



US009502750B2

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

(10) **Patent No.:** **US 9,502,750 B2**  
(45) **Date of Patent:** **Nov. 22, 2016**

(54) **ELECTRONIC DEVICE WITH REDUCED EMITTED RADIATION DURING LOADED ANTENNA OPERATING CONDITIONS**

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

(72) Inventors: **Salih Yarga**, Sunnyvale, CA (US); **Qingxiang Li**, Mountain View, 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 598 days.

(21) Appl. No.: **13/855,568**

(22) Filed: **Apr. 2, 2013**

(65) **Prior Publication Data**  
US 2014/0292587 A1 Oct. 2, 2014

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 9/04** (2006.01)  
**H01Q 1/38** (2006.01)  
**H01Q 5/378** (2015.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 1/245** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/378** (2015.01); **H01Q 9/0421** (2013.01)

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

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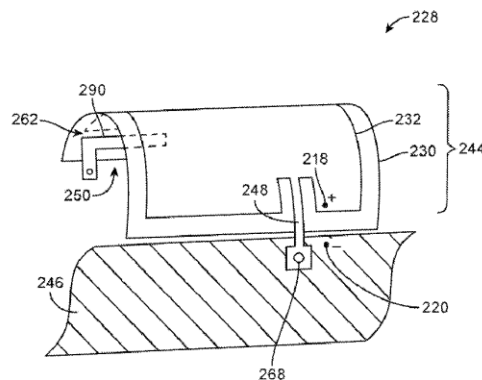
\* cited by examiner

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

(57) **ABSTRACT**

An electronic device may have an antenna for providing coverage in wireless communications bands of interest. The wireless communications bands may include a communications band at a first frequency. The antenna may have a parasitic antenna resonating element that supports a low efficiency resonance. In response to operation of the electronic device in free space, the low efficiency resonance will be located at a second frequency that is greater than the first frequency. In response to operation of the electronic device in proximity to a user's body or other external object, the antenna will be loaded and the low efficiency resonance associated with the parasitic antenna resonating element will shift to the communications band at the first frequency. The antenna may include a resonating element formed on a flexible printed circuit or a dielectric carrier such as a plastic support structure.

**7 Claims, 13 Drawing Sheets**





US009502752B2

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

(10) **Patent No.:** **US 9,502,752 B2**  
(45) **Date of Patent:** **\*Nov. 22, 2016**

(54) **ANTENNA HAVING FLEXIBLE FEED STRUCTURE WITH COMPONENTS**

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

(72) Inventors: **Dean F. Darnell**, San Jose, CA (US);  
**William J. Noellert**, Sunnyvale, CA (US);  
**Mattia Pascolini**, San Francisco, 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 169 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/486,602**

(22) Filed: **Sep. 15, 2014**

(65) **Prior Publication Data**

US 2015/0035706 A1 Feb. 5, 2015

**Related U.S. Application Data**

(63) Continuation of application No. 13/435,351, filed on Mar. 30, 2012, now Pat. No. 8,836,587.

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 1/48** (2006.01)  
**H01Q 1/50** (2006.01)  
**H05K 1/02** (2006.01)

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(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/50** (2013.01); **H01Q 9/045** (2013.01); **H05K 1/028** (2013.01); **H05K 1/181** (2013.01); **H05K 1/189** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/243; H01Q 1/48; H01Q 1/50; H01Q 9/045  
USPC ..... 343/702  
See application file for complete search history.

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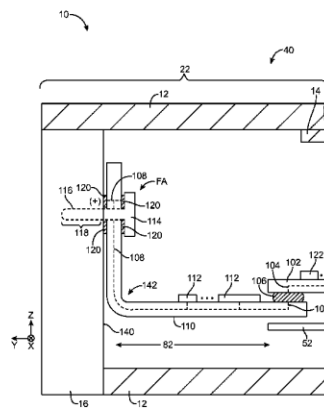
*Primary Examiner* — Hoang V Nguyen

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

(57) **ABSTRACT**

Electronic devices may include antenna structures. The antenna structures may form an antenna having first and second feeds at different locations. Transceiver circuitry for transmitting and receiving radio-frequency antenna signals may be mounted on one end of a printed circuit board. Transmission line structures may be used to convey signals between an opposing end of the printed circuit board and the transceiver circuitry. The printed circuit board may be coupled to an antenna feed structure formed from a flexible printed circuit using solder connections. The flexible printed circuit may have a bend and may be screwed to conductive electronic device housing structures using one or more screws at one or more respective antenna feed terminals. Electrical components such as an amplifier circuit and filter circuitry may be mounted on the flexible printed circuit.

**19 Claims, 12 Drawing Sheets**





US009502757B2

(12) **United States Patent  
Zuniga**

(10) **Patent No.:** US 9,502,757 B2  
(45) **Date of Patent:** Nov. 22, 2016

- (54) **LOW-COST ULTRA WIDEBAND LTE ANTENNA**
- (71) Applicant: **Eleazar Zuniga**, Escondido, CA (US)
- (72) Inventor: **Eleazar Zuniga**, Escondido, CA (US)
- (73) Assignee: **TAOGLAS GROUP HOLDINGS LIMITED**, Wexford (IE)
- (\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 42 days.

- (21) Appl. No.: **14/438,611**
- (22) PCT Filed: **Oct. 8, 2013**
- (86) PCT No.: **PCT/US2013/063947**  
§ 371 (c)(1),  
(2) Date: **May 1, 2015**
- (87) PCT Pub. No.: **WO2014/058926**  
PCT Pub. Date: **Apr. 17, 2014**

- (65) **Prior Publication Data**  
US 2015/0288059 A1 Oct. 8, 2015

**Related U.S. Application Data**

- (60) Provisional application No. 61/711,196, filed on Oct. 8, 2012.
- (51) **Int. Cl.**  
**H01Q 1/38** (2006.01)  
**H01Q 1/24** (2006.01)  
**H01Q 1/36** (2006.01)  
**H01Q 9/42** (2006.01)

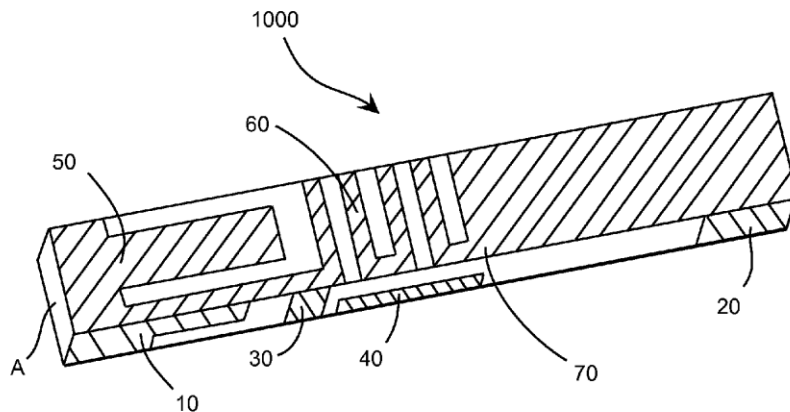
- H01Q 5/364** (2015.01)
- H01Q 5/10** (2015.01)
- H01Q 5/371** (2015.01)
- H01Q 9/40** (2006.01)
- (52) **U.S. Cl.**  
CPC ..... **H01Q 1/38** (2013.01); **H01Q 5/10** (2015.01); **H01Q 5/364** (2015.01); **H01Q 5/371** (2015.01); **H01Q 9/40** (2013.01); **H01Q 9/42** (2013.01)
- (58) **Field of Classification Search**  
CPC .... H01Q 1/38; H01Q 9/0414; H01Q 9/0421; H01Q 5/364  
See application file for complete search history.

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

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*Primary Examiner* — Dameon E Levi  
*Assistant Examiner* — Ricardo Magallanes  
(74) *Attorney, Agent, or Firm* — Coastal Patent Law Group, P.C.

- (57) **ABSTRACT**  
An antenna capable of operating among all LTE bands, and also capable of operation among all remote side cellular applications, such as GSM, AMPS, GPRS, CDMA, WCDMA, UMTS, and HSPA among others. The antenna provides a low cost alternative to active-tunable antennas suggested in the prior art for the same multi-platform objective.

**14 Claims, 7 Drawing Sheets**





US009502769B2

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

(10) **Patent No.:** **US 9,502,769 B2**  
(45) **Date of Patent:** **Nov. 22, 2016**

(54) **MULTIBAND SWITCHABLE ANTENNA STRUCTURE**

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

(72) Inventors: **Chin-Lung Tsai**, Taoyuan (TW);  
**Chung-Ting Hung**, Taoyuan (TW);  
**Ying-Cong Deng**, Taoyuan (TW);  
**Chung-Hung Lo**, Taoyuan (TW);  
**Kuan-Hsien Lee**, 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 11 days.

(21) Appl. No.: **14/695,817**

(22) Filed: **Apr. 24, 2015**

(65) **Prior Publication Data**  
US 2016/0156101 A1 Jun. 2, 2016

(30) **Foreign Application Priority Data**  
Nov. 28, 2014 (TW) ..... 103141339 A

(51) **Int. Cl.**  
**H01Q 9/00** (2006.01)  
**H01Q 5/328** (2015.01)  
**H01Q 9/42** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 5/328** (2015.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 5/328  
See application file for complete search history.

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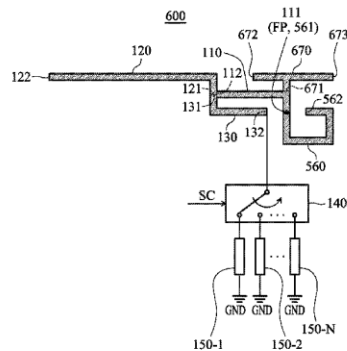
*Primary Examiner* — Trinh Dinh

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

(57) **ABSTRACT**

A multiband switchable antenna structure includes a feeding element, a first radiation element, a second radiation element, circuit branches, and a switch circuit. A first end of the feeding element is a feeding point. A first end of the first radiation element is coupled to a second end of the feeding element. A second end of the first radiation element is open. A first end of the second radiation element is coupled to the second end of the feeding element. The circuit branches have different impedance values. The switch circuit selects one of the circuit branches as a matching branch according to a control signal. A second end of the second radiation element is coupled through the matching branch to a ground voltage.

**9 Claims, 7 Drawing Sheets**





US009502770B2

(12) **United States Patent**  
**Rao**

(10) **Patent No.:** **US 9,502,770 B2**  
(45) **Date of Patent:** **Nov. 22, 2016**

(54) **COMPACT MULTIPLE-BAND ANTENNA FOR WIRELESS DEVICES**

FOREIGN PATENT DOCUMENTS

- (71) Applicant: **BlackBerry Limited**, Waterloo (CA)
- (72) Inventor: **Qinjiang Rao**, Kanata (CA)
- (73) Assignee: **BlackBerry Limited**, Waterloo (CA)

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WO	2008122112	10/2008

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 320 days.

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- (21) Appl. No.: **13/948,845**
- (22) Filed: **Jul. 23, 2013**

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(65) **Prior Publication Data**  
US 2014/0028511 A1 Jan. 30, 2014

**Related U.S. Application Data**

(62) Division of application No. 12/615,267, filed on Nov. 10, 2009, now Pat. No. 8,514,132.

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(51) **Int. Cl.**  
**H01Q 5/35** (2015.01)  
**H01Q 1/24** (2006.01)  
**H01Q 9/04** (2006.01)  
**H01Q 5/30** (2015.01)

*Primary Examiner* — Robert Karacsony  
 (74) *Attorney, Agent, or Firm* — Moffat & Co.

(52) **U.S. Cl.**  
 CPC ..... **H01Q 5/35** (2015.01); **H01Q 1/243** (2013.01); **H01Q 5/30** (2015.01); **H01Q 9/0421** (2013.01)

(57) **ABSTRACT**

A device in a wireless communication system, comprising a transmitter for transmitting information over a plurality of frequency bands, a receiver for receiving information over a plurality of frequency bands and a multiple-band antenna electrically connected to said transmitter and said receiver, wherein said multiple-band antenna is comprised of a first feed point configured to electrically connect said multiple-band antenna to said transmitter and said receiver, wherein said multiple-band antenna forms a first antenna type and a second feed point configured to electrically connect said multiple-band antenna to said transmitter and said receiver, wherein said multiple-band antenna forms a second antenna type.

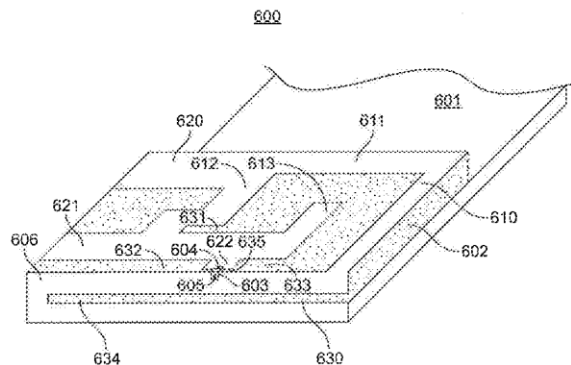
(58) **Field of Classification Search**  
 None  
 See application file for complete search history.

(56) **References Cited**

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**9 Claims, 8 Drawing Sheets**





US009502771B2

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

(10) **Patent No.:** **US 9,502,771 B2**  
(45) **Date of Patent:** **Nov. 22, 2016**

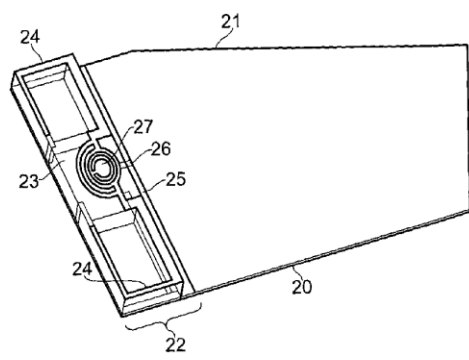
- (54) **LOOP ANTENNA FOR MOBILE HANDSET AND OTHER APPLICATIONS**
- (75) Inventors: **Marc Harper**, Cambridge (GB); **Devis Tellici**, Cambridge (GB); **Christopher Tomlin**, Cambridge (GB)
- (73) Assignee: **Microsoft Technology Licensing, LLC**, Redmond, WA (US)
- (\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 297 days.
- (21) Appl. No.: **13/878,971**
- (22) PCT Filed: **Sep. 28, 2011**
- (86) PCT No.: **PCT/GB2011/051837**  
§ 371 (c)(1), (2), (4) Date: **Apr. 11, 2013**
- (87) PCT Pub. No.: **WO2012/049473**  
PCT Pub. Date: **Apr. 19, 2012**
- (65) **Prior Publication Data**  
US 2013/0201074 A1 Aug. 8, 2013
- (30) **Foreign Application Priority Data**  
Oct. 15, 2010 (GB) ..... 1017472
- (51) **Int. Cl.**  
**H01Q 7/00** (2006.01)  
**H01Q 5/378** (2015.01)  
(Continued)
- (52) **U.S. Cl.**  
CPC ..... **H01Q 5/378** (2015.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/321** (2015.01);  
(Continued)
- (58) **Field of Classification Search**  
CPC ..... H01Q 7/00; H01Q 7/005  
USPC ..... 343/870, 702, 744, 866, 749  
See application file for complete search history.

- (56) **References Cited**
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- Primary Examiner* — Huedung Mancuso
- (74) *Attorney, Agent, or Firm* — Brandon Roper; Judy Yee; Micky Minhas

(57) **ABSTRACT**

There is disclosed a loop antenna for mobile handsets and other devices. The antenna comprises a dielectric substrate (23) having first and second opposed surfaces and a conductive track (24) formed on the substrate (23). A feed point (26) and a grounding point (25) are provided adjacent to each other on the first surface of the substrate (23), with the conductive track (24) extending in generally opposite directions from the feed point (26) and grounding point (25) respectively and winding around the substrate (23) to the second surface and passing along a path generally opposite to the path taken on the first surface of the dielectric substrate (23). The conductive tracks (24) then connect to respective sides of a conductive arrangement (27) that extends into a central part of a loop formed by the conductive track (24) on the second surface of the dielectric substrate (23). The conductive arrangement (27) comprises both inductive and capacitive elements. The antenna can be multi-moded and operate in several frequency bands. Alternatively, the loop antenna is fed parasitically by a monopole or a feeding loop. The parasitic loop antenna may alternatively comprise a conductive loading plate instead of the conductive arrangement.

**18 Claims, 8 Drawing Sheets**





US009502772B2

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

(10) **Patent No.:** **US 9,502,772 B2**  
(45) **Date of Patent:** **Nov. 22, 2016**

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

USPC ..... 343/770  
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) Inventors: **Jin-Bo Chen**, New Taipei (TW);  
**Che-Yen Lin**, New Taipei (TW);  
**Cho-Kang Hsu**, New Taipei (TW)

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

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 420 days.

(21) Appl. No.: **14/061,929**

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(22) Filed: **Oct. 24, 2013**

TW 201132119 9/2011

(65) **Prior Publication Data**

US 2014/0354497 A1 Dec. 4, 2014

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(30) **Foreign Application Priority Data**

Jun. 4, 2013 (TW) ..... 102119701 A

*Primary Examiner* — Dameon E Levi  
*Assistant Examiner* — Hasan Islam  
(74) *Attorney, Agent, or Firm* — Zhigang Ma

(51) **Int. Cl.**  
**H01Q 13/10** (2006.01)  
**H01Q 5/378** (2015.01)  
**H01Q 9/42** (2006.01)  
**H01Q 1/24** (2006.01)  
**H01Q 5/371** (2015.01)

(57) **ABSTRACT**

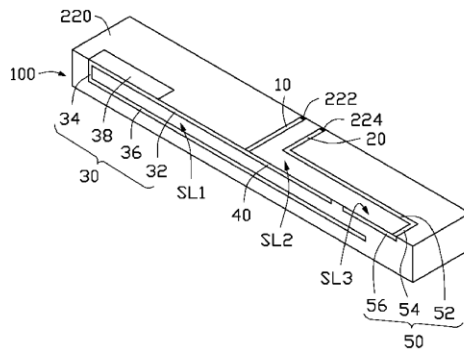
An antenna structure includes a feed section, a ground section, a first radiator, a second radiator, and a third radiator. The first radiator and the second radiator are both connected to the feed section. The third radiator is connected to the ground section. The first radiator defines a first slot. A second slot is defined between the second radiator and the third radiator. The third radiator defines a third slot. The third slot communicates with the second slot. Current is coupled from the first radiator and the second radiator to the third radiator via the first slot, the second slot, and the third slot.

(52) **U.S. Cl.**  
CPC ..... **H01Q 5/378** (2015.01); **H01Q 9/42** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 13/10; H01Q 9/42

**20 Claims, 3 Drawing Sheets**

200





US009502775B1

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

(10) **Patent No.:** US 9,502,775 B1  
(45) **Date of Patent:** Nov. 22, 2016

(54) **SWITCHING A SLOT ANTENNA**  
(71) Applicant: **GOOGLE INC.**, Mountain View, CA (US)  
(72) Inventors: **Ajay Chandra Venkata Gummalla**, Sunnyvale, CA (US); **Huan Liao**, Mountain View, CA (US)  
(73) Assignee: **Google Inc.**, Mountain View, CA (US)  
(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 85 days.

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*Primary Examiner* — David Bilodeau  
(74) *Attorney, Agent, or Firm* — Brake Hughes Bellemann LLP

(21) Appl. No.: **14/254,546**  
(22) Filed: **Apr. 16, 2014**  
(51) **Int. Cl.**  
**H01Q 13/10** (2006.01)  
**H04B 1/401** (2015.01)  
(52) **U.S. Cl.**  
CPC ..... **H01Q 13/10** (2013.01); **H04B 1/401** (2013.01)  
(58) **Field of Classification Search**  
CPC ..... H01Q 13/10; H01Q 1/243  
See application file for complete search history.

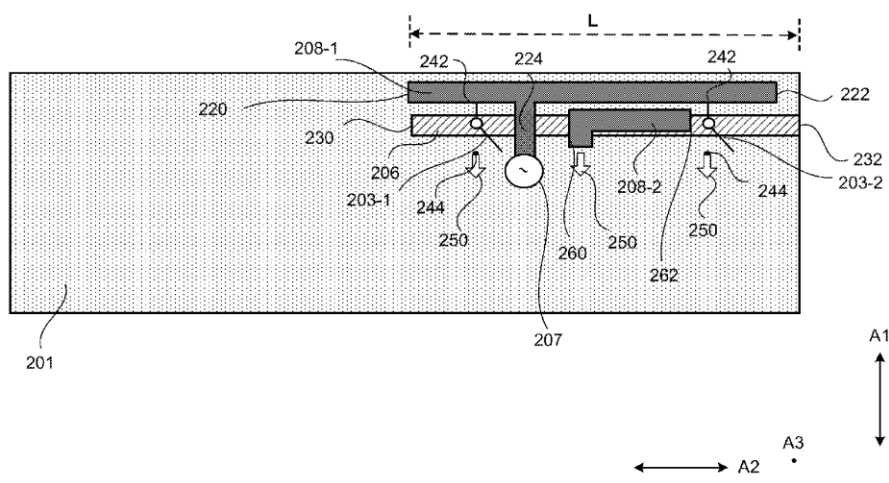
(57) **ABSTRACT**

A computing device may include a conductive member, a slot antenna having a slot defined by the conductive member and an antenna pattern portion disposed proximate to the slot, and/or a slot switch configured to switch a portion of the slot. The slot switch may have a first terminal and a second terminal such that the portion of the slot is disposed between the first terminal and the second terminal. The slot switch may be switchable between a first configuration in which the first and second terminals are electrically connected and a second configuration in which the first and second terminals are not electrically connected. The computing device may also include a switching controller configured to switch the slot switch between the first and second configurations.

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**14 Claims, 5 Drawing Sheets**

200







US009502776B2

(12) **United States Patent**  
**Di Nallo et al.**

(10) **Patent No.:** **US 9,502,776 B2**  
(45) **Date of Patent:** **Nov. 22, 2016**

(54) **ANTENNA SURROUNDED BY METAL HOUSING**

(71) Applicants: **Carlo Di Nallo**, Plantation, FL (US);  
**Simone Paulotto**, Rockville, MD (US)

(72) Inventors: **Carlo Di Nallo**, Plantation, FL (US);  
**Simone Paulotto**, Rockville, MD (US)

(73) Assignee: **MAXTENA**

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 385 days.

(21) Appl. No.: **13/841,744**

(22) Filed: **Mar. 15, 2013**

(65) **Prior Publication Data**  
US 2014/0111388 A1 Apr. 24, 2014

**Related U.S. Application Data**  
(60) Provisional application No. 61/621,910, filed on Apr. 9, 2012, provisional application No. 61/767,773, filed on Feb. 21, 2013.

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 9/42** (2006.01)  
**H01Q 5/00** (2015.01)  
**H01Q 13/10** (2006.01)  
**H01Q 1/22** (2006.01)  
**H01Q 5/364** (2015.01)  
**H01Q 5/378** (2015.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 13/106** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/364** (2015.01); **H01Q 5/378** (2015.01); **H01Q 9/42** (2013.01); **H01Q 13/10** (2013.01)

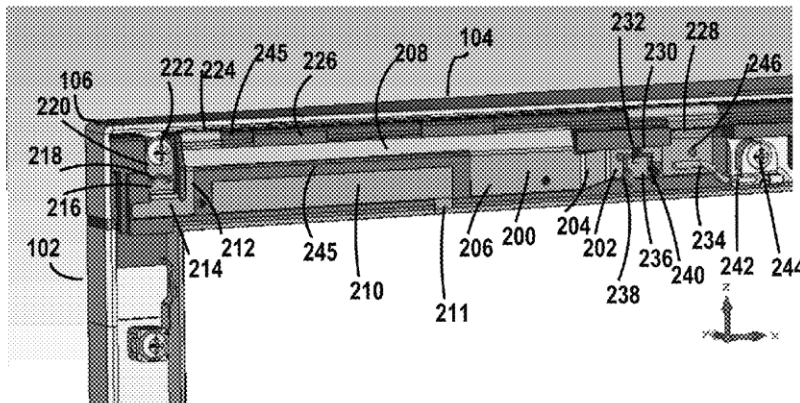
(58) **Field of Classification Search**  
CPC .... H01Q 1/2258; H01Q 1/2266; H01Q 1/24; H01Q 1/241; H01Q 1/242; H01Q 1/243; H01Q 1/44; H01Q 5/278; H01Q 5/385; H01Q 5/392; H01Q 9/0421; H01Q 13/10; H01Q 13/103; H01Q 13/106; H01Q 13/16; H01Q 13/18; H01Q 5/314; H01Q 5/328; H01Q 5/378  
USPC ..... 343/702  
See application file for complete search history.

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

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*Primary Examiner* — Sue A Purvis  
*Assistant Examiner* — Patrick Holecek

(57) **ABSTRACT**  
An antenna system includes a metal housing including a first edge and a second edge that meet at a corner and a slot located proximate the second edge that extends from the first edge parallel to the second edge defining a strip and an antenna located behind and in close proximity to the strip. The antenna is coupled to the strip. A parasitic element is located proximate the antenna and the strip includes a ground coupling that crosses the slot in spaced relation thereto. The parasitic element assists in establishing second and third higher frequency modes of the antenna system.

**21 Claims, 9 Drawing Sheets**





US009502772B2

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

(10) **Patent No.:** **US 9,502,772 B2**  
(45) **Date of Patent:** **Nov. 22, 2016**

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

USPC ..... 343/770  
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) Inventors: **Jin-Bo Chen**, New Taipei (TW);  
**Che-Yen Lin**, New Taipei (TW);  
**Cho-Kang Hsu**, New Taipei (TW)

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

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 420 days.

(21) Appl. No.: **14/061,929**

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(22) Filed: **Oct. 24, 2013**

TW 201132119 9/2011

(65) **Prior Publication Data**

US 2014/0354497 A1 Dec. 4, 2014

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(30) **Foreign Application Priority Data**

Jun. 4, 2013 (TW) ..... 102119701 A

*Primary Examiner* — Dameon E Levi  
*Assistant Examiner* — Hasan Islam  
(74) *Attorney, Agent, or Firm* — Zhigang Ma

(51) **Int. Cl.**  
**H01Q 13/10** (2006.01)  
**H01Q 5/378** (2015.01)  
**H01Q 9/42** (2006.01)  
**H01Q 1/24** (2006.01)  
**H01Q 5/371** (2015.01)

(57) **ABSTRACT**

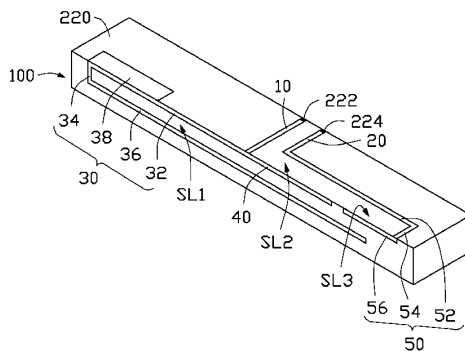
An antenna structure includes a feed section, a ground section, a first radiator, a second radiator, and a third radiator. The first radiator and the second radiator are both connected to the feed section. The third radiator is connected to the ground section. The first radiator defines a first slot. A second slot is defined between the second radiator and the third radiator. The third radiator defines a third slot. The third slot communicates with the second slot. Current is coupled from the first radiator and the second radiator to the third radiator via the first slot, the second slot, and the third slot.

(52) **U.S. Cl.**  
CPC ..... **H01Q 5/378** (2015.01); **H01Q 9/42** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 13/10; H01Q 9/42

**20 Claims, 3 Drawing Sheets**

200





US009509042B1

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

(10) **Patent No.:** **US 9,509,042 B1**  
(45) **Date of Patent:** **Nov. 29, 2016**

(54) **SINGLE FEED PASSIVE ANTENNA FOR A METAL BACK COVER**

(71) Applicant: **Amazon Technologies, Inc.**, Seattle, WA (US)  
(72) Inventors: **Ming Zheng**, Cupertino, CA (US); **Adrian Napoles**, Cupertino, CA (US); **Jerry Kuo**, San Jose, CA (US); **Khaled Obeidat**, Santa Clara, CA (US)

(73) Assignee: **Amazon Technologies, Inc.**, Seattle, WA (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.: **14/819,412**

(22) Filed: **Aug. 5, 2015**

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 1/48** (2006.01)  
**H01Q 5/307** (2015.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/307** (2015.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/243; H01Q 1/48; H01Q 5/307  
USPC ..... 343/702, 872, 846, 848, 700 MS  
See application file for complete search history.

(56) **References Cited**

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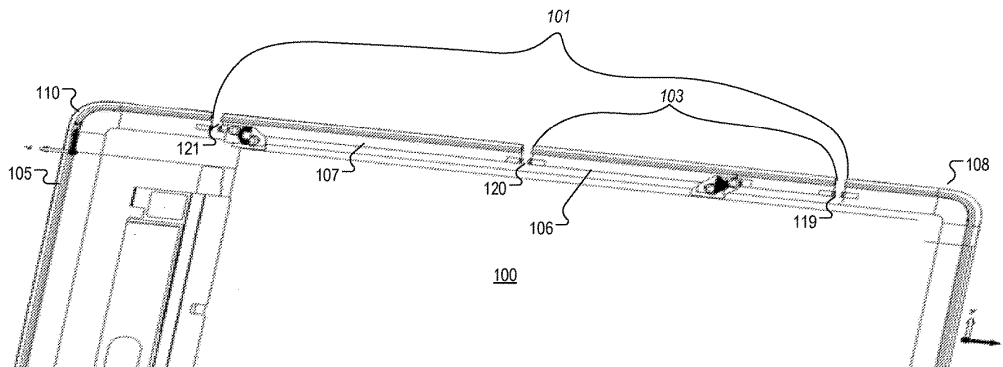
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*Primary Examiner* — Hoanganh Le  
(74) *Attorney, Agent, or Firm* — Lowenstein Sandler LLP

(57) **ABSTRACT**

Antenna structures and methods of operating the same are described. One apparatus includes a metal cover having a first corner ground element, a second corner ground element, a first strip element, a second strip element, a radio frequency (RF) feed, and a RF circuit. The first strip element is physically separated from the first corner ground element by a first cutout in the metal cover. The first strip element is physically separated from the second strip element by a second cutout in the metal cover. The second strip element is physically separated from the second corner ground element by a third cutout in the metal cover. The RF circuitry is coupled to the RF feed, where the RF circuitry is operable to cause the first corner ground element and the first strip element as well as the second corner ground element and the second strip element to radiate electromagnetic energy.

**20 Claims, 9 Drawing Sheets**





US009509048B2

(12) **United States Patent**  
**Kashiwagi**

(10) **Patent No.:** **US 9,509,048 B2**  
(45) **Date of Patent:** **Nov. 29, 2016**

(54) **ANTENNA APPARATUS AND ELECTRONIC DEVICE INCLUDING THE ANTENNA APPARATUS**

(71) Applicant: **KABUSHIKI KAISHA TOSHIBA**,  
Minato-ku, Tokyo (JP)

(72) Inventor: **Ippei Kashiwagi**, Tokyo (JP)

(73) Assignee: **KABUSHIKI KAISHA TOSHIBA**,  
Tokyo (JP)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 11 days.

(21) Appl. No.: **14/726,970**

(22) Filed: **Jun. 1, 2015**

(65) **Prior Publication Data**  
US 2016/0064818 A1 Mar. 3, 2016

**Related U.S. Application Data**

(60) Provisional application No. 62/043,280, filed on Aug. 28, 2014.

(51) **Int. Cl.**  
**H01Q 5/371** (2015.01)  
**H01Q 5/378** (2015.01)  
**H01Q 9/42** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 5/371** (2015.01); **H01Q 5/378** (2015.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 5/364; H01Q 5/371  
See application file for complete search history.

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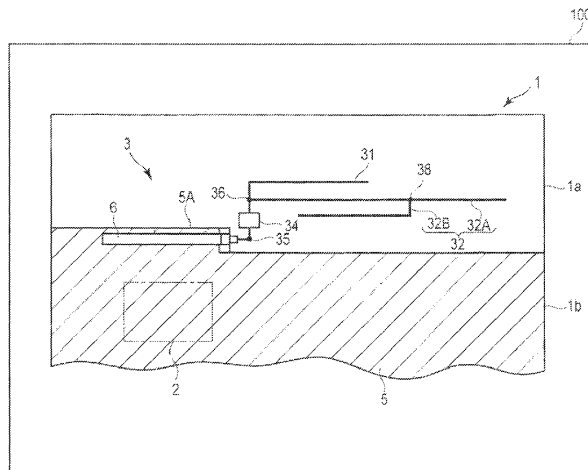
*Primary Examiner* — Robert Karacsony

(74) *Attorney, Agent, or Firm* — Foley & Lardner LLP

(57) **ABSTRACT**

According to one embodiment, an antenna includes a second element that has an end connected to a first point of a first element, and first and second ends kept open, and includes a first portion extending from a feed terminal to the first end, and a second portion extending from the feed terminal and bifurcated at a second point between the first point and the first end. The lengths of the first and second portions are set to substantially 1/4 of a resonance frequency, and substantially 3/4 of a resonance frequency, severally. The second portion includes a portion extending from the feed terminal to the second point, and a portion extending from the second point to the second end and interposed between the portion and a ground.

**10 Claims, 12 Drawing Sheets**





US009509814B1

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

(10) **Patent No.:** **US 9,509,814 B1**  
(45) **Date of Patent:** **Nov. 29, 2016**

(54) **MOBILE TERMINAL**

(71) Applicants: **Hua Jiang**, Shenzhen (CN); **Li Han**, Shenzhen (CN)

(72) Inventors: **Hua Jiang**, Shenzhen (CN); **Li Han**, 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.: **15/061,834**

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

(30) **Foreign Application Priority Data**

Jul. 31, 2015 (CN) ..... 2015 1 0460536

(51) **Int. Cl.**  
**H04M 1/00** (2006.01)  
**H04M 1/02** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H04M 1/0274** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H04M 1/0202; H04M 1/0249; H04M 1/0254; H04M 1/0274  
USPC ..... 455/575.1, 575.3, 575.4, 575.5, 90.3  
See application file for complete search history.

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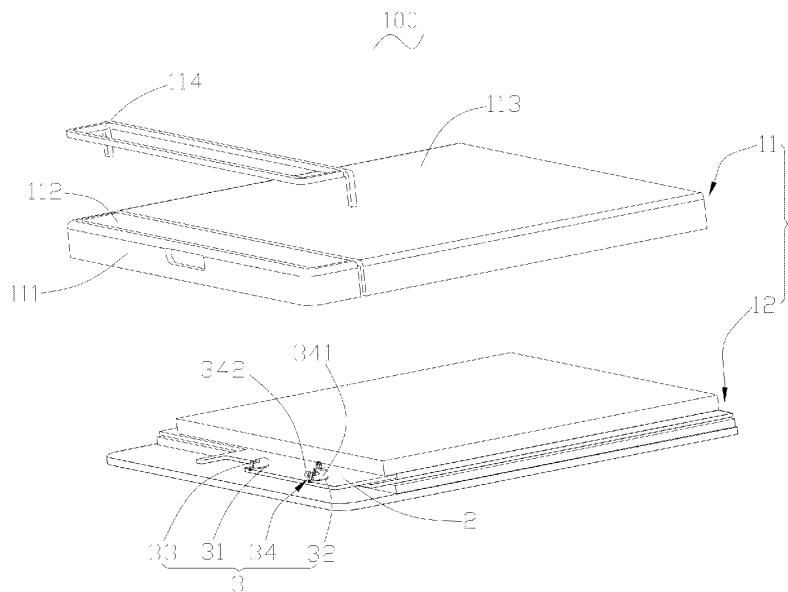
*Primary Examiner* — Tuan Pham

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

(57) **ABSTRACT**

A mobile terminal is disclosed. The mobile terminal includes a housing with an accommodation space, the housing including a metal rear cover serving as a radiator, the metal rear cover including a first metal part, a second metal part and a third metal part insulated to each other; a mainboard received in the accommodation space, the mainboard including a grounding part and a feed part; an antenna module including a grounding dynamic switch unit and a feed dynamic switch unit; wherein the grounding dynamic switch unit is connected between the grounding part and the first metal part, one end of the feed dynamic switch unit connects with the feed part, and the other end connects with the first metal part or the second metal part selectively.

**10 Claims, 8 Drawing Sheets**





US009515381B2

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

(10) **Patent No.:** **US 9,515,381 B2**  
(45) **Date of Patent:** **Dec. 6, 2016**

(54) **ANTENNA**

(71) Applicants: **LG INNOTEK CO., LTD.**, Seoul (KR); **INDUSTRY-UNIVERSITY COOPERATION FOUNDATION HANYANG UNIVERSITY**, Seoul (KR)

(72) Inventors: **Sae Won Oh**, Seoul (KR); **Hyeong Dong Kim**, Seoul (KR); **Sin Hyung Jeon**, Seoul (KR); **Bum Ki Park**, Seoul (KR); **Jin Hyuk Jang**, Seoul (KR)

(73) Assignee: **LG INNOTEK, CO., LTD.**, Seoul (KR)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 575 days.

(21) Appl. No.: **13/871,741**

(22) Filed: **Apr. 26, 2013**

(65) **Prior Publication Data**  
US 2013/0285872 A1 Oct. 31, 2013

(30) **Foreign Application Priority Data**  
Apr. 27, 2012 (KR) ..... 10-2012-0044991

(51) **Int. Cl.**  
**H01Q 5/00** (2015.01)  
**H01Q 1/24** (2006.01)  
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(52) **U.S. Cl.**  
CPC ..... **H01Q 5/0041** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/335** (2015.01); **H01Q 5/357** (2015.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 5/335; H01Q 5/357; H01Q 5/371; H01Q 5/314  
See application file for complete search history.

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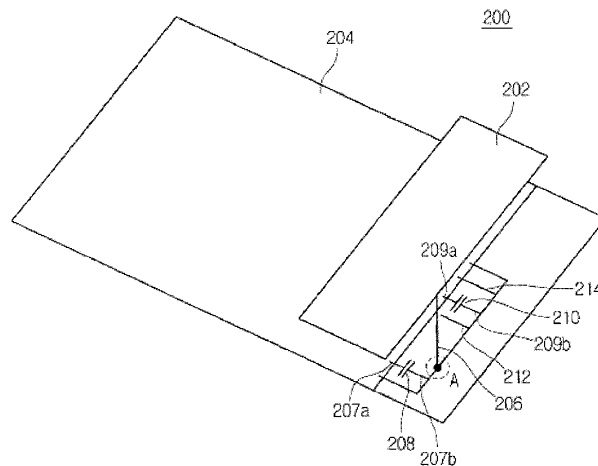
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*Primary Examiner* — Sue A Purvis  
*Assistant Examiner* — Daniel J Munoz  
(74) *Attorney, Agent, or Firm* — Saliwanchik, Lloyd & Eisenschenk

(57) **ABSTRACT**  
An antenna according to an embodiment includes a substrate; a radiator; a ground plane spaced apart from the radiator; a feeding pin for feeding an RF signal; a first branch reactance at one side of the feeding pin, the first branch reactance including one end connected to the substrate and an opposite end connected to the ground plane; and a second branch reactance at an opposite end of the feeding pin, the second branch reactance including one end connected to the substrate and an opposite end connected to the ground plane.

**11 Claims, 3 Drawing Sheets**





US009520641B2

(12) **United States Patent**  
**Lin**

(10) **Patent No.:** **US 9,520,641 B2**  
(45) **Date of Patent:** **Dec. 13, 2016**

(54) **ANTENNA ASSEMBLY AND ELECTRONIC DEVICE USING THE ANTENNA ASSEMBLY**

USPC ..... 343/700 MS, 702, 829, 846, 848  
See application file for complete search history.

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

(56) **References Cited**

(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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				343/700 MS
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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 508 days.

(21) Appl. No.: **14/014,633**

(22) Filed: **Aug. 30, 2013**

(65) **Prior Publication Data**

US 2014/0313098 A1 Oct. 23, 2014

(30) **Foreign Application Priority Data**

Apr. 23, 2013 (TW) ..... 102114467 A

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 9/42** (2006.01)  
**H01Q 5/378** (2015.01)  
**H01Q 5/392** (2015.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 5/378** (2015.01); **H01Q 5/392** (2015.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/234; H01Q 5/378; H01Q 5/392; H01Q 9/42

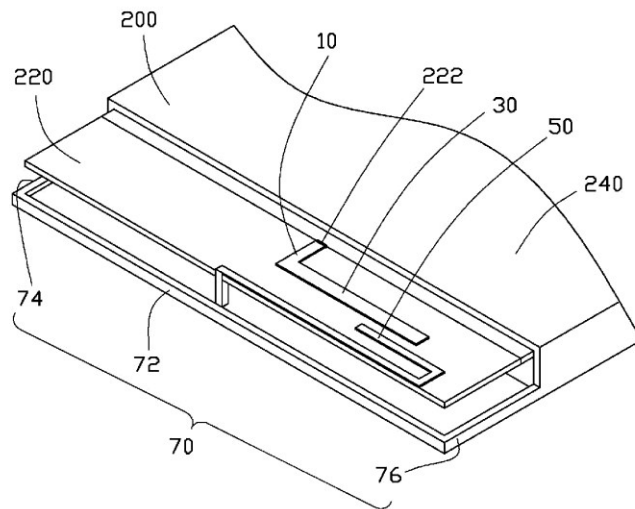
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*Primary Examiner* — Tho G Phan  
(74) *Attorney, Agent, or Firm* — Zhigang Ma

(57) **ABSTRACT**

An antenna assembly which can be adapted for the metal housing of any wireless device includes a feeding terminal, a first radiator connecting to the feeding terminal, a second radiator positioned parallel and adjacent to the first radiator, and a metal element connecting to the second radiator. The wireless signal fed to the first radiator can be coupled to the second radiator, and flows through the metal element to ground, thus utilizing the metal housing itself in the wireless transmission and reception process. An electronic device using the antenna assembly is also described.

**13 Claims, 6 Drawing Sheets**





US009520650B2

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

(10) **Patent No.:** **US 9,520,650 B2**  
(45) **Date of Patent:** **Dec. 13, 2016**

(54) **COMBINATION LTE AND WIGIG ANTENNA**

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

(72) Inventors: **Songnan Yang**, San Jose, CA (US);  
**Helen K. Pan**, Portland, OR (US);  
**Manish A. Hiranandanl**, Santa Clara, CA (US);  
**Fan (Cherry) Xia**, Shanghai (CN);  
**Ulun Karacaoglu**, San Diego, CA (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 218 days.

(21) Appl. No.: **14/230,316**

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

(65) **Prior Publication Data**

US 2015/0280318 A1 Oct. 1, 2015

(51) **Int. Cl.**  
**H01Q 9/40** (2006.01)  
**H01Q 21/00** (2006.01)  
**H01Q 5/378** (2015.01)  
**H01Q 5/40** (2015.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 9/40** (2013.01); **H01Q 5/378** (2015.01); **H01Q 5/40** (2015.01); **H01Q 21/00** (2013.01)

(58) **Field of Classification Search**

CPC ..... H01Q 9/40; H01Q 5/378  
USPC ..... 343/700 MS, 725, 729, 893, 702  
See application file for complete search history.

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				343/700 MS
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				343/700 MS
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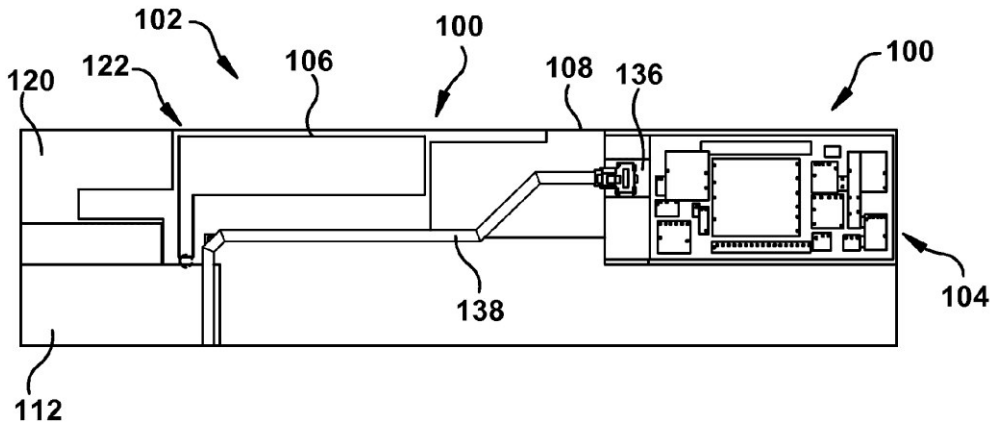
*Primary Examiner* — Hoanganh Le

(74) *Attorney, Agent, or Firm* — Eschweiler & Associates, LLC

(57) **ABSTRACT**

A combined antenna device includes a coupled feed antenna including a first grounded coupling element and a millimeter wave phased array antenna having a ground plane structure including a portion of the first grounded coupling element.

**16 Claims, 3 Drawing Sheets**







US009521222B1

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

(10) **Patent No.:** **US 9,521,222 B1**  
(45) **Date of Patent:** **Dec. 13, 2016**

(54) **MOBILE COMMUNICATION DEVICE**  
(71) Applicant: **Acer Incorporated**, New Taipei (TW)  
(72) Inventors: **Hsin-Wu Chiang**, New Taipei (TW);  
**Wan-Chu Wei**, New Taipei (TW);  
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**Pei-Yuan Chiu**, 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.

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*Primary Examiner* — Shahriar Behnamian

(74) *Attorney, Agent, or Firm* — Jianq Chyun IP Office

(21) Appl. No.: **15/057,125**  
(22) Filed: **Mar. 1, 2016**  
(30) **Foreign Application Priority Data**  
Nov. 25, 2015 (TW) ..... 104139251 A

(51) **Int. Cl.**  
**H04M 1/00** (2006.01)  
**H04M 1/02** (2006.01)  
**H01Q 1/24** (2006.01)  
**H04W 88/02** (2009.01)

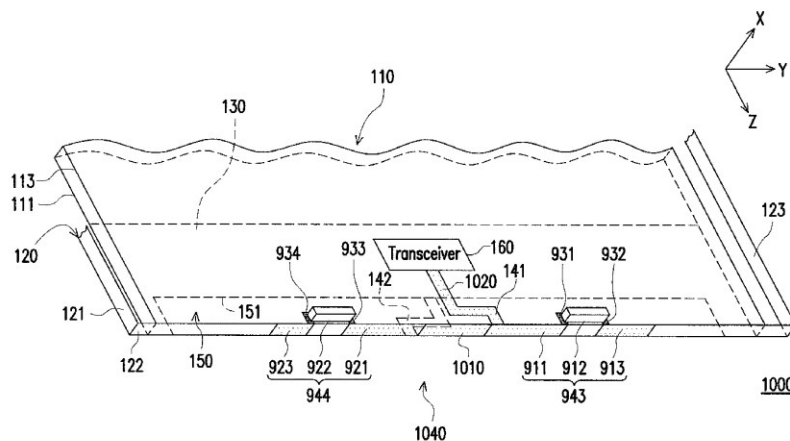
(52) **U.S. Cl.**  
CPC ..... **H04M 1/026** (2013.01); **H01Q 1/243** (2013.01); **H04W 88/02** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H04M 1/026; H01Q 1/243; H04W 88/02  
USPC ..... 455/575.5, 575.7  
See application file for complete search history.

(56) **References Cited**  
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(57) **ABSTRACT**  
A mobile communication device includes a substrate, a frame, a ground plane, and an antenna element. The substrate includes a first surface and a side wall. The frame includes a frame portion adjacent to the side wall. The ground plane is arranged on the first surface and includes a notch. An opening of the notch faces the frame portion. The antenna element includes a first radiation portion having a feeding point, a second radiation portion electrically connected to the ground plane, a third radiation portion electrically connected to the first radiation portion, and a fourth radiation portion electrically connected to the second radiation portion. Orthogonal projections of the first and second radiation portions on the first surface are located in the notch of the ground plane, and the third and fourth radiation portions are located on the frame portion or the side wall of the substrate.

**10 Claims, 7 Drawing Sheets**





US009524602B2

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

(10) **Patent No.:** **US 9,524,602 B2**  
(45) **Date of Patent:** **Dec. 20, 2016**

(54) **COMPACT ANTENNA STRUCTURE WITH A COUPLING DEVICE**

(71) Applicant: **CONTINENTAL AUTOMOTIVE GMBH**, Hannover (DE)

(72) Inventors: **Guy-Aymar Chakam**, Regensburg (DE); **Martin Weinberger**, Munich (DE)

(73) Assignee: **CONTINENTAL AUTOMOTIVE GMBH**, Hanover (DE)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 129 days.

(21) Appl. No.: **14/369,950**

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

(86) PCT No.: **PCT/EP2012/076129**

§ 371 (c)(1),  
(2) Date: **Sep. 18, 2014**

(87) PCT Pub. No.: **WO2013/098151**

PCT Pub. Date: **Jul. 4, 2013**

(65) **Prior Publication Data**

US 2015/0042452 A1 Feb. 12, 2015

(30) **Foreign Application Priority Data**

Dec. 29, 2011 (DE) ..... 10 2011 090 139

(51) **Int. Cl.**  
**G08B 21/00** (2006.01)  
**G07C 9/00** (2006.01)  
(Continued)

(52) **U.S. Cl.**  
CPC ..... **G07C 9/00944** (2013.01); **G07C 9/00007** (2013.01); **H01Q 1/3241** (2013.01);  
(Continued)

(58) **Field of Classification Search**

CPC ..... G07C 2009/00769; G07C 9/00007;  
G07C 9/00944; H04B 1/03; H01Q 9/26  
USPC ..... 340/5.64  
See application file for complete search history.

(56) **References Cited**

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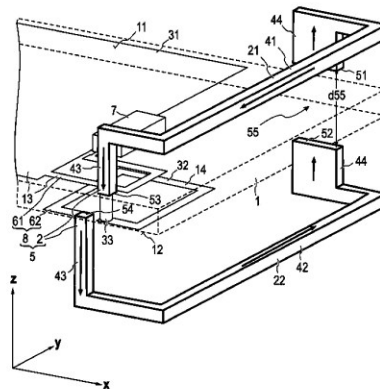
*Primary Examiner* — Mark Rushing

(74) *Attorney, Agent, or Firm* — Slayden Grubert Beard PLLC

(57) **ABSTRACT**

A transmission arrangement for a radio station of an access system may include a printed circuit board with an upper main surface and a first metallization plane in which conducting paths are formed. A drive circuit for supplying a frequency signal and an antenna structure are also provided. The antenna structure includes a coupling device, a conductor structure and a continuous, electrically conductive path having first and second ends opposite each other. The coupling device is configured to couple a frequency signal supplied by the drive circuit into the conductor structure. The first and/or second ends form end(s) of the conductor

(Continued)





US009525208B2

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

(10) **Patent No.:** **US 9,525,208 B2**  
(45) **Date of Patent:** **Dec. 20, 2016**

(54) **MULTIBAND ANTENNA**

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

(72) Inventors: **I-Shan Chen**, Hsinchu (TW);  
**Chia-Hong Lin**, Hsinchu (TW);  
**Yu-Chun Huang**, Hsinchu (TW);  
**Hsin-Lung Hsiao**, 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 115 days.

(21) Appl. No.: **14/155,383**

(22) Filed: **Jan. 15, 2014**

(65) **Prior Publication Data**  
US 2015/0048989 A1 Feb. 19, 2015

(30) **Foreign Application Priority Data**  
Aug. 19, 2013 (TW) ..... 102129691 A

(51) **Int. Cl.**  
**H01Q 5/00** (2015.01)  
**H01Q 9/42** (2006.01)  
(Continued)

(52) **U.S. Cl.**  
CPC ..... **H01Q 5/321** (2015.01); **H01Q 5/378** (2015.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 5/30; H01Q 5/307; H01Q 5/342; H01Q 5/378; H01Q 5/385; H01Q 5/40; H01Q 5/50; H01Q 19/005; H01Q 19/22; H01Q 19/26; H01Q 19/28; H01Q 19/32; H01Q 5/357; H01Q 5/392; H01Q 9/04; H01Q 9/0407; H01Q 9/0421; H01Q 9/045; H01Q 9/0457; H01Q 9/30  
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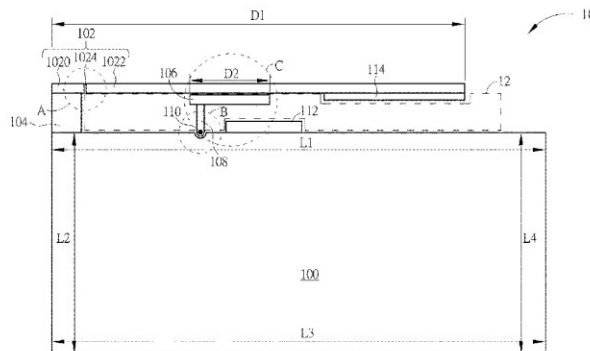
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*Primary Examiner* — Sue A Purvis  
*Assistant Examiner* — Patrick Holecek  
(74) *Attorney, Agent, or Firm* — Winston Hsu; Scott Margo

(57) **ABSTRACT**

A multiband antenna for receiving or transmitting wireless signals of a plurality of frequency bands includes a grounding sheet, formed with a hole at a first side, for providing grounding, a first micro-strip line, substantially parallel to the first side of the grounding sheet, a connecting unit, connecting to the first side of the grounding sheet and the first micro-strip line, for forming a resonant cavity with the first side of the grounding sheet and the first micro-strip line, a second micro-strip line, formed in the resonant cavity and substantially parallel to the first micro-strip line, a third micro-strip line, extending from the hole of the grounding sheet to the second micro-strip line, and a feed-in terminal, formed on the third micro-strip line within the hole, for transmitting the wireless signals.

**9 Claims, 9 Drawing Sheets**





US009525761B1

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

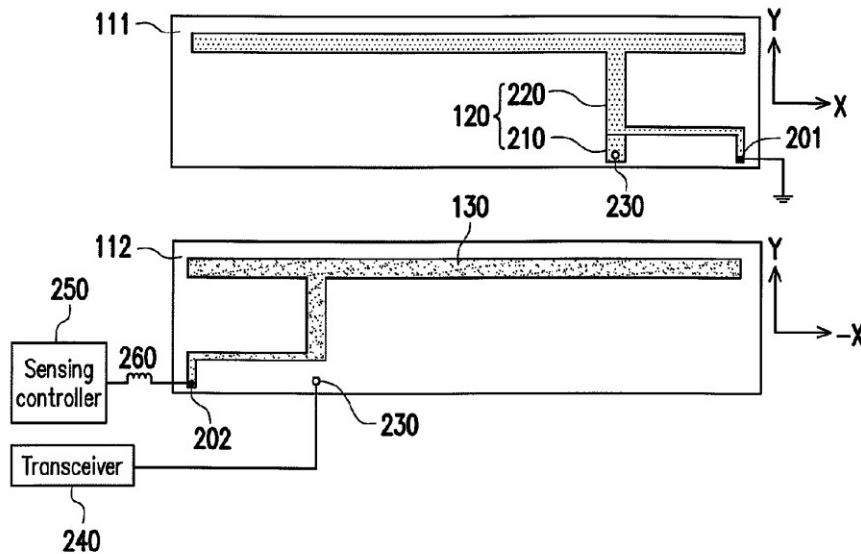
(10) **Patent No.:** **US 9,525,761 B1**  
(45) **Date of Patent:** **Dec. 20, 2016**

- (54) **MOBILE COMMUNICATION DEVICE**
- (71) Applicant: **Acer Incorporated**, New Taipei (TW)
- (72) Inventors: **Kun-Sheng Chang**, New Taipei (TW);  
**Ching-Chi Lin**, 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.: **14/958,912**
- (22) Filed: **Dec. 3, 2015**
- (30) **Foreign Application Priority Data**  
Sep. 4, 2015 (TW) ..... 104129400 A
- (51) **Int. Cl.**  
**H04M 1/00** (2006.01)  
**H04M 1/02** (2006.01)  
**H04B 1/3827** (2015.01)
- (52) **U.S. Cl.**  
CPC ..... **H04M 1/02** (2013.01); **H04B 1/3838** (2013.01)
- (58) **Field of Classification Search**  
CPC ..... H01Q 1/242-1/245; H01Q 1/084;  
H04B 1/3833; H04B 1/3838  
USPC ..... 455/90.1, 90.3, 550.1, 575.1,  
575.5, 455/575.7, 333  
See application file for complete search history.

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- Primary Examiner* — Nhan Le  
(74) *Attorney, Agent, or Firm* — Jianq Chyun IP Office

(57) **ABSTRACT**  
A mobile communication device including a substrate, an antenna element and a sensing element is provided. The substrate includes a first surface and a second surface opposite to each other. The antenna element is disposed on the first surface and converts a feeding signal into an electromagnetic wave. The antenna element includes a first portion receiving the feeding signal and a second portion electrically connected to a ground. The sensing element is disposed on the second surface and generates a sensing signal in response to proximity of an object. An orthogonal projection of the sensing element on the first surface and an orthogonal projection of the second portion on the first surface are overlapped with each other and have the same shape.

**10 Claims, 4 Drawing Sheets**





US009525762B2

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

(10) **Patent No.:** **US 9,525,762 B2**  
(45) **Date of Patent:** **Dec. 20, 2016**

(54) **MOBILE TERMINAL HAVING ANTENNA**

(2013.01); **H01Q 1/48** (2013.01); **H01Q 1/52**  
(2013.01); **H01Q 13/16** (2013.01); **H04B**  
**1/3838** (2013.01)

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

(58) **Field of Classification Search**

(72) Inventors: **Oh Yong Kwon**, Hwaseong-si (KR);  
**Jeon Il Lee**, Suwon-si (KR)

CPC ..... G06K 19/077  
USPC ..... 455/274  
See application file for complete search history.

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

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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 56 days.

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(21) Appl. No.: **14/511,533**

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(22) Filed: **Oct. 10, 2014**

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(65) **Prior Publication Data**

US 2015/0024810 A1 Jan. 22, 2015

**Related U.S. Application Data**

(63) Continuation of application No. 13/404,281, filed on  
Feb. 24, 2012, now Pat. No. 8,880,132.

*Primary Examiner* — Vladimir Magloire  
*Assistant Examiner* — Randy Peaches  
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(30) **Foreign Application Priority Data**

Sep. 23, 2011 (KR) ..... 10-2011-0096203

(57) **ABSTRACT**

A mobile terminal that can prevent radiation performance deterioration of an antenna is provided. The mobile terminal includes a circuit board in which an antenna and one or more key buttons are mounted, a housing mounted on the antenna and the circuit board, and a case for enclosing a periphery of the one or more key buttons and having a plurality of openings according to the quantity of the key buttons, wherein an antenna adjacent opening among the plurality of openings is extended through a slot toward an edge of the case to embody a loop antenna. Therefore, radiation deterioration of an antenna due to a case can be prevented. In addition, production costs can be minimized, and a desired external appearance of the mobile terminal is not compromised.

(51) **Int. Cl.**

**H04B 7/00** (2006.01)  
**H04M 1/02** (2006.01)  
**H01Q 1/24** (2006.01)  
**H01Q 1/48** (2006.01)  
**H01Q 1/52** (2006.01)  
**H01Q 13/16** (2006.01)  
**H04B 1/3827** (2015.01)

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

CPC ..... **H04M 1/0202** (2013.01); **H01Q 1/243**

**22 Claims, 12 Drawing Sheets**

