



US010133462B2

(12) **United States Patent**
Nishioka

(10) **Patent No.:** **US 10,133,462 B2**
(45) **Date of Patent:** **Nov. 20, 2018**

(54) **ELECTRONIC DEVICE HAVING A SLOT ANTENNA**

2203/04803 (2013.01); G09G 5/38 (2013.01);
G09G 2340/12 (2013.01); G09G 2370/00
(2013.01)

(71) Applicant: **LENOVO (SINGAPORE) PTE. LTD.**,
Singapore (SG)

(58) **Field of Classification Search**
CPC H01Q 13/10; H01Q 1/2258
See application file for complete search history.

(72) Inventor: **Yoshio Nishioka**, Kanagawa-ken (JP)

(56) **References Cited**

(73) Assignee: **LENOVO (SINGAPORE) PTE LTD.**,
Singapore (SG)

U.S. PATENT DOCUMENTS

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 103 days.

2012/0050975 A1* 3/2012 Garelli G06F 1/1615
361/679.27
2012/0068893 A1* 3/2012 Guterman H01Q 1/2266
343/702
2013/0293425 A1* 11/2013 Zhu H01Q 1/243
343/702
2017/0346164 A1* 11/2017 Kim H01Q 1/243

(21) Appl. No.: **15/332,762**

* cited by examiner

(22) Filed: **Oct. 24, 2016**

(65) **Prior Publication Data**

US 2017/0365930 A1 Dec. 21, 2017

Primary Examiner — Dameon E Levi

Assistant Examiner — David Lotter

(74) *Attorney, Agent, or Firm* — Antony P. Ng; Russell
Ng PLLC

(30) **Foreign Application Priority Data**

Jun. 20, 2016 (JP) 2016-121936

(57) **ABSTRACT**

(51) **Int. Cl.**

H01Q 13/10 (2006.01)

G06F 3/0484 (2013.01)

G06F 3/14 (2006.01)

H01Q 1/22 (2006.01)

H01Q 21/28 (2006.01)

G06F 3/0487 (2013.01)

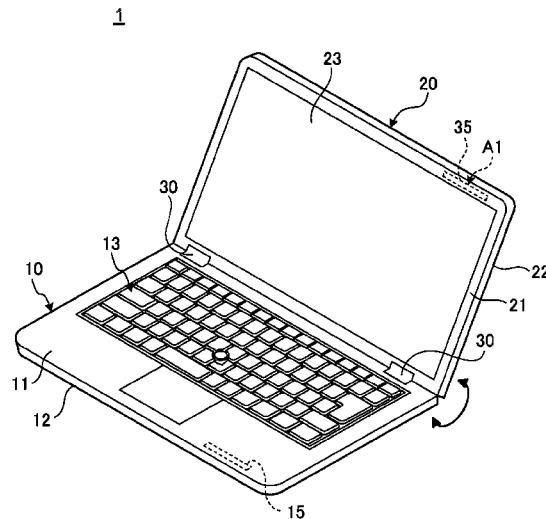
G09G 5/38 (2006.01)

An electronic device having a slot antenna is disclosed. The electronic device includes a main unit chassis and a display chassis. The main unit chassis includes a base cover formed of a conductor, and a keyboard and a keyboard cover formed of a dielectric. The base cover includes a slot. The display chassis is connected to the main unit chassis through a hinge. The upper surface of the display chassis is covered by a display rear cover formed of a conductor. The lower surface of the display chassis is covered by a display unit and a bezel formed of a dielectric. A slot antenna is formed in a bezel area of the display rear cover. The slot of the base cover is located at a position that opposes a slot of the slot antenna when the display rear cover of the display chassis is overlapping with the main unit chassis.

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

CPC **G06F 3/04845** (2013.01); **G06F 3/14**
(2013.01); **G06F 3/1454** (2013.01); **H01Q**
1/2258 (2013.01); **H01Q 1/2266** (2013.01);
H01Q 13/10 (2013.01); **H01Q 21/28**
(2013.01); **G06F 3/0487** (2013.01); **G06F**

20 Claims, 6 Drawing Sheets



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

(10) **Patent No.:** **US 10,135,115 B2**
(45) **Date of Patent:** **Nov. 20, 2018**

(54) **INTEGRATED MODULE HAVING ANTENNA**

(71) Applicant: **HONGBO WIRELESS COMMUNICATION TECHNOLOGY CO., LTD.**, Taipei (TW)

(72) Inventors: **Yu-Lin Shih**, Taipei (TW); **Kuan-Wei Lee**, Taipei (TW); **Yao-Yuan Chang**, Taipei (TW); **Tsung-Wen Chiu**, Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 49 days.

(21) Appl. No.: **15/371,110**

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

(65) **Prior Publication Data**

US 2017/0309990 A1 Oct. 26, 2017

(30) **Foreign Application Priority Data**

Apr. 26, 2016 (TW) 105112884 A

(51) **Int. Cl.**

H01Q 1/22 (2006.01)
H01Q 5/35 (2015.01)
H01Q 5/371 (2015.01)
H01Q 9/42 (2006.01)
H01Q 9/04 (2006.01)
H01Q 1/44 (2006.01)

(Continued)

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

CPC **H01Q 1/2266** (2013.01); **H01Q 1/44** (2013.01); **H01Q 5/35** (2015.01); **H01Q 5/371** (2015.01); **H01Q 7/00** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01); **H01Q 21/29** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/2266; H01Q 5/35; H01Q 5/371; H01Q 9/42; H01Q 9/0421
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,515,629 B1 * 2/2003 Kuo H01Q 1/38 343/700 MS

7,561,111 B2 7/2009 Yu
(Continued)

FOREIGN PATENT DOCUMENTS

TW 201448349 A 12/2014

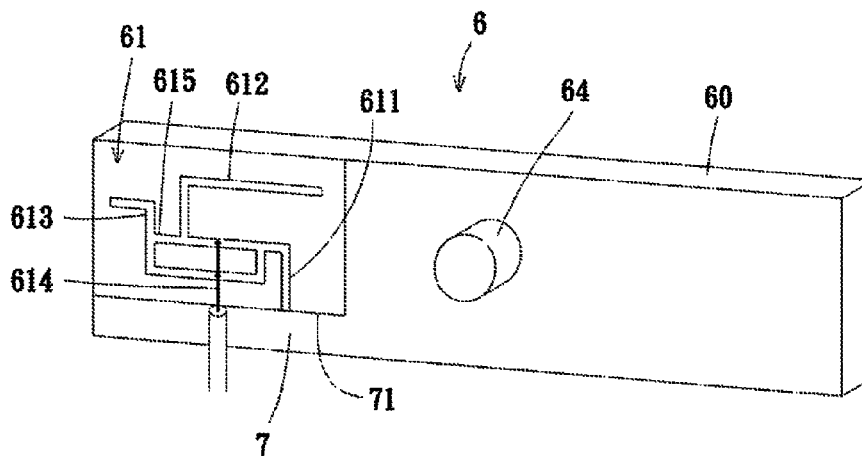
Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — OPES IP Consulting Co. Ltd.

(57) **ABSTRACT**

An integrated module having an antenna comprises a module substrate, a camera module and the antenna disposed on the module substrate. The antenna comprises a grounding portion connected to ground plane, a low-frequency radiating arm, a high-frequency radiating arm, a feed-in line and a shorting portion. A connection portion of the low-frequency radiating arm and a connection portion of the high-frequency radiating arm are connected to the grounding portion. A free-end portion of the high-frequency radiating arm and a free-end portion of the low-frequency radiating arm are back-to-back and extend towards opposite directions. The feed-in line is perpendicular to an edge of the ground plane and extends away from the ground plane. The feed-in line crosses and connects the high-frequency radiating arm to provide a second feeding-point. The end of the feed-in line is connected to the connection portion of the low-frequency radiating arm to provide a first feeding-point.

10 Claims, 9 Drawing Sheets



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

(10) **Patent No.:** **US 10,135,121 B2**
(45) **Date of Patent:** **Nov. 20, 2018**

(54) **ANTENNA FOR PORTABLE DEVICE**

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

(72) Inventors: **Hoon Park**, Seoul (KR); **Ho-Saeng Kim**, Gyeonggi-do (KR); **Yeon-Woo Kim**, Seoul (KR); **Seong-Tae Jeong**, Gyeonggi-do (KR); **Sang-Min Han**, 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 30 days.

(21) Appl. No.: **15/478,330**

(22) Filed: **Apr. 4, 2017**

(65) **Prior Publication Data**

US 2017/0207517 A1 Jul. 20, 2017

Related U.S. Application Data

(63) Continuation of application No. 14/101,550, filed on Dec. 10, 2013, now Pat. No. 9,647,321.

(30) **Foreign Application Priority Data**

Mar. 28, 2013 (KR) 10-2013-0033475

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 1/38 (2006.01)

H01Q 1/48 (2006.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243

USPC 343/702

See application file for complete search history.

(56)

References Cited

U.S. PATENT DOCUMENTS

2008/0136716 A1* 6/2008 Annamaa H01Q 1/22 343/702

2009/0167631 A1* 7/2009 Tai H01Q 1/22 343/906

2011/0115679 A1* 5/2011 Kong H01Q 1/243 343/702

2011/0193752 A1* 8/2011 Wang H01Q 1/243 343/702

2012/0182201 A1* 7/2012 Guo G06K 19/07 343/906

2012/0280989 A1 11/2012 Birtwistle et al.

* cited by examiner

Primary Examiner — Dameon E Levi

Assistant Examiner — Walter Davis

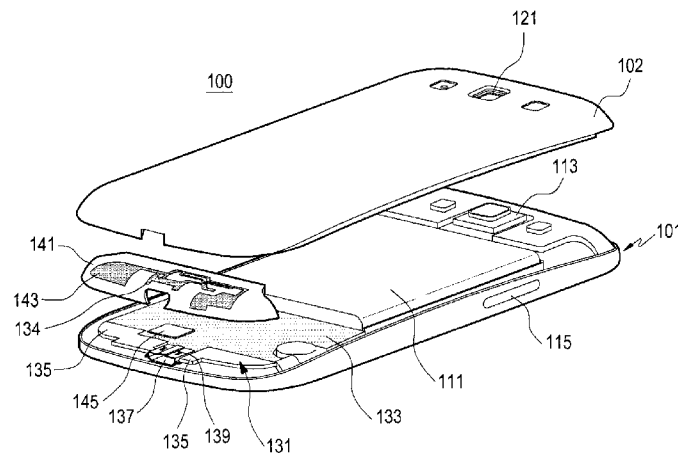
(74) *Attorney, Agent, or Firm* — Cha & Reiter, LLC.

(57)

ABSTRACT

An antenna device of a portable device such as a smartphone includes a connecting member having a conductive case and mounted on a circuit board of the portable device in a manner such that the case is connected to a ground surface of the circuit board; a radiator spaced from the circuit board; and at least one connecting pin provided between the case and the radiator. The radiator is connected to the ground surface through the connecting pin and the case. The antenna device advantageously may be easily installed in the internal space of a miniaturized, lightened and/or slimmed portable device by practically using a conductive component, e.g., the case, of the connecting member.

12 Claims, 7 Drawing Sheets





US010135125B2

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

(10) **Patent No.:** **US 10,135,125 B2**

(45) **Date of Patent:** **Nov. 20, 2018**

(54) **ULTRA-WIDEBAND (UWB) ANTENNA**

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

(72) Inventors: **Artem Rudolfovich Vilenskiy**, Moscow
(RU); **Andrey Vladimirovich Kletsov**,
Moscow (RU); **Vladimir Yakovlevich**
Arkhipenkov, Mytishchi (RU); **Dong**
Wook Kim, Seoul (KR); **Jong Jin**
Kim, Hwaseong-si (KR)

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

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 129 days.

(21) Appl. No.: **14/097,742**

(22) Filed: **Dec. 5, 2013**

(65) **Prior Publication Data**

US 2014/0152514 A1 Jun. 5, 2014

(30) **Foreign Application Priority Data**

Dec. 5, 2012 (RU) 2012152251
Sep. 17, 2013 (KR) 10-2013-0111730

(51) **Int. Cl.**

H01Q 1/27 (2006.01)

H01Q 9/04 (2006.01)

(Continued)

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

CPC **H01Q 1/273** (2013.01); **H01Q 5/20**
(2015.01); **H01Q 5/25** (2015.01); **H01Q 5/364**
(2015.01); **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/273

(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,040,060 A * 8/1977 Kaloi H01Q 9/0421
343/700 MS

6,680,705 B2 * 1/2004 Tan et al. 343/702
(Continued)

FOREIGN PATENT DOCUMENTS

JP 2002-223114 A 8/2002
JP 2007-60615 A 3/2007

(Continued)

OTHER PUBLICATIONS

Chahat et al. (A Compact UWB Antenna for On-Body Applications,
IEEE Transaction on Antenna and Propagation, vol. 59, No. 4, Apr.
2011).*

(Continued)

Primary Examiner — Daniel J Munoz

Assistant Examiner — Bamidele A Jegede

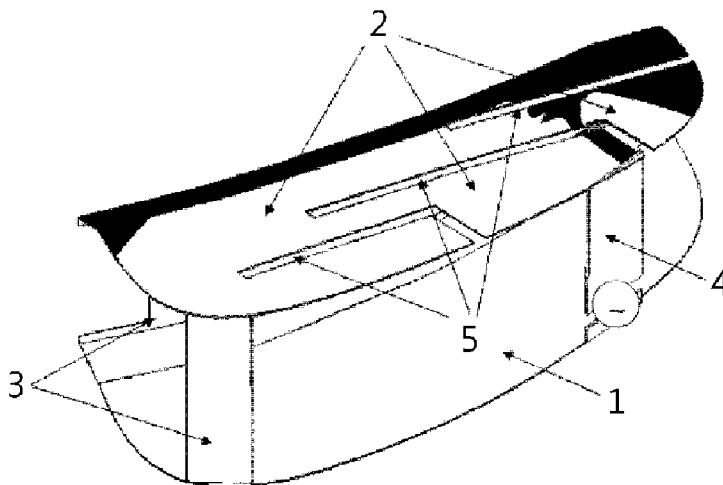
(74) *Attorney, Agent, or Firm* — NSIP Law

(57)

ABSTRACT

A small-sized ultra-wideband (UWB) antenna includes a
radiating unit configured to have a contour of a first shape,
a ground unit configured to have a contour of a shape
substantially equal to the first shape, and disposed parallel to
the radiating unit, at least one shorting pin connected
orthogonal to the ground unit and the radiating unit to
connect a first area of the ground unit and a first area of the
radiating unit, and a feeding unit connected orthogonal to the
ground unit and the radiating unit to connect a second area
of the ground unit and a second area of the radiating unit.

20 Claims, 2 Drawing Sheets



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

(10) **Patent No.:** **US 10,135,128 B2**
(45) **Date of Patent:** **Nov. 20, 2018**

(54) **ANTENNA MODULE**

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

(72) Inventors: **Sang Bae Oh**, Seoul (KR); **In Pyo Park**, Seoul (KR)

(73) Assignee: **LG INNOTEK 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 40 days.

(21) Appl. No.: **15/137,479**

(22) Filed: **Apr. 25, 2016**

(65) **Prior Publication Data**

US 2016/0315390 A1 Oct. 27, 2016

(30) **Foreign Application Priority Data**

Apr. 24, 2015 (KR) 10-2015-0057841

(51) **Int. Cl.**

H01Q 1/22 (2006.01)

H01Q 5/328 (2015.01)

H01Q 1/36 (2006.01)

H01Q 1/38 (2006.01)

H01Q 9/42 (2006.01)

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

CPC **H01Q 1/36** (2013.01); **H01Q 1/38** (2013.01); **H01Q 9/42** (2013.01); **H01Q 1/2291** (2013.01); **H01Q 5/328** (2015.01)

(58) **Field of Classification Search**

CPC H01Q 1/2291; H01Q 1/36; H01Q 1/38; H01Q 9/42; H01Q 5/30; H01Q 5/307; H01Q 5/314; H01Q 5/328; H01Q 5/378; H01Q 1/2258; H01Q 1/2266; H01Q

1/2275; H01Q 1/24; H01Q 1/241; H01Q 1/242; H01Q 1/243; H01Q 9/0414; H01Q 5/392; H01Q 5/385; H01Q 1/48; H01Q 9/04; H01Q 9/0407; H01Q 9/0442
See application file for complete search history.

(56)

References Cited

U.S. PATENT DOCUMENTS

7,209,081 B2 * 4/2007 Chang H01Q 1/38 343/700 MS
8,405,552 B2 * 3/2013 Bae H01Q 1/2208 343/700 MS
8,854,268 B2 * 10/2014 Lin H01Q 1/2266 343/702
2001/0043159 A1 * 11/2001 Masuda H01Q 1/38 343/700 MS

* cited by examiner

Primary Examiner — Tho G Phan

Assistant Examiner — Patrick Holeccek

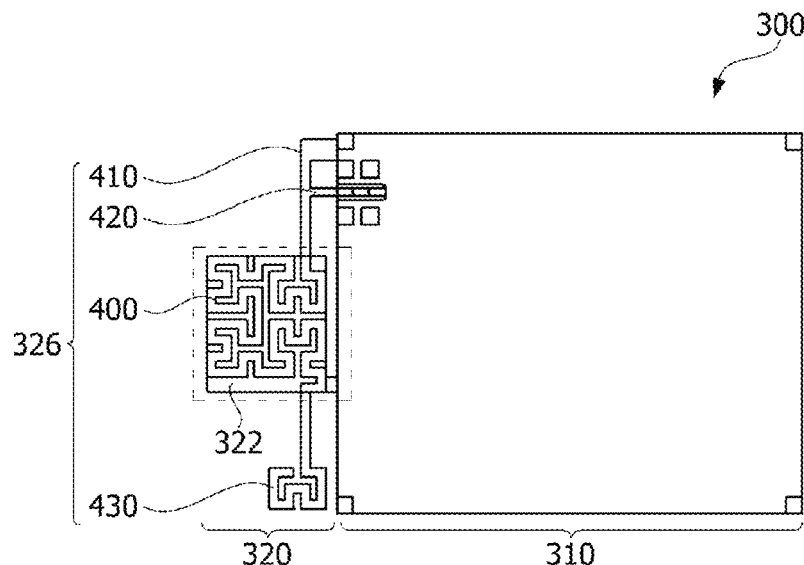
(74) *Attorney, Agent, or Firm* — Saliwanchik, Lloyd & Eisenschenk

(57)

ABSTRACT

An antenna module is provided. The antenna module according to one embodiment of the present invention includes a ground portion which has a lower ground plane, a dielectric layer disposed on the lower ground plane, and an upper ground plane disposed on the dielectric layer, and an antenna portion disposed at an adjoining surface of the ground portion and configured to have a patch layer, a dielectric layer disposed on the patch layer, and an antenna layer disposed on the dielectric layer, and having a plurality of unit patterns which continuously repeat.

9 Claims, 15 Drawing Sheets





US010135129B2

(12) **United States Patent**
Zuniga-Juarez

(10) **Patent No.:** **US 10,135,129 B2**

(45) **Date of Patent:** **Nov. 20, 2018**

(54) **LOW-COST ULTRA WIDEBAND LTE ANTENNA**

(71) Applicant: **TAOGLAS GROUP HOLDINGS LIMITED**, Enniscorthy, County Wexford (IE)

(72) Inventor: **Jose Eleazar Zuniga-Juarez**, Ensenada (MX)

(73) Assignee: **TAOGLAS GROUP HOLDING LIMITED**, Enniscorthy (IE)

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

(21) Appl. No.: **15/922,582**

(22) Filed: **Mar. 15, 2018**

(65) **Prior Publication Data**

US 2018/0233814 A1 Aug. 16, 2018

Related U.S. Application Data

(63) Continuation of application No. 15/298,932, filed on Oct. 20, 2016, which is a continuation-in-part of application No. 14/438,611, filed as application No. PCT/US2013/063947 on Oct. 8, 2013, now Pat. No. 9,502,757.

(60) Provisional application No. 61/711,196, filed on Oct. 8, 2012.

(51) **Int. Cl.**

H01Q 1/38 (2006.01)
H01Q 9/06 (2006.01)
H01Q 5/371 (2015.01)
H01Q 1/24 (2006.01)
H01Q 7/00 (2006.01)
H01Q 9/42 (2006.01)
H01Q 21/28 (2006.01)

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

CPC **H01Q 1/38** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01); **H01Q 7/00** (2013.01); **H01Q 9/065** (2013.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/38; H01Q 5/371
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,281,848 B1	8/2001	Nagumo et al.
6,596,634 B2	7/2003	Umetsu et al.
6,657,593 B2	12/2003	Nagumo et al.
6,740,582 B2	5/2004	Siniaguine
6,812,549 B2	11/2004	Umetsu et al.
7,115,972 B2	10/2006	Dotta et al.
7,276,780 B2	10/2007	Dotta et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CN	201440454 U	4/2010
CN	202042593 U	11/2011

(Continued)

Primary Examiner — Dameon E Levi

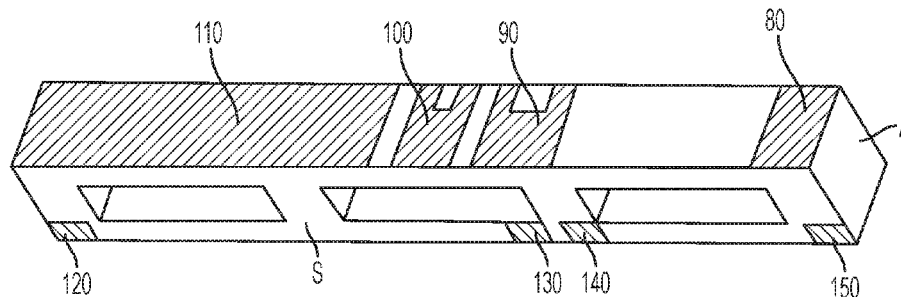
Assistant Examiner — David Lotter

(74) *Attorney, Agent, or Firm* — Shartsis Friese, LLP;
Cecily Anne O'Regan; Kevin J. Everett, Jr.

(57) **ABSTRACT**

An antenna system capable of operating among all LTE bands, and also capable of operation among all remote side cellular applications, such as GSM, AMPS, GPRS, CDMA, WCDMA, UMTS, and HSPA among others. The antenna provides a low cost alternative to active-tunable antennas suggested in the prior art for the same multi-platform objective.

20 Claims, 15 Drawing Sheets





US010135132B2

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

(10) **Patent No.:** **US 10,135,132 B2**

(45) **Date of Patent:** **Nov. 20, 2018**

(54) **ANTENNA EQUIPMENT AND TERMINAL**

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

(72) Inventors: **Zhengyan Mao**, Wuhan (CN); **Kemeng Wang**, Wuhan (CN); **Dejin Zhu**,
Shenzhen (CN); **Xiaoping Gao**, Wuhan
(CN); **Yiwen Gong**, Mountain View,
CA (US); **Song Wu**, Wuhan (CN); **Wei Wang**, Wuhan (CN)

(73) Assignee: **Huawei Technologies 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 0 days.

(21) Appl. No.: **15/540,914**

(22) PCT Filed: **Dec. 30, 2014**

(86) PCT No.: **PCT/CN2014/095697**

§ 371 (c)(1),

(2) Date: **Jun. 29, 2017**

(87) PCT Pub. No.: **WO2016/106612**

PCT Pub. Date: **Jul. 7, 2016**

(65) **Prior Publication Data**

US 2017/0338552 A1 Nov. 23, 2017

(51) **Int. Cl.**

H01Q 1/48 (2006.01)

H01Q 1/52 (2006.01)

(Continued)

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

CPC **H01Q 1/48** (2013.01); **H01Q 1/52**
(2013.01); **H01Q 3/00** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 1/38** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/48; H01Q 3/00

(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,424,300 B1 7/2002 Sanford et al.

2010/0045552 A1* 2/2010 Ueki H01Q 1/243
343/745

(Continued)

FOREIGN PATENT DOCUMENTS

CN 202025847 U 11/2011
CN 102349196 A 2/2012

(Continued)

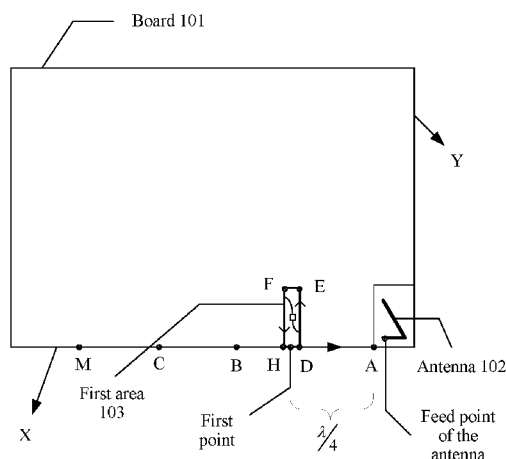
Primary Examiner — Andrea Lindgren Baltzell

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

(57) **ABSTRACT**

An antenna equipment includes an antenna and a board on which the antenna is disposed, and includes an area that is disposed on the board and that is not covered by a metal layer. A first edge of the board is a longer edge of the board in two edges of the board that are close to the antenna, a point that is on the first edge and whose distance with a current maximum point on the first edge is $\lambda/4$ is a first point, the current maximum point is on the first edge and that is closest to a feed point of the antenna, and λ is an operating wavelength of the antenna. The area that is not covered by a metal layer includes the first point, and a maximum distance from an edge of the area to the first edge of the board is $\lambda/4$.

16 Claims, 3 Drawing Sheets



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

(10) **Patent No.:** **US 10,135,141 B2**
(45) **Date of Patent:** **Nov. 20, 2018**

(54) **MOBILE DEVICE**

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

(72) Inventors: **Shih-Ting Huang**, New Taipei (TW);
Kun-Sheng Chang, New Taipei (TW);
Ching-Chi Lin, New Taipei (TW)

(73) Assignee: **Acer Incorporated**, New Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1 day.

(21) Appl. No.: **15/436,346**

(22) Filed: **Feb. 17, 2017**

(65) **Prior Publication Data**

US 2018/0131075 A1 May 10, 2018

(30) **Foreign Application Priority Data**

Nov. 4, 2016 (TW) 105135839 A

(51) **Int. Cl.**

H01Q 9/04 (2006.01)

H01Q 7/00 (2006.01)

H01Q 1/24 (2006.01)

H01Q 9/42 (2006.01)

H01Q 5/364 (2015.01)

H01Q 5/371 (2015.01)

H01Q 1/48 (2006.01)

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

CPC **H01Q 9/0421** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/364** (2015.01); **H01Q 5/371** (2015.01); **H01Q 7/00** (2013.01); **H01Q 9/42** (2013.01); **H01Q 1/48** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/38
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,619,572 B2 11/2009 Su et al.
2010/0134366 A1* 6/2010 Yu H01Q 1/38
343/700
2016/0064820 A1 3/2016 Kim et al.

FOREIGN PATENT DOCUMENTS

TW 1531124 4/2016

* cited by examiner

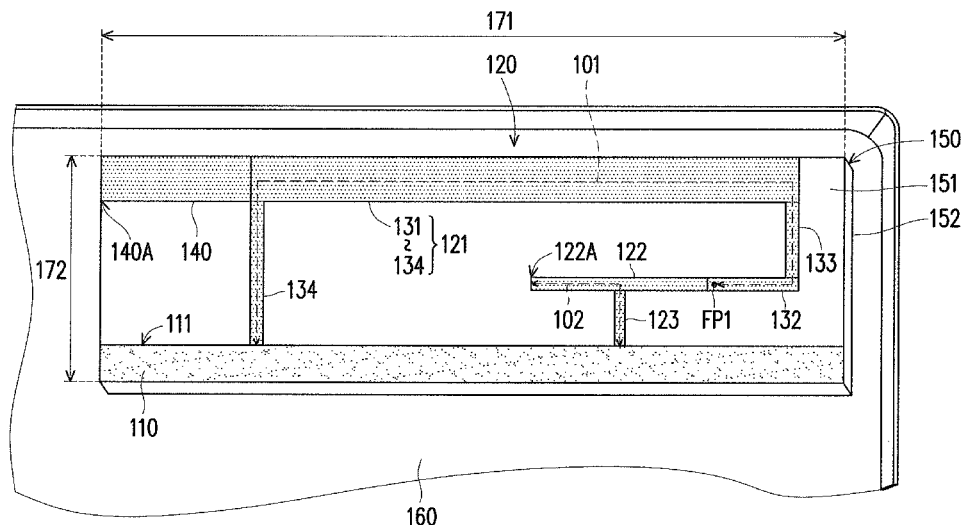
Primary Examiner — Graham Smith

(74) *Attorney, Agent, or Firm* — J.C. Patents

(57) **ABSTRACT**

A mobile device includes a ground element and an antenna element. The antenna element includes a first radiation portion, a second radiation portion, and a third radiation portion. The first radiation portion is electrically connected between a feeding point and an edge of the ground element, and the antenna element operates in a first frequency band through a first path formed by the first radiation portion. A first end of the second radiation portion is electrically connected to the first radiation portion, and a second end of the second radiation portion is a first open end. The third radiation portion is electrically connected between the second radiation portion and the edge of the ground element. The antenna element operates in a second frequency band through a second path formed by the second radiation portion and the third radiation portion.

18 Claims, 3 Drawing Sheets





US010135152B2

(12) **United States Patent**
Ito

(10) **Patent No.:** **US 10,135,152 B2**

(45) **Date of Patent:** **Nov. 20, 2018**

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

(71) Applicant: **Murata Manufacturing Co., Ltd.**,
Nagaokakyo-shi, Kyoto-fu (JP)

2013/0307746 A1* 11/2013 Nakano H01Q 1/2225
343/850

(72) Inventor: **Hiromitsu Ito**, Nagaokakyo (JP)

2015/0116168 A1* 4/2015 Yosui H01Q 7/00
343/722

(73) Assignee: **MURATA MANUFACTURING CO., LTD.**, Kyoto (JP)

2015/0123858 A1 5/2015 Kato

FOREIGN PATENT DOCUMENTS

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

JP 2014-027389 A 2/2014
JP 2014-075775 A 4/2014

(Continued)

(21) Appl. No.: **15/652,286**

OTHER PUBLICATIONS

(22) Filed: **Jul. 18, 2017**

Official Communication issued in International Patent Application No. PCT/JP2016/069837, dated Sep. 20, 2016.

(65) **Prior Publication Data**

US 2017/0317425 A1 Nov. 2, 2017

(Continued)

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2016/069837, filed on Jul. 5, 2016.

Primary Examiner — Andrea Lindgren Baltzell

(74) *Attorney, Agent, or Firm* — Keating & Bennett, LLP

(30) **Foreign Application Priority Data**

Jul. 6, 2015 (JP) 2015-135044

(57) **ABSTRACT**

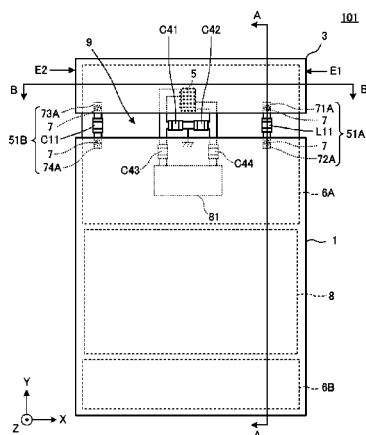
(51) **Int. Cl.**
H01Q 19/00 (2006.01)
G06K 19/077 (2006.01)
(Continued)

An antenna device includes a power supply coil coupled to a first power supply circuit operating in a first frequency band, a first conductive member including a first main surface, a second conductive member including a second main surface, a third conductive member, and first connections. The second main surface of the second conductive member is disposed with at least a portion thereof opposing the first main surface. The third conductive member has an area that is smaller than an area of the first conductive member when viewed in a direction perpendicular or substantially perpendicular to the first main surface. The first conductive member, the third conductive member, and the first connections define a loop of a magnetic field antenna in the first frequency band. The power supply coil is closer to the third conductive member than to the first conductive member when viewed in the Z-direction.

(52) **U.S. Cl.**
CPC **H01Q 19/00** (2013.01); **G06K 19/077** (2013.01); **H01Q 7/00** (2013.01); **H01Q 5/378** (2015.01); **H01Q 13/106** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 19/00; H01Q 7/00; H01Q 5/378; H01Q 13/106; H01Q 21/28
(Continued)

10 Claims, 22 Drawing Sheets





US010141632B2

(12) **United States Patent**
Galeev

(10) **Patent No.:** **US 10,141,632 B2**
(45) **Date of Patent:** **Nov. 27, 2018**

(54) **WIRELESS ELECTRONIC DEVICES WITH
METAL PERIMETER PORTIONS
INCLUDING A PLURALITY OF ANTENNAS**

(56) **References Cited**

U.S. PATENT DOCUMENTS

(71) Applicant: **Sony Corporation**, Tokyo (JP)

7,079,079 B2 * 7/2006 Jo H01Q 1/243

7,764,236 B2 * 7/2010 Hill H01Q 1/243

(72) Inventor: **Roustem Galeev**, Lund (SE)

8,432,320 B2 * 4/2013 Jagielski H01Q 1/243

(73) Assignee: **SONY MOBILE
COMMUNICATIONS INC.**, Tokyo
(JP)

8,750,949 B2 * 6/2014 Merz H04B 1/38

8,907,853 B2 * 12/2014 Ying H01Q 1/243

343/702

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

2004/0257283 A1 12/2004 Asano et al.

2012/0112969 A1 5/2012 Caballero et al.

2012/0175165 A1 6/2012 Merz et al.

2013/0076580 A1 3/2013 Zhang et al.

2013/0194138 A1 * 8/2013 Hammond H01Q 1/243

343/702

(21) Appl. No.: **14/355,703**

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

FOREIGN PATENT DOCUMENTS

(86) PCT No.: **PCT/JP2013/068306**

EP 2 528 165 A1 11/2012

§ 371 (c)(1),

WO WO 2011/106899 A1 9/2011

(2) Date: **May 1, 2014**

OTHER PUBLICATIONS

(87) PCT Pub. No.: **WO2014/207945**

International Search Report and Written Opinion Corresponding to
PCT International Application No. PCT/JP2013/068306; dated Feb.
26, 2014; 10 Pages.

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

(65) **Prior Publication Data**

US 2015/0244061 A1 Aug. 27, 2015

* cited by examiner

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 1/50 (2006.01)

Primary Examiner — Dameon E Levi

Assistant Examiner — Hasan Islam

(74) *Attorney, Agent, or Firm* — Myers Bigel, P.A.

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/50**
(2013.01)

(57) **ABSTRACT**

Wireless electronic devices may include a ground plane and
metal antenna portions separated by input connector por-
tions improving the metal look and feel of the wireless
electronic device.

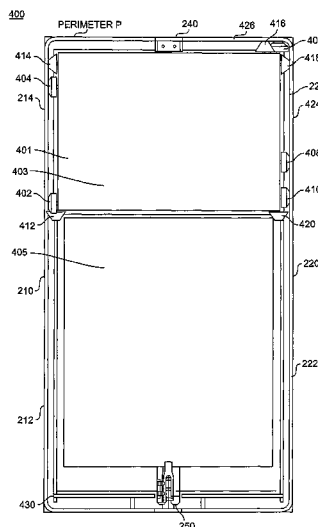
(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/50

USPC 343/702

See application file for complete search history.

22 Claims, 12 Drawing Sheets





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

(10) **Patent No.:** **US 10,141,634 B2**
(45) **Date of Patent:** **Nov. 27, 2018**

(54) **ANTENNA FOR USE IN MOBILE TERMINAL**

(71) Applicant: **Beijing Xiaomi Mobile Software Co., Ltd.**, Beijing (CN)

(72) Inventors: **Zonglin Xue**, Beijing (CN); **Linchuan Wang**, Beijing (CN); **Xiaofeng Xiong**, Beijing (CN)

(73) Assignee: **Beijing Xiaomi Mobile Software Co., Ltd.**, Beijing (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 20 days.

(21) Appl. No.: **15/407,346**

(22) Filed: **Jan. 17, 2017**

(65) **Prior Publication Data**

US 2017/0222304 A1 Aug. 3, 2017

(30) **Foreign Application Priority Data**

Jan. 29, 2016 (CN) 2016 1 0066990

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/42 (2006.01)
H01Q 5/385 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/42** (2013.01); **H01Q 5/385** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/385; H01Q 1/38; H01Q 1/42
USPC 343/702
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2014/0306856 A1* 10/2014 Fan H01Q 1/38 343/749
2014/0320349 A1 10/2014 Lee et al.
2014/0361929 A1 12/2014 Lin
2015/0070239 A1 3/2015 Hung et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 102157779 A 8/2011
CN 102170043 A 8/2011
CN 202444054 U 9/2012
(Continued)

OTHER PUBLICATIONS

Extended Search Report for European Application No. 16204497.8 from the European Patent Office, dated Jun. 27, 2017.

(Continued)

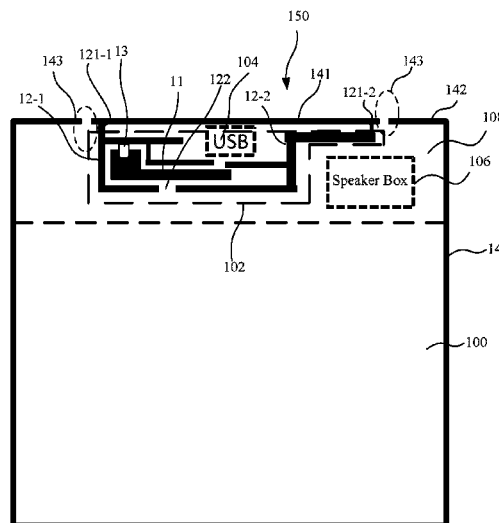
Primary Examiner — Andrea Lindgren Baltzell

(74) *Attorney, Agent, or Firm* — Finnegan, Henderson, Farabow, Garrett & Dunner LLP

(57) **ABSTRACT**

An antenna for use in a mobile terminal includes a first radiation unit including a feed portion for inputting energy, the feed portion being provided at one end of the first radiation unit, and at least one coupling branch. The first radiation unit and the at least one coupling branch form a coupled feeding structure between each other. A first end portion of the at least one coupling branch is connected to a metal frame of the mobile terminal. The at least one coupling branch is disposed around the first radiation unit. The at least one coupling branch and the first radiation unit are not in contact with each other. The at least one coupling branch has an opening.

4 Claims, 3 Drawing Sheets



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

(10) **Patent No.:** **US 10,141,652 B2**
(45) **Date of Patent:** **Nov. 27, 2018**

(54) **ANTENNA APPARATUS AND DEVICE**

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

(72) Inventors: **Qing Liu**, Shenzhen (CN); **Yuzhen Zhang**, Wuhan (CN); **Yao Lan**, Shenzhen (CN); **Dingjie Wang**, Shenzhen (CN)

(73) Assignee: **HUAWEI TECHNOLOGIES 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 38 days.

(21) Appl. No.: **15/507,313**

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

(86) PCT No.: **PCT/CN2014/085401**

§ 371 (c)(1),

(2) Date: **Feb. 28, 2017**

(87) PCT Pub. No.: **WO2016/029404**

PCT Pub. Date: **Mar. 3, 2016**

(65) **Prior Publication Data**

US 2017/0288310 A1 Oct. 5, 2017

(51) **Int. Cl.**

H01Q 9/04 (2006.01)

H01Q 9/42 (2006.01)

(Continued)

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

CPC **H01Q 9/0421** (2013.01); **B32B 38/1841** (2013.01); **H01L 21/67144** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC H01Q 9/0421; H01Q 5/335; H01Q 5/342; B32B 38/1841; H01L 21/67144

See application file for complete search history.

(56)

References Cited

U.S. PATENT DOCUMENTS

2006/0250310 A1 11/2006 Yeh et al.
2011/0181487 A1 7/2011 Kim et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CN 101425619 A 5/2009
CN 101465465 A 6/2009

(Continued)

OTHER PUBLICATIONS

Foreign Communication From a Counterpart Application, European Application No. 14900869.0, Extended European Search Report dated Jul. 18, 2017, 8 pages.

(Continued)

Primary Examiner — Dameon E Levi

Assistant Examiner — David Lotter

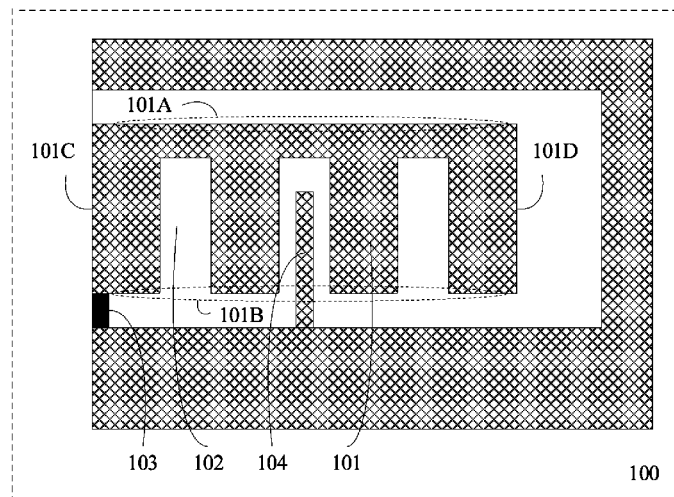
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

(57)

ABSTRACT

An antenna apparatus includes: an antenna radiator, at least one antenna cable trough, a feedpoint, and at least one first protruding metal strip; where the at least one antenna cable trough is disposed on the antenna radiator; the at least one antenna cable trough extends along a top edge to a bottom edge of the antenna radiator; the feedpoint is further disposed on the antenna radiator, and the feedpoint is disposed at an end of the bottom edge of the antenna radiator and is near a side edge of the antenna radiator; and the at least one first protruding metal strip is inserted in the antenna cable trough and is separated from the antenna radiator.

11 Claims, 5 Drawing Sheets





US010148011B2

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

(10) **Patent No.:** **US 10,148,011 B2**
(45) **Date of Patent:** **Dec. 4, 2018**

(54) **ANTENNA STRUCTURE**

(56) **References Cited**

(71) Applicant: **Arcadyan Technology Corporation,**
Hsinchu (TW)

U.S. PATENT DOCUMENTS

(72) Inventors: **Min-Chi Wu,** Zhubei (TW); **I-Min Chen,** Kaohsiung (TW)

8,085,202 B2 12/2011 Ayatollahi et al.
8,937,578 B2 1/2015 Montgomery
(Continued)

(73) Assignee: **Arcadyan Technology Corporation**
(TW)

FOREIGN PATENT DOCUMENTS

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

CN 102570010 9/2014
EP 2680365 A1 1/2014
EP 3065215 A1 9/2016

OTHER PUBLICATIONS

(21) Appl. No.: **15/673,113**

European Search Report corresponding to EP17192182, dated Mar. 27, 2018, 1 page.

(22) Filed: **Aug. 9, 2017**

(65) **Prior Publication Data**

US 2018/0269578 A1 Sep. 20, 2018

Primary Examiner — Howard Williams

(74) *Attorney, Agent, or Firm* — Innovation Counsel LLP

(30) **Foreign Application Priority Data**

Mar. 15, 2017 (TW) 106108590 A

(57) **ABSTRACT**

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 1/52 (2006.01)
H01Q 5/35 (2015.01)
H01Q 5/40 (2015.01)
H01Q 9/42 (2006.01)
H01Q 21/28 (2006.01)

(Continued)

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

CPC **H01Q 5/40** (2015.01); **H01Q 1/243**
(2013.01); **H01Q 1/521** (2013.01); **H01Q**
5/321 (2015.01); **H01Q 5/328** (2015.01);
H01Q 5/35 (2015.01); **H01Q 9/42** (2013.01);
H01Q 21/28 (2013.01)

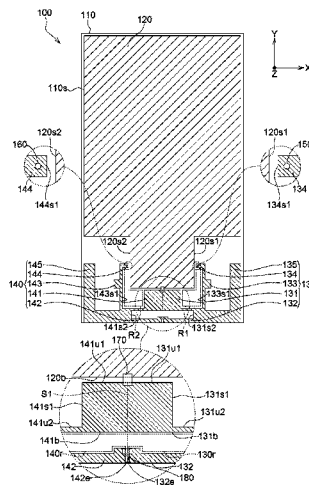
(58) **Field of Classification Search**

None

See application file for complete search history.

An antenna structure including a substrate, a grounding layer, a first antenna layer, a second antenna layer, an inductance element and a capacitance element is provided. The substrate has a surface. The grounding layer is formed on the surface of the substrate. The first antenna layer includes a first radiating portion and a second radiating portion. The second antenna layer includes a third radiating portion and a fourth radiating portion. The third radiating portion is connected to the first radiating portion at a connection portion. The connection portion is separated from the grounding layer, and the fourth radiating portion and the second radiating portion are disposed oppositely and separated from each other. The inductance element bridges the grounding layer and the connection portion. The capacitance element bridges the fourth radiating portion and the second radiating portion.

20 Claims, 12 Drawing Sheets





US010153539B2

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

(10) **Patent No.:** **US 10,153,539 B2**
(45) **Date of Patent:** **Dec. 11, 2018**

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

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

(72) Inventors: **Jung-Hoon Seo**, Gyeonggi-do (KR);
Ui-Chul Jeong, Gyeonggi-do (KR);
Se-Hyun Park, Gyeonggi-do (KR);
Jae-Ho Lim, Seoul (KR)

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

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

(21) Appl. No.: **15/056,419**

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

(65) **Prior Publication Data**

US 2016/0254590 A1 Sep. 1, 2016

(30) **Foreign Application Priority Data**

Feb. 27, 2015 (KR) 10-2015-0028663

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/00 (2015.01)
H04B 1/00 (2006.01)
H01Q 5/335 (2015.01)
H01Q 5/364 (2015.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/335** (2015.01); **H01Q 5/364** (2015.01); **H01Q 9/42** (2013.01); **H04B 1/006** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/357; H01Q 5/364; H01Q 5/371;
H01Q 5/378; H01Q 5/385; H01Q 5/392

See application file for complete search history.

(56)

References Cited

U.S. PATENT DOCUMENTS

8,330,657 B2 * 12/2012 Liu H01Q 9/145
343/700 MS
2003/0122721 A1 * 7/2003 Sievenpiper H01Q 9/14
343/767
2006/0097918 A1 * 5/2006 Oshiyama H01Q 1/243
343/700 MS
2008/0231532 A1 9/2008 Rao et al.
2008/0266199 A1 10/2008 Milosavljevic et al.
(Continued)

FOREIGN PATENT DOCUMENTS

EP 2 498 337 9/2012

OTHER PUBLICATIONS

International Search Report dated May 26, 2016 issued in counter-part application No. PCT/KR2016/001705, 10 pages.

(Continued)

Primary Examiner — Daniel J Munoz

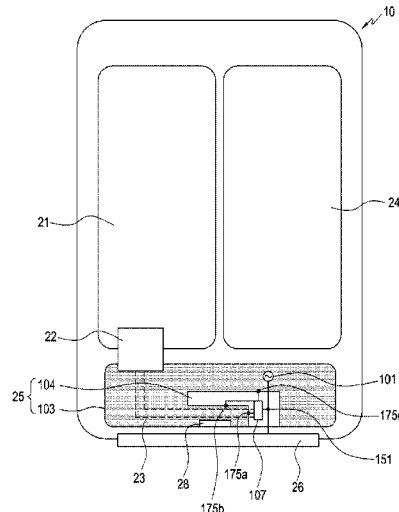
(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(57)

ABSTRACT

Disclosed are an antenna device and an electronic device that includes the antenna device. The antenna device includes a power feeding unit, a ground unit, a radiating unit that is electrically connected to the power feeding unit, and a switching element that selects one or more points from a plurality of different points of the ground unit and connects the radiating unit to the selected one or more points.

18 Claims, 17 Drawing Sheets



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

(10) **Patent No.:** **US 10,158,163 B2**
(45) **Date of Patent:** **Dec. 18, 2018**

(54) **MOBILE TERMINAL**

(56) **References Cited**

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

(72) Inventors: **Cheolgu Gang**, Seoul (KR); **Hyunsuk Yang**, Seoul (KR); **Jongmo Kang**, Seoul (KR); **Jinho Jang**, 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 42 days.

U.S. PATENT DOCUMENTS					
8,947,302	B2 *	2/2015	Caballero	.....	H01Q 1/243 343/702
2008/0079651	A1 *	4/2008	Kim	.....	H01Q 1/243 343/872
2010/0302110	A1 *	12/2010	Leem	.....	H01Q 1/243 343/702
2011/0165916	A1 *	7/2011	Park	.....	H01Q 1/06 455/566
2011/0273340	A1 *	11/2011	Jeon	.....	H01Q 1/243 343/702
2013/0321219	A1 *	12/2013	Cho	.....	H01Q 1/243 343/702
2014/0139379	A1 *	5/2014	Bolin	.....	H01Q 1/243 343/702
2014/0225787	A1	8/2014	Ramachandran et al.		
2015/0009075	A1	1/2015	Lau et al.		
(Continued)					

(21) Appl. No.: **15/241,605**

(22) Filed: **Aug. 19, 2016**

(65) **Prior Publication Data**
US 2017/0054199 A1 Feb. 23, 2017

(30) **Foreign Application Priority Data**
Aug. 20, 2015 (KR) 10-2015-0117416

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

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

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 21/28
See application file for complete search history.

OTHER PUBLICATIONS

International Search Report and Written Opinion issued in PCT/KR2016/008106 dated Nov. 9, 2016.

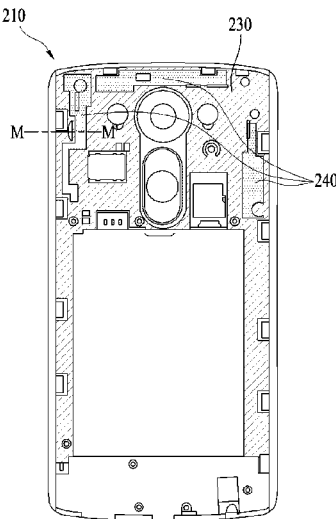
Primary Examiner — Hoang Nguyen
Assistant Examiner — Awat Salih

(74) *Attorney, Agent, or Firm* — KED & Associates, LLP

(57) **ABSTRACT**

Disclosed is a mobile terminal, by which extensibility of an antenna pattern and radiation efficiency of an antenna can be increased. The present invention includes a display, a frame configured to support a back of the display, a first antenna to be provided to at least one side of a top portion and a bottom portion of the frame, a rear case to attach to a back of the frame, a second antenna provided to at least one of an inner side and an outer side of the rear case, and a third antenna configured in a beam shape to be attached to at least one of a right lateral side and a left lateral side of the frame, the third antenna configured to be electrically connected to either the first antenna or the second antenna.

18 Claims, 14 Drawing Sheets





(12) **United States Patent**
Gagne-Keats

(10) **Patent No.:** **US 10,158,164 B2**
(45) **Date of Patent:** **Dec. 18, 2018**

(54) **HANDHELD MOBILE DEVICE WITH
HIDDEN ANTENNA FORMED OF METAL
INJECTION MOLDED SUBSTRATE**

(58) **Field of Classification Search**
CPC H01C 1/243; H01C 1/2283
See application file for complete search history.

(71) Applicant: **Essential Products, Inc.**, Palo Alto, CA
(US)

(56) **References Cited**

(72) Inventor: **Jason Sean Gagne-Keats**, Cupertino,
CA (US)

U.S. PATENT DOCUMENTS

5,118,567 A 6/1992 Komiyama et al.
5,456,779 A 10/1995 Sinha et al.

(73) Assignee: **ESSENTIAL PRODUCTS, INC.**, Palo
Alto, CA (US)

(Continued)

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

FOREIGN PATENT DOCUMENTS
CN 1788385 B 6/2011
TW 200620543 A 6/2006
(Continued)

(21) Appl. No.: **15/697,373**

OTHER PUBLICATIONS

(22) Filed: **Sep. 6, 2017**

International Search Report PCT/US16/59512 dated Mar. 17, 2017,
9 pages.

(65) **Prior Publication Data**

US 2017/0373377 A1 Dec. 28, 2017

(Continued)

Related U.S. Application Data

Primary Examiner — Hoang Nguyen

Assistant Examiner — Awat Salih

(63) Continuation-in-part of application No. 15/336,701,
filed on Oct. 27, 2016, now Pat. No. 9,896,777.

(74) *Attorney, Agent, or Firm* — Perkins Coie LLP

(Continued)

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
B32B 7/12 (2006.01)

(Continued)

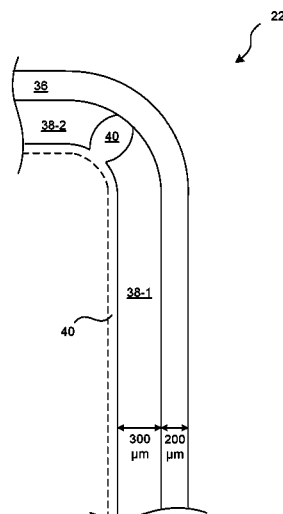
(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **B32B 7/12**
(2013.01); **B32B 15/00** (2013.01); **C23C 22/00**
(2013.01); **C25D 11/026** (2013.01); **C25D**
11/16 (2013.01); **C25D 11/26** (2013.01); **C25D**
11/30 (2013.01); **C25F 3/08** (2013.01); **B23H**
3/00 (2013.01);

(Continued)

(57) **ABSTRACT**

The disclosed embodiments include a housing of a handheld mobile device. The housing includes a ceramic layer forming a continuous outermost surface of the handheld mobile device, and an antenna layer adjacent to the ceramic layer. The antenna layer including conductive elements formed from a metal injection molded substrate, and an antenna break formed of non-conductive material electrically separating the conductive elements to collectively form an antenna of the handheld mobile device that is hidden by the ceramic layer from an exterior view of the handheld mobile device.

19 Claims, 7 Drawing Sheets



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

(10) **Patent No.:** **US 10,158,381 B2**
(45) **Date of Patent:** **Dec. 18, 2018**

(54) **WIRELESS COMMUNICATION DEVICE**

(71) Applicant: **HTC CORPORATION**, Taoyuan (TW)

(72) Inventors: **Tiao-Hsing Tsai**, Taoyuan (TW);
Chien-Pin Chiu, Taoyuan (TW);
Hsiao-Wei Wu, Taoyuan (TW);
Yi-Hsiang Kung, Taoyuan (TW);
Shen-Fu Tzeng, Taoyuan (TW);
Li-Yuan Fang, Taoyuan (TW)

(73) Assignee: **HTC CORPORATION**, Taoyuan (TW)

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

(21) Appl. No.: **15/821,777**

(22) Filed: **Nov. 23, 2017**

(65) **Prior Publication Data**

US 2018/0152208 A1 May 31, 2018

Related U.S. Application Data

(60) Provisional application No. 62/428,183, filed on Nov. 30, 2016.

(51) **Int. Cl.**

H04B 1/38 (2015.01)

H04B 1/00 (2006.01)

H04B 1/40 (2015.01)

H04W 88/06 (2009.01)

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

CPC **H04B 1/006** (2013.01); **H04B 1/40** (2013.01); **H04W 88/06** (2013.01)

(58) **Field of Classification Search**

CPC H04B 1/0053; H04B 1/0064; H01Q 1/00;
H01Q 5/00

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2012/0001815 A1* 1/2012 Wong H01Q 1/243
343/749

2013/0063313 A1* 3/2013 Ban H01Q 13/106
343/700 MS

2014/0184465 A9* 7/2014 Uejima H01Q 9/14
343/850

* cited by examiner

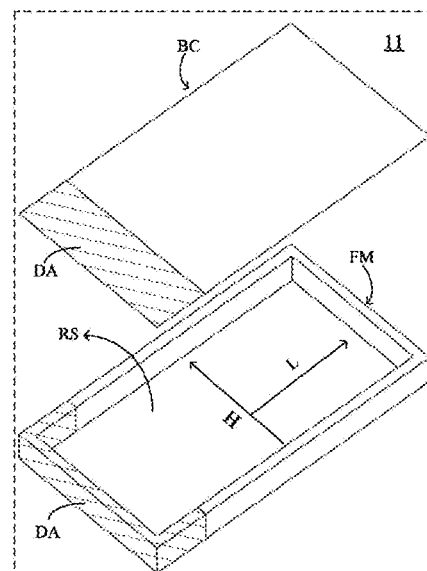
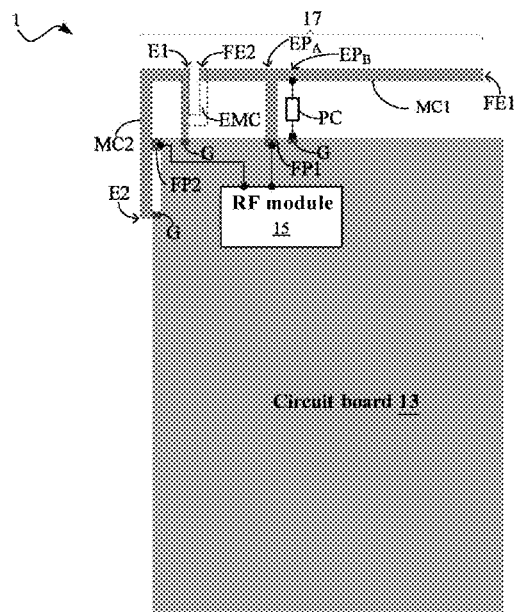
Primary Examiner — Tuan Pham

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

(57) **ABSTRACT**

A wireless communication device is provided. The wireless communication device includes a housing, a circuit board, a radio frequency module and an antenna. The housing has a frame and a back cover to define a receiving space. The circuit board is disposed in the receiving space, and defines a clearance area from the housing in the receiving space. The circuit board includes a ground terminal, a first feeding point, and a second feeding point. The antenna includes at least one metal conductor coupled to the first feeding point and the second feeding point, respectively, to provide a low frequency resonant path, a first middle frequency resonant path, a second middle frequency resonant path and a high frequency resonant path.

12 Claims, 22 Drawing Sheets



(12)
United States Patent
Yarga et al.

(10) Patent No.: US 10,158,384 B1
(45) Date of Patent: Dec. 18, 2018

(54) ELECTRONIC DEVICES WITH INDIRECTLY-FED ADJUSTABLE SLOT ELEMENTS

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

(72) Inventors: **Salih Yarga**, Sunnyvale, CA (US); **Xu Gao**, Santa Clara, CA (US); **Georgios Atmatzakis**, Cupertino, CA (US); **Xu Han**, Santa Clara, CA (US); **Bilgehan Ayser**, Mountain View, CA (US); **Hao Xu**, Cupertino, CA (US); **Yijun Zhou**, Mountain View, CA (US); **Mattia Pascolini**, San Francisco, 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 3 days.

(21) Appl. No.: **15/699,869**

(22) Filed: **Sep. 8, 2017**

(51) **Int. Cl.**
H04M 1/00 (2006.01)
H04B 1/04 (2006.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC **H04B 1/0483** (2013.01); **H01Q 1/243** (2013.01); **H04B 1/0458** (2013.01)

(58) **Field of Classification Search**
CPC H04B 1/0483; H04B 1/0458
USPC 455/575.7
See application file for complete search history.

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

8,615,209	B1 *	12/2013	Khlat	.....	H04W 52/30	455/126
9,059,504	B2 *	6/2015	Eom	.....	H01Q 5/35	
9,236,659	B2 *	1/2016	Vazquez	.....	H01Q 13/103	
9,577,318	B2 *	2/2017	Pascolini	.....	G06K 9/00006	
9,583,838	B2 *	2/2017	Zhu	.....	H01Q 13/10	
9,627,770	B2 *	4/2017	Svendsen	.....	H01Q 13/103	
9,680,510	B2 *	6/2017	Broyde	.....	H01Q 1/52	
9,768,491	B2 *	9/2017	Jin	.....	H01Q 1/243	
9,768,506	B2 *	9/2017	Krogerus	.....	H01Q 5/30	
9,813,532	B2 *	11/2017	Kim	.....	H04M 1/026	
9,876,272	B2 *	1/2018	Hu	.....	H01Q 1/243	
2015/0303568	A1 *	10/2015	Yarga	.....	H01Q 5/321	343/720
2017/0264001	A1 *	9/2017	Azad	.....	H01Q 9/0442	

* cited by examiner

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

(57) **ABSTRACT**

An electronic device may be provided with wireless circuitry and control circuitry. The wireless circuitry may include multiple antennas and transceiver circuitry. An antenna in the electronic device may have an inverted-F antenna resonating element formed from portions of a peripheral conductive electronic device housing structure and may have an antenna ground that is separated from the antenna resonating element by a gap. The antenna may also include an indirectly-fed antenna resonating element that is indirectly fed by a harmonic mode of the inverted-F antenna resonating element via near field electromagnetic coupling. The indirectly-fed antenna resonating element may be a slot. The antenna ground may define at least three edges of the slot and the slot may be aligned with a dielectric-filled gap in the peripheral conductive housing structures. An adjustable circuit may be coupled across the slot to tune the indirectly-fed antenna resonating element.

20 Claims, 10 Drawing Sheets

