue Mion, PLLC

(57) **ABSTRACT**

A ground conductor constituting a bottom board and a loop antenna formed of a strip conductor formed separately from and around the ground conductor are provided on one face of a dielectric substrate, and a transmitter-receiver is connected to one end of the loop antenna serving as the power dispatching unit via a first matching circuit, and a second matching circuit is connected to the other end. A conductor formed of the strip conductor is provided on the dielectric substrate on the other face of the dielectric substrate so as to oppose the loop antenna with the intermediary of the dielectric substrate. A third matching circuit is connected to one end of the conductor and a fourth matching circuit is connected to the other end of the conductor. The loop antenna and the conductor are set to have a wavelength shorter than that of the frequency band to be used.

16 Claims, 7 Drawing Sheets



US007898493B1

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

(10) **Patent No.: US 7,898,493 B1**
(45) **Date of Patent: Mar. 1, 2011**

(54) **IMPLEMENTATION OF ULTRA WIDE BAND (UWB) ELECTRICALLY SMALL ANTENNAS BY MEANS OF DISTRIBUTED NON FOSTER LOADING**

(75) Inventors: **Roberto G. Rojas**, Upper Arlington, OH (US); **Bryan D. Raines**, Columbus, OH (US); **Khaled A. Obeidat**, Columbus, OH (US)

(73) Assignee: **The Ohio State University**, Columbus, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 340 days.

(21) Appl. No.: **12/139,424**

(22) Filed: **Jun. 13, 2008**

Related U.S. Application Data

(60) Provisional application No. 60/943,776, filed on Jun. 13, 2007.

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

(52) **U.S. Cl.** **343/850**; 343/860

(58) **Field of Classification Search** 343/850, 343/860

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,716,867	A		2/1973	Mayes et al.
6,121,940	A	*	9/2000	Skahill et al. 343/860
6,509,875	B1		1/2003	Nair et al.
7,123,198	B2		10/2006	Svigelj et al.

OTHER PUBLICATIONS

Best, S.R., The Radiation Properties of Electrically Small Folded Spherical Helix Antennas, IEEE Transactions on Antennas and Propagation, Apr. 2004, pp. 953-960, vol. 52, No. 4.

Di Nallo, C. et al., Wideband Antenna using non-Foster Loading Elements, IEEE, 2007, pp. 4501-4504.

Garbacz, R.J., Modal Expansions for Resonance Scattering Phenomena, Proceedings of the IEEE, Aug. 1965, pp. 856-864.

Hansen, R.C., Wideband Dipole Arrays Using Non-Foster Coupling, Microwave and Optical Technology Letters, Sep. 20, 2003, pp. 453-455, vol. 38, No. 6.

Harrington, R.F. et al., Theory of Characteristic Modes for Conducting Bodies, IEEE Transactions on Antennas and Propagation, Sep. 1971, pp. 622-628, vol. AP-19, No. 5.

Harrington, R.F. et al., Computation of Characteristic Modes for Conducting Bodies, IEEE Transactions on Antennas and Propagation, Sep. 1971, pp. 629-639, vol. AP-19, No. 5.

Harrington, R.F. et al., Control of Radar Scattering by Reactive Loading, IEEE Transactions on Antennas and Propagation, Jul. 1972, pp. 446-454, vol. AP-20, No. 4.

Harrington, R.F. et al., Pattern Synthesis for Loaded N-Port Scatterers, IEEE Transactions on Antennas and Propagation, Mar. 1974, pp. 184-190, vol. AP-22, No. 2.

Mautz, J.R. et al., Modal Analysis of Loaded N-Port Scatterers, IEEE Transactions on Antennas and Propagation, Mar. 1973, pp. 188-199, vol. AP-21, No. 2.

(Continued)

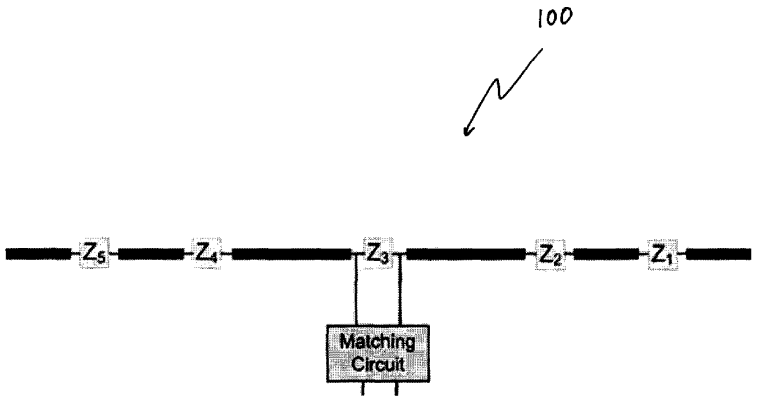
Primary Examiner — Hoang V Nguyen

(74) *Attorney, Agent, or Firm* — Standley Law Group LLP

(57) **ABSTRACT**

A method to design antennas with broadband characteristics. In an exemplary embodiment, a method comprises loading an antenna structure with multiple reactive loads. The multiple loads are synthesized by applying the theory of Characteristic Modes. Another exemplary embodiment includes an antenna adapted to have broadband characteristics. One example is a wire dipole antenna. In an exemplary embodiment, a loaded antenna may be adapted to resonate an arbitrary current over a wide frequency band. The loads may require non-Foster elements when realized. Exemplary embodiments may include the broadband characteristics of the both the input impedance at the terminal of the antenna as well as the radiation pattern.

21 Claims, 22 Drawing Sheets



US007903030B2

(12) **United States Patent**
Nagai

(10) **Patent No.: US 7,903,030 B2**
(45) **Date of Patent: Mar. 8, 2011**

(54) **PLANAR ANTENNA DEVICE AND RADIO COMMUNICATION DEVICE USING THE SAME**

(75) Inventor: **Shuichi Nagai**, Kyoto (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 409 days.

(21) Appl. No.: **11/916,547**

(22) PCT Filed: **Apr. 12, 2006**

(86) PCT No.: **PCT/JP2006/307723**
§ 371 (c)(1),
(2), (4) Date: **Dec. 5, 2007**

(87) PCT Pub. No.: **WO2006/132032**
PCT Pub. Date: **Dec. 14, 2006**

(65) **Prior Publication Data**

US 2009/0256777 A1 Oct. 15, 2009

(30) **Foreign Application Priority Data**

Jun. 6, 2005 (JP) 2005-166091

(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, 343/702, 846, 848
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,040,060	A *	8/1977	Kaloi	343/700 MS
4,074,270	A *	2/1978	Kaloi	343/700 MS
4,157,548	A *	6/1979	Kaloi	343/700 MS
4,291,312	A *	9/1981	Kaloi	343/700 MS
4,356,492	A *	10/1982	Kaloi	343/700 MS
6,005,522	A *	12/1999	Arias et al.	343/700 MS
6,466,172	B1 *	10/2002	Ryken et al.	343/700 MS
6,943,651	B2	9/2005	Mukaiyama et al.	
2006/0140156	A1	6/2006	Hayashi et al.	
2006/0251122	A1	11/2006	Abe et al.	

(Continued)

FOREIGN PATENT DOCUMENTS

JP	11-266118	9/1999
JP	2001-203529	7/2001

(Continued)

OTHER PUBLICATIONS

English language Abstract of JP 2004-56498.

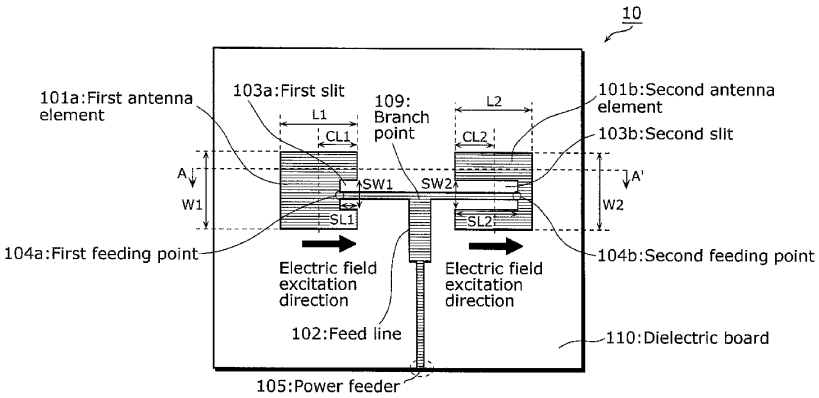
(Continued)

Primary Examiner — HoangAnh T Le
(74) *Attorney, Agent, or Firm* — Greenblum & Bernstein P.L.C.

(57) **ABSTRACT**

Provided a practical planar antenna device which has antenna elements facing each other, in which electrical power is fed between the antenna elements. The first feeding point is provided near an end of the first antenna element, which faces the opposite antenna element. The second feeding point is provided near an outer end of the second antenna element, by providing a second slit longer than the distance from the end of the second antenna element to its center. Since the feeding points are provided at the same level, the same electric field is excited in the two antenna elements in phase. The planar antenna device, to which electrical power is fed from the facing sides of the pair of opposite antenna elements, saves a bend conventionally required in a feed line, thereby allowing a wiring area to be smaller than in the conventional method.

6 Claims, 9 Drawing Sheets



US007903031B2

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

(10) **Patent No.: US 7,903,031 B2**
(45) **Date of Patent: Mar. 8, 2011**

(54) **ANTENNA APPARATUS**

(75) Inventors: **Masahiro Yanagi**, Shinagawa (JP); **Shigemi Kurashima**, Shinagawa (JP); **Hideki Iwata**, Shinagawa (JP); **Takashi Yuba**, Shinagawa (JP); **Masahiro Kaneko**, Shinagawa (JP); **Yuriko Segawa**, Shinagawa (JP); **Takashi Arita**, Shinagawa (JP); **Toshihiro Kusagaya**, Shinagawa (JP); **Kazuhiko Ikeda**, Iiyama (JP); **Hiroshi Matsumiya**, Iiyama (JP); **Kazuo Nomura**, Iiyama (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 0 days.

(21) Appl. No.: **12/662,691**

(22) Filed: **Apr. 28, 2010**

(65) **Prior Publication Data**

US 2010/0212142 A1 Aug. 26, 2010

Related U.S. Application Data

(62) Division of application No. 11/581,376, filed on Oct. 17, 2006, now Pat. No. 7,737,908.

(30) **Foreign Application Priority Data**

Mar. 30, 2006 (JP) 2006-094429
Sep. 6, 2006 (JP) 2006-242016

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

(52) **U.S. Cl.** ..... **343/700 MS**; 343/846; 343/873; 343/906

(58) **Field of Classification Search** ..... 343/700 MS, 343/830, 846, 873, 906
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,971,032	A *	7/1976	Munson et al.	343/770
4,170,013	A	10/1979	Black	343/700 MS
4,661,821	A	4/1987	Smith	343/743
4,700,194	A	10/1987	Ogawa et al.	343/700 MS
5,245,745	A *	9/1993	Jensen et al.	29/600
5,600,340	A *	2/1997	Ho et al.	343/846
5,913,174	A	6/1999	Casarez et al.	455/557
6,037,912	A	3/2000	DeMarre	343/815
6,313,798	B1	11/2001	Bancroft et al.	343/700 MS
7,199,758	B2 *	4/2007	Ikeda et al.	343/700 MS
2005/0285805	A1	12/2005	Ikeda et al.	343/713
2008/0055183	A1	3/2008	Yuba et al.	343/872

FOREIGN PATENT DOCUMENTS

JP	4-15186	1/1992
JP	2000-196327	7/2000
JP	2002-280822	9/2002
JP	2003-152429	5/2003

(Continued)

OTHER PUBLICATIONS

Takuya Taniguchi et al., "An Omnidirectional and Low-VSWR Antenna for the FCC-Approved UWB Frequency Band", *The Institute of Electronics, Information and Communication Engineers,* B-1-133, 2003.

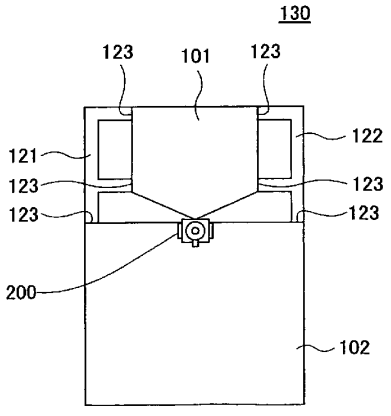
(Continued)

Primary Examiner — Tho G Phan
(74) *Attorney, Agent, or Firm* — Staas & Halsey LLP

(57) **ABSTRACT**

A disclosed antenna apparatus includes: a punched out antenna element made of a sheet metal; a punched out ground element made of a sheet metal, the ground element facing the antenna element; and a surface mount type coaxial connector mounted across the antenna element and the ground element.

2 Claims, 27 Drawing Sheets



US007903032B2

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

(10) **Patent No.: US 7,903,032 B2**
(45) **Date of Patent: *Mar. 8, 2011**

(54) **ANTENNA FOR A COMMUNICATION TERMINAL**

(75) Inventors: **Zhinong Ying**, Lund (SE); **Johan Andersson**, Malmö (SE)

(73) Assignee: **Sony Ericsson Mobile Communications AB**, Lund (SE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 924 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **11/740,310**

(22) Filed: **Apr. 26, 2007**

(65) **Prior Publication Data**

US 2008/0246690 A1 Oct. 9, 2008

Related U.S. Application Data

(60) Provisional application No. 60/910,252, filed on Apr. 5, 2007.

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

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

(58) **Field of Classification Search** ..... 343/700 MS, 343/702, 895, 846

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,750,821	B2 *	6/2004	Fang et al.	343/700 MS
7,639,188	B2 *	12/2009	Ying et al.	343/702
7,649,501	B2 *	1/2010	Wong et al.	343/702
2003/0058176	A1	3/2003	Keilen et al.	
2003/0214444	A1	11/2003	Asai et al.	
2004/0125030	A1	7/2004	Sung et al.	
2006/0214856	A1	9/2006	Nakano	

FOREIGN PATENT DOCUMENTS

DE	103 47 722	7/2004

OTHER PUBLICATIONS

International Search Report for corresponding Application No. PCT/EP2007/060431 mailed Jan. 21, 2008.

* cited by examiner

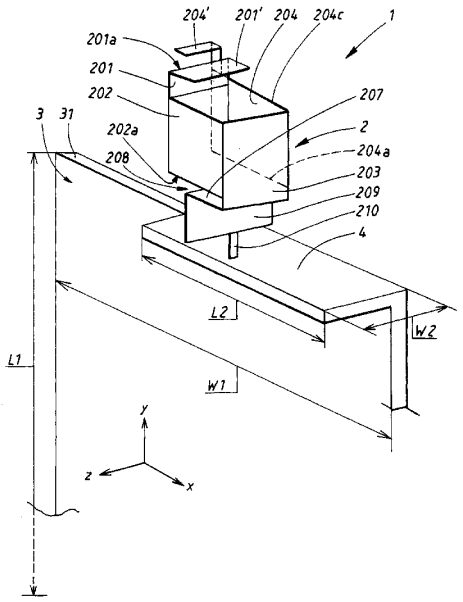
Primary Examiner — Tan Ho

(74) *Attorney, Agent, or Firm* — Renner, Otto, Boisselle & Sklar, LLP

(57) **ABSTRACT**

A radio antenna device for a radio communication terminal, e.g. a mobile telephone, comprising a flat ground plane and an antenna element having a radio signal feeding point disposed at the ground plane. The antenna element has a folded three dimensional box-like shape. The inventive antenna design provides for an antenna device with compact size, which at the same time is operable in UWB (Ultra Wideband) frequency regions. The antenna device may therefore advantageously be incorporated into a portable communication terminal such as a mobile telephone.

18 Claims, 6 Drawing Sheets



US007903033B2

(12) **United States Patent**
Bellows

(10) **Patent No.: US 7,903,033 B2**
(45) **Date of Patent: Mar. 8, 2011**

(54) **ANTENNAS INCORPORATED IN A FITTED ACCESSORY OF A MOBILE UNIT**

(75) Inventor: **David Bellows**, Wantagh, NY (US)

(73) Assignee: **Symbol Technolgies, Inc.**, Holtsville, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 473 days.

(21) Appl. No.: **11/872,388**

(22) Filed: **Oct. 15, 2007**

(65) **Prior Publication Data**

US 2009/0096680 A1 Apr. 16, 2009

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

(52) **U.S. Cl.** **343/702**; 343/797

(58) **Field of Classification Search** ..... 343/702, 343/700 MS, 795, 797, 770, 867
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,870,279	A *	2/1999	Mahany et al.	361/679.01
6,025,802	A *	2/2000	Eggleston et al.	343/700 MS
6,563,042	B2 *	5/2003	Barabash	174/359
6,897,373	B2 *	5/2005	Barabash	174/377
2007/0182634	A1 *	8/2007	Yamamoto et al.	343/700 MS
2007/0285320	A1 *	12/2007	Hayes et al.	343/702
2008/0122705	A1 *	5/2008	Kurashima et al.	343/702
2009/0066587	A1 *	3/2009	Hayes et al.	343/702

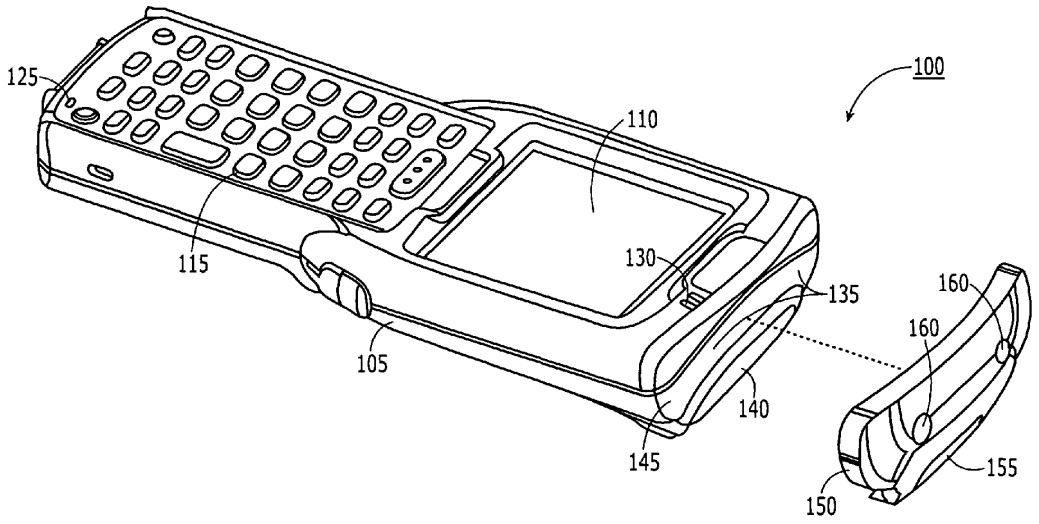
* cited by examiner

Primary Examiner — HoangAnh T Le

(57) **ABSTRACT**

A fitted accessory comprises two antennas incorporated within the fitted accessory. The fitted accessory also comprises an electrical contact coupling to a corresponding electrical contact disposed on the housing so that an electrical connection is established between the components of the fitted accessory and components in the housing. The fitted accessory couples to the housing.

10 Claims, 4 Drawing Sheets



US007903034B2

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

(10) **Patent No.: US 7,903,034 B2**
(45) **Date of Patent: Mar. 8, 2011**

(54) **ANTENNA SET, PORTABLE WIRELESS DEVICE, AND USE OF A CONDUCTIVE ELEMENT FOR TUNING THE GROUND-PLANE OF THE ANTENNA SET**

(75) Inventors: **Jaume Anguera**, Vinaros (ES); **Antonio Condes**, Sta. Coloma de Cervelló (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 286 days.

(21) Appl. No.: **12/066,897**

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

(86) PCT No.: **PCT/EP2006/009019**

§ 371 (c)(1),
(2), (4) Date: **Apr. 22, 2008**

(87) PCT Pub. No.: **WO2007/039071**

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

(65) **Prior Publication Data**

US 2008/0252536 A1 Oct. 16, 2008

Related U.S. Application Data

(60) Provisional application No. 60/718,537, filed on Sep. 19, 2005.

(30) **Foreign Application Priority Data**

Sep. 19, 2005 (EP) 05108616

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

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

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,571,595	A	2/1986	Phillips et al.
6,039,583	A	3/2000	Korsunsky et al.
6,340,952	B1	1/2002	Tsai et al.
6,466,176	B1	10/2002	Maoz et al.
6,480,155	B1	11/2002	Eggleston
6,639,560	B1	10/2003	Kadambi et al.
6,717,494	B2	4/2004	Kikuchi et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CA	2416437	A1	1/2002

(Continued)

OTHER PUBLICATIONS

Lindberg, P, ; Öjefors, E., A bandwidth enhancement technique for mobile handset antennas using wavetraps, IEEE Transactions on antennas and propagation, vol. 54, No. 8, Aug. 2006.

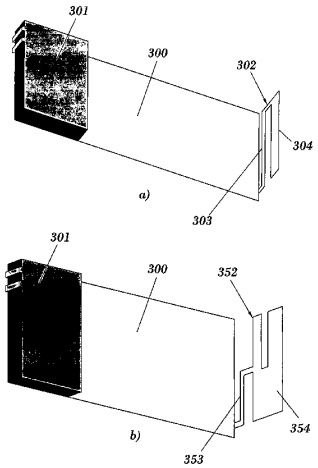
(Continued)

Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — Winstead PC

(57) **ABSTRACT**

An antenna set comprising at least one antenna element and a ground plane, is complemented by a conductive element coupled to the ground plane, so as to modify the frequency performance of the antenna set, adding an operating band to the antenna set, and/or increasing the bandwidth of one operating band of the antenna set, and/or enhancing voltage standing wave ration, efficiency and/or gain of the antenna set. Thus, the conductive element can be used to tune the antenna set in accordance with specific requirements concerning, for example, compatibility with different wireless services.

42 Claims, 17 Drawing Sheets



US007903035B2

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

(10) **Patent No.: US 7,903,035 B2**
(45) **Date of Patent: Mar. 8, 2011**

(54) **INTERNAL ANTENNA AND METHODS**

(75) Inventors: **Jyrki Mikkola**, Evijärvi (FI); **Ari Raappana**, Kello (FI); **Pasi Keskitalo**, Oulu (FI); **Pertti Nissinen**, Kempele (FI)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 68 days.

(21) Appl. No.: **12/082,514**

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

(65) **Prior Publication Data**

US 2009/0140942 A1 Jun. 4, 2009

Related U.S. Application Data

(63) Continuation of application No. PCT/FI2006/050407, filed on Sep. 25, 2006.

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

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

(58) **Field of Classification Search** ..... 343/702, 343/845, 846, 825, 829, 700 MS
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,069,483	A	1/1978	Kaloi	
5,278,528	A	1/1994	Turunen	
5,382,959	A	1/1995	Pett et al.	
5,432,489	A	7/1995	Yrjola	
5,557,292	A	9/1996	Nygren et al.	
5,764,190	A	6/1998	Murch et al.	
5,892,490	A	4/1999	Asakura et al.	
5,905,475	A	5/1999	Annamaa	
6,016,130	A	1/2000	Annamaa	
6,097,345	A	8/2000	Walton	
6,133,879	A	10/2000	Grangeat et al.	
6,140,973	A	10/2000	Annamaa	
6,147,650	A	11/2000	Kawahata et al.	
6,177,908	B1	1/2001	Kawahata	
6,185,434	B1	2/2001	Hagstrom	
6,195,049	B1	2/2001	Kim et al.	
6,246,368	B1	6/2001	Deming et al.	
6,252,554	B1	6/2001	Isohatala	
6,268,831	B1 *	7/2001	Sanford	343/702
6,323,811	B1	11/2001	Tsubaki	

(Continued)

FOREIGN PATENT DOCUMENTS

DE 101 50 149 A1 4/2003

(Continued)

OTHER PUBLICATIONS

U.S. Appl. No. 11/883,945, filed Jun. 23, 2008, Ari Raappana.

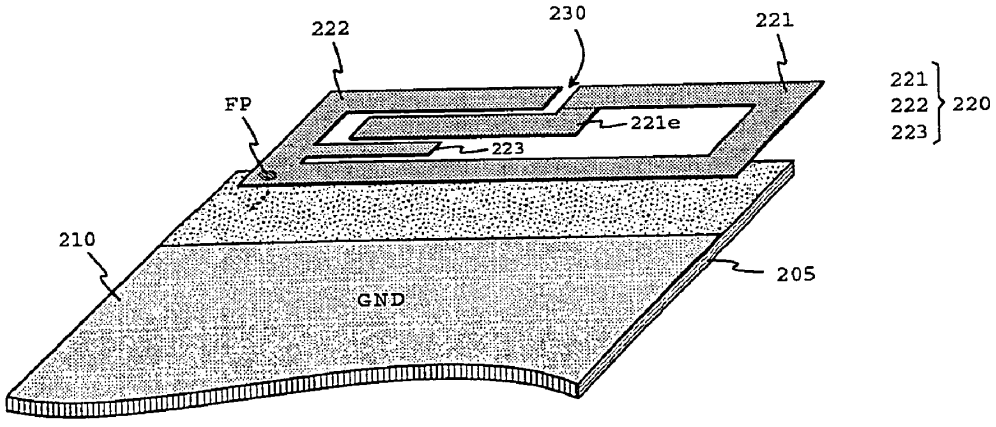
(Continued)

Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — Gazdzinski & Associates, PC

(57) **ABSTRACT**

An internal antenna especially aimed at flat radio devices. The antenna (**200**) comprises a planar radiator (**220**) with a branch (**221**) for forming a lower operating band for the antenna and a second branch (**222**) for forming an upper operating band. The branches typically form a frame-like pattern. There remains a slot (**230**) between the branches, opening to the outer edge of the radiator approximately in the middle of the edge running in the direction of the end of the circuit board (**205**) and being outside the circuit board as seen from above. The omnidirectional radiation of the antenna on its upper operating band improves as compared to the corresponding, known antennas, and its efficiency improves, because the average antenna gain increases.

53 Claims, 4 Drawing Sheets



US007903036B2

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

(10) **Patent No.: US 7,903,036 B2**
(45) **Date of Patent: Mar. 8, 2011**

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

(75) Inventors: **Yasunori Takaki**, Saitama (JP); **Toshiyuki Wada**, Saitama (JP); **Hiroyuki Aoyama**, Saitama (JP)

(73) Assignee: **Hitachi Metals, 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 212 days.

(21) Appl. No.: **12/227,849**

(22) PCT Filed: **May 30, 2007**

(86) PCT No.: **PCT/JP2007/000579**

§ 371 (c)(1),
(2), (4) Date: **Feb. 3, 2009**

(87) PCT Pub. No.: **WO2007/141910**

PCT Pub. Date: **Dec. 13, 2007**

(65) **Prior Publication Data**

US 2009/0167614 A1 Jul. 2, 2009

(30) **Foreign Application Priority Data**

May 31, 2006 (JP) 2006-152670

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 11/12 (2006.01)

(52) **U.S. Cl.** ..... **343/702**; 343/741; 343/700 MS

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,880,697	A *	3/1999	McCarrick et al.	343/742
6,239,753	B1 *	5/2001	Kado et al.	343/702
6,680,708	B2 *	1/2004	Yamaki	343/741
7,034,754	B2 *	4/2006	Hung et al.	343/700 MS
7,342,540	B2 *	3/2008	Nahar et al.	343/702
7,671,808	B2 *	3/2010	Boyle	343/702
2005/0068234	A1 *	3/2005	Hung et al.	343/702
2005/0128151	A1 *	6/2005	Kwak et al.	343/702
2006/0017629	A1 *	1/2006	Ko et al.	343/702
2006/0197705	A1 *	9/2006	Chen et al.	343/700 MS
2007/0164904	A1 *	7/2007	Nahar et al.	343/700 MS

FOREIGN PATENT DOCUMENTS

WO 2007/141910 12/2007

* cited by examiner

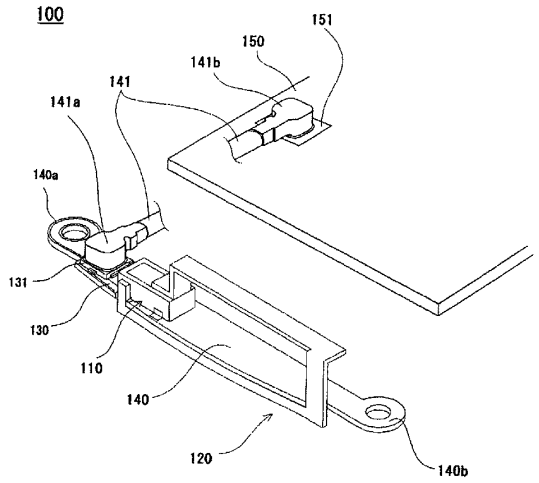
Primary Examiner — Trinh V Dinh
(74) *Attorney, Agent, or Firm* — McGinn IP Law Group, PLLC

(57) **ABSTRACT**

To realize an antenna device that can operate in wide bands (in a plurality of frequency bands) and can achieve an excellent antenna gain and maintain non-directivity of vertically polarized waves in each band in a space-saving manner, and also to provide a technique capable of maintaining mechanical reliability of the antenna device.

An antenna device including; an approximately U-shaped conductor antenna, on one end side of which a power feeding portion is provided and on the other end side of which an end portion is provided as an open end terminal, and which has a folded-back portion; a base body made of an insulating material; a substrate on which said conductor antenna and said base body are mounted; conductor planes of said one end side and said the other end side of said conductor antenna constituted to be approximately perpendicular to each other; said base body being fixed on said substrate; at least said one end side of said conductor antenna being fixed on said base body; and said folded-back portion being fixed on said substrate.

20 Claims, 19 Drawing Sheets



US007903037B2

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

(10) **Patent No.: US 7,903,037 B2**
(45) **Date of Patent: *Mar. 8, 2011**

(54) **MULTIBAND ANTENNA FOR HANDHELD TERMINAL**

(75) Inventors: **David Gala Gala**, Barcelona (ES); **Carles Puente Baliarda**, Barcelona (ES); **Jordi Soler Castany**, Mataro (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 62 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/316,460**

(22) Filed: **Dec. 12, 2008**

(65) **Prior Publication Data**

US 2010/0149064 A1 Jun. 17, 2010

Related U.S. Application Data

(63) Continuation of application No. 11/021,597, filed on Dec. 23, 2004, now Pat. No. 7,486,242, which is a continuation of application No. PCT/EP02/07002, filed on Jun. 25, 2002.

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

(52) **U.S. Cl.** **343/702**; 343/843; 343/846

(58) **Field of Classification Search** ..... 343/700 MS, 343/702, 846, 895, 825, 826, 828, 829, 843; 455/575.7

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,608,572	A	8/1986	Blakney et al.
4,907,006	A	3/1990	Nishikawa
5,262,792	A	11/1993	Egashira
5,497,167	A	3/1996	Luoma
5,646,637	A	7/1997	Miller
5,703,600	A	12/1997	Burrell
5,903,239	A	5/1999	Takahashi
5,903,822	A	5/1999	Sekine et al.
6,002,367	A	12/1999	Engblom et al.
6,104,349	A	8/2000	Cohen
6,140,975	A	10/2000	Cohen
6,218,992	B1	4/2001	Sadler
6,239,765	B1	5/2001	Johnson et al.
6,285,326	B1	9/2001	Diximus

(Continued)

FOREIGN PATENT DOCUMENTS

CA	2416437	A1	1/2002

(Continued)

OTHER PUBLICATIONS

X. H. Yang et al., "Multifrequency Operation Technique for Aperture Coupled Microstrip Antennae", IEEE, 1994, pp. 1198-1201.

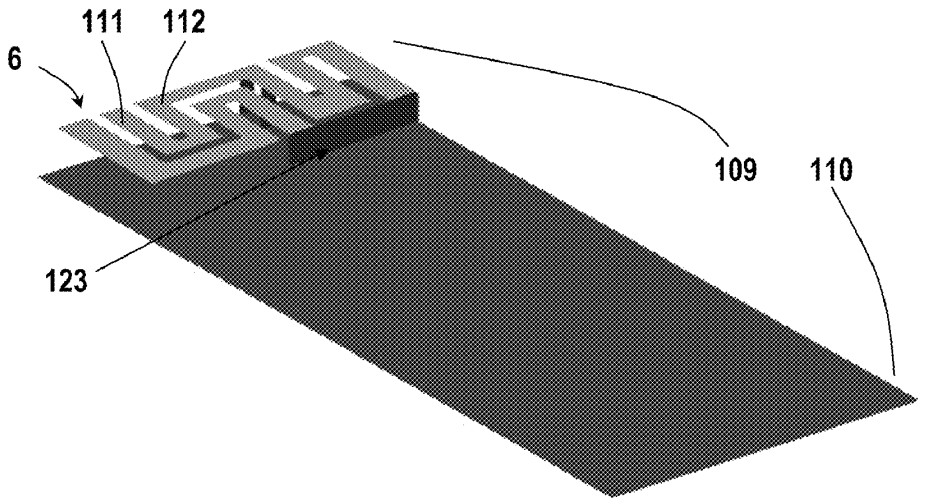
(Continued)

Primary Examiner — Michael C Wimer
(74) *Attorney, Agent, or Firm* — Winstead PC

(57) **ABSTRACT**

A multiband antenna includes a first conducting layer and a second conducting layer. The first conducting layer acts as a radiating element being placed over the second conducting layer while the second conducting layer acts as a ground plane. The first conducting layer includes a feeding point, the feeding point being a starting point for a first shorter arm and a second longer arm, the first and second arms forming a multilevel structure for the multiband antenna.

44 Claims, 11 Drawing Sheets



US007903039B2

(12) **United States Patent**
Yu

(10) **Patent No.: US 7,903,039 B2**
(45) **Date of Patent: Mar. 8, 2011**

(54) **BROADBAND MULTI-LOOP ANTENNA FOR MOBILE COMMUNICATION DEVICE**

(75) Inventor: **Wei Yu**, Shenzhen (CN)

(73) Assignee: **Shenzhen Sunway Communication Co., Ltd.**, Shenzhen (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 253 days.

(21) Appl. No.: **11/721,336**

(22) PCT Filed: **Feb. 5, 2005**

(86) PCT No.: **PCT/CN2005/000163**

§ 371 (c)(1),
(2), (4) Date: **Apr. 28, 2009**

(87) PCT Pub. No.: **WO2006/081704**

PCT Pub. Date: **Aug. 10, 2006**

(65) **Prior Publication Data**

US 2010/0134366 A1 Jun. 3, 2010

(51) **Int. Cl.**
H01Q 11/12 (2006.01)

(52) **U.S. Cl.** **343/742**; 343/702; 343/867

(58) **Field of Classification Search** ..... 343/700 MS, 343/702, 742, 867
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,166,694	A *	12/2000	Ying	343/702
6,552,686	B2 *	4/2003	Ollikainen et al.	343/700 MS
7,102,575	B2 *	9/2006	Pan	343/702
7,768,468	B2 *	8/2010	Gustafson et al.	343/750
2010/0085268	A1 *	4/2010	Yeh et al.	343/803

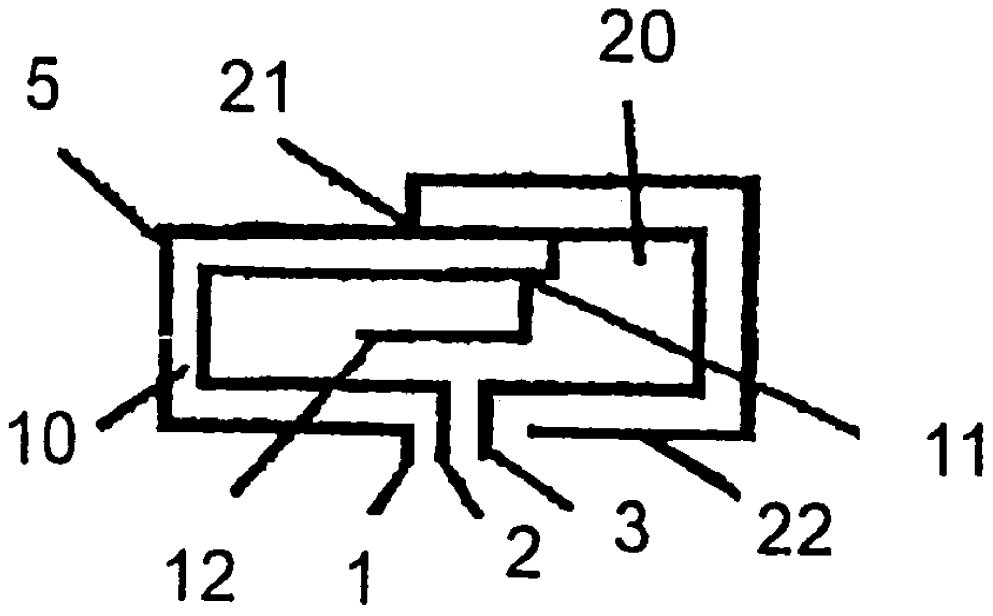
* cited by examiner

Primary Examiner — Tan Ho

(57) **ABSTRACT**

A broadband multi-signal loop antenna in a mobile communication device such as a cellular phone having a chassis is disclosed. The antenna includes a conductor assembly electrically connected to the chassis and including a plurality of loops each starting at a common feed point and ending at respective grounding point; and a member for mounting the conductor assembly thereon. The loop has a grounding point. The ground points are located at different physical positions. The antenna is adapted to operate at multi-band.

14 Claims, 8 Drawing Sheets



US007904126B2

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

(10) **Patent No.: US 7,904,126 B2**
(45) **Date of Patent: Mar. 8, 2011**

(54) **ANTENNA APPLIED TO SLIDE TYPE MOBILE COMMUNICATION TERMINAL**

(75) Inventors: **Yong-jin Kim**, Seoul (KR); **Do-hoon Kwon**, Seoul (KR); **Young-eil Kim**, Suwon-si (KR); **Ji-hun Koo**, Yongin-si (KR); **Ick-jae Yoon**, Seoul (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1155 days.

(21) Appl. No.: **11/486,280**

(22) Filed: **Jul. 14, 2006**

(65) **Prior Publication Data**

US 2007/0126644 A1 Jun. 7, 2007

(30) **Foreign Application Priority Data**

Dec. 5, 2005 (KR) 10-2005-0117554

(51) **Int. Cl.**
H04M 1/00 (2006.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.** **455/575.4**; 343/702

(58) **Field of Classification Search** 455/575.4, 455/575.5, 41.1, 575.3, 575.1, 550.1; 343/702, 343/700, 729, 795, 725, 102, 821, 793, 797, 343/799, 830

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,966,099	A	10/1999	Xue	
6,097,342	A *	8/2000	Engblom	343/702
6,209,173	B1 *	4/2001	Salter et al.	16/342
6,246,374	B1	6/2001	Perrotta et al.	
6,256,481	B1 *	7/2001	Jeong et al.	455/575.3
6,539,208	B1 *	3/2003	Mori	455/575.3
6,751,488	B2 *	6/2004	Lee	455/575.3
6,981,296	B2 *	1/2006	Lee et al.	16/330
7,102,881	B2 *	9/2006	Park et al.	361/679.08
7,225,000	B2 *	5/2007	Katayanagi	455/567
7,239,289	B2 *	7/2007	Kim	343/860
7,286,089	B2 *	10/2007	Lee et al.	343/702
7,539,512	B2 *	5/2009	Iida	455/550.1
7,580,734	B2 *	8/2009	Ahn et al.	455/575.1
7,786,975	B2 *	8/2010	Ording et al.	345/156
2001/0016474	A1 *	8/2001	Nagashima	455/90
2001/0044320	A1 *	11/2001	Ono et al.	455/550
2002/0080074	A1 *	6/2002	Wang	343/700 MS
2002/0137476	A1 *	9/2002	Shin	455/90
2002/0187818	A1 *	12/2002	Kang	455/575
2003/0008677	A1 *	1/2003	Kim et al.	455/550
2003/0064688	A1 *	4/2003	Mizuta et al.	455/90
2003/0087609	A1 *	5/2003	Cheng	455/90
2003/0114198	A1 *	6/2003	Han	455/566

(Continued)

FOREIGN PATENT DOCUMENTS

DE 20120405 U 4/2002

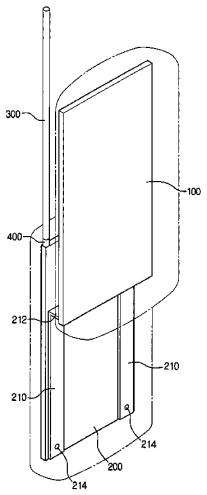
(Continued)

Primary Examiner — Melody Mehrpour
(74) *Attorney, Agent, or Firm* — Sughrue Mion, PLLC

(57) **ABSTRACT**

An antenna applied to a slide type mobile communication terminal includes a first board mounted in a first body; a second board mounted in a second body; a radiating element mounted to the second body; and a first contact formed to connect to the second board at one end and contact with the first board at the other end when the first body slides. Accordingly, an antenna with directionality can be realized for applications to short range communication systems.

10 Claims, 6 Drawing Sheets



US007907092B2

(12) **United States Patent**
Soler Castany et al.

(10) **Patent No.: US 7,907,092 B2**
(45) **Date of Patent: *Mar. 15, 2011**

(54) **ANTENNA WITH ONE OR MORE HOLES**

(75) Inventors: **Jordi Soler Castany**, Sant Cugat del Valles (ES); **Carles Puente Baliarda**, Sant Cugat del Valles (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 159 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/246,964**

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

(65) **Prior Publication Data**

US 2009/0073067 A1 Mar. 19, 2009

Related U.S. Application Data

(63) Continuation of application No. 11/036,509, filed on Jan. 12, 2005, now Pat. No. 7,471,246, which is a continuation of application No. PCT/EP02/07836, filed on Jul. 15, 2002.

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 13/12 (2006.01)
H01Q 13/10 (2006.01)

(52) **U.S. Cl.** ..... **343/700 MS**; 343/769; 343/770

(58) **Field of Classification Search** ..... 343/700 MS, 343/767, 769, 770, 793, 810
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,210,542 A 5/1993 Pett et al.
5,606,733 A 2/1997 Kanayama
5,872,546 A 2/1999 Ihara et al.
6,097,345 A 8/2000 Walton
6,104,349 A 8/2000 Cohen
6,140,975 A 10/2000 Cohen
6,195,048 B1 2/2001 Chiba et al.
6,278,410 B1 8/2001 Soliman et al.
6,281,846 B1 8/2001 Puente Baliarda et al.
6,366,260 B1 4/2002 Carrender
6,407,710 B2 6/2002 Keilen
6,650,301 B1 11/2003 Zimmerman
6,806,834 B2 10/2004 Yoon

(Continued)

FOREIGN PATENT DOCUMENTS

CA 2416437 A1 1/2002

(Continued)

OTHER PUBLICATIONS

Skrivervik , A. K. et al, PCS antenna design—The challenge of miniaturization, IEEE Antennas and Propagation Magazine, Aug. 2001.

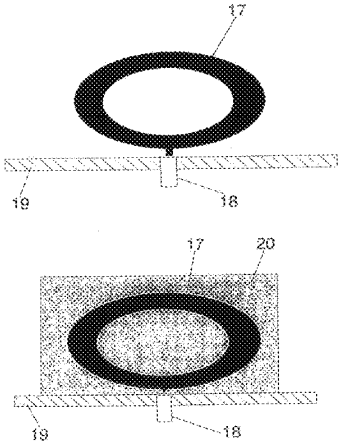
(Continued)

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

(57) **ABSTRACT**

A new type of multihole antenna which is mainly suitable for mobile communications or in general to any other application where the integration of telecom systems or applications in a single antenna is important. The antenna includes a radiating element which at least includes one hole. By means of this configuration, the antenna provides a broadband and multiband performance, and hence it features a similar behaviour through different frequency bands. Also, the antenna features a smaller size with respect to other prior art antennas operating at the same frequency.

42 Claims, 10 Drawing Sheets



US007907099B2

(12) **United States Patent**
Chiang

(10) **Patent No.: US 7,907,099 B2**
(45) **Date of Patent: *Mar. 15, 2011**

(54) **ANTENNA**

(75) Inventor: **Yu-Yu Chiang**, 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.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/649,140**

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

(65) **Prior Publication Data**

US 2010/0103063 A1 Apr. 29, 2010

Related U.S. Application Data

(63) Continuation of application No. 12/172,879, filed on Jul. 14, 2008, now Pat. No. 7,667,662.

(30) **Foreign Application Priority Data**

Jan. 31, 2008 (TW) ..... 97202097 U

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

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

(58) **Field of Classification Search** ..... 343/700 MS, 343/702, 828, 846, 893
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,483,462	B2 *	11/2002	Weinberger	343/700 MS
6,999,037	B2 *	2/2006	Apostolos	343/767
7,667,662	B2 *	2/2010	Chiang	343/846
2007/0103367	A1 *	5/2007	Wang	343/700 MS

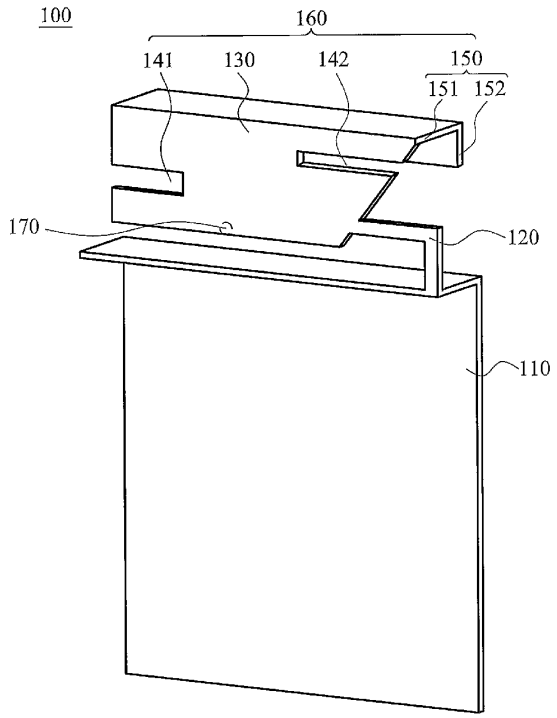
* cited by examiner

Primary Examiner — Michael C Wimer

(57) **ABSTRACT**

An antenna is provided. The antenna has a ground element, a radiator and a conductive element. The radiator has a body, wherein the body has a first edge, a second edge, a third edge and a fourth edge, and the first edge is parallel to the third edge, a length of the first edge is shorter than a length of the third edge, the first edge is close to the ground element, the second edge connects the first edge and the third edge, a fourth edge connects the first edge and the third edge, and a first slot is formed on the radiator. The second edge and the fourth edge extend separately from the first edge to the third edge. The conductive element connects the ground element and the radiator.

18 Claims, 10 Drawing Sheets



US007911014B2

(12) **United States Patent**
Doan

(10) **Patent No.: US 7,911,014 B2**
(45) **Date of Patent: Mar. 22, 2011**

(54) **ON CHIP ANTENNA AND METHOD OF MANUFACTURING THE SAME**

(76) Inventor: **My The Doan**, Calgary (CA)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 226 days.

(21) Appl. No.: **12/241,031**

(22) Filed: **Sep. 29, 2008**

(65) **Prior Publication Data**

US 2009/0085133 A1 Apr. 2, 2009

Related U.S. Application Data

(60) Provisional application No. 60/976,412, filed on Sep. 29, 2007.

(51) **Int. Cl.**
H01L 27/14 (2006.01)

(52) **U.S. Cl.** **257/428**; 257/531; 257/E31.001; 438/59; 438/73; 438/463; 438/676; 438/767

(58) **Field of Classification Search** 257/428, 257/531, E31.001; 438/59, 73, 463, 676, 438/767

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,539,241 A 7/1996 Abidi et al.
2003/0104649 A1 6/2003 Ozgur et al.

OTHER PUBLICATIONS

K. K. O, et al, "The feasibility of on-chip interconnection using antennas," in Proceedings of the IEEE/ACM Computer-Aided Design, pp. 979-984, 2005.

R. N. Simons, et al, "RF telemetry system for an implantable Bio-MEMS sensor," in Proc. IEEE MTT-S, pp. 1433-1436, 2004.

J. N. Burghartz, et al, "Spiral inductors and transmission lines in silicon technology using copper damascene interconnects and low-loss substrates," IEEE Trans. Microw. Theory Tech., vol. 45, No. 10, pp. 1961-1968, 1997.

J. Y.-C. Chang, A. A. Abidi, and M. Gaitan, "Large suspended inductors on silicon and their use in a 2 um CMOS RF amplifier," IEEE Electron Device Lett., vol. 14, No. 5, pp. 246-248, 1993.

M. Ozgur, M. E. Zaghloul, and M. Gaitan, "Optimization of back side micromachined CMOS inductors for RF applications," in Proc. IEEE Int. Symp. Circuits Syst, pp. V-185-188, 2000.

L. H. Guo, et al, "A small OCA on a 1 0.5-mm2 2.45-GHz RFID Tag—design and integration based on a CMOS-compatible manufacturing technology," IEEE Electron Device Lett., vol. 27, pp. 96-98, 2006.

W. G. Yeoh, et al, "A 2.45-GHz RFID tag with on-chip antenna," in IEEE RFIC Symp. Dig., 2006.

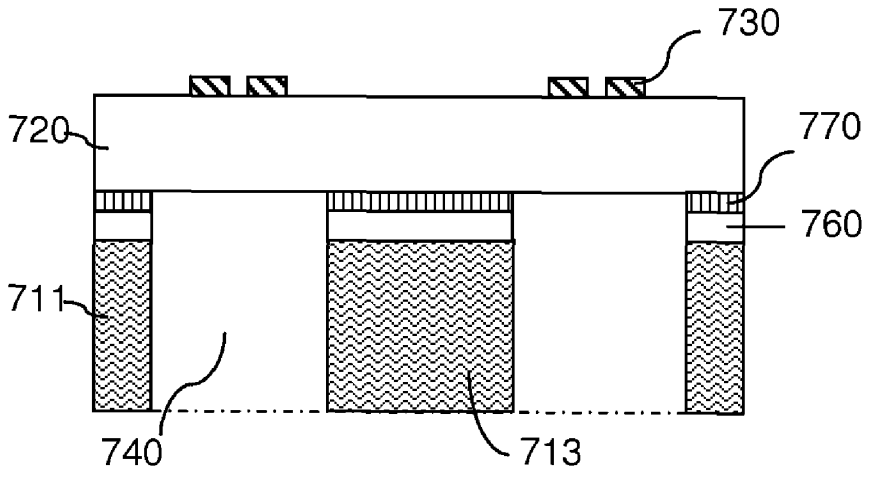
(Continued)

Primary Examiner — Tan N Tran

(57) **ABSTRACT**

An antenna with air-filled trench is integrated with a radio frequency (RF) circuit. The trench locates directly under the metal lines that made up the antenna and is formed by etching from the back side of the semiconductor substrate until all the substrate material in the trench is removed. The air-filled trench greatly reduces the losses due to the semiconductor substrate; therefore the performance of the antenna improves greatly. When the antenna is a large planar spiral inductor, the air-filled trench means the semiconductor substrate inside the spiral inductor is untouched; hence integrated circuit can be built inside the antenna and on that substrate. Therefore the RF integrated circuit has a smaller size. Air-filled trench can also be used to reduce the semiconductor substrate noise coupling between digital circuit block and analog/RF circuit block. This air-filled trench and the air-filled trench under the antenna are formed at the same time.

7 Claims, 7 Drawing Sheets



US007911387B2

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

(10) **Patent No.: US 7,911,387 B2**
(45) **Date of Patent: Mar. 22, 2011**

(54) **HANDHELD ELECTRONIC DEVICE ANTENNAS**

(75) Inventors: **Robert J. Hill**, Salinas, CA (US); **Robert W. Schlub**, Campbell, CA (US); **Ruben Caballero**, San Jose, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 932 days.

(21) Appl. No.: **11/821,363**

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

(65) **Prior Publication Data**

US 2008/0316117 A1 Dec. 25, 2008

(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** ..... 343/700 MS, 343/702, 767, 846
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,590,614	A	5/1986	Erat
4,894,663	A	1/1990	Urbish et al.
4,980,694	A	12/1990	Hines
5,021,010	A	6/1991	Wright
5,041,838	A	8/1991	Liimatainen et al.
5,048,118	A	9/1991	Brooks et al.
5,561,437	A	10/1996	Phillips et al.
5,754,143	A	5/1998	Warnagiris et al.
5,798,984	A	8/1998	Koch
6,011,699	A	1/2000	Murray et al.
6,097,345	A	8/2000	Walton
6,326,919	B1	12/2001	Diximus et al.
6,337,662	B1	1/2002	Cassel
6,622,031	B1	9/2003	McCleary et al.
6,670,923	B1	12/2003	Kadambi et al.
6,741,214	B1	5/2004	Kadambi et al.
6,747,601	B2	6/2004	Boyle
6,856,294	B2	2/2005	Kadambi et al.
6,968,508	B2	11/2005	Lucaci et al.

(Continued)

FOREIGN PATENT DOCUMENTS

EP	1 351 334	10/2003

(Continued)

OTHER PUBLICATIONS

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

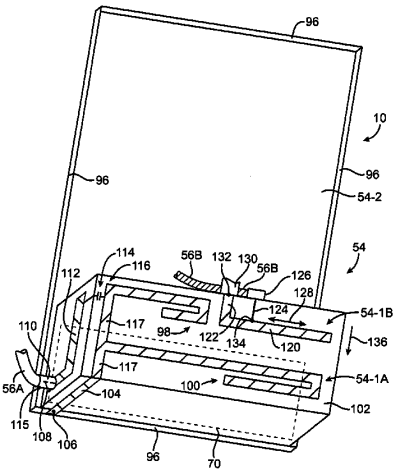
(Continued)

Primary Examiner — Shih-Chao Chen
(74) *Attorney, Agent, or Firm* — Treyz Law Group; G. Victor Treyz; David C. Kellogg

(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.

24 Claims, 38 Drawing Sheets



US007911390B2

(12) **United States Patent**
Chiu

(10) **Patent No.: US 7,911,390 B2**
(45) **Date of Patent: Mar. 22, 2011**

(54) **ANTENNA STRUCTURE**

(75) Inventor: **Yi-Hung Chiu**, Taipei Hsien (TW)

(73) Assignee: **Wistron NeWeb Corporation**, Hsi-Chih, 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 341 days.

(21) Appl. No.: **12/099,787**

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

(65) **Prior Publication Data**

US 2009/0179800 A1 Jul. 16, 2009

(30) **Foreign Application Priority Data**

Jan. 15, 2008 (TW) ..... 97101505 A

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

(52) **U.S. Cl.** ..... **343/700 MS**; 343/702; 343/830; 343/829; 343/846

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,812,892	B2 *	11/2004	Tai et al.	343/700 MS
6,850,197	B2 *	2/2005	Paun	343/702
6,950,068	B2 *	9/2005	Bordi et al.	343/702
7,075,484	B2 *	7/2006	Sung	343/700 MS
7,333,067	B2 *	2/2008	Hung et al.	343/770
7,535,422	B2 *	5/2009	Liu et al.	343/702
7,541,984	B2 *	6/2009	Peng et al.	343/700 MS
7,675,463	B2 *	3/2010	Wallace et al.	343/700 MS

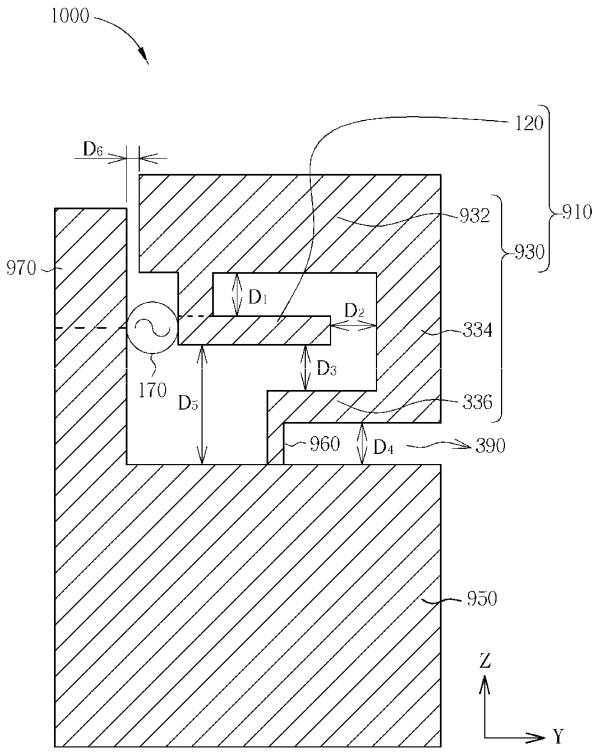
* cited by examiner

Primary Examiner — Trinh V Dinh
(74) *Attorney, Agent, or Firm* — Winston Hsu; Scott Margo

(57) **ABSTRACT**

An antenna structure includes a radiation element, a grounding element, a short point, and a feeding point. The radiation element includes a first radiator and a second radiator. The second radiator partially surrounds the first radiator and there is a predetermined distance included between the first radiator and the second radiator for matching impedance. The short point is coupled between the second radiator and the grounding element. The feeding point is coupled between a joint point of the first radiator and the second radiator and the grounding element.

20 Claims, 13 Drawing Sheets



US007911391B2

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

(10) **Patent No.: US 7,911,391 B2**
(45) **Date of Patent: Mar. 22, 2011**

(54) **DUAL-BAND ANTENNA**

(75) Inventors: **Yung-Chih Tsai**, Taipei Hsien (TW); **Lan-Yung Hsiao**, Taipei Hsien (TW); **Kai Shih**, Taipei Hsien (TW); **Yu-Yuan Wu**, Taipei Hsien (TW)

(73) Assignee: **Cheng Uei Precision Industry 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 372 days.

(21) Appl. No.: **12/145,418**

(22) Filed: **Jun. 24, 2008**

(65) **Prior Publication Data**

US 2009/0315781 A1 Dec. 24, 2009

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

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

(58) **Field of Classification Search** ..... 343/700 MS, 343/702, 846, 848
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,333,067	B2 *	2/2008	Hung et al.	343/770
7,446,717	B2 *	11/2008	Hung et al.	343/702
7,501,987	B2 *	3/2009	Wang et al.	343/702
7,633,448	B2 *	12/2009	Su et al.	343/702
7,667,664	B2 *	2/2010	Tao	343/873
2008/0007461	A1 *	1/2008	Su et al.	343/700 MS

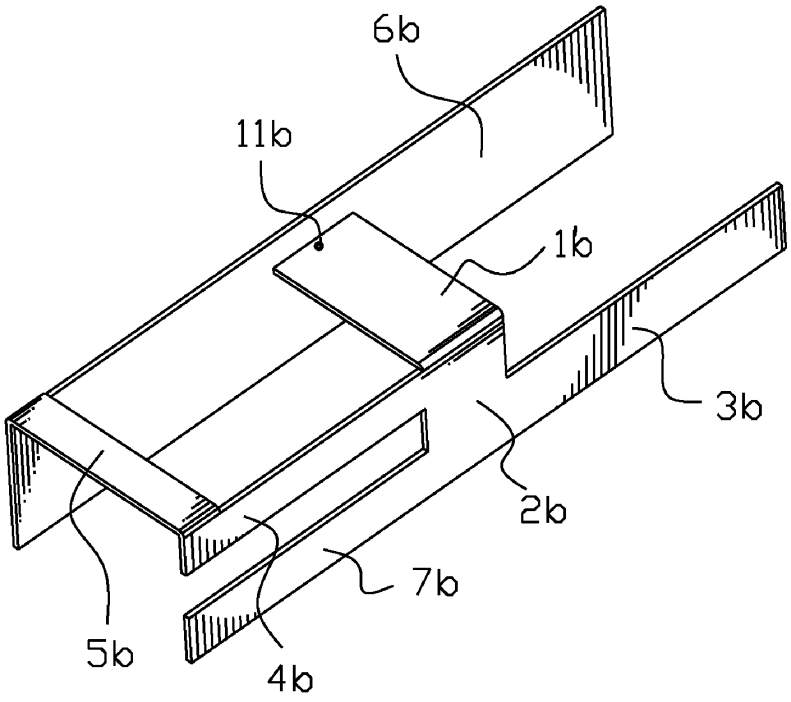
* cited by examiner

Primary Examiner — Douglas W Owens
Assistant Examiner — Chuc D Tran
(74) *Attorney, Agent, or Firm* — WPAT, P.C.; Anthony King

(57) **ABSTRACT**

A dual-band antenna has a feeding conductor with a feeding point and a connecting portion extending downwardly from the feeding conductor. A first radiating conductor and a loop protrusion respectively extend outward from two opposite sides of the connecting portion. A grounding portion faces the loop protrusion and is spaced apart from the feeding conductor to form a small gap therebetween. A loop connection is disposed away from the feeding conductor and connects an upper portion of the loop protrusion and an upper portion of the grounding portion.

6 Claims, 9 Drawing Sheets



US007911392B2

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

(10) **Patent No.: US 7,911,392 B2**
(45) **Date of Patent: Mar. 22, 2011**

(54) **MULTIPLE FREQUENCY BAND ANTENNA ASSEMBLY FOR HANDHELD COMMUNICATION DEVICES**

(75) Inventors: **Qinjiang Rao**, Waterloo (CA); **Shirook M. Ali**, Mississauga (CA); **Dong Wang**, Waterloo (CA)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 323 days.

(21) Appl. No.: **12/276,946**

(22) Filed: **Nov. 24, 2008**

(65) **Prior Publication Data**

US 2010/0127936 A1 May 27, 2010

(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.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,547,100	A	8/1996	Johnson	
5,633,646	A	5/1997	Strickland	
6,593,887	B2	7/2003	Luk et al.	
6,803,881	B2 *	10/2004	Ishihara et al.	343/700 MS
6,950,071	B2	9/2005	Wen et al.	
6,950,072	B2 *	9/2005	Miyata et al.	343/702
7,023,387	B2	4/2006	Wen et al.	
7,038,627	B2	5/2006	Ikuta et al.	
7,113,133	B2 *	9/2006	Chen et al.	343/700 MS
7,283,097	B2	10/2007	Wen et al.	
7,352,328	B2	4/2008	Moon et al.	
7,369,089	B2	5/2008	Wen et al.	
7,400,300	B2	7/2008	Qi et al.	
7,403,165	B2	7/2008	Qi et al.	
7,538,732	B2 *	5/2009	Ishihara et al.	343/702
2004/0085245	A1	5/2004	Miyata et al.	
2006/0244665	A1 *	11/2006	Tung	343/702
2007/0109204	A1	5/2007	Phillips et al.	
2008/0062058	A1	3/2008	Bishop	
2008/0231530	A1	9/2008	Rao et al.	
2008/0284661	A1	11/2008	He	
2008/0287171	A1	11/2008	Qi et al.	

FOREIGN PATENT DOCUMENTS

EP	1077505	A2	2/2001
EP	1162688	A1	12/2001
JP	2008167393	A	7/2008
JP	20080167393		7/2008

(Continued)

OTHER PUBLICATIONS

European Search Report and Written Opinion for Application No. 09176843.2, mailed Feb. 16, 2010.

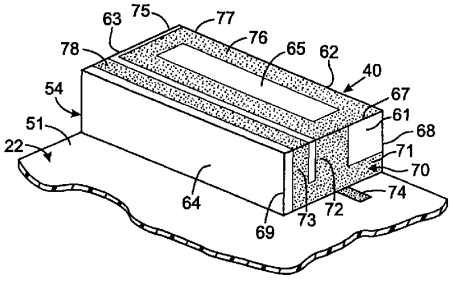
(Continued)

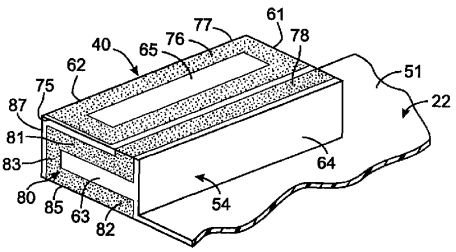
Primary Examiner — Tan Ho
(74) *Attorney, Agent, or Firm* — Quarles & Brady LLP

(57) **ABSTRACT**

An antenna assembly has a plurality of conductive elements to enable use in multiple frequency bands assigned for a mobile wireless communications. The antenna assembly has a six-sided support frame non-electrically conductive material which provides external surfaces on which specific conductive patterns are formed with the patterns on different surface being selectively connected together. The support frame is mounted on one major surface of a dielectric substrate that has an opposite major surface with a conductive layer that serves as ground plane. A portion of the opposite major surface, on which the conductive layer is not applied, forms one surface of the support frame.

23 Claims, 4 Drawing Sheets





US007911394B2

(12) **United States Patent**
Quintero Illera et al.

(10) **Patent No.: US 7,911,394 B2**
(45) **Date of Patent: *Mar. 22, 2011**

(54) **MULTILEVEL AND SPACE-FILLING GROUND-PLANES FOR MINIATURE AND MULTIBAND ANTENNAS**

(75) Inventors: **Ramiro Quintero Illera**, Barcelona (ES); **Carles Puente Baliarda**, 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 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/652,412**

(22) Filed: **Jan. 5, 2010**

(65) **Prior Publication Data**

US 2010/0141548 A1 Jun. 10, 2010

Related U.S. Application Data

(63) Continuation of application No. 12/033,446, filed on Feb. 19, 2008, now Pat. No. 7,688,276, which is a continuation of application No. 10/797,732, filed on Mar. 10, 2004, now Pat. No. 7,362,283, which is a continuation of application No. PCT/EP01/10589, filed on Sep. 13, 2001.

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

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

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

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,696,438	A	10/1972	Ingerson
5,262,792	A	11/1993	Egashira
5,495,261	A	2/1996	Baker et al.
5,497,167	A	3/1996	Luoma
5,646,637	A	7/1997	Miller
5,703,600	A	12/1997	Burrell et al.
5,903,822	A	5/1999	Sekine et al.
5,945,954	A	8/1999	Johnson
6,002,367	A	12/1999	Engblom et al.
6,140,975	A	10/2000	Cohen
6,218,992	B1	4/2001	Sadler
6,271,798	B1	8/2001	Endo et al.
6,285,326	B1	9/2001	Diximus et al.
6,314,273	B1	11/2001	Matsuda
6,359,589	B1	3/2002	Bae
6,362,790	B1	3/2002	Proctor, Jr. et al.
6,366,243	B1	4/2002	Isohatala et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CA	2416437	A1	7/2001

(Continued)

OTHER PUBLICATIONS

Shafai, L. L. et al, Dual-band dual-polarized perforated microstrip antennas for SAR applications, IEEE Transactions on antennas and propagation, Jan. 2000.

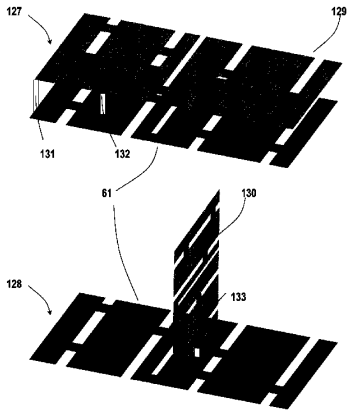
(Continued)

Primary Examiner — HoangAnh T Le
(74) *Attorney, Agent, or Firm* — Winstead PC

(57) **ABSTRACT**

An antenna system includes one or more conductive elements acting as radiating elements, and a multilevel or space-filling ground-plane, wherein said ground-plane has a particular geometry which affects the operating characteristics of the antenna. The return loss, bandwidth, gain, radiation efficiency, and frequency performance can be controlled through multilevel and space-filling ground-plane design. Also, said ground-plane can be reduced compared to those of antennas with solid ground-planes.

50 Claims, 19 Drawing Sheets



US007911396B2

(12) **United States Patent**
Rudant

(10) **Patent No.: US 7,911,396 B2**
(45) **Date of Patent: Mar. 22, 2011**

(54) **MEANDERED ANTENNA**

(75) Inventor: **Lionel Rudant**, Grenoble (FR)

(73) Assignee: **Radiall**, Rosny-Sous-Bois (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 120 days.

(21) Appl. No.: **11/920,834**

(22) PCT Filed: **May 30, 2006**

(86) PCT No.: **PCT/FR2006/050492**
§ 371 (c)(1),
(2), (4) Date: **Feb. 20, 2008**

(87) PCT Pub. No.: **WO2007/003827**
PCT Pub. Date: **Jan. 11, 2007**

(65) **Prior Publication Data**

US 2008/0284657 A1 Nov. 20, 2008

(30) **Foreign Application Priority Data**

Jun. 2, 2005 (FR) 05 51484

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

(52) **U.S. Cl.** **343/702**; 343/806

(58) **Field of Classification Search** ..... 343/700 MS, 343/895, 702, 804, 806, 803, 792
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,134,979	A *	5/1964	Bell	343/792.5
3,369,243	A *	2/1968	Greiser	343/770
5,754,143	A	5/1998	Warnagiris et al.	
5,867,126	A *	2/1999	Kawahata et al.	343/702
6,094,170	A	7/2000	Peng	
6,111,545	A	8/2000	Saari	
6,255,999	B1	7/2001	Faulkner et al.	
6,285,331	B1	9/2001	Jesman et al.	
6,642,893	B1 *	11/2003	Hebron et al.	343/702
2002/0080088	A1	6/2002	Boyle	
2003/0210188	A1	11/2003	Hebron et al.	
2004/0145523	A1	7/2004	Shamblin et al.	

FOREIGN PATENT DOCUMENTS

EP	1 351 334	A	10/2003
WO	WO 2004/025778	A1	3/2004

OTHER PUBLICATIONS

Oct. 5, 2009 European Office Action for corresponding European application No. 06794470.2 with computer-generated translation.

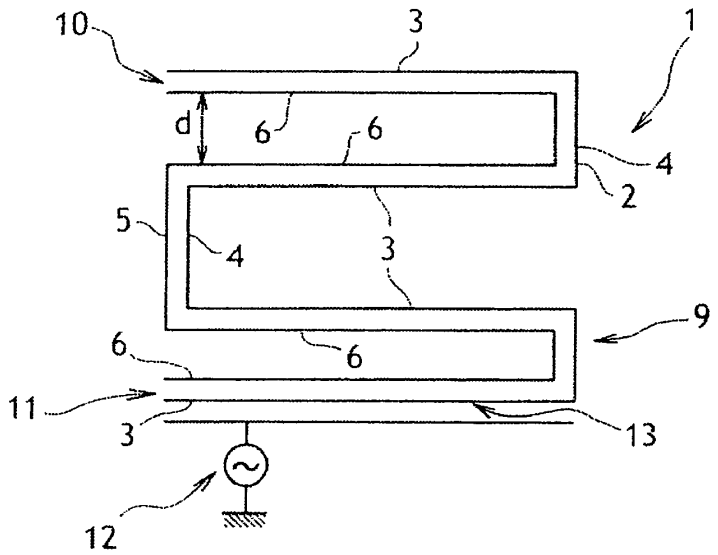
* cited by examiner

Primary Examiner — Jacob Y Choi
Assistant Examiner — Kyana R Robinson
(74) *Attorney, Agent, or Firm* — Oliff & Berridge, PLC

(57) **ABSTRACT**

The invention concerns a meandered antenna comprising: a first meandered conductive element including a plurality of arms, two consecutive arms forming a meander; a second conductive element forming with the first conductive element a radiating two-wired line, the second conductive element including a plurality of arms engaged each between two consecutive arms of the first conductive element. The antenna is characterized in that it is designed to operate without ground element, in particular without ground plane.

15 Claims, 1 Drawing Sheet



US007911399B2

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

(10) **Patent No.: US 7,911,399 B2**
(45) **Date of Patent: Mar. 22, 2011**

(54) **ANTENNA ASSEMBLY**

(75) Inventors: **Jia-Jia Yang**, Kunshan (CN); **Dao-Yuan Chen**, Kunshan (CN)

(73) Assignee: **Hon Hai Precision Ind. Co., Ltd.**, New Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 411 days.

(21) Appl. No.: **12/150,359**

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

(65) **Prior Publication Data**

US 2008/0266200 A1 Oct. 30, 2008

(30) **Foreign Application Priority Data**

Apr. 27, 2007 (CN) 2007 2 0037201

(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** 343/872, 343/702
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,903,695 B2 * 6/2005 Sjoblom et al. 343/702
6,972,721 B2 * 12/2005 Park 343/702
7,170,452 B2 * 1/2007 Yang 343/702
7,292,194 B2 * 11/2007 Tai et al. 343/702
7,499,000 B2 * 3/2009 Chan et al. 343/872

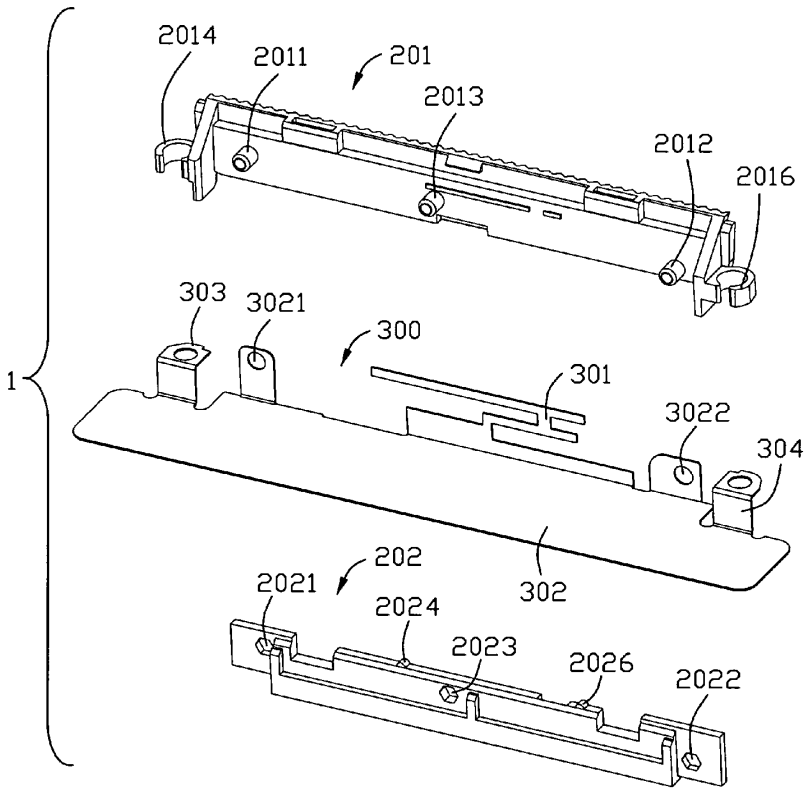
* cited by examiner

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

(57) **ABSTRACT**

An antenna assembly assembled in an electric device includes an inner antenna comprising a planar radiating element, a cover fixing the antenna on the electric device and comprising at least one protrusion to fix the radiating element.

18 Claims, 3 Drawing Sheets



US007916086B2

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

(10) **Patent No.: US 7,916,086 B2**
(45) **Date of Patent: Mar. 29, 2011**

(54) **ANTENNA COMPONENT AND METHODS**

(75) Inventors: **Kimmo Koskiniemi**, Oulu (FI); **Vesa Kuronen**, Oulu (FI)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 568 days.

(21) Appl. No.: **11/801,894**

(22) Filed: **May 11, 2007**

(65) **Prior Publication Data**

US 2008/0007459 A1 Jan. 10, 2008

Related U.S. Application Data

(63) Continuation of application No. PCT/FI2005/050382, filed on Oct. 27, 2005.

(30) **Foreign Application Priority Data**

Nov. 11, 2004 (FI) 20041455

(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, 343/702, 846

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,069,483	A	1/1978	Kaloi
5,157,363	A	10/1992	Puurunen
5,281,326	A	1/1994	Galla
5,298,873	A	3/1994	Ala-Kojola
5,349,700	A	9/1994	Parker
RE34,898	E	4/1995	Turunen
5,408,206	A	4/1995	Turunen
5,506,554	A	4/1996	Ala-Kojola
5,521,561	A	5/1996	Yrjola
5,550,519	A	8/1996	Korpela
5,675,301	A	10/1997	Nappa
5,764,190	A	6/1998	Murch et al.
5,892,490	A	4/1999	Asakura et al.

(Continued)

FOREIGN PATENT DOCUMENTS

EP 0 376 643 A2 4/1990

(Continued)

OTHER PUBLICATIONS

Wong, K., et al.; "A Low-Profile Planar Monopole Antenna for Multiband Operation of Mobile Handsets"; IEEE Transactions on Antennas and Propagation, Jan. '03, vol. 51, No. 1.

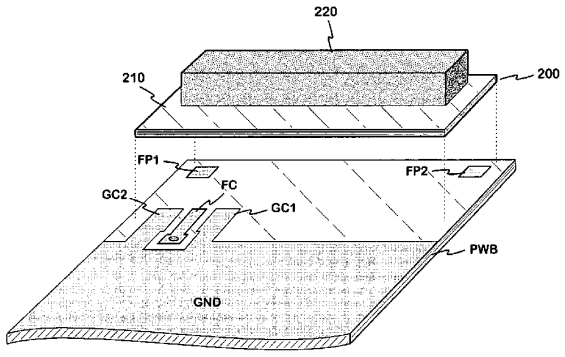
(Continued)

Primary Examiner — Tho G Phan
(74) *Attorney, Agent, or Firm* — Gazdzinski & Associates, PC

(57) **ABSTRACT**

An antenna component suited for small-sized radio devices for forming a dielectric antenna. A small auxiliary circuit board (**210**) is used for the matching of the antenna, the matching being based on a conductor pattern on it. A substrate chip (**220**), on the surface of which the radiator is, and the auxiliary board are fastened to each other, whereby the radiator is electrically connected to said conductor pattern. The radiator, its substrate and the auxiliary board form a unitary, solid antenna component (**200**), which is mounted on the circuit board (PWB) of the radio device. The antenna with its feed and matching circuits can be designed and tested as a whole of its own, in which case the reproducibility is good. In the design of the circuit board of the radio device, the antenna needs to be taken into account only by reserving a space for the antenna component on the circuit board.

45 Claims, 3 Drawing Sheets



US007916087B2

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

(10) **Patent No.: US 7,916,087 B2**
(45) **Date of Patent: Mar. 29, 2011**

(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 249 days.

(21) Appl. No.: **12/331,518**

(22) Filed: **Dec. 10, 2008**

(65) **Prior Publication Data**

US 2009/0091502 A1 Apr. 9, 2009

Related U.S. Application Data

(63) 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 1/38 (2006.01)
H01Q 1/24 (2006.01)

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

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

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,929,813	A	7/1999	Eggleston	343/700 MS
6,049,314	A	4/2000	Munson et al.	343/846
6,133,880	A	10/2000	Grangeat et al.	343/700 MS
6,140,966	A	10/2000	Pankinaho	343/700 MS
6,157,348	A	12/2000	Openlander	343/846
6,333,716	B1	12/2001	Pontoppidan	343/702

(Continued)

FOREIGN PATENT DOCUMENTS

CN	1338796	A	3/2002

(Continued)

OTHER PUBLICATIONS

Sittironnarit et al., A dual-band vehicular planar inverted-F antenna for ultra high frequency (UHF) application, VTC Spring 2002, IEEE 55th, Vehicular Technology Conference, May 6-9, 2002, vol. 1, pp. 345-349.

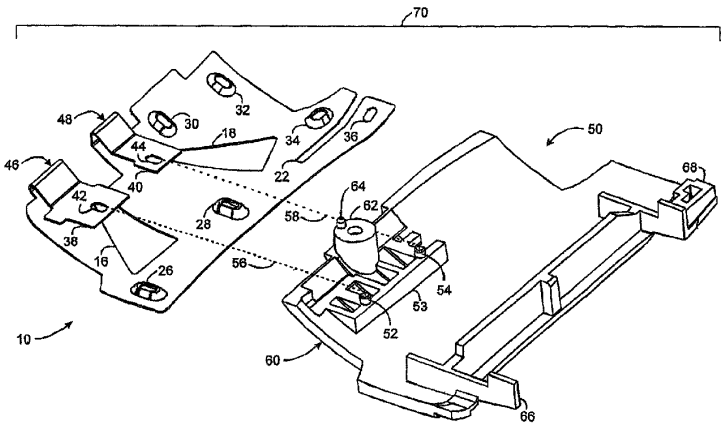
Primary Examiner — Tan Ho

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

(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.

26 Claims, 7 Drawing Sheets



US007916089B2

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

(10) **Patent No.: US 7,916,089 B2**
(45) **Date of Patent: Mar. 29, 2011**

(54) **ANTENNA ISOLATION FOR PORTABLE ELECTRONIC DEVICES**

(75) Inventors: **Robert W. Schlub**, Santa Clara, CA (US); **Robert J. Hill**, Salinas, 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 609 days.

(21) Appl. No.: **11/969,684**

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

(65) **Prior Publication Data**

US 2009/0174611 A1 Jul. 9, 2009

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

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

(58) **Field of Classification Search** ..... 343/702, 343/700 MS, 833–835

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,509,056	A	4/1985	Ploussios	
5,463,406	A	10/1995	Vannatta et al.	
5,784,032	A	7/1998	Johnston et al.	
5,917,458	A	6/1999	Ho et al.	
6,184,845	B1	2/2001	Leisten et al.	
6,552,692	B1	4/2003	Zeilinger et al.	
6,570,538	B2	5/2003	Vaisanen et al.	
6,639,558	B2	10/2003	Kellerman et al.	
6,987,485	B2	1/2006	Ito et al.	
7,053,850	B1	5/2006	Bogdans et al.	
7,405,702	B2 *	7/2008	Annamaa et al.	343/702
7,592,969	B2 *	9/2009	Proctor et al.	343/893
2005/0041624	A1	2/2005	Hui et al.	
2006/0038736	A1	2/2006	Hui et al.	
2006/0238437	A1	10/2006	Huang	
2008/0316121	A1 *	12/2008	Hobson et al.	343/702
2009/0275370	A1 *	11/2009	Schlub et al.	455/575.7
2010/0080151	A1 *	4/2010	Proctor et al.	370/279

FOREIGN PATENT DOCUMENTS

EP	1083622	3/2001
WO	2006018711	2/2006

OTHER PUBLICATIONS

Schlub et al. U.S. Appl. No. 11/650,071, filed Jan. 4, 2007.

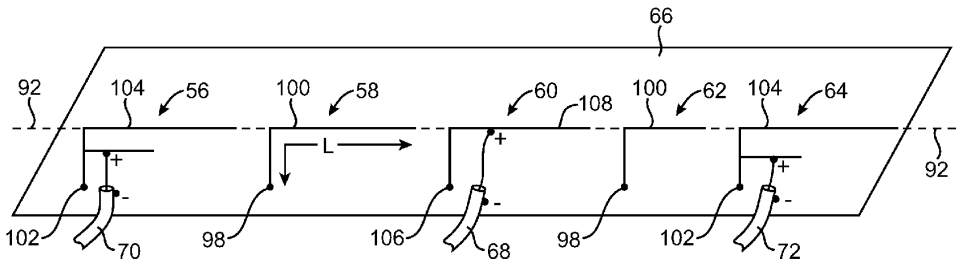
* cited by examiner

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

(57) **ABSTRACT**

Portable electronic devices are provided with wireless circuitry that includes antennas and antenna isolation elements. The antennas may include antennas that have multiple arms and that are configured to handle communications in multiple frequency bands. The antennas may also include one or more antennas that are configured to handle communications in a single frequency band. The antennas may be coupled to different radio-frequency transceivers. For example, there may be first, second, and third antennas and first and second transceivers. The first and third antennas may be coupled to the first transceiver and the second antenna may be coupled to the second transceiver. The antenna isolation elements may be interposed between the antennas and may serve to reduce radio-frequency interference between the antennas. There may be a first antenna isolation element between the first and second antennas and a second antenna isolation element between the second and third antennas.

19 Claims, 16 Drawing Sheets



US007916091B2

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

(10) **Patent No.: US 7,916,091 B2**
(45) **Date of Patent: Mar. 29, 2011**

(54) **ANTENNA MODULE FOR A WIRELESS ELECTRONIC DEVICE**

(75) Inventors: **I-Huang Chang**, Kaohsiung (TW); **Hung-Hsien Chiu**, Hsinchu (TW)

(73) Assignee: **Wha Yu Industrial Co., Ltd.**, Hsinchu (TW)

(*) 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.: **12/237,352**

(22) Filed: **Sep. 24, 2008**

(65) **Prior Publication Data**

US 2009/0015511 A1 Jan. 15, 2009

Related U.S. Application Data

(63) Continuation-in-part of application No. 11/324,391, filed on Jan. 4, 2006, now abandoned.

(30) **Foreign Application Priority Data**

Feb. 5, 2005 (TW) ..... 94103977 A

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

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

(58) **Field of Classification Search** ..... 343/702, 343/700 MS, 893, 725
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2003/0076265	A1 *	4/2003	Chen	343/702
2003/0112188	A1 *	6/2003	Bordi et al.	343/702
2004/0085248	A1 *	5/2004	Onaka et al.	343/702
2004/0145521	A1 *	7/2004	Hebron et al.	343/700 MS
2010/0271270	A1 *	10/2010	Sung et al.	343/702

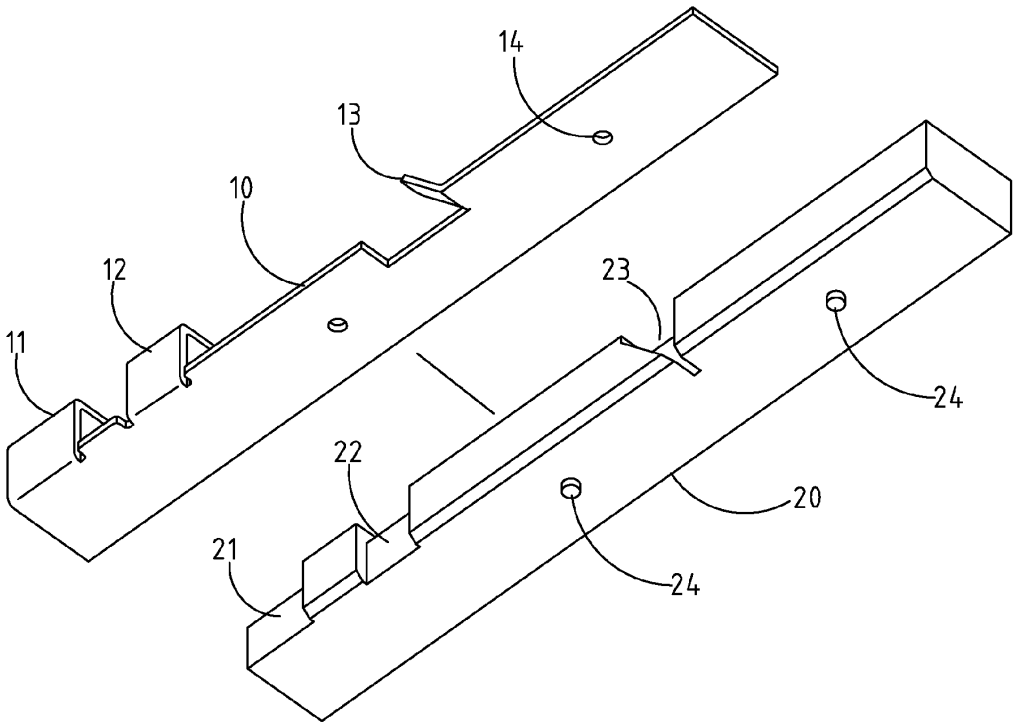
* cited by examiner

Primary Examiner — HoangAnh T Le
(74) *Attorney, Agent, or Firm* — Egbert Law Offices PLLC

(57) **ABSTRACT**

The antenna module fabrication for a wireless electronic device includes setting up the antenna and the assembly base that is to connect the antenna to the designated circuit board. The antenna and the assembly base are two independent pieces, and the positioning parts are for positioning so that the antenna and assembly base are one body. The antenna module of the invention can achieve the advantages such as simple production, cost effectiveness, prevention of the antenna module from deforming and quality improvement.

3 Claims, 9 Drawing Sheets



US007916093B2

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

(10) **Patent No.: US 7,916,093 B2**
(45) **Date of Patent: Mar. 29, 2011**

(54) **MULTIBAND ANTENNA**

(75) Inventors: **Li-Cheng Chiang**, Taipei Hsien (TW); **Chih-Yuan Yang**, Taipei Hsien (TW); **Hung-Chang Ko**, Taipei Hsien (TW); **Po-Wei Kuo**, Taipei Hsien (TW); **Suo-Bing Su**, Taipei Hsien (TW); **Wen-Chun Chen**, Taipei Hsien (TW)

(73) Assignee: **Hon Hai Precision Industry Co., Ltd.**, Tu-Cheng, 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 379 days.

(21) Appl. No.: **12/241,060**

(22) Filed: **Sep. 30, 2008**

(65) **Prior Publication Data**

US 2009/0322638 A1 Dec. 31, 2009

(30) **Foreign Application Priority Data**

Jun. 30, 2008 (CN) 2008 1 0302429

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

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

(58) **Field of Classification Search** ..... 343/702, 343/700 MS, 767, 769, 770
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,573,869	B2 *	6/2003	Moore	343/702
6,741,214	B1 *	5/2004	Kadambi et al.	343/700 MS
7,486,242	B2 *	2/2009	Gala Gala et al.	343/702
2001/0048391	A1 *	12/2001	Annamaa et al.	343/700 MS
2003/0112198	A1 *	6/2003	Wang et al.	343/770
2007/0205947	A1	9/2007	Boyle	

* cited by examiner

Primary Examiner — HoangAnh T Le
(74) *Attorney, Agent, or Firm* — Frank R. Niranjan

(57) **ABSTRACT**

A multiband antenna includes a conductive sheet, a feeding point, and a grounding point. The conductive sheet defines a first slot, a second slot, a third slot, a fourth slot, a fifth slot, a sixth slot, and a seventh slot thereon. The second slot and the third slot extend from a same short side of the first slot and are parallel to each other. The fourth slot, the fifth slot, the sixth slot, and the seventh slot extend perpendicularly from a short side of the third slot away from the first slot in sequence. The feeding point is formed on the conductive sheet at a long side of the first slot away from the third slot. The grounding point is formed on the conductive sheet at a margin of the slots different from the location of the feeding point.

18 Claims, 2 Drawing Sheets