



US009660326B2

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

(10) **Patent No.:** **US 9,660,326 B2**
(45) **Date of Patent:** **May 23, 2017**

(54) **CONDUCTIVE LOOP ANTENNAS**

(71) Applicant: **Galtronics Corporation Ltd.**, Tempe, AZ (US)

(72) Inventors: **Matti Martiskainen**, Tiberias (IL); **Jongmin Na**, Suwon-si (KR); **Eeungyu Bae**, Suwon-si (KR); **Taihong Kim**, Busan (KR)

(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.: **14/601,799**

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

(65) **Prior Publication Data**

US 2015/0207211 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.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 21/30 (2006.01)
H01Q 7/00 (2006.01)
H01Q 5/371 (2015.01)
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** (2013.01); **H01Q 9/42** (2013.01); **H01Q 13/10** (2013.01); **H01Q 21/30** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 5/364; H01Q 7/00; H01Q 21/30; H01Q 5/307
See application file for complete search history.

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Primary Examiner — Hoang Nguyen

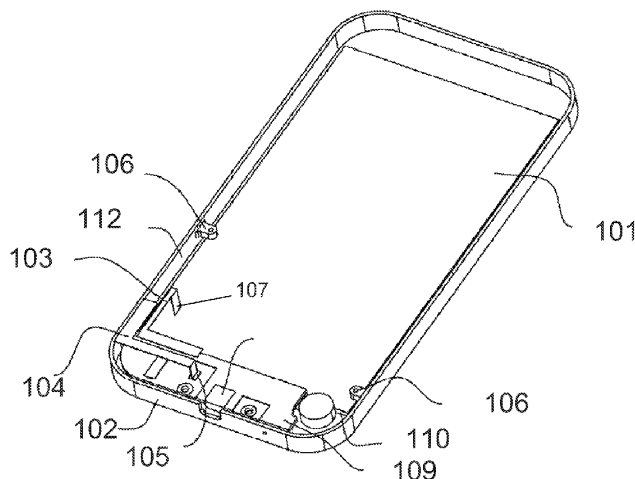
Assistant Examiner — Michael Bouizza

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

(57) **ABSTRACT**

A antenna for a wireless device is provided. The antenna may include a dielectric substrate, a counterpoise disposed on the dielectric substrate, a first conductive element electrically connected to the counterpoise, and a second conductive element electrically connected to a feed point. The first conductive element may form at least a portion of a radiating loop resonant at a first frequency, and the second conductive element may form at least a portion of a radiating spur resonant at a second frequency higher than the first frequency. The antenna may further include a conductive frame constituting at least a portion of the radiating loop or the radiating spur.

22 Claims, 7 Drawing Sheets





US009660329B2

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

(10) **Patent No.:** **US 9,660,329 B2**
(45) **Date of Patent:** **May 23, 2017**

(54) **DIRECTIONAL ANTENNA**

(71) Applicants: **Ting-Yi Lin**, Taipei (TW); **Tsung-Hsun Hsieh**, Taipei (TW); **Chi-Hsien Chiu**, Taipei (TW); **Yu-Chia Chang**, Taipei (TW)

(72) Inventors: **Ting-Yi Lin**, Taipei (TW); **Tsung-Hsun Hsieh**, Taipei (TW); **Chi-Hsien Chiu**, 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 320 days.

(21) Appl. No.: **14/048,042**

(22) Filed: **Oct. 8, 2013**

(65) **Prior Publication Data**

US 2014/0111399 A1 Apr. 24, 2014

Related U.S. Application Data

(60) Provisional application No. 61/715,307, filed on Oct. 18, 2012.

(30) **Foreign Application Priority Data**

Aug. 2, 2013 (CN) 2013 1 0334918

(51) **Int. Cl.**
H01Q 11/00 (2006.01)
H01Q 1/36 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/36** (2013.01); **H01Q 1/243** (2013.01); **H01Q 9/16** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/36; H01Q 19/30; H01Q 19/005; H01Q 1/246; H01Q 5/378
(Continued)

(56) **References Cited**

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Primary Examiner — Graham Smith

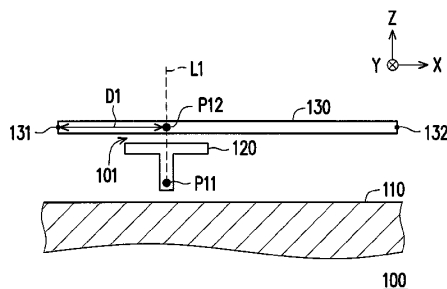
Assistant Examiner — Collin Dawkins

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

(57) **ABSTRACT**

A directional antenna including a ground plane, a feeding element and a radiating element is provided. The feeding element is adjacent to the ground plane and includes a feeding point. A coupling gap is formed between the radiating element and the feeding element, and the radiating element includes a coupling point. Both the coupling point of the radiating element and the feeding point of the feeding element are at the perpendicular line of a ground plane. Further, a distance between the coupling point and an open end of the radiating element is smaller than 0.16λ of a resonant frequency of the directional antenna.

6 Claims, 4 Drawing Sheets





US009660335B2

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

(10) **Patent No.:** **US 9,660,335 B2**
(45) **Date of Patent:** **May 23, 2017**

(54) **ANTENNA SYSTEM AND A COMMUNICATION DEVICE**

(71) Applicant: **Climax Technology Co., LTD.**, Taipei (TW)
(72) Inventors: **Cheng-Wei Chen**, Taipei (TW);
Meng-Chih Lin, Taipei (TW);
Dau-Chyrh Chang, Taipei (TW)
(73) Assignee: **Climax Technology Co., Ltd.**, Taipei (TW)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 44 days.

(21) Appl. No.: **14/825,955**

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

(65) **Prior Publication Data**
US 2017/0012353 A1 Jan. 12, 2017

(30) **Foreign Application Priority Data**
Jul. 8, 2015 (TW) 104122174 A

(51) **Int. Cl.**
H01Q 1/48 (2006.01)
H01Q 9/42 (2006.01)
H01Q 19/22 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 1/48** (2013.01); **H01Q 9/42** (2013.01); **H01Q 19/22** (2013.01)
(58) **Field of Classification Search**
CPC H01Q 1/48; H01Q 1/38; H01Q 1/24
USPC 343/848, 860, 700 MS, 876
See application file for complete search history.

(56) **References Cited**

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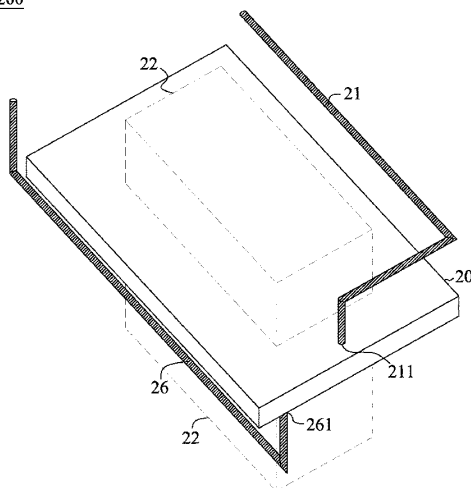
Primary Examiner — Huedung Mancuso
(74) *Attorney, Agent, or Firm* — Donald E. Stout; Stout, Uxa & Buyan, LLP

(57) **ABSTRACT**

An antenna system includes a monopole antenna with a first end connected to a feed point on a printed circuit board (PCB) and a second end being electrically floating; and a matching conductive stub with a first end connected to a ground point on the PCB and a second end being electrically floating.

24 Claims, 8 Drawing Sheets

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US009660347B2

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

(10) **Patent No.:** **US 9,660,347 B2**

(45) **Date of Patent:** **May 23, 2017**

(54) **PRINTED COUPLED-FED MULTI-BAND ANTENNA AND ELECTRONIC SYSTEM**

(71) Applicant: **ARCADYAN TECHNOLOGY CORPORATION**, Hsinchu (TW)

(72) Inventors: **Jian-Jhih Du**, Taipei (TW); **Jing-Teng Chang**, Hsinchu County (TW)

(73) Assignee: **ARCADYAN TECHNOLOGY CORPORATION**, Hsinchu (TW)

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

(21) Appl. No.: **14/846,852**

(22) Filed: **Sep. 7, 2015**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Apr. 8, 2015 (TW) 104111239 A

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 9/06 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 9/0457** (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 9/0442; H01Q 9/0457; H01Q 9/065; H01Q 9/42; H01Q 1/38
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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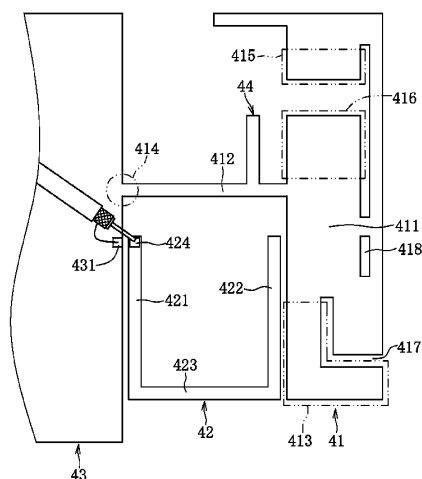
Primary Examiner — Hoang Nguyen

(74) *Attorney, Agent, or Firm* — Li & Cai Intellectual Property (USA) Office

(57) **ABSTRACT**

The disclosure is related to a printed coupled-fed multi-band antenna, and a related electronic system. The antenna includes a first antenna member structurally with a mushroom-shaped radiation portion and an antenna connection portion being electrically connected with a ground plane. The mushroom-shaped radiation portion is employed to activate first band electromagnetic wave. The antenna includes a second antenna member, which may be shaped as a U-shaped radiation portion. The second antenna member is floating within a region surrounded by the mushroom-shaped radiation portion, the antenna connection portion and the ground plane. The U-shaped radiation portion is coupled with both the ground plane and the mushroom-shaped radiation portion. The coupling effect allows the second antenna member to activate a second band electromagnetic wave. The multiple band signaling paths are formed over the printed antenna for application of a multi-band antenna.

15 Claims, 8 Drawing Sheets



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US009660346B2

(12) **United States Patent**
Wu

(10) **Patent No.:** **US 9,660,346 B2**
(45) **Date of Patent:** **May 23, 2017**

(54) **ANTENNA STRUCTURE**

(71) Applicant: **GETAC TECHNOLOGY CORPORATION**, Hsinchu County (TW)

(72) Inventor: **Jiun-Wei Wu**, Taipei (TW)

(73) Assignee: **Getac Technology Corporation**, Hsinchu County (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 121 days.

(21) Appl. No.: **14/270,314**

(22) Filed: **May 5, 2014**

(65) **Prior Publication Data**

US 2015/0318617 A1 Nov. 5, 2015

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

(52) **U.S. Cl.**
CPC **H01Q 9/0421** (2013.01); **H01Q 9/0428** (2013.01)

(58) **Field of Classification Search**

CPC .. H01Q 9/0407; H01Q 9/0421; H01Q 9/0428; H01Q 9/30; H01Q 9/42; H01Q 21/24; H01Q 25/001; H01Q 1/22; H01Q 1/2258; H01Q 1/2266; H01Q 1/2283; H01Q 1/2291; H01Q 1/24; H01Q 1/241; H01Q 1/243; H01Q 9/045; H01Q 9/0492; H01Q 9/0478; H01Q 11/14; H01Q 5/364; H01Q 5/371

USPC 343/702

See application file for complete search history.

(56) **References Cited**

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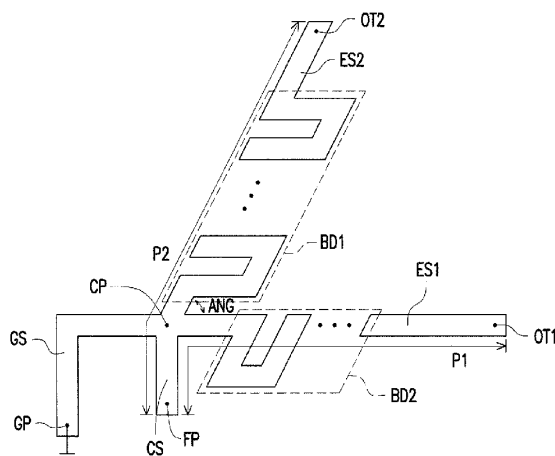
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Primary Examiner — Tho G Phan
Assistant Examiner — Patrick Holecek

(57) **ABSTRACT**

An antenna structure and an electronic device are provided. The antenna structure includes a connecting part, a grounding part, a first extending part and a second extending part. An angle is larger than zero between a first vector from the connecting point to the first open terminal and a second vector from the connecting point to the second open terminal. Also, a difference between the path length of a first path length and the path length of a second path length would be a quarter of the wave length of the radio frequency signal or a positive integer times thereof, so that the antenna is capable of receiving the radio frequency signal with circular polarizing.

15 Claims, 2 Drawing Sheets





US009660347B2

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

(10) **Patent No.:** **US 9,660,347 B2**

(45) **Date of Patent:** **May 23, 2017**

(54) **PRINTED COUPLED-FED MULTI-BAND ANTENNA AND ELECTRONIC SYSTEM**

(71) Applicant: **ARCADYAN TECHNOLOGY CORPORATION**, Hsinchu (TW)

(72) Inventors: **Jian-Jhih Du**, Taipei (TW); **Jing-Teng Chang**, Hsinchu County (TW)

(73) Assignee: **ARCADYAN TECHNOLOGY CORPORATION**, Hsinchu (TW)

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

(21) Appl. No.: **14/846,852**

(22) Filed: **Sep. 7, 2015**

(65) **Prior Publication Data**

US 2016/0301140 A1 Oct. 13, 2016

(30) **Foreign Application Priority Data**

Apr. 8, 2015 (TW) 104111239 A

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 9/06 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 9/0457** (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 9/0442; H01Q 9/0457; H01Q 9/065; H01Q 9/42; H01Q 1/38
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

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343/700 MS
8,378,897 B2 * 2/2013 Lai H01Q 9/42
343/700 MS

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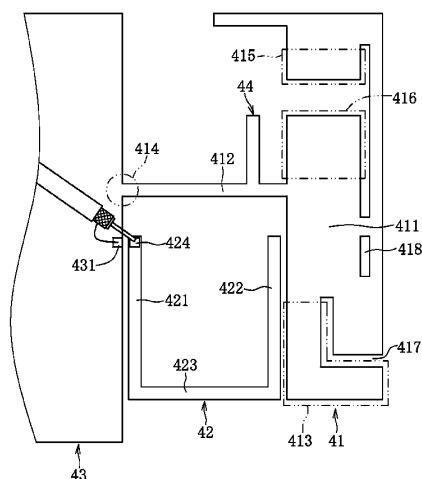
Primary Examiner — Hoang Nguyen

(74) *Attorney, Agent, or Firm* — Li & Cai Intellectual Property (USA) Office

(57) **ABSTRACT**

The disclosure is related to a printed coupled-fed multi-band antenna, and a related electronic system. The antenna includes a first antenna member structurally with a mushroom-shaped radiation portion and an antenna connection portion being electrically connected with a ground plane. The mushroom-shaped radiation portion is employed to activate first band electromagnetic wave. The antenna includes a second antenna member, which may be shaped as a U-shaped radiation portion. The second antenna member is floating within a region surrounded by the mushroom-shaped radiation portion, the antenna connection portion and the ground plane. The U-shaped radiation portion is coupled with both the ground plane and the mushroom-shaped radiation portion. The coupling effect allows the second antenna member to activate a second band electromagnetic wave. The multiple band signaling paths are formed over the printed antenna for application of a multi-band antenna.

15 Claims, 8 Drawing Sheets





US009660350B2

(12) **United States Patent**
Lo Hine Tong et al.

(10) **Patent No.:** **US 9,660,350 B2**

(45) **Date of Patent:** **May 23, 2017**

(54) **METHOD FOR CREATING A SLOT-LINE ON A MULTILAYER SUBSTRATE AND MULTILAYER PRINTED CIRCUIT COMPRISING AT LEAST ONE SLOT-LINE REALIZED ACCORDING TO SAID METHOD AND USED AS AN ISOLATING SLOT OR ANTENNA**

(71) Applicant: **THOMSON LICENSING**, Issy de Moulineaux (FR)

(72) Inventors: **Dominique Lo Hine Tong**, Rennes (FR); **Philippe Minard**, Saint Medarde sur Ille (FR); **Jean-Luc Robert**, Betton (FR)

(73) Assignee: **THOMSON LICENSING**, Issy-les-Moulineaux (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 117 days.

(21) Appl. No.: **14/400,382**

(22) PCT Filed: **May 6, 2013**

(86) PCT No.: **PCT/EP2013/059394**

§ 371 (c)(1),

(2) Date: **Nov. 11, 2014**

(87) PCT Pub. No.: **WO2013/171087**

PCT Pub. Date: **Nov. 21, 2013**

(65) **Prior Publication Data**

US 2015/0123861 A1 May 7, 2015

(30) **Foreign Application Priority Data**

May 14, 2012 (FR) 12 54368

(51) **Int. Cl.**

H01Q 13/10 (2006.01)

H05K 1/02 (2006.01)

(Continued)

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

CPC **H01Q 13/106** (2013.01); **H01P 3/023**

(2013.01); **H01Q 1/38** (2013.01); **H01Q 9/42**

(2013.01);

(Continued)

(58) **Field of Classification Search**

CPC H01Q 1/52; H01Q 1/521; H01Q 1/525

See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — Brian J. Dorini; Patricia A. Verlangieri

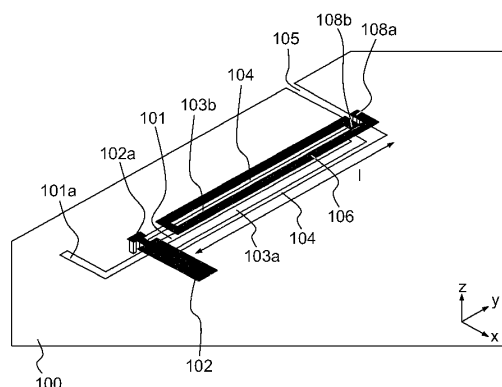
(57) **ABSTRACT**

The present invention relates to a method for realizing a short-circuited slot-line on a multilayer substrate comprising at least a first conductive layer, a dielectric layer and a second conductive layer, the method comprising the following steps:

etching in the first conductive layer a slot-line having an electrical length L ,

etching in the first conductive layer, around the slot-line, a first portion of a first band having an electrical length $L_1 \leq L$,

(Continued)





US009666934B2

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

(10) **Patent No.:** **US 9,666,934 B2**

(45) **Date of Patent:** **May 30, 2017**

(54) **ANTENNA LINK IN ULTRA-THIN DEVICE
WITH SINGLE-PIECE METAL HOUSING**

USPC 343/702, 745
See application file for complete search history.

(71) Applicant: **Motorola Mobility LLC**, Chicago, IL
(US)

(56) **References Cited**

(72) Inventors: **Michael J Lombardi**, Lake Zurich, IL
(US); **Mohammed Abdul-Gaffoor**,
Palatine, IL (US); **Joseph L Allore**,
Mundelein, IL (US); **Joshua D**
Boerman, Lake Zurich, IL (US); **Ugur**
Olgun, Waukegan, IL (US); **Abu T**
Sayem, Gurnee, IL (US)

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343/745

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

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 93 days.

Joseph L Allore, et al., "Single-Piece Metal Housing with Integral
Antennas", U.S. Appl. No. 14/613,406, filed Feb. 4, 2015.

(21) Appl. No.: **14/681,879**

* cited by examiner

(22) Filed: **Apr. 8, 2015**

Primary Examiner — Peguy Jean Pierre

(65) **Prior Publication Data**

US 2016/0301139 A1 Oct. 13, 2016

(74) *Attorney, Agent, or Firm* — Miller, Matthias & Hull
LLP

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/42 (2006.01)
H01Q 21/30 (2006.01)

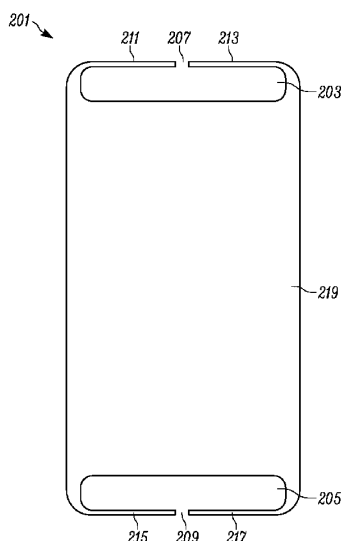
(57) **ABSTRACT**

An enhanced portable communication device includes a
one-piece metal back plate with integral antennas. The
one-piece metal back plate includes four integral antennas in
an embodiment, forming an antenna pair at each end of the
device. A printed circuit board (PCB) of the device is
configured to drive one or more of the antennas capacitively
or, in an embodiment, via a direct feed.

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

(58) **Field of Classification Search**
CPC H01Q 9/0407; H01Q 1/36

20 Claims, 12 Drawing Sheets





US009666935B2

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

(10) **Patent No.:** **US 9,666,935 B2**

(45) **Date of Patent:** ***May 30, 2017**

(54) **MOBILE WIRELESS COMMUNICATIONS
DEVICE ANTENNA ASSEMBLY WITH
ANTENNA ELEMENT AND FLOATING
DIRECTOR ELEMENT ON FLEXIBLE
SUBSTRATE AND RELATED METHODS**

(71) Applicant: **BLACKBERRY LIMITED**, Waterloo
(CA)

(72) Inventors: **Yihong Qi**, Waterloo (CA); **Ying Tong
Man**, Waterloo (CA); **Adrian Cooke**,
Kitchener (CA)

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

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

This patent is subject to a terminal dis-
claimer.

(21) Appl. No.: **15/048,074**

(22) Filed: **Feb. 19, 2016**

(65) **Prior Publication Data**

US 2016/0254593 A1 Sep. 1, 2016

Related U.S. Application Data

(63) Continuation of application No. 13/927,691, filed on
Jun. 26, 2013, now Pat. No. 9,300,035, which is a
(Continued)

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

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

CPC **H01Q 1/245** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 1/38** (2013.01); **H01Q**
9/0421 (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC H01Q 1/245; H01Q 1/243; H01Q 1/38;
H01Q 9/0421; H01Q 19/005

(Continued)

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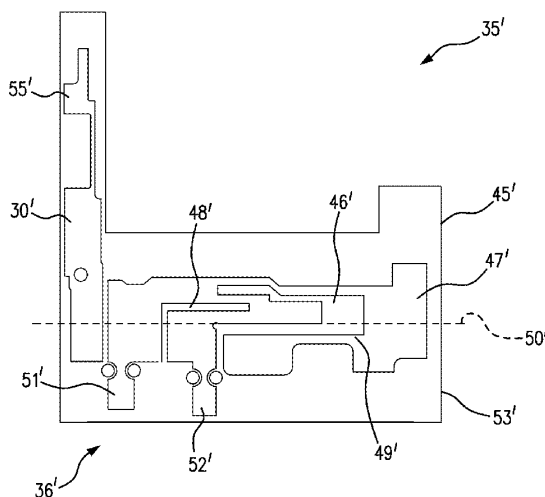
Primary Examiner — Dylan White

(74) *Attorney, Agent, or Firm* — Matthew Tropper;
Guntin & Gust, PLC

(57) **ABSTRACT**

A mobile wireless communications device may include a portable housing, a circuit board carried by the portable housing and having a ground plane thereon, wireless communications circuitry carried by the circuit board, and an antenna assembly carried by the housing. More particularly, the antenna assembly may include a flexible substrate, an electrically conductive antenna element on the flexible substrate and connected to the wireless communications circuitry and the ground plane, and a floating, electrically conductive director element on the flexible substrate for directing a beam pattern of the antenna element.

20 Claims, 7 Drawing Sheets





US009666939B2

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

(10) **Patent No.:** **US 9,666,939 B2**
(45) **Date of Patent:** **May 30, 2017**

(54) **ANTENNA BANDWIDTH EXPANDER**

(2015.01); **H04B 1/0458** (2013.01); **H04B 1/18** (2013.01); **H04B 1/40** (2013.01)

(71) Applicants: **JOINSET CO., LTD.**, Ansan-si, Kyeonggi-do (KR); **Sun-Ki Kim**, Gunpo-si, Kyeonggi-do (KR)

(58) **Field of Classification Search**
CPC .. H01Q 1/50; H01Q 1/24; H01Q 1/38; H01Q 5/314; H04B 1/18
USPC 455/77, 78, 87
See application file for complete search history.

(72) Inventors: **Jong-Cheol Yoon**, Ansan-si (KR); **Sun-Ki Kim**, Gunpo-si (KR); **In-Yeup Song**, Ansan-si (KR)

(56) **References Cited**

(73) Assignees: **Joinset Co., Ltd.** (KR); **Sun-Ki Kim** (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 0 days.

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2014/0009361 A1 * 1/2014 Kato H01Q 1/243 343/860

(21) Appl. No.: **14/987,212**

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

(65) **Prior Publication Data**

US 2016/0240918 A1 Aug. 18, 2016

(30) **Foreign Application Priority Data**

Feb. 17, 2015 (KR) 10-2015-0023812
Oct. 21, 2015 (KR) 10-2015-0146862

(51) **Int. Cl.**
H04B 1/40 (2015.01)
H01Q 1/50 (2006.01)
H01Q 1/24 (2006.01)
H04B 1/04 (2006.01)
H04B 1/18 (2006.01)
H01Q 1/38 (2006.01)
H01Q 5/314 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 1/50** (2013.01); **H01Q 1/24** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/314**

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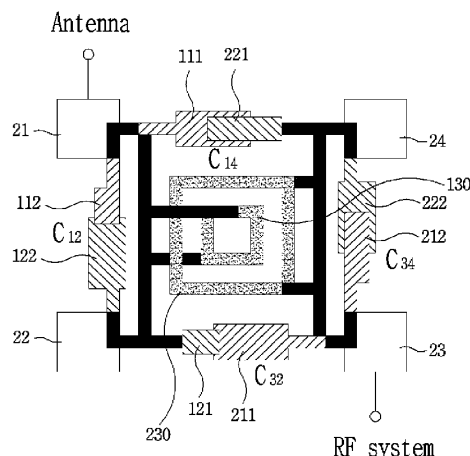
Primary Examiner — MD Talukder

(74) *Attorney, Agent, or Firm* — Park & Associates IP Law, P. C.

(57) **ABSTRACT**

Disclosed is an antenna bandwidth expander capable of improving transmission/reception performance of a wireless communication device by expanding a bandwidth of an antenna in which broadband frequency characteristics including various communication bands are necessary like an LTE smartphone. The antenna bandwidth expander may improve the transmission and reception performance of a terminal by easily and conveniently expanding a bandwidth of an antenna in first and second resonant frequency bands.

8 Claims, 13 Drawing Sheets





US009666945B2

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

(10) **Patent No.:** **US 9,666,945 B2**

(45) **Date of Patent:** **May 30, 2017**

(54) **MULTI-BAND ANTENNA AND APPARATUS AND METHOD FOR ADJUSTING OPERATING FREQUENCY OF THE MULTI-BAND ANTENNA IN A WIRELESS COMMUNICATION SYSTEM**

(75) Inventors: **Yong-Soo Kwak**, Suwon-si (KR); **Joon-Ho Byun**, Yongin-si (KR); **Seong-Tae Jeong**, Yongin-si (KR); **Bum-Jin Cho**, Hwaseong-si (KR); **Soon-Ho Hwang**, Seoul (KR); **Austin Kim**, Seongnam-si (KR); **Jae-Hoon Jo**, Seoul (KR); **Jae-Hyung Kim**, Seoul (KR); **A-Hyun Sin**, Busan (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 209 days.

(21) Appl. No.: **13/395,789**

(22) PCT Filed: **Sep. 17, 2010**

(86) PCT No.: **PCT/KR2010/006451**

§ 371 (c)(1),

(2), (4) Date: **Mar. 13, 2012**

(87) PCT Pub. No.: **WO2011/034391**

PCT Pub. Date: **Mar. 24, 2011**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Sep. 17, 2009 (KR) 10-2009-0088095

(51) **Int. Cl.**

H01Q 9/04 (2006.01)

H01Q 9/14 (2006.01)

H01Q 5/00 (2015.01)

H01Q 5/371 (2015.01)

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

CPC **H01Q 9/0421** (2013.01); **H01Q 5/371** (2015.01); **H01Q 9/145** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/0421; H01Q 9/145

USPC 343/700 MS, 702, 876

See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Graham Smith

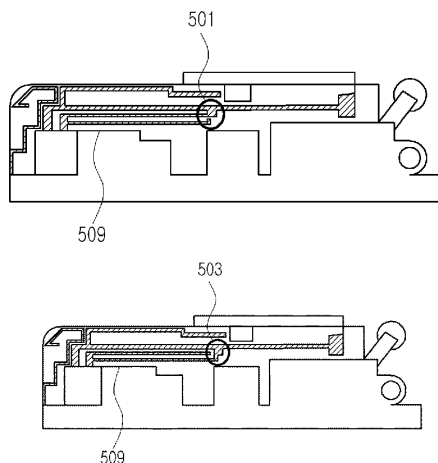
Assistant Examiner — Daniel J Munoz

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

(57) **ABSTRACT**

An apparatus and method for adjusting an operating frequency of a multi-band antenna and a system supporting the same in a wireless communication system are provided, in which a plurality of shorting pins spaced from a radiation patch by difference distances, and a switch connects one of the shorting pins to the radiation patch.

10 Claims, 8 Drawing Sheets





US009666946B1

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

(10) **Patent No.:** **US 9,666,946 B1**

(45) **Date of Patent:** **May 30, 2017**

(54) **FOUR ELEMENT RECONFIGURABLE
MIMO ANTENNA SYSTEM**

(71) Applicant: **KING FAHD UNIVERSITY OF
PETROLEUM AND MINERALS,**
Dhahran (SA)

(72) Inventors: **Mohammad S. Sharawi,** Dhahran
(SA); **Rifaqat Hussain,** Dhahran (SA)

(73) Assignee: **KING FAHD UNIVERSITY OF
PETROLEUM AND MINERALS,**
Dhahran (SA)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 13 days.

(21) Appl. No.: **14/940,118**

(22) Filed: **Nov. 12, 2015**

(51) **Int. Cl.**
H01Q 1/48 (2006.01)
H01Q 9/04 (2006.01)
H01Q 1/12 (2006.01)
H01Q 21/06 (2006.01)
H01Q 5/321 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0442** (2013.01); **H01Q 1/12**
(2013.01); **H01Q 1/48** (2013.01); **H01Q 5/321**
(2015.01); **H01Q 21/065** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/12; H01Q 1/48; H01Q 5/321
USPC 343/750
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Graham Smith

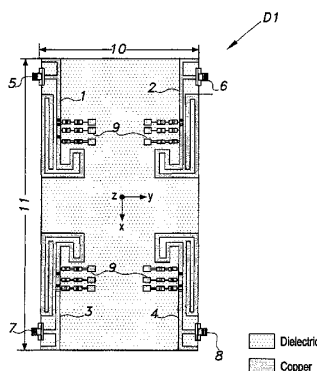
Assistant Examiner — Andrea Lindgren Baltzell

(74) *Attorney, Agent, or Firm* — Richard C. Litman

(57) **ABSTRACT**

The four element reconfigurable MIMO antenna system includes four conducting PIFA elements disposed on a top surface of a rectangular dielectric substrate. For each PIFA, an F-head portion of the PIFA defines two arms extending to a long peripheral edge of the substrate. An F-tail portion of the PIFA extends from a short peripheral edge of the substrate. A first PIFA and a second PIFA are mirror images of each other, and a third PIFA and a fourth PIFA are mirror images of each other. A meander pattern of conducting material extends from a bottom region of the F-tail portion of the PIFAs. For each PIFA, PIN/varactor diode bias circuits are disposed on the substrate's top surface, connecting to and extending away from a unique location on the F-tail portion of the PIFA, thereby creating separate radiating branches of the PIFA to achieve reconfigurability.

12 Claims, 13 Drawing Sheets





US009666951B2

(12) **United States Patent**
Wang

(10) **Patent No.:** **US 9,666,951 B2**

(45) **Date of Patent:** **May 30, 2017**

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

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

(72) Inventor: **Hanyang Wang**, Shenzhen (CN)

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

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 224 days.

(21) Appl. No.: **14/517,418**

(22) Filed: **Oct. 17, 2014**

(65) **Prior Publication Data**

US 2015/0048982 A1 Feb. 19, 2015

Related U.S. Application Data

(63) Continuation of application No.
PCT/CN2013/081193, filed on Aug. 9, 2013.

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

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 13/106** (2013.01); **H01Q 5/314**
(2015.01); **H01Q 5/357** (2015.01); **H01Q**
5/378 (2015.01); **H01Q 13/16** (2013.01);
H01Q 21/30 (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/357; H01Q 13/16; H01Q 5/314;
H01Q 5/378; H01Q 13/106; H01Q 21/30
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(56) **References Cited**

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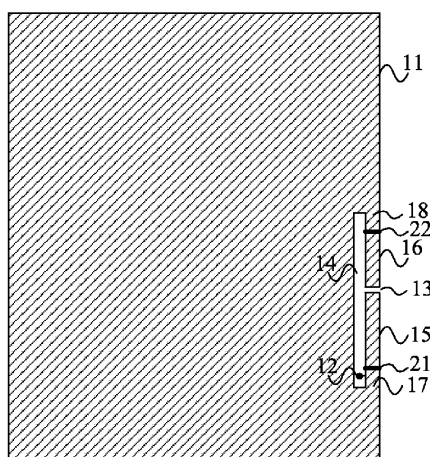
Primary Examiner — Hoanganh Le

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

(57) **ABSTRACT**

A printed circuit board antenna includes a printed circuit
board and a feedpoint that is disposed on the printed circuit
board. A copper coating is disposed on the printed circuit
board. A split is disposed on the copper coating on the
printed circuit board. The split is connected to a board edge
of the printed circuit board. A slot perpendicular to the split
is disposed on the copper coating on the printed circuit
board. The slot is connected to the split. The copper coating
at two sides of the split forms a first antenna and a second
antenna. The feedpoint is configured to, together with the
first antenna and the second antenna, form a first resonance
loop and a second resonance loop. Resonance frequencies of
the first resonance loop and the second resonance loop are
different.

20 Claims, 8 Drawing Sheets





US009667296B2

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

(10) **Patent No.:** **US 9,667,296 B2**

(45) **Date of Patent:** **May 30, 2017**

(54) **MOBILE TERMINAL HAVING AN ANTENNA**

(71) Applicant: **LG ELECTRONICS INC.**, Seoul
(KR)

(72) Inventors: **Changil Kim**, Seoul (KR); **Dongjin Kim**, Seoul (KR); **Yeomin Yoon**, Seoul (KR); **Hyeongsik Yoon**, Seoul (KR); **Jaegon Lee**, Seoul (KR); **Chisang You**, Seoul (KR)

(73) Assignee: **LG ELECTRONICS INC.**, Seoul
(KR)

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

(21) Appl. No.: **14/443,996**

(22) PCT Filed: **Dec. 16, 2013**

(86) PCT No.: **PCT/KR2013/011656**

§ 371 (c)(1),

(2) Date: **May 19, 2015**

(87) PCT Pub. No.: **WO2015/002359**

PCT Pub. Date: **Jan. 8, 2015**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jul. 5, 2013 (KR) 10-2013-0078880

Jul. 5, 2013 (KR) 10-2013-0078881

(51) **Int. Cl.**

H04B 1/38 (2015.01)

H04M 1/00 (2006.01)

(Continued)

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

CPC **H04B 1/3888** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 1/42** (2013.01); **H01Q 1/44**
(2013.01);

(Continued)

(58) **Field of Classification Search**

CPC **H04B 1/3888**; **H04B 15/005**; **H01Q 1/243**;
H01Q 1/42; **H01Q 1/44**; **H04M 1/0274**
See application file for complete search history.

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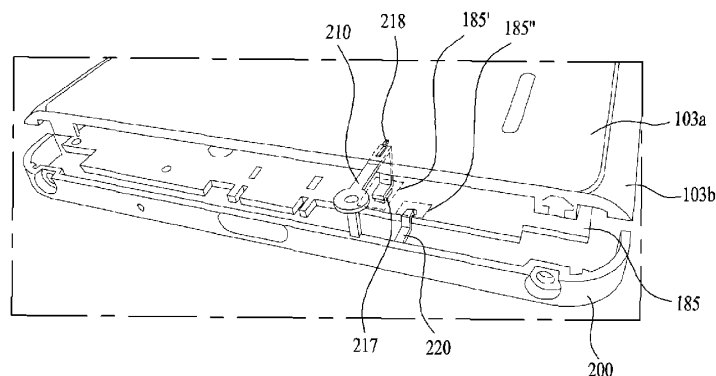
Primary Examiner — Nguyen Vo

(74) *Attorney, Agent, or Firm* — Lee, Hong, Degerman, Kang & Waimey

(57) **ABSTRACT**

A mobile terminal, comprises: a case including a conductive metal part; a main board mounted inside the case and having a power supply part and a ground surface; a first antenna radiator disposed so as to be spaced from the power supply part to the first antenna radiator; a power supply line for electrically connecting the power supply part to the first antenna radiator and ground line for electrically connecting

(Continued)





US009673507B2

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

(10) **Patent No.:** **US 9,673,507 B2**
(45) **Date of Patent:** **Jun. 6, 2017**

(54) **CHASSIS-EXCITED ANTENNA APPARATUS
AND METHODS**

(71) Applicant: **Pulse Finland OY**, Kempele (FI)

(72) Inventors: **Prasadh Ramachandran**, Kempele
(FI); **Petteri Annamaa**, Oulunsalo (FI)

(73) Assignee: **Pulse Finland OY**, Oulunsalo (FI)

(*) 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.: **14/223,898**

(22) Filed: **Mar. 24, 2014**

(65) **Prior Publication Data**

US 2014/0300518 A1 Oct. 9, 2014

Related U.S. Application Data

(63) Continuation-in-part of application No. 14/177,093,
filed on Feb. 10, 2014, which is a continuation of
(Continued)

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

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/38**
(2013.01); **H01Q 1/40** (2013.01); **H01Q 1/50**
(2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/2266; H01Q 1/2258;
H01Q 5/321; H01Q 5/371; H01Q 21/28;
(Continued)

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Primary Examiner — Dameon E Levi

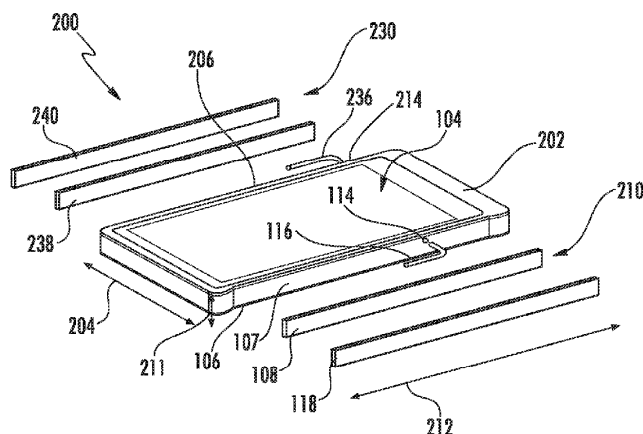
Assistant Examiner — Awat Salih

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

(57) **ABSTRACT**

A chassis-excited antenna apparatus, and methods of tuning
and utilizing the same. In one embodiment, a distributed
loop antenna configuration is used within a handheld mobile
device (e.g., cellular telephone). The antenna comprises two
radiating elements: one configured to operate in a high-
frequency band, and the other in a low-frequency band. The
two antenna elements are disposed on different side surfaces
of the metal chassis of the portable device; e.g., on the
opposing sides of the device enclosure. Each antenna com-
ponent comprises a radiator and an insulating cover. The
radiator is coupled to a device feed via a feed conductor and
a ground point. A portion of the feed conductor is disposed
with the radiator to facilitate forming of the coupled loop
resonator structure.

20 Claims, 19 Drawing Sheets





US009673510B2

(12) **United States Patent**
Lin

(10) **Patent No.:** **US 9,673,510 B2**

(45) **Date of Patent:** **Jun. 6, 2017**

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

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

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

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 322 days.

(21) Appl. No.: **14/491,430**

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

(65) **Prior Publication Data**

US 2015/0155616 A1 Jun. 4, 2015

(30) **Foreign Application Priority Data**

Nov. 30, 2013 (CN) 2013 1 0623053

(51) **Int. Cl.**
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 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 1/243; H01Q 5/371; H01Q 5/378; H01Q 9/42

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

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343/702

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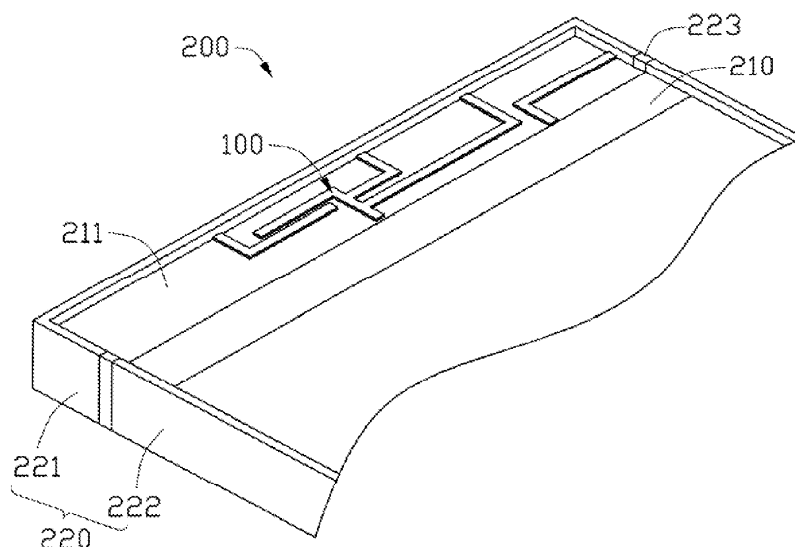
Primary Examiner — Hoanganh Le

(74) *Attorney, Agent, or Firm* — Steven Reiss

(57) **ABSTRACT**

An antenna structure includes a first frame, a feed end, at least one ground end, a first radiator, a first extending section, a second extending section, a coupling section, and a second radiator. The first radiator is coupled to the feed end and is parallel to the first frame. The first extending section is coupled between the feed end and first frame. The second extending section is coupled between the feed end and the first frame. The coupling section is coupled to the first frame. The second radiator is coupled between the at least one ground end and the first frame.

19 Claims, 6 Drawing Sheets





US009673511B2

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

(10) **Patent No.:** **US 9,673,511 B2**

(45) **Date of Patent:** **Jun. 6, 2017**

(54) **EXCITING DUAL FREQUENCY BANDS
FROM AN ANTENNA COMPONENT WITH A
DUAL BRANCH COUPLING FEED**

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

(72) Inventors: **Kwan Ho Lee**, Mountain View, CA
(US); **Songnan Yang**, San Jose, CA
(US); **Anand Konanur**, Sunnyvale, CA
(US); **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 234 days.

(21) Appl. No.: **14/492,921**

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

(65) **Prior Publication Data**
US 2016/0087328 A1 Mar. 24, 2016

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/44 (2006.01)
H01Q 13/10 (2006.01)
H01Q 21/30 (2006.01)
H01Q 5/307 (2015.01)
H01Q 1/22 (2006.01)
H01Q 25/00 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/38**
(2013.01); **H01Q 1/44** (2013.01); **H01Q 5/307**
(2015.01); **H01Q 13/10** (2013.01); **H01Q**
13/106 (2013.01); **H01Q 21/30** (2013.01);
H01Q 1/2291 (2013.01); **H01Q 25/00**
(2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 13/10; H01Q 5/307;
H01Q 1/44; H01Q 13/106; H01Q 21/30;
H01Q 1/38; H01Q 25/00
USPC 343/702, 770, 769, 767, 768
See application file for complete search history.

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Feb. 17, 2016.

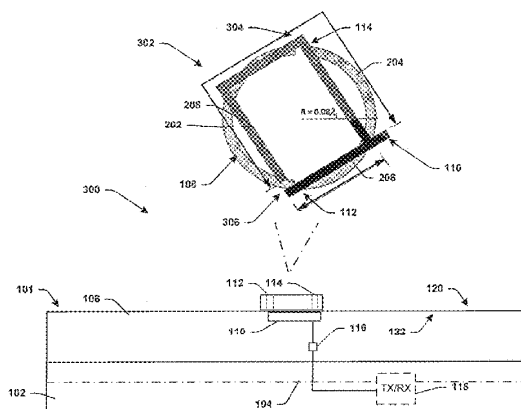
Primary Examiner — Hoanganh Le

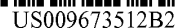
(74) *Attorney, Agent, or Firm* — Eschweiler & Potashnik,
LLC

(57) **ABSTRACT**

An antenna element forms a ring slot antenna comprising a
first slot and second slot. The antenna element is located on
a first surface of a conductive chassis that encases a body or
a volume for wireless communication signals to be received
or transmitted. A coupling component is located on an
opposite side of the conductive chassis and behind the
antenna element. The coupling component facilitates a cou-
pling between a communication component and the antenna
element as a function of the orientation and geometric shape
of the coupling component to facilitate different resonant
frequencies via the first and second slots of the antenna
element.

24 Claims, 12 Drawing Sheets





(10) **Patent No.:** US 9,673,512 B2
(45) **Date of Patent:** Jun. 6, 2017

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

- (56)
- References Cited**

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343/702 |
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- Primary Examiner* — Robert Karacsony

- (74) *Attorney, Agent, or Firm* — Steven Reiss

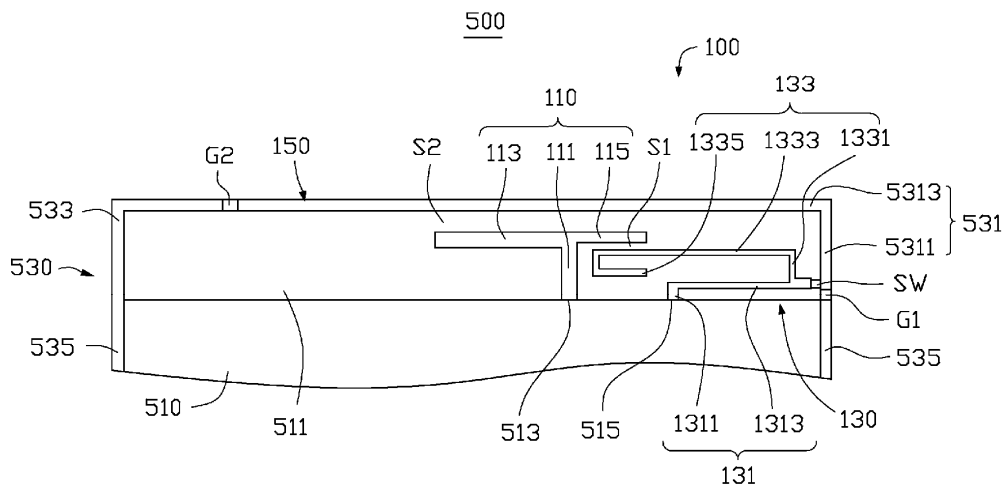
- (57) **ABSTRACT**

- An antenna assembly includes a first radiating portion, a second radiating portion, a third radiating portion, and a switch circuit. The switch circuit is electrically connected between the second radiating portion and the third radiating portion. The switch circuit includes a plurality of branch circuit with different impedances. The first radiating portion and the second radiating portion are electrically coupled and configured to operate at a first frequency band; the first radiating portion, the third radiating portion, the switch circuit, and the second radiating portion are electrically coupled and configured to operate at a second frequency band; the switch circuit is configured to adjust a resonance mode of the antenna assembly by switching to different impedances. A wireless communication device employing the antenna assembly is also provided.

- 14 Claims, 8 Drawing Sheets**

- (51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
H01Q 21/30 (2006.01)
H01Q 5/314 (2015.01)

- (52) **U.S. Cl.**
CPC *H01Q 1/243* (2013.01); *H01Q 5/314*
(2015.01); *H01Q 9/42* (2013.01); *H01Q 21/30*
(2013.01)





US009673513B2

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

(10) **Patent No.:** **US 9,673,513 B2**

(45) **Date of Patent:** **Jun. 6, 2017**

(54) **RADIATOR FRAME HAVING ANTENNA PATTERN EMBEDDED THEREIN AND ELECTRONIC DEVICE INCLUDING THE SAME**

(58) **Field of Classification Search**

CPC H01Q 1/36; H01Q 1/243
See application file for complete search history.

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

(56) **References Cited**

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(72) Inventors: **Ha Ryong Hong**, Suwon-si (KR); **Sun Hee Lee**, Suwon-si (KR); **Chan Gwang An**, Suwon-si (KR); **Dae Ki Lim**, Suwon-si (KR); **Hyeon Gil Nam**, Suwon-si (KR); **Sung Eun Cho**, Suwon-si (KR); **Dae Kyu Lee**, Suwon-si (KR); **Dae Seong Jeon**, Suwon-si (KR); **Hyun Do Park**, Suwon-si (KR)

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(73) Assignee: **Samsung Electro-Mechanics 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 78 days.

Korean Office Action issued on Jan. 5, 2016, in counterpart Korean Application No. 10-2014-0178231 (7 pages in English, 5 pages in Korean).

Primary Examiner — Dameon E Levi

Assistant Examiner — Andrea Lindgren Baltzell

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

(21) Appl. No.: **14/834,063**

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

(65) **Prior Publication Data**

US 2016/0056532 A1 Feb. 25, 2016

(30) **Foreign Application Priority Data**

Aug. 25, 2014 (KR) 10-2014-0110977
Dec. 11, 2014 (KR) 10-2014-0178231

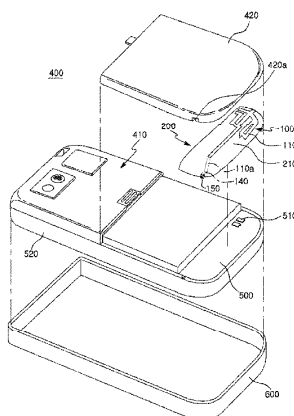
(51) **Int. Cl.**
H01Q 9/42 (2006.01)
H01Q 1/24 (2006.01)
H01Q 5/371 (2015.01)

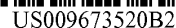
(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01); **H01Q 9/42** (2013.01)

(57) **ABSTRACT**

A radiator frame includes: a main radiator including an antenna pattern part configured to transmit or receive a signal, an internal terminal part provided on one end of the antenna pattern part and configured to electrically connect the antenna pattern part and a circuit substrate, and an external terminal part provided on another end of the antenna pattern part and configured to be connected to an auxiliary radiator to improve radiation performance of the antenna pattern part; and a molded frame molded around the radiator, the molded frame allowing the internal terminal part to be exposed at a first surface of the molded frame, and allowing the external terminal part to be exposed at a second surface of the molded frame.

13 Claims, 11 Drawing Sheets





(10) **Patent No.:** US 9,673,520 B2
(45) **Date of Patent:** Jun. 6, 2017

- (58) **Field of Classification Search**
USPC 343/700 MS, 702, 720, 833, 834, 835,
343/893, 815, 817, 818, 819, 836, 837
See application file for complete search history.

- (56)
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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 188 days.

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- (21) Appl. No.: 13/247,358

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- (22) Filed: **Sep. 28, 2011**

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- (65) **Prior Publication Data**

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No. 12178055.5; Dated: Nov. 15, 2012; 7 Pages.

- (51) **Int. Cl.**
H01Q 1/52 (2006.01)
H01Q 5/00 (2015.01)
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)
H01Q 9/42 (2006.01)
H01Q 21/28 (2006.01)
H01Q 25/00 (2006.01)
H01Q 5/364 (2015.01)

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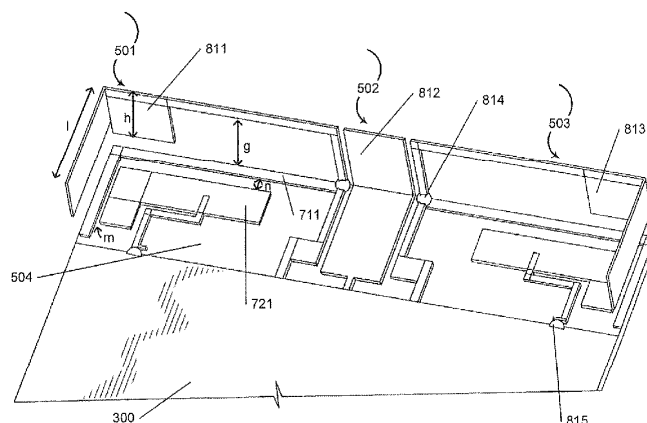
- (52) **U.S. Cl.**
CPC *H01Q 1/521* (2013.01); *H01Q 1/243*
(2013.01); *H01Q 1/38* (2013.01); *H01Q 5/364*
(2015.01); *H01Q 9/42* (2013.01); *H01Q 21/28*
(2013.01); *H01Q 25/00* (2013.01)

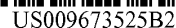
Primary Examiner — Tho G Phan
Assistant Examiner — Patrick Holecek
(74) Attorney, Agent, or Firm — Myers Bigel, P.A.

- (57) **ABSTRACT**

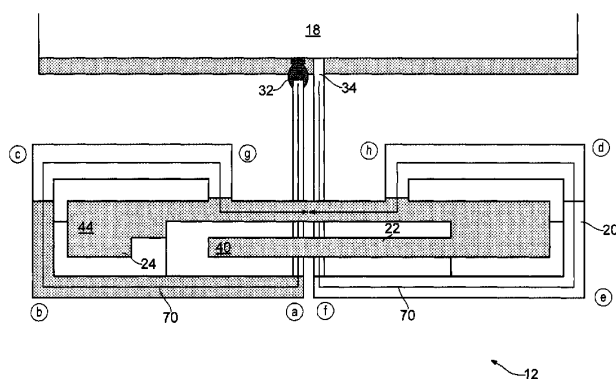
An antenna system may include a backplate that includes an end portion. The antenna system may also include first and second antennas spaced apart from each other along the end portion of the backplate. The antenna system may additionally include a parasitic element between the first and second antennas along the end portion of the backplate.

16 Claims, 18 Drawing Sheets





(45) **Date of Patent:** **Jun. 6, 2017**





US009673531B2

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

(10) **Patent No.:** **US 9,673,531 B2**
(45) **Date of Patent:** **Jun. 6, 2017**

(54) **ANTENNA**

(71) Applicants: **Yun Ghit Chan**, Shenzhen (CN); **Ng Guan Hong**, Shenzhen (CN); **Yew Siow Tay**, Shenzhen (CN)

(72) Inventors: **Yun Ghit Chan**, Shenzhen (CN); **Ng Guan Hong**, Shenzhen (CN); **Yew Siow Tay**, 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 119 days.

(21) Appl. No.: **14/592,076**

(22) Filed: **Jan. 8, 2015**

(65) **Prior Publication Data**

US 2015/0200457 A1 Jul. 16, 2015

(30) **Foreign Application Priority Data**

Jan. 10, 2014 (CN) 2014 1 0013088

(51) **Int. Cl.**

H01Q 5/00 (2015.01)

H01Q 9/40 (2006.01)

H01Q 5/371 (2015.01)

H01Q 5/357 (2015.01)

H01Q 5/392 (2015.01)

H01Q 5/385 (2015.01)

H01Q 5/378 (2015.01)

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

CPC **H01Q 9/40** (2013.01); **H01Q 5/357** (2015.01); **H01Q 5/371** (2015.01); **H01Q 5/378** (2015.01); **H01Q 5/385** (2015.01); **H01Q 5/392** (2015.01)

(58) **Field of Classification Search**

CPC H01Q 5/371; H01Q 5/378; H01Q 5/385;

H01Q 5/392; H01Q 5/357

See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Dameon E Levi

Assistant Examiner — Jennifer F Hu

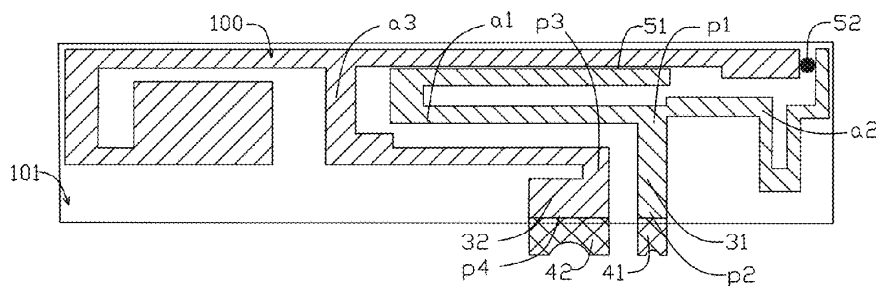
(74) *Attorney, Agent, or Firm* — Na Xu; IPro, PLLC

(57) **ABSTRACT**

An antenna is disclosed. The antenna includes a coupling portion, a ground connection portion corresponding to the coupling portion, and a radiation body. The a radiation body further includes a first antenna portion extending from a first end of the coupling portion in a direction, a second antenna portion extending from the first end in a direction opposite to that of the first antenna portion, and a third antenna portion extending from an end of the ground connection portion in a direction surrounding the first antenna portion, wherein two gaps are provided for separating the third antenna portion from the first antenna portion and the second antenna portion respectively.

11 Claims, 3 Drawing Sheets

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US009674321B2

(12) **United States Patent**
Jiang

(10) **Patent No.:** **US 9,674,321 B2**
(45) **Date of Patent:** **Jun. 6, 2017**

(54) **MOBILE TERMINAL ANTENNA MODULE
HOUSED WITHIN METAL REAR COVER
SERVING AS A RADIATOR**

(71) Applicant: **Hua Jiang**, Shenzhen (CN)
(72) Inventor: **Hua Jiang**, 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.: **15/062,056**

(22) Filed: **Mar. 5, 2016**

(65) **Prior Publication Data**
US 2017/0034321 A1 Feb. 2, 2017

(30) **Foreign Application Priority Data**
Jul. 31, 2015 (CN) 2015 1 0464050

(51) **Int. Cl.**
H04M 1/02 (2006.01)
H01Q 1/24 (2006.01)
(52) **U.S. Cl.**
CPC **H04M 1/026** (2013.01); **H01Q 1/24**
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/44; H01Q 5/378; H01Q 5/385;
H01Q 1/48; H01Q 1/24; H01Q 1/242;
H01Q 1/243; H04M 1/0274; H04M
1/026; H04M 1/0202; H04M 1/0249;
H04M 1/0254

See application file for complete search history.

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343/702
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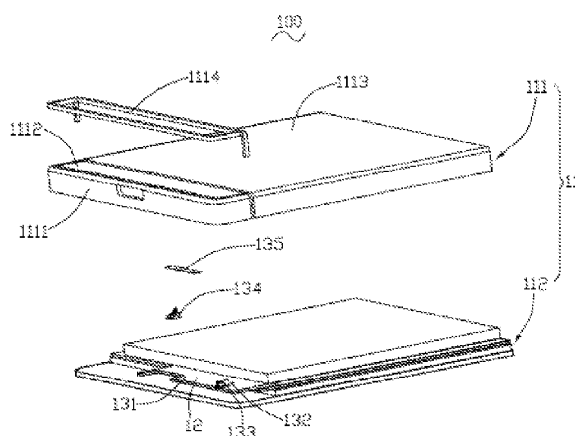
Primary Examiner — Devan Sandiford

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

(57) **ABSTRACT**

A mobile terminal is disclosed. The mobile terminal includes an antenna module including a parasitic coupling piece and a dynamic switch; a housing having an accommodation space, the housing including a metal rear cover serving as a radiator of the antenna module, the radiator including a first metal part, a second metal part and a third metal part isolated from each other; and a main board received in the accommodation space and having a grounding point disposed on a surface thereof. The parasitic coupling piece is affixed on a surface of the second metal part facing to the main board, the parasitic coupling piece couples the second metal part and connects with the grounding point through the dynamic switch.

7 Claims, 2 Drawing Sheets





US009680203B2

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

(10) **Patent No.:** **US 9,680,203 B2**

(45) **Date of Patent:** **Jun. 13, 2017**

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

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

(72) Inventors: **Geng-Hong Liou**, New Taipei (TW);
Yen-Hui Lin, New Taipei (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 293 days.

(21) Appl. No.: **14/141,677**

(22) Filed: **Dec. 27, 2013**

(65) **Prior Publication Data**

US 2014/0340280 A1 Nov. 20, 2014

(30) **Foreign Application Priority Data**

May 14, 2013 (TW) 102117119 A

(51) **Int. Cl.**
H01Q 5/371 (2015.01)
H01Q 1/24 (2006.01)

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

(58) **Field of Classification Search**

CPC H01Q 21/00; H01Q 5/371; H01Q 1/243

USPC 343/702, 846

See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Graham Smith

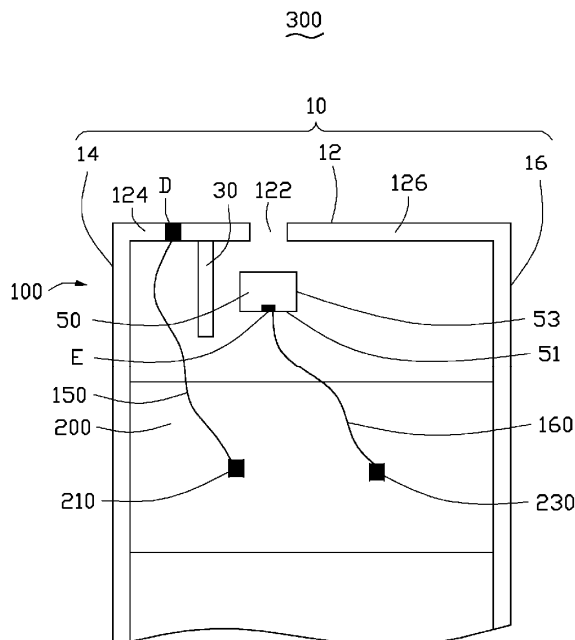
Assistant Examiner — Noel Maldonado

(74) *Attorney, Agent, or Firm* — Steven Reiss

(57) **ABSTRACT**

An antenna structure includes a metal member, an extending section, and a metal sheet. The metal member defines a gap. The gap divides the metal member into a first portion and a second portion. The extending section is connected to the first portion of the metal member to cooperatively form a first antenna. The first antenna, the metal sheet and the second portion of the metal member cooperatively form a second antenna.

8 Claims, 1 Drawing Sheet





US009680206B2

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

(10) **Patent No.:** **US 9,680,206 B2**

(45) **Date of Patent:** ***Jun. 13, 2017**

(54) **MOBILE TERMINAL**

H01Q 1/44 (2013.01); **H04M 1/0249**
(2013.01); **H04M 1/18** (2013.01)

(71) Applicant: **LG Electronics Inc.**, Seoul (KR)

(58) **Field of Classification Search**

(72) Inventors: **Yeomin Youn**, Seoul (KR); **Jaehyun Choi**, Seoul (KR); **Jungsun Ahn**, Seoul (KR); **Changil Kim**, Seoul (KR); **Kangjae Jung**, Seoul (KR)

CPC **H04M 1/0202**; **H04M 1/0249**; **H04M 1/0214**; **H04M 1/23**; **H04M 1/0277**; **H04M 1/18**; **H04W 88/02**; **H05K 5/03**; **H05K 5/061**; **H05K 5/062**; **H01Q 1/243**; **H01Q 1/44**; **G06F 1/1626**; **G06F 1/1698**; **G06F 1/203**

(73) Assignee: **LG Electronics Inc.**, Seoul (KR)

See application file for complete search history.

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 310 days.

(56) **References Cited**

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343/878
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343/846

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(21) Appl. No.: **14/480,149**

(22) Filed: **Sep. 8, 2014**

(65) **Prior Publication Data**

US 2015/0155614 A1 Jun. 4, 2015

Primary Examiner — Nizar Sivji
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(30) **Foreign Application Priority Data**

Dec. 3, 2013 (KR) 10-2013-0149413

(57) **ABSTRACT**

A mobile terminal includes a metal frame including a base portion and an edge portion formed along the outer edge of the base portion, first and second cases bonded to the front and back sides of the metal frame so as to expose the edge portion to the outside, first and second waterproof layers formed between the cases and the metal frame, conductive members that operate a radiator for antennas, together with the edge portion, and are formed on one side of the second case, and feeding portions for feeding the conductive members, the feeding portions being disposed in an enclosed space formed by the waterproof layers.

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H04M 1/02 (2006.01)

G06F 1/16 (2006.01)

G06F 1/20 (2006.01)

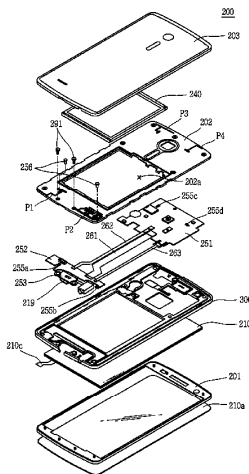
H01Q 1/44 (2006.01)

H04M 1/18 (2006.01)

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

CPC **H01Q 1/243** (2013.01); **G06F 1/1626** (2013.01); **G06F 1/1656** (2013.01); **G06F 1/1698** (2013.01); **G06F 1/203** (2013.01);

3 Claims, 15 Drawing Sheets





US009680216B2

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

(10) **Patent No.:** **US 9,680,216 B2**

(45) **Date of Patent:** **Jun. 13, 2017**

(54) **COMMUNICATION DEVICE WITH A
GROUND ELEMENT DIRECTLY
CONNECTED TO AN INVERTED T-SHAPED
GROUND PLANE**

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

(72) Inventors: **Hung-Ren Hsu**, Taoyuan (TW);
Chun-I Lin, Taoyuan (TW); **Huei Lin**,
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 86 days.

(21) Appl. No.: **14/818,575**

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

(65) **Prior Publication Data**

US 2017/0012352 A1 Jan. 12, 2017

(30) **Foreign Application Priority Data**

Jul. 9, 2015 (TW) 104122256 A

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 1/48 (2006.01)
H01Q 5/378 (2015.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/48** (2013.01); **H01Q 5/378**
(2015.01); **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/241; H01Q 1/243; H01Q 1/48;
H01Q 1/24; H01Q 5/378; H01Q 9/0421;
H01Q 1/38
USPC 343/702, 700 MS, 846, 848
See application file for complete search history.

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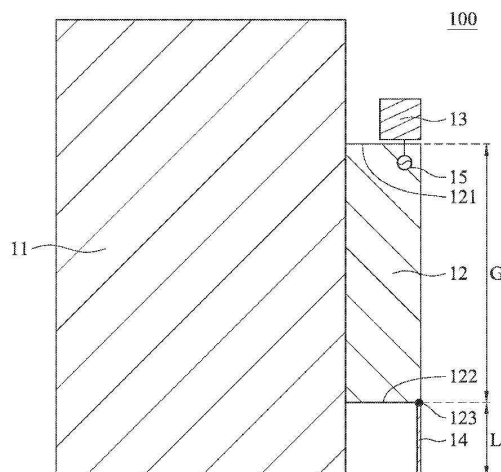
Primary Examiner — Tho G Phan

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

(57) **ABSTRACT**

A communication device includes a system ground plane, a ground element, an antenna element, and a metal guide line. The ground element is coupled to the system ground plane. The ground element has a first edge, a second edge, and a connection point. The first edge and the second edge are opposite to each other. The connection point is positioned at the second edge. The antenna element is disposed adjacent to, or at, the first edge. One end of the metal guide line is coupled to the connection point, and another end of the metal guide line is open.

10 Claims, 6 Drawing Sheets





US009680222B2

(12) **United States Patent**
Lin

(10) **Patent No.:** **US 9,680,222 B2**

(45) **Date of Patent:** **Jun. 13, 2017**

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

H01Q 9/285 (2013.01); *H01Q 13/10* (2013.01); *H01Q 21/061* (2013.01)

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

(58) **Field of Classification Search**

CPC *H01Q 1/243*; *H01Q 3/44*; *H01Q 13/10*; *H01Q 9/285*; *H01Q 1/1207*; *H01Q 21/061*

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

USPC 343/702, 700, 893, 878, 767, 795
See application file for complete search history.

(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 230 days.

(56) **References Cited**

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343/702

(21) Appl. No.: **14/576,791**

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

(65) **Prior Publication Data**

US 2015/0318601 A1 Nov. 5, 2015

Primary Examiner — Joseph Lauture

(74) Attorney, Agent, or Firm — Steven Reiss

(30) **Foreign Application Priority Data**

Apr. 30, 2014 (CN) 2014 1 0179877

(57) **ABSTRACT**

A wireless communication device includes a metallic housing and an antenna structure. The metallic housing includes a bottom frame and a side frame spaced from the bottom frame. The antenna structure includes a feed end plate, a ground end plate, a main radiator, and a coupling section. The ground end plate is coupled to the bottom frame. The main radiator is coupled between the feed end plate and the side frame. The coupling section is coupled to the main radiator and extending parallel to the bottom frame. A first end of the coupling section is coupled to a distal end of the feed end plate, and a second end of the coupling section extends towards the ground end plate, current is coupled from the feed end plate to the ground end plate via the coupling section and is coupled from the coupling section to the bottom frame.

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 5/371 (2015.01)

H01Q 1/48 (2006.01)

H01Q 21/28 (2006.01)

H01Q 5/328 (2015.01)

H01Q 9/28 (2006.01)

H01Q 21/06 (2006.01)

H01Q 1/12 (2006.01)

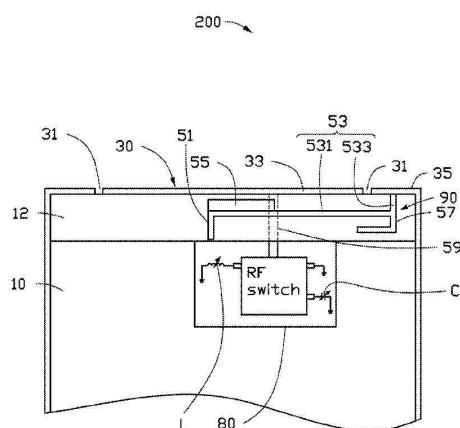
H01Q 3/44 (2006.01)

H01Q 13/10 (2006.01)

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

CPC *H01Q 5/371* (2015.01); *H01Q 1/243* (2013.01); *H01Q 1/48* (2013.01); *H01Q 5/328* (2015.01); *H01Q 21/28* (2013.01); *H01Q 1/1207* (2013.01); *H01Q 3/44* (2013.01);

19 Claims, 5 Drawing Sheets





US009680223B2

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

(10) **Patent No.:** **US 9,680,223 B2**
(45) **Date of Patent:** **Jun. 13, 2017**

(54) **MOBILE DEVICE AND MANUFACTURING METHOD THEREOF**

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

(72) Inventors: **Chun-Yih Wu**, Taoyuan (TW);
Yen-Liang Kuo, Taoyuan (TW);
Chien-Chih Chen, Taoyuan (TW)

(73) Assignee: **HTC CORPORATION**, Taoyuan (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 338 days.

(21) Appl. No.: **14/316,050**

(22) Filed: **Jun. 26, 2014**

(65) **Prior Publication Data**

US 2015/0380820 A1 Dec. 31, 2015

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

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

(58) **Field of Classification Search**
CPC H01Q 5/378; H01Q 9/30; H01Q 1/24; H01Q 1/38; H01Q 1/44; H01Q 5/314; H01Q 13/10; H01Q 1/52; H01Q 9/0421; H01Q 1/241–1/244

See application file for complete search history.

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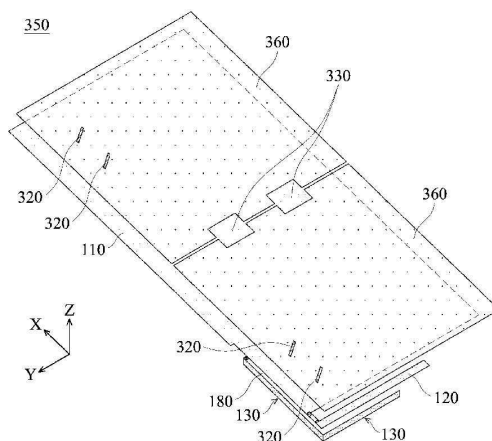
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Primary Examiner — Jessica Han
Assistant Examiner — Awat Salih
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**

A mobile device includes a ground plane, a first radiation branch, and a second radiation branch. The second radiation branch is coupled to the ground plane, and is disposed adjacent to the first radiation branch. An antenna structure is formed by the first radiation branch and the second radiation branch. The first radiation branch is fed from a signal source. The second radiation branch is excited by the first radiation branch through coupling therebetween.

23 Claims, 14 Drawing Sheets





US009680441B2

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

(10) **Patent No.:** **US 9,680,441 B2**
(45) **Date of Patent:** **Jun. 13, 2017**

(54) **IMPEDANCE MATCHING CIRCUIT AND ANTENNA SYSTEM**

(71) Applicant: **TAIYO YUDEN CO., LTD.**, Tokyo (JP)

(72) Inventors: **Fumitaka Iizuka**, Tokyo (JP); **Kentaro Nakamura**, Tokyo (JP)

(73) Assignee: **TAIYO YUDEN CO., LTD.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 138 days.

(21) Appl. No.: **13/938,883**

(22) Filed: **Jul. 10, 2013**

(65) **Prior Publication Data**
US 2014/0091980 A1 Apr. 3, 2014

(30) **Foreign Application Priority Data**
Sep. 28, 2012 (JP) 2012-215469

(51) **Int. Cl.**
H01Q 1/50 (2006.01)
H01Q 5/00 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC **H03H 7/38** (2013.01); **H01Q 1/50** (2013.01); **H01Q 5/314** (2015.01); **H03H 7/40** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 23/00; H01Q 5/30; H01Q 5/307; H01Q 5/314; H01Q 5/328; H01Q 5/335;
(Continued)

(56) **References Cited**

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Primary Examiner — Tho G Phan

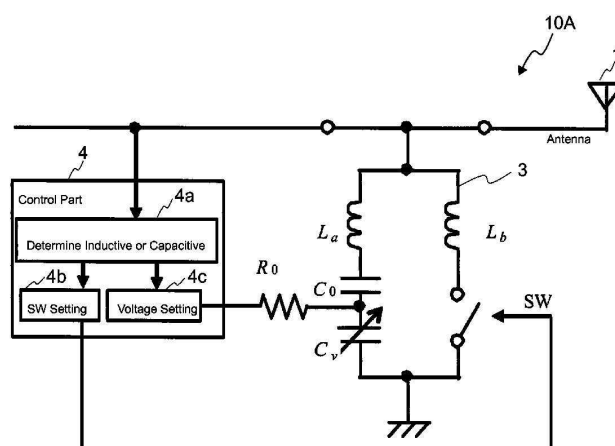
Assistant Examiner — Patrick Holecek

(74) *Attorney, Agent, or Firm* — Chen Yoshimura LLP

(57) **ABSTRACT**

An impedance matching circuit is connected to a first circuit block (impedance matching target circuit) that requires impedance matching and that has one terminal connected to a signal line and the other terminal connected to a ground, the impedance matching circuit having a second circuit block that has a first circuit and a second circuit connected in parallel. In the first circuit, a first capacitor having a variable capacitance and a first inductor having a first inductance are connected in series, and in the second circuit, a second inductor having a second inductance and a switch are connected are connected in series. The impedance matching circuit has one terminal connected to the signal line of the first circuit block and the other terminal connected to the ground of the first circuit block.

5 Claims, 17 Drawing Sheets





US009685692B2

(12) **United States Patent**
Hsu

(10) **Patent No.:** **US 9,685,692 B2**

(45) **Date of Patent:** **Jun. 20, 2017**

(54) **ANTENNA STRUCTURE**

(71) Applicant: **Chi Mei Communication Systems, Inc.**, New Taipei (TW)

(72) Inventor: **Cho-Kang Hsu**, New Taipei (TW)

(73) Assignee: **Chi Mei 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 87 days.

(21) Appl. No.: **13/930,284**

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

(65) **Prior Publication Data**

US 2014/0292583 A1 Oct. 2, 2014

(30) **Foreign Application Priority Data**

Mar. 27, 2013 (TW) 102110826 A

(51) **Int. Cl.**
H01Q 5/35 (2015.01)
H01Q 1/24 (2006.01)
H01Q 13/10 (2006.01)
H01Q 13/16 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/35** (2015.01); **H01Q 13/10** (2013.01); **H01Q 13/16** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/38

USPC 343/700 MS, 702

See application file for complete search history.

(56) **References Cited**

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455/73

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Primary Examiner — Dameon E Levi

Assistant Examiner — Walter Davis

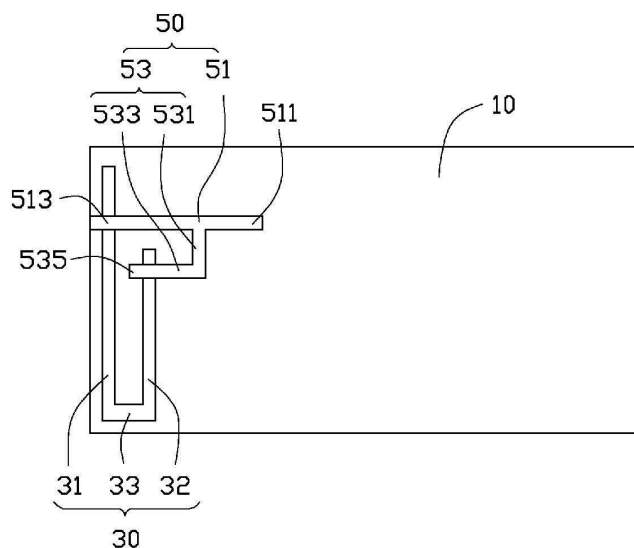
(74) *Attorney, Agent, or Firm* — Steven Reiss

(57) **ABSTRACT**

An antenna structure is configured to transmit and receive signal for a wireless communication device. The antenna structure includes a base board, a radiating unit, and a feed unit. The radiating unit and the feed unit are formed on the base board. The feed unit partially overlaps on the radiating unit to form a number of signal feed paths.

13 Claims, 2 Drawing Sheets

100





US009685694B2

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

(10) **Patent No.:** **US 9,685,694 B2**
(45) **Date of Patent:** **Jun. 20, 2017**

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

(71) Applicant: **LG ELECTRONICS INC.**, Seoul
(KR)

(72) Inventors: **Jaehyun Choi**, Seoul (KR);
Hyengcheul Choi, Seoul (KR);
Chisang You, Seoul (KR)

(73) Assignee: **LG ELECTRONICS INC.**, Seoul
(KR)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 103 days.

(21) Appl. No.: **14/702,524**

(22) Filed: **May 1, 2015**

(65) **Prior Publication Data**

US 2016/0164168 A1 Jun. 9, 2016

(30) **Foreign Application Priority Data**

Dec. 4, 2014 (KR) 10-2014-0173074

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

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

(58) **Field of Classification Search**
USPC 343/702, 700 MS, 748, 846, 848
See application file for complete search history.

(56) **References Cited**

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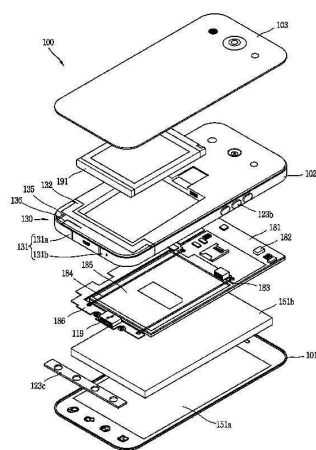
Primary Examiner — Khai M Nguyen

(74) *Attorney, Agent, or Firm* — Lee Hong Degerman
Kang & Waimey

(57) **ABSTRACT**

The present disclosure relates to an antenna module and a mobile terminal having the same, and the antenna module may include a first conductive member connected to a feeding portion and a grounding portion, a second conductive member disposed to be separated from the first conductive member, a first connecting member configured to connect the first conductive member to the second conductive member at a position adjacent to the feeding portion, and a second connecting member configured to connect the first conductive member to the second conductive member at a position adjacent to the grounding portion, wherein a slit is formed on the first conductive member, and the slit is formed between the feeding portion and the grounding portion.

29 Claims, 19 Drawing Sheets





US009685696B2

(12) **United States Patent**
Uchida

(10) **Patent No.:** **US 9,685,696 B2**
(45) **Date of Patent:** **Jun. 20, 2017**

(54) **ANTENNA AND ELECTRONIC DEVICE**

(71) Applicant: **NEC Platforms, Ltd.**, Kanagawa (JP)

(72) Inventor: **Jun Uchida**, Kanagawa (JP)

(73) Assignee: **NEC Platforms, LTD.**, Kanagawa (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 113 days.

(21) Appl. No.: **14/767,329**

(22) PCT Filed: **Feb. 19, 2014**

(86) PCT No.: **PCT/JP2014/000837**

§ 371 (c)(1),

(2) Date: **Aug. 12, 2015**

(87) PCT Pub. No.: **WO2014/132590**

PCT Pub. Date: **Sep. 4, 2014**

(65) **Prior Publication Data**

US 2015/0380809 A1 Dec. 31, 2015

(30) **Foreign Application Priority Data**

Feb. 26, 2013 (JP) 2013-035234

(51) **Int. Cl.**

H01Q 1/38 (2006.01)

H01Q 7/00 (2006.01)

H01Q 9/04 (2006.01)

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

CPC **H01Q 1/38** (2013.01); **H01Q 7/00** (2013.01); **H01Q 9/04** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 7/00; H01Q 7/005; H01Q 7/02; H01Q 7/04; H01Q 7/06; H01Q 7/08

See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Dameon E Levi

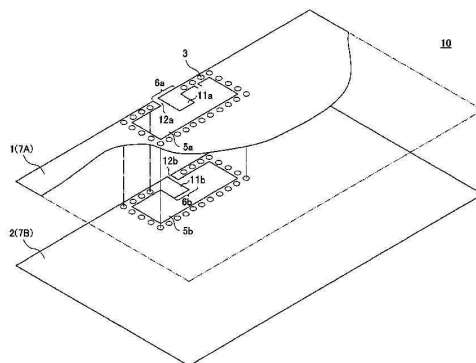
Assistant Examiner — Daniel J Munoz

(74) *Attorney, Agent, or Firm* — Wilmer Cutler Pickering Hale and Dorr LLP

(57) **ABSTRACT**

A split section (6a) has an auxiliary conductor pattern (11a) formed on one end of a substantially C-shaped section of a first split-ring section, and a split (12a) formed between the auxiliary conductor pattern (11a) and the other end of the substantially C-shaped section. A split section (6b) has an auxiliary conductor pattern (11b) formed on one end of a substantially C-shaped section of a second split-ring section, and a split (12b) formed between the auxiliary conductor pattern (11b) and the other end of the substantially C-shaped section. The auxiliary conductor pattern (11b) is formed so as to face the auxiliary conductor pattern (11a). The split (12b) is formed so as to be opposite from the position facing the split (12a) and consequently sandwich the auxiliary conductor pattern (11b) therebetween. A split (14) is formed between the auxiliary conductor pattern (11a) and the auxiliary conductor pattern (11b), stores electrical charges hav-

(Continued)





US009685697B2

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

(10) **Patent No.:** **US 9,685,697 B2**

(45) **Date of Patent:** **Jun. 20, 2017**

(54) **TUNABLE ANTENNA STRUCTURE AND WIRELESS COMMUNICATION DEVICE EMPLOYING SAME**

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

(72) Inventors: **Jin-Bo 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 213 days.

(21) Appl. No.: **14/463,888**

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

(65) **Prior Publication Data**

US 2015/0054697 A1 Feb. 26, 2015

(30) **Foreign Application Priority Data**

Aug. 22, 2013 (CN) 2013 1 0367231

(51) **Int. Cl.**
H01Q 1/48 (2006.01)
H01Q 1/50 (2006.01)
H03H 7/38 (2006.01)
H01F 21/12 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/50** (2013.01); **H01F 21/12** (2013.01); **H03H 7/38** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/42; H01Q 1/24; H01Q 13/203; H01Q 21/20

USPC 343/845, 745, 739
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Graham Smith

Assistant Examiner — Collin Dawkins

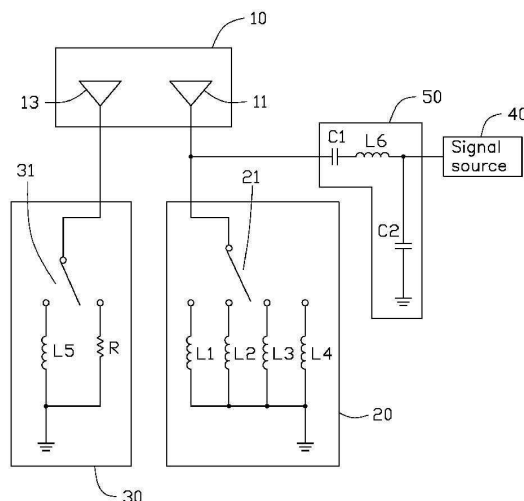
(74) *Attorney, Agent, or Firm* — Steven Reiss

(57) **ABSTRACT**

A tunable antenna structure includes an antenna, a first switch circuit and a second switch circuit. The antenna structure includes a feeding point configured to feed current signal and a grounding point configured to be grounded. The first switch circuit includes a first plurality of loads and a first switch electronically coupled to the feeding point and the first plurality of loads. The first switch is configured to selectively couple one of the first plurality of loads to the feeding point. The second switch circuit includes a second plurality of loads and a second switch electronically coupled to the grounding point and the second plurality of loads. The second switch is configured to selectively couple one of the second plurality of loads to the grounding point.

8 Claims, 2 Drawing Sheets

100





US009685698B2

(12) **United States Patent**
Ramachandran

(10) **Patent No.:** **US 9,685,698 B2**
(45) **Date of Patent:** **Jun. 20, 2017**

(54) **MULTI-TAP FREQUENCY SWITCHABLE ANTENNA APPARATUS, SYSTEMS AND METHODS**

(71) Applicant: **Pulse Finland OY**, Oulunsalo (FI)

(72) Inventor: **Prasadh Ramachandran**, Oulu (FI)

(73) Assignee: **PULSE FINLAND OY** (FI)

(*) 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.: **14/877,393**

(22) Filed: **Oct. 7, 2015**

(65) **Prior Publication Data**

US 2017/0104266 A1 Apr. 13, 2017

(51) **Int. Cl.**

H04B 1/40 (2015.01)

H01Q 1/50 (2006.01)

H01Q 5/20 (2015.01)

H04M 1/02 (2006.01)

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

CPC **H01Q 1/50** (2013.01); **H01Q 5/20** (2015.01); **H04M 1/026** (2013.01)

(58) **Field of Classification Search**

CPC . A61B 5/14552; A61B 5/02416; A61B 5/021; A61B 5/1455; A61B 5/08; B60L 11/182; H01F 38/14; H02J 7/025
USPC 455/73, 75, 88; 330/301; 600/324, 479; 315/159

See application file for complete search history.

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Primary Examiner — Phuoc H Doan

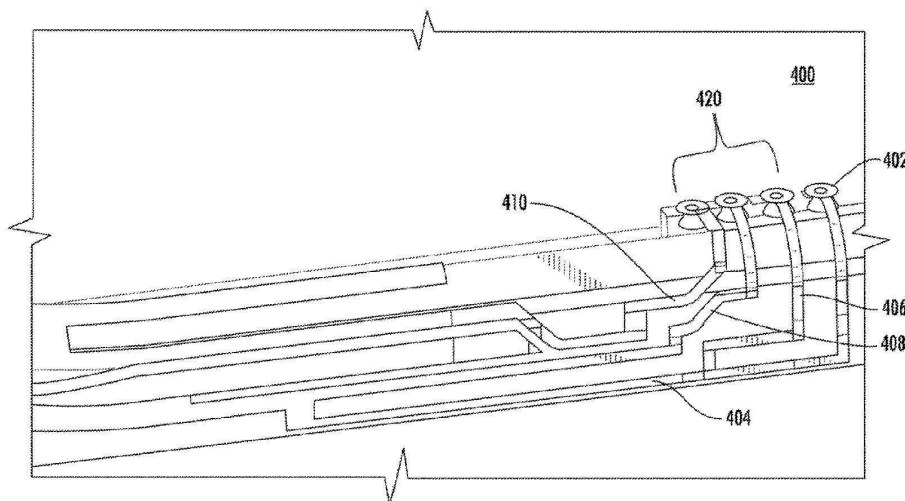
(74) *Attorney, Agent, or Firm* — Gazdzinski & Associates, PC

(57)

ABSTRACT

Multi-tap switchable antenna apparatus for use with mobile devices and other applications, and methods of utilizing the same. In one embodiment, the multi-tap switchable antenna apparatus includes a main radiator coupled to an antenna feed or source. Galvanically connected to the main radiator is a plurality of switchable antenna radiators which are in turn connected to an nPmT switch. The output of the nPmT switch can be connected to a variety of differing electronic component impedances. By altering the state of the nPmT switch, the operational length of the antenna (and hence, the operational frequency band of the antenna) can be varied. Performance characteristics associated with a given implementation of the multi-tap switchable apparatus are also disclosed.

20 Claims, 7 Drawing Sheets





US009685701B2

(12) **United States Patent
Montgomery**

(10) **Patent No.: US 9,685,701 B2**

(45) **Date of Patent: Jun. 20, 2017**

(54) **HIGH ISOLATION ANTENNA SYSTEM**

(56) **References Cited**

(71) Applicant: **Achilles Technology Management Co II, Inc.**, Palo Alto, CA (US)

U.S. PATENT DOCUMENTS

(72) Inventor: **Mark T. Montgomery**, Melbourne Beach, FL (US)

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(73) Assignee: **Achilles Technology Management Co II, Inc.**, Palo Alto, CA (US)

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

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(21) Appl. No.: **14/558,269**

"International Search Report and Written Opinion for PCT/US2010/047529 dated Apr. 25, 2011".

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

Primary Examiner — Dieu H Duong

(65) **Prior Publication Data**

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

US 2015/0084824 A1 Mar. 26, 2015

Related U.S. Application Data

(57) **ABSTRACT**

(63) Continuation of application No. 12/873,823, filed on Sep. 1, 2010, now Pat. No. 8,937,578.

(Continued)

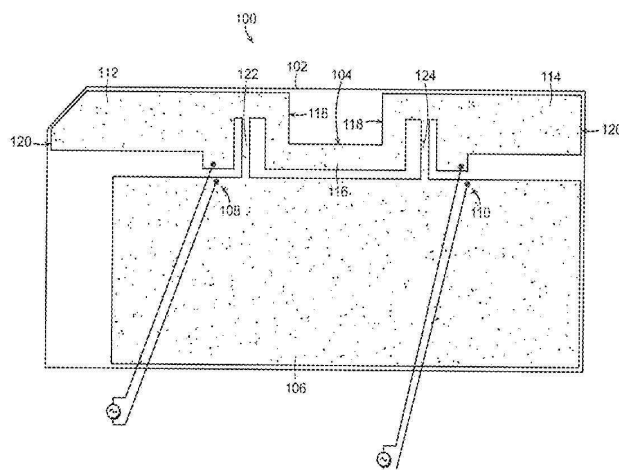
An antenna system supports a common resonance mode and differential resonance mode, each with approximately equal radiation resistance and bandwidth at a given operating frequency band. The antenna system includes a resonant antenna section, a counterpoise, and two antenna ports. The resonant antenna section includes two spaced-apart poles and a distributed network therebetween. Each of the poles has a proximal end connected to the distributed network and an opposite distal end. The distal ends of the poles are separated from each other by a distance of $\frac{1}{3}$ to $\frac{2}{3}$ of the electrical wavelength at the given operating frequency. Each of the two antenna ports is defined by a pair of feed terminals with one feed terminal located on the counterpoise and the other feed terminal located on a different one of the poles of the resonant antenna section. The resonant antenna section, counterpoise, and ports are configured such that a signal within the given operating frequency band applied to one port is isolated from the other port.

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

(52) **U.S. Cl.**
CPC **H01Q 1/523** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/521** (2013.01); **H01Q 5/328** (2015.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/521; H01Q 1/243; H01Q 9/16; H01Q 9/42
(Continued)

17 Claims, 7 Drawing Sheets





US009685703B2

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

(10) **Patent No.:** **US 9,685,703 B2**

(45) **Date of Patent:** **Jun. 20, 2017**

(54) **TUNABLE ANTENNA**

(71) Applicants: **Yeh-Chun Kao**, Taipei (TW); **You-Fu Cheng**, Taipei (TW); **Yu-Chia Chang**, 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 155 days.

(21) Appl. No.: **14/548,310**

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Nov. 28, 2013 (TW) 102143486 A

(51) **Int. Cl.**

H01Q 3/24 (2006.01)

H01Q 5/321 (2015.01)

H01Q 9/04 (2006.01)

H01Q 9/42 (2006.01)

H01Q 21/30 (2006.01)

H01Q 5/371 (2015.01)

H01Q 5/378 (2015.01)

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

CPC **H01Q 5/321** (2015.01); **H01Q 5/371** (2015.01); **H01Q 5/378** (2015.01); **H01Q 9/0421** (2013.01); **H01Q 9/42** (2013.01); **H01Q 21/30** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 3/24; H01Q 21/28; H01Q 1/243; H01Q 1/38

USPC 343/876, 725, 904, 846
See application file for complete search history.

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Primary Examiner — Dameon E Levi

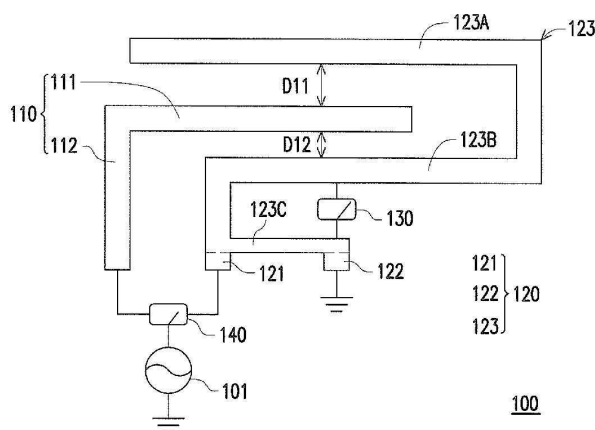
Assistant Examiner — Collin Dawkins

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

(57) **ABSTRACT**

A tunable antenna including a first radiating element, a second radiating element, a connection circuit and a switch circuit is provided. The first radiating element includes a coupling portion and a first feeding portion. The second radiating element includes a second feeding portion, a grounding portion and a radiation portion. The grounding portion is electrically connected to a ground plane, and the radiation portion surrounds the coupling portion to form a first coupling gap and the second coupling gap. The connection circuit is electrically connected to the radiation portion and a state of the connection circuit is changed according to a control signal, so as to adjust a length of the resonant path of the radiation portion. A feeding signal is transmitted to the first feeding portion or the second feeding portion by the switch circuit.

15 Claims, 5 Drawing Sheets





US009685705B2

(12) **United States Patent**
Azad

(10) **Patent No.:** **US 9,685,705 B2**

(45) **Date of Patent:** **Jun. 20, 2017**

(54) **WIDE BAND ANTENNA**

(71) Applicant: **Wistron Corporation**, New Taipei (TW)

(72) Inventor: **Mohammed Ziaul Azad**, Rolling Meadows, IL (US)

(73) Assignee: **Wistron Corporation**, 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 179 days.

(21) Appl. No.: **14/560,677**

(22) Filed: **Dec. 4, 2014**

(65) **Prior Publication Data**

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H01Q 9/42 (2006.01)
H01Q 1/24 (2006.01)
H01Q 5/371 (2015.01)

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

(58) **Field of Classification Search**
CPC H01Q 9/42; H01Q 1/243; H01Q 5/371
USPC 343/700 MS, 702
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Dameon E Levi

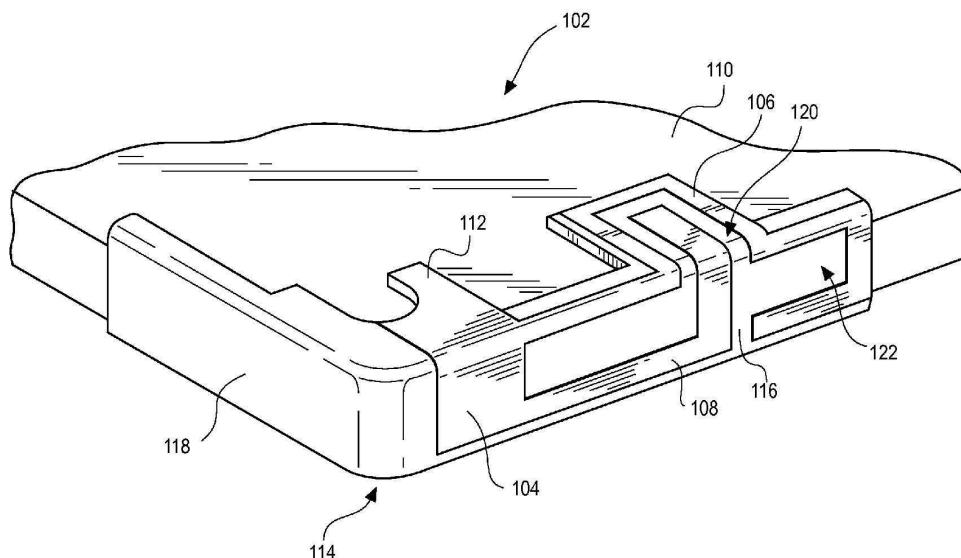
Assistant Examiner — David Lotter

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

(57) **ABSTRACT**

A wide band antenna for interfacing an electronic device with a plurality of radio access technologies is provided. The antenna includes a first resonator and a second resonator. Both the first resonator and the second resonator are attached to an antenna feed structure. The length of the first resonator provides one mode of operation of the antenna, and the length of the second resonator provides a second mode of operation of the antenna. And a third mode of operation of the antenna is provided by mutual coupling and current flow between both the first resonator and the second resonator.

18 Claims, 6 Drawing Sheets





US009685706B2

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

(10) **Patent No.:** **US 9,685,706 B2**

(45) **Date of Patent:** **Jun. 20, 2017**

(54) **FULL-BAND ANTENNA SYSTEM**

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(72) Inventors: **Tan Yew Choon**, Singapore (SG); **Ng Guan Hong**, Singapore (SG); **Tay Yew Siow**, Singapore (SG)

(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 106 days.

(21) Appl. No.: **14/930,225**

(22) Filed: **Nov. 2, 2015**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Apr. 29, 2015 (CN) 2015 1 0212532

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

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

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

(58) **Field of Classification Search**

CPC H01Q 9/42; H01Q 1/243

USPC 343/860

See application file for complete search history.

Primary Examiner — Dameon E Levi

Assistant Examiner — Andrea Lindgren Baltzell

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

(57) **ABSTRACT**

The disclosure provides a full-band antenna system including a metal backing and a main antenna module. The metal backing includes a header, a middle cover and a lower head. The main antenna module includes a circuit board, a feed part on the circuit board, a ground point and a matching circuit. The circuit board includes a substrate and an earth plate. The feed part and the matching circuit are located on the substrate, and the ground point is on the earth plate. The matching circuit is connected with the feed part, including a variable capacitance. By the variable capacitance of the matching circuit, it is beneficial to adjust the performance of antenna of all range of frequency conveniently and optimize the antenna's radiant efficiency up to the utmost extent.

9 Claims, 3 Drawing Sheets

