

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

(10) **Patent No.:** **US 10,389,010 B2**
(45) **Date of Patent:** **Aug. 20, 2019**

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

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

(72) Inventors: **Yi-Chieh Lee**, New Taipei (TW);
Geng-Hong Liou, New Taipei (TW)

(73) Assignee: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 188 days.

(21) Appl. No.: **15/657,053**

(22) Filed: **Jul. 21, 2017**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 62/365,344, filed on Jul. 21, 2016.

(30) **Foreign Application Priority Data**

Jul. 18, 2017 (CN) 2017 1 0586519

(51) **Int. Cl.**

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H01Q 5/335 (2015.01)
H01Q 13/10 (2006.01)
H01Q 9/42 (2006.01)
H01Q 21/28 (2006.01)
H04M 1/02 (2006.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 5/335** (2015.01); **H01Q 9/42** (2013.01); **H01Q 13/10** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 9/42; H01Q 21/28;
H01Q 13/10; H01Q 5/335; H01Q 5/378;
(Continued)

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Primary Examiner — Daniel Munoz

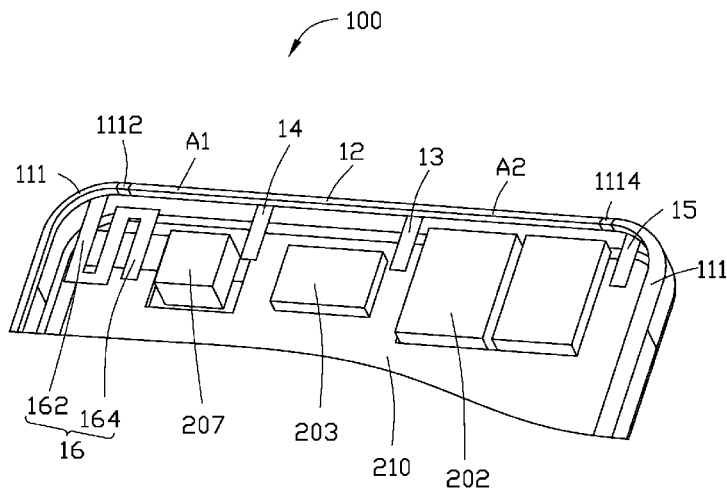
Assistant Examiner — Awat M Salih

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

(57) **ABSTRACT**

An antenna structure includes a metallic member, a feed portion, a ground portion and a radiating portion. The metallic member includes a front frame, a backboard, and a side frame. The side frame defines a slot. The front frame defines a first gap and a second gap, which are in communication with the slot and extend across the front frame. A straight portion of the front frame between the first gap and the second gap forms a radiating section. The feed portion and the ground portion are electrically connected to the radiating section. Current enters the radiating section from the feed portion. The current flows through the radiating section and towards the second gap. The radiating portion obtains current from the radiating section by coupling. The radiating section and the radiating portion generate radiation signals in two different frequency bands. A wireless communication device using the antenna structure is provided.

28 Claims, 29 Drawing Sheets





US010389011B2

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

(10) **Patent No.:** **US 10,389,011 B2**

(45) **Date of Patent:** **Aug. 20, 2019**

(54) **ANTENNA DEVICE FOR MOBILE TERMINAL AND MOBILE TERMINAL**

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

(71) Applicant: **GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP., LTD.**, Dongguan (CN)

(56) **References Cited**

U.S. PATENT DOCUMENTS

(72) Inventors: **Ning Zhao**, Dongguan (CN); **Haijun Tang**, Dongguan (CN); **Guolin Liu**, Dongguan (CN); **Shasha Hu**, Dongguan (CN)

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514/44 R

(73) Assignee: **GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP. LTD.**, Dongguan, Guangdong (CN)

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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 0 days.

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Dec. 28, 2016 (CN) 2016 1 1237642
Dec. 28, 2016 (CN) 2016 2 1462704 U

Primary Examiner — Peguy Jean Pierre

(74) *Attorney, Agent, or Firm* — Hodgson Russ LLP

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 5/335 (2015.01)
H01Q 13/10 (2006.01)
H01Q 5/314 (2015.01)

(57) **ABSTRACT**

An antenna device includes a slot, a connecting assembly, a first capacitor and a match circuit. The slot is defined in a shell of the mobile terminal. The slot separates the shell into a first part and a second part, and the first part couples with a mainboard via a feeding point to form a slot antenna. The connecting assembly connects the first part with the second part. The first capacitor couples the first part with the feeding point. The match circuit couples the first part with the feeding point.

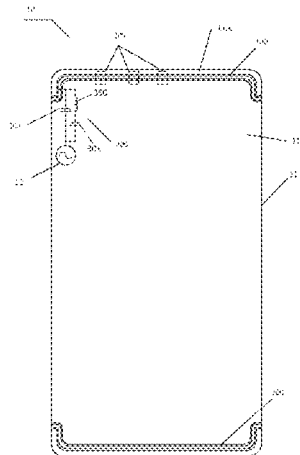
(52) **U.S. Cl.**

CPC **H01Q 1/243** (2013.01); **H01Q 5/314** (2015.01); **H01Q 5/335** (2015.01); **H01Q 13/10** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 13/18; H01Q 5/35

18 Claims, 4 Drawing Sheets



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

(10) **Patent No.:** **US 10,389,012 B2**
(45) **Date of Patent:** **Aug. 20, 2019**

(54) **ANTENNA SYSTEM AND COMMUNICATION DEVICE CONTAINING THE SAME**

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

(71) Applicant: **AAC Technologies Pte. Ltd.**,
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(56) **References Cited**

(72) Inventors: **Hongjuan Han**, Shenzhen (CN);
Yuehua Yue, Shenzhen (CN)

U.S. PATENT DOCUMENTS

(73) Assignee: **AAC TECHNOLOGIES PTE. LTD.**,
Singapore (SG)

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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 0 days.

Primary Examiner — Robert Karacsony
(74) *Attorney, Agent, or Firm* — Na Xu; IPro, PLLC

(21) Appl. No.: **15/869,183**

(57) **ABSTRACT**

(22) Filed: **Jan. 12, 2018**

The present disclosure relates to an antenna system and a communication device. The antenna system includes a rear housing, a metal middle frame including two side frame portions and a bottom frame portion, a mainboard and a first tuning switch. The bottom frame portion defines a first slit and a second slit and includes a first, second and third positions, a third slit communicated with the first and second slits is defined between the rear housing and the bottom frame portion along an extending direction of the side frame portion. The mainboard includes a feeding point, a first ground point and a second ground point, the feeding point connected with the first position, the first ground point connected with the second position, the second ground point connected with the third position by the first tuning switch, thereby forming a first antenna, a second antenna and a third antenna.

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jun. 22, 2017 (CN) 2017 1 0482838

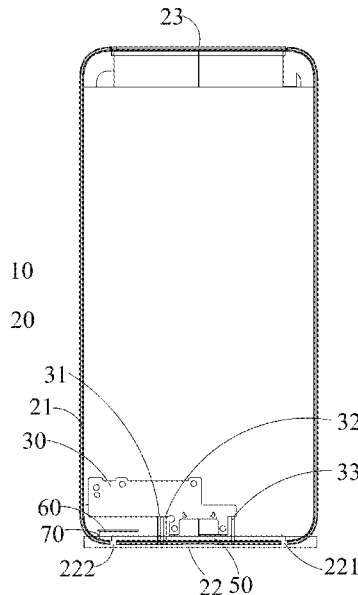
(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
H01Q 21/28 (2006.01)
H01Q 5/328 (2015.01)
H01Q 5/378 (2015.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 5/328** (2015.01); **H01Q 5/378** (2015.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01)

9 Claims, 3 Drawing Sheets





US010389021B1

(12) **United States Patent**
Thakur

(10) **Patent No.:** **US 10,389,021 B1**
(45) **Date of Patent:** **Aug. 20, 2019**

- (54) **ANTENNA PORTS DECOUPLING TECHNIQUE**
- (71) Applicant: **Intel Corporation**, Santa Clara, CA (US)
- (72) Inventor: **Jayprakash Thakur**, Bangalore (IN)
- (73) Assignee: **Intel Corporation**, Santa Clara, CA (US)

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- (21) Appl. No.: **15/897,682**
- (22) Filed: **Feb. 15, 2018**
- (51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/52 (2006.01)
H01Q 5/335 (2015.01)
H01Q 1/48 (2006.01)
- (52) **U.S. Cl.**
CPC *H01Q 1/521* (2013.01); *H01Q 5/335* (2015.01); *H01Q 1/243* (2013.01); *H01Q 1/48* (2013.01)
- (58) **Field of Classification Search**
CPC H01Q 1/521; H01Q 5/335; H01Q 1/243
See application file for complete search history.

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 What’s the Difference Between Broadband and Narrowband RF Communications? Precision Clock Generator with square wave clocks to 2.05 GHz! Microwaves&Rf. 26 pages.
 “Why does an Inductor Need a Fly-Back Diode?” West Florida Components. 3 pages.
 International Search Report dated Apr. 5, 2019 for International Application No. PCT/US2019/013600.

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Primary Examiner — Dieu Hien T Duong
 (74) *Attorney, Agent, or Firm* — Eschweiler & Potashnik, LLC

(57) **ABSTRACT**

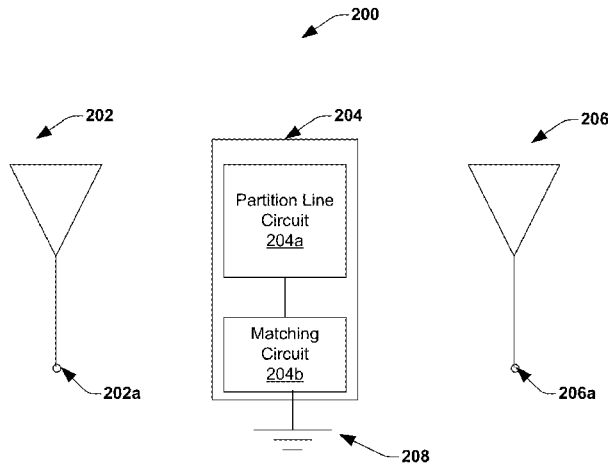
An antenna isolation circuit configured to provide an isolation between two adjacent antennas in a wireless communication device is disclosed. The antenna isolation circuit comprises a partition line circuit comprising a conductive element configured to be placed between the two adjacent antennas; and a matching circuit having a first end and a second end. In some embodiments, the matching circuit is coupled to the partition line circuit at the first end and to a ground circuit at the second end. In some embodiments, the matching circuit is configured to provide an impedance. In some embodiments, a dimension of the conductive element and the impedance of the matching circuit are configured to result in an isolation between the two adjacent antennas.

20 Claims, 7 Drawing Sheets

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

(10) **Patent No.:** **US 10,389,025 B2**
(45) **Date of Patent:** **Aug. 20, 2019**

(54) **METAL BODY ANTENNA HAVING LOOP TYPE RADIATION ELEMENTS**

(71) Applicant: **ACE TECHNOLOGIES CORPORATION**, Incheon (KR)
(72) Inventors: **Sung Nam An**, Seoul (KR); **Won Whi Jin**, Bucheon-si (KR); **Jun Hee Kim**, Incheon (KR)

(73) Assignee: **ACE TECHNOLOGIES CORPORATION**, Incheon (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 259 days.

(21) Appl. No.: **15/454,002**

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

(65) **Prior Publication Data**
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(30) **Foreign Application Priority Data**
Mar. 23, 2016 (KR) 10-2016-0034362

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 7/00 (2006.01)
H01Q 21/28 (2006.01)
H01Q 5/335 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 7/00** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/335** (2015.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 7/00; H01Q 21/28
See application file for complete search history.

(56) **References Cited**

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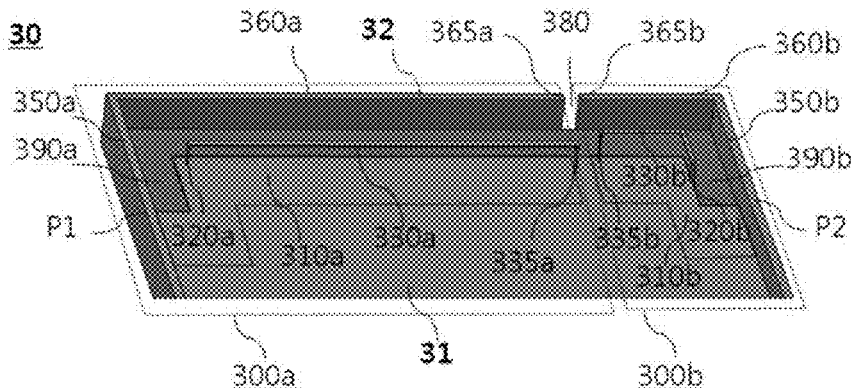
Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — LRK Patent Law Firm

(57) **ABSTRACT**

A metal body antenna having loop type radiation elements in which a housing unit is used as an antenna includes a radiation element supplied with a signal from a feeding power port, a ground coupled to the radiation element by loop coupling and in which an induction current is generated, and a frame bezel unit having an open end part separated from the ground by a dielectric and a gap. The frame bezel unit having the open end part supplied with an electric current induced into the ground is connected, and the metal body antenna operates in a wideband in multiple bands having an electrical length of a half wavelength. Accordingly, the bezel unit of a frame unit is effectively used and all of the Penta bands (i.e., GSM850, EGSM, DCS, PCS, and W2100) used in mobile phones is satisfied through a wideband multi-antenna structure having a small radiation loss.

20 Claims, 9 Drawing Sheets



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

(10) **Patent No.:** **US 10,389,026 B2**
(45) **Date of Patent:** **Aug. 20, 2019**

(54) **METAL BODY ANTENNA HAVING LOOP TYPE RADIATION ELEMENTS**

(71) Applicant: **ACE TECHNOLOGIES CORPORATION**, Incheon (KR)
(72) Inventors: **Sung Nam An**, Seoul (KR); **Won Whi Jin**, Bucheon-si (KR); **Jun Hee Kim**, Incheon (KR)

(73) Assignee: **ACE TECHNOLOGIES CORPORATION**, Incheon (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 257 days.

(21) Appl. No.: **15/455,242**

(22) Filed: **Mar. 10, 2017**

(65) **Prior Publication Data**
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(30) **Foreign Application Priority Data**
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(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 7/00 (2006.01)
H01Q 21/28 (2006.01)
H01Q 5/335 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 7/00** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/335** (2015.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 7/00; H01Q 21/28
See application file for complete search history.

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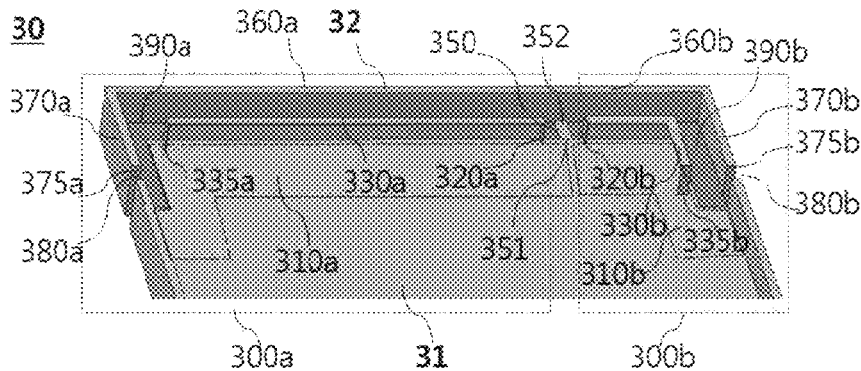
Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — LRK Patent Law Firm

(57) **ABSTRACT**

A metal body antenna using a housing unit and a battery cover as an antenna. The metal body antenna includes a radiation element supplied with a signal from a feeding power port, a ground coupled to the radiation element by loop coupling to generate an induction current, a frame bezel unit separated from the ground by a dielectric and a gap, and a connection line configured to connect the ground and the frame bezel unit and formed over the dielectric so that an electric current induced into the ground flows into the frame bezel unit, wherein an antenna having an electrical length of a half wavelength operates in a wideband. Accordingly, a bezel unit is effectively used, and a wideband and multi-band antenna structure having a radiation loss satisfies all of the Penta Band (i.e., GSM850, EGSM, DCS, PCS, and W2100), that is, bands chiefly used in mobile phones.

16 Claims, 9 Drawing Sheets



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

(10) **Patent No.:** **US 10,389,030 B2**
(45) **Date of Patent:** **Aug. 20, 2019**

(54) **ANTENNA STRUCTURE**
(71) Applicant: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)
(72) Inventors: **Cho-Kang Hsu**, New Taipei (TW); **Te-Chang Lin**, New Taipei (TW)
(73) Assignee: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 52 days.

USPC 343/845
See application file for complete search history.

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Primary Examiner — Brian K Young

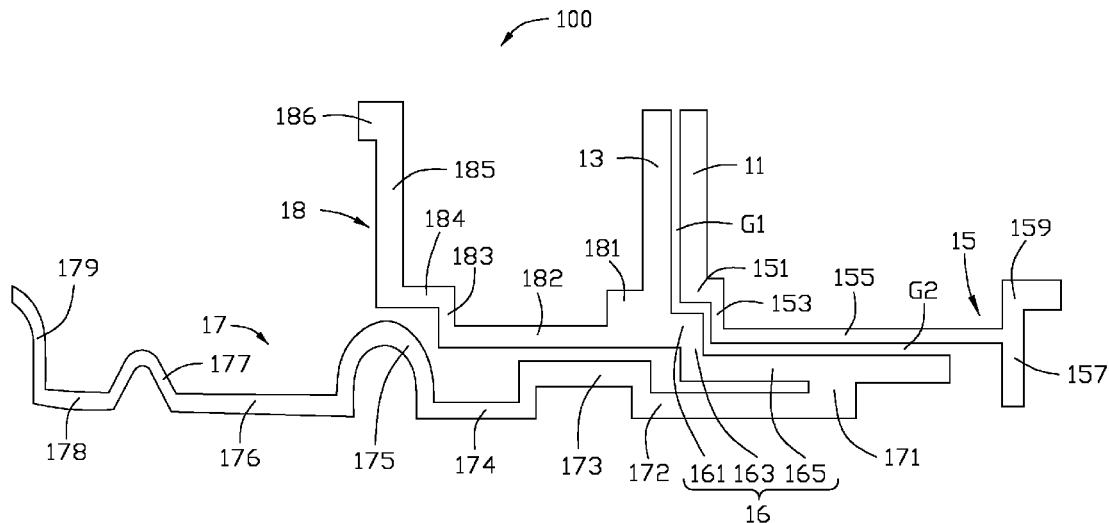
(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

An antenna structure includes a feed portion, a high-frequency radiating portion, a low-frequency radiating portion, an extension portion, and a switching unit. The high-frequency radiating portion is electrically connected to the feed portion. The low-frequency radiating portion is electrically connected to the high-frequency radiating portion. The extension portion is electrically connected to the feed portion and the high-frequency radiating portion. The switching unit is electrically connected to the extension portion to control the extension portion to be in one of an open-circuit state and a short-circuit state.

9 Claims, 4 Drawing Sheets

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H01Q 9/14 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/378 (2015.01)
H01Q 1/50 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 9/14** (2013.01); **H01Q 5/378**
(2015.01); **H01Q 9/42** (2013.01); **H01Q 1/48**
(2013.01); **H01Q 1/50** (2013.01)
(58) **Field of Classification Search**
CPC H01Q 9/14; H01Q 9/42; H01Q 5/378; H01Q
1/50; H01Q 1/48



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

(10) **Patent No.:** US 10,389,857 B2
(45) **Date of Patent:** Aug. 20, 2019

(54) **MOBILE COMMUNICATIONS TERMINAL**

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

(72) Inventors: **Qiao Sun**, Xi'an (CN); **Yi Wang**, Xi'an (CN); **Hanyang Wang**, Reading (GB); **Yibo Chen**, Shenzhen (CN); **Bao Lu**, Shenzhen (CN); **Shiqiang Lu**, Xi'an (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.: **16/063,519**

(22) PCT Filed: **Dec. 17, 2015**

(86) PCT No.: **PCT/CN2015/097707**

§ 371 (c)(1),
(2) Date: **Jun. 18, 2018**

(87) PCT Pub. No.: **WO2017/101068**

PCT Pub. Date: **Jun. 22, 2017**

(65) **Prior Publication Data**

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(51) **Int. Cl.**

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CPC **H04M 1/0202** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 9/42** (2013.01); **H04M 1/02** (2013.01)

(58) **Field of Classification Search**

CPC H01Q
1/22; H01Q 1/38; H01Q 1/243; H01Q
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(Continued)

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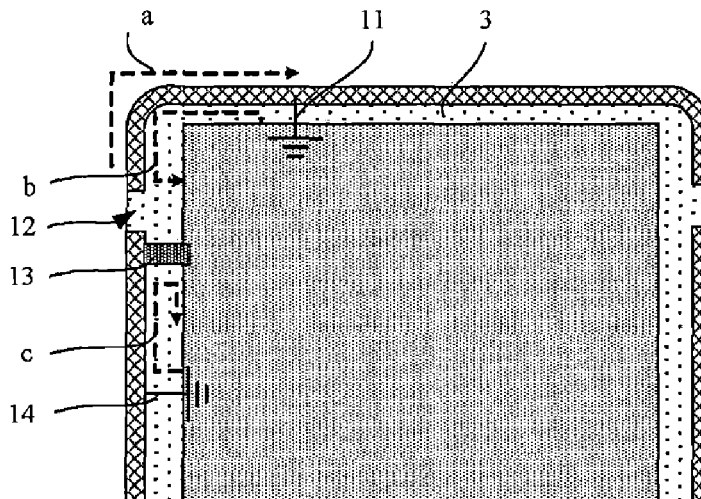
Primary Examiner — George Eng
Assistant Examiner — Hung K Du

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

(57) **ABSTRACT**

A mobile communications terminal includes a metal backplane, a circuit board, and a metal frame. A feeding structure is located between a first ground point and a second ground point. A slot is located between the first ground point and the feeding structure. The first antenna uses, as a radiator, a part of the metal frame between the slot and the first ground point. The second antenna uses, as a radiation slot, a gap between the metal backplane and the part of the metal frame between the slot and the first ground point. The third antenna uses, as another radiation slot, a gap between the metal backplane and a part of the metal frame between the slot and the second ground point.

12 Claims, 16 Drawing Sheets



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

(10) **Patent No.:** **US 10,396,433 B2**
(45) **Date of Patent:** **Aug. 27, 2019**

(54) **MOBILE TERMINAL**

(71) Applicants: **Xiaopu Wu**, Shenzhen (CN); **Yongli Chen**, Shenzhen (CN)

(72) Inventors: **Xiaopu Wu**, Shenzhen (CN); **Yongli Chen**, Shenzhen (CN)

(73) Assignee: **AAC TECHNOLOGIES PTE. LTD.**, Singapore (SG)

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H01Q 5/35 (2015.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/2291** (2013.01); **H01Q 1/42** (2013.01); **H01Q 1/50** (2013.01); **H01Q 5/335** (2015.01); **H01Q 5/35** (2015.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/50; H01Q 1/2291; H01Q 5/35; H01Q 5/335; H01Q 1/42
See application file for complete search history.

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Primary Examiner — Hai V Tran

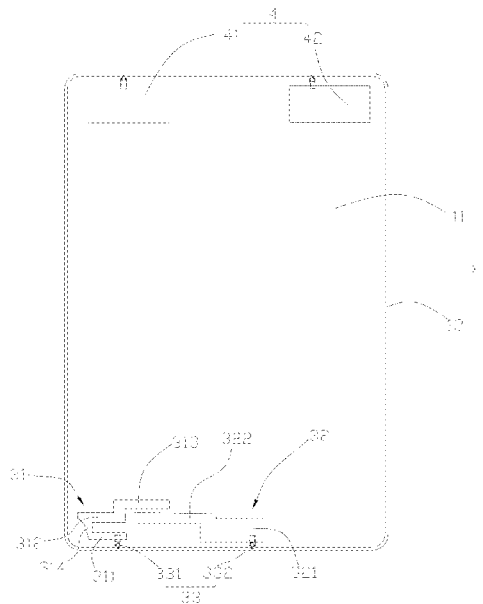
Assistant Examiner — Michael M Bouizza

(74) *Attorney, Agent, or Firm* — Na Xu; IPPro, PLLC

(57) **ABSTRACT**

A mobile terminal is disclosed. The mobile terminal includes a housing having an accommodation space, the housing including a metal frame; a mainboard received in the accommodation space and including a ground point provided on a surface thereof; an antenna system grounded through the mainboard. The antenna system includes a main antenna including a low-frequency feeding portion and a high-frequency feeding portion both of which are respectively connected to the metal frame; and a matching system configured on the metal frame for adjusting the frequency band of the antenna system. The high-frequency feeding portion is isolated from the low-frequency feeding portion through a LC filtering system.

10 Claims, 3 Drawing Sheets





US010396434B2

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

(10) **Patent No.:** **US 10,396,434 B2**

(45) **Date of Patent:** **Aug. 27, 2019**

(54) **ELECTRONIC DEVICE WITH ANTENNA**

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

(72) Inventors: **Young Gwon Koo**, Seoul (KR); **Dong Ryul Shin**, Daegu (KR); **Jin Woo Jung**, Seoul (KR); **Byoung Uk Yoon**, Gyeonggi-do (KR); **Jae Bong Chun**, Gyeonggi-do (KR); **Hyun Suk Choi**, Daegu (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 192 days.

(21) Appl. No.: **15/411,340**

(22) Filed: **Jan. 20, 2017**

(65) **Prior Publication Data**

US 2017/0207516 A1 Jul. 20, 2017

(30) **Foreign Application Priority Data**

Jan. 20, 2016 (KR) 10-2016-0007191

(51) **Int. Cl.**
H01Q 1/12 (2006.01)
H01Q 1/22 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/1207** (2013.01); **H01Q 1/2291** (2013.01); **H01Q 1/38** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/48; H01Q 1/38; H05K 1/028
See application file for complete search history.

(56) **References Cited**

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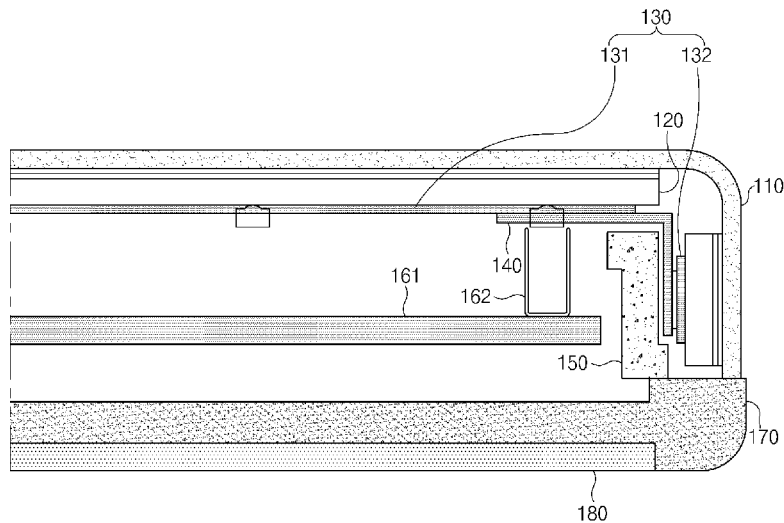
Primary Examiner — Ricardo I Magallanes

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

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a housing including a first surface, a second surface, and a side plate surrounding part of a space between the first surface and the second surface, a display disposed in the housing, a first plate attached to or integrated into the display, a second plate facing in the third direction and positioned adjacent to the side plate, a flexible printed circuit board (FPCB) including a first planar portion coupled to the first plate, and a second planar portion coupled to the second plate and angled from the first planar portion, a printed circuit board (PCB) interposed between the display and the second surface, and a mid-plate disposed in the housing, wherein the second planar portion of the FPCB is interposed between a side surface of the mid-plate and the second plate separated from each other by a gap.

17 Claims, 19 Drawing Sheets





US010396438B1

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

(10) **Patent No.:** **US 10,396,438 B1**
(45) **Date of Patent:** **Aug. 27, 2019**

(54) **ANTENNA SYSTEM AND ELECTRONIC DEVICE INCLUDING ONE OR MORE CONDUCTIVE ELEMENTS FOR USE WITH A DIFFERENTIAL AND AN ALTERNATIVE SIGNAL SOURCE**

2017/0098951	A1*	4/2017	Olgun	H02J 7/025
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- (71) Applicant: **Motorola Mobility LLC**, Chicago, IL (US)
- (72) Inventors: **Hugh Smith**, Palatine, IL (US);
Mohammed Abdul-Gaffoor, Palatine, IL (US)
- (73) Assignee: **Motorola Mobility LLC**, Chicago, IL (US)

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 Yuji Tanabe et al., "A Small Dual-Band Asymmetric Dipole Antenna for 13.56 MHz Power and 2.45 GHz Data Transmission", IEEE Antennas and Wireless Propagation Letters, vol. 13, 2014, pp. 1120-1123.

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

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Primary Examiner — Hoang V Nguyen

(74) Attorney, Agent, or Firm — Loppnow & Chapa

(21) Appl. No.: **15/994,970**

(22) Filed: **May 31, 2018**

(51) **Int. Cl.**
H01Q 7/00 (2006.01)
H01Q 1/24 (2006.01)
H03H 7/40 (2006.01)
H01Q 1/22 (2006.01)

(52) **U.S. Cl.**
 CPC **H01Q 1/243** (2013.01); **H01Q 1/2283** (2013.01); **H01Q 7/00** (2013.01); **H03H 7/40** (2013.01)

(58) **Field of Classification Search**
 CPC H01Q 1/24; H01Q 1/241; H01Q 1/242; H01Q 1/243; H01Q 7/00
 See application file for complete search history.

(57) **ABSTRACT**

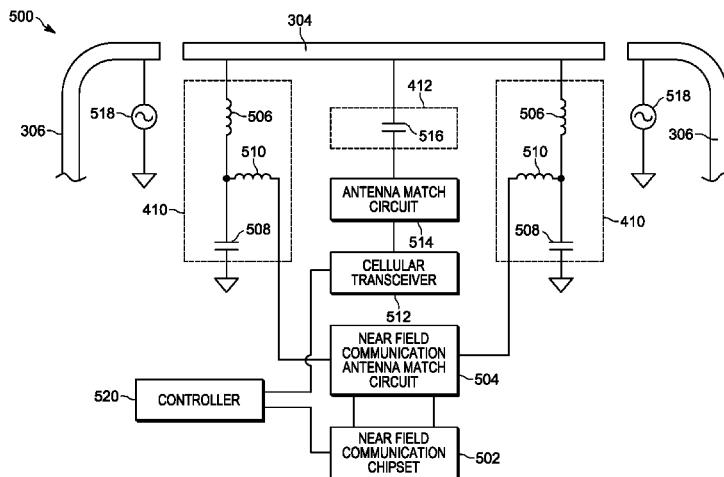
The present application provides an antenna system for use in an electronic device. The antenna system includes a conductive substrate. The antenna system further includes a conductive element, which extends along a length between two ends a distance away from the conductive substrate. An area between the conductive substrate and the conductive element form at least part of a loop which is internal to the antenna system. The antenna system still further includes a differential signal source coupled between two points along the length of the conductive element. Each of the two points are proximate a respective one of the two ends of the conductive element. The differential signal source is coupled to each of the two points via a high frequency blocking circuit. Further yet, the antenna system includes an alternative signal source coupled to the conductive element between the two ends of the conductive element toward a center of the conductive element via a low frequency blocking circuit.

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20 Claims, 6 Drawing Sheets





US010403963B2

(12) **United States Patent**
Bonnet

(10) **Patent No.:** **US 10,403,963 B2**
(45) **Date of Patent:** **Sep. 3, 2019**

(54) **ANTENNA FOR MOBILE COMMUNICATION DEVICE**

(2015.01); **H01Q 9/0421** (2013.01); **H01Q 9/42** (2013.01); **H01Q 1/48** (2013.01)

(71) Applicant: **STMICROELECTRONICS (TOURS) SAS**, Tours (FR)

(58) **Field of Classification Search**
CPC **H01Q 1/242**; **H01Q 5/30**; **H01Q 9/0421**; **H01Q 1/48**
See application file for complete search history.

(72) Inventor: **Benoit Bonnet**, Tours (FR)

(73) Assignee: **STMICROELECTRONICS (TOURS) SAS**, Tours (FR)

(56) **References Cited**

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 72 days.

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(21) Appl. No.: **15/691,285**

(22) Filed: **Aug. 30, 2017**

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(65) **Prior Publication Data**

US 2018/0205137 A1 Jul. 19, 2018

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(30) **Foreign Application Priority Data**

Jan. 19, 2017 (FR) 17 50418
Jan. 19, 2017 (FR) 17 50419

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Primary Examiner — Dieu Hien T Duong
(74) *Attorney, Agent, or Firm* — Slater Matsil, LLP

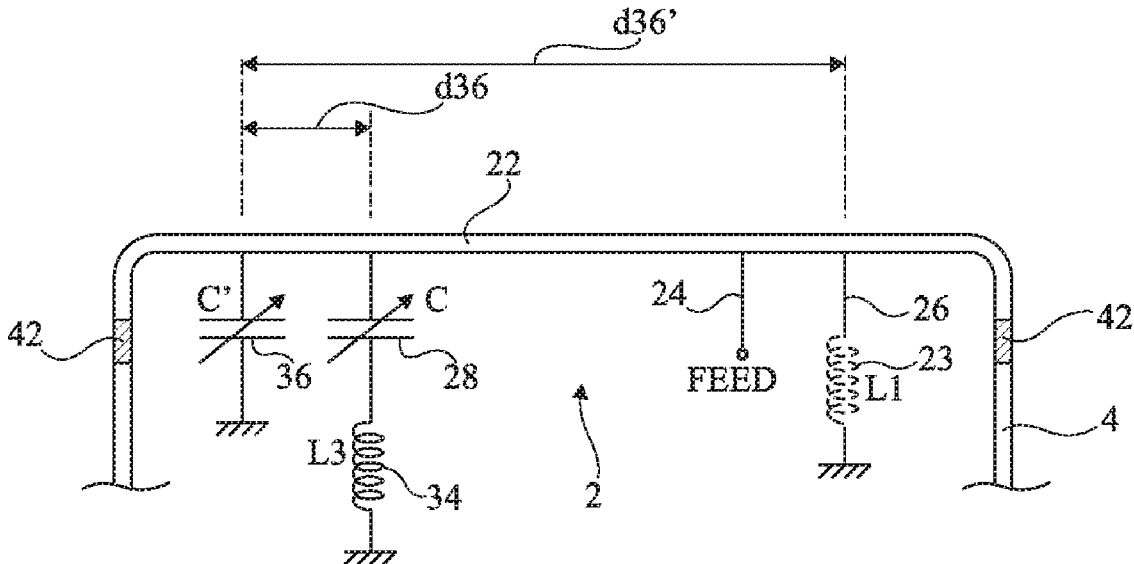
(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/04 (2006.01)
H01Q 5/30 (2015.01)
H01Q 9/42 (2006.01)
H01Q 5/328 (2015.01)
H01Q 1/48 (2006.01)

(57) **ABSTRACT**

The invention relates to an antenna comprising: an elongate conducting band; an antenna socket; a connection to earth; at least one first capacitive element of adjustable capacitance; and at least one first inductive element in series with the first capacitive element.

(52) **U.S. Cl.**
CPC **H01Q 1/242** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/30** (2015.01); **H01Q 5/328**

19 Claims, 2 Drawing Sheets



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

(10) **Patent No.:** **US 10,403,964 B2**
(45) **Date of Patent:** **Sep. 3, 2019**

(54) **TERMINAL INCLUDING MULTIBAND ANTENNA AS CONDUCTIVE BORDER**

USPC 343/702, 745, 700 MS
See application file for complete search history.

(71) Applicant: **Pantech Inc.**, Seoul (KR)
(72) Inventors: **Kyoung Sang Yoo**, Seoul (KR); **Myung Gu Kang**, Seoul (KR)
(73) Assignee: **Pantech 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 618 days.

(56) **References Cited**

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(21) Appl. No.: **14/222,090**

(22) Filed: **Mar. 21, 2014**

(65) **Prior Publication Data**

US 2014/0292590 A1 Oct. 2, 2014

(30) **Foreign Application Priority Data**

Mar. 29, 2013 (KR) 10-2013-0034406

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 7/00 (2006.01)
H01Q 9/42 (2006.01)
H01Q 21/28 (2006.01)
H01Q 5/371 (2015.01)
H01Q 5/378 (2015.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01); **H01Q 5/378** (2015.01); **H01Q 7/00** (2013.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01); **Y10T 29/49016** (2015.01)

(58) **Field of Classification Search**

CPC .. Y10T 29/49016; H01Q 5/371; H01Q 5/378; H01Q 1/243; H01Q 9/42; H01Q 21/28; H01Q 7/00

Primary Examiner — Graham P Smith

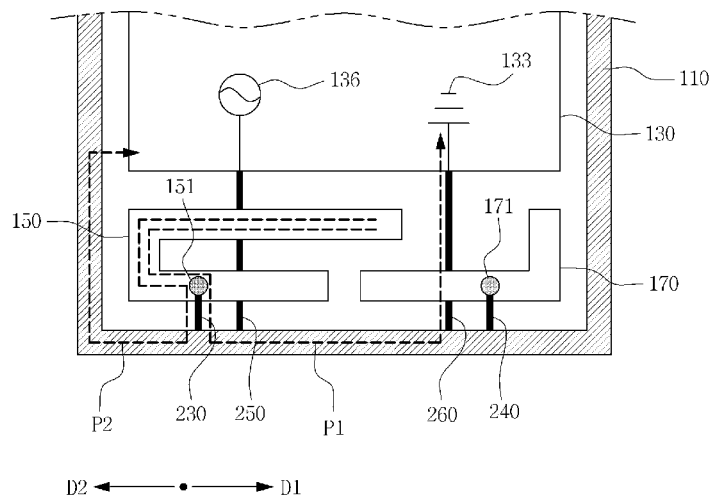
Assistant Examiner — Jae K Kim

(74) *Attorney, Agent, or Firm* — H.C. Park & Associates, PLC

(57) **ABSTRACT**

A conductive border surrounds a terminal along a direction. A mobile terminal includes a wireless transmission/reception circuit to output a signal for a wireless communication of the mobile terminal; a conductive border that forms side surfaces of the mobile terminal; a ground element electrically connected to the conductive border; a first antenna element electrically connected to the conductive border and the wireless transmission/reception circuit; and a second antenna element electrically connected to the conductive border and the ground element.

16 Claims, 22 Drawing Sheets



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

(10) **Patent No.:** **US 10,403,967 B1**
(45) **Date of Patent:** **Sep. 3, 2019**

(54) **ELECTRONIC DEVICE COMPRISING ANTENNA**

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

(72) Inventors: **Sung Won Kim**, Gyeonggi-do (KR);
No Hwan Park, Gyeonggi-do (KR); **Ki Sung Bae**, Gyeonggi-do (KR); **Jun Hee 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.

(21) Appl. No.: **15/977,196**

(22) Filed: **May 11, 2018**

(30) **Foreign Application Priority Data**

Mar. 30, 2018 (KR) 10-2018-0037624

(51) **Int. Cl.**
H01Q 5/30 (2015.01)
H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)
H01Q 7/00 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/30** (2015.01); **H01Q 7/00** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 1/24; H01Q 5/30; H01Q 1/48; H01Q 7/00
USPC 343/702
See application file for complete search history.

(56) **References Cited**

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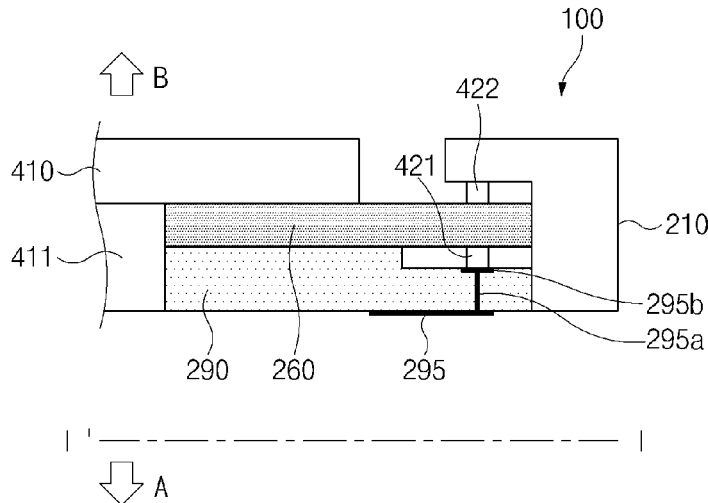
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Primary Examiner — Andrea Lindgren Baltzell
(74) *Attorney, Agent, or Firm* — Cha & Reiter, LLC.

(57) **ABSTRACT**

An electronic device includes a housing that includes a first plate, a second plate, and a side member, the side member including a first conductive portion, a second conductive portion, a third conductive portion, a first insulating portion, and a second insulating portion, a wireless communication circuitry that is electrically connected to a first point of the first conductive portion, wherein the first point is adjacent to the second insulating portion, a ground member that is included in the housing, a first switching circuitry that includes a first terminal electrically connected to a second point of the first conductive portion, which is more distant from the second insulating portion than the first point, and at least one second terminal electrically connected to the ground member through at least one first passive element, and a conductive pattern that is electrically connected to the second point and forms a closed loop.

20 Claims, 9 Drawing Sheets





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

(10) **Patent No.:** **US 10,403,971 B2**
(45) **Date of Patent:** **Sep. 3, 2019**

(54) **ANTENNA AND MOBILE TERMINAL**

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

(72) Inventors: **Dong Yu**, Shanghai (CN); **Hanyang Wang**, Shenzhen (CN); **Jianming Li**, Taipei (TW)

(73) Assignee: **Huawei Device Co., Ltd.**, Dongguan (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 51 days.

(21) Appl. No.: **15/112,635**

(22) PCT Filed: **Feb. 6, 2015**

(86) PCT No.: **PCT/CN2015/072406**
§ 371 (c)(1),
(2) Date: **Jul. 19, 2016**

(87) PCT Pub. No.: **WO2015/120779**
PCT Pub. Date: **Aug. 20, 2015**

(65) **Prior Publication Data**
US 2016/0336649 A1 Nov. 17, 2016

(30) **Foreign Application Priority Data**
Feb. 12, 2014 (CN) 2014 1 0049186

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

(52) **U.S. Cl.**
CPC **H01Q 1/38** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/328** (2015.01);
(Continued)

(58) **Field of Classification Search**

CPC H01Q 1/38; H01Q 5/328; H01Q 5/371; H01Q 5/335; H01Q 5/378; H01Q 1/243; H01Q 1/48; H01Q 7/00; H01Q 9/42
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Primary Examiner — Dieu Hien T Duong

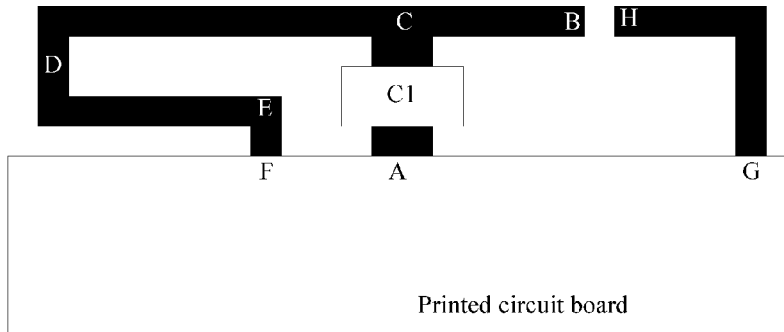
Assistant Examiner — Bamidele A Jegede

(74) *Attorney, Agent, or Firm* — Slater Matsil, LLP

(57) **ABSTRACT**

An antenna includes a first radiator and a first capacitor structure. A first end of the first radiator is electrically connected to a signal feed end of a printed circuit board by means of the first capacitor structure, and a second end of the first radiator is electrically connected to a ground end of the printed circuit board. The first radiator, the first capacitor structure, the signal feed end, and the ground end form a first antenna configured to produce a first resonance frequency. An electrical length of the first radiator is greater than one eighth of a wavelength corresponding to the first resonance

(Continued)





US010403976B2

(12) **United States Patent**
Uchida

(10) **Patent No.:** **US 10,403,976 B2**
(45) **Date of Patent:** **Sep. 3, 2019**

(54) **ANTENNA AND WIRELESS COMMUNICATION APPARATUS**

(71) Applicant: **NEC Platforms, Ltd.**, Kawasaki-shi, Kanagawa (JP)

(72) Inventor: **Jun Uchida**, Kanagawa (JP)

(73) Assignee: **NEC PLATFORMS, LTD**, Kanagawa (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 138 days.

(21) Appl. No.: **15/506,811**

(22) PCT Filed: **Sep. 11, 2015**

(86) PCT No.: **PCT/JP2015/004640**

§ 371 (c)(1),

(2) Date: **Feb. 27, 2017**

(87) PCT Pub. No.: **WO2016/042747**

PCT Pub. Date: **Mar. 24, 2016**

(65) **Prior Publication Data**

US 2017/0294952 A1 Oct. 12, 2017

(30) **Foreign Application Priority Data**

Sep. 19, 2014 (JP) 2014-190945

(51) **Int. Cl.**

H04B 1/00 (2006.01)

H01Q 5/321 (2015.01)

(Continued)

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

CPC **H01Q 5/321** (2015.01); **H01Q 1/38** (2013.01); **H01Q 5/328** (2015.01); **H01Q 5/371** (2015.01);

(Continued)

(58) **Field of Classification Search**

CPC H01Q 5/321; H01Q 5/328; H01Q 5/378; H01Q 5/371; H01Q 1/38; H01Q 1/243; (Continued)

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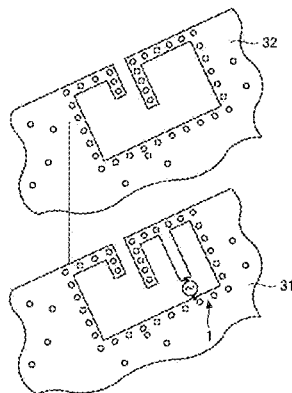
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Primary Examiner — Michelle M Koeth

(57) **ABSTRACT**

In order to provide an antenna that is small and resonates at a plurality of frequencies, an antenna according to the present invention is provided with: a first conductor of a ring shape, having an air gap; a second conductor arranged inside the ring, with both ends of the second conductor connected to the first conductor, having a first gap; and a third conductor arranged in a region surrounded by a part not including the air gap out of the first conductor, and the second conductor, with both ends connected to the first conductor, having a second gap, and a value obtained by multiplying a length of an outer periphery of a region surrounded by a part including the air gap out of the first conductor, and the third conductor, by capacitance of the air gap is different from a value obtained by multiplying a length of an outer periphery of a region surrounded by the second conductor, the third

(Continued)





US010411324B2

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

(10) **Patent No.:** **US 10,411,324 B2**
(45) **Date of Patent:** **Sep. 10, 2019**

- (54) **ANTENNA STRUCTURE OF A COMMUNICATIONS DEVICE**
- (71) Applicant: **Quanta Computer Inc.**, Taoyuan (TW)
- (72) Inventors: **Hui Lin**, Taoyuan (TW); **Chun-I Lin**, Taoyuan (TW); **Hung-Ren Hsu**, Taoyuan (TW); **Jun-Yu Lu**, Taoyuan (TW)
- (73) Assignee: **QUANTA COMPUTER INC.**, Guishan Dist., 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.: **15/830,300**
(22) Filed: **Dec. 4, 2017**

(65) **Prior Publication Data**
US 2019/0044214 A1 Feb. 7, 2019

(30) **Foreign Application Priority Data**
Aug. 3, 2017 (TW) 106126208 A

- (51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/40 (2006.01)
H01Q 1/48 (2006.01)
H01Q 9/30 (2006.01)
H01Q 21/28 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/2258** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/40** (2013.01); **H01Q 1/48** (2013.01); **H01Q 9/30** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/22–1/2266; H01Q 1/24–1/243; H01Q 1/40; H01Q 1/48
See application file for complete search history.

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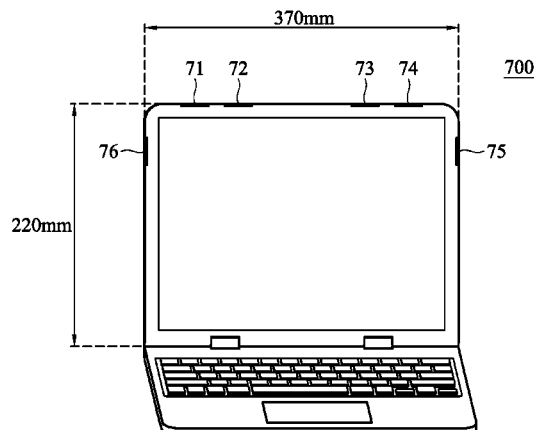
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Primary Examiner — Dameon E Levi
Assistant Examiner — Hasan Z Islam
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**
A communications device includes a ground plane, a signal source, a filling material and an antenna. The signal source is electrically connected to the ground plane. The antenna has a predetermined metal pattern and is coupled to the signal source. The filling material is a non-conductive material and the filling material and the predetermined metal pattern are bonded heterogeneously via a surface-mount technology.

9 Claims, 10 Drawing Sheets





US010411333B1

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

(10) **Patent No.:** **US 10,411,333 B1**
(45) **Date of Patent:** **Sep. 10, 2019**

(54) **ELECTRONIC DEVICE**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

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

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(73) Assignee: **ACER INCORPORATED**, New Taipei (TW)

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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 0 days.

Primary Examiner — Justin Y Lee

(21) Appl. No.: **16/163,848**

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

(22) Filed: **Oct. 18, 2018**

(57) **ABSTRACT**

(30) **Foreign Application Priority Data**

Aug. 24, 2018 (TW) 107129650 A

An electronic device includes a dielectric substrate, a first radiation element, a second radiation element, a third radiation element, and a sensing pad. The first radiation element includes a first branch, a second branch, and a first connection element. The first connection element is coupled between the first branch and the second branch. The second branch is coupled to a ground voltage. The second radiation element has a feeding point. The third radiation element is coupled to the feeding point. An antenna structure is formed by the first radiation element, the second radiation element, and the third radiation element. The sensing pad includes a third branch, a fourth branch, and a second connection element. The second connection element is coupled between the third branch and the fourth branch. The second connection element has a meandering structure.

(51) **Int. Cl.**

H04M 1/00 (2006.01)
H01Q 1/36 (2006.01)
G06F 1/16 (2006.01)
H01Q 5/50 (2015.01)
H01Q 5/392 (2015.01)

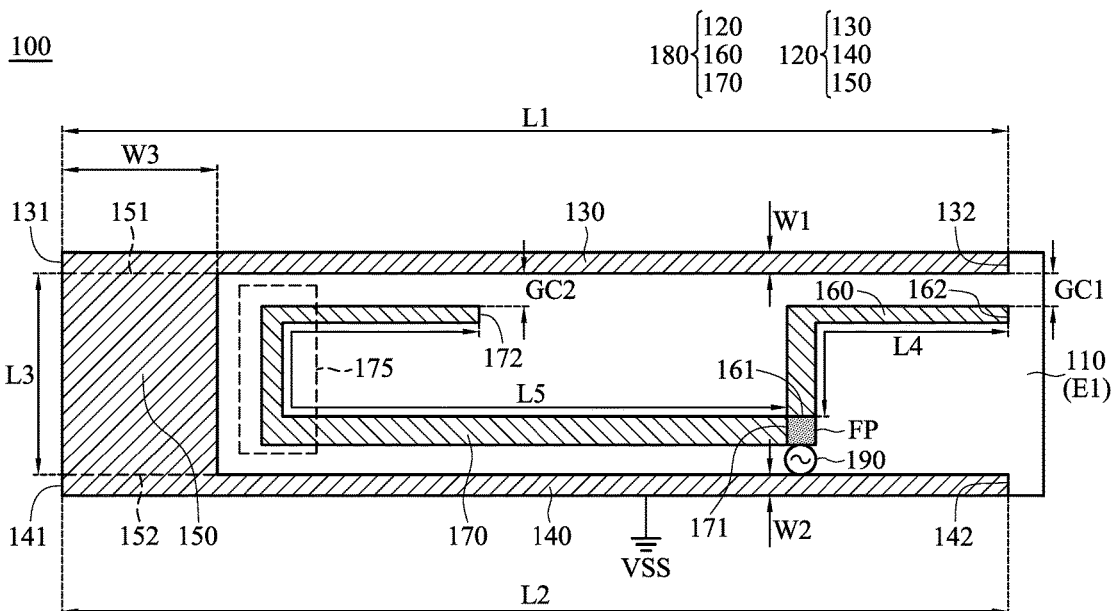
(52) **U.S. Cl.**

CPC **H01Q 1/36** (2013.01); **G06F 1/1698** (2013.01); **H01Q 5/392** (2015.01); **H01Q 5/50** (2015.01)

(58) **Field of Classification Search**

CPC H01Q 1/36
See application file for complete search history.

10 Claims, 7 Drawing Sheets





US010411338B2

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

(10) **Patent No.:** **US 10,411,338 B2**
(45) **Date of Patent:** **Sep. 10, 2019**

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

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

(72) Inventors: **Chae Up Yoo**, Seoul (KR); **Ho Jung Nam**, Goyang-si (KR); **Min Cheol Seo**, Seoul (KR); **Sung Koo Park**, Suwon-si (KR); **Jung Ho Park**, Hwaseong-si (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 76 days.

(21) Appl. No.: **15/435,715**

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

(65) **Prior Publication Data**
US 2017/0244163 A1 Aug. 24, 2017

(30) **Foreign Application Priority Data**
Feb. 19, 2016 (KR) 10-2016-0020035

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 1/52 (2006.01)
H01Q 9/04 (2006.01)
H01Q 21/06 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/521** (2013.01); **H01Q 1/38** (2013.01); **H01Q 9/0442** (2013.01); **H01Q 21/06** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/521; H01Q 1/38; H01Q 9/0442; H01Q 21/06
See application file for complete search history.

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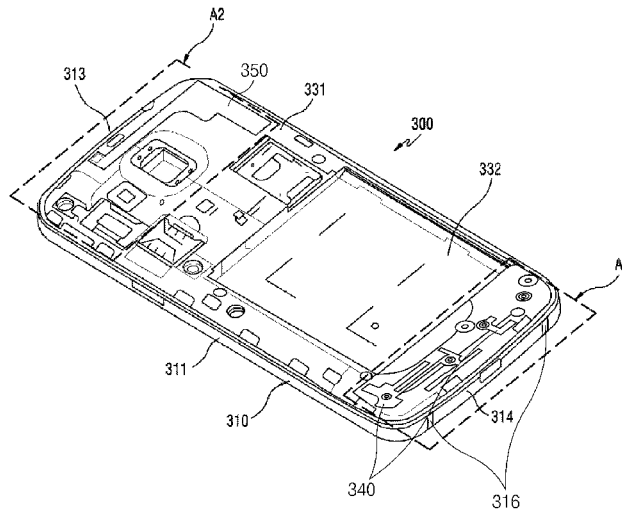
Primary Examiner — Graham P Smith

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

(57) **ABSTRACT**

An electronic device includes a carrier having a surface, a first antenna radiator configured to transmit and/or receive a signal of a specific frequency band, a second antenna radiator configured to transmit and/or receive a signal of the specific frequency band, a communication circuit electrically connected to the first antenna radiator and the second antenna radiator, and a processor configured to control the communication circuit. The first antenna radiator includes a first conductive pattern disposed at a portion of the surface of the carrier. The second antenna radiator includes a second conductive pattern disposed at another portion of the surface of the carrier. The first antenna radiator includes a first open stub extending from one point of the first conductive pattern and configured to provide a transmission coefficient between the first antenna radiator and the second antenna radiator that is lower than a specific value at the specific frequency band.

9 Claims, 12 Drawing Sheets



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

(10) **Patent No.:** **US 10,411,358 B2**
(45) **Date of Patent:** ***Sep. 10, 2019**

(54) **ANTENNA DEVICE FOR MOBILE TERMINAL AND MOBILE TERMINAL**

(58) **Field of Classification Search**
CPC H01Q 13/18; H01Q 5/35; H01Q 5/335;
H01Q 5/214

(71) Applicant: **GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP., LTD.**, Dongguan (CN)

(Continued)

(72) Inventors: **Ning Zhao**, Dongguan (CN); **Haijun Tang**, Dongguan (CN); **Guolin Liu**, Dongguan (CN); **Shasha Hu**, Dongguan (CN)

(56) **References Cited**

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(73) Assignee: **GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP., LTD.**, Dongguan, Guangdong (CN)

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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 0 days.

This patent is subject to a terminal disclaimer.

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(21) Appl. No.: **15/668,798**

Primary Examiner — Peggy Jean Pierre

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

(74) *Attorney, Agent, or Firm* — Hodgson Russ LLP

(65) **Prior Publication Data**

US 2018/0183151 A1 Jun. 28, 2018

(30) **Foreign Application Priority Data**

Dec. 28, 2016 (CN) 2016 1 1235437
Dec. 28, 2016 (CN) 2016 2 1462737 U

(51) **Int. Cl.**
H01Q 13/18 (2006.01)
H01Q 5/35 (2015.01)

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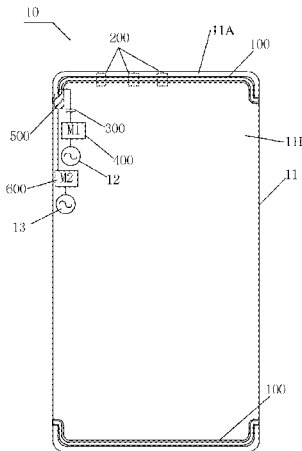
(52) **U.S. Cl.**
CPC **H01Q 13/18** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/314** (2015.01); **H01Q 5/335** (2015.01);

(Continued)

(57) **ABSTRACT**

An antenna device includes a slot, a connecting assembly, a first capacitor, a first match circuit, an antenna and a second match circuit. The slot is defined in a shell of the mobile terminal. The slot separates the shell into a first part and a second part. The first part is configured to couple with a mainboard via a first feeding point to form a slot antenna. The connecting assembly connects the first part with the second part. The first capacitor couples the first part and the first feeding point. The first match circuit couples the first capacitor and the first feeding point. The antenna is configured to send a signal through the slot. The antenna is disposed above the mainboard and below the slot and the antenna couples with the mainboard via a second feeding point.

20 Claims, 3 Drawing Sheets





US010418689B2

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

(10) **Patent No.:** **US 10,418,689 B2**

(45) **Date of Patent:** **Sep. 17, 2019**

(54) **ELECTRONIC DEVICE COMPRISING ANTENNA**

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

(72) Inventors: **Ji Ho Kim**, Anyang-si (KR); **Kyung Moon Seol**, Yongin-si (KR); **Kyi Hyun Jang**, Seoul (KR); **Kyung Kyun Kang**, Suwon-si (KR); **Gyu Bok Park**, Suwon-si (KR); **Hyun Jeong Lee**, Suwon-si (KR); **Hyo Seok Na**, Yongin-si (KR); **So Young Lee**, Gwacheon-si (KR); **Jae Bong Chun**, Suwon-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 0 days.

(21) Appl. No.: **16/010,838**

(22) Filed: **Jun. 18, 2018**

(65) **Prior Publication Data**

US 2018/0366812 A1 Dec. 20, 2018

(30) **Foreign Application Priority Data**

Jun. 20, 2017 (KR) 10-2017-0078005

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H04M 1/02 (2006.01)

(Continued)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/44** (2013.01); **H01Q 5/364** (2015.01); **H01Q 5/378** (2015.01);

(Continued)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/44; H01Q 5/364;
H01Q 5/378; H01Q 9/42; H01Q 13/106;
H04M 1/0266; H04M 1/0277

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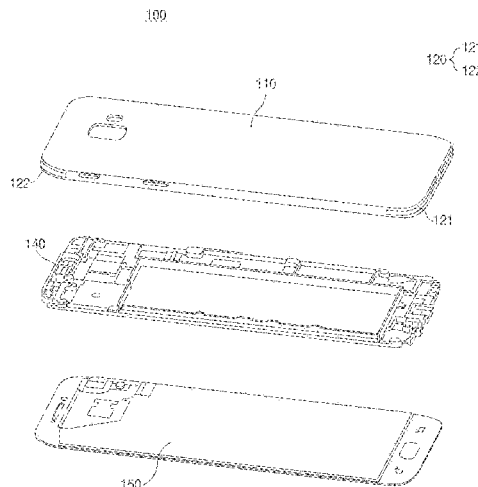
Primary Examiner — Mong-Thuy T Tran

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

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a housing that includes a slit, a first antenna element extending along a portion of the housing, a second antenna element spaced apart from at least a portion of the first antenna element by the slit and extends along another portion of the housing, and a wireless communication circuit positioned inside the housing and electrically connected to the first antenna element. The first antenna element is electrically connected to the second antenna element.

19 Claims, 19 Drawing Sheets





(12) **United States Patent**
Izawa

(10) **Patent No.:** **US 10,418,701 B2**
(45) **Date of Patent:** **Sep. 17, 2019**

(54) **ANTENNA DEVICE**

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

(72) Inventor: **Masahiro Izawa**, Nagaokakyo (JP)

(73) Assignee: **MURATA MANUFACTURING CO., LTD.**,
Nagaokakyo-Shi, Kyoto-Fu (JP)

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

(21) Appl. No.: **15/902,073**

(22) Filed: **Feb. 22, 2018**

(65) **Prior Publication Data**
US 2018/0183145 A1 Jun. 28, 2018

Related U.S. Application Data
(63) Continuation of application No. PCT/JP2016/081034, filed on Oct. 20, 2016.

(30) **Foreign Application Priority Data**
Oct. 22, 2015 (JP) 2015-207679

(51) **Int. Cl.**
H01Q 1/52 (2006.01)
H01Q 21/28 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/521** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/371** (2015.01); **H01Q 7/00** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/521; H01Q 1/48; H01Q 21/30; H01Q 21/006; H01Q 21/28
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(56) **References Cited**

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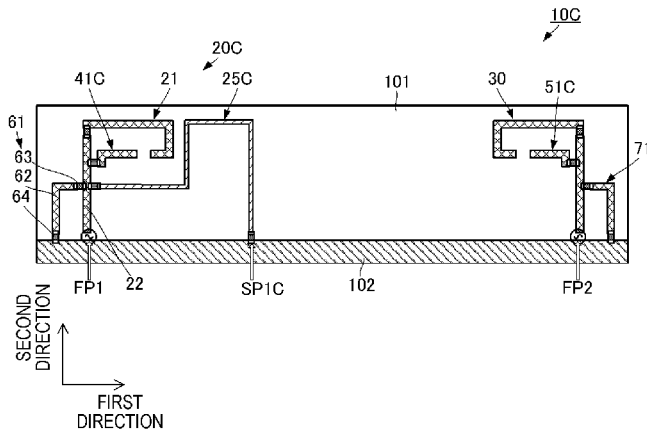
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Primary Examiner — Lam T Mai
(74) *Attorney, Agent, or Firm* — Arent Fox LLP

(57) **ABSTRACT**

An antenna device including a ground conductor and first and second antennas. The first and second antennas are linear antennas and have respective feeding points at ends on a side of the ground conductor. The first and second antennas perform transmission/reception at first and second frequencies that are adjacent to each other, respectively. Moreover, the first antenna includes a first monopole antenna and a loop antenna branched off from the first monopole antenna. An end of the loop antenna opposing a branching point at which the loop antenna is branched off from the first monopole antenna is short-circuited between the feeding points of the first and second antennas on the ground conductor.

19 Claims, 4 Drawing Sheets





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

(10) **Patent No.:** **US 10,418,704 B2**
(45) **Date of Patent:** **Sep. 17, 2019**

(54) **CO-LOCATED ACTIVE STEERING ANTENNAS CONFIGURED FOR BAND SWITCHING, IMPEDANCE MATCHING AND UNIT SELECTIVITY**

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

(72) Inventors: **Olivier Pajona**, Nice (FR); **Jaakko Kyllonen**, Nice (FR); **Laurent Desclos**, San Diego, CA (US)

(73) Assignee: **Ethertronics, Inc.**, San Diego, CA (US)

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

(21) Appl. No.: **16/139,161**

(22) Filed: **Sep. 24, 2018**

(65) **Prior Publication Data**

US 2019/0027824 A1 Jan. 24, 2019

Related U.S. Application Data

(63) Continuation of application No. 15/218,982, filed on Jul. 25, 2016, now Pat. No. 10,224,626.
(Continued)

(51) **Int. Cl.**
H01Q 3/24 (2006.01)
H01Q 21/00 (2006.01)
H01Q 1/48 (2006.01)
H01Q 7/00 (2006.01)
H04B 7/0404 (2017.01)
H01Q 5/392 (2015.01)
H01Q 3/36 (2006.01)
H01Q 1/24 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 3/24** (2013.01); **H01Q 1/245** (2013.01); **H01Q 1/48** (2013.01); **H01Q 3/36** (2013.01); **H01Q 5/392** (2015.01); **H01Q 7/00** (2013.01); **H01Q 21/00** (2013.01); **H01Q 21/28** (2013.01); **H04B 7/0404** (2013.01); **H04B 7/0805** (2013.01); **H01Q 5/335** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/48; H01Q 21/28; H01Q 1/24; H01Q 21/00; H01Q 3/24; H01Q 5/392; H01Q 3/36; H01Q 1/245; H01Q 7/00; H01Q 5/335
USPC 343/876, 702
See application file for complete search history.

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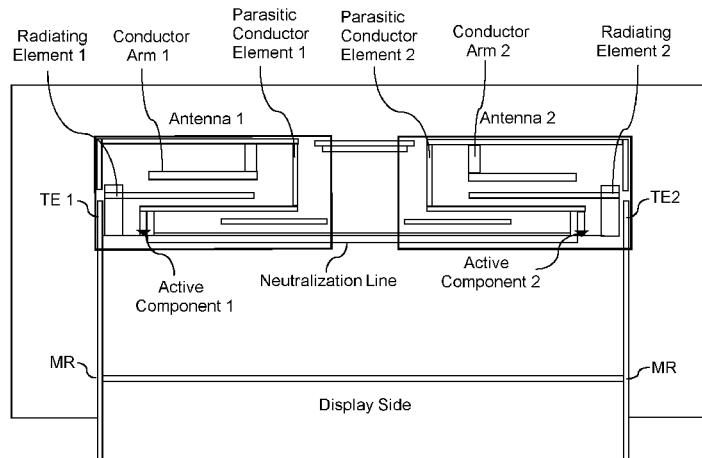
Primary Examiner — Hai V Tran

(74) *Attorney, Agent, or Firm* — Dority & Manning, P.A.

(57) **ABSTRACT**

An antenna system includes collocated active steering antennas implemented in a bottom portion of a wireless communication device designed for positioning near a user's mouth or chin. The co-located active steering antennas are each configured to steer a radiation pattern of the respective antenna, and can be further configured for active band switching and/or active impedance matching. These collocated active steering antennas can be used independently, or in a multi-input multi-output (MIMO) configuration. In addition, the antenna system is capable of antenna unit selectivity, which includes the ability to select one of the co-located antennas with the lowest head and hand loss for use, while disabling the antenna with the highest loss attributed to hand head loading.

13 Claims, 11 Drawing Sheets





US010418709B1

(12) **United States Patent**
Furlan

(10) **Patent No.:** **US 10,418,709 B1**
(45) **Date of Patent:** **Sep. 17, 2019**

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

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

(72) Inventor: **Vladimir Furlan**, Munich (DE)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 7 days.

(21) Appl. No.: **15/904,751**

(22) Filed: **Feb. 26, 2018**

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/04 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/371 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0421** (2013.01); **H01Q 1/244** (2013.01); **H01Q 5/371** (2015.01); **H01Q 9/42** (2013.01)

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

(56) **References Cited**
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Primary Examiner — Howard Williams
(74) *Attorney, Agent, or Firm* — Knobbe, Martens, Olson & Bear, LLP; Kevin J. Everett, Jr.

(57) **ABSTRACT**

A Planar Inverted-F Antenna, PIFA, comprises a sheet of conductive material including first, second, third and fourth contiguous sections, the first and third sections extending orthogonally away from the second section and the fourth section extending away from the third section. The sections are folded relative to one another to define a volume with a height of the second section, a width of the second section and a depth of the third section extending away from the second section. A supporting pin and a feed pin extend from the second section along an outer edge. A supporting leg extends from either the third or fourth sections, the supporting leg lying outside the plane of the supporting pin to support the PIFA when mounted on a printed circuit board, while allowing components to at least partially occupy the volume under the PIFA.

11 Claims, 5 Drawing Sheets

