

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

(10) **Patent No.:** **US 10,811,774 B2**
(45) **Date of Patent:** ***Oct. 20, 2020**

(54) **LOOP ANTENNA**

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

(72) Inventors: **Ya-Wen Hsiao**, Taipei (TW);
Saou-Wen Su, Taipei (TW); **Cheng-Tse Lee**, 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 34 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/226,718**

(22) Filed: **Dec. 20, 2018**

(65) **Prior Publication Data**

US 2019/0214730 A1 Jul. 11, 2019

(30) **Foreign Application Priority Data**

Jan. 8, 2018 (TW) 107100704 A

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 7/00 (2006.01)
H01Q 21/24 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 7/005** (2013.01); **H01Q 21/245** (2013.01); **H01Q 1/2266** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/321; H01Q 5/378; H01Q 9/42; H01Q 1/241-245; H01Q 1/2266; H01Q 7/005; H01Q 21/245; H01Q 21/005
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2008/0036666 A1* 2/2008 Shih H01Q 1/243
343/702
2009/0179800 A1* 7/2009 Chiu H01Q 1/2266
343/700 MS

(Continued)

FOREIGN PATENT DOCUMENTS

TW 1227576 B 2/2005
TW 1293215 B 2/2008

(Continued)

OTHER PUBLICATIONS

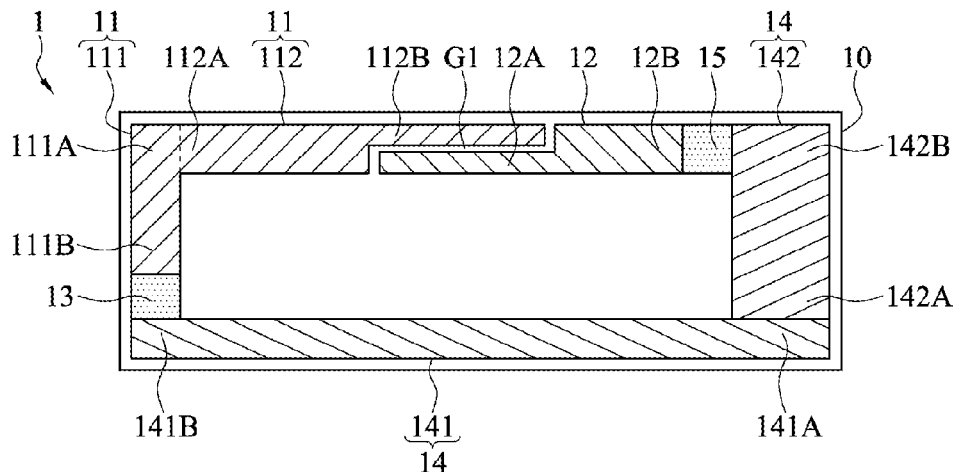
Office Action issued in corresponding Taiwan patent application dated Dec. 20, 2018.

Primary Examiner — Awat M Salih
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

This disclosure provides a loop antenna, including a substrate, and a grounding portion, a matching portion, a first radiating portion, a second radiating portion, and a feed portion that are located on the substrate. The first radiating portion includes a first radiating segment and a second radiating segment. The grounding portion includes a first grounding segment and a second grounding segment. The second grounding segment is perpendicularly connected to a first end of the first grounding segment. The matching portion is connected to a second end of the first grounding segment and the first radiating segment. The first radiating segment extends from the matching portion away from the first grounding segment. The second radiating segment extends from the first radiating segment toward the second grounding segment. There is a coupling gap between the second radiating portion and the second radiating segment, and the second radiating portion extends toward the second grounding segment. The feed portion is located between an

(Continued)





US010811775B2

(12) **United States Patent**
Su

(10) **Patent No.:** **US 10,811,775 B2**

(45) **Date of Patent:** ***Oct. 20, 2020**

(54) **LOOP ANTENNA**

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

(72) Inventor: **Saou-Wen Su**, 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 18 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/244,299**

(22) Filed: **Jan. 10, 2019**

(65) **Prior Publication Data**
US 2019/0288395 A1 Sep. 19, 2019

(30) **Foreign Application Priority Data**
Mar. 15, 2018 (TW) 107108923 A

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 7/00 (2006.01)
H01Q 5/328 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 7/005** (2013.01); **H01Q 5/328** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 1/241-245; H01Q 1/2266; H01Q 7/005; H01Q 5/321; H01Q 5/378; H01Q 5/328; H01Q 9/42
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,698,673 B2 4/2014 Wong et al.
9,407,003 B1* 8/2016 Kruse H01Q 1/242
(Continued)

FOREIGN PATENT DOCUMENTS

TW M241808 U 8/2004
TW I227576 B 2/2005
(Continued)

OTHER PUBLICATIONS

“Quarter-wavelength printed loop antenna for GSM/DCS/PCS/UMTS operation” 2008 Asia-Pacific Microwave Conference Year: 2008, pp. 1-4.

(Continued)

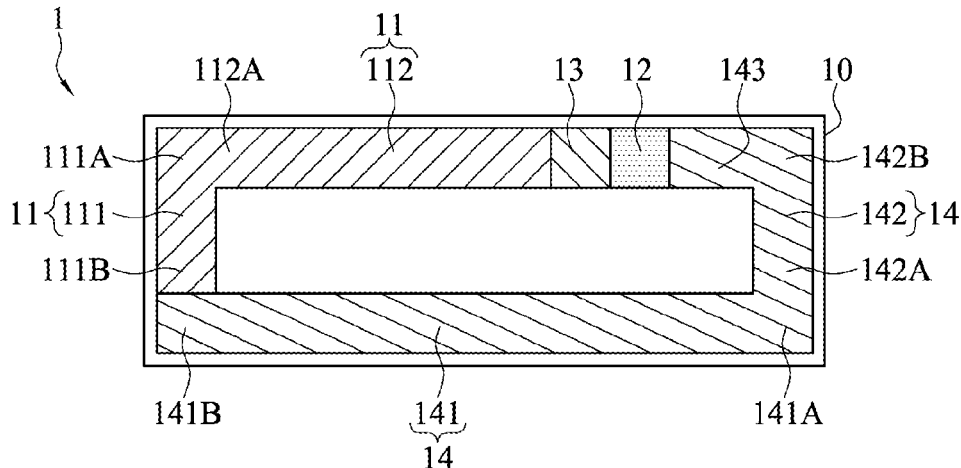
Primary Examiner — Awat M Salih

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

(57) **ABSTRACT**

The present disclosure provides a loop antenna, including a substrate, and a grounding portion, a radiating portion, a matching portion, and a feeding portion that are located on the substrate. The grounding portion includes a first grounding segment and a second grounding segment. The second grounding segment is perpendicular to the first grounding segment, and a first end of the second grounding segment is connected to a first end of the first grounding segment. The radiating portion includes a first radiating segment and a second radiating segment. The first radiating segment is connected to a second end of the first grounding segment and extending from the first grounding segment towards a direction away from the first grounding segment. The second radiating segment is connected to the first radiating segment and extending from the first radiating segment towards a direction facing the second grounding segment. The matching portion is located at an end of the second radiating segment close to the second grounding segment. The feeding

(Continued)





US010811780B2

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

(10) **Patent No.:** **US 10,811,780 B2**
(45) **Date of Patent:** **Oct. 20, 2020**

(54) **SLOT ANTENNA AND ELECTRONIC DEVICE**
(71) Applicant: **HUAWEI TECHNOLOGIES CO., LTD.**, Shenzhen (CN)
(72) Inventors: **Hanyang Wang**, Reading (GB); **Jianming Li**, Beijing (CN); **Xuefei Zhang**, Shenzhen (CN); **Chi Liu**, Shenzhen (CN)
(73) Assignee: **HUAWEI TECHNOLOGIES CO., LTD.**, Shenzhen (CN)

(56) **References Cited**
U.S. PATENT DOCUMENTS
6,618,020 B2 9/2003 Wang et al.
7,187,337 B2 3/2007 Aikawa et al.
(Continued)

FOREIGN PATENT DOCUMENTS
CN 1363968 A 8/2002
CN 103187615 A 7/2013
(Continued)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 63 days.

OTHER PUBLICATIONS

Zhe-Jun Jin et al., "Compact Wideband Open-End Slot Antenna With Inherent Matching", IEEE Antennas and Wireless Propagation Letters, vol. 13, dated Jul. 15, 2014, pp. 1385-1388.

(21) Appl. No.: **15/576,723**
(22) PCT Filed: **May 28, 2015**
(86) PCT No.: **PCT/CN2015/080123**
§ 371 (c)(1),
(2) Date: **Nov. 24, 2017**

Primary Examiner — Daniel Munoz
Assistant Examiner — Patrick R Holecek
(74) *Attorney, Agent, or Firm* — Kilpatrick Townsend & Stockton LLP

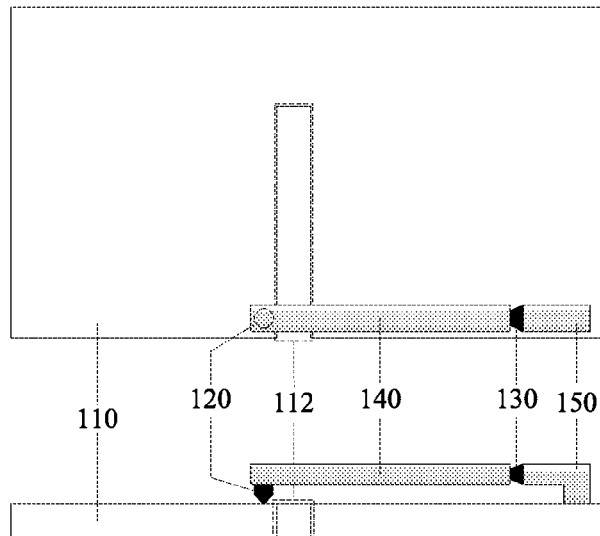
(87) PCT Pub. No.: **WO2016/187886**
PCT Pub. Date: **Dec. 1, 2016**

(57) **ABSTRACT**

A slot antenna includes: a printed circuit board having a slot, a first capacitor, a radio frequency signal source, a transmission line, and a ground cable. The printed circuit board is grounded; one end of the slot is open, and the other end is closed; the first capacitor and the ground cable are disposed on the printed circuit board, the first capacitor is located on the open end of the slot, and is disposed on one side of the slot; the first capacitor is connected to the radio frequency signal source by using the transmission line, and the radio frequency signal source connects the transmission line to the ground cable; and the radio frequency signal source is configured to: stimulate a feeding signal, and feed the feeding signal to the open end of the slot by using the first capacitor.

(65) **Prior Publication Data**
US 2019/0006763 A1 Jan. 3, 2019
(51) **Int. Cl.**
H01Q 13/10 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 13/10** (2013.01); **H01Q 13/103** (2013.01); **H01Q 13/106** (2013.01)
(58) **Field of Classification Search**
CPC .. H01Q 1/2258; H01Q 1/2266; H01Q 1/2275; H01Q 1/241; H01Q 1/242;
(Continued)

20 Claims, 9 Drawing Sheets



(12) **United States Patent**
Takamine

(10) **Patent No.:** **US 10,812,043 B2**
(45) **Date of Patent:** **Oct. 20, 2020**

(54) **ACOUSTIC WAVE FILTER DEVICE**

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

(72) Inventor: **Yuichi Takamine**, 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 0 days.

(21) Appl. No.: **16/374,765**

(22) Filed: **Apr. 4, 2019**

(65) **Prior Publication Data**

US 2019/0238116 A1 Aug. 1, 2019

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2017/035498, filed on Sep. 29, 2017.

(30) **Foreign Application Priority Data**

Oct. 13, 2016 (JP) 2016-201710

(51) **Int. Cl.**
H03H 9/145 (2006.01)
H03H 9/72 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H03H 9/1457** (2013.01); **H03H 7/0161** (2013.01); **H03H 9/02574** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H03H 9/725; H03H 9/1457; H03H 9/6483; H03H 9/6436; H03H 9/02637;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,874,869 A 2/1999 Ueda et al.
2005/0190014 A1 9/2005 Saitou et al.
(Continued)

FOREIGN PATENT DOCUMENTS

JP 10-41704 A 2/1998
JP 10-163803 A 6/1998
(Continued)

OTHER PUBLICATIONS

Official Communication issued in corresponding Japanese Patent Application No. 2018-544960, dated Jan. 21, 2020.

(Continued)

Primary Examiner — Robert J Pascal

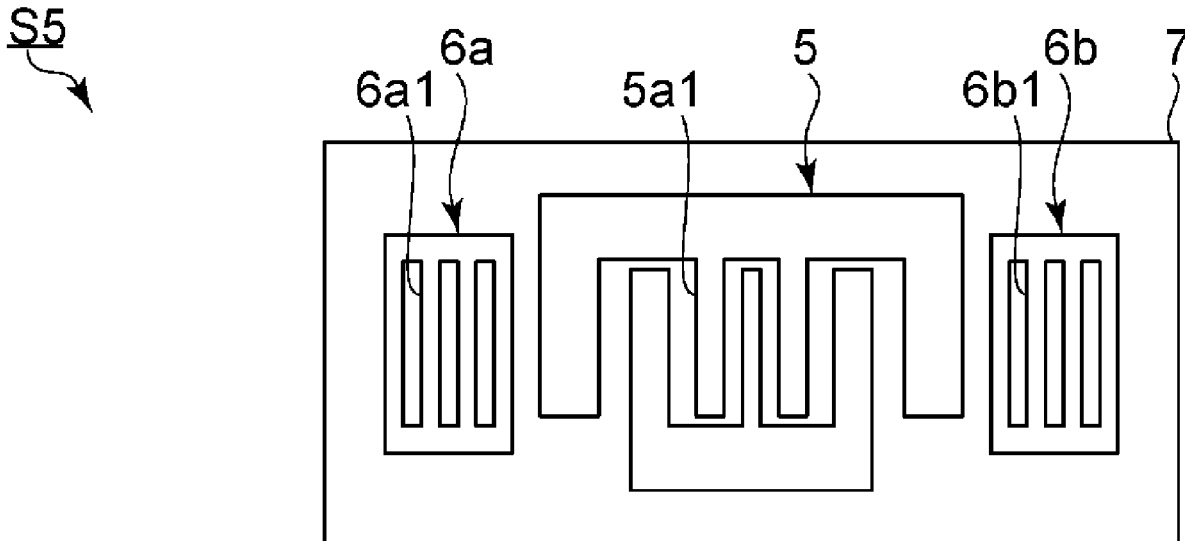
Assistant Examiner — Jorge L Salazar, Jr.

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

(57) **ABSTRACT**

An acoustic wave filter device includes a first band pass filter including a first acoustic wave resonator connected between an antenna terminal and a first signal terminal and having a first pass band, and a second band pass filter connected with the antenna terminal and having a second pass band on a higher side of the first pass band. The first acoustic wave resonator includes a substrate on a surface of which a piezoelectric thin film is provided, an IDT electrode provided on the substrate, and reflectors. At least a pitch of some electrode fingers is different from a pitch of other electrode fingers in at least one of the IDT electrode and the reflectors of the first acoustic wave resonator on a side closest to the antenna terminal.

20 Claims, 7 Drawing Sheets



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

(10) **Patent No.:** **US 10,819,005 B2**
(45) **Date of Patent:** **Oct. 27, 2020**

(54) **CONVERTIBLE MOBILE DEVICE**
(71) Applicant: **Wistron NeWeb Corp.**, Hsinchu (TW)
(72) Inventors: **Hong-Jun Jian**, Hsinchu (TW);
Yu-Sheng Fan, Hsinchu (TW)
(73) Assignee: **WISTRON NEWEB CORP.**, Hsinchu (TW)

H01Q 1/243; H01Q 9/06; H01Q 1/52;
H04B 1/3827; G06F 1/1681; G06F
1/1616; G06F 1/1698; H04M 1/0216;
H04M 1/0214
See application file for complete search history.

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 14 days.

(56) **References Cited**

U.S. PATENT DOCUMENTS

10,056,696 B2* 8/2018 Tseng H01Q 1/36
2010/0103069 A1* 4/2010 Wang H01Q 9/42
343/846

(Continued)

FOREIGN PATENT DOCUMENTS

CN 107689485 A 2/2018
TW M537316 U 2/2017

Primary Examiner — Daniel D Chang

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

(21) Appl. No.: **16/392,882**

(22) Filed: **Apr. 24, 2019**

(65) **Prior Publication Data**

US 2019/0348745 A1 Nov. 14, 2019

(30) **Foreign Application Priority Data**

May 14, 2018 (TW) 107116286 A

(51) **Int. Cl.**

H01Q 1/22 (2006.01)
H04B 1/3827 (2015.01)
H01Q 5/35 (2015.01)
H01Q 1/24 (2006.01)
G06F 1/16 (2006.01)
H01Q 9/06 (2006.01)

(Continued)

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

CPC **H01Q 1/2266** (2013.01); **G06F 1/1616** (2013.01); **G06F 1/1681** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/52** (2013.01); **H01Q 5/35** (2015.01); **H01Q 9/06** (2013.01); **H04B 1/3827** (2013.01); **H04M 1/0216** (2013.01)

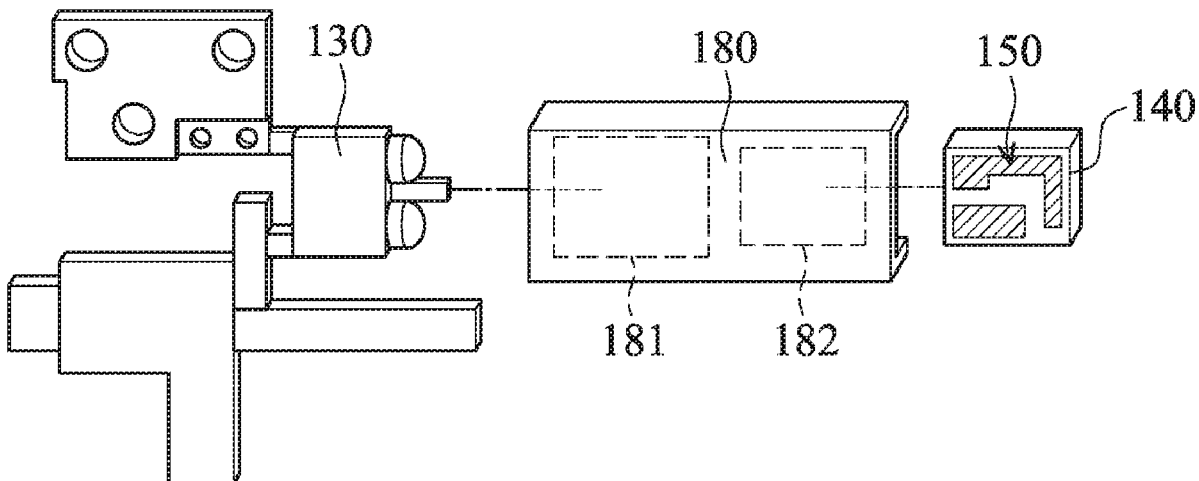
(58) **Field of Classification Search**

CPC H01Q 1/2266; H01Q 13/10; H01Q 5/35;

(57) **ABSTRACT**

A convertible mobile device includes an upper cover, a base, a hinge element, a supporting element, an antenna structure, and a cover element. The hinge element is connected between the upper cover and the base, so that the convertible mobile device can flip over and operate in a notebook mode or a tablet mode. The antenna structure is disposed on the supporting element. The antenna structure includes a first radiation element and a second radiation element. One of the first radiation element and the second radiation element has a positive feeding point, and the other of the first radiation element and the second radiation element has a negative feeding point. A coupling gap is formed between the first radiation element and the second radiation element. The cover element covers the supporting element, the antenna structure, and at least a portion of the hinge element.

17 Claims, 8 Drawing Sheets





US010819010B2

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

(10) **Patent No.:** **US 10,819,010 B2**
(45) **Date of Patent:** **Oct. 27, 2020**

(54) **ELECTRONIC DEVICE INCLUDING ANTENNA**

(56) **References Cited**

(71) Applicant: **Samsung Electronics Co., Ltd.**,
Gyeonggi-do (KR)
(72) Inventors: **Hyung Joo Lee**, Gyeonggi-do (KR);
Gyu Sub Kim, Seoul (KR); **Se Hyun Park**,
Gyeonggi-do (KR); **Jaе Bong Chun**,
Gyeonggi-do (KR)

U.S. PATENT DOCUMENTS

7,420,511 B2 9/2008 Oshiyama et al.
7,558,607 B2 7/2009 Edeler et al.
9,041,617 B2 5/2015 Sorensen et al.
9,065,165 B2 6/2015 Wong et al.
9,070,968 B2 6/2015 Mow et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CN 1766663 5/2006
KR 10-0924769 11/2009

OTHER PUBLICATIONS

International Search Report dated Apr. 6, 2017 issued in counterpart application No. PCT/KR2016/014670, 10 pages.

(Continued)

(73) Assignee: **Samsung Electronics Co., Ltd** (KR)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 465 days.

(21) Appl. No.: **15/380,479**

(22) Filed: **Dec. 15, 2016**

(65) **Prior Publication Data**
US 2017/0170562 A1 Jun. 15, 2017

Primary Examiner — Daniel Munoz
Assistant Examiner — Bamidele A Jegede
(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(30) **Foreign Application Priority Data**
Dec. 15, 2015 (KR) 10-2015-0179242

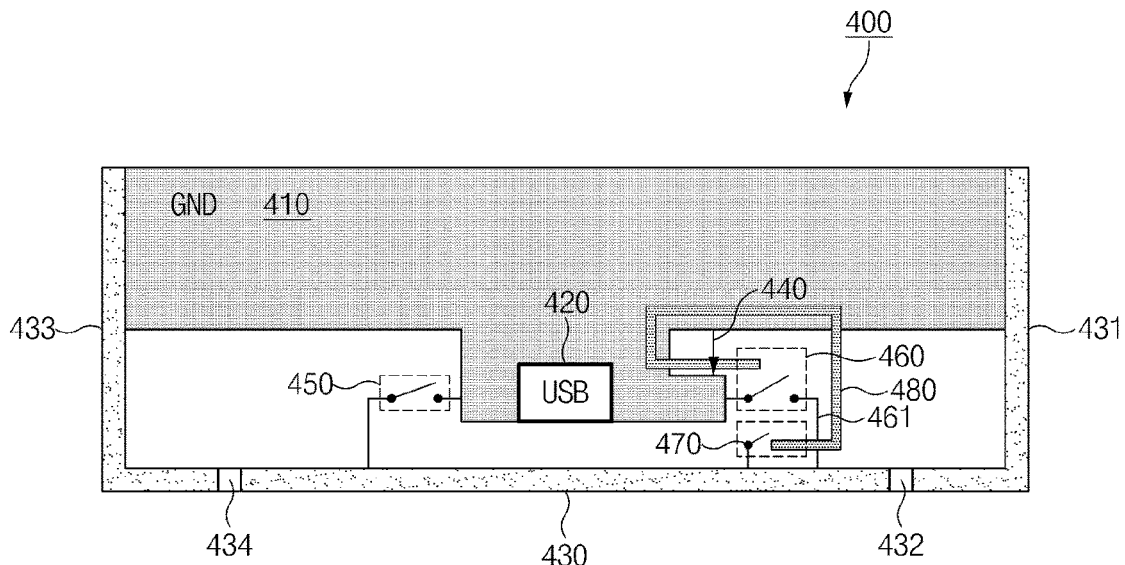
(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
H01Q 9/14 (2006.01)
H01Q 7/00 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 7/00**
(2013.01); **H01Q 9/14** (2013.01); **H01Q 9/42**
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 9/14; H01Q 9/42;
H01Q 21/30; H01Q 7/00
See application file for complete search history.

(57) **ABSTRACT**

An electronic device including an antenna is provided. The electronic device includes a ground plane, an antenna element that is electrically connected to the ground plane through a first electrical path, a receptacle that accommodates an external connector that is electrically connected to the ground plane and comprises a conductive line, and a control circuit that is configured to: detect whether the external connector is inserted into the receptacle, and change the first electrical path to a second electrical path or add the second electrical path to the first electrical path between the antenna element and the ground plane, when the external connector is inserted into the receptacle.

14 Claims, 20 Drawing Sheets





US010819011B2

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

(10) **Patent No.:** **US 10,819,011 B2**
(45) **Date of Patent:** **Oct. 27, 2020**

(54) **ELECTRONIC DEVICE COMPRISING AN ANTENNA**

(71) Applicant: **Samsung Electronics Co., Ltd.**,
Gyeonggi-do (KR)
(72) Inventors: **Han Bin Lee**, Gyeonggi-do (KR); **Jaehyung Kim**, Gyeonggi-do (KR); **Hua Li**, Gyeonggi-do (KR); **Je Sun Moon**, Gyeonggi-do (KR); **Jin Kyu Bang**, Gyeonggi-do (KR); **Chang Ha Yu**, Gyeonggi-do (KR); **Sung Yeul Hong**, Gyeonggi-do (KR)

(73) Assignee: **Samsung Electronics Co., Ltd** (KR)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 182 days.

(21) Appl. No.: **15/991,504**
(22) Filed: **May 29, 2018**

(65) **Prior Publication Data**
US 2018/0342793 A1 Nov. 29, 2018

(30) **Foreign Application Priority Data**
May 29, 2017 (KR) 10-2017-0066463

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

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/2291** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/335** (2015.01); **H01Q 13/106** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/2291; H01Q 13/106; H01Q 9/0421
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,848,771 B2 12/2010 Boyle
9,716,307 B2 7/2017 Tsai et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 1788390 6/2006
CN 103811863 5/2014
(Continued)

OTHER PUBLICATIONS

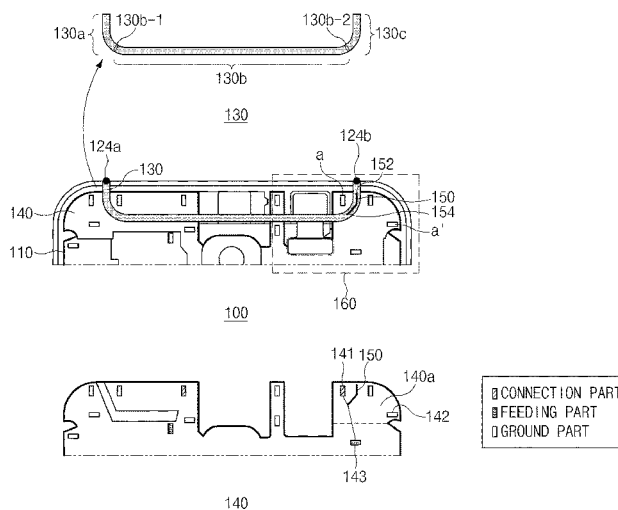
International Search Report dated Aug. 31, 2018 issued in counterpart application No. PCT/KR2018/006075, 13 pages.
(Continued)

Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a housing including a first plate, a second plate facing the first plate, and a side member surrounding a space between the first plate and the second plate and a circuit board, which is accommodated inside a housing and in which a wireless communication circuit is disposed. The second plate includes a slot filled with a non-conductive material. An area other than the slot is formed of a conductive material. The circuit board includes a conductive pattern formed on the circuit board along with the slot of the second plate, and the wireless communication circuit is configured to feed one point of the second plate adjacent to the slot to receive a signal of a first frequency band through an electrical path formed by the slot and to feed the conductive pattern to receive a signal of a second frequency band through the slot.

19 Claims, 12 Drawing Sheets



(12) **United States Patent**
Liu

(10) **Patent No.:** **US 10,819,012 B2**
(45) **Date of Patent:** **Oct. 27, 2020**

(54) **ANTENNA AND MOBILE TERMINAL**

(71) Applicant: **Beijing Xiaomi Mobile Software Co., Ltd.**, Beijing (CN)

(72) Inventor: **Jiarong Liu**, 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 47 days.

2016/0064820 A1 3/2016 Kim et al.
2017/0346159 A1* 11/2017 Xue H01Q 5/314
2018/0212313 A1* 7/2018 Harper H01Q 5/328
2018/0375209 A1* 12/2018 Su H01Q 5/30
2019/0067821 A1* 2/2019 Kim H01Q 7/00
2019/0207297 A1* 7/2019 Gu H01Q 5/335

FOREIGN PATENT DOCUMENTS

CN 105337036 A 2/2016
CN 105811079 A 7/2016
CN 105811103 A 7/2016
CN 107181045 A 9/2017

(Continued)

(21) Appl. No.: **16/354,564**

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

(65) **Prior Publication Data**

US 2020/0036082 A1 Jan. 30, 2020

(30) **Foreign Application Priority Data**

Jul. 27, 2018 (CN) 2018 1 0841024

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/50 (2015.01)
H01Q 9/06 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/50** (2015.01); **H01Q 9/06** (2013.01)

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,728,854 B2 8/2017 Kim et al.
2013/0127673 A1 5/2013 Chang et al.

OTHER PUBLICATIONS

Extended Search Report for European Application No. 19188095.4 from the European Patent Office, dated Nov. 18, 2019.

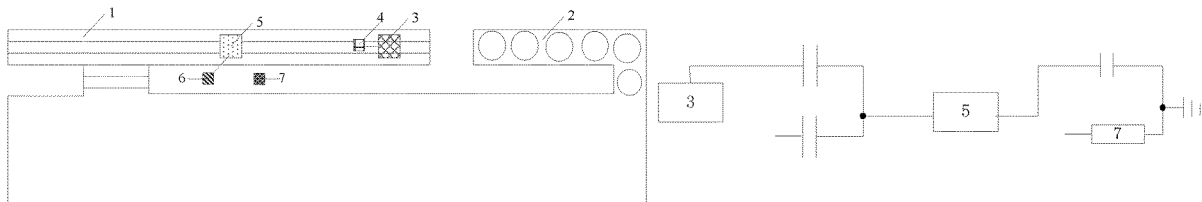
(Continued)

Primary Examiner — Jany Richardson
(74) *Attorney, Agent, or Firm* — Finnegan, Henderson, Farabow, Garrett & Dunner, L.L.P.

(57) **ABSTRACT**

An antenna applied to a mobile terminal, includes: a first sub-antenna; and a second sub-antenna. The mobile terminal includes a first metal frame and a second metal frame, a breaking joint being provided between a first end of the first metal frame and a first end of the second metal frame, a length of the first metal frame being within a range of a quarter wavelength of a specified band, and the length of the first metal frame being greater than a length of the second metal frame. The first sub-antenna and the second sub-antenna are formed based on the first metal frame and the second metal frame.

20 Claims, 8 Drawing Sheets





US010819013B2

(12) **United States Patent**
Lin

(10) **Patent No.:** **US 10,819,013 B2**

(45) **Date of Patent:** **Oct. 27, 2020**

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

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

(72) Inventor: **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 30 days.

(21) Appl. No.: **16/385,615**

(22) Filed: **Apr. 16, 2019**

(65) **Prior Publication Data**

US 2019/0348750 A1 Nov. 14, 2019

(30) **Foreign Application Priority Data**

May 8, 2018 (CN) 2018 1 0431335

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)
H01Q 5/30 (2015.01)
H01Q 1/52 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/521** (2013.01); **H01Q 5/30** (2015.01)

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

10,305,168 B2	5/2019	Liu et al.
2013/0076579 A1	3/2013	Zhang et al.
2013/0162496 A1	6/2013	Wakabayashi
2017/0117614 A1	4/2017	Wu et al.
2018/0191077 A1*	7/2018	Lee
2019/0067821 A1*	2/2019	Kim
2020/0058983 A1*	2/2020	Chen

FOREIGN PATENT DOCUMENTS

CN	103682639 A	3/2014
CN	203536554 U	4/2014
CN	105305066 A	2/2016
CN	105932408 A	9/2016
CN	107026324 A	8/2017

* cited by examiner

Primary Examiner — Jany Richardson

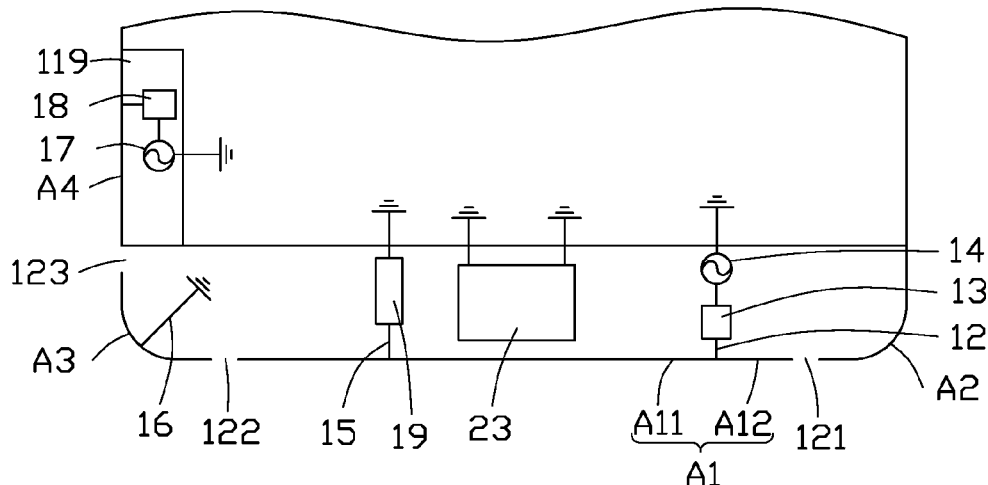
(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

An antenna structure includes a housing, a first feed source, and a second feed source. The housing includes a side frame. The side frame defines a first gap, a second gap, and a groove. The first gap, the second gap, and the groove divide the side frame into a first radiating portion, an isolation portion, and a second radiating portion. The first feed source is electrically connected to the first radiating portion for supplying current to the first radiating portion. The second feed source is electrically connected to or being coupled to the second radiating portion for supplying current to the second radiating portion. The isolation portion is positioned between the first radiating portion and the second radiating portion. The isolation portion is grounded. The current from the first radiating portion and the current from the second radiating portion are respectively coupled to the isolation portion.

23 Claims, 18 Drawing Sheets

100



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

(10) **Patent No.:** **US 10,819,016 B2**
(45) **Date of Patent:** **Oct. 27, 2020**

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

H01Q 21/0056; H01Q 21/06; H01Q 21/064; H01Q 13/02; H01Q 13/0233; H01Q 13/06; H01P 3/121

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

See application file for complete search history.

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

2017/0294705 A1* 10/2017 Khripkov H01Q 21/24

FOREIGN PATENT DOCUMENTS

CN 108808214 A1 11/2018

OTHER PUBLICATIONS

PCT search report dated Aug. 1, 2019 by SIPO in related PCT Patent Application No. PCT/CN2019/087448 (4 Pages).

* cited by examiner

Primary Examiner — Jimmy T Vu

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

(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.

(21) Appl. No.: **16/525,580**

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

(65) **Prior Publication Data**

US 2020/0052382 A1 Feb. 13, 2020

(30) **Foreign Application Priority Data**

Aug. 12, 2018 (CN) 2018 1 0912502

(51) **Int. Cl.**

H01Q 13/02 (2006.01)
H01Q 1/24 (2006.01)
H01Q 5/328 (2015.01)
H01Q 1/38 (2006.01)
H01Q 9/26 (2006.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/328** (2015.01); **H01Q 9/26** (2013.01)

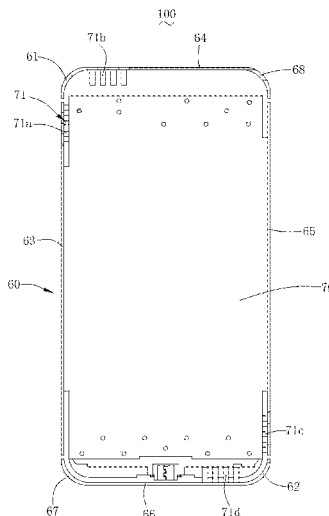
(58) **Field of Classification Search**

CPC H01Q 1/12; H01Q 1/241; H01Q 1/247; H01Q 1/248; H01Q 1/243; H01Q 1/38; H01Q 5/328; H01Q 9/26; H01Q 21/0043;

(57) **ABSTRACT**

A mobile terminal includes a metal frame, and the metal frame includes two corners provided diagonally. The antenna system includes four SIW horn antenna arrays formed on the metal frame. The circumference side of each corner is respectively provided with two SIW horn antenna arrays arranged perpendicular to each other and one of the SIW horn antenna arrays is provided at an end of the long frame close to the connected corner, and the other SIW horn antenna array is provided at an end of the short frame close to the connected corner. The SIW horn antenna array includes multiple SIW horns. The metal frame is provided with multiple spaced through holes at positions corresponding to the SIW horns. The antenna system and the mobile terminal of the present disclosure have good overall coverage efficiency.

10 Claims, 7 Drawing Sheets





US010819017B2

(12) **United States Patent**
Gu

(10) **Patent No.:** **US 10,819,017 B2**
(45) **Date of Patent:** **Oct. 27, 2020**

- (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.

(21) Appl. No.: **16/527,074**
(22) Filed: **Jul. 31, 2019**

(65) **Prior Publication Data**
US 2020/0044315 A1 Feb. 6, 2020

(30) **Foreign Application Priority Data**
Aug. 3, 2018 (CN) 2018 1 0876533

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
H04B 7/0413 (2017.01)
H01Q 21/28 (2006.01)
H01Q 9/26 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 9/26** (2013.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01); **H04B 7/0413** (2013.01)

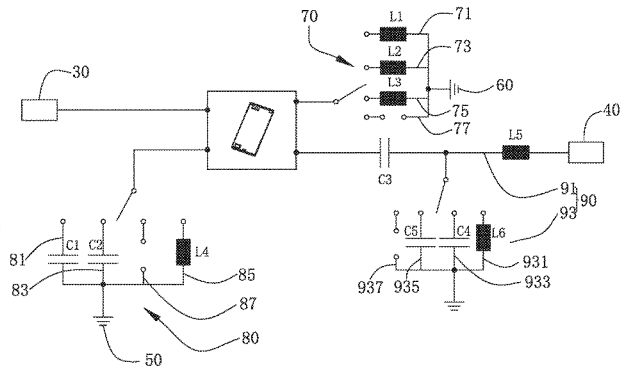
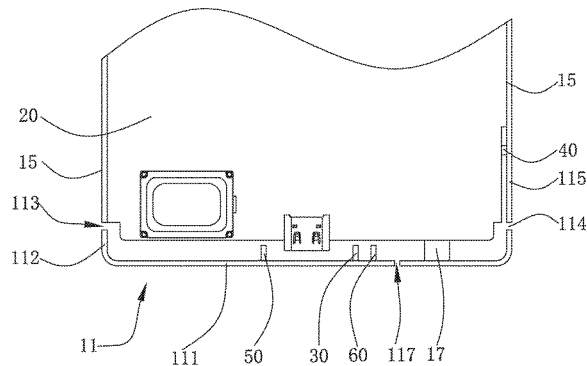
(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 9/42; H01Q 21/28; H01Q 9/26; H01Q 5/35; H01Q 5/328; H01Q 5/335; H01Q 5/378; H01Q 1/22; H01Q 1/2258; H01Q 1/242; H01Q 1/36;
(Continued)

- (56) **References Cited**
- U.S. PATENT DOCUMENTS
- 2019/0027833 A1* 1/2019 Ayala Vazquez H01Q 1/48
- 2019/0058781 A1* 2/2019 Hong H01Q 1/243
(Continued)
- FOREIGN PATENT DOCUMENTS
- CN 204947066 B1 1/2016
- CN 105742812 A1 7/2016
(Continued)

OTHER PUBLICATIONS
1st Office Action dated Dec. 4, 2019 by SIPO in related Chinese Patent Application No. 201810876533.4 (9 Pages).
Primary Examiner — Renan Luque
(74) *Attorney, Agent, or Firm* — W&G Law Group LLP

(57) **ABSTRACT**
An antenna system and a mobile terminal are provided. The antenna system includes a metal frame, a mainboard received inside the metal frame, and a first feeding point, a second feeding point, a first grounding point and a second grounding point provided on the mainboard. The metal frame includes a bottom frame separated by the breach into a first radiation portion located at the bottom left corner and a second radiation portion located at the bottom right corner. A first antenna is formed by feeding of the first feeding point, a second antenna is formed by feeding of the second feeding point, a working frequency of the first antenna covers LTE low frequency, and the working frequencies of the first antenna and the second antenna cover LTE intermediate frequency and high frequency & 3.4-3.8 GHz & C frequency band.

17 Claims, 9 Drawing Sheets





US010819018B2

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

(10) **Patent No.:** **US 10,819,018 B2**
(45) **Date of Patent:** **Oct. 27, 2020**

(54) **CONDUCTIVE STRUCTURE DISPOSED TO CORRESPOND TO ANTENNA MODULE AND ELECTRONIC DEVICE INCLUDING THE SAME**

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

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

(56) **References Cited**

(72) Inventors: **Seunghan Seo**, Suwon-si (KR);
Seunggil Jeon, Suwon-si (KR);
Sungchul Park, Suwon-si (KR)

U.S. PATENT DOCUMENTS

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

7,391,372 B2 *	6/2008	Lynch	.....	H01Q 9/0457
				343/700 MS
8,633,857 B2 *	1/2014	Wang	.....	H01Q 1/2266
				343/700 MS
9,609,094 B2 *	3/2017	Yamashita	.....	H04M 1/0202
9,666,934 B2 *	5/2017	Lombardi	.....	H01Q 1/243
9,667,762 B1 *	5/2017	Takahashi	.....	H04B 1/3888
10,256,872 B2 *	4/2019	Jiang	.....	H04B 7/0408
10,461,793 B2 *	10/2019	Lee	.....	H01Q 13/10
10,516,201 B2 *	12/2019	Khripkov	.....	H01Q 1/38

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

(Continued)

FOREIGN PATENT DOCUMENTS

(21) Appl. No.: **16/573,290**

KR 10-2018-0079012 A 7/2018

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

Primary Examiner — Tuan A Tran

(65) **Prior Publication Data**

US 2020/0144698 A1 May 7, 2020

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

(30) **Foreign Application Priority Data**

Nov. 6, 2018 (KR) 10-2018-0135260

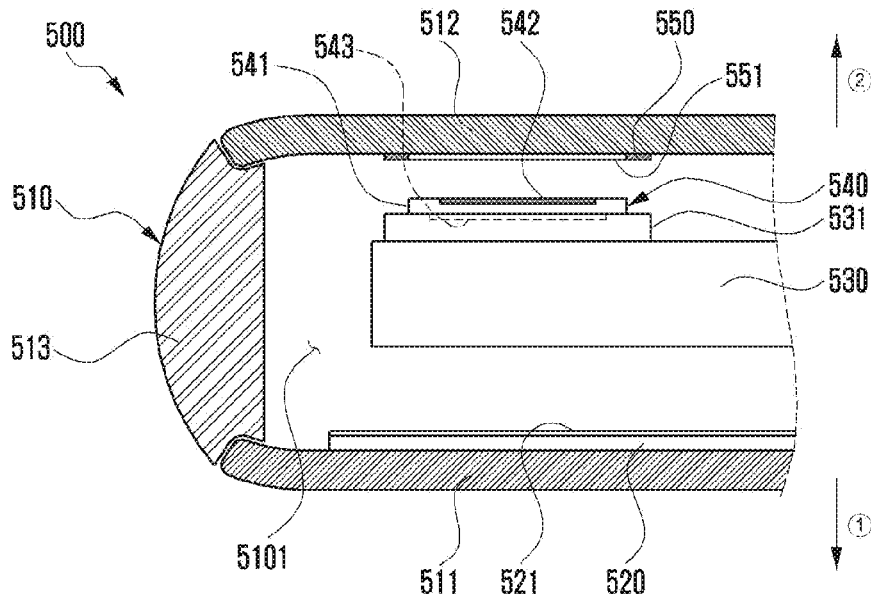
(57) **ABSTRACT**

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 1/24 (2006.01)
H05K 1/18 (2006.01)
H01Q 3/26 (2006.01)

An electronic device is provided. The electronic device includes a housing including a first plate facing in a first direction, a second plate opposite to the first plate and facing in a second direction, and a side member enclosing a space between the first plate and the second plate, an antenna structure including at least one antenna element disposed substantially parallel to the second plate in the space and disposed to face the second plate, a conductive structure disposed in the space and including an opening, the antenna structure being disposed to at least partially overlap the opening when viewed from above the second plate, and a wireless communication circuit configured to form a directional beam through the at least one antenna element. In addition, various embodiments may be available.

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 3/26** (2013.01); **H05K 1/189** (2013.01); **H05K 2201/10098** (2013.01)

20 Claims, 16 Drawing Sheets





US010819020B2

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

(10) **Patent No.:** **US 10,819,020 B2**
(45) **Date of Patent:** **Oct. 27, 2020**

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

USPC 455/575.7
See application file for complete search history.

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

(56) **References Cited**

(72) Inventors: **Jianpeng Zhu**, Shenzhen (CN); **Li Han**, Shenzhen (CN); **Hua Jiang**, Shenzhen (CN); **Xufeng Zhang**, Shenzhen (CN)

U.S. PATENT DOCUMENTS

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

8,446,989 B2 * 5/2013 Oizumi H04L 25/0204
375/259
8,866,692 B2 * 10/2014 Vazquez H01Q 1/2291
343/702
9,385,795 B1 * 7/2016 Ananthanarayanan ... H04L 5/08
9,472,861 B2 * 10/2016 Bi H01Q 21/28
10,331,179 B1 * 6/2019 Xia H01Q 21/0006
10,581,153 B2 * 3/2020 Edwards H01Q 9/42
2007/0066245 A1 * 3/2007 Snider H04B 1/48
455/78
2011/0268037 A1 * 11/2011 Fujimoto H04B 7/0851
370/328
2016/0066307 A1 * 3/2016 Huang H04B 1/0064
370/329

(*) 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.: **16/703,891**

(Continued)

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

Primary Examiner — Sonny Trinh

(65) **Prior Publication Data**

US 2020/0212543 A1 Jul. 2, 2020

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

(30) **Foreign Application Priority Data**

Dec. 28, 2018 (CN) 2018 2 2274774 U

(57) **ABSTRACT**

(51) **Int. Cl.**

H04M 1/00 (2006.01)
H01Q 1/24 (2006.01)
H01Q 5/307 (2015.01)
H01Q 1/48 (2006.01)
H04M 1/02 (2006.01)

The embodiments of the present invention relate to the field of communication technology, and disclose an antenna system and a mobile terminal. In the present disclosure, the antenna system includes: a first antenna, a second antenna, a third antenna, a fourth antenna, and a fifth antenna, wherein the first antenna, the second antenna, the fourth antenna, and the fifth antenna constitute a 4*4 MIMO operating at 3300 MHz to 3600 MHz, the second antenna and the third antenna constitute a 2*2 MIMO operating at 4800 MHz~5000 MHz, so that the antenna system of the present disclosure can support the operating band of the terminal in 5G communication, promoting the development of mobile terminal in the aspect of 5G communication.

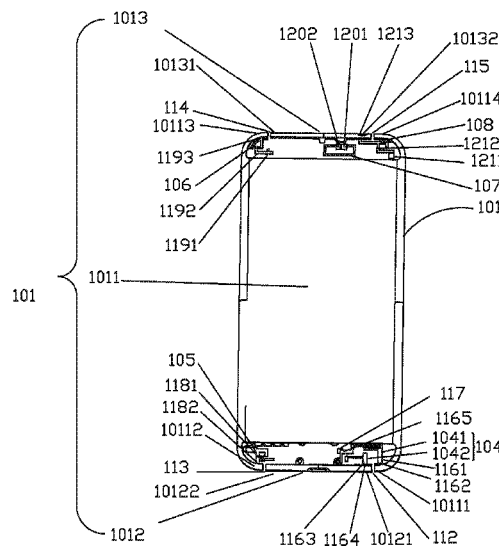
(52) **U.S. Cl.**

CPC **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/307** (2015.01); **H04M 1/026** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 5/307; H01Q 1/48; H04M 1/026

18 Claims, 17 Drawing Sheets





US010819021B2

(12) **United States Patent
Shen**

(10) **Patent No.:** **US 10,819,021 B2**

(45) **Date of Patent:** **Oct. 27, 2020**

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

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

(72) Inventor: **Yachuan Shen**, 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.

(21) Appl. No.: **16/524,080**

(22) Filed: **Jul. 28, 2019**

(65) **Prior Publication Data**

US 2020/0044319 A1 Feb. 6, 2020

(30) **Foreign Application Priority Data**

Aug. 3, 2018 (CN) 2018 2 1267573 U

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 5/50 (2015.01)

H01Q 5/328 (2015.01)

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

CPC **H01Q 1/245** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 5/328** (2015.01); **H01Q 5/50**
(2015.01)

(58) **Field of Classification Search**

CPC H01Q 1/245; H01Q 5/50; H01Q 5/328;
H01Q 1/243; H01Q 9/42; H01Q 5/335

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2015/0155614 A1* 6/2015 Youn H01Q 1/243
343/702

2019/0386377 A1* 12/2019 Dong H04M 1/0266

2019/0387649 A1* 12/2019 Hong H05K 1/144

2020/0212540 A1* 7/2020 Shen H01Q 5/335

* cited by examiner

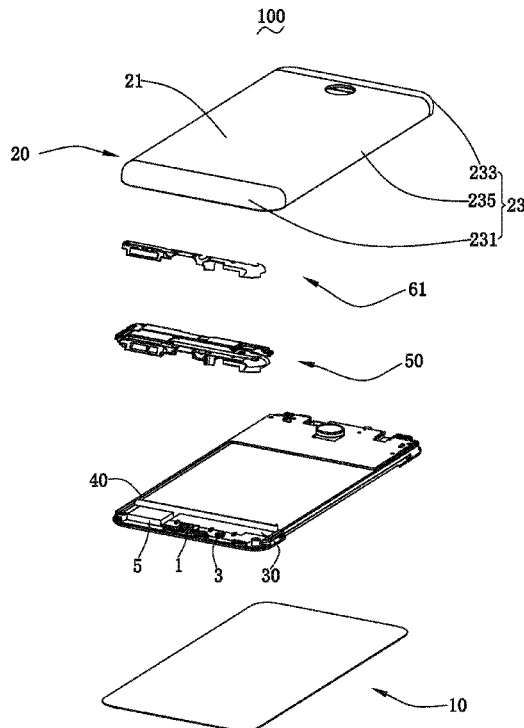
Primary Examiner — Daniel D Chang

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

(57) **ABSTRACT**

An antenna module and a mobile device are provided. The antenna module includes a radiator formed on a surface of the plastic rear housing facing the back cover, and a feed point, a first ground point, and a second ground point that are disposed on the motherboard. The antenna module further includes a matching network, a first tuning switch, and a second tuning switch. The feed point is connected to the radiator through the matching network. The first ground point is connected to the radiator through the first tuning switch. The second ground point is connected to the radiator through the second tuning switch. The surface of the plastic rear housing facing the back cover includes a first shaping zone for shaping the radiator and a second zone other than the first shaping zone, and the radiator completely covers the first shaping zone.

6 Claims, 6 Drawing Sheets



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

(10) **Patent No.:** **US 10,819,025 B2**
(45) **Date of Patent:** **Oct. 27, 2020**

(54) **ANTENNA STRUCTURE**
(71) Applicant: **Wistron NeWeb Corp.**, Hsinchu (TW)
(72) Inventors: **An-Ting Hsiao**, Hsinchu (TW);
Shang-Sian You, 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 61 days.

2012/0169562 A1* 7/2012 Nysen H01Q 9/40
343/843
2012/0299798 A1* 11/2012 Leisten H01Q 5/35
343/895
2014/0062824 A1* 3/2014 Yamaguchi H01Q 21/0006
343/835

(Continued)

FOREIGN PATENT DOCUMENTS

CN 106941208 A 7/2017
CN 106972242 A 7/2017

(Continued)

OTHER PUBLICATIONS

Li, Q. et al.; "Planar Quasi-Isotropic Magnetic Dipole Antenna Using Fractional-Order Circular Sector Cavity Resonant Mode," IEEE Access; vol. 5; Apr. 2017; pp. 8515-8525.

Primary Examiner — Raymond R Chai
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(21) Appl. No.: **16/278,334**
(22) Filed: **Feb. 18, 2019**
(65) **Prior Publication Data**
US 2019/0372208 A1 Dec. 5, 2019
(30) **Foreign Application Priority Data**
Jun. 4, 2018 (TW) 107119160 A

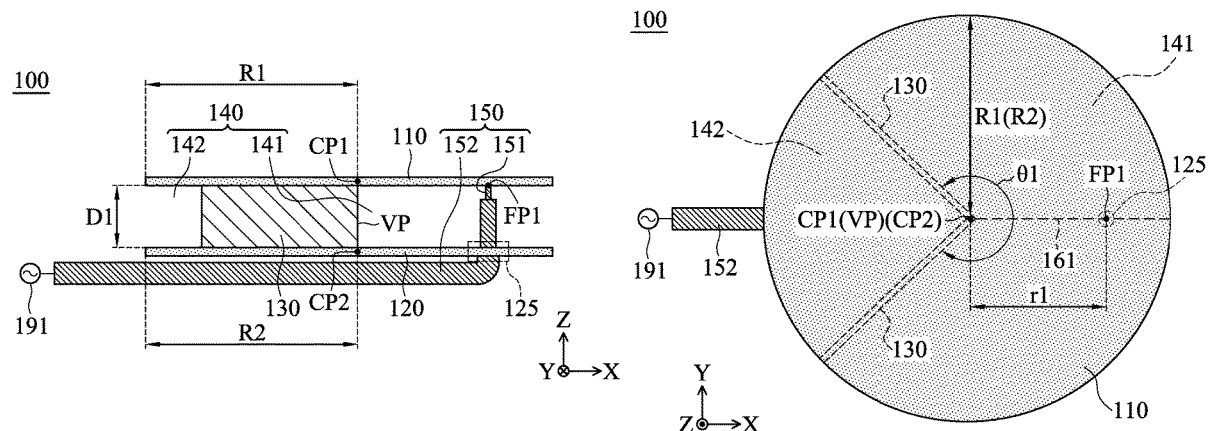
(57) **ABSTRACT**

An antenna structure includes a first conductive layer, a second conductive layer, a bent conductive layer, and a first coaxial cable. The second conductive layer has a first opening. A cavity is formed between the first conductive layer and the second conductive layer. The bent conductive layer is coupled between the first conductive layer and the second conductive layer. The bent conductive layer is configured to divide the cavity into a first portion and a second portion. The first coaxial cable includes a first central conductive line and a first conductive shielding. The first central conductive line extending through the first opening is coupled to a first feeding point on the first conductive layer. The first conductive shielding is coupled to the second conductive layer.

(51) **Int. Cl.**
H01Q 1/36 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 1/364** (2013.01)
(58) **Field of Classification Search**
CPC H01Q 1/346; H01Q 9/42; H01Q 5/35
See application file for complete search history.

19 Claims, 9 Drawing Sheets

(56) **References Cited**
U.S. PATENT DOCUMENTS
2002/0044099 A1* 4/2002 Yamamoto H01Q 13/18
343/789
2005/0116867 A1* 6/2005 Park H01Q 9/0457
343/725
2006/0125713 A1* 6/2006 Thevenot H01Q 5/28
343/909





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

(10) **Patent No.:** **US 10,819,029 B2**
(45) **Date of Patent:** **Oct. 27, 2020**

(54) **ELECTRONIC DEVICE HAVING MULTI-FREQUENCY ULTRA-WIDEBAND ANTENNAS**

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)
(72) Inventors: **Mikal Askarian Amiri**, Tempe, AZ (US); **Carlo di Nallo**, Belmont, CA (US); **David Garrido Lopez**, Campbell, CA (US); **Harish Rajagopalan**, San Jose, CA (US); **Nikolaj P. Kammersgaard**, København (DK); **Rodney A. Gomez Angulo**, Santa Clara, CA (US); **Umar Azad**, Santa Clara, 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 51 days.

(21) Appl. No.: **16/271,617**
(22) Filed: **Feb. 8, 2019**

(65) **Prior Publication Data**
US 2020/0259258 A1 Aug. 13, 2020

(51) **Int. Cl.**
H01Q 5/25 (2015.01)
H01Q 1/24 (2006.01)
H01Q 9/16 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 5/25** (2015.01); **H01Q 1/24** (2013.01); **H01Q 9/16** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/25; H01Q 9/16; H01Q 1/24
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,880,684 B2	2/2011	Schantz	
9,105,966 B1 *	8/2015	Dou	H01Q 1/243
9,368,869 B2	6/2016	Chen et al.	
9,673,511 B2	6/2017	Lee et al.	
9,768,506 B2	9/2017	Krogerus	
10,135,149 B2	11/2018	Zhou	
2008/0198075 A1 *	8/2008	Yoshioka	H01Q 9/40 343/700 MS
2009/0007185 A1	1/2009	Nix et al.	

(Continued)

FOREIGN PATENT DOCUMENTS

WO 2011076582 A1 6/2011

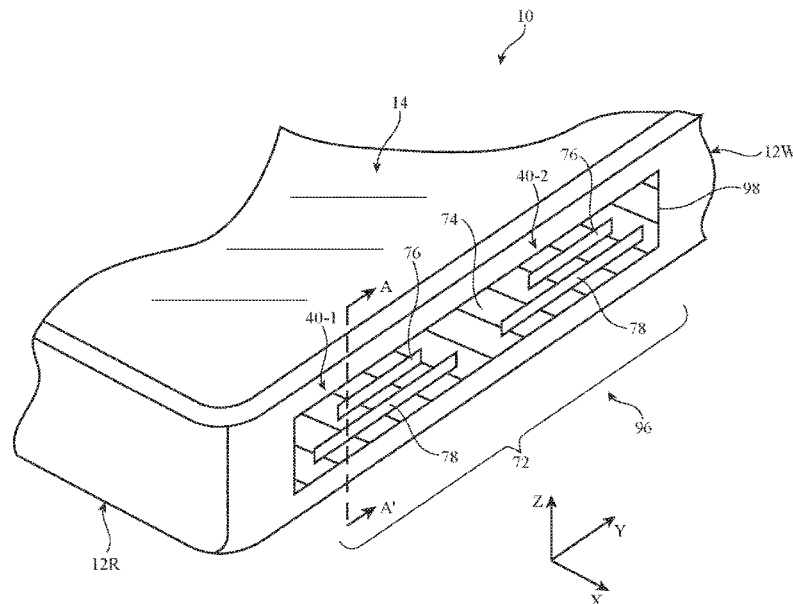
Primary Examiner — Raymond R Chai

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

(57) **ABSTRACT**

An electronic device may be provided with control circuitry and doublets of first and second antennas that are used to determine the position and orientation of the device relative to external wireless equipment. The control circuitry may determine the relative position and orientation of the external equipment by measuring the angle of arrival of radio-frequency signals from the external equipment. Each doublet may include first and second cavity-backed slot antennas. The first and second antennas may each include a first slot element that is directly fed and a second slot element that is parasitically fed by the first slot element. The first slot element may radiate in an ultra-wideband communications band at 8.0 GHz and the second slot element may radiate in an ultra-wideband communications band at 6.5 GHz. The doublet may be aligned with a dielectric window in a conductive sidewall for the device.

20 Claims, 11 Drawing Sheets





US010819031B2

(12) **United States Patent**
Wang

(10) **Patent No.:** **US 10,819,031 B2**

(45) **Date of Patent:** **Oct. 27, 2020**

(54) **PRINTED CIRCUIT BOARD ANTENNA AND TERMINAL**

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

(72) Inventor: **Hanyang Wang**, Reading (GB)

(73) Assignee: **HUAWEI DEVICE CO., LTD.**, Dongguan (CN)

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

(21) Appl. No.: **16/426,701**

(22) Filed: **May 30, 2019**

(65) **Prior Publication Data**

US 2019/0280382 A1 Sep. 12, 2019

Related U.S. Application Data

(63) Continuation of application No. 15/461,297, filed on Mar. 16, 2017, now Pat. No. 10,355,357, which is a (Continued)

(51) **Int. Cl.**
H01Q 1/00 (2006.01)
H01Q 5/357 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/357** (2015.01); **H01Q 1/242** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/314** (2015.01);
(Continued)

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,489,913 A 2/1996 Raguinet et al.
6,140,966 A 10/2000 Pankinaho
(Continued)

FOREIGN PATENT DOCUMENTS

CN 1286508 A 3/2001
CN 1806367 A 7/2006
(Continued)

OTHER PUBLICATIONS

Behdad, Nader, "Design of Dual-Band Cavity-Backed Slot Antennas Using Lumped Elements," Department of Electrical Engineering and Computer Science, University of Central Florida, Jun. 9, 2007, XP055274914, 4 pages.

(Continued)

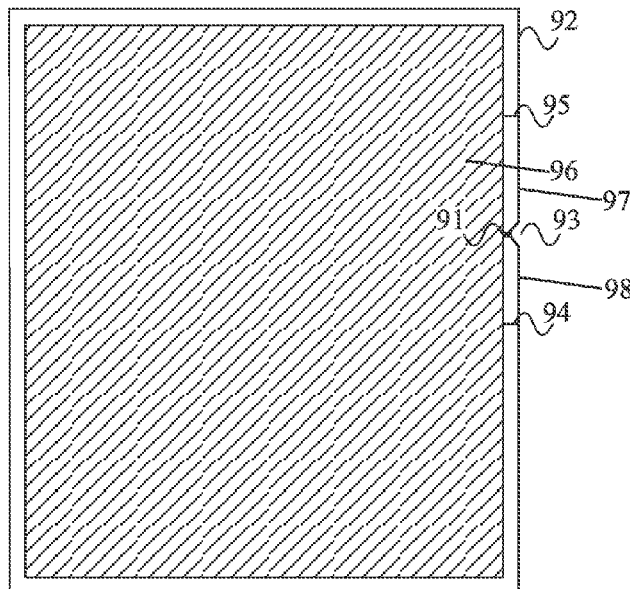
Primary Examiner — Trinh V Dinh

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

(57) **ABSTRACT**

An antenna and a terminal are disclosed. In an embodiment an antenna includes a feedpoint disposed on a printed circuit board of a mobile terminal and a metal frame being an outer frame of a mobile terminal, wherein the metal frame has a split, a first ground point and a second ground point, wherein the first ground point and the second ground point are located at two sides of the split, the first ground point and the second ground point being grounded, wherein the metal frame between the feedpoint and the first ground point forms a first resonance loop, and wherein the metal frame between the feedpoint and the second ground point forms a second resonance loop.

17 Claims, 11 Drawing Sheets





US010819398B2

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

(10) **Patent No.:** **US 10,819,398 B2**
(45) **Date of Patent:** **Oct. 27, 2020**

(54) **MULTI INPUT MULTI OUTPUT ANTENNA DEVICE OF TERMINAL AND METHOD FOR REALIZING ANTENNA SIGNAL TRANSMISSION**

(52) **U.S. Cl.**
CPC **H04B 7/0404** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/35** (2015.01); **H01Q 7/00** (2013.01);

(Continued)

(71) Applicant: **ZTE CORPORATION**, Shenzhen, Guangdong (CN)

(58) **Field of Classification Search**
CPC H04B 7/0404; H04B 7/0413; H01Q 1/38; H01Q 1/48; H01Q 21/30; H01Q 21/0025; H01Q 7/00; H01Q 5/35; H01Q 21/065
See application file for complete search history.

(72) Inventors: **Xiaoming Wang**, Guangdong (CN); **Chuangzhu Zhou**, Guangdong (CN); **Zibin Weng**, Guangdong (CN)

(73) Assignee: **ZTE CORPORATION**, Shenzhen (CN)

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

8,750,798 B2* 6/2014 Rao H01Q 21/28 455/41.2
2011/0018777 A1* 1/2011 Brown H01Q 21/30 343/788

(Continued)

(21) Appl. No.: **16/753,891**

Primary Examiner — Thanh C Le

(22) PCT Filed: **Oct. 15, 2018**

(86) PCT No.: **PCT/CN2018/110224**

§ 371 (c)(1),
(2) Date: **Apr. 6, 2020**

(57) **ABSTRACT**

(87) PCT Pub. No.: **WO2019/076260**

PCT Pub. Date: **Apr. 25, 2019**

The present disclosure provides a multi input multi output antenna device including a main board, two end areas of the main board are respectively provided with a group of antenna radiating units, a middle area of the main board is provided with a metal ground unit, wherein a first group of antenna radiating units on one end area of the main board includes a first top-layer radiating subunit and a first bottom-layer radiating subunit, a second group of antenna radiating units on the other end area of the main board includes a second top-layer radiating subunit and a second bottom-layer radiating subunit, and the metal ground unit on the middle area of the main board includes a top-layer metal ground and a bottom-layer metal ground, and a first feeding port and a second feeding port are arranged on the bottom metal ground.

(65) **Prior Publication Data**

US 2020/0259530 A1 Aug. 13, 2020

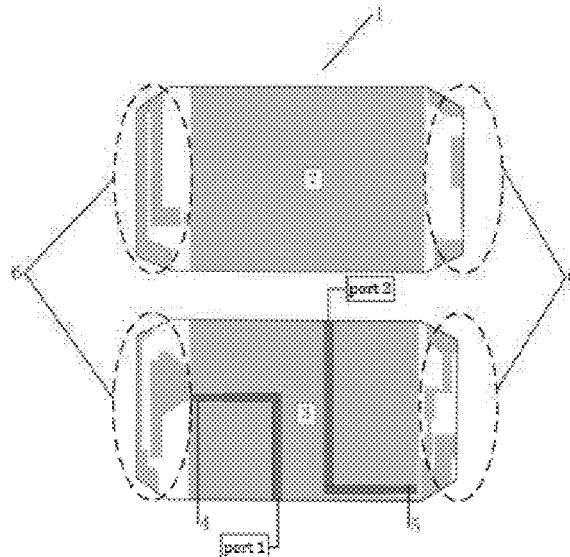
(30) **Foreign Application Priority Data**

Oct. 17, 2017 (CN) 2017 1 0965699

(51) **Int. Cl.**
H04B 7/0404 (2017.01)
H01Q 1/48 (2006.01)

(Continued)

11 Claims, 6 Drawing Sheets





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

(10) **Patent No.:** **US 10,819,834 B2**
(45) **Date of Patent:** **Oct. 27, 2020**

- (54) **ELECTRONIC DEVICE**
- (71) Applicant: **LG ELECTRONICS INC.**, Seoul (KR)
- (72) Inventors: **Byungwoon Jung**, Seoul (KR); **Soyeon 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 0 days.

- (56) **References Cited**
- U.S. PATENT DOCUMENTS
- 8,723,740 B2 * 5/2014 Chiu H01Q 1/243 343/702
- 10,608,325 B2 * 3/2020 Hashizume H01Q 1/243 (Continued)
- FOREIGN PATENT DOCUMENTS
- CN 104852122 A 8/2015
- CN 106030902 A 10/2016 (Continued)

- (21) Appl. No.: **16/623,190**
- (22) PCT Filed: **Jul. 4, 2017**
- (86) PCT No.: **PCT/KR2017/007089**
§ 371 (c)(1),
(2) Date: **Dec. 16, 2019**
- (87) PCT Pub. No.: **WO2019/009441**
PCT Pub. Date: **Jan. 10, 2019**

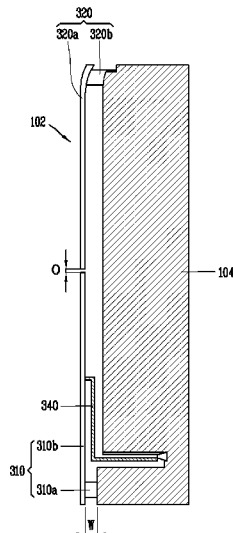
Primary Examiner — Lewis G West
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

- (65) **Prior Publication Data**
US 2020/0162591 A1 May 21, 2020
- (51) **Int. Cl.**
H04M 1/02 (2006.01)
H01Q 5/371 (2015.01)
(Continued)
- (52) **U.S. Cl.**
CPC **H04M 1/02** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/371** (2015.01)
- (58) **Field of Classification Search**
CPC H04M 1/02; H01Q 5/371; H01Q 1/243; H01Q 1/38; H01Q 1/24
See application file for complete search history.

(57) **ABSTRACT**

An electronic device of the present disclosure comprises: a housing including a metal frame; and a first antenna unit which is arranged at one side of the housing and transmits and receives a signal at a specific frequency band, wherein: the first antenna unit includes a first metal member which is connected to the metal frame, receives power by a power feeding unit, and has a length set to be radiated at the specific frequency band, and a second metal member which is arranged at a spaced gap of a preset interval from the first metal member and has one end coming into contact with the metal frame; a current, which is induced through the second metal member coupled with the first metal member, moves to the metal frame by means of the spaced gap; the first metal member, the second metal member and the metal frame are arranged to be separated from one another; and the first and second metal members are formed to resonate at the specific frequency band.

20 Claims, 12 Drawing Sheets





US010826159B2

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

(10) **Patent No.:** **US 10,826,159 B2**

(45) **Date of Patent:** **Nov. 3, 2020**

(54) **ELECTRONIC DEVICE INCLUDING ANTENNA**

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

(72) Inventors: **Gyu Sub Kim**, Seoul (KR); **Jin Woo Jung**, Seoul (KR); **Byoung Ryoul Song**, Suwon-si (KR); **Sin Hyung Jeon**, Suwon-si (KR); **So Young Lee**, Gwacheon-si (KR); **Jae Bong Chun**, Suwon-si (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 161 days.

(21) Appl. No.: **15/977,551**

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

(65) **Prior Publication Data**

US 2018/0331418 A1 Nov. 15, 2018

(30) **Foreign Application Priority Data**

May 12, 2017 (KR) 10-2017-0059451

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 21/28 (2006.01)

(Continued)

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

CPC **H01Q 1/243** (2013.01); **B29C 45/14655** (2013.01); **H01Q 1/38** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC B29C 45/14655; H01Q 1/24; H01Q 1/243; H01Q 1/38; H01Q 21/28; H01Q 9/04; H01Q 9/0414; H01Q 9/42

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,203,491 B2 * 6/2012 Yang H01Q 1/40
343/700 MS

8,364,212 B2 * 1/2013 Waku H01Q 1/243
455/347

(Continued)

FOREIGN PATENT DOCUMENTS

CN 104079313 A 10/2014

CN 105873388 A 8/2016

CN 105892570 A 8/2016

OTHER PUBLICATIONS

European Search Report dated Aug. 28, 2018; Reference #: P256685EP/PXC; Application #: 18171880.0-1205.

(Continued)

Primary Examiner — Tho G Phan

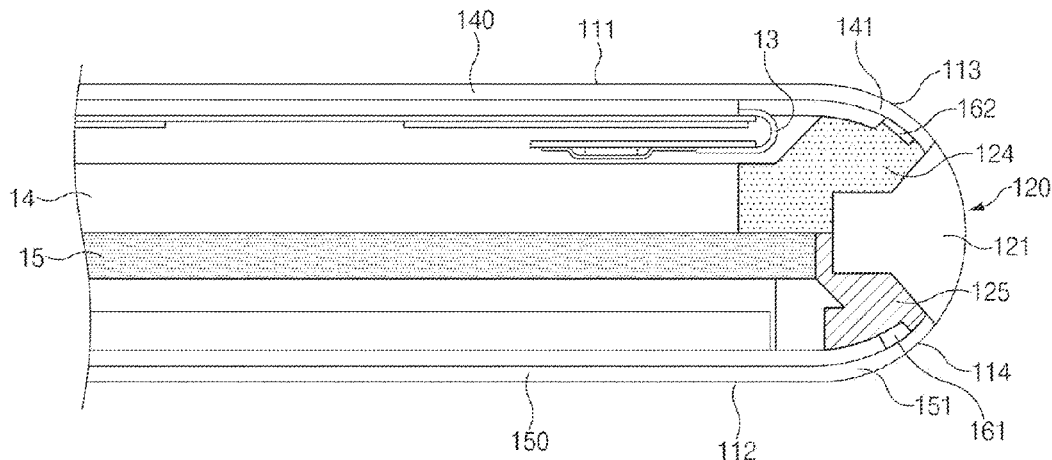
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a front glass plate, a back glass plate, and a side member including a conductive portion, at least one conductive pattern formed on an edge portion of the front glass plate, a wireless communication circuit positioned inside a housing and electrically connected to the conductive portion and the at least one conductive pattern. In addition, various embodiments understood through the disclosure may be provided.

13 Claims, 19 Drawing Sheets

900





US010826170B2

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

(10) **Patent No.:** **US 10,826,170 B2**
(45) **Date of Patent:** **Nov. 3, 2020**

(54) **ANTENNA AND MOBILE TERMINAL**

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

(72) Inventors: **Dong Yu**, Shanghai (CN); **Hanyang Wang**, Reading (GB); **Jianming Li**, Shanghai (CN)

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

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

(21) Appl. No.: **16/526,450**

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

(65) **Prior Publication Data**

US 2019/0356045 A1 Nov. 21, 2019

Related U.S. Application Data

(63) Continuation of application No. 15/112,635, filed on Jul. 19, 2016, now Pat. No. 10,403,971, which is a (Continued)

(30) **Foreign Application Priority Data**

Feb. 12, 2014 (CN) 2014 1 0049186

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

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

(58) **Field of Classification Search**

CPC H01Q 1/38; H01Q 5/378; H01Q 5/371; H01Q 5/328; H01Q 1/48; H01Q 1/243; H01Q 5/335; H01Q 9/42; H01Q 7/00
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2002/0019247 A1 2/2002 Egorov
2004/0085245 A1* 5/2004 Miyata H01Q 1/243
343/700 MS

(Continued)

FOREIGN PATENT DOCUMENTS

CN 1805215 A 7/2006
CN 101127513 A 2/2008

(Continued)

OTHER PUBLICATIONS

Withayachumnankul et al., Compact Electric-LC Resonators for Metamaterial. Optics Express, 18(25), 25912. (Year: 2010).*

(Continued)

Primary Examiner — Dimary S Lopez Cruz

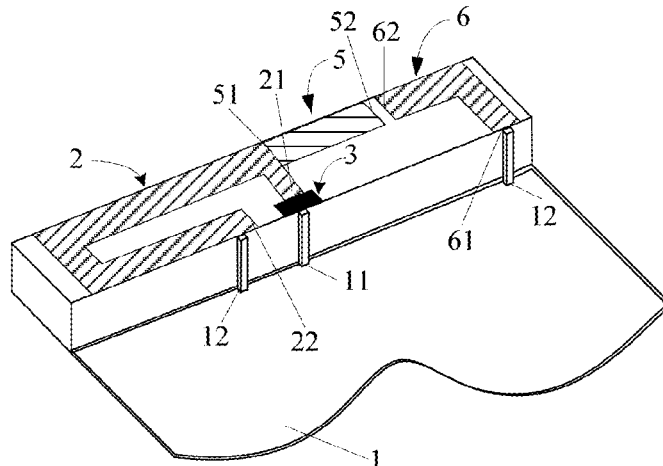
Assistant Examiner — Bamidele A Jegede

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

(57) **ABSTRACT**

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

(Continued)



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

(10) **Patent No.:** **US 10,826,178 B2**
(45) **Date of Patent:** **Nov. 3, 2020**

(54) **MULTI-BAND ANTENNA**

(71) Applicants: **Wen-Jiao Liao**, Taipei (TW); **Hao-Ju Hsieh**, Taipei (TW); **Yen-Hao Yu**, Taipei (TW); **Shih-Chia Liu**, Taipei (TW); **Liang-Che Chou**, Taipei (TW); **Li-Chun Lee**, Taipei (TW)

(72) Inventors: **Wen-Jiao Liao**, Taipei (TW); **Hao-Ju Hsieh**, Taipei (TW); **Yen-Hao Yu**, Taipei (TW); **Shih-Chia Liu**, Taipei (TW); **Liang-Che Chou**, Taipei (TW); **Li-Chun Lee**, Taipei (TW)

(73) Assignee: **COMPAL ELECTRONICS, 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.

(21) Appl. No.: **16/026,075**

(22) Filed: **Jul. 3, 2018**

(65) **Prior Publication Data**
US 2019/0006755 A1 Jan. 3, 2019

Related U.S. Application Data

(60) Provisional application No. 62/528,419, filed on Jul. 3, 2017.

(51) **Int. Cl.**
H01Q 5/30 (2015.01)
H01Q 5/335 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/335** (2015.01); **H01Q 1/36** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/342** (2015.01);
(Continued)

(58) **Field of Classification Search**

CPC .. H01Q 1/38; H01Q 5/30–5/392; H01Q 13/10
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,079,079 B2* 7/2006 Jo H01Q 1/243
343/700 MS
7,548,214 B2* 6/2009 Chou H01Q 1/38
343/700 MS

(Continued)

FOREIGN PATENT DOCUMENTS

TW	200522440	7/2005
TW	200835055	8/2008

OTHER PUBLICATIONS

“Office Action of Taiwan Counterpart Application”, dated May 31, 2019, pp. 1-5.

Primary Examiner — Dameon E Levi

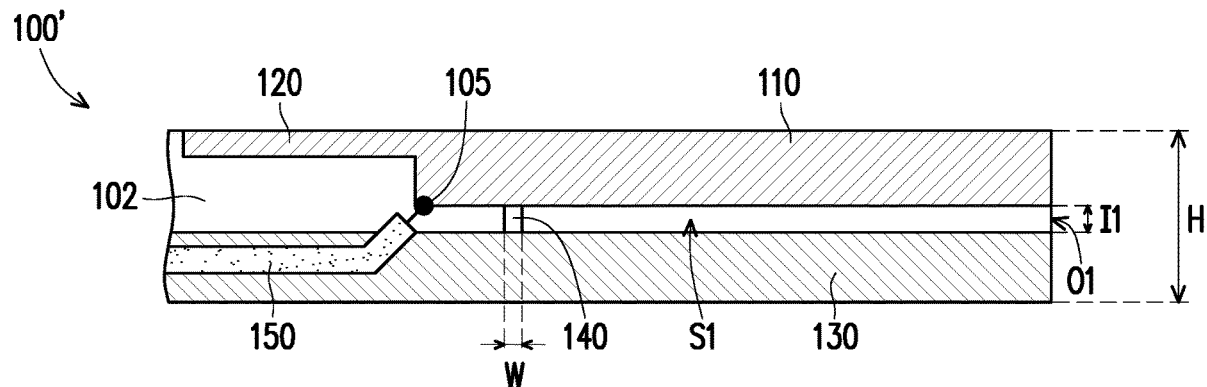
Assistant Examiner — Hasan Z Islam

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

(57) **ABSTRACT**

A multi-band antenna including a ground portion, a first radiation portion, a second radiation portion, a feeding portion and a matching portion is provided. The first radiation portion is disposed beside the ground portion, a first gap is existed between the ground portion and the first radiation portion so as to form a first slot, and the first slot has a first open terminal located at the first gap. The second radiation portion is connected to the first radiation portion. The feeding portion is located between the first radiation portion and the second radiation portion. The matching portion is located in the first slot and connected to the first radiation portion and the ground portion. The feeding portion excites the first slot to generate a first resonant mode. The second radiation portion generates a second resonant mode.

13 Claims, 8 Drawing Sheets





US010826180B2

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

(10) **Patent No.:** **US 10,826,180 B2**
(45) **Date of Patent:** **Nov. 3, 2020**

(54) **LOW-PROFILE MULTI-BAND STACKED PATCH ANTENNA**
(71) Applicant: **The Board of Trustees of The University of Alabama**, Tuscaloosa, AL (US)
(72) Inventors: **Yang-Ki Hong**, Tuscaloosa, AL (US); **Woncheol Lee**, Tuscaloosa, AL (US)
(73) Assignee: **The Board of Trustees of the University of Alabama**, Tuscaloosa, AL (US)

(56) **References Cited**
U.S. PATENT DOCUMENTS
5,422,649 A * 6/1995 Huang H01Q 21/0075 343/700 MS
6,091,365 A * 7/2000 Derneryd H01Q 1/246 343/700 MS
(Continued)

FOREIGN PATENT DOCUMENTS
KR 10-2005-0064493 6/2005

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 64 days.

OTHER PUBLICATIONS
M. Weigle, "Standards: WAVE/DSRC/802.11p," Old Dominion University, 2008: available at <http://www.cs.odu.edu/~mweigle/courses/cs795-s08/lectures/5c-DSRC.pdf> 19 pages.
(Continued)

(21) Appl. No.: **16/204,357**

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

(65) **Prior Publication Data**
US 2019/0165476 A1 May 30, 2019

Primary Examiner — Dieu Hien T Duong
(74) *Attorney, Agent, or Firm* — Meunier Carlin & Curman LLC

Related U.S. Application Data

(60) Provisional application No. 62/592,029, filed on Nov. 29, 2017.

(57) **ABSTRACT**

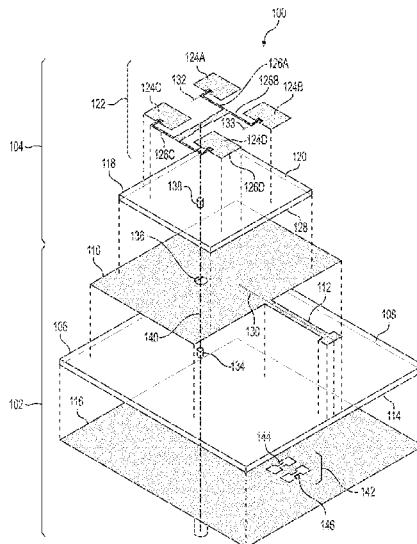
(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 9/04 (2006.01)
(Continued)

The exemplified systems and methods provides a low-profile stacked patch multi-frequency antenna (e.g., a dual-frequency antenna). A design is disclosed which is configured to operate at the 5.9-GHz band (e.g., for Dedicated Short Range Communications) and the 28-GHz band (e.g., for 5G communications). With a low-profile, the exemplified systems and methods can be integrated into existing microelectronic packaging systems as well as readily integrated into communication systems having smaller form factor.

(52) **U.S. Cl.**
CPC **H01Q 9/0414** (2013.01); **H01Q 5/392** (2015.01); **H01Q 19/005** (2013.01); **H01Q 21/065** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0414; H01Q 21/28; H01Q 21/065; H01Q 19/005; H01Q 5/392
See application file for complete search history.

18 Claims, 24 Drawing Sheets
(2 of 24 Drawing Sheet(s) Filed in Color)





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

(10) **Patent No.:** **US 10,826,326 B2**
(45) **Date of Patent:** **Nov. 3, 2020**

(54) **PORTABLE TERMINAL HAVING WIRELESS CHARGING MODULE**

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

(72) Inventors: **Ki-Hyun Kim**, Suwon-si (KR); **Jin-Hyoung Park**, Wonju-si (KR); **Ki-Ho Kim**, Seoul (KR); **Se-Ho Park**, Suwon-si (KR); **Young-Min Lee**, Yongin-si (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 80 days.

(21) Appl. No.: **15/925,627**

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

(65) **Prior Publication Data**

US 2018/0212473 A1 Jul. 26, 2018

Related U.S. Application Data

(63) Continuation of application No. 14/234,912, filed as application No. PCT/KR2012/007492 on Sep. 19, 2012, now Pat. No. 9,948,126.

(30) **Foreign Application Priority Data**

Sep. 30, 2011 (KR) 10-2011-0099865
Sep. 12, 2012 (KR) 10-2012-0101541

(51) **Int. Cl.**

H02J 7/00 (2006.01)
H02J 50/12 (2016.01)

(Continued)

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

CPC **H02J 50/12** (2016.02); **H01Q 1/243** (2013.01); **H02J 7/025** (2013.01); **H02J 50/70** (2016.02); **H04B 1/3883** (2013.01); **H02J 7/0042** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 13/10; H01Q 1/38; H01Q 7/00; H01Q 21/28; H01Q 5/371;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,754,815 B2 6/2014 Leem
8,766,484 B2 7/2014 Baarman et al.
(Continued)

FOREIGN PATENT DOCUMENTS

EP 1 686 651 8/2006
JP 5773224 9/2015
(Continued)

OTHER PUBLICATIONS

PCT/ISA/237 Written Opinion dated Dec. 12, 2012 in PCT/KR2012/007492.

(Continued)

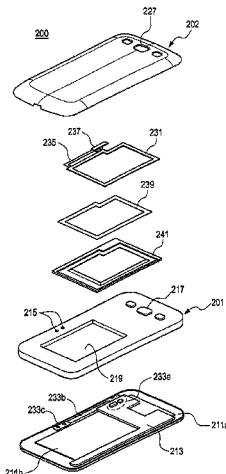
Primary Examiner — Binh C Tat

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

(57) **ABSTRACT**

A portable terminal is provided, including a cover member which is detachably provided at a rear surface of a main body of a terminal, a resonant antenna for a reception unit provided inside of the cover member, a reception circuit unit provided inside of the main body, and a connection unit for connecting the resonant antenna for a reception unit with the reception circuit unit. The portable terminal efficiently receives the signal power provided from a charger by arranging the resonant antenna inside of the cover member, and minimizes the thickness of the portable terminal by providing the reception circuit unit inside of the main body of the terminal.

18 Claims, 4 Drawing Sheets





US010833396B2

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

(10) **Patent No.:** **US 10,833,396 B2**

(45) **Date of Patent:** ***Nov. 10, 2020**

(54) **ELECTRONIC DEVICE**

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

(72) Inventors: **Jianming Li**, Shanghai (CN); **Kun Feng**, Shanghai (CN); **Xuefei Zhang**, Shenzhen (CN); **Hanyang Wang**, Reading (GB)

(73) Assignee: **HUAWEI DEVICE CO., LTD.**, Dongguan (CN)

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

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/377,990**

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

(65) **Prior Publication Data**

US 2019/0237854 A1 Aug. 1, 2019

Related U.S. Application Data

(63) Continuation of application No. 15/124,449, filed as application No. PCT/CN2015/073649 on Mar. 4, 2015, now Pat. No. 10,290,922.

(30) **Foreign Application Priority Data**

Mar. 21, 2014 (CN) 2014 1 0109571

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/50** (2013.01); **H01Q 5/328** (2015.01); **H01Q 5/335** (2015.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/50; H01Q 1/48; H01Q 5/335; H01Q 5/328; H01Q 9/42
See application file for complete search history.

(56) **References Cited**
U.S. PATENT DOCUMENTS

10,290,922 B2* 5/2019 Li H01Q 1/243
2003/0025637 A1 2/2003 Mendolia et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 102956954 A 3/2013
CN 103296385 A 9/2013
(Continued)

OTHER PUBLICATIONS

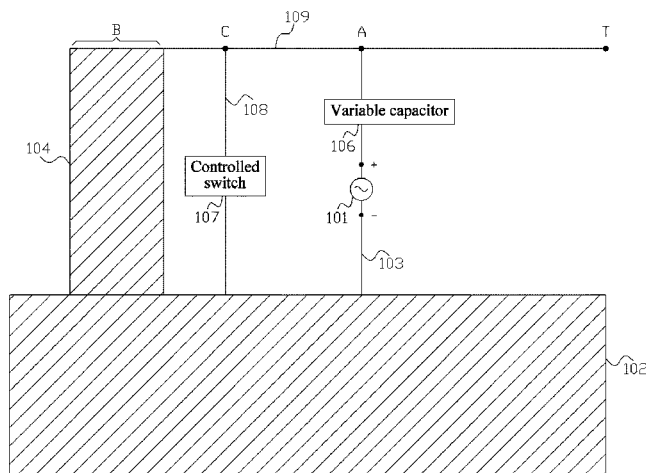
International Search Report (including English translation) issued in corresponding International Application No. PCT/CN2015/073649, dated Jun. 12, 2015, 6 pages.

(Continued)

Primary Examiner — Dieu Hien T Duong
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

(57) **ABSTRACT**
An electronic device includes a metal frame, an antenna feeding point, an antenna ground, a feeding branch, a grounding branch, an antenna resonance arm, a variable capacitor, and a control circuit. The antenna resonance arm is a part of the metal frame after segmentation, the antenna feeding point is disposed on the feeding branch, a first connection portion and a second connection portion are disposed on the antenna resonance arm, the feeding branch is disposed between the second connection portion and the antenna ground, the grounding branch is disposed between the first connection portion and the antenna ground, the variable capacitor is disposed on the feeding branch, the variable capacitor is disposed between the antenna feeding point and the second connection portion, and the control

(Continued)





US010833397B2

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

(10) **Patent No.:** **US 10,833,397 B2**
(45) **Date of Patent:** **Nov. 10, 2020**

(54) **FOLDABLE DEVICE COMPRISING ANTENNA**

(56) **References Cited**

(71) Applicant: **Samsung Electronics Co., Ltd.**, Suwon-si (KR)
(72) Inventors: **Woosup Lee**, Suwon-si (KR); **Yongyoun Kim**, Suwon-si (KR); **Jungsik Park**, Suwon-si (KR); **Sehwan Choi**, 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.

U.S. PATENT DOCUMENTS

6,031,497 A	2/2000	Nam	
7,290,718 B2	11/2007	Sekita	
10,075,569 B2	9/2018	Kim et al.	
10,079,425 B2	9/2018	Chun et al.	
2006/0118625 A1	6/2006	Sekita	
2007/0080872 A1*	4/2007	Nishikido	H01Q 1/243 343/702
2009/0264156 A1*	10/2009	Burghardt	H04M 1/021 455/566
2013/0106666 A1*	5/2013	Shan	H01Q 21/28 343/725
2014/0097992 A1*	4/2014	Cheng	H01Q 1/2266 343/702
2014/0240178 A1	8/2014	Chun et al.	

(Continued)

(21) Appl. No.: **16/562,179**

FOREIGN PATENT DOCUMENTS

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

CN	105789827 A	7/2016
KR	10-2008-0019326 A	3/2008

(Continued)

(65) **Prior Publication Data**

US 2020/0076062 A1 Mar. 5, 2020

(30) **Foreign Application Priority Data**

Sep. 5, 2018 (KR) 10-2018-0105928

OTHER PUBLICATIONS

ISA/KR, International Search Report, International Application No. PCT/KR2019/011454, dated Jan. 3, 2020, 3 pages.

Primary Examiner — Congvan Tran

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H04M 1/02 (2006.01)
H01Q 5/307 (2015.01)

(57) **ABSTRACT**

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

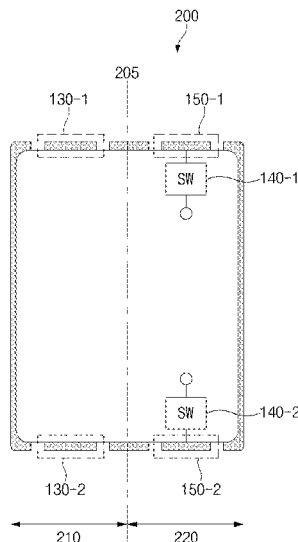
CPC **H01Q 1/243** (2013.01); **H01Q 5/307** (2015.01); **H04M 1/0268** (2013.01); **H04M 1/0277** (2013.01); **H04M 1/0291** (2013.01)

Disclosed is an electronic device. The electronic device may comprise a first structure and a second structure mutually foldably connected with the first structure about a first axis extending in a first direction. A wireless communication circuit of the electronic device is electrically connected with a first radiator and a second radiator and is electrically separated from the second radiator in a folded state.

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 5/307; H04M 1/0291; H04M 1/0268; H04M 1/0277
USPC 455/575.3
See application file for complete search history.

19 Claims, 14 Drawing Sheets





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

(10) **Patent No.:** **US 10,833,398 B2**
(45) **Date of Patent:** ***Nov. 10, 2020**

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

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

(72) Inventors: **Tiao-Hsing Tsai**, Taoyuan (TW);
Chien-Pin Chiu, Taoyuan (TW);
Hsiao-Wei Wu, Taoyuan (TW);
Chao-Chiang Kuo, 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.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/660,051**

(22) Filed: **Oct. 22, 2019**

(65) **Prior Publication Data**

US 2020/0052386 A1 Feb. 13, 2020

Related U.S. Application Data

(63) Continuation of application No. 15/599,247, filed on May 18, 2017, now Pat. No. 10,490,883, which is a (Continued)

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 13/10 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 13/106** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 13/106; H01Q 13/10; H01Q 1/24; H01Q 1/243; H01Q 1/38
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,885,676 A 5/1959 Baldwin
6,400,571 B1 6/2002 Kimura et al.
(Continued)

FOREIGN PATENT DOCUMENTS

CN 1595718 A 3/2005
CN 1262133 C 6/2006
(Continued)

OTHER PUBLICATIONS

Chen et al., "Mobile Communication System and Mobile Phone Repair Technology," 2nd Edition, China Machine Press, Aug. 2012, pp. 14-17 (8 pages total), with English abstract.

(Continued)

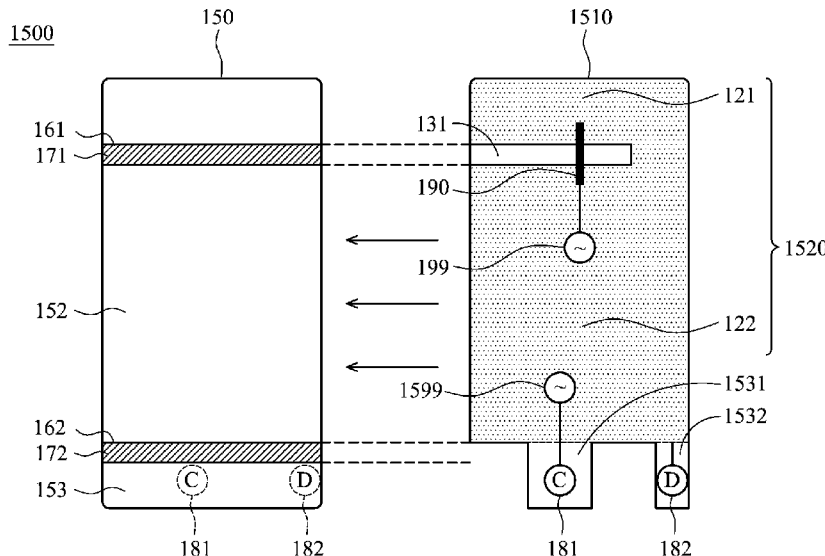
Primary Examiner — Tho G Phan

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

(57) **ABSTRACT**

A mobile device includes a dielectric substrate, a metal layer, a metal housing, a nonconductive partition, at least one connection element, and a feeding element. The metal layer is disposed on the dielectric substrate, and includes an upper element and a main element, wherein a slot is formed between the upper element and the main element. The metal housing is substantially a hollow structure, and has a slit, wherein the slit is substantially aligned with the slot of the metal layer. The connection element couples the upper element of the metal layer to the metal housing. The feeding element is coupled to the upper element of the metal layer or coupled to the metal housing. An antenna structure is formed by the feeding element, the upper element of the metal layer, the connection element, and the metal housing.

27 Claims, 59 Drawing Sheets





US010833403B2

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

(10) **Patent No.:** **US 10,833,403 B2**

(45) **Date of Patent:** **Nov. 10, 2020**

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

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

(72) Inventors: **Jaehyung Kim**, Suwon-si (KR);
Hanbin Lee, Suwon-si (KR); **Sangmin Han**,
Suwon-si (KR); **Jongsuk Kim**, Suwon-si (KR);
Taegyu Kim, Suwon-si (KR); **Minseok Park**,
Suwon-si (KR); **Jinkyu Bang**, 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.: **16/402,688**

(22) Filed: **May 3, 2019**

(65) **Prior Publication Data**

US 2019/0341688 A1 Nov. 7, 2019

(30) **Foreign Application Priority Data**

May 4, 2018 (KR) 10-2018-0052101

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 1/50 (2006.01)

(Continued)

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

CPC **H01Q 1/526** (2013.01); **G06F 1/1698**
(2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38**
(2013.01);

(Continued)

(58) **Field of Classification Search**

CPC H01Q 3/44; H01Q 1/50; H01Q 1/243;
H01Q 1/088; H01Q 1/38; H01Q 9/0421;

(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

10,158,163 B2* 12/2018 Gang H01Q 21/28
2013/0094126 A1 4/2013 Rappoport et al.

(Continued)

FOREIGN PATENT DOCUMENTS

KR 10-2016-0104482 A 9/2016
KR 10-2018-0035605 A 4/2018
KR 10-2018-0105356 A 9/2018

OTHER PUBLICATIONS

International Search Report with Written Opinion dated Aug. 26,
2019; International Appin. No. PCT/KR2019/005307.

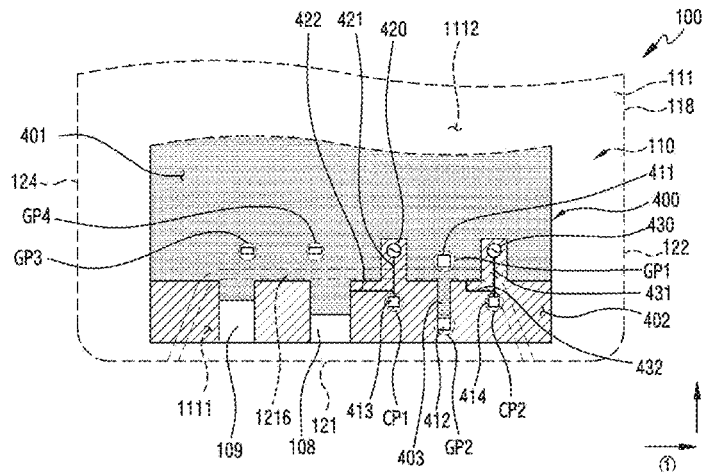
Primary Examiner — Minh D A

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

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a housing, a touch screen display arranged inside the housing, a printed circuit board (PCB) which is arranged in parallel with a rear plate, and which includes a ground plane and a conductive path, and a wireless communication circuit arranged on the PCB. The housing includes a first side surface, a second side surface, a third side surface, and a fourth side surface. The first side surface includes a first conductive part, a first nonconductive part, a second conductive part, a second nonconductive part, and a third conductive part successively arranged between the second side surface and the fourth side surface. The rear plate includes, when seen from above the rear plate, a nonconductive slit extending from the first nonconductive part to the second nonconductive part, a first conductive area, and a second conductive area positioned outside the first conductive area across the nonconductive slit.

20 Claims, 17 Drawing Sheets





US010833410B2

(12) **United States Patent**
Ayala Vazquez et al.

(10) **Patent No.:** **US 10,833,410 B2**
(45) **Date of Patent:** **Nov. 10, 2020**

(54) **ELECTRONIC DEVICE ANTENNAS HAVING MULTIPLE SIGNAL FEED TERMINALS**

(56) **References Cited**

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)
(72) Inventors: **Enrique Ayala Vazquez**, Watsonville, CA (US); **Hongfei Hu**, Cupertino, CA (US); **Nanbo Jin**, San Jose, CA (US); **Xu Gao**, Santa Clara, CA (US); **Erica J. Tong**, Pacifica, CA (US); **Erdinc Irci**, Sunnyvale, CA (US); **Han Wang**, San Jose, CA (US); **Mattia Pascolini**, San Francisco, CA (US); **Kevin M. Froese**, San Francisco, CA (US)

U.S. PATENT DOCUMENTS

8,798,554 B2	8/2014	Darnell et al.	
9,276,319 B2	3/2016	Vazquez et al.	
10,381,710 B1 *	8/2019	Kuo	H01Q 1/2291
2011/0128190 A1 *	6/2011	Galeev	H01Q 9/0421
			343/702
2012/0112969 A1 *	5/2012	Caballero	H04M 1/0266
			343/702
2015/0188225 A1 *	7/2015	Chang	H01Q 1/243
			343/702
2016/0112219 A1	4/2016	Lee et al.	
2017/0141469 A1	5/2017	Huang	
2017/0264721 A1	9/2017	Yli-Peltola	

(Continued)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 350 days.

Primary Examiner — Graham P Smith
Assistant Examiner — Jae K Kim
(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; Michael H. Lyons; Matthew R. Williams

(21) Appl. No.: **15/902,907**

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

(57) **ABSTRACT**

(65) **Prior Publication Data**
US 2019/0260126 A1 Aug. 22, 2019

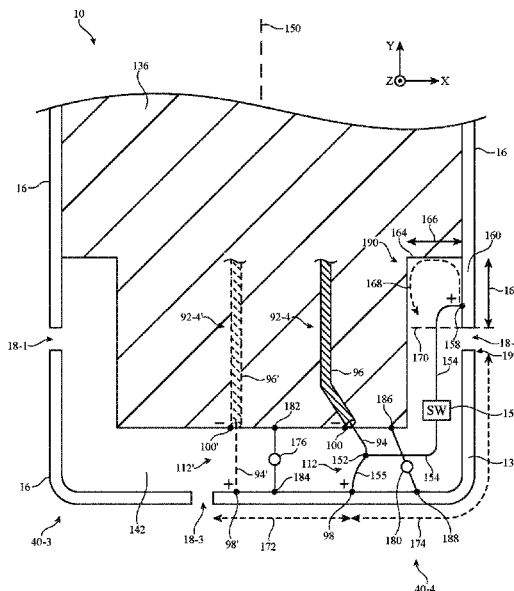
An electronic device may include a conductive housing and an antenna. The antenna may include an arm formed from a first segment of the housing. A gap may separate the first segment from a second segment. Respective first and second slots may separate an antenna ground from the first and second segments. The antenna may have a first positive antenna feed terminal on the first segment and a second positive antenna feed terminal on the second segment. A transmission line may include a signal conductor having a first branch coupled to the first positive antenna feed terminal and a second branch coupled to the second positive antenna feed terminal. A switch may be interposed on the second branch for switching the antenna between a first mode in which the second slot is directly fed and a second mode in which the second segment is indirectly fed by the first segment.

(51) **Int. Cl.**
H01Q 5/35 (2015.01)
H01Q 9/06 (2006.01)
H01Q 9/04 (2006.01)
H01Q 9/28 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/35** (2015.01); **H01Q 9/0485** (2013.01); **H01Q 9/065** (2013.01); **H01Q 9/285** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/35; H01Q 9/0485; H01Q 9/065; H01Q 9/285; H01Q 21/30; H01Q 9/42; H01Q 5/328
See application file for complete search history.

20 Claims, 9 Drawing Sheets





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

(10) **Patent No.:** **US 10,833,413 B2**
(45) **Date of Patent:** **Nov. 10, 2020**

(54) **COMMUNICATION DEVICE**

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

(71) Applicant: **SILERGY SEMICONDUCTOR TECHNOLOGY (HANGZHOU) LTD.**, Hangzhou (CN)

(72) Inventors: **Yupang Chou**, New Taipei (TW); **Chuohsun Sun**, Taipei (TW)

(73) Assignee: **Silergy Semiconductor Technology (Hangzhou) LTD**, Hangzhou (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 106 days.

(21) Appl. No.: **16/110,261**

(22) Filed: **Aug. 23, 2018**

(65) **Prior Publication Data**
US 2020/0021029 A1 Jan. 16, 2020

(30) **Foreign Application Priority Data**
Jul. 10, 2018 (TW) 107123878 A

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/38 (2006.01)
H01Q 9/40 (2006.01)
H01Q 21/28 (2006.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0421** (2013.01); **H01Q 1/245** (2013.01); **H01Q 1/38** (2013.01); **H01Q 9/04** (2013.01); **H01Q 9/40** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0421; H01Q 1/38; H01Q 9/40; H01Q 21/28; H01Q 1/245

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,552,916 B2 *	10/2013	Hossain	.....	H01Q 7/00 343/745
9,374,119 B1 *	6/2016	Chou	.....	H04B 1/3838
2013/0130633 A1 *	5/2013	Lin	.....	H01Q 1/245 455/127.1
2013/0241796 A1 *	9/2013	Nagumo	.....	H01Q 1/243 343/861
2014/0315606 A1 *	10/2014	You	.....	H01Q 1/245 455/575.5
2015/0295318 A1 *	10/2015	Chiu	.....	H01Q 1/245 343/745
2016/0087343 A1 *	3/2016	Chang	.....	H01Q 5/378 343/720
2017/0084985 A1 *	3/2017	Ku	.....	H01Q 1/243

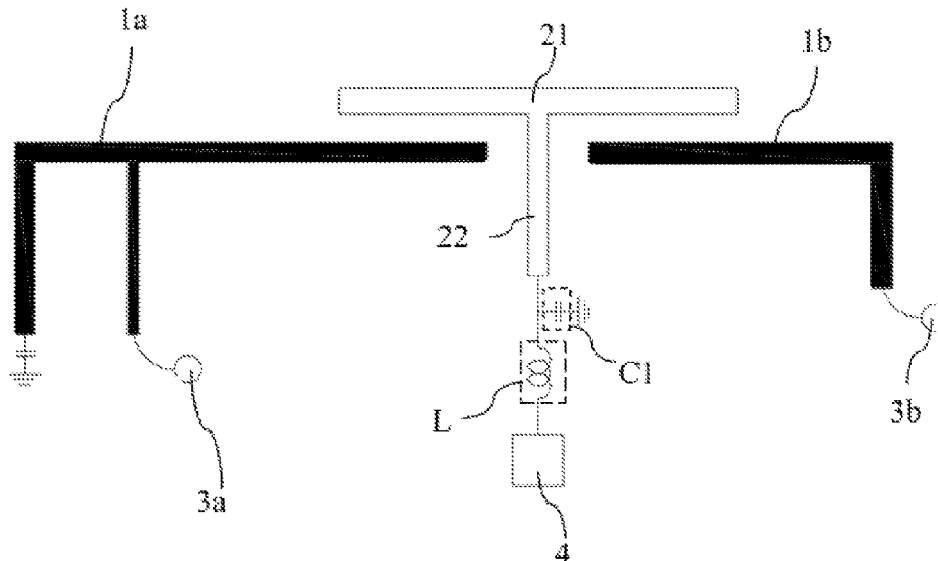
* cited by examiner

Primary Examiner — Hai V Tran

(57) **ABSTRACT**

A communication device comprises a plurality of antennas, a sensing unit, a plurality of radio frequency circuits, and a sensing module. The sensing unit is electrically connected to the ground through at least one grounding capacitor, and the sensing unit is further configured to isolate and be coupled to each antenna. Each the radio frequency circuit is electrically connected to the corresponding each antenna. The sensing module is electrically connected to the sensing unit through an inductor, wherein the sensing module is used to sense the distance between the sensing unit and an external object by the sensing unit, and the sensing module generates a distance signal according to the distance.

10 Claims, 8 Drawing Sheets



(12) **United States Patent**
Cheng

(10) **Patent No.:** **US 10,833,418 B2**
(45) **Date of Patent:** **Nov. 10, 2020**

(54) **ANTENNA STRUCTURE**
(71) Applicant: **Wistron NeWeb Corp.**, Hsinchu (TW)
(72) Inventor: **Chia-Shang Cheng**, 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 0 days.

H01Q 5/378; H01Q 5/385; H01Q 9/065;
H01Q 9/16; H01Q 19/005; H01Q 1/241;
H01Q 5/321; H01Q 5/48
See application file for complete search history.

(21) Appl. No.: **16/426,221**
(22) Filed: **May 30, 2019**

(56) **References Cited**
U.S. PATENT DOCUMENTS
6,515,634 B2 * 2/2003 Desclos H01Q 3/12
343/815
7,501,992 B2 * 3/2009 Yamagajo H01Q 21/24
343/795
8,427,337 B2 * 4/2013 Wilbur H01Q 9/285
340/870.02
8,717,245 B1 * 5/2014 Krivokapic H01Q 5/378
343/795
8,952,858 B2 * 2/2015 de Rochemont H01Q 9/26
343/803
9,257,741 B2 * 2/2016 Cheng H01Q 1/36
10,164,339 B1 * 12/2018 Hsu H01Q 15/14
(Continued)

(65) **Prior Publication Data**
US 2020/0287288 A1 Sep. 10, 2020

(30) **Foreign Application Priority Data**
Mar. 7, 2019 (TW) 108107545 A

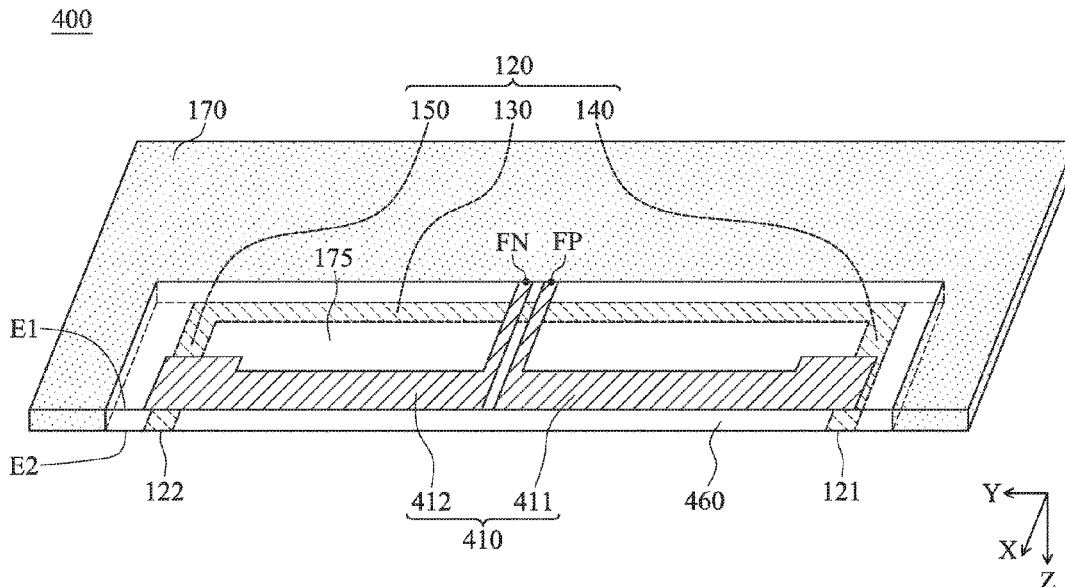
FOREIGN PATENT DOCUMENTS
JP 2007251241 A * 9/2007
TW 1255584 B 5/2006
TW 1256752 B 6/2006
Primary Examiner — Vibol Tan
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(51) **Int. Cl.**
H01Q 1/36 (2006.01)
H01Q 9/28 (2006.01)
H01Q 19/10 (2006.01)
H01Q 9/18 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)
H01Q 1/38 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 9/18** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/36** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01); **H01Q 9/28** (2013.01); **H01Q 19/108** (2013.01)

(57) **ABSTRACT**
An antenna structure includes a dipole antenna element and a floating metal element. The floating metal element is disposed adjacent to the dipole antenna element. The vertical projection of the dipole antenna element at least partially overlaps the floating metal element. The floating metal element is configured for fine-tuning the radiation pattern of the antenna structure and to increase the operation bandwidth of the antenna structure.

(58) **Field of Classification Search**
CPC H01Q 9/285; H01Q 1/243; H01Q 19/108; H01Q 1/38; H01Q 15/14; H01Q 19/10;

18 Claims, 11 Drawing Sheets





US010840586B2

(12) **United States Patent**
Mata Garcia et al.

(10) **Patent No.:** **US 10,840,586 B2**
(45) **Date of Patent:** **Nov. 17, 2020**

(54) **BROADBAND LTE ANTENNA SYSTEM FOR A VEHICLE**

(71) Applicant: **Advanced Automotive Antennas, S.L.U.**, Barcelona (ES)
(72) Inventors: **Victor Mata Garcia**, Barcelona (ES); **Enrique Martinez Ortigosa**, Barcelona (ES); **Ramiro Quintero Illera**, Barcelona (ES)

(73) Assignee: **Advanced Automotive Antennas, S.L.U.**, Barcelona (ES)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 112 days.

(21) Appl. No.: **16/248,387**

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

(65) **Prior Publication Data**
US 2019/0221925 A1 Jul. 18, 2019

(30) **Foreign Application Priority Data**
Jan. 15, 2018 (EP) 18382011

(51) **Int. Cl.**
H01Q 1/32 (2006.01)
H01Q 1/48 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/3275** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/521** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 9/40; H01Q 1/521; H01Q 1/48; H01Q 5/378; H01Q 1/3275; H01Q 5/335; H01Q 21/28
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,012,741 A * 3/1977 Johnson H01Q 9/0428 343/700 MS
7,042,414 B1 * 5/2006 Lee H01Q 1/243 343/795

(Continued)

FOREIGN PATENT DOCUMENTS

JP 2005110123 A 4/2005
JP 2012200007 A 10/2012

OTHER PUBLICATIONS

Eldek, A. A., "Numerical Analysis of a Small Ultra Wideband Microstrip-Fed Tap Monopole Antenna," Progress in Electromagnetics Research, PIER 65, 59-69, 2006.

(Continued)

Primary Examiner — Graham P Smith

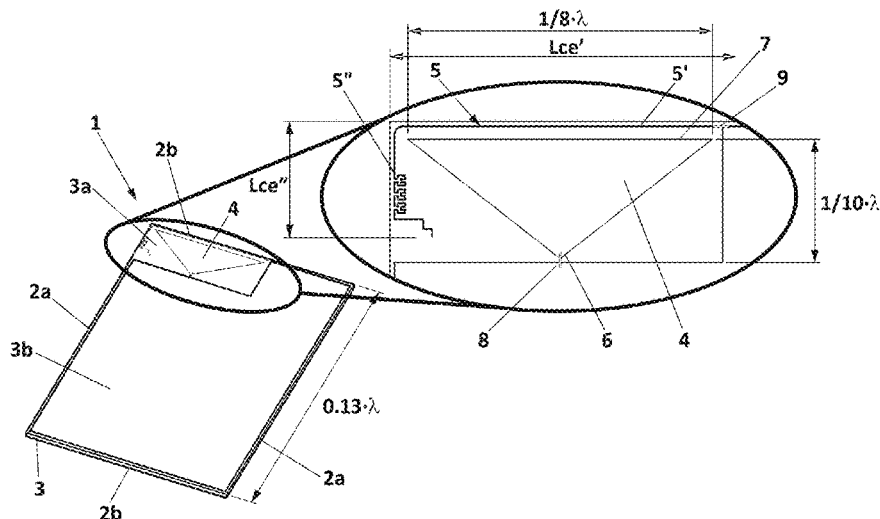
Assistant Examiner — Jae K Kim

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

(57) **ABSTRACT**

A broadband LTE antenna system for a vehicle, comprising a main LTE antenna system and a secondary LTE antenna, both antennas being arranged relative to each other, such as their radiation patterns are perpendicular to each other wherein the main LTE antenna comprises a ground plane circumscribed by a rectangle having major and minor sides, a dielectric substrate comprising a first portion area, a radiating element for operating at a frequency band and having at least three angles and three sides, a first side being substantially aligned with one side of the rectangle, and a first angle having an apex being the closest point of the radiating element to the ground plane, and a conductive element having at least a first portion extending between the radiating element and one side of the first portion area.

20 Claims, 22 Drawing Sheets





US010840592B2

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

(10) **Patent No.:** **US 10,840,592 B2**

(45) **Date of Patent:** **Nov. 17, 2020**

- (54) **ELECTRONIC DEVICE AND ANTENNA ASSEMBLY THEREOF**
- (71) Applicant: **PEGATRON CORPORATION**, Taipei (TW)
- (72) Inventors: **Chien-Yi Wu**, Taipei (TW); **Chao-Hsu Wu**, Taipei (TW); **Shih-Keng Huang**, Taipei (TW); **Ya-Jyun Li**, Taipei (TW); **Ching-Hsiang Ko**, Taipei (TW); **Chun-Chih Chen**, Taipei (TW)
- (73) Assignee: **PEGATRON 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 91 days.

(21) Appl. No.: **16/275,762**

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

(65) **Prior Publication Data**
US 2019/0296431 A1 Sep. 26, 2019

(30) **Foreign Application Priority Data**
Mar. 23, 2018 (TW) 107109938 A

(51) **Int. Cl.**
H01Q 1/52 (2006.01)
H01Q 5/335 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/523** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/335** (2015.01); **H01Q 25/005** (2013.01)

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

(56) **References Cited**
U.S. PATENT DOCUMENTS

6,809,690 B2 10/2004 Tao
6,977,613 B2* 12/2005 He et al. H01Q 9/0407
343/700 MS

(Continued)

FOREIGN PATENT DOCUMENTS

TW M250188 11/2004
TW 200843205 11/2008

(Continued)

OTHER PUBLICATIONS

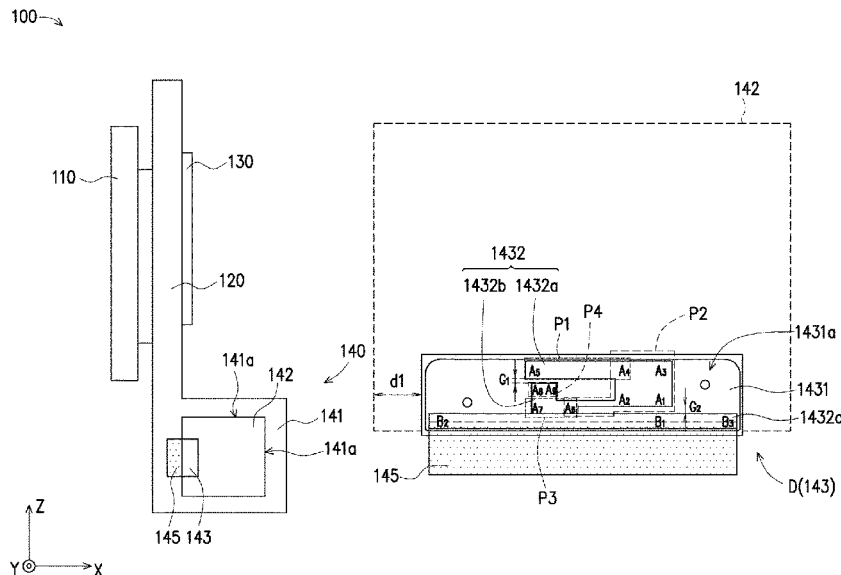
“Office Action of Taiwan Counterpart Application,” dated Jul. 9, 2019, p. 1-p. 5.

Primary Examiner — Amy Cohen Johnson
Assistant Examiner — James H Cho
(74) *Attorney, Agent, or Firm* — J.C. Patents

(57) **ABSTRACT**

An electronic device and its antenna assembly are provided. The electronic device includes a display screen, a metal foothold, a motherboard, and an antenna assembly. The display screen and the motherboard are disposed at two opposite surfaces of the metal foothold. The antenna assembly electrically connected to the motherboard includes a metal frame, a plastic sheet, an antenna, and a conductive sheet. The metal frame is disposed at the metal foothold, and one side of the metal frame has an opening, so that the plastic sheet can be embedded in the opening. The antenna includes an antenna main board disposed at the plastic sheet and a double-sided antenna disposed at two opposite sides of the antenna main board. The conductive sheet is connected to the double-sided antenna and lapped over the metal frame.

20 Claims, 10 Drawing Sheets





US010840599B2

(12) **United States Patent**
Foo

(10) **Patent No.:** **US 10,840,599 B2**
(45) **Date of Patent:** **Nov. 17, 2020**

(54) **DIFFERENTIAL-MODE APERTURE-COUPLED PATCH ANTENNA**

6,288,679 B1 * 9/2001 Fischer H01Q 9/0457 343/700 MS
7,626,549 B2 * 12/2009 Channabasappa ... H01Q 9/0457 343/700 MS
2014/0184455 A1 7/2014 Lea et al.
2016/0240925 A1 8/2016 Xue et al.
2017/0271767 A1 9/2017 Nair et al.

(71) Applicant: **Senglee Foo**, Ottawa (CA)
(72) Inventor: **Senglee Foo**, Ottawa (CA)
(73) Assignee: **Huawei Technologies Co., Ltd.**, Shenzhen (CN)

FOREIGN PATENT DOCUMENTS

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 169 days.

CN 105789875 A 7/2016

* cited by examiner

(21) Appl. No.: **16/039,853**

Primary Examiner — Hai V Tran

(22) Filed: **Jul. 19, 2018**

Assistant Examiner — Michael M Bouizza

(65) **Prior Publication Data**

US 2020/0028267 A1 Jan. 23, 2020

(57) **ABSTRACT**

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/22 (2006.01)

An aperture-coupled patch antenna is described. The antenna includes at least one radiating patch. A first aperture couples a reception signal from the patch to first and second receive ports. A second orthogonal aperture couples a transmission signal from a transmit port to the patch. The transmit feed circuit is a single-ended feed circuit. The receive feed circuit is a differential-mode feed circuit. The receive feed circuit defines a difference port, where the electrical path lengths from the first receive port to the difference port and from the second receive port to the difference port differ by an odd integer multiple of half a signal wavelength. The receive feed circuit also defines a sum port, where the electrical path lengths from the first receive port to the sum port and from the second receive port to the sum port are equal in path length.

(52) **U.S. Cl.**
CPC **H01Q 9/0442** (2013.01); **H01Q 1/2283** (2013.01); **H01Q 9/045** (2013.01)

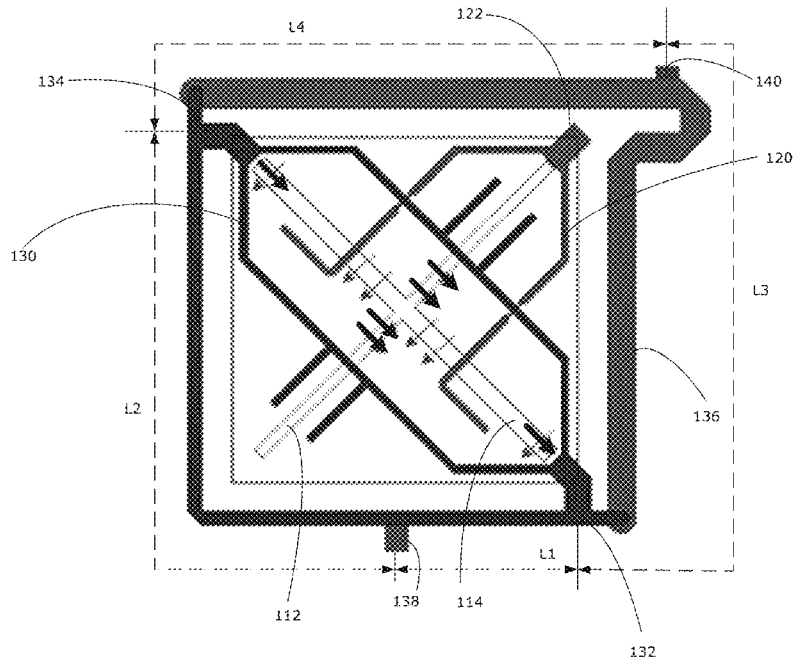
(58) **Field of Classification Search**
CPC H01Q 9/0442; H01Q 1/2283; H01Q 9/045; H01Q 9/0457; H01Q 1/243
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,241,321 A * 8/1993 Tsao H01Q 9/0442 343/700 MS
6,054,953 A * 4/2000 Lindmark H01Q 1/38 343/700 MS

18 Claims, 10 Drawing Sheets





US010840604B2

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

(10) **Patent No.:** **US 10,840,604 B2**

(45) **Date of Patent:** **Nov. 17, 2020**

(54) **ANTENNA SYSTEM**

(71) Applicant: **Wistron NeWeb Corporation**, Hsinchu (TW)

(72) Inventors: **Cheng-Geng Jan**, Hsinchu (TW);
Chieh-Sheng Hsu, Hsinchu (TW)

(73) Assignee: **Wistron NeWeb Corporation**, Hsinchu (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.: **16/568,216**

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

(65) **Prior Publication Data**

US 2020/0106190 A1 Apr. 2, 2020

(30) **Foreign Application Priority Data**

Sep. 27, 2018 (TW) 107133945 A

(51) **Int. Cl.**

H01Q 21/00 (2006.01)
H01Q 1/42 (2006.01)
H04B 7/06 (2006.01)
H01Q 1/38 (2006.01)
H04W 72/04 (2009.01)

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

CPC **H01Q 21/0068** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/422** (2013.01); **H01Q 1/425** (2013.01); **H04B 7/0617** (2013.01); **H04W 72/046** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 21/0068; H01Q 1/422; H01Q 1/38;

H01Q 1/425; H01Q 3/36; H01Q 21/0075;
H01Q 9/0457; H01Q 21/28; H01Q 21/065; H01Q 1/24; H04B 7/0617; H04W 72/046

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,448,930 B1 *	9/2002	Judd	.....	H01Q 1/007 343/700 MS
2005/0110683 A1 *	5/2005	Song	.....	H01Q 25/00 343/700 MS
2008/0088510 A1 *	4/2008	Murata	.....	H01Q 19/28 343/700 MS
2017/0229774 A1 *	8/2017	Schuehler	.....	H01Q 3/24
2018/0026379 A1 *	1/2018	Barker	.....	H01Q 21/065 343/844
2018/0233820 A1 *	8/2018	Chen	.....	H01Q 21/205

* cited by examiner

Primary Examiner — Renan Luque

(74) *Attorney, Agent, or Firm* — Winston Hsu

(57) **ABSTRACT**

An antenna system for receiving and transmitting wireless signals includes a first complex antenna including a first dielectric layer, a first metal grounding sheet, first to fourth antenna arrays and a first transmission line device for transmitting radio-frequency signals to the first to fourth antenna arrays, a second complex antenna including a second dielectric layer, a second metal grounding sheet, fifth to eighth antenna arrays and a second transmission line device for transmitting radio-frequency signals to the fifth to eighth antenna arrays, and a feeding device, for alternatively outputting radio-frequency signals to the first complex antenna and the second complex antenna via the first and second transmission line devices, and switching phases of the radio-frequency signals outputted to the first to eighth antenna arrays.

8 Claims, 14 Drawing Sheets

