



US010720697B2

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

(10) **Patent No.:** **US 10,720,697 B2**
(45) **Date of Patent:** **Jul. 21, 2020**

(54) **ANTENNA MODULE, MIMO ANTENNA, AND TERMINAL**

(71) Applicant: **HUAWEI TECHNOLOGIES CO., LTD.**, Shenzhen, Guangdong (CN)

(72) Inventors: **Geyi Wen**, Nanjing (CN); **Jun Wang**, Hangzhou (CN); **Ming Zhang**, Hangzhou (CN); **Xueliang Shi**, Hangzhou (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 82 days.

(21) Appl. No.: **16/018,664**

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

(65) **Prior Publication Data**
US 2018/0309193 A1 Oct. 25, 2018

Related U.S. Application Data
(63) Continuation of application No. PCT/CN2016/106980, filed on Nov. 23, 2016.

(30) **Foreign Application Priority Data**
Dec. 29, 2015 (CN) 2015 1 1020439

(51) **Int. Cl.**
H01Q 1/48 (2006.01)
H01Q 1/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/246** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/371** (2015.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/246; H01Q 5/371; H01Q 1/243; H01Q 1/48; H01Q 9/42; H01Q 21/061; H01Q 21/28; H01Q 21/30
See application file for complete search history.

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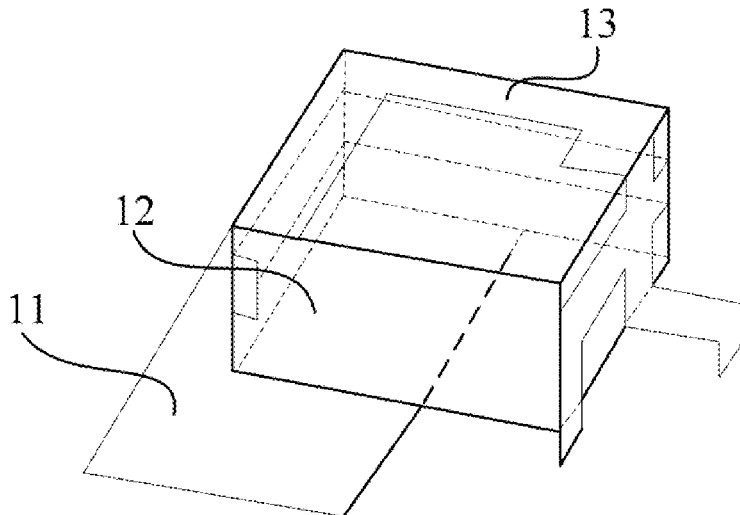
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Primary Examiner — Graham P Smith
(74) *Attorney, Agent, or Firm* — Fish & Richardson P.C.

(57) **ABSTRACT**
This application describes examples of antenna modules, MIMO antennas, and terminals. One example antenna module includes a clearance area, a support, and at least two branches. Each branch is disposed on the support, and a partial projection of the support on a horizontal plane falls within the clearance area, while a projection on the horizontal plane of one end that is of each branch and that is configured to connect to a feed point is outside the clearance area. A projection of a tail end on the horizontal plane is inside the clearance area.

15 Claims, 18 Drawing Sheets





US010720705B2

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

(10) **Patent No.:** **US 10,720,705 B2**
(45) **Date of Patent:** **Jul. 21, 2020**

(54) **5G WIDEBAND MIMO ANTENNA SYSTEM
BASED ON COUPLED LOOP ANTENNAS
AND MOBILE TERMINAL**

(71) Applicant: **SHENZHEN SUNWAY
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Shenzhen, Guangdong (CN)

(72) Inventors: **Anping Zhao, Shenzhen (CN);
Zhouyou Ren, Shenzhen (CN)**

(73) Assignee: **SHENZHEN SUNWAY
COMMUNICATION 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.: **16/276,123**

(22) Filed: **Feb. 14, 2019**

(65) **Prior Publication Data**
US 2020/0161765 A1 May 21, 2020

Related U.S. Application Data
(63) Continuation of application No.
PCT/CN2019/070602, filed on Jan. 7, 2019.

(30) **Foreign Application Priority Data**
Nov. 19, 2018 (CN) 2018 1 1374186

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

(52) **U.S. Cl.**
CPC **H01Q 7/00** (2013.01); **H01Q 21/062**
(2013.01); **H04B 7/0413** (2013.01)

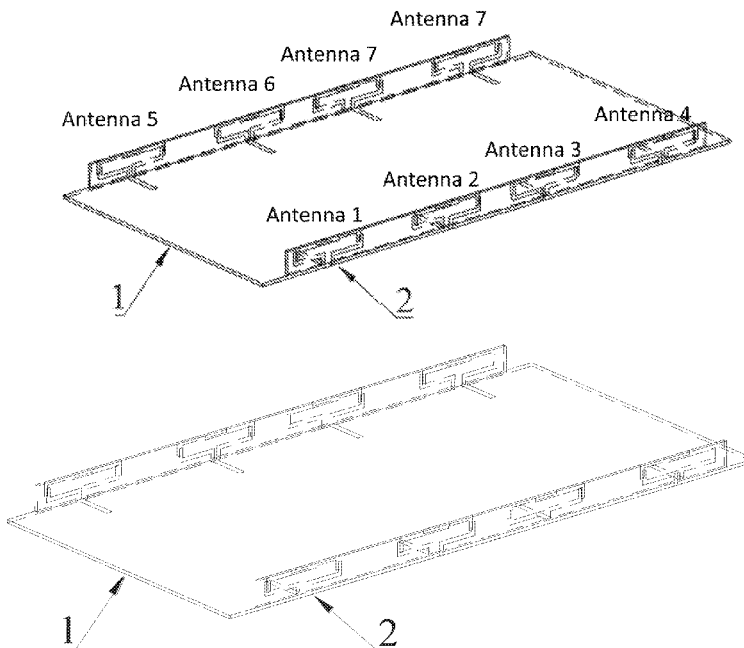
(58) **Field of Classification Search**
CPC H01Q 1/521; H01Q 1/243; H01Q 9/30;
H01Q 5/10; H01Q 1/38; H01Q 21/06;
(Continued)

(56) **References Cited**
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343/700 MS
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343/700 MS
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Primary Examiner — Pablo N Tran
(74) *Attorney, Agent, or Firm* — Oliff PLC

(57) **ABSTRACT**
A 5G wideband MIMO antenna system based on coupled loop antennas and a mobile terminal are disclosed. The antenna system comprises at least four antenna units comprising an antenna frame, a first coupling branch, a second coupling branch, a feed branch and an ground branch, wherein one end of the first coupling branch and one end of the ground branch are overlapped in the thickness or length direction of the frame, one end of the second coupling branch and one end of the feed branch are overlapped in the thickness or length direction of the frame. A traditional loop antenna is converted into a coupled loop antenna with three coupling regions. The coupled loop antenna system is high in antenna efficiency, good in isolation, simple in structure and easy to manufacture and has a small height when placed vertically, thereby making the mobile terminal lighter and thinner.

18 Claims, 4 Drawing Sheets



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

(10) **Patent No.:** **US 10,727,569 B2**
(45) **Date of Patent:** **Jul. 28, 2020**

(54) **MOBILE DEVICE AND MANUFACTURING METHOD THEREOF**

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 7/005; H01Q 5/364;
H01Q 1/48; H01Q 9/0421; H01Q 1/38;
(Continued)

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

(72) Inventors: **Tiao-Hsing Tsai**, Taoyuan (TW);
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Li-Yuan Fang, Taoyuan (TW)

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(73) Assignee: **HTC Corporation**, Taoyuan (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 416 days.

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(21) Appl. No.: **15/723,336**

Primary Examiner — Hai V Tran

(22) Filed: **Oct. 3, 2017**

Assistant Examiner — Michael M. Bouizza

(65) **Prior Publication Data**

US 2018/0175484 A1 Jun. 21, 2018

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

Related U.S. Application Data

(60) Provisional application No. 62/437,226, filed on Dec. 21, 2016.

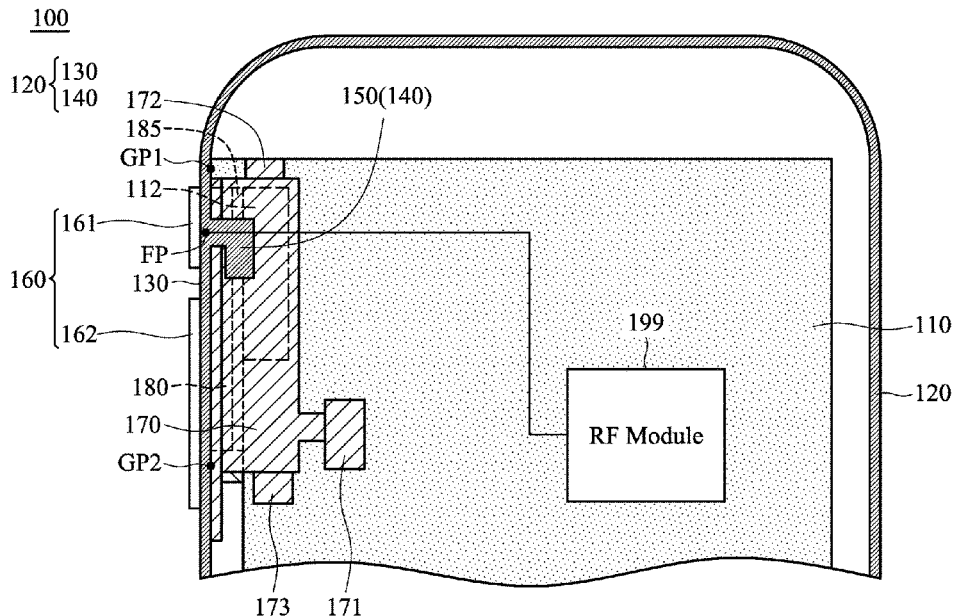
(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)
(Continued)

(57) **ABSTRACT**

A mobile device includes a first circuit board, a metal frame, an extension radiation element, an electronic component, a second circuit board, and an RF (Radio Frequency) module. The first circuit board includes a system ground plane. The metal frame includes a first portion coupled to the system ground plane. A clearance region is formed between the first portion and the system ground plane. The first portion and the extension radiation element are both coupled to a feeding point. An antenna structure is formed by the first portion and the extension radiation element. The second circuit board is coupled to the electronic component. The electronic component and the second circuit board are both adjacent to the first portion. The RF module is coupled to the feeding point, so as to excite the antenna structure.

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/35** (2015.01);
(Continued)

39 Claims, 11 Drawing Sheets





US010727590B2

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

(10) **Patent No.:** **US 10,727,590 B2**
(45) **Date of Patent:** **Jul. 28, 2020**

(54) **ELECTRONIC DEVICES HAVING INTERIOR ANTENNAS**

(56) **References Cited**

U.S. PATENT DOCUMENTS

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)
(72) Inventors: **Joel D. Barrera**, San Jose, CA (US);
Jerzy S. Guterman, Sunnyvale, CA (US)
(73) Assignee: **Apple Inc.**, Cupertino, CA (US)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 152 days.

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(21) Appl. No.: **15/980,511**

(22) Filed: **May 15, 2018**

Primary Examiner — Dieu Hien T Duong

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

(65) **Prior Publication Data**

US 2019/0356051 A1 Nov. 21, 2019

(57) **ABSTRACT**

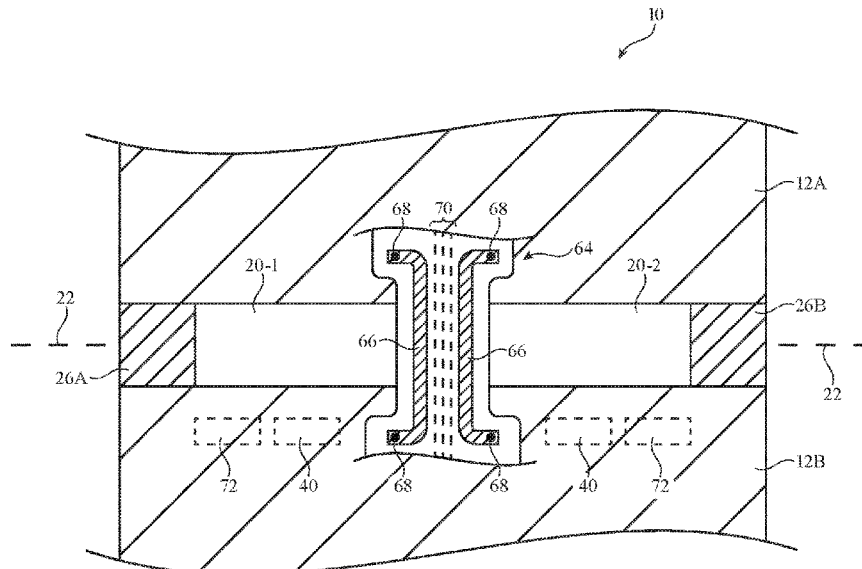
(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/392 (2015.01)
H01Q 5/35 (2015.01)
H01Q 13/10 (2006.01)
H01Q 1/22 (2006.01)

An electronic device may have an upper housing with a display and a lower housing with a keyboard. The upper housing may rotate between open and closed positions. The lower housing may include a first conductive wall separated from the upper housing by an upper slot and a second conductive wall separated from the upper housing by a lower slot. An antenna resonating element may be mounted within the lower housing and may convey signals in low and high frequency bands through the lower slot when the upper housing closed. The resonating element may be grounded to the second conductive wall and may be separated from a conductive cavity wall by at least one-sixteenth of a wavelength in the low frequency band. A parasitic element may be used to redirect signals in the low frequency band towards and through the upper slot when the upper housing open.

(52) **U.S. Cl.**
CPC **H01Q 5/392** (2015.01); **H01Q 1/2266** (2013.01); **H01Q 5/35** (2015.01); **H01Q 13/106** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/392; H01Q 5/35; H01Q 13/106; H01Q 1/2266; H01Q 1/1221; H01Q 5/378; H01Q 3/24; H01Q 5/371; H01Q 9/0421; H01Q 1/44; H01Q 21/28
See application file for complete search history.

20 Claims, 11 Drawing Sheets



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

(10) **Patent No.:** **US 10,727,593 B2**
(45) **Date of Patent:** ***Jul. 28, 2020**

(54) **ANTENNA, ANTENNA DEVICE AND COMMUNICATION DEVICE**

(71) Applicant: **Panasonic Intellectual Property Management Co., Ltd.**, Osaka (JP)

(72) Inventors: **Shuichiro Yamaguchi**, Osaka (JP); **Masaaki Sano**, Osaka (JP)

(73) Assignee: **Panasonic Intellectual Property Management Co., Ltd.**, Osaka (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.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/121,278**

(22) Filed: **Sep. 4, 2018**

(65) **Prior Publication Data**
US 2018/0375211 A1 Dec. 27, 2018

Related U.S. Application Data
(63) Continuation of application No. 14/783,796, filed as application No. PCT/JP2014/001956 on Apr. 3, 2014, now Pat. No. 10,096,903.

(30) **Foreign Application Priority Data**
Apr. 12, 2013 (JP) 2013-083534
May 17, 2013 (JP) 2013-104718

(51) **Int. Cl.**
H01Q 7/08 (2006.01)
H01Q 1/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 7/08** (2013.01); **H01Q 1/22** (2013.01); **H01Q 1/2216** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 9/0421; H01Q 1/42; H01Q 7/08; H01Q 1/22;
(Continued)

(56) **References Cited**
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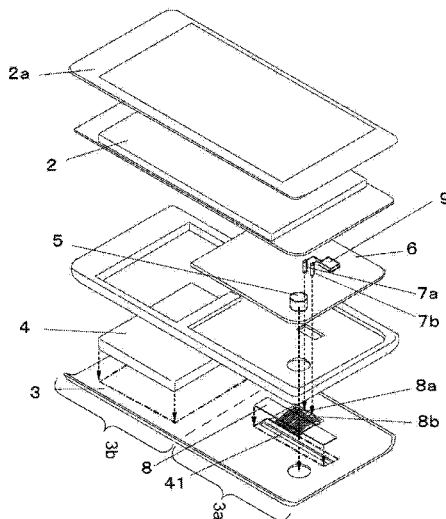
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Primary Examiner — Ab Salam Alkassim, Jr.
(74) *Attorney, Agent, or Firm* — Seed IP Law Group LLP

(57) **ABSTRACT**
Provided is an antenna that can facilitate favorable communications even if no metal body is located near the antenna and even if the antenna is located within a metal body. An antenna is characterized in that the antenna comprises: a core (11) having a plane; a coil winding part (area B) of the plane about which a coil is wound; and no-coil winding parts (areas A, C) of the plane about which no coil is wound, wherein the coil winding part is sandwiched between the no-coil winding parts in the axial direction of the coil on the plane, and the width of the plane in the axial direction of the coil is equal to or greater than the width of the plane in the winding direction of the coil.

9 Claims, 35 Drawing Sheets





US010727595B2

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

(10) **Patent No.:** **US 10,727,595 B2**
(45) **Date of Patent:** **Jul. 28, 2020**

(54) **PATCH ANTENNA UNIT AND ANTENNA**

(56) **References Cited**

(71) Applicant: **Huawei Technologies Co., Ltd.**,
Shenzhen (CN)
(72) Inventors: **Liangsheng Liu**, Shenzhen (CN);
Xinhong Li, Hsinchu (TW); **HuiLi Fu**,
Shenzhen (CN)
(73) Assignee: **HUAWEI TECHNOLOGIES CO.,**
LTD., Shenzhen (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 2 days.

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(21) Appl. No.: **16/049,104**
(22) Filed: **Jul. 30, 2018**

Machine Translation and Abstract of Chinese Publication No.
CN101141023, Mar. 12, 2008, 13 pages.

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(65) **Prior Publication Data**
US 2018/0337456 A1 Nov. 22, 2018

Related U.S. Application Data

(63) Continuation of application No.
PCT/CN2016/109322, filed on Dec. 9, 2016.

Primary Examiner — Tho G Phan
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

(30) **Foreign Application Priority Data**
Jan. 30, 2016 (CN) 2016 1 0071196

(57) **ABSTRACT**

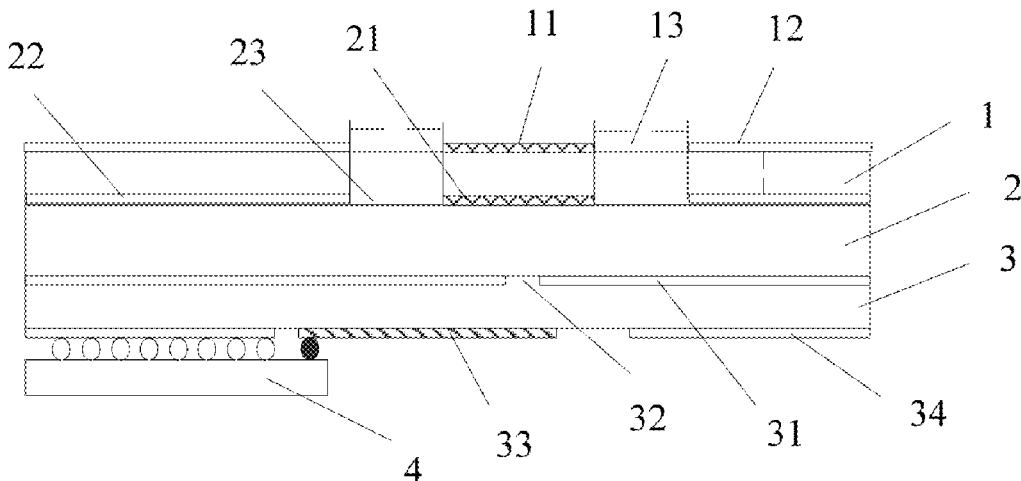
(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 9/04 (2006.01)
(Continued)

A patch antenna unit and an antenna that relate to the field of communications technology wherein the patch antenna unit includes a first support layer, a substrate, a second support layer, and an integrated circuit that are stacked. One radiation patch is attached to the first support layer, and one radiation patch is attached to the second support layer. A ground layer is disposed on the second support layer, a coupling slot is disposed on the ground layer, and a feeder corresponding to the coupling slot is disposed on the second support layer. The integrated circuit is connected to the first ground layer and the feeder. In the foregoing specific technical solution, a four-layer substrate is used for fabrication.

(52) **U.S. Cl.**
CPC **H01Q 9/0414** (2013.01); **H01Q 1/2283**
(2013.01); **H01Q 1/48** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/2283; H01Q 1/22; H01Q 1/38;
H01Q 1/48; H01Q 21/00; H01Q 21/0075;
(Continued)

16 Claims, 12 Drawing Sheets





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

(10) **Patent No.:** **US 10,727,596 B2**
(45) **Date of Patent:** **Jul. 28, 2020**

(54) **ANTENNA STRUCTURE**
(71) Applicant: **TAOGLAS LIMITED**, Taoyuan (TW)
(72) Inventors: **Ronan Quinlan**, Taoyuan (TW);
Wen-Chieh Yang, Taoyuan (TW);
Ming-Wei Chen, Taoyuan (TW)
(73) Assignee: **Taoglas Limited**, Taoyuan (TW)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/990,347**
(22) Filed: **May 25, 2018**

(65) **Prior Publication Data**
US 2018/0342808 A1 Nov. 29, 2018

(30) **Foreign Application Priority Data**
May 26, 2017 (TW) 106117543 A

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/371 (2015.01)
H01Q 1/24 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 9/0421** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01); **H01Q 9/045** (2013.01); **H01Q 9/42** (2013.01)

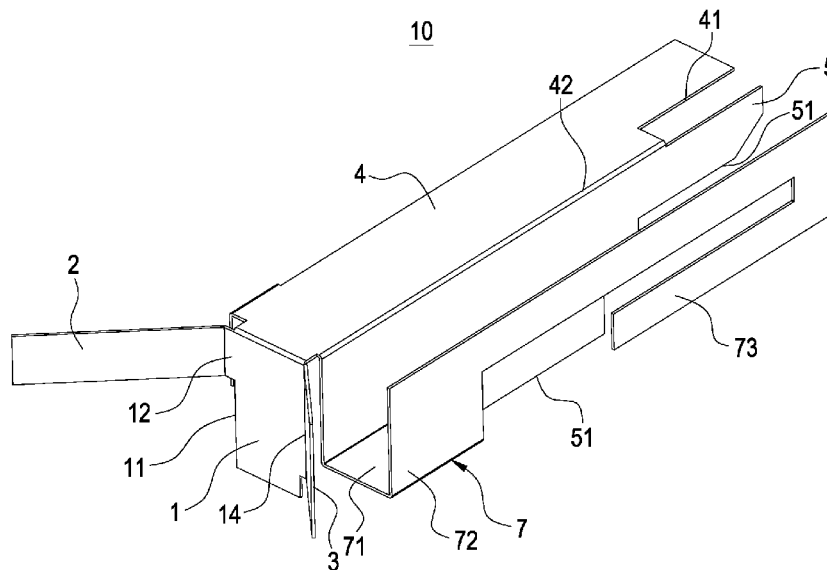
(58) **Field of Classification Search**
CPC H01Q 9/0421; H01Q 5/371; H01Q 1/243; H01Q 9/045; H01Q 9/42
See application file for complete search history.

(56) **References Cited**
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Primary Examiner — Dameon E Levi
Assistant Examiner — David E Lotter
(74) *Attorney, Agent, or Firm* — Knobbe, Martens, Olson & Bear, LLP

(57) **ABSTRACT**
An antenna structure (10) includes an antenna feed-in element (1), a first antenna trace element (2), a second antenna trace element (3), a supporting element (4), a grounded-short-circuit element (5), a third antenna trace element (6) and a fourth antenna trace element (7). The first antenna trace element (2), the second antenna trace element (3), the third antenna trace element (6) and the fourth antenna trace element (7) which have vertical segments in different lengths form a multi-trace planar inverted-F antenna to obtain the best bandwidth covering the full band, so that the height of the antenna structure (10) is lower, the length is shorter and the structure is denser. The impedance matching of the antenna structure (10) is controlled easily. No external matching element is required. With the multi-trace and grounded-short-circuit design of the antenna structure (10), the better resonance in the LTE full band is obtained.

20 Claims, 3 Drawing Sheets





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

(10) **Patent No.:** **US 10,727,597 B2**
(45) **Date of Patent:** **Jul. 28, 2020**

(54) **DIELECTRIC ANTENNA DEVICE FOR WIRELESS COMMUNICATIONS**

(75) Inventors: **Vincenzo Boffa**, Milan (IT); **Simone Germani**, Milan (IT); **Stefano Passi**, Mede (IT); **Fabrizio Ricci**, Milan (IT); **Roberto Vallauri**, Turin (IT)

(73) Assignee: **ADVANCED DIGITAL BROADCAST S.A.**, Bellevue (CH)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 792 days.

(21) Appl. No.: **12/311,429**

(22) PCT Filed: **Oct. 9, 2006**

(86) PCT No.: **PCT/EP2006/009647**
§ 371 (c)(1),
(2), (4) Date: **Aug. 6, 2009**

(87) PCT Pub. No.: **WO2008/043369**
PCT Pub. Date: **Apr. 17, 2008**

(65) **Prior Publication Data**
US 2009/0305652 A1 Dec. 10, 2009

(51) **Int. Cl.**
H04B 1/38 (2015.01)
H01Q 9/04 (2006.01)
H01Q 1/44 (2006.01)
H01Q 1/42 (2006.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0485** (2013.01); **H01Q 1/246** (2013.01); **H01Q 1/42** (2013.01); **H01Q 1/44** (2013.01)

(58) **Field of Classification Search**

USPC 455/90.3; 343/700 R, 830.911 R
See application file for complete search history.

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Primary Examiner — Yuwen Pan

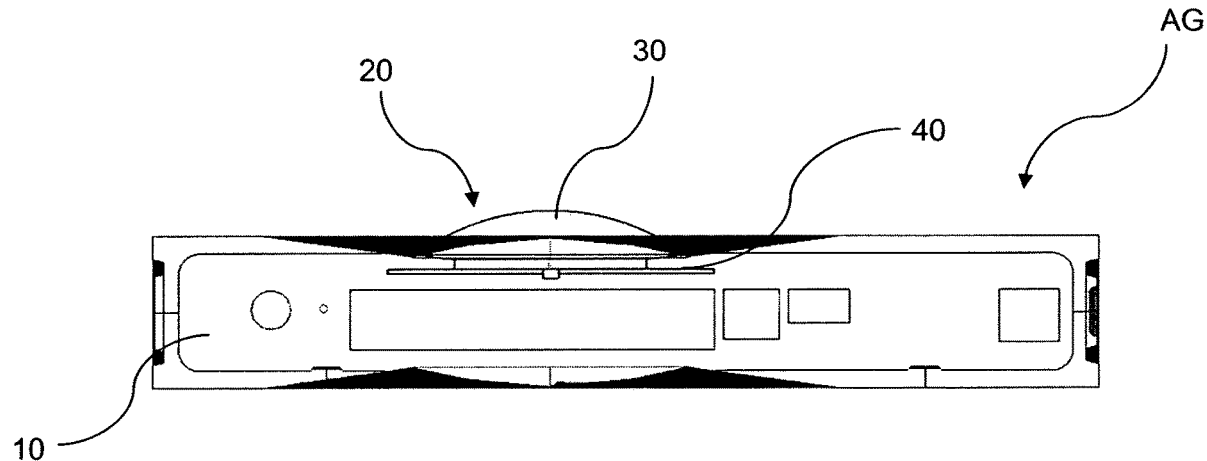
Assistant Examiner — Erica L Fleming-Hall

(74) *Attorney, Agent, or Firm* — Mark M. Friedman

(57) **ABSTRACT**

A wireless transceiver station including an antenna device and a casing, the antenna device including at least one resonator element cooperating with the casing of the wireless transceiver station and having a shape with a low aspect ratio so as to be conformal with the casing, the at least one resonator element including a composite material and being adapted to be excited by a feed system which is positioned inside the resonator element so as to allow the antenna device to irradiate with a substantially omnidirectional radiation pattern.

23 Claims, 11 Drawing Sheets





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

(10) **Patent No.:** **US 10,727,598 B2**

(45) **Date of Patent:** **Jul. 28, 2020**

(54) **ANTENNA ARRAY SUITABLE FOR 5G MOBILE TERMINAL DEVICES**

H01Q 1/243; H01Q 1/246; H01Q 3/24; H01Q 3/26; H01Q 3/2617; H01Q 3/30; H01Q 3/34; H01Q 3/36; H01Q 3/38; H01Q 9/16; H01Q 9/285; H01Q 13/085; H01Q 21/062; H01Q 21/064; H01Q 21/065; H01Q 21/22; H01Q 21/28; H01Q 21/29; H01Q 21/293; H01Q 25/002

(71) Applicant: **SPEED WIRELESS TECHNOLOGY INC.**, San Jose, CA (US)

See application file for complete search history.

(72) Inventors: **Bin Yu**, Suzhou (CN); **Zhanyi Qian**, Suzhou (CN); **Xitong Wu**, Suzhou (CN)

(56) **References Cited**

(73) Assignee: **SPEEDLINK TECHNOLOGY INC.**, Cupertino, CA (US)

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 46 days.

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342/372
7,075,485 B2 * 7/2006 Song H01Q 1/246
343/700 MS

(Continued)

(21) Appl. No.: **15/725,167**

Primary Examiner — Daniel Munoz

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

Assistant Examiner — Patrick R Holecek

(65) **Prior Publication Data**

(74) *Attorney, Agent, or Firm* — Womble Bond Dickinson (US) LLP

US 2018/0309186 A1 Oct. 25, 2018

(30) **Foreign Application Priority Data**

(57) **ABSTRACT**

Apr. 20, 2017 (CN) 2017 1 0262532

A new antenna array of the invention which has simple structure, small volume and can adopt a variety of realization forms, it can be easily integrated in the PCB of the mobile terminal using surface mount technology (SMT) or multi-layer PCB integration and other forms of technology. The antenna array is compact and can be configured with different number of antenna elements to meet the gain requirements. The antenna array is small in size and has a wide antenna bandwidth that can cover multiple 5G millimeter-wave bands while maintaining a directional high antenna gain and a stable radiation pattern. The antenna array can satisfy the millimeter-wave 5G communication requirements such as high gain, beam forming characteristics, beam scanning characteristics, and can be easily integrated into a portable mobile terminal.

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 21/22 (2006.01)
H01Q 21/29 (2006.01)
H01Q 9/16 (2006.01)
H01Q 1/38 (2006.01)

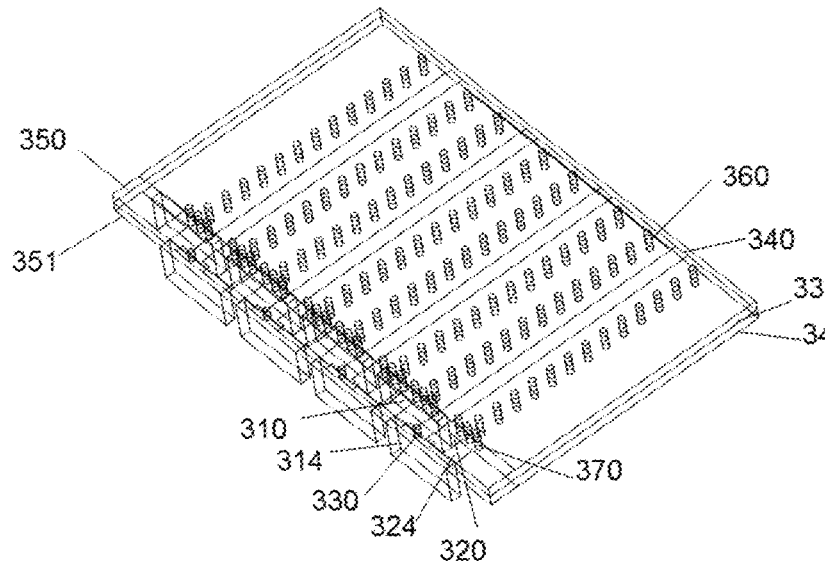
(52) **U.S. Cl.**

CPC **H01Q 9/16** (2013.01); **H01Q 1/241** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 21/22** (2013.01); **H01Q 21/29** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/2283; H01Q 1/241; H01Q 1/242;

9 Claims, 20 Drawing Sheets





US010728637B2

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

(10) **Patent No.:** **US 10,728,637 B2**
(45) **Date of Patent:** **Jul. 28, 2020**

(54) **ELECTRONIC APPARATUS HAVING A CHASSIS FOR A SPEAKER AND AN ANTENNA**

(71) Applicant: **Lenovo (Singapore) Pte. Ltd.**,
Singapore (SG)
(72) Inventors: **Jun Ishihara**, Kanagawa (JP);
Shigekazu Hawaka, Kanagawa (JP)

(73) Assignee: **Lenovo (Singapore) Pte. Ltd.**,
Singapore (SG)

(*) 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.: **16/396,158**

(22) Filed: **Apr. 26, 2019**

(65) **Prior Publication Data**
US 2020/0186900 A1 Jun. 11, 2020

(30) **Foreign Application Priority Data**
Dec. 11, 2018 (JP) 2018-231851

(51) **Int. Cl.**
H04R 1/02 (2006.01)
G06F 1/16 (2006.01)
H01Q 1/22 (2006.01)

(52) **U.S. Cl.**
CPC **H04R 1/02** (2013.01); **G06F 1/1656** (2013.01); **G06F 1/1688** (2013.01); **G06F 1/1698** (2013.01); **H01Q 1/2266** (2013.01); **G06F 1/1616** (2013.01); **H04R 2499/15** (2013.01)

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

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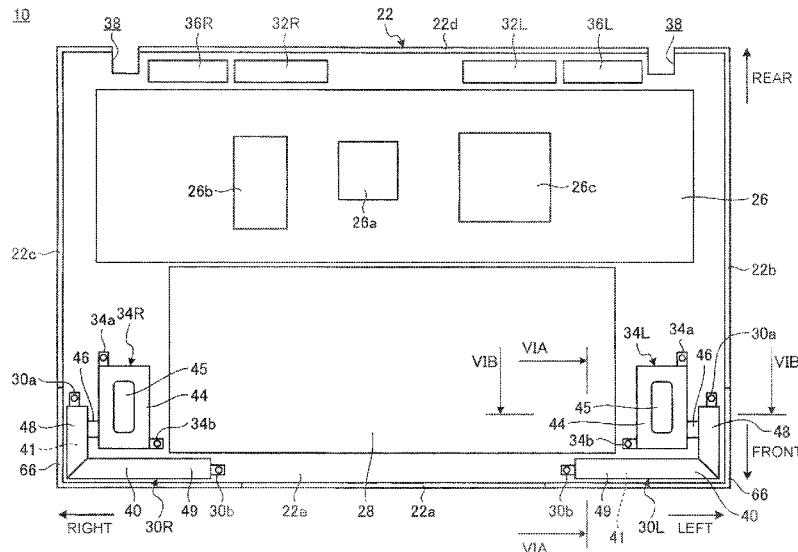
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Primary Examiner — Duc Nguyen
Assistant Examiner — Assad Mohammed
(74) *Attorney, Agent, or Firm* — Osha Liang LLP

(57) **ABSTRACT**

An electronic apparatus includes a floating section which has a speaker part and a first box part provided with a first cavity portion functioning as a back chamber of the speaker part and is fixed to a main body chassis in a floatable state inside the main body chassis, a rigid section which has a second box part provided with a second cavity portion and which is rigidly fixed to the main body chassis inside the main body chassis and formed with an antenna on at least a part of the second box part, and a connecting pipe which connects the first box part and the second box part through a vibration buffer part and communicates the first cavity portion and the second cavity portion with each other.

6 Claims, 9 Drawing Sheets





US010734707B2

(12) **United States Patent**
Suzuki

(10) **Patent No.:** **US 10,734,707 B2**

(45) **Date of Patent:** **Aug. 4, 2020**

(54) **ANTENNA, RADIO DEVICE, MOUNTING DEVICE, AND CHARGING DEVICE**

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

(72) Inventor: **Masaki Suzuki**, 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 189 days.

(21) Appl. No.: **15/738,709**

(22) PCT Filed: **Mar. 23, 2016**

(86) PCT No.: **PCT/JP2016/001659**

§ 371 (c)(1),

(2) Date: **Dec. 21, 2017**

(87) PCT Pub. No.: **WO2017/013818**

PCT Pub. Date: **Jan. 26, 2017**

(65) **Prior Publication Data**

US 2018/0183135 A1 Jun. 28, 2018

(30) **Foreign Application Priority Data**

Jul. 17, 2015 (JP) 2015-142796

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 9/42 (2006.01)

H02J 7/00 (2006.01)

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

CPC **H01Q 1/242** (2013.01); **H01Q 9/42** (2013.01); **H02J 7/00** (2013.01); **H02J 7/0044** (2013.01); **H02J 7/0042** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/242; H01Q 9/42; H02J 7/00; H02J 7/0044; H02J 7/0042

See application file for complete search history.

(56) **References Cited**

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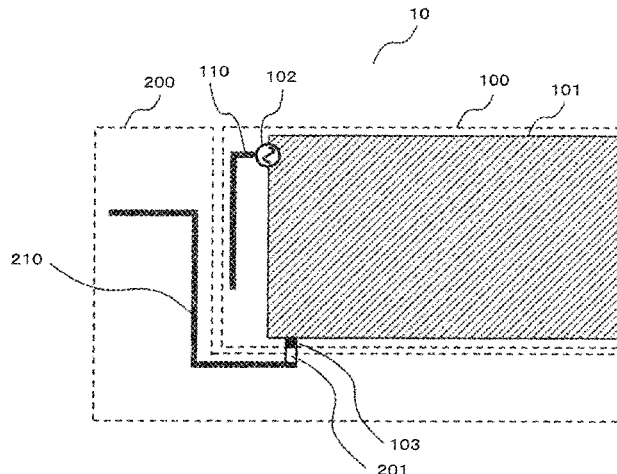
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Primary Examiner — Dieu Hien T Duong

(57) **ABSTRACT**

In order to implement an external antenna of a radio device with a simple configuration, an antenna according to the present invention includes: a conductor plate; a first linear conductor including a portion disposed substantially in parallel to an edge of the conductor plate, and being curved halfway and connected to the conductor plate with a gap being interposed; a second linear conductor intersecting with a line extending from an end of the first linear conductor opposite to a connection end thereof connected to the conductor plate, and being connected to the conductor plate; a third linear conductor being connected to an end of the second linear conductor opposite to an end thereof connected to the conductor plate, and being disposed substantially in parallel to the first linear conductor; and a fourth linear conductor being disposed in a direction apart from the conductor plate at an end of the third linear conductor opposite to an end thereof connected to the second linear conductor.

7 Claims, 35 Drawing Sheets





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

(10) **Patent No.:** **US 10,734,720 B2**
(45) **Date of Patent:** **Aug. 4, 2020**

(54) **ANTENNA AND COMMUNICATIONS DEVICE**

(71) Applicant: **HUAWEI TECHNOLOGIES CO., LTD.**, Shenzhen, Guangdong (CN)

(72) Inventors: **Geyi Wen**, Nanjing (CN); **Ming Zhang**, Hangzhou (CN)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 122 days.

(21) Appl. No.: **16/021,318**

(22) Filed: **Jun. 28, 2018**

(65) **Prior Publication Data**

US 2018/0316088 A1 Nov. 1, 2018

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2016/107785, filed on Nov. 29, 2016.

(30) **Foreign Application Priority Data**

Dec. 29, 2015 (CN) 2015 1 1024590

(51) **Int. Cl.**
H01Q 1/48 (2006.01)
H01Q 1/52 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/521** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/50** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01G 1/521; H01G 5/371; H01G 1/38; H01G 1/48; H01G 1/50; H01G 9/42; H01G 21/28

See application file for complete search history.

(56) **References Cited**

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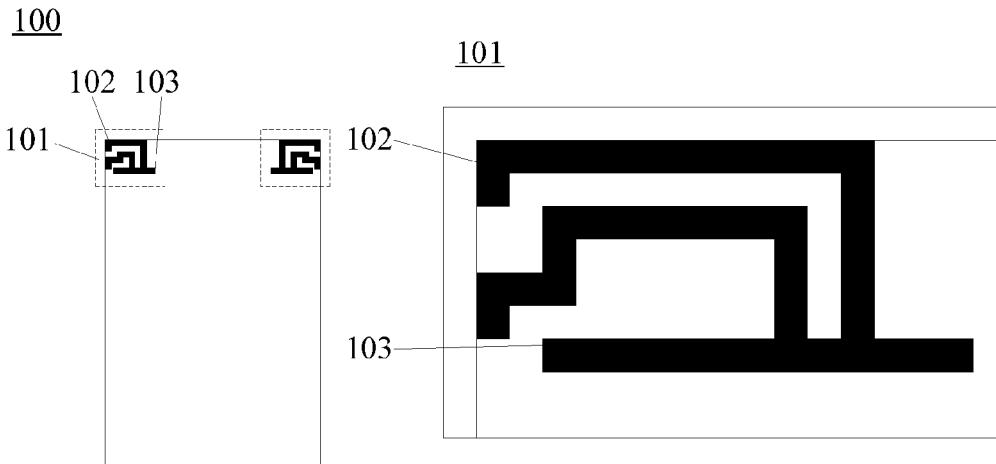
Primary Examiner — Graham P Smith

(74) *Attorney, Agent, or Firm* — Womble Bond Dickinson (US) LLP

(57) **ABSTRACT**

Embodiments of the present invention provide an antenna and a communications device. The antenna of the present invention includes a plurality of antenna units. Each antenna unit includes a plurality of antenna branches and one feed branch. Different antenna branches in a same antenna unit correspond to different frequency bands. At least one antenna unit pair exists in the plurality of antenna units. A distance between two antenna units in each antenna unit pair is less than a first preset distance. Radiation directions of antenna branches in each antenna unit pair that correspond to a same frequency band are different. By means of the present invention, isolation between the antenna units in the antenna can be increased.

11 Claims, 10 Drawing Sheets



(12) **United States Patent**
Endo

(10) **Patent No.:** **US 10,741,463 B2**
(45) **Date of Patent:** **Aug. 11, 2020**

- (54) **SHIELDED MODULE**
- (71) Applicant: **Murata Manufacturing Co., Ltd.**,
Kyoto (JP)
- (72) Inventor: **Shigeru Endo**, Kyoto (JP)
- (73) Assignee: **MURATA MANUFACTURING CO., LTD.**, Kyoto (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.: **15/995,534**
- (22) Filed: **Jun. 1, 2018**
- (65) **Prior Publication Data**
US 2018/0277457 A1 Sep. 27, 2018

- Related U.S. Application Data**
- (63) Continuation of application No. PCT/JP2016/085723, filed on Dec. 1, 2016.

- (30) **Foreign Application Priority Data**
Dec. 4, 2015 (JP) 2015-237996

- (51) **Int. Cl.**
H01L 23/552 (2006.01)
H01L 23/28 (2006.01)
(Continued)
- (52) **U.S. Cl.**
CPC **H01L 23/28** (2013.01); **H01L 23/04** (2013.01); **H01L 23/552** (2013.01); **H01P 3/08** (2013.01);
(Continued)
- (58) **Field of Classification Search**
CPC H01L 24/97; H01L 2924/3045; H01L 2224/73265; H01L 2224/83; H01L 24/45;
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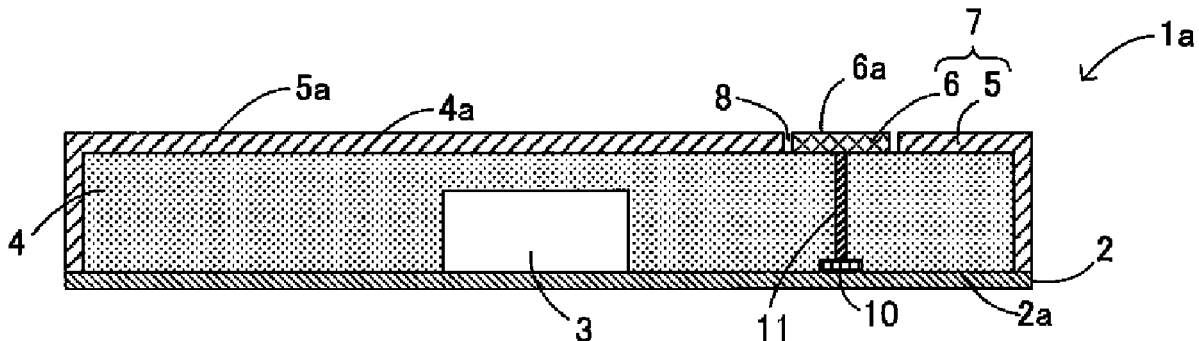
- (56) **References Cited**
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Written Opinion for International Application No. PCT/JP2016/085723, dated Jan. 24, 2017.

Primary Examiner — S. V. Clark
(74) *Attorney, Agent, or Firm* — Pearne & Gordon LLP

- (57) **ABSTRACT**
- A module **1a** includes a multilayer wiring board **2**, a component **3** that is mounted on a main surface **2a** of the multilayer wiring board **2**, a sealing-resin layer **4** that is laminated on the main surface **2a** of the multilayer wiring board **2**, and a resin coating layer **7** that coats a surface of the sealing-resin layer **4**. The resin coating layer **7** includes a shield film **5** and outer electrodes **6**, and opposite surfaces **6a** of the outer electrodes **6** and an opposite surface **5a** of the shield film **5** are formed on the same plane. The module **1a** can be connected to, for example, an external antenna without using a wiring electrode of a mother substrate, and thus, signal loss can be suppressed.

10 Claims, 4 Drawing Sheets



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

(10) **Patent No.:** **US 10,741,904 B2**
(45) **Date of Patent:** **Aug. 11, 2020**

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

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

(72) Inventors: **Seungkyu Kim**, Daegu (KR);
Hyunjong Oh, Daegu (KR);
Chulhyung Yang, Gumi-si (KR); **Jiwoo Lee**, Gumi-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 200 days.

(21) Appl. No.: **15/433,343**

(22) Filed: **Feb. 15, 2017**

(65) **Prior Publication Data**
US 2017/0244149 A1 Aug. 24, 2017

(30) **Foreign Application Priority Data**
Feb. 18, 2016 (KR) 10-2016-0019089

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 5/307 (2015.01)
H01Q 1/24 (2006.01)
H01Q 5/371 (2015.01)
H01Q 5/35 (2015.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/2291** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/307** (2015.01); **H01Q 5/35** (2015.01); **H01Q 5/371** (2015.01); **H04W 84/12** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/2291; H01Q 1/38; H01Q 5/371;
H01Q 1/243; H01Q 5/35; H01Q 1/48;
H04W 84/12
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Graham P Smith

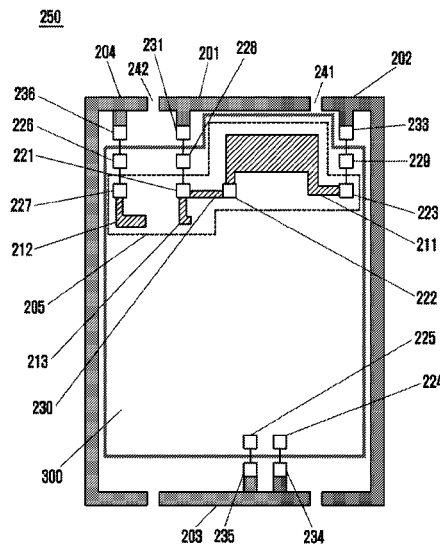
Assistant Examiner — Jae K Kim

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

(57) **ABSTRACT**

An electronic device is provided, including a housing, a side member, a display, a printed circuit board (PCB), and a communication device. The housing includes a first plate facing a first direction and a second plate facing a second direction opposite to the first direction, forming a space between the first and second plates. The side member surrounds at least part of the space. The communication device is disposed in the housing and connected with the PCB. The side member includes a first antenna unit disposed on one side of the electronic device, electrically connected with a radio frequency (RF) module, and having a first metal frame. The housing further includes a board-type antenna which includes a second antenna unit electrically connected with a WiFi module, an antenna connector configured to electrically connect the first and second antenna units, and a third antenna unit electrically connected with the antenna connector.

9 Claims, 23 Drawing Sheets



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

(10) **Patent No.:** **US 10,741,915 B2**
(45) **Date of Patent:** **Aug. 11, 2020**

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

H01Q 1/2291; H01Q 1/44; H01Q 1/48;
H01Q 5/328; H01Q 5/378; H01Q 5/392;
H01Q 13/10; H01Q 13/106; H01Q 9/30;
H04B 1/18; H04B 1/0458

(71) Applicant: **Wistron NeWeb Corp.**, Hsinchu (TW)

See application file for complete search history.

(72) Inventors: **Wei-Chen Chen**, Hsinchu (TW);
Cheng-Wei Chang, Hsinchu (TW)

(56) **References Cited**

(73) Assignee: **WISTRON NEWEB CORP.**, Hsinchu (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 13 days.

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(21) Appl. No.: **16/278,340**

Primary Examiner — Haissa Philogene

(22) Filed: **Feb. 18, 2019**

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

(65) **Prior Publication Data**

US 2020/0185831 A1 Jun. 11, 2020

(30) **Foreign Application Priority Data**

Dec. 5, 2018 (TW) 107143591 A

(57) **ABSTRACT**

An antenna structure includes a metal mechanism element, a ground element, a feeding radiation element, a coupling element, a dielectric substrate, and a switchable circuit. The metal mechanism element has a slot. The feeding radiation element extends across the slot. A coupling gap is formed between the feeding radiation element and the coupling element. The feeding radiation element and the coupling element are disposed on the dielectric substrate. The switchable circuit includes a first metal element, a second metal element, a reactance element, a capacitor, and a diode. The first metal element is coupled to the coupling element. The reactance element is embedded in the first metal element. The second metal element is coupled through the capacitor to the ground element. The diode is coupled between the first metal element and the second metal element. The diode is turned on or off according to the control voltage difference.

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 5/328	(2015.01)
H01Q 5/335	(2015.01)
H01Q 9/30	(2006.01)
H01Q 13/10	(2006.01)

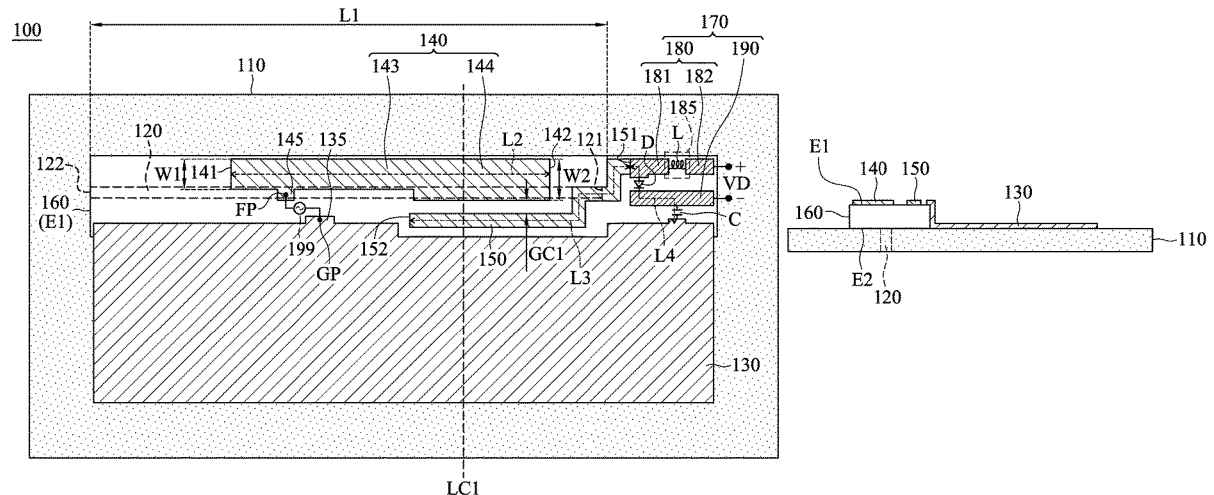
(52) **U.S. Cl.**

CPC **H01Q 5/328** (2015.01); **H01Q 1/243** (2013.01); **H01Q 5/335** (2015.01); **H01Q 9/30** (2013.01); **H01Q 13/10** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/24; H01Q 1/243; H01Q 1/245;

20 Claims, 9 Drawing Sheets





US010741929B2

(12) **United States Patent**
Toyao

(10) **Patent No.:** **US 10,741,929 B2**

(45) **Date of Patent:** ***Aug. 11, 2020**

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

(71) Applicant: **NEC CORPORATION**, Tokyo (JP)

(72) Inventor: **Hiroshi Toyao**, Tokyo (JP)

(73) Assignee: **NEC CORPORATION**, Minato-ku, Tokyo (JP)

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

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **15/590,317**

(22) Filed: **May 9, 2017**

(65) **Prior Publication Data**

US 2017/0244162 A1 Aug. 24, 2017

Related U.S. Application Data

(63) Continuation of application No. 14/437,253, filed as application No. PCT/JP2013/080586 on Nov. 12, 2013, now Pat. No. 9,748,662.

(30) **Foreign Application Priority Data**

Nov. 12, 2012 (JP) 2012-248169

(51) **Int. Cl.**

H01Q 1/38 (2006.01)

H01Q 15/00 (2006.01)

(Continued)

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

CPC **H01Q 15/0086** (2013.01); **H01Q 1/48** (2013.01); **H01Q 9/265** (2013.01); **H01Q 21/24** (2013.01); **H01Q 21/28** (2013.01); **H01Q 21/30** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/48; H01Q 5/312; H01Q 5/328

See application file for complete search history.

(56) **References Cited**

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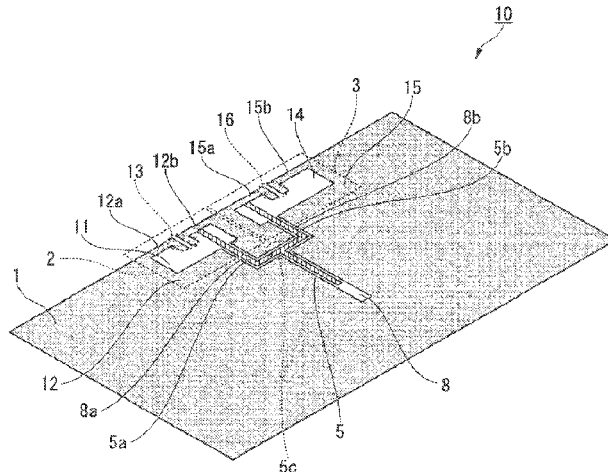
Primary Examiner — Dieu Hien T Duong

(74) *Attorney, Agent, or Firm* — Sughrue Mion, PLLC

(57) **ABSTRACT**

A small antenna operating at a plurality of frequency bands includes a first conductor plane in which a first split ring resonator and a second split ring resonator that have different resonant frequencies are formed and a feed line including a first branch line, a second branch line and a branch portion. Each of the split ring resonators includes a conductor region along an opening edge of an opening formed in the first conductor plane and a split portion cutting through a portion of the conductor region. One end of the first branch line is connected to the first split ring resonator and the other end extends to the branch portion across the conductor region; one end of the second branch line is connected to the second

(Continued)





US010749247B2

(12) **United States Patent**
Tornatta, Jr. et al.

(10) **Patent No.:** **US 10,749,247 B2**
(45) **Date of Patent:** **Aug. 18, 2020**

(54) **MULTI-RESONANT ANTENNA STRUCTURE**

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

(72) Inventors: **Paul Anthony Tornatta, Jr.**, Melbourne, FL (US); **Young Joong Lee**, Gyeonggi-do (KR); **Hak Ryoul Kim**, Seoul (KR)

(73) Assignee: **Cavendish Kinetics, Inc.**, San Jose, 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.: **16/342,935**

(22) PCT Filed: **Oct. 18, 2017**

(86) PCT No.: **PCT/US2017/057084**
§ 371 (c)(1),
(2) Date: **Apr. 17, 2019**

(87) PCT Pub. No.: **WO2018/075578**
PCT Pub. Date: **Apr. 26, 2018**

(65) **Prior Publication Data**
US 2020/0044309 A1 Feb. 6, 2020

Related U.S. Application Data

(60) Provisional application No. 62/410,933, filed on Oct. 21, 2016.

(51) **Int. Cl.**
H04B 1/40 (2015.01)
H04M 1/02 (2006.01)
(Continued)

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

(58) **Field of Classification Search**

CPC . H04B 1/03; H04B 1/08; H04B 1/163; H04B 1/1638; H04B 1/04; H04B 1/16;
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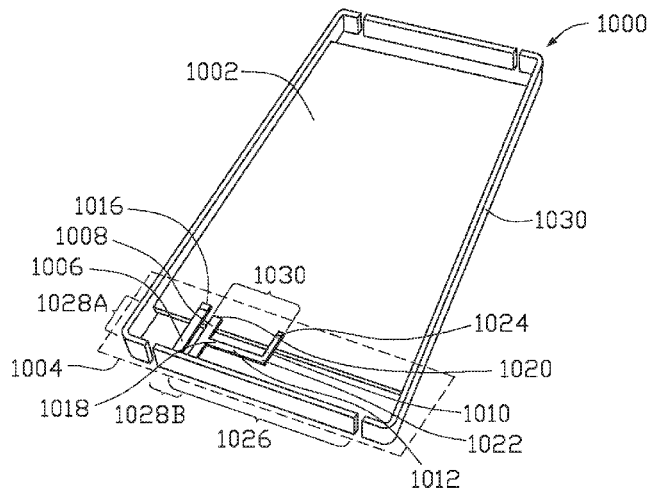
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(57) **ABSTRACT**

The present disclosure generally relates to any device capable of wireless communication, such as a mobile telephone or wearable device, having one or more antennas. The antenna has a structure with multiple resonances to cover all commercial wireless communications bands from a single antenna with one feed connection to the main radio system. The antenna is usable where there are two highly efficient, closely spaced resonances in the lower part of the frequency band. One of those resonances can be adjusted in real time by using a variable reactance attached to the radiator while the other resonance is fixed.

15 Claims, 8 Drawing Sheets





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(54) **DUAL-POLARIZED MILLIMETER-WAVE ANTENNA SYSTEM APPLICABLE TO 5G COMMUNICATIONS AND MOBILE TERMINAL**

(58) **Field of Classification Search**
CPC H01Q 21/24; H01Q 15/04; H01Q 5/371
See application file for complete search history.

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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 21 days.

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Related U.S. Application Data

(63) Continuation of application No. PCT/CN2019/072003, filed on Jan. 16, 2019.

(57) **ABSTRACT**

(30) **Foreign Application Priority Data**

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A dual-polarized millimeter-wave antenna system applicable to 5G communications and a mobile terminal are disclosed. Each antenna element comprises a radiating body and a director, wherein the radiating body comprises a first dielectric layer, a main radiating part, a first feeding branch, a second feeding branch, a third feeding branch and a fourth branch, and the director comprises a second dielectric layer, a first director part and a second director part. The director has the same effect on a +45° polarization pattern and a -45° polarization pattern of the radiating body, so that wide-angle coverage is realized, and the consistency of the two polarization patterns is good; and the antenna system occupies a small area does not need a clearance area and can be placed on a complete metal ground plate, there by being suitable for full-screen equipment.

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 21/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 21/24** (2013.01); **H01Q 5/371** (2015.01); **H01Q 15/04** (2013.01)

18 Claims, 8 Drawing Sheets

