



US010211512B2

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

(10) **Patent No.:** **US 10,211,512 B2**
(45) **Date of Patent:** ***Feb. 19, 2019**

(54) **MULTI-BAND ANTENNA ON THE SURFACE OF WIRELESS COMMUNICATION DEVICES**

(2015.01); **H01Q 9/0407** (2013.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01); **H01Q 5/371** (2015.01)

(71) Applicant: **Futurewei Technologies, Inc.**, Plano, TX (US)

(58) **Field of Classification Search**
CPC H01Q 1/2291; H01Q 1/22; H01Q 1/24; H01Q 1/243; H01Q 1/38; H01Q 1/48; H01Q 5/10
See application file for complete search history.

(72) Inventors: **Wee Kian Toh**, San Diego, CA (US); **Hongwei Liu**, San Diego, CA (US); **Ping Shi**, San Diego, CA (US)

(56) **References Cited**

(73) Assignee: **FUTUREWEI TECHNOLOGIES, INC.**, Plano, TX (US)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 178 days.

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This patent is subject to a terminal disclaimer.

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(21) Appl. No.: **15/375,814**

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CN 103636064 A 3/2014

(22) Filed: **Dec. 12, 2016**

Primary Examiner — Tho G Phan
(74) *Attorney, Agent, or Firm* — Slater Matsil, LLP

(65) **Prior Publication Data**

US 2017/0093019 A1 Mar. 30, 2017

(57) **ABSTRACT**

Related U.S. Application Data

(63) Continuation of application No. 14/596,002, filed on Jan. 13, 2015, now Pat. No. 9,548,525.

An embodiment wireless communication device includes a circuit board and a cover having a back surface covering a portion of a first surface of the circuit board and an opening in the back surface. A top antenna is disposed within the cover and is electrically connected to the circuit board at a first feed point on a first edge of the circuit board. A secondary antenna disposed within the cover has a first antenna portion connected to the circuit board at a second feed point, and a second antenna portion of the second antenna extends laterally from a second edge of the circuit board over the first surface of the circuit board and between the back surface of the cover and the first surface of the circuit board such that at least a portion of the second antenna portion is exposed through the opening in the back surface.

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

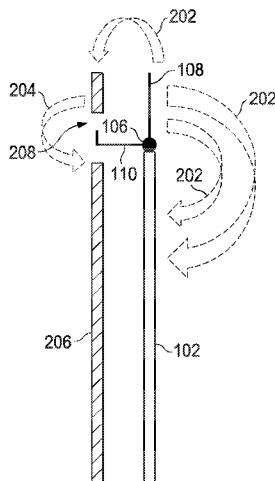
H01Q 1/22 (2006.01)

(Continued)

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

CPC **H01Q 1/2291** (2013.01); **H01Q 1/24** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/42** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/521** (2013.01); **H01Q 5/10**

20 Claims, 3 Drawing Sheets





US010211515B2

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

(10) **Patent No.:** **US 10,211,515 B2**

(45) **Date of Patent:** **Feb. 19, 2019**

(54) **ANTENNA DEVICE FOR PORTABLE TERMINAL**

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

(72) Inventors: **Soon-Ho Hwang**, Seoul (KR);
Sung-Koo Park, Suwon-si (KR);
Kyung-Jae Lee, Seoul (KR); **Joon-Ho Byun**,
Yongin-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.: **15/185,738**

(22) Filed: **Jun. 17, 2016**

(65) **Prior Publication Data**
US 2016/0301126 A1 Oct. 13, 2016

Related U.S. Application Data
(63) Continuation of application No. 13/937,725, filed on
Jul. 9, 2013, now Pat. No. 9,373,883.

(30) **Foreign Application Priority Data**
Jan. 30, 2013 (KR) 10-2013-0010477

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

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/44**
(2013.01); **H01Q 1/48** (2013.01); **H01Q 1/50**
(2013.01); **H01Q 13/10** (2013.01)

(58) **Field of Classification Search**
CPC H01C 1/241; H01C 1/243; H01C 1/44;
H01C 13/10; H01C 13/103; H01C
13/106; H01C 13/16; H01C 1/22-1/245
See application file for complete search history.

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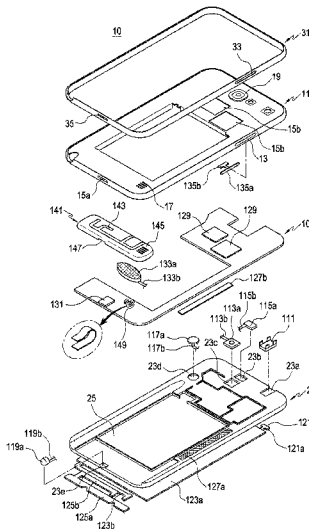
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Korean Appln. No. 10-2013-0010477.

Primary Examiner — Tho G Phan
Assistant Examiner — Patrick Holecek
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**
An antenna device of a portable terminal including conduc-
tive components is provided. The antenna device includes a
first radiator connected to a power feeding unit of the
portable terminal and a second radiator connected to each of
the power feeding unit and a ground part of the portable
terminal. At least one of the conductive components is
connected to at least one the first radiator and the second
radiator. The conductive components may be used as a
radiator of the antenna device such that the antenna device
may be easily installed within an inner space of a miniatur-
ized and lightened portable terminal and the inner space of
the portable terminal may be efficiently used.

6 Claims, 6 Drawing Sheets



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

(10) **Patent No.:** **US 10,211,516 B2**
(45) **Date of Patent:** **Feb. 19, 2019**

(54) **ELECTRONIC DEVICE INCLUDING ANTENNA**

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

(72) Inventors: **Minho Soh**, Suwon-si (KR); **Sangmin Jung**, Anyang-si (KR); **Gwangun Oh**,
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 67 days.

(21) Appl. No.: **15/427,429**

(22) Filed: **Feb. 8, 2017**

(65) **Prior Publication Data**

US 2017/0237150 A1 Aug. 17, 2017

(30) **Foreign Application Priority Data**

Feb. 17, 2016 (KR) 10-2016-0018443

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
H01Q 21/28 (2006.01)
H01Q 5/35 (2015.01)
H01Q 5/371 (2015.01)
H01Q 5/385 (2015.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 5/35** (2015.01); **H01Q 5/371** (2015.01); **H01Q 5/385** (2015.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 9/42; H01Q 21/28;
H01Q 5/35

See application file for complete search history.

(56) **References Cited**

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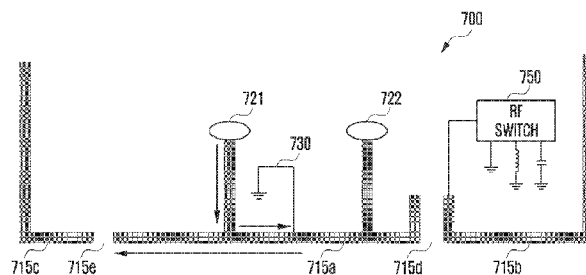
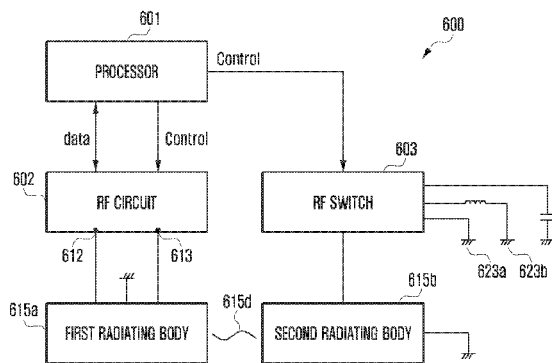
Primary Examiner — Dieu Hien T Duong

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

(57) **ABSTRACT**

An electronic device including an antenna is provided. The electronic device includes a housing, a radio frequency (RF) circuit located within the housing and configured to output a first RF signal and a second RF signal, at least one processor located within the housing and configured to electrically connect to the RF circuit, a first radiating body electrically connected to the RF circuit, a second radiating body electrically connected to the first radiating body, and an RF switch located within the housing and electrically connected to the processor and the second radiating body, wherein the at least one processor is further configured to control the RF switch to emit at least one of the first RF signal and the second RF signal output from the RF circuit to at least one of the first radiating body and the second radiating body.

16 Claims, 15 Drawing Sheets



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

(10) **Patent No.:** **US 10,211,517 B2**
(45) **Date of Patent:** **Feb. 19, 2019**

(54) **MOBILE DEVICE**

USPC 343/702, 861, 854, 700 MS
See application file for complete search history.

(71) Applicant: **Acer Incorporated**, New Taipei (TW)

(56) **References Cited**

(72) Inventors: **Ming-Ching Yen**, New Taipei (TW);
Kun-Sheng Chang, New Taipei (TW);
Ching-Chi Lin, New Taipei (TW)

U.S. PATENT DOCUMENTS

(73) Assignee: **ACER INCORPORATED**, New Taipei (TW)

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343/700 MS
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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 24 days.

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(21) Appl. No.: **15/464,580**

TW 1329389 B 8/2010
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(22) Filed: **Mar. 21, 2017**

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(65) **Prior Publication Data**
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TW Office Action dated Jan. 19, 2018 in corresponding Taiwan application (No. 105118334).
Search Report issued in TW Office Action dated Jan. 19, 2018 in corresponding Taiwan application (No. 105118334).

(30) **Foreign Application Priority Data**

* cited by examiner

Jun. 13, 2016 (TW) 105118334 A

Primary Examiner — Dameon E Levi
Assistant Examiner — Collin Dawkins
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/20 (2015.01)
H01Q 1/38 (2006.01)
H01Q 1/22 (2006.01)
H01Q 5/35 (2015.01)
H01Q 5/40 (2015.01)
H04W 88/02 (2009.01)

(57) **ABSTRACT**

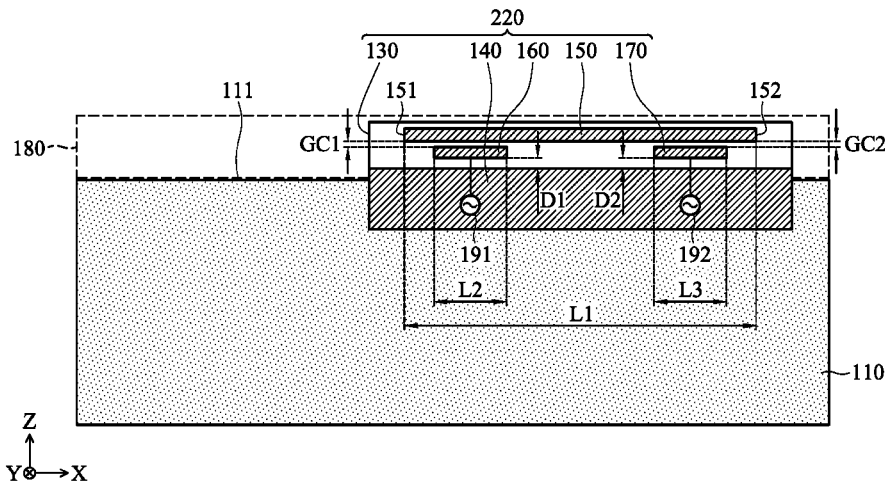
A mobile device includes a system ground plane and an antenna system. The antenna system includes a dielectric substrate, an antenna ground plane, a radiation element, and at least one feeding element. The antenna ground plane is coupled to the system ground plane. The feeding element is coupled to a signal source. The feeding element is positioned between the radiation element and the antenna ground plane. The feeding element and the radiation element are completely separate from each other. The radiation element is excited by the feeding element by coupling.

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/20** (2015.01); **H01Q 5/35** (2015.01); **H01Q 5/40** (2015.01); **H04W 88/02** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 9/0421; H01Q 9/30

9 Claims, 11 Drawing Sheets

200





US010211518B2

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

(10) **Patent No.:** **US 10,211,518 B2**
(45) **Date of Patent:** **Feb. 19, 2019**

(54) **MOBILE TERMINAL**

(71) Applicant: **Guangdong Oppo Mobile Telecommunications Corp., Ltd.**, Dongguan, Guangdong (CN)

(72) Inventors: **Qing Wu**, Dongguan (CN); **Yuanbin Xiang**, Dongguan (CN)

(73) Assignee: **GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP., LTD.**, Dongguan, Guangdong (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.: **15/787,858**

(22) Filed: **Oct. 19, 2017**

(65) **Prior Publication Data**
US 2018/0159205 A1 Jun. 7, 2018

(30) **Foreign Application Priority Data**
Dec. 7, 2016 (CN) 2016 1 1118262
Dec. 7, 2016 (CN) 2016 2 1340998 U

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/52 (2006.01)
H01Q 9/42 (2006.01)
H04M 1/02 (2006.01)
H01Q 21/30 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/52** (2013.01); **H01Q 9/42** (2013.01); **H01Q 21/30** (2013.01); **H04M 1/0274** (2013.01); **H04M 1/0281** (2013.01)

(58) **Field of Classification Search**
CPC ... H04Q 1/243; H04M 1/0274; H04M 1/0281
See application file for complete search history.

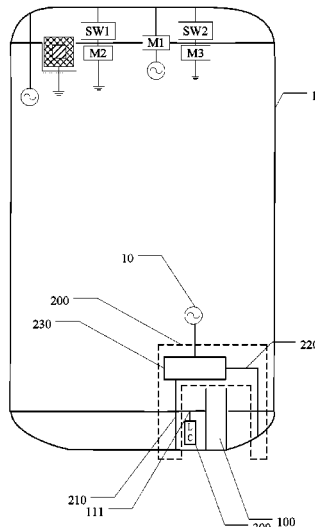
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Primary Examiner — Lewis G West
(74) *Attorney, Agent, or Firm* — Hodgson Russ LLP

(57) **ABSTRACT**
A mobile terminal includes an external interface body, an antenna assembly, and a first filter unit. The antenna assembly includes a first antenna, a second antenna, and a diplexer. The external interface body is disposed in an antenna clearance area defined by the first antenna and the second antenna. The diplexer is connected to the first antenna, the second antenna, and a feed of a board of the mobile terminal. The first filter unit is disposed between the first antenna and the external interface body and is connected to a first circuit board of the external interface body to reduce interference from the external interface body to the antenna assembly.

15 Claims, 6 Drawing Sheets





US010211533B2

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

(10) **Patent No.:** **US 10,211,533 B2**

(45) **Date of Patent:** **Feb. 19, 2019**

(54) **DUAL BAND PRINTED ANTENNA**

(71) Applicant: **PEGATRON CORPORATION**, Taipei (TW)

(72) Inventors: **Chun-Yen Huang**, Taipei (TW); **I-Shu Lee**, Taipei (TW); **Hung-Ming Yu**, 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 12 days.

(21) Appl. No.: **15/487,445**

(22) Filed: **Apr. 14, 2017**

(65) **Prior Publication Data**

US 2017/0331187 A1 Nov. 16, 2017

(30) **Foreign Application Priority Data**

May 10, 2016 (TW) 105114435 A

(51) **Int. Cl.**

H01Q 1/38 (2006.01)
H01Q 5/00 (2015.01)
H01Q 9/04 (2006.01)
H01Q 5/328 (2015.01)
H01Q 5/335 (2015.01)
H01Q 1/48 (2006.01)

(Continued)

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

CPC **H01Q 5/328** (2015.01); **H01Q 1/2291** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/335** (2015.01); **H01Q 5/378** (2015.01); **H01Q 9/0421** (2013.01); **H01Q 9/0442** (2013.01); **H01Q 9/30** (2013.01); **H01Q 13/106** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/328; H01Q 5/378; H01Q 9/30; H01Q 1/2291; H01Q 13/106; H01Q 1/48; H01Q 1/38; H01Q 9/0442; H01Q 5/335; H01Q 9/0421
USPC 343/700 MS
See application file for complete search history.

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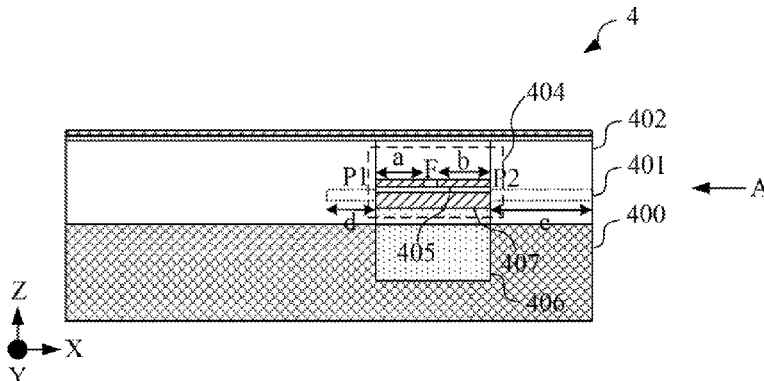
Primary Examiner — Jean B Jeanglaude

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

(57) **ABSTRACT**

A dual band printed antenna that includes a metal substrate, an electrically isolated supporting element and a monopole antenna element. The metal substrate includes a slot. A side of the isolated supporting element is formed on the metal substrate. The monopole antenna element is formed on the other side of the isolated supporting element and corresponding to the position of the slot. The monopole antenna element includes a radiation part that includes a feed point and a ground part separated from the radiation part for a distance. The radiation part resonates with the slot to generate a radiation pattern of a first frequency band. The radiation part resonates itself to generate a radiation pattern of a second frequency band.

20 Claims, 11 Drawing Sheets



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

(10) **Patent No.:** **US 10,211,536 B2**
(45) **Date of Patent:** **Feb. 19, 2019**

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

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

(72) Inventors: **Chia-Ming Liang**, New Taipei (TW);
Sheng-Chieh Liang, New Taipei (TW);
Ming-Yu Chou, New Taipei (TW);
Chang-Hsin Ou, New Taipei (TW);
Cheng-I Chang, New Taipei (TW)

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

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

(21) Appl. No.: **15/690,304**

(22) Filed: **Aug. 30, 2017**

(65) **Prior Publication Data**

US 2018/0062270 A1 Mar. 1, 2018

Related U.S. Application Data

(60) Provisional application No. 62/382,762, filed on Sep. 1, 2016.

(30) **Foreign Application Priority Data**

Dec. 29, 2016 (CN) 2016 1 1243441

(51) **Int. Cl.**
H01Q 13/10 (2006.01)
H01Q 5/335 (2015.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 13/106** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/42** (2013.01); **H01Q 3/24** (2013.01); **H01Q 5/328** (2015.01); **H01Q 5/335** (2015.01); **H01Q 9/42** (2013.01); **H01Q 1/2291** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/30** (2015.01); **H01Q 7/00** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/48; H01Q 1/2291; H01Q 7/00; H01Q 1/243; H01Q 5/30; H01Q 5/335; H01Q 13/16
See application file for complete search history.

(56) **References Cited**

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2014/0266941 A1 9/2014 Vazquez et al.
(Continued)

Primary Examiner — Joseph Lauture

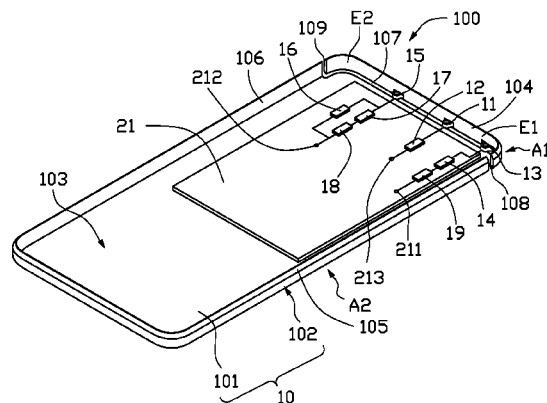
(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

An antenna structure includes a housing, a first connecting portion, a matching unit, a second connecting portion, and a first switching circuit. The housing defines a slot, a first gap, and a second gap. The housing is divided into a first portion and a second portion by the slot, the first gap, and the second gap. The second portion is grounded. One end of the first connecting portion electrically connected to the first portion and another end of the first connecting portion electrically connected to a feed point through the matching unit. The first portion is divided into a first radiating portion and a second radiating portion by the first connecting portion. One end of the second connecting portion is electrically connected to the first radiating portion and another end of the second connecting portion is grounded through the first switching circuit.

25 Claims, 24 Drawing Sheets

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

(10) **Patent No.:** **US 10,211,858 B2**
(45) **Date of Patent:** **Feb. 19, 2019**

(54) **WIRELESS COMMUNICATION DEVICE**

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

(72) Inventors: **Tiao-Hsing Tsai**, Taoyuan (TW);
Chien-Pin Chiu, Taoyuan (TW);
Hsiao-Wei Wu, Taoyuan (TW);
Yi-Hsiang Kung, Taoyuan (TW);
Shen-Fu Tzeng, Taoyuan (TW);
Li-Yuan Fang, 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.

(21) Appl. No.: **16/139,107**

(22) Filed: **Sep. 24, 2018**

(65) **Prior Publication Data**

US 2019/0028125 A1 Jan. 24, 2019

Related U.S. Application Data

(62) Division of application No. 15/821,777, filed on Nov. 23, 2017.

(60) Provisional application No. 62/428,183, filed on Nov. 30, 2016.

(51) **Int. Cl.**
H04B 1/38 (2015.01)
H04B 1/00 (2006.01)
H04B 1/40 (2015.01)
H04W 88/06 (2009.01)

(52) **U.S. Cl.**
CPC **H04B 1/006** (2013.01); **H04B 1/40** (2013.01); **H04W 88/06** (2013.01)

(58) **Field of Classification Search**

CPC H04B 1/0053; H04B 1/0064; H01Q 1/00;
H01Q 5/00; H01Q 1/243; H01Q 1/36;
H01Q 1/48
See application file for complete search history.

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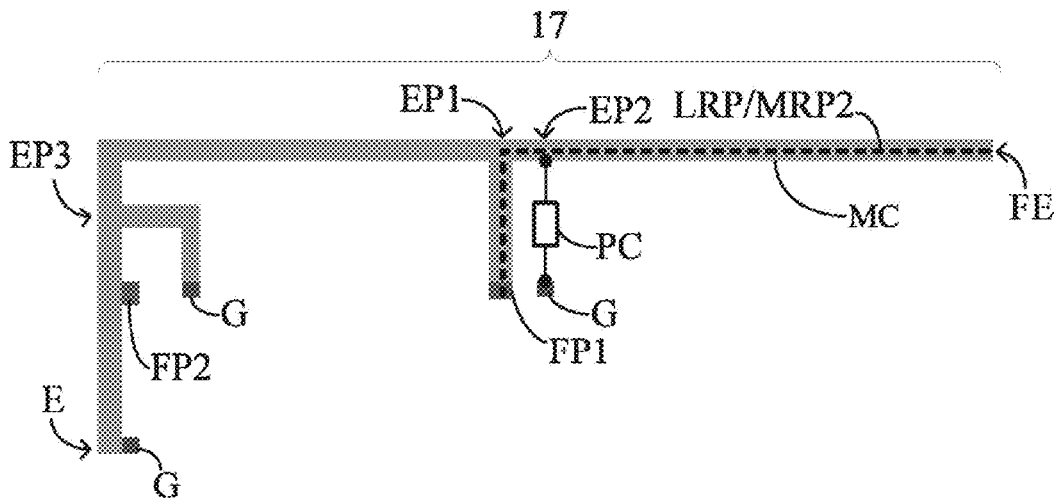
Primary Examiner — Tuan Pham

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

(57) **ABSTRACT**

A wireless communication device is provided. The wireless communication device includes a housing, a circuit board, a radio frequency module and an antenna. The housing has a frame and a back cover to define a receiving space. The circuit board is disposed in the receiving space, and defines a clearance area from the housing in the receiving space. The circuit board includes a ground terminal, a first feeding point, and a second feeding point. The antenna includes at least one metal conductor coupled to the first feeding point and the second feeding point, respectively, to provide a low frequency resonant path, a first middle frequency resonant path, a second middle frequency resonant path and a high frequency resonant path.

11 Claims, 22 Drawing Sheets



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

(10) **Patent No.:** **US 10,218,051 B2**
(45) **Date of Patent:** **Feb. 26, 2019**

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

(2015.01); **H01Q 9/42** (2013.01); **H01Q 13/18** (2013.01); **H01Q 21/28** (2013.01)

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

(58) **Field of Classification Search**

CPC **H01Q 1/243**; **H01Q 9/42**; **H01Q 21/28**;
H01Q 5/314; **H01Q 5/50**; **H01Q 13/18**;
H01Q 1/242; **H01Q 1/48**; **H01Q 5/371**
See application file for complete search history.

(72) Inventors: **Chih-Ho Lee**, New Taipei (TW);
Tun-Yuan Tsou, New Taipei (TW);
Hsi-Chieh Chen, New Taipei (TW)

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(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 20 days.

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455/77

(Continued)

(21) Appl. No.: **15/655,893**

Primary Examiner — Jessica Han

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

Assistant Examiner — Jae Kim

(65) **Prior Publication Data**

US 2018/0026333 A1 Jan. 25, 2018

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

Related U.S. Application Data

(60) Provisional application No. 62/365,340, filed on Jul. 21, 2016.

(57) **ABSTRACT**

An antenna structure includes a metallic member, a radiating portion, and a second matching circuit. The metallic member includes a front frame, a backboard, and a side frame. The side frame defines a slot. The front frame defines a first gap, a second gap, and a fourth gap communicating with the slot and extending across the front frame. A portion of the front frame between the first gap and the second gap forms a first radiating section; another portion between the second gap and the fourth gap forms a third radiating section. The radiating portion crosses the second gap and connects to the first radiating section and the third radiating section; an end of the second matching circuit electrically connects to the radiating portion, the other end connects to a ground. A wireless communication device using the antenna structure is provided.

(30) **Foreign Application Priority Data**

Jul. 14, 2017 (CN) 2017 1 0577219

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

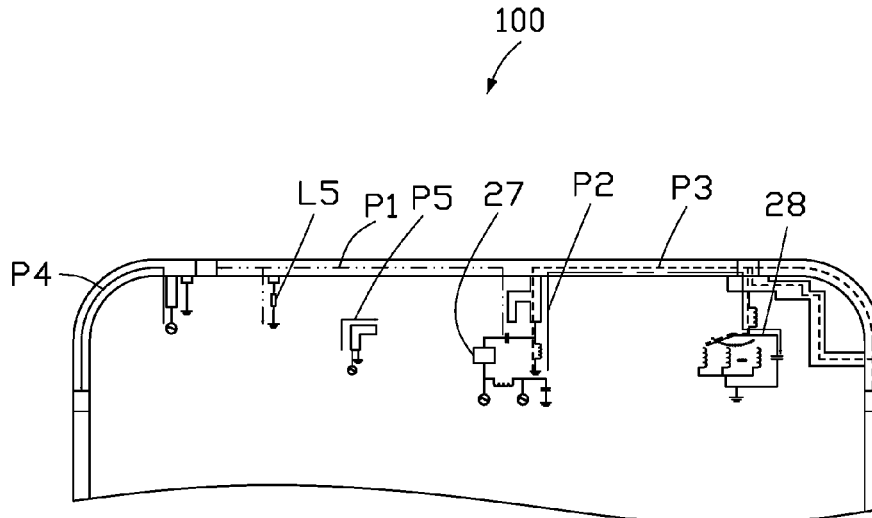
H01Q 1/48 (2006.01)

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

CPC **H01Q 1/242** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/314** (2015.01); **H01Q 5/371** (2015.01); **H01Q 5/50**

20 Claims, 24 Drawing Sheets





US010218052B2

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

(10) **Patent No.:** **US 10,218,052 B2**
(45) **Date of Patent:** **Feb. 26, 2019**

(54) **ELECTRONIC DEVICE WITH TUNABLE HYBRID ANTENNAS**

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)
(72) Inventors: **Mattia Pascolini**, San Francisco, CA (US); **Umar Azad**, San Jose, CA (US); **Rodney A. Gomez Angulo**, Sunnyvale, CA (US); **Erdinc Irci**, Santa Clara, CA (US); **Qingxiang Li**, Mountain View, CA (US); **Matthew A. Mow**, Los Altos, CA (US); **Harish Rajagopalan**, San Jose, CA (US); **Miroslav Samardzija**, Mountain View, CA (US); **Ming-Ju Tsai**, Cupertino, CA (US)

(73) Assignee: **Apple Inc.**, Cupertino, CA (US)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 249 days.

(21) Appl. No.: **14/710,377**

(22) Filed: **May 12, 2015**

(65) **Prior Publication Data**
US 2016/0336643 A1 Nov. 17, 2016

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

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/328** (2015.01); **H01Q 9/0421** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/12; H01Q 1/1264; H01Q 1/38; H01Q 11/04; H01Q 21/00; H01Q 21/0087; Y10T 29/49018
(Continued)

(56) **References Cited**

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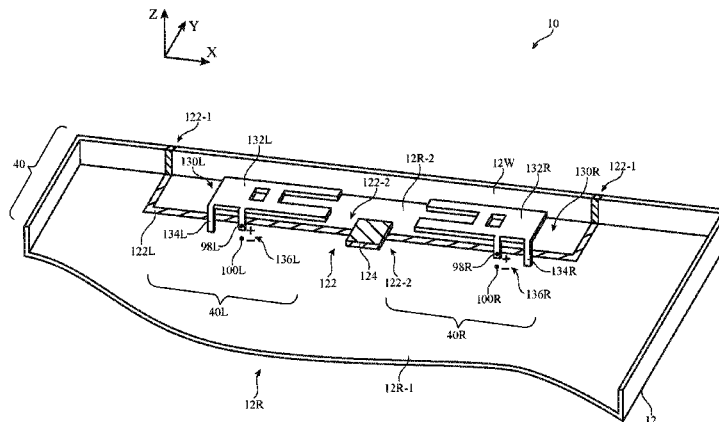
Zhu et al., U.S. Appl. No. 14/180,866, filed Feb. 14, 2014.
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Primary Examiner — Dieu Hien T Duong
Assistant Examiner — Bamidele A Jegede
(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; G. Victor Treyz; Tianyi He

(57) **ABSTRACT**

An electronic device may have hybrid antennas that include slot antenna resonating elements formed from slots in a ground plane and planar inverted-F antenna resonating elements. The planar inverted-F antenna resonating elements may each have a planar metal member that overlaps one of the slots. The slot of each slot antenna resonating element may divide the ground plane into first and second portions. A return path and feed may be coupled in parallel between the planar metal member and the first portion of the ground plane. Tunable components such as tunable inductors may be used to tune the hybrid antennas. A tunable inductor may bridge the slot in hybrid antenna, may be coupled between the planar metal member of the planar inverted-F antenna resonating element and the ground plane, or multiple tunable inductors may bridge the slot on opposing sides of the planar inverted-F antenna resonating element.

20 Claims, 11 Drawing Sheets



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

(10) **Patent No.:** **US 10,218,055 B2**
(45) **Date of Patent:** **Feb. 26, 2019**

(54) **ANTENNA**

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

(72) Inventors: **Shih-Hsien Tseng**, Hsinchu (TW);
Chih-Ming Wang, 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 148 days.

(21) Appl. No.: **15/262,531**

(22) Filed: **Sep. 12, 2016**

(65) **Prior Publication Data**

US 2017/0271747 A1 Sep. 21, 2017

(30) **Foreign Application Priority Data**

Mar. 18, 2016 (TW) 105108418 A

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 13/08 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 13/085** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/241; H01Q 1/242; H01Q 1/243; H01Q 5/30; H01Q 5/307; H01Q 5/314; H01Q 5/321; H01Q 5/357; H01Q 5/378; H01Q 5/40; H01Q 13/085; H01Q 13/10; H01Q 13/103

See application file for complete search history.

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Primary Examiner — Tho G Phan

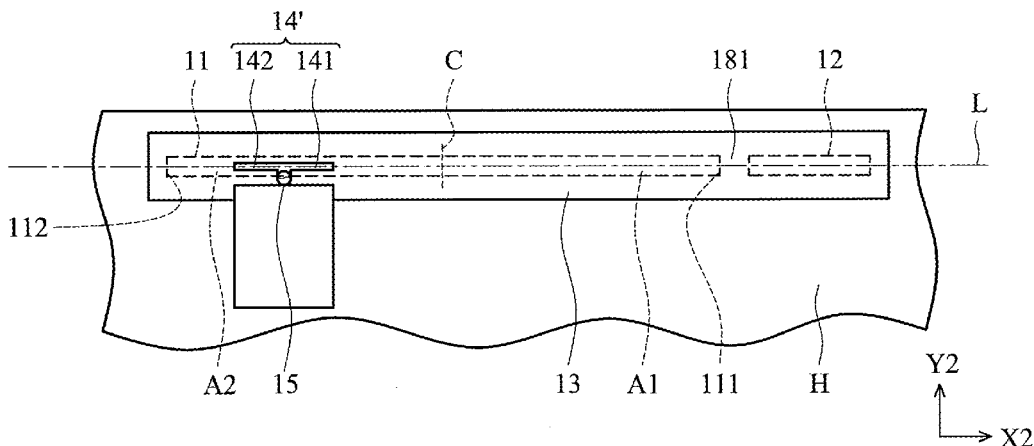
Assistant Examiner — Patrick R Holecek

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

(57) **ABSTRACT**

An antenna is provided adapted to be formed on a metal housing of an electronic device. The antenna includes a first slot, a second slot, a substrate, a feed conductor and a signal source. The first slot and the second slot are formed on the metal housing. The first slot and the second slot are aligned along an axis. The substrate is disposed on the metal housing. The feed conductor is disposed on the substrate and corresponding to the first slot. The feed conductor includes a first section and a second section, the first section is extended in a first direction, the first slot is extended in the first direction toward the second slot, the second section extends in a second direction, and the second slot extends in the second direction toward the first slot. The signal source is electrically connected to the feed conductor.

5 Claims, 8 Drawing Sheets



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

(10) **Patent No.:** **US 10,218,065 B2**
(45) **Date of Patent:** **Feb. 26, 2019**

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

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

(72) Inventors: **Cheng-Han Lee**, New Taipei (TW);
Yi-Wen Hsu, New Taipei (TW);
Wei-Xuan Ye, 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 65 days.

(21) Appl. No.: **15/626,160**

(22) Filed: **Jun. 18, 2017**

(65) **Prior Publication Data**

US 2018/0026360 A1 Jan. 25, 2018

Related U.S. Application Data

(60) Provisional application No. 62/364,303, filed on Jul. 19, 2016.

(30) **Foreign Application Priority Data**

Aug. 31, 2016 (CN) 2016 1 0774244

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 1/42 (2006.01)
H01Q 9/42 (2006.01)
H01Q 13/18 (2006.01)
H01Q 21/28 (2006.01)
H01Q 5/371 (2015.01)
H01Q 9/14 (2006.01)

(Continued)

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

CPC **H01Q 1/42** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/314** (2015.01); **H01Q 5/328** (2015.01); **H01Q 5/371** (2015.01); **H01Q 9/14** (2013.01); **H01Q 9/42** (2013.01); **H01Q 13/18** (2013.01); **H01Q 21/28** (2013.01); **H01Q 9/065** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/42; H01Q 9/065; H01Q 13/18; H01Q 1/24; H01Q 1/243; H01Q 1/38; H01Q 21/28; H01Q 5/314; H01Q 5/328; H01Q 5/371; H01Q 9/14; H01Q 9/42
See application file for complete search history.

(56) **References Cited**

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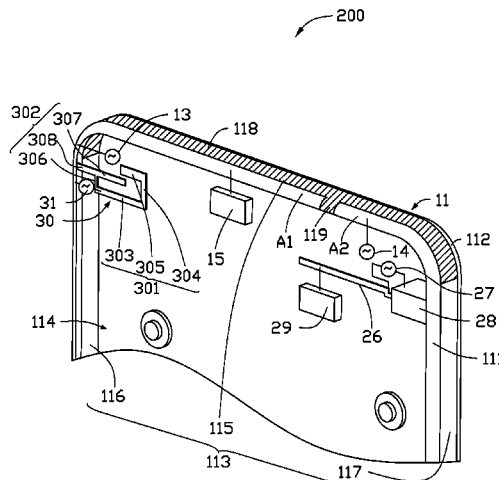
Primary Examiner — Tho G Phan

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

(57) **ABSTRACT**

An antenna structure includes a metallic member, a first radiator, and an isolating portion. The metallic member includes a front frame, a backboard, and a side frame. The side frame includes at least a top portion, a first side portion, and a second side portion. The isolating portion is electrically connected to the first radiator. The side frame defines a slot and the slot is defined on the top portion. The front frame defines a gap. The gap communicates with the slot and extends across the front frame. The first portion of the front frame from a first side of the gap to a first end of the slot forms a short portion. The first radiator is positioned adjacent to the short portion and the isolation portion improves isolation between the short portion and the first radiator.

41 Claims, 26 Drawing Sheets



(12) **United States Patent**
Toyao

(10) **Patent No.:** **US 10,218,071 B2**
(45) **Date of Patent:** **Feb. 26, 2019**

(54) **ANTENNA AND ELECTRONIC DEVICE**

(71) Applicant: **Hiroshi Toyao**, Tokyo (JP)
(72) Inventor: **Hiroshi Toyao**, Tokyo (JP)
(73) Assignee: **NEC CORPORATION**, Tokyo (JP)

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

(21) Appl. No.: **15/299,125**

(22) Filed: **Oct. 20, 2016**

(65) **Prior Publication Data**
US 2017/0040689 A1 Feb. 9, 2017

Related U.S. Application Data
(63) Continuation of application No. 14/239,527, filed as application No. PCT/JP2012/071433 on Aug. 24, 2012, now Pat. No. 9,496,616.

(30) **Foreign Application Priority Data**
Aug. 24, 2011 (JP) 2011-182325
Feb. 8, 2012 (JP) 2012-024848

(51) **Int. Cl.**
H01Q 7/00 (2006.01)
H01Q 13/10 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 7/00** (2013.01); **H01P 5/107** (2013.01); **H01Q 1/48** (2013.01); **H01Q 13/10** (2013.01); **H01Q 13/16** (2013.01)

(58) **Field of Classification Search**
CPC H01P 5/107; H01Q 7/00; H01Q 13/16; H01Q 13/10
See application file for complete search history.

(56) **References Cited**

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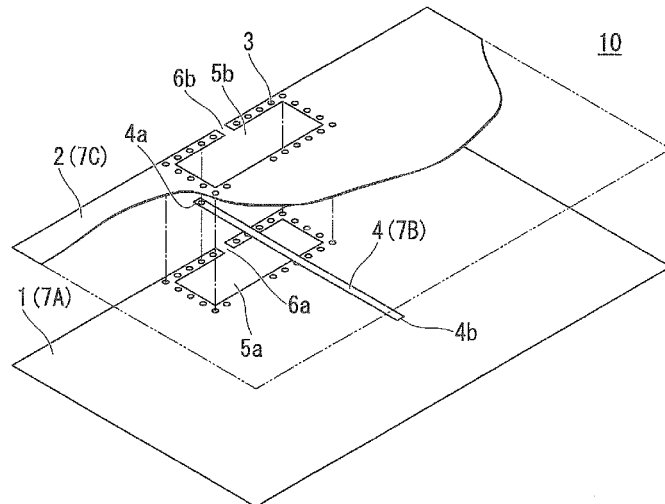
Notice of Allowance in U.S. Appl. No. 14/239,527 dated Jul. 13, 2016.
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Primary Examiner — Jessica Han
Assistant Examiner — Jae Kim
(74) *Attorney, Agent, or Firm* — McGinn I.P. Law Group, PLLC.

(57) **ABSTRACT**

An antenna includes a dielectric multilayer substrate that includes a first conductor layer and a second conductor layer different from the first conductor layer, the first conductor layer including a first conductor, the first conductor including a first split ring part, the first split ring part surrounding a first opening part and being divided by a first split part, and a power feed line that is provided on the second conductor layer, the power feed line including a first end and a second end, the first end being connected to the first split ring part, the second end spanning the first opening part and extending to a region opposing the first conductor.

20 Claims, 18 Drawing Sheets





US010218077B2

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

(10) **Patent No.:** **US 10,218,077 B2**
(45) **Date of Patent:** **Feb. 26, 2019**

(54) **WIRELESS COMMUNICATION DEVICE HAVING A MULTI-BAND SLOT ANTENNA WITH A PARASITIC ELEMENT**

(56) **References Cited**

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(71) Applicant: **TYCO ELECTRONICS CORPORATION**, Berwyn, PA (US)

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2017/0054196	A1*	2/2017	Hu H01Q 1/243

(72) Inventors: **Hilario Lepe**, Gilroy, CA (US); **Bruce Foster Bishop**, Aptos, CA (US)

(73) Assignee: **TE Connectivity Corporation**, Berwyn, PA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 127 days.

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(21) Appl. No.: **15/228,641**

(22) Filed: **Aug. 4, 2016**

Primary Examiner — Robert Karacsony

(65) **Prior Publication Data**

US 2018/0040942 A1 Feb. 8, 2018

(57) **ABSTRACT**

(51) **Int. Cl.**
H01Q 13/10 (2006.01)
H01Q 5/378 (2015.01)
H01Q 1/22 (2006.01)
H01Q 1/24 (2006.01)
H01Q 21/28 (2006.01)
H01Q 5/371 (2015.01)

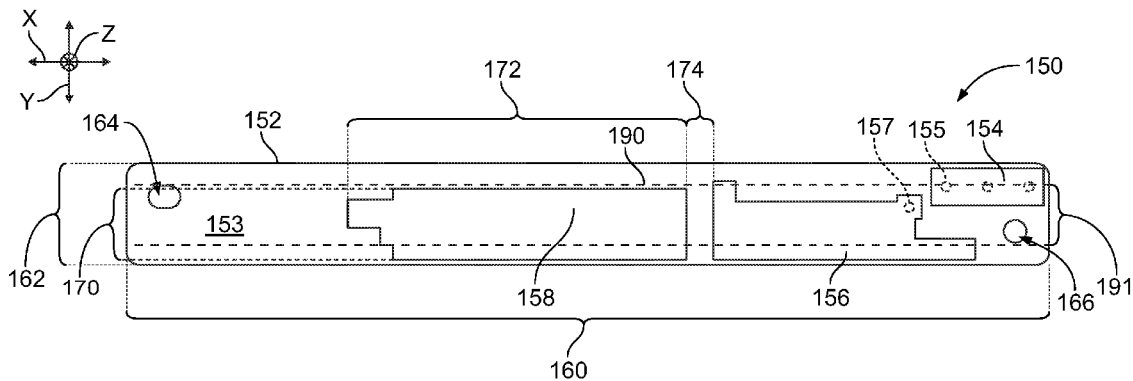
Wireless communication device includes a conductive wall having an antenna slot. The wireless communication device also includes an antenna sub-assembly positioned relative to the antenna slot to form a multi-band slot antenna. The multi-band slot antenna includes a dielectric body and a feed trace coupled to the dielectric body. The feed trace is operably aligned with the antenna slot. The multi-band slot antenna also includes a parasitic trace coupled to the dielectric body. The parasitic trace is operably aligned with the antenna slot and spaced apart from the feed trace. The feed trace is configured to communicate at a first frequency band and the parasitic trace enables the multi-band slot antenna to communicate at a second frequency band. The first frequency band is based on a size and shape of the parasitic trace.

(52) **U.S. Cl.**
CPC **H01Q 13/106** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/245** (2013.01); **H01Q 5/371** (2015.01); **H01Q 5/378** (2015.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/378; H01Q 5/385; H01Q 5/392; H01Q 13/10; H01Q 13/106; H01Q 13/18

See application file for complete search history.

20 Claims, 5 Drawing Sheets





US010218085B2

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

(10) **Patent No.:** **US 10,218,085 B2**
(45) **Date of Patent:** **Feb. 26, 2019**

(54) **ANTENNA SYSTEM**

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

(72) Inventors: **Po-Hsun Huang**, Hsinchu (TW); **Yu Tao**, Hsinchu (TW); **Chung-Yen Hsiao**, 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 240 days.

(21) Appl. No.: **15/370,282**

(22) Filed: **Dec. 6, 2016**

(65) **Prior Publication Data**

US 2018/0159226 A1 Jun. 7, 2018

(51) **Int. Cl.**

- H01Q 21/28** (2006.01)
- H01Q 1/24** (2006.01)
- H01Q 1/48** (2006.01)
- H01Q 3/24** (2006.01)
- H01Q 9/42** (2006.01)
- H01Q 5/321** (2015.01)
- H01Q 5/371** (2015.01)
- H01Q 1/22** (2006.01)

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

CPC **H01Q 21/28** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 3/24** (2013.01); **H01Q 5/321** (2015.01); **H01Q 5/371** (2015.01); **H01Q 9/42** (2013.01); **H01Q 1/2291** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/48; H01Q 3/24; H01Q 5/321; H01Q 5/328; H01Q 5/335; H01Q 5/35; H01Q 5/371; H01Q 9/0421; H01Q 9/42; H01Q 21/28

See application file for complete search history.

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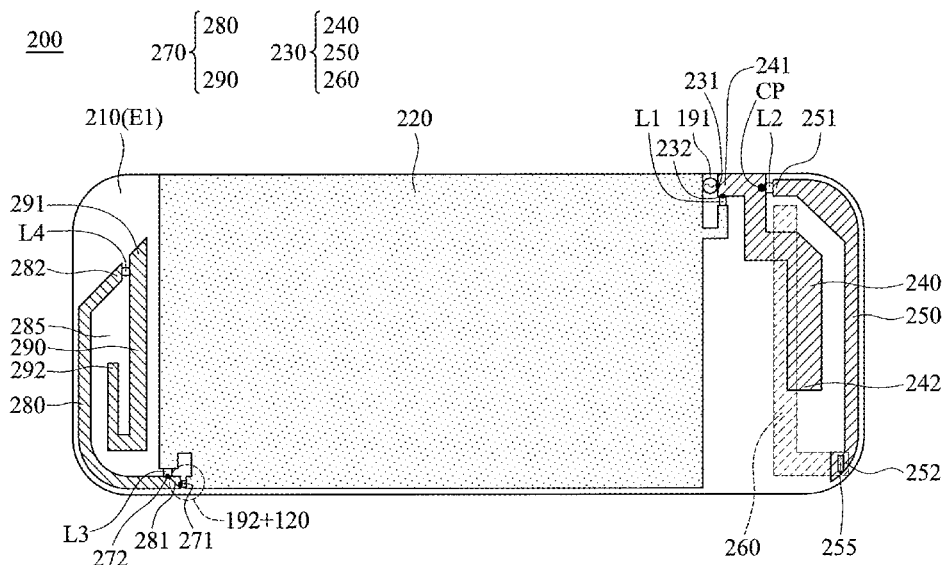
Primary Examiner — Robert Karacsony

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

(57) **ABSTRACT**

An antenna system includes a ground element, a switch element, a first antenna, and a second antenna. The switch element is selectively closed or opened according to a control signal. The first antenna has a first feeding terminal. The first feeding terminal of the first antenna is coupled to a first signal source. The second antenna has a second feeding terminal and a grounding terminal. The second feeding terminal of the second antenna is coupled through the switch element to a second signal source. The grounding terminal of the second antenna is coupled to the ground element.

19 Claims, 7 Drawing Sheets



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

(10) **Patent No.:** **US 10,218,396 B2**
(45) **Date of Patent:** **Feb. 26, 2019**

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

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

(72) Inventors: **Gunhee Son**, Gyeongsangbuk-do (KR);
Hyeongwoo Kim, Busan (KR);
Soon-Sang Park, Daegu (KR);
Seunghyun Yeo, Daegu (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.: **15/222,899**

(22) Filed: **Jul. 28, 2016**

(65) **Prior Publication Data**

US 2017/0033812 A1 Feb. 2, 2017

(30) **Foreign Application Priority Data**

Jul. 28, 2015 (KR) 10-2015-0106687

(51) **Int. Cl.**

H04B 1/04 (2006.01)
H01Q 1/24 (2006.01)

(Continued)

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

CPC **H04B 1/0483** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 5/328** (2015.01); **H01Q**
5/371 (2015.01);

(Continued)

(58) **Field of Classification Search**

CPC combination set(s) only.
See application file for complete search history.

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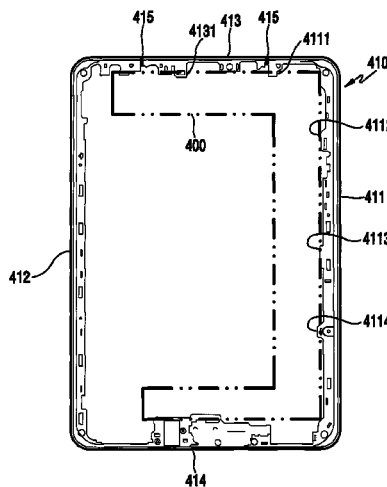
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Primary Examiner — Junpeng Chen

(57) **ABSTRACT**

Various embodiments provide an antenna device that includes: a metal member configured to have a length that contributes to at least a part of an electronic device; a printed circuit board (PCB) configured to be feed-connected to a preset position of the metal member in order to apply the metal member as an antenna radiator; and at least one electronic component electrically connected to a position different from the feeding position of the metal member and grounded to the PCB, and provide an electronic device that includes the same. Accordingly, the antenna device is grounded to the PCB in a desired position of the metal member by using the basically provided electronic component so that it is possible to exclude a separate electrical connection member, thereby reducing the cost, increasing the use of space, enhancing the degree of freedom of the design of the antenna radiator.

16 Claims, 21 Drawing Sheets



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

(10) **Patent No.:** **US 10,219,389 B2**
(45) **Date of Patent:** **Feb. 26, 2019**

(54) **ELECTRONIC DEVICE HAVING MILLIMETER WAVE ANTENNAS**

USPC 343/702
See application file for complete search history.

(71) Applicant: **MOTOROLA MOBILITY LLC**,
Chicago, IL (US)

(56) **References Cited**

(72) Inventors: **Md Rashidul Islam**, Lombard, IL (US); **Eric Krenz**, Crystal Lake, IL (US); **Hugh Smith**, Palatine, IL (US); **Istvan Szini**, Grayslake, IL (US)

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(73) Assignee: **Motorola Mobility LLC**, Chicago, IL (US)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 234 days.

Yoon, Y., et al., A Vertical W-band Surface-Micromachined Yagi-Uda Antenna, IEEE Antennas and Propagation Society International Symposium, vol. 4B, (Jul. 2005).

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(21) Appl. No.: **15/442,974**

Primary Examiner — Huedung X Mancuso

(22) Filed: **Feb. 27, 2017**

(74) *Attorney, Agent, or Firm* — Yudell Isidore PLLC

(65) **Prior Publication Data**

US 2018/0248254 A1 Aug. 30, 2018

(57) **ABSTRACT**

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H05K 3/30 (2006.01)

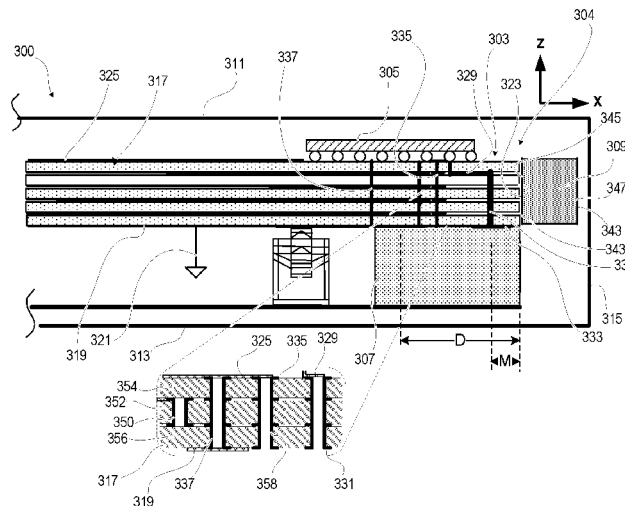
(Continued)

An antenna assembly is formed in a multilayer printed circuit board (PCB) for transceiving in a millimeter wave (mmWave) frequency band. A ground plane is formed on at least a portion of a planar surface of the multilayer PCB. Two metal components are physically attached to the multilayer PCB and electrically coupled to the ground plane. A monopole antenna is positioned vertically through one or more layers of the multilayer PCB. The antenna is positioned proximate to one lateral side of the multilayer PCB, and aligned between the two metal components. Vertical stubs are formed through the multilayer PCB, vertically aligned with the monopole antenna, and spaced to a side of the monopole antenna opposite to the one lateral side of the multilayer PCB. Each vertical stub is electrically grounded to the ground plane. The two metal components and the vertical stubs shape beam directivity of the monopole antenna.

(52) **U.S. Cl.**
CPC **H05K 3/30** (2013.01); **G06F 1/1684** (2013.01); **H01Q 1/243** (2013.01); **H01Q 19/06** (2013.01); **H01Q 19/102** (2013.01); **H01Q 19/13** (2013.01); **H01Q 19/32** (2013.01); **H01Q 21/08** (2013.01); **H05K 1/0243** (2013.01); **H05K 1/18** (2013.01); **H05K 3/4038** (2013.01); **H01Q 9/30** (2013.01); **H01Q 21/205** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 19/06; H01Q 21/08; H01Q 19/13; H05K 3/30; H05K 1/18

20 Claims, 22 Drawing Sheets





US010224603B2

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

(10) **Patent No.:** **US 10,224,603 B2**

(45) **Date of Patent:** **Mar. 5, 2019**

(54) **ANTENNA USING COUPLING AND ELECTRONIC DEVICE INCLUDING THE SAME**

(56) **References Cited**

U.S. PATENT DOCUMENTS

- (71) Applicant: **Samsung Electronics Co., Ltd.**, Gyeonggi-do (KR)
- (72) Inventors: **Dong Ryul Shin**, Daegu (KR); **Min Sakong**, Gyeongsangbuk-do (KR); **Chae Up Yoo**, Seoul (KR); **Jin Woo Jung**, Seoul (KR); **Ho Saeng Kim**, Gyeonggi-do (KR); **Byung Chan Jang**, Gyeongsangbuk-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 10 days.

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(21) Appl. No.: **14/922,967**

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(22) Filed: **Oct. 26, 2015**

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(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Oct. 24, 2014 (KR) 10-2014-0145540

Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

- (51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/378 (2015.01)
H01Q 9/42 (2006.01)

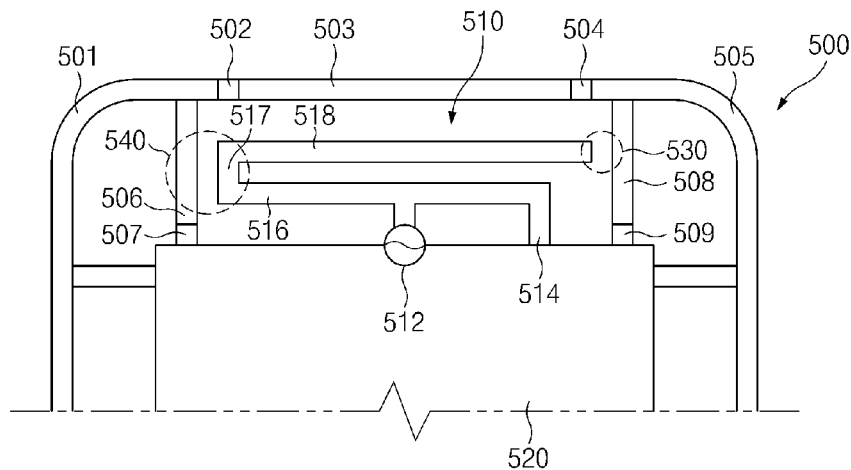
(57) **ABSTRACT**

- (52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/241** (2013.01); **H01Q 5/378** (2015.01); **H01Q 9/42** (2013.01)

An electronic device is provided. The electronic device includes a housing including a segment part used to insulate a portion of the housing and an antenna disposed at a position corresponding to the segment part.

- (58) **Field of Classification Search**
CPC H01Q 1/243
See application file for complete search history.

11 Claims, 13 Drawing Sheets





(12) **United States Patent**
Kato

(10) **Patent No.:** **US 10,224,604 B2**
(45) **Date of Patent:** **Mar. 5, 2019**

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

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

(72) Inventor: **Noboru Kato**, 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 65 days.

(21) Appl. No.: **14/959,142**

(22) Filed: **Dec. 4, 2015**

(65) **Prior Publication Data**

US 2016/0087330 A1 Mar. 24, 2016

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2014/064666, filed on Jun. 3, 2014.

(30) **Foreign Application Priority Data**

Jun. 14, 2013 (JP) 2013-125186

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/50 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/22** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/50** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 7/08; H01Q 1/48; H01Q 1/50; H01Q 1/22; H01Q 7/00
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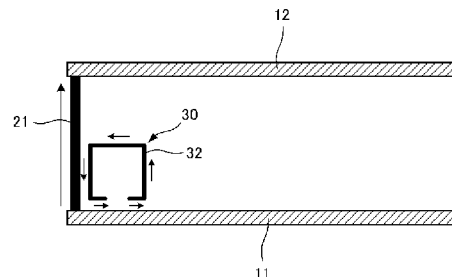
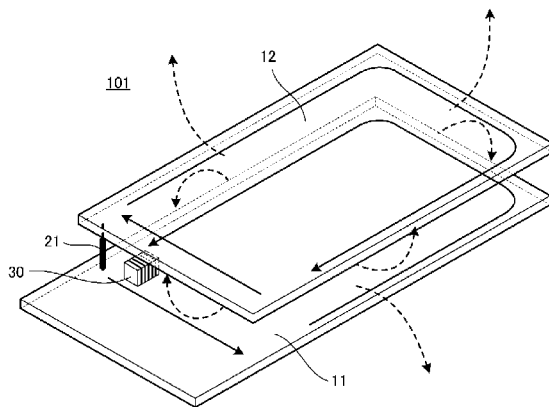
Primary Examiner — Hai Tran

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

(57) **ABSTRACT**

An antenna device includes two conductor surfaces at opposing positions with a space interposed between the conductor surfaces, a first connection conductor connecting the two conductor surfaces galvanically at one location, and an antenna coil arranged in proximity to the first connection conductor. The antenna coil is arranged at a position at which the antenna coil causes an induced current to flow through the first connection conductor by electromagnetic induction. Currents in the opposite directions flow through peripheral edge portions of the two conductor surfaces, so that a magnetic field is radiated from a space across which the two conductor surfaces oppose each other. This enables a conductor surface defined by a metal plate or the like to be used as a radiation element without providing a slit or an opening in the metal plate so as to avoid problems of a decrease in mechanical strength, design restrictions, and a decrease in an electric field shielding effect.

18 Claims, 5 Drawing Sheets



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

(10) **Patent No.:** **US 10,224,605 B2**
(45) **Date of Patent:** **Mar. 5, 2019**

(54) **ANTENNA AND MOBILE TERMINAL**
(71) Applicant: **Huawei Device (Dongguan) Co., Ltd.**,
Dongguan (CN)
(72) Inventors: **Hanyang Wang**, Shenzhen (CN);
Jianming Li, Taipei (TW)
(73) Assignee: **HUAWEI DEVICE (DONGGUAN)**
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 74 days.

(56) **References Cited**
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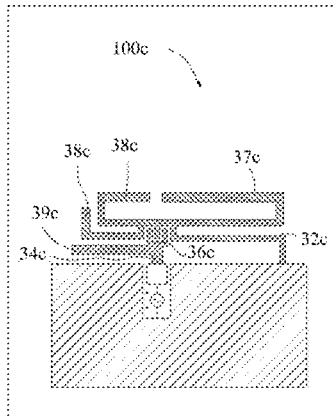
(21) Appl. No.: **15/025,714**
(22) PCT Filed: **Mar. 28, 2014**
(86) PCT No.: **PCT/CN2014/074299**
§ 371 (c)(1),
(2) Date: **Mar. 29, 2016**
(87) PCT Pub. No.: **WO2015/143714**
PCT Pub. Date: **Oct. 1, 2015**

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cation No. JP2004236273, Oct. 31, 2016, 7 pages.
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Primary Examiner — Hai Tran
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

(65) **Prior Publication Data**
US 2016/0248146 A1 Aug. 25, 2016
(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/00 (2015.01)
(Continued)
(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/36**
(2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48**
(2013.01);
(Continued)
(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 9/42; H01Q 9/0414;
H01Q 1/38; H01Q 1/48; H01Q 1/36;
H01Q 5/00
(Continued)

(57) **ABSTRACT**
An antenna, including a first radiation part, a matching
circuit, and a feed source, where the first radiation part
includes a first radiator, a second radiator, and a capacitor
structure, a first end of the first radiator is connected to the
feed source using the matching circuit, the feed source is
connected to a grounding part, a second end of the first
radiator is connected to a first end of the second radiator
using the capacitor structure, a second end of the second
radiator is connected to the grounding part, the first radiation
part is configured to generate a first resonance frequency,
and a length of the second radiator is one-eighth of a
wavelength corresponding to the first resonance frequency
which helps to reduce an antenna length, and a volume of a
mobile terminal.

17 Claims, 7 Drawing Sheets





US010224606B2

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

(10) **Patent No.:** **US 10,224,606 B2**

(45) **Date of Patent:** **Mar. 5, 2019**

(54) **ELECTRONIC DEVICE WITH MULTI-BAND ANTENNA FOR SUPPORTING CARRIER AGGREGATION USING NON-SEGMENTED CONDUCTIVE BORDER MEMBER**

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/48; H01Q 9/42; H01Q 5/328; H01Q 5/335; H01Q 1/521
See application file for complete search history.

(71) Applicant: **SAMSUNG ELECTRO-MECHANICS CO., LTD.**, Suwon-si (KR)

(56) **References Cited**

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(Continued)

Primary Examiner — Dieu Hien T Duong

(74) *Attorney, Agent, or Firm* — NSIP Law

(72) Inventors: **Nam Ki Kim**, Suwon-si (KR); **Dae Seong Jeon**, Suwon-si (KR); **Young Min Cheon**, Suwon-si (KR); **Hyun Do Park**, Suwon-si (KR); **Dae Ki Lim**, Suwon-si (KR)

(73) Assignee: **Samsung Electro-Mechanics 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 265 days.

(21) Appl. No.: **15/158,845**

(57) **ABSTRACT**

(22) Filed: **May 19, 2016**

An electronic device including a multi-band antenna, a cover, a substrate, and a conductive border member is disclosed, where the device includes a first feed terminal connected to a circuit of a substrate embedded in the device, a second feed terminal connected to the circuit and insulated from the first feed terminal, a ground disposed on the substrate, a conductive border member continuously disposed along a periphery of the electronic device, a first antenna connected to the first feed terminal and the conductive border member, and the first antenna forming a multiple resonance for covering a first multi-band having a plurality of bands, a second antenna connected to the second feed terminal and the conductive border member and the second antenna forming a multiple resonance for covering a second multi-band, and a bypass conductor to bypass interference signals generated by the first antenna and the second antenna to the ground.

(65) **Prior Publication Data**

US 2017/0033440 A1 Feb. 2, 2017

(30) **Foreign Application Priority Data**

Jul. 30, 2015 (KR) 10-2015-0108246
Dec. 30, 2015 (KR) 10-2015-0189250

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

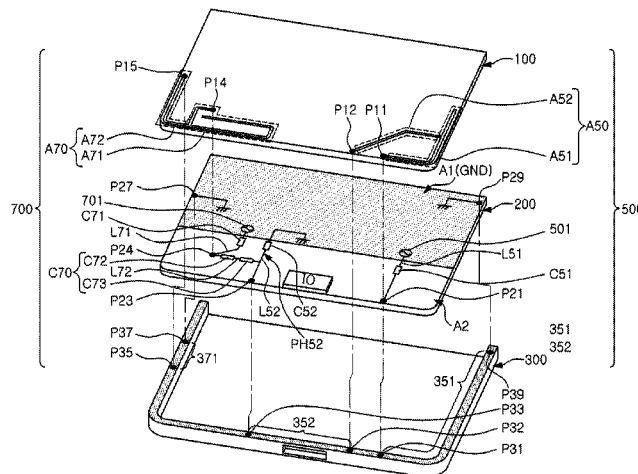
H01Q 1/48 (2006.01)

(Continued)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/521** (2013.01); **H01Q 5/328** (2015.01); **H01Q 5/335** (2015.01); **H01Q 9/42** (2013.01)

27 Claims, 15 Drawing Sheets



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

(10) **Patent No.:** **US 10,224,626 B1**
(45) **Date of Patent:** **Mar. 5, 2019**

(54) **CO-LOCATED ACTIVE STEERING ANTENNAS CONFIGURED FOR BAND SWITCHING, IMPEDANCE MATCHING AND UNIT SELECTIVITY**

5/392 (2015.01); *H01Q 7/00* (2013.01); *H01Q 21/00* (2013.01); *H04B 7/0404* (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/48; H01Q 21/28; H01Q 1/24
USPC 343/702
See application file for complete search history.

(71) Applicant: **ETHERTRONICS, INC.**, San Diego, CA (US)

(72) Inventors: **Olivier Pajona**, Nice (FR); **Jaakko Kyllonen**, Nice (FR); **Laurent Desclos**, San Diego, CA (US)

(56) **References Cited**

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(73) Assignee: **Ethertronics, Inc.**, San Diego, CA (US)

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

(21) Appl. No.: **15/218,982**

(22) Filed: **Jul. 25, 2016**

Related U.S. Application Data

(60) Provisional application No. 62/196,794, filed on Jul. 24, 2015.

(51) **Int. Cl.**
H01Q 1/14 (2006.01)
H01Q 3/24 (2006.01)
H01Q 1/24 (2006.01)
H01Q 3/36 (2006.01)
H01Q 5/392 (2015.01)
H01Q 7/00 (2006.01)
H04B 7/0404 (2017.01)
H01Q 5/335 (2015.01)
H01Q 21/00 (2006.01)
H01Q 1/48 (2006.01)

(52) **U.S. Cl.**
CPC *H01Q 3/24* (2013.01); *H01Q 1/245* (2013.01); *H01Q 1/48* (2013.01); *H01Q 3/36* (2013.01); *H01Q 5/335* (2015.01); *H01Q*

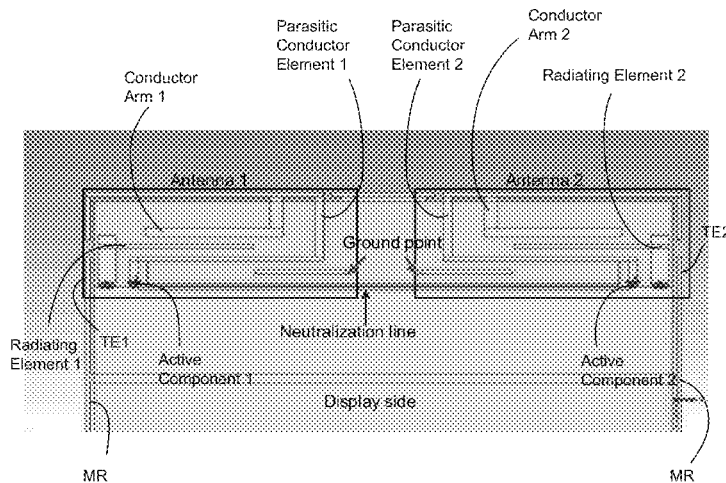
Primary Examiner — Hai Tran

(74) *Attorney, Agent, or Firm* — Dority & Manning, P.A.

(57) **ABSTRACT**

An antenna system includes co-located active steering antennas implemented in a bottom portion of a wireless communication device designed for positioning near a user's mouth or chin. The co-located active steering antennas are each configured to steer a radiation pattern of the respective antenna, and can be further configured for active band switching and/or active impedance matching. These co-located active steering antennas can be used independently, or in a multi-input multi-output (MIMO) configuration. In addition, the antenna system is capable of antenna unit selectivity, which includes the ability to select one of the co-located antennas with the lowest head and hand loss for use, while disabling the antenna with the highest loss attributed to hand/head loading.

13 Claims, 11 Drawing Sheets



(12) **United States Patent**
Iellici

(10) **Patent No.:** **US 10,224,630 B2**
(45) **Date of Patent:** **Mar. 5, 2019**

- (54) **MULTIBAND ANTENNA**
- (71) Applicant: **MICROSOFT CORPORATION**,
Redmond, WA (US)
- (72) Inventor: **Devis Iellici**, Cambridge (GB)
- (73) Assignee: **Microsoft Technology Licensing, LLC**,
Redmond, WA (US)
- (*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 95 days.
- (21) Appl. No.: **14/434,711**
- (22) PCT Filed: **Oct. 11, 2013**
- (86) PCT No.: **PCT/US2013/064715**
§ 371 (c)(1),
(2) Date: **Apr. 9, 2015**
- (87) PCT Pub. No.: **WO2014/059382**
PCT Pub. Date: **Apr. 17, 2014**

(65) **Prior Publication Data**
US 2015/0236417 A1 Aug. 20, 2015

(30) **Foreign Application Priority Data**
Oct. 11, 2012 (GB) 1218286.1

- (51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 5/328 (2015.01)
(Continued)
- (52) **U.S. Cl.**
CPC **H01Q 5/328** (2015.01); **H01Q 1/24**
(2013.01); **H01Q 1/38** (2013.01); **H01Q 5/335**
(2015.01); **H01Q 11/12** (2013.01)
- (58) **Field of Classification Search**
CPC H01Q 5/328; H01Q 5/335; H01Q 11/12;
H01Q 1/24; H01Q 1/38
(Continued)

- (56) **References Cited**
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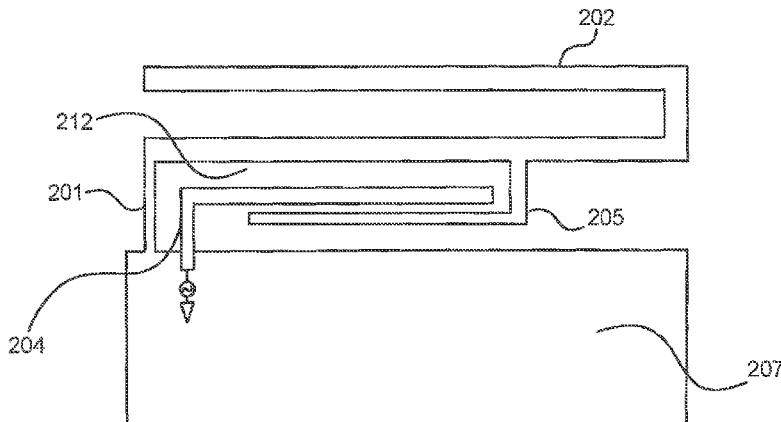
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Primary Examiner — Hai Tran
(74) *Attorney, Agent, or Firm* — Holzer Patel Drennan

- (57) **ABSTRACT**
There is disclosed a multiband antenna device comprising a
conductive elongate antenna element configured for electri-
cal connection to a groundplane at a grounding point, and a
conductive elongate feeding element configured for electri-
cal connection to a radio transmitter/receiver at a feeding
point. At least a major portion of the antenna element is
configured to extend in a first direction and to double back
on itself in a second, substantially counter-parallel direction
forming a slot. The feeding point is adjacent to the ground-
ing point, and the feeding element is configured to extend
substantially parallel to the first and second directions of the
major portion of the antenna element. The antenna device
can operate in multiple frequency bands, and can be con-
figured on a dielectric insulating former that fits compactly
in a corner of a mobile communications handset housing.

19 Claims, 29 Drawing Sheets





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

(10) **Patent No.:** **US 10,230,154 B2**
(45) **Date of Patent:** **Mar. 12, 2019**

(54) **MULTI FEEDING ANTENNA AND ELECTRONIC DEVICE INCLUDING THE SAME**

(56) **References Cited**

U.S. PATENT DOCUMENTS

- (71) Applicant: **Samsung Electronics Co., Ltd.**, Gyeonggi-do (KR)
- (72) Inventors: **Jae-Woong Jeon**, Gyeonggi-do (KR); **Dong-Hun Park**, Gyeonggi-do (KR); **Siyoul Jang**, Gyeonggi-do (KR); **Changtae Kim**, 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 0 days.

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(21) Appl. No.: **15/938,531**

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

(65) **Prior Publication Data**

US 2018/0288203 A1 Oct. 4, 2018

(30) **Foreign Application Priority Data**

Mar. 28, 2017 (KR) 10-2017-0039326

(51) **Int. Cl.**

- H01Q 1/24** (2006.01)
- H01Q 5/30** (2015.01)
- H01Q 5/50** (2015.01)
- H05K 1/02** (2006.01)
- H01Q 5/35** (2015.01)

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

CPC **H01Q 1/241** (2013.01); **H01Q 1/242** (2013.01); **H01Q 5/30** (2015.01); **H01Q 5/50** (2015.01); **H05K 1/0243** (2013.01); **H01Q 5/35** (2015.01)

(58) **Field of Classification Search**

CPC H01Q 1/241-1/245; H01Q 5/00-5/55
See application file for complete search history.

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KR	1020160120643	10/2016

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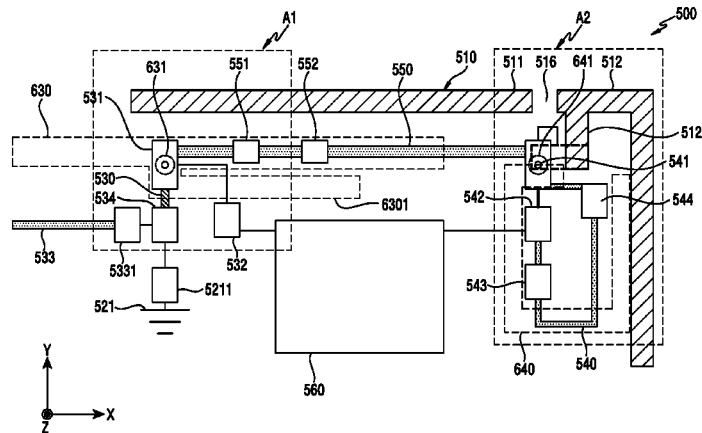
Primary Examiner — Duc M Nguyen

(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(57) **ABSTRACT**

Disclosed is an electronic device which may provide a multi-feeding antenna operating in multiple frequency bands by reducing performance degradation, and can contribute to slimness by implementing at least a portion of the patterns in a printed circuit board.

20 Claims, 11 Drawing Sheets



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

(10) **Patent No.:** **US 10,230,157 B2**
(45) **Date of Patent:** **Mar. 12, 2019**

(54) **WIFI AND GPS ANTENNA**

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(72) Inventors: **Linchuan Wang**, Beijing (CN); **Zonglin Xue**, Beijing (CN); **Xiaofeng Xiong**, 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 3 days.

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(22) Filed: **Jan. 23, 2017**

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(30) **Foreign Application Priority Data**
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H01Q 1/48 (2006.01)
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(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/335** (2015.01); **H01Q 5/371** (2015.01);
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(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/371; H01Q 5/335; H01Q 9/42; H01Q 7/00; H01Q 1/48; H01Q 9/045
See application file for complete search history.

(56) **References Cited**

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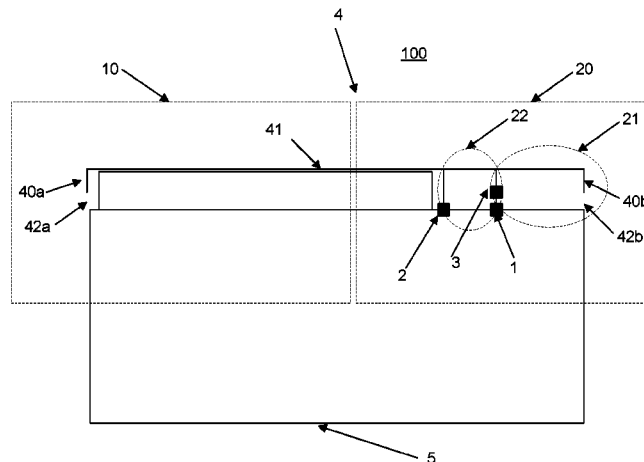
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(57) **ABSTRACT**

A WIFI & GPS antenna applied to a mobile terminal with a metallic body. The metallic body includes a metallic body part and a receiving zone located above the metallic body part. The WIFI & GPS antenna includes a feeding point and a ground point each disposed on the metallic body part, and a capacitive tuning component connected to a top edge of the receiving zone, and connected to the feeding point in series. The receiving zone includes a component zone and an antenna zone. The feeding point, the ground point, and the capacitive tuning component are disposed in the antenna zone. A part of the top edge of the receiving zone operates as a radiator for the WIFI & GPS antenna.

5 Claims, 1 Drawing Sheet





US010230162B2

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

(10) **Patent No.:** **US 10,230,162 B2**
(45) **Date of Patent:** **Mar. 12, 2019**

(54) **ANTENNA SYSTEM**

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(72) Inventors: **Chao Wang**, Shenzhen (CN); **Yongli Chen**, Shenzhen (CN); **Ya Wang**, Shenzhen (CN)

(73) Assignee: **AAC TECHNOLOGIES PTE. LTD.**, Singapore (SG)

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(22) Filed: **Jan. 26, 2017**

(65) **Prior Publication Data**

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H01Q 1/22 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)

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

CPC **H01Q 1/48** (2013.01); **H01Q 1/2291** (2013.01); **H01Q 1/243** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/48; H01Q 1/36; H01Q 1/2291; H01Q 7/00
USPC 343/702
See application file for complete search history.

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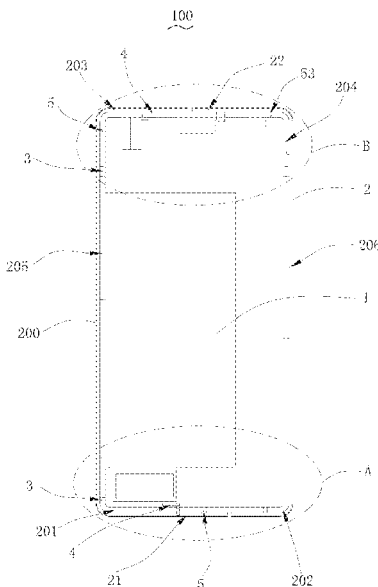
Primary Examiner — Hai Tran

(74) Attorney, Agent, or Firm — Na Xu; IPro, PLLC

(57) **ABSTRACT**

Provided is an antenna system, including a system ground unit, a metal back cover, a frame as antenna radiator, and a grounding circuit, a feeding circuit and a tuning switch, the antenna radiator includes a main radiator and an auxiliary radiator; the main radiator includes a first main radiator which forms, together with the metal back cover, a first main gap, a second main radiator extending from the first main radiator and forms, together with the metal back cover, a second main gap, and a first fracture separating the first main radiator into two parts; the auxiliary radiator includes a first auxiliary radiator which forms, together with the metal back cover, a first auxiliary gap, a second auxiliary radiator extending from the first auxiliary radiator and forms, together with the metal back cover, a second auxiliary gap, and a second fracture separating the first auxiliary radiator into two parts.

10 Claims, 11 Drawing Sheets





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

(10) **Patent No.:** **US 10,224,599 B2**

(45) **Date of Patent:** **Mar. 5, 2019**

(54) **WIFI ANTENNA DEVICE**

(56) **References Cited**

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(72) Inventors: **Guang-Yong Zhong**, Shanghai (CN);
Soon-Kuan Tan, Shanghai (CN)

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Primary Examiner — Hoang V Nguyen

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(74) *Attorney, Agent, or Firm* — Molex, LLC

(30) **Foreign Application Priority Data**

(57) **ABSTRACT**

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The present disclosure discloses a WIFI antenna device, the WIFI antenna device includes a carrier, a grounding portion, a first radiation portion, a second radiation portion and a third radiation portion which all are provided on the carrier. The first radiation portion, the second radiation portion and the third radiation portion are coupled to the grounding portion. The coupling portion couples an electrical signal to the first radiation portion, the second radiation portion and the third radiation portion. The first radiation portion, the second radiation portion and the third radiation portion convert the electrical signal into the radiation signal. The first radiation portion determines a low frequency resonance point of a radiation signal emitted by the WIFI antenna device. The second radiation portion determines a first high frequency resonance point of the radiation signal. The third radiation portion determines a second high frequency resonance point of the radiation signal.

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 1/36 (2006.01)
H01Q 1/48 (2006.01)
H01Q 21/30 (2006.01)

(52) **U.S. Cl.**
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(58) **Field of Classification Search**
CPC .. H01Q 1/2258; H01Q 1/2266; H01Q 1/2291; H01Q 1/36; H01Q 1/48; H01Q 21/30; H01Q 21/20

See application file for complete search history.

23 Claims, 9 Drawing Sheets

