



US009577301B2

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

(10) **Patent No.:** **US 9,577,301 B2**

(45) **Date of Patent:** **Feb. 21, 2017**

(54) **DIELECTRIC PHASE-SHIFT MODULE AND PHASE-SHIFT UNIT THEREOF, FEEDING NETWORK AND ANTENNA**

(58) **Field of Classification Search**

CPC H01Q 3/32; H01Q 1/50; H04B 1/18; H01P 1/184

(Continued)

(71) Applicant: **COMBA TELECOM SYSTEM (CHINA) LTD.**, Guangdong (CN)

(56) **References Cited**

(72) Inventors: **Ming Cao**, Guangzhou (CN); **Peitao Liu**, Guangzhou (CN); **Shanqiu Sun**, Guangzhou (CN)

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(73) Assignee: **COMBA TELECOM SYSTEM (CHINA) LTD.**, Guangzhou (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 18 days.

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(21) Appl. No.: **14/765,777**

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(22) PCT Filed: **Jan. 16, 2014**

(Continued)

(86) PCT No.: **PCT/CN2014/000046**

§ 371 (c)(1),

(2) Date: **Aug. 4, 2015**

Primary Examiner — Hoanganh Le

(74) *Attorney, Agent, or Firm* — Roy Gross; The Roy Gross Law Firm, L

(87) PCT Pub. No.: **WO2014/117635**

PCT Pub. Date: **Aug. 7, 2014**

(65) **Prior Publication Data**

US 2015/0372362 A1 Dec. 24, 2015

(30) **Foreign Application Priority Data**

Feb. 4, 2013 (CN) 2013 1 0043728

(51) **Int. Cl.**
H01Q 1/50 (2006.01)
H01P 1/18 (2006.01)

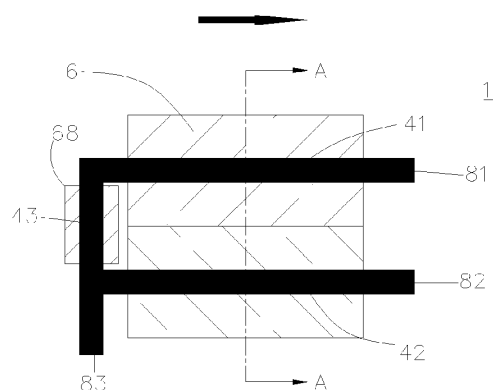
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(52) **U.S. Cl.**
CPC **H01P 1/184** (2013.01); **H01Q 1/50** (2013.01); **H01Q 3/32** (2013.01); **H04B 1/18** (2013.01)

(57) **ABSTRACT**

A feeding network is realized by dielectric phase shifting module. The module includes a dielectric device into which interlayer space is defined, a first conductor and a second conductor disposed side by side into the interlayer space and a third conductor located outside of the interlayer space and connected, at different locations, to one end, located at a same side, of each of the first and second conductors. Another end of the first conductor is defined as an input end, while another end of the second conductor and any end of the third conductor are all defined as output ends. The dielectric device is configured to slide along a longitudinal direction of the first and second conductors under external force so as to change phase of signals fed in from the input end and fed out from the output ends. Two dielectric phase-shift modules constitute a phase-shift unit thereof.

31 Claims, 6 Drawing Sheets





US009577316B2

(12) **United States Patent**
Jeong

(10) **Patent No.:** **US 9,577,316 B2**

(45) **Date of Patent:** **Feb. 21, 2017**

(54) **ANTENNA WITH A COMBINED
BANDPASS/BANDSTOP FILTER NETWORK**

(71) Applicant: **BlackBerry Limited**, Waterloo (CA)

(72) Inventor: **Seong Heon Jeong**, Irving, TX (US)

(73) Assignee: **BlackBerry Limited**, Waterloo, Ontario
(CA)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 98 days.

(21) Appl. No.: **13/931,036**

(22) Filed: **Jun. 28, 2013**

(65) **Prior Publication Data**

US 2015/0002347 A1 Jan. 1, 2015

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 9/30 (2006.01)

H01Q 5/321 (2015.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 5/321**
(2015.01); **H01Q 9/30** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/36

USPC 343/722, 746, 702

See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Dameon E Levi

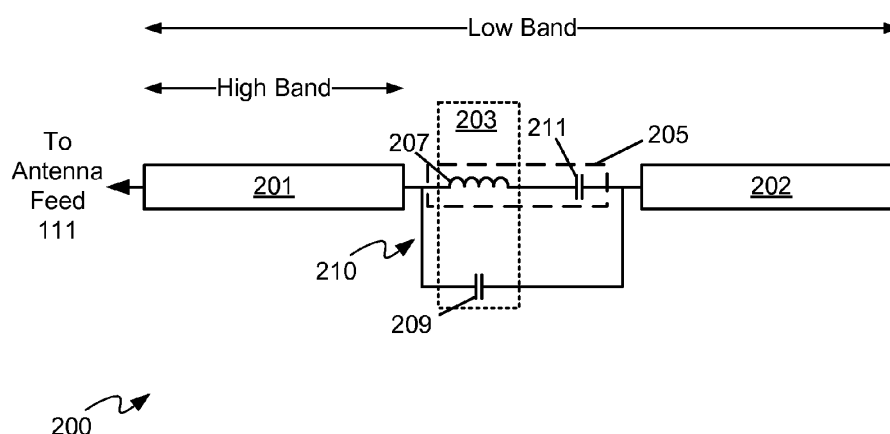
Assistant Examiner — Walter Davis

(74) *Attorney, Agent, or Firm* — Fish & Richardson P.C.

(57) **ABSTRACT**

An antenna with a combined bandpass/bandstop filter network is provided. The antenna includes: a first radiating arm connectable to an antenna feed, the first radiating arm configured to resonate at a first frequency; a second radiating arm, the second radiating arm and the first radiating arm, when electrically connected, configured to resonate at a second frequency lower than the first frequency; and, a filter network comprising a bandstop filter and a bandpass filter, the filter network filtering an electrical connection between the first radiating arm and the second radiating arm, the filter network configured to: electrically isolate the first radiating arm from the second radiating arm at the first frequency, and electrically connect the first radiating arm and the second radiating arm at the second frequency.

18 Claims, 16 Drawing Sheets





US009577318B2

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

(10) **Patent No.:** **US 9,577,318 B2**

(45) **Date of Patent:** **Feb. 21, 2017**

(54) **ELECTRONIC DEVICE WITH
FINGERPRINT SENSOR AND TUNABLE
HYBRID ANTENNA**

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

(72) Inventors: **Mattia Pascolini**, San Francisco, CA
(US); **Nanbo Jin**, Milpitas, 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 193 days.

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343/700 MS

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(22) Filed: **Aug. 19, 2014**

(Continued)

(65) **Prior Publication Data**

US 2016/0056527 A1 Feb. 25, 2016

Primary Examiner — Tho G Phan

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

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

G06K 9/00 (2006.01)

H01Q 13/10 (2006.01)

G06F 21/32 (2013.01)

H01Q 9/42 (2006.01)

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

CPC **H01Q 1/243** (2013.01); **G06F 21/32**
(2013.01); **G06K 9/00006** (2013.01); **H01Q**
9/42 (2013.01); **H01Q 13/10** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 13/10; H01Q 1/243; H01Q 9/42
USPC 343/700 MS, 702, 725, 729, 767,
846,343/876

See application file for complete search history.

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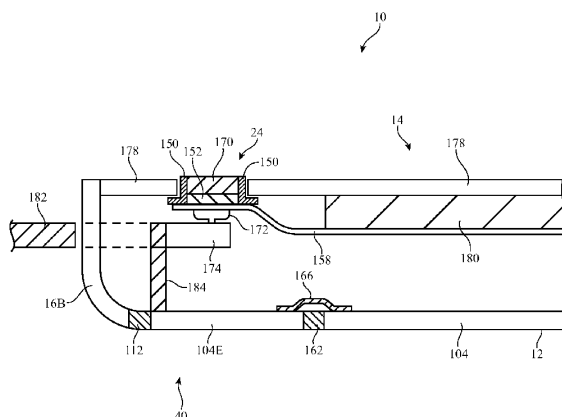
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(57)

ABSTRACT

An electronic device may have wireless circuitry and components such as sensors. The electronic device may have a metal housing having first and second planar rear wall portions separated by a gap. Conductive structures may bridge the gap to electrically couple the first and second rear wall portions. The wireless circuitry may include a hybrid slot inverted-F antenna. The antenna may have an inverted-F antenna resonating element formed from peripheral housing structures that are separated from the second rear wall portion by an opening. The opening may form a C-shaped slot antenna resonating element for the antenna. The sensors may include a fingerprint sensor. The fingerprint sensor may be coupled to a button member in a button. The fingerprint sensor and other portions of the button may overlap the second planar rear wall portion to minimize interference with antenna operation.

22 Claims, 12 Drawing Sheets





(10) **Patent No.:** US 9,577,320 B2
(45) **Date of Patent:** Feb. 21, 2017

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

- (56) **References Cited**
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343/700 MS |

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- Primary Examiner — Robert Karacsony
(74) Attorney, Agent, or Firm — Zhigang Ma

- (57) **ABSTRACT**

- An antenna assembly includes an elastic piece, a connecting portion, a first radiating portion, and a second radiating portion. The connecting portion is coupled to the base board and includes a feeding point and a ground point. The first radiating portion is electrically connected to the feeding point and the elastic piece. The second radiating portion is electrically connected to the ground point and spaced from the first radiating portion. The first radiating portion, the elastic piece, and the second radiating portion are configured to operate at a first frequency band; the first radiating portion and the elastic piece generate a frequency-doubled effect to operate at a second frequency band. A wireless communication device employing the antenna assembly is also provided.

- 20 Claims, 4 Drawing Sheets**

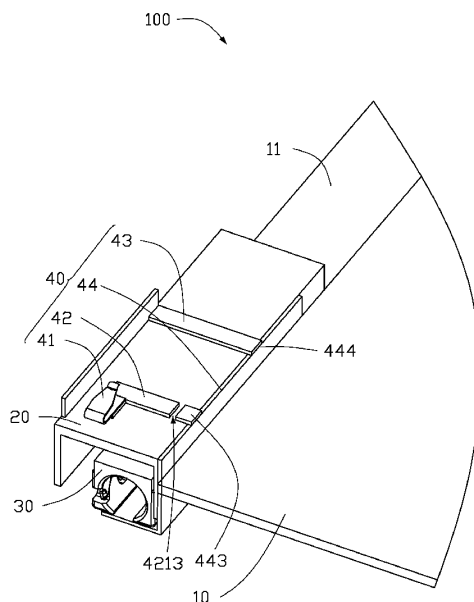
- US 2016/0126620 A1 May 5, 2016

- (30) **Foreign Application Priority Data**

- Oct. 31, 2014 (CN) 2014 1 0600735

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

- (52) U.S. Cl.
CPC *H01Q 1/243* (2013.01); *H01Q 1/2291*
(2013.01)





US009577321B2

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

(10) **Patent No.:** **US 9,577,321 B2**
(45) **Date of Patent:** **Feb. 21, 2017**

(54) **DUALBAND ANTENNA WITH ISOLATION
ENHANCED AND METHOD THEREOF**

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

(71) Applicant: **REALTEK SEMICONDUCTOR
CORP.**, Hsinchu (TW)

(56) **References Cited**

U.S. PATENT DOCUMENTS

(72) Inventors: **Sy Been Wang**, Chu Pei (TW); **Ching
Wei Ling**, Chu Pei (TW); **Chih Pao
Lin**, Chu Pei (TW)

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				455/550.1

(73) Assignee: **REALTEK SEMICONDUCTOR
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 70 days.

FOREIGN PATENT DOCUMENTS

(21) Appl. No.: **14/724,199**

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TW	I323528 B	4/2010

(22) Filed: **May 28, 2015**

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(65) **Prior Publication Data**

US 2016/0190700 A1 Jun. 30, 2016

Primary Examiner — Brian Young

(74) *Attorney, Agent, or Firm* — Muncy, Geissler, Olds &
Lowe PC

(30) **Foreign Application Priority Data**

Dec. 26, 2014 (TW) 103145730 A

(57) **ABSTRACT**

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 1/52 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/371 (2015.01)

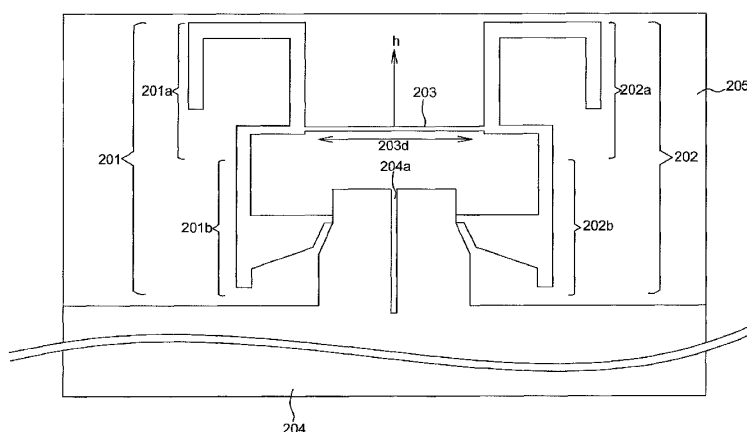
An antenna set includes a first antenna, a second antenna, and a neutralized line. Each of the first antenna and the second antenna has a low frequency resonant path and a high frequency resonant path. The neutralized line is couple to the low frequency resonant path of the first antenna and the low frequency resonant path of the second antenna. The low frequency resonant path of the first antenna and the low frequency resonant path of the second antenna correspond to a first frequency band, the high frequency resonant path of the first antenna and the high frequency resonant path of the second antenna correspond to a second frequency band, and the two low frequency resonant paths do not overlap the two high frequency resonant paths.

(52) **U.S. Cl.**
CPC **H01Q 1/38** (2013.01); **H01Q 1/521**
(2013.01); **H01Q 5/371** (2015.01); **H01Q 9/42**
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 5/371; H01Q 1/521;
H01Q 9/42

12 Claims, 8 Drawing Sheets

200





US009577331B2

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

(10) **Patent No.:** **US 9,577,331 B2**
(45) **Date of Patent:** **Feb. 21, 2017**

(54) **WIRELESS COMMUNICATION DEVICE**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

(72) Inventors: **Kuan-Hsueh Tseng**, Hsinchu (TW);
Chung-Hsuan Chen, Hsinchu (TW)

(73) Assignee: **Wistron NeWeb Corporation**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 84 days.

(21) Appl. No.: **14/700,168**

(22) Filed: **Apr. 30, 2015**

(65) **Prior Publication Data**

US 2016/0049719 A1 Feb. 18, 2016

(30) **Foreign Application Priority Data**

Aug. 15, 2014 (TW) 103214641 U

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/371 (2015.01)
H01Q 9/42 (2006.01)
H01Q 21/28 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/371** (2015.01); **H01Q 1/243** (2013.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 13/106; H01Q 1/24; H01Q 1/243; H01Q 21/28; H01Q 5/10; H01Q 5/371; H01Q 9/42
USPC 343/705, 700 MS, 702, 829, 846, 848
See application file for complete search history.

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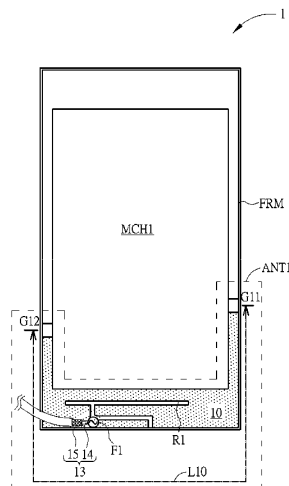
Primary Examiner — Tho G. Phan

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

(57) **ABSTRACT**

A wireless communication device includes a metal frame, a mechanical part on which a ground is formed for providing grounding, and at least one antenna, wherein each one of the at least one antenna includes a radiator, a feed terminal electrically connected to the radiator, disposed adjacent to the metal frame and for feeding a radio-frequency signal, a first ground terminal disposed at a first side of the feed terminal for electrically connecting the metal frame with the ground of the mechanical part, and a second ground terminal disposed at a second side of the feed terminal for electrically connecting the metal frame with the ground of the mechanical part, wherein an area enclosed by the metal frame, the mechanical part and the first and second ground terminals forms a first slot.

14 Claims, 6 Drawing Sheets





US009577332B2

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

(10) **Patent No.:** **US 9,577,332 B2**
(45) **Date of Patent:** **Feb. 21, 2017**

(54) **ELECTRONIC DEVICE AND MULTI-BAND ANTENNA**

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

(72) Inventors: **Wei-Yu Chen**, New Taipei (TW);
Yueh-Chu Lin, New Taipei (TW)

(73) Assignee: **HON HAI PRECISION INDUSTRY CO., LTD.**, 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.: **14/797,831**

(22) Filed: **Jul. 13, 2015**

(65) **Prior Publication Data**

US 2016/0352014 A1 Dec. 1, 2016

(30) **Foreign Application Priority Data**

May 27, 2015 (CN) 2015 1 0276463

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 5/50 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 5/50** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 7/00; H01Q 1/2208; H01Q 21/28;
H01Q 1/2216; H01Q 5/371; H01Q 5/328;
H01Q 1/243

See application file for complete search history.

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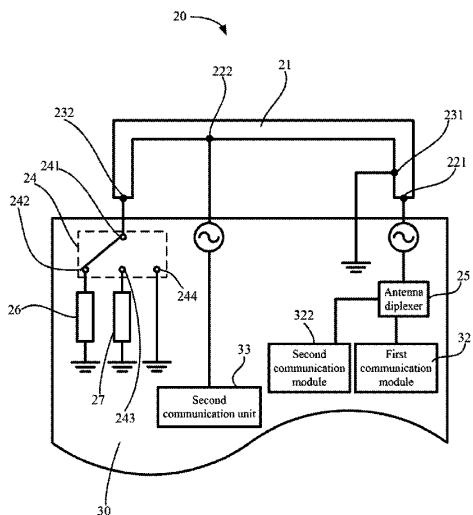
Primary Examiner — Linh Nguyen

(74) Attorney, Agent, or Firm — Zhigang Ma

(57) **ABSTRACT**

An electronic device has a multi-band antenna which includes an antenna frame and multiple feed points and multiple ground points located on the antenna frame. The multiple feed points include a first feed point located at one end portion of the antenna frame and a second feed point located between two end portions of the antenna frame. The multiple ground points include a first ground point located between the two end portions of the antenna frame and a second ground point located at the other end portion of the antenna frame. The multiple feed points and the multiple ground points are alternately located on the antenna frame, and multiple radiating elements are formed on the antenna frame and are configured to radiate signals having different frequency bands. Each radiating element is formed between a feed point and a ground point.

18 Claims, 3 Drawing Sheets





US009577333B2

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

(10) **Patent No.:** **US 9,577,333 B2**
(45) **Date of Patent:** **Feb. 21, 2017**

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

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

(72) Inventors: **Yen-Jung Tseng**, New Taipei (TW);
Yi-Ting Chen, New Taipei (TW);
Cho-Kang Hsu, 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 114 days.

(21) Appl. No.: **14/584,900**

(22) Filed: **Dec. 29, 2014**

(65) **Prior Publication Data**
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(30) **Foreign Application Priority Data**
Sep. 19, 2014 (CN) 2014 1 0480631

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 7/00 (2006.01)
H01Q 1/48 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 7/00** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/243; H01Q 1/48; H01Q 7/00
USPC 343/702, 866
See application file for complete search history.

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Primary Examiner — Hoang V Nguyen

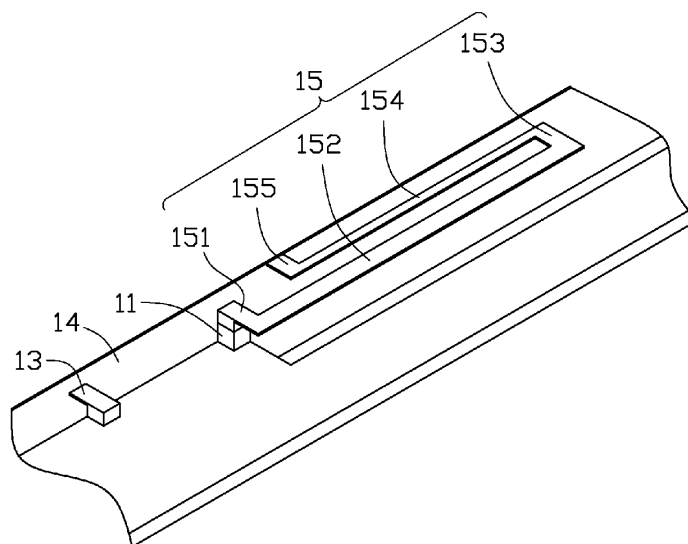
(74) *Attorney, Agent, or Firm* — Zhigang Ma

(57) **ABSTRACT**

An antenna structure includes a feed portion, a ground portion, at least one metallic portion, and a radiating portion. The ground portion is spaced apart from the feed portion. The least one metallic portion is electrically connected to the ground portion. The radiating portion has a first end electrically connected to the feed portion and a second end electrically connected to the at least one metallic portion.

17 Claims, 4 Drawing Sheets

10





US009577336B2

(12) **United States Patent**
Ying

(10) **Patent No.:** **US 9,577,336 B2**

(45) **Date of Patent:** **Feb. 21, 2017**

(54) **INVERTED-F ANTENNA WITH A CHOKE NOTCH FOR WIRELESS ELECTRONIC DEVICES**

USPC 343/700 MS, 702, 829, 846
See application file for complete search history.

(71) Applicant: **Sony Corporation**, Tokyo (JP)

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

(73) Assignees: **Sony Corporation**, Tokyo (JP); **Sony Mobile Communications Inc.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 273 days.

(21) Appl. No.: **14/529,397**

(22) Filed: **Oct. 31, 2014**

(65) **Prior Publication Data**

US 2016/0126632 A1 May 5, 2016

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 9/04 (2006.01)

H01Q 1/48 (2006.01)

H01Q 9/28 (2006.01)

H01Q 9/42 (2006.01)

H01Q 1/52 (2006.01)

H01Q 21/08 (2006.01)

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

CPC **H01Q 9/045** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 9/285** (2013.01); **H01Q 9/42** (2013.01); **H01Q 1/523** (2013.01); **H01Q 21/08** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/38; H01Q 9/44; H01Q 1/48; H01Q 1/243; H01Q 9/045; H01Q 9/285; H01Q 1/523; H01Q 21/08; H01Q 9/42

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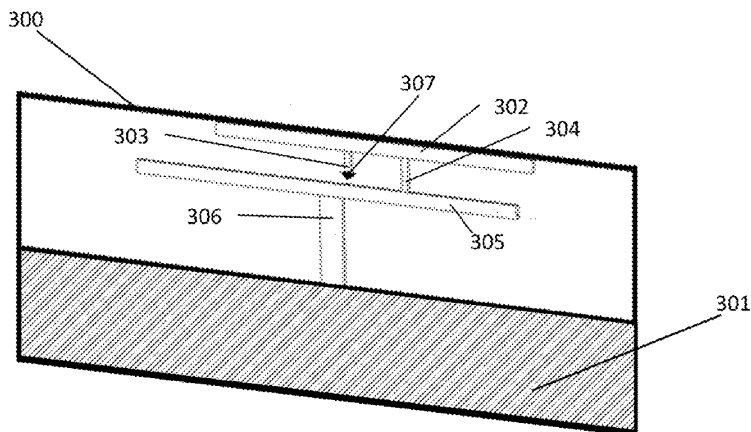
Primary Examiner — Tho G Phan

(74) *Attorney, Agent, or Firm* — Myers Bigel, P.A.

(57) **ABSTRACT**

A wireless electronic device includes an inverted-F antenna (IFA) having an IFA exciting element, an IFA feed, and a grounding pin. The IFA exciting element is configured to resonate at a resonant frequency when excited by a signal received through the IFA feed. The wireless electronic device includes a choke notch having a length defined based on the resonant frequency of the IFA exciting element. The choke notch is electrically coupled to the IFA exciting element through the grounding pin. A ground patch is electrically coupled between the choke notch and the ground plane.

16 Claims, 10 Drawing Sheets





US009577338B2

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

(10) **Patent No.:** **US 9,577,338 B2**
(45) **Date of Patent:** **Feb. 21, 2017**

(54) **ANTENNA FOR ACHIEVING EFFECTS OF MIMO ANTENNA**

(71) Applicants: **Chun-Jui Pan**, New Taipei (TW);
Sheng-Hsiung Yang, New Taipei (TW);
Wen-Chieh Tsai, New Taipei (TW)

(72) Inventors: **Chun-Jui Pan**, New Taipei (TW);
Sheng-Hsiung Yang, New Taipei (TW);
Wen-Chieh Tsai, New Taipei (TW)

(73) Assignee: **HON HAI PRECISION INDUSTRY CO., LTD.**, 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 533 days.

(21) Appl. No.: **13/656,753**

(22) Filed: **Oct. 22, 2012**

(65) **Prior Publication Data**

US 2013/0106670 A1 May 2, 2013

(30) **Foreign Application Priority Data**

Oct. 28, 2011 (TW) 100139312 A

(51) **Int. Cl.**
H01Q 9/42 (2006.01)
H01Q 1/50 (2006.01)
H01Q 5/378 (2015.01)
H01Q 5/35 (2015.01)
H01Q 1/38 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/42** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/50** (2013.01); **H01Q 5/35** (2015.01); **H01Q 5/378** (2015.01)

(58) **Field of Classification Search**

CPC H01Q 5/35; H01Q 5/378
See application file for complete search history.

(56) **References Cited**

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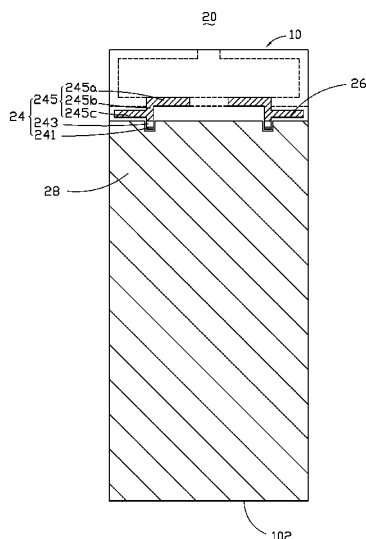
Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — Zhigang Ma

(57) **ABSTRACT**

An antenna disposed on a substrate includes a radiating portion, a first coupling and feeding portion, and a second coupling and feeding portion. A length of the radiating portion is substantially equal to a half wavelength of electromagnetic signals radiated by the radiating portion. Each coupling and feeding portion includes a feeding part and a coupling part. The feeding part feeds the electromagnetic signals to the radiating portion via the coupling part so as to achieve effects of a multiple-input multiple-output (MIMO) antenna. A gap is defined between the coupling part and the radiating portion to improve an isolation of the MIMO antenna.

11 Claims, 29 Drawing Sheets





US009583824B2

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

(10) **Patent No.:** **US 9,583,824 B2**

(45) **Date of Patent:** **Feb. 28, 2017**

(54) **MULTI-BAND WIRELESS TERMINALS WITH A HYBRID ANTENNA ALONG AN END PORTION, AND RELATED MULTI-BAND ANTENNA SYSTEMS**

H01Q 9/30; H01Q 9/42; H01Q 1/241;
H01Q 1/243; H01Q 1/52; H01Q 1/521;
H01Q 5/307; H01Q 5/342; H01Q 21/28;
H01Q 25/00

(75) Inventors: **Shuai Zhang**, Stockholm (SE);
Zhinong Ying, Lund (SE)

(Continued)

(73) Assignees: **Sony Corporation**, Tokyo (JP); **Sony Mobile Communications Inc.**, Tokyo (JP)

(56) **References Cited**

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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 66 days.

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(21) Appl. No.: **13/419,961**

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(22) Filed: **Mar. 14, 2012**

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(65) **Prior Publication Data**

US 2013/0076580 A1 Mar. 28, 2013

Related U.S. Application Data

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(63) Continuation-in-part of application No. 13/247,358, filed on Sep. 28, 2011.

Primary Examiner — Sue A Purvis

Assistant Examiner — Patrick Holecsek

(74) *Attorney, Agent, or Firm* — Myers Bigel, P.A.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 21/28 (2006.01)
H01Q 1/52 (2006.01)

(Continued)

(57) **ABSTRACT**

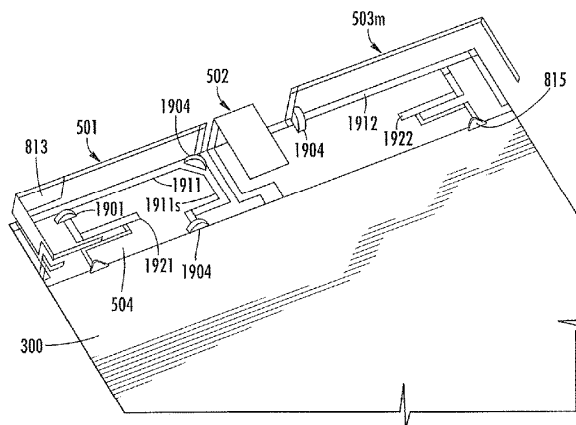
An antenna system may include a backplate that includes an end portion. The antenna system may also include a hybrid antenna that includes first and second antenna elements spaced apart from each other along the end portion of the backplate. The first antenna element may include a type of antenna element that is structurally different from the second antenna element. Additionally, the antenna system may further include a parasitic element between the first and second antenna elements along the end portion of the backplate.

(52) **U.S. Cl.**
CPC **H01Q 1/521** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/364** (2015.01);

(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/50; H01Q 5/25; H01Q 5/314;
H01Q 5/328; H01Q 5/335; H01Q 5/50;

20 Claims, 35 Drawing Sheets





US009583825B2

(12) **United States Patent**
Jung

(10) **Patent No.:** **US 9,583,825 B2**

(45) **Date of Patent:** **Feb. 28, 2017**

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

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

(72) Inventor: **Young-Hwan Jung**, 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 147 days.

(21) Appl. No.: **14/445,762**

(22) Filed: **Jul. 29, 2014**

(65) **Prior Publication Data**

US 2015/0042528 A1 Feb. 12, 2015

(30) **Foreign Application Priority Data**

Aug. 6, 2013 (KR) 10-2013-0093151

(51) **Int. Cl.**

H01Q 1/00 (2006.01)

H01Q 1/52 (2006.01)

H01Q 1/24 (2006.01)

H01Q 1/44 (2006.01)

H01Q 9/04 (2006.01)

H01Q 7/00 (2006.01)

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

CPC **H01Q 1/523** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 1/44** (2013.01); **H01Q**
9/0407 (2013.01); **H01Q 7/00** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/0407; H01Q 1/243; H01Q 1/526
USPC 343/787, 841
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Dameon E Levi

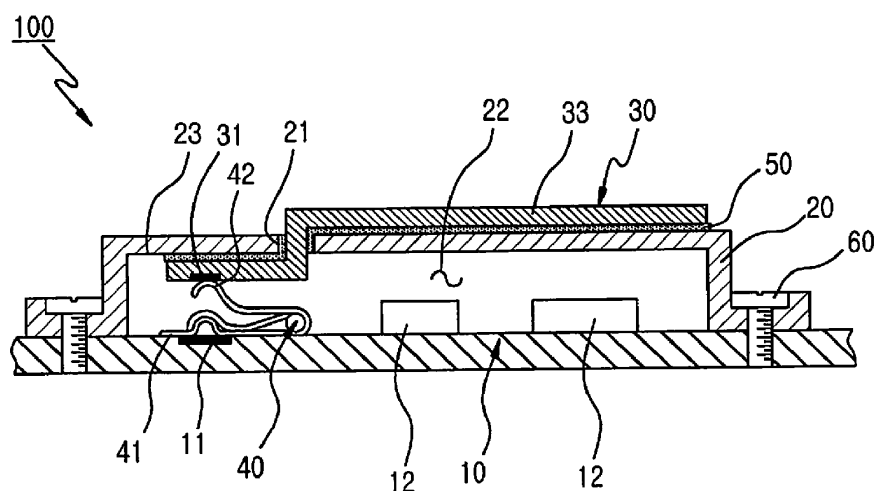
Assistant Examiner — Hasan Islam

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

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a printed circuit board (PCB), a shield can disposed on the PCB, an antenna radiator of which at least a part enters an internal space of the shield can and is installed at an inner surface of the shield can, and an electrical connecting means which is installed at a corresponding position of the PCB so as to be electrically connected with the at least a part of the antenna radiator installed at the inner surface of the shield can.

16 Claims, 9 Drawing Sheets





US009583826B2

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

(10) **Patent No.:** **US 9,583,826 B2**

(45) **Date of Patent:** **Feb. 28, 2017**

(54) **RESONANCE CIRCUIT FOR INHIBITING
INTERFERENCE BETWEEN HIGH-SPEED
CONNECTOR AND ANTENNA**

(71) Applicant: **Alpha Networks Inc.**, Hsinchu (TW)

(72) Inventors: **Fu-Chi Chuang**, Hsinchu (TW);
Yu-Cheng Huang, Hsinchu (TW)

(73) Assignee: **ALPHA NETWORKS INC.**, Hsinchu
(TW)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 243 days.

(21) Appl. No.: **14/309,254**

(22) Filed: **Jun. 19, 2014**

(65) **Prior Publication Data**

US 2015/0214614 A1 Jul. 30, 2015

(30) **Foreign Application Priority Data**

Jan. 27, 2014 (TW) 103102923 A

(51) **Int. Cl.**
H01Q 1/52 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/526** (2013.01); **H01Q 1/2275**
(2013.01); **H01Q 1/243** (2013.01); **H01Q 9/42**
(2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/526; H01Q 1/2275
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Dameon E Levi

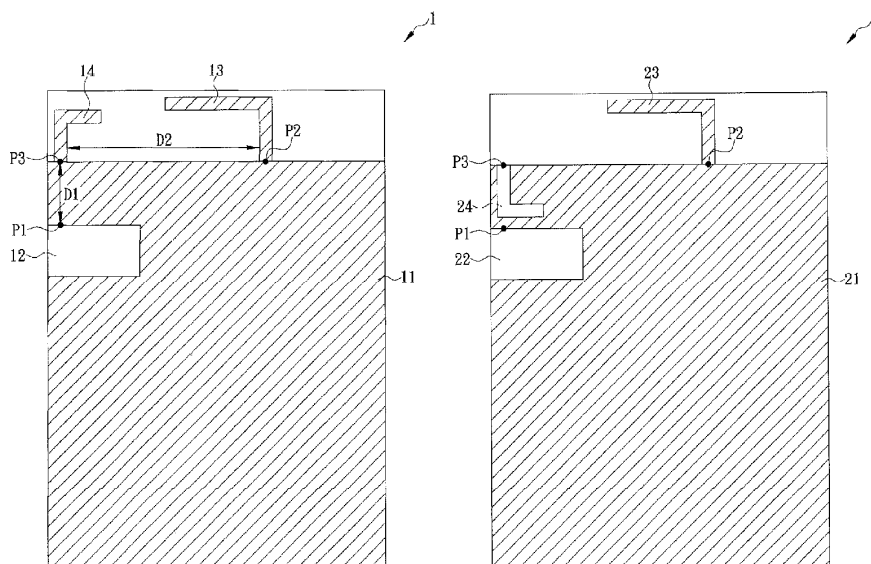
Assistant Examiner — Amal Patel

(74) *Attorney, Agent, or Firm* — Bacon & Thomas, PLLC

(57) **ABSTRACT**

The present invention is to provide a resonance circuit, which is applicable to a circuit board of a first electronic device provided thereon with a circuit layout, a high-speed connector (e.g., a USB 3.0 connector) at a lateral side of the circuit layout for connecting with a second electronic device, and an antenna for enabling the circuit board to receive and transmit wireless information at a predetermined frequency. The connector and antenna are respectively connected to first and second connecting points of the circuit layout, and the distance between the two connecting points is not less than one wavelength. The resonance circuit is connected to a third connecting point of the circuit layout provided between the above two connecting points, such that the resonance frequency of the resonance circuit covers the reception and transmission frequencies of the antenna, for effectively inhibiting interference between the connector and the antenna.

12 Claims, 3 Drawing Sheets





US009583835B2

(12) **United States Patent**
Lin

(10) **Patent No.:** **US 9,583,835 B2**

(45) **Date of Patent:** **Feb. 28, 2017**

(54) **MULTIBAND ANTENNA AND WIRELESS COMMUNICATION DEVICE EMPLOYING SAME**

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

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

(56) **References Cited**

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(72) Inventor: **Yen-Hui Lin**, New Taipei (TW)

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(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 215 days.

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(21) Appl. No.: **14/011,912**

2012/0001815 A1 * 1/2012 Wong H01Q 1/243

(22) Filed: **Aug. 28, 2013**

343/749

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(65) **Prior Publication Data**

US 2014/0111381 A1 Apr. 24, 2014

Primary Examiner — Sue A Purvis

Assistant Examiner — Patrick Holecek

(30) **Foreign Application Priority Data**

Oct. 19, 2012 (TW) 101138631 A

(74) *Attorney, Agent, or Firm* — Zhigang Ma

(57) **ABSTRACT**

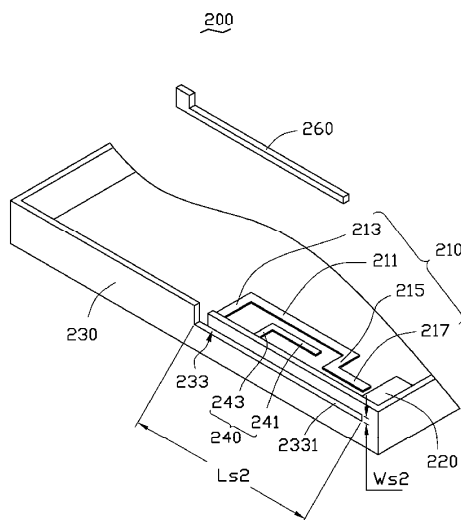
(51) **Int. Cl.**
H01Q 5/00 (2015.01)
H01Q 9/04 (2006.01)
H01Q 5/357 (2015.01)
H01Q 5/378 (2015.01)

A multiband antenna includes a radiating portion, a grounding portion, a metal member, and a resonating portion. The radiating portion receives feed signals. The grounding portion is grounded. The metal member connects to the radiating portion and the grounding portion, and defines a slit that is adjacent to the radiating portion and the grounding portion. The resonating portion is positioned in an area surrounded by the radiating portion, the grounding portion, and the metal member. The resonating portion resonates with the radiating portion and the metal member to enable the multiband antenna to receive and send wireless signals at different frequencies.

(52) **U.S. Cl.**
CPC **H01Q 9/04** (2013.01); **H01Q 5/357** (2015.01); **H01Q 5/378** (2015.01); **H01Q 9/0407** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/378; H01Q 5/385; H01Q 1/24; H01Q 1/241; H01Q 5/392; H01Q 5/40; H01Q 9/04; H01Q 9/0407

17 Claims, 7 Drawing Sheets





US00958383B2

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

(10) **Patent No.:** **US 9,583,838 B2**
(45) **Date of Patent:** **Feb. 28, 2017**

(54) **ELECTRONIC DEVICE WITH INDIRECTLY FED SLOT ANTENNAS**

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

(72) Inventors: **Jiang Zhu**, Sunnyvale, CA (US); **Harish Rajagopalan**, Cupertino, CA (US); **Rodney A. Gomez Angulo**, Sunnyvale, CA (US); **Qingxiang Li**, Mountain View, CA (US); **Robert W. Schlub**, Cupertino, CA (US); **John Raff**, Menlo Park, CA (US)

(73) Assignee: **Apple Inc.**, Cupertino, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 99 days.

(21) Appl. No.: **14/220,467**

(22) Filed: **Mar. 20, 2014**

(65) **Prior Publication Data**

US 2015/0270618 A1 Sep. 24, 2015

(51) **Int. Cl.**

H01Q 13/10 (2006.01)

H01Q 1/24 (2006.01)

H01Q 1/22 (2006.01)

H01Q 5/40 (2015.01)

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

CPC **H01Q 13/10** (2013.01); **H01Q 1/2258** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/40** (2015.01); **H01Q 13/103** (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 5/328
USPC 343/700 MS, 702, 725, 729, 767, 789; 455/41.1, 41.2

See application file for complete search history.

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Primary Examiner — Dameon E Levi

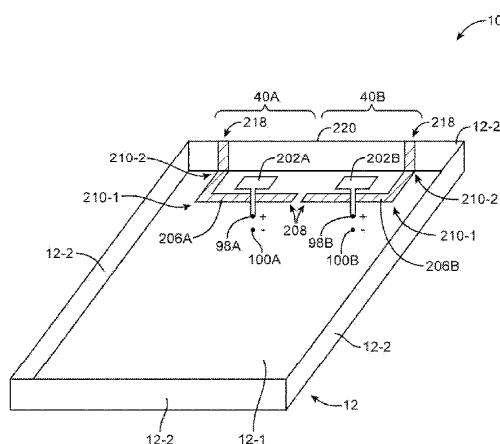
Assistant Examiner — Ab Salam Alkassim, Jr.

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

(57) **ABSTRACT**

An electronic device may be provided with antennas. Antennas for the electronic device may be formed from slot antenna structures. A slot antenna structure may be formed from portions of a metal housing for an electronic device. The slots of the slot antenna structures may be indirectly fed to form first and second indirectly fed slot antennas. The first and second indirectly fed slot antennas may be formed from slots in a rear surface of an electronic device and a sidewall of the electronic device. The slots may have open ends along an edge of the sidewall and may have closed ends that face each other. A hybrid antenna may also be formed in the electronic device.

18 Claims, 12 Drawing Sheets





US009590290B2

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

(10) **Patent No.:** **US 9,590,290 B2**
(45) **Date of Patent:** **Mar. 7, 2017**

(54) **MULTIPLE BAND CHASSIS ANTENNA**

(2013.01); **H01Q 9/42** (2013.01); **H01Q 13/10**
(2013.01); **H01Q 21/30** (2013.01)

(71) Applicants: **Matti Martiskainen**, Tiberias (IL);
Vitali Spector, Tiberias (IL)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/24
USPC 343/702
See application file for complete search history.

(72) Inventors: **Matti Martiskainen**, Tiberias (IL);
Vitali Spector, Tiberias (IL)

(56) **References Cited**

(73) Assignee: **GALTRONICS CORPORATION,**
LTD, Tiberias (IL)

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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.: **14/601,758**

(22) Filed: **Jan. 21, 2015**

(65) **Prior Publication Data**

US 2015/0207209 A1 Jul. 23, 2015

Related U.S. Application Data

(60) Provisional application No. 61/954,685, filed on Mar. 18, 2014, provisional application No. 61/944,638, filed on Feb. 26, 2014, provisional application No. 61/930,029, filed on Jan. 22, 2014, provisional application No. 61/971,650, filed on Mar. 28, 2014.

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(Continued)

Primary Examiner — Graham Smith

(74) *Attorney, Agent, or Firm* — Ingrassia Fisher & Lorenz, P.C.

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 5/371	(2015.01)
H01Q 21/30	(2006.01)
H01Q 7/00	(2006.01)
H01Q 5/307	(2015.01)
H01Q 13/10	(2006.01)
H01Q 9/42	(2006.01)

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

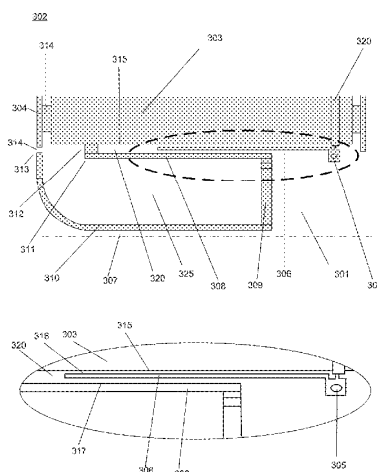
CPC **H01Q 1/243** (2013.01); **H01Q 5/307**
(2015.01); **H01Q 5/371** (2015.01); **H01Q 7/00**

(57)

ABSTRACT

A wireless device including a conductive chassis and a conductive coupling element is provided. The conductive coupling element may be connected to the conductive chassis and may cooperate with the conductive chassis to form a slit. An elongate feed element may be disposed within the slit. The coupling element may be configured to activate at least a portion of the conductive chassis to enable the chassis to operate as an antenna.

20 Claims, 12 Drawing Sheets





US009590291B2

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

(10) **Patent No.:** **US 9,590,291 B2**
(45) **Date of Patent:** **Mar. 7, 2017**

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

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

(72) Inventors: **Kyung-Jong Lee**, Gyeonggi-do (KR);
Se-Woong Kim, Gyeongsangnam-do (KR); **Jung-Ho Park**, Gyeonggi-do (KR); **Kyung-Jae Lee**, Seoul (KR);
Soo-Young Jang, Daegu (KR); **Austin Kim**, Gyeonggi-do (KR); **Seung-Hwan Kim**, Seoul (KR); **Joon-Ho Byun**, 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.

(21) Appl. No.: **14/831,355**

(22) Filed: **Aug. 20, 2015**

(65) **Prior Publication Data**
US 2016/0056531 A1 Feb. 25, 2016

(30) **Foreign Application Priority Data**
Aug. 21, 2014 (KR) 10-2014-0109086

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
H01Q 19/10 (2006.01)
H01Q 7/00 (2006.01)
H01Q 21/30 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 7/00** (2013.01); **H01Q 9/42** (2013.01); **H01Q 19/10** (2013.01); **H01Q 21/30** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 19/10; H01Q 1/243; H01Q 21/30; H01Q 7/00; H01Q 9/42
USPC 343/700 MS, 702, 829, 846
See application file for complete search history.

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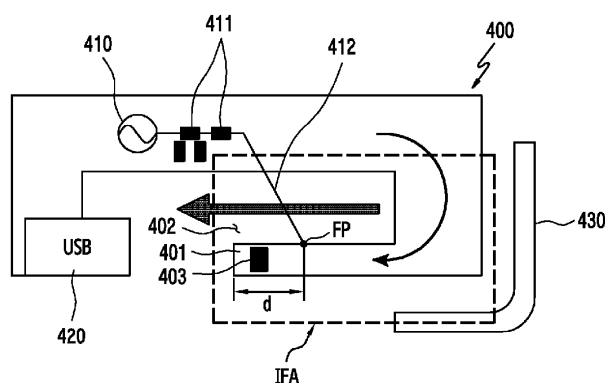
Primary Examiner — Tho G Phan

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

(57) **ABSTRACT**

An antenna apparatus and an electronic device having the same is provided. The electronic device includes an antenna radiator formed in a loop shape having at least one opening end part opened by a slit, at least a portion of the at least one opening end part is fed, at least one electronic component of metal material electrically connected with the antenna radiator, and at least one metal member arranged around the antenna radiator, where the at least one opening end part is formed in a reverse direction from the direction of the metal member.

20 Claims, 21 Drawing Sheets





US009590295B2

(12) **United States Patent**
Yanagi

(10) **Patent No.:** **US 9,590,295 B2**

(45) **Date of Patent:** **Mar. 7, 2017**

(54) **ANTENNA APPARATUS**

USPC 343/904, 813, 815, 817
See application file for complete search history.

(71) Applicant: **FUJITSU COMPONENT LIMITED**,
Tokyo (JP)

(56) **References Cited**

(72) Inventor: **Masahiro Yanagi**, Tokyo (JP)

U.S. PATENT DOCUMENTS

(73) Assignee: **FUJITSU COMPONENT LIMITED**,
Tokyo (JP)

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324/750.01

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 220 days.

(21) Appl. No.: **14/281,983**

(22) Filed: **May 20, 2014**

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(65) **Prior Publication Data**

US 2014/0347250 A1 Nov. 27, 2014

JP 2004-364023 12/2004

(30) **Foreign Application Priority Data**

May 27, 2013 (JP) 2013-111242

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Primary Examiner — Graham Smith

Assistant Examiner — Collin Dawkins

(74) *Attorney, Agent, or Firm* — IPUSA, PLLC

(51) **Int. Cl.**
H01Q 1/00 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)

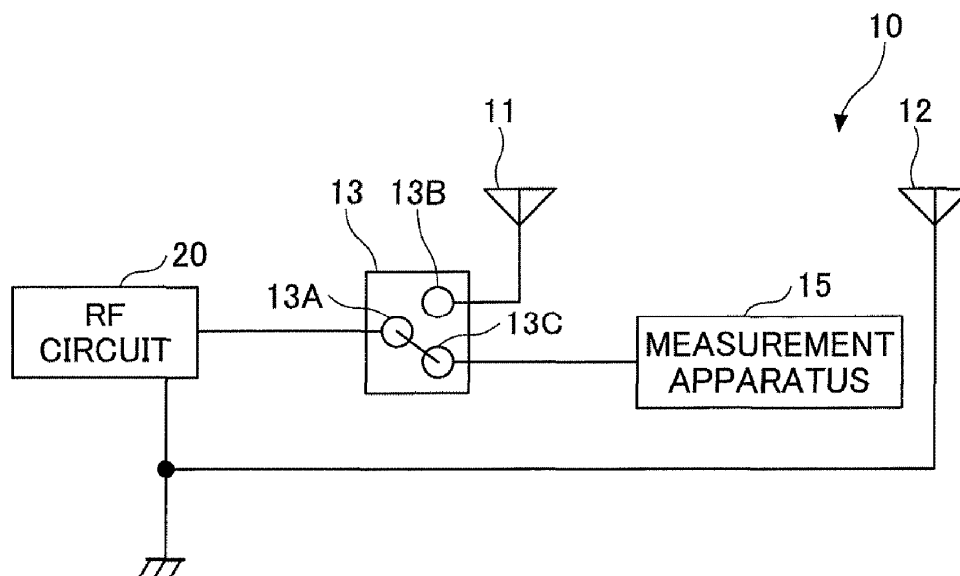
(57) **ABSTRACT**

An antenna apparatus includes an antenna element connected to a power feed point, a parasitic element disposed to overlap the antenna element as viewed from above and configured to be coupled to the antenna element, and a switch connected to the parasitic element and configured to switch connections to connect the parasitic element either to a given potential point or to a test-purpose terminal.

(52) **U.S. Cl.**
CPC **H01Q 1/38** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/20; H01Q 1/241; H01Q 9/0407;
H01Q 21/10; H01Q 1/38

10 Claims, 6 Drawing Sheets





US009590303B2

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

(10) **Patent No.:** **US 9,590,303 B2**
(45) **Date of Patent:** **Mar. 7, 2017**

(54) **ANTENNA**

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

(72) Inventors: **Yeh-Chun Kao**, Taipei (TW); **You-Fu Cheng**, Taipei (TW); **Yu-Chia Chang**, Taipei (TW)

(73) Assignee: **ASUSTeK COMPUTER INC.**, Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 365 days.

(21) Appl. No.: **14/138,119**

(22) Filed: **Dec. 22, 2013**

(65) **Prior Publication Data**

US 2014/0210682 A1 Jul. 31, 2014

Related U.S. Application Data

(60) Provisional application No. 61/757,718, filed on Jan. 29, 2013.

(30) **Foreign Application Priority Data**

Sep. 3, 2013 (TW) 102131729 A

(51) **Int. Cl.**
H01Q 7/00 (2006.01)
H01Q 5/371 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 7/00** (2013.01); **H01Q 5/371** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 7/00; H01Q 5/371
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Hoang V Nguyen

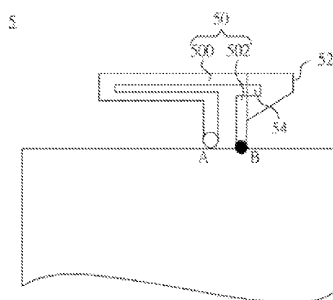
Assistant Examiner — Michael Bouizza

(74) *Attorney, Agent, or Firm* — CKC & Partners Co., Ltd.

(57) **ABSTRACT**

An antenna device is provided. The antenna includes a feeding end, a grounding end, a loop metal portion and a protruded metal portion. The grounding end is electrically connected to a ground plane. The loop metal portion extends from the feeding end to the grounding end to form a loop antenna structure. The protruded metal portion is electrically connected to the loop metal portion, wherein the distance between the protruded metal portion and the grounding end is shorter than the distance between the protruded metal portion and the feeding end.

13 Claims, 4 Drawing Sheets





US009590304B2

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

(10) **Patent No.:** **US 9,590,304 B2**
(45) **Date of Patent:** **Mar. 7, 2017**

(54) **BROADBAND ANTENNA**

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

(72) Inventors: **Shang-Sian You**, Hsinchu (TW);
Chien-Ting Huang, Hsinchu (TW);
Chih-Ming Wang, Hsinchu (TW)

(73) Assignee: **Wistron NeWeb Corporation**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 45 days.

(21) Appl. No.: **14/603,310**

(22) Filed: **Jan. 22, 2015**

(65) **Prior Publication Data**

US 2015/0236422 A1 Aug. 20, 2015

(30) **Foreign Application Priority Data**

Feb. 20, 2014 (TW) 103105733 A

(51) **Int. Cl.**

H01Q 1/38 (2006.01)
H01Q 7/00 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/371 (2015.01)
H01Q 5/378 (2015.01)

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

CPC **H01Q 7/00** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01); **H01Q 5/378** (2015.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/0407; H01Q 21/00; H01Q 7/00; H01Q 9/42; H01Q 5/371; H01Q 5/378
See application file for complete search history.

(56) **References Cited**

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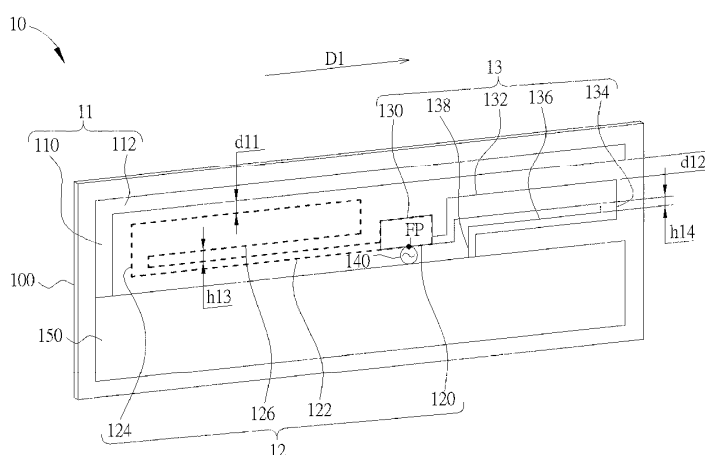
Primary Examiner — Trinh Dinh

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

(57) **ABSTRACT**

A broadband antenna includes a substrate; a grounding unit; a first radiating element, including a first segment and a second segment substantially perpendicular to each other, wherein the first segment is electrically connected to the grounding unit and the second segment extends toward a direction; a second radiating element, coupled to the first radiating element; a third radiating element having a terminal coupled to or electrically connected to the second radiating element and another terminal electrically connected to the grounding unit; and a signal feed-in element electrically connected to the third radiating element for transmitting or receiving a radio signal; where the first, the second and the third radiating elements are disposed on the substrate along the direction defined by an order of the first segment of the first radiating element, the second radiating element and the third radiating element.

10 Claims, 11 Drawing Sheets





US009590308B2

(12) **United States Patent**
Leppaluoto

(10) **Patent No.:** **US 9,590,308 B2**

(45) **Date of Patent:** **Mar. 7, 2017**

(54) **REDUCED SURFACE AREA ANTENNA
APPARATUS AND MOBILE
COMMUNICATIONS DEVICES
INCORPORATING THE SAME**

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

(72) Inventor: **Timo Leppaluoto**, Suzhou (CN)

(73) Assignee: **Pulse Electronics, 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 168 days.

(21) Appl. No.: **14/558,562**

(22) Filed: **Dec. 2, 2014**

(65) **Prior Publication Data**

US 2015/0200462 A1 Jul. 16, 2015

Related U.S. Application Data

(60) Provisional application No. 61/911,418, filed on Dec.
3, 2013.

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

(52) **U.S. Cl.**
CPC **H01Q 9/0414** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 5/371** (2015.01); **H01Q 9/42**
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 9/0414
(Continued)

(56) **References Cited**

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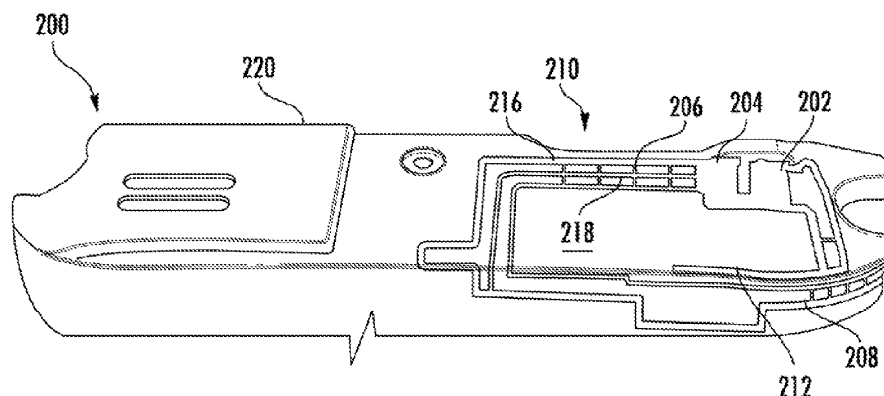
Primary Examiner — Hoang V Nguyen

(74) *Attorney, Agent, or Firm* — Gazdzinski &
Associates, PC

(57) **ABSTRACT**

Space- and cost-efficient antenna apparatus and methods of making and using the same. Antenna may comprise one or more planar radiator elements fabricated from an electrically conductive material. Surface area of the antenna radiator metallized portion may be reduced by utilizing a crosshatch pattern. The pattern may comprise of one or more metal-free elements disposed within the outline of the radiator. The elements may be interconnected by conductive crosslinks. The antenna may be coupled to radio electronics at one or more connection points. At least one of a size and/or a placement of the crosslinks may be configured based on distance from the connecting points. Crosslink size and/or placement may be configured to provide a prescribed current flow within the antenna. Reducing surface area of the antenna radiator may reduce manufacturing time and/or cost compared with prior art antenna design approaches.

20 Claims, 7 Drawing Sheets





US009590662B2

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

(10) **Patent No.:** **US 9,590,662 B2**

(45) **Date of Patent:** **Mar. 7, 2017**

(54) **INTEGRATED ANTENNA AND SENSOR
ELEMENT APPARATUS FOR A PORTABLE
WIRELESS TERMINAL**

(52) **U.S. Cl.**
CPC **H04B 1/0053** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 1/44** (2013.01); **H01Q 9/42**
(2013.01);

(Continued)

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

(58) **Field of Classification Search**

CPC H01Q 1/242; H01Q 1/243; H01Q 3/24;
H01Q 1/24; H04B 7/0814; H04B 1/3838;

(Continued)

(72) Inventors: **Gyu-Bok Park**, Gyeonggi-do (KR);
Hee-Jun Lee, Gyeonggi-do (KR);
Cheol-Hong Son, Seoul (KR); **Austin**
Kim, Gyeonggi-do (KR); **Joon-Ho**
Byun, Gyeonggi-do (KR); **Se-Hyun**
Park, Gyeonggi-do (KR); **Seong-Tae**
Jeong, Gyeonggi-do (KR)

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343/700 MS

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

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

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(21) Appl. No.: **14/864,160**

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(65) **Prior Publication Data**

US 2016/0013817 A1 Jan. 14, 2016

Related U.S. Application Data

(63) Continuation of application No. 13/441,992, filed on
Apr. 9, 2012, now Pat. No. 9,231,293.

Primary Examiner — Pablo Tran

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

(30) **Foreign Application Priority Data**

Jul. 27, 2011 (KR) 10-2011-0074503

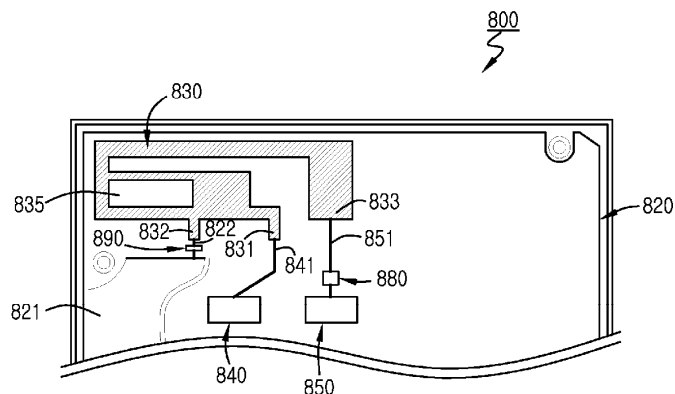
(57) **ABSTRACT**

An apparatus interworking with a metal member used both
as an antenna and a sensor element in a portable terminal is
disclosed. The apparatus includes the metal member, respon-
sive to a sensed body, and for transmitting and receiving a
signal in at least one or more communication service bands,
and a main board having a communication module for
processing a signal transmitted and received by the metal

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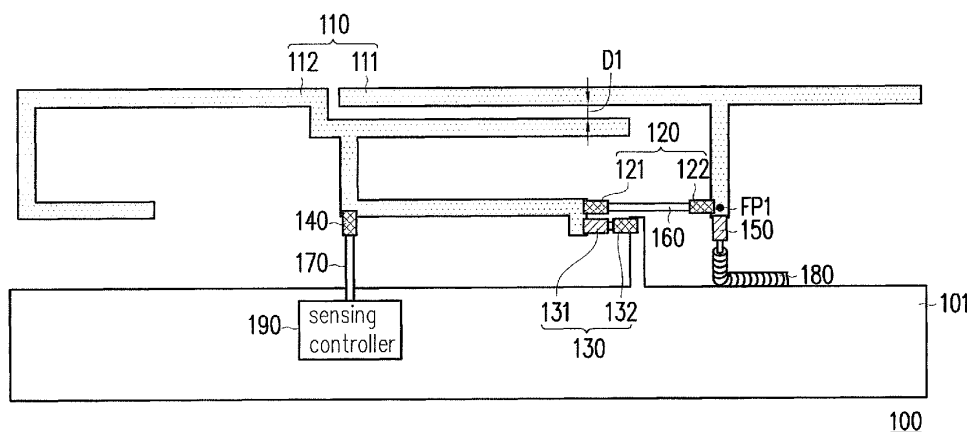
(51) **Int. Cl.**
H04B 1/00 (2006.01)
H04B 15/00 (2006.01)

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(45) **Date of Patent:** Mar. 7, 2017





US009595751B2

(12) **United States Patent**
Enomoto

(10) **Patent No.:** **US 9,595,751 B2**
(45) **Date of Patent:** **Mar. 14, 2017**

(54) **ELECTRONIC DEVICE**

(71) Applicant: **Sony Corporation**, Tokyo (JP)

(72) Inventor: **Takashi Enomoto**, Nagano (JP)

(73) Assignee: **SONY 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 197 days.

(21) Appl. No.: **14/357,021**

(22) PCT Filed: **Oct. 19, 2012**

(86) PCT No.: **PCT/JP2012/077053**

§ 371 (c)(1),

(2) Date: **May 8, 2014**

(87) PCT Pub. No.: **WO2013/073334**

PCT Pub. Date: **May 23, 2013**

(65) **Prior Publication Data**

US 2014/0306850 A1 Oct. 16, 2014

(30) **Foreign Application Priority Data**

Nov. 17, 2011 (JP) 2011-251696

(51) **Int. Cl.**

H01Q 1/22 (2006.01)

H01Q 5/00 (2015.01)

H01Q 9/30 (2006.01)

H01Q 1/24 (2006.01)

H01Q 9/36 (2006.01)

H01Q 5/378 (2015.01)

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

CPC **H01Q 1/24** (2013.01); **H01Q 1/2266**
(2013.01); **H01Q 5/378** (2015.01); **H01Q 9/36**
(2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/2266; H01Q 1/2291; H01Q 1/24;
H01Q 1/241; H01Q 1/243; H01Q 5/378;
H01Q 5/385; H01Q 5/392; H01Q 1/2258;
H01Q 1/245; H01Q 5/30; H01Q 5/307;
H01Q 9/42; H01Q 9/30; H01Q 1/2275
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Sue A Purvis

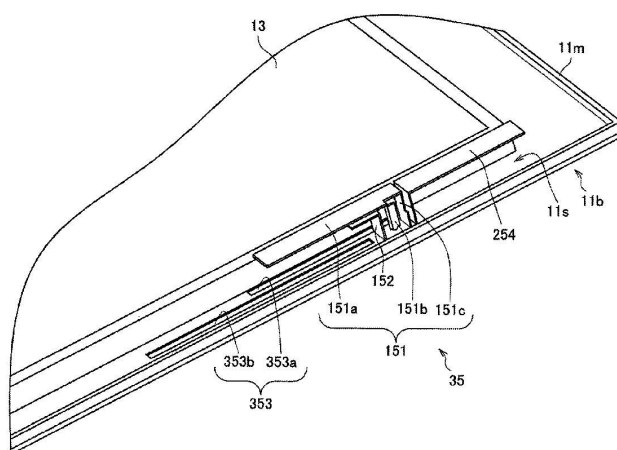
Assistant Examiner — Patrick Holecek

(74) *Attorney, Agent, or Firm* — Chip Law Group

(57) **ABSTRACT**

Provided is an electronic device including a case including a conductor part, and an antenna that is provided on a case surface on an inner side of the conductor part and includes an antenna element extending in a first direction parallel to the case surface, the antenna element being grounded to the case surface. A slit extending in the first direction is formed in an area of the case surface, the area being parallel to the antenna element.

10 Claims, 34 Drawing Sheets





US009595759B2

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

(10) **Patent No.:** **US 9,595,759 B2**

(45) **Date of Patent:** **Mar. 14, 2017**

(54) **SINGLE ELEMENT DUAL-FEED ANTENNAS AND AN ELECTRONIC DEVICE INCLUDING THE SAME**

(71) Applicant: **Nvidia Corporation**, Santa Clara, CA (US)

(72) Inventors: **Sung Hoon Oh**, Santa Clara, CA (US); **Joselito Gavilan**, Santa Clara, CA (US); **Warren Lee**, Santa Clara, CA (US)

(73) Assignee: **Nvidia Corporation**, Santa Clara, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 128 days.

(21) Appl. No.: **14/160,277**

(22) Filed: **Jan. 21, 2014**

(65) **Prior Publication Data**

US 2015/0207228 A1 Jul. 23, 2015

(51) **Int. Cl.**
H01Q 7/00 (2006.01)
H01Q 5/35 (2015.01)
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/35** (2015.01); **H01Q 1/243** (2013.01); **H01Q 7/00** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 5/35; H01Q 7/10; H01Q 1/48; H01Q 1/243; H01Q 5/20; H01Q 21/28; H01Q 5/40
IPC H01Q 5/35, 7/10, 1/48, 1/243, 5/20, 21/28, 5/40

See application file for complete search history.

(56) **References Cited**

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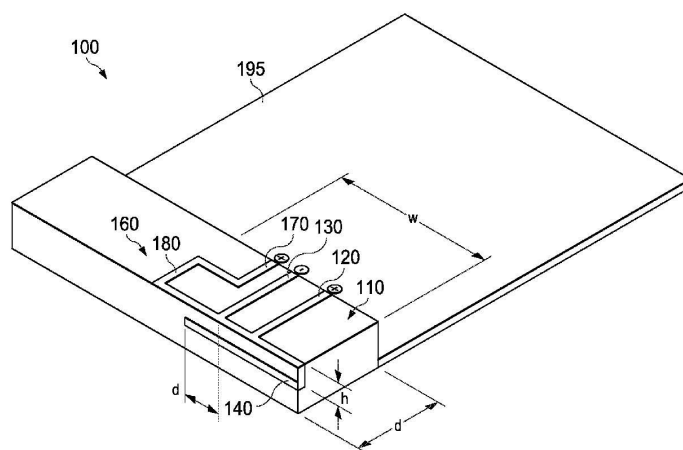
Primary Examiner — Dameon E Levi

Assistant Examiner — Andrea Lindgren Baltzell

(57) **ABSTRACT**

Provided is an antenna. The antenna, in this aspect, includes an inverted-F GPS antenna structure, the inverted-F GPS antenna structure embodying a GPS feed element, a GPS extending arm, and a ground element. The antenna, in this aspect, further includes a loop WiFi antenna structure, the loop WiFi antenna structure embodying a WiFi feed element, the ground element, and a WiFi connecting arm coupling the WiFi feed element to the ground element. In this particular aspect, the ground element is located between the GPS feed element and the WiFi feed element.

20 Claims, 2 Drawing Sheets





US009596330B2

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

(10) **Patent No.:** **US 9,596,330 B2**
(45) **Date of Patent:** **Mar. 14, 2017**

(54) **ANTENNA SYSTEM WITH RECEIVER DIVERSITY AND TUNABLE MATCHING CIRCUIT**

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

(72) Inventors: **Ruben Caballero**, San Jose, CA (US);
Mattia Pascolini, San Francisco, CA (US);
Mohit Narang, Cupertino, CA (US);
Matthew A. Mow, Los Altos, CA (US);
Robert W. Schlub, 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 216 days.

(21) Appl. No.: **14/490,576**

(22) Filed: **Sep. 18, 2014**

(65) **Prior Publication Data**

US 2015/0005037 A1 Jan. 1, 2015

Related U.S. Application Data

(63) Continuation of application No. 12/941,010, filed on Nov. 5, 2010, now Pat. No. 8,872,706.

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

(52) **U.S. Cl.**
CPC **H04M 1/026** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/44** (2013.01); **H01Q 9/0421** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/242; H01Q 21/28
(Continued)

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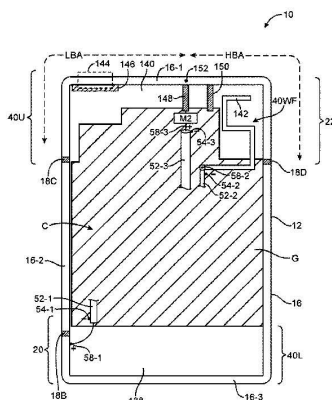
Primary Examiner — Graham Smith

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

(57) **ABSTRACT**

Electronic devices may be provided that contain wireless communications circuitry. The wireless communications circuitry may include radio-frequency transceiver circuitry and antenna structures. An electronic device may include a display mounted within a housing. A peripheral conductive member may run around the edges of the display and housing. Dielectric-filled gaps may divide the peripheral conductive member into individual segments. A ground plane may be formed within the housing from conductive housing structures, printed circuit boards, and other conductive elements. The ground plane and the segments of the peripheral conductive member may form antennas in upper and lower portions of the housing. The radio-frequency transceiver circuitry may implement receiver diversity using both the upper and lower antennas. The lower antenna may be used in transmitting signals. The upper antenna may be tuned using a tunable matching circuit.

20 Claims, 11 Drawing Sheets





US009601823B2

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

(10) **Patent No.:** **US 9,601,823 B2**

(45) **Date of Patent:** **Mar. 21, 2017**

(54) **MOBILE DEVICE HOUSING INCLUDING AT LEAST ONE ANTENNA**

(71) Applicant: **INTEL CORPORATION**, Santa Clara, CA (US)

(72) Inventors: **Anand Konanur**, Sunnyvale, CA (US);
Ulun Karacaoglu, San Diego, CA (US); **Songnan Yang**, San Jose, CA (US); **Shawn McEuen**, Portland, OR (US)

(73) Assignee: **INTEL CORPORATION**, Santa Clara, 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.: **15/092,886**

(22) Filed: **Apr. 7, 2016**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. 14/871,532, filed on Sep. 30, 2015, which is a continuation of application No. 14/280,796, filed on May 19, 2014, now Pat. No. 9,160,061, which is a continuation of application No. 13/076,990, filed on Mar. 31, 2011, now Pat. No. 8,760,349.

(60) Provisional application No. 61/417,292, filed on Nov. 26, 2010.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/40 (2006.01)
H01Q 21/28 (2006.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 1/40** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**

USPC 343/712, 700, 745, 873
See application file for complete search history.

(56) **References Cited**

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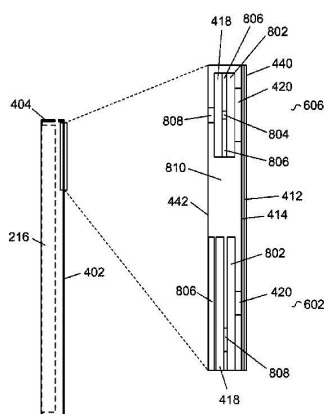
Primary Examiner — Allyson Trail

(74) *Attorney, Agent, or Firm* — Shichrur & Co.

(57) **ABSTRACT**

Embodiments of systems and methods for providing in-mold laminate antennas are generally described herein. Other embodiments may be described and claimed.

14 Claims, 5 Drawing Sheets





US009601825B1

(12) **United States Patent**
Lo

(10) **Patent No.:** **US 9,601,825 B1**
(45) **Date of Patent:** **Mar. 21, 2017**

(54) **MOBILE DEVICE**

(71) Applicant: **Quanta Computer Inc.**, Taoyuan (TW)

(72) Inventor: **Wen-Yuan Lo**, Taoyuan (TW)

(73) Assignee: **QUANTA COMPUTER INC.**,
Guishan Dist., Taoyuan (TW)

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

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(21) Appl. No.: **15/008,970**

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

(30) **Foreign Application Priority Data**

Dec. 8, 2015 (TW) 104141044 A

(51) **Int. Cl.**
H04B 1/00 (2006.01)
H01Q 1/52 (2006.01)
H04B 1/3827 (2015.01)
H01Q 1/22 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/521** (2013.01); **H01Q 1/2266**
(2013.01); **H04B 1/3827** (2013.01)

(58) **Field of Classification Search**
CPC H04B 7/0404; H04B 7/0825
USPC 455/575.7, 121, 193.1
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Wen Huang

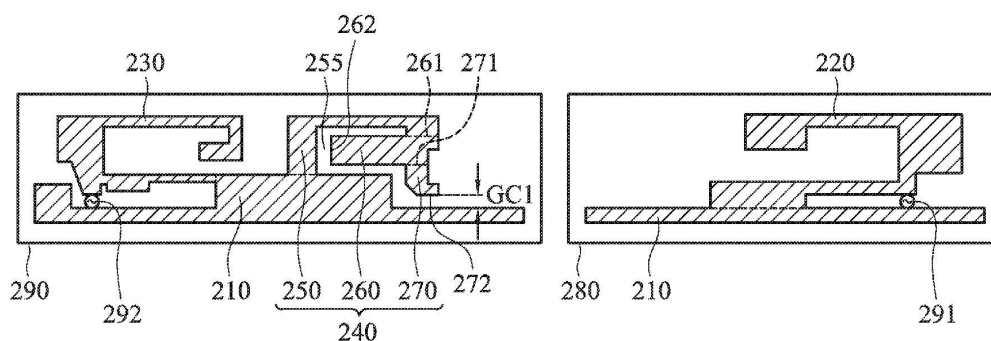
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

A mobile device includes a ground element, a first antenna, a second antenna, and a filter. The filter is disposed between the first antenna and the second antenna. The filter includes a main branch and a tuning branch. The tuning branch is coupled through the main branch to the ground element. The first antenna and the second antenna cover the same operation frequency band. The filter is configured to enhance the isolation between the first antenna and the second antenna in the operation frequency band.

6 Claims, 7 Drawing Sheets

200





US009601826B2

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

(10) **Patent No.:** **US 9,601,826 B2**
(45) **Date of Patent:** **Mar. 21, 2017**

(54) **MIMO ANTENNA, TERMINAL AND METHOD FOR IMPROVING ISOLATION**

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

(72) Inventors: **Hao Ai**, Shenzhen (CN); **Yan Shi**, Shenzhen (CN); **Long Li**, Shenzhen (CN); **Lu Zhang**, Shenzhen (CN); **Jun Xing**, Shenzhen (CN); **Hao Sun**, Shenzhen (CN)

(73) Assignee: **ZTE CORPORATION**, Shenzhen, 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.: **14/904,214**

(22) PCT Filed: **Nov. 26, 2013**

(86) PCT No.: **PCT/CN2013/087850**

§ 371 (c)(1),

(2) Date: **Feb. 16, 2016**

(87) PCT Pub. No.: **WO2014/161327**

PCT Pub. Date: **Oct. 9, 2014**

(65) **Prior Publication Data**

US 2016/0254596 A1 Sep. 1, 2016

(30) **Foreign Application Priority Data**

Jul. 17, 2013 (CN) 2013 1 0300672

(51) **Int. Cl.**
H01Q 21/00 (2006.01)
H01Q 1/52 (2006.01)
H01Q 1/38 (2006.01)
H01Q 21/28 (2006.01)
H01Q 1/24 (2006.01)

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

CPC **H01Q 1/523** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC H01Q 21/08; H01Q 1/246; H01Q 1/38; H01Q 3/26

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Primary Examiner — Graham Smith

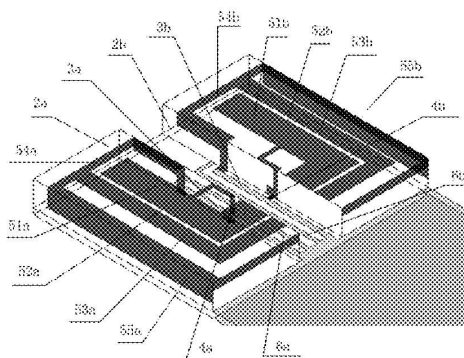
Assistant Examiner — Collin Dawkins

(74) *Attorney, Agent, or Firm* — Oppedahl Patent Law Firm LLC

(57) **ABSTRACT**

Disclosed are an MIMO antenna, a terminal and a method for improving MIMO antenna isolation. The MIMO antenna comprises at least two single antennas arranged on a printed circuit board (PCB); the single antenna comprising: an antenna support, a feeding grounding branch node used for shielding low-frequency coupling between the single antennas, a feeding point, a grounding point and an antenna radiation part, wherein the antenna support is arranged on the PCB, and the antenna radiation part is arranged on the

(Continued)





US009601829B2

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

(10) **Patent No.:** **US 9,601,829 B2**
(45) **Date of Patent:** **Mar. 21, 2017**

(54) **COMPACT BROADBAND ANTENNA**

(75) Inventors: **Snir Azulay**, Tiberias (IL); **Steve Krupa**, Haifa (IL)

(73) Assignee: **GALTRONICS CORPORATION, LTD.**, Tiberias (IL)

(*) 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.: **13/978,092**

(22) PCT Filed: **Jan. 3, 2012**

(86) PCT No.: **PCT/IL2012/000001**

§ 371 (c)(1),
(2), (4) Date: **Aug. 8, 2013**

(87) PCT Pub. No.: **WO2012/093391**

PCT Pub. Date: **Jul. 12, 2012**

(65) **Prior Publication Data**

US 2013/0307734 A1 Nov. 21, 2013

Related U.S. Application Data

(60) Provisional application No. 61/429,240, filed on Jan. 3, 2011.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/364 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/364** (2015.01); **H01Q 1/243**
(2013.01); **H01Q 1/38** (2013.01); **H01Q 5/307**
(2015.01);
(Continued)

(58) **Field of Classification Search**

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

(56) **References Cited**

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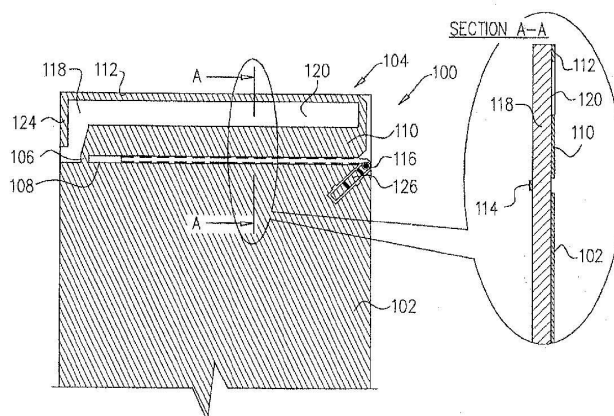
Primary Examiner — Dieu H Duong

(74) Attorney, Agent, or Firm — Lorenz & Kopf, LLP.

(57) **ABSTRACT**

An antenna including a substrate formed of a non-conductive material, a ground plane disposed on the substrate, a wideband radiating element having one end connected to an edge of the ground plane and an elongate feed arm feeding the wideband radiating element and having a maximum width of $1/100$ of a predetermined wavelength, the predetermined wavelength being defined by formula (I) wherein λ_p is the predetermined wavelength, f is a lowest operating frequency of the wideband radiating element, μ is a permeability of the substrate, ϵ_r is a relative bulk permittivity of the substrate, W is a width of a conductive trace disposed above the substrate and H is a thickness of the substrate, wherein formula (II).

17 Claims, 4 Drawing Sheets





US009601830B2

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

(10) **Patent No.:** **US 9,601,830 B2**

(45) **Date of Patent:** **Mar. 21, 2017**

(54) **ANTENNA STRUCTURE**

USPC 343/700 MS, 702, 846, 848
See application file for complete search history.

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

(72) Inventors: **Kun-Sheng Chang**, New Taipei (TW);
Ching-Chi Lin, New Taipei (TW);
Chung-Wen Yang, New Taipei (TW);
Chuan-Chun Wang, New Taipei (TW);
Kuan-Jen Chung, New Taipei (TW)

(73) Assignee: **ACER INCORPORATED**, 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.: **14/755,240**

(22) Filed: **Jun. 30, 2015**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 5/00 (2015.01)
H01Q 9/04 (2006.01)
H01Q 5/371 (2015.01)
H01Q 1/24 (2006.01)
H01Q 7/00 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/371** (2015.01); **H01Q 1/243** (2013.01); **H01Q 7/00** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 1/385; H01Q 5/371; H01Q 9/04

(56) **References Cited**

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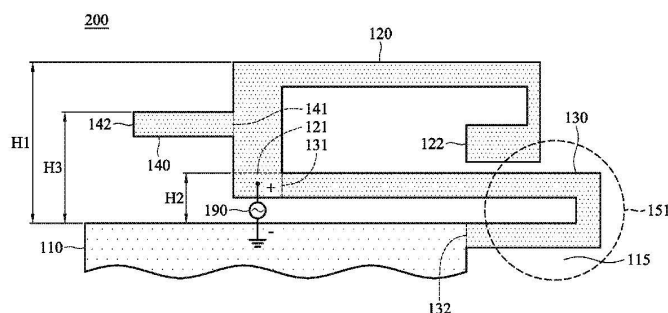
Primary Examiner — Khai M Nguyen

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

(57) **ABSTRACT**

An antenna structure includes a ground element, a first radiation branch, and a second radiation branch. The first radiation branch has a first end and a second end. The first end of the first radiation branch is coupled to a signal source. The second end of the first radiation branch is open. The second radiation branch has a first end and a second end. The first end of the second radiation branch is coupled to the signal source. The second end of the second radiation branch is coupled to the ground element. The length of the second radiation branch is substantially equal to that of the first radiation branch.

9 Claims, 3 Drawing Sheets





US009602173B2

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

(10) **Patent No.:** **US 9,602,173 B2**

(45) **Date of Patent:** **Mar. 21, 2017**

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

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

(72) Inventors: **Liang-Kai Chen**, Hsinchu (TW);
Jen-Hao Cheng, Hsinchu (TW);
Yuan-Chin Hsu, Hsinchu (TW);
Tzu-Min Wu, 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 84 days.

(21) Appl. No.: **14/700,796**

(22) Filed: **Apr. 30, 2015**

(65) **Prior Publication Data**

US 2015/0357716 A1 Dec. 10, 2015

(30) **Foreign Application Priority Data**

Jun. 5, 2014 (TW) 103119503 A

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H04B 5/00 (2006.01)

(52) **U.S. Cl.**
CPC **H04B 5/0081** (2013.01)

(58) **Field of Classification Search**
CPC H04B 5/0081
USPC 343/702, 700 MS
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Khai M Nguyen

(74) *Attorney, Agent, or Firm* — Muncy, Geissler, Olds & Lowe, P.C.

(57) **ABSTRACT**

An antenna structure includes a ferromagnetic patch, first metal conductive lines, second metal conductive lines, and metal connection elements. The ferromagnetic patch has a first surface and a second surface, and the second surface is opposite to the first surface. The first metal conductive lines are disposed on the first surface of the ferromagnetic patch. The second metal conductive lines are disposed on the second surface of the ferromagnetic patch. The metal connection elements penetrate the ferromagnetic patch. The metal connection elements further connect the first metal conductive lines to the second metal conductive lines, respectively.

19 Claims, 13 Drawing Sheets

