US011128025B2

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

(10) **Patent No.: US 11,128,025 B2**
(45) **Date of Patent: Sep. 21, 2021**

(54) **SIGNAL TRANSMISSION DEVICE**

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

(72) Inventors: **Szu-Yuan Chen**, Hsinchu (TW); **Man-Ning Lu**, Hsinchu (TW); **Chiung-Wen Hsin**, Hsinchu (TW); **Yi-Chieh Lin**, Hsinchu (TW)

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

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 28 days.

(21) Appl. No.: **16/700,051**

(22) Filed: **Dec. 2, 2019**

(65) **Prior Publication Data**

US 2020/0365984 A1 Nov. 19, 2020

(30) **Foreign Application Priority Data**

May 14, 2019 (TW) ..... 108116527

(51) **Int. Cl.**

| | |
|---|---|
| ***H01Q 1/02*** | (2006.01) |
| ***H01Q 9/28*** | (2006.01) |
| ***H01Q 21/00*** | (2006.01) |
| ***H01Q 21/08*** | (2006.01) |
| ***H01Q 1/12*** | (2006.01) |

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

CPC ..... ***H01Q 1/02*** (2013.01); ***H01Q 1/1207*** (2013.01); ***H01Q 1/241*** (2013.01); ***H01Q 1/523*** (2013.01); ***H01Q 9/16*** (2013.01); ***H01Q 9/285*** (2013.01); ***H01Q 21/0025*** (2013.01); ***H01Q 21/065*** (2013.01); ***H01Q 21/08*** (2013.01); ***H01Q 21/20*** (2013.01); ***H01Q 21/28*** (2013.01); ***H01Q 23/00*** (2013.01)

(58) **Field of Classification Search**

CPC ..... H01Q 1/02; H01Q 1/2283; H01Q 1/52; H01Q 1/521; H01Q 1/523; H01Q 1/525; H01Q 1/526; H01Q 1/241; H01Q 1/1207; H01Q 9/285; H01Q 9/16; H01Q 21/0025; H01Q 21/20; H01Q 21/28; H01Q 21/08; H01Q 21/065; H01Q 23/00

See application file for complete search history.

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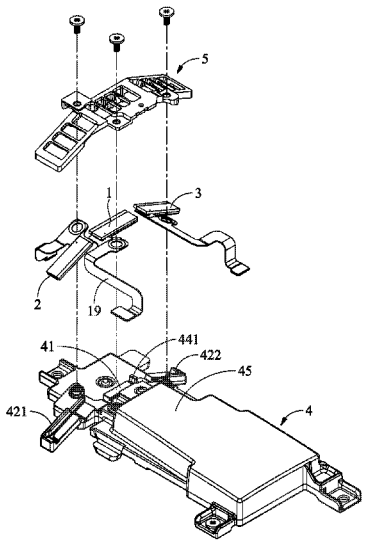
*Primary Examiner* — Robert Karacsony

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

(57) **ABSTRACT**

A signal transmission device is provided. The signal transmission device includes a heat dissipation member, a first antenna module and a positioning clamp. The first antenna module is disposed on the heat dissipation member and thermally connected to the heat dissipation member. The positioning clamp is disposed on the heat dissipation member. The first antenna module is sandwiched between the positioning clamp and the heat dissipation member. The positioning clamp is adapted to restrict the first antenna module. The positioning clamp includes a plurality of clamp openings and a plurality of spacing ribs. At least a few of the clamp openings correspond to the first antenna module, and the clamp openings are defined by the spacing ribs.

**16 Claims, 8 Drawing Sheets**



US011128032B2

(12) **United States Patent**
**Da Costa Bras Lima et al.**

(10) **Patent No.: US 11,128,032 B2**
(45) **Date of Patent: Sep. 21, 2021**

(54) **ELECTRONIC DEVICES HAVING MULTI-BAND ANTENNAS**

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

(72) Inventors: **Eduardo Jorge Da Costa Bras Lima**, Sunnyvale, CA (US); **Andrea Ruaro**, Campbell, CA (US); **Carlo Di Nallo**, Belmont, CA (US); **Dimitrios Papantonis**, Cupertino, CA (US); **Jayesh Nath**, Milpitas, CA (US); **Jiaxiao Niu**, Shanghai (CN); **Johan Avendal**, Cupertino, CA (US); **Mattia Pascolini**, San Francisco, CA (US); **Max O. Landaeus**, Cupertino, CA (US); **Ryan C. Perkins**, San Francisco, CA (US)

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

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 96 days.

(21) Appl. No.: **16/537,220**

(22) Filed: **Aug. 9, 2019**

(65) **Prior Publication Data**

US 2021/0043999 A1 Feb. 11, 2021

(51) **Int. Cl.**

| | |
|---|---|
| ***H01Q 1/24*** | (2006.01) |
| ***H01Q 1/22*** | (2006.01) |
| ***H01Q 5/25*** | (2015.01) |
| ***H01Q 9/42*** | (2006.01) |
| ***H01Q 5/30*** | (2015.01) |

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

CPC ..... ***H01Q 1/2291*** (2013.01); ***H01Q 1/24*** (2013.01); ***H01Q 5/25*** (2015.01); ***H01Q 5/30*** (2015.01); ***H01Q 9/42*** (2013.01)

(58) **Field of Classification Search**

CPC ..... H01Q 1/48; H01Q 1/241; H01Q 1/243; H01Q 1/273; H01Q 5/371; H01Q 9/42; H01Q 21/28

See application file for complete search history.

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(Continued)

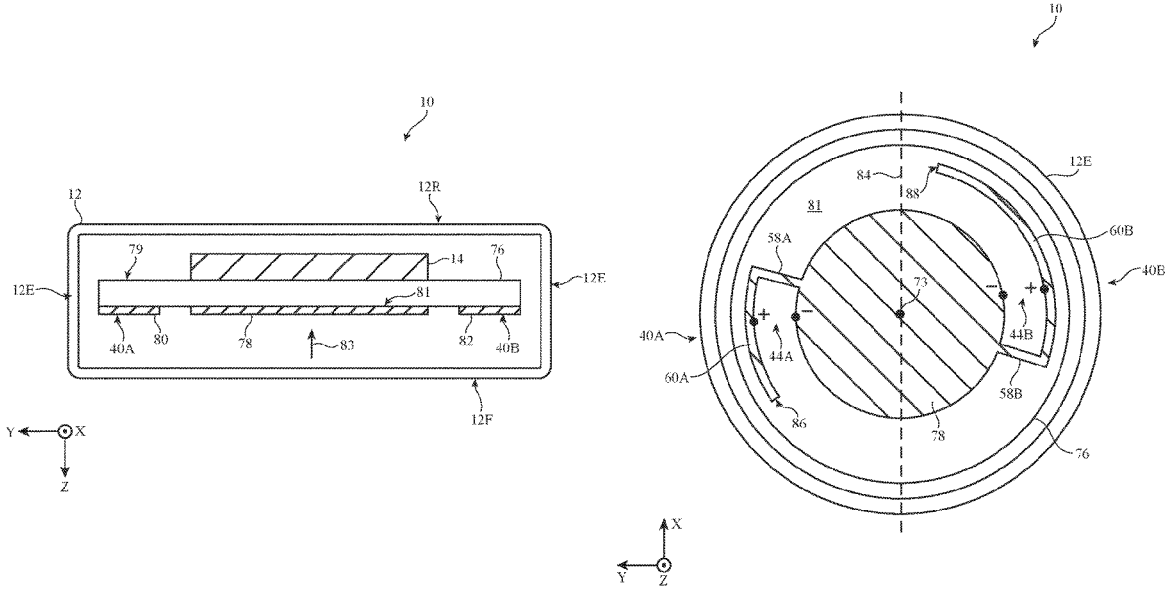
*Primary Examiner* — Tung X Le

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

(57) **ABSTRACT**

An electronic device may be provided with a housing, a logic board, and wireless circuitry on the logic board. The wireless circuitry may include first and second antennas formed from conductive traces on a surface of the logic board. The first and second antennas may include resonating element arms at opposing sides of the logic board. The first antenna may have a fundamental mode that radiates in a Bluetooth® communications band at 2.4 GHz. The second antenna may radiate in a first ultra-wideband communications band such as a 6.5 GHz ultra-wideband communications band. If desired, the second antenna may also radiate in a second ultra-wideband communications band such as an 8.0 GHz ultra-wideband communications band. In another suitable arrangement, a harmonic mode of the first antenna may radiate in the second ultra-wideband communications band.

**20 Claims, 8 Drawing Sheets**



US011128046B2

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

(10) **Patent No.: US 11,128,046 B2**
(45) **Date of Patent: Sep. 21, 2021**

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

(71) Applicant: **Murata Manufacturing Co., Ltd.**, Nagaokakyo (JP)

(72) Inventors: **Kentaro Mikawa**, Nagaokakyo (JP); **Kenichi Ishizuka**, Nagaokakyo (JP); **Takafumi Nasu**, Nagaokakyo (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 209 days.

(21) Appl. No.: **16/354,222**

(22) Filed: **Mar. 15, 2019**

(65) **Prior Publication Data**

US 2019/0214727 A1 Jul. 11, 2019

**Related U.S. Application Data**

(63) Continuation of application No. PCT/JP2017/042706, filed on Nov. 29, 2017.

(30) **Foreign Application Priority Data**

Nov. 29, 2016 (JP) ..... JP2016-231024
Dec. 28, 2016 (JP) ..... JP2016-255729
(Continued)

(51) **Int. Cl.**
***H01Q 1/24*** (2006.01)
***H01Q 5/335*** (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ..... ***H01Q 5/335*** (2015.01); ***H01Q 1/24*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 9/0457*** (2013.01); ***H03H 7/38*** (2013.01)

(58) **Field of Classification Search**
CPC ..... H01Q 5/335; H01Q 1/24; H01Q 9/0457; H01Q 1/48; H03H 7/38
See application file for complete search history.

(56) **References Cited**

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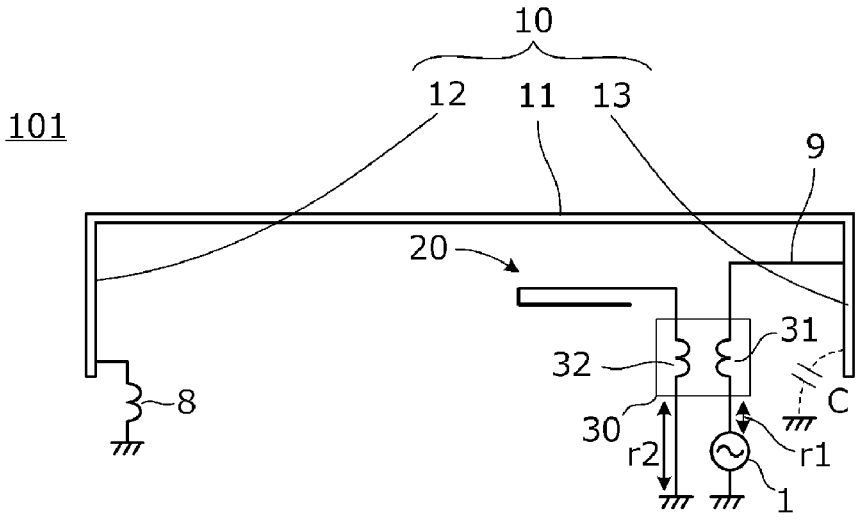
*Primary Examiner* — Dieu Hien T Duong
(74) *Attorney, Agent, or Firm* — Keating & Bennett, LLP

(57) **ABSTRACT**

An antenna device includes a radiating element, a coupling circuit, and a non-radiating resonant circuit. The coupling circuit includes first and second coupling elements, the first coupling element being connected between a feeder circuit and the radiating element, the second coupling element being coupled to the first coupling element. An end of the second coupling element is grounded, and another end of the second coupling element is connected to the non-radiating resonant circuit. A frequency characteristic of a return loss of the radiating element when seen from the feeder circuit is adjusted by a resonant frequency characteristic of the non-radiating resonant circuit.

**20 Claims, 31 Drawing Sheets**



US011128047B2

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

(10) **Patent No.: US 11,128,047 B2**
(45) **Date of Patent: Sep. 21, 2021**

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

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

(72) Inventors: **Liang Xue**, Shanghai (CN); **Pengfei Wu**, Shanghai (CN); **Laiwei Shen**, Shanghai (CN); **Zhiyuan Xie**, Shanghai (CN); **Jiaqing You**, Shanghai (CN); **Dong Yu**, Shanghai (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 36 days.

(21) Appl. No.: **16/637,185**

(22) PCT Filed: **Nov. 10, 2017**

(86) PCT No.: **PCT/CN2017/110440**
§ 371 (c)(1),
(2) Date: **Feb. 6, 2020**

(87) PCT Pub. No.: **WO2019/090690**
PCT Pub. Date: **May 16, 2019**

(65) **Prior Publication Data**

US 2020/0373669 A1 Nov. 26, 2020

(51) **Int. Cl.**
***H01Q 1/48*** (2006.01)
***H01Q 5/35*** (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ..... ***H01Q 5/35*** (2015.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/52*** (2013.01); ***H01Q 5/328*** (2015.01); *H01Q 5/335* (2015.01); *H01Q 13/10* (2013.01)

(58) **Field of Classification Search**
CPC ..... H01Q 5/35; H01Q 5/328; H01Q 1/243; H01Q 1/52; H01Q 5/335; H01Q 13/10
See application file for complete search history.

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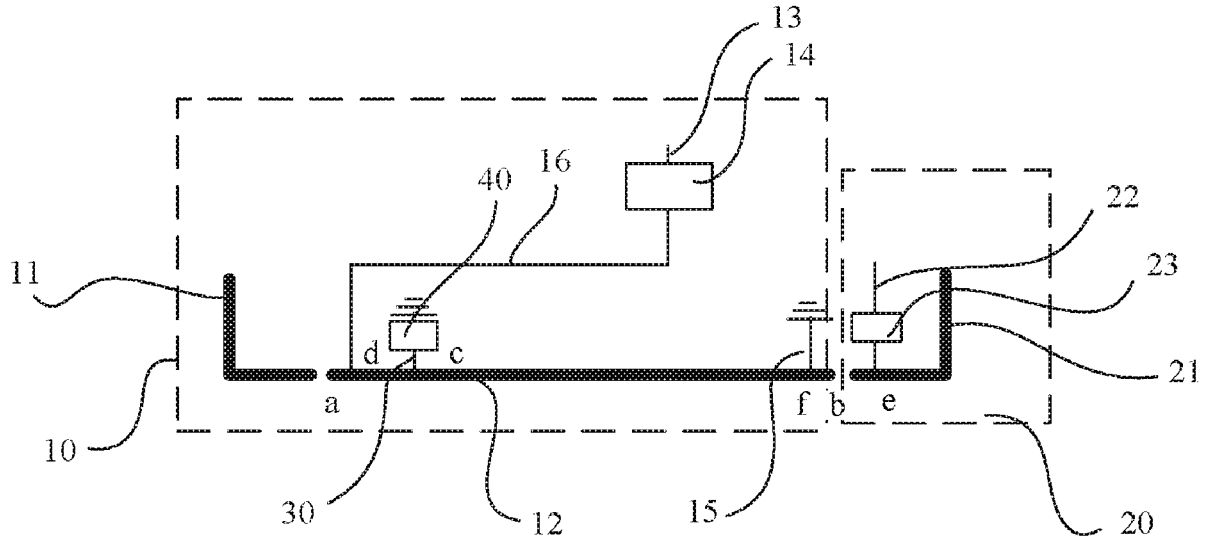
*Primary Examiner* — Joseph J Lauture
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

(57) **ABSTRACT**

An antenna includes a radiator, where the radiator includes three parts separated by a gap, an end of a second part proximate to a first part is a first end, and an end of the second part proximate to a third part is a second end, a medium-high frequency feeder, electrically coupled to the radiator at a first coupling point, a low frequency feeder electrically coupled to the radiator, a first ground cable electrically coupled to the radiator at a second coupling point, where an adjustable component for controlling conduction of the first ground cable is disposed on the first ground cable, a length from the second coupling point to an end that is in the first end and the second end and that is further from the first coupling point is a quarter of a wavelength corresponding to a resonance frequency.

**20 Claims, 6 Drawing Sheets**



US011128050B1

(12) **United States Patent**
**Chuang**

(10) **Patent No.: US 11,128,050 B1**
(45) **Date of Patent: Sep. 21, 2021**

(54) **ANTENNA STRUCTURE**

(71) Applicant: **Wistron Corp.**, New Taipei (TW)

(72) Inventor: **Shih Ming Chuang**, New Taipei (TW)

(73) Assignee: **WISTRON CORP.**, New Taipei (TW)

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

(21) Appl. No.: **16/908,459**

(22) Filed: **Jun. 22, 2020**

(30) **Foreign Application Priority Data**

May 14, 2020 (TW) ..... 109115965

(51) **Int. Cl.**

| | |
|---|---|
| ***H01Q 13/10*** | (2006.01) |
| *H01Q 13/12* | (2006.01) |
| *H01Q 1/38* | (2006.01) |
| *H01Q 9/00* | (2006.01) |
| *H01Q 21/30* | (2006.01) |
| *H01Q 1/24* | (2006.01) |

(52) **U.S. Cl.**
CPC ..... ***H01Q 13/10*** (2013.01); *H01Q 1/243* (2013.01); *H01Q 1/38* (2013.01); *H01Q 9/00* (2013.01); *H01Q 13/106* (2013.01); *H01Q 13/12* (2013.01); *H01Q 21/30* (2013.01)

(58) **Field of Classification Search**
CPC ..... H01Q 13/10; H01Q 13/12; H01Q 13/106; H01Q 1/243; H01Q 1/38; H01Q 21/30; H01Q 9/00
See application file for complete search history.

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Chinese language office action dated Dec. 18, 2020, issued in application No. TW 109115965.

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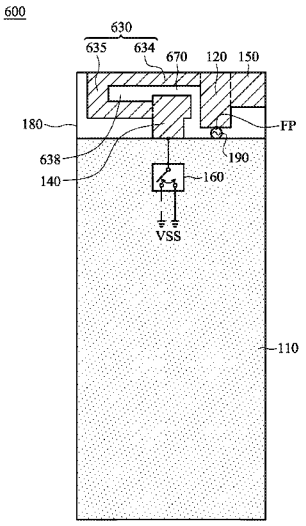
*Primary Examiner* — Joseph J Lauture
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

An antenna structure includes a ground element, a feeding radiation element, a first radiation element, a second radiation element, a third radiation element, and a switch circuit. The ground element provides a ground voltage. The feeding radiation element has a feeding point. The feeding radiation element is coupled through the first radiation element to the second radiation element. The third radiation element is coupled to the feeding radiation element. The feeding radiation element is disposed between the first radiation element and the third radiation element. The switch circuit selectively couples the second radiation element to the ground voltage according to a control voltage. A slot is formed and surrounded by the ground element, the feeding radiation element, the first radiation element, and the second radiation element.

**20 Claims, 6 Drawing Sheets**



US011128055B2

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

(10) **Patent No.: US 11,128,055 B2**
(45) **Date of Patent: Sep. 21, 2021**

(54) **DUAL DIPOLE OMNIDIRECTIONAL ANTENNA**

(71) Applicant: **Communication Components Antenna Inc.**, Kanata (CA)

(72) Inventors: **Nasrin Hojjat**, Kanata (CA); **Sadegh Farzaneh**, Kanata (CA); **Minya Gavrilovic**, Kanata (CA); **Des Bromley**, Kanata (CA); **Parna Kazerani**, Kanata (CA)

(73) Assignee: **Communication Components Antenna Inc.**, Kanata (CA)

( * ) 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.: **15/609,448**

(22) Filed: **May 31, 2017**

(65) **Prior Publication Data**

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**Related U.S. Application Data**

(60) Provisional application No. 62/349,846, filed on Jun. 14, 2016.

(51) **Int. Cl.**

| | |
|---|---|
| ***H01Q 25/00*** | (2006.01) |
| ***H01Q 21/06*** | (2006.01) |
| ***H01Q 5/48*** | (2015.01) |
| ***H01Q 9/44*** | (2006.01) |
| ***H01Q 21/28*** | (2006.01) |
| ***H01Q 21/24*** | (2006.01) |

(Continued)

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

CPC ..... ***H01Q 21/062*** (2013.01); ***H01Q 5/48*** (2015.01); ***H01Q 9/32*** (2013.01); ***H01Q 9/44*** (2013.01); ***H01Q 21/24*** (2013.01); ***H01Q 21/28*** (2013.01); ***H01Q 25/001*** (2013.01); *H01Q 9/16* (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/065; H01Q 5/48; H01Q 9/44; H01Q 21/28

See application file for complete search history.

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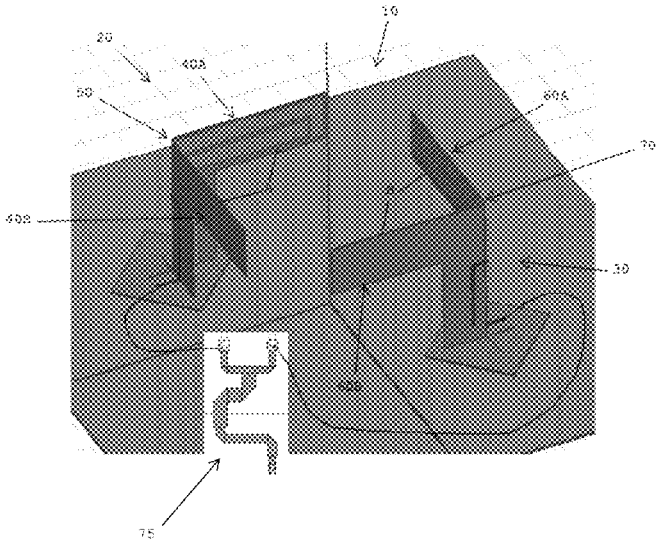
*Primary Examiner* — Ab Salam Alkassim, Jr.

(74) *Attorney, Agent, or Firm* — Ipsilon USA, LLP

(57) **ABSTRACT**

Systems and devices relating to antennas and antenna systems. A horizontal omnidirectional antenna has two dipoles with each dipole being in a V-configuration such that the arms of the dipole define an angle. The two dipoles are arranged so that the angles defined by each of the dipoles face and open toward each other. The horizontal omnidirectional antenna can be configured to operate with specific frequency bands. By nesting two instances of this antenna, with one configured for high band frequencies and one configured for low band frequencies, a dualband omnidirectional antenna can be obtained. The resulting antenna is physically compact and can be used in small MIMO systems along with vertical omnidirectional antennas.

**19 Claims, 20 Drawing Sheets**



US011128059B2

(12) **United States Patent**
**Rogers**

(10) **Patent No.: US 11,128,059 B2**
(45) **Date of Patent: Sep. 21, 2021**

(54) **ANTENNA ASSEMBLY HAVING ONE OR MORE CAVITIES**

(71) Applicant: **THE BOEING COMPANY**, Chicago, IL (US)

(72) Inventor: **John E. Rogers**, Huntsville, AL (US)

(73) Assignee: **THE BOEING COMPANY**, Chicago, IL (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.: **16/443,256**

(22) Filed: **Jun. 17, 2019**

(65) **Prior Publication Data**

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(51) **Int. Cl.**

| | |
|---|---|
| ***H01Q 21/06*** | (2006.01) |
| ***H01Q 1/42*** | (2006.01) |
| ***H01Q 21/00*** | (2006.01) |
| ***H01Q 9/04*** | (2006.01) |
| ***H01Q 1/28*** | (2006.01) |

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

CPC ..... ***H01Q 21/065*** (2013.01); ***H01Q 1/28*** (2013.01); ***H01Q 1/42*** (2013.01); ***H01Q 9/0428*** (2013.01); ***H01Q 9/0457*** (2013.01); ***H01Q 21/0075*** (2013.01); *H01Q 1/286* (2013.01)

(58) **Field of Classification Search**

CPC ..... H01Q 1/28; H01Q 1/42; H01Q 9/0428; H01Q 21/065; H01Q 21/0075; H01Q 1/286; H01Q 9/0407; H01Q 9/045; H01Q 9/0457; H01Q 9/0464; H01Q 21/0081

See application file for complete search history.

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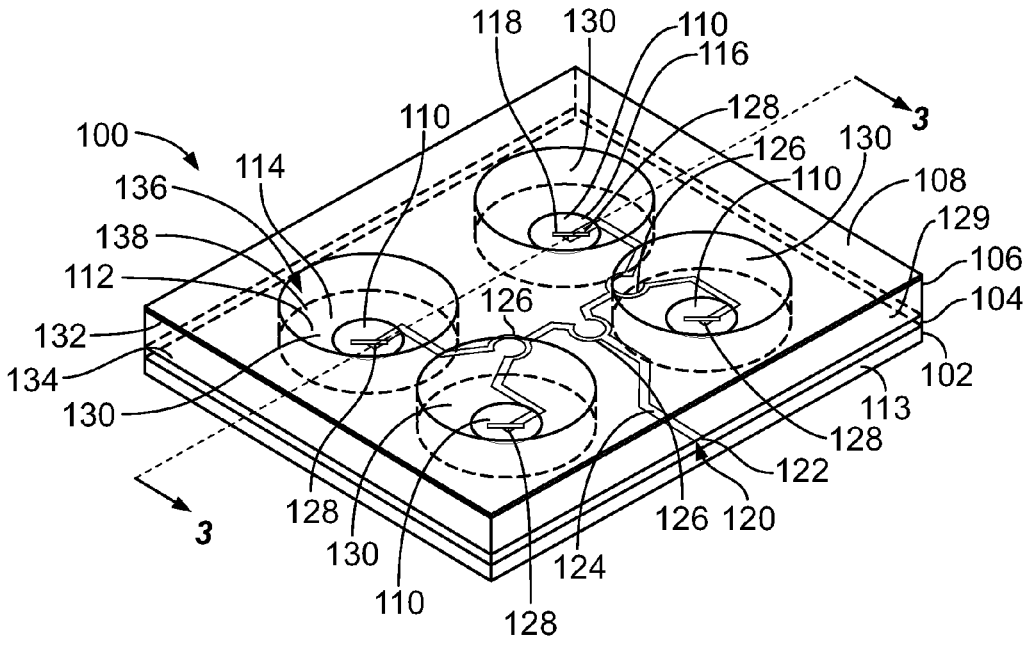
*Primary Examiner* — Robert Karacsony

(74) *Attorney, Agent, or Firm* — The Small Patent Law Group LLC; Joseph M. Butscher

(57) **ABSTRACT**

An antenna assembly and method of forming the same includes a dielectric support base including an antenna element layer having one or more antenna elements, and a cavity layer coupled to the dielectric support base. The cavity layer includes a main body having one or more cavities. The one or more antenna elements are disposed within the one or more cavities.

**18 Claims, 3 Drawing Sheets**



US011128060B2

(12) **United States Patent**
**Liu**

(10) **Patent No.: US 11,128,060 B2**
(45) **Date of Patent: Sep. 21, 2021**

(54) **MULTI-BAND ANTENNA MODULE**

(71) Applicants: **ASKEY COMPUTER CORP.**, New Taipei (TW); **ASKEY TECHNOLOGY (JIANGSU) LTD.**, Jiangsu (CN)

(72) Inventor: **Chien-Sheng Liu**, Taoyuan (TW)

(73) Assignees: **ASKEY COMPUTER CORP.**, New Taipei (TW); **ASKEY TECHNOLOGY (JIANGSU) LTD.**, Jiangsu (CN)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 15 days.

(21) Appl. No.: **16/716,517**

(22) Filed: **Dec. 17, 2019**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jul. 3, 2019 (TW) ..... 108123420

(51) **Int. Cl.**

| | |
|---|---|
| ***H01Q 1/24*** | (2006.01) |
| ***H01Q 21/30*** | (2006.01) |
| ***H01Q 5/314*** | (2015.01) |
| ***H01Q 1/42*** | (2006.01) |

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

CPC ..... ***H01Q 21/30*** (2013.01); ***H01Q 1/42*** (2013.01); ***H01Q 5/314*** (2015.01)

(58) **Field of Classification Search**

CPC ..... H01Q 21/30; H01Q 5/314

USPC ..... 343/893, 846, 861

See application file for complete search history.

(56) **References Cited**

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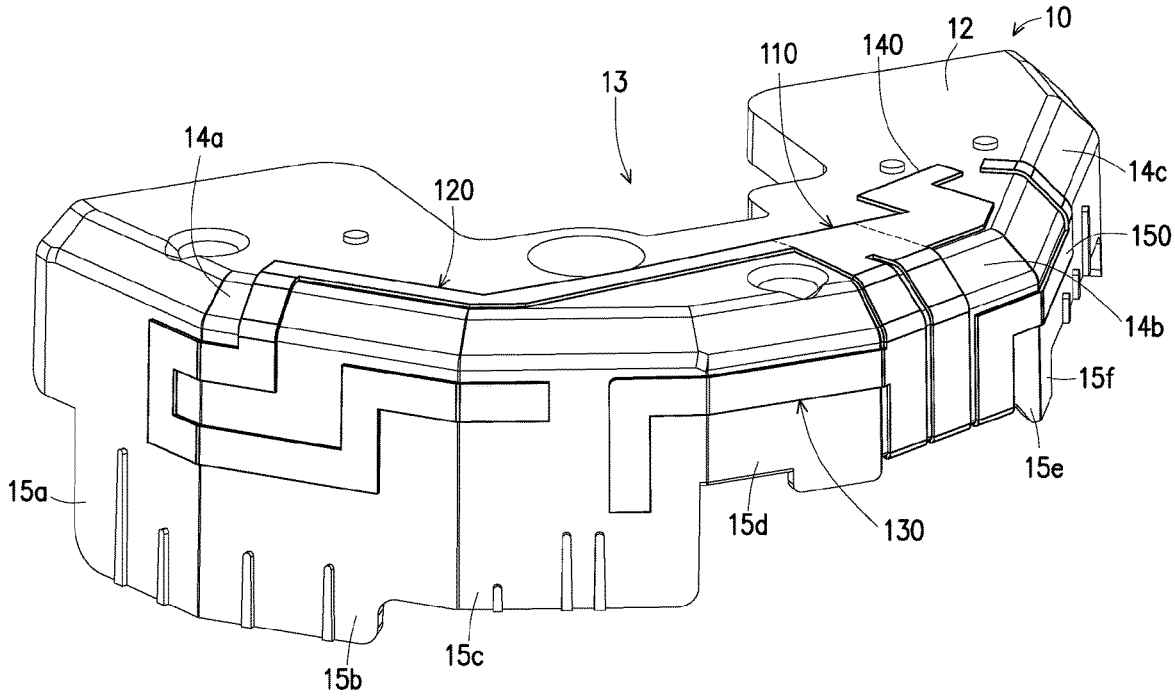
*Primary Examiner* — Peguy Jean Pierre
(74) *Attorney, Agent, or Firm* — JCIPRNET

(57) **ABSTRACT**

A multi-band antenna module is adapted to be disposed on a casing. The multi-band antenna module includes a main radiator, and a first, a second, a third and a fourth radiator. The main radiator has a feed-in terminal and a first ground terminal. The first radiator is connected to the main radiator and configured to couple a first frequency band. The second radiator is connected to the main radiator and configured to couple a second frequency band. The third radiator is connected to the main radiator and configured to couple a third frequency band. The fourth radiator is located beside the main radiator and configured to couple a fourth frequency band and has a second ground terminal. The main radiator, the first radiator, the second radiator, the third radiator and the fourth radiator are adapted to form a 3D structure along an outline of the casing.

**8 Claims, 9 Drawing Sheets**



US011133572B2

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

(10) **Patent No.: US 11,133,572 B2**
(45) **Date of Patent: Sep. 28, 2021**

(54) **ELECTRONIC DEVICE WITH SEGMENTED HOUSING HAVING MOLDED SPLITS**

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

(72) Inventors: **Yaocheng Zhang**, Cupertino, CA (US); **John J. Baker**, Cupertino, CA (US); **Martin J. Auclair**, Waterloo (CA); **Paul U. Leutheuser**, Saratoga, CA (US); **Christopher J. Durning**, Cupertino, CA (US); **Jun Ham**, Cupertino, CA (US)

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

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 99 days.

(21) Appl. No.: **16/205,145**

(22) Filed: **Nov. 29, 2018**

(65) **Prior Publication Data**

US 2020/0076058 A1 Mar. 5, 2020

**Related U.S. Application Data**

(60) Provisional application No. 62/725,197, filed on Aug. 30, 2018, provisional application No. 62/729,319, filed on Sep. 10, 2018.

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

(52) **U.S. Cl.**
CPC ..... ***H01Q 1/243*** (2013.01); ***G06F 1/181*** (2013.01); ***H01Q 1/2258*** (2013.01); ***H01Q 1/38*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC ..... H01Q 1/243; H01Q 1/2258; H01Q 1/38; H01Q 9/30; H01Q 9/045; H01Q 13/10; H04B 1/3888; G06F 1/181; H05K 5/0247
See application file for complete search history.

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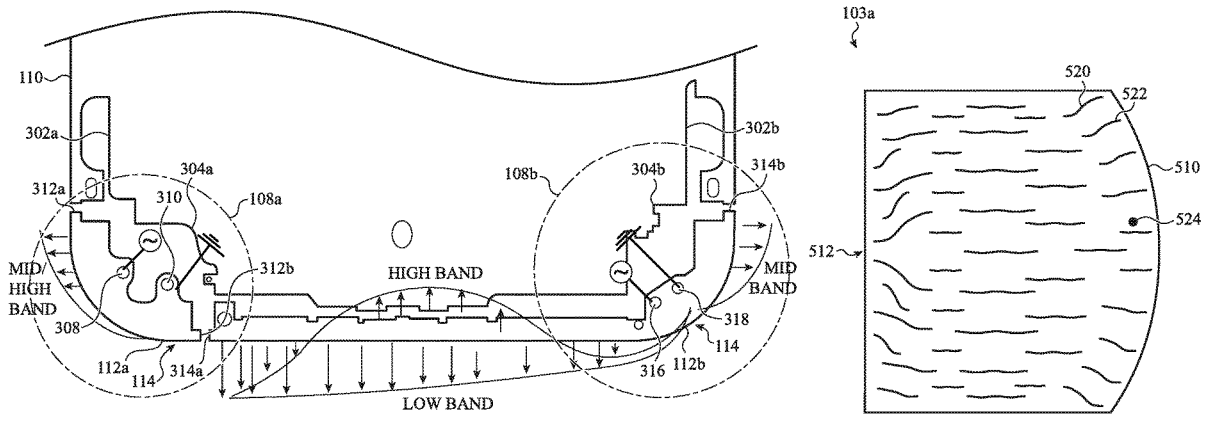
*Primary Examiner* — Dieu Hien T Duong
(74) *Attorney, Agent, or Firm* — Brownstein Hyatt Farber Schreck, LLP

(57) **ABSTRACT**

The disclosure is directed to a multi-segment housing for an electronic device that includes multiple conductive segments that are structurally coupled by one or more non-conductive housing segments or splits. One or more of the conductive segments may be configured to operate as an antenna and the non-conductive housing segments may provide electrical insulation between the conductive segment and one or more adjacent housing segments. The non-conductive housing segment may be formed from a polymer having an array of fibers dispersed within the polymer. The fibers may be aligned along one or more fiber directions, which may be substantially perpendicular to an exterior surface of the housing.

**17 Claims, 21 Drawing Sheets**



US011133573B2

(12) **United States Patent**
**Chen**

(10) **Patent No.: US 11,133,573 B2**
(45) **Date of Patent: Sep. 28, 2021**

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

(71) Applicant: **VIVO MOBILE COMMUNICATION CO., LTD.**, Guangdong (CN)

(72) Inventor: **Yuwen Chen**, Chang'an Dongguan (CN)

(73) Assignee: **VIVO MOBILE COMMUNICATION CO., LTD.**, Chang'an Dongguan (CN)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 101 days.

(21) Appl. No.: **16/499,085**

(22) PCT Filed: **Dec. 28, 2017**

(86) PCT No.: **PCT/CN2017/119236**
§ 371 (c)(1),
(2) Date: **Sep. 27, 2019**

(87) PCT Pub. No.: **WO2018/176948**
PCT Pub. Date: **Oct. 4, 2018**

(65) **Prior Publication Data**

US 2020/0058983 A1 Feb. 20, 2020

(30) **Foreign Application Priority Data**

Mar. 28, 2017 (CN) ..... 201710191650.2

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

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

(58) **Field of Classification Search**
CPC ..... H01Q 1/243; H01Q 1/36; H01Q 1/42; H01Q 1/48; H01Q 1/521; H01Q 1/52;
(Continued)

(56) **References Cited**

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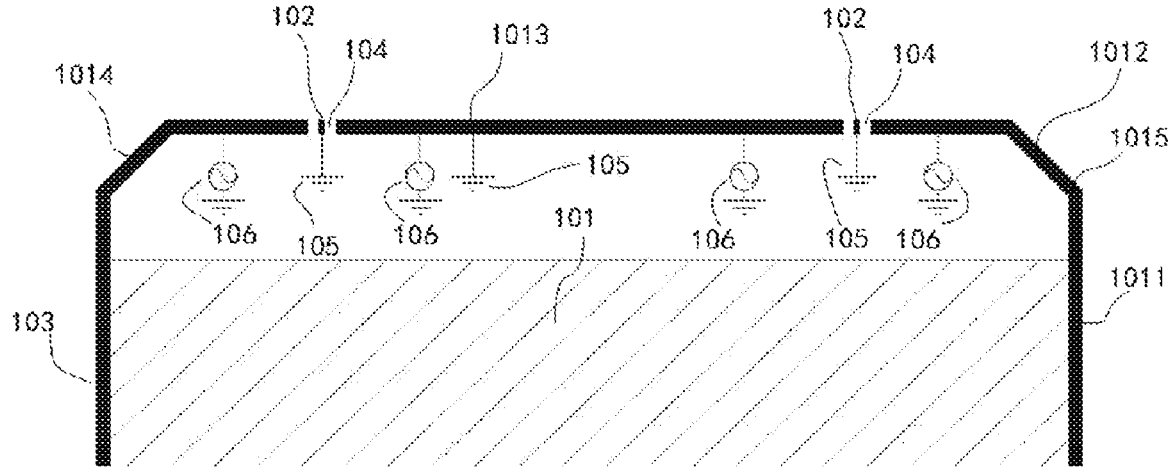
*Primary Examiner* — Tho G Phan
(74) *Attorney, Agent, or Firm* — Maschoff Brennan

(57) **ABSTRACT**

Mobile terminal antenna and mobile terminal are provided. Mobile terminal antenna includes: main ground board, isolation sheet and metal frame surrounding main ground board; main ground board is within metal frame, part of edge of which is connected with inner edge of metal frame and another part of edge of which is separated from inner edge of metal frame; metal frame includes first section and second section, inner edge of metal frame corresponding to first section is connected with edge of main ground board, inner edge of metal frame corresponding to second section is separated from edge of main ground board; opening is provided in second section, portions of metal frame on sides of opening are connected with grounding terminal and feed, so portions each form antenna arm; isolation sheet is in opening and connected with grounding terminal. Mobile terminal includes any described mobile terminal antenna.

**18 Claims, 5 Drawing Sheets**



US011133581B2

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

(10) **Patent No.: US 11,133,581 B2**
(45) **Date of Patent: Sep. 28, 2021**

(54) **ELECTRONIC DEVICE COMPRISING ANTENNA**

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

(72) Inventors: **Mincheol Seo**, Suwon-si (KR); **Hosaeng Kim**, Suwon-si (KR); **Donghun Shin**, Suwon-si (KR); **Yoonjae Lee**, 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.: **16/790,059**

(22) Filed: **Feb. 13, 2020**

(65) **Prior Publication Data**

US 2020/0259251 A1 Aug. 13, 2020

(30) **Foreign Application Priority Data**

Feb. 13, 2019 (KR) ..... 10-2019-0016597

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

(52) **U.S. Cl.**
CPC ..... ***H01Q 1/38*** (2013.01); ***H01Q 1/1221*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/42*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC ..... H01Q 1/243; H01Q 1/1221; H01Q 1/22; H01Q 1/38; H01Q 1/42; H01Q 5/371;
(Continued)

(56) **References Cited**

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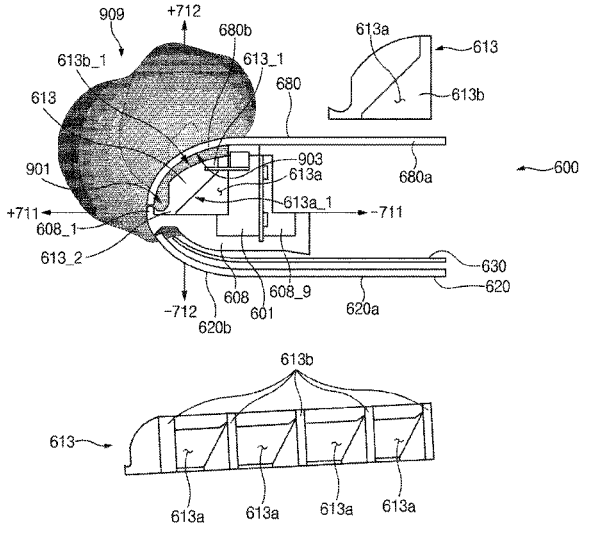
*Primary Examiner* — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a support member, a front plate disposed on a front surface of the support member, a back plate disposed on a back surface of the support member, a non-conductive structure interposed between the back plate and an edge of the support member and fixed to the support member, and an antenna structure interposed between the back plate and an edge of the support member. At least a portion of the antenna structure may be disposed to face the non-conductive structure. In a region of the non-conductive structure, which faces the antenna structure, a separated distance from the antenna structure varies depending on a distance from a bottom surface of the support member to which the non-conductive structure is fixed.

**19 Claims, 19 Drawing Sheets**



US011133595B2

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

(10) **Patent No.: US 11,133,595 B2**
(45) **Date of Patent: Sep. 28, 2021**

(54) **ANTENNA MODULE USING METAL BEZEL AND ELECTRONIC DEVICE INCLUDING THEREOF**

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

(72) Inventors: **Sungchul Park**, Gyeonggi-do (KR); **Wonjoon Choi**, Gyeonggi-do (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.: **16/724,920**

(22) Filed: **Dec. 23, 2019**

(65) **Prior Publication Data**

US 2020/0212584 A1 Jul. 2, 2020

(30) **Foreign Application Priority Data**

Dec. 28, 2018 (KR) ..... 10-2018-0171607

(51) **Int. Cl.**

| | |
|---|---|
| ***H01Q 13/18*** | (2006.01) |
| ***H01Q 1/24*** | (2006.01) |
| ***H01Q 21/06*** | (2006.01) |
| ***H01Q 5/35*** | (2015.01) |

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

CPC ..... ***H01Q 13/18*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 5/35*** (2015.01); ***H01Q 21/064*** (2013.01)

(58) **Field of Classification Search**

CPC ..... H01Q 21/064; H01Q 1/243; H01Q 13/18; H01Q 13/16; H01Q 1/38; H01Q 21/08; H01Q 5/35; H01Q 3/28; H01Q 3/36

See application file for complete search history.

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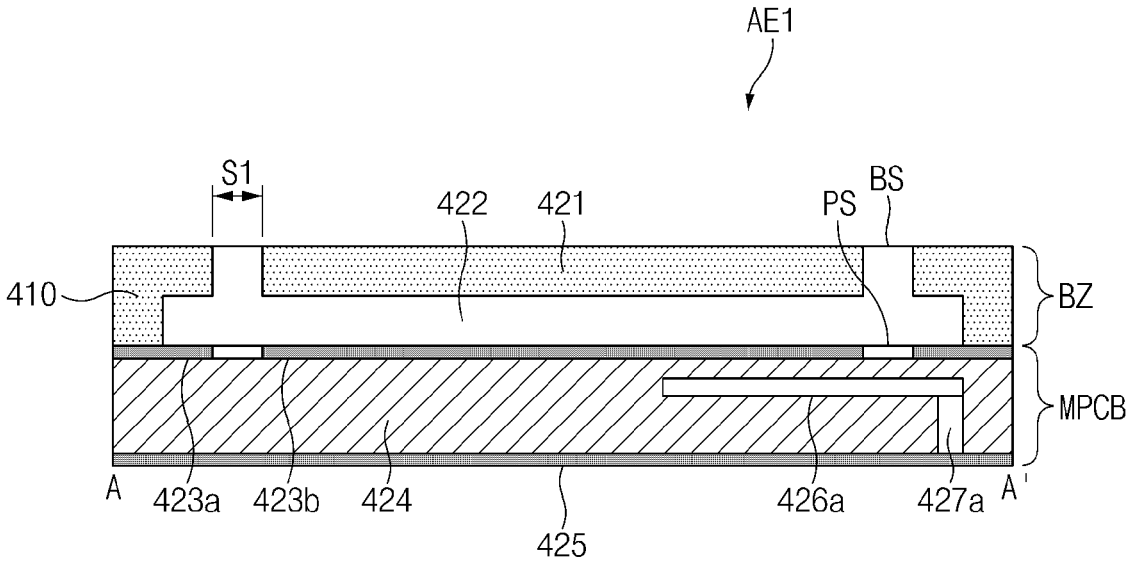
*Primary Examiner* — Graham P Smith
*Assistant Examiner* — Jae K Kim
(74) *Attorney, Agent, or Firm* — Cha & Reiter, LLC

(57) **ABSTRACT**

Disclosed is an electronic device including a metal bezel including a bezel patch separated through a bezel slit, a printed circuit board including a first conductive pattern and a second conductive pattern, which are separated through a substrate slit and a communication module transmitting or receiving an antenna signal, using an antenna element including the bezel patch, the first conductive pattern, and the second conductive pattern. The first conductive pattern is connected to a part of the metal bezel. The bezel patch and the second conductive pattern is arranged to be aligned vertically. A bezel cavity is formed between the bezel patch and the second conductive pattern.

**20 Claims, 30 Drawing Sheets**



US011133596B2

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

(10) **Patent No.: US 11,133,596 B2**
(45) **Date of Patent: Sep. 28, 2021**

(54) **ANTENNA WITH GRADIENT-INDEX METAMATERIAL**

(71) Applicant: **QUALCOMM Incorporated**, San Diego, CA (US)

(72) Inventors: **Yu-Chin Ou**, San Diego, CA (US); **Mohammad Ali Tassoudji**, San Diego, CA (US)

(73) Assignee: **QUALCOMM Incorporated**, 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 298 days.

(21) Appl. No.: **16/145,799**

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

(65) **Prior Publication Data**

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(51) **Int. Cl.**
***H01Q 21/06*** (2006.01)
***H01Q 15/00*** (2006.01)
***H01Q 5/357*** (2015.01)

(52) **U.S. Cl.**
CPC ..... ***H01Q 15/0086*** (2013.01); ***H01Q 5/357*** (2015.01); ***H01Q 21/065*** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 15/0086; H01Q 5/357; H01Q 21/065; H01Q 9/0442; H01Q 9/0414
See application file for complete search history.

(56) **References Cited**

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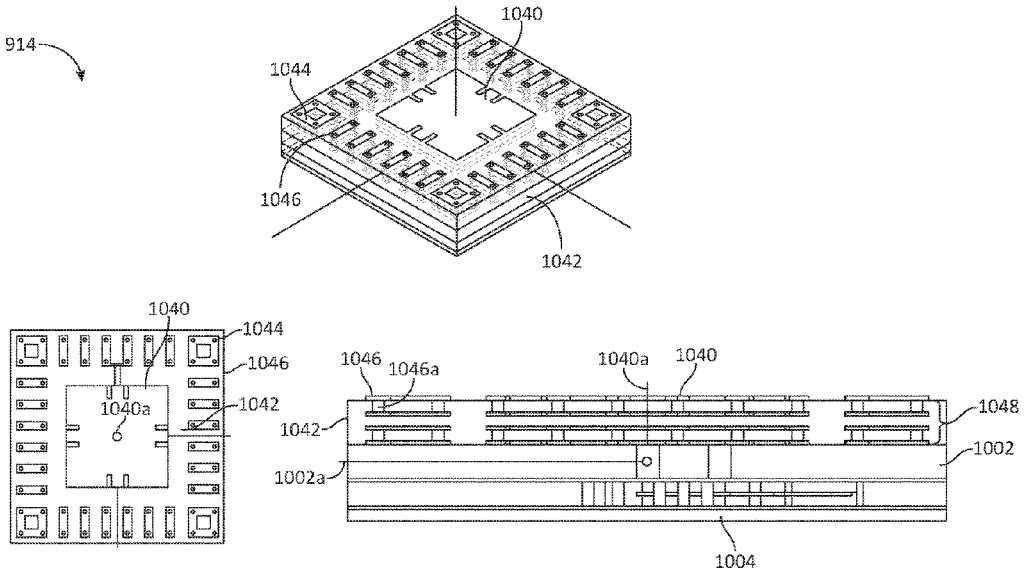
*Primary Examiner* — Awat M Salih
(74) *Attorney, Agent, or Firm* — Qualcomm Incorporated

(57) **ABSTRACT**

Techniques for improving the bandwidth performance of an antenna assembly in a mobile device are provided. An example of an apparatus according to the disclosure includes a dielectric substrate having a first area and a second area disposed around the first area, a first radiator disposed on a surface of the dielectric substrate in the first area, the first radiator being configured to transmit and receive radio signals at an operational frequency, and a plurality of metamaterial structures disposed in a periodic pattern on the surface of the dielectric substrate in the second area and within a near field of the first radiator, wherein a maximum width of each of the plurality of metamaterial structures is less than half of a wavelength of the operational frequency.

**28 Claims, 18 Drawing Sheets**



US011133605B2

(12) **United States Patent**
**Wei**

(10) **Patent No.: US 11,133,605 B2**
(45) **Date of Patent: Sep. 28, 2021**

(54) **ANTENNA STRUCTURE**

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

(72) Inventor: **Shih-Chiang Wei**, Hsinchu (TW)

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

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 735 days.

(21) Appl. No.: **15/611,028**

(22) Filed: **Jun. 1, 2017**

(65) **Prior Publication Data**

US 2018/0048076 A1 Feb. 15, 2018

(30) **Foreign Application Priority Data**

Aug. 11, 2016 (TW) ..... 105212154

(51) **Int. Cl.**

| | |
|---|---|
| ***H01Q 5/371*** | (2015.01) |
| ***H01Q 1/24*** | (2006.01) |
| ***H01Q 9/42*** | (2006.01) |
| ***H01Q 9/04*** | (2006.01) |
| ***H01Q 21/30*** | (2006.01) |

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

CPC ..... ***H01Q 21/30*** (2013.01); ***H01Q 1/242*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 5/371*** (2015.01); ***H01Q 9/045*** (2013.01); ***H01Q 9/0421*** (2013.01); ***H01Q 9/42*** (2013.01)

(58) **Field of Classification Search**

CPC . H01Q 1/242–244; H01Q 5/371; H01Q 21/30

See application file for complete search history.

(56) **References Cited**

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*Primary Examiner* — Andrea Lindgren Baltzell
*Assistant Examiner* — Amal Patel
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

An antenna structure includes a ground plane, a feeding connection element, a first radiation element, a second radiation element, a third radiation element, and a shorting radiation element. The feeding connection element is coupled to a signal source. The first radiation element and the second radiation element are coupled to the feeding connection element. The second radiation element and the first radiation element substantially extend in opposite directions. The third radiation element is coupled to the ground plane. The third radiation element partially surrounds the second radiation element. The shorting radiation element is coupled between the feeding connection element and the third radiation element.

**19 Claims, 3 Drawing Sheets**