US010985444B2

(12) **United States Patent**
Wang

(10) **Patent No.: US 10,985,444 B2**
(45) **Date of Patent: Apr. 20, 2021**

(54) **ANTENNA MODULE AND TERMINAL**

(71) Applicant: **BEIJING XIAOMI MOBILE SOFTWARE CO., LTD.**, Beijing (CN)

(72) Inventor: **Yali Wang**, Beijing (CN)

(73) Assignee: **BEIJING XIAOMI MOBILE SOFTWARE CO., LTD.**, Beijing (CN)

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

(21) Appl. No.: **16/699,388**

(22) Filed: **Nov. 29, 2019**

(65) **Prior Publication Data**

US 2021/0066787 A1 Mar. 4, 2021

(30) **Foreign Application Priority Data**

Aug. 30, 2019 (CN) 201910817109.7

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/04 (2006.01)
H04M 1/02 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 9/0464*** (2013.01); ***H04M 1/026*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/01; H01Q 9/0464; H04M 1/026
See application file for complete search history.

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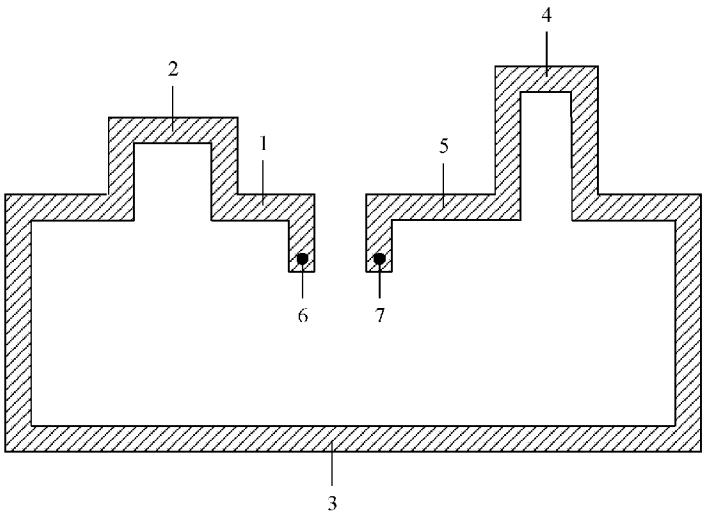
Primary Examiner — Md K Talukder
(74) *Attorney, Agent, or Firm* — Syncoda LLC; Feng Ma

(57) **ABSTRACT**

An antenna module includes: a feeding branch, a first branch, a second branch, a third branch and a grounding branch; the feeding branch is connected to a feeding point, and the grounding branch is connected to a grounding point; the first branch and the third branch are concave branches; the second branch is a bent branch; the feeding branch, the first branch, the second branch, the third branch and the grounding branch are connected in sequence to form an annular structure with a slot, the slot is located between the feeding branch and the grounding branch, and the slot is internally insulated.

19 Claims, 6 Drawing Sheets



US010985452B2

(12) **United States Patent**
Hung

(10) **Patent No.: US 10,985,452 B2**
(45) **Date of Patent: Apr. 20, 2021**

(54) **ANTENNA ELEMENTS**

(71) Applicant: **Hewlett-Packard Development Company, L.P.**, Spring, TX (US)

(72) Inventor: **Kuan-Jung Hung**, Taipei (TW)

(73) Assignee: **Hewlett-Packard Development Company, L.P.**, Spring, TX (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.: **16/603,855**

(22) PCT Filed: **Apr. 17, 2017**

(86) PCT No.: **PCT/US2017/027947**
§ 371 (c)(1),
(2) Date: **Oct. 9, 2019**

(87) PCT Pub. No.: **WO2018/194546**
PCT Pub. Date: **Oct. 25, 2018**

(65) **Prior Publication Data**

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(51) **Int. Cl.**

H01Q 1/48	(2006.01)
H01Q 1/38	(2006.01)
H01Q 13/10	(2006.01)
H01Q 5/321	(2015.01)
H01Q 9/42	(2006.01)
H01Q 5/328	(2015.01)
H01Q 1/22	(2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/38*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/321*** (2015.01); ***H01Q 5/328*** (2015.01); ***H01Q 9/42*** (2013.01); ***H01Q 13/10*** (2013.01); *H01Q 1/2266* (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 1/48; H01Q 1/2258; H01Q 13/10; H01Q 5/321; H01Q 5/328; H01Q 9/42
See application file for complete search history.

(56) **References Cited**

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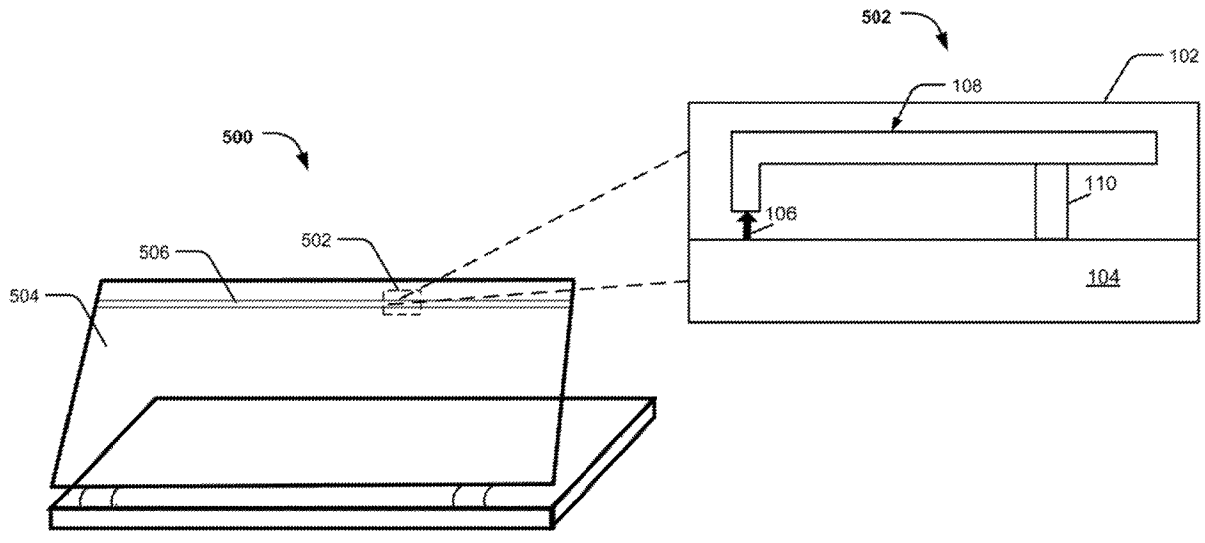
Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — HPI Patent Department

(57) **ABSTRACT**

Examples of antenna elements are described herein. In an example, the antenna element may include a substrate for being disposed on an enclosure. The substrate may include a ground plane. Further, the antenna element may include an antenna feeder that may be electrically coupled to the ground plane. The antenna element may also include a radiator. The radiator may be electrically coupled to the antenna feeder. In addition, the antenna element may include a lump component connected to the radiator.

11 Claims, 8 Drawing Sheets



US010985459B2

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

(10) **Patent No.: US 10,985,459 B2**
(45) **Date of Patent: Apr. 20, 2021**

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

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

(72) Inventors: **Tun-Yuan Tsou**, New Taipei (TW); **Shu-Wei Jhang**, New Taipei (TW); **Yi-Te Chou**, New Taipei (TW); **Chang-Ching Huang**, New Taipei (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 34 days.

(21) Appl. No.: **16/684,981**

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Nov. 30, 2018 (CN) 201811455055.6

(51) **Int. Cl.**

H01Q 1/52	(2006.01)
H01Q 5/335	(2015.01)
H04B 1/00	(2006.01)
H01Q 1/22	(2006.01)
H01Q 1/24	(2006.01)

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

CPC ***H01Q 5/335*** (2015.01); ***H01Q 1/2291*** (2013.01); ***H01Q 1/243*** (2013.01); ***H04B 1/0064*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/335
USPC 343/853, 702, 852
See application file for complete search history.

(56) **References Cited**

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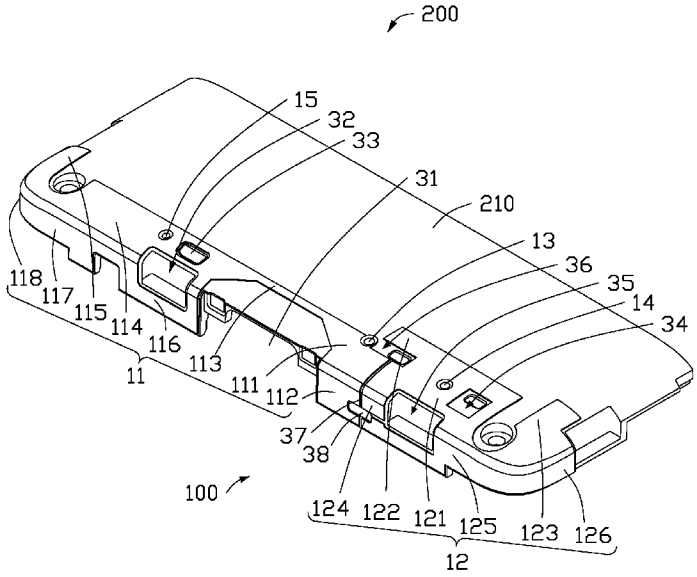
Primary Examiner — Peguy Jean Pierre
(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

An antenna structure of few components and reduced size which functions by switching between components to achieve radiation in three different frequency bands includes two radiating portions, a feeding portion, a matching circuit, and a first switching circuit. With the first switching circuit closed, current flows along a first radiating portion to activate a first frequency band. A second radiating portion obtains the current from the first switching circuit by coupling with the first radiating portion, to activate a second frequency band. Current in the first radiating portion can activate a third frequency band. With the first switching circuit open, current in the first radiating portion activates radiation in the first frequency band. The second radiating portion can radiate in second frequency band by coupling current from the first radiating portion. Frequency multiplication of the first frequency band can activate the third frequency band.

18 Claims, 15 Drawing Sheets



US010985460B2

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

(10) **Patent No.: US 10,985,460 B2**
(45) **Date of Patent: Apr. 20, 2021**

(54) **ANTENNA STRUCTURE**

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

(72) Inventors: **Yun-Jian Chang**, New Taipei (TW); **Geng-Hong Liou**, New Taipei (TW); **Yen-Hui Lin**, New Taipei (TW)

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

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

(21) Appl. No.: **16/535,215**

(22) Filed: **Aug. 8, 2019**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Aug. 9, 2018 (CN) 201810903857.2

(51) **Int. Cl.**

H01Q 5/371	(2015.01)
H01Q 5/335	(2015.01)
H01Q 5/328	(2015.01)
H01Q 21/00	(2006.01)
H01Q 9/04	(2006.01)
H01Q 9/14	(2006.01)
H01Q 13/10	(2006.01)
H01Q 1/24	(2006.01)

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

CPC ***H01Q 5/371*** (2015.01); ***H01Q 1/243*** (2013.01); ***H01Q 5/328*** (2015.01); ***H01Q 5/335*** (2015.01); ***H01Q 9/0407*** (2013.01); ***H01Q 9/14*** (2013.01); ***H01Q 13/10*** (2013.01); ***H01Q 21/0006*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/125; H01Q 1/185

See application file for complete search history.

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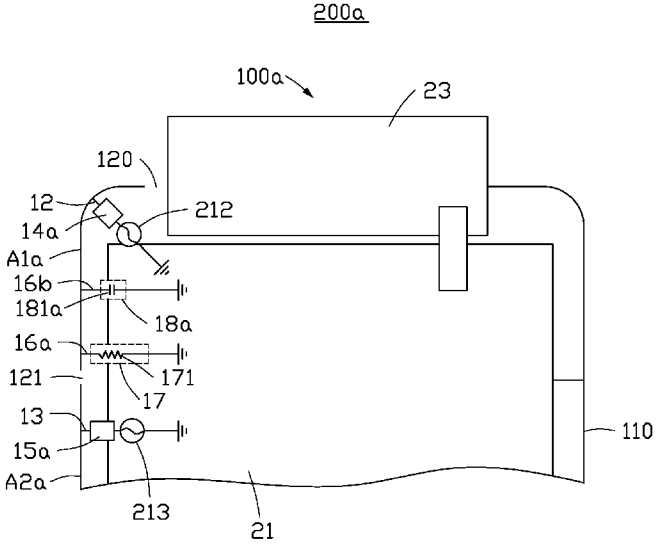
Primary Examiner — Daniel D Chang
(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

An antenna structure includes a border frame, a first feed portion, a second feed portion, and two ground portions. The border frame includes a first gap and a second gap passing through the border frame, thereby defining a first radiating portion and a second radiating portion. The first feed portion is electrically coupled to the first radiating portion to supply an electric current to the first radiating portion. The second feed portion is electrically coupled to the second radiating portion to supply an electric current to the second radiating portion. The two ground portions are disposed between the first feed portion and the second feed portion and separated from each other. The two ground portions are electrically coupled to the first radiating portion or the second radiating portion.

12 Claims, 14 Drawing Sheets



US010985473B2

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

(10) **Patent No.: US 10,985,473 B2**
(45) **Date of Patent: Apr. 20, 2021**

(54) **DIELECTRIC RESONATOR ANTENNA**

(71) Applicant: **City University of Hong Kong**, Kowloon (HK)

(72) Inventors: **Kwok Wa Leung**, Kowloon Tong (HK); **Nan Yang**, Sham Shui Po (HK); **Weiwei Li**, Toronto (CA)

(73) Assignee: **City University of Hong Kong**, Kowloon (HK)

(*) 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.: **16/556,499**

(22) Filed: **Aug. 30, 2019**

(65) **Prior Publication Data**

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(51) **Int. Cl.**

H01Q 1/38	(2006.01)
H01Q 21/24	(2006.01)
H01Q 21/00	(2006.01)
H01Q 1/50	(2006.01)
H01Q 9/04	(2006.01)

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

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(58) **Field of Classification Search**

CPC .. H01Q 1/38; H01Q 1/50; H01Q 9/04; H01Q 9/045; H01Q 9/0485; H01Q 21/0075; H01Q 21/06; H01Q 21/065; H01Q 21/24

See application file for complete search history.

(56) **References Cited**

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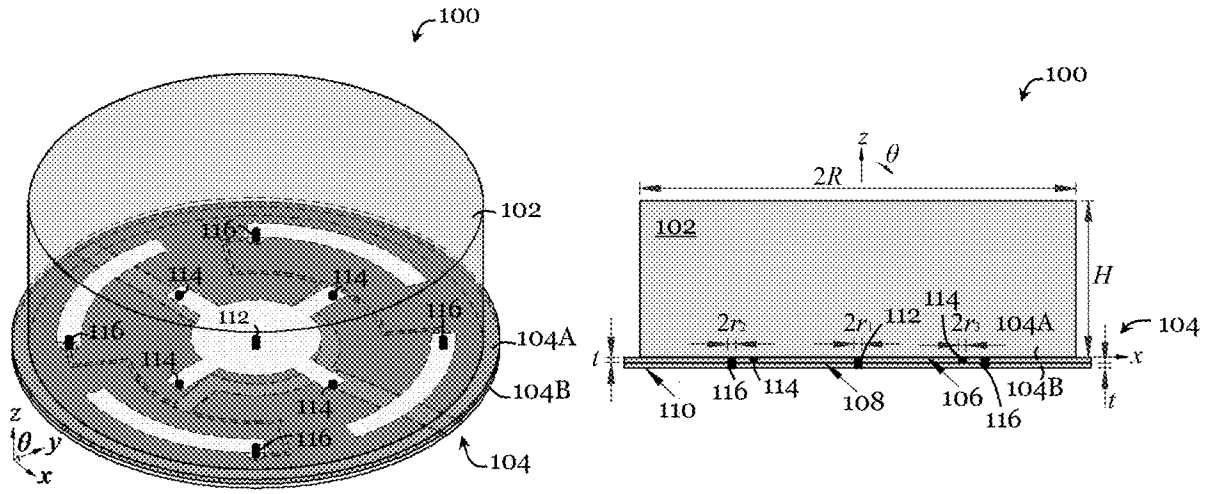
Primary Examiner — Jimmy T Vu

(74) *Attorney, Agent, or Firm* — Renner Kenner Greive Bobak Taylor & Weber

(57) **ABSTRACT**

A dielectric resonator antenna having a dielectric resonator element and a substrate assembly attached to the dielectric resonator element. The substrate assembly includes a feeding network arranged to: feed the dielectric resonator element to produce a first linearly-polarized omnidirectional radiation pattern at a first resonant mode, and feed the dielectric resonator element to produce a second linearly-polarized omnidirectional radiation pattern at a second resonant mode different from the first resonant mode.

26 Claims, 8 Drawing Sheets



US010990136B2

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

(10) **Patent No.: US 10,990,136 B2**
(45) **Date of Patent: Apr. 27, 2021**

(54) **WIRELESS COMMUNICATION DEVICE AND CASE ASSEMBLY**

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

(72) Inventors: **Cheng Hung Lin**, Taoyuan (TW); **Szu Po Wang**, Taoyuan (TW); **Chun Hsien Lee**, Taoyuan (TW)

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

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

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(22) Filed: **Aug. 12, 2019**

(65) **Prior Publication Data**

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(51) **Int. Cl.**

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H04B 1/3888	(2015.01)
H01Q 1/12	(2006.01)
H01Q 21/06	(2006.01)
H01Q 1/24	(2006.01)
H04B 7/0413	(2017.01)
H04B 7/06	(2006.01)

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

CPC ***G06F 1/166*** (2013.01); ***G06F 1/1626*** (2013.01); ***H01Q 1/125*** (2013.01); ***H01Q 21/065*** (2013.01); ***H04B 1/3888*** (2013.01); *H01Q 1/242* (2013.01); *H04B 7/0413* (2013.01); *H04B 7/0617* (2013.01)

(58) **Field of Classification Search**

CPC G06F 1/166; G06F 1/1626; H01Q 1/125; H01Q 21/065; H04B 1/3888

See application file for complete search history.

(56) **References Cited**

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2019/0393598	A1 *	12/2019	Logothetis	H01Q 3/08

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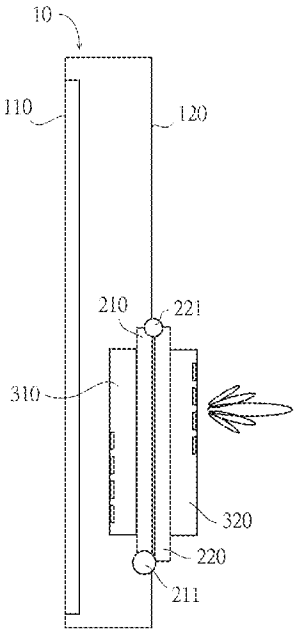
Primary Examiner — James Wu
Assistant Examiner — Hung Q Dang
(74) *Attorney, Agent, or Firm* — Cantor Colburn LLP

(57) **ABSTRACT**

A wireless communication device and a case assembly are provided. The wireless communication device includes main body, kickstand structure and antenna module. The main body includes display portion, back portion and RF signal module. The display and back portions are opposite, which the RF signal module is disposed between. The kickstand structure is rotationally pivoted to the back portion of main body. The antenna module is disposed on the kickstand structure and electrically connected to the RF signal module of main body. The case assembly is partially covered the wireless communication device and includes case covering the back portion of wireless communication device, kickstand structure rotationally pivoted to the case and antenna module disposed on the kickstand structure and electrically connecting to the RF signal module of wireless communication device. Thus, rotation of kickstand structure can change orientation of antenna module to transmit and receive wireless signals, so as to improve wireless signal transmission.

5 Claims, 7 Drawing Sheets



US010992043B2

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

(10) **Patent No.: US 10,992,043 B2**
(45) **Date of Patent: Apr. 27, 2021**

(54) **ANTENNA DEVICE AND CONTROL METHOD THEREOF**

(71) Applicant: **ASUSTeK COMPUTER INC.**, Taipei (TW)

(72) Inventors: **Pei-Chuan Huang**, Taipei (TW); **Shao-Kai Liu**, Taipei (TW)

(73) Assignee: **ASUSTEK COMPUTER INC.**, 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.

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(22) Filed: **Jul. 12, 2019**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jul. 19, 2018 (CN) 201810794869.6

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 9/04	(2006.01)
H01Q 1/36	(2006.01)
H01Q 19/00	(2006.01)
H01Q 1/50	(2006.01)

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

CPC ***H01Q 9/045*** (2013.01); ***H01Q 1/24*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/36*** (2013.01); ***H01Q 1/50*** (2013.01); ***H01Q 19/005*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 21/30; H01Q 5/371; H01Q 5/335; H01Q 21/28; H01Q 5/321;

(Continued)

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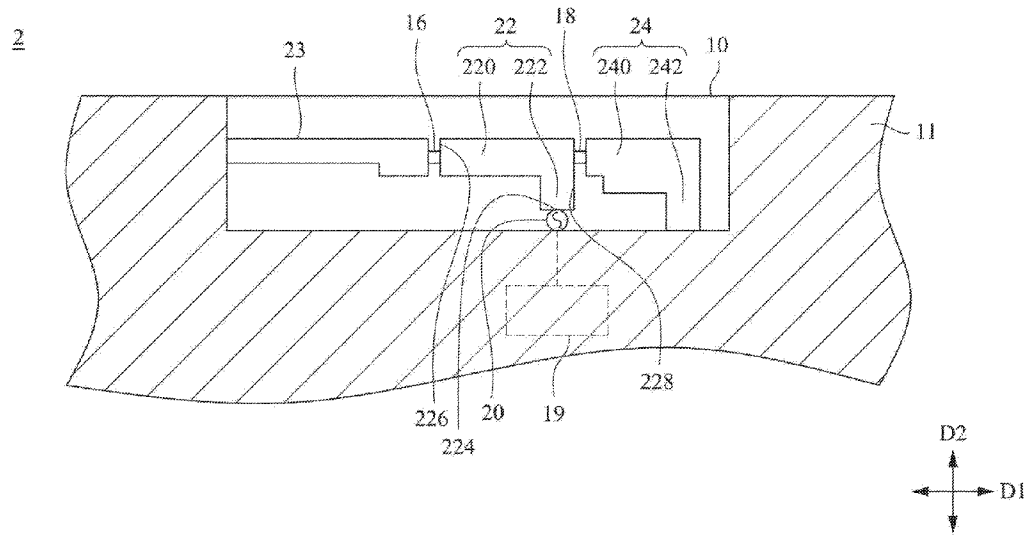
Primary Examiner — Vibol Tan
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

An antenna device and its control method is provided. The antenna device includes: a ground layer; a feeding element, connecting to the ground layer; a first radiating element, extending along a first direction and connected to the ground layer; a second radiating element, extending along a second direction which is orthogonal to the first direction, and connected the ground layer; a first switching element, coupled between the feeding element and the first radiating element, and configured to electrically connect or disconnect the feeding element and the first radiating element; and a second switching element disposed between the feeding element and the second radiating element, and configured to electrically connect or disconnect the feeding element and the second radiating element.

16 Claims, 10 Drawing Sheets



US010992059B2

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

(10) **Patent No.: US 10,992,059 B2**
(45) **Date of Patent: Apr. 27, 2021**

(54) **MILLIMETER WAVE ARRAY ANTENNA MODULE AND MOBILE TERMINAL**

(71) Applicant: **AAC Technologies Pte. Ltd.**, Singapore (SG)

(72) Inventors: **Zhimin Zhu**, Shenzhen (CN); **Zhengdong Yong**, Shenzhen (CN); **Xiaoyue Xia**, Shenzhen (CN); **Chao Wang**, Shenzhen (CN)

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

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(21) Appl. No.: **16/706,880**

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(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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H01Q 1/22 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 21/08*** (2013.01); ***H01Q 1/2283*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 3/38*** (2013.01); ***H01Q 9/0407*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/08; H01Q 1/2283; H01Q 1/243; H01Q 3/38; H01Q 9/0407
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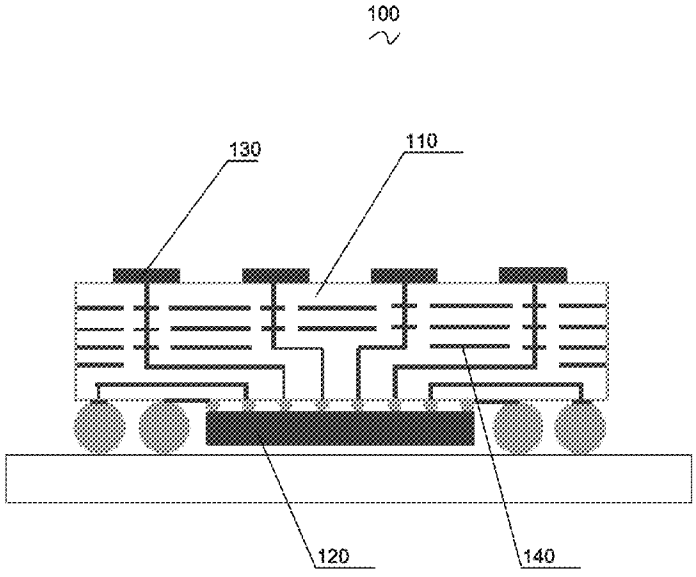
Primary Examiner — Hai V Nguyen
(74) *Attorney, Agent, or Firm* — W&G Law Group LLP

(57) **ABSTRACT**

A millimeter wave array antenna module and a mobile terminal are provided. The millimeter wave array antenna module includes a dielectric substrate, a radio frequency integrated circuit chip affixed to one side of the dielectric substrate, a plurality of antenna units arranged in an array and disposed on a side of the dielectric substrate facing away from the radio frequency integrated circuit chip, and a feeding network formed in the dielectric substrate. Each antenna unit is electrically connected to the radio frequency integrated circuit chip through the feeding network, and includes a substrate integrated waveguide and a patch antenna. The substrate integrated waveguide has a back cavity and the patch antenna is arranged in the back cavity and affixed to the substrate integrated waveguide.

11 Claims, 3 Drawing Sheets



US010992064B2

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

(10) **Patent No.: US 10,992,064 B2**
(45) **Date of Patent: Apr. 27, 2021**

(54) **MOBILE DEVICE**

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

(72) Inventors: **Yu-Chia Chang**, New Taipei (TW); **Wan Chu Wei**, New Taipei (TW); **Chun-Hong Kuo**, New Taipei (TW); **Tsung-Te Lin**, 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 5 days.

(21) Appl. No.: **16/416,332**

(22) Filed: **May 20, 2019**

(65) **Prior Publication Data**

US 2020/0313308 A1 Oct. 1, 2020

(30) **Foreign Application Priority Data**

Mar. 29, 2019 (TW) 108111140

(51) **Int. Cl.**

H01Q 21/28	(2006.01)
H04B 7/0426	(2017.01)
H01Q 21/29	(2006.01)
H01Q 1/50	(2006.01)

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

CPC ***H01Q 21/28*** (2013.01); ***H01Q 1/50*** (2013.01); ***H01Q 21/29*** (2013.01); ***H04B 7/0426*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 21/28; H01Q 1/50; H01Q 21/29; H04B 4/0426; H04B 7/0456; H04B 7/0602

See application file for complete search history.

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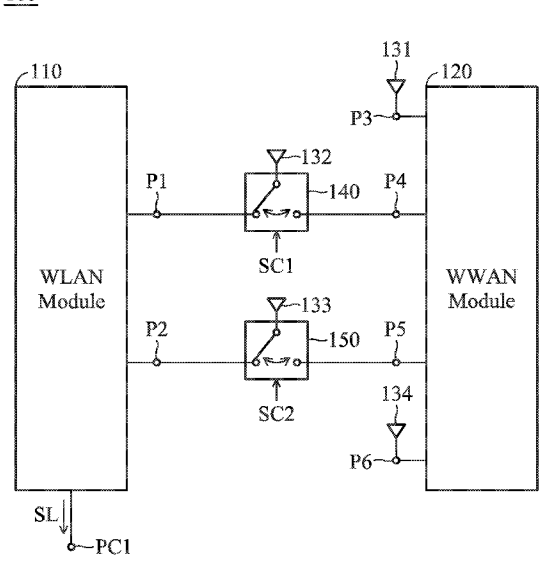
(Continued)

Primary Examiner — Wei (Victor) Y Chan
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

A mobile device includes a WLAN (Wireless Local Area Network) module, a WWAN (Wireless Wide Area Network) module, a first antenna element, a second antenna element, a third antenna element, a fourth antenna element, a first switch element, and a second switch element. The WLAN module has a first port, a second port, and a first control port. The WWAN module has a third port, a fourth port, a fifth port, and a sixth port. The first antenna element is coupled to the third port. The first switch element couples the second antenna element to the first port or the fourth port according to a first control signal. The second switch element couples the third antenna element to the second port or the fifth port according to a second control signal. The fourth antenna element is coupled to the sixth port.

12 Claims, 8 Drawing Sheets



US010992065B2

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

(10) **Patent No.: US 10,992,065 B2**
(45) **Date of Patent: Apr. 27, 2021**

(54) **MIMO ANTENNA AND TERMINAL**

(71) Applicant: **AAC Technologies Pte. Ltd.**, Singapore (SG)

(72) Inventors: **Yue Liang**, Shenzhen (CN); **Jianan Wang**, Shenzhen (CN); **Yongli Chen**, Shenzhen (CN)

(73) Assignee: **AAC Technologies 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 27 days.

(21) Appl. No.: **16/703,889**

(22) Filed: **Dec. 5, 2019**

(65) **Prior Publication Data**

US 2020/0212599 A1 Jul. 2, 2020

(30) **Foreign Application Priority Data**

Dec. 28, 2018 (CN) 201811625843.5

(51) **Int. Cl.**

H01Q 21/28	(2006.01)
H01Q 1/24	(2006.01)
H01Q 1/22	(2006.01)
H01Q 21/06	(2006.01)
H01Q 21/30	(2006.01)
H04B 7/0413	(2017.01)

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

CPC ***H01Q 21/28*** (2013.01); ***H01Q 1/2283*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 21/064*** (2013.01); ***H01Q 21/065*** (2013.01); ***H01Q 21/30*** (2013.01); *H04B 7/0413* (2013.01)

(58) **Field of Classification Search**

CPC H01Q 21/28; H01Q 1/2283; H01Q 1/243; H01Q 21/064; H01Q 21/065; H01Q 21/30

See application file for complete search history.

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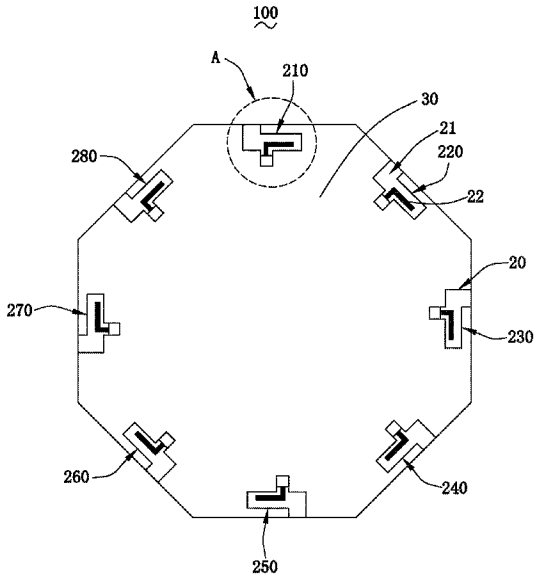
Primary Examiner — Graham P Smith
(74) *Attorney, Agent, or Firm* — W&G Law Group LLP

(57) **ABSTRACT**

The present invention provides a MIMO antenna. The MIMO antenna includes a regular octagonal substrate and eight antenna components with a same structure arranged along eight edges of the regular octagonal substrate, and the eight antenna components are distributed in an annular array. The present disclosure further provides a terminal applying with the MIMO antenna. The eight antenna components in the MIMO antenna provided by the present disclosure are distributed in an annular array, so that an area occupied by the MIMO antenna in the terminal is greatly reduced; and moreover, the antenna components have good isolation therebetween and are simple in form, and the MIMO antenna has a higher bandwidth.

12 Claims, 4 Drawing Sheets



US010998609B2

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

(10) **Patent No.: US 10,998,609 B2**
(45) **Date of Patent: May 4, 2021**

(54) **LOOP ANTENNA**

(71) Applicant: **Japan Aviation Electronics Industry, Limited**, Tokyo (JP)

(72) Inventors: **Kenta Tsuchiya**, Tokyo (JP); **Osamu Hirata**, Tokyo (JP); **Daisuke Hiraoka**, Tokyo (JP); **Mitsunori Sato**, Tokyo (JP); **Yutaka Takezawa**, Tokyo (JP); **Yutaro Kogawa**, Tokyo (JP)

(73) Assignee: **Japan Aviation Electronics Industry, Limited**, 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.

(21) Appl. No.: **16/613,633**

(22) PCT Filed: **Jan. 23, 2018**

(86) PCT No.: **PCT/JP2018/001893**
§ 371 (c)(1),
(2) Date: **Nov. 14, 2019**

(87) PCT Pub. No.: **WO2018/220893**
PCT Pub. Date: **Dec. 6, 2018**

(65) **Prior Publication Data**

US 2020/0203830 A1 Jun. 25, 2020

(30) **Foreign Application Priority Data**

May 31, 2017 (JP) JP2017-108033

(51) **Int. Cl.**
H01Q 7/00 (2006.01)
H01Q 1/12 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/1271*** (2013.01); ***H01Q 7/00*** (2013.01); ***H01Q 21/30*** (2013.01); *H01Q 1/38* (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/1271; H01Q 7/00
(Continued)

(56) **References Cited**

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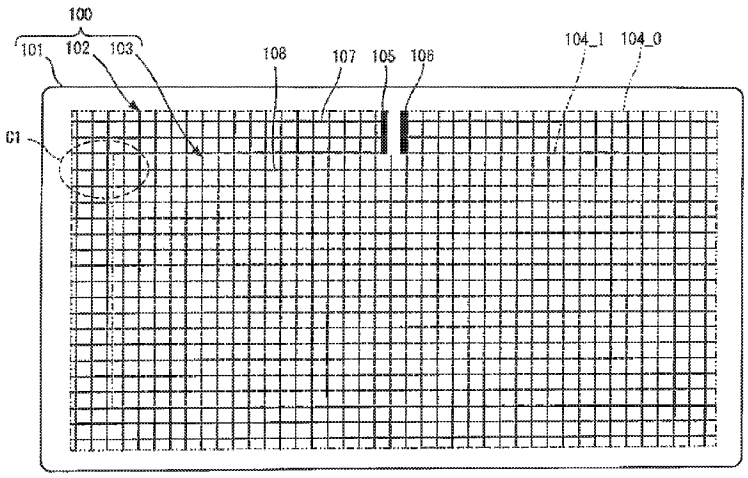
Primary Examiner — Peguy Jean Pierre
(74) *Attorney, Agent, or Firm* — Collard & Roe, P.C.

(57) **ABSTRACT**

This loop antenna is provided with: an insulating substrate; an antenna portion that is a conductor provided on the substrate and includes a first feeding portion, a second feeding portion, and an antenna mesh portion having a mesh structure and forming a loop shape by connecting the two feeding portions to each other; and a dummy pattern part portion that is a conductor having a mesh structure and provided in a region surrounded by the antenna portion, and is isolated from the antenna portion. The dummy pattern portion has at least one cut portion that cuts a path included in the mesh structure.

7 Claims, 18 Drawing Sheets



US010998610B2

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

(10) **Patent No.: US 10,998,610 B2**
(45) **Date of Patent: May 4, 2021**

(54) **ELECTRONIC DEVICE, METHOD FOR ADJUSTING OPERATING FREQUENCY BAND OF ANTENNA OF ELECTRONIC DEVICE**

(71) Applicant: **BEIJING XIAOMI MOBILE SOFTWARE CO., LTD.**, Beijing (CN)

(72) Inventors: **Fan Nie**, Beijing (CN); **Bingxiao Wang**, Beijing (CN); **Linchuan Wang**, Beijing (CN)

(73) Assignee: **BEIJING XIAOMI MOBILE SOFTWARE CO., LTD.**, Beijing (CN)

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

(21) Appl. No.: **16/425,920**

(22) Filed: **May 29, 2019**

(65) **Prior Publication Data**

US 2019/0372195 A1 Dec. 5, 2019

(30) **Foreign Application Priority Data**

May 31, 2018 (CN) 201810551275.2

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 5/378 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/22*** (2013.01); ***H01Q 1/50*** (2013.01); ***H01Q 5/378*** (2015.01); ***H01Q 9/42*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 13/10; H01Q 1/50; H01Q 1/36; H01Q 5/50
(Continued)

(56) **References Cited**

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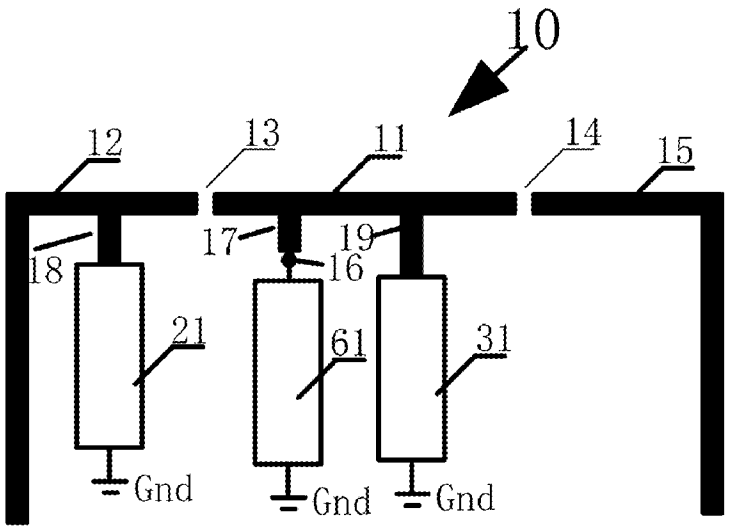
Primary Examiner — Jany Richardson
(74) *Attorney, Agent, or Firm* — Syncoda LLC; Feng Ma

(57) **ABSTRACT**

An electronic device includes a feeding point, a first switch module, a second switch module, a first connecting portion, a second connecting portion and a third connecting portion; the feeding point is connected to an end of the first sub-bezel through the first connecting portion; a first end of the first switch module is connected to the second partition through the second connecting portion, and a second end of the first switch module is grounded; a connection position between the second connecting portion and the second partitioning is adjacent to the feeding point; and a first end of the second switch module is connected to the first sub-bezel through the third connecting portion, and a second end of the second switch module is grounded.

18 Claims, 8 Drawing Sheets



US010998616B2

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

(10) **Patent No.: US 10,998,616 B2**
(45) **Date of Patent: May 4, 2021**

(54) **ELECTRONIC DEVICE WITH MILLIMETER WAVE ANTENNA ARRAYS**

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

(72) Inventors: **Matthew A. Mow**, Los Altos, CA (US); **Basim H. Noori**, San Jose, CA (US); **Mattia Pascolini**, San Francisco, CA (US); **Xu Han**, San Jose, CA (US); **Victor C. Lee**, Sunnyvale, CA (US); **Ming-Ju Tsai**, Cupertino, CA (US); **Simone Paulotto**, Redwood City, 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 200 days.

(21) Appl. No.: **16/272,932**

(22) Filed: **Feb. 11, 2019**

(65) **Prior Publication Data**

US 2019/0173160 A1 Jun. 6, 2019

Related U.S. Application Data

(63) Continuation of application No. 15/275,183, filed on Sep. 23, 2016, now Pat. No. 10,205,224.

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

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/22*** (2013.01); ***H01Q 1/242*** (2013.01); ***H01Q 1/48*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC ... H01Q 21/062; H01Q 21/065; H01Q 1/2283
See application file for complete search history.

(56) **References Cited**

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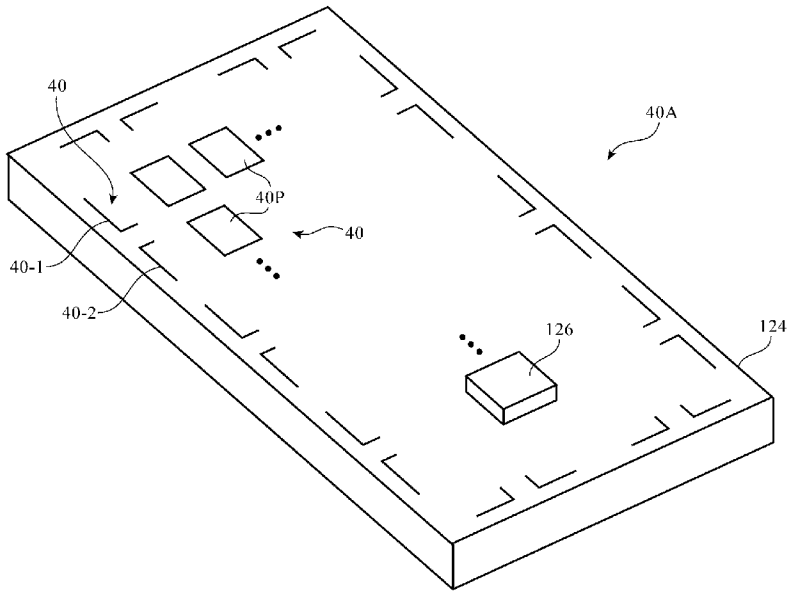
(Continued)

Primary Examiner — Ricardo I Magallanes
(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; Tianyi He

(57) **ABSTRACT**

An electronic device may be provided with wireless circuitry. The wireless circuitry may include one or more antennas. The antennas may include millimeter wave antenna arrays formed from arrays of patch antennas, dipole antennas or other millimeter wave antennas on millimeter wave antenna array substrates. Circuitry such as upconverter and downconverter circuitry may be mounted on the substrates. The upconverter and downconverter may be coupled to wireless communications circuitry such as a baseband processor circuit using an intermediate frequency signal path. The electronic device may have opposing front and rear faces. A display may cover the front face. A rear housing wall may cover the rear face. A metal midplate may be interposed between the display and rear housing wall. Millimeter wave antenna arrays may transmit and receive antenna signals through the rear housing wall.

19 Claims, 8 Drawing Sheets



US010998622B2

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

(10) **Patent No.: US 10,998,622 B2**
(45) **Date of Patent: May 4, 2021**

(54) **ANTENNA FOR WIRELESS COMMUNICATION AND ELECTRONIC DEVICE INCLUDING THE SAME**

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

(72) Inventors: **Min Sakong**, Gyeongsangbuk-do (KR); **Dong Ryul Shin**, Daegu (KR); **Yoon Jae Lee**, Seoul (KR); **Seong Tae Jeong**, Gyeonggi-do (KR); **Jin Woo Jung**, Seoul (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 190 days.

(21) Appl. No.: **15/656,669**

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

(65) **Prior Publication Data**

US 2018/0026361 A1 Jan. 25, 2018

(30) **Foreign Application Priority Data**

Jul. 21, 2016 (KR) 10-2016-0092871
Mar. 28, 2017 (KR) 10-2017-0039558

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 3/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 3/00*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/245*** (2013.01); ***H01Q 1/48*** (2013.01); ***H04B 1/3838*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/30; H01Q 5/335; H01Q 9/24; H01Q 1/245; H01Q 1/48; H04B 1/3838
See application file for complete search history.

(56) **References Cited**

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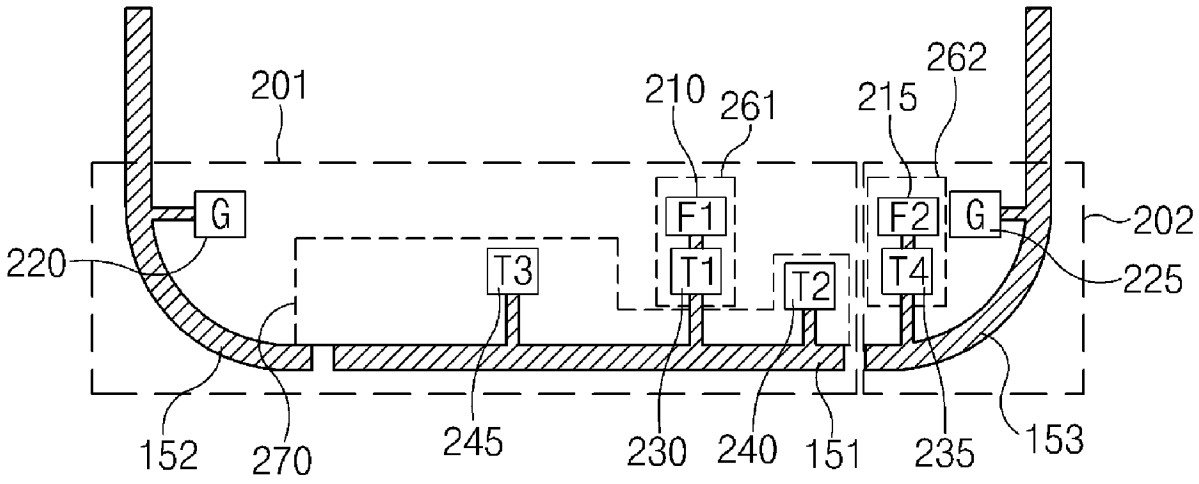
Primary Examiner — Awat M Salih
(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(57) **ABSTRACT**

A communication method performed in an electronic device including a conductive pattern and the electronic device are provided. The electronic device includes a conductive pattern used as a radiator for wireless communication, a feeding unit connected with the conductive pattern, a ground unit connected with the conductive pattern, a first impedance matching circuit disposed in a first area adjacent to the feeding unit and connected to the conductive pattern, a second impedance matching circuit disposed in a second area adjacent to the conductive pattern and connected to the conductive pattern, and a control unit that matches impedance by controlling at least one of the first impedance matching circuit and the second impedance matching circuit by a closed-loop scheme.

14 Claims, 19 Drawing Sheets



US010998631B2

(12) **United States Patent**
Duan

(10) **Patent No.: US 10,998,631 B2**
(45) **Date of Patent: May 4, 2021**

(54) **ANTENNA SYSTEM**

(71) Applicant: **Sercomm Corporation**, Taipei (TW)

(72) Inventor: **Jhih-Hao Duan**, Taipei (TW)

(73) Assignee: **SERCOMM CORPORATION**, Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 186 days.

(21) Appl. No.: **16/263,418**

(22) Filed: **Jan. 31, 2019**

(65) **Prior Publication Data**

US 2019/0252778 A1 Aug. 15, 2019

(30) **Foreign Application Priority Data**

Feb. 13, 2018 (CN) 201820255966.3

(51) **Int. Cl.**
H01Q 5/48 (2015.01)
H01Q 21/30 (2006.01)
H01Q 9/26 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 5/48*** (2015.01); ***H01Q 9/26*** (2013.01); ***H01Q 21/30*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/48; H01Q 21/30; H01Q 9/26; H01Q 7/00; H01Q 21/28; H01Q 25/00; H01Q 1/521; H01Q 1/52; H01Q 5/371
See application file for complete search history.

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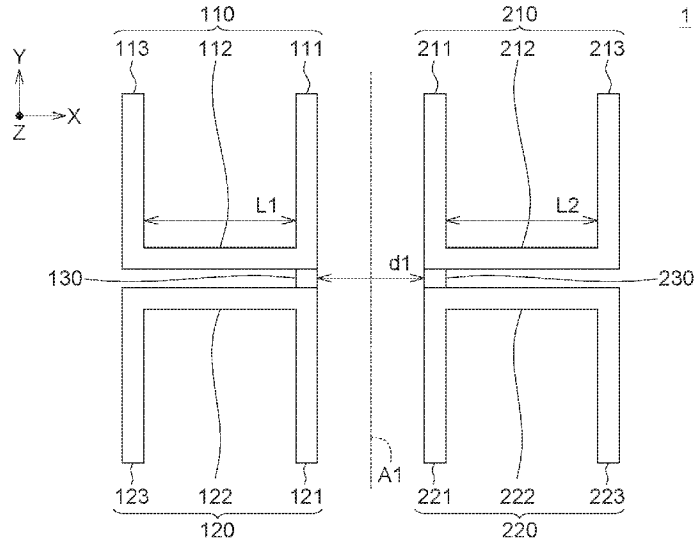
(Continued)

Primary Examiner — Alexander H Taningco
Assistant Examiner — Amy X Yang
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

An antenna system is configured to transceive a wireless signal. The antenna system includes a first dipole antenna and a second dipole antenna. The first dipole antenna includes a first radiator, a second radiator, and a first feeding point. The second dipole antenna includes a third radiator, a fourth radiator, and a second feeding point. The first radiator and the third radiator have a notch facing towards a first direction. The second radiator and the fourth radiator have a notch facing towards a second direction inverse to the first direction. The first feeding point, disposed between the first radiator and the second radiator, is located on one side of the first dipole antenna adjacent to the second dipole antenna. The second feeding point, disposed between the third radiator and the fourth radiator, is located on one side of the second dipole antenna adjacent to the first dipole antenna.

11 Claims, 6 Drawing Sheets



US010998632B2

(12) **United States Patent**
Gu

(10) **Patent No.: US 10,998,632 B2**
(45) **Date of Patent: *May 4, 2021**

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

(71) Applicant: **AAC Technologies Pte. Ltd.**, Singapore (SG)

(72) Inventor: **Haichuan Gu**, Shenzhen (CN)

(73) Assignee: **AAC Technologies 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.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/524,041**

(22) Filed: **Jul. 27, 2019**

(65) **Prior Publication Data**

US 2020/0044346 A1 Feb. 6, 2020

(30) **Foreign Application Priority Data**

Aug. 3, 2018 (CN) 201810876500.X

(51) **Int. Cl.**

H01Q 5/50	(2015.01)
H01Q 5/335	(2015.01)
H04B 7/0413	(2017.01)
H01Q 5/328	(2015.01)
H01Q 1/24	(2006.01)

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

CPC ***H01Q 5/50*** (2015.01); ***H01Q 1/241*** (2013.01); ***H01Q 5/328*** (2015.01); ***H04B 7/0413*** (2013.01)

(58) **Field of Classification Search**

CPC .. H01Q 5/00; H01Q 5/35; H01Q 5/50; H01Q 5/328; H01Q 5/335; H01Q 1/241–243; H04B 7/0413

See application file for complete search history.

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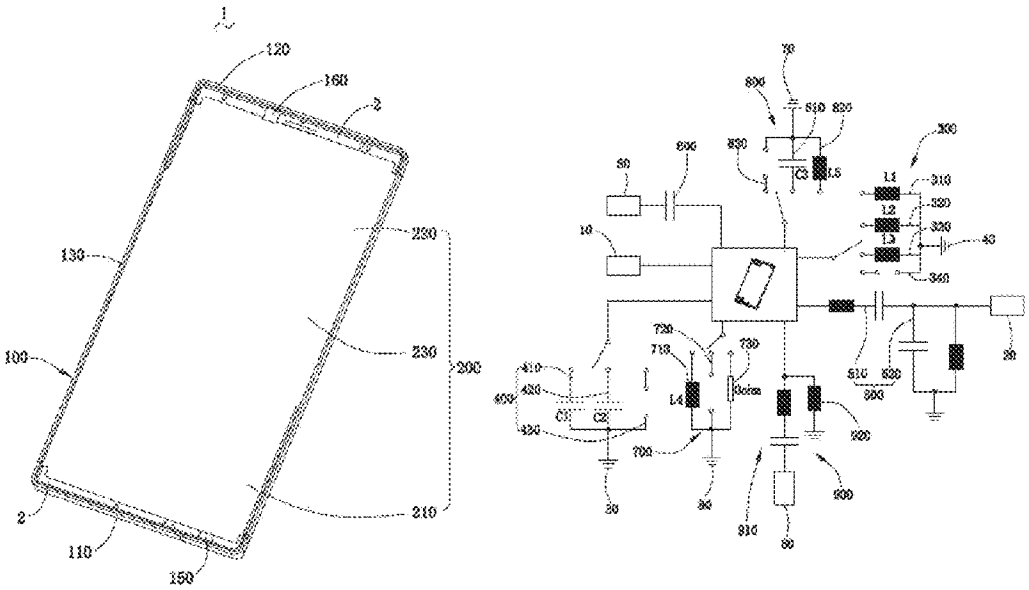
Primary Examiner — Henry Luong
(74) *Attorney, Agent, or Firm* — W&G Law Group LLP

(57) **ABSTRACT**

The present disclosure provides an antenna system and a mobile terminal. The antenna system comprises a metal frame, a main board received in the metal frame, and a first feeding point, a second feeding point, a first grounding point, a second grounding point, a third feeding point, a fourth feeding point, a third grounding point, a fourth grounding point, a first tuning switch, a second tuning switch, a first matching network, a variable capacitor, a third tuning switch, a fourth tuning switch, and a second matching network disposed at the main board. The metal frame is partitioned into a first radiating portion and a second radiating portion at the bottom and a third radiating portion and a fourth radiating portion at the top.

15 Claims, 13 Drawing Sheets



US010998633B2

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

(10) **Patent No.: US 10,998,633 B2**
(45) **Date of Patent: May 4, 2021**

(54) **COMPACT WIDEBAND HIGH GAIN CIRCULARLY POLARIZED ANTENNA**

(71) Applicant: **Agency for Science, Technology and Research**, Singapore (SG)

(72) Inventors: **Nasimuddin**, Singapore (SG); **Xianming Qing**, Singapore (SG)

(73) Assignee: **Agency for Science, Technology and Research**, 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.: **16/499,460**

(22) PCT Filed: **Mar. 19, 2018**

(86) PCT No.: **PCT/SG2018/050118**
§ 371 (c)(1),
(2) Date: **Sep. 30, 2019**

(87) PCT Pub. No.: **WO2018/182507**
PCT Pub. Date: **Oct. 4, 2018**

(65) **Prior Publication Data**

US 2020/0076082 A1 Mar. 5, 2020

(30) **Foreign Application Priority Data**

Mar. 31, 2017 (SG) 10201702690U

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

(52) **U.S. Cl.**
CPC ***H01Q 9/0428*** (2013.01); ***H01Q 9/045*** (2013.01); ***H01Q 21/065*** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 9/0428; H01Q 9/0421; H01Q 21/065; H01Q 9/0414; H01Q 9/045; H01Q 9/0442; H01Q 21/24
See application file for complete search history.

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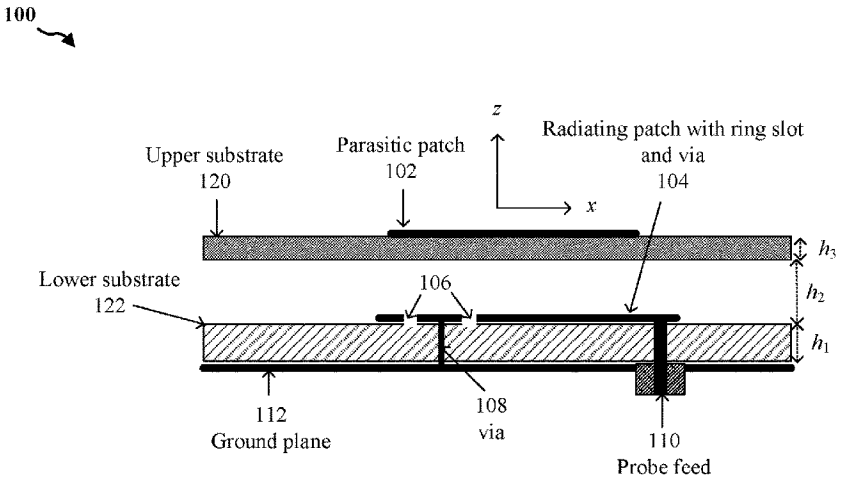
Primary Examiner — Graham P Smith
Assistant Examiner — Jae E Kim
(74) *Attorney, Agent, or Firm* — Winstead PC

(57) **ABSTRACT**

A compact wideband single feed circularly polarized antenna is provided. The circularly polarized antenna may include a ground plane. The circularly polarized antenna may include a radiating patch with an embedded ring-shaped slot. The circularly polarized antenna may include a via that shorts a round section of the radiating patch surrounded by the ring-shaped slot to the ground plane. The circularly polarized antenna may include a coaxial feed. The inner conductive material of the coaxial feed may be connected to the radiating patch and the outer conductive material of the coaxial feed may touch the ground plane. The circularly polarized antenna may include a slit-slotted parasitic square patch.

20 Claims, 15 Drawing Sheets



US011005154B2

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

(10) **Patent No.: US 11,005,154 B2**
(45) **Date of Patent: May 11, 2021**

(54) **ANTENNAS IN FRAMES FOR DISPLAY PANELS**

(71) Applicant: **Hewlett-Packard Development Company, L.P.**, Spring, TX (US)

(72) Inventors: **Kuan-Jung Hung**, Taipei (TW); **Chun-Chih Liu**, Taipei (TW)

(73) Assignee: **Hewlett-Packard Development Company, L.P.**, Spring, TX (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.: **16/603,612**

(22) PCT Filed: **Apr. 11, 2017**

(86) PCT No.: **PCT/US2017/027008**
§ 371 (c)(1),
(2) Date: **Oct. 8, 2019**

(87) PCT Pub. No.: **WO2018/190808**
PCT Pub. Date: **Oct. 18, 2018**

(65) **Prior Publication Data**

US 2020/0136230 A1 Apr. 30, 2020

(51) **Int. Cl.**

H01Q 1/22	(2006.01)
H01Q 7/00	(2006.01)
H01Q 5/385	(2015.01)
G06F 1/16	(2006.01)

(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/2266*** (2013.01); ***G06F 1/1681*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/385*** (2015.01); ***H01Q 7/00*** (2013.01); ***H01Q 9/42*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/2258; H01Q 1/2266; H01Q 1/48; H01Q 5/385; H01Q 7/00; H01Q 9/42; H01Q 1/22
See application file for complete search history.

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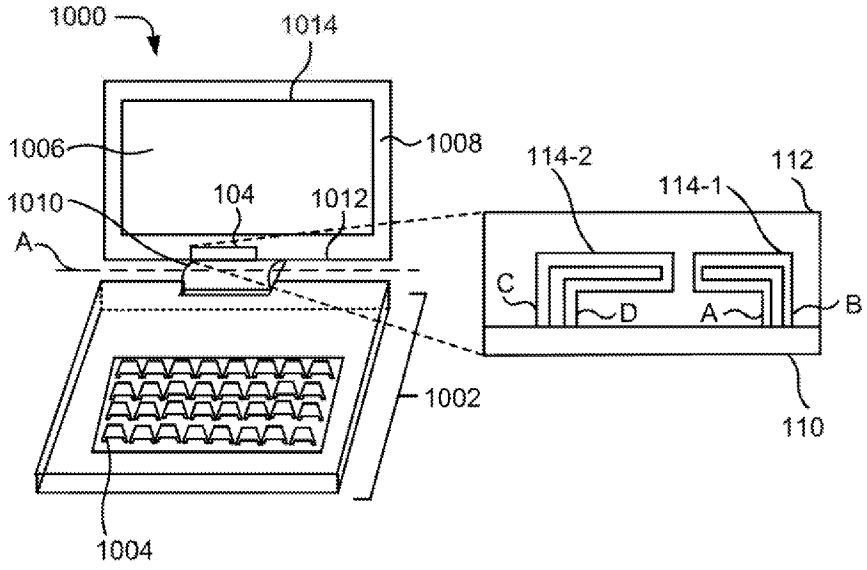
Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — HPI Patent Department

(57) **ABSTRACT**

The present subject matter describes positioning of an antenna inside a frame for a display panel of an electronic device. The antenna comprises a ground plate extending along a side of the frame, a substrate positioned on the ground plate, and two loop antenna elements formed on the substrate, both ends of each of the two loop antenna elements being connected to the ground plate.

15 Claims, 8 Drawing Sheets



US011005156B2

(12) **United States Patent**
Ying

(10) **Patent No.: US 11,005,156 B2**
(45) **Date of Patent: May 11, 2021**

(54) **ANTENNA ON PROTRUSION OF MULTI-LAYER CERAMIC-BASED STRUCTURE**

(71) Applicant: **Sony Mobile Communications Inc.**, Tokyo (JP)

(72) Inventor: **Zhinong Ying**, Lund (SE)

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

(*) 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.: **16/331,071**

(22) PCT Filed: **Sep. 15, 2016**

(86) PCT No.: **PCT/EP2016/071849**

§ 371 (c)(1),
(2) Date: **Mar. 6, 2019**

(87) PCT Pub. No.: **WO2018/050230**

PCT Pub. Date: **Mar. 22, 2018**

(65) **Prior Publication Data**

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

(52) **U.S. Cl.**
CPC ***H01Q 1/2283*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 9/0457*** (2013.01); ***H01Q 9/285*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/2283; H01Q 1/243; H01Q 9/0457; H01Q 9/285; H01Q 13/106; H01Q 21/205; H01Q 21/28; H01Q 21/30
See application file for complete search history.

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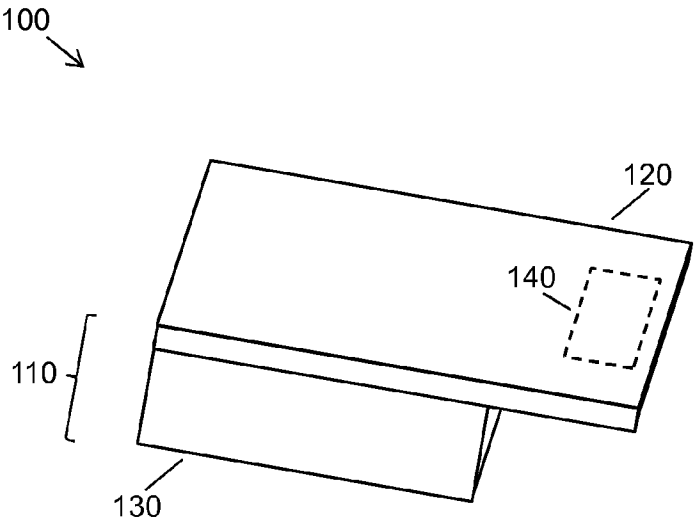
Primary Examiner — Jimmy T Vu
(74) *Attorney, Agent, or Firm* — Tucker Ellis LLP

(57) **ABSTRACT**

Antenna on protrusion of multi-layer ceramic-basedstructure An antenna device (**100**) includes a multi-layer ceramic-basedstructure (**110**) with a plurality of ceramic-basedlayers. Further, the antenna device (**100**) includes a protrusion (**120**) formed by at least one of the ceramic-basedlayers extending beyond at least one other of the ceramic-basedlayers at an edge of the multi-layer ceramic-basedstructure (**110**). Further, the antenna device (**100**) includes at least one antenna (**140**) formed by at least one conductive layer on the protrusion (**120**).

14 Claims, 6 Drawing Sheets



US011005162B2

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

(10) **Patent No.: US 11,005,162 B2**
(45) **Date of Patent: May 11, 2021**

(54) **ANTENNA STRUCTURE OF WIRELESS COMMUNICATION DEVICE**

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

(72) Inventors: **Cheng-Nan Hu**, New Taipei (TW); **Kwo-Jyr Wong**, New Taipei (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 55 days.

(21) Appl. No.: **16/545,213**

(22) Filed: **Aug. 20, 2019**

(65) **Prior Publication Data**

US 2020/0067178 A1 Feb. 27, 2020

(30) **Foreign Application Priority Data**

Aug. 21, 2018 (CN) 201810955002.4

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 1/36	(2006.01)
H01Q 9/04	(2006.01)
H01Q 5/378	(2015.01)
H01Q 5/328	(2015.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/36*** (2013.01); ***H01Q 5/328*** (2015.01); ***H01Q 5/378*** (2015.01); ***H01Q 9/0414*** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

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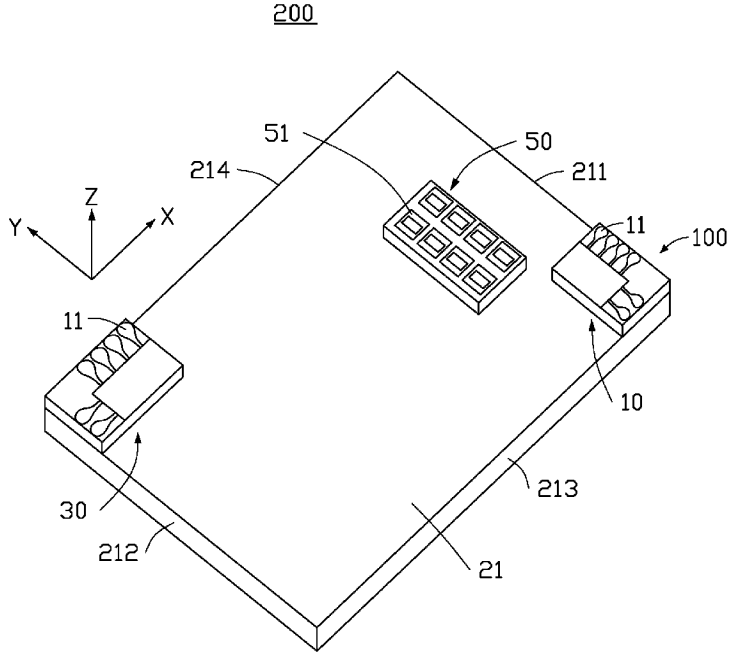
(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

An antenna structure includes a first array antenna having a number of first antenna units. The antenna units are arranged along a first direction and a second direction. The first antenna units are monopole antennas. The monopole antennas include a radiating body having a strip portion and a bulb portion. The radiating body generates radiation along the first direction or the second direction. The strip portion is electrically coupled to a signal source. The bulb portion is electrically coupled to the strip portion. An end of the bulb portion away from the strip portion is semi-circular in shape.

20 Claims, 19 Drawing Sheets



US011005171B2

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

(10) **Patent No.: US 11,005,171 B2**
(45) **Date of Patent: May 11, 2021**

(54) **ANTENNA DEVICE**

(71) Applicant: **DENSO CORPORATION**, Kariya (JP)

(72) Inventors: **Yuji Sugimoto**, Nisshin (JP); **Shiro Koide**, Kariya (JP); **Hiroyuki Izumi**, Obu (JP)

(73) Assignee: **DENSO CORPORATION**, Kariya (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.: **16/373,675**

(22) Filed: **Apr. 3, 2019**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. PCT/JP2017/034828, filed on Sep. 27, 2017.

(30) **Foreign Application Priority Data**

Oct. 5, 2016 (JP) JP2016-197466

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/42 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/42*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 9/0407*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC .. H01Q 9/0464; H01Q 9/0471; H01Q 9/0428; H01Q 9/065; H01Q 9/005;
(Continued)

(56) **References Cited**

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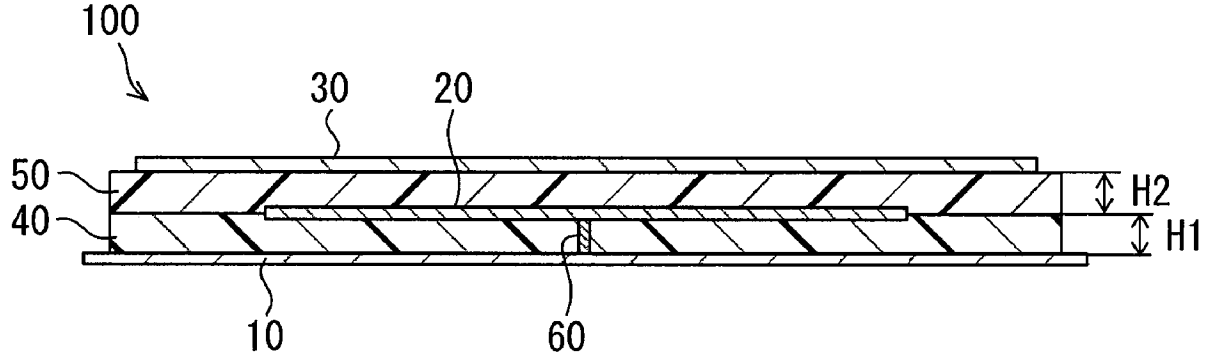
Primary Examiner — Awat M Salih
(74) *Attorney, Agent, or Firm* — Hamess, Dickey & Pierce, P.L.C.

(57) **ABSTRACT**

An antenna device includes a ground plate that is a plate-shaped conductor member, a patch portion that is a plate-shaped conductor member placed to be opposed to the ground plate with a predetermined distance therebetween, a short-circuit portion that is a conductor member electrically connecting together the patch portion and the ground plate, and an additional conductor that is a plate-shaped conductor member placed to be opposed to the patch portion with a predetermined distance therebetween. The additional conductor is placed on a side of the patch portion on which the ground plate is not placed. An inductance of the short-circuit portion, a capacitance formed by the ground plate and the patch portion, and a capacitance formed by the patch portion and the additional conductor are used to perform parallel resonance.

7 Claims, 3 Drawing Sheets



US011005174B2

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

(10) **Patent No.: US 11,005,174 B2**
(45) **Date of Patent: May 11, 2021**

(54) **POINT SYMMETRIC COMPLEMENTARY MEANDER LINE SLOTS FOR MUTUAL COUPLING REDUCTION**

(71) Applicants: **University of Florida Research Foundation, Inc.**, Gainesville, FL (US); **Electronics and Telecommunication Research Institute (ETRI)**, Daejeon (KR)

(72) Inventors: **Yong-Kyu Yoon**, Gainesville, FL (US); **Seahee Hwangbo**, Gainesville, FL (US); **Hae Yong Yang**, Daejeon (KR)

(73) Assignees: **University of Florida Research Foundation, Incorporated**, Gainesville, FL (US); **Electronics and Telecommunication Research Institute (ETRI)**, Daejeon (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 143 days.

(21) Appl. No.: **16/310,294**

(22) PCT Filed: **Jun. 15, 2017**

(86) PCT No.: **PCT/US2017/037724**
§ 371 (c)(1),
(2) Date: **Dec. 14, 2018**

(87) PCT Pub. No.: **WO2017/218806**
PCT Pub. Date: **Dec. 21, 2017**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 62/350,442, filed on Jun. 15, 2016.

(51) **Int. Cl.**
H01Q 1/52 (2006.01)
H01Q 21/06 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/523*** (2013.01); ***H01Q 1/52*** (2013.01); ***H01Q 3/00*** (2013.01); ***H01Q 9/0407*** (2013.01); ***H01Q 21/06*** (2013.01); ***H01Q 21/065*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/523; H01Q 21/065; H01Q 3/00; H01Q 1/52; H01Q 9/0407; H01Q 21/06
(Continued)

(56) **References Cited**

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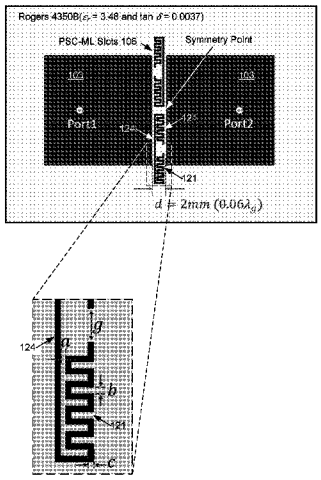
Primary Examiner — Hai V Tran
(74) *Attorney, Agent, or Firm* — Thomas|Horstemeyer, LLP

(57) **ABSTRACT**

Various examples are provided for point symmetric complementary meander line (PSC-ML) slots, which can be used for mutual coupling reduction. In one example, an antenna array includes first and second patch antenna elements disposed on a first side of a substrate, the first and second patch antenna elements separated by a gap. The antenna array can include point symmetric complementary meander line (PSC-ML) slots formed in a ground plane disposed on a second side of the substrate. The PSC-ML slots can include a pair of ML slots aligned with the gap between the first and second patch antenna elements. In another example, a
(Continued)



US011005190B1

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

(10) **Patent No.: US 11,005,190 B1**
(45) **Date of Patent: May 11, 2021**

(54) **ANTENNA ARRAY**

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

(72) Inventors: **Po-Tsang Lin**, New Taipei (TW); **Ying-Sheng Fang**, 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 40 days.

(21) Appl. No.: **16/710,494**

(22) Filed: **Dec. 11, 2019**

(30) **Foreign Application Priority Data**

Oct. 30, 2019 (TW) 108139167

(51) **Int. Cl.**

H01Q 21/00	(2006.01)
H01Q 21/08	(2006.01)
H01Q 7/00	(2006.01)
H01Q 1/38	(2006.01)
H01Q 1/22	(2006.01)
H01Q 1/24	(2006.01)
H01Q 5/20	(2015.01)
H01Q 21/28	(2006.01)
H01Q 25/00	(2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 21/08*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 7/00*** (2013.01); *H01Q 1/2225* (2013.01); *H01Q 1/2283* (2013.01); *H01Q 1/243* (2013.01); *H01Q 5/20* (2015.01); *H01Q 21/28* (2013.01); *H01Q 25/00* (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/2225; H01Q 25/00; H01Q 1/243; H01Q 5/20; H01Q 21/28; H01Q 1/2283; H01Q 5/335; H01Q 5/392
USPC 343/867, 702, 893
See application file for complete search history.

(56) **References Cited**

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(Continued)

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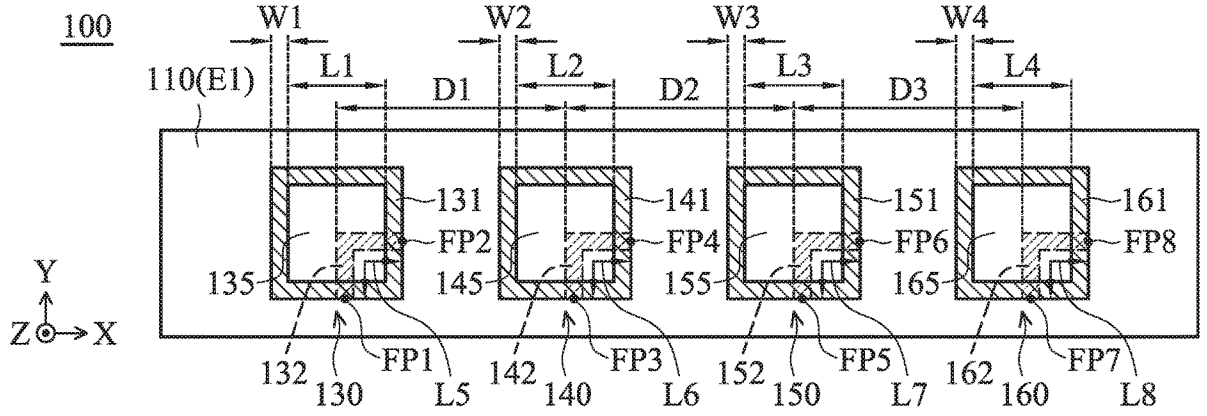
(Continued)

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

(57) **ABSTRACT**

An antenna array includes a dielectric substrate, a ground metal plane, a first antenna unit, a second antenna unit, a third antenna unit, and a fourth antenna unit. The first antenna unit includes a first metal loop and a first feeding metal element. The first feeding metal element is adjacent to the first metal loop. The second antenna unit includes a second metal loop and a second feeding metal element. The second feeding metal element is adjacent to the second metal loop. The third antenna unit includes a third metal loop and a third feeding metal element. The third feeding metal element is adjacent to the third metal loop. The fourth antenna unit includes a fourth metal loop and a fourth feeding metal element. The fourth feeding metal element is adjacent to the fourth metal loop.

20 Claims, 6 Drawing Sheets



US011005980B1

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

(10) **Patent No.: US 11,005,980 B1**
(45) **Date of Patent: May 11, 2021**

(54) **MOBILE TERMINAL**

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

(72) Inventors: **Soyeon Lee**, Seoul (KR); **Changil Kim**, Seoul (KR); **Hanphil Rhyu**, Seoul (KR); **Changwon Yoon**, Seoul (KR); **Jaewoo Lee**, Seoul (KR)

(73) Assignee: **LG ELECTRONICS INC.**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 43 days.

(21) Appl. No.: **16/620,785**

(22) PCT Filed: **Dec. 8, 2017**

(86) PCT No.: **PCT/KR2017/014371**

§ 371 (c)(1),
(2) Date: **Dec. 9, 2019**

(87) PCT Pub. No.: **WO2019/054572**

PCT Pub. Date: **Mar. 21, 2019**

Related U.S. Application Data

(60) Provisional application No. 62/559,644, filed on Sep. 18, 2017.

(51) **Int. Cl.**

H01Q 1/22	(2006.01)
H04M 1/02	(2006.01)
H01Q 1/24	(2006.01)
H01Q 9/04	(2006.01)
H01Q 21/28	(2006.01)

(Continued)

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

CPC ***H04M 1/026*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/44*** (2013.01); ***H01Q 9/0464*** (2013.01); ***H01Q 21/28*** (2013.01)

(58) **Field of Classification Search**

CPC H04M 1/026; H01Q 1/243; H01Q 1/44; H01Q 9/0464; H01Q 21/28

USPC 455/566

See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Lee Nguyen

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

(57) **ABSTRACT**

Provided is a mobile terminal comprising: a body: a ground embedded inside the body and having a vertical length longer than a horizontal length; a side case positioned on the periphery of a side surface of the body and comprising a first side member and a second side member positioned on the left and right side surfaces of the body, respectively; a first patch for connecting one end of the first side member and one end of the second side member; a second patch for connecting the other end of the first side member and the other end of the second side member; and a power supply part connected to the second patch, wherein the first side member, the second side member, the first patch, and the second patch from a loop form a loop ring-patch antenna.

13 Claims, 14 Drawing Sheets