



US009019160B2

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

(10) **Patent No.:** **US 9,019,160 B2**
(45) **Date of Patent:** **Apr. 28, 2015**

(54) **CSRR-LOADED MIMO ANTENNA SYSTEMS**

(56) **References Cited**

(71) Applicant: **King Fahd University of Petroleum and Minerals, Dhahran (SA)**

U.S. PATENT DOCUMENTS

(72) Inventors: **Mohammad S. Sharawi, Dhahran (SA); Muhammad Umar Khan, Dhahran (SA); Ahmad Bilal Numan, Dhahran (SA)**

2001/0038325	A1	*	11/2001	Smith et al.	333/202
2007/0024399	A1	*	2/2007	Martin Antolin et al.	333/205
2010/0283687	A1	*	11/2010	Ehelen	343/700 MS
2011/0260946	A1		10/2011	Dandekar et al.	
2012/0223869	A1		9/2012	Kim et al.	

(73) Assignee: **King Fahd University of Petroleum and Minerals, Dhahran (SA)**

FOREIGN PATENT DOCUMENTS

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 254 days.

CN 101388489 A 3/2009

* cited by examiner

(21) Appl. No.: **13/846,841**

Primary Examiner — Tan Ho

(22) Filed: **Mar. 18, 2013**

(74) *Attorney, Agent, or Firm* — Richard C Litman

(65) **Prior Publication Data**

US 2014/0266974 A1 Sep. 18, 2014

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 21/28 (2006.01)

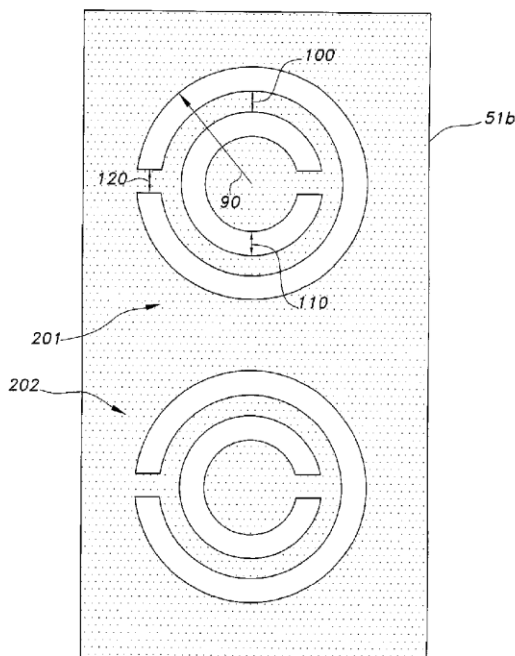
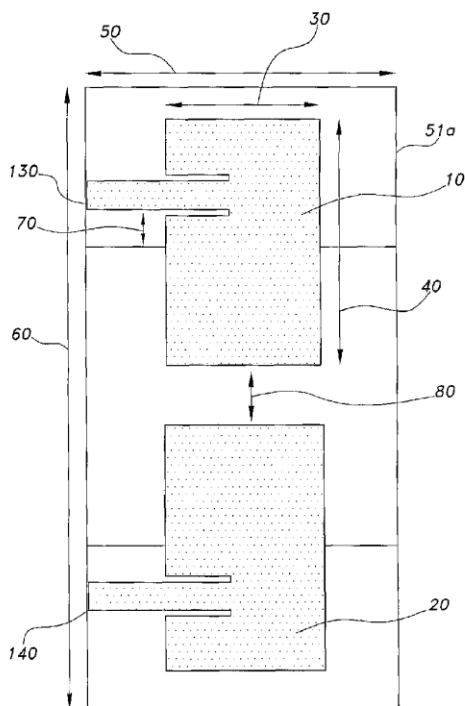
(57) **ABSTRACT**

The CSRR-loaded MIMO antenna systems provide highly compact designs for multiple-input-multiple-output (MIMO) antennas for use in wireless mobile devices. Exemplary two element (2x1), and four element (2x2) MIMO antenna systems are disclosed in which complementary split-ring resonators load patch antennas elements. The overall dimensions of the exemplary MIMO antenna system designed for operation from 750 MHz to 6 GHz band remain within 100x50x0.8 mm².

(52) **U.S. Cl.**
CPC **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**
USPC 343/700 MS, 893; 333/202, 205
See application file for complete search history.

11 Claims, 6 Drawing Sheets





US009019163B2

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

(10) **Patent No.:** **US 9,019,163 B2**
(45) **Date of Patent:** **Apr. 28, 2015**

(54) **SMALL ANTENNA APPARATUS OPERABLE IN MULTIPLE BANDS INCLUDING LOW-BAND FREQUENCY AND HIGH-BAND FREQUENCY WITH ULTRA WIDE BANDWIDTH**

(75) Inventors: **Kenichi Asanuma**, Kyoto (JP); **Atsushi Yamamoto**, Kyoto (JP); **Tsutomu Sakata**, Osaka (JP)

(73) Assignee: **Panasonic Intellectual Property Corporation of America**, Torrance, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 204 days.

(21) Appl. No.: **13/989,460**

(22) PCT Filed: **Aug. 31, 2012**

(86) PCT No.: **PCT/JP2012/005538**

§ 371 (c)(1),
(2), (4) Date: **May 24, 2013**

(87) PCT Pub. No.: **WO2013/061502**

PCT Pub. Date: **May 2, 2013**

(65) **Prior Publication Data**

US 2013/0249753 A1 Sep. 26, 2013

(30) **Foreign Application Priority Data**

Oct. 27, 2011 (JP) 2011-235902

(51) **Int. Cl.**
H01Q 5/00 (2006.01)
H01Q 9/42 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/0024** (2013.01); **H01Q 9/42** (2013.01); **H01Q 7/005** (2013.01); **H01Q 9/065** (2013.01); **H01Q 9/28** (2013.01); **H01Q 5/321** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 9/42; H01Q 5/0024; H01Q 9/28; H01Q 7/005; H01Q 9/065; H01Q 5/321

USPC 343/702, 748, 749, 866, 745, 741, 744
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,529,170 B1 3/2003 Nishizawa et al.
8,933,853 B2* 1/2015 Asanuma et al. 343/749

(Continued)

FOREIGN PATENT DOCUMENTS

JP 08-213820 8/1996
JP 2001-185938 7/2001

(Continued)

OTHER PUBLICATIONS

International Search Report issued Oct. 9, 2012 in International (PCT) Application No. PCT/JP2012/005538.
(Continued)

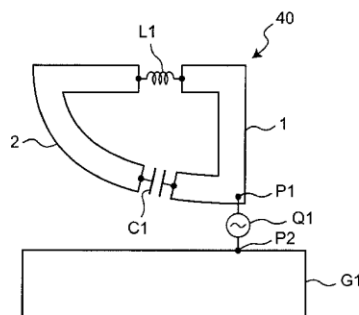
Primary Examiner — Hoanganh Le

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

(57) **ABSTRACT**

A radiator includes a looped radiation conductor, a capacitor, an inductor, and a feed point on a radiation conductor. In a portion where the radiation conductor and a ground conductor are close to each other, a distance between the radiation conductor and the ground conductor gradually increases as a distance from the feed point along the looped radiation conductor increases. When the radiator is excited at a low-band resonance frequency, a current flows along a first path extending along an inner perimeter of the looped radiation conductor and including the inductor and the capacitor. When the radiator is excited at a high-band resonance frequency, a second current flows through a second path including a section extending along an outer perimeter of the looped radiation conductor, and the section including the capacitor but not including the inductor, and the section extending between the feed point and the inductor.

20 Claims, 35 Drawing Sheets





US009020447B2

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

(10) **Patent No.:** **US 9,020,447 B2**
(45) **Date of Patent:** **Apr. 28, 2015**

(54) **ELECTRONIC DEVICES, METHODS, AND COMPUTER PROGRAM PRODUCTS FOR MAKING A CHANGE TO AN ANTENNA ELEMENT BASED ON A POWER LEVEL OF A TRANSMISSION POWER AMPLIFIER**

USPC 455/522, 13.4, 77, 78, 83, 87, 73,
455/562.1, 193.1, 269, 272, 277.1
See application file for complete search history.

(75) Inventors: **Erik Lennart Bengtsson**, Eslöv (SE);
Olof Zander, Lund (SE); **Scott LaDell**
Vance, Staffanstorp (SE); **Pär**
Håkansson, Malmö (SE); **Daniel**
Lönblad, Genarp (SE)

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,600,933 B1 * 7/2003 Hiramatsu et al. 455/561
2008/0139128 A1 6/2008 Liao

FOREIGN PATENT DOCUMENTS

JP 2004-363863 12/2004
WO WO 02/29990 A1 4/2002

OTHER PUBLICATIONS

(73) Assignees: **Sony Corporation**, Tokyo (JP); **Sony**
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 415 days.

European Search Report Corresponding to European Application
No. 13163270.5-1852; Dated: Apr. 14, 2014; 6 Pages.
Extended European Search Report Corresponding to European
Application No. 13163270.5; Dated: Sep. 5, 2014; 9 Pages.

(21) Appl. No.: **13/480,099**

* cited by examiner

(22) Filed: **May 24, 2012**

Primary Examiner — Tuan Pham

(65) **Prior Publication Data**

US 2013/0316662 A1 Nov. 28, 2013

(74) *Attorney, Agent, or Firm* — Myers Bigel Sibley &
Sajovec, PA

(51) **Int. Cl.**
H04B 1/44 (2006.01)
H04B 7/08 (2006.01)
H04B 17/00 (2006.01)
H04W 52/42 (2009.01)

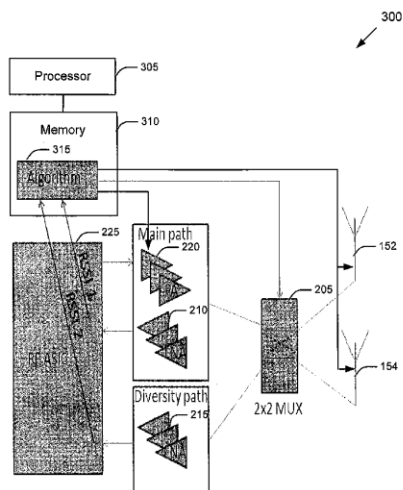
(57) **ABSTRACT**

A method of operating an electronic device includes provid-
ing a plurality of antenna elements, determining that a change
is to be made to at least one of the plurality of antenna
elements, and scheduling the change to the at least one of the
plurality of antenna elements during a time interval that a
transmission power amplifier has a power level below a
threshold. The change to the at least one of the plurality of
antenna elements may also be made responsive to a reduction
to the power level of the transmission power amplifier below
the threshold.

(52) **U.S. Cl.**
CPC **H04B 7/0874** (2013.01); **H04B 17/00**
(2013.01); **H04W 52/42** (2013.01)

(58) **Field of Classification Search**
CPC H04B 7/0874; H04B 1/0064; H04B 1/44;
H04B 7/0802; H04B 7/0825; H04W 52/42

21 Claims, 7 Drawing Sheets





US009024819B2

(12) **United States Patent**
Shor

(10) **Patent No.:** **US 9,024,819 B2**
(45) **Date of Patent:** **May 5, 2015**

(54) **MULTIPLE ANTENNAS HAVING GOOD ISOLATION DISPOSED IN A LIMITED SPACE**

(75) Inventor: **Arie Shor**, Santa Clara, 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 1890 days.

(21) Appl. No.: **11/686,325**

(22) Filed: **Mar. 14, 2007**

(65) **Prior Publication Data**

US 2007/0229364 A1 Oct. 4, 2007

Related U.S. Application Data

(60) Provisional application No. 60/744,106, filed on Mar. 31, 2006.

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 5/00 (2006.01)
H01Q 21/24 (2006.01)
H01Q 25/00 (2006.01)
H01Q 9/42 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/52 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/42** (2013.01); **H01Q 1/2291** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/521** (2013.01); **H01Q 21/24** (2013.01); **H01Q 25/00** (2013.01)

(58) **Field of Classification Search**
USPC 343/700 MS, 702, 795, 830, 846, 893
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,836,976	A *	9/1974	Monser et al.	343/795
4,486,758	A *	12/1984	de Ronde	343/700 MS
4,672,386	A *	6/1987	Wood	343/770
4,929,959	A *	5/1990	Sorbello et al.	343/700 MS
5,534,877	A *	7/1996	Sorbello et al.	343/700 MS
6,538,605	B2	3/2003	Lebaric et al.	
6,573,876	B1 *	6/2003	Maroko et al.	343/906
6,718,619	B2	4/2004	Lebaric et al.	
6,734,828	B2	5/2004	Shor	
6,741,219	B2	5/2004	Shor	
6,747,605	B2	6/2004	Lebaric et al.	
6,874,222	B2	4/2005	Lebaric et al.	
6,883,227	B2	4/2005	Lebaric et al.	
2002/0140612	A1	10/2002	Kadambi et al.	

FOREIGN PATENT DOCUMENTS

WO 2004/017462 A1 2/2004

OTHER PUBLICATIONS

ISA/US, International Search Report and Written Opinion, International Application No. PCT/US2007/006583, Sep. 12, 2008, 4 pgs. EPO/Munich, Supplementary European Search Report, European Patent Application No. 07753228, Search Authority, May 9, 2011, 5 pgs.

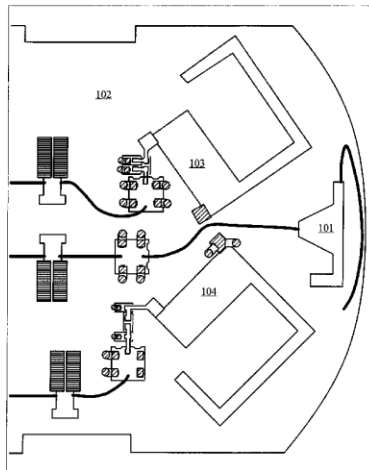
* cited by examiner

Primary Examiner — Michael C Wimer
(74) *Attorney, Agent, or Firm* — Holland & Hart LLP

(57) **ABSTRACT**

An apparatus and method are taught for instantiation of a plurality of high-frequency antennas in a limited space in a manner that provides good isolation. The instantiation may include relative rotations of linear conductors, mirror images, as well as horizontally and vertically polarized antennas. In one embodiment, the antennas may be multi-band antennas.

7 Claims, 5 Drawing Sheets





US009024822B2

(12) **United States Patent**
Tang

(10) **Patent No.:** **US 9,024,822 B2**
(45) **Date of Patent:** **May 5, 2015**

(54) **HOUSING ASSEMBLY AND ELECTRONIC DEVICE USING THE SAME**

(75) Inventor: **Zi-Ming Tang**, Shenzhen (CN)

(73) Assignees: **Fu Tai Industry (Shenzhen) Co., Ltd.**, Shenzhen (CN); **Hon Hai Precision Industry 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 993 days.

(21) Appl. No.: **12/979,468**

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

(65) **Prior Publication Data**
US 2012/0133560 A1 May 31, 2012

(30) **Foreign Application Priority Data**
Nov. 29, 2010 (CN) 2010 1 0564647

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
G06F 1/16 (2006.01)
H04M 1/02 (2006.01)
H01Q 1/38 (2006.01)

(52) **U.S. Cl.**
CPC **G06F 1/1698** (2013.01); **G06F 1/1626** (2013.01); **G06F 1/1637** (2013.01); **H01Q 1/243** (2013.01); **H04M 1/0249** (2013.01); **H01Q 1/38** (2013.01)

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

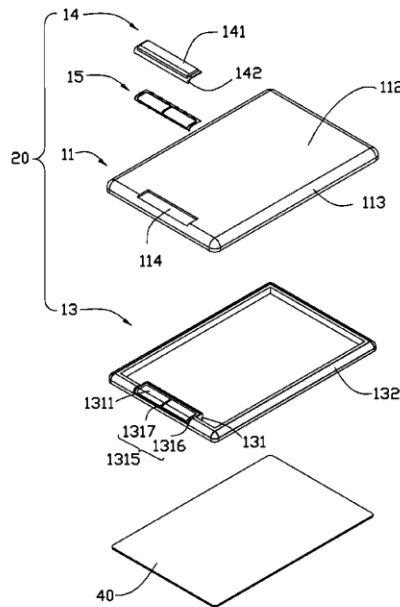
(56) **References Cited**
U.S. PATENT DOCUMENTS
2002/0192998 A1* 12/2002 Noro 439/497
2008/0055166 A1* 3/2008 Kobayashi 343/702
2008/0316121 A1* 12/2008 Hobson et al. 343/702

FOREIGN PATENT DOCUMENTS
CN 101573009 A 11/2009
CN 101621118 A 1/2010
CN 201491423 U 5/2010

* cited by examiner
Primary Examiner — Graham Smith
(74) *Attorney, Agent, or Firm* — Novak Druce Connolly Bove + Quigg LLP

(57) **ABSTRACT**
An housing assembly includes an outer housing, an antenna cover, a support member, and an elastic member. The outer housing defines an antenna opening. The antenna cover is positioned in the antenna opening of the outer housing. The support member is positioned in the outer housing. The support member forms an assembly portion for receiving the antenna module. The assembly portion is aligned with the antenna opening. The elastic member is positioned between the support member and the antenna cover, generating elastic force snugly fixing the antenna cover to the outer housing. An electronic device using the housing assembly is also provided.

16 Claims, 4 Drawing Sheets





US009024823B2

(12) **United States Patent**
Bevelacqua

(10) **Patent No.:** **US 9,024,823 B2**
(45) **Date of Patent:** **May 5, 2015**

(54) **DYNAMICALLY ADJUSTABLE ANTENNA SUPPORTING MULTIPLE ANTENNA MODES**

(75) Inventor: **Peter Bevelacqua**, Cupertino, 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 125 days.

(21) Appl. No.: **13/118,276**

(22) Filed: **May 27, 2011**

(65) **Prior Publication Data**

US 2012/0299785 A1 Nov. 29, 2012

(51) **Int. Cl.**

H01Q 21/30 (2006.01)

H01Q 1/24 (2006.01)

H01Q 5/00 (2006.01)

H01Q 9/42 (2006.01)

H01Q 13/10 (2006.01)

(52) **U.S. Cl.**

CPC **H01Q 1/243** (2013.01); **H01Q 5/0037** (2013.01); **H01Q 9/42** (2013.01); **H01Q 13/10** (2013.01)

USPC **343/702**; 343/745; 343/861; 343/725

(58) **Field of Classification Search**

CPC H01Q 13/10; H01Q 1/243; H01Q 5/0037; H01Q 9/42

USPC 343/702
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,515,625 B1 2/2003 Johnson
6,864,848 B2* 3/2005 Sievenpiper 343/767
7,164,387 B2* 1/2007 Sievenpiper 343/702

7,215,283 B2* 5/2007 Boyle 343/700 MS
7,420,511 B2* 9/2008 Oshiyama et al. 343/700 MS
7,439,911 B2 10/2008 Wang
7,595,759 B2 9/2009 Schlub et al.
7,612,725 B2 11/2009 Hill et al.
7,626,551 B2 12/2009 Chien et al.
7,808,438 B2 10/2010 Schlub et al.

(Continued)

FOREIGN PATENT DOCUMENTS

EP 2328233 1/2011
JP S58-104504 6/1983

(Continued)

OTHER PUBLICATIONS

Antenna Theory: A Review, Balanis, Proc. IEEE vol. 80 No. 1 Jan. 1992.*

(Continued)

Primary Examiner — Robert Karacsony

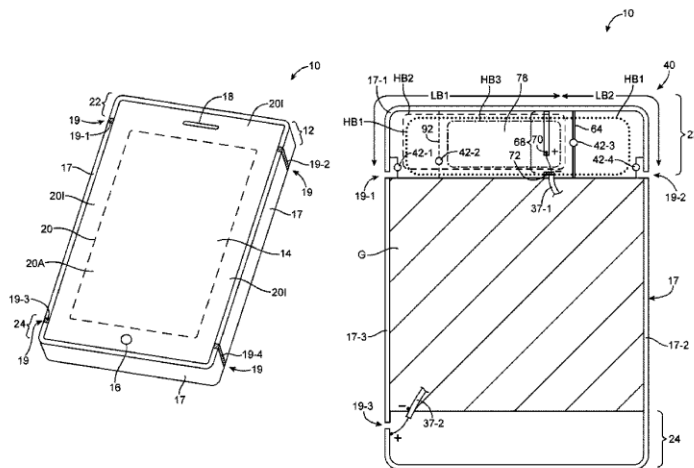
Assistant Examiner — Amal Patel

(74) *Attorney, Agent, or Firm* — Treyz Law Group; G. Victor Treyz; Michael H. Lyons

(57) **ABSTRACT**

Electronic devices may be provided that contain wireless communications circuitry. The wireless communications circuitry may include radio-frequency transceiver circuitry coupled to an adjustable antenna. The adjustable antenna may contain conductive antenna structure such as conductive electronic device housing structures. Electrical components such as switches and resonant circuits may be used in configuring the antenna to operate in two or more different antenna modes at different respective communications bands. Control circuitry may be used in controlling the switches. The antenna may be configured to operate as an inverted-F antenna in one mode of operation and a slot antenna in a second mode of operation.

8 Claims, 12 Drawing Sheets





US009024824B2

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

(10) **Patent No.:** **US 9,024,824 B2**
(45) **Date of Patent:** **May 5, 2015**

(54) **ANTENNA ASSEMBLY AND WIRELESS COMMUNICATION DEVICE EMPLOYING THE SAME**

USPC 343/702, 892
See application file for complete search history.

(75) Inventors: **Cho-Kang Hsu**, New Taipei (TW);
Yi-Ting Chen, New Taipei (TW);
Mei-Tsu Tsao, New Taipei (TW)

(56) **References Cited**

U.S. PATENT DOCUMENTS

2008/0074329 A1* 3/2008 Caballero et al. 343/702
2008/0150811 A1* 6/2008 Honda et al. 343/702
2012/0194393 A1* 8/2012 Uttermann et al. 343/702

(73) Assignee: **Chi Mei Communication Systems, Inc.**, New Taipei (TW)

FOREIGN PATENT DOCUMENTS

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 617 days.

CN 1893703 A 1/2007

* cited by examiner

(21) Appl. No.: **13/298,399**

Primary Examiner — Dieu H Duong

(22) Filed: **Nov. 17, 2011**

(74) *Attorney, Agent, or Firm* — Novak Druce Connolly Bove + Quigg LLP

(65) **Prior Publication Data**

US 2012/0249383 A1 Oct. 4, 2012

(57) **ABSTRACT**

(30) **Foreign Application Priority Data**

Mar. 29, 2011 (TW) 100110673 A

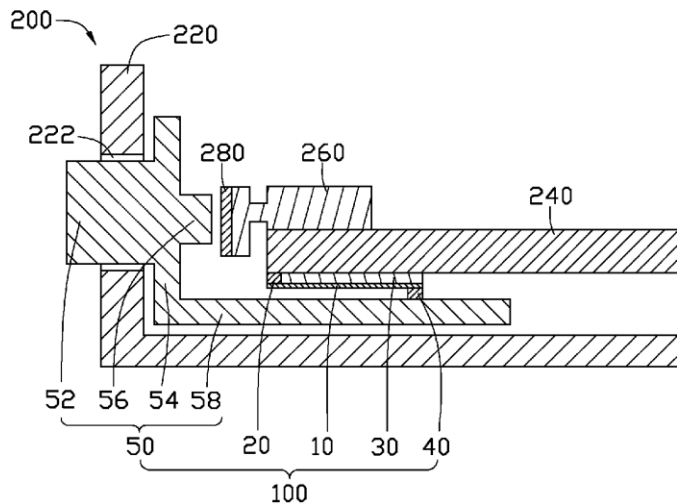
An antenna assembly is used in a wireless communication device, the wireless communication device includes a main body and a circuit board received within the main body. The antenna assembly includes a first antenna unit located in the main body, a feed point and a second antenna unit. The feed point is electrically connected to the circuit board and the first antenna unit. One part of the second antenna unit is exposed from the main body, the other part of the second antenna unit is located within the main body and produces resonance with the first antenna unit to receive and transmit radio signals. The antenna assembly can occupy small space in the wireless communication device and reduce coupled interference of other electronic components on the antenna assembly.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 21/28 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/241; H01Q 1/242; H01Q 1/2258

19 Claims, 2 Drawing Sheets





US009024825B2

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

(10) **Patent No.:** **US 9,024,825 B2**
(45) **Date of Patent:** **May 5, 2015**

(54) **MOBILE DEVICES WITH CONDUCTIVE LIQUID ANTENNAS AND RELATED METHODS**

(52) **U.S. Cl.**
CPC *H01Q 3/24* (2013.01); *H01Q 1/243* (2013.01); *H01Q 1/364* (2013.01); *H01Q 3/01* (2013.01)

(71) Applicant: **HTC Corporation**, Taoyuan, Taoyuan County (TW)

(58) **Field of Classification Search**
USPC 343/860, 876, 702
See application file for complete search history.

(72) Inventors: **Tae Young Yang**, Cary, NC (US); **William Haywood Tolbert**, Chapel Hill, NC (US); **Koichiro Takamizawa**, Cary, NC (US)

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,211,830 B1* 4/2001 Monma et al. 343/702
2013/0021217 A1* 1/2013 Tsai et al. 343/807

* cited by examiner

Primary Examiner — Dieu H Duong

(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 302 days.

(57) **ABSTRACT**

Mobile devices with conductive liquid antennas and related methods are provided. In this regard, a representative mobile device includes a first antenna having a first channel and a first liquid, the first channel defining a first interior volume, the first liquid being electrically conductive and located within the first channel, the first liquid further exhibiting a first volume smaller than the first interior volume; and a first antenna feed mounted such that, responsive to the device being in a first orientation, the first liquid electrically communicates with the first antenna feed.

20 Claims, 5 Drawing Sheets

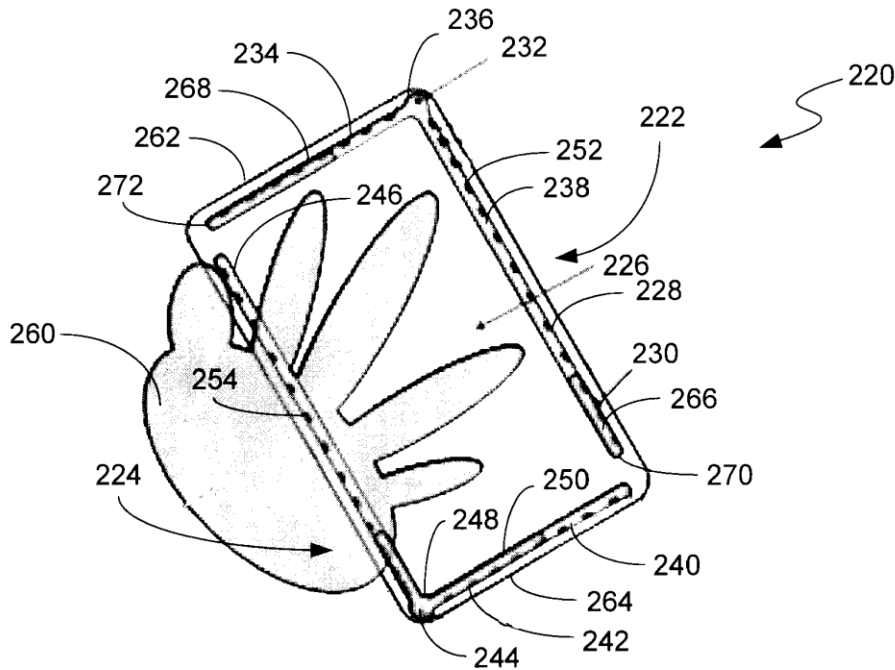
(21) Appl. No.: **13/684,262**

(22) Filed: **Nov. 23, 2012**

(65) **Prior Publication Data**

US 2014/0145899 A1 May 29, 2014

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 3/24 (2006.01)
H01Q 1/36 (2006.01)
H01Q 3/01 (2006.01)





US009024830B2

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

(10) **Patent No.:** **US 9,024,830 B2**
(45) **Date of Patent:** **May 5, 2015**

(54) **EYEGLASSES-TYPE WIRELESS COMMUNICATIONS APPARATUS**

(75) Inventors: **Yusuke Okajima**, Osaka (JP);
Tomofumi Katayama, Osaka (JP)

(73) Assignee: **Sharp Kabushiki Kaisha**, Osaka (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 289 days.

(21) Appl. No.: **13/876,385**

(22) PCT Filed: **Dec. 20, 2011**

(86) PCT No.: **PCT/JP2011/079437**
§ 371 (c)(1),
(2), (4) Date: **Mar. 27, 2013**

(87) PCT Pub. No.: **WO2012/086619**
PCT Pub. Date: **Jun. 28, 2012**

(65) **Prior Publication Data**
US 2013/0194141 A1 Aug. 1, 2013

(30) **Foreign Application Priority Data**
Dec. 22, 2010 (JP) 2010-286381

(51) **Int. Cl.**
H01Q 1/12 (2006.01)
H01Q 1/27 (2006.01)
G02C 11/00 (2006.01)
H01Q 9/26 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/273** (2013.01); **G02C 11/10**
(2013.01); **H01Q 9/26** (2013.01); **H01Q 9/42**
(2013.01); **H04B 1/385** (2013.01)

(58) **Field of Classification Search**

USPC 343/718, 793; 351/158
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,020,150 A * 5/1991 Shannon 455/343.1
2008/0055537 A1 * 3/2008 Asrani et al. 351/41
2012/0169990 A1 * 7/2012 Burnstein 351/115
2012/0215291 A1 * 8/2012 Pugh et al. 607/93
2013/0265169 A1 * 10/2013 Mates 340/686.1
2014/0194078 A1 * 7/2014 Hikino 455/90.2

FOREIGN PATENT DOCUMENTS

JP 55-8142 A 1/1980
JP 62-193220 U 12/1987
JP 4-211524 A 8/1992
JP 2007-174612 A 7/2007

OTHER PUBLICATIONS

English version of International Search Report dated Mar. 19, 2012.

* cited by examiner

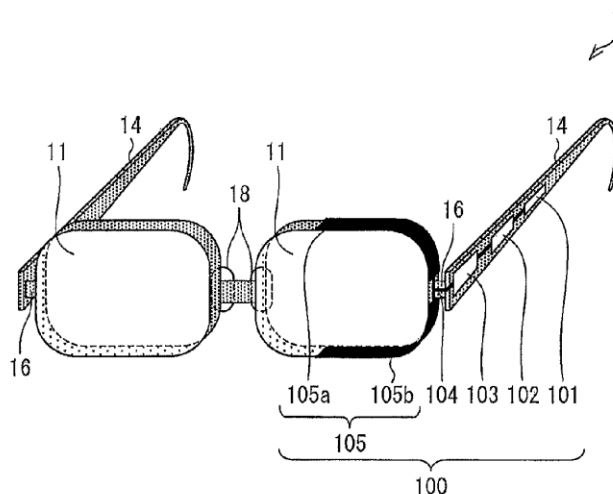
Primary Examiner — Tan Ho

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

(57) **ABSTRACT**

An eyeglasses-type wireless communications device includes: left and right eyepiece sections; pads; endpieces; temples; and an antenna element for carrying out wireless communications, and the antenna element is disposed in a region along an outer edge(s) of the right eyepiece section and/or the left eyepiece section, the region including corresponding one(s) of the endpieces but excluding connecting parts of the eyepiece sections which parts are connected to the respectively corresponding pads.

17 Claims, 9 Drawing Sheets





US009030358B2

(12) **United States Patent**
Chou

(10) **Patent No.:** **US 9,030,358 B2**
(45) **Date of Patent:** **May 12, 2015**

(54) **MINIATURE MULTI-FREQUENCY ANTENNA**

(56) **References Cited**

(75) Inventor: **Chih-Shen Chou**, Jhunan Township,
Miaoli County (TW)
(73) Assignee: **Unictron Technologies Corporation**,
Hsin-Chu (TW)
(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 369 days.

U.S. PATENT DOCUMENTS
6,867,736 B2 * 3/2005 Faraone et al. 343/700 MS
6,917,335 B2 * 7/2005 Kadambi et al. 343/700 MS
7,012,568 B2 * 3/2006 Desclos et al. 343/700 MS
7,012,570 B2 * 3/2006 Chen et al. 343/700 MS
2002/0122007 A1 * 9/2002 Jansen 343/702
2007/0171131 A1 * 7/2007 Sorvala et al. 343/700 MS
2008/0165063 A1 * 7/2008 Schlub et al. 343/702

(21) Appl. No.: **12/888,163**

* cited by examiner
Primary Examiner — Hoang V Nguyen
Assistant Examiner — Hai Tran
(74) *Attorney, Agent, or Firm* — Muncy, Geissler, Olds &
Lowe, P.C.

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

(65) **Prior Publication Data**
US 2011/0095947 A1 Apr. 28, 2011

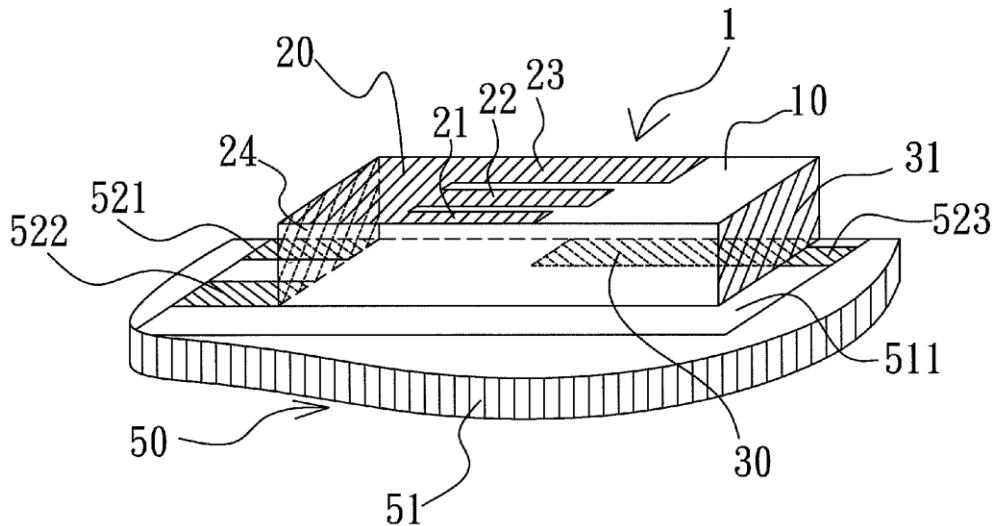
(57) **ABSTRACT**
A miniature multi-frequency antenna, comprising at least one dielectric substrate, at least one signal electrode and at least one ground electrode. The signal electrode and the ground electrode are disposed on a substrate. The signal electrode contains at least two branches and at least one branch is partially overlapped with the ground electrode. Each interlayer region between the partially overlapped electrodes forms a specific capacitance. By utilizing this interlayer capacitive effect, the resonant frequency of lower frequency band is achieved while the size of the antenna is effectively reduced. For obtaining the resonant frequency of the high frequency bands, the design concept of PIFA is applied on other branches of the signal electrode. A miniature antenna thus obtained is capable of transmitting/receiving multi-frequency signals having the benefits of easily adjusting impedance and resonant frequency.

(30) **Foreign Application Priority Data**
Oct. 23, 2009 (TW) 98219658 U

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 9/04 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 9/0421** (2013.01); **H01Q 5/371**
(2015.01)

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

17 Claims, 16 Drawing Sheets





US009030361B2

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

(10) **Patent No.:** **US 9,030,361 B2**
(45) **Date of Patent:** **May 12, 2015**

(54) **AUTOMATIC SIGNAL, SAR, AND HAC ADJUSTMENT WITH MODAL ANTENNA USING PROXIMITY SENSORS OR PRE-DEFINED CONDITIONS**

(71) Applicant: **Ethertronics, Inc.**, San Diego, CA (US)

(72) Inventors: **Laurent Desclos**, San Diego, CA (US);
Barry Matsumori, La Jolla, CA (US);
Sebastian Rowson, San Diego, CA (US);
Jeffrey Shamblin, San Marcos, CA (US)

(73) Assignee: **Ethertronics, Inc.**, 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 267 days.

(21) Appl. No.: **13/674,117**

(22) Filed: **Nov. 12, 2012**

(65) **Prior Publication Data**
US 2013/0127670 A1 May 23, 2013

Related U.S. Application Data

(63) Continuation-in-part of application No. 13/029,564, filed on Feb. 17, 2011, now Pat. No. 8,362,962, which is a continuation of application No. 12/043,090, filed on Mar. 5, 2008, now Pat. No. 7,911,402.

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 25/04 (2006.01)
H01Q 1/24 (2006.01)
H01Q 3/00 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 25/04** (2013.01); **H01Q 1/243** (2013.01); **H01Q 3/00** (2013.01); **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 25/04; H01Q 3/00; H01Q 9/0421
USPC 343/700 MS, 745, 815, 818, 834
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,166,694	A *	12/2000	Ying	343/702
6,326,921	B1 *	12/2001	Egorov et al.	343/700 MS
7,319,432	B2 *	1/2008	Andersson	343/702
7,834,813	B2 *	11/2010	Caimi et al.	343/745
2007/0241977	A1 *	10/2007	Vance	343/745

* cited by examiner

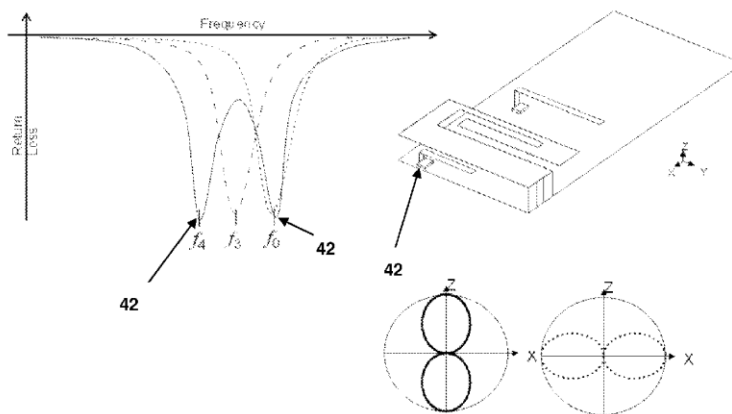
Primary Examiner — Tho G Phan

(74) *Attorney, Agent, or Firm* — Coastal Patent Law Group, P.C.

(57) **ABSTRACT**

A modal adaptive antenna system that dynamically samples proximity sensors or other sensors to determine the use case for the wireless device and then adjust the antenna radiating mode to optimize communication link performance. The modal adaptive antenna system is capable of modifying the antenna radiation pattern to improve communication link quality along with near-field parameters such as SAR and HAC. An algorithm and look-up table containing pre-measured electrical parameters to include TRP, TIS, and SAR are developed and integrated with hardware which includes an antenna and active components to dynamically modify the radiation pattern of the antenna as well as proximity sensors and or other sensing devices.

6 Claims, 10 Drawing Sheets





US009030368B2

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

(10) **Patent No.:** **US 9,030,368 B2**
(45) **Date of Patent:** **May 12, 2015**

(54) **ANTENNA**

(71) Applicant: **Wistron NeWeb Corporation**, Hsinchu (TW)

(72) Inventors: **Chung-Hung Chen**, Hsinchu (TW);
Chih-Sen Hsieh, Hsinchu (TW);
Chih-Ming Wang, Hsinchu (TW)

(73) Assignee: **Wistron NeWeb Corporation**, Hsinchu Science Park, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 211 days.

(21) Appl. No.: **13/919,990**

(22) Filed: **Jun. 17, 2013**

(65) **Prior Publication Data**
US 2014/0240190 A1 Aug. 28, 2014

(30) **Foreign Application Priority Data**
Feb. 27, 2013 (TW) 102107051 A

(51) **Int. Cl.**
H01Q 11/00 (2006.01)
H01Q 5/00 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/0027** (2013.01); **H01Q 5/307** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/0027; H01Q 5/307
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,681,053	B2 *	3/2014	Nagoshi et al.	343/700	MS
2008/0169981	A1 *	7/2008	Hotta et al.	343/700	MS
2011/0043408	A1 *	2/2011	Shi et al.	343/700	MS
2012/0105292	A1 *	5/2012	Wong et al.	343/749	
2012/0176291	A1 *	7/2012	Hsueh	343/843	
2012/0274517	A1 *	11/2012	Nagoshi et al.	343/700	MS
2012/0293376	A1 *	11/2012	Hung et al.	343/702	
2012/0299779	A1 *	11/2012	Yen et al.	343/700	MS
2012/0299780	A1 *	11/2012	Hsieh et al.	343/700	MS

* cited by examiner

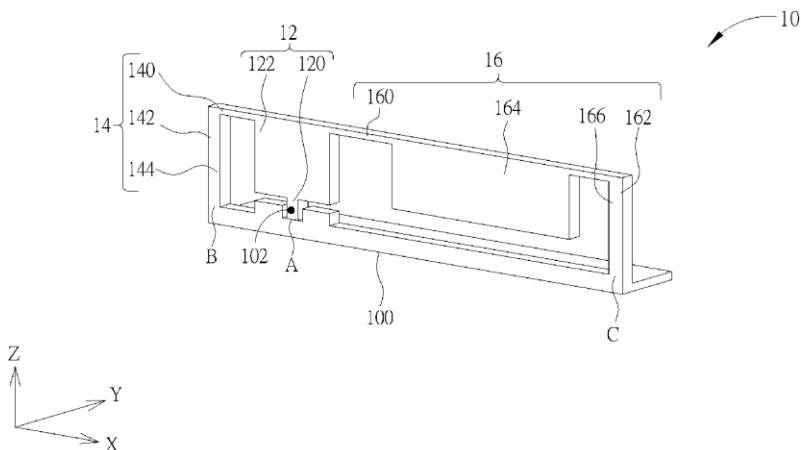
Primary Examiner — Trinh Dinh

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

(57) **ABSTRACT**

An antenna for receiving radio signals of at least a first frequency band and a second frequency band includes a grounding unit for providing grounding, a connecting unit electrically connected to a first terminal of the grounding unit, a feeding terminal, formed on the connecting unit, for transmitting the radio signals of the first frequency band and the second frequency band, a first radiating element electrically connected between the connecting unit and a second terminal of the grounding unit, and a second radiating element electrically connected between the connecting unit and a third terminal of the grounding unit. Lengths of signal routes from the feeding terminal through the first radiating element and the second radiating element to the grounding unit are substantially equal to a half wavelength of the radio signals of the first frequency band and a half wavelength of the radio signals of the second frequency band, respectively.

13 Claims, 27 Drawing Sheets





US009035830B2

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

(10) **Patent No.:** **US 9,035,830 B2**
(45) **Date of Patent:** **May 19, 2015**

(54) **ANTENNA ARRANGEMENT**
(71) Applicant: **Nokia Corporation**, Espoo (FI)
(72) Inventors: **Mikko S. Komulainen**, Oulu (FI); **Sami Hienonen**, Oulu (FI); **Tommi Lepisto**, Kempele (FI)

7,307,591 B2 12/2007 Zheng 343/702
7,696,928 B2* 4/2010 Rowell 343/700 MS
7,701,401 B2* 4/2010 Suzuki et al. 343/702
7,830,320 B2* 11/2010 Shamblin et al. 343/747
7,864,117 B2* 1/2011 Aurinsalo et al. 343/700 MS
2003/0193437 A1 10/2003 Kangasvieri et al. 343/702
2006/0038736 A1 2/2006 Hui et al. 343/835

(Continued)

(73) Assignee: **Nokia Technologies Oy**, Espoo (FI)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 199 days.

FOREIGN PATENT DOCUMENTS

EP 1 760 833 A1 3/2007
GB 2 396 484 A 6/2004

(Continued)

(21) Appl. No.: **13/630,018**

OTHER PUBLICATIONS

(22) Filed: **Sep. 28, 2012**

Chebihi et al., "A Novel Isolation Technique for Closely Spaced PIFAs for UMTS Mobile Phones", IEEE Antennas and Wireless Propagation Letters, vol. 7, 2008, pp. 665-669.

(Continued)

(65) **Prior Publication Data**
US 2014/0091981 A1 Apr. 3, 2014

Primary Examiner — Tho G Phan
(74) *Attorney, Agent, or Firm* — Harrington & Smith

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 1/52 (2006.01)
H01Q 21/28 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)

(57) **ABSTRACT**

An apparatus for antenna arrangement isolation is described. The apparatus includes a first antenna element (for example, a CMMB TV antenna) having a first radiator component and a second antenna element (for example, a cellular antenna) having a second radiator component. A first portion of the first radiator component is adjacent to a second portion of the second radiator component. The second radiator component is configured with at least one operational frequency range. The first portion of the first radiator corresponds to at least one minimum electric field region of at least one resonant frequency of the first radiator. The at least one resonant frequency of the first radiator overlaps with the at least one operational frequency range. Methods, Apparatus and Computer readable media for providing the antenna arrangement are also described.

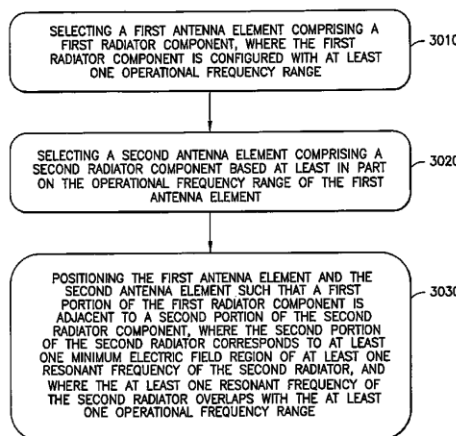
(52) **U.S. Cl.**
CPC **H01Q 21/28** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/521** (2013.01); **H01Q 5/371** (2015.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/00; H01Q 5/01
USPC 343/700 MS, 702, 829, 846, 893
See application file for complete search history.

(56) **References Cited**
U.S. PATENT DOCUMENTS

4,584,585 A * 4/1986 Marko et al. 343/702
5,173,715 A * 12/1992 Rodal et al. 343/795

26 Claims, 29 Drawing Sheets





US009035832B2

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

(10) **Patent No.:** **US 9,035,832 B2**
(45) **Date of Patent:** **May 19, 2015**

(54) **MOBILE COMMUNICATION DEVICE WITH IMPROVED ANTENNA PERFORMANCE**

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

(75) Inventors: **Pasi Tikka**, Munich (DE); **Pasi Lehtonen**, Rusko (FI); **Juha Ella**, Halikko (FI)

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,411,557 B2	8/2008	Shimizu et al.	
7,505,006 B2	3/2009	Ollikainen et al.	
7,782,261 B2*	8/2010	An et al.	343/702
7,940,223 B2*	5/2011	Dou et al.	343/702
2010/0081407 A1	4/2010	Adler et al.	

(73) Assignee: **EPCOS AG**, Munich (DE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 329 days.

FOREIGN PATENT DOCUMENTS

EP	1 763 152 A1	3/2007
EP	2 109 230 A1	10/2009
JP	2004-072605 A	3/2004

(Continued)

OTHER PUBLICATIONS

Ollikainen, J., "Design and Implementation Techniques of Wideband Mobile Communications Antennas," Dissertation, Helsinki University of Technology Radio Laboratory Publications, Report S 266, Nov. 2004, 70 pages.

Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — Slater & Matsil, L.L.P.

(21) Appl. No.: **13/643,915**

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

(86) PCT No.: **PCT/EP2010/055549**

§ 371 (c)(1),
(2), (4) Date: **Dec. 28, 2012**

(87) PCT Pub. No.: **WO2011/134492**

PCT Pub. Date: **Nov. 3, 2011**

(65) **Prior Publication Data**

US 2013/0120219 A1 May 16, 2013

(57) **ABSTRACT**

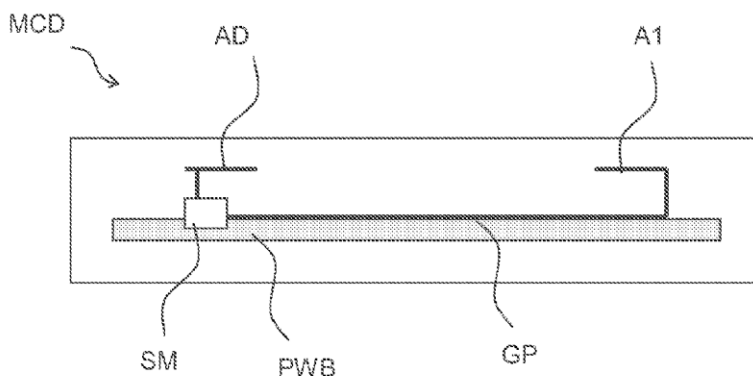
Mobile communication devices with improved antenna performance are provided. A mobile communication device includes a first antenna, a ground plane, and a diversity antenna. In a mode of operation which is not a multi-antenna transmission mode, the diversity antenna is electrically coupled to the ground plane. The diversity antenna increases the electrical length of the ground plane and enhances the antenna performance of the radiating assembly of the first antenna in combination with the ground antenna and the diversity antenna.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 21/00 (2006.01)
H01Q 21/28 (2006.01)
H04B 7/06 (2006.01)
H04B 7/08 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 21/00** (2013.01); **H01Q 1/243** (2013.01); **H01Q 21/28** (2013.01); **H04B 7/0613** (2013.01); **H04B 7/0825** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 21/00; H01Q 21/28

11 Claims, 4 Drawing Sheets





US009035833B2

(12) **United States Patent**
Zhang

(10) **Patent No.:** **US 9,035,833 B2**

(45) **Date of Patent:** **May 19, 2015**

(54) **FIVE-BAND BLUETOOTH BUILT-IN ANTENNA AND ITS MOBILE COMMUNICATION TERMINAL**

(75) Inventor: **Lian Zhang**, Guangdong (CN)

(73) Assignee: **HUIZHOU TCL MOBILE COMMUNICATION CO., LTD.**, Huizhou, Guangdong (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 241 days.

(21) Appl. No.: **13/810,801**

(22) PCT Filed: **Nov. 5, 2011**

(86) PCT No.: **PCT/CN2011/081836**

§ 371 (c)(1),
(2), (4) Date: **Jan. 17, 2013**

(87) PCT Pub. No.: **WO2012/071968**

PCT Pub. Date: **Jun. 7, 2012**

(65) **Prior Publication Data**

US 2013/0115884 A1 May 9, 2013

(30) **Foreign Application Priority Data**

Dec. 1, 2010 (CN) 2010 1 0568400

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 13/10 (2006.01)
H01Q 9/04 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 13/10** (2013.01); **H01Q 1/243** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 21/30** (2013.01); **H04B 7/00** (2013.01); **H01Q 5/357** (2015.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 5/0051; H01Q 7/00; H01Q 13/10; H01Q 21/30; H01Q 9/0421
USPC 343/702, 700 MS, 846, 848
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,985,108 B2 * 1/2006 Mikkola et al. 343/700 MS
7,352,327 B2 * 4/2008 Yeh et al. 343/700 MS

(Continued)

FOREIGN PATENT DOCUMENTS

CN 1495966 A 5/2004
CN 101662067 A 3/2010

(Continued)

OTHER PUBLICATIONS

"Internal Hybrid Antenna for Multiband Operation in the Mobile Phone", Chun-I Lin, Microwave and Optical Technology Letters, vol. 50, Issue 1, pp. 38-42, Jan. 2008.

(Continued)

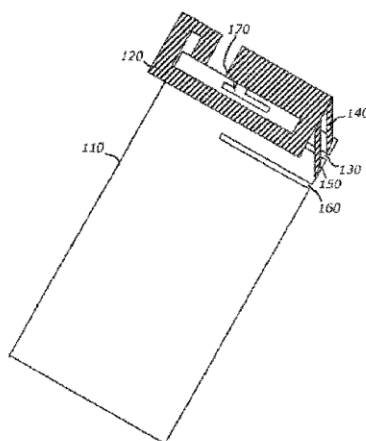
Primary Examiner — Hoanganh Le

(74) *Attorney, Agent, or Firm* — Shimokaji & Associates P.C.

(57) **ABSTRACT**

A five-band Bluetooth built-in antenna and its mobile communication terminal provide bandwidth for communication. A built-in antenna comprises an antenna radiation unit and a first slot, a second slot and a third slot. Slots are added to approach a center frequency of a low-frequency branch part of the antenna so that the antenna generates resonance, so the low-frequency bandwidth of the antenna is increased. A high-frequency part of the antenna generates resonance by means of capacitive coupling.

20 Claims, 3 Drawing Sheets





US009035836B2

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

(10) **Patent No.:** **US 9,035,836 B2**
(45) **Date of Patent:** **May 19, 2015**

(54) **SUPERIMPOSED MULTIMODE ANTENNA FOR ENHANCED SYSTEM FILTERING**

(71) Applicant: **Ethertronics, Inc.**, San Diego, CA (US)

(72) Inventors: **Laurent Desclos**, San Diego, CA (US); **Sebastian Rowson**, San Diego, CA (US); **Jeffrey Shamblin**, San Marcos, CA (US)

(73) Assignee: **Ethertronics, Inc.**, 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 268 days.

(21) Appl. No.: **13/674,100**

(22) Filed: **Nov. 12, 2012**

(65) **Prior Publication Data**

US 2013/0141293 A1 Jun. 6, 2013

Related U.S. Application Data

(63) Continuation-in-part of application No. 13/029,564, filed on Feb. 17, 2011, now Pat. No. 8,362,962, which is a continuation of application No. 12/043,090, filed on Mar. 5, 2008, now Pat. No. 7,911,402, application No. 13/674,100, which is a continuation-in-part of application No. 13/289,901, filed on Nov. 4, 2011, now Pat. No. 8,717,241, which is a continuation of application No. 12/894,052, filed on Sep. 29, 2010, now Pat. No. 8,077,116, which is a continuation of application No. 11/841,207, filed on Aug. 20, 2007, now Pat. No. 7,830,320.

(51) **Int. Cl.**
H01Q 9/38 (2006.01)
H01Q 9/06 (2006.01)
H01Q 1/24 (2006.01)
H01Q 3/00 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/06** (2013.01); **H01Q 1/243** (2013.01); **H01Q 3/00** (2013.01); **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 3/00
USPC 343/700 MS, 745, 815, 816, 834
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,326,921 B1 *	12/2001	Egorov et al.	343/700 MS
6,429,818 B1 *	8/2002	Johnson et al.	343/702
6,614,400 B2 *	9/2003	Egorov	343/702
6,765,536 B2 *	7/2004	Phillips et al.	343/702
6,950,065 B2 *	9/2005	Ying et al.	343/700 MS
7,081,854 B2 *	7/2006	Ying et al.	343/702

* cited by examiner

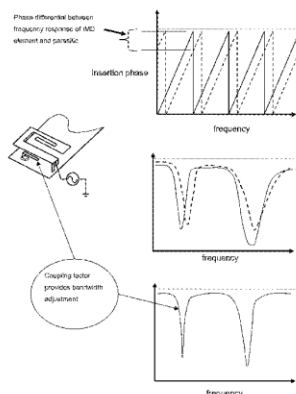
Primary Examiner — Tho G Phan

(74) *Attorney, Agent, or Firm* — Coastal Patent Law Group, P.C.

(57) **ABSTRACT**

In a typical system a combination of filters (BAW, SAW, etc) and an antenna are configured to achieve frequency filtering effect and efficient transmission and reception of communication signals. Wireless communication systems require specific bandwidth and out-of-band rejection; typically this metric is characterized in frequency roll-off in units of dB/MHz. This number is distributed between the antenna and filter, with the antenna contributing little to date to the filtering effect. Loss and cost penalties are incurred when multi-mode systems are designed which require additional rejection from the filter elements. Described here is a method of designing antennas to reduce the amount of rejection and complexity from the filter system. A superposition of a symmetrical frequency response from the antenna structure coupled with a non-symmetrical frequency response from a counterpoise structure generates increased rejection of out-of-band components.

7 Claims, 17 Drawing Sheets





US009035837B2

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

(10) **Patent No.:** **US 9,035,837 B2**
(45) **Date of Patent:** **May 19, 2015**

(54) **BUILT-IN ANTENNA FOR ELECTRONIC DEVICE**

(71) Applicant: **Samsung Electronics Co., Ltd.**,
Gyeonggi-do (KR)

(72) Inventors: **Yong-Soo Kwak**, Gyeonggi-do (KR);
A-Hyun Sin, Gyeonggi-do (KR);
Dong-Hyun Lee, Ulsan (KR);
Seong-Tae Jeong, Gyeonggi-do (KR);
Joon-Ho Byun, Gyeonggi-do (KR)

(73) Assignee: **Samsung Electrics Co., Ltd.**,
Yeongtong-gu, Suwon-si, Gyeonggi-do
(KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 180 days.

(21) Appl. No.: **13/747,829**

(22) Filed: **Jan. 23, 2013**

(65) **Prior Publication Data**
US 2013/0234903 A1 Sep. 12, 2013

(30) **Foreign Application Priority Data**
Mar. 9, 2012 (KR) 10-2012-0024590

(51) **Int. Cl.**
H01Q 9/00 (2006.01)
H01Q 5/00 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/0034** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 5/0058** (2013.01); **H01Q 9/42**
(2013.01)

(58) **Field of Classification Search**
USPC 343/700 MS, 702, 745, 749
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,012,570	B2 *	3/2006	Chen et al.	343/700 MS
8,279,121	B2 *	10/2012	Ishizuka et al.	343/700 MS
8,643,558	B2 *	2/2014	Tseng et al.	343/750
2005/0168384	A1	8/2005	Wang et al.	
2010/0053007	A1 *	3/2010	Ni et al.	343/745
2011/0199272	A1 *	8/2011	He et al.	343/741
2012/0105292	A1 *	5/2012	Wong et al.	343/749
2012/0146865	A1	6/2012	Hayashi et al.	

FOREIGN PATENT DOCUMENTS

KR 10-2009-0049513 A 5/2009

* cited by examiner

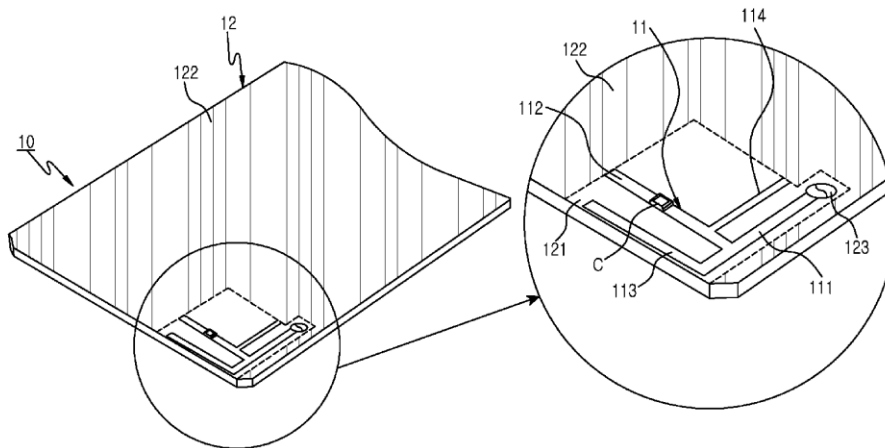
Primary Examiner — Tan Ho

(74) *Attorney, Agent, or Firm* — Cha & Reiter, LLC

(57) **ABSTRACT**

A built-in antenna apparatus for a electronic device is provided. The antenna apparatus comprises a PCB with conductive and non-conductive areas. An antenna radiator is disposed at the non-conductive area of the PCB; the antenna radiator has a feeding portion and at least a first radiating portion configured in a first pattern branched from the feeding portion and has an end portion electrically connected to the conductive area. At least one capacitor is electrically connected in series within the first radiating portion. A resonant frequency of the first radiating portion is a function of a capacitance value of the at least one capacitor. The antenna can be provided in a smaller size for a given frequency band due to the capacitance. A second antenna radiator branched from the feeding portion can also be provided for operation at a different frequency band.

20 Claims, 9 Drawing Sheets





US009035840B1

(12) **United States Patent**
Lee

(10) **Patent No.:** **US 9,035,840 B1**
(45) **Date of Patent:** **May 19, 2015**

(54) **DUAL-BAND ANTENNA WITH GROUNDED PATCH AND COUPLED FEED**

6,404,395 B1 *	6/2002	Masuda	343/702
7,256,741 B2 *	8/2007	Wen et al.	343/700 MS
7,427,957 B2 *	9/2008	Zeinolabedin Rafi et al.	343/700 MS
2002/0101381 A1 *	8/2002	Segerstedt	343/702
2003/0076268 A1 *	4/2003	Tarvas et al.	343/702
2005/0146475 A1 *	7/2005	Bettner et al.	343/767
2006/0061512 A1 *	3/2006	Asano et al.	343/702

(75) Inventor: **Tzung-I Lee**, San Jose, CA (US)

(73) Assignee: **Amazon Technologies, Inc.**, Reno, NV (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 192 days.

OTHER PUBLICATIONS

The A.R.R.L. Antenna Book, American Radio Relay League, 1988, pp. 2-24 to 2-25.*

* cited by examiner

(21) Appl. No.: **13/419,634**

(22) Filed: **Mar. 14, 2012**

(51) **Int. Cl.**
H01Q 13/10 (2006.01)
H01Q 9/04 (2006.01)
H01Q 5/01 (2006.01)

Primary Examiner — Robert Karacsony
Assistant Examiner — Daniel J Munoz
(74) *Attorney, Agent, or Firm* — Lowenstein Sandler LLP

(52) **U.S. Cl.**
CPC **H01Q 13/10** (2013.01); **H01Q 9/0471** (2013.01)

(57) **ABSTRACT**

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 1/243; H01Q 9/0407; H01Q 13/10; H01Q 9/0471
USPC 343/700 MS, 702, 770
See application file for complete search history.

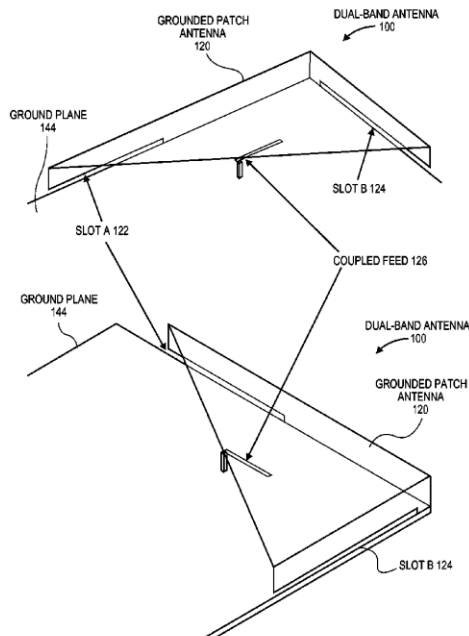
Methods and systems for radiating electromagnetic energy with a patch antenna structure are described. The patch antenna structure may be formed of a metal member of the user device and is coupled to a ground plane in a first plane and is coupled to a radio frequency (RF) feed) at a portion of the patch antenna structure disposed in a second plane. The patch antenna structure is configured to radiate at an opening between the patch antenna and the ground plane.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,229,777 A *	7/1993	Doyle	343/700 MS
6,400,322 B2 *	6/2002	Fang et al.	343/700 MS

22 Claims, 7 Drawing Sheets





US009035841B2

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

(10) **Patent No.:** **US 9,035,841 B2**
(45) **Date of Patent:** **May 19, 2015**

(54) **COMMUNICATION ELECTRONIC DEVICE AND ANTENNA STRUCTURE THEREOF**

(75) Inventors: **Kin-Lu Wong**, New Taipei (TW);
Wun-Jian Lin, New Taipei (TW)

(73) Assignee: **ACER INCORPORATED**, Xizhi Dist.
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 718 days.

(21) Appl. No.: **13/115,999**

(22) Filed: **May 26, 2011**

(65) **Prior Publication Data**
US 2012/0256802 A1 Oct. 11, 2012

(30) **Foreign Application Priority Data**
Apr. 8, 2011 (TW) 100112294 A

(51) **Int. Cl.**
H01Q 13/10 (2006.01)
H01Q 1/22 (2006.01)
H01Q 5/00 (2006.01)
H01Q 21/30 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/2266** (2013.01); **H01Q 5/0072** (2013.01); **H01Q 13/106** (2013.01); **H01Q 21/30** (2013.01)

(58) **Field of Classification Search**
USPC 343/767-771
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2005/0200545	A1	9/2005	Bancroft	
2009/0153409	A1	6/2009	Chiang	
2009/0153411	A1*	6/2009	Chiang et al.	343/702
2010/0073242	A1*	3/2010	Ayala Vazquez et al.	343/702

FOREIGN PATENT DOCUMENTS

CN	1930731	A	3/2007
CN	1947446	A	4/2007
CN	201191648	Y	2/2009
CN	100556165	C	10/2009
CN	101662067	A	3/2010
EP	2 157 659	A1	2/2010

* cited by examiner

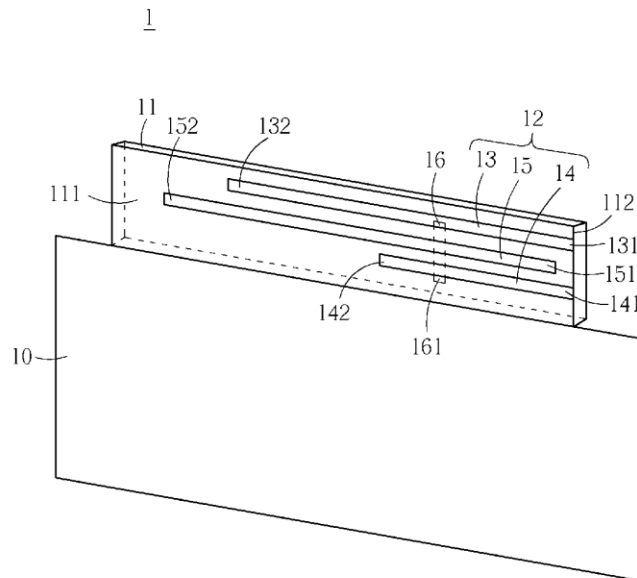
Primary Examiner — Matthew Mikels

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

(57) **ABSTRACT**

A communication electronic device which comprises a grounding element and a slot antenna is provided. The slot antenna is formed by a feeding element, a first slot, a second slot, and a third slot. The first slot is an open slot, which has an open end at the first side edge and a closed end extended toward the interior of the electrical conductor. The second slot is an open slot, which also has an open end at the first side edge and a closed end extended toward the interior of the electrical conductor. The second slot is substantially parallel to the first slot and is closer than the first slot to the grounding element. The third slot is a closed slot, whose two closed ends are all in the interior of the electrical conductor. The third slot is aligned between the first slot and the second slot.

16 Claims, 4 Drawing Sheets





US009035847B2

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

(10) **Patent No.:** **US 9,035,847 B2**
(45) **Date of Patent:** **May 19, 2015**

(54) **ANTENNA PATTERN FRAME AND MOLD FOR MANUFACTURING ELECTRONIC DEVICE CASE INCLUDING THE SAME**

USPC 343/702, 873; 425/116
See application file for complete search history.

(75) Inventors: **Ha Ryong Hong**, Gyeonggi-do (KR); **Sung Eun Cho**, Gyeonggi-do (KR); **Dae Kyu Lee**, Gyeonggi-do (KR); **Chan Gwang An**, Gyeonggi-do (KR); **Jae Suk Sung**, Gyeonggi-do (KR); **Ki Won Chang**, Gyeonggi-do (KR); **Dae Ki Lim**, Gyeonggi-do (KR); **Chang Mok Han**, Chungcheongnam-do (KR); **Hyun Do Park**, Gyeonggi-do (KR)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,427,615 A 1/1984 Eskesen
6,396,444 B1 5/2002 Goward et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 1363967 8/2002
EP 0500219 A1 8/1992
(Continued)

OTHER PUBLICATIONS

European Search Report in 11250206.7 issued on Jul. 8, 2011.
(Continued)

(73) Assignee: **SAMSUNG ELECTRO-MECHANICS CO., LTD.**, Suwon, Gyeonggi-Do (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 462 days.

(21) Appl. No.: **13/027,345**

(22) Filed: **Feb. 15, 2011**

(65) **Prior Publication Data**

US 2011/0205141 A1 Aug. 25, 2011

(30) **Foreign Application Priority Data**

Feb. 25, 2010 (KR) 10-2010-0017247

(51) **Int. Cl.**
H01Q 1/40 (2006.01)
H01Q 1/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **B29C 45/1671** (2013.01); **B29C 45/006** (2013.01); **B29C 45/14065** (2013.01); **B29C 45/14639** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC B29C 45/14065; H01Q 1/38

Primary Examiner — Dameon E Levi
Assistant Examiner — Ricardo Magallanes
(74) *Attorney, Agent, or Firm* — McDermott Will & Emery LLP

(57) **ABSTRACT**

There is provided an antenna pattern frame including: a radiator comprising an antenna pattern portion transmitting and receiving a signal and a connection terminal portion allowing the signal to be transmitted to and received from a circuit board of an electronic device; and a radiator frame manufactured by injection molding on the radiator, allowing the antenna pattern portion to be embedded in a case of the electronic device, and supporting the radiator. The radiator frame includes a hydraulic recess introducing a resin material to a mold for manufacturing a case of the electronic device in which the radiator is embedded through injection molding, so that the radiator frame contacts the mold by injection pressure.

6 Claims, 9 Drawing Sheets

