



US009722294B2

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

(10) **Patent No.:** **US 9,722,294 B2**

(45) **Date of Patent:** **Aug. 1, 2017**

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

USPC 343/702, 872, 878, 700 MS
See application file for complete search history.

(71) Applicant: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)

(56) **References Cited**

U.S. PATENT DOCUMENTS

(72) Inventors: **Jin-Bo Chen**, New Taipei (TW);
Cho-Kang Hsu, New Taipei (TW)

4,329,689	A *	5/1982	Yee		H01Q 5/385
					343/700 MS
6,380,903	B1 *	4/2002	Hayes		H01Q 1/243
					343/700 MS
6,421,011	B1 *	7/2002	Van Egmond		H01Q 1/42
					343/700 MS
6,573,869	B2 *	6/2003	Moore		H01Q 1/243
					343/700 MS
6,670,925	B2 *	12/2003	Iwai		H01Q 9/0414
					343/700 MS
7,339,528	B2 *	3/2008	Wang		H01Q 1/243
					343/700 MS
2004/0058723	A1 *	3/2004	Mikkola		H01Q 9/042
					455/575.7
2012/0188144	A1 *	7/2012	Chen		H01Q 9/42
					343/893

(73) Assignee: **Chiun Mai Communication Systems, Inc.**, 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 158 days.

(21) Appl. No.: **14/464,353**

(22) Filed: **Aug. 20, 2014**

(65) **Prior Publication Data**

US 2015/0054694 A1 Feb. 26, 2015

* cited by examiner

(30) **Foreign Application Priority Data**

Aug. 22, 2013 (CN) 2013 1 03672504

Primary Examiner — Dameon E Levi

Assistant Examiner — Collin Dawkins

(74) *Attorney, Agent, or Firm* — Steven Reiss

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 1/12 (2006.01)

H01Q 9/04 (2006.01)

H01Q 5/378 (2015.01)

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

CPC **H01Q 1/1207** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/378** (2015.01); **H01Q 9/0421** (2013.01)

(57) **ABSTRACT**

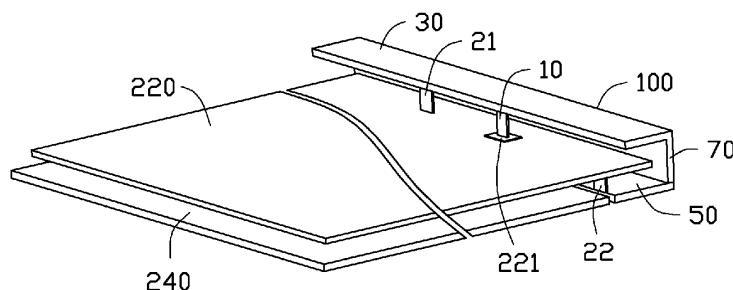
An antenna structure includes a feed end, a first ground end, a first antenna, a second ground end, a second antenna, and a holder. The first antenna is connected to the feed end and the first ground end. The second antenna is a parasitic antenna, the second antenna is connected to the second ground end, and is opposite to the first antenna. The holder is connected between the first antenna and a second antenna.

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/38; H01Q 9/0421; H01Q 1/42

10 Claims, 3 Drawing Sheets

200





US009722299B2

(12) **United States Patent**
Lin

(10) **Patent No.:** **US 9,722,299 B2**
(45) **Date of Patent:** **Aug. 1, 2017**

(54) **ANTENNA ASSEMBLY, WIRELESS COMMUNICATION DEVICE AND METHOD OF MANUFACTURING SAME**

(71) Applicant: **FIH (Hong Kong) Limited**, Kowloon (HK)
(72) Inventor: **Po-Chih Lin**, New Taipei (TW)
(73) Assignee: **FIH (Hong Kong) Limited**, Kowloon (HK)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 652 days.

(21) Appl. No.: **14/093,062**
(22) Filed: **Nov. 29, 2013**

(65) **Prior Publication Data**
US 2014/0340266 A1 Nov. 20, 2014

(30) **Foreign Application Priority Data**
May 16, 2013 (TW) 102117454 A

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 9/42** (2013.01); **Y10T 29/49016** (2015.01)
(58) **Field of Classification Search**
CPC H01Q 1/2258; H01Q 1/2266; H01Q 1/24; H01Q 1/241; H01Q 1/243; H01Q 9/30; H01Q 9/42; H01Q 9/0407; H01Q 9/0421; H01Q 9/045; H01Q 9/0471
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,812,899 B2 * 11/2004 Moren H01Q 1/243 343/702
6,853,336 B2 * 2/2005 Asano H01Q 1/22 343/702
6,856,285 B2 * 2/2005 Bettin H01Q 1/243 343/700 MS
7,064,719 B2 * 6/2006 Wu H01Q 1/243 343/702
7,183,980 B2 * 2/2007 Chang H01Q 1/243 343/700 MS
7,626,551 B2 * 12/2009 Chien H01Q 5/371 343/700 MS

FOREIGN PATENT DOCUMENTS

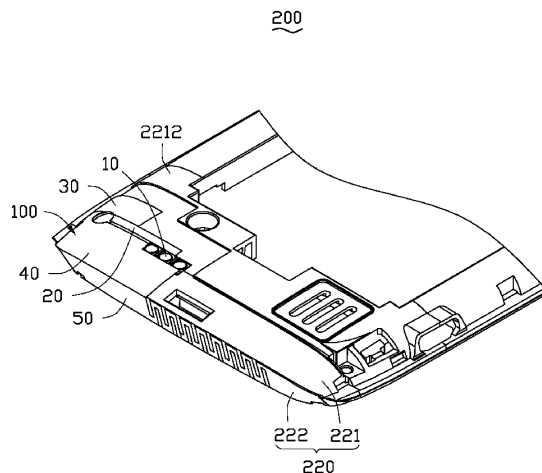
FI WO 2004109847 A1 * 12/2004 H01Q 1/241
* cited by examiner

Primary Examiner — Tho G Phan
Assistant Examiner — Patrick Holecek
(74) *Attorney, Agent, or Firm* — Steven Reiss

(57) **ABSTRACT**

An antenna assembly includes a holder having a first surface and a second surface opposite from the first surface. The antenna assembly defines a number of holes through the first surface and the second surface. A number of connectors are correspondingly received and secured in the holes. The connectors includes an elastic thimble portion on one end. An antenna module is formed on the holder. One end of the connectors connects to the antenna module, while the end with elastic thimble protrudes from the second surface for connecting to a circuit board. A wireless communication device employing the antenna assembly and a method of manufacturing the wireless communication device are also disclosed.

4 Claims, 5 Drawing Sheets





US009722300B2

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

(10) **Patent No.:** **US 9,722,300 B2**

(45) **Date of Patent:** **Aug. 1, 2017**

(54) **ANTENNA MODULE AND MOBILE
TERMINAL USING THE SAME**

(56) **References Cited**

U.S. PATENT DOCUMENTS

(71) Applicant: **LG ELECTRONICS INC.**, Seoul
(KR)

2011/0267245 A1 11/2011 Park et al.
2013/0069842 A1 3/2013 Lee et al.

(Continued)

(72) Inventors: **Hyengcheul Choi**, Seoul (KR);
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FOREIGN PATENT DOCUMENTS

(73) Assignee: **LG ELECTRONICS INC.**, Seoul
(KR)

EP 2500979 9/2012
EP 2629361 8/2013

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 266 days.

OTHER PUBLICATIONS

European Patent Office Application Serial No. 15001355.5, Search
Report dated Sep. 21, 2016, 12 pages.

(Continued)

(21) Appl. No.: **14/702,512**

(22) Filed: **May 1, 2015**

Primary Examiner — Joseph Lauture

(65) **Prior Publication Data**

US 2016/0164167 A1 Jun. 9, 2016

(74) *Attorney, Agent, or Firm* — Lee Hong Degerman
Kang & Waimey

(30) **Foreign Application Priority Data**

Dec. 9, 2014 (KR) 10-2014-0176142

(57) **ABSTRACT**

The present disclosure relates to an antenna module and a mobile terminal having the same, and the antenna module may include a conductive member, a first conductive arm formed at one side of the conductive member to form a first loop along with the conductive member so as to implement a first resonant frequency, a second conductive arm formed at the other side of the conductive member to form a second loop along with the conductive member so as to implement a second resonant frequency different from the first resonant frequency, a first feeding portion formed adjacent to the first conductive arm to feed the first conductive arm and conductive member, and a second feeding portion formed adjacent to the second conductive arm to feed the second conductive arm and conductive member.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 7/00 (2006.01)

(Continued)

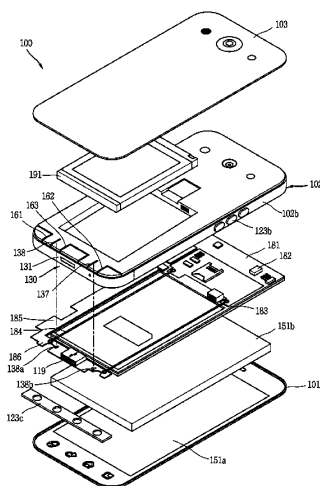
(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/52**
(2013.01); **H01Q 1/521** (2013.01); **H01Q 5/35**
(2015.01);

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(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 7/00; H01Q 1/38; H01Q
1/48; H01Q 3/26

(Continued)

29 Claims, 14 Drawing Sheets





US009722301B2

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

(10) **Patent No.:** **US 9,722,301 B2**

(45) **Date of Patent:** **Aug. 1, 2017**

(54) **ANTENNA DEVICE AND ELECTRONIC
DEVICE INCLUDING THE SAME**

(71) Applicant: **SAMSUNG ELECTRONICS CO.,
LTD.**, Suwon-si, Gyeonggi-do (KR)

(72) Inventors: **Kyung Bin Kim**, Hwaseong-si (KR);
Jinu Kim, Seoul (KR); **Byeonghwan
Youn**, Suwon-si (KR); **Gi-Uk Gang**,
Suwon-si (KR); **Nak-Chung Choi**,
Seoul (KR)

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

(21) Appl. No.: **15/256,926**

(22) Filed: **Sep. 6, 2016**

(65) **Prior Publication Data**

US 2017/0133748 A1 May 11, 2017

(30) **Foreign Application Priority Data**

Nov. 6, 2015 (KR) 10-2015-0155861

(51) **Int. Cl.**
H05K 5/02 (2006.01)
H01Q 1/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H05K 5/006**
(2013.01); **H05K 5/0017** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC .. H05K 5/2017; H05K 5/0239; H05K 5/0243;
H05K 5/0247
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,283,104 A 2/1994 Aoude et al.
6,458,670 B2 10/2002 Nagasaka

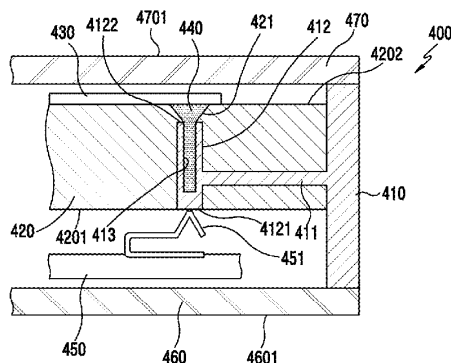
Primary Examiner — Jeremy C Norris

(74) *Attorney, Agent, or Firm* — Nixon & Vanderhye,
P.C.

(57) **ABSTRACT**

Various embodiments of the present disclosure may provide an electronic device that includes: a first cover configured to form a first surface of the electronic device; a second cover configured to form a second surface of the electronic device, the second cover being opposite to the first surface; a conductive sidewall configured to surround at least a part of a space formed between the first cover and the second cover; a conductive member located in the space and configured to integrally extend from the conductive sidewall, the conductive member including a first surface directed toward the first cover and a second surface directed toward the second cover; a non-conductive member located in the space to make contact with the conductive member, the non-conductive member including a first surface directed toward the first cover and a second surface directed toward the second cover; a conductive pattern disposed on the second surface of the non-conductive member and electrically connected to the conductive member; and a conductive structure disposed between the conductive pattern and the conductive member to electrically connect the conductive pattern to the conductive member. The non-conductive member may include a via hole that at least partially passes through the area between the first surface and the second surface thereof, and the conductive structure may include a first part having a first cross-sectional area and a second part having a second cross-sectional area that is larger than the first cross-sectional area, wherein at least a part of the conductive structure may be disposed within a through-hole of the non-conductive member, and the second part may be disposed closer to the second surface of the non-conductive member than the first part. Various other embodiments are possible.

20 Claims, 24 Drawing Sheets





US009722307B2

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

(10) **Patent No.:** **US 9,722,307 B2**
(45) **Date of Patent:** **Aug. 1, 2017**

(54) **TERMINAL ANTENNA STRUCTURE AND TERMINAL**

(71) Applicant: **Huawei Device Co., Ltd.**, Shenzhen (CN)

(72) Inventors: **Lintao Jiang**, Shenzhen (CN); **Yi Fan**, Shenzhen (CN); **Yao Lan**, Shenzhen (CN); **Jie Qi**, Shenzhen (CN)

(73) Assignee: **Huawei Device 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 260 days.

(21) Appl. No.: **14/529,494**

(22) Filed: **Oct. 31, 2014**

(65) **Prior Publication Data**

US 2015/0214601 A1 Jul. 30, 2015

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2014/084581, filed on Aug. 18, 2014.

(30) **Foreign Application Priority Data**

Jan. 26, 2014 (CN) 2014 1 0038405

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/50 (2006.01)
H01P 1/00 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/50** (2013.01); **H01P 1/00** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/50; H01P 1/00
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2004/0233014 A1 11/2004 Juenemann et al.
2011/0193757 A1* 8/2011 Choi H01Q 13/10
343/749
2012/0050124 A1 3/2012 Tu

FOREIGN PATENT DOCUMENTS

CN 1925223 A 3/2007
CN 101697380 A 4/2010
CN 102377019 A 3/2012

(Continued)

OTHER PUBLICATIONS

Partial English Translation and Abstract of Chinese Patent Application No. CN1925223, Part 1, Oct. 28, 2015, 4 pages.

(Continued)

Primary Examiner — Dieu H Duong

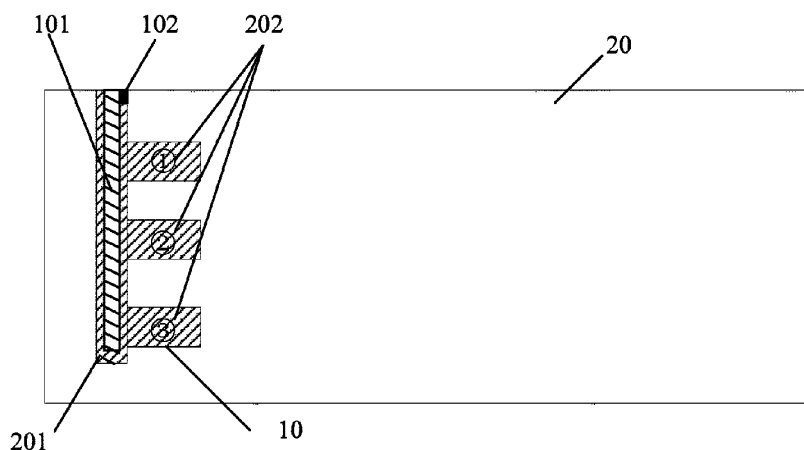
Assistant Examiner — Michael Bouizza

(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

(57) **ABSTRACT**

A terminal antenna structure, the antenna structure includes: a dielectric plate, a metal plate, a coplanar waveguide (CPW) feeding strip, and a feeding point, where the metal plate covers a dielectric plate; the CPW feeding strip and the feeding point are disposed on the dielectric plate; the feeding point is disposed at one end of the feeding strip, and the feeding point is connected to the metal plate to implement feed connection between the CPW feeding strip and the metal plate; a hole is opened on the metal plate, and the hole includes a first part and a second part on one side of the first part close to the center of the metal plate or on two sides of the first part.

20 Claims, 5 Drawing Sheets





US009728841B2

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

(10) **Patent No.:** **US 9,728,841 B2**

(45) **Date of Patent:** **Aug. 8, 2017**

(54) **ANTENNA STRUCTURE AND WIRELESS COMMUNICATION DEVICE USING THE ANTENNA STRUCTURE**

(71) Applicant: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)

(72) Inventors: **Geng-Hong Liou**, New Taipei (TW);
Yen-Hui Lin, New Taipei (TW)

(73) Assignee: **Chiun Mai Communication Systems, Inc.**, 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 186 days.

(21) Appl. No.: **14/496,744**

(22) Filed: **Sep. 25, 2014**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Dec. 31, 2013 (CN) 2013 1 0748981

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 5/371 (2015.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01)

(58) **Field of Classification Search**

CPC H01Q 5/371; H01Q 1/243; H01Q 21/30; H01Q 1/48

USPC 343/702, 700 MS, 893
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2013/0135157 A1* 5/2013 Tsou H01Q 1/2266
343/702

FOREIGN PATENT DOCUMENTS

CN 103078176 A 5/2013
TW M453978 5/2013

* cited by examiner

Primary Examiner — Jessica Han

Assistant Examiner — Jae Kim

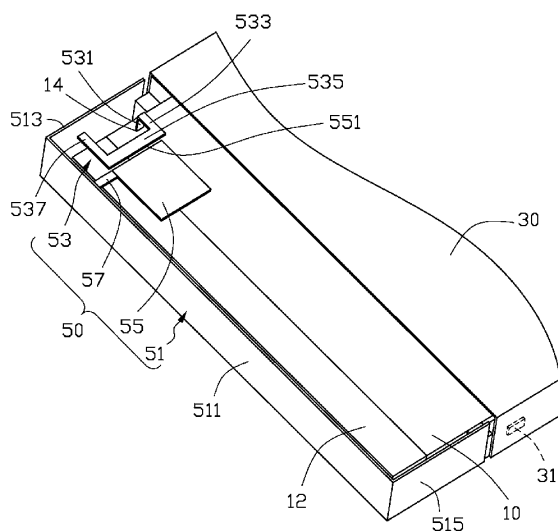
(74) *Attorney, Agent, or Firm* — Steven Reiss

(57) **ABSTRACT**

An antenna structure includes a metal member, a radiating portion, a coupling portion, and a connecting portion. The metal member is grounded. The coupling portion is spaced apart from the radiating portion. The connecting portion has a first end electronically connected to the coupling portion and a second end electronically connected to the metal member. The radiating portion is configured to deliver current to the coupling portion.

11 Claims, 3 Drawing Sheets

100





US009728842B2

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

(10) **Patent No.:** **US 9,728,842 B2**

(45) **Date of Patent:** **Aug. 8, 2017**

(54) **ANTENNA STRUCTURE AND WIRELESS COMMUNICATION DEVICE USING THE ANTENNA STRUCTURE**

(71) Applicant: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)

(72) Inventors: **Tze-Hsuan Chang**, New Taipei (TW);
Cho-Kang Hsu, New Taipei (TW)

(73) Assignee: **Chiun Mai Communication Systems, Inc.**, 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 235 days.

(21) Appl. No.: **14/554,818**

(22) Filed: **Nov. 26, 2014**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Dec. 18, 2013 (CN) 2013 1 0696297

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 7/00 (2006.01)
H01Q 1/38 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 7/00** (2013.01); **H01Q 1/38** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 7/00
USPC 343/702, 741
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,768,466 B2 * 8/2010 Chi H01Q 7/00
343/700 MS

* cited by examiner

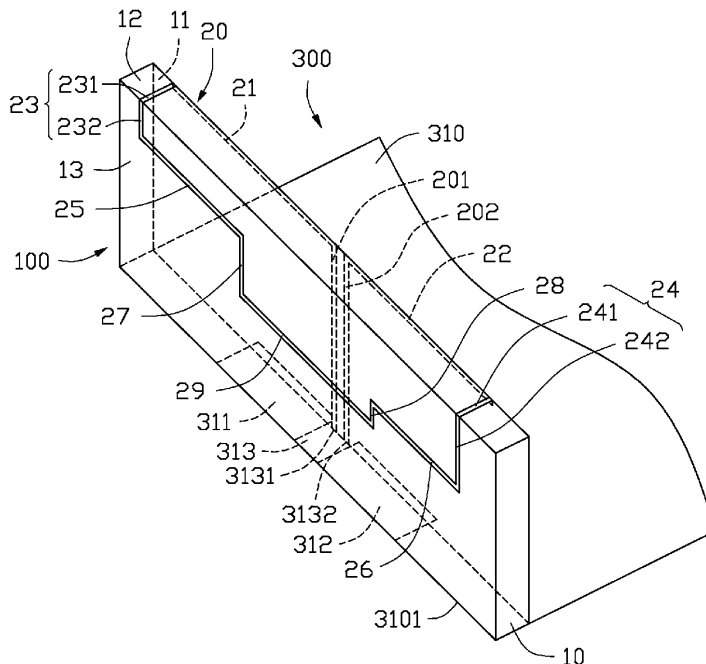
Primary Examiner — Huedung Mancuso

(74) *Attorney, Agent, or Firm* — Steven Reiss

(57) **ABSTRACT**

An antenna structure includes an antenna holder, a feed portion, a grounding portion, and a radiating body. The antenna holder includes a plurality of surfaces. The feed portion and the ground portion are both positioned on one surface of the antenna holder. The radiating body is positioned on at least one surface of the antenna holder. The feed portion is electronically connected to a first end of the radiating body. The ground portion is electronically connected to a second end of the radiating body so as to form a loop antenna.

13 Claims, 2 Drawing Sheets





US009728845B2

(12) **United States Patent**
Iellici

(10) **Patent No.:** **US 9,728,845 B2**

(45) **Date of Patent:** **Aug. 8, 2017**

(54) **DUAL ANTENNA STRUCTURE HAVING
CIRCULAR POLARISATION
CHARACTERISTICS**

(75) Inventor: **Devis Iellici**, Cambridge (GB)

(73) Assignee: **Microsoft Technology Licensing, LLC**,
Redmond, WA (US)

(*) 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.: **13/979,433**

(22) PCT Filed: **Jan. 13, 2012**

(86) PCT No.: **PCT/GB2012/050071**

§ 371 (c)(1),

(2), (4) Date: **Sep. 13, 2013**

(87) PCT Pub. No.: **WO2012/095673**

PCT Pub. Date: **Jul. 19, 2012**

(65) **Prior Publication Data**

US 2014/0009343 A1 Jan. 9, 2014

(30) **Foreign Application Priority Data**

Jan. 14, 2011 (GB) 1100617.8

(51) **Int. Cl.**
H01Q 1/36 (2006.01)
H01Q 1/38 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/36** (2013.01); **H01Q 1/38**
(2013.01); **H01Q 9/0428** (2013.01); **H01Q**
9/42 (2013.01);

(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 1/48
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,966,097 A 10/1999 Fukasawa et al.
6,028,563 A * 2/2000 Higgins H01Q 1/246
343/797

(Continued)

FOREIGN PATENT DOCUMENTS

EP 1315238 A2 5/2003
EP 1315238 B1 8/2006

(Continued)

OTHER PUBLICATIONS

International Searching Authority; U.S. Patent and Trademark
Office; International Search Report for PCT/US2013/021611, dated
Jun. 10, 2013, 3 pages.

(Continued)

Primary Examiner — Dameon E Levi

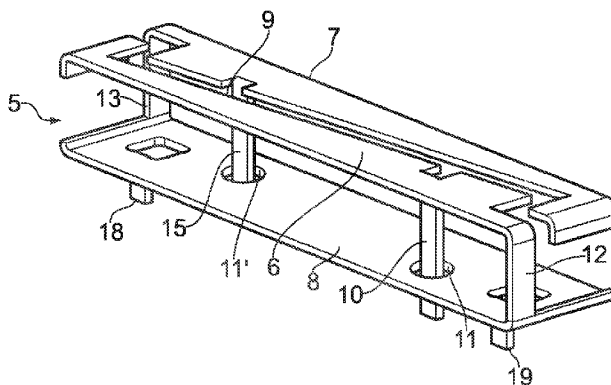
Assistant Examiner — Walter Davis

(74) *Attorney, Agent, or Firm* — Holzer Patel Drennan

(57) **ABSTRACT**

There is disclosed an antenna device made up of at least first, second and third conductive metal plates arranged in a parallelepiped configuration. The third plate defines a lower plane and the first and second plates together define an upper plane substantially parallel to the lower plane. The first and second plates are separated by a slot in the upper plane, and the second and third plates are connected to each other by a grounding connection. The first plate comprises a first, active antenna arm that is provided with a feed connection, and the second plate comprises a second antenna arm that may be passive or active. The antenna device generates a circularly polarized radiation pattern that is good for personal navigation devices, while being significantly more compact than existing ceramic patch antennas that are typically used in these devices.

22 Claims, 11 Drawing Sheets





US009728853B2

(12) **United States Patent**
Hung

(10) **Patent No.:** **US 9,728,853 B2**
(45) **Date of Patent:** **Aug. 8, 2017**

(54) **ANTENNA STRUCTURE**

(71) Applicant: **MEDIATEK Inc.**, Hsin-Chu (TW)

(72) Inventor: **Chung-Yu Hung**, Taipei (TW)

(73) Assignee: **MEDIATEK INC.**, 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 64 days.

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(22) Filed: **May 6, 2015**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 62/063,499, filed on Oct. 14, 2014.

(51) **Int. Cl.**
H01Q 5/371 (2015.01)
H01Q 1/48 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/371** (2015.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 7/00** (2013.01);

(Continued)

(58) **Field of Classification Search**
CPC H01Q 13/10; H01Q 1/243; H01Q 1/48; H01Q 21/30; H01Q 5/371; H01Q 7/00; H01Q 9/0421; H01Q 9/42

(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,157,344 A * 12/2000 Bateman G06F 1/1616
343/700 MS
6,342,856 B1 * 1/2002 Nakano H01Q 7/00
343/700 MS

(Continued)

FOREIGN PATENT DOCUMENTS

EP 2528165 11/2012
EP 2704255 A1 3/2014

(Continued)

OTHER PUBLICATIONS

EP Search Report dated Feb. 5, 2016 in corresponding application (No. 15172390.5-1811).

(Continued)

Primary Examiner — Tho G Phan

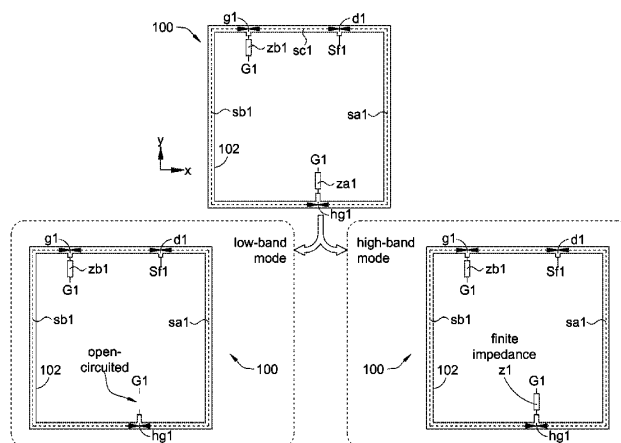
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57)

ABSTRACT

The present disclosure provides an antenna structure, including a feed terminal, an intermediate grounding terminal, a tail grounding terminal, a conductive head section and a conductive intermediate section. The feed terminal is for connecting a feed signal. The intermediate grounding terminal is responsible for conducting to a ground plane via an intermediate impedance during a second operation mode, and ceasing conducting via the intermediate impedance during a first operation mode. The tail grounding terminal is for connecting the ground plane. The head section extends from the feed terminal to the intermediate grounding terminal along a loop. The intermediate section extends from the intermediate grounding terminal to the tail grounding terminal along the loop.

21 Claims, 35 Drawing Sheets





US009728854B2

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

(10) **Patent No.:** **US 9,728,854 B2**

(45) **Date of Patent:** **Aug. 8, 2017**

(54) **ANTENNA USING EXTERIOR METAL FRAME AND ELECTRONIC DEVICE UTILIZING THE SAME**

(2013.01); **H01Q 5/10** (2015.01); **H01Q 7/00** (2013.01); **H01Q 9/04** (2013.01); **H01Q 9/045** (2013.01);

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

(Continued)
(58) **Field of Classification Search**
CPC .. H01Q 1/24; H01Q 1/48; H01Q 5/10; H01Q 5/50; H01Q 9/045; H01Q 13/10
See application file for complete search history.

(72) Inventors: **Jae-Hyung Kim**, Seoul (KR);
Jong-Suk Kim, Gyeonggi-do (KR);
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Jin-Kyu Bang, Gyeonggi-do (KR);
Dong-Jun Oh, Gyeonggi-do (KR);
Kyung-Bae Ko, Gyeonggi-do (KR);
Dong-Hwan Kim, Gyeonggi-do (KR);
Ki-Young Chang, Seoul (KR)

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,612,725 B2 11/2009 Hill et al.
2010/0123632 A1 5/2010 Hill et al.
(Continued)

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

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 0 days.

EP 2 528 165 11/2012
EP 2 597 724 5/2013

OTHER PUBLICATIONS

(21) Appl. No.: **14/843,393**

European Search Report dated Dec. 18, 2015 issued in counterpart application No. 15183446.2-1811, 8 pages.

(22) Filed: **Sep. 2, 2015**

Primary Examiner — Hoang Nguyen

(65) **Prior Publication Data**

US 2016/0064820 A1 Mar. 3, 2016

(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(30) **Foreign Application Priority Data**

Sep. 2, 2014 (KR) 10-2014-0116104

(57) **ABSTRACT**

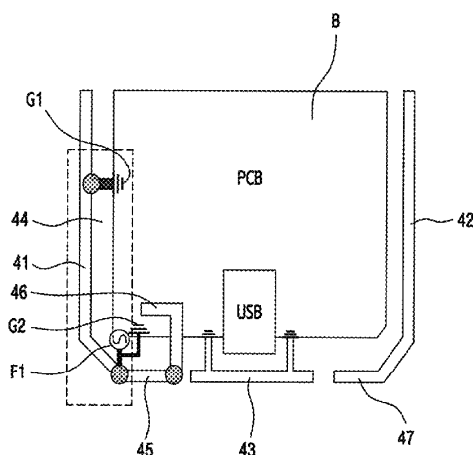
(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/50 (2015.01)

(Continued)

An antenna device that uses an exterior metal frame is provided. The antenna includes a Printed Circuit Board (PCB); a plurality of segment-type exterior metal frames spaced apart from the PCB; a feeding portion connected to one metal frame of the plurality of segment-type exterior metal frames; and a slit located between the PCB and the one metal frame, wherein the one metal frame fed through the feeding portion operates with radiation, or the slit operates with radiator, or another exterior metal frame fed through the feeding portion operates with radiation.

(52) **U.S. Cl.**
CPC **H01Q 5/50** (2015.01); **H01Q 1/24** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/42** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/50**

18 Claims, 20 Drawing Sheets





US009728857B2

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

(10) **Patent No.:** **US 9,728,857 B2**

(45) **Date of Patent:** **Aug. 8, 2017**

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

(71) Applicant: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)

(72) Inventors: **Geng-Hong Liou**, New Taipei (TW);
Yen-Hui Lin, New Taipei (TW)

(73) Assignee: **Chiun Mai Communication Systems, Inc.**, 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 222 days.

(21) Appl. No.: **14/576,768**

(22) Filed: **Dec. 19, 2014**

(65) **Prior Publication Data**

US 2015/0263428 A1 Sep. 17, 2015

(30) **Foreign Application Priority Data**

Mar. 17, 2014 (CN) 2014 1 0096878

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/371 (2015.01)

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

CPC **H01Q 9/42** (2013.01); **H01Q 5/371** (2015.01); **H01Q 1/243** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/38; H01Q 9/0421
USPC 343/702, 872, 878
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2015/0102976 A1* 4/2015 Wong H01Q 1/243
343/860

* cited by examiner

Primary Examiner — Dameon E Levi

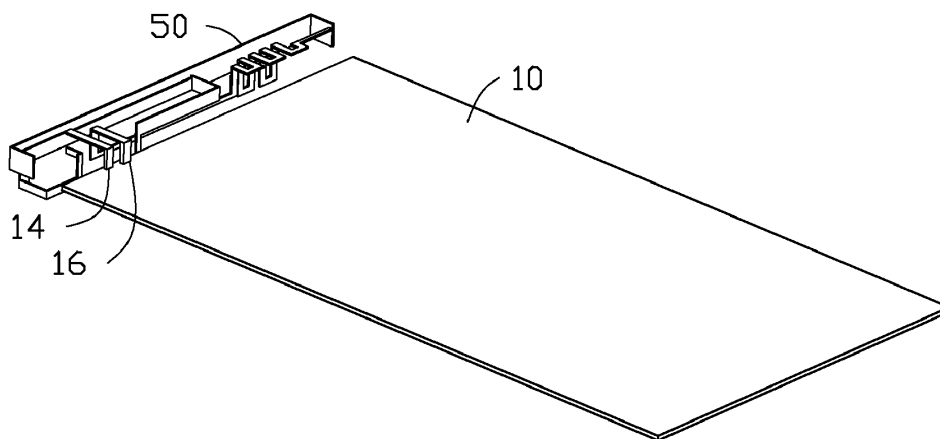
Assistant Examiner — Collin Dawkins

(74) *Attorney, Agent, or Firm* — Steven Reiss

(57) **ABSTRACT**

An antenna structure includes a feed end plate, a ground end plate, a first radiator, a second radiator, and a metallic plate. The first radiator is coupled to the feed end plate. The second radiator is coupled to the ground end plate. The metallic plate is spaced from the first radiator and is coupled to the second radiator. The metallic plate includes a main sheet and at least one side sheet connected to the main sheet, a gap is defined between the main sheet and the first radiator, and the second radiator is coupled to the at least one side sheet.

14 Claims, 6 Drawing Sheets





US009728858B2

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

(10) **Patent No.:** **US 9,728,858 B2**

(45) **Date of Patent:** **Aug. 8, 2017**

(54) **ELECTRONIC DEVICES WITH HYBRID ANTENNAS**

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)

(72) Inventors: **Jiang Zhu**, Sunnyvale, CA (US);
Rodney A. Gomez Angulo, Sunnyvale, CA (US); **Qingxiang Li**, Mountain View, CA (US); **Robert W. Schlub**, Cupertino, CA (US); **Hongfei Hu**, Santa Clara, 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 239 days.

(21) Appl. No.: **14/260,800**

(22) Filed: **Apr. 24, 2014**

(65) **Prior Publication Data**

US 2015/0311594 A1 Oct. 29, 2015

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

(52) **U.S. Cl.**
CPC **H01Q 13/10** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 1/243** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0421; H01Q 1/38; H01Q 13/10; H01Q 1/241-1/244; H01Q 13/085; H01Q 13/16; H01Q 13/18
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,016,490 A 4/1977 Weckenmann et al.
4,614,937 A 9/1986 Poujois
(Continued)

FOREIGN PATENT DOCUMENTS

CN 1343380 4/2002
CN 1543010 11/2004
(Continued)

OTHER PUBLICATIONS

The ARRL Antenna Book, Published by The American Radio Relay League.*

(Continued)

Primary Examiner — Hoang Nguyen

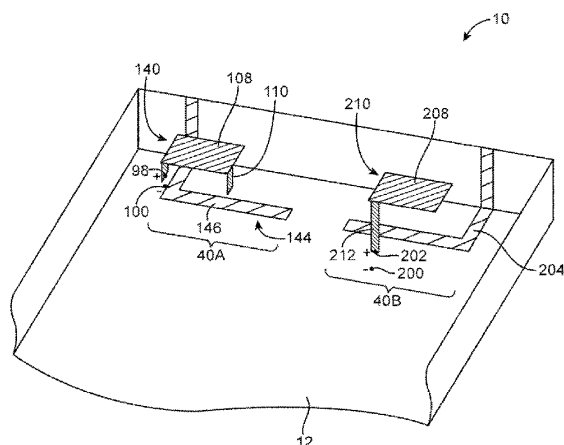
Assistant Examiner — Awat Salih

(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.;
G Victor Treyz; Tianyi He

(57) **ABSTRACT**

An electronic device may be provided with hybrid planar inverted-F slot antennas and indirectly fed slot antennas. A hybrid antenna may be used to form a dual band wireless local area network antenna. An indirectly fed slot antenna may be used to form a cellular telephone antenna. Antenna slots may be formed in a metal electronic device housing wall. The housing wall may have a planar rear portion and sidewall portions that extend upwards from the planar rear portion. The slots may have one or more bends. A hybrid antenna may have a slot antenna portion and a planar inverted-F antenna portion. The planar inverted-F antenna portion may have a metal resonating element patch that is supported by a support structure. The support structure may be a plastic speaker box containing a speaker driver that is not overlapped by the metal resonating element patch.

20 Claims, 14 Drawing Sheets





US009735462B2

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

(10) **Patent No.:** **US 9,735,462 B2**

(45) **Date of Patent:** **Aug. 15, 2017**

(54) **ELECTRONIC DEVICE**

(71) Applicant: **KYOCERA CORPORATION**,
Kyoto-shi, Kyoto (JP)

(72) Inventors: **Naoki Nishizaka**, Sagamihara (JP);
Daisuke Togashi, Yokohama (JP);
Motonori Imamura, Yokohama (JP)

(73) Assignee: **KYOCERA CORPORATION**, Kyoto
(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.: **14/761,615**

(22) PCT Filed: **Dec. 25, 2013**

(86) PCT No.: **PCT/JP2013/084627**

§ 371 (c)(1),

(2) Date: **Jul. 16, 2015**

(87) PCT Pub. No.: **WO2014/115473**

PCT Pub. Date: **Jul. 31, 2014**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jan. 22, 2013 (JP) 2013-009302

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

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/371**
(2015.01); **H01Q 9/42** (2013.01); **H01Q 13/10**
(2013.01); **H05K 5/0247** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/38; H01Q 1/2266;
H01Q 5/328; H01Q 13/106; H01Q
1/2291; H01Q 1/42

(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,936,583 A 8/1999 Sekine et al.
8,624,788 B2 * 1/2014 Ayatollahi H01Q 1/243
343/745

(Continued)

FOREIGN PATENT DOCUMENTS

JP 4-291502 A 10/1992
JP 6-169217 A 6/1994

(Continued)

OTHER PUBLICATIONS

International Search Report mailed Feb. 18, 2014, corresponding to
International application No. PCT/JP2013/084627.

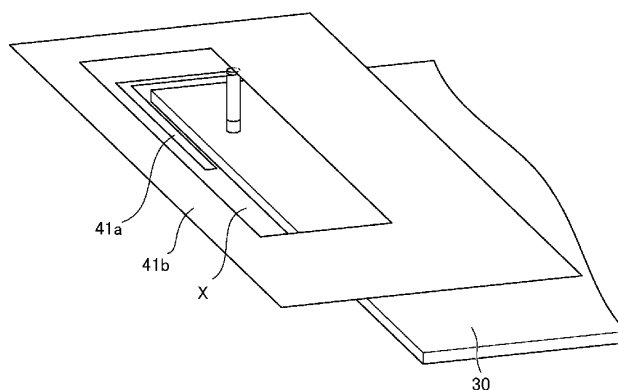
Primary Examiner — Linh Nguyen

(74) *Attorney, Agent, or Firm* — Hauptman Ham, LLP

(57) **ABSTRACT**

Provided is an electronic device in which, if an antenna
element is formed on the surface of a housing, restrictions on
the formation of the antenna element are less likely to arise.
The following are provided: a rear case, an antenna element,
and a power supply unit that supplies power to the antenna
element. The antenna unit comprises a first section that is
formed by applying a conductive material onto a first main
surface of the rear case, and a second section. A dielectric or
an insulator is interposed between the first section and the
second section.

9 Claims, 18 Drawing Sheets





US009735463B2

(12) **United States Patent**
Lee

(10) **Patent No.:** **US 9,735,463 B2**
(45) **Date of Patent:** **Aug. 15, 2017**

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

(71) Applicant: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)

(72) Inventor: **Chih-Ho Lee**, New Taipei (TW)

(73) Assignee: **Chiun Mai Communication Systems, Inc.**, 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 16 days.

(21) Appl. No.: **14/816,566**

(22) Filed: **Aug. 3, 2015**

(65) **Prior Publication Data**
US 2017/0040667 A1 Feb. 9, 2017

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

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

(58) **Field of Classification Search**
CPC H01Q 1/243
USPC 343/702
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,853,341 B1	2/2005	Hellgren et al.	
7,321,334 B2 *	1/2008	Yu	G06F 1/1616 343/702
8,344,957 B2 *	1/2013	Wakabayashi	H04W 88/06 343/702
2004/0257283 A1	12/2004	Asano et al.	
2014/0266928 A1	9/2014	Gummalla	

FOREIGN PATENT DOCUMENTS

TW 201220597 5/2012

* cited by examiner

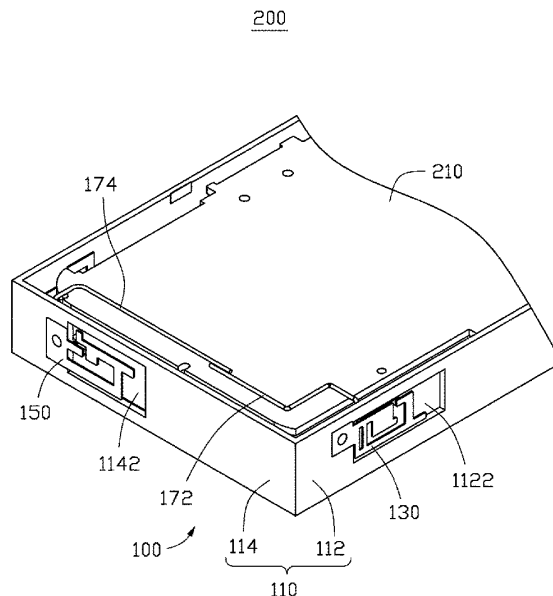
Primary Examiner — Graham Smith

(74) *Attorney, Agent, or Firm* — Steven Reiss

(57) **ABSTRACT**

A wireless communication device includes a housing and an antenna assembly. The housing including a metallic frame having a first side plate and a second side plate connected to the first side plate, the first side plate defines a first opening, and the second side plate defines a second opening. The antenna assembly includes a first antenna and a second antenna. The first antenna is received in the first opening, secured on the first side plate and grounded by the first side plate. The second antenna is received in the second opening and is secured on the second side plate and grounded by the second side plate.

18 Claims, 9 Drawing Sheets





US009735471B2

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

(10) **Patent No.:** **US 9,735,471 B2**

(45) **Date of Patent:** **Aug. 15, 2017**

(54) **ANTENNA STRUCTURE AND WIRELESS COMMUNICATION DEVICE EMPLOYING SAME**

(71) Applicant: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)

(72) Inventors: **Geng-Hong Liou**, New Taipei (TW);
Yen-Hui Lin, New Taipei (TW)

(73) Assignee: **Chiun Mai Communication Systems, Inc.**, 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 84 days.

(21) Appl. No.: **14/471,304**

(22) Filed: **Aug. 28, 2014**

(65) **Prior Publication Data**

US 2015/0061960 A1 Mar. 5, 2015

(30) **Foreign Application Priority Data**

Aug. 30, 2013 (CN) 2013 1 03858768

(51) **Int. Cl.**

H01Q 1/38 (2006.01)

H01Q 5/378 (2015.01)

H01Q 5/335 (2015.01)

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

CPC **H01Q 5/378** (2015.01); **H01Q 5/335** (2015.01)

(58) **Field of Classification Search**

CPC H01Q 1/38; H01Q 1/243

USPC 343/700 MS

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2016/0351998 A1 * 12/2016 Ahn H01Q 9/0414

* cited by examiner

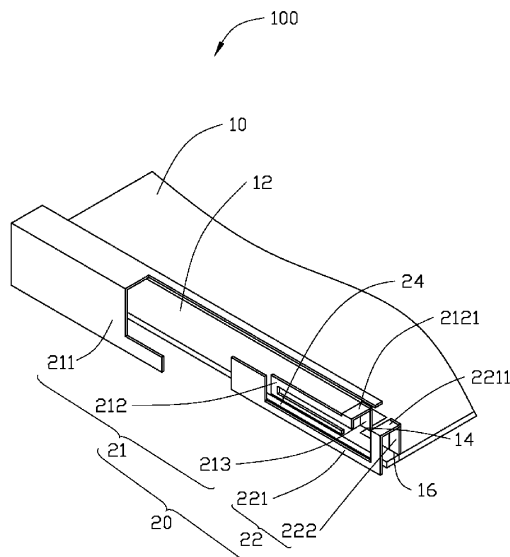
Primary Examiner — Graham Smith

(74) *Attorney, Agent, or Firm* — Steven Reiss

(57) **ABSTRACT**

An antenna structure includes a monopole antenna, a short parasitic antenna and an impedance matching circuit. The monopole antenna includes a first radiating body, a second radiating body and a feeding portion coupled to the first radiating body and the second radiating body. The first radiating body configured to excite a low-frequency resonating mode; the second radiating body configured to excite a first high-frequency resonating mode. The short parasitic antenna includes a parasitic body spaced apart from the second radiating body and a grounding portion coupled to the parasitic body. The short parasitic antenna configured to excite a second high-frequency resonating mode, and resonate with the second radiating body to excite a third high-frequency resonating mode. The impedance matching circuit includes a variable capacitor configured to regulate operating frequency band of the low-frequency resonating mode.

7 Claims, 7 Drawing Sheets





US009735829B2

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

(10) **Patent No.:** **US 9,735,829 B2**

(45) **Date of Patent:** **Aug. 15, 2017**

(54) **ELECTRONIC DEVICE INCLUDING
MULTI-FEED, MULTI-BAND ANTENNA
USING EXTERNAL CONDUCTOR**

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 9/42; H01Q 13/10;
H01Q 9/0421; H01Q 21/28; H01Q 1/48;
(Continued)

(71) Applicant: **SAMSUNG
ELECTRO-MECHANICS CO., LTD.,**
Suwon-si (KR)

(56) **References Cited**

U.S. PATENT DOCUMENTS

2006/0197712 A1 * 9/2006 Niemi H01Q 1/243
343/873
2012/0231750 A1 9/2012 Jin et al.
(Continued)

(72) Inventors: **Young Min Cheon**, Suwon-si (KR);
Dae Seong Jeon, Suwon-si (KR); **Jun
Seung Yi**, Suwon-si (KR); **Nam Ki
Kim**, Suwon-si (KR)

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

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 0 days.

KR 10-2012-0102517 A 9/2012
KR 10-2013-0115319 A 10/2013
(Continued)

Primary Examiner — Golam Sorowar

(74) *Attorney, Agent, or Firm* — NSIP Law

(21) Appl. No.: **15/050,980**

(22) Filed: **Feb. 23, 2016**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Mar. 18, 2015 (KR) 10-2015-0037322
Dec. 28, 2015 (KR) 10-2015-0187603

(51) **Int. Cl.**
H04B 1/44 (2006.01)
H04B 1/525 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC **H04B 1/525** (2013.01); **H04B 1/3827**
(2013.01); **H04B 1/48** (2013.01); **H04B**
2001/485 (2013.01)

(57) **ABSTRACT**

An electronic device includes a board embedded in the electronic device, having a peripheral portion and a conductive region including a ground and a non-conductive region, an external conductor located in the peripheral portion and including a first non-segmented conductor having persistence with respect to performing an antenna function and connected to the ground. The device also includes a first antenna pattern configured to receive a first feed signal that contribute to first resonance for a first communications band, a second antenna pattern configured to receive a second feed signal that contributes to second resonance for a second communications band, and a first shield located between the first antenna pattern and the second antenna pattern that is connected to each of the ground and the first non-segmented conductor.

16 Claims, 14 Drawing Sheets

