



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.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,529,749 B1 * 3/2003 Hayes H01Q 1/243 343/702

8,294,621 B2 10/2012 Tran

9,118,109 B2 8/2015 Oh et al.

9,496,600 B2 11/2016 Irci et al.

9,865,915 B2 1/2018 Shiu et al.

(Continued)

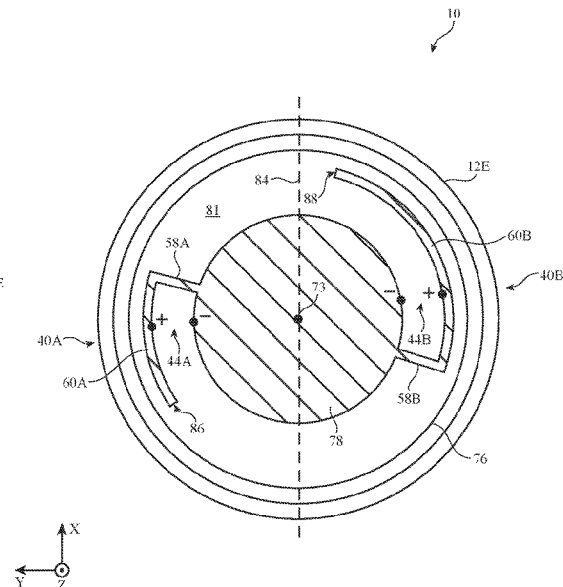
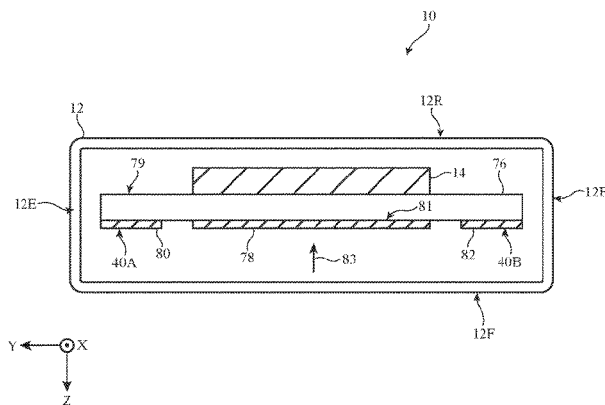
Primary Examiner — Tung X Le

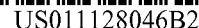
(74) Attorney, Agent, or Firm — Treyz Law Group, P.C.; Michael H. Lyons

(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





(45) **Date of Patent:** Sep. 21, 2021

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2002/0044092	A1 *	4/2002	Kushihi	H01Q 5/335 343/702
2006/0262028	A1 *	11/2006	Takei	H01Q 9/0442 343/850

(Continued)

JP	42-7857	Y1	4/1967
JP	54-183246	U	12/1979

(Continued)

OTHER PUBLICATIONS

Official Communication issued in International Patent Application
No. PCT/JP2017/042706, dated Feb. 20, 2018.

Primary Examiner — Dieu Hien T Duong

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

(57) **ABSTRACT**

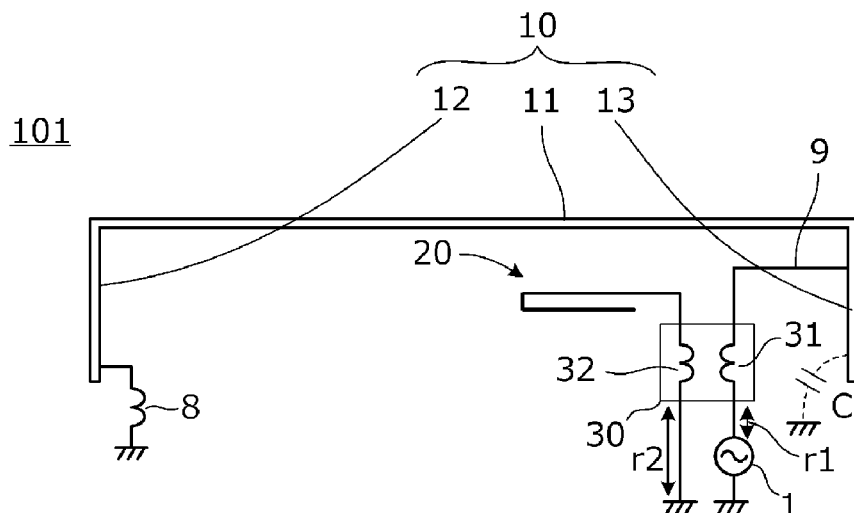
An antenna device includes a radiating element, a coupling circuit, and a non-radiating resonant circuit. The coupling circuit includes first and second coupling elements, the first coupling element being connected between a feeder circuit and the radiating element, the second coupling element being 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.

(Continued)

(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)

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.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,276,319 B2 3/2016 Vazquez et al.
9,444,130 B2 9/2016 Bevelacqua et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 104103888 A 10/2014
CN 205081230 U 3/2016
(Continued)

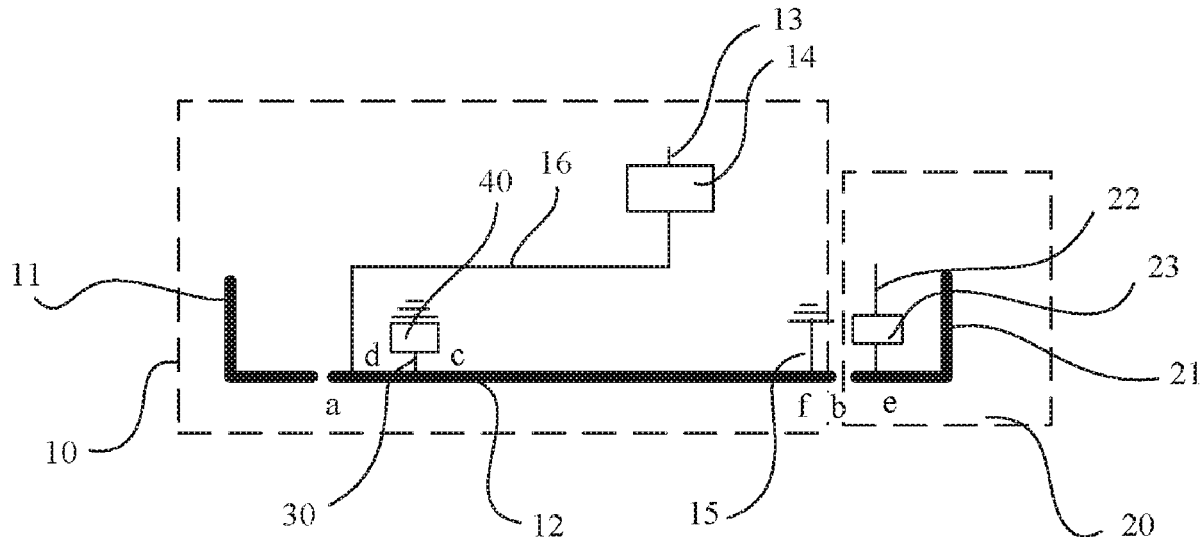
Primary Examiner — Joseph J Lauture

(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



(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.

(56) **References Cited**

U.S. PATENT DOCUMENTS

10,069,196 B1 9/2018 Yen et al.
2009/0135071 A1* 5/2009 Huang H01Q 9/0421
343/700 MS

2012/0194390 A1 8/2012 Endo et al.
2013/0154888 A1 6/2013 Lin et al.
2014/0253398 A1 9/2014 Hsieh et al.
2016/0156101 A1 6/2016 Tsai et al.

FOREIGN PATENT DOCUMENTS

EP 2 942 834 A1 11/2015
TW 201715791 A 5/2017

OTHER PUBLICATIONS

European Search Report dated Jan. 21, 2021, issued in application No. EP 20188176.0.
Chinese language office action dated Dec. 18, 2020, issued in application No. TW 109115965.

* cited by examiner

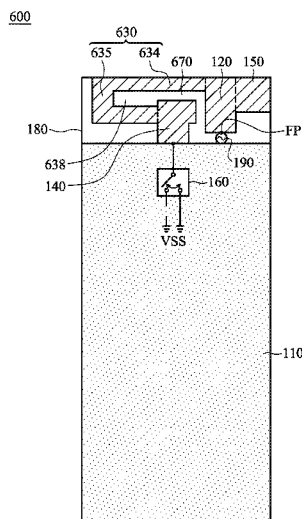
Primary Examiner — Joseph J Lauture

(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



(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**

(2013.01); **H01Q 21/24** (2013.01); **H01Q 21/28** (2013.01); **H01Q 25/001** (2013.01); **H01Q 9/16** (2013.01)

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

(58) **Field of Classification Search**
CPC H01Q 9/065; H01Q 5/48; H01Q 9/44; H01Q 21/28

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

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,434,425 A * 2/1984 Barbano H01Q 19/17 343/797
5,767,809 A 8/1998 Bosse
(Continued)

(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.

OTHER PUBLICATIONS

Quan, Xu Lin, et al. "Development of a broadband horizontally polarized omnidirectional planar antenna and its array for base stations." Progress in Electromagnetics Research 128 (2012): 441-456.

(21) Appl. No.: **15/609,448**

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

Primary Examiner — Ab Salam Alkassim, Jr.

(65) **Prior Publication Data**

US 2017/0358870 A1 Dec. 14, 2017

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

Related U.S. Application Data

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

(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.

(51) **Int. Cl.**

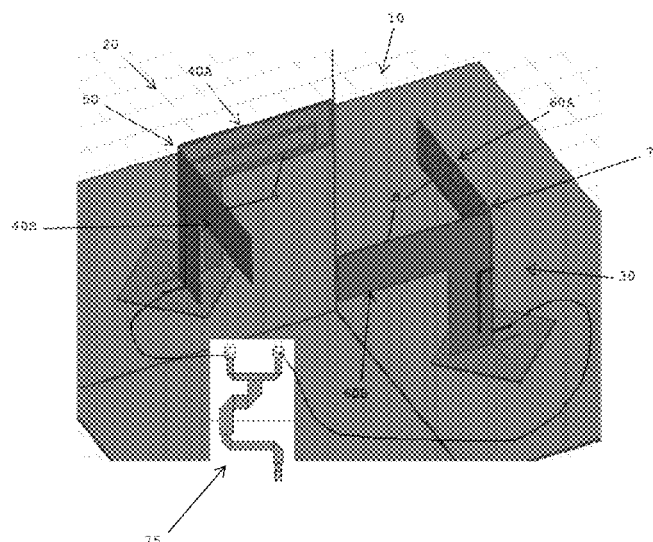
H01Q 25/00 (2006.01)
H01Q 21/06 (2006.01)
H01Q 5/48 (2015.01)
H01Q 9/44 (2006.01)
H01Q 21/28 (2006.01)
H01Q 21/24 (2006.01)

(Continued)

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

CPC **H01Q 21/062** (2013.01); **H01Q 5/48** (2015.01); **H01Q 9/32** (2013.01); **H01Q 9/44**

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**

1/286; H01Q 9/0407; H01Q 9/045; H01Q 9/0457; H01Q 9/0464; H01Q 21/0081

See application file for complete search history.

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

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

(73) Assignee: **THE BOEING COMPANY**, Chicago, IL (US)

6,140,968 A * 10/2000 Kawahata H01Q 1/243
343/700 MS
7,889,150 B2 * 2/2011 Gottwald H01Q 1/3233
343/878

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

9,772,422 B2 9/2017 Hull
2005/0200531 A1 * 9/2005 Huang H01Q 21/0006
343/700 MS
2016/0351996 A1 * 12/2016 Ou H01Q 21/065
2020/0106192 A1 * 4/2020 Avser H01Q 9/0414

(21) Appl. No.: **16/443,256**

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

(65) **Prior Publication Data**

US 2020/0395672 A1 Dec. 17, 2020

(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

OTHER PUBLICATIONS

Fonseca, M. A., et al., "Flexible wireless passive pressure sensors for biomedical applications," Hilton Head 2006, Jun. 2006.
Abad, E., et al., "Flexible tag microlab development: gas sensors integration in RFID flexible tags for food logistics," Sensors and Actuators B, Jul. 2007.

(Continued)

Primary Examiner — Robert Karacsony

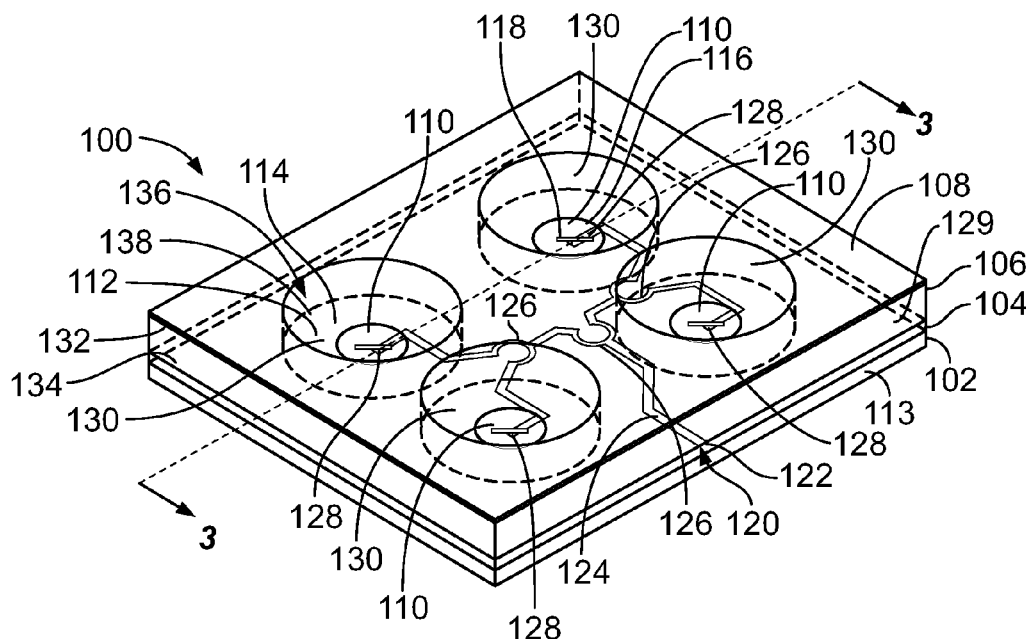
(74) *Attorney, Agent, or Firm* — The Small Patent Law Group LLC; Joseph M. Butscher

(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**

USPC 343/893, 846, 861
See application file for complete search history.

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,484,631 B1 * 11/2016 Napoles H01Q 5/371
2010/0182215 A1 * 7/2010 Hsiao H01Q 1/38
343/846
2015/0002339 A1 * 1/2015 Lin H01Q 9/0421
343/700 MS
2015/0061960 A1 * 3/2015 Liou H01Q 5/335
343/861

(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.

* cited by examiner

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

Primary Examiner — Peguy Jean Pierre

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

(74) *Attorney, Agent, or Firm* — JCIPRNET

(65) **Prior Publication Data**

US 2021/0005984 A1 Jan. 7, 2021

(30) **Foreign Application Priority Data**

Jul. 3, 2019 (TW) 108123420

(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.

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 21/30 (2006.01)

H01Q 5/314 (2015.01)

H01Q 1/42 (2006.01)

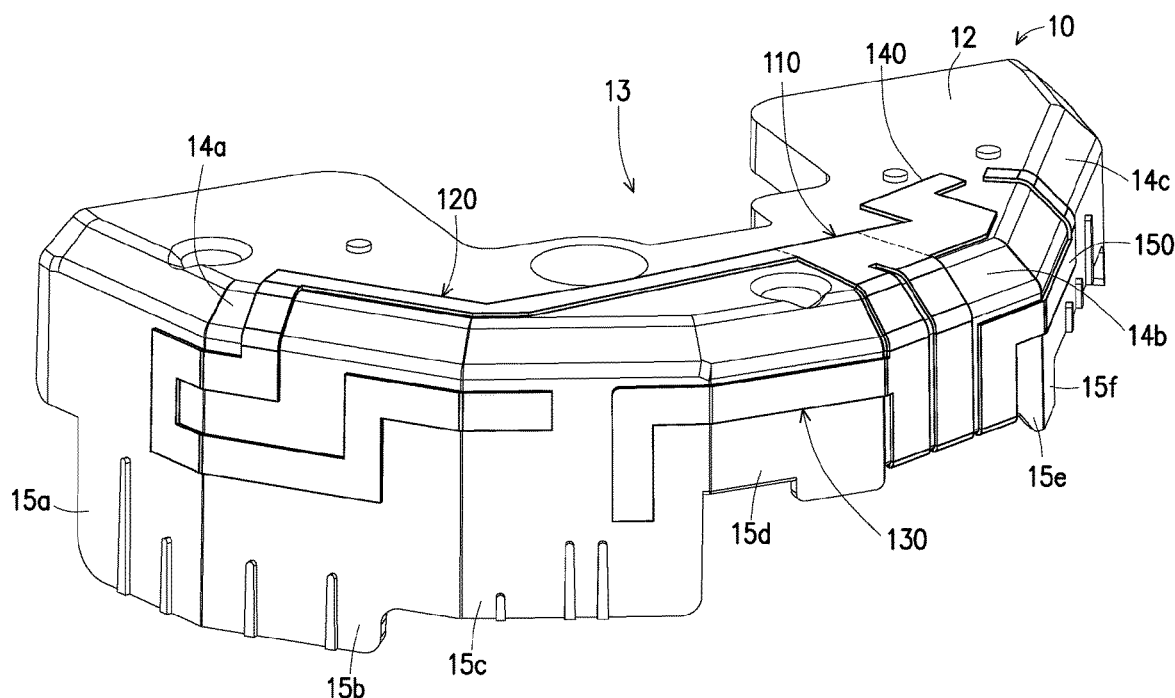
(52) **U.S. Cl.**

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

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.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,106,839 A 8/1978 Cooper
4,256,412 A 3/1981 Tybus et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 101087500 12/2007
CN 102159045 8/2011
(Continued)

OTHER PUBLICATIONS

Author Unknown, "Improved Touchscreen Products," Research Disclosure, Kenneth Mason Publications, Hampshire, UK, GB, vol. 428, No. 53, Dec. 1, 1999.

(Continued)

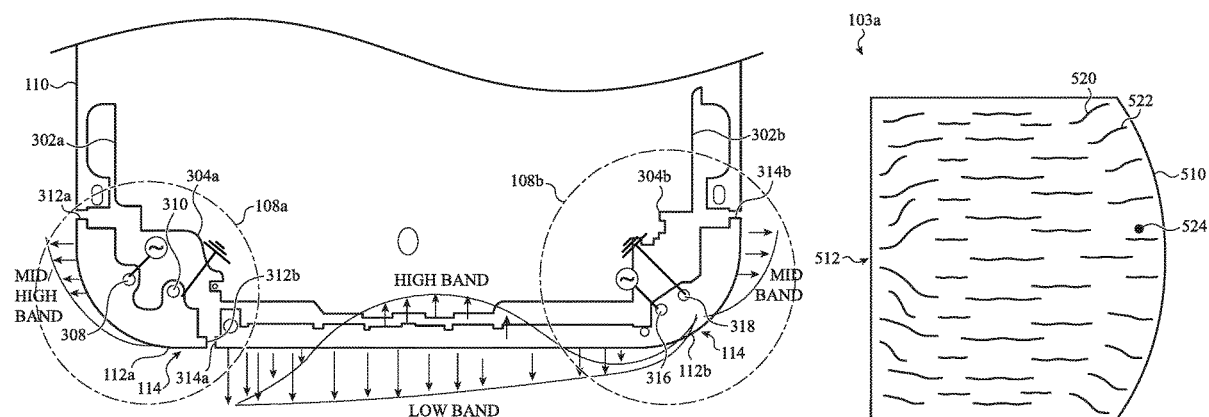
Primary Examiner — Dieu Hien T Duong

(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**

U.S. PATENT DOCUMENTS

9,972,891 B2 * 5/2018 Ayala Vazquez H01Q 5/378
10,186,755 B2 * 1/2019 Xiong H01Q 5/50
(Continued)

FOREIGN PATENT DOCUMENTS

CN 102522625 A 6/2012
CN 103034291 A 4/2013

(Continued)

OTHER PUBLICATIONS

EP Search Report in Application No. 17903936.7 dated Mar. 16,
2020.

(Continued)

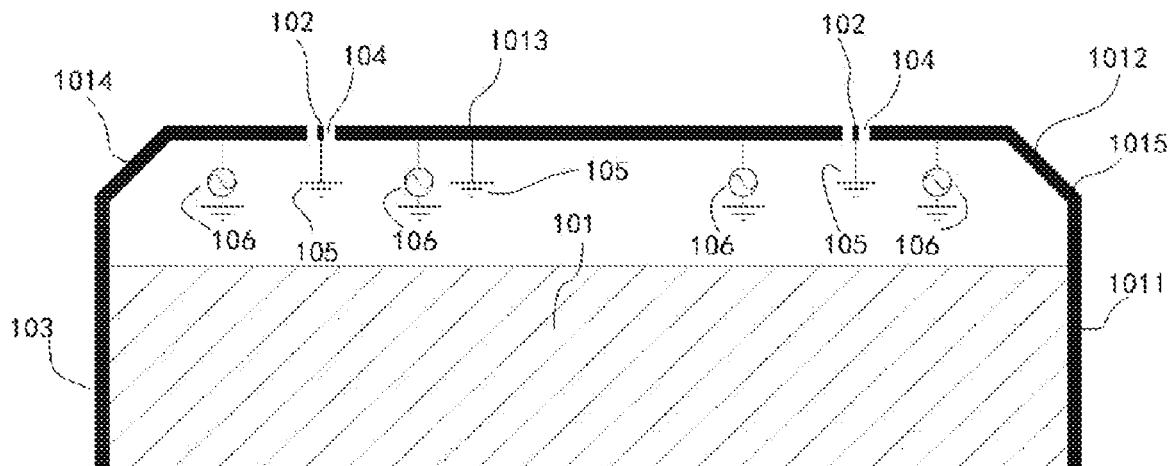
Primary Examiner — Tho G Phan

(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 1/221**
(2013.01); **H01Q 1/243** (2013.01); **H01Q 1/42**
(2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/221; H01Q 1/22;
H01Q 1/38; H01Q 1/42; H01Q 5/371;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,088,290 B2 8/2006 Ohno et al.
7,161,555 B2 1/2007 Ohno et al.
(Continued)

FOREIGN PATENT DOCUMENTS

JP 2000-278030 A 10/2000
KR 10-2015-0116417 A 10/2015

OTHER PUBLICATIONS

International Search Report dated Jun. 11, 2020, issued in International Application No. PCT/KR2020/002027.

(Continued)

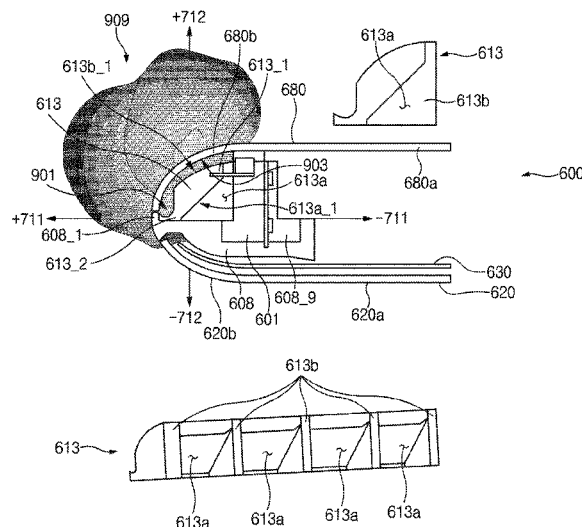
Primary Examiner — Hoang V Nguyen

(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**

(56) **References Cited**

U.S. PATENT DOCUMENTS

(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)

7,071,883 B2 * 7/2006 Cubley H01Q 1/2266
343/702
7,417,596 B2 * 8/2008 Zellweger H01Q 1/273
343/702
7,466,269 B2 12/2008 Haziza
7,466,281 B2 12/2008 Haziza
7,554,505 B2 6/2009 Haziza
(Continued)

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

FOREIGN PATENT DOCUMENTS

CN 106058436 A 10/2016
KR 10-2017-0084632 A 7/2017
KR 10-2018-0060299 A 6/2018

(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.

OTHER PUBLICATIONS

International Search Report dated Apr. 28, 2020.

Primary Examiner — Graham P Smith

Assistant Examiner — Jae K Kim

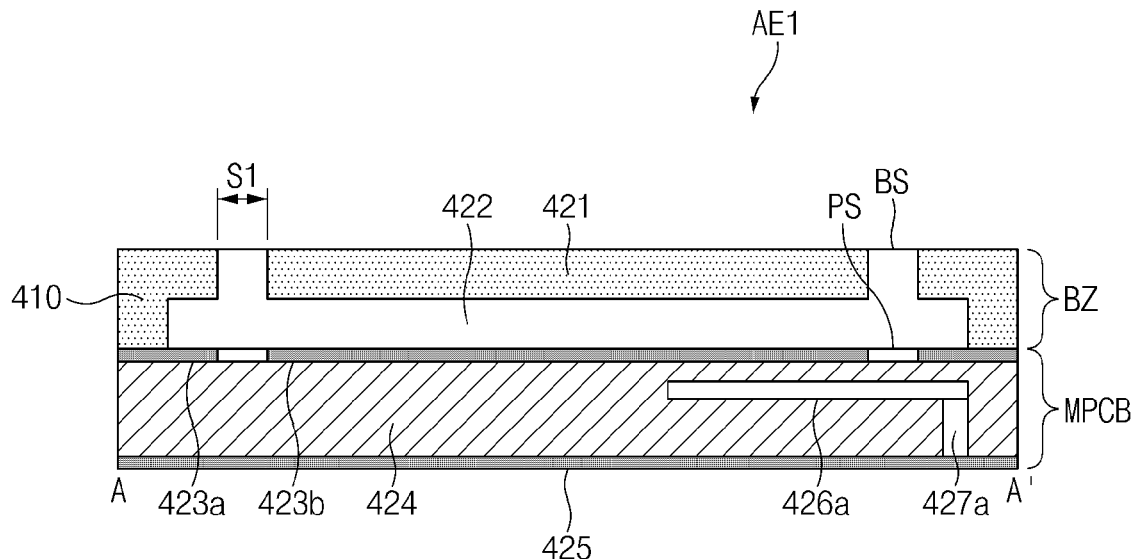
(74) *Attorney, Agent, or Firm* — Cha & Reiter, LLC

(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





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**

U.S. PATENT DOCUMENTS

7,289,071 B2 * 10/2007 Hung H01Q 9/42
343/702
8,638,271 B2 * 1/2014 Wang H01Q 5/364
343/846
8,779,986 B2 * 7/2014 Fan H01Q 9/42
343/700 MS
9,905,912 B2 * 2/2018 Wu H01Q 1/243
2012/0299781 A1 * 11/2012 Lee H01Q 9/42
343/700 MS
2012/0313827 A1 * 12/2012 Kim H01Q 1/243
343/702
2015/0200456 A1 * 7/2015 You H01Q 9/42
343/722
2015/0200457 A1 * 7/2015 Chan H01Q 5/357
343/700 MS

* cited by examiner

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

100

