



US010109908B2

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

(10) **Patent No.:** **US 10,109,908 B2**
(45) **Date of Patent:** **Oct. 23, 2018**

(54) **ANTENNA MODULE AND ELECTRONIC DEVICES COMPRISING THE SAME**

(71) Applicant: **Samsung Electronics Co., Ltd.**,
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(72) Inventors: **Byeong Hwan Youm**, Suwon-si (KR);
Jong Kwon Ko, Suwon-si (KR);
Hyung Jin Kim, Seoul (KR); **Seung Hwan Kim**, Seoul (KR); **Kyung Bin Kim**, Hwaseong-si (KR); **Austin Kim**, Seongnam-si (KR); **Joon Ho Byun**, Yongin-si (KR); **Yu Ri Sin**, Seoul (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 16 days.

(21) Appl. No.: **14/677,217**

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

(65) **Prior Publication Data**

US 2015/0288055 A1 Oct. 8, 2015

(30) **Foreign Application Priority Data**

Apr. 4, 2014 (KR) 10-2014-0040492
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(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 5/371**
(2015.01);
(Continued)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/40
See application file for complete search history.

(56) **References Cited**

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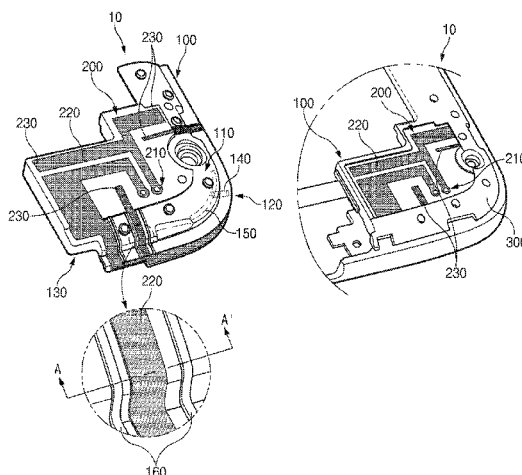
Primary Examiner — Robert Karacsony

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

(57) **ABSTRACT**

An antenna module and an electronic device are provided. The antenna module may include a first case including a case surface, wherein at least one antenna protection part is disposed on the first case, and wherein the at least one antenna projection part is formed to be distinguishable from the case surface, an antenna including a pattern, wherein at least a part of the pattern of the antenna is adjacently disposed to the antenna protection part.

16 Claims, 22 Drawing Sheets





US010109909B1

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

(10) **Patent No.:** **US 10,109,909 B1**
(45) **Date of Patent:** ***Oct. 23, 2018**

(54) **ANTENNA WITH PROXIMITY SENSOR FUNCTION**

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

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

(56)

References Cited

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

U.S. PATENT DOCUMENTS

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

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

This patent is subject to a terminal disclaimer.

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(21) Appl. No.: **15/263,270**

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

Related U.S. Application Data

(63) Continuation-in-part of application No. 13/965,101, filed on Aug. 12, 2013, now Pat. No. 9,478,870.

(60) Provisional application No. 61/682,145, filed on Aug. 10, 2012.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/22 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/245** (2013.01); **H01Q 1/2258** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/48; H01Q 25/04; H01Q 1/24; H01Q 1/22; H01Q 1/36

Primary Examiner — Huedung Mancuso

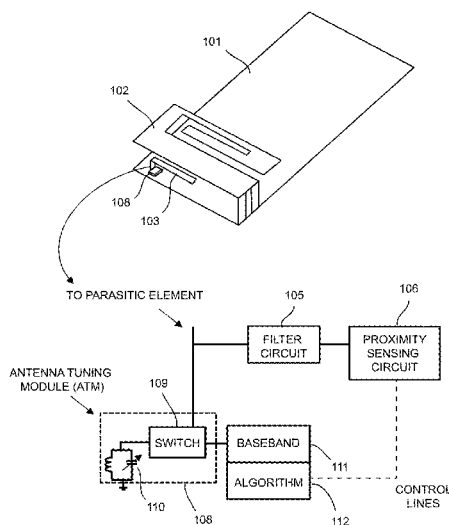
(74) *Attorney, Agent, or Firm* — Dority & Manning, P.A.

(57)

ABSTRACT

The disclosure concerns an antenna with proximity sensor function. The antenna and proximity sensors can be implemented in a laptop computer, and proximity sensor loading states are surveyed and used to determine when and to what degree to alter the reactance at the junction of or along the parasitic element to optimize the frequency response and/or the impedance properties of the antenna system. An algorithm or look-up table is configured to relate proximity sensor loading states to reactance required to alter antenna characteristics.

9 Claims, 7 Drawing Sheets





(12) **United States Patent**
Caporal Del Barrio et al.

(10) **Patent No.:** **US 10,109,914 B2**
(45) **Date of Patent:** **Oct. 23, 2018**

(54) **ANTENNA SYSTEM**

(71) Applicant: **Intel IP Corporation**, Santa Clara, CA
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(72) Inventors: **Samantha Caporal Del Barrio**,
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Pedersen, Storvorde (DK); **Ole**
Jagielski, Frederikshavn (DK); **Simon**
Svendsen, Aalborg (DK); **Boyan**
Yanakiev, Aalborg (DK)

(73) Assignee: **Intel IP 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 317 days.

(21) Appl. No.: **14/671,470**

(22) Filed: **Mar. 27, 2015**

(65) **Prior Publication Data**
US 2016/0285159 A1 Sep. 29, 2016

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

(52) **U.S. Cl.**
CPC **H01Q 1/50** (2013.01); **H01Q 1/242**
(2013.01); **H01Q 1/38** (2013.01); **H01Q 5/314**
(2015.01); **H01Q 7/00** (2013.01); **H01Q 7/005**
(2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/50; H01Q 7/00; H01Q 1/242;
H01Q 5/314; H01Q 7/005
(Continued)

(56) **References Cited**

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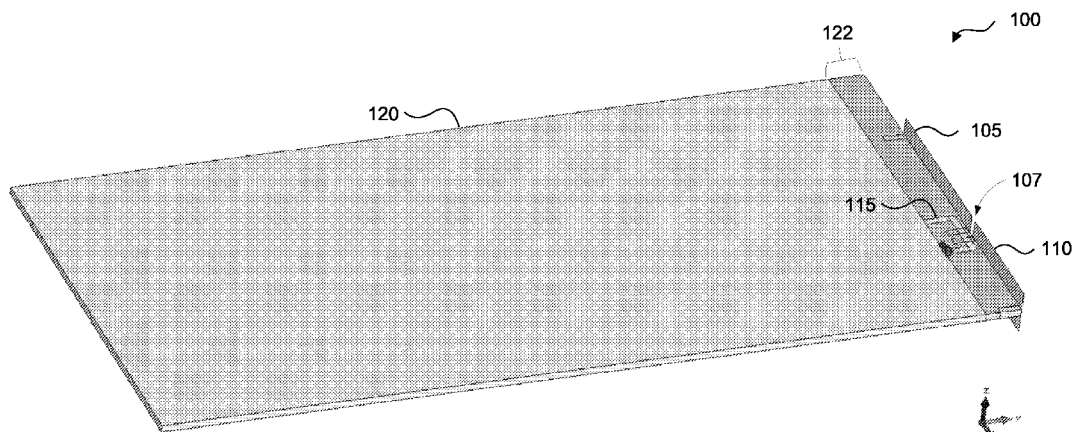
Primary Examiner — Huedung Mancuso

(74) *Attorney, Agent, or Firm* — Schiff Hardin LLP

(57) **ABSTRACT**

Antenna systems that can include first and second radiators and an electromagnetic coupler disposed adjacent to the first and the second radiators. The radiators can be tunable to one or more frequencies. The electromagnetic coupler can be, for example, an inductive coupler or a capacitive coupler. One or more of the antenna systems can be configured to use carrier aggregation by tuning the first and/or the second radiators. For example, one or more of the antenna systems can be configured to use inter-band aggregation, intra-band contiguous aggregation, and intra-band non-contiguous aggregation.

21 Claims, 11 Drawing Sheets



(12) **United States Patent**
Liu

(10) **Patent No.:** **US 10,109,922 B2**
(45) **Date of Patent:** **Oct. 23, 2018**

- (54) **CAPACITIVE-FED MONOPOLE ANTENNA**
- (71) Applicant: **Microsoft Technology Licensing, LLC**,
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- (72) Inventor: **Luyi Liu**, Sammamish, WA (US)
- (73) Assignee: **Microsoft Technology Licensing, LLC**,
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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 201 days.

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

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- (21) Appl. No.: **14/870,485**
- (22) Filed: **Sep. 30, 2015**
- (65) **Prior Publication Data**
- US 2017/0093044 A1 Mar. 30, 2017
- (51) **Int. Cl.**
- H01Q 9/04** (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/40 (2006.01)
H01Q 5/357 (2015.01)
H01Q 5/378 (2015.01)
- (52) **U.S. Cl.**
- CPC **H01Q 9/0457** (2013.01); **H01Q 1/2266**
(2013.01); **H01Q 1/245** (2013.01); **H01Q**
5/357 (2015.01); **H01Q 5/378** (2015.01);
H01Q 9/0414 (2013.01); **H01Q 9/0485**
(2013.01); **H01Q 9/40** (2013.01)
- (58) **Field of Classification Search**
- CPC H01Q 9/0457; H01Q 5/378; H01Q 1/2266;
H01Q 1/245; H01Q 9/0485; H01Q 9/40
USPC 343/700 MS
See application file for complete search history.

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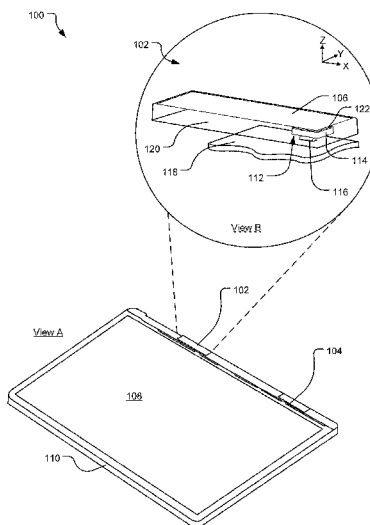
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Primary Examiner — Dameon E Levi
Assistant Examiner — Hasan Islam
(74) *Attorney, Agent, or Firm* — Holzer Patel Drennan

(57) **ABSTRACT**

A monopole antenna structure disclosed herein includes a ceramic block with a metallic surface coupled to a feed structure and a planar radiation element electrically floating relative to the ceramic block. The planar radiation element is in a parallel plane alignment with the metallic surface of the ceramic block. When the feed structure provides signal of one or more select frequencies to the metallic surface of the ceramic block, the ceramic block radiates (e.g., transmits a carrier wave) and in turn, excites the planar radiation element to re-radiate the signal.

17 Claims, 6 Drawing Sheets





US010109926B2

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

(10) **Patent No.:** **US 10,109,926 B2**

(45) **Date of Patent:** **Oct. 23, 2018**

(54) **ANTENNA RADIATOR, ANTENNA AND MOBILE TERMINAL**

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

(72) Inventors: **Munyong Choi**, Shenzhen (CN);
Mingqian Shao, Shenzhen (CN); **Wei Zhao**, Shenzhen (CN)

(73) Assignee: **BYD Company Limited** (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 5 days.

(21) Appl. No.: **15/328,802**

(22) PCT Filed: **Mar. 25, 2015**

(86) PCT No.: **PCT/CN2015/075074**

§ 371 (c)(1),

(2) Date: **Jan. 24, 2017**

(87) PCT Pub. No.: **WO2016/019733**

PCT Pub. Date: **Feb. 11, 2016**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Aug. 7, 2014 (CN) 2014 2 0445855 U

(51) **Int. Cl.**

H01Q 13/16 (2006.01)

H01Q 1/48 (2006.01)

H01Q 1/50 (2006.01)

H01Q 1/24 (2006.01)

H01Q 9/04 (2006.01)

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

CPC **H01Q 13/16** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/50** (2013.01); **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/371; H01Q 5/328; H01Q 5/357;
H01Q 5/364; H01Q 5/30; H01Q 1/243;
H01Q 1/48; H01Q 9/0421

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Primary Examiner — Dameon E Levi

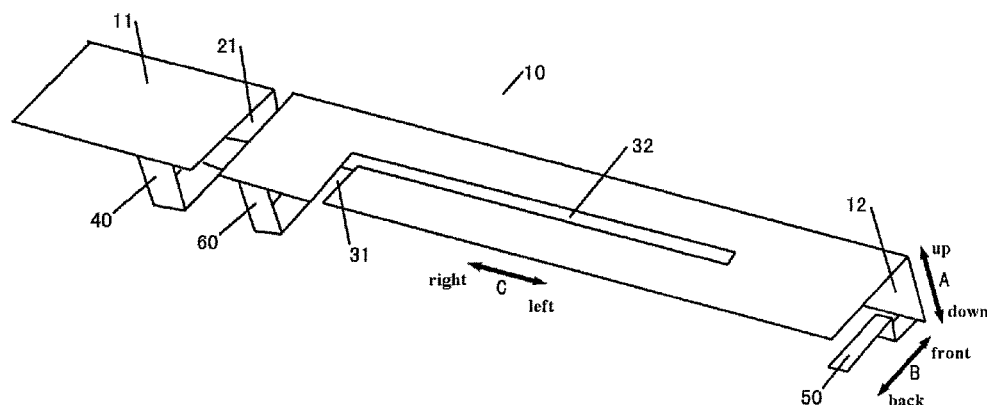
Assistant Examiner — Jennifer F Hu

(74) *Attorney, Agent, or Firm* — Calfee, Halter & Griswold LLP

(57) **ABSTRACT**

An antenna comprises: a circuit board; an antenna radiator, wherein the antenna radiator is provided with a first gap, a second gap, a first grounding piece, a second grounding piece and a feed piece, the first gap and the second gap forming a first inverted-F antenna connected to the first grounding piece and a second inverted-F antenna connected to the second grounding piece on the antenna radiator, and the feed piece being respectively connected to the first inverted-F antenna and the second inverted-F antenna; and an antenna frequency reconstruction system, wherein the antenna frequency reconstruction system is provided on the circuit board, the antenna frequency reconstruction system is

(Continued)





US010116039B2

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

(10) **Patent No.:** **US 10,116,039 B2**
(45) **Date of Patent:** **Oct. 30, 2018**

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

(56) **References Cited**

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(71) Applicant: **Samsung Electronics Co., Ltd.**,
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(72) Inventors: **Jong-Hyuck Lee**, Gyeonggi-do (KR);
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Gyu-Sub Kim, Seoul (KR); **Yong-Eui Hong**, Seoul (KR)

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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 310 days.

(21) Appl. No.: **14/830,237**

(22) Filed: **Aug. 19, 2015**

FOREIGN PATENT DOCUMENTS

(65) **Prior Publication Data**

KR 10-2011-0124131 11/2011
KR 10-2012-0117048 10/2012

US 2016/0056530 A1 Feb. 25, 2016

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(30) **Foreign Application Priority Data**

Aug. 19, 2014 (KR) 10-2014-0107666

Primary Examiner — Tho G Phan

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

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 9/04 (2006.01)

H01Q 5/378 (2015.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 5/378**
(2015.01); **H01Q 9/0407** (2013.01)

(58) **Field of Classification Search**

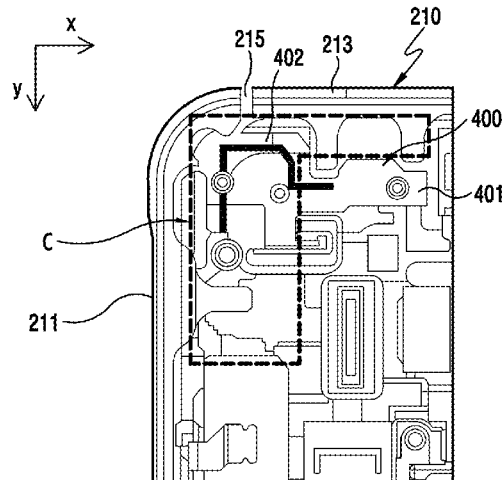
CPC H01Q 1/243; H01Q 9/0407; H01Q 5/378;
H01Q 1/38

See application file for complete search history.

ABSTRACT

An antenna apparatus and an electronic device are provided. The electronic device includes a plurality of metal parts, an antenna radiator arranged around the plurality of metal parts, and at least one sub antenna radiator arranged to electrically connect with the antenna radiator around the antenna radiator, and prevent deterioration of radiation efficiency of the antenna radiator caused by the plurality of metal parts.

15 Claims, 18 Drawing Sheets





US010116040B2

(12) **United States Patent**
Li

(10) **Patent No.:** **US 10,116,040 B2**

(45) **Date of Patent:** **Oct. 30, 2018**

(54) **MULTI-FREQUENCY ANTENNA AND TERMINAL**

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

(72) Inventor: **Qun Li**, Shenzhen (CN)

(73) Assignee: **ZTE Corporation**, Shenzhen, Guangdong (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 31 days.

(21) Appl. No.: **15/023,756**

(22) PCT Filed: **Apr. 18, 2014**

(86) PCT No.: **PCT/CN2014/075721**

§ 371 (c)(1),

(2) Date: **Apr. 12, 2016**

(87) PCT Pub. No.: **WO2015/039435**

PCT Pub. Date: **Mar. 26, 2015**

(65) **Prior Publication Data**

US 2016/0233576 A1 Aug. 11, 2016

(30) **Foreign Application Priority Data**

Sep. 22, 2013 (CN) 2013 1 0438081

(51) **Int. Cl.**

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H01Q 5/371 (2015.01)

(Continued)

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

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(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 5/371; H01Q 9/0421; H01Q 7/00

See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Jessica Han

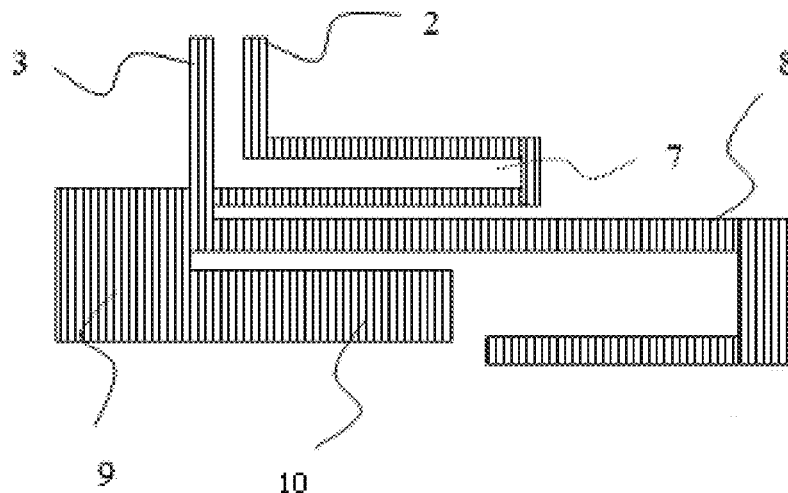
Assistant Examiner — Michael Bouizza

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

(57) **ABSTRACT**

The present disclosure discloses a multi-frequency antenna and a terminal. An antenna body of the multi-frequency antenna includes: a grounding part, a feed part, and a first radiation branch arm and a second radiation branch arm which are connected with the feed part; the antenna body further includes a third radiation branch arm; one end of the third radiation branch arm is connected with the feed part, and the other end of the third radiation branch arm is connected with the grounding part.

15 Claims, 3 Drawing Sheets





US010116047B1

(12) **United States Patent**
Chang

(10) **Patent No.:** **US 10,116,047 B1**
(45) **Date of Patent:** **Oct. 30, 2018**

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

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

(71) Applicant: **AMBIT MICROSYSTEMS (SHANGHAI) LTD.**, Shanghai (CN)

(56) **References Cited**

U.S. PATENT DOCUMENTS

(72) Inventor: **Wei-Jen Chang**, New Taipei (TW)

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343/795

(73) Assignee: **AMBIT MICROSYSTEMS (SHANGHAI) LTD.**, Shanghai (CN)

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455/575.5

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

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(21) Appl. No.: **15/636,577**

Primary Examiner — Andrea Lindgren Baltzell

(22) Filed: **Jun. 28, 2017**

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

(51) **Int. Cl.**

H01Q 1/38 (2006.01)
H01Q 1/24 (2006.01)
H04M 1/23 (2006.01)
H01Q 9/30 (2006.01)
H01Q 9/04 (2006.01)
H01Q 3/24 (2006.01)

(57) **ABSTRACT**

An antenna device includes a first antenna and a second antenna. The first antenna and the second antenna are disposed in a PCB to radiate signals. The first antenna includes a first ground portion, a first short portion and a first feeding part. The first short portion and the first ground portion are electrically coupled together to form a first storage space. Further, THE first storage space has a first notch. The first feeding part is disposed in the first storage space. The first feeding part and the first short portion are not contacted through any metallic conductors. The first feeding part and the first ground portion are not contacted through any metallic conductors. A communication device is also provided.

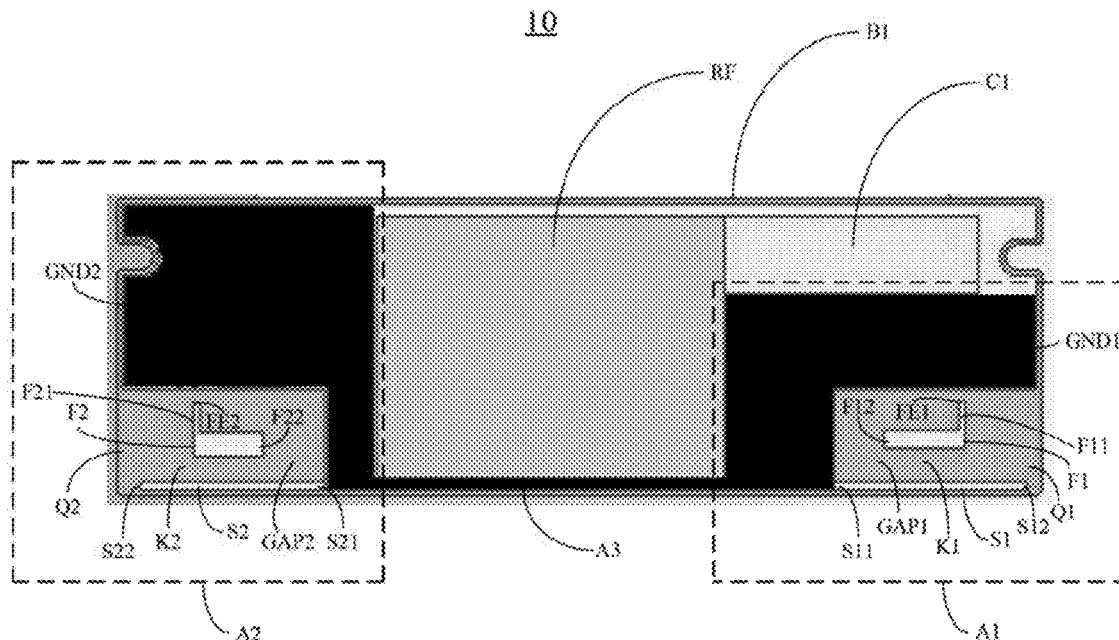
(52) **U.S. Cl.**

CPC **H01Q 1/38** (2013.01); **H01Q 1/24** (2013.01); **H01Q 1/243** (2013.01); **H01Q 3/24** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 9/30** (2013.01); **H04M 1/233** (2013.01)

(58) **Field of Classification Search**

CPC .. H01Q 1/38; H01Q 1/24; H01Q 3/24; H01Q 9/04; H01Q 9/30

16 Claims, 4 Drawing Sheets





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(12) **United States Patent**
Nezhad-Ahmadi et al.

(10) **Patent No.:** **US 10,116,052 B2**
(45) **Date of Patent:** **Oct. 30, 2018**

(54) **TUNABLE ANTENNA FOR
HIGH-EFFICIENCY, WIDEBAND
FREQUENCY COVERAGE**

(71) Applicant: **SEMICONDUCTOR COMPONENTS
INDUSTRIES, LLC**, Phoenix, AZ
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(72) Inventors: **Mohammad-Reza Nezhad-Ahmadi**,
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Kitchener (CA)

(73) Assignee: **SEMICONDUCTOR COMPONENTS
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(US)

(*) 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.: **15/161,120**

(22) Filed: **May 20, 2016**

(65) **Prior Publication Data**

US 2017/0141753 A1 May 18, 2017

Related U.S. Application Data

(60) Provisional application No. 62/255,617, filed on Nov.
16, 2015.

(51) **Int. Cl.**
H01Q 5/321 (2015.01)
H01Q 5/392 (2015.01)
H01Q 5/371 (2015.01)
H01Q 5/328 (2015.01)
H01Q 5/385 (2015.01)
H01Q 9/42 (2006.01)
H01Q 1/24 (2006.01)
H03H 7/38 (2006.01)

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

CPC **H01Q 5/321** (2015.01); **H01Q 1/243**
(2013.01); **H01Q 5/328** (2015.01); **H01Q**
5/371 (2015.01); **H01Q 5/385** (2015.01);
H01Q 5/392 (2015.01); **H01Q 9/42** (2013.01);
H03H 7/38 (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 5/314; H01Q 5/321;
H01Q 5/328; H01Q 5/364; H01Q 5/371;
H01Q 5/378; H01Q 5/385; H01Q 5/392;
H01Q 7/005; H01Q 9/42

See application file for complete search history.

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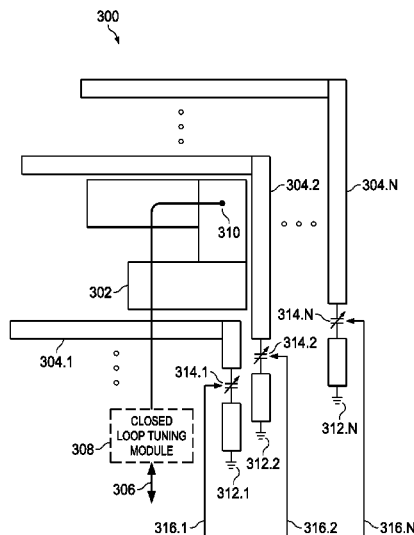
Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — Dickinson Wright PLLC

(57) **ABSTRACT**

A system, in some embodiments, comprises: a processor; a transceiver coupled to the processor; and an antenna including a central element that connects to one or more of the processor and the transceiver, said antenna further including multiple coupling elements that electromagnetically couple to the central element, wherein each of the multiple coupling elements comprises a separate variable capacitor.

23 Claims, 5 Drawing Sheets





US010122069B2

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

(10) **Patent No.:** **US 10,122,069 B2**

(45) **Date of Patent:** **Nov. 6, 2018**

(54) **MOBILE TERMINAL DEVICE**

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

(72) Inventors: **Chan Yun Ghit**, Shenzhen (CN); **Ng Guan Hong**, Shenzhen (CN); **Tay Yew Siow**, 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 514 days.

(21) Appl. No.: **15/062,100**

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

(65) **Prior Publication Data**

US 2017/0033438 A1 Feb. 2, 2017

(30) **Foreign Application Priority Data**

Jul. 31, 2015 (CN) 2015 1 0465475

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

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

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 5/30; H01Q 9/0421
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Dameon E Levi

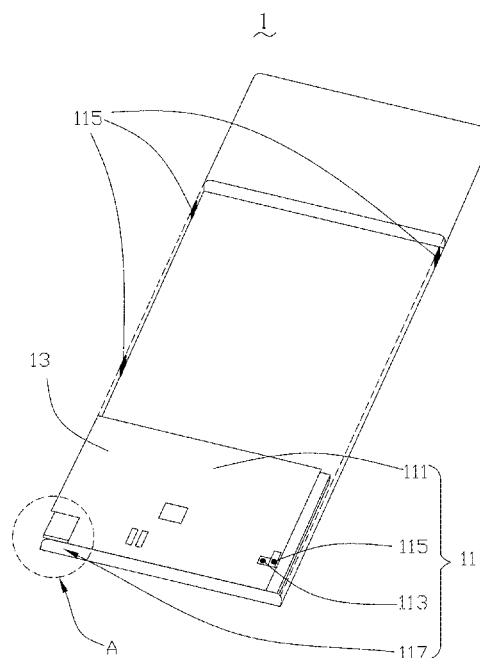
Assistant Examiner — David Lotter

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

(57) **ABSTRACT**

A mobile terminal device is provided in the present disclosure. The mobile terminal device includes a metal back cover with a groove, a printed circuit board with a groove opening corresponding to the groove, and an antenna module. The antenna module includes a radiator body and a groove adaptor member, at least part of the metal back cover serves as the radiator body of the antenna module. The groove adaptor member includes a groove adapting part and a supporting part for supporting the groove adapting part, the groove adapting part includes a main body, a first extending piece and a second extending piece. The main body is received in the groove opening and aligned with the groove; the first extending piece and the second extending piece respectively extend from two opposite edges of the main body and are connected to the printed circuit board.

16 Claims, 7 Drawing Sheets





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

(10) **Patent No.:** **US 10,122,070 B2**
(45) **Date of Patent:** **Nov. 6, 2018**

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

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

(71) Applicant: **Beijing Xiaomi Mobile Software Co.,
Ltd.**, Beijing (CN)

(56) **References Cited**

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

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(73) Assignee: **BEIJING XIAOMI MOBILE
SOFTWARE CO., LTD.**, Beijing (CN)

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 174 days.

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(21) Appl. No.: **15/347,790**

International Search Report for International Application No. PCT/
CN2016/101021, dated Dec. 21, 2016.

(22) Filed: **Nov. 10, 2016**

(Continued)

(65) **Prior Publication Data**

US 2017/0271749 A1 Sep. 21, 2017

(30) **Foreign Application Priority Data**

Mar. 16, 2016 (CN) 2016 1 0151249

Primary Examiner — Andrea Lindgren Baltzell
(74) *Attorney, Agent, or Firm* — Jun He Law Offices
P.C.; James J. Zhu

(57) **ABSTRACT**

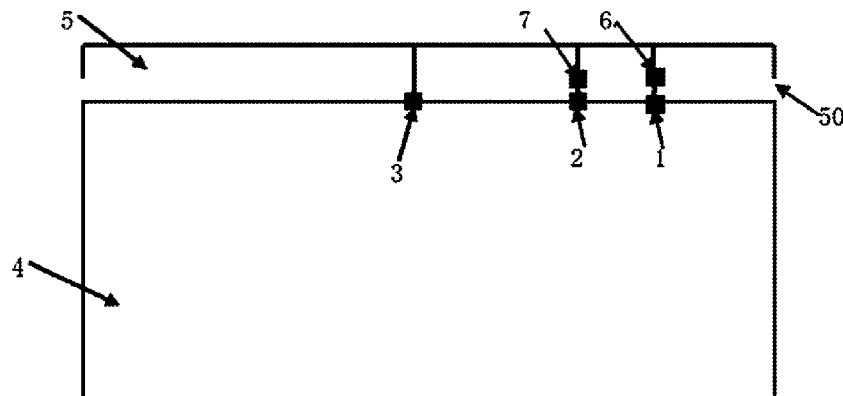
(51) **Int. Cl.**
H01Q 9/42 (2006.01)
H01Q 1/24 (2006.01)
H01Q 5/50 (2015.01)
H01Q 1/48 (2006.01)
H01Q 9/04 (2006.01)
H01Q 5/314 (2015.01)
H01Q 5/371 (2015.01)

A diversity antenna applied in a mobile terminal and a
mobile terminal are provided. The mobile terminal includes
a metal housing and the metal housing includes a housing
body and a receiving region located over the housing body,
and the receiving region is a frame structure in which a side
is provided with a slit. The diversity antenna includes a feed
point, a first ground point and a second ground point, and the
feed point, the first ground point and the second ground
point are all arranged on the housing body, and a distance
between the feed point and the slit is 3 mm to 15 mm. The
diversity antenna further includes a capacitive element con-
nected to the frame structure and arranged in series with the
feed point, and a switch arranged in series with the first
ground point.

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/48**
(2013.01); **H01Q 5/314** (2015.01); **H01Q**
5/371 (2015.01); **H01Q 5/50** (2015.01); **H01Q**
9/0421 (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/314; H01Q 5/371;
H01Q 5/50; H01Q 1/48; H01Q 9/42

20 Claims, 1 Drawing Sheet



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

(10) **Patent No.:** **US 10,122,071 B2**
(45) **Date of Patent:** **Nov. 6, 2018**

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

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)
(72) Inventors: **Mattia Pascolini**, San Francisco, CA
(US); **Nanbo Jin**, Milpitas, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 158 days.

(21) Appl. No.: **15/374,745**

(22) Filed: **Dec. 9, 2016**

(65) **Prior Publication Data**
US 2017/0125889 A1 May 4, 2017

Related U.S. Application Data

(62) Division of application No. 14/463,299, filed on Aug.
19, 2014, now Pat. No. 9,577,318.

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

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **G06F 21/32**
(2013.01); **G06K 9/0002** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 13/103; H01Q 1/2258; H01Q 1/243;
H01Q 1/38; H01Q 1/48; H01Q 3/247;
(Continued)

(56) **References Cited**

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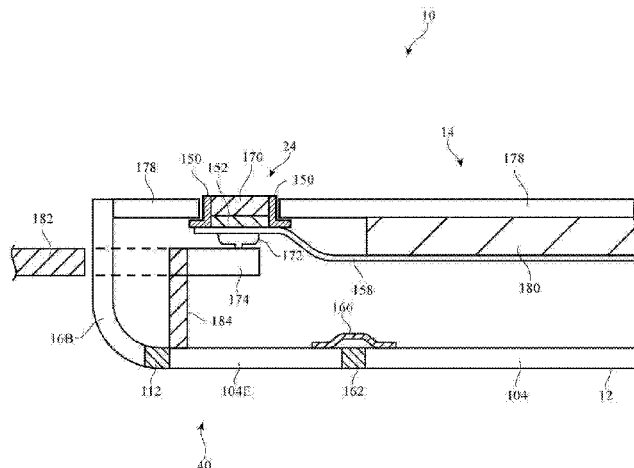
Primary Examiner — Tho G Phan

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

(57) **ABSTRACT**

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

20 Claims, 12 Drawing Sheets



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

(10) **Patent No.:** **US 10,122,086 B2**
(45) **Date of Patent:** **Nov. 6, 2018**

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

(71) Applicant: **Murata Manufacturing Co., Ltd.**,
Kyoto (JP)

(72) Inventors: **Katsuhito Kuroda**, Kyoto (JP); **Kengo Onaka**, Kyoto (JP)

(73) Assignee: **MURATA MANUFACTURING CO., LTD.**, Kyoto (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 9 days.

(21) Appl. No.: **15/585,439**

(22) Filed: **May 3, 2017**

(65) **Prior Publication Data**

US 2017/0237168 A1 Aug. 17, 2017

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2015/080476, filed on Oct. 29, 2015.

(30) **Foreign Application Priority Data**

Nov. 14, 2014 (JP) 2014-231888

(51) **Int. Cl.**
H01Q 9/14 (2006.01)
H01Q 1/24 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/321** (2015.01); **H01Q 1/242** (2013.01); **H01Q 5/328** (2015.01); **H01Q 9/145** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/321; H01Q 5/328; H01Q 9/14; H01Q 9/145; H01Q 1/242; H01Q 1/24
See application file for complete search history.

(56) **References Cited**

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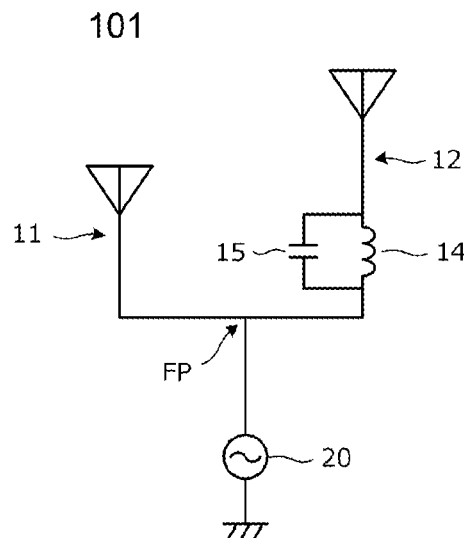
Primary Examiner — Hoang Nguyen

(74) *Attorney, Agent, or Firm* — Pearne & Gordon LLP

(57) **ABSTRACT**

In an antenna device including a high-band antenna element and a low-band antenna element that are connected to a common feed point and feeding electric power using one feed point, influence by unnecessary resonance of the low-band antenna element in a high band is suppressed. The antenna device includes a high-band antenna element and a low-band antenna element that are connected to a common feed point, an antenna-shortening inductor that is connected to between the low-band antenna element and the feed point, and a capacitor that is connected to the antenna-shortening inductor in parallel.

15 Claims, 11 Drawing Sheets





US010122401B2

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

(10) **Patent No.:** **US 10,122,401 B2**

(45) **Date of Patent:** **Nov. 6, 2018**

(54) **MOBILE TERMINAL**

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

(72) Inventors: **Yeomin Youn**, Seoul (KR); **Jaehyun Choi**, Seoul (KR); **Jungsun Ahn**, Seoul (KR); **Changil Kim**, Seoul (KR); **Kangjae Jung**, 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.: **15/961,227**

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

(65) **Prior Publication Data**

US 2018/0241430 A1 Aug. 23, 2018

Related U.S. Application Data

(63) Continuation of application No. 15/783,873, filed on Oct. 13, 2017, now Pat. No. 9,985,679, which is a
(Continued)

(30) **Foreign Application Priority Data**

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

(51) **Int. Cl.**
H04M 1/00 (2006.01)
H04B 1/3888 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC **H04B 1/3888** (2013.01); **G06F 1/1626** (2013.01); **G06F 1/1656** (2013.01);
(Continued)

(58) **Field of Classification Search**

CPC . H04M 1/0202; H04B 7/0413; H04B 1/3838;
H04B 1/38; H01Q 1/243; H01Q 1/245
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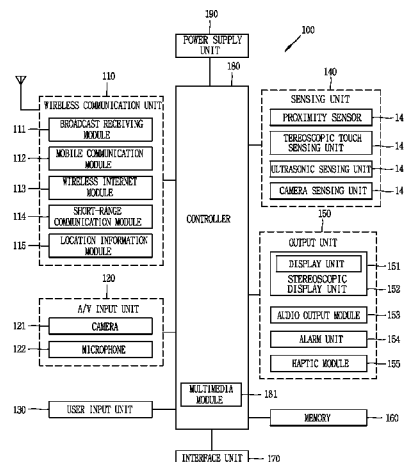
Primary Examiner — April G Gonzales

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

(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.

30 Claims, 15 Drawing Sheets



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

(10) **Patent No.:** **US 10,122,402 B2**
(45) **Date of Patent:** **Nov. 6, 2018**

(54) **METHOD AND APPARATUS FOR A TUNABLE ANTENNA**

(56) **References Cited**

(71) Applicant: **Futurewei Technologies, Inc.**, Plano, TX (US)
(72) Inventors: **Shing Lung Steven Yang**, San Diego, CA (US); **Ping Shi**, San Diego, CA (US); **Daejong Kim**, San Diego, CA (US); **Wee Kian Toh**, San Diego, CA (US); **Navid Nader**, San Diego, CA (US); **Guangdong Jiang**, Beijing (CN)
(73) Assignee: **Futurewei Technologies, Inc.**, Plano, TX (US)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 80 days.

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(21) Appl. No.: **13/732,097**

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(22) Filed: **Dec. 31, 2012**

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(65) **Prior Publication Data**

US 2014/0187178 A1 Jul. 3, 2014

(Continued)

(51) **Int. Cl.**
H04B 1/40 (2015.01)
H01Q 9/06 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/392 (2015.01)
H01Q 1/24 (2006.01)

Primary Examiner — Nay A Maung
Assistant Examiner — Erica Fleming-Hall
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

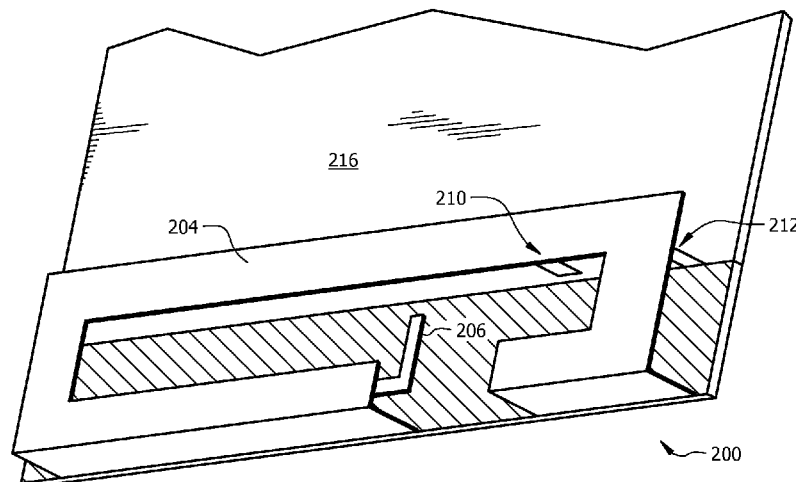
(52) **U.S. Cl.**
CPC **H04B 1/40** (2013.01); **H01Q 5/392** (2015.01); **H01Q 9/06** (2013.01); **H01Q 9/42** (2013.01); **H01Q 1/243** (2013.01)

(57) **ABSTRACT**

(58) **Field of Classification Search**
USPC 455/77; 343/745, 746, 748
See application file for complete search history.

A method for tuning an antenna comprising determining an operating frequency band of the antenna, and adjusting a capacitance of a tunable load according to the operating frequency band, wherein the tunable load is electromagnetically coupled to the antenna via a parasitic arm, and wherein the operating frequency band depends on the capacitance.

21 Claims, 12 Drawing Sheets



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

(10) **Patent No.:** **US 10,122,516 B2**
(45) **Date of Patent:** ***Nov. 6, 2018**

(54) **STATE PREDICTION PROCESS AND METHODOLOGY**

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

(72) Inventors: **Olivier Pajona**, Antibes (FR);
Sebastian Rowson, San Diego, CA (US); **Laurent Desclos**, San Diego, CA (US)

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

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

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **15/209,644**

(22) Filed: **Jul. 13, 2016**

(65) **Prior Publication Data**

US 2016/0323085 A1 Nov. 3, 2016

Related U.S. Application Data

(63) Continuation of application No. 14/077,128, filed on Nov. 11, 2013, now Pat. No. 9,425,497, which is a (Continued)

(51) **Int. Cl.**

H04B 1/00 (2006.01)
H04L 5/00 (2006.01)
H01Q 1/24 (2006.01)
H01Q 3/44 (2006.01)
H01Q 19/28 (2006.01)
H04B 7/0413 (2017.01)
H04B 7/06 (2006.01)

H04B 17/318 (2015.01)

H04B 7/10 (2017.01)

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

CPC **H04L 5/0057** (2013.01); **H01Q 1/243** (2013.01); **H01Q 3/44** (2013.01); **H01Q 19/28** (2013.01); **H04B 7/0413** (2013.01); **H04B 7/0689** (2013.01); **H04B 17/318** (2015.01); **H04B 7/10** (2013.01)

(58) **Field of Classification Search**

CPC **H04B 7/10**; **H04B 7/0871**; **H04B 7/0413**; **H04B 7/0689**; **H04B 17/318**; **H04B 7/04**; **H04B 7/0404**; **H04B 7/0802**; **H04B 7/0825**; **H04B 7/0848**; **H04B 7/0854**; **H04B 7/0857**; **H04B 7/0452**; **H04B 7/0456**; **H04B 7/0626**; **H04B 7/0417**; **H04B 7/0617**

USPC 455/63.4

See application file for complete search history.

(56) **References Cited**

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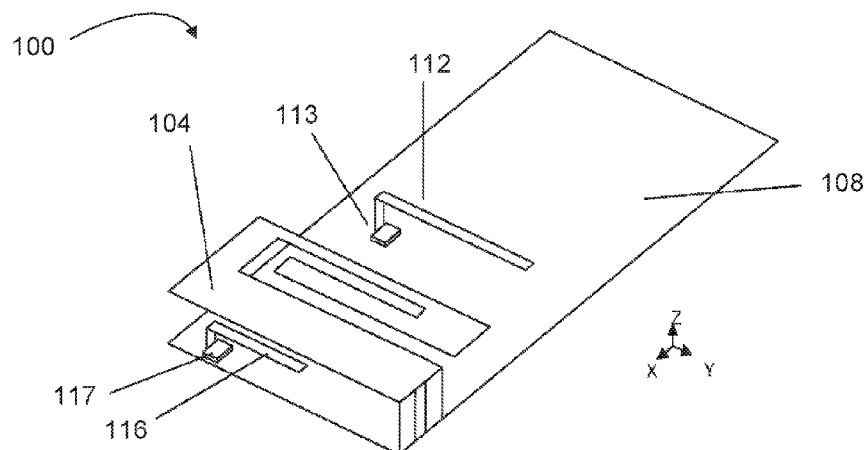
Primary Examiner — Ajibola Akinyemi

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

(57) **ABSTRACT**

A system and method for optimizing the performance for MIMO are provided, the system including multiple antennas, including at least one modal antenna, wherein each of the at least one modal antenna has multiple modes corresponding to multiple radiation patterns, and a processor coupled to the multiple antennas and configured to select a mode among the multiple modes to optimize signal quality for each time interval based on a CQI by considering envelop correlation effects.

18 Claims, 6 Drawing Sheets





US010128560B2

(12) **United States Patent**
Heng

(10) **Patent No.:** **US 10,128,560 B2**
(45) **Date of Patent:** **Nov. 13, 2018**

(54) **HYBRID ANTENNA AND INTEGRATED PROXIMITY SENSOR USING A SHARED CONDUCTIVE STRUCTURE**

(56) **References Cited**

U.S. PATENT DOCUMENTS

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

(72) Inventor: **Chew Chwee Heng**, Singapore (SG)

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

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

(21) Appl. No.: **14/968,893**

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

(65) **Prior Publication Data**

US 2016/0172749 A1 Jun. 16, 2016

Related U.S. Application Data

(60) Provisional application No. 62/090,887, filed on Dec. 12, 2014.

(51) **Int. Cl.**

H01Q 1/52 (2006.01)

H01Q 1/24 (2006.01)

H01Q 1/44 (2006.01)

H01Q 9/42 (2006.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/44** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 9/42; H01Q 1/44

See application file for complete search history.

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Primary Examiner — Jessica Han

Assistant Examiner — Michael Bouizza

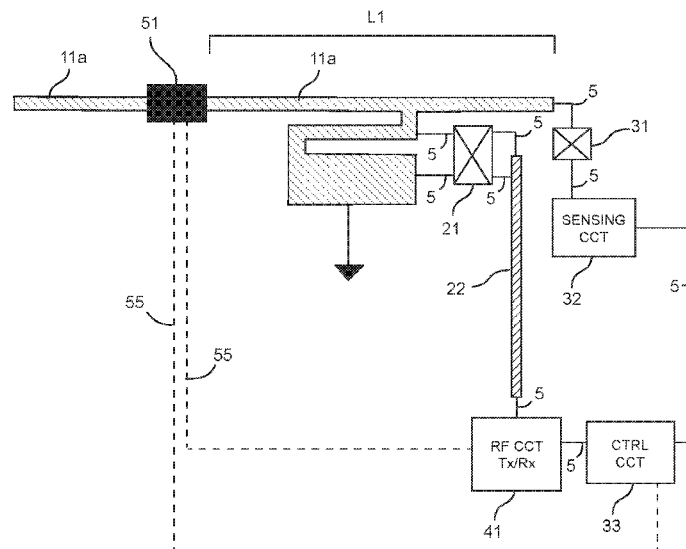
(74) *Attorney, Agent, or Firm* — Dority & Manning, P.A.

(57)

ABSTRACT

A hybrid antenna and integrated proximity sensor is described wherein a commonly shared conductive structure is used for both antenna functions as well as a proximity sensor functions.

16 Claims, 4 Drawing Sheets



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

(10) **Patent No.:** **US 10,128,561 B2**
(45) **Date of Patent:** **Nov. 13, 2018**

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

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

(72) Inventors: **Jungsik Park**, Suwon-si (KR); **Wangik Son**, Hwaseong-si (KR)

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

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

(21) Appl. No.: **15/593,891**

(22) Filed: **May 12, 2017**

(65) **Prior Publication Data**

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Related U.S. Application Data

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(30) **Foreign Application Priority Data**

Apr. 28, 2014 (KR) 10-2014-0050444

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 13/10 (2006.01)
H01Q 1/42 (2006.01)
H01Q 1/44 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/48 (2006.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/241** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/42** (2013.01); **H01Q 1/44** (2013.01); **H01Q 1/48** (2013.01); **H01Q 13/10** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/38; H01Q 1/42; H01Q 1/48; H01Q 13/10
See application file for complete search history.

(56) **References Cited**

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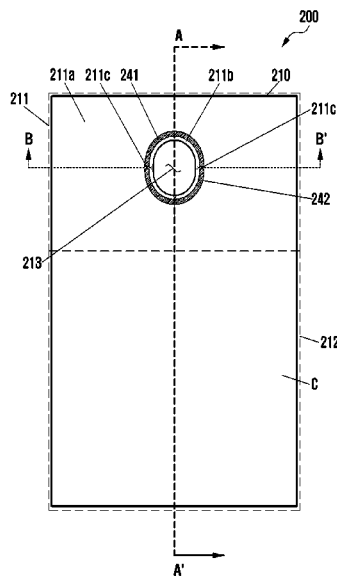
Primary Examiner — Hoang Nguyen

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

(57) **ABSTRACT**

An antenna apparatus is provided. The antenna apparatus includes a first section including at least one slit spaced apart from an outer edge of the antenna apparatus by a predetermined distance, a second section distinguished from the first section through the slit, and a feeding module for supplying a current to at least one of the first section and the second section.

20 Claims, 11 Drawing Sheets





US010128569B2

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

(10) **Patent No.:** **US 10,128,569 B2**
(45) **Date of Patent:** **Nov. 13, 2018**

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

(71) Applicant: **Xiaomi Inc.**, Haidian District, Beijing (CN)

(72) Inventors: **Wei Kuang**, Beijing (CN); **Wendong Liu**, Beijing (CN); **Youquan Su**, Beijing (CN)

(73) Assignee: **XIAOMI INC.**, Haidian District, Beijing

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 23 days.

(21) Appl. No.: **15/385,851**

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Dec. 21, 2015 (CN) 2015 1 0965362

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 1/52 (2006.01)
H01Q 1/48 (2006.01)
H01Q 13/10 (2006.01)
H01Q 5/328 (2015.01)

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

CPC **H01Q 1/528** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/328** (2015.01); **H01Q 13/103** (2013.01); **H01Q 1/243** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/48; H01Q 1/24; H01Q 1/241; H01Q 1/243; H01Q 5/328

See application file for complete search history.

(56) **References Cited**

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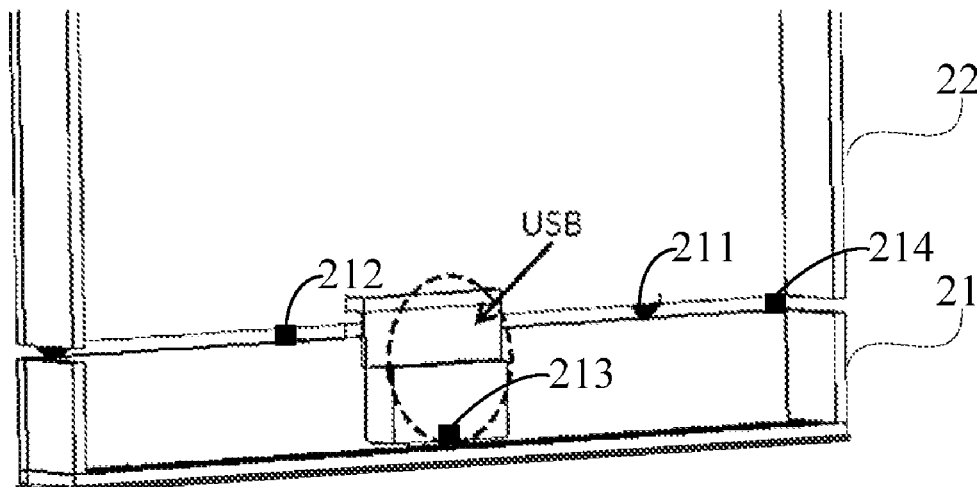
Primary Examiner — Hoang Nguyen

(74) *Attorney, Agent, or Firm* — Jun He Law Offices P.C.; James J. Zhu

(57) **ABSTRACT**

An antenna assembly and an electronic device are provided. The antenna assembly includes: an antenna body having a feed point, a first grounding point, a second grounding point, and a third grounding point; a feed circuit connected with the antenna body via the feed point; a first grounding circuit configured to provide at least two low frequency states and connected with the antenna body via the first grounding point; a second grounding circuit connected with the antenna body via the second grounding point; and a third grounding circuit connected with the antenna body via the third grounding point.

11 Claims, 4 Drawing Sheets





US010128573B2

(12) **United States Patent**
Caporal Del Barrio et al.

(10) **Patent No.:** **US 10,128,573 B2**
(45) **Date of Patent:** **Nov. 13, 2018**

(54) **TUNABLE MULTIPLE-RESONANCE ANTENNA SYSTEMS, DEVICES, AND METHODS FOR HANDSETS OPERATING IN LOW LTE BANDS WITH WIDE DUPLEX SPACING**

(71) Applicant: **wiSpry, Inc.**, Irvine, CA (US)

(72) Inventors: **Samantha Caporal Del Barrio**, Aalborg (DK); **Gert Frølund Pedersen**, Storvorde (DK); **Arthur S. Morris, III**, Raleigh, NC (US)

(73) Assignee: **WISPRY, INC.**, Irvine, CA (US)

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

(21) Appl. No.: **14/885,779**

(22) Filed: **Oct. 16, 2015**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 62/065,106, filed on Oct. 17, 2014.

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 5/392 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 9/0442** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/314** (2015.01);
(Continued)

(58) **Field of Classification Search**

CPC H01Q 5/314; H01Q 5/328; H01Q 5/378;
H01Q 5/385; H01Q 5/392; H01Q 5/321;
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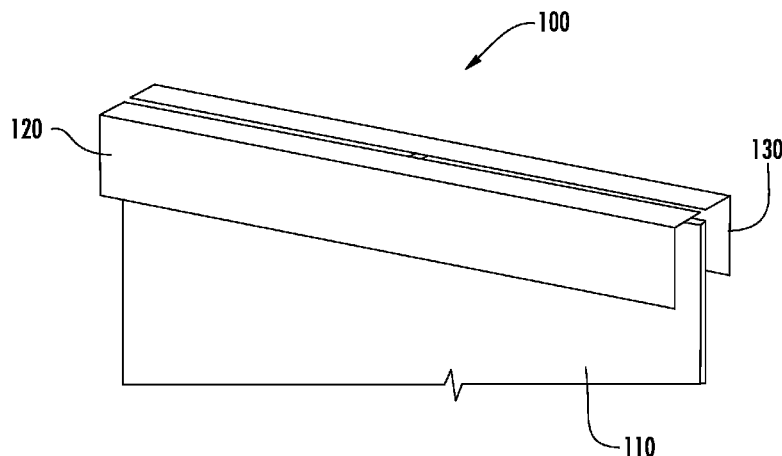
Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — Jenkins, Wilson, Taylor, & Hunt, P.A.

(57) **ABSTRACT**

The present subject matter relates to antenna systems, devices, and methods that provide efficient coverage of low frequency bands (e.g., 700 MHz-bands and 600 MHz-bands) for the new generations of mobile communication. For example, a dual-resonant radiating system can include a ground plane, a radiating coupler spaced apart from but in communication with the ground plane, and a ground plane extension in communication with the ground plane. In this arrangement, one or both of the radiating coupler and the ground plane extension are tunable to tune a dual-resonance frequency response.

22 Claims, 7 Drawing Sheets



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

(10) **Patent No.:** **US 10,128,883 B2**
(45) **Date of Patent:** ***Nov. 13, 2018**

(54) **SMALL ANTENNA APPARATUS AND METHOD FOR CONTROLLING THE SAME**

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

(72) Inventors: **Jungsik Park**, Bucheon-si (KR);
Sooung Chun, Suwon-si (KR)

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

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

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **15/082,280**

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

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. 13/727,205, filed on Dec. 26, 2012, now Pat. No. 9,306,288.

(30) **Foreign Application Priority Data**

Jan. 13, 2012 (KR) 10-2012-0004448

(51) **Int. Cl.**

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H04B 1/04 (2006.01)
H04B 1/18 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/14 (2006.01)

(Continued)

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

CPC **H04B 1/18** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 9/145** (2013.01); **H01Q 9/16** (2013.01); **H01Q 9/42** (2013.01); **H04W 88/02** (2013.01); **H04B 1/0458** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/48; H01Q 9/145; H01Q 9/16; H01Q 9/42; H04B 1/18; H04B 1/0458; H04W 88/02
See application file for complete search history.

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Primary Examiner — Nguyen Vo

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

(57) **ABSTRACT**

An antenna apparatus for a mobile terminal is provided. The antenna apparatus includes an antenna pattern, a first electric circuit and a second electric circuit respectively connected between both ends of the antenna pattern and a system ground, and a third electric circuit disposed between the antenna pattern and a feeding line, wherein the first electric circuit and the second electric circuit extend electrical wavelengths of the antenna pattern and the third electric circuit increases input impedance matching.

15 Claims, 13 Drawing Sheets

