

(10) **Patent No.:** US 9,692,107 B2
(45) **Date of Patent:** Jun. 27, 2017

- (58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 21/30; H01Q 5/378;
H01Q 21/00
USPC 343/702, 710 MS
See application file for complete search history.

- (56)
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- Primary Examiner — Hoanganh Le
(74) Attorney, Agent, or Firm — Steven Reiss

- (57) **ABSTRACT**

- An antenna structure includes a first carrier, a second carrier and an antenna main body. The antenna main body includes a main antenna and a sub antenna. The main antenna is printed on the first carrier, the sub antenna is printed on the second carrier. The present invention also provides a wireless communication device using the antenna structure.

- 12 Claims, 5 Drawing Sheets**

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US009692108B2

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

(10) **Patent No.:** **US 9,692,108 B2**

(45) **Date of Patent:** ***Jun. 27, 2017**

(54) **ANTENNA APPARATUS FOR PORTABLE TERMINAL**

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

(72) Inventors: **Jae-Bong Chun**, Gyeonggi-do (KR);
Sung-Cheol Kim, Gyeonggi-do (KR);
Jae-Ho Lim, Gyeonggi-do (KR);
Kyung-Jong Lee, Gyeonggi-do (KR);
Austin Kim, Gyeonggi-do (KR);
Jae-Ho Lee, Gyeonggi-do (KR)

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

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 38 days.

This patent is subject to a terminal dis-
claimer.

(21) Appl. No.: **14/725,433**

(22) Filed: **May 29, 2015**

(65) **Prior Publication Data**

US 2015/0263414 A1 Sep. 17, 2015

Related U.S. Application Data

(63) Continuation of application No. 13/275,701, filed on
Oct. 18, 2011, now Pat. No. 9,065,168.

(30) **Foreign Application Priority Data**

Oct. 20, 2010 (KR) 10-2010-0102263

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

(Continued)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/38**
(2013.01); **H01Q 1/48** (2013.01); **H01Q 5/378**
(2015.01);

(Continued)

(58) **Field of Classification Search**

USPC 343/700 MS, 702, 720, 848, 767
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Hoang Nguyen

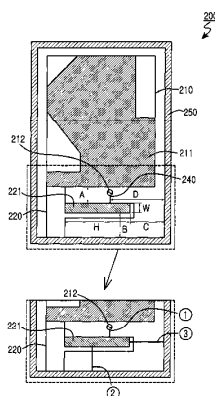
Assistant Examiner — Hai Tran

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

(57) **ABSTRACT**

An antenna apparatus for a portable terminal which is light, thin, compact, and small. The antenna apparatus preferably includes a main board equipped with a power feeding part for feeding power and a ground surface for grounding the main board and at least one sub-board, each sub-board which has a ground surface and electrically communicates with the main board, wherein the ground surface of each sub-board receives power from the power feeding part of the main board and resonates.

24 Claims, 13 Drawing Sheets





US009692122B2

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

(10) **Patent No.:** **US 9,692,122 B2**

(45) **Date of Patent:** **Jun. 27, 2017**

(54) **MULTI LEVELED ACTIVE ANTENNA
CONFIGURATION FOR MULTIBAND MIMO
LTE SYSTEM**

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

(72) Inventors: **Laurent Desclos**, San Diego, CA (US);
Jeffrey Shamblin, San Marcos, CA
(US); **Sung-Su Nam**, Seoul (KR); **Sung
Hawan**, Gyeonggi-do (KR); **Ji-Chul
Lee**, Gyeonggi-do (KR); **Chun-Su
Yoon**, Gyeonggi-do (KR)

(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 684 days.

(21) Appl. No.: **14/094,778**

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

(65) **Prior Publication Data**

US 2015/0155624 A1 Jun. 4, 2015

Related U.S. Application Data

(63) Continuation of application No. 13/612,809, filed on
Sep. 12, 2012, now abandoned, which is a
(Continued)

(51) **Int. Cl.**
H01Q 9/06 (2006.01)
H01Q 3/22 (2006.01)
(Continued)

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

CPC **H01Q 3/22** (2013.01); **H01Q 1/246**
(2013.01); **H01Q 1/521** (2013.01); **H01Q 5/28**
(2015.01); **H01Q 9/42** (2013.01); **H01Q 21/28**
(2013.01)

(58) **Field of Classification Search**

CPC H01Q 3/22; H01Q 1/246; H01Q 1/521;
H01Q 21/28; H01Q 5/28; H01Q 9/42
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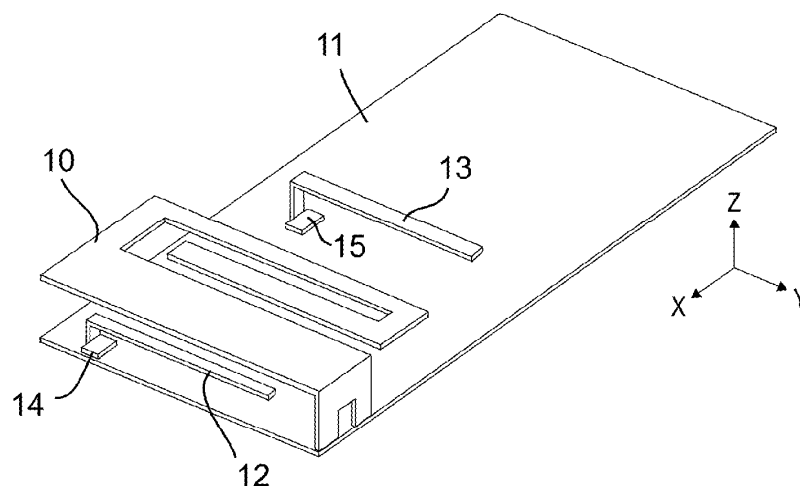
Primary Examiner — Tho G Phan

(74) *Attorney, Agent, or Firm* — Coastal Patent Law
Group, P.C.

(57) **ABSTRACT**

An active antenna system and algorithm is described that provides for dynamic tuning and optimization of antenna system parameters for a MIMO system where correlation and isolation between antennas in the system are dynamically altered to provide for greater throughput. As one or multiple antennas are loaded or de-tuned due to environmental changes, corrections to correlation and/or isolation are made by selecting the optimal antenna radiation pattern and by adjusting electrical length and/or reactive loading of transmission lines connecting the antennas. Multiple Isolated Magnetic Dipole (IMD) antennas are co-located and connected with a feed network that can include switches that adjust phase length for transmission lines connecting the antennas. Filtering is integrated into the feed network to improve rejection of unwanted frequencies. Filtering can also be implemented on the antenna structure.

9 Claims, 11 Drawing Sheets





US009698480B2

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

(10) **Patent No.:** **US 9,698,480 B2**

(45) **Date of Patent:** **Jul. 4, 2017**

(54) **SMALL ANTENNA APPARATUS OPERABLE
IN MULTIPLE FREQUENCY BANDS**

(71) Applicant: **Panasonic Corporation**, Kadoma-shi,
Osaka (JP)

(72) Inventors: **Kazuya Tani**, Osaka (JP); **Toshiharu
Ishimura**, Osaka (JP); **Kenji
Nishikawa**, Hyogo (JP); **Kazuya
Nakano**, Osaka (JP)

(73) Assignee: **PANASONIC INTELLECTUAL
PROPERTY MANAGEMENT CO.,
LTD.**, Osaka (JP)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 392 days.

(21) Appl. No.: **13/787,158**

(22) Filed: **Mar. 6, 2013**

(65) **Prior Publication Data**

US 2014/0071000 A1 Mar. 13, 2014

(30) **Foreign Application Priority Data**

Sep. 13, 2012 (JP) 2012-201477

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

(52) **U.S. Cl.**
CPC **H01Q 5/001** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 5/371** (2015.01); **H01Q 9/42**
(2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 9/04; H01Q 5/42; H01Q 1/38; H01Q
1/48; H01Q 5/371; H01Q 5/001; H01Q
9/42; H01Q 1/243
See application file for complete search history.

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No. 2013-044484 on May 10, 2016.

Primary Examiner — Graham Smith

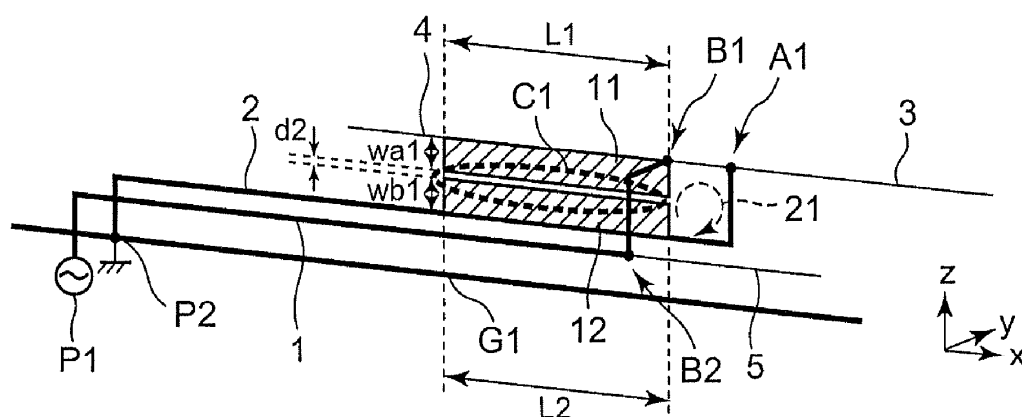
Assistant Examiner — Noel' Maldonado

(74) *Attorney, Agent, or Firm* — Hamre, Schumann,
Mueller & Larson, P.C.

(57) **ABSTRACT**

A first base radiation element has a first end connected to the feed point, and a second end. A second base radiation element has a first end connected to the ground point, and a second end. The first and second base radiation elements respectively include portions extending in a first direction and close to each other. The first base radiation element is branched into first and second branch radiation elements at a first branch point located at the second end of the first base radiation element, the first branch radiation element includes a portion extending in the first direction, and the second branch radiation element includes a portion extending in a second direction opposite to the first direction. The end of the second base radiation element is connected to a connecting point different from the first branch point of the first branch radiation element.

19 Claims, 30 Drawing Sheets





US009698481B2

(12) **United States Patent**
Mikata

(10) **Patent No.:** **US 9,698,481 B2**
(45) **Date of Patent:** **Jul. 4, 2017**

(54) **CHIP ANTENNA AND COMMUNICATION CIRCUIT SUBSTRATE FOR TRANSMISSION AND RECEPTION**

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

(72) Inventor: **Jin Mikata**, 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 244 days.

(21) Appl. No.: **14/486,727**

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

(65) **Prior Publication Data**

US 2015/0116179 A1 Apr. 30, 2015

(30) **Foreign Application Priority Data**

Oct. 30, 2013 (JP) 2013-224955

(51) **Int. Cl.**

H01Q 5/00 (2015.01)

H01Q 5/371 (2015.01)

H01Q 1/22 (2006.01)

H01Q 1/24 (2006.01)

H01Q 1/38 (2006.01)

H01Q 9/42 (2006.01)

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

CPC **H01Q 5/371** (2015.01); **H01Q 1/2291** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/2291; H01Q 1/243; H01Q 1/38; H01Q 5/371; H01Q 9/42

USPC 343/845

See application file for complete search history.

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Primary Examiner — Dameon E Levi

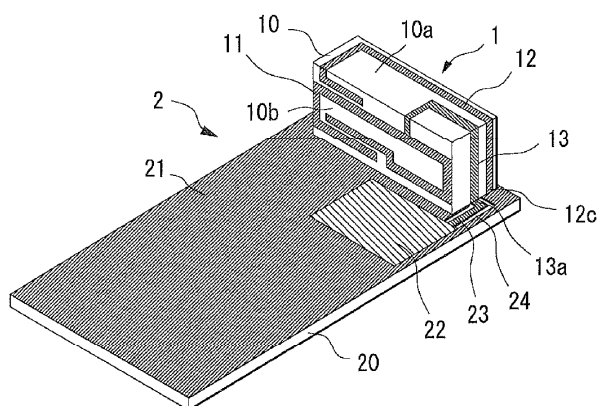
Assistant Examiner — Ab Salam Alkassim, Jr.

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

(57) **ABSTRACT**

A first radiating electrode of a split ring resonator type is formed on a side face of a substrate of a rectangular cuboid antenna device so as to be at a right angle to a ground electrode surface, a second radiating electrode is provided on a top surface of the substrate, the first radiating electrode and the second radiating electrode are capacitively coupled, and the resonance frequency of the first radiating electrode and second radiating electrode are configured to be approximately in symmetry with the central frequency of the used frequency.

6 Claims, 18 Drawing Sheets





US009698495B2

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

(10) **Patent No.:** **US 9,698,495 B2**
(45) **Date of Patent:** **Jul. 4, 2017**

(54) **RECONFIGURABLE MIMO AND SENSING ANTENNA SYSTEM**

(71) Applicant: **KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS**, Dhahran (SA)
(72) Inventors: **Mohammad Said 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 95 days.

(21) Appl. No.: **14/873,171**

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

(65) **Prior Publication Data**

US 2017/0098897 A1 Apr. 6, 2017

(51) **Int. Cl.**
H01Q 9/00 (2006.01)
H01Q 21/28 (2006.01)
H01Q 5/314 (2015.01)
H01Q 5/20 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 21/28** (2013.01); **H01Q 5/20** (2015.01); **H01Q 5/314** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 21/12; H01Q 9/42; H01Q 11/02; H01Q 3/26; H01Q 1/243
USPC 343/751, 893, 876, 879
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Dameon E Levi

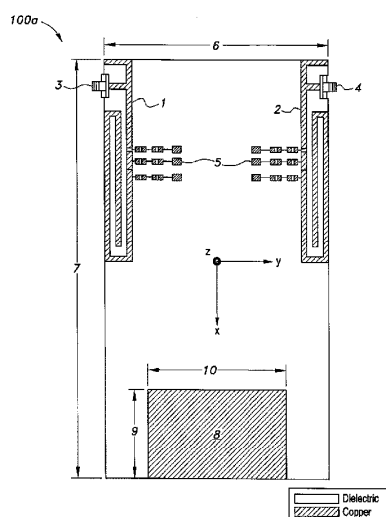
Assistant Examiner — Collin Dawkins

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

(57) **ABSTRACT**

The reconfigurable MIMO and sensing antenna system combines a 2-element reconfigurable MIMO antenna system with a UWB element. The complete setup is suitable for CR platforms that require sensing UWB band availability. The design is planar in structure and includes a pair of PIFAs disposed on a dielectric substrate top surface. The UWB sensing element is disposed on the dielectric substrate bottom surface. An F-head portion of each PIFA has two arms extending to a longer peripheral edge of the substrate. An F-tail portion of each PIFA extends from the substrate's shorter peripheral edge. The two PIFAs are mirror images of each other. For each PIFA, three diode circuits include a PIN diode in combination with a varactor diode connected to and extending away from the F-tail portion of the PIFA, thereby creating separate radiating branches of the PIFA.

9 Claims, 14 Drawing Sheets





US009698854B2

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

(10) **Patent No.:** **US 9,698,854 B2**
(45) **Date of Patent:** **Jul. 4, 2017**

(54) **ELECTRONIC DEVICE HAVING ANTENNA TUNING INTEGRATED CIRCUITS WITH SENSORS**

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

(72) Inventors: **Matthew A. Mow**, Los Altos, CA (US);
Liang Han, Sunnyvale, CA (US);
Ming-Ju Tsai, Cupertino, CA (US);
Thomas E. Biedka, San Jose, CA (US);
Victor Lee, Sunnyvale, CA (US);
James G. Judkins, Campbell, CA (US);
Mattia Pascolini, San Francisco, CA (US)

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

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

(21) Appl. No.: **14/980,574**

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

(65) **Prior Publication Data**

US 2016/0204820 A1 Jul. 14, 2016

Related U.S. Application Data

(60) Provisional application No. 62/101,901, filed on Jan. 9, 2015.

(51) **Int. Cl.**
H04M 1/00 (2006.01)
H04B 1/40 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC **H04B 1/40** (2013.01); **H04B 1/0458** (2013.01); **H04B 1/18** (2013.01)

(58) **Field of Classification Search**

USPC 455/550.1, 552.1, 575.7, 63.1, 67.11, 455/67.13, 73

See application file for complete search history.

(56) **References Cited**

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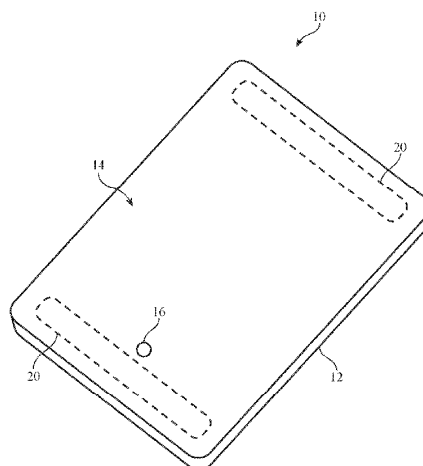
Primary Examiner — Fayyaz Alam

(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.;
G. Victor Treyz; Vineet Dixit

(57) **ABSTRACT**

An electronic device may be provided with wireless circuitry. The wireless circuitry may include one or more antennas. An antenna may have an antenna feed that is coupled to a radio-frequency transceiver with a transmission line. An impedance matching circuit may be coupled to the antenna feed to match the impedance of the transmission line and the antenna. The impedance matching circuit and tunable circuitry in the antenna may be formed using integrated circuits. Each integrated circuit may include switching circuitry that is used in switching components such as inductors and capacitors into use. Sensors such as temperature sensors, current and voltage sensors, power sensors, and impedance sensors may be integrated into the integrated circuits. Each integrated circuit may store settings for the switching circuitry and may include communications and control circuitry for communicating with external circuits and processing sensor data.

20 Claims, 11 Drawing Sheets





US009705180B2

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

(10) **Patent No.:** **US 9,705,180 B2**

(45) **Date of Patent:** **Jul. 11, 2017**

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

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

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

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

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

(21) Appl. No.: **14/825,011**

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

(65) **Prior Publication Data**

US 2015/0364813 A1 Dec. 17, 2015

Related U.S. Application Data

(63) Continuation of application No. 14/486,602, filed on
Sep. 15, 2014, now Pat. No. 9,502,752, which is a
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(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/48**
(2013.01); **H01Q 1/50** (2013.01); **H01Q 9/045**
(2013.01);
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(58) **Field of Classification Search**

CPC H01Q 1/24; H01Q 1/243; H01Q 1/48; H01Q
1/50; H01Q 9/045

See application file for complete search history.

(56) **References Cited**

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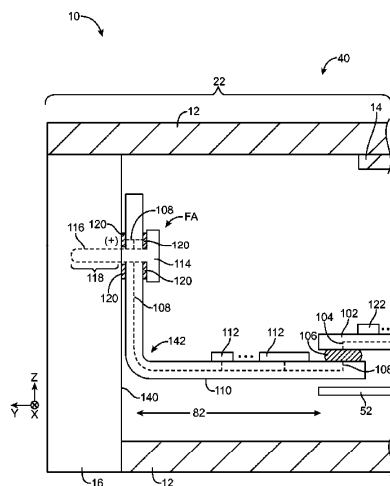
Primary Examiner — Hoang Nguyen

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

(57) **ABSTRACT**

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

19 Claims, 12 Drawing Sheets





US009705188B2

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

(10) **Patent No.:** **US 9,705,188 B2**

(45) **Date of Patent:** **Jul. 11, 2017**

(54) **ANTENNA PATTERN FRAME AND METHOD AND MOLD FOR MANUFACTURING THE SAME**

(71) Applicant: **SAMSUNG ELECTRO-MECHANICS CO., LTD.**, Suwon-Si, Gyeonggi-Do (KR)

(72) Inventors: **Jae Suk Sung**, Gyeonggi-Do (KR); **Ha Ryong Hong**, Gyeonggi-Do (KR); **Yong Shik Na**, Gyeonggi-Do (KR); **Dae Seong Jeon**, Gyeonggi-Do (KR); **Duk Woo Lee**, Gyeonggi-Do (KR); **Sang Woo Bae**, Gyeonggi-Do (KR); **Dae Ki Lim**, Gyeonggi-Do (KR); **Sung Eun Cho**, Gyeonggi-Do (KR); **Nam Il Seo**, Seoul (KR)

(73) Assignee: **Samsung Electro-Mechanics 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 96 days.

(21) Appl. No.: **14/321,451**

(22) Filed: **Jul. 1, 2014**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. 12/649,912, filed on Dec. 30, 2009, now abandoned.

(30) **Foreign Application Priority Data**

Apr. 23, 2009 (KR) 10-2009-0035633

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

(52) **U.S. CL.**
CPC **H01Q 1/40** (2013.01); **B29C 45/14065** (2013.01); **B29C 45/14639** (2013.01);
(Continued)

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

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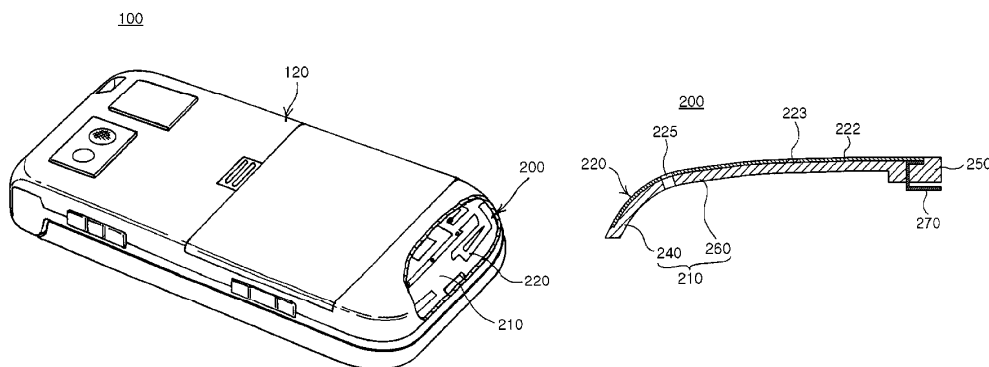
Primary Examiner — Robert Karacsony

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

(57) **ABSTRACT**

An antenna pattern frame according to an aspect of the invention may include: a radiator having an antenna pattern portion transmitting and receiving a signal and a connection terminal portion allowing the signal to be transmitted to and received from a circuit board of an electronic device; a connection portion partially forming the radiator and connecting the antenna pattern portion and the connection terminal portion to be arranged in different planes; and a radiator frame manufactured by injection molding on the radiator so that the antenna pattern portion is provided on one side of the radiator frame and the connection terminal

(Continued)





US009705206B2

(12) **United States Patent**
Yosui

(10) **Patent No.:** **US 9,705,206 B2**
(45) **Date of Patent:** **Jul. 11, 2017**

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

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Nagaokakyo-shi, Kyoto-fu (JP)

(72) Inventor: **Kuniaki Yosui**, Nagaokakyo (JP)

(73) Assignee: **Murata Manufacturing Co., Ltd.**,
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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 129 days.

(21) Appl. No.: **14/591,038**

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

(65) **Prior Publication Data**

US 2015/0116168 A1 Apr. 30, 2015

Related U.S. Application Data

(63) Continuation of application No.
PCT/JP2013/083601, filed on Dec. 16, 2013.

(30) **Foreign Application Priority Data**

Dec. 21, 2012 (JP) 2012-280243

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

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 21/28** (2013.01); **H01Q 1/2208**
(2013.01); **H01Q 1/2216** (2013.01); **H01Q**
1/243 (2013.01);

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(58) **Field of Classification Search**
CPC H01Q 21/28

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Primary Examiner — Graham Smith

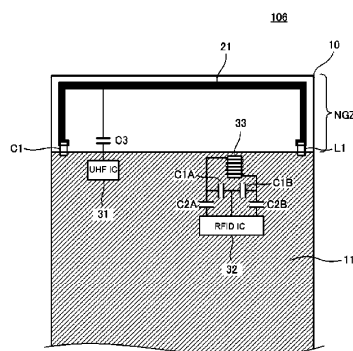
Assistant Examiner — Jae Kim

(74) *Attorney, Agent, or Firm* — Keating & Bennett, LLP

(57) **ABSTRACT**

A square bracket-shaped radiation element is in a non-ground region of a board. A first reactance element that equivalently enters a short-circuited state in a second frequency band is connected between a second end of the radiation element and a ground conductor. A second reactance element that equivalently enters a short-circuited state in a first frequency band is connected between a first end of the radiation element and the ground conductor. In the UHF band, the radiation element and the ground conductor function as an inverted F antenna that contributes to field emission. In the HF band, a loop including the radiation element and the ground conductor functions as a loop antenna that contributes to magnetic field emission.

18 Claims, 12 Drawing Sheets





US009705549B1

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

(10) **Patent No.:** **US 9,705,549 B1**
(45) **Date of Patent:** **Jul. 11, 2017**

(54) **ANTENNA FOR WEARABLE ELECTRONIC DEVICES**

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

(72) Inventors: **Aycan Erentok**, Sunnyvale, CA (US);
Huan-Sheng Hwang, San Diego, CA (US);
John Groff, San Francisco, CA (US);
Thomas H. Liu, Fremont, 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 0 days.

(21) Appl. No.: **15/193,356**

(22) Filed: **Jun. 27, 2016**

(51) **Int. Cl.**
H04B 1/38 (2015.01)
H04B 1/3827 (2015.01)
H04W 4/00 (2009.01)
H04W 4/20 (2009.01)

(52) **U.S. Cl.**
CPC **H04B 1/385** (2013.01); **H04W 4/008** (2013.01); **H04W 4/203** (2013.01); **H04B 2001/3861** (2013.01)

(58) **Field of Classification Search**
CPC H04B 1/385; H04B 2001/3861; H04W 4/008
See application file for complete search history.

(56) **References Cited**

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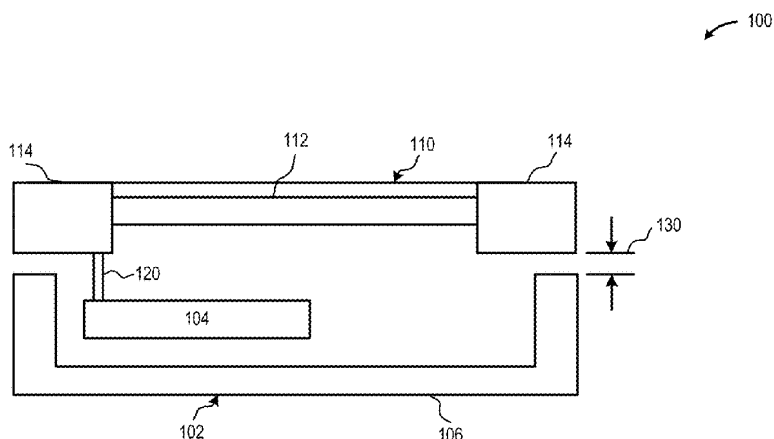
Primary Examiner — Nguyen Vo

(74) *Attorney, Agent, or Firm* — Grossman, Tucker, Perreault & Pfleger, PLLC

(57) **ABSTRACT**

A wearable electronic device includes a first member and a second member. The second member includes a first, RF-attenuating, portion and a second, electrically conductive portion. A gap exists between the first member and at least the second portion of the second member. One or more transmitter/receivers, such as one or more BLUETOOTH®, BLUETOOTH® low energy, and/or IEEE 802.11 transceivers may be mounted in the first member. The one or more transmitter/receivers are conductively coupled to the second portion of the second member. RF signals generated by the one or more transceivers are emitted from the second portion of the second member.

25 Claims, 8 Drawing Sheets





US009711841B2

(12) **United States Patent**
Yong

(10) **Patent No.:** **US 9,711,841 B2**

(45) **Date of Patent:** **Jul. 18, 2017**

(54) **APPARATUS FOR TUNING MULTI-BAND
FRAME ANTENNA**

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

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

(56) **References Cited**

(72) Inventor: **Check Chin Yong**, Tokyo (JP)

U.S. PATENT DOCUMENTS

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

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 297 days.

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WO WO 2014/151558 A1 9/2014

(21) Appl. No.: **14/476,048**

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(22) Filed: **Sep. 3, 2014**

(65) **Prior Publication Data**

US 2015/0084817 A1 Mar. 26, 2015

Extended European Search Report issued Mar. 11, 2015 in Patent
Application No. 14185306.9.

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Related U.S. Application Data

(60) Provisional application No. 61/880,635, filed on Sep.
20, 2013.

Primary Examiner — Dameon E Levi

Assistant Examiner — Andrea Lindgren Baltzell

(74) *Attorney, Agent, or Firm* — Oblon, McClelland,
Maier & Neustadt, L.L.P.

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 1/50 (2006.01)
H01Q 5/378 (2015.01)
H01Q 5/335 (2015.01)
H01Q 3/24 (2006.01)

(Continued)

(57) **ABSTRACT**

A multi-band frame antenna is used for LTE, MIMO, and other frequency bands. The frame antenna includes a conductive block and a metallic frame with no gaps or discontinuities. The conductive block functions as a system ground and has at least one electronic component mounted on the surface. The outer perimeter of the metallic frame surrounds the conductive block, and there is a gap between the metallic frame and the conductive block. One or more antenna feeds are routed across the gap, between the metallic frame and the conductive block. One or more connections can be made across the gap, and at least one electronic element connects the conductive block to the metallic frame.

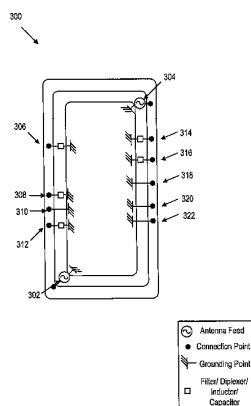
(52) **U.S. Cl.**

CPC **H01Q 1/243** (2013.01); **H01Q 1/50**
(2013.01); **H01Q 5/335** (2015.01); **H01Q**
5/378 (2015.01); **H01Q 3/247** (2013.01);
H01Q 5/328 (2015.01); **H01Q 5/35** (2015.01);
H01Q 9/0464 (2013.01); **H01Q 9/145**
(2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/50; H01Q 5/0041;
H01Q 5/0062

20 Claims, 22 Drawing Sheets





US009711855B2

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

(10) **Patent No.:** **US 9,711,855 B2**

(45) **Date of Patent:** **Jul. 18, 2017**

(54) **MULTIBAND ANTENNA AND WIRELESS DEVICE**

(71) Applicant: **Asahi Glass Company, Limited**, Tokyo (JP)

(72) Inventors: **Ryuta Sonoda**, Tokyo (JP); **Koji Ikawa**, Tokyo (JP); **Toshiki Sayama**, Tokyo (JP)

(73) Assignee: **Asahi Glass Company, Limited**, Tokyo (JP)

(*) 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.: **14/747,178**

(22) Filed: **Jun. 23, 2015**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. PCT/JP2013/084964, filed on Dec. 26, 2013.

(30) **Foreign Application Priority Data**

Dec. 28, 2012 (JP) 2012-289053

(51) **Int. Cl.**
H01Q 5/50 (2015.01)
H01Q 9/42 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/50** (2015.01); **H01Q 1/22** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01);
(Continued)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

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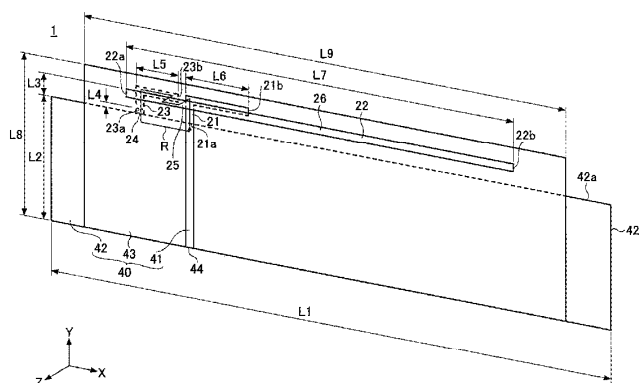
Primary Examiner — Howard Williams

(74) *Attorney, Agent, or Firm* — Oblon, McClelland, Maier & Neustadt, L.L.P.

(57) **ABSTRACT**

A multiband antenna includes a feeding element connected to a feeding point, a radiating element functioning as a radiating conductor, the radiating element being positioned apart from the feeding element and fed with electric power by electromagnetically coupling to the feeding element, a ground plane, and a non-feeding element being positioned close to the radiating element and connected to the ground plane via a reactance element. The reactance element has a reactance that causes the multiband antenna to match with a frequency other than a resonance frequency of a resonance mode of the radiating element.

20 Claims, 5 Drawing Sheets





US009712203B2

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

(10) **Patent No.:** **US 9,712,203 B2**
(45) **Date of Patent:** **Jul. 18, 2017**

(54) **RADIO FREQUENCY PROPERTIES OF A CASE FOR A COMMUNICATIONS DEVICE**

(71) Applicant: **Tech 21 Licensing Limited**,
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(72) Inventors: **Jason Lloyd Roberts**, Twickenham
(GB); **Wilhelm Marschall**, London
(GB); **Benjamin Richard Thorpe**,
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(73) Assignee: **TECH 21 LICENSING LIMITED**,
Twickenham (GB)

(*) 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.: **15/240,481**

(22) Filed: **Aug. 18, 2016**

(65) **Prior Publication Data**
US 2016/0359517 A1 Dec. 8, 2016

Related U.S. Application Data

(63) Continuation-in-part of application No. 15/050,973,
filed on Feb. 23, 2016, which is a continuation of
(Continued)

(30) **Foreign Application Priority Data**

May 29, 2015 (GB) 1509317.2

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

(52) **U.S. Cl.**
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(2013.01); **H01Q 1/242** (2013.01); **H01Q**
1/243 (2013.01); **H01Q 1/422** (2013.01);
H04M 1/0202 (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/24; H01Q 1/241; H01Q 1/242;
H01Q 1/243; H01Q 1/42; H01Q 1/422;
H04B 1/3888; H04M 1/0202
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Primary Examiner — Hoang Nguyen

(74) *Attorney, Agent, or Firm* — Stephen J. Weyer, Esq.;
Stites & Harbison, PLLC.

(57) **ABSTRACT**

A case is provided for a portable Radio Frequency (RF) communications device in which the portable RF communications device has an RF antenna arrangement internal to or integrated with an outer housing, the outer housing having an outer surface having a first portion, dielectric characteristics adjacent to which having a relatively low effect on a frequency characteristic of the RF antenna arrangement; and a second portion, dielectric characteristics adjacent to which having a relatively high effect on the frequency characteristic of the RF antenna arrangement. The case has a base, dimensioned to fit a back of the RF communications device; and a plurality of walls, extending from the base and dimensioned to fit corresponding walls of the RF communications device. The case is configured to cover part of the first portion so as to cause a dielectric parameter adjacent a part of the first portion to be relatively high. The case being further adapted such that a dielectric parameter adjacent the

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