



US010186752B2

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

(10) **Patent No.:** **US 10,186,752 B2**  
(45) **Date of Patent:** **Jan. 22, 2019**

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

(2015.01); **H01Q 5/50** (2015.01); **H01Q 9/42** (2013.01); **H01Q 13/18** (2013.01); **H04M 1/0264** (2013.01); **H04M 1/0266** (2013.01)

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

(58) **Field of Classification Search**  
CPC ..... H01Q 13/18; H01Q 1/24; H01Q 1/242; H01Q 1/48; H01Q 5/50; H01Q 1/243; H01Q 21/28; H01Q 5/314; H01Q 5/371  
See application file for complete search history.

(72) Inventors: **Yi-Ting Chen**, New Taipei (TW); **Yen-Jung Tseng**, New Taipei (TW); **Tze-Hsuan Chang**, New Taipei (TW)

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

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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 0 days.

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(21) Appl. No.: **15/655,902**

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

*Primary Examiner* — Tho G Phan

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

(65) **Prior Publication Data**

US 2018/0026337 A1 Jan. 25, 2018

**Related U.S. Application Data**

(60) Provisional application No. 62/365,341, filed on Jul. 21, 2016.

(30) **Foreign Application Priority Data**

Jul. 12, 2017 (CN) ..... 2017 1 0564746

(57) **ABSTRACT**

An antenna structure includes a metallic member including a front frame and a side frame. The side frame defines a slot. The front frame defines a second gap and a third gap communicating with the slot and extending across the front frame. A portion of the front frame between the second gap and the third gap forms a first radiating section. Current enters the first radiating section from the first feed portion, flows through the first radiating section and towards the second gap to generate radiation signals in a first frequency band, flows through the first radiating section and towards the third gap to generate radiation signals in a second frequency band, and flows through the first radiating section and towards the second gap and the third gap to generate radiation signals in a third frequency band. A wireless communication device using the antenna structure is provided.

**18 Claims, 26 Drawing Sheets**

(51) **Int. Cl.**

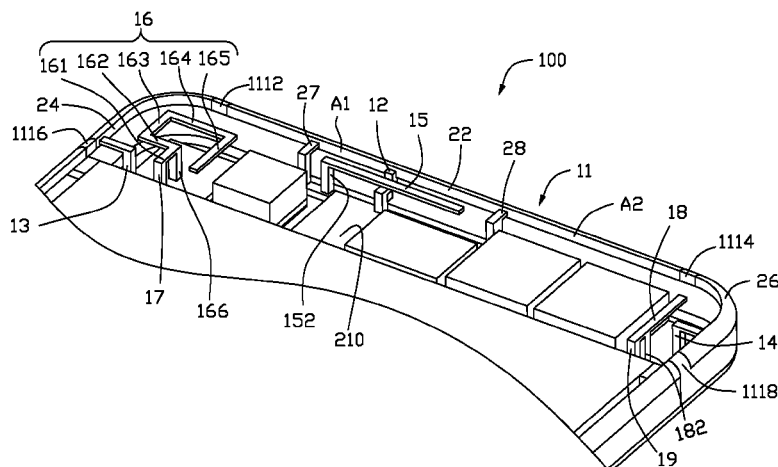
**H01Q 1/24** (2006.01)

**H01Q 13/18** (2006.01)

(Continued)

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

CPC ..... **H01Q 1/242** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/335** (2015.01); **H01Q 5/35** (2015.01); **H01Q 5/378**



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

(10) **Patent No.:** **US 10,186,755 B2**  
(45) **Date of Patent:** **Jan. 22, 2019**

(54) **ANTENNA MODULE AND MOBILE TERMINAL USING THE SAME**

(71) Applicant: **Xiaomi Inc.**, Beijing (CN)  
(72) Inventors: **Xiaofeng Xiong**, Beijing (CN);  
**Linchuan Wang**, Beijing (CN);  
**Zonglin Xue**, Beijing (CN)

(73) Assignee: **Xiaomi Inc.**, Beijing (CN)  
( \* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 221 days.

(21) Appl. No.: **15/018,114**

(22) Filed: **Feb. 8, 2016**

(65) **Prior Publication Data**  
US 2016/0233574 A1 Aug. 11, 2016

(30) **Foreign Application Priority Data**  
Feb. 11, 2015 (CN) ..... 2015 1 0073377

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

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 1/2258** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 1/521** (2013.01); **H01Q 5/50** (2015.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/243; H01Q 1/521; H01Q 1/52; H01Q 21/28; H01Q 5/50; H01Q 1/2258; H01Q 1/2266

See application file for complete search history.

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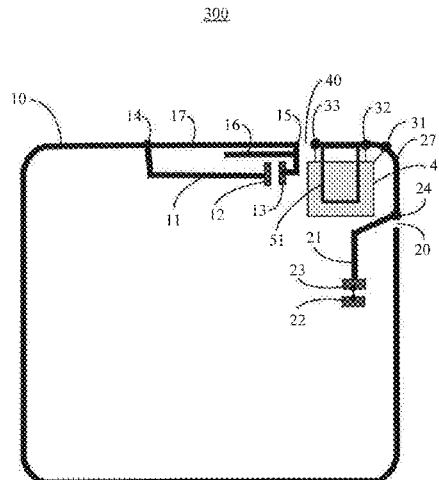
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*Primary Examiner* — Dameon E Levi  
*Assistant Examiner* — Ab Salam Alkassim, Jr.  
(74) *Attorney, Agent, or Firm* — Finnegan, Henderson, Farabow, Garrett & Dunner LLP

(57) **ABSTRACT**

An antenna module is provided. The antenna module includes: a first antenna electrically connected to a first section of a metal frame of a mobile terminal, the first antenna comprising a first feed point and a first ground point; and a second antenna electrically connected to a second section of the metal frame of the mobile terminal, the second antenna comprising a second feed point and a second ground point, wherein a slot is formed between the second section of the metal frame and the first section of the metal frame, and the second section of the metal frame is electrically connected to a ground point of the mobile terminal via a first contact point.

**14 Claims, 7 Drawing Sheets**



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

(10) **Patent No.:** **US 10,186,758 B2**  
(45) **Date of Patent:** **Jan. 22, 2019**

(54) **ANTENNA SYSTEM AND MOBILE TERMINAL CONTAINING THE SAME**

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

(72) Inventors: **Jianan Wang**, Shenzhen (CN); **Xinying Xu**, 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.: **15/828,550**

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

(65) **Prior Publication Data**  
US 2018/0358698 A1 Dec. 13, 2018

(30) **Foreign Application Priority Data**  
Jun. 9, 2017 (CN) ..... 2017 2 0672294 U

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 5/335** (2015.01)  
**H01Q 5/328** (2015.01)  
**H01Q 1/38** (2006.01)  
**H01Q 1/48** (2006.01)  
**H01Q 5/10** (2015.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 1/24** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/328** (2015.01); **H01Q 5/335** (2015.01); **H01Q 5/10** (2015.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/24; H01Q 1/243; H01Q 5/335; H01Q 1/38; H01Q 1/48; H01Q 5/10; H01Q 5/328; H01Q 1/2266; H01Q 1/2258

See application file for complete search history.

(56) **References Cited**

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*Primary Examiner* — Dameon E Levi

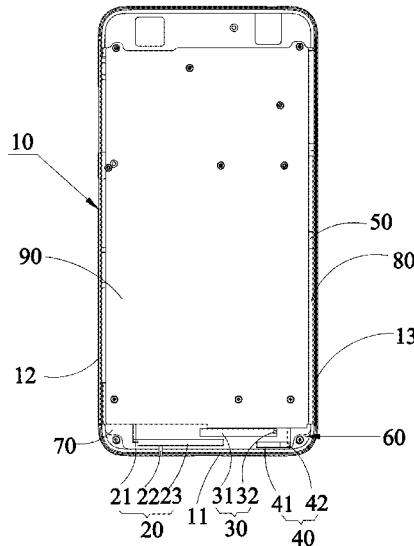
*Assistant Examiner* — Ab Salam Alkassim, Jr.

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

(57) **ABSTRACT**

The present disclosure relates to an antenna system and a mobile terminal containing the same. The antenna system includes a system ground, a metal frame surrounding the system ground without slit and in closed circle shape, a first radiation unit, a second radiation unit and a third radiation unit. The system ground is electrically connected with the metal frame; the first radiation unit comprises a tuning switch connected with the system ground, a first metal wiring connected with the tuning switch, and a second metal wiring connecting the first metal wiring to the metal frame; the second radiation unit comprises a feeding point and a third metal wiring connected with the feeding point, and the third metal wiring at least partially faces the first metal wiring; the third radiation unit comprises a grounding point connected with the system ground and a fourth metal wiring connected with the grounding point.

**10 Claims, 5 Drawing Sheets**





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

(10) **Patent No.:** **US 10,186,784 B2**  
(45) **Date of Patent:** **Jan. 22, 2019**

(54) **ANTENNA APPARATUS**

(71) Applicant: **Huawei Technologies Co., Ltd.**,  
Shenzhen (CN)  
(72) Inventors: **Ross Murch**, Hong Kong (HK); **Saber Soltani**, Hong Kong (HK); **Rongdao Yu**, Shenzhen (CN)  
(73) Assignee: **Huawei Technologies Co., Ltd.**,  
Shenzhen (CN)

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

(21) Appl. No.: **15/270,935**

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

(65) **Prior Publication Data**  
US 2017/0012362 A1 Jan. 12, 2017

**Related U.S. Application Data**

(63) Continuation of application No. PCT/CN2014/073820, filed on Mar. 21, 2014.

(51) **Int. Cl.**  
**H01Q 13/16** (2006.01)  
**H01Q 21/06** (2006.01)  
(Continued)

(52) **U.S. Cl.**  
CPC ..... **H01Q 13/106** (2013.01); **H01Q 1/241** (2013.01); **H01Q 13/16** (2013.01); **H01Q 21/064** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 13/08; H01Q 13/10; H01Q 13/16; H01Q 1/38; H01Q 5/49; H01Q 5/378; H01Q 21/061; H01Q 13/106; H01Q 13/18

See application file for complete search history.

(56) **References Cited**

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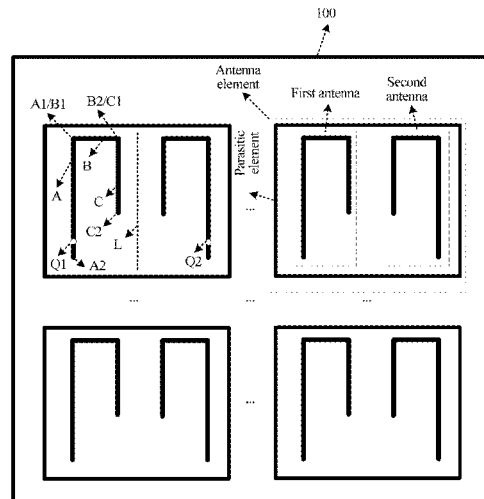
*Primary Examiner* — Dameon E Levi  
*Assistant Examiner* — Ricardo Magallanes

(74) *Attorney, Agent, or Firm* — Leydig, Voit & Mayer, Ltd.

(57) **ABSTRACT**

Embodiments of the present invention provide an antenna apparatus, including multiple antenna elements, where the antenna element includes a dielectric plate, one two-antenna array element, and one parasitic element; the two-antenna array element is located at the front of the dielectric plate; the parasitic element is located on the back of the dielectric plate, and a location of the two-antenna array element falls within an area of the parasitic element; a first antenna and a second antenna that are in the two-antenna array element are bent slot slot antennas symmetrical to each other with respect to a central axis between the first antenna and the second antenna; the first antenna is formed by connecting three sections.

**14 Claims, 5 Drawing Sheets**



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

(10) **Patent No.:** **US 10,193,210 B2**  
(45) **Date of Patent:** **Jan. 29, 2019**

(54) **TERMINAL DEVICE HAVING HYBRID ANTENNA INTEGRATING WITH CAPACITIVE PROXIMITY SENSORS**

USPC ..... 343/720, 852, 702, 866  
See application file for complete search history.

(71) Applicant: **TAIWAN ANJIE ELECTRONICS CO., LTD.**, Hsinchu (TW)

(56) **References Cited**

(72) Inventors: **Yen-Cheng Chen**, Hsinchu (TW);  
**Yeh-Chian Lin**, Hsinchu (TW)

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(73) Assignee: **TAIWAN ANJIE ELECTRONICS CO., LTD.**, Hsinchu (TW)

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2015/0077307 A1\* 3/2015 Liou ..... H01Q 7/00  
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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 118 days.

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*Primary Examiner* — Dameon E Levi  
*Assistant Examiner* — Collin Dawkins  
(74) *Attorney, Agent, or Firm* — Schmeiser, Olsen & Watts, LLP

(21) Appl. No.: **15/392,022**

(57) **ABSTRACT**

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

A terminal device having hybrid antenna integrating with capacitive proximity sensors comprises a ground, a radiator, a first capacitance electrode and a second capacitance electrode. The radiator has a feeding portion, a low-frequency radiating path and a high-frequency radiating branch. The low-frequency radiating path has a first coupling portion. The feeding portion is disposed between the first coupling portion and the ground. The high-frequency radiating branch acts as a second coupling portion. The first capacitance electrode has a first shorting portion and a first electrode portion. The first shorting portion is connected to the ground. The first electrode coupling with the first coupling portion generates a first coupling resonant mode. The second capacitance electrode has a second shorting portion and a second electrode portion. The second shorting portion is connected to the ground. The second electrode coupling with the high-frequency radiating branch generates a second coupling resonant mode.

(65) **Prior Publication Data**

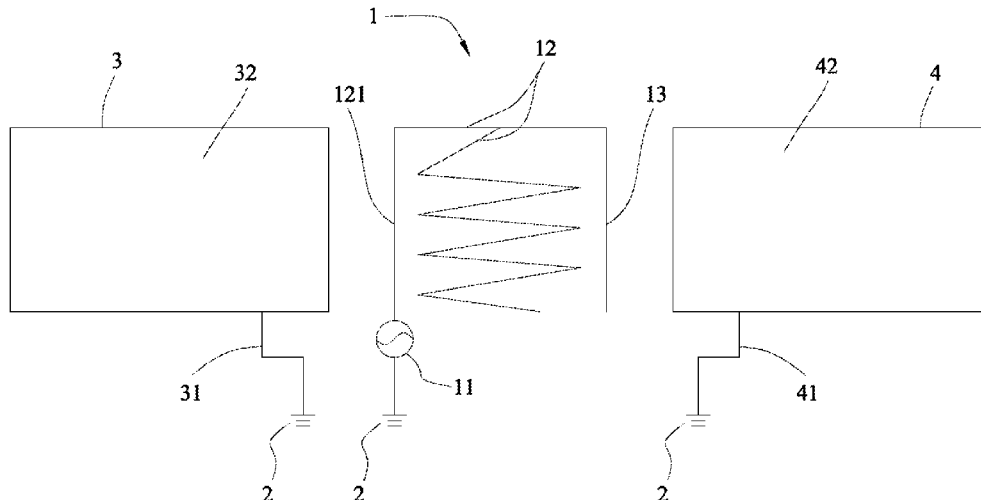
US 2018/0183131 A1 Jun. 28, 2018

(51) **Int. Cl.**  
**H01Q 1/00** (2006.01)  
**H01Q 1/22** (2006.01)  
**H01Q 1/24** (2006.01)  
**H01Q 1/48** (2006.01)  
**H01Q 9/42** (2006.01)  
**H01Q 5/371** (2015.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/22** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/371** (2015.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**  
CPC .. H01Q 1/44; H01Q 1/46; H01Q 5/00; H01Q 7/00; H01Q 1/38

**9 Claims, 7 Drawing Sheets**



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

(10) **Patent No.:** **US 10,193,213 B2**  
(45) **Date of Patent:** **Jan. 29, 2019**

(54) **SELF-ADAPTIVE ANTENNA SYSTEMS FOR ELECTRONIC DEVICES HAVING MULTIPLE FORM FACTORS**

(71) Applicant: **MICROSOFT TECHNOLOGY LICENSING, LLC**, Redmond, WA (US)

(72) Inventor: **Luyi Liu**, Sammamish, WA (US)

(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 309 days.

(21) Appl. No.: **14/883,254**

(22) Filed: **Oct. 14, 2015**

(65) **Prior Publication Data**

US 2017/0110786 A1 Apr. 20, 2017

(51) **Int. Cl.**

**H01Q 1/24** (2006.01)  
**H01Q 1/22** (2006.01)  
**G06F 1/16** (2006.01)  
**H01Q 5/378** (2015.01)  
**H04M 1/02** (2006.01)

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

CPC ..... **H01Q 1/243** (2013.01); **G06F 1/1698** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 5/378** (2015.01); **H04M 1/0214** (2013.01); **H04M 1/0247** (2013.01)

(58) **Field of Classification Search**

CPC ..... H01Q 1/243; H01Q 5/378; H01Q 1/2266  
See application file for complete search history.

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*Primary Examiner* — Dieu H Duong

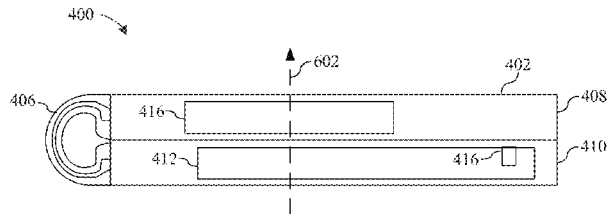
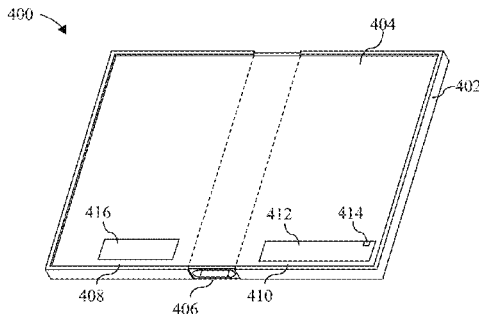
(74) *Attorney, Agent, or Firm* — Fiala & Weaver P.L.L.C.

(57)

**ABSTRACT**

An electronic device is described that is configurable to be transitioned from a first operating mode having a first form factor to a second operating mode having a second form factor. The electronic device includes a first device portion and a second device portion that is connected to the first device portion. The first device portion includes an RF antenna. The second device portion includes an antenna adaptation element. The antenna adaptation element is positioned more closely to the RF antenna in the second operating mode than in the first operating mode. The antenna adaptation element is configured to, in the second operating mode, passively counteract or mitigate a shifting of a resonant frequency of the RF antenna that would otherwise occur as a result of the electronic device being transitioned from the first operating mode to the second operating mode.

**20 Claims, 12 Drawing Sheets**



(12) **United States Patent**  
**Mai**

(10) **Patent No.:** **US 10,193,215 B2**  
(45) **Date of Patent:** **Jan. 29, 2019**

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

USPC ..... 343/702, 729  
See application file for complete search history.

(71) Applicant: **Jianchun Mai**, Shenzhen (CN)

(56) **References Cited**

(72) Inventor: **Jianchun Mai**, Shenzhen (CN)

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

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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 123 days.

\* cited by examiner

(21) Appl. No.: **15/417,195**

*Primary Examiner* — Hai V Tran

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

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

(65) **Prior Publication Data**

US 2018/0115052 A1 Apr. 26, 2018

(57) **ABSTRACT**

(30) **Foreign Application Priority Data**

Oct. 25, 2016 (CN) ..... 2016 1 0940525

The present disclosure provides an antenna device. The antenna device includes a metal back plate, a metal frame surrounding a periphery of the metal back plate and is connected with the metal back plate, and a radiator configured to receive and radiate electromagnetic waves, the metal back plate and the radiator are spaced so as to form a gap, the gap includes a first gap provided along a short axis direction of the metal back plate and a second gap and a third gap which are bended and extend from two ends of the first gap, respectively, a length of the first gap is smaller than a width of the metal back plate along its short axis. The antenna device of the present disclosure has less influence to antenna performance when being hand-held, and the antenna radiating performance is good.

(51) **Int. Cl.**

**H01Q 1/24** (2006.01)  
**H01Q 21/28** (2006.01)  
**H01Q 9/06** (2006.01)

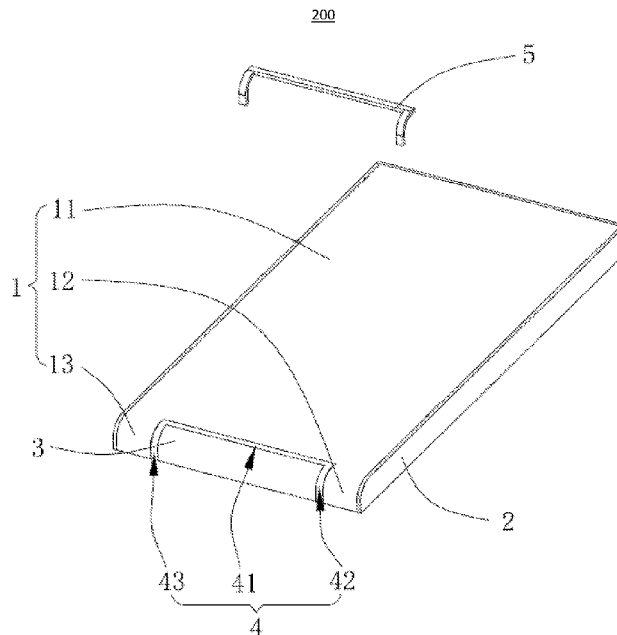
(52) **U.S. Cl.**

CPC ..... **H01Q 1/243** (2013.01); **H01Q 1/24**  
(2013.01); **H01Q 9/06** (2013.01); **H01Q 21/28**  
(2013.01)

(58) **Field of Classification Search**

CPC ..... H01Q 1/243; H01Q 1/48; H01Q 1/24;  
H01Q 21/28; H01Q 9/06

**9 Claims, 4 Drawing Sheets**





US010199716B2

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

(10) **Patent No.:** **US 10,199,716 B2**  
(45) **Date of Patent:** **Feb. 5, 2019**

(54) **ELECTRONIC DEVICE AND ANTENNA OF THE SAME**

(58) **Field of Classification Search**  
CPC ..... H01Q 1/2266; H01Q 13/10; H01Q 1/243; H01Q 21/30  
See application file for complete search history.

(71) Applicant: **BYD COMPANY LIMITED**,  
Shenzhen, Guangdong (CN)

(56) **References Cited**

(72) Inventors: **Qinyang Cai**, Guangdong (CN); **Yijin Wang**, Guangdong (CN); **Wensong Wang**, Guangdong (CN); **Munyong Choi**, Guangdong (CN)

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(73) Assignee: **BYD COMPANY LIMITED (CN)**

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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 50 days.

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(21) Appl. No.: **15/313,015**

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(22) PCT Filed: **May 26, 2015**

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(86) PCT No.: **PCT/CN2015/079773**

§ 371 (c)(1),  
(2) Date: **Nov. 21, 2016**

*Primary Examiner* — Dameon E Levi  
*Assistant Examiner* — David Lotter  
(74) *Attorney, Agent, or Firm* — Calfee, Halter & Griswold LLP

(87) PCT Pub. No.: **WO2015/180618**

PCT Pub. Date: **Dec. 3, 2015**

(65) **Prior Publication Data**

US 2017/0149116 A1 May 25, 2017

(57) **ABSTRACT**

(30) **Foreign Application Priority Data**

May 26, 2014 (CN) ..... 2014 2 0273632 U

An electronic device and an antenna of an electronic device are provided. The electronic device includes a metal shell, and the antenna includes: a radiating surface formed by metal shell and having a slot group penetrated therethrough in an up and down direction of the metal shell, the slot group including a plurality of slots; a medium filling layer including a body part disposed on a lower surface of the metal shell and a plurality of filling parts disposed on an upper surface of the body part and filled in the plurality of slots respectively; and an excitation sheet disposed on a lower surface of the medium filling layer.

(51) **Int. Cl.**

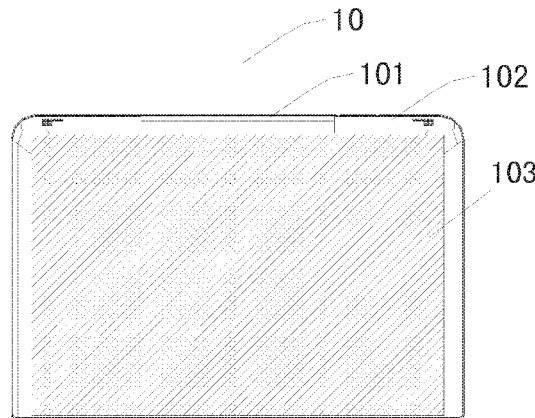
**H01Q 1/22** (2006.01)  
**H01Q 13/10** (2006.01)

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**10 Claims, 4 Drawing Sheets**

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

CPC ..... **H01Q 1/2266** (2013.01); **H01Q 1/42** (2013.01); **H01Q 13/10** (2013.01); **H01Q 1/243** (2013.01); **H01Q 21/30** (2013.01)





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

(10) **Patent No.:** **US 10,199,719 B2**  
(45) **Date of Patent:** **Feb. 5, 2019**

(54) **ANTENNA AND ELECTRONIC DEVICE HAVING THE SAME**

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

(72) Inventors: **Yeonwoo Kim**, Suwon-si (KR);  
**Seunggil Jeon**, Suwon-si (KR);  
**Jung-Sik Park**, 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 186 days.

(21) Appl. No.: **15/013,496**

(22) Filed: **Feb. 2, 2016**

(65) **Prior Publication Data**

US 2016/0226132 A1 Aug. 4, 2016

(30) **Foreign Application Priority Data**

Feb. 2, 2015 (KR) ..... 10-2015-0016266

(51) **Int. Cl.**

**H01Q 1/24** (2006.01)  
**H01Q 1/48** (2006.01)  
**H01Q 5/378** (2015.01)  
**H01Q 21/30** (2006.01)

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

CPC ..... **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/378** (2015.01); **H01Q 21/30** (2013.01)

(58) **Field of Classification Search**

CPC ..... H01Q 1/243; H01Q 5/378; H01Q 1/48; H01Q 21/30

See application file for complete search history.

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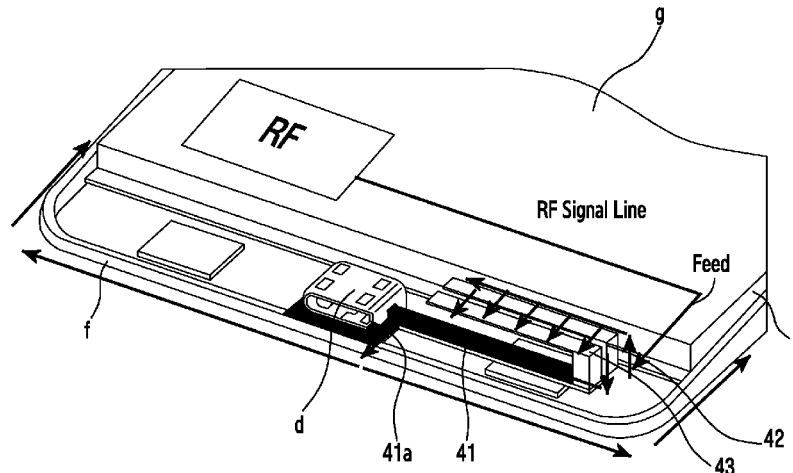
*Primary Examiner* — Graham Smith

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

(57) **ABSTRACT**

An antenna of an electronic device is provided. The antenna includes a substrate including a ground portion, an external metallic frame of the electronic device, a float ground portion arranged to be connected to the external metallic frame in a state of being disconnected from the substrate, and at least one radiator electrically connected to the float ground portion. Upon being fed with power, the at least one radiator may operate as an antenna radiator, or a section of the external metallic frame may operate as the antenna radiator.

**20 Claims, 43 Drawing Sheets**



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

(10) **Patent No.:** **US 10,205,221 B2**  
(45) **Date of Patent:** **Feb. 12, 2019**

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

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

(72) Inventors: **Szu-Chi Fan**, New Taipei (TW);  
**Yen-Hui Lin**, New Taipei (TW)

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

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 451 days.

(21) Appl. No.: **14/980,737**

(22) Filed: **Dec. 28, 2015**

(65) **Prior Publication Data**

US 2016/0352013 A1 Dec. 1, 2016

(30) **Foreign Application Priority Data**

May 29, 2015 (CN) ..... 2015 1 0285623

(51) **Int. Cl.**

**H01Q 5/10** (2015.01)  
**H01Q 1/24** (2006.01)  
**H01Q 9/04** (2006.01)  
**H01Q 13/10** (2006.01)  
**H01Q 5/371** (2015.01)

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

CPC ..... **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01); **H01Q 9/0421** (2013.01); **H01Q 13/10** (2013.01)

(58) **Field of Classification Search**

CPC ..... H01Q 5/10; H01Q 1/243; H01Q 1/38; H01Q 13/10; H01Q 5/371; H01Q 5/50; H01Q 9/0421

See application file for complete search history.

(56) **References Cited**

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*Primary Examiner* — Graham Smith

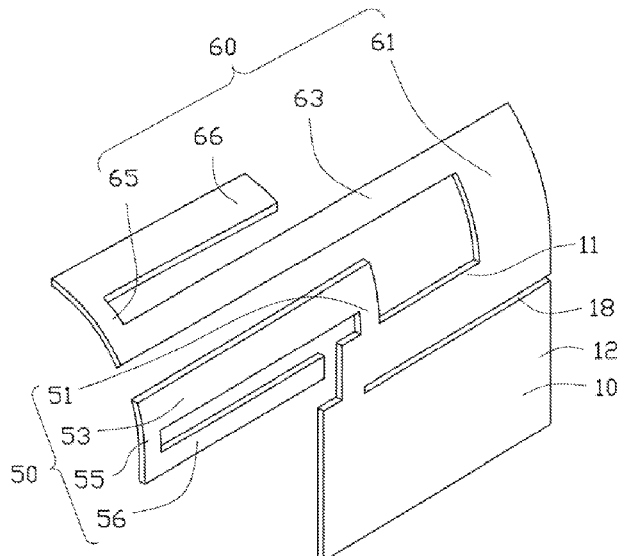
*Assistant Examiner* — Jae Kim

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

(57) **ABSTRACT**

A multiband antenna structure includes a matching portion, a first radiator, and a second radiator. The first radiator and the second radiator extend from a first edge of the matching portion. The second radiator and the matching portion resonate a first mode. The first radiator and the matching portion resonate a second mode. The slot, the first radiator, and the matching portion resonate a third mode. The second radiator includes a first connection section, a second connection section, a third connection section, and a fourth connection section. The first connection section is perpendicularly connected to a first end of the first edge. The second connection section is perpendicularly connected to the first connection section and extends parallel to the first edge. The third connection section is parallel to the first connection section. The fourth connection section is parallel to the second connection section.

**14 Claims, 8 Drawing Sheets**



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

(10) **Patent No.:** **US 10,205,223 B2**  
(45) **Date of Patent:** **Feb. 12, 2019**

(54) **COMMUNICATION DEVICE USING INTERNAL COMPONENTS OF DEVICE AS RADIO ANTENNA**

(58) **Field of Classification Search**  
CPC ..... H01Q 1/50; H01Q 1/243; H01Q 1/38  
USPC ..... 343/702  
See application file for complete search history.

(71) Applicant: **HON HAI PRECISION INDUSTRY CO., LTD.**, New Taipei (TW)

(56) **References Cited**

(72) Inventors: **Hao-Ying Chang**, New Taipei (TW);  
**Pai-Cheng Huang**, New Taipei (TW);  
**Chih-Yang Tsai**, New Taipei (TW);  
**Ching-Sung Wang**, New Taipei (TW)

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(73) Assignee: **HON HAI PRECISION INDUSTRY CO., LTD.**, New Taipei (TW)

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					343/702

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 183 days.

\* cited by examiner

(21) Appl. No.: **15/260,274**

*Primary Examiner* — Huedung Mancuso

(22) Filed: **Sep. 8, 2016**

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

(65) **Prior Publication Data**

US 2017/0194696 A1 Jul. 6, 2017

(57) **ABSTRACT**

(30) **Foreign Application Priority Data**

Dec. 31, 2015 (TW) ..... 104144804 A

A device communicating wirelessly using internal function components as antenna includes a case, and within the case a circuit board, a camera mechanism, and a wireless communication mechanism. The case includes an upper shell and a lower shell, the lower shell defining a slot is filled with an insulation strip. The camera mechanism and the wireless communication mechanism are arranged on the circuit board. The wireless communication mechanism faces the slot. The wireless communication mechanism and the camera mechanism cooperatively form an antenna. A wireless signal generated by the wireless communication mechanism is enhanced by the antenna and radiates outward from the slot.

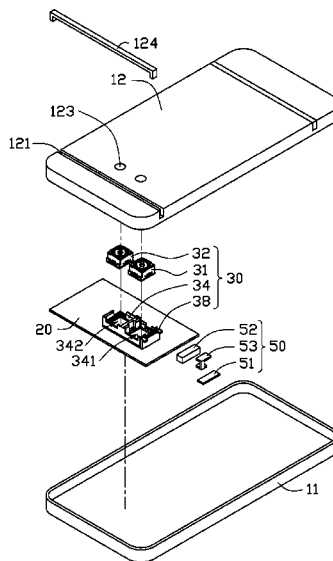
(51) **Int. Cl.**

<b>H01Q 1/24</b>	(2006.01)
<b>H01Q 1/38</b>	(2006.01)
<b>H01Q 1/50</b>	(2006.01)
<b>H04M 1/02</b>	(2006.01)
<b>H01Q 1/44</b>	(2006.01)

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

CPC ..... **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/44** (2013.01); **H01Q 1/50** (2013.01); **H04M 1/0264** (2013.01)

**12 Claims, 7 Drawing Sheets**





US010205224B2

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

(10) **Patent No.:** **US 10,205,224 B2**

(45) **Date of Patent:** **Feb. 12, 2019**

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

(58) **Field of Classification Search**  
CPC ..... H01Q 21/293; H01Q 1/2283; H01Q 1/242-1/243

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

See application file for complete search history.

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

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*Primary Examiner* — Ricardo I Magallanes

(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.;  
G. Victor Treyz; Joseph F. Guihan

(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 20 days.

(21) Appl. No.: **15/275,183**

(22) Filed: **Sep. 23, 2016**

(65) **Prior Publication Data**  
US 2018/0090816 A1 Mar. 29, 2018

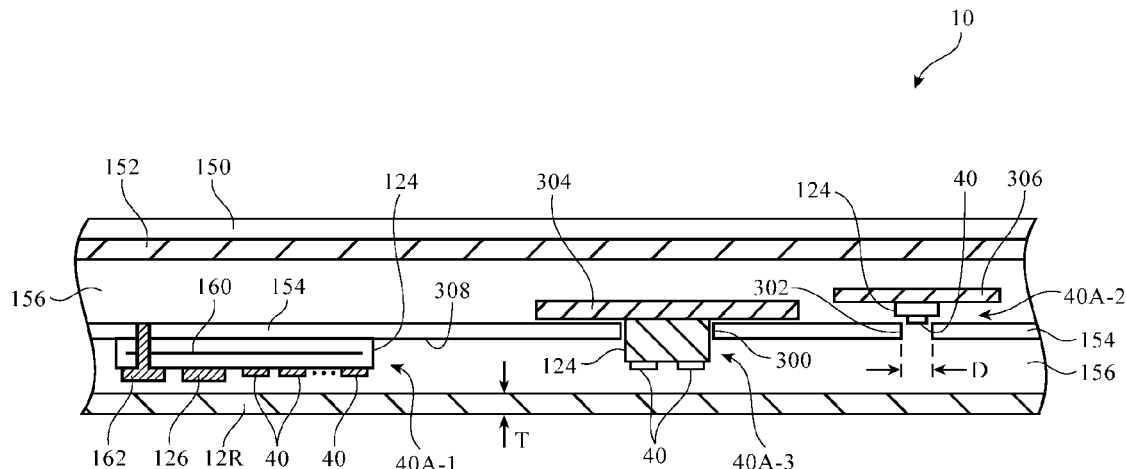
(51) **Int. Cl.**  
**H01Q 1/22** (2006.01)  
**H01Q 1/24** (2006.01)  
**H01Q 1/48** (2006.01)  
**H01Q 9/04** (2006.01)  
**H01Q 21/06** (2006.01)  
**H01Q 21/28** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 1/22** (2013.01); **H01Q 1/242** (2013.01); **H01Q 1/48** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 21/062** (2013.01); **H01Q 21/065** (2013.01); **H01Q 21/28** (2013.01); **H01Q 1/2283** (2013.01)

(57) **ABSTRACT**

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

**22 Claims, 8 Drawing Sheets**





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

(10) **Patent No.:** **US 10,205,230 B2**  
(45) **Date of Patent:** **Feb. 12, 2019**

(54) **ANTENNA SYSTEM COUPLED TO AN EXTERNAL DEVICE**

(71) Applicant: **Ethertronics, Inc.**, San Diego, CA (US)

(72) Inventors: **Laurent Desclos**, San Diego, CA (US); **Sebastian Rowson**, San Diego, CA (US); **Jeffrey Shamblin**, San Marcos, CA (US)

(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.: **15/677,996**

(22) Filed: **Aug. 15, 2017**

(65) **Prior Publication Data**  
US 2018/0026359 A1 Jan. 25, 2018

**Related U.S. Application Data**  
(63) Continuation of application No. 13/295,979, filed on Nov. 14, 2011, now abandoned.  
(60) Provisional application No. 61/412,473, filed on Nov. 11, 2010.

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 1/40** (2006.01)  
**H01Q 1/52** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/40** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/521** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/243; H01Q 1/521; H01Q 1/40  
See application file for complete search history.

(56) **References Cited**

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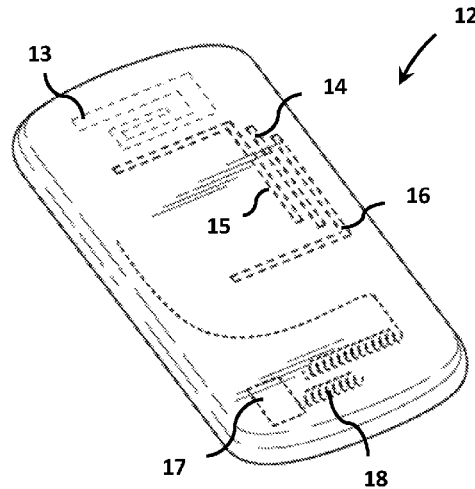
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*Primary Examiner* — Dieu H Duong  
(74) *Attorney, Agent, or Firm* — Dority & Manning, P.A.

(57) **ABSTRACT**

An antenna system is integrated into a cover or accessory and adapted to couple to an antenna in a host device to improve transmission and reception of signals. The antenna system can be passive or active, with the active antenna system designed to amplify coupled signals on the integrated antenna elements in the cover or accessory. Single or multiple frequency bands can be improved with the integrated antenna system, and multiple antennas in the host device can be coupled to and improved. The antenna system can couple to the existing antennas in the host device by capacitive coupling, i.e. no physical contact required, or a connector can be designed into the cover or accessory containing the integrated antenna system that makes contact to electrical ground of the host device or power supply signals or other control signals.

**18 Claims, 6 Drawing Sheets**





US010205232B2

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

(10) **Patent No.:** **US 10,205,232 B2**  
(45) **Date of Patent:** **Feb. 12, 2019**

(54) **MULTI-ANTENNA AND RADIO APPARATUS INCLUDING THEREOF**

(58) **Field of Classification Search**  
CPC .. H01Q 1/24; H01Q 1/48; H01Q 3/24; H01Q 1/52; H01Q 9/42; H01Q 21/28  
See application file for complete search history.

(71) Applicant: **ASAHI GLASS COMPANY, LIMITED**, Chiyoda-ku (JP)

(56) **References Cited**

(72) Inventors: **Toshiki Sayama**, Chiyoda-ku (JP); **Ryuta Sonoda**, Chiyoda-ku (JP); **Koji Ikawa**, Chiyoda-ku (JP)

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(73) Assignee: **AGC Inc.**, Chiyoda-ku (JP)

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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 0 days.

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

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**Related U.S. Application Data**

(63) Continuation of application No. PCT/JP2015/065315, filed on May 27, 2015.

*Primary Examiner* — Dieu H Duong  
(74) *Attorney, Agent, or Firm* — Oblon, McClelland, Maier & Neustadt, L.L.P.

**Foreign Application Priority Data**

(30) May 30, 2014 (JP) ..... 2014-113074

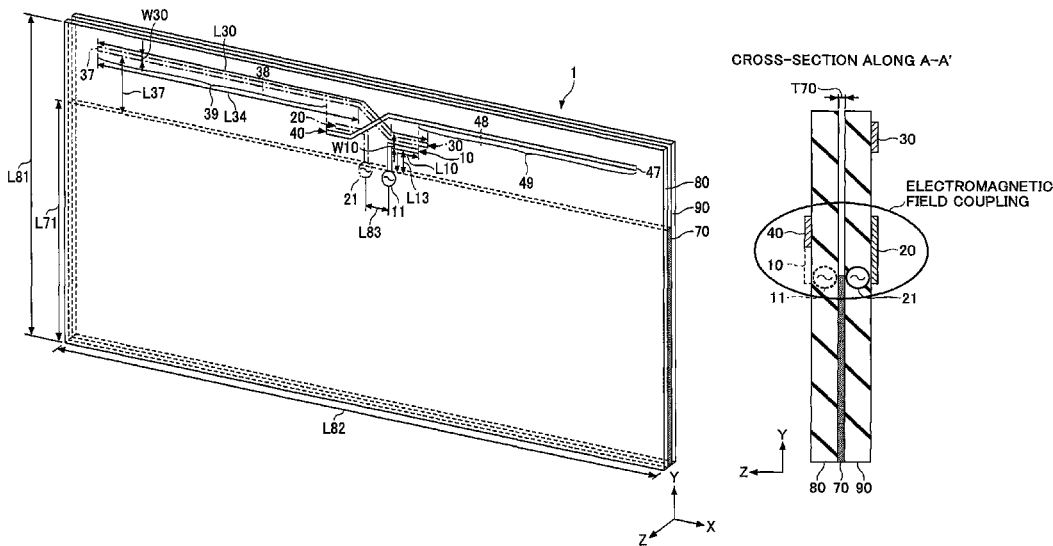
(57) **ABSTRACT**

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 1/52** (2006.01)  
(Continued)

A multi-antenna includes a ground plane; a first feeding point; a second feeding point that is different from the first feeding point; a first feed element that is connected to the first feeding point; a second feed element that is connected to the second feeding point, a cancellation electric current being generated in the second feed element; and a radiating element that functions as a radiation conductor when power is supplied by establishing electromagnetic field coupling with the first feed element and the second feed element.

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/52** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/523** (2013.01); **H01Q 3/24** (2013.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01)

**20 Claims, 22 Drawing Sheets**





US010205239B1

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

(10) **Patent No.:** **US 10,205,239 B1**  
(45) **Date of Patent:** **Feb. 12, 2019**

- (54) **COMPACT PIFA ANTENNA**
- (71) Applicant: **ENERGOUS CORPORATION**, San Jose, CA (US)
- (72) Inventors: **Harry Contopanagos**, Kifissia (GR); **Michael A. Leabman**, San Ramon, CA (US)
- (73) Assignee: **Energous Corporation**, San Jose, CA (US)
- (\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 108 days.

- (56) **References Cited**
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*Primary Examiner* — Alfonso Perez Borroto  
(74) *Attorney, Agent, or Firm* — Morgan, Lewis & Bockius LLP

**ABSTRACT**

(57) Various planar inverted-F antenna configurations may include an antenna element formed on the top of a PCB and a ground element formed on the bottom of the PCB. Two or more slots may be included in the antenna element for reducing the antenna area while maintaining a suitable impedance bandwidth. A slot may be included in the ground element for reducing the ground area while increasing radiation efficiency. A folded ground may be formed on the top of the PCB for reducing system area while maintaining suitable performance. By moving the folded ground closer to the antenna element and increasing the PCB thickness, significant reductions in system area may be achieved, while maintaining or improving performance in terms of radiation pattern, radiation efficiency and impedance bandwidth.

**20 Claims, 8 Drawing Sheets**

- (21) Appl. No.: **14/586,254**
- (22) Filed: **Dec. 30, 2014**

**Related U.S. Application Data**

- (63) Continuation-in-part of application No. 14/272,265, filed on May 7, 2014.

- (51) **Int. Cl.**  
**H01F 38/00** (2006.01)  
**H01Q 9/04** (2006.01)  
**H02J 17/00** (2006.01)  
**H01Q 1/48** (2006.01)  
**H02J 5/00** (2016.01)

- (52) **U.S. Cl.**  
CPC ..... **H01Q 9/0407** (2013.01); **H01Q 1/48** (2013.01); **H02J 5/005** (2013.01); **H02J 17/00** (2013.01)

- (58) **Field of Classification Search**  
CPC ..... H02J 5/005; H02J 17/00  
USPC ..... 307/107  
See application file for complete search history.

