



US009041606B2

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

(10) **Patent No.:** **US 9,041,606 B2**  
(45) **Date of Patent:** **May 26, 2015**

(54) **UNINTERRUPTED BEZEL ANTENNA**

(75) Inventors: **Antonio Faraone**, Fort Lauderdale, FL (US); **Giorgi G. Bit-Babik**, Sunrise, FL (US)

(73) Assignee: **Motorola Solutions, Inc.**, Schaumburg, IL (US)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 217 days.

(21) Appl. No.: **13/308,100**

(22) Filed: **Nov. 30, 2011**

(65) **Prior Publication Data**

US 2013/0135158 A1 May 30, 2013

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 13/10** (2006.01)  
**H01Q 7/00** (2006.01)

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

(58) **Field of Classification Search**  
CPC ..... H01Q 5/00; H01Q 1/243; H01Q 9/0421  
USPC ..... 343/702, 743, 746, 767  
See application file for complete search history.

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*Primary Examiner* — Dameon E Levi

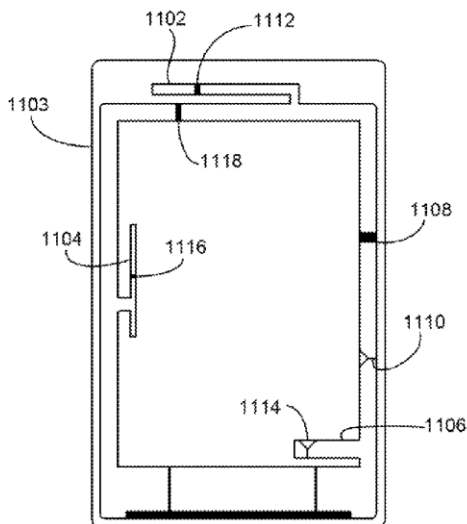
*Assistant Examiner* — Ricardo Magallanes

(74) *Attorney, Agent, or Firm* — Barbara R. Dautre

(57) **ABSTRACT**

A bezel forms a continuous, uninterrupted outer perimeter around the outside of a handheld radio device. The bezel is made of an electrically conductive material and is used as an antenna element. The bezel can be operated in either a common excitation mode or a differential excitation mode, depending on whether a user is presently holding the device, and making contact with the bezel.

**25 Claims, 7 Drawing Sheets**





US009041619B2

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

(10) **Patent No.:** **US 9,041,619 B2**  
(45) **Date of Patent:** **May 26, 2015**

(54) **ANTENNA WITH VARIABLE DISTRIBUTED CAPACITANCE**

(75) Inventors: **Emily B. McMilin**, Mountain View, CA (US); **Qingxiang Li**, Mountain View, 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 359 days.

(21) Appl. No.: **13/452,585**

(22) Filed: **Apr. 20, 2012**

(65) **Prior Publication Data**

US 2013/0278480 A1 Oct. 24, 2013

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

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 9/0457** (2013.01); **H01Q 5/314** (2015.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/00; H01Q 1/38  
USPC ..... 343/904, 700 MS, 814-817  
See application file for complete search history.

(56) **References Cited**

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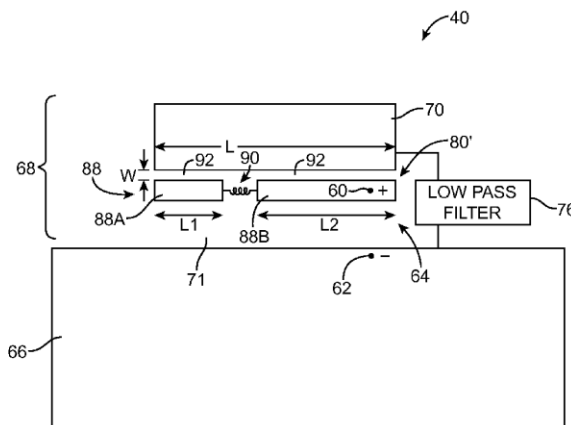
Primary Examiner — Huedung Mancuso

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

(57) **ABSTRACT**

Electronic devices may be provided with antennas. An antenna may be formed from conductive antenna structures that include a frequency-dependent distributed capacitor. The antenna may include an antenna ground and an antenna resonating element that are separated by a gap. A low pass filter circuit may bridge the gap. The antenna resonating element may have antenna resonating element conductive structures that serve as first and second electrodes for the distributed capacitor. The second electrode may have first and second conductive elements coupled by a filter. The filter may be a low pass filter implemented using an inductor. The inductor may have a first terminal coupled to the first conductive element and a second terminal coupled to the second conductive element. A first antenna feed terminal may be coupled to the first conductive element and a second antenna feed terminal may be coupled to the antenna ground.

**19 Claims, 14 Drawing Sheets**





US009048528B1

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

(10) **Patent No.:** **US 9,048,528 B1**  
(45) **Date of Patent:** **Jun. 2, 2015**

- (54) **ANTENNA STRUCTURE WITH STRONGLY COUPLED GROUNDING ELEMENT**
- (71) Applicant: **AMAZON TECHNOLOGIES, INC.**,  
Reno, NV (US)
- (72) Inventors: **Tzung-I Lee**, San Jose, CA (US); **Young R. Cha**, Cupertino, 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 0 days.
- (21) Appl. No.: **14/466,767**
- (22) Filed: **Aug. 22, 2014**

**Related U.S. Application Data**

- (63) Continuation of application No. 13/626,404, filed on Sep. 25, 2012, now Pat. No. 8,847,828.
- (51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 9/04** (2006.01)  
**H01Q 5/00** (2006.01)
- (52) **U.S. Cl.**  
CPC ..... **H01Q 9/0414** (2013.01); **H01Q 9/0407** (2013.01); **H01Q 5/0044** (2013.01); **H01Q 5/378** (2015.01); **H01Q 5/30** (2015.01)
- (58) **Field of Classification Search**  
CPC ..... H01Q 5/30; H01Q 5/378; H01Q 1/24; H01Q 1/242; H01Q 1/243; H01Q 9/0407; H01Q 9/0414  
USPC ..... 343/702, 848  
See application file for complete search history.

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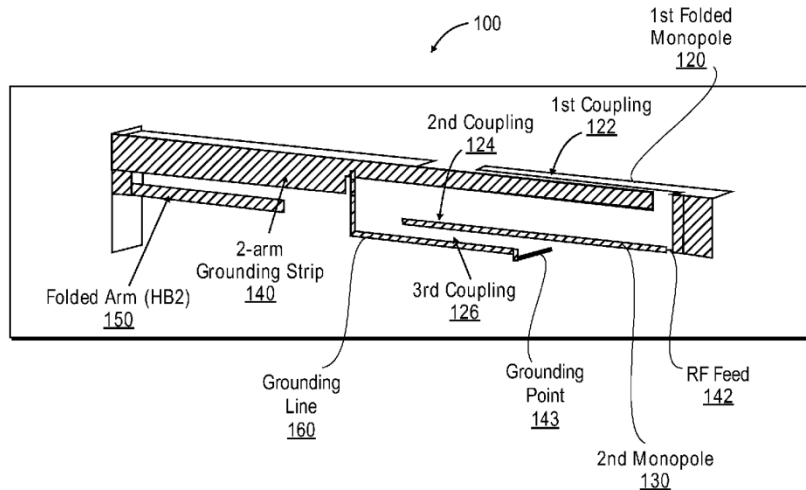
*Primary Examiner* — Hoang V Nguyen

(74) *Attorney, Agent, or Firm* — Lowenstein Sandler LLP

(57) **ABSTRACT**

Antenna structures of electronic devices and methods of operating the electronic devices with the antenna structures are described. One antenna structure includes a ground plane, a radio frequency (RF) feed, a first antenna element coupled to the RF feed, a second antenna element coupled to the RF feed and a third antenna element coupled to the ground plane at a grounding point. The third antenna element is at least partially disposed between the first and second antenna elements to form a first coupling between the first antenna element and the third antenna element, a second coupling between the second antenna element and the third antenna element and a third coupling between the second antenna element and the third antenna element.

**20 Claims, 9 Drawing Sheets**





US009048532B2

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

(10) **Patent No.:** **US 9,048,532 B2**  
(45) **Date of Patent:** **Jun. 2, 2015**

(54) **MULTI-BAND ANTENNA**

(71) Applicants: **Chung-Ta Yu**, Taipei (TW); **Shih-Ping Liu**, Taipei (TW)

(72) Inventors: **Chung-Ta Yu**, Taipei (TW); **Shih-Ping Liu**, Taipei (TW)

(73) Assignee: **COMPAL ELECTRONICS, INC.**, Taipei (TW)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 201 days.

(21) Appl. No.: **13/721,028**

(22) Filed: **Dec. 20, 2012**

(65) **Prior Publication Data**

US 2014/0132453 A1 May 15, 2014

(30) **Foreign Application Priority Data**

Nov. 14, 2012 (TW) ..... 101142420 A

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 1/22** (2006.01)  
**H01Q 9/04** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/2266** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 5/371** (2015.01)

(58) **Field of Classification Search**  
CPC .... H01Q 1/2266; H01Q 5/371; H01Q 9/0421  
USPC ..... 343/702, 700 MS  
See application file for complete search history.

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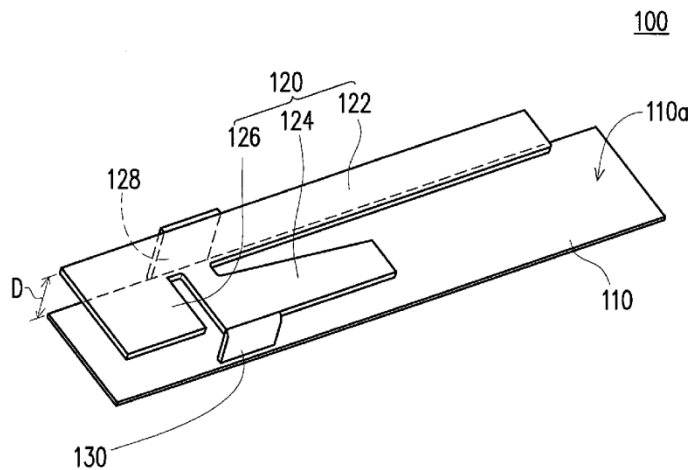
*Primary Examiner* — Hoang V Nguyen

(74) *Attorney, Agent, or Firm* — Jianq Chyun IP Office

(57) **ABSTRACT**

A multi-band antenna suitable for an electronic device is provided. The electronic device has a metal shell. The multi-band antenna includes a ground portion, a radiating portion and a feeding portion. The ground portion has a ground plane. The radiating portion has at least one radiating section and a short-circuit section. An extending direction of the radiating section is parallel to the ground plane. The short-circuit section is electrically connected between the radiating section and the ground plane. The ground portion is adapted to obstruct a path between the metal shell and the radiating section. The feeding portion is electrically connected to the radiating section.

**13 Claims, 8 Drawing Sheets**





US009048538B2

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

(10) **Patent No.:** **US 9,048,538 B2**  
(45) **Date of Patent:** **Jun. 2, 2015**

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

(71) Applicants: **Kun-Lin Sung**, New Taipei (TW);  
**Ting-Chih Tseng**, New Taipei (TW);  
**Yen-Hui Lin**, New Taipei (TW)

(72) Inventors: **Kun-Lin Sung**, New Taipei (TW);  
**Ting-Chih Tseng**, New Taipei (TW);  
**Yen-Hui Lin**, New Taipei (TW)

(73) Assignee: **Chi Mei 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 145 days.

(21) Appl. No.: **13/650,112**

(22) Filed: **Oct. 11, 2012**

(65) **Prior Publication Data**

US 2014/0009352 A1 Jan. 9, 2014

(30) **Foreign Application Priority Data**

Jul. 6, 2012 (TW) ..... 101124421

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 13/10** (2006.01)  
**H01Q 21/30** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 13/106** (2013.01); **H01Q 21/30** (2013.01); **H01Q 5/371** (2015.01)

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

(56) **References Cited**

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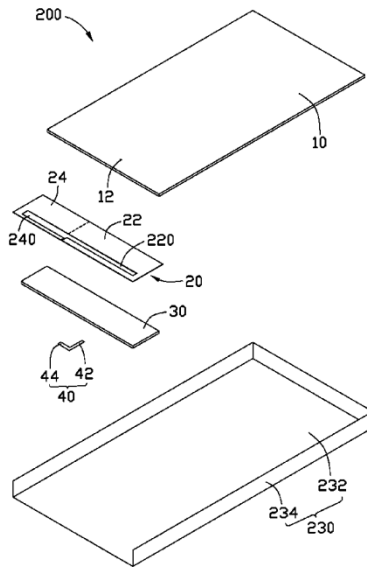
*Primary Examiner* — Dieu H Duong

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

(57) **ABSTRACT**

A wireless communication device includes a housing and an antenna assembly. The antenna assembly includes a base board, a feed member electronically connecting with the base board to carry an electrical current, and a radio member including a first radio portion, the first radio portion defining a first slot. The radiator couples with the feed member, inducing an electrical current in the first radio portion. The radio member is electronically connected to the base board through the metal housing, enabling the induced electrical current to flow through the first radio portion, the metal housing, and the base board to form a current loop. The induced electrical current flows through the first slot to excite a first resonance mode, enabling the antenna assembly to receive/transmit a first wireless signal.

**17 Claims, 4 Drawing Sheets**





US009048545B2

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

(10) **Patent No.:** **US 9,048,545 B2**  
(45) **Date of Patent:** **Jun. 2, 2015**

(54) **ENHANCED HIGH EFFICIENCY 3G/4G/LTE ANTENNAS, DEVICES AND ASSOCIATED PROCESSES**

USPC ..... 343/725, 700 MS, 702  
See application file for complete search history.

(71) Applicant: **NETGEAR, INC.**, San Jose, CA (US)

(56) **References Cited**

(72) Inventors: **Joseph Amalan Arul Emmanuel**,  
Cupertino, CA (US); **Chia-Wei Liu**,  
Fremont, CA (US)

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(73) Assignee: **NETGEAR, INC.**, San Jose, CA (US)

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(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 264 days.

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(21) Appl. No.: **13/830,018**

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(22) Filed: **Mar. 14, 2013**

*Primary Examiner* — Hoang V Nguyen

(65) **Prior Publication Data**

US 2014/0266936 A1 Sep. 18, 2014

(74) *Attorney, Agent, or Firm* — Michael A. Glenn; Perkins Coie LLP

(51) **Int. Cl.**  
**H01Q 21/00** (2006.01)  
**H01Q 9/42** (2006.01)  
**H01Q 5/00** (2006.01)

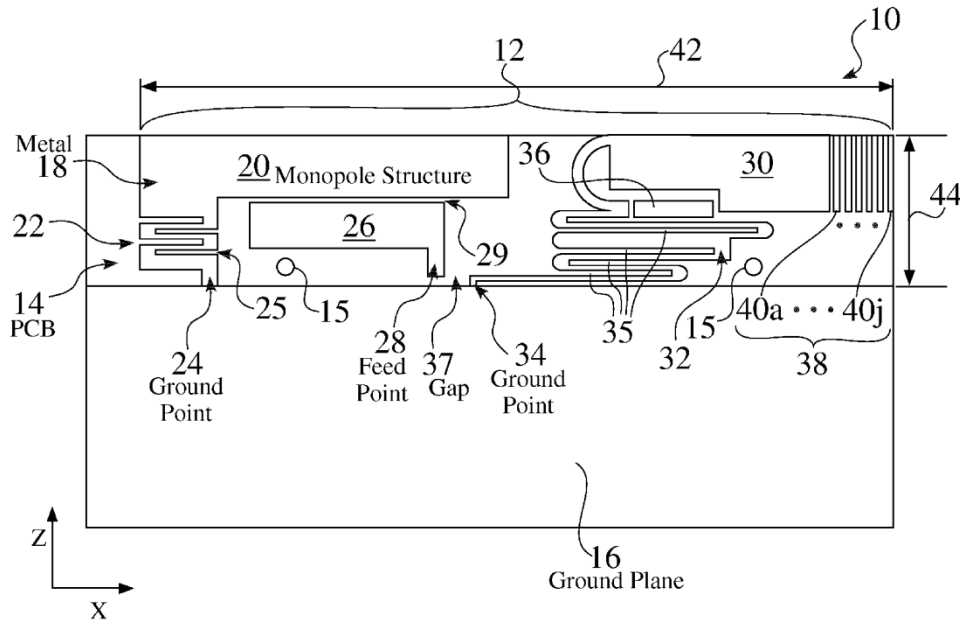
(57) **ABSTRACT**

(52) **U.S. Cl.**  
CPC ..... **H01Q 9/42** (2013.01); **H01Q 5/0065** (2013.01)

Embodiments of the invention provide several antenna designs that exhibit both high bandwidth and efficiency, such as for operation in one or more bands, such as but not limited to operation in 3G, 4G, LTE bands. A first aspect of the invention concerns the form factor of the enhanced antenna; a second aspect of the invention concerns the ease with which the enhanced antenna is manufactured; and a third aspect concerns the superior performance exhibited by the enhanced antenna across one or more bandwidths.

(58) **Field of Classification Search**  
CPC . H01Q 5/0024; H01Q 5/0062; H01Q 5/0065; H01Q 9/42; H01Q 21/30

**30 Claims, 35 Drawing Sheets**





US009054407B2

(12) **United States Patent**  
**Komura**

(10) **Patent No.:** **US 9,054,407 B2**  
(45) **Date of Patent:** **Jun. 9, 2015**

(54) **ANTENNA DEVICE, ANTENNA MODULE, AND PORTABLE TERMINAL**

USPC ..... 343/700 MS, 702, 749, 750, 876  
See application file for complete search history.

(71) Applicant: **MURATA MANUFACTURING CO., LTD.**, Kyoto-fu (JP)

(56) **References Cited**

(72) Inventor: **Ryo Komura**, Kyoto-fu (JP)

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(73) Assignee: **Murata Manufacturing Co., Ltd.**, Kyoto-fu (JP)

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(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 178 days.

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(21) Appl. No.: **13/762,277**

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(22) Filed: **Feb. 7, 2013**

The first Office Action issued by the State Intellectual Property Office of People's Republic of China on Mar. 19, 2014, which corresponds to Chinese Patent Application No. 201180039913.9 and is related to U.S. Appl. No. 13/762,277; with English language translation.

(Continued)

(65) **Prior Publication Data**

US 2013/0147674 A1 Jun. 13, 2013

**Related U.S. Application Data**

(63) Continuation of application No. PCT/JP2011/079136, filed on Dec. 16, 2011.

*Primary Examiner* — Robert Karacsony

(74) *Attorney, Agent, or Firm* — Studebaker & Brackett PC

(30) **Foreign Application Priority Data**

Dec. 21, 2010 (JP) ..... 2010-284214

(57) **ABSTRACT**

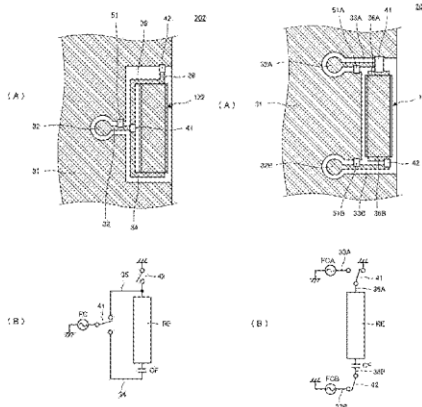
(51) **Int. Cl.**  
**H01Q 9/04** (2006.01)  
**H01Q 3/24** (2006.01)  
(Continued)

Radiation electrodes are formed on a dielectric base body of an antenna chip. A capacitive feeding electrode is formed on a first end surface of the dielectric base body. A ground electrode, a feeding circuit connection electrode, feeding lines, a tip electrode, and the like are formed on the top surface of a base member of a substrate. When a first switching element selects the feeding line side, a second switching element is made to enter a conducting state. In this state, the radiation electrodes are capacitively fed. When the first switching element selects the feeding line side, the second switching element is made to enter an open state. In this state, the radiation electrodes are directly fed. In this manner, the directivity direction of an antenna can be switched using a single radiation element.

(52) **U.S. Cl.**  
CPC ..... **H01Q 9/045** (2013.01); **H01Q 9/0457** (2013.01); **H01Q 3/247** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/243** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/243; H01Q 1/38; H01Q 3/24; H01Q 3/247; H01Q 5/01; H01Q 9/045; H01Q 9/0457; H01Q 1/50

**10 Claims, 14 Drawing Sheets**





US009054411B2

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

(10) **Patent No.:** **US 9,054,411 B2**  
(45) **Date of Patent:** **Jun. 9, 2015**

(54) **ANTENNA COMPONENT AND ELECTRONIC COMMUNICATION DEVICE**

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

(72) Inventors: **Bin Zhang**, Shenzhen (CN); **Yaming Jiang**, Wuhan (CN); **Pengsheng Chen**, Wuhan (CN)

(73) Assignee: **HUAWEI DEVICE CO., LTD.**, Shenzhen (CN)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 242 days.

(21) Appl. No.: **13/729,740**

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

(65) **Prior Publication Data**

US 2013/0113663 A1 May 9, 2013

**Related U.S. Application Data**

(63) Continuation of application No. PCT/CN2011/077048, filed on Jul. 12, 2011.

(30) **Foreign Application Priority Data**

Jul. 12, 2010 (CN) ..... 2010 1 0227602  
Aug. 13, 2010 (CN) ..... 2010 2 0291352 U

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 1/22** (2006.01)  
(Continued)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/241** (2013.01); **H01Q 1/2275** (2013.01); **H01R 13/44** (2013.01); **H01R 35/04** (2013.01); **H01R 2107/00** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/2275; H01Q 1/241; H01R 35/04; H01R 13/44; H01R 2107/00  
USPC ..... 343/700 MS, 702, 872, 873  
See application file for complete search history.

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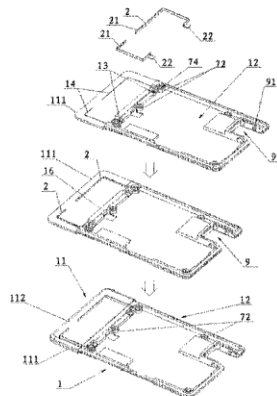
*Primary Examiner* — Hoanganh Le

(74) *Attorney, Agent, or Firm* — Brinks Gilson & Lione

(57) **ABSTRACT**

The embodiments of the invention discloses an antenna component and an electronic communication device. The antenna component comprises a plate-shaped front cover made of a transparent plastic material and at least one antenna made of a conductor material. The front cover comprises an antenna accommodation part and a circuit accommodation part. One end of the antenna is embedded in the antenna accommodation part via an injection molding process, and the other end of the antenna extends to the circuit accommodation part and is exposed out of the circuit accommodation part. The electronic communication device comprises a housing, a circuit board, and an antenna component disclosed in the present invention. The present invention is applied to reduce the volume of the antenna component.

**10 Claims, 7 Drawing Sheets**







US009054419B2

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

(10) **Patent No.:** **US 9,054,419 B2**  
(45) **Date of Patent:** **\*Jun. 9, 2015**

(54) **ANTENNA DEVICE OF MOBILE TERMINAL**

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

(72) Inventors: **Sang Bong Sung**, Gyeongsangbuk-do (KR); **In Jin Hwang**, Gyeongsangbuk-do (KR); **Seung Hwan Kim**, Gyeonggi-do (KR); **Jae Ho Lee**, Gyeonggi-do (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.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/962,483**

(22) Filed: **Aug. 8, 2013**

(65) **Prior Publication Data**

US 2013/0321221 A1 Dec. 5, 2013

**Related U.S. Application Data**

(63) Continuation of application No. 13/458,453, filed on Apr. 27, 2012, now Pat. No. 8,531,342, which is a continuation of application No. 12/489,044, filed on Jun. 22, 2009, now Pat. No. 8,188,930.

(30) **Foreign Application Priority Data**

Jun. 20, 2008 (KR) ..... 10-2008-0058619

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 1/48** (2006.01)  
**H01Q 9/42** (2006.01)  
**H04M 1/02** (2006.01)

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

CPC ..... **H01Q 1/48** (2013.01); **H01Q 1/243** (2013.01); **H01Q 9/42** (2013.01); **H01Q 1/24** (2013.01); **H04M 1/026** (2013.01)

(58) **Field of Classification Search**

CPC ..... H01Q 1/243; H01Q 9/42; H01Q 1/48; H01Q 1/24; H04M 1/026  
USPC ..... 343/702, 700 MS  
See application file for complete search history.

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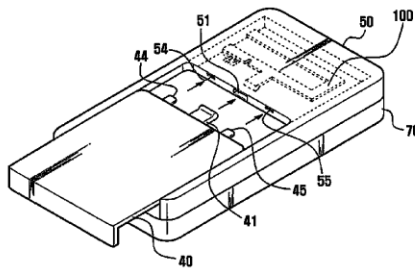
Primary Examiner — Hoanganh Le

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

(57) **ABSTRACT**

An antenna device of a mobile terminal that can secure radiation performance is provided. The antenna device having a battery cover composed of a metal material includes a radiation unit for transmitting and receiving a signal, a feeding unit formed at an end portion of a first side of the radiation unit for electrically connecting the radiation unit to a Printed Circuit Board (PCB), and a ground part disposed a predetermined distance from the feeding unit and formed at a second side of the radiation unit. When the battery cover is fastened to the mobile terminal, the ground part contacts a first side of the battery cover.

**20 Claims, 7 Drawing Sheets**





US009054420B2

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

(10) **Patent No.:** **US 9,054,420 B2**  
(45) **Date of Patent:** **Jun. 9, 2015**

(54) **ANTENNA MODULE**  
(71) Applicant: **WISTRON CORP.**, New Taipei (TW)  
(72) Inventors: **Kuan-Jen Chung**, New Taipei (TW);  
**Wen-Yi Tsai**, New Taipei (TW);  
**Chia-Wei Su**, New Taipei (TW)  
(73) Assignee: **Wistron Corp.**, 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 195 days.

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(21) Appl. No.: **13/714,271**  
(22) Filed: **Dec. 13, 2012**  
(65) **Prior Publication Data**  
US 2013/0335295 A1 Dec. 19, 2013  
(30) **Foreign Application Priority Data**  
Jun. 13, 2012 (TW) ..... 101121067 A

(51) **Int. Cl.**  
**H01Q 1/50** (2006.01)  
**H01Q 1/52** (2006.01)  
**H01Q 21/28** (2006.01)  
(52) **U.S. Cl.**  
CPC ..... **H01Q 1/50** (2013.01); **H01Q 1/521**  
(2013.01); **H01Q 21/28** (2013.01); **H01Q 5/328**  
(2015.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/00; H01Q 1/24; H01Q 1/38  
USPC ..... 343/904, 700 MS, 702, 804; 455/272  
See application file for complete search history.

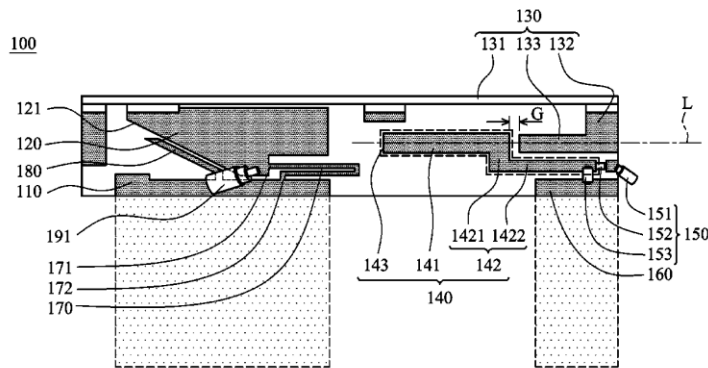
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*Primary Examiner* — Huedung Mancuso

(57) **ABSTRACT**

An antenna module is provided. The antenna module includes a first ground element, a body, a radiator and a parasitic element. The body is electrically connected to the first ground element. The radiator is connected to the body, wherein the radiator includes an extending portion, a bending portion and a terminal portion, and the bending portion is connected to the extending portion, and the terminal portion is connected to the bending portion. The parasitic element includes a parasitic extending portion and a parasitic conductive portion, wherein the parasitic extending portion is connected to the parasitic conductive portion, and the terminal portion and the parasitic extending portion is located on a same straight line, and the terminal portion is separated from the parasitic extending portion.

**18 Claims, 6 Drawing Sheets**





US009054422B2

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

(10) **Patent No.:** **US 9,054,422 B2**  
(45) **Date of Patent:** **Jun. 9, 2015**

- (54) **ANTENNA**
- (71) Applicant: **HON HAI PRECISION INDUSTRY CO., LTD.**, New Taipei (TW)
- (72) Inventors: **Hsin-Lung Tu**, New Taipei (TW); **Che-Ming Chang**, 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 166 days.
- (21) Appl. No.: **13/849,531**
- (22) Filed: **Mar. 24, 2013**
- (65) **Prior Publication Data**  
US 2014/0152524 A1 Jun. 5, 2014
- (30) **Foreign Application Priority Data**  
Dec. 3, 2012 (TW) ..... 101145362 A
- (51) **Int. Cl.**  
**H01Q 11/00** (2006.01)  
**H01Q 1/24** (2006.01)  
**H01Q 1/52** (2006.01)  
**H01Q 1/48** (2006.01)

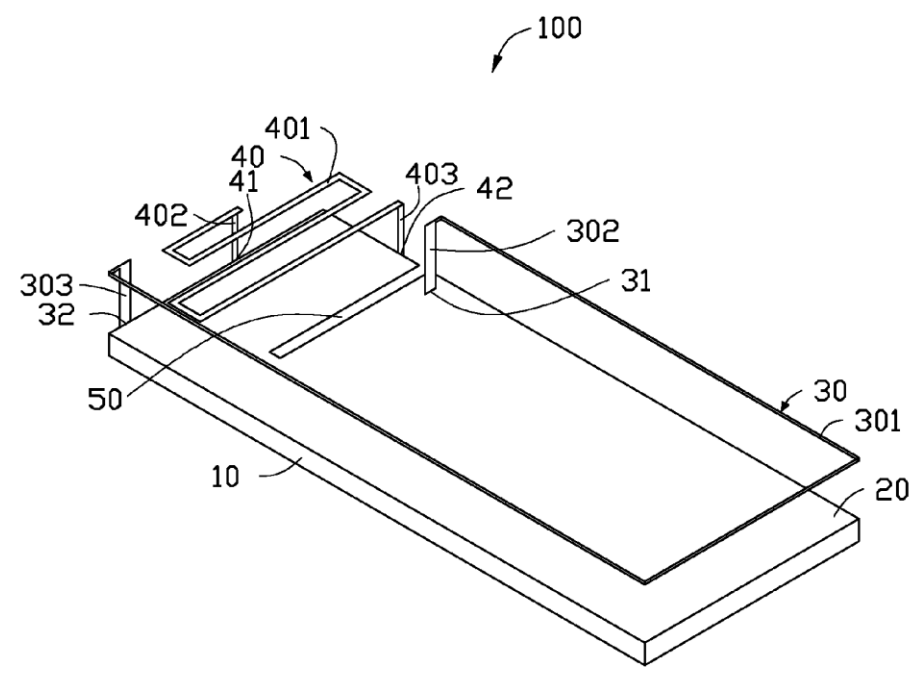
- (52) **U.S. Cl.**  
CPC . **H01Q 1/521** (2013.01); **H01Q 1/48** (2013.01)
- (58) **Field of Classification Search**  
USPC ..... 343/700 MS, 702, 843  
See application file for complete search history.
- (56) **References Cited**  
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*Primary Examiner* — Tan Ho  
(74) *Attorney, Agent, or Firm* — Novak Druce Connolly Bove + Quigg LLP

(57) **ABSTRACT**  
An antenna includes a base, a ground layer printed on the base, a first antenna portion, a second antenna portion, and an isolation slot defined in the grounded layer. The isolation slot is arranged between the first antenna portion and the second antenna portion to reduce the interference between the first antenna portion and the second antenna portion.

**7 Claims, 2 Drawing Sheets**





US009054426B2

(12) **United States Patent**  
**Soekawa**

(10) **Patent No.:** **US 9,054,426 B2**  
(45) **Date of Patent:** **Jun. 9, 2015**

(54) **RADIO APPARATUS AND ANTENNA DEVICE**

(56) **References Cited**

(75) Inventor: **Kouji Soekawa**, 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 745 days.

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(21) Appl. No.: **13/239,994**

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(22) Filed: **Sep. 22, 2011**

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(65) **Prior Publication Data**  
US 2012/0119963 A1 May 17, 2012

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(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 1/38** (2006.01)  
**H01Q 13/10** (2006.01)  
**H01Q 1/36** (2006.01)  
**H01Q 1/48** (2006.01)

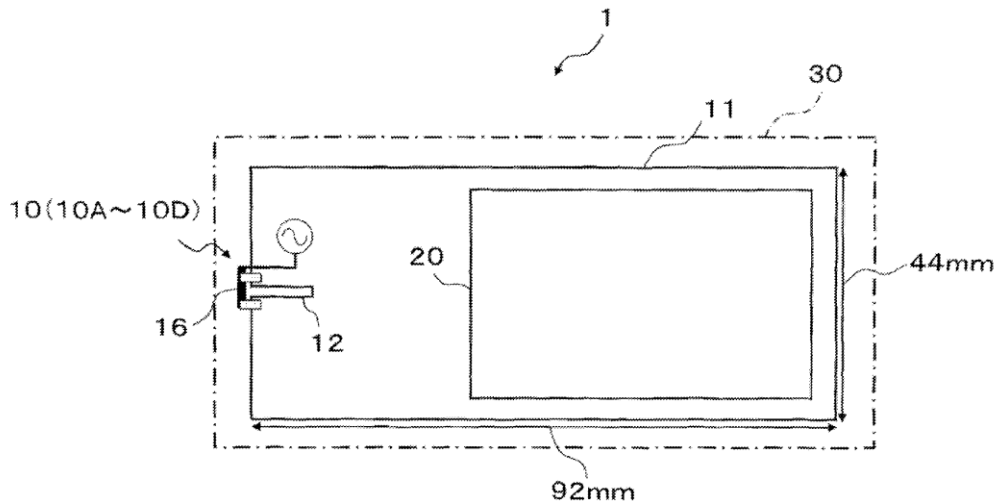
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*Primary Examiner* — Michael C Wimer  
(74) *Attorney, Agent, or Firm* — Westerman, Hattori, Daniels & Adrian, LLP

(52) **U.S. Cl.**  
CPC ..... **H01Q 13/10** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/36** (2013.01); **H01Q 1/48** (2013.01)

(57) **ABSTRACT**  
There is provided a radio apparatus which includes an antenna device and a housing to which the antenna device is attached. The antenna device includes a substrate includes an electrically conductive layer with a slit. The slit is formed at an end of the electrically conductive layer so that the slit includes an opening end. The antenna element is electrically coupled with the electrically conductive layer across the opening end via a matching circuit, and receives an electric power through one end of the antenna element.

(58) **Field of Classification Search**  
CPC ..... H01Q 1/38; H01Q 13/106; H01Q 1/243; H01Q 1/36; H01Q 1/48; H01Q 13/10  
USPC ..... 343/702, 725, 767, 770, 726, 729  
See application file for complete search history.

**12 Claims, 15 Drawing Sheets**





US009054429B2

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

(10) **Patent No.:** **US 9,054,429 B2**  
(45) **Date of Patent:** **Jun. 9, 2015**

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

(71) Applicants: **Ipppei Kashiwagi**, Fuchu (JP); **Hiroyuki Hotta**, Ome (JP)

(72) Inventors: **Ipppei Kashiwagi**, Fuchu (JP); **Hiroyuki Hotta**, Ome (JP)

(73) Assignee: **Kabushiki Kaisha Toshiba**, Tokyo (JP)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 168 days.

(21) Appl. No.: **13/719,707**

(22) Filed: **Dec. 19, 2012**

(65) **Prior Publication Data**  
US 2013/0257681 A1 Oct. 3, 2013

(30) **Foreign Application Priority Data**  
Mar. 30, 2012 (JP) ..... 2012-082411

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 21/28** (2006.01)  
**H01Q 21/30** (2006.01)  
**H01Q 1/22** (2006.01)  
**H01Q 9/42** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 21/28** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 9/42** (2013.01); **H01Q 21/30** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/2266; H01Q 21/28; H01Q 21/30; H01Q 5/0024  
USPC ..... 343/702, 700 MS, 848  
See application file for complete search history.

(56) **References Cited**

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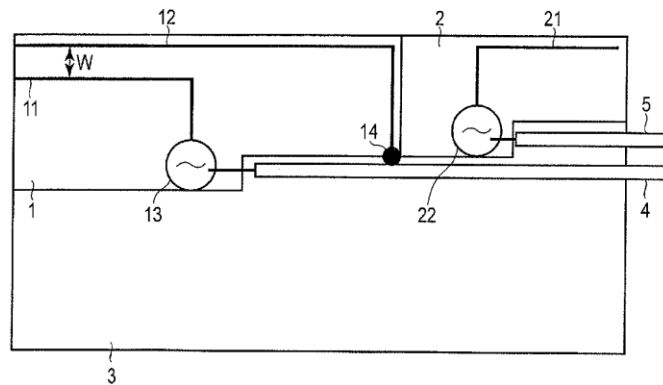
*Primary Examiner* — Hoang V Nguyen

(74) *Attorney, Agent, or Firm* — Blakely Sokoloff Taylor & Zafman LLP

(57) **ABSTRACT**

According to one embodiment, an antenna apparatus includes a first antenna unit disposed along a side of a ground pattern, a second antenna unit disposed along the side of the ground pattern so as to be juxtaposed with the first antenna unit, a first RF cable configured to connect the first antenna unit and the radio circuit unit, and a second RF cable configured to connect the second antenna unit and the radio circuit unit. The first RF cable and the second RF cable are routed from the first antenna unit and the second antenna unit in an arrangement direction of the first antenna unit and the second antenna unit so as to be parallel to each other, with the first RF cable being disposed so as to pass over the ground pattern.

**17 Claims, 6 Drawing Sheets**





US009059499B2

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

(10) **Patent No.:** **US 9,059,499 B2**  
(45) **Date of Patent:** **\*Jun. 16, 2015**

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

(71) Applicant: **Kabushiki Kaisha Toshiba**, Tokyo (JP)

(72) Inventors: **Hiroyuki Hotta**, Ome (JP); **Koichi Sato**, Tachikawa (JP); **Ipei Kashiwagi**, Fuchu (JP)

(73) Assignee: **Kabushiki Kaisha Toshiba**, Tokyo (JP)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 146 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/771,484**

(22) Filed: **Feb. 20, 2013**

(65) **Prior Publication Data**

US 2013/0285870 A1 Oct. 31, 2013

(30) **Foreign Application Priority Data**

Apr. 26, 2012 (JP) ..... 2012-101759

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

(52) **U.S. Cl.**  
CPC ..... **H01Q 5/001** (2013.01); **H01Q 1/243** (2013.01); **H01Q 9/42** (2013.01); **H01Q 5/371** (2015.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/243; H01Q 9/42  
USPC ..... 343/700, 702, 829, 846  
See application file for complete search history.

(56) **References Cited**

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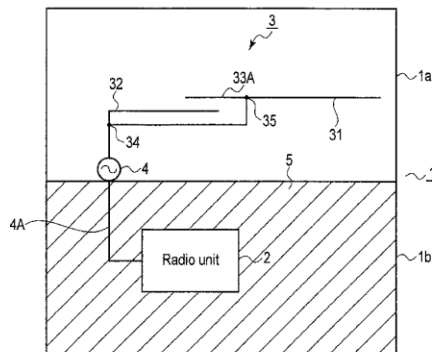
*Primary Examiner* — Tho G Phan

(74) *Attorney, Agent, or Firm* — Blakely Sokoloff Taylor & Zafman LLP

(57) **ABSTRACT**

According to one embodiment, an antenna apparatus includes a first antenna element, a second antenna element, and a third antenna element. The first antenna element has one end connected to a feed terminal, and other end open. The second antenna element has one end connected to a first position set on an element of the first antenna element, and other end open, with a portion between one end and the other end being disposed parallel to the first antenna element. The third antenna element has one end connected to a second position set between the other end and the first position on the element of the first antenna element, and other end open, with at least part of a portion between one end and the other end being disposed near the second antenna element.

**20 Claims, 30 Drawing Sheets**





US009059500B2

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

(10) **Patent No.:** **US 9,059,500 B2**  
(45) **Date of Patent:** **Jun. 16, 2015**

(54) **CAPACITIVE LOOP ANTENNA AND ELECTRONIC DEVICE**

(75) Inventors: **Chi-Kang Su**, Hsinchu (TW);  
**Chia-Tien Li**, Hsinchu (TW)

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

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 467 days.

(21) Appl. No.: **13/223,323**

(22) Filed: **Sep. 1, 2011**

(65) **Prior Publication Data**  
US 2012/0326941 A1 Dec. 27, 2012

(30) **Foreign Application Priority Data**  
Jun. 22, 2011 (TW) ..... 100211354 U

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

(52) **U.S. Cl.**  
CPC ..... **H01Q 7/005** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/378** (2015.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 7/00  
USPC ..... 343/866, 702  
See application file for complete search history.

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*Primary Examiner* — Dameon E Levi

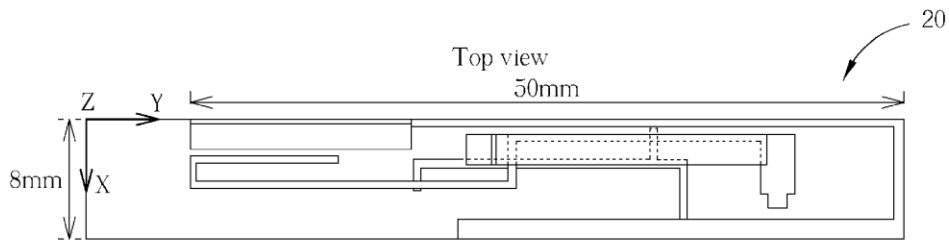
*Assistant Examiner* — Andrea Lindgren Baltzell

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

(57) **ABSTRACT**

A capacitive loop antenna is disclosed. The capacitive loop antenna comprises a shorting-to-ground terminal, for providing grounding, a feeding terminal, for receiving a first radio frequency feeding signal, and a first capacitive loop. The first capacitive loop comprises a first connection element, a first radiator, comprising an end electrically connected to the feeding terminal via the first connection element, to feed the first radio frequency feeding signal to the first radiator, a second connection element, and a second radiator, comprising an end electrically connected to the shorting-to-ground terminal via the second connection element. A first section of another end of the first radiator is capacitively coupled with the second radiator.

**16 Claims, 7 Drawing Sheets**





US009059504B2

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

(10) **Patent No.:** **US 9,059,504 B2**  
(45) **Date of Patent:** **Jun. 16, 2015**

(54) **ANTENNA APPARATUS OF MOBILE TERMINAL**

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

(75) Inventors: **Sang-Jin Eom**, Gyeonggi-do (KR);  
**Ho-Saeng Kim**, Gyeonggi-do (KR);  
**Jin-Kyu Bang**, Gyeonggi-do (KR);  
**Hyun-Jun Jang**, Gyeonggi-do (KR);  
**Min-Kyung Lee**, Gyeonggi-do (KR);  
**Kyung-Moon Seol**, Gyeonggi-do (KR)

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(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 220 days.

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(21) Appl. No.: **13/466,609**

(22) Filed: **May 8, 2012**

(65) **Prior Publication Data**

US 2013/0050038 A1 Feb. 28, 2013

(30) **Foreign Application Priority Data**

Aug. 25, 2011 (KR) ..... 10-2011-0085046

Primary Examiner — Robert Karacsony

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

(51) **Int. Cl.**  
**H01Q 1/38** (2006.01)  
**H01Q 1/24** (2006.01)  
**H01Q 1/20** (2006.01)  
**H01Q 9/42** (2006.01)

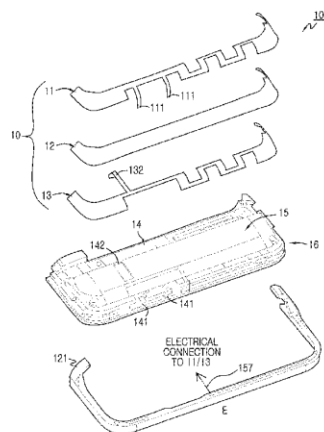
(57) **ABSTRACT**

A built-in antenna apparatus of a mobile terminal includes a main board having at least one feeding portion for feeding RF power and at least one grounding portion at ground potential. The antenna apparatus includes first and second thin metal plates configured to be stacked on the main board and spaced from one another. The second metal plate is electrically connected to the feeding portion and has a length sufficient to resonate within a communication frequency band of the mobile terminal. The first metal plate is electrically connected to the grounding portion and electromagnetically coupled with the second metal plate to resonate.

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 1/20** (2013.01); **H01Q 1/38** (2013.01); **H01Q 9/42** (2013.01); **H01Q 5/35** (2015.01); **H01Q 5/378** (2015.01); **H01Q 5/392** (2015.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/243; H01Q 9/42; H01Q 9/0414; H01Q 9/0421; H01Q 5/0062; H01Q 5/0068; H01Q 5/0048

**19 Claims, 16 Drawing Sheets**







US009059505B1

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

(10) **Patent No.:** **US 9,059,505 B1**  
(45) **Date of Patent:** **Jun. 16, 2015**

(54) **SYSTEMS AND METHODS FOR A RECONFIGURABLE ANTENNA USING DESIGN ELEMENTS ON AN ELECTRONIC DEVICE HOUSING**

(71) Applicant: **Motorola Mobility LLC**, Libertyville, IL (US)

(72) Inventors: **Vijay L Asrani**, Round Lake, IL (US);  
**Timothy J Sutherland**, Gurnee, IL (US)

(73) Assignee: **Google Technology Holdings LLC**, Mountain View, 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.

(21) Appl. No.: **14/144,547**

(22) Filed: **Dec. 31, 2013**

(51) **Int. Cl.**  
**H04M 1/00** (2006.01)  
**H01Q 1/24** (2006.01)  
**H01Q 21/30** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 21/30** (2013.01); **H04B 1/3888** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/243; H01Q 9/42; H01Q 1/38; H01Q 19/005; H01Q 1/244; H01Q 1/36; H01Q 5/001; H01Q 5/0034; H01Q 1/273; H01Q 1/40; H04W 88/02; H04W 4/02; H04B 1/3833; H04B 1/3877; H04B 1/3888  
USPC ..... 455/575.7  
See application file for complete search history.

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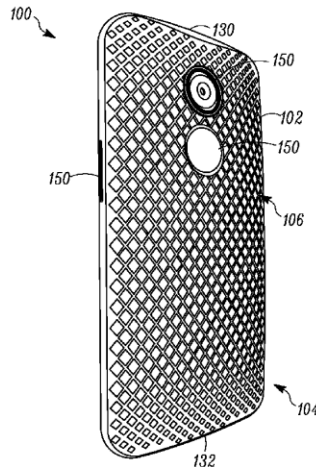
*Primary Examiner* — Kwasi Karikari

(74) *Attorney, Agent, or Firm* — Leydig, Voit & Mayer, Ltd.

(57) **ABSTRACT**

Systems and methods are disclosed for providing an electronic device (700) that includes a back housing (702) at least partially formed from a plurality of discrete antenna elements (706) and an antenna switching module (701) for selectively coupling two or more of the antenna elements to an antenna feed (723). The coupled antenna elements form an antenna for transmitting and/or receiving wireless communication signals. The antenna switching module includes a plurality of switches (716) configured to selectively couple together two or more of the antenna elements; a plurality of electrical posts (729) coupled to the switches; a plurality of radio frequency chokes (735) respectively coupled to the electrical posts; and a biasing module (725) coupled to the radio frequency chokes for selectively applying a bias voltage to the switches.

**29 Claims, 10 Drawing Sheets**





US009059506B2

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

(10) **Patent No.:** **US 9,059,506 B2**  
(45) **Date of Patent:** **\*Jun. 16, 2015**

- (54) **ANTENNA APPARATUS FOR PORTABLE TERMINAL**
- (71) Applicant: **Samsung Electronics Co., Ltd.**,  
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- (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.: **14/461,527**
- (22) Filed: **Aug. 18, 2014**
- (65) **Prior Publication Data**  
US 2014/0354491 A1 Dec. 4, 2014

**Related U.S. Application Data**

- (63) Continuation of application No. 13/440,235, filed on  
Apr. 5, 2012, now Pat. No. 8,842,048.

**Foreign Application Priority Data**

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

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

- H01Q 21/28** (2006.01)  
**H01Q 21/29** (2006.01)
- (52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 1/44**  
(2013.01); **H01Q 21/28** (2013.01); **H01Q 21/29**  
(2013.01)
- (58) **Field of Classification Search**  
CPC ..... H01Q 1/243; H01Q 1/44; H01Q 21/28;  
H01Q 21/29  
USPC ..... 343/702, 700 MS, 846, 848  
See application file for complete search history.

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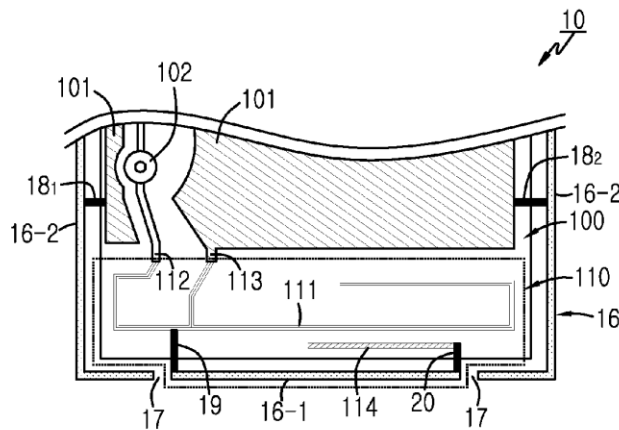
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*Primary Examiner* — Hoanganh Le  
(74) *Attorney, Agent, or Firm* — Cha & Reiter, LLC

(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 separated. 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 main board. The metal frame enhances overall antenna performance rather than causing degradation through interference.

**20 Claims, 4 Drawing Sheets**





US009059510B2

(12) **United States Patent  
Harper**

(10) **Patent No.: US 9,059,510 B2**  
(45) **Date of Patent: Jun. 16, 2015**

- (54) **DIELECTRIC CHIP ANTENNAS**
- (75) Inventor: **Marc Harper**, Cambridge (GB)
- (73) Assignee: **Microsoft Technology Licensing, LLC**, Redmond, WA (US)
- (\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 330 days.

- (21) Appl. No.: **13/636,921**
- (22) PCT Filed: **Mar. 22, 2011**
- (86) PCT No.: **PCT/GB2011/050564**  
§ 371 (c)(1),  
(2), (4) Date: **Sep. 24, 2012**
- (87) PCT Pub. No.: **WO2011/117621**  
PCT Pub. Date: **Sep. 29, 2011**

- (65) **Prior Publication Data**  
US 2013/0021216 A1 Jan. 24, 2013

- (30) **Foreign Application Priority Data**  
Mar. 26, 2010 (GB) ..... 1005121.7

- (51) **Int. Cl.**  
**H01Q 7/08** (2006.01)  
**H01Q 9/30** (2006.01)  
**H01Q 7/00** (2006.01)

- (52) **U.S. Cl.**  
CPC . **H01Q 9/30** (2013.01); **H01Q 7/00** (2013.01);  
**H01Q 5/385** (2015.01); **H01Q 5/40** (2015.01)

- (58) **Field of Classification Search**  
CPC ..... H01Q 5/01; H01Q 7/00; H01Q 9/04;  
H01Q 9/138  
USPC ..... 343/788, 700 MS, 702  
See application file for complete search history.

- (56) **References Cited**  
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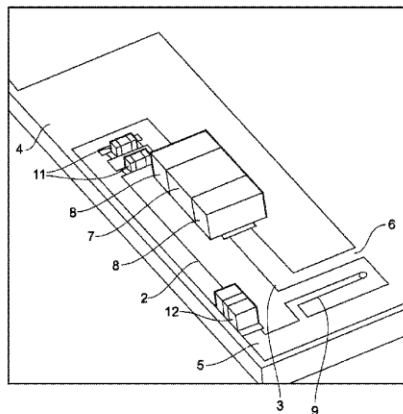
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*Primary Examiner* — Huedung Mancuso  
(74) *Attorney, Agent, or Firm* — Ladislav Kusnyer; Jeremy Snodgrass; Micky Minhas

(57) **ABSTRACT**  
There is disclosed an antenna arrangement having a parasitic conductive loop (1) and at least one active radiating element (9). The conductive loop (1) comprises first and second electrically conductive passive radiating elements (2, 3) each with first and second ends. The first ends of the passive radiating elements are each connected to ground, and the second ends of the radiating elements are each connected respectively to mutually discrete metalized surface regions (8) of a dielectric block (7). The at least one active radiating element (9) is not conductively connected to the passive radiating elements (2, 3). The passive radiating elements (2, 3) are configured to be fed parasitically by the at least one active radiating element (9). The antenna arrangement has excellent resistance to detuning and can be located in different regions of a PCB substrate without significantly affecting performance. Further, the antenna is small in size and may be arranged for dual band operation.

**27 Claims, 4 Drawing Sheets**





US009059513B2

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

(10) **Patent No.:** **US 9,059,513 B2**  
(45) **Date of Patent:** **Jun. 16, 2015**

(54) **MULTIBAND ANTENNA STRUCTURE**

(56) **References Cited**

(75) Inventors: **Yu-Tsung Huang**, Kaohsiung (TW);  
**Jian-Min Tsai**, New Taipei (TW);  
**Ching-Wei Chang**, New Taipei (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 134 days.

(21) Appl. No.: **13/618,201**

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

(65) **Prior Publication Data**  
US 2014/0078000 A1 Mar. 20, 2014

(51) **Int. Cl.**  
**H01Q 1/38** (2006.01)  
**H01Q 5/40** (2015.01)  
**H01Q 1/24** (2006.01)  
**H01Q 9/42** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 5/40** (2015.01); **H01Q 1/243**  
(2013.01); **H01Q 1/38** (2013.01); **H01Q 9/42**  
(2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/243; H01Q 1/38; H01Q 5/40  
USPC ..... 343/702, 700 MS  
See application file for complete search history.

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*Primary Examiner* — Dameon E Levi

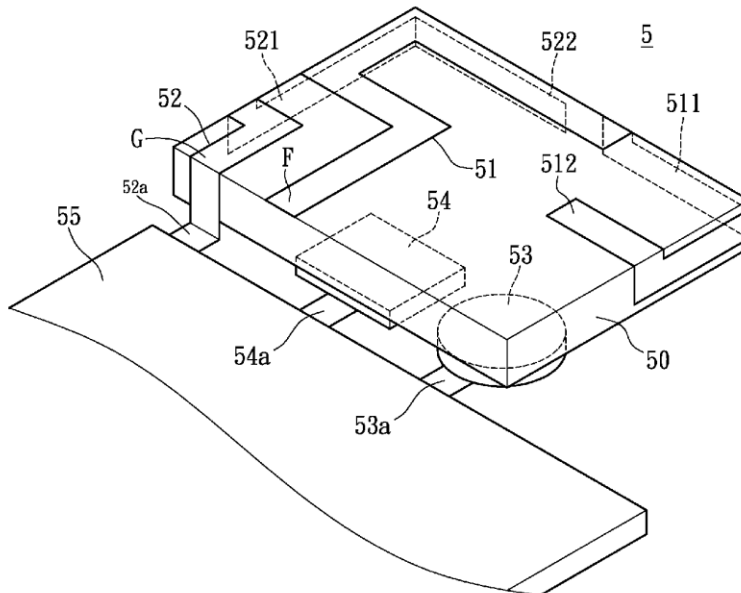
*Assistant Examiner* — Hasan Islam

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

(57) **ABSTRACT**

A multiband antenna structure comprises a substrate, a first radiating unit and a second radiating unit. The first radiating unit is disposed on the substrate, having a feed-in end, a first radiating path and a first terminal. The first radiating unit is operated at a first operating frequency. The second radiating unit is disposed on the substrate and has a grounding end, a second radiating path and a second terminal. The second radiating unit is operated at a second operating frequency. The first terminal of the first radiating unit is adjacent to the second radiating path or the second terminal of the second radiating unit is adjacent to the first radiating path for the first radiating unit or the second unit to excite a third operating frequency. The third operating frequency is lower than the lower frequency among the first operating frequency and the second operating frequency.

**8 Claims, 5 Drawing Sheets**





US009059514B2

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

(10) **Patent No.:** **US 9,059,514 B2**  
(45) **Date of Patent:** **Jun. 16, 2015**

(54) **STRUCTURES FOR SHIELDING AND MOUNTING COMPONENTS IN ELECTRONIC DEVICES**

USPC ..... 343/702, 841, 878  
See application file for complete search history.

(75) Inventors: **Emery A. Sanford**, San Francisco, CA (US); **Qingxiang Li**, Mountain View, CA (US); **Lijun Zhang**, San Jose, CA (US); **Anthony S. Montevirgen**, San Francisco, CA (US); **Teodor Dabov**, San Francisco, CA (US); **Erik G. P. de Jong**, San Francisco, CA (US); **Wey-Jiun Lin**, Los Altos Hills, CA (US)

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

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(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 229 days.

*Primary Examiner* — Tho G Phan

(21) Appl. No.: **13/524,997**

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

(22) Filed: **Jun. 15, 2012**

(57) **ABSTRACT**

(65) **Prior Publication Data**

US 2013/0335275 A1 Dec. 19, 2013

An electronic device may be provided with a conductive housing. An antenna window structure may be formed in an opening in the housing. The antenna window structure may have an antenna support structure that is attached to the conductive housing and that supports antenna structures. An antenna window cap may be mounted in the opening and attached to the antenna support structure with liquid adhesive. Alignment structures may be provided in the antenna support structure. An antenna support plate with mating alignment structures may be used in attaching the antenna structures to the antenna support structures. Metal shielding structures may be used to provide electromagnetic shielding. A shielding wall may be formed from a sheet metal structure supported by a plastic support structure. A flexible metal shielding foil layer may be welded to the shielding wall using a sacrificial plate.

**Related U.S. Application Data**

(60) Provisional application No. 61/652,796, filed on May 29, 2012.

(51) **Int. Cl.**

**H01Q 1/24** (2006.01)  
**H01Q 1/42** (2006.01)  
**H01Q 1/38** (2006.01)

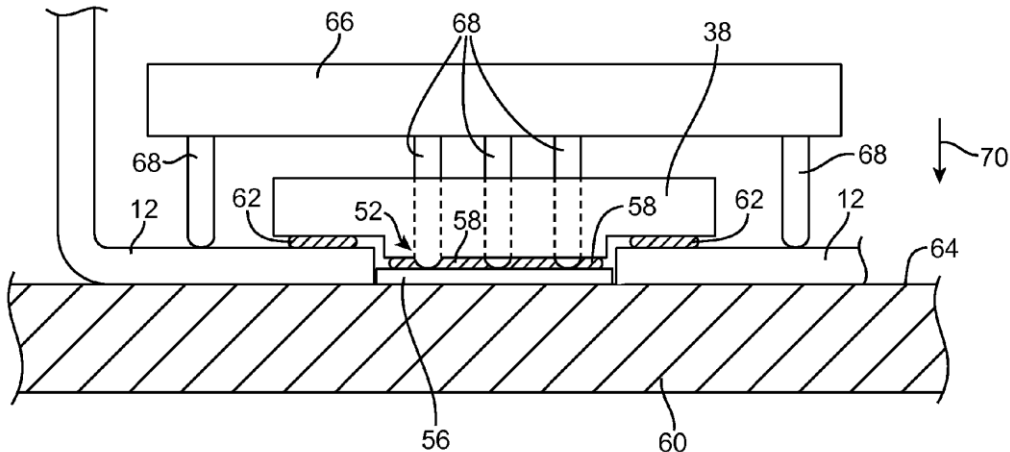
(52) **U.S. Cl.**

CPC ..... **H01Q 1/42** (2013.01); **Y10T 29/49016** (2015.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01)

(58) **Field of Classification Search**

CPC ..... H01Q 1/243; H01Q 1/38

**27 Claims, 14 Drawing Sheets**





US009059519B2

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

(10) **Patent No.:** **US 9,059,519 B2**  
(45) **Date of Patent:** **Jun. 16, 2015**

(54) **MIMO ANTENNA DEVICE, ANTENNA AND ANTENNA PACKAGE**

(56) **References Cited**

(75) Inventors: **Ken-Huang Lin**, Kaohsiung (TW);  
**Tzyy-Sheng Horng**, Kaohsiung (TW);  
**Tzu-Chun Tang**, Kaohsiung (TW)

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(73) Assignee: **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 409 days.

(Continued)

(21) Appl. No.: **13/608,922**

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(22) Filed: **Sep. 10, 2012**

TW	M418410	12/2001
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(65) **Prior Publication Data**

US 2013/0321234 A1 Dec. 5, 2013

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*Primary Examiner* — Hoang V Nguyen

*Assistant Examiner* — Patrick Holecek

(74) *Attorney, Agent, or Firm* — Muncy, Geissler, Olds & Lowe, P.C.

(30) **Foreign Application Priority Data**

May 30, 2012 (TW) ..... 101119355 A

(57) **ABSTRACT**

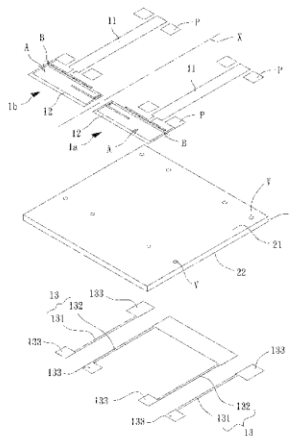
(51) **Int. Cl.**  
**H01Q 21/00** (2006.01)  
**H01Q 21/28** (2006.01)  
**H01Q 9/04** (2006.01)

A multi-input and multi-output antenna device is disclosed. The MIMO antenna device comprises two antennas symmetrically disposed on a substrate. Each antenna comprises a T-shaped feeding unit, a radiation unit and a ground unit. The T-shaped feeding unit and the radiation unit are disposed on a first surface of the substrate. The T-shaped feeding unit forms a strip portion and a top portion. The radiation unit has first and second ends. The radiation unit extends from the first end to the second end to form a rectangular region and a spacing. The first end extends parallel to the top portion. The ground unit is disposed along two sides of the strip portion and electrically coupled to the second end. The two strip portions of the two T-shaped feeding units are parallel to and aligned with each other. The two ground units are electrically connected to each other.

(52) **U.S. Cl.**  
CPC ..... **H01Q 21/28** (2013.01); **H01Q 21/0075** (2013.01); **H01Q 9/0442** (2013.01); **H01Q 9/045** (2013.01)

(58) **Field of Classification Search**  
CPC .. H01Q 1/2283; H01Q 9/0407; H01Q 9/0414  
USPC ..... 343/700 MS, 702, 720, 741, 742, 855, 343/866, 867  
See application file for complete search history.

**12 Claims, 9 Drawing Sheets**





US009059520B2

(12) **United States Patent**  
**Bungo**

(10) **Patent No.:** **US 9,059,520 B2**  
(45) **Date of Patent:** **Jun. 16, 2015**

(54) **WIRELESS COMMUNICATION DEVICE AND COMMUNICATION TERMINAL APPARATUS**

- (71) Applicant: **SONY MOBILE COMMUNICATIONS JAPAN, INC.**, Tokyo (JP)
- (72) Inventor: **Akihiro Bungo**, Tokyo (JP)
- (73) Assignees: **Sony Corporation**, Tokyo (JP); **Sony Mobile Communications Inc.**, Tokyo (JP)
- (\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 258 days.

(21) Appl. No.: **13/713,099**

(22) Filed: **Dec. 13, 2012**

(65) **Prior Publication Data**  
US 2013/0194143 A1 Aug. 1, 2013

**Related U.S. Application Data**

(60) Provisional application No. 61/592,889, filed on Jan. 31, 2012.

(51) **Int. Cl.**  
**H01Q 21/00** (2006.01)  
**H01Q 21/28** (2006.01)  
**H01Q 1/24** (2006.01)  
**H01Q 9/04** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 21/28** (2013.01); **H01Q 1/243** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 9/0435** (2013.01); **H01Q 9/0442** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 21/28  
USPC ..... 343/725, 767, 769, 702, 745; 455/77, 455/73, 90.3

See application file for complete search history.

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*Primary Examiner* — Huedung Mancuso

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

(57) **ABSTRACT**

A communication terminal apparatus and wireless communication device include comprising a first antenna having a first feed point, and a second antenna including a slit antenna and having a second feed point, the second antenna being spaced apart from the first antenna. The slit antenna includes a first conductive plate, a second conductive plate disposed substantially parallel to the first conductive plate, and a short-circuiting structure electrically connected between the first conductive plate and the second conductive plate so as to electrically short the first conductive plate to the second conductive plate.

**17 Claims, 19 Drawing Sheets**

