



US009742063B2

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

(10) **Patent No.:** **US 9,742,063 B2**

(45) **Date of Patent:** **Aug. 22, 2017**

(54) **EXTERNAL LTE MULTI-FREQUENCY BAND ANTENNA**

(71) Applicant: **ARCADYAN TECHNOLOGY CORPORATION**, Hsinchu (TW)

(72) Inventors: **Wen-Szu Tao**, Hsinchu (TW);
Shin-Lung Kuo, Hsinchu (TW);
Yi-Cheng Lin, Hsinchu (TW);
Po-Hsun Wei, Hsinchu (TW)

(73) Assignee: **ARCADYAN TECHNOLOGY CORPORATION**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 237 days.

(21) Appl. No.: **14/536,629**

(22) Filed: **Nov. 9, 2014**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 62/012,108, filed on Jun. 13, 2014.

(30) **Foreign Application Priority Data**

Jul. 11, 2014 (TW) 103124037 A

(51) **Int. Cl.**
H01Q 5/307 (2015.01)
H01Q 1/48 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/307** (2015.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/378** (2015.01);

(Continued)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,835,063 A 11/1998 Brachat et al.
2007/0146214 A1 6/2007 Yuba et al.

(Continued)

FOREIGN PATENT DOCUMENTS

EP 2065972 A1 6/2009
TW 201017990 A 5/2010
TW 201205958 A 2/2012

OTHER PUBLICATIONS

European Search Report for counterpart European Patent Application No. 14195091.5.

(Continued)

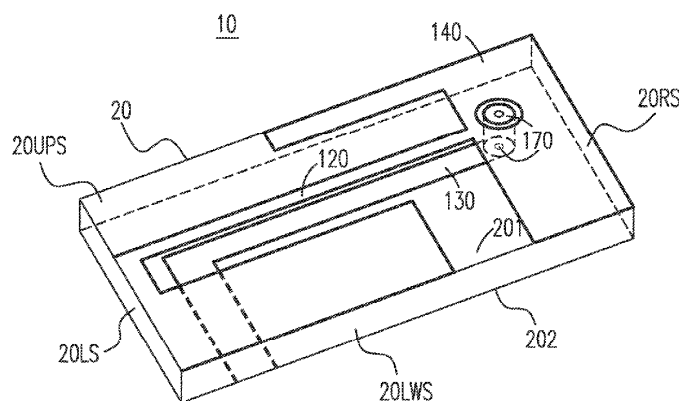
Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — The PL Law Group, PLLC

(57) **ABSTRACT**

An antenna is provided. The antenna includes a substrate having a first end and a second end opposite to the first end, wherein a direction from the first end to the second end is an extending direction of the antenna; a radiating portion; a feed-in conductor; and a ground portion electrically connected to the radiating portion, coupled to the feed-in conductor, disposed on the substrate from the first end along the extending direction, and including a main ground conductor; and a high frequency band bandwidth adjusting conductor extended from the main ground conductor along the extending direction.

13 Claims, 14 Drawing Sheets





US009742067B2

(12) **United States Patent**
Kim

(10) **Patent No.:** **US 9,742,067 B2**

(45) **Date of Patent:** **Aug. 22, 2017**

(54) **ANTENNA APPARATUS**

(56) **References Cited**

(71) Applicant: **LG INNOTEK CO., LTD.**, Seoul (KR)

U.S. PATENT DOCUMENTS

(72) Inventor: **Chang Wook Kim**, Seoul (KR)

5,959,582 A * 9/1999 Kawahata H01Q 1/243
343/700 MS

(73) Assignee: **LG INNOTEK CO., LTD.**, Seoul (KR)

6,255,994 B1 7/2001 Saito
6,700,543 B2 * 3/2004 Konishi H01Q 1/38
343/700 MS

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 225 days.

2002/0190907 A1 12/2002 Konishi et al.
2003/0052827 A1 3/2003 Umehara et al.
2005/0007279 A1 * 1/2005 Chang H01Q 1/243
343/700 MS
2009/0002244 A1 * 1/2009 Woo H01Q 1/38
343/702

(21) Appl. No.: **13/928,596**

2009/0322618 A1 12/2009 Shoji
2011/0037665 A1 2/2011 Ahn et al.
2011/0122043 A1 5/2011 Ridgeway
2012/0092220 A1 4/2012 Tani et al.
2012/0127056 A1 5/2012 Park et al.

(22) Filed: **Jun. 27, 2013**

(Continued)

(65) **Prior Publication Data**

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FOREIGN PATENT DOCUMENTS

(30) **Foreign Application Priority Data**

CN 101615725 A 12/2009
CN 201749938 U 2/2011
CN 101071901 B 2/2012

Jun. 28, 2012 (KR) 10-2012-0070373

(Continued)

(51) **Int. Cl.**

H01Q 9/04 (2006.01)

H01Q 1/22 (2006.01)

H01Q 1/24 (2006.01)

H01Q 9/42 (2006.01)

H01Q 5/364 (2015.01)

Primary Examiner — Dameon E Levi

Assistant Examiner — Walter Davis

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

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

CPC **H01Q 9/04** (2013.01); **H01Q 1/2283** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/364** (2015.01); **H01Q 9/42** (2013.01)

(57) **ABSTRACT**

Disclosed is an antenna apparatus. The antenna apparatus includes a feeding pad for supplying a signal, a main device extended from the feeding pad, and a sub-device extended from the feeding pad and spaced apart from the main device while overlapping with the main device. The antenna apparatus includes the sub-device overlapped with the main device, so that the resonance frequency band of the antenna apparatus is enlarged.

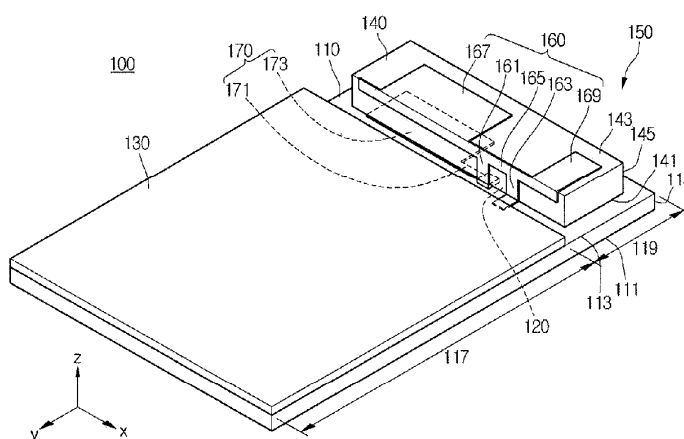
(58) **Field of Classification Search**

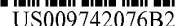
CPC H01Q 9/04

USPC 343/700 MS

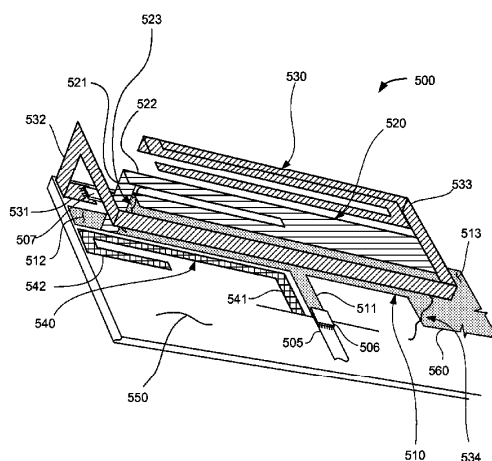
See application file for complete search history.

5 Claims, 5 Drawing Sheets





(45) **Date of Patent:** **Aug. 22, 2017**





US009742459B2

(12) **United States Patent**
Ayala Vazquez et al.

(10) **Patent No.:** **US 9,742,459 B2**

(45) **Date of Patent:** **Aug. 22, 2017**

(54) **ELECTRONIC DEVICE HAVING SENSORS
AND ANTENNA MONITOR FOR
CONTROLLING WIRELESS OPERATION**

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

(72) Inventors: **Enrique Ayala Vazquez**, Watsonville, CA (US); **Hongfei Hu**, Santa Clara, CA (US); **Mattia Pascolini**, San Francisco, CA (US); **Yuehui Ouyang**, Sunnyvale, CA (US); **Salih Yarga**, Sunnyvale, CA (US); **Yijun Zhou**, Sunnyvale, CA (US); **Erdinc Irci**, Sunnyvale, CA (US); **Jayesh Nath**, Milpitas, CA (US); **Ming-Ju Tsai**, Cupertino, CA (US); **Matthew A. Mow**, Los Altos, CA (US); **Liang Han**, Sunnyvale, CA (US); **James G. Judkins**, Campbell, CA (US); **Robert W. Schlub**, 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 154 days.

(21) Appl. No.: **14/283,039**

(22) Filed: **May 20, 2014**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
H04B 1/04 (2006.01)
H01Q 11/12 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H04B 1/40** (2013.01); **H04B 1/0458** (2013.01); **H04B 1/18** (2013.01)

(58) **Field of Classification Search**

CPC H04B 1/40; H04B 1/3822; H04B 1/406; H04B 1/44; H04B 1/54; H04B 1/0458; (Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,633,378 B2 12/2009 Rodgers et al.
7,930,010 B2 4/2011 Johansson et al.
(Continued)

OTHER PUBLICATIONS

Jadhav et al., U.S. Appl. No. 14/201,620, filed Mar. 7, 2014.
Schlub et al., U.S. Appl. No. 13/865,578, filed Apr. 18, 2013.
Mow et al., U.S. Appl. No. 14/310,240, filed Jun. 20, 2014.

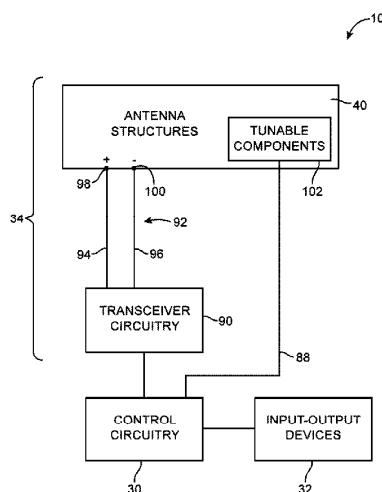
Primary Examiner — Nhan Le

(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.;
G. Victor Treyz; Joseph F. Guihan

(57) **ABSTRACT**

An electronic device may be provided with wireless circuitry. Control circuitry may be used to adjust the wireless circuitry. The wireless circuitry may include an antenna that is tuned using tunable components. The control circuitry may gather information on the current operating mode of the electronic device, sensor data from a proximity sensor, accelerometer, microphone, and other sensors, antenna impedance information for the antenna, and information on the use of connectors in the electronic device. Based on this gathered data, the control circuitry can adjust the tunable components to compensate for antenna detuning due to loading from nearby external objects, may adjust transmit power levels, and may make other wireless circuit adjustments.

19 Claims, 6 Drawing Sheets





US009746571B2

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

(10) **Patent No.:** **US 9,746,571 B2**
(45) **Date of Patent:** **Aug. 29, 2017**

(54) **PROXIMITY SENSOR ANTENNA DEVICE
AND ANTENNA STRUCTURE THEREOF**

(71) Applicant: **AUDEN TECHNO CORP.**, Taoyuan
County (TW)

(72) Inventors: **Peng-Hao Juan**, Taipei (TW);
Yu-Tsung Huang, Kaohsiung (TW)

(73) Assignee: **AUDEN TECHNO CORP.**, 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 47 days.

(21) Appl. No.: **14/959,352**

(22) Filed: **Dec. 4, 2015**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
H01Q 1/44 (2006.01)
G01V 3/08 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/24 (2006.01)
H01Q 5/378 (2015.01)
H01Q 5/328 (2015.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **G01V 3/08** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 1/38** (2013.01); **H01Q 5/328**
(2015.01); **H01Q 5/378** (2015.01); **H01Q 9/42**
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/44; H01Q 5/328;
H01Q 5/378; H01Q 9/42
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,478,870	B2 *	10/2016	Desclos		H01Q 1/243
9,502,768	B2 *	11/2016	Huang		H01Q 1/002
2015/0022403	A1 *	1/2015	Lin		H01Q 1/44
					343/702
2015/0200447	A1 *	7/2015	Tang		H01Q 1/243
					343/720
2016/0087343	A1 *	3/2016	Chang		H01Q 1/245
					343/720

* cited by examiner

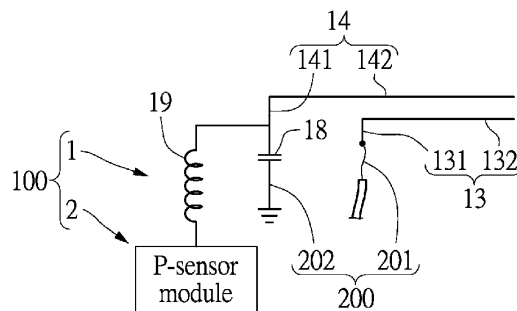
Primary Examiner — Hoang Nguyen

(74) *Attorney, Agent, or Firm* — Li & Cai Intellectual
Property (USA) Office

(57) **ABSTRACT**

A P-sensor device includes an antenna structure and a P-sensor module. The antenna structure includes a first conductor, a second conductor, a capacitance member, and an inductance member. The capacitance member and inductance member are electrically connected to the second conductor. When the second conductor is in a capacitance electrode mode, a capacitance value between the second conductor and an external object is variable, and the capacitance member is configured to block a detecting signal, which travels in the second conductor. When the second conductor is in a coupling antenna mode, the inductance member is configured to block a RF signal, which travels in the second conductor. The P-sensor module is electrically connected to the inductance member and is electrically connected to the second conductor via the inductance member.

6 Claims, 3 Drawing Sheets





US009748633B2

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

(10) **Patent No.:** **US 9,748,633 B2**

(45) **Date of Patent:** **Aug. 29, 2017**

(54) **ANTENNA STRUCTURE**

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

(72) Inventors: **Yi-Ting Chen**, 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 219 days.

(21) Appl. No.: **14/011,925**

(22) Filed: **Aug. 28, 2013**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Oct. 26, 2012 (TW) 101139597 A

(51) **Int. Cl.**

H01Q 5/00 (2015.01)

H01Q 1/24 (2006.01)

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H01Q 5/371 (2015.01)

H01Q 5/378 (2015.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01); **H01Q 5/378** (2015.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/242; H01Q 1/243; H01Q 5/30; H01Q 5/307; H01Q 5/378; H01Q 1/2258; H01Q 1/2266; H01Q 1/2275; H01Q 1/24;

H01Q 5/342; H01Q 5/371; H01Q 5/392;

H01Q 9/42; H01Q 19/22; H01Q 19/28;

H01Q 1/22; H01Q 1/241; H01Q 5/357;

H01Q 5/364

USPC 343/702

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,119,748 B2 * 10/2006 Autti H01Q 1/243

343/700 MS

8,659,492 B2 * 2/2014 Lee H01Q 5/357

343/749

8,988,292 B2 * 3/2015 Hotta H01Q 1/243

343/700 MS

2004/0137950 A1 * 7/2004 Bolin et al. 455/562.1

FOREIGN PATENT DOCUMENTS

FI WO 2010122220 A1 * 10/2010 H01Q 1/243

JP 2007-535836 A 12/2007

WO 2010122220 A1 10/2010

* cited by examiner

Primary Examiner — Tho G Phan

Assistant Examiner — Patrick Holecek

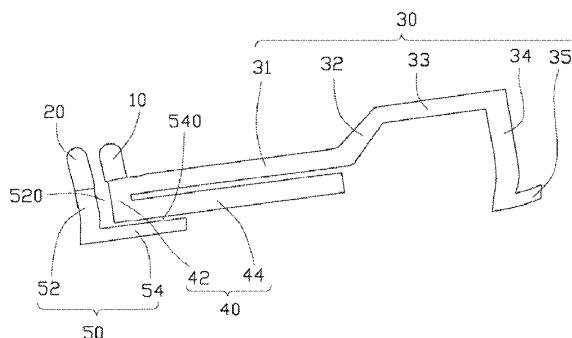
(74) *Attorney, Agent, or Firm* — Steven Reiss

(57) **ABSTRACT**

An antenna structure includes a feed end, a ground end, a first radiator, a second radiator, and a third radiator. Both of the first radiator and the second radiator are connected to the feed end. The second radiator includes a first connection section and a second connection section. The third radiator is connected to the ground end, and includes a first coupling section separated from the first connection section and a second coupling section separated from the second connection section. A first gap is defined between the first coupling section and the first connection section; and a second gap is defined between the second coupling section and the second connection section.

16 Claims, 2 Drawing Sheets

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US009748637B2

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

(10) **Patent No.:** **US 9,748,637 B2**

(45) **Date of Patent:** ***Aug. 29, 2017**

(54) **ANTENNA AND METHOD FOR STEERING
ANTENNA BEAM DIRECTION FOR WIFI
APPLICATIONS**

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

(72) Inventors: **Sebastian Rowson**, San Diego, CA
(US); **Laurent Desclos**, 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 0 days.

This patent is subject to a terminal dis-
claimer.

(21) Appl. No.: **14/965,881**

(22) Filed: **Dec. 10, 2015**

(65) **Prior Publication Data**
US 2016/0099501 A1 Apr. 7, 2016

Related U.S. Application Data

(63) Continuation-in-part of application No. 14/144,461,
filed on Dec. 30, 2013, now Pat. No. 9,240,634,
which is a continuation of application No.
13/726,477, filed on Dec. 24, 2012, now Pat. No.
8,648,755, which is a continuation 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.**
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H01Q 1/24 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **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 3/00; H01Q 9/0421;
H01Q 9/00
USPC 343/700 MS, 745, 815, 817, 833, 834,
343/876
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,693,594 B2 * 2/2004 Pankinaho H01Q 1/243
343/700 MS
6,876,329 B2 * 4/2005 Milosavljevic H01Q 1/243
343/700 MS
7,265,720 B1 * 9/2007 Ponce De Leon H01Q 1/243
343/700 MS

(Continued)

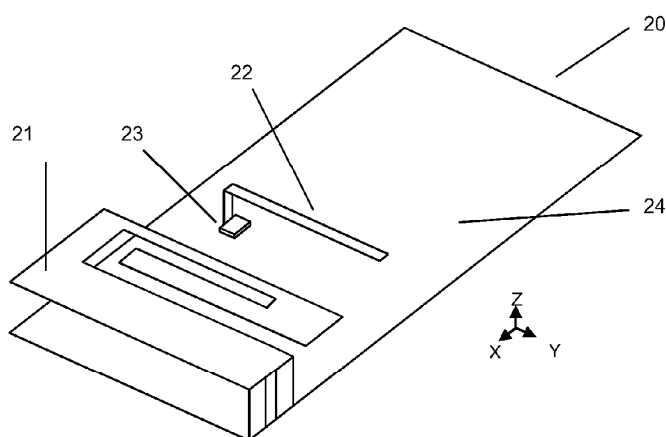
Primary Examiner — Tho G Phan

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

(57) **ABSTRACT**

An antenna comprising an IMD element and one or more
parasitic and active tuning elements is disclosed. The IMD
element, when used in combination with the active tuning
and parasitic elements, allows antenna operation at multiple
resonant frequencies. In addition, the direction of antenna
radiation pattern may be arbitrarily rotated in accordance
with the parasitic and active tuning elements. Unique
antenna architectures for beam steering in Wi-Fi band appli-
cations is further described.

11 Claims, 16 Drawing Sheets





US009748650B2

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

(10) **Patent No.:** **US 9,748,650 B2**

(45) **Date of Patent:** **Aug. 29, 2017**

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

(71) Applicant: **FIH (HONG KONG) LIMITED,**
Kowloon (HK)

(72) Inventors: **Chuan-Chou Chi**, New Taipei (TW);
Chi-Sheng Liu, New Taipei (TW);
Cheng-Hung Ko, New Taipei (TW);
Hao-Ying Chang, 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 128 days.

(21) Appl. No.: **14/685,027**

(22) Filed: **Apr. 13, 2015**

(65) **Prior Publication Data**
US 2016/0190689 A1 Jun. 30, 2016

(30) **Foreign Application Priority Data**
Dec. 31, 2014 (TW) 103146459 A

(51) **Int. Cl.**
H01Q 5/00 (2015.01)
H01Q 5/371 (2015.01)
H01Q 1/24 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/371** (2015.01); **H01Q 1/243** (2013.01); **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**
USPC 343/700 MS, 702, 843
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2012/0249393 A1 * 10/2012 Hotta H01Q 1/243
343/843

* cited by examiner

Primary Examiner — Hoang Nguyen

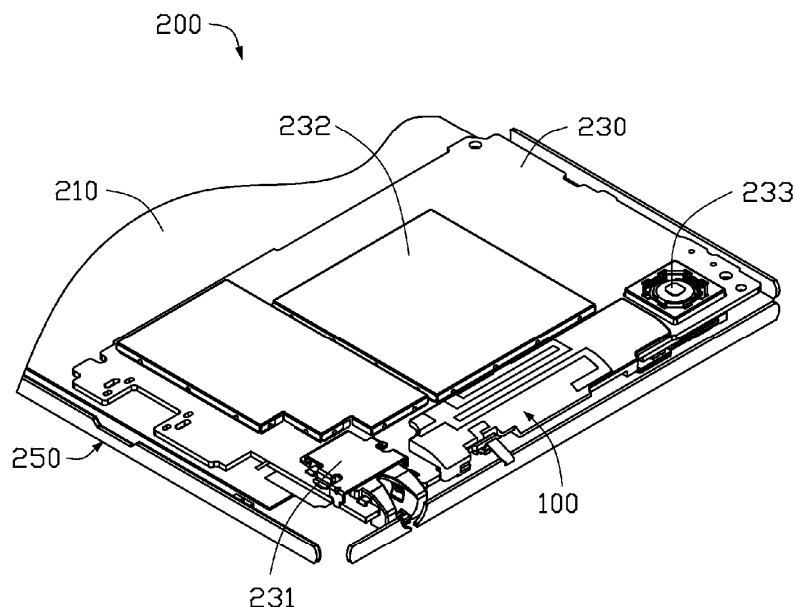
Assistant Examiner — Hai Tran

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

(57) **ABSTRACT**

An antenna structure includes a feed unit, a grounding unit, a first radiating unit, a second radiating unit, third radiating unit, fourth radiating unit, and a fifth radiating unit. The grounding unit is spaced apart from the feed unit. The first radiating unit is electrically connected to the feed unit. The second radiating unit is electrically connected to the grounding unit. The third radiating unit is electrically connected to the first radiating unit, the second radiating unit, and the fourth radiating unit. The fifth radiating unit is electrically connected to the feed unit and couples with the fourth radiating unit.

20 Claims, 6 Drawing Sheets





US009748661B2

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

(10) **Patent No.:** **US 9,748,661 B2**

(45) **Date of Patent:** **Aug. 29, 2017**

(54) **ANTENNA FOR ACHIEVING EFFECTS OF MIMO ANTENNA**

(71) Applicant: **HON HAI PRECISION INDUSTRY CO., LTD.**, New Taipei (TW)

(72) Inventors: **Chun-Jui Pan**, New Taipei (TW);
Sheng-Hsiung Yang, New Taipei (TW);
Wen-Chieh Tsai, New Taipei (TW)

(73) Assignee: **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 0 days.

(21) Appl. No.: **15/142,621**

(22) Filed: **Apr. 29, 2016**

(65) **Prior Publication Data**

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Related U.S. Application Data

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
H01Q 9/42 (2006.01)
H01Q 1/50 (2006.01)
H01Q 5/35 (2015.01)

H01Q 5/378 (2015.01)

H01Q 1/38 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/42** (2013.01); **H01Q 1/38**
(2013.01); **H01Q 1/50** (2013.01); **H01Q 5/35**
(2015.01); **H01Q 5/378** (2015.01)

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

2008/0174508 A1* 7/2008 Iwai H01Q 9/30
343/850
2011/0122040 A1* 5/2011 Wakabayashi H01Q 1/243
343/833
2013/0016024 A1* 1/2013 Shi H01Q 1/243
343/833

* cited by examiner

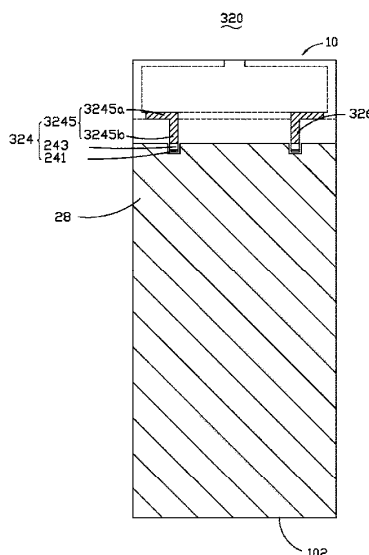
Primary Examiner — Robert Karacsony

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

(57) **ABSTRACT**

An antenna disposed on a substrate includes a radiating portion, a first coupling and feeding portion, and a second coupling and feeding portion. A length of the radiating portion is substantially equal to a half wavelength of electromagnetic signals radiated by the radiating portion. Each coupling and feeding portion includes a feeding part and a coupling part. The feeding part feeds the electromagnetic signals to the radiating portion via the coupling part so as to achieve effects of a multiple-input multiple-output (MIMO) antenna.

4 Claims, 29 Drawing Sheets





US009755302B2

(12) **United States Patent**
Flores-Cuadras et al.

(10) **Patent No.:** **US 9,755,302 B2**

(45) **Date of Patent:** **Sep. 5, 2017**

(54) **MULTIPATH OPEN LOOP ANTENNA WITH
WIDEBAND RESONANCES FOR WAN
COMMUNICATIONS**

(71) Applicant: **Taoglas Group Holdings Limited,**
Enniscorthy (IE)

(72) Inventors: **Javier Ruben Flores-Cuadras,** Tijuana
(MX); **Ming Wei-Chen,** Zhongli (TW)

(73) Assignee: **Taoglas Group Holdings Limited,**
Enniscorthy (IE)

(*) 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.: **14/603,201**

(22) Filed: **Jan. 22, 2015**

(65) **Prior Publication Data**

US 2015/0303556 A1 Oct. 22, 2015

Related U.S. Application Data

(60) Provisional application No. 61/930,143, filed on Jan.
22, 2014.

(51) **Int. Cl.**
H01Q 21/00 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/08 (2006.01)
H01Q 1/24 (2006.01)
H01Q 7/00 (2006.01)
H01Q 5/364 (2015.01)
H01Q 5/392 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 1/38** (2013.01); **H01Q 1/085**
(2013.01); **H01Q 1/243** (2013.01); **H01Q**
5/364 (2015.01); **H01Q 5/392** (2015.01);
H01Q 7/00 (2013.01)

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

2006/0214867 A1 * 9/2006 Chen H01Q 9/285
343/795
2007/0046557 A1 * 3/2007 Chen H01Q 9/26
343/795
2012/0127056 A1 * 5/2012 Park H01Q 1/521
343/853

* cited by examiner

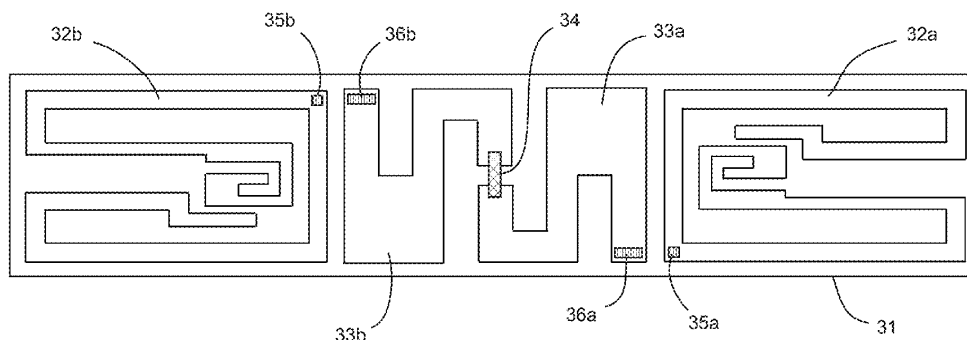
Primary Examiner — Trinh Dinh

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

(57) **ABSTRACT**

The disclosure concerns an antenna with open loops and
multipath current distribution to achieve ultra wideband
characteristics and antenna miniaturization, while simulta-
neously keeping high performance for a more reliable WAN
communication, with higher data transfer, less dropping
connections and improved sensitivity. To further reduce
spatial requirements, the antenna may be incorporated on a
flex substrate for bending with the contour of a device
housing or the like.

5 Claims, 7 Drawing Sheets





US009755307B2

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

(10) **Patent No.:** **US 9,755,307 B2**

(45) **Date of Patent:** **Sep. 5, 2017**

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

(71) Applicant: **FIH (Hong Kong) Limited**, Kowloon (HK)

(72) Inventors: **Chuan-chou Chi**, New Taipei (TW);
Hao-Ying Chang, 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 266 days.

(21) Appl. No.: **14/469,881**

(22) Filed: **Aug. 27, 2014**

(65) **Prior Publication Data**

US 2015/0061943 A1 Mar. 5, 2015

(30) **Foreign Application Priority Data**

Aug. 29, 2013 (TW) 102131141 A

(51) **Int. Cl.**
H01Q 5/00 (2015.01)
H01Q 21/30 (2006.01)
H01Q 5/371 (2015.01)
H01Q 5/378 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 5/371** (2015.01); **H01Q 5/378** (2015.01); **H01Q 21/30** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/371; H01Q 5/378; H01Q 21/30
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,872,707 B2 * 10/2014 Chen H01Q 1/2266
343/700 MS
9,002,262 B1 * 4/2015 Kuo H01Q 1/50
343/702

OTHER PUBLICATIONS

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

* cited by examiner

Primary Examiner — Robert Karacsony

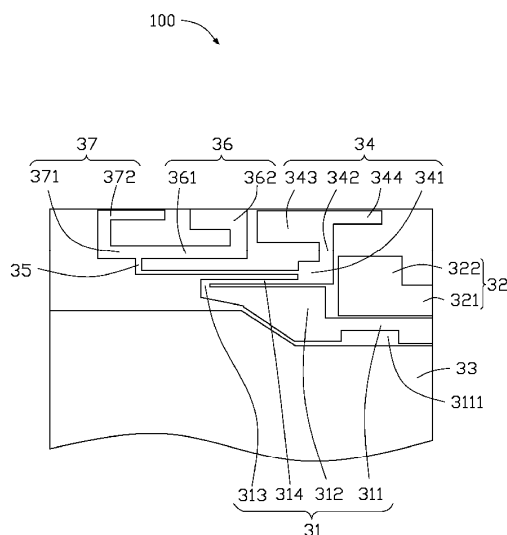
Assistant Examiner — Amal Patel

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

(57) **ABSTRACT**

An antenna structure includes a feeding portion, a first grounding portion, a second grounding portion, a first radiating portion, a second radiating portion, a third radiating portion, and a fourth radiating portion. The feeding portion is configured to feed current signals. The first and second grounding portions are positioned at two opposite sides of the feeding portion respectively. The first, second and third radiating portions cooperatively form a first current path to excite a low-frequency resonate mode and a first high-frequency resonate mode; the first radiating portion resonates with the first grounding portion to excite a second high-frequency resonate mode; the second, third and fourth radiating portion cooperatively form a second current path to excite a third high-frequency resonate mode.

6 Claims, 4 Drawing Sheets





US009755308B2

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

(10) **Patent No.:** **US 9,755,308 B2**

(45) **Date of Patent:** **Sep. 5, 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 157 days.

(21) Appl. No.: **14/508,261**

(22) Filed: **Oct. 7, 2014**

(65) **Prior Publication Data**

US 2015/0097753 A1 Apr. 9, 2015

(30) **Foreign Application Priority Data**

Oct. 9, 2013 (CN) 2013 1 0466065

(51) **Int. Cl.**
H01Q 21/00 (2006.01)
H01Q 7/00 (2006.01)
H01Q 5/40 (2015.01)
H01Q 1/50 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 7/00** (2013.01); **H01Q 5/40**
(2015.01); **H01Q 1/50** (2013.01); **H01Q 21/00**
(2013.01)

(58) **Field of Classification Search**

USPC 343/700 MS, 702, 867, 795
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2008/0180333 A1* 7/2008 Martiskainen H01Q 1/243
343/722
2009/0273530 A1* 11/2009 Chi H01Q 1/243
343/741
2011/0063180 A1* 3/2011 Su H01Q 3/24
343/795
2012/0218151 A1* 8/2012 Wong H01Q 1/243
343/700 MS

* cited by examiner

Primary Examiner — Jessica Han

Assistant Examiner — Hai Tran

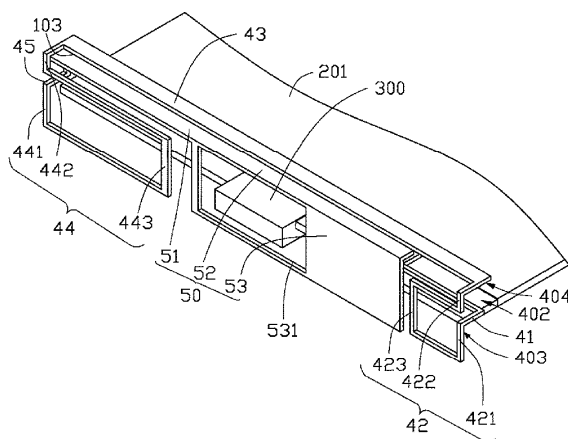
(74) *Attorney, Agent, or Firm* — Steven Reiss

(57) **ABSTRACT**

An antenna structure includes a feeding portion, a first grounding portion, a second grounding portion, a first loop antenna and a second loop antenna. The feeding portion has a first side and a second side parallel to the first side. The first grounding portion is positioned adjacent and apart from the first side of the feeding portion. The second grounding portion is positioned adjacent and apart from the second side of the grounding portion. The first loop antenna is defined to accept a second loop antenna therein, and is electronically coupled to the first and second grounding portions. The second loop antenna is positioned inside and apart from the first loop antenna, and further electronically coupled to the feeding portion.

18 Claims, 5 Drawing Sheets

200





US009755310B2

(12) **United States Patent**
Quinlan

(10) **Patent No.:** **US 9,755,310 B2**

(45) **Date of Patent:** **Sep. 5, 2017**

(54) **TEN-FREQUENCY BAND ANTENNA**

(71) Applicant: **TAOGLAS LIMITED**, Taoyuan (TW)

(72) Inventor: **Ronan Quinlan**, Taoyuan (TW)

(73) Assignee: **TAOGLAS LIMITED**, Taoyuan (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 164 days.

(21) Appl. No.: **14/948,226**

(22) Filed: **Nov. 20, 2015**

(65) **Prior Publication Data**

US 2017/0149138 A1 May 25, 2017

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

(52) **U.S. Cl.**
CPC **H01Q 9/04** (2013.01); **H01Q 1/38** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/10; H01Q 5/30; H01Q 5/307; H01Q 5/342; H01Q 5/357; H01Q 5/364; H01Q 5/371; H01Q 1/22; H01Q 1/2258-1/243; H01Q 1/245; H01Q 1/38; H01Q 9/04; H01Q 9/40; H01Q 9/42

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,373,599 B2 * 2/2013 Lin H01Q 1/243
343/700 MS
8,779,988 B2 * 7/2014 Yang H01Q 1/243
343/700 MS

8,970,436 B2 * 3/2015 Yang H01Q 1/243
343/700 MS
9,461,359 B2 * 10/2016 Kanj H01Q 1/243
2012/0169555 A1 * 7/2012 Tsou H01Q 5/364
343/749

FOREIGN PATENT DOCUMENTS

WO 2014058926 A1 4/2014

OTHER PUBLICATIONS

Search Report dated Feb. 1, 2017 of the corresponding European patent application.

* cited by examiner

Primary Examiner — Tho G Phan

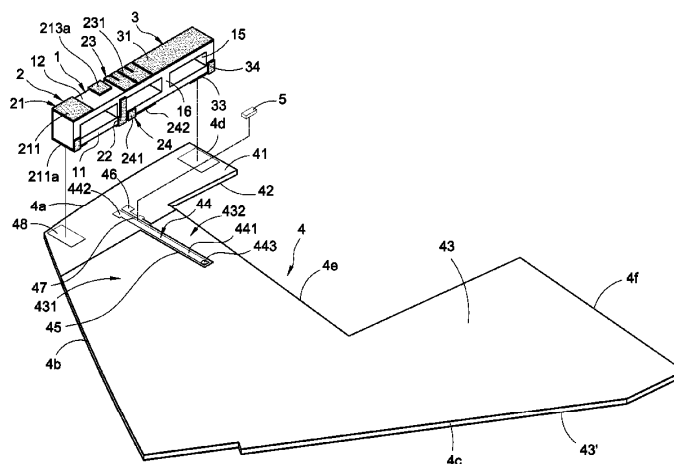
Assistant Examiner — Patrick Holecek

(74) *Attorney, Agent, or Firm* — Chun-Ming Shih; HDLS IPR Services

(57) **ABSTRACT**

A ten-frequency band antenna includes a carrier, a high-frequency segment, a low-frequency segment, a printed circuit board (PCB) and an inductor. The high-frequency segment is arranged on left side of the carrier and the low-frequency segment is arranged on right side of the carrier. The radiator on the bottom face of the carrier electrically connects with the micro strip of the PCB and the ground line of the ground metal when the carrier is fixed to the PCB. The low-frequency segment is located at an opened area and corresponding to a metal face with smaller area such that the low-frequency segment is at a free space to enhance the frequency response of the low-frequency segment and the bandwidth of the high-frequency segment. The area and the volume of blind hole on the carrier can adjust the effective dielectric constant to adjust the resonant frequency and bandwidth of the antenna.

14 Claims, 9 Drawing Sheets





US009755684B2

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

(10) **Patent No.:** **US 9,755,684 B2**

(45) **Date of Patent:** **Sep. 5, 2017**

(54) **ELECTRONIC DEVICE INCLUDING
ANTENNA DEVICE**

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

(72) Inventors: **Chae-Up Yoo**, Seoul (KR); **Jung-Kyu
Lee**, Gyeonggi-do (KR); **Byung-Man
Lim**, Seoul (KR)

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

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/055,096**

(22) Filed: **Feb. 26, 2016**

(65) **Prior Publication Data**

US 2016/0254832 A1 Sep. 1, 2016

(30) **Foreign Application Priority Data**

Feb. 26, 2015 (KR) 10-2015-0027594

(51) **Int. Cl.**
H04M 1/00 (2006.01)
H04B 1/3827 (2015.01)

(Continued)

(52) **U.S. Cl.**
CPC **H04B 1/3838** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 5/35** (2015.01); **H01Q 5/378**
(2015.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H04M 1/0277; H05K 13/0023; H05K
5/0017; H05K 5/0217; H05K 5/03; H05K
5/04; H05K 7/1417; H05K 9/0015
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

2010/0271270 A1 * 10/2010 Sung B29C 45/14065
343/702

2012/0112969 A1 5/2012 Caballero et al.
(Continued)

FOREIGN PATENT DOCUMENTS

EP 2 629 361 8/2013
EP 2 677 600 12/2013

OTHER PUBLICATIONS

International Search Report dated May 31, 2016 issued in counter-
part application No. PCT/KR2016/001707, 8 pages.

(Continued)

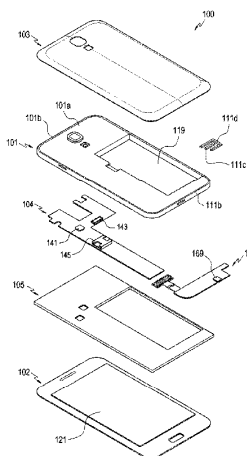
Primary Examiner — Tu X Nguyen

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

(57) **ABSTRACT**

An electronic device including an antenna device is provided. The electronic device includes a case member, a frame disposed around a periphery of one surface of the case member, forming sidewalls, and an antenna device for transmitting and receiving wireless signals. The antenna device includes a first radiation conductor forming a first part of the frame, a second radiation conductor disposed in a vicinity of the first radiation conductor, forming a second part of the frame, a third radiation conductor provided on the case member and connected to a first power supply of the electronic device, together with the first radiation conductor, and a fourth radiation conductor provided on the case member and connected to a ground of the electronic device. At least a part of the fourth radiation conductor is disposed in a vicinity of the second radiation conductor.

28 Claims, 11 Drawing Sheets





US009761925B2

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

(10) **Patent No.:** **US 9,761,925 B2**

(45) **Date of Patent:** **Sep. 12, 2017**

(54) **MULTI-BAND ANTENNA AND TERMINAL DEVICE**

USPC 343/702, 828
See application file for complete search history.

(71) Applicant: **SONY MOBILE COMMUNICATIONS AB**, Lund (SE)

(56) **References Cited**

(72) Inventors: **Takahiro Sato**, Tokyo (JP); **Tomihiko Omuro**, Tokyo (JP)

U.S. PATENT DOCUMENTS

(73) Assignees: **Sony Corporation**, Tokyo (JP); **Sony Mobile Communications Inc.**, Tokyo (JP)

5,877,727 A * 3/1999 Saitou H01Q 1/1278
343/704
7,990,321 B2 8/2011 Shih
8,743,010 B2 * 6/2014 Yanagi et al. 343/845
8,890,753 B1 * 11/2014 Lee 343/702
2011/0140978 A1 6/2011 Maruyama

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 574 days.

* cited by examiner

(21) Appl. No.: **13/765,319**

Primary Examiner — Hoang Nguyen

(22) Filed: **Feb. 12, 2013**

(74) *Attorney, Agent, or Firm* — Oblon, McClelland, Maier & Neustadt, L.L.P.

(65) **Prior Publication Data**

US 2014/0225781 A1 Aug. 14, 2014

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

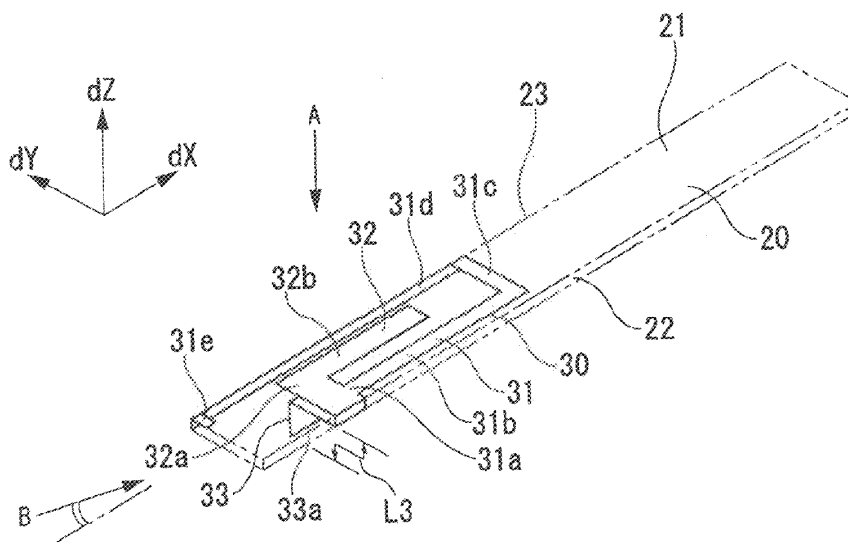
(57) **ABSTRACT**

An antenna that includes a first element extending from a connection point, and has a curvature such that a first tip end of the first element extends in a direction toward the connection point. A second element is connected to the connection point, and has a second tip end that extends in a direction away from the connection point, the second tip being disposed within an outer periphery of the first element. A distance between a portion of the first element that is parallel to the second element is greater than $\lambda_{gx}/100$, where λ_{gx} represents an effective wavelength of a first anti-resonance frequency.

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

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/371; H01Q 9/42

21 Claims, 46 Drawing Sheets





US009761926B2

(12) **United States Patent**
Suh

(10) **Patent No.:** **US 9,761,926 B2**

(45) **Date of Patent:** **Sep. 12, 2017**

(54) **ANTENNA AND MOBILE DEVICE
THEREWITH**

USPC 343/700 MS, 702, 872, 873
See application file for complete search history.

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

(72) Inventor: **Young-Hoon Suh**, Gyeonggi-do (KR)

5,929,813 A * 7/1999 Eggleston H01Q 1/243

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

6,388,626 B1 * 5/2002 Gamalielsson H01Q 1/243

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 96 days.

8,253,633 B2 * 8/2012 Sanz H01Q 1/243

2007/0030202 A1 * 2/2007 Lee H01Q 1/38

2009/0051584 A1 2/2009 Hellsten H01Q 1/243

2009/0051620 A1 * 2/2009 Ishibashi H01Q 1/243

2010/0066608 A1 3/2010 McCarthy et al. H01Q 1/243

2012/0064843 A1 * 3/2012 Kim H01Q 1/243

2013/0044041 A1 * 2/2013 Liu H01Q 1/243

343/702

343/702

343/702

343/702

343/702

343/702

343/702

343/702

343/702

343/702

343/702

343/702

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(21) Appl. No.: **14/792,323**

(22) Filed: **Jul. 6, 2015**

(65) **Prior Publication Data**

US 2016/0006126 A1 Jan. 7, 2016

(30) **Foreign Application Priority Data**

Jul. 4, 2014 (KR) 10-2014-0083862

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 21/30 (2006.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/245**

(2013.01); **H01Q 21/30** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/245; H01Q 21/30;

H01Q 9/0407

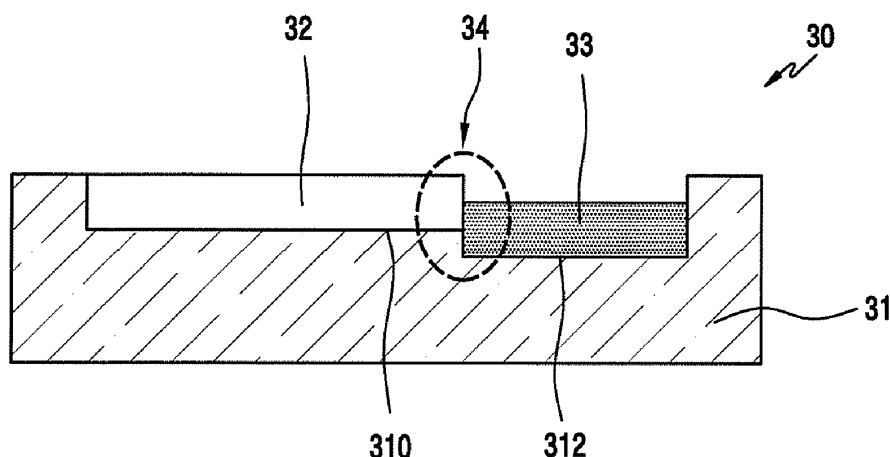
* cited by examiner

Primary Examiner — Tho G Phan

(57) **ABSTRACT**

An antenna of a mobile device is provided. The antenna includes two antennas that are disposed to be stepped from each other, thereby preventing degradation of an OTA characteristic and reducing an SAR. The antenna includes first and second surfaces stepped from each other on the top surface of an antenna carrier, and a low-band antenna emitter disposed on the first surface and a high-band antenna emitter disposed on the recessed second surface.

16 Claims, 14 Drawing Sheets





US009761927B2

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

(10) **Patent No.:** **US 9,761,927 B2**

(45) **Date of Patent:** **Sep. 12, 2017**

(54) **BATTERY CASE WITH SUPPLEMENTAL ANTENNA FEATURES FOR CELLULAR TELEPHONE**

(56) **References Cited**

U.S. PATENT DOCUMENTS

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

8,565,843 B1 * 10/2013 Lugo H04M 1/04

(72) Inventors: **Darshan R. Kasar**, San Francisco, CA (US); **Kirill Kalinichev**, San Francisco, CA (US); **Ian P. Colahan**, Menlo Park, CA (US); **Timothy J. Rasmussen**, Sunnyvale, CA (US)

8,646,698 B2 2/2014 Chen et al.

8,774,716 B2 * 7/2014 Chan H04B 5/0062

8,954,122 B2 2/2015 Wilmhoff et al.

9,124,677 B2 9/2015 Wenger et al.

(Continued)

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

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 88 days.

CN 201976377 U 9/2011

CN 202111753 U 1/2012

(Continued)

(21) Appl. No.: **14/848,034**

OTHER PUBLICATIONS

(22) Filed: **Sep. 8, 2015**

Hu et al., U.S. Appl. No. 14/477,596, filed Sep. 4, 2014.

(65) **Prior Publication Data**

US 2017/0069955 A1 Mar. 9, 2017

Primary Examiner — Hoang Nguyen

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

G. Victor Treyz; Zachary D. Hadd

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 9/04 (2006.01)

H01Q 1/40 (2006.01)

H01Q 1/42 (2006.01)

(57) **ABSTRACT**

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/40** (2013.01); **H01Q 1/42** (2013.01); **H01Q 9/0442** (2013.01)

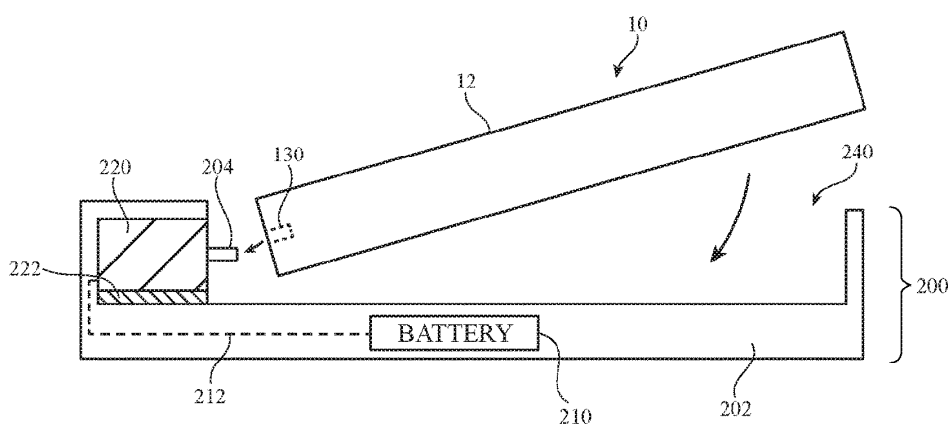
A removable case may receive an electronic device. A male connector in the case may mate with a female connector in the device. A battery in the case may supply power to the device through the male connector. The electronic device may have an antenna. The case may have a supplemental antenna that compensates for variations in performance in the antenna when the device is received within the case. The supplemental antenna may be a parasitic antenna resonating element that is formed from metal traces on a flexible printed circuit. The flexible printed circuit, a metal trim structure, and a plastic support structure may form portions of a connector support structure in the case.

(58) **Field of Classification Search**

CPC .. H01Q 1/40; H01Q 1/42; H01Q 1/24; H01Q 1/241; H01Q 1/242; H01Q 1/243; H04M 1/0237; H04M 1/0264; H04M 1/0272; H04M 1/0283; H04M 1/03; H04M 1/21; H04M 1/72522

See application file for complete search history.

20 Claims, 6 Drawing Sheets





US009761936B2

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

(10) **Patent No.:** **US 9,761,936 B2**

(45) **Date of Patent:** **Sep. 12, 2017**

(54) **PLANAR INVERTED-F ANTENNA**

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

(71) Applicant: **FOXCONN INTERCONNECT TECHNOLOGY LIMITED**, Grand Cayman (KY)

(56) **References Cited**

U.S. PATENT DOCUMENTS

(72) Inventors: **Tzu-Yao Hwang**, New Taipei (TW);
Lung-Sheng Tai, New Taipei (TW)

6,404,394 B1 *	6/2002	Hill		H01Q 1/243
				343/700 MS
2009/0153407 A1 *	6/2009	Zhang		H01Q 1/243
				343/702
2010/0079351 A1 *	4/2010	Huang		H01Q 1/48
				343/846

(73) Assignee: **FOXCONN INTERCONNECT TECHNOLOGY LIMITED**, Grand Cayman (KY)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

* cited by examiner

Primary Examiner — Dameon E Levi

Assistant Examiner — Andrea Lindgren Baltzell

(21) Appl. No.: **14/810,725**

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

(22) Filed: **Jul. 28, 2015**

(57) **ABSTRACT**

(65) **Prior Publication Data**

US 2016/0036129 A1 Feb. 4, 2016

(30) **Foreign Application Priority Data**

Jul. 30, 2014 (TW) 103213468 U

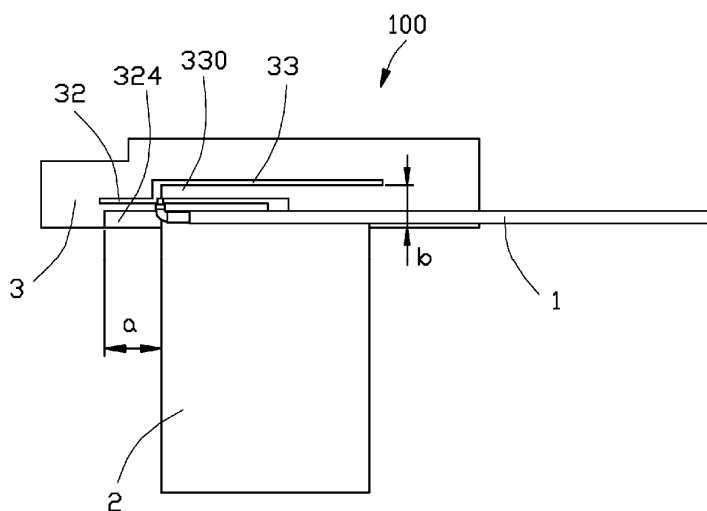
(51) **Int. Cl.**
H01Q 1/48 (2006.01)
H01Q 9/04 (2006.01)
H01Q 5/371 (2015.01)

A planar inverted-F antenna includes an antenna body including a grounding portion, a first and a second radiating arm extending in a lengthwise direction substantially, a coaxial cable and a metal foil attached the grounding portion. The first radiating arm and the second radiating arm extend in opposite directions from a joint point thereof, the joint point and the grounding portion connect with each other by a connecting portion. A first slot is defined between the first radiating arm and the grounding arm, a second slot is defined between the second radiating arm and the grounding portion. A coaxial cable includes a core soldered to the joint point and a shielding layer soldered to the grounding portion. The metal foil covers a most portion of the grounding portion, thereby exposes a first end of the grounding portion near to the first radiating arm to an exterior.

(52) **U.S. Cl.**
CPC **H01Q 1/48** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 5/371** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 9/045; H01Q 1/48

18 Claims, 4 Drawing Sheets





US009761943B2

(12) **United States Patent**
Yang

(10) **Patent No.:** **US 9,761,943 B2**

(45) **Date of Patent:** **Sep. 12, 2017**

(54) **ANTENNA STRUCTURE**

(71) Applicant: **Acer Incorporated**, New Taipei (TW)

(72) Inventor: **Chung-Wen Yang**, New Taipei (TW)

(73) Assignee: **ACER INCORPORATED**, 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 30 days.

(21) Appl. No.: **14/828,797**

(22) Filed: **Aug. 18, 2015**

(65) **Prior Publication Data**

US 2016/0359231 A1 Dec. 8, 2016

(30) **Foreign Application Priority Data**

Jun. 3, 2015 (TW) 104117909 A

(51) **Int. Cl.**
H01Q 1/48 (2006.01)
H01Q 5/371 (2015.01)
H01Q 1/24 (2006.01)
H01Q 7/00 (2006.01)
H01Q 5/40 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 5/371** (2015.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/40** (2015.01); **H01Q 7/00** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/371; H01Q 1/38; H01Q 5/307; H01Q 1/243
USPC 343/845, 700 MS, 720, 702
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2006/0097918 A1 5/2006 Oshiyama et al.
2012/0050121 A1* 3/2012 Kim H01Q 1/243
343/745

FOREIGN PATENT DOCUMENTS

EP 2 048 739 4/2009
TW I329391 8/2010
TW I355777 1/2012
TW I466381 12/2014

OTHER PUBLICATIONS

Chinese language office action dated May 20, 2016, issued in application No. TW 104117909.

European Search Report dated Oct. 18, 2016, issued in application No. 15191180.7-1811.

* cited by examiner

Primary Examiner — Dameon E Levi

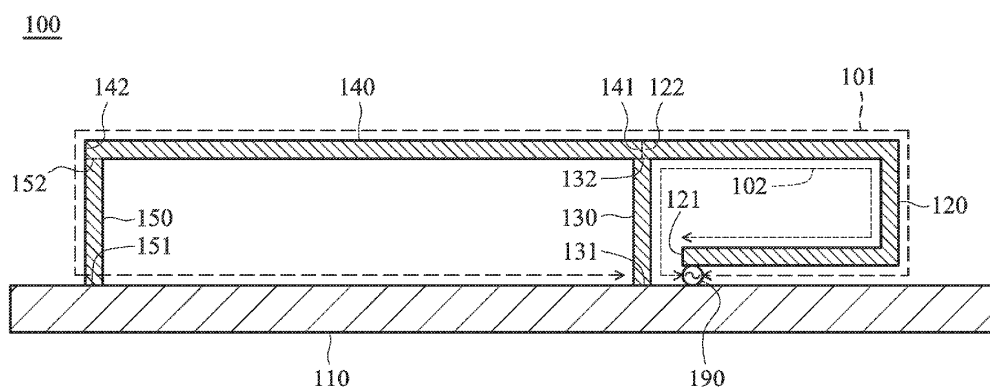
Assistant Examiner — Collin Dawkins

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

(57) **ABSTRACT**

An antenna structure includes a ground element, a first radiation branch, a first ground branch, a second radiation branch, and a second ground branch. A first end of the first radiation branch is coupled to a signal source. A first end of the first ground branch is coupled to the ground element. A second end of the first ground branch is coupled to a second end of the first radiation branch. A first end of the second radiation branch is coupled to the second end of the first radiation branch. A first end of the second ground branch is coupled to the ground element. A second end of the second ground branch is coupled to a second end of the second radiation branch.

8 Claims, 8 Drawing Sheets





US009762710B2

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

(10) **Patent No.:** **US 9,762,710 B2**

(45) **Date of Patent:** **Sep. 12, 2017**

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

H04B 2001/485 (2013.01); *H04W 4/008* (2013.01); *H04W 84/042* (2013.01); *H04W 84/12* (2013.01)

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

(58) **Field of Classification Search**

None

See application file for complete search history.

(72) Inventors: **Hyung Joo Lee**, Seongnam-si (KR);
Gyu Sub Kim, Seoul (KR); **Dong Yeon Kim**, Suwon-si (KR); **Chae Up Yoo**, Seoul (KR)

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,358,906 B2 * 4/2008 Sato H01Q 1/243
343/700 MS

7,639,194 B2 12/2009 Chi et al.

(Continued)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

FOREIGN PATENT DOCUMENTS

EP 2 528 165 A1 11/2012

GB 2516304 A 1/2015

KR 10-2008-0112502 A 12/2008

Primary Examiner — Tuan A Tran

(21) Appl. No.: **15/234,547**

(22) Filed: **Aug. 11, 2016**

(74) Attorney, Agent, or Firm — Jefferson IP Law, LLP

(65) **Prior Publication Data**

US 2017/0048363 A1 Feb. 16, 2017

(30) **Foreign Application Priority Data**

Aug. 13, 2015 (KR) 10-2015-0114638

(57) **ABSTRACT**

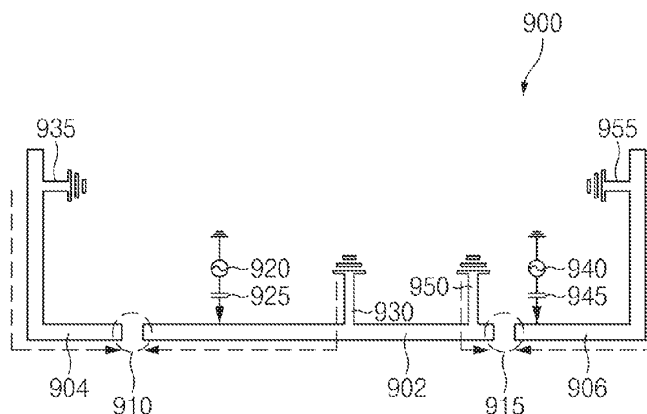
An electronic device is provided. The electronic device includes a housing including a first surface, a second surface disposed facing an opposite side of the first surface, and a side surface configured to surround at least a portion of a space between the first surface and the second surface, a first elongated metal member configured to form a first portion of the side surface and including a first end and a second end, at least one communication circuit electrically connected to a first point of the first elongated metal member through a capacitive element, at least one ground member disposed in an interior of the housing, and a first conductive member configured to electrically connect a second point of the first elongated metal member to the ground member. The second point of the first elongated metal member is disposed closer to the second end than to the first point.

17 Claims, 42 Drawing Sheets

(51) **Int. Cl.**
H04B 1/44 (2006.01)
H04M 1/02 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H04M 1/0202** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/521** (2013.01); **H01Q 5/314** (2015.01); **H01Q 5/328** (2015.01); **H01Q 5/35** (2015.01); **H04B 1/3833** (2013.01); **H04B 1/48** (2013.01);





US009768491B2

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

(10) **Patent No.:** **US 9,768,491 B2**

(45) **Date of Patent:** **Sep. 19, 2017**

(54) **ELECTRONIC DEVICE WITH PERIPHERAL HYBRID ANTENNA**

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

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

(56) **References Cited**

(72) Inventors: **Nanbo Jin**, Milpitas, CA (US); **Anand Lakshmanan**, San Jose, CA (US); **Enrique Ayala Vazquez**, Watsonville, CA (US); **Erica J. Tong**, Pacifica, CA (US); **Hongfei Hu**, Santa Clara, CA (US); **Matthew A. Mow**, Los Altos, CA (US); **Mattia Pascolini**, San Francisco, CA (US); **Ming-Ju Tsai**, Cupertino, CA (US)

U.S. PATENT DOCUMENTS

6,373,439 B1	4/2002	Zurcher et al.
6,903,693 B1	6/2005	Lee et al.
7,187,329 B2	3/2007	Okado
7,876,274 B2	1/2011	Hobson et al.

(Continued)

FOREIGN PATENT DOCUMENTS

EP	2500979	9/2012
EP	2528165	11/2012

(Continued)

OTHER PUBLICATIONS

(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 120 days.

Mow et al., U.S. Appl. No. 14/701,323, filed Apr. 30, 2015.

(21) Appl. No.: **14/691,304**

(22) Filed: **Apr. 20, 2015**

Primary Examiner — Dieu H Duong

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

(65) **Prior Publication Data**

US 2016/0308271 A1 Oct. 20, 2016

(57) **ABSTRACT**

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 1/48 (2006.01)

H01Q 1/50 (2006.01)

H04B 1/3888 (2015.01)

H01Q 13/10 (2006.01)

H01Q 21/28 (2006.01)

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

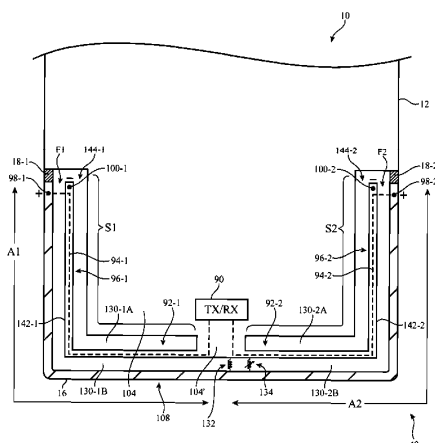
CPC **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/50** (2013.01); **H01Q 13/103** (2013.01); **H01Q 21/28** (2013.01); **H04B 1/3888** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/48; H01Q 1/50; H01Q 21/28; H01Q 13/103

An electronic device may have wireless circuitry with antennas. An antenna resonating element arm for an antenna may be formed from peripheral conductive structures running along the edges of a device housing. Elongated conductive members may longitudinally divide openings between the peripheral conductive housing structures and the ground. The elongated conductive members may extend from an internal ground to outer ends of the elongated conductive members that are located adjacent to the gaps. Transmission lines may extend along the elongated conductive members to antenna feeds at the outer ends. The elongated conductive members may form open slots that serve as slot antenna resonating elements for the antenna.

21 Claims, 9 Drawing Sheets





US009768492B2

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

(10) **Patent No.:** **US 9,768,492 B2**

(45) **Date of Patent:** ***Sep. 19, 2017**

(54) **ANTENNA APPARATUS FOR PORTABLE
TERMINAL**

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

(72) Inventors: **Jaе-Hee Kim**, Gyeonggi-do (KR);
Joon-Ho Byun, Gyeonggi-do (KR);
Se-Hyun Park, Gyeonggi-do (KR);
Dong-Hyun Lee, Gyeonggi-do (KR);
Austin Kim, Gyeonggi-do (KR)

(73) Assignee: **Samsung Electronics 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 0 days.

This patent is subject to a terminal dis-
claimer.

(21) Appl. No.: **15/180,326**

(22) Filed: **Jun. 13, 2016**

(65) **Prior Publication Data**

US 2016/0285156 A1 Sep. 29, 2016

Related U.S. Application Data

(63) Continuation of application No. 14/719,642, filed on
May 22, 2015, now Pat. No. 9,385,418, which is a
(Continued)

(30) Foreign Application Priority Data

Apr. 14, 2011 (KR) 10-2011-0034548

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/44 (2006.01)

(Continued)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/44**
(2013.01); **H01Q 1/48** (2013.01); **H01Q 1/50**
(2013.01); **H01Q 21/28** (2013.01); **H01Q**
21/29 (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/50; H01Q 1/48; H01Q
1/44; H01Q 21/29; H01Q 21/28
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,048,118 A 9/1991 Brooks et al.
7,612,725 B2 11/2009 Hill et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 101814649 A 8/2010
CN 202353552 U 7/2012
(Continued)

OTHER PUBLICATIONS

European Search Report dated Jul. 21, 2016.
Chinese Search Report dated Aug. 3, 2016.

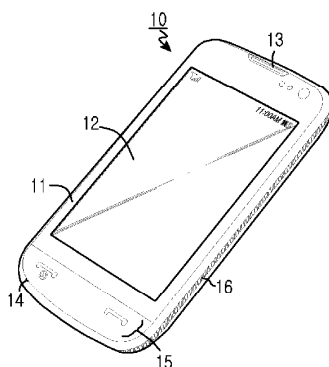
Primary Examiner — Huedung Mancuso

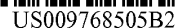
(74) *Attorney, Agent, or Firm* — Cha & Reiter, LLC

(57) **ABSTRACT**

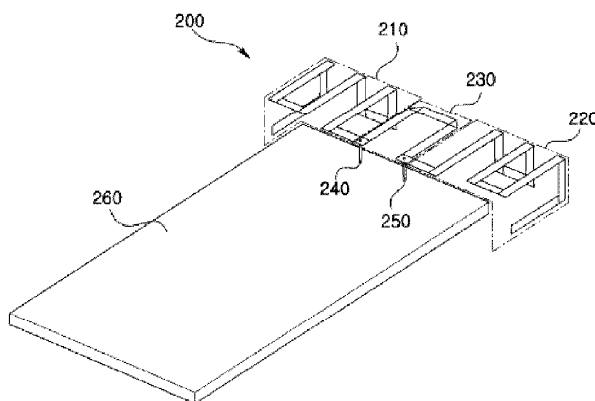
An antenna apparatus for a portable terminal having a main
board is provided. The antenna apparatus includes a main
antenna that electrically connects to a feed line of the main
board. A metal frame is constructed as part of a case frame
forming an exterior of the portable terminal. The metal
frame is divided into first and second parts that are sepa-
rated. The first part electrically connects to the main antenna
or to the main board feed line, and is designed to radiate. The
second part electrically connects to a ground surface of the

(Continued)





(45) **Date of Patent:** Sep. 19, 2017





US009768506B2

(12) **United States Patent**
Krogerus

(10) **Patent No.:** **US 9,768,506 B2**

(45) **Date of Patent:** **Sep. 19, 2017**

(54) **MULTI-ANTENNNA ISOLATION
ADJUSTMENT**

(71) Applicant: **Microsoft Technology Licensing, LLC**,
Redmond, WA (US)

(72) Inventor: **Joonas Krogerus**, Espoo (FI)

(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 72 days.

(21) Appl. No.: **14/854,353**

(22) Filed: **Sep. 15, 2015**

(65) **Prior Publication Data**

US 2017/0077603 A1 Mar. 16, 2017

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/30 (2015.01)
H01Q 5/10 (2015.01)
H01Q 1/38 (2006.01)
H01Q 1/50 (2006.01)
H01Q 5/328 (2015.01)
H01Q 1/42 (2006.01)
H01Q 1/52 (2006.01)
H01Q 13/10 (2006.01)
H01Q 21/28 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/30** (2015.01); **H01Q 1/24**
(2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38**
(2013.01); **H01Q 1/42** (2013.01); **H01Q 1/50**
(2013.01); **H01Q 1/52** (2013.01); **H01Q 5/10**
(2015.01); **H01Q 5/328** (2015.01); **H01Q**
13/10 (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 13/10; H01Q 1/243; H01Q 5/35;
H01Q 5/357

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,245,259 B2 7/2007 Puckey et al.
7,893,889 B2 2/2011 Proctor et al.
8,570,229 B2 10/2013 Yoon et al.
(Continued)

FOREIGN PATENT DOCUMENTS

EP 0716786 A1 6/1996
WO 2014106440 A1 7/2014

OTHER PUBLICATIONS

"International Search Report and Written Opinion Issued in PCT
Application No. PCT/US2016/045666", Mailed Date: Nov. 7, 2016,
16 Pages.

Zhong, et al., "Multiband Slot Antennas for Metal Back Cover
Mobile Handsets", In Proceedings of Progress in Electromagnetics
Research Letters, vol. 39, Apr. 23, 2015, pp. 115-126.

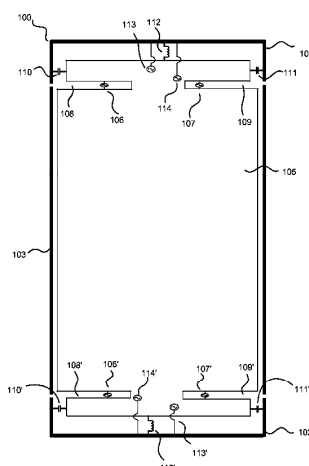
(Continued)

Primary Examiner — Hoang Nguyen

(57) **ABSTRACT**

In an embodiment, isolation between antennas of a multi
antenna system is disclosed. According to another embodi-
ment, a device is disclosed comprising a conductive portion
of a cover of the device; a first antenna feed configured to
a first radio frequency band; a second antenna feed configured
to a second radio frequency band; at least two slots of a
printed wiring board, feeds being coupled to the slots and
slots being coupled to the conductive portion; a first capaci-
tive component; a second capacitive component; wherein
the first and the second capacitive component are configured
between the printed wiring board and the conductive por-
tion.

20 Claims, 10 Drawing Sheets





US009768507B2

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

(10) **Patent No.:** **US 9,768,507 B2**

(45) **Date of Patent:** **Sep. 19, 2017**

(54) **ANTENNA DEVICES HAVING
FREQUENCY-DEPENDENT CONNECTION
TO ELECTRICAL GROUND**

H01Q 9/0407 (2013.01); *H01Q 9/42*
(2013.01); *H01Q 15/008* (2013.01); *H01Q*
15/0086 (2013.01)

(71) Applicant: **Tyco Electronics Services GmbH**,
Schaffhausen (CH)

(58) **Field of Classification Search**

None

See application file for complete search history.

(72) Inventors: **Sunil Kumar Rajgopal**, San Diego,
CA (US); **Cheng Jung Lee**, Santa
Clara, CA (US); **Ajay Gummalla**,
Sunnyvale, CA (US)

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,592,957 B2	9/2009	Achour et al.	
8,816,912 B2	8/2014	Rajgopal et al.	
2007/0159401 A1 *	7/2007	Baliarda	H01Q 1/241 343/702

(Continued)

FOREIGN PATENT DOCUMENTS

CN	1778014 A	5/2006
CN	1918744 A	2/2007

(Continued)

OTHER PUBLICATIONS

"International Application Serial No. PCT/US2009/069840, Search
Report mailed Jun. 30, 2010", 3 pgs.

(Continued)

(73) Assignee: **Tyco Electronics Services GmbH** (CH)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 237 days.

(21) Appl. No.: **14/467,708**

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

(65) **Prior Publication Data**

US 2015/0102968 A1 Apr. 16, 2015

Related U.S. Application Data

(63) Continuation of application No. 12/649,906, filed on
Dec. 30, 2009, now Pat. No. 8,816,912.

(51) **Int. Cl.**
H01Q 5/328 (2015.01)
H01Q 9/04 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/48 (2006.01)
H01Q 15/00 (2006.01)
H01Q 9/42 (2006.01)
H01P 1/203 (2006.01)
H01P 3/08 (2006.01)

(52) **U.S. Cl.**
CPC *H01Q 5/328* (2015.01); *H01P 1/203*
(2013.01); *H01P 3/081* (2013.01); *H01Q*
1/2275 (2013.01); *H01Q 1/48* (2013.01);

Primary Examiner — Robert Karacsony

(57) **ABSTRACT**

Antenna devices and techniques that provide specific control
of the spatial distributions of DC and RF signals at various
positions in a wireless apparatus are disclosed. The wireless
apparatus includes various device components each having
specifications for achieving desired operations in antenna
devices.

13 Claims, 41 Drawing Sheets

16003

