US009553355B2

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

(10) **Patent No.: US 9,553,355 B2**
(45) **Date of Patent: Jan. 24, 2017**

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

(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 88 days.

(21) Appl. No.: **14/467,649**

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

(65) **Prior Publication Data**

US 2015/0054695 A1 Feb. 26, 2015

(30) **Foreign Application Priority Data**

Aug. 26, 2013 (CN) 2013 1 03740893

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 5/335	(2015.01)
H01Q 9/04	(2006.01)
H01Q 1/42	(2006.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/42*** (2013.01); ***H01Q 5/335*** (2015.01); ***H01Q 9/0421*** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

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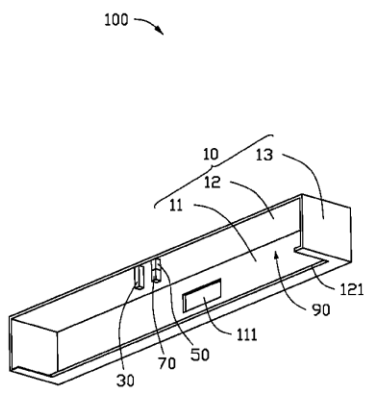
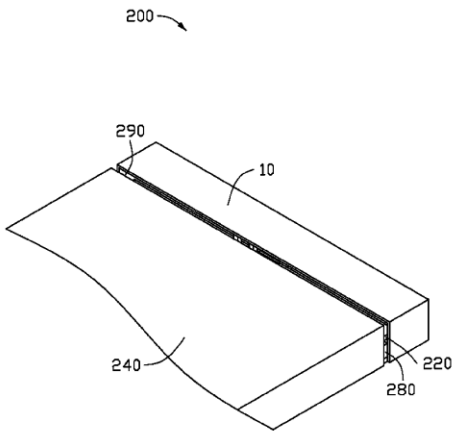
Primary Examiner — Robert Karacsony
(74) *Attorney, Agent, or Firm* — Zhigang Ma

(57) **ABSTRACT**

An antenna structure includes a radiation body, a grounding portion, a feeding portion, and a variable capacitor. The grounding portion is coupled to the radiation body and is configured to couple to ground. The feeding portion is coupled between the radiation body and the variable capacitor, the feeding portion is configured to receive feeding signals via the variable capacitor.

11 Claims, 5 Drawing Sheets





US009553356B2

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

(10) **Patent No.: US 9,553,356 B2**
(45) **Date of Patent: Jan. 24, 2017**

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

(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 111 days.

(21) Appl. No.: **14/582,645**

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

(65) **Prior Publication Data**

US 2015/0188234 A1 Jul. 2, 2015

(30) **Foreign Application Priority Data**

Dec. 31, 2013 (CN) 2013 1 0748988

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 1/22	(2006.01)
H01Q 7/00	(2006.01)
H01Q 5/378	(2015.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/2291*** (2013.01); ***H01Q 5/378*** (2015.01); ***H01Q 7/00*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/241; H01Q 1/242; H01Q 1/243; H01Q 1/2291; H01Q 5/378
See application file for complete search history.

(56) **References Cited**

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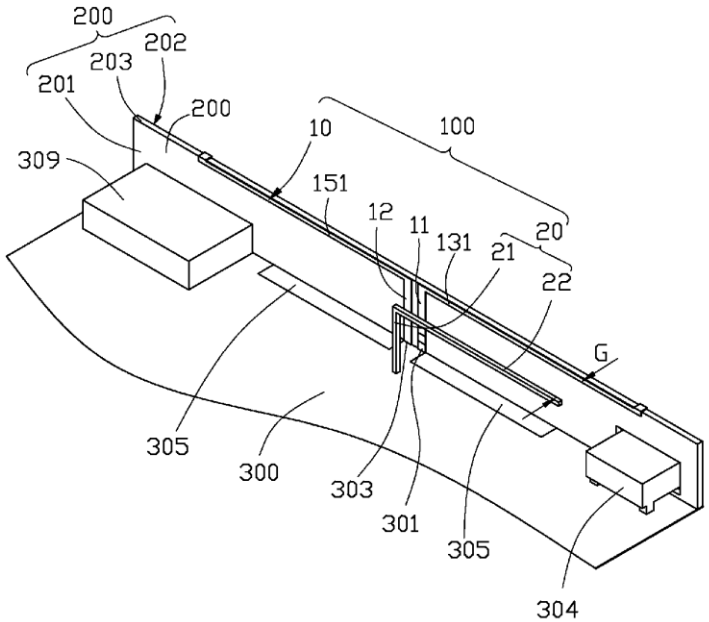
Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — Zhigang Ma

(57) **ABSTRACT**

An antenna module includes a main antenna and a parasitic resonator. The main antenna includes a feed arm, a ground arm, a first radiating body connected to one end of the feed arm, a second radiating body, and a third radiating body connected to one end of the ground arm. The first radiating body and the third radiating body are connected to the second radiating body and positioned at two sides of the second radiating body. The parasitic resonator is resonated with the main antenna and configured for widening a high frequency bandwidth of the main antenna.

19 Claims, 5 Drawing Sheets



US009553361B2

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

(10) **Patent No.: US 9,553,361 B2**
(45) **Date of Patent: Jan. 24, 2017**

(54) **BALANCED ANTENNA SYSTEM**

(75) Inventors: **Zhen Hua Sampson Hu**, Heshan (CN); **Peter Hall**, Birmingham (GB)

(73) Assignee: **SMART ANTENNA TECHNOLOGIES LTD**, Birmingham (GB)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 509 days.

(21) Appl. No.: **13/990,189**

(22) PCT Filed: **Nov. 11, 2011**

(86) PCT No.: **PCT/GB2011/001598**
§ 371 (c)(1),
(2), (4) Date: **Jul. 26, 2013**

(87) PCT Pub. No.: **WO2012/072969**
PCT Pub. Date: **Jun. 7, 2012**

(65) **Prior Publication Data**

US 2013/0307742 A1 Nov. 21, 2013

(30) **Foreign Application Priority Data**

Nov. 29, 2010 (GB) 1020202.6
May 19, 2011 (GB) 1108456.3

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

(52) **U.S. Cl.**
CPC ***H01Q 1/50*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/521*** (2013.01); ***H01Q 9/265*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 9/265; H01Q 21/0006; H03H 7/38; H03H 7/465
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(56) **References Cited**

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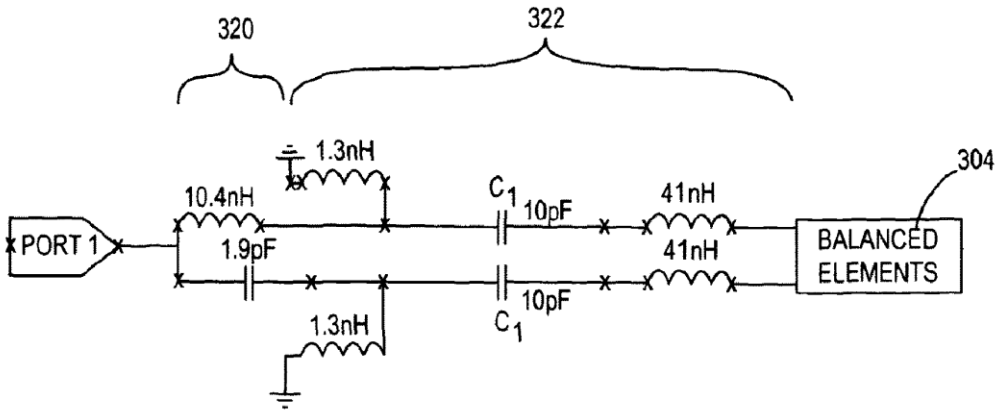
Primary Examiner — Hoanganh Le
(74) *Attorney, Agent, or Firm* — Barnes & Thornburg LLP

(57) **ABSTRACT**

The invention relates to a balanced antenna system comprising a radiator connected via a matching circuit to a balun. In certain embodiments, the radiator comprises a first radiating element and a second radiating element and the matching circuit comprises a first impedance-matching circuit connected to the first radiating element and a second impedance-matching circuit connected to the second radiating element. The first and second matching circuits may be identical and are connected through the balun to a single port. To minimize the component count, the design of the matching circuit and balun is co-optimized.

32 Claims, 19 Drawing Sheets



US009553367B2

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

(10) **Patent No.: US 9,553,367 B2**
(45) **Date of Patent: Jan. 24, 2017**

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

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

(72) Inventors: **Chuan-Chou Chi**, New Taipei (TW); **Chi-Sheng Liu**, New Taipei (TW); **Chih-Yang Tsai**, New Taipei (TW); **Hao-Ying Chang**, New Taipei (TW); **Chao-Wei Ho**, New Taipei (TW); **Pai-Cheng Huang**, 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 265 days.

(21) Appl. No.: **14/315,008**

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

(65) **Prior Publication Data**

US 2015/0002366 A1 Jan. 1, 2015

(30) **Foreign Application Priority Data**

Jun. 28, 2013 (TW) ..... 102123216 A

(51) **Int. Cl.**

H01Q 19/00	(2006.01)
H01Q 21/00	(2006.01)
H01Q 5/371	(2015.01)
H01Q 1/24	(2006.01)
H01Q 9/42	(2006.01)
H01Q 21/28	(2006.01)

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

(58) **Field of Classification Search**
CPC H01Q 21/28; H01Q 5/371; H01Q 5/357; H01Q 1/243; H01Q 1/521; H01Q 1/523; H01Q 1/525; H01Q 1/36; H01Q 9/42
See application file for complete search history.

(56) **References Cited**

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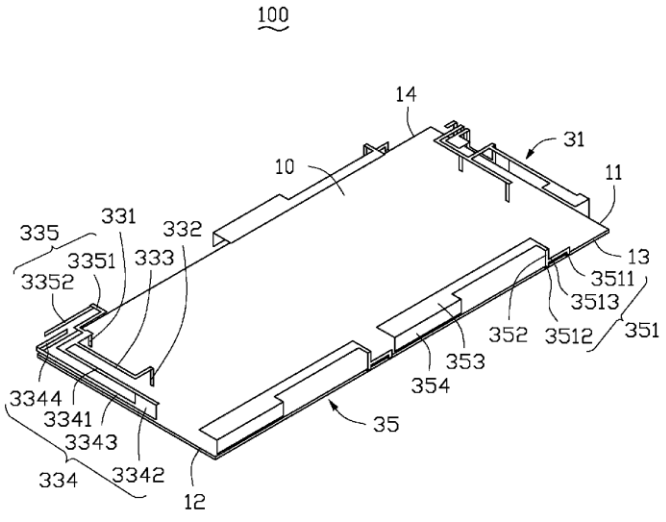
Primary Examiner — Dameon E Levi
Assistant Examiner — Ricardo Magallanes
(74) *Attorney, Agent, or Firm* — Zhigang Ma

(57) **ABSTRACT**

An antenna structure includes a main antenna, a diversity antenna, and at least one accessorial antenna. The main antenna extends in a main antenna direction. The diversity antenna is spaced apart from the main antenna and extends in a first radiation direction substantially parallel to the main antenna direction. The at least one accessorial antenna extends in a second radiation direction which is substantially perpendicular to either the main antenna direction or the first radiation direction.

20 Claims, 2 Drawing Sheets



US009559422B2

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

(10) **Patent No.: US 9,559,422 B2**
(45) **Date of Patent: Jan. 31, 2017**

(54) **COMMUNICATION DEVICE AND METHOD FOR DESIGNING MULTI-ANTENNA SYSTEM THEREOF**

(71) Applicants: **Industrial Technology Research Institute**, Hsinchu (TW); **National Sun Yat-sen University**, Kaohsiung (TW)

(72) Inventors: **Kin-Lu Wong**, Kaohsiung (TW); **Yeh-Chun Kao**, Taoyuan County (TW); **Po-Wei Lin**, Taichung (TW); **Wei-Yu Li**, Yilan County (TW)

(73) Assignees: **Industrial Technology Research Institute**, Hsinchu (TW); **National Sun Yat-sen University**, Kaohsiung (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 414 days.

(21) Appl. No.: **14/460,377**

(22) Filed: **Aug. 15, 2014**

(65) **Prior Publication Data**

US 2015/0311588 A1 Oct. 29, 2015

(30) **Foreign Application Priority Data**

Apr. 23, 2014 (TW) ..... 103114701 A

(51) **Int. Cl.**
H01Q 7/00 (2006.01)
H01Q 13/10 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 7/00*** (2013.01); ***H01Q 9/14*** (2013.01); ***H01Q 13/10*** (2013.01); ***H01Q 21/20*** (2013.01); ***H01Q 21/30*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 7/00; H01Q 9/04; H01Q 9/06; H01Q 9/14; H01Q 9/145; H01Q 13/10; H01Q 13/103; H01Q 13/106; H01Q 21/06; H01Q 21/20; H01Q 21/30; H01Q 3/24; H01Q 9/0407; H01Q 1/36; H01Q 1/38; H01Q 13/18; H01Q 21/28
See application file for complete search history.

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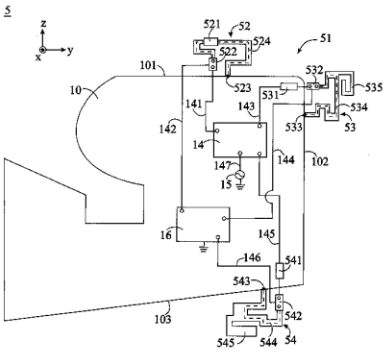
Primary Examiner — Bernarr Gregory
(74) *Attorney, Agent, or Firm* — Jianq Chyun IP Office

(57) **ABSTRACT**

The disclosure provides a communication device. The communication device includes a ground conductor portion and a multi-antenna system. The multi-antenna system includes at least a first and a second resonant portion, each of which is disposed on the corresponding radiating edge of the ground conductor portion. Each of the resonant portions may have a loop resonant structure or may have an open-slot resonant structure, and has a resonant path. The electrically coupling portion makes the length of the resonant path less than or equal to 0.18 times the wavelength of the lowest operating frequency of the multi-antenna system, and thereby excites the corresponding radiating edge and forms a strong surface current distribution, and generates an effective radiating energy and at least one resonant mode, in
(Continued)



US009559423B2

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

(10) **Patent No.: US 9,559,423 B2**
(45) **Date of Patent: Jan. 31, 2017**

(54) **WIDEBAND DEFORMED DIPOLE ANTENNA FOR LTE AND GPS BANDS**

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

(72) Inventors: **Wen Chieh Yang**, Taoyuan (TW); **Ronan Quinlan**, San Diego, CA (US)

(73) Assignee: **TAOGLAS GROUP HOLDINGS LIMITED**, Wexford (IE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 63 days.

(21) Appl. No.: **14/438,613**

(22) PCT Filed: **Oct. 8, 2013**

(86) PCT No.: **PCT/US2013/063949**
§ 371 (c)(1),
(2) Date: **May 1, 2015**

(87) PCT Pub. No.: **WO2014/058928**
PCT Pub. Date: **Apr. 17, 2014**

(65) **Prior Publication Data**

US 2015/0303579 A1 Oct. 22, 2015

Related U.S. Application Data

(60) Provisional application No. 61/711,194, filed on Oct. 8, 2012.

(51) **Int. Cl.**

H01Q 9/28	(2006.01)
H01Q 9/20	(2006.01)
H01Q 1/38	(2006.01)
H01Q 5/364	(2015.01)
H01Q 5/371	(2015.01)
H01Q 13/04	(2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 9/20*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 5/364*** (2015.01); ***H01Q 5/371*** (2015.01); ***H01Q 9/28*** (2013.01); ***H01Q 9/285*** (2013.01); *H01Q 13/04* (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/371; H01Q 9/285; H01Q 5/364; H01Q 9/28; H01Q 13/04; H01Q 9/20; H01Q 1/38
USPC ..... 343/793, 795, 700 MS
See application file for complete search history.

(56) **References Cited**

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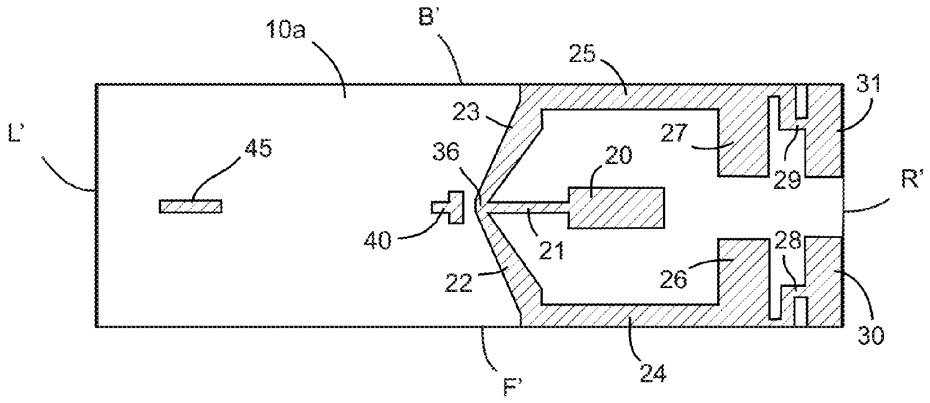
Primary Examiner — Khai M Nguyen
(74) *Attorney, Agent, or Firm* — Coastal Patent Law Group, P.C.

(57) **ABSTRACT**

A deformed dipole is suggested with trace elements configured for wideband LTE and GPS operation. The deformed dipole comprises a first dipole conductor disposed on a first surface and first side of the circuit board and a second dipole conductor disposed on an opposite surface and opposite side of the circuit board.

17 Claims, 4 Drawing Sheets



Top View

US009559425B2

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

(10) **Patent No.: US 9,559,425 B2**
(45) **Date of Patent: Jan. 31, 2017**

(54) **ELECTRONIC DEVICE WITH SLOT ANTENNA AND PROXIMITY SENSOR**

(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)

(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 127 days.

(21) Appl. No.: **14/221,133**

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

(65) **Prior Publication Data**

US 2015/0270619 A1 Sep. 24, 2015

(51) **Int. Cl.**

H01Q 13/10	(2006.01)
G01V 3/00	(2006.01)
H01Q 1/22	(2006.01)
H01Q 1/24	(2006.01)
G06F 1/16	(2006.01)

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

CPC ***H01Q 13/10*** (2013.01); ***G01V 3/00*** (2013.01); ***G06F 1/1613*** (2013.01); ***H01Q 1/2266*** (2013.01); ***H01Q 1/243*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/24; H01Q 1/241; H01Q 1/242; H01Q 1/243; H01Q 5/30; H01Q 5/307; H01Q 5/314; H01Q 5/328

USPC ..... 343/700 MS, 702, 725, 729, 767, 789; 455/41.1, 41.2

See application file for complete search history.

(56) **References Cited**

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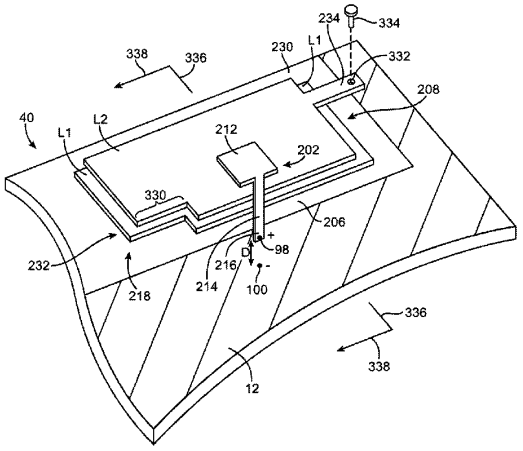
Primary Examiner — Dameon E Levi
Assistant Examiner — Ab Salam Alkassim, Jr.
(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; G. Victor Treyz; Michael H. Lyons

(57) **ABSTRACT**

An electronic device may be provided with slot antennas. A slot antenna may be formed from metal structures that have a dielectric gap defining an antenna slot. The metal structures may include multiple metal layers that overlap a plastic antenna window and that serve as capacitive electrodes in a capacitive proximity sensor. The metal structures may also include a metal electronic device housing. The metal electronic device housing and the metal layers may be formed on opposing sides of the antenna slot. The metal layers may have a notch that locally widens the antenna slot at an open end of the antenna slot. One of the metal layers may be shorted to the metal electronic device housing at an opposing closed end of the antenna slot. The antenna slot may be indirectly fed using a near-field-coupled antenna feed structure such as a metal patch that overlaps the antenna slot.

26 Claims, 17 Drawing Sheets



US009559433B2

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

(10) **Patent No.: US 9,559,433 B2**
(45) **Date of Patent: Jan. 31, 2017**

(54) **ANTENNA SYSTEM HAVING TWO ANTENNAS AND THREE PORTS**

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

(72) Inventors: **Yijun Zhou**, Sunnyvale, CA (US); **Nanbo Jin**, Sunnyvale, CA (US); **Yuehui Ouyang**, Sunnyvale, CA (US); **Enrique Ayala Vazquez**, Watsonville, CA (US); **Anand Lakshmanan**, San Jose, CA (US); **Robert W. Schlub**, Cupertino, CA (US); **Mattia Pascolini**, Campbell, CA (US); **Matthew A. Mow**, Los Altos, 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 464 days.

(21) Appl. No.: **13/846,481**

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

(65) **Prior Publication Data**

US 2014/0266923 A1 Sep. 18, 2014

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

(52) **U.S. Cl.**
CPC ***H01Q 21/28*** (2013.01); ***H01Q 1/24*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 5/35*** (2015.01); ***H01Q 9/0421*** (2013.01); ***H01Q 9/06*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 11/28; H01Q 5/35
(Continued)

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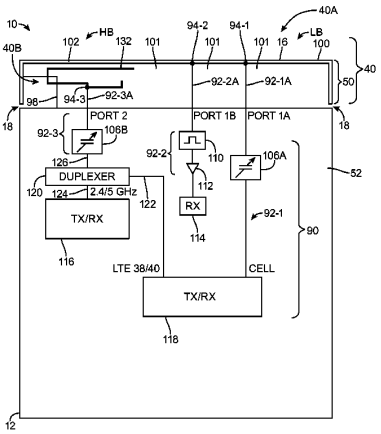
Jin et al., U.S. Appl. No. 13/846,471, filed Mar. 18, 2013.
Ouyang et al., U.S. Appl. No. 13/846,459, filed Mar. 18, 2013.

Primary Examiner — Dameon E Levi
Assistant Examiner — Walter Davis
(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; G. Victor Treyz; Michael H. Lyons

(57) **ABSTRACT**

Electronic devices may include radio-frequency transceiver circuitry and antenna structures. The antenna structures may form a dual arm inverted-F antenna and a monopole antenna sharing a common antenna ground. The antenna structures may have three ports. A first antenna port may be coupled to an inverted-F antenna resonating element at a first location and a second antenna port may be coupled to the inverted-F antenna resonating element at a second location. A third antenna port may be coupled to the monopole antenna. Tunable circuitry can be used to tune the antenna structures. An adjustable capacitor may be coupled to the first port to tune the inverted-F antenna. An additional adjustable capacitor may be coupled to the third port to tune the monopole antenna. Transceiver circuitry for supporting wireless local area network communications, satellite navigation system communications, and cellular communications may be coupled to the first, second, and third antenna ports.

22 Claims, 6 Drawing Sheets



US009559756B2

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

(10) **Patent No.: US 9,559,756 B2**
(45) **Date of Patent: Jan. 31, 2017**

(54) **ANTENNA SYSTEM OPTIMIZED FOR SISO AND MIMO OPERATION**

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

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

(73) Assignee: **ETHERTRONICS, INC.**, San Diego, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1081 days.

(21) Appl. No.: **13/621,811**

(22) Filed: **Sep. 17, 2012**

(65) **Prior Publication Data**

US 2013/0109449 A1 May 2, 2013

Related U.S. Application Data

(63) Continuation-in-part of application No. 13/029,564, filed on Feb. 17, 2011, now Pat. No. 8,362,962, which is a continuation of application No. 12/043,090, filed on Mar. 5, 2008, now Pat. No. 7,911,402, application No. 13/621,811, which is a continuation-in-part of application No. 13/289,901, filed on Nov. 4, 2011, now Pat. No. 8,717,241, which is a continuation of application No. 12/894,052, filed on Sep. 29, 2010, now Pat. No. 8,077,116, which is a continuation of application No. 11/841,207, filed on Aug. 20, 2007, now Pat. No. 7,830,320, application No. 13/621,811, which is a continuation-in-part of application No. 13/227,361, filed on Sep. 7, 2011, now abandoned.

(Continued)

(51) **Int. Cl.**

H04B 7/185	(2006.01)
H04B 7/04	(2006.01)
H01Q 1/24	(2006.01)
H01Q 3/00	(2006.01)
H01Q 9/04	(2006.01)

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

CPC ***H04B 7/0413*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 3/00*** (2013.01); ***H01Q 9/0421*** (2013.01)

(58) **Field of Classification Search**

CPC . H04W 52/241; H04W 52/243; H04B 7/0413; H04B 17/318

USPC ... 455/13.3, 25, 63.4, 575.7, 279.1; 343/893

See application file for complete search history.

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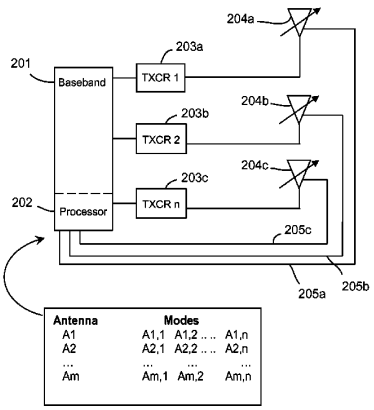
Primary Examiner — Sonny Trinh

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

(57) **ABSTRACT**

An active antenna system and algorithm is described that provides for improved performance from LTE communication systems operating in Category 1 mode, where one antenna is used. For the LTE SISO case (category 1), a modal antenna capable of generating multiple radiation patterns will provide improved throughput due to improved resistance to fading. Modal (Null Steering) antenna technology is implemented in a multi-antenna system to provide for single and multiple antenna operation wherein one or more antennas have two or more radiation modes. An algorithm has been developed that determines when to switch from SISO to MIMO operation.

8 Claims, 8 Drawing Sheets



US009564675B2

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

(10) **Patent No.: US 9,564,675 B2**
(45) **Date of Patent: Feb. 7, 2017**

(54) **DISPLAY DEVICE HAVING ANTENNA**

(71) Applicant: **Samsung Display Co., Ltd.**, Yongin (KR)

(72) Inventors: **Sangrock Yoon**, Hwaseong (KR); **Sunghwan Kim**, Seoul (KR); **Onsik Choi**, Hwaseong-si (KR); **Ung Choi**, Asan-si (KR)

(73) Assignee: **Samsung Display Co., Ltd.**, Yongin-si (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 644 days.

(21) Appl. No.: **13/958,053**

(22) Filed: **Aug. 2, 2013**

(65) **Prior Publication Data**

US 2014/0292588 A1 Oct. 2, 2014

(30) **Foreign Application Priority Data**

Apr. 2, 2013 (KR) 10-2013-0035912

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 1/38 (2006.01)
H01Q 21/28 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/2266*** (2013.01); ***H01Q 1/2283*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 21/28*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/22; H01Q 1/2266; H01Q 1/2283; H01Q 1/38; H01Q 21/28
USPC 343/702, 721; 361/679.21, 679.26, 361/679.27, 679.28
See application file for complete search history.

(56) **References Cited**

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KR	10-2006-0044044	5/2006
KR	10-0669665	9/2006
KR	10-0806108	3/2007
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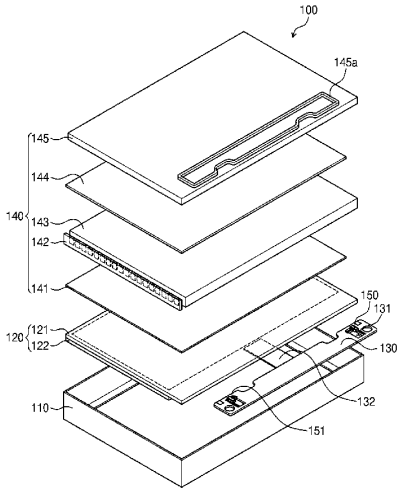
(Continued)

Primary Examiner — Tho G Phan
(74) *Attorney, Agent, or Firm* — H.C. Park & Associates, PLC

(57) **ABSTRACT**

A display device includes a display panel which displays an image, a driving circuit substrate disposed on a rear surface of the display panel and controlling the display panel to display the image, and a chip antenna connected to an end portion of the driving circuit substrate in a longitudinal direction of the driving circuit substrate.

13 Claims, 5 Drawing Sheets



US009564677B2

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

(10) **Patent No.: US 9,564,677 B2**
(45) **Date of Patent: Feb. 7, 2017**

(54) **MOBILE TERMINAL**

(75) Inventors: **Shoudong Tian**, Beijing (CN); **Gang Yan**, Beijing (CN); **Shaolian Liu**, Beijing (CN); **Rong Zhang**, Beijing (CN); **Zhijun Gao**, Beijing (CN)

(73) Assignees: **BEIJING LENOVO SOFTWARE LTD.**, Haidian District, Beijing (CN); **LENOVO (BEIJING) CO., LTD.**, Haidian District, Beijing (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 185 days.

(21) Appl. No.: **13/518,931**

(22) PCT Filed: **Dec. 16, 2010**

(86) PCT No.: **PCT/CN2010/079865**

§ 371 (c)(1),
(2), (4) Date: **Jun. 25, 2012**

(87) PCT Pub. No.: **WO2011/076080**

PCT Pub. Date: **Jun. 30, 2011**

(65) **Prior Publication Data**

US 2012/0262347 A1 Oct. 18, 2012

(30) **Foreign Application Priority Data**

Dec. 23, 2009 (CN) ..... 2009 2 0278248 U
Dec. 31, 2009 (CN) ..... 2009 2 0350859 U

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

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/40*** (2013.01); ***H01Q 1/42*** (2013.01); ***H01Q 5/364*** (2015.01); ***H01Q 9/42*** (2013.01); *H04M 1/0249* (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 1/243; H01Q 1/26; H01Q 9/0407
(Continued)

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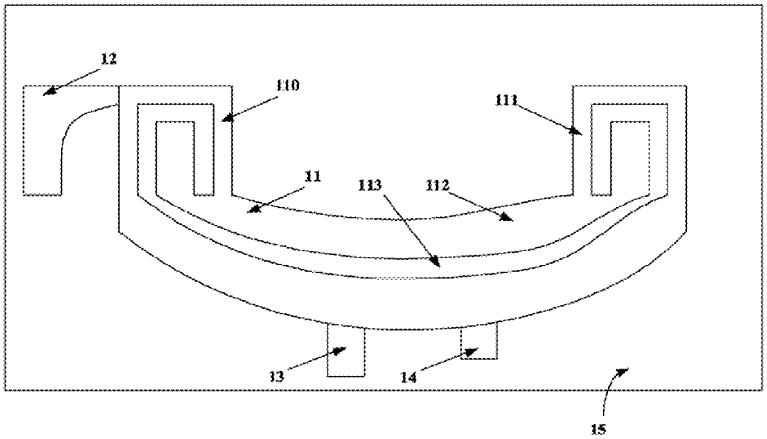
Primary Examiner — Sue A Purvis
Assistant Examiner — Daniel J Munoz
(74) *Attorney, Agent, or Firm* — Brinks Gilson & Lione; G. Peter Nichols

(57) **ABSTRACT**

A mobile terminal and an antenna thereof are provided. The mobile terminal includes a housing, a main board arranged within said housing, and an antenna arranged on the outer surface of said housing such that the antenna is connected with said main board. The height of the mobile phone antenna can be effectively increased and, thus the performance of the antenna is improved.

20 Claims, 5 Drawing Sheets



US009564679B2

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

(10) **Patent No.: US 9,564,679 B2**
(45) **Date of Patent: Feb. 7, 2017**

(54) **ANTENNA DEVICE AND MOBILE TERMINAL HAVING SAME**

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

(72) Inventors: **Sungjung Rho**, Seoul (KR); **Byungwoon Jung**, Seoul (KR); **Youngbae Kwon**, Seoul (KR); **Hanphil Rhyu**, Seoul (KR); **Changwon Yun**, Seoul (KR); **Duckyun Kim**, Seoul (KR); **Deuksu Choi**, Seoul (KR); **Jaewoo Lee**, Seoul (KR); **Sungjoon Hong**, Seoul (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 11 days.

(21) Appl. No.: **14/648,850**

(22) PCT Filed: **Aug. 6, 2013**

(86) PCT No.: **PCT/KR2013/007101**
§ 371 (c)(1),
(2) Date: **Jun. 1, 2015**

(87) PCT Pub. No.: **WO2015/020244**
PCT Pub. Date: **Feb. 12, 2015**

(65) **Prior Publication Data**

US 2015/0340757 A1 Nov. 26, 2015

(30) **Foreign Application Priority Data**

Aug. 6, 2013 (KR) 10-2013-0093223

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

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/46*** (2013.01); ***H01Q 5/342*** (2015.01); ***H01Q 5/35*** (2015.01); ***H01Q 9/42*** (2013.01); ***H01Q 13/10*** (2013.01)

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

(56) **References Cited**

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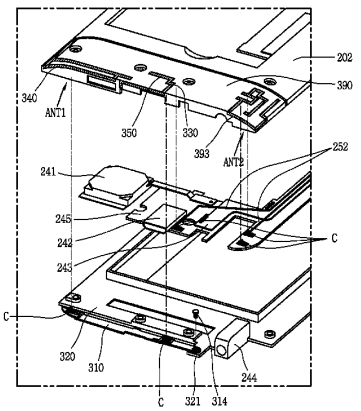
Primary Examiner — Robert Karacsony
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**

An antenna apparatus according to one exemplary embodiment disclosed herein includes a first member and a second member limiting a slot, a feeding unit provided on one surface of a carrier covering the slot and configured to feed the slot, and a first radiator formed on the one surface of the carrier with being spaced apart from the feeding unit, and electrically connected to the first member, the first radiator configured to resonate together with the slot at a first frequency band and a second frequency band.

22 Claims, 9 Drawing Sheets



US009564684B2

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

(10) **Patent No.: US 9,564,684 B2**
(45) **Date of Patent: Feb. 7, 2017**

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

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

(72) Inventors: **Ting-Chih Tseng**, 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 212 days.

(21) Appl. No.: **14/014,666**

(22) Filed: **Aug. 30, 2013**

(65) **Prior Publication Data**

US 2014/0191906 A1 Jul. 10, 2014

(30) **Foreign Application Priority Data**

Jan. 9, 2013 (TW) ..... 102100800 A

(51) **Int. Cl.**

H01Q 5/307	(2015.01)
H01Q 9/42	(2006.01)
H01Q 5/10	(2015.01)
H01Q 5/371	(2015.01)
H01Q 5/378	(2015.01)

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

CPC ***H01Q 5/307*** (2015.01); ***H01Q 5/10*** (2015.01); ***H01Q 5/371*** (2015.01); ***H01Q 5/378*** (2015.01); ***H01Q 9/42*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/00; H01Q 5/378; H01Q 5/392

See application file for complete search history.

(56) **References Cited**

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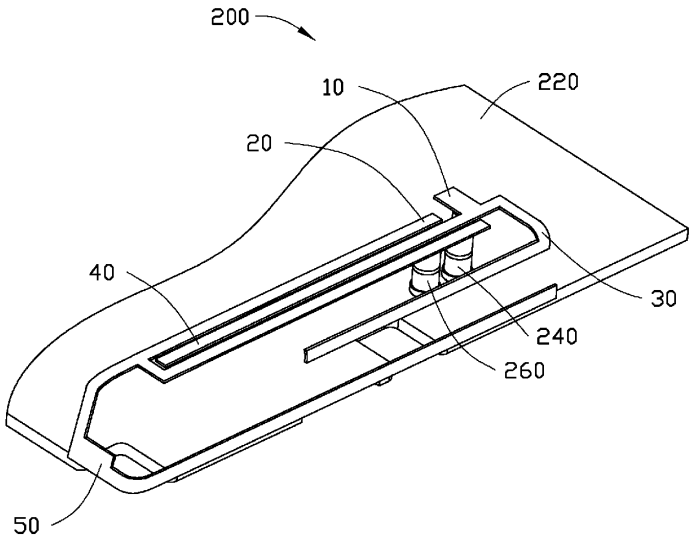
Primary Examiner — Michael C Wimer
Assistant Examiner — Noel Maldonado
(74) *Attorney, Agent, or Firm* — Zhigang Ma

(57) **ABSTRACT**

An antenna structure includes a feed portion, a ground portion, a first radiating body, a second radiating body and a third radiating body. The first radiating body is connected to the feed portion and configured to obtain a first resonance frequency band. The second radiating body is connected to the feed portion. The third radiating body includes a first connection section connected the ground end, a second connection section, and a third connection section perpendicularly connected between the first connection section and the second connection section. The first connection section and the second connection section are positioned at two opposite sides of the second radiating body so that the third radiating body and the second radiating body cooperatively obtain a second resonance frequency band.

2 Claims, 3 Drawing Sheets



US009564934B2

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

(10) **Patent No.: US 9,564,934 B2**
(45) **Date of Patent: Feb. 7, 2017**

(54) **TELECONTROL FOR AUTOMOBILE COMPRISING A DEVICE FOR SUPPRESSING MAGNETIC COUPLING**

(71) Applicants: **VALEO SECURITE HABITACLE**, Creteil (FR); **VALEO INTERIOR CONTROLS (SHENZHEN) CO., LTD**, Shenzhen (CN)

(72) Inventors: **José Robineau**, Creteil (FR); **Jean-Michel Tessier**, Creteil (FR); **Yalong Liu**, Shenzhen (CN); **Chunlin Wu**, Shenzhen (CN)

(73) Assignee: **VALEO SECURITE HABITACLE**, Créteil (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 53 days.

(21) Appl. No.: **14/652,405**

(22) PCT Filed: **Dec. 17, 2013**

(86) PCT No.: **PCT/EP2013/076959**
§ 371 (c)(1),
(2) Date: **Jun. 15, 2015**

(87) PCT Pub. No.: **WO2014/095908**
PCT Pub. Date: **Jun. 26, 2014**

(65) **Prior Publication Data**

US 2015/0311924 A1 Oct. 29, 2015

(30) **Foreign Application Priority Data**

Dec. 21, 2012 (EP) 12199249

(51) **Int. Cl.**
G05D 1/00 (2006.01)
G06F 7/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04B 1/0346*** (2013.01); ***G07C 9/00007*** (2013.01); ***G07C 9/00309*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC combination set(s) only.
See application file for complete search history.

(56) **References Cited**

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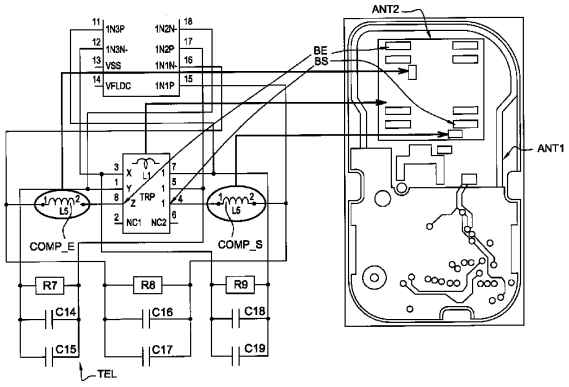
Primary Examiner — Bhavesh V Amin
(74) *Attorney, Agent, or Firm* — Osha Liang LLP

(57) **ABSTRACT**

The invention relates to a telecontrol (TEL) for the locking/unlocking and the starting of a motor vehicle comprising: —an electronic circuit (ELEC) comprising at least one pathway comprising an input pin (BE) and an output pin (BS), —a first radiofrequency antenna (ANT**1**) comprising a first loop disposed in the plane of the electronic circuit (ELEC), —a second radiofrequency antenna (ANT**2**) comprising a second loop disposed in the plane of the electronic circuit (ELEC), said second antenna (ANT**2**) comprising: —an input connector (CE) connected to the input pin (BE), —an output connector (CS) connected to the output pin (BS), —a tuning capacitor (C) linked to the electronic circuit (CIRC), for tuning the second antenna (ANT**2**) to a tuning frequency, characterized in that it comprises: —an inductive input component (COMP_E) placed between the input connector (CE) and the input pin (BE), and/or —an inductive
(Continued)



US009570796B2

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

(10) **Patent No.: US 9,570,796 B2**
(45) **Date of Patent: Feb. 14, 2017**

(54) **ANTENNA FOR MOBILE DEVICE HAVING METALLIC SURFACE**

(71) Applicants: **Osama Nafeth Alrabadi**, Aalborg (DK); **Alexandru Daniel Tatomirescu**, Aalborg (DK); **Mikael Bergholz Knudsen**, Gistrup (DK); **Gert F. Pedersen**, Storvorde (DK); **Poul Olesen**, Stovring (DK); **Peter Bundgaard**, Aalborg (DK)

(72) Inventors: **Osama Nafeth Alrabadi**, Aalborg (DK); **Alexandru Daniel Tatomirescu**, Aalborg (DK); **Mikael Bergholz Knudsen**, Gistrup (DK); **Gert F. Pedersen**, Storvorde (DK); **Poul Olesen**, Stovring (DK); **Peter Bundgaard**, Aalborg (DK)

(73) Assignee: **Intel IP Corporation**, Santa Clara, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 461 days.

(21) Appl. No.: **14/064,800**

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

(65) **Prior Publication Data**

US 2015/0116158 A1 Apr. 30, 2015

(51) **Int. Cl.**

H01Q 13/10 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/44 (2006.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/44*** (2013.01); ***H01Q 13/103*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 13/103; H01Q 1/44
See application file for complete search history.

(56) **References Cited**

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Aberle, et al., Reconfigurable Antennas for Wireless Devices, IEEE Antennas and Propagation Magazine, vol. 45, No. 6, pp. 148-154, Dec. 2003.

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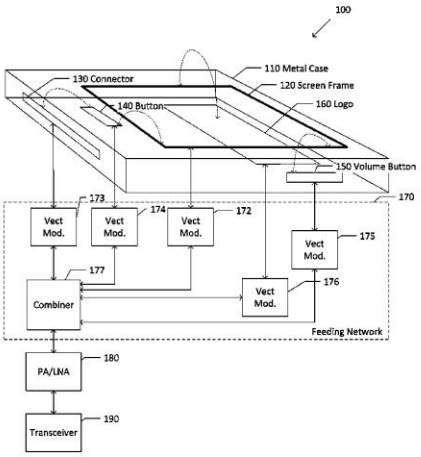
Primary Examiner — Hoang V Nguyen
Assistant Examiner — Michael Bouizza
(74) *Attorney, Agent, or Firm* — Schiff Hardin LLP

(57) **ABSTRACT**

An antenna having a plurality of ports coupled to at least one radiator opening or protuberance formed on a metallic surface. A plurality of modulators are coupled to the plurality of respective ports and configured to modulate phase or amplitude of a plurality of signals radiated at the plurality of respective ports. A combiner is configured to combine the modulated signals to substantially cancel power reflected from the plurality of respective ports, wherein the plurality of respective ports are functionally aggregated into a single port.

23 Claims, 6 Drawing Sheets



US009570800B2

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

(10) **Patent No.: US 9,570,800 B2**
(45) **Date of Patent: Feb. 14, 2017**

(54) **GROUND ANTENNA AND GROUND RADIATOR USING CAPACITOR**

(71) Applicants: **Hyun Min Jang**, Jecheon-si (KR); **Hyeng Cheul Choi**, Seoul (KR); **Dong Ryeol Lee**, Seoul (KR); **Yang Liu**, Seoul (KR); **Hyung Jin Lee**, Ansan-si (KR); **Jae Kyu Yu**, Namyangju-si (KR)

(72) Inventors: **Hyun Min Jang**, Jecheon-si (KR); **Hyeng Cheul Choi**, Seoul (KR); **Dong Ryeol Lee**, Seoul (KR); **Yang Liu**, Seoul (KR); **Hyung Jin Lee**, Ansan-si (KR); **Jae Kyu Yu**, Namyangju-si (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 466 days.

(21) Appl. No.: **14/047,008**

(22) Filed: **Oct. 6, 2013**

(65) **Prior Publication Data**

US 2014/0062820 A1 Mar. 6, 2014

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2012/001027, filed on Feb. 10, 2012.

(30) **Foreign Application Priority Data**

Apr. 6, 2011 (KR) 10-2011-0031913
Nov. 3, 2011 (KR) 10-2011-0113754

(51) **Int. Cl.**
H01Q 9/00 (2006.01)
H01Q 1/48 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/48*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 13/10*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/145; H01Q 9/30; H01Q 9/14; H01Q 5/0034
(Continued)

(56) **References Cited**

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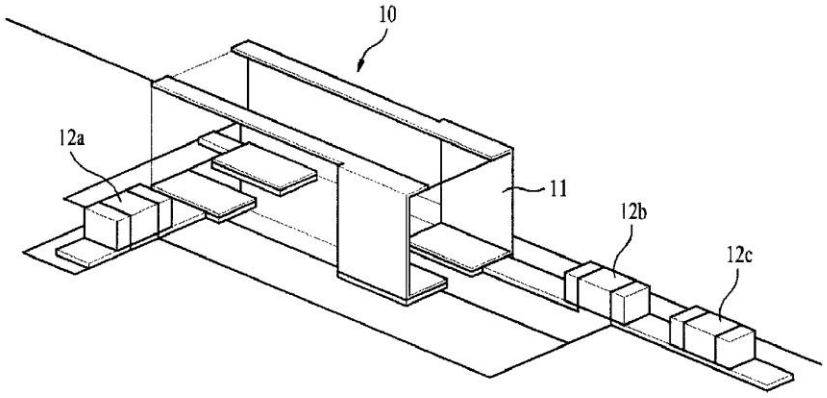
Primary Examiner — Dameon E Levi
Assistant Examiner — Collin Dawkins
(74) *Attorney, Agent, or Firm* — Park, Kim & Suh, LLC

(57) **ABSTRACT**

By providing a radiator configuration circuit and a feeding circuit each having a simple structure, a ground radiation antenna having a more simplified fabrication process as well as a remarkably reduced fabrication cost is provided herein. Additionally, a ground radiation antenna having an excellent radiation performance, even when one side of a mobile communication terminal is covered with a conductive substance, such as an LCD panel, is also provided herein.

5 Claims, 15 Drawing Sheets



US009570803B2

(12) **United States Patent**
Shimura

(10) **Patent No.: US 9,570,803 B2**
(45) **Date of Patent: Feb. 14, 2017**

(54) **MULTI-BAND ANTENNA**

(71) Applicant: **CANON KABUSHIKI KAISHA**, Tokyo (JP)

(72) Inventor: **Hajime Shimura**, Tokyo (JP)

(73) Assignee: **CANON KABUSHIKI KAISHA**, Tokyo (JP)

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

(21) Appl. No.: **15/045,915**

(22) Filed: **Feb. 17, 2016**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. 13/951,815, filed on Jul. 26, 2013, now Pat. No. 9,287,621.

(30) **Foreign Application Priority Data**

Aug. 8, 2012 (JP) 2012-176372
May 17, 2013 (JP) 2013-105627

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/10 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 5/10*** (2015.01); ***H01Q 1/12*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 5/307*** (2015.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/371; H01Q 7/00; H01Q 9/065
(Continued)

(56) **References Cited**

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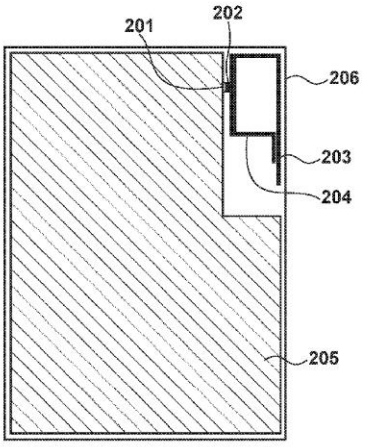
Primary Examiner — Hoanganh Le
(74) *Attorney, Agent, or Firm* — Fitzpatrick, Cella, Harper & Scinto

(57) **ABSTRACT**

An antenna which operates in a plurality of frequency bands includes a feeding point, a first conductor which is connected to the feeding point, and at least two second conductors which are branched from the first conductor, have a linear shape, and include open ends as ends on a side opposite to the first conductor. The open ends of the two second conductors face in almost the same direction substantially parallel to a side closest to the feeding point out of the sides of an antenna region. The two second conductors include a part at which the distance between the two conductors at a portion parallel to the side is a first distance, and another part at which the distance is a second distance shorter than the first distance, and are electromagnetically coupled at, at least the other part.

11 Claims, 17 Drawing Sheets



US009570805B2

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

(10) **Patent No.: US 9,570,805 B2**
(45) **Date of Patent: Feb. 14, 2017**

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

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

(72) Inventors: **Chih-Hung Lai**, 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 150 days.

(21) Appl. No.: **14/543,266**

(22) Filed: **Nov. 17, 2014**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Nov. 30, 2013 (CN) 2013 1 0622289

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 5/371	(2015.01)
H01Q 9/42	(2006.01)
H01Q 5/378	(2015.01)

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

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

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/38; H01Q 9/0421; H01Q 9/0407

USPC ..... 343/702, 700 MS, 853, 872

See application file for complete search history.

(56) **References Cited**

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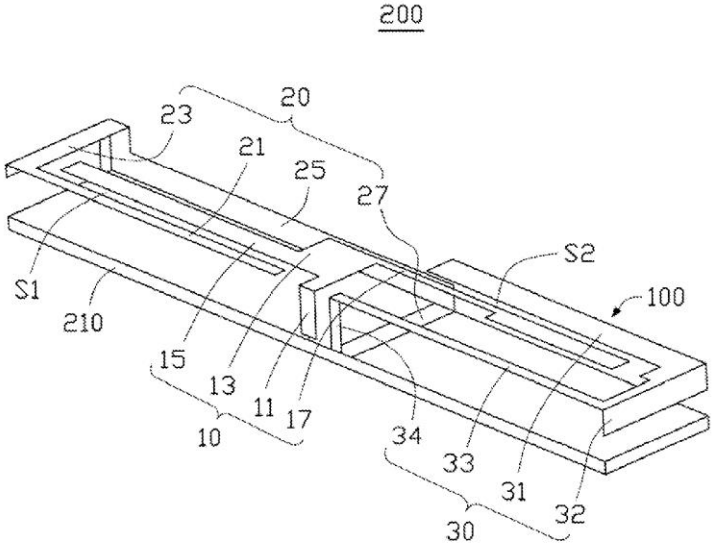
Primary Examiner — Dameon E Levi
Assistant Examiner — Collin Dawkins
(74) *Attorney, Agent, or Firm* — Zhigang Ma

(57) **ABSTRACT**

An antenna structure includes a main body, a first radiating body, and a second radiating body. The main body includes a feeding portion, a connecting portion, a first coupling portion, and a second coupling portion. The connecting portion is perpendicularly connected to the feeding portion. The first coupling portion and the second coupling portion are positioned at two opposite sides of the connecting portion. The first radiating body is configured to surround and resonate with the first coupling portion. The second radiating body is configured to surround and resonate with the second coupling portion.

18 Claims, 7 Drawing Sheets



US009570807B2

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

(10) **Patent No.: US 9,570,807 B2**
(45) **Date of Patent: Feb. 14, 2017**

(54) **ANTENNA MODULE AND TERMINAL APPARATUS**

(71) Applicant: **FUJITSU LIMITED**, Kawasaki-shi, Kanagawa (JP)

(72) Inventors: **Ryosaku Inamura**, Hadano (JP); **Koichi Kasai**, Kawasaki (JP)

(73) Assignee: **FUJITSU LIMITED**, Kawasaki (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 207 days.

(21) Appl. No.: **14/282,102**

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jun. 14, 2013 (JP) 2013-126110

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 7/06	(2006.01)
H01F 27/36	(2006.01)
H01F 38/14	(2006.01)
H01Q 1/52	(2006.01)
H01Q 7/00	(2006.01)

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

CPC ***H01Q 7/06*** (2013.01); ***H01F 27/365*** (2013.01); ***H01F 38/14*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/526*** (2013.01); *H01Q 7/00* (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.

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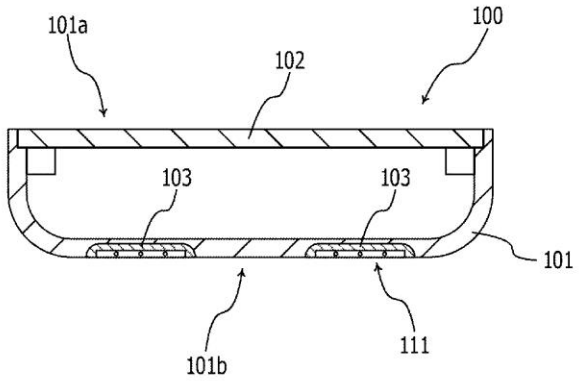
Primary Examiner — Dameon E Levi
Assistant Examiner — Collin Dawkins
(74) *Attorney, Agent, or Firm* — Westerman, Hattori, Daniels & Adrian, LLP

(57) **ABSTRACT**

An antenna module includes an antenna line disposed annularly, a magnetic body formed annularly along the antenna line, having a bottom part and a pair of side parts to accommodate the antenna line, and provided with end faces of the pair of side parts disposed in a same direction, and an insulator disposed between the magnetic body and the antenna line.

16 Claims, 8 Drawing Sheets



US009570813B2

(12) **United States Patent**
Dou

(10) **Patent No.: US 9,570,813 B2**
(45) **Date of Patent: Feb. 14, 2017**

(54) **REFLECTORS FOR REFLECTING ELECTROMAGNETIC ENERGY AWAY FROM A USER DEVICE IN A FIRST DIRECTION**

(71) Applicant: **AMAZON TECHNOLOGIES, INC.**, Reno, NV (US)

(72) Inventor: **Weiping Dou**, San Jose, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 321 days.

(21) Appl. No.: **14/280,399**

(22) Filed: **May 16, 2014**

(65) **Prior Publication Data**

US 2014/0266945 A1 Sep. 18, 2014

Related U.S. Application Data

(63) Continuation of application No. 12/857,987, filed on Aug. 17, 2010, now Pat. No. 8,754,822.

(51) **Int. Cl.**

H01Q 13/10	(2006.01)
H01Q 19/10	(2006.01)
H01Q 1/24	(2006.01)
H01Q 19/22	(2006.01)
H01Q 5/378	(2015.01)

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

CPC ***H01Q 19/10*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/245*** (2013.01); ***H01Q 5/378*** (2015.01); ***H01Q 13/10*** (2013.01); ***H01Q 19/22*** (2013.01); *Y10T 29/49018* (2015.01)

(58) **Field of Classification Search**

CPC H01Q 13/10; H01Q 13/12; H01Q 21/24; H01Q 1/38

See application file for complete search history.

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Primary Examiner — Dameon E Levi
Assistant Examiner — Hasan Islam
(74) *Attorney, Agent, or Firm* — Lowenstein Sandler LLP

(57) **ABSTRACT**

A user device having a dielectric carrier, a multi-band slot antenna, a reflector and a feed line connector is described. The multi-band slot antenna has slot openings in a second portion of conductive material disposed on a second side of the user device and is operable to radiate electromagnetic energy. The reflector is additional conductive material disposed on the second side and is operable to reflect a majority of the radiated electromagnetic energy away from the user device in a first direction.

20 Claims, 12 Drawing Sheets