



US009270012B2

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

(10) **Patent No.:** **US 9,270,012 B2**

(45) **Date of Patent:** **Feb. 23, 2016**

(54) **ELECTRONIC DEVICE WITH CALIBRATED TUNABLE ANTENNA**

(75) Inventors: **Joshua G. Nickel**, San Jose, CA (US);
Mattia Pascolini, Campbell, 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 679 days.

(21) Appl. No.: **13/363,743**

(22) Filed: **Feb. 1, 2012**

(65) **Prior Publication Data**

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(51) **Int. Cl.**

H01Q 9/00 (2006.01)

H01Q 1/24 (2006.01)

H01Q 9/42 (2006.01)

H01Q 5/328 (2015.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 5/328**
(2015.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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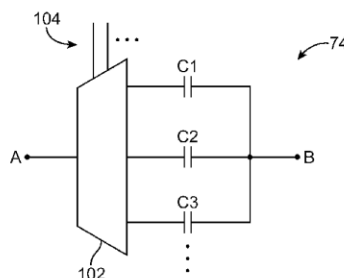
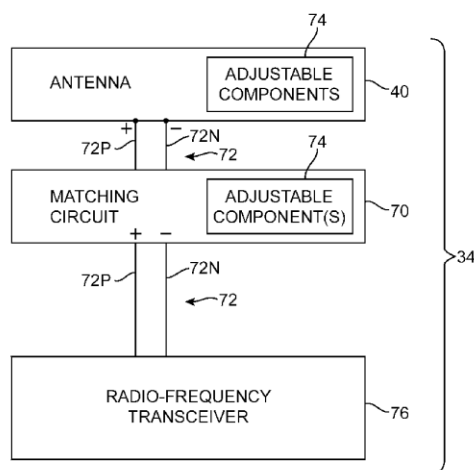
Primary Examiner — Trinh Dinh

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

(57) **ABSTRACT**

An electronic device may have tunable antenna structures. A tunable antenna may have an antenna resonating element and an antenna ground. An adjustable electronic component such as an adjustable capacitor, adjustable inductor, or adjustable phase-shift element may be used in tuning the antenna. An impedance matching circuit may be coupled between the tunable antenna and a radio-frequency transceiver. The adjustable electronic component may be coupled to the antenna resonating element or other structures in the antenna or may form part of the impedance matching circuit, a transmission line, a parasitic antenna element, or other antenna structures. During manufacturing, manufacturing variations may cause the performance of the tunable antenna to deviate from desired specifications. Calibration operations may be performed to identify compensating adjustments to be made with the adjustable electronic component. Calibration data for the adjustable component may be stored in control circuitry in the electronic device.

19 Claims, 12 Drawing Sheets





US009270014B2

(12) **United States Patent**
Lin

(10) **Patent No.:** **US 9,270,014 B2**
(45) **Date of Patent:** **Feb. 23, 2016**

(54) **HANDHELD ELECTRONIC DEVICE**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

(72) Inventor: **Ching-Chi Lin**, New Taipei (TW)

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(73) Assignee: **Acer Incorporated**, New Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 318 days.

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(22) Filed: **Dec. 10, 2012**

(65) **Prior Publication Data**

US 2014/0062798 A1 Mar. 6, 2014

(30) **Foreign Application Priority Data**

Aug. 28, 2012 (TW) 101131225 A

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 1/48 (2006.01)

H01Q 1/22 (2006.01)

H01Q 1/44 (2006.01)

H01Q 9/42 (2006.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 1/44** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/2266; H01Q 1/44; H01Q 9/42

See application file for complete search history.

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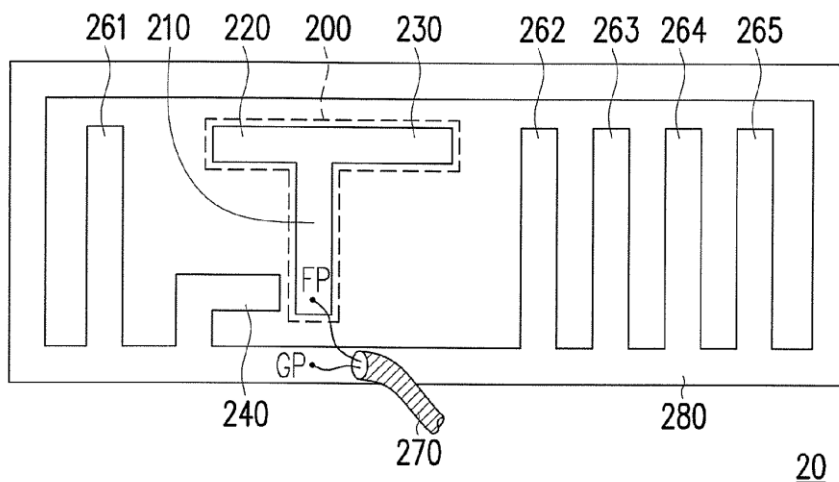
Primary Examiner — Trinh Dinh

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

(57) **ABSTRACT**

A handheld electronic device is provided. The handheld electronic device includes a main body, a heat vent structure, and an antenna. The heat vent structure is disposed on the main body. The antenna is disposed on the heat vent structure for transmitting/receiving at least one radio frequency signal.

3 Claims, 2 Drawing Sheets





US009270249B2

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

(10) **Patent No.:** **US 9,270,249 B2**
(45) **Date of Patent:** **Feb. 23, 2016**

(54) **TUNABLE IMPEDANCE MATCHING CIRCUIT**

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(75) Inventors: **Yu-Meng Yen**, Taoyuan County (TW);
Chen-Fang Tai, Taoyuan County (TW);
Pei-Zong Rao, Taoyuan County (TW);
Wei-Shin Tung, Taoyuan County (TW);
Wan-Ming Chen, Taoyuan County (TW)

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

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 299 days.

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"Office Action of China Counterpart Application", issued on Jan. 23, 2015, p. 1-p. 5.

(21) Appl. No.: **13/590,178**

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(22) Filed: **Aug. 20, 2012**

(65) **Prior Publication Data**

US 2014/0049442 A1 Feb. 20, 2014

Primary Examiner — Dameon E Levi

Assistant Examiner — Andrea Lindgren Baltzell

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

(51) **Int. Cl.**
H01Q 1/50 (2006.01)
H03H 7/40 (2006.01)
H04B 1/04 (2006.01)

(57) **ABSTRACT**

(52) **U.S. Cl.**
CPC **H03H 7/40** (2013.01); **H04B 1/0458** (2013.01)

A tunable impedance matching circuit is provided for matching a signal source to an impedance of an antenna. The tunable impedance matching circuit includes two terminals, a series path, and two shunt paths. The first terminal is coupled to the signal source, and the second terminal is coupled to the antenna. The series path is coupled between the first terminal and the second terminal and includes a first tunable capacitor and at least one tunable inductor. One of the two shunt paths is coupled between the first terminal and a ground end, and the other one of the two shunt paths is coupled between the second terminal and the ground end. Each of the shunt paths includes a second tunable capacitor.

(58) **Field of Classification Search**

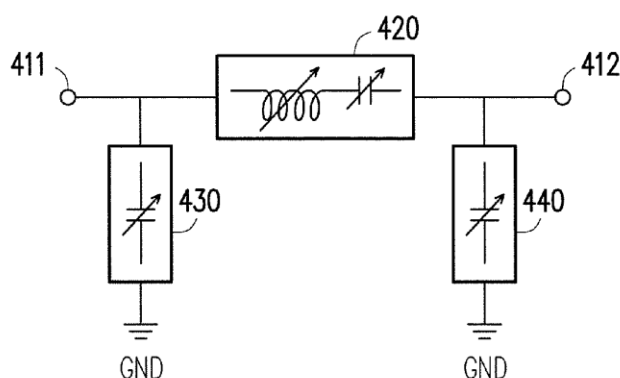
CPC H01Q 1/50
USPC 343/861
See application file for complete search history.

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9 Claims, 5 Drawing Sheets





US009270357B2

(12) **United States Patent**
Kim

(10) **Patent No.:** **US 9,270,357 B2**

(45) **Date of Patent:** **Feb. 23, 2016**

(54) **METHOD AND APPARATUS FOR
SELECTING MULTI-ANTENNA
TRANSMISSION MODE IN ELECTRONIC
DEVICE**

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

(72) Inventor: **Jin Kim**, 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 107 days.

(21) Appl. No.: **14/103,071**

(22) Filed: **Dec. 11, 2013**

(65) **Prior Publication Data**

US 2014/0192927 A1 Jul. 10, 2014

(30) **Foreign Application Priority Data**

Jan. 9, 2013 (KR) 10-2013-0002448

(51) **Int. Cl.**

H04M 1/00 (2006.01)

H04B 7/06 (2006.01)

H01Q 1/24 (2006.01)

H01Q 21/28 (2006.01)

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

CPC **H04B 7/0689** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**

CPC H04B 7/06

USPC 455/550.1, 125, 129, 67.11

See application file for complete search history.

(56) **References Cited**

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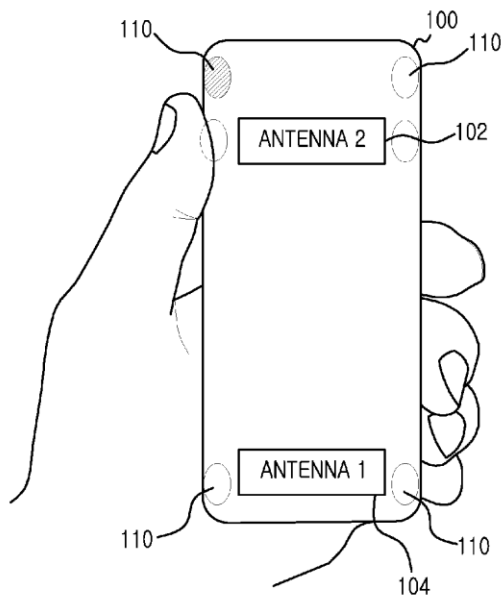
Primary Examiner — Sanh Phu

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

(57) **ABSTRACT**

A method for selecting a multi-antenna transmission mode of an electronic device is provided. The method includes determining, by using a detection signal from a sensor, whether there is a contact with a human body, changing a second transmission mode to a first transmission mode when there is a contact with a human body that affects the electromagnetic field around an antenna, and transmitting the same data stream through at least two antennas according to the first transmission mode.

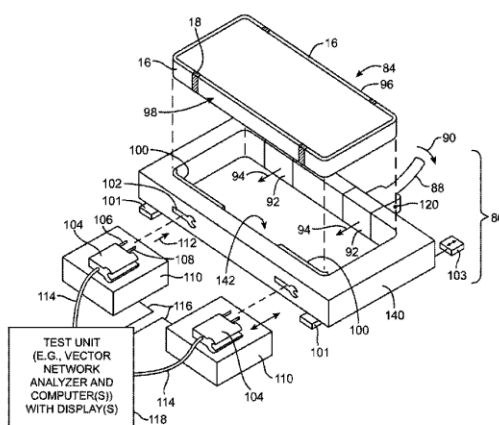
8 Claims, 6 Drawing Sheets





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

- (54) TESTING SYSTEM WITH CAPACITIVELY COUPLED PROBE FOR EVALUATING ELECTRONIC DEVICE STRUCTURES





US009274564B2

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

(10) **Patent No.:** **US 9,274,564 B2**
(45) **Date of Patent:** **Mar. 1, 2016**

(54) **ANTENNA IN OR BELOW KEYBOARD**

(71) Applicant: **GOOGLE INC.**, Mountain View, CA (US)

(72) Inventors: **Yuan-Jen Chang**, Taipei (TW); **Ajay Chandra Venkata Gummalla**, Sunnyvale, CA (US)

(73) Assignee: **Google Inc.**, Mountain View, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 110 days.

(21) Appl. No.: **14/142,421**

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

(65) **Prior Publication Data**

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G06F 1/16 (2006.01)

(52) **U.S. Cl.**
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(58) **Field of Classification Search**
CPC **G06F 1/1662**
USPC **361/679.09**
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Tuan T Dinh

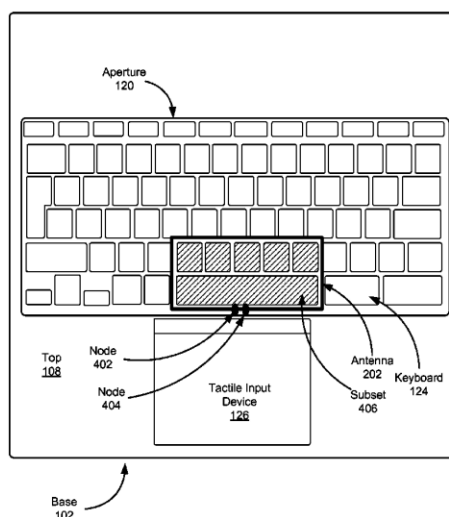
Assistant Examiner — Rockshana Chowdhury

(74) Attorney, Agent, or Firm — Brake Hughes Bellermann LLP

(57) **ABSTRACT**

An electronic device may include a housing enclosing electronic components, the housing including an aperture on a top portion of the housing, a keyboard within the aperture of the housing, the keyboard comprising multiple keys, and an antenna extending around a subset of the multiple keys.

17 Claims, 10 Drawing Sheets





US009276311B2

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

(10) **Patent No.:** **US 9,276,311 B2**

(45) **Date of Patent:** **Mar. 1, 2016**

(54) **PANEL ANTENNA**

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

(72) Inventors: **John Chow**, Saratoga, CA (US);
Yun-Cheng Hou, New Taipei (TW);
Chang-Ching Lin, New Taipei (TW);
Sheng-Che Chang, New Taipei (TW);
Chih-Hao Chang, New Taipei (TW);
Chi-Hsuan Chang, New Taipei (TW)

(73) Assignee: **HON HAI PRECISION INDUSTRY CO., LTD.**, New Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 302 days.

(21) Appl. No.: **13/919,157**

(22) Filed: **Jun. 17, 2013**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jun. 16, 2012 (CN) 2012 1 0198303

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 9/42 (2006.01)
H01Q 21/24 (2006.01)

(52) **U.S. Cl.**
CPC . **H01Q 1/38** (2013.01); **H01Q 9/42** (2013.01);
H01Q 21/24 (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/38; H01Q 21/24; H01Q 9/42
See application file for complete search history.

(56) **References Cited**

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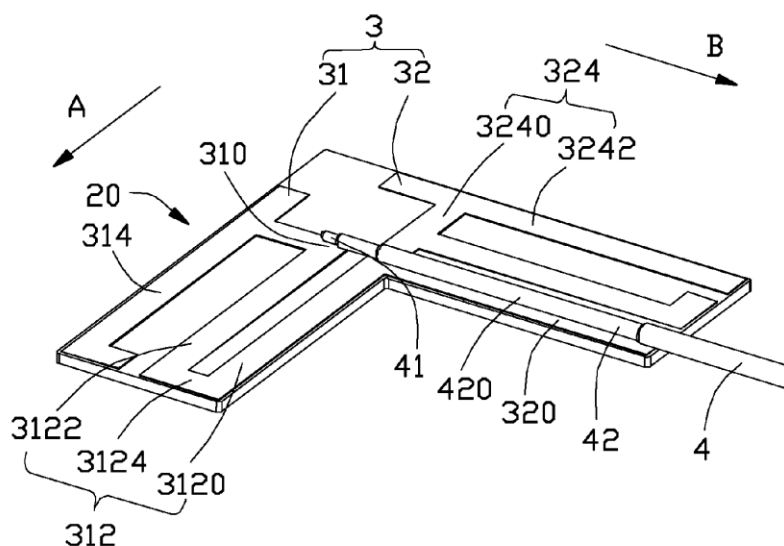
Primary Examiner — Trinh Dinh

(74) *Attorney, Agent, or Firm* — Ming Chieh Chang; Wei Te Chung

(57) **ABSTRACT**

A panel antenna includes a panel portion and a feeder cable. The panel portion includes a first portion and a second portion connected with the first portion to form a L-shape. A first metal sheet is disposed on the first portion. A second metal sheet is disposed on the second portion. The first and second metal sheets connect with each other. The first metal sheet has a feeding point and the second metal sheet has an elongate connecting arm. The overall structure of the first and second metal sheets forms a L-shape. The feeder cable includes an inner conductor electrically connecting with the feeding point and an outer conductor extending along the connecting arm. The outer conductor has an exposed part contacted with the connecting arm.

11 Claims, 3 Drawing Sheets





US009276316B2

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

(10) **Patent No.:** **US 9,276,316 B2**
(45) **Date of Patent:** **Mar. 1, 2016**

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

(71) Applicant: **FIH (Hong Kong) Limited**, Kowloon (HK)

(72) Inventors: **Chuan-Chou Chi**, New Taipei (TW);
Chih-Yang Tsai, New Taipei (TW);
Chi-Sheng Liu, New Taipei (TW);
Hao-Ying Chang, New Taipei (TW)

(73) Assignee: **FIH (Hong Kong) Limited**, Kowloon (HK)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 543 days.

(21) Appl. No.: **13/693,046**

(22) Filed: **Dec. 4, 2012**

(65) **Prior Publication Data**

US 2013/0229312 A1 Sep. 5, 2013

(30) **Foreign Application Priority Data**

Mar. 1, 2012 (TW) 101106826 A

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 5/00 (2015.01)
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/378 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 5/0055** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/378** (2015.01); **H01Q 9/42** (2013.01)

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

(56) **References Cited**

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Primary Examiner — Hoang V Nguyen

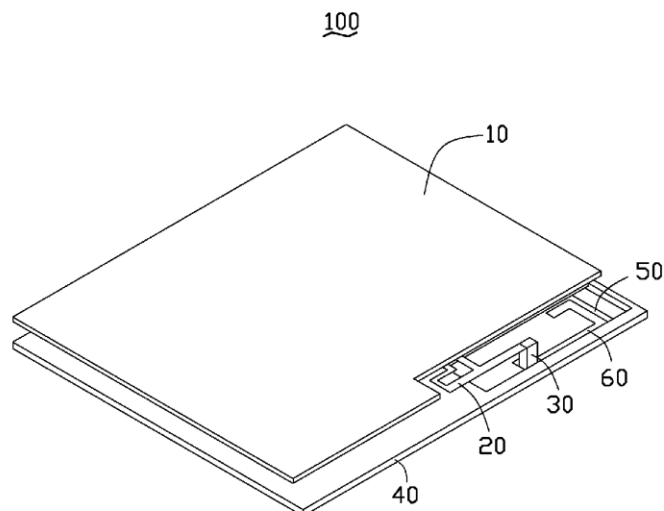
Assistant Examiner — Hai Tran

(74) *Attorney, Agent, or Firm* — Novak Druce Connolly Bove + Quigg LLP

(57) **ABSTRACT**

An antenna module includes an antenna, a connecting member attached to the antenna, a sliding board configured for sliding relative to connecting member, and a radiation member attached to the sliding board. When the sliding board is slid by a user, the radiation member makes contact with or separates from the connecting member, enabling one antenna module to receive and transmit wireless signals of different wavelengths.

15 Claims, 4 Drawing Sheets





US009276317B1

(12) **United States Patent**
Zheng

(10) **Patent No.:** **US 9,276,317 B1**
(45) **Date of Patent:** **Mar. 1, 2016**

(54) **QUAD-MODE ANTENNA**

(75) Inventor: **Ming Zheng**, Cupertino, CA (US)

(73) Assignee: **Amazon Technologies, Inc.**, Reno, NV (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 524 days.

(21) Appl. No.: **13/557,001**

(22) Filed: **Jul. 24, 2012**

Related U.S. Application Data

(60) Provisional application No. 61/605,842, filed on Mar. 2, 2012.

(51) **Int. Cl.**
H01Q 7/00 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/16 (2006.01)
H01Q 9/26 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 7/00** (2013.01); **H01Q 1/243** (2013.01); **H01Q 9/26** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/242; H01Q 7/00;

H01Q 1/241; H01Q 1/24; H01Q 5/00; H01Q 5/15; H01Q 5/35; H01Q 5/357; H01Q 5/364; H01Q 5/30; H01Q 9/16; H01Q 9/26

USPC 343/742, 747, 748
See application file for complete search history.

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Primary Examiner — Dameon E Levi

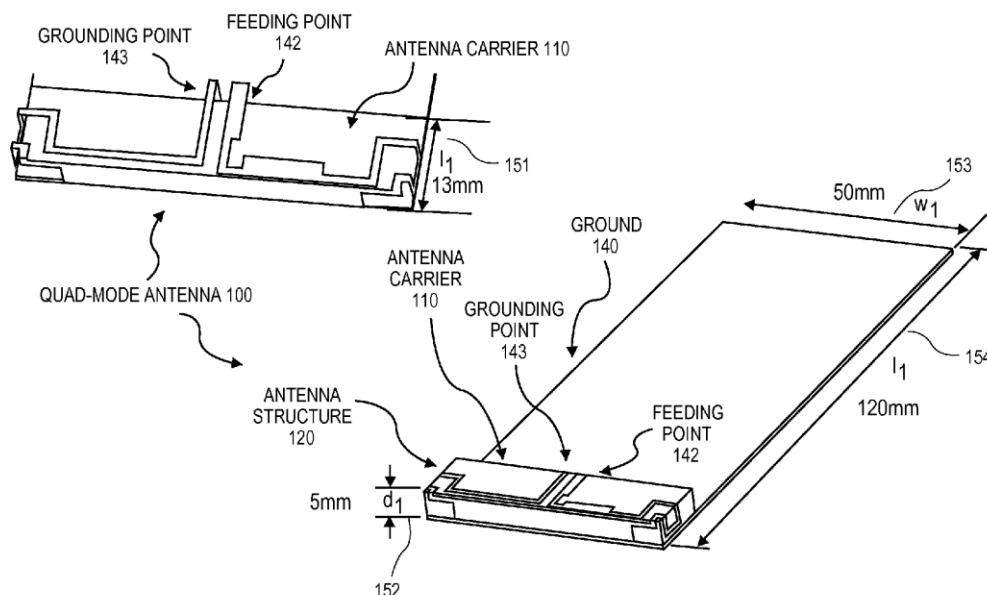
Assistant Examiner — Jennifer F Hu

(74) *Attorney, Agent, or Firm* — Lowenstein Sandler LLP

(57) **ABSTRACT**

Methods, apparatuses, and systems for quad-mode antennas of user devices are described. The quad-mode antenna includes a loop element coupled to a single radio frequency (RF) input and ground. The loop element is configured to operate in four resonant modes to radiate electromagnetic energy in response to the single RF input.

20 Claims, 13 Drawing Sheets





US009276319B2

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

(10) **Patent No.:** **US 9,276,319 B2**
(45) **Date of Patent:** **Mar. 1, 2016**

(54) **ELECTRONIC DEVICE ANTENNA WITH
MULTIPLE FEEDS FOR COVERING THREE
COMMUNICATIONS BANDS**

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

(72) Inventors: **Enrique Ayala Vazquez**, Watsonville, CA (US); **Hongfei Hu**, Santa Clara, CA (US); **Mattia Pascolini**, San Mateo, CA (US); **Matthew A. Mow**, Los Altos, CA (US); **Ming-Ju Tsai**, Cupertino, CA (US); **Robert W. Schlub**, Cupertino, CA (US); **Dean F. Darnell**, San Jose, CA (US); **Yuehui Ouyang**, Sunnyvale, CA (US); **Nanbo Jin**, Sunnyvale, CA (US); **Liang Han**, Sunnyvale, CA (US); **David Pratt**, Gilroy, 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 406 days.

(21) Appl. No.: **13/889,987**

(22) Filed: **May 8, 2013**

(65) **Prior Publication Data**

US 2014/0333495 A1 Nov. 13, 2014

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

(52) **U.S. Cl.**
CPC **H01Q 9/06** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 5/328** (2015.01); **H01Q 5/35**
(2015.01);
(Continued)

(58) **Field of Classification Search**
USPC 343/700 MS, 702, 745
See application file for complete search history.

(56) **References Cited**

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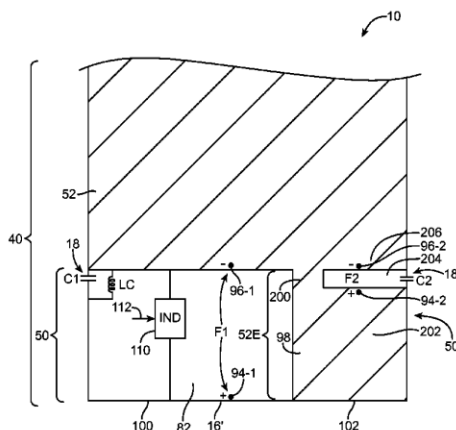
Primary Examiner — Tan Ho

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

(57) **ABSTRACT**

Electronic devices may be provided that include radio-frequency transceiver circuitry and antennas. An antenna may be formed from an antenna resonating element and an antenna ground. The antenna resonating element may have a shorter portion that resonates at higher communications band frequencies and a longer portion that resonates at lower communications band frequencies. An extended portion of the antenna ground may form an inverted-F antenna resonating element portion of the antenna resonating element. The antenna resonating element may be formed from a peripheral conductive electronic device housing structure that is separated from the antenna ground by an opening. A first antenna feed may be coupled between the peripheral conductive electronic device housing structures and the antenna ground across the opening. A second antenna feed may be coupled to the inverted-F antenna resonating element portion of the antenna resonating element.

20 Claims, 9 Drawing Sheets





US009276320B2

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

(10) **Patent No.:** **US 9,276,320 B2**
(45) **Date of Patent:** **Mar. 1, 2016**

(54) **MULTI-BAND ANTENNA**

(75) Inventors: **Yi-Feng Wu**, Hsinchu County (TW);
Wei-Shan Chang, Hsinchu County
(TW)

(73) Assignee: **Wistron NeWeb Corp.**, 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 88 days.

(21) Appl. No.: **13/274,611**

(22) Filed: **Oct. 17, 2011**

(65) **Prior Publication Data**

US 2012/0306709 A1 Dec. 6, 2012

(30) **Foreign Application Priority Data**

Jun. 3, 2011 (TW) 100119574 A

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 9/42 (2006.01)
H01Q 1/24 (2006.01)
H01Q 5/371 (2015.01)
H01Q 5/378 (2015.01)

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

(58) **Field of Classification Search**
USPC 343/767, 700 MS, 702
See application file for complete search history.

(56) **References Cited**

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Property Office on Jul. 22, 2014 along with an English translation
thereof.

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Primary Examiner — Hoang V Nguyen

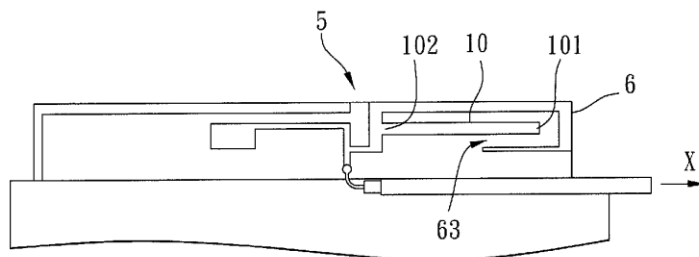
Assistant Examiner — Hai Tran

(74) *Attorney, Agent, or Firm* — Dickstein Shapiro LLP

(57) **ABSTRACT**

A multi-band antenna is to be electrically connected to a
transceiving terminal of a radio frequency circuit by a feeding
unit and includes a grounding section, a feed-in section elec-
trically connected to the feeding unit, first and second radiator
arms respectively disposed at opposite lateral sides of the
feed-in section and electrically connected to the feed-in sec-
tion, and a first coupling component. The first and second
radiator arms are configured to generate first and second
resonant modes, respectively. When the multi-band antenna
transceives radio frequency signals, the second radiator arm
and the first coupling component generate a coupling effect
such that the first coupling component generates a third reso-
nant mode. Center frequencies of the first, second, and third
resonant modes are different from each other.

10 Claims, 8 Drawing Sheets





US009276322B2

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

(10) **Patent No.:** **US 9,276,322 B2**
(45) **Date of Patent:** **Mar. 1, 2016**

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

(75) Inventors: **Yasumitsu Ban**, Yokosuka (JP); **Takashi Yamagajo**, Yokosuka (JP); **Kouji Soekawa**, Kawasaki (JP)

(73) Assignee: **FUJITSU LIMITED**, Kawasaki (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 283 days.

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(21) Appl. No.: **13/599,273**

(22) Filed: **Aug. 30, 2012**

(65) **Prior Publication Data**

US 2013/0063313 A1 Mar. 14, 2013

(30) **Foreign Application Priority Data**

Sep. 9, 2011	(JP)	2011-197582
Aug. 22, 2012	(JP)	2012-183650

European Search Report dated Nov. 28, 2012 from corresponding European Application No. 12183173.9.
Office Action dated Apr. 21, 2014, from the corresponding Chinese Patent Application No. 201210328344.6.

(Continued)

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 13/10 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 13/106** (2013.01)

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

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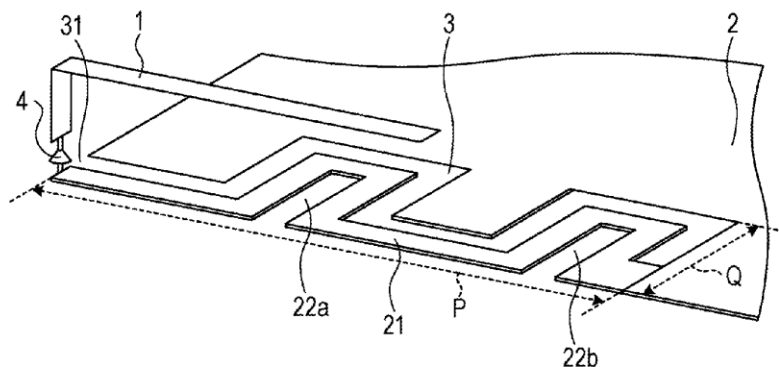
Primary Examiner — Sue A Purvis
Assistant Examiner — Hai Tran

(74) *Attorney, Agent, or Firm* — Katten Muchin Rosenman LLP

(57) **ABSTRACT**

There is provided an antenna device that includes a substrate, a slot provided in the substrate so that the slot includes a cut opening that is close to an edge of the substrate and the slot includes a crooked portion, a conductor section configured to include a slit in an area of the substrate, the area being sandwiched by the slot in the crooked portion, and an antenna that is placed close to the conductor section and is side by side with a surface of the substrate.

14 Claims, 21 Drawing Sheets





US009281553B2

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

(10) **Patent No.:** **US 9,281,553 B2**
(45) **Date of Patent:** **Mar. 8, 2016**

(54) **WEARABLE DEVICE**

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

(72) Inventors: **Wen-Yi Tsai**, New Taipei (TW);
Chia-Ching Lee, New Taipei (TW)

(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 58 days.

(21) Appl. No.: **14/301,345**

(22) Filed: **Jun. 11, 2014**

(65) **Prior Publication Data**

US 2015/0255855 A1 Sep. 10, 2015

(30) **Foreign Application Priority Data**

Mar. 5, 2014 (TW) 103107456 A

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 1/12 (2006.01)

G04R 60/06 (2013.01)

H01Q 1/27 (2006.01)

H01Q 13/10 (2006.01)

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

CPC **H01Q 1/243** (2013.01); **G04R 60/06**
(2013.01); **H01Q 1/273** (2013.01); **H01Q 13/10**
(2013.01)

(58) **Field of Classification Search**

USPC 343/702, 718
See application file for complete search history.

(56) **References Cited**

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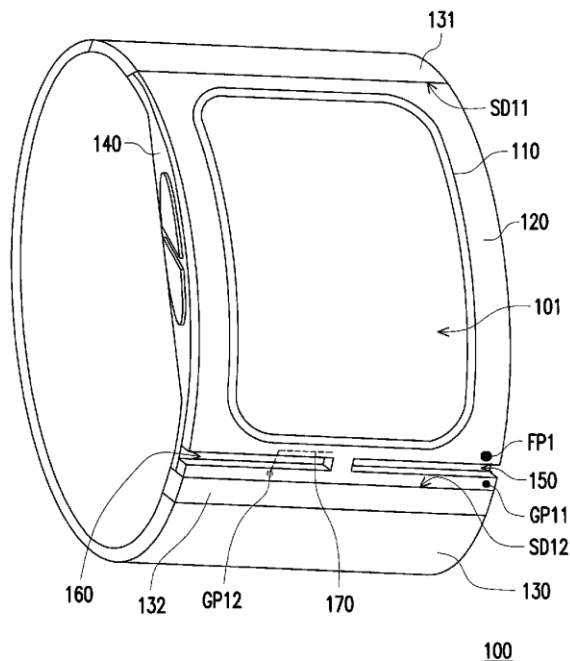
Primary Examiner — Tan Ho

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

(57) **ABSTRACT**

A wearable device including a display unit, a conductive frame and a belt-like structure is provided. The conductive frame surrounds a display region of the display unit, and the conductive frame has a first open slot. Besides, a feeding point and a first ground point are disposed on two sides of an opening of the first open slot, and the conductive frame forms a first antenna element. The belt-like structure is respectively connected to a first edge and a second edge, which are opposite to each other, of the conductive frame.

14 Claims, 7 Drawing Sheets



100



US009281558B2

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

(10) **Patent No.:** **US 9,281,558 B2**
(45) **Date of Patent:** **Mar. 8, 2016**

(54) **HIGH ISOLATION ELECTROMAGNETIC
TRANSMITTER AND RECEIVER**

(71) Applicant: **SOUTHERN TAIWAN UNIVERSITY
OF SCIENCE AND TECHNOLOGY,**
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(72) Inventors: **Wen-Shan Chen,** Tainan (TW);
Ke-Ming Lin, Tainan (TW)

(73) Assignee: **Southern Taiwan University of Science
and Technology,** Tainan (TW)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 166 days.

(21) Appl. No.: **14/164,488**

(22) Filed: **Jan. 27, 2014**

(65) **Prior Publication Data**

US 2015/0214612 A1 Jul. 30, 2015

(51) **Int. Cl.**

H01Q 1/52 (2006.01)

H01Q 9/42 (2006.01)

H01Q 21/28 (2006.01)

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

CPC **H01Q 1/525** (2013.01); **H01Q 9/42**
(2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/523; H01Q 1/525;
H01Q 21/28; C07D 221/26

USPC 343/702, 850, 835, 833, 834, 841

See application file for complete search history.

(56) **References Cited**

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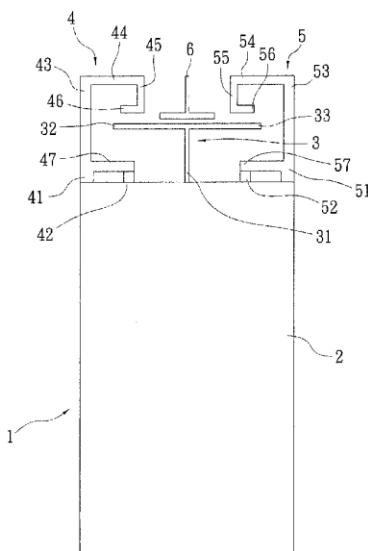
Primary Examiner — Jean B Jeanglaude

(74) *Attorney, Agent, or Firm* — Rosenberg, Klein & Lee

(57) **ABSTRACT**

A high isolation electromagnetic transmitter and receiver is revealed. An isolation portion, a first antenna body and a second antenna body are extended from and formed over a grounding portion. The isolation portion is extended to and formed between the first antenna body and the second antenna body. A parasitic element corresponding to the isolation portion is disposed between the first antenna body and the second antenna body. The isolation portion is T-shaped. The parasitic element is reverse T-shaped and arranged over the grounding portion. The structure is simple and able to be applied to the design of planar printed antennas. The production is easy and the cost is reduced. The volume is minimized to be used in various mini wireless mobile communication devices. No interference occurs even that the first and the second antennas are close due to good isolation.

9 Claims, 4 Drawing Sheets





US009281562B2

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

(10) **Patent No.:** **US 9,281,562 B2**
(45) **Date of Patent:** **Mar. 8, 2016**

(54) **APPARATUS WITH ANTENNA AND METHOD FOR WIRELESS COMMUNICATION**

(75) Inventors: **Jouni Vesa Juhani Karkinen**, Oulu (FI);
Marko Tapio Autti, Oulu (FI)

(73) Assignee: **Nokia Technologies Oy**, Espoo (FI)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 205 days.

(21) Appl. No.: **14/130,980**

(22) PCT Filed: **Jul. 6, 2011**

(86) PCT No.: **PCT/IB2011/053002**

§ 371 (c)(1),
(2), (4) Date: **Jan. 6, 2014**

(87) PCT Pub. No.: **WO2013/005080**

PCT Pub. Date: **Jan. 10, 2013**

(65) **Prior Publication Data**

US 2014/0152522 A1 Jun. 5, 2014

(51) **Int. Cl.**
H01Q 5/00 (2015.01)
H01Q 7/00 (2006.01)
H01Q 5/35 (2015.01)
H01Q 5/50 (2015.01)
H01Q 5/335 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 5/0093** (2013.01); **H01Q 5/335**
(2015.01); **H01Q 5/35** (2015.01); **H01Q 5/50**
(2015.01); **H01Q 7/00** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/335; H01Q 5/35; H01Q 5/50;
H01Q 5/314
USPC 343/803, 852
See application file for complete search history.

(56) **References Cited**

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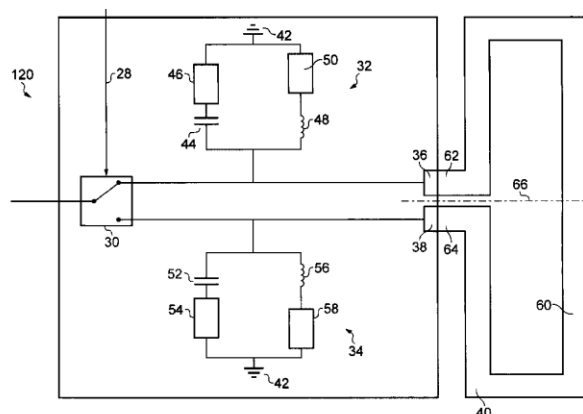
Primary Examiner — Hoang V Nguyen

(74) Attorney, Agent, or Firm — Harrington & Smith

(57) **ABSTRACT**

An apparatus including a first port configured to couple to a first location on an antenna; a second port configured to couple to a second location on the antenna; a switch configured to switch between a first electrical configuration in which the first port is coupled to radio circuitry, and a second electrical configuration in which the second port is coupled to the radio circuitry; first reactive circuitry configured to impedance match the antenna with the radio circuitry at a first operational resonant frequency band; and second reactive circuitry, different to the first reactive circuitry, and configured to impedance match the antenna with the radio circuitry at a second operational resonant frequency band, different to the first operational resonant frequency band.

19 Claims, 6 Drawing Sheets





US009281565B2

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

(10) **Patent No.:** **US 9,281,565 B2**
(45) **Date of Patent:** **Mar. 8, 2016**

(54) **MULTI-FREQUENCY ANTENNA**

(71) Applicant: **ADVANCED-CONNECTEK INC.**,
New Taipei (TW)

(72) Inventors: **Tsung-Wen Chiu**, New Taipei (TW);
Fu-Ren Hsiao, New Taipei (TW);
Yao-Yuan Chang, New Taipei (TW);
Kuo-Chan Fu, New Taipei (TW)

(73) Assignee: **ADVANCED-CONNECTEK 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 408 days.

(21) Appl. No.: **13/954,747**

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

(65) **Prior Publication Data**

US 2013/0307733 A1 Nov. 21, 2013

Related U.S. Application Data

(63) Continuation-in-part of application No. 13/025,000,
filed on Feb. 10, 2011, now abandoned.

(30) **Foreign Application Priority Data**

Sep. 17, 2010 (TW) 99131559 A

(51) **Int. Cl.**

H01Q 1/38 (2006.01)

H01Q 9/16 (2006.01)

H01Q 1/22 (2006.01)

H01Q 9/26 (2006.01)

H01Q 5/371 (2015.01)

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

CPC **H01Q 9/16** (2013.01); **H01Q 1/2266**
(2013.01); **H01Q 5/371** (2015.01); **H01Q 9/26**
(2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/26; H01Q 5/371

USPC 343/700 MS, 702, 829, 846

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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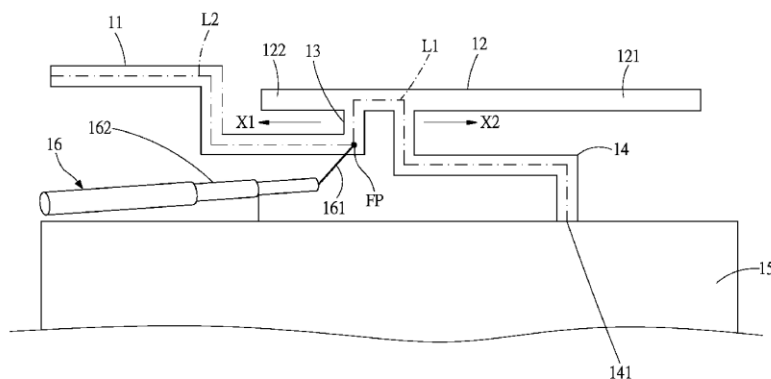
Primary Examiner — Tho G Phan

(74) *Attorney, Agent, or Firm* — Tracy M. Heims; Apex
Juris, PLLc

(57) **ABSTRACT**

A multi-frequency antenna includes a first antenna element, a second antenna element, a connection element, a third antenna element and a shorted element. The connection element is connected between the first antenna element and a neighborhood portion of the third antenna element. A feeding point is located in or nearby a first junction between the connection element and the first antenna element or located in the connection element. The shorted element is connected between the second antenna element and the grounding plane. The shorted element extends from a second junction between the second antenna element and the third antenna element to the grounding plane. The first conductive path that extends from the feeding point to the other end of the shorted element is substantially equal to a second conductive length that extends from the feeding point to the free end of the first antenna element.

20 Claims, 4 Drawing Sheets





US009281567B2

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

(10) **Patent No.:** **US 9,281,567 B2**
(45) **Date of Patent:** **Mar. 8, 2016**

(54) **BROADBAND BUILT-IN ANTENNA USING A DOUBLE ELECTROMAGNETIC COUPLING**

(75) Inventors: **Byoung-Nam Kim**, Gyeonggi-do (KR);
Jong-Ho Jung, Gyeonggi-do (KR);
Seung-Cheol Lee, Incheon-si (KR)

(73) Assignee: **ACE TECHNOLOGIES CORPORATION**, Incheon-si (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 255 days.

(21) Appl. No.: **13/501,859**

(22) PCT Filed: **Oct. 13, 2010**

(86) PCT No.: **PCT/KR2010/007010**

§ 371 (c)(1),
(2), (4) Date: **Apr. 13, 2012**

(87) PCT Pub. No.: **WO2011/046368**

PCT Pub. Date: **Apr. 21, 2011**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Oct. 13, 2009 (KR) 10-2009-0097275
Feb. 10, 2010 (KR) 10-2010-0012529

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

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

(58) **Field of Classification Search**
USPC 343/700 MS, 702, 818
See application file for complete search history.

(56) **References Cited**

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343/700 MS

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Primary Examiner — Hoang V Nguyen

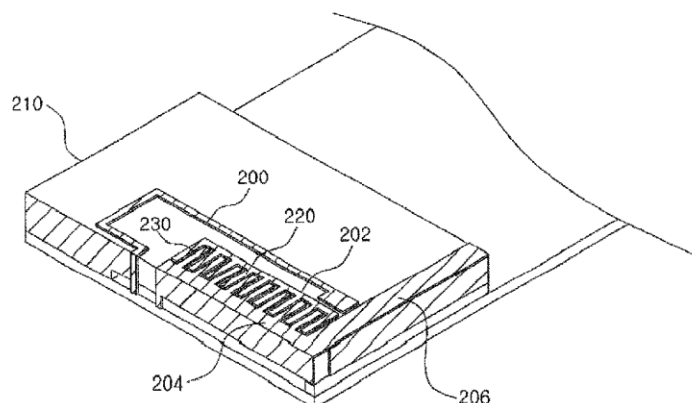
Assistant Examiner — Hai Tran

(74) *Attorney, Agent, or Firm* — TechLaw LLP

(57) **ABSTRACT**

A broadband internal antenna using double electromagnetic coupling is disclosed. The disclosed antenna may include: a first conducting member electrically connected to a feeding point; a second conducting member placed at a designated distance from at least a portion of the first conducting member so as to allow a first electromagnetic coupling with at least a portion of the first conducting member, and remaining in a floating state without being coupled to a ground and the feeding point; a third conducting member placed at a designated distance from the second conducting member so as to allow a second electromagnetic coupling with the second conducting member, and electrically connected to the ground; and a fourth conducting member extending from the third conducting member, for radiating RF signals. The disclosed antenna has the advantage of providing broadband characteristics within a limited size.

9 Claims, 3 Drawing Sheets





US009285781B2

(12) **United States Patent**
Fujisawa

(10) **Patent No.:** **US 9,285,781 B2**
(45) **Date of Patent:** ***Mar. 15, 2016**

(54) **TIMEPIECE WITH INTERNAL ANTENNA**

(71) Applicant: **Seiko Epson Corporation**, Tokyo (JP)

(72) Inventor: **Teruhiko Fujisawa**, Shiojiri (JP)

(73) Assignee: **Seiko Epson Corporation**, Tokyo (JP)

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

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/801,912**

(22) Filed: **Jul. 17, 2015**

(65) **Prior Publication Data**

US 2015/0323907 A1 Nov. 12, 2015

Related U.S. Application Data

(63) Continuation of application No. 14/565,457, filed on Dec. 10, 2014, now Pat. No. 9,116,512, which is a continuation of application No. 14/263,434, filed on Apr. 28, 2014, now Pat. No. 8,942,068, which is a

(Continued)

(30) **Foreign Application Priority Data**

Sep. 1, 2009 (JP) 2009-201557
Jun. 24, 2010 (JP) 2010-143886

(51) **Int. Cl.**
G04R 60/10 (2013.01)
G04C 10/00 (2006.01)
G04C 9/08 (2006.01)

(52) **U.S. Cl.**
CPC **G04R 60/10** (2013.01); **G04C 9/08** (2013.01);
G04C 10/00 (2013.01)

(58) **Field of Classification Search**

CPC G04G 5/002; G04G 9/0076; G04G 21/04;
H01Q 1/273; H01Q 1/52; H01Q 9/0407;
G04R 60/10; G04R 60/12; G04R 20/04;
G04C 9/02; G04C 10/02
USPC 368/46, 47, 64, 76, 14, 10, 13, 185, 55,
368/276, 278; 343/718, 702, 846, 848, 720
See application file for complete search history.

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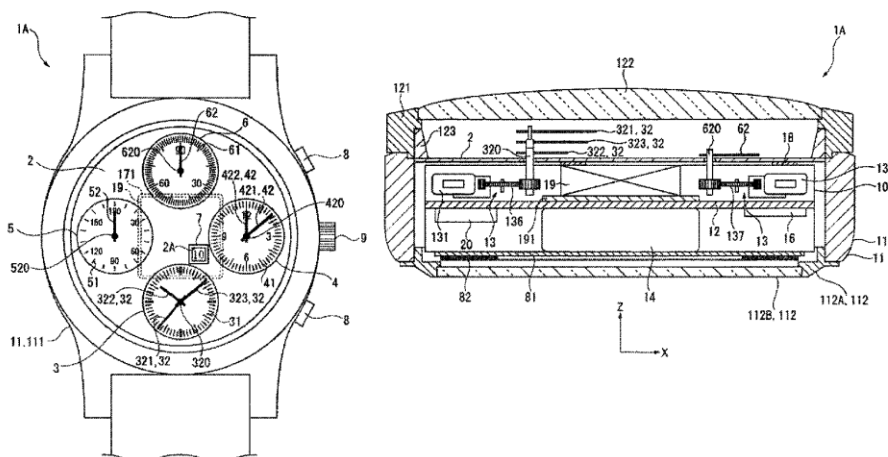
(Continued)

Primary Examiner — Edwin A. Leon

(57) **ABSTRACT**

A timepiece includes a case; a movement that is housed in the case and has multiple motors that drive respective staffs disposed at different locations; a patch antenna that is disposed inside the case and at the back side of the dial; and a battery that supplies power to the motors and is disposed at a position in the case that does not overlap the patch antenna in plan view. The position at which the battery is disposed overlaps at least one of the motors in plan view.

6 Claims, 17 Drawing Sheets





US009287612B2

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

(10) **Patent No.:** **US 9,287,612 B2**
(45) **Date of Patent:** **Mar. 15, 2016**

(54) **TRANSPARENT ANTENNAS FOR WIRELESS TERMINALS**

(71) Applicant: **Sony Mobile Communications AB**,
Lund (SE)

(72) Inventors: **Thomas Bolin**, Lund (SE); **Henrik Jensfelt**, Lund (SE); **Zhinong Ying**,
Lund (SE)

(73) Assignee: **Sony Mobile Communications AB**,
Lund (SE)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 518 days.

(21) Appl. No.: **13/679,527**

(22) Filed: **Nov. 16, 2012**

(65) **Prior Publication Data**

US 2014/0139379 A1 May 22, 2014

(51) **Int. Cl.**
H01Q 9/06 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)
H01Q 21/30 (2006.01)
H01Q 5/371 (2015.01)
H01Q 5/378 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 9/06**
(2013.01); **H01Q 1/38** (2013.01); **H01Q 5/371**
(2015.01); **H01Q 5/378** (2015.01); **H01Q 21/30**
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 9/06
USPC 343/702, 700 MS
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Dameon E Levi

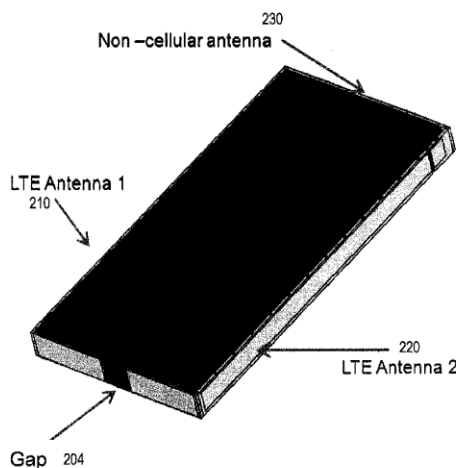
Assistant Examiner — Andrea Lindgren Baltzell

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

(57) **ABSTRACT**

Transparent antennas are described. An antenna apparatus for a radio transceiver of a wireless communication terminal having a housing includes a transparent antenna coupled to the housing around a perimeter of the housing and electrically connected to the transceiver. The transparent antenna has a conductive mesh acting as one or more radiating elements. Light and images may pass through the transparent antenna. The transparent antenna may have a ring shape around the housing of the terminal.

13 Claims, 9 Drawing Sheets





(10) **Patent No.:** US 9,287,618 B2
(45) **Date of Patent:** Mar. 15, 2016

USPC 343/702, 876
See application file for complete search history.

(56) **References Cited**

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U.S. Appl. No. 14/594,594, filed Jan. 12, 2015, Kodama, et al.
(Continued)

Primary Examiner — Dieu H Duong
(74) *Attorney, Agent, or Firm* — Oblon, McClelland, Maier
& Neustadt, L.L.P.

(57) **ABSTRACT**

A mobile terminal that includes a first antenna element disposed in proximity to a first side of the mobile terminal, a second antenna element disposed in proximity to a second side of the mobile terminal, and a third antenna element disposed in proximity to a third side of the mobile terminal. The mobile terminal further including a switching mechanism that switches between a first connection mode in which the first and second antenna elements are feed elements and the third antenna element is a parasitic element, and a second connection mode in which the first and third antenna elements are feed elements, and a control unit that controls the switching mechanism to switch between the first connection mode and the second connection mode in accordance with a predetermined condition.

6 Claims, 12 Drawing Sheets

200
MOBILE TERMINAL

210 CONTROL UNIT

212 COMMUNICATION UNIT

213 DISPLAY UNIT

214 OPERATION UNIT

215 STORAGE UNIT

216 VOICE PROCESSING UNIT

217 SPEAKER

218 MICROPHONE

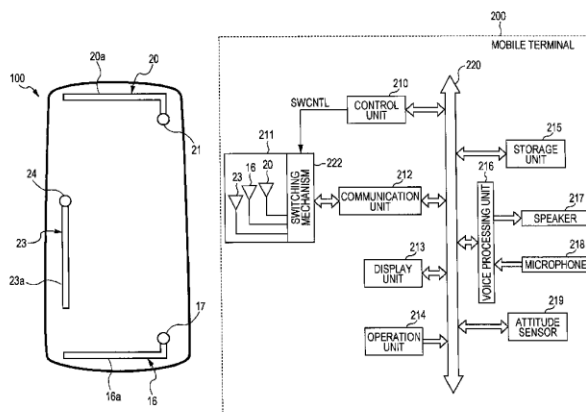
219 ATTITUDE SENSOR

220

TL

Z22

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 3/24; H01Q 1/521





US009287621B2

(12) **United States Patent**
Shimura

(10) **Patent No.:** **US 9,287,621 B2**
(45) **Date of Patent:** **Mar. 15, 2016**

(54) **MULTI-BAND ANTENNA**

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

(71) Applicant: **CANON KABUSHIKI KAISHA,**
Tokyo (JP)

(56) **References Cited**

(72) Inventor: **Hajime Shimura,** Tokyo (JP)

U.S. PATENT DOCUMENTS

(73) Assignee: **CANON KABUSHIKI KAISHA,**
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 266 days.

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(21) Appl. No.: **13/951,815**

CN 10-1283479 A 10/2008
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(22) Filed: **Jul. 26, 2013**

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(65) **Prior Publication Data**

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tions", Wiley, ISBN 978-0-470-51069-8, pp. 257-279 (2007).

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(30) **Foreign Application Priority Data**

Aug. 8, 2012 (JP) 2012-176372
May 17, 2013 (JP) 2013-105627

Primary Examiner — Hoanganh Le

(74) *Attorney, Agent, or Firm* — Fitzpatrick, Cella, Harper &
Scinto

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 5/00 (2015.01)
H01Q 9/04 (2006.01)
H01Q 9/06 (2006.01)
H01Q 5/307 (2015.01)
H01Q 5/371 (2015.01)

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

CPC **H01Q 5/0027** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 5/307** (2015.01); **H01Q 5/371**
(2015.01); **H01Q 9/0407** (2013.01); **H01Q**
9/065 (2013.01)

(58) **Field of Classification Search**

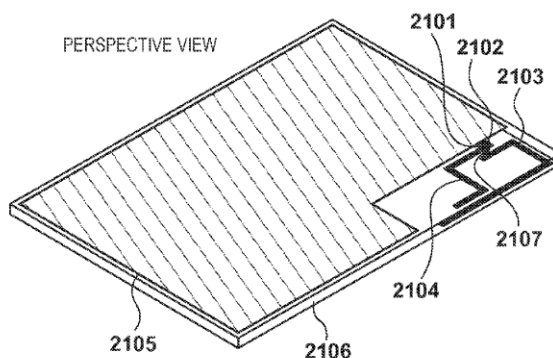
CPC H01Q 1/243; H01Q 9/0407; H01Q 5/371;
H01Q 5/0027; H01Q 5/307; H01Q 9/065

(57)

ABSTRACT

An antenna which operates in a plurality of frequency bands includes a feeding point, a first conductor which is connected to the feeding point, and at least two second conductors which are branched from the first conductor, have a linear shape, and include open ends as ends on a side opposite to the first conductor. The open ends of the two second conductors face in almost the same direction substantially parallel to a side closest to the feeding point out of the sides of an antenna region. The two second conductors include a part at which the distance between the two conductors at a portion parallel to the side is a first distance, and another part at which the distance is a second distance shorter than the first distance, and are electromagnetically coupled at, at least the other part.

13 Claims, 17 Drawing Sheets





US009287622B2

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

(10) **Patent No.:** **US 9,287,622 B2**
(45) **Date of Patent:** **Mar. 15, 2016**

(54) **TUNABLE LONG TERM EVOLUTION
ANTENNA**

(71) Applicant: **AUDEN TECHNO CORP.**, Taoyuan
County (TW)

(72) Inventors: **Yu-Tsung Huang**, Kaohsiung (TW);
Yen-Chao Li, Taoyuan County (TW)

(73) Assignee: **AUDEN TECHNO CORP.**, Taoyuan
County (TW)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 135 days.

(21) Appl. No.: **14/276,931**

(22) Filed: **May 13, 2014**

(65) **Prior Publication Data**

US 2015/0333399 A1 Nov. 19, 2015

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/307 (2015.01)
H01Q 5/10 (2015.01)
H01Q 5/30 (2015.01)
H01Q 5/378 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 5/307** (2015.01); **H01Q 5/10**
(2015.01); **H01Q 5/30** (2015.01); **H01Q 5/378**
(2015.01)

(58) **Field of Classification Search**
CPC H01Q 5/30; H01Q 5/307; H01Q 5/378;
H01Q 5/10; H01Q 1/243
USPC 343/702
See application file for complete search history.

(56) **References Cited**

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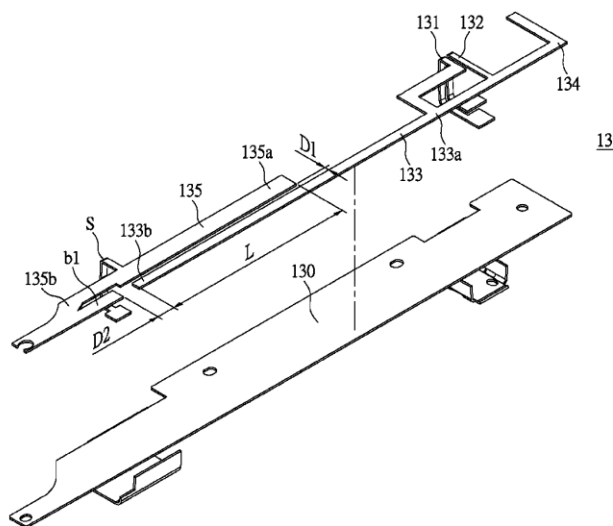
Primary Examiner — Hoang V Nguyen

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

(57) **ABSTRACT**

A tunable long term evolution antenna comprises a feeding portion, a grounding portion, a first radiation portion, a second radiation portion and a coupling radiation portion. The shape of the first radiation portion is a strip. Two terminals of the strip respectively are a first terminal and a second terminal. The first terminal is connected to the feeding portion and the grounding portion. The second radiation portion is connected to the grounding portion and the first terminal of the first radiation portion. The coupling radiation portion has a switching terminal coupled to a switch, a low frequency coupling portion and a high frequency coupling portion. The switch controls the switching terminal to be coupled to the ground or floating. The tunable long term evolution antenna operates in a LTE technology mode or a 3G mode depending on the switching terminal is coupled to the ground floating.

10 Claims, 6 Drawing Sheets





US009287626B2

(12) **United States Patent**
Zou

(10) **Patent No.:** **US 9,287,626 B2**
(45) **Date of Patent:** **Mar. 15, 2016**

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

USPC 343/700 MS, 728, 744, 866, 702
See application file for complete search history.

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

(56) **References Cited**

(72) Inventor: **Yanyan Zou**, Wuhan (CN)

U.S. PATENT DOCUMENTS

(73) Assignee: **Huawei Device Co., Ltd.**, Shenzhen (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 172 days.

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(21) Appl. No.: **14/104,590**

(22) Filed: **Dec. 12, 2013**

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(63) Continuation of application No. PCT/CN2012/081222, filed on Sep. 11, 2012.

Primary Examiner — Dieu H Duong

(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.; Grant Rodolph; Nicholas K. Beaulieu

(30) **Foreign Application Priority Data**

Mar. 16, 2012 (CN) 2012 1 0070698

(57) **ABSTRACT**

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 9/04 (2006.01)
H01Q 7/00 (2006.01)

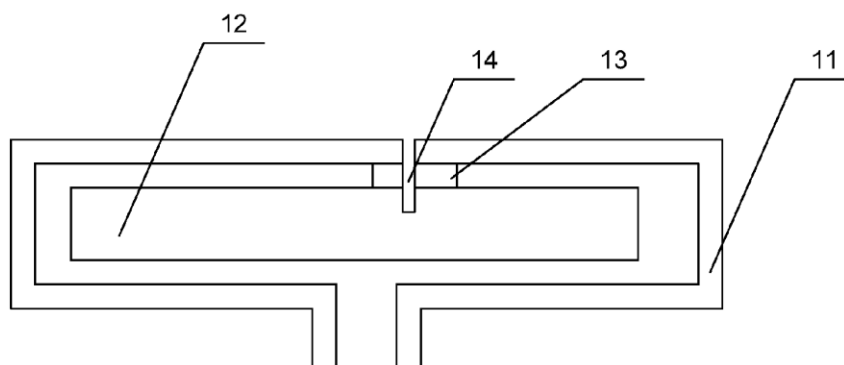
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(52) **U.S. Cl.**
CPC **H01Q 9/0407** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/245** (2013.01); **H01Q 7/00** (2013.01); **H01Q 9/265** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 7/00; H01Q 1/245; H01Q 9/265

Embodiments of the present invention provide an antenna and a wireless terminal device. Through a first conductor connected to the inner side of an antenna body, the embodiments of the present invention can avoid the problem that in the prior art, while the antenna ensures the Specific Absorption Rate (SAR) performance of the wireless terminal device, the wireless performance of the wireless terminal device is greatly reduced. By adopting technical solutions of the present invention, while the SAR performance of the wireless terminal device is ensured, the wireless performance of the wireless terminal device cannot be affected.

20 Claims, 3 Drawing Sheets





US009287627B2

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

(10) **Patent No.:** **US 9,287,627 B2**
(45) **Date of Patent:** **Mar. 15, 2016**

(54) **CUSTOMIZABLE ANTENNA FEED
STRUCTURE**

FOREIGN PATENT DOCUMENTS

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(75) Inventors: **Daniel W. Jarvis**, Sunnyvale, CA (US);
Mattia Pascolini, San Mateo, CA (US);
Joshua G. Nickel, San Jose, 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 583 days.

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(6 pages).

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(21) Appl. No.: **13/223,102**

(22) Filed: **Aug. 31, 2011**

(65) **Prior Publication Data**

US 2013/0050046 A1 Feb. 28, 2013

Primary Examiner — Dameon E Levi

Assistant Examiner — Andrea Lindgren Baltzel

(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; G.
Victor Treyz; Zachary D. Hadd

(51) **Int. Cl.**
H01Q 1/50 (2006.01)
G01R 31/28 (2006.01)
H01Q 9/04 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/14 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0421** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 9/145** (2013.01); **Y10T**
29/49004 (2015.01)

(58) **Field of Classification Search**
CPC H01Q 1/50; G01R 31/28
USPC 343/852; 29/593
See application file for complete search history.

(56) **References Cited**

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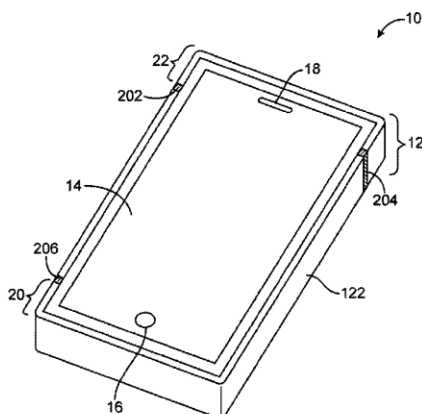
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(57) **ABSTRACT**

Custom antenna structures may be used to compensate for manufacturing variations in electronic device antennas. An antenna may have an antenna feed and conductive structures such as portions of a peripheral conductive electronic device housing member. The custom antenna structures compensate for manufacturing variations that could potentially lead to undesired variations in antenna performance. The custom antenna structures may make customized alterations to antenna feed structures or conductive paths within an antenna. An antenna may be formed from a conductive housing member that surrounds an electronic device. The custom antenna structures may be formed from a printed circuit board with a customizable trace. The customizable trace may have a contact pad portion on the printed circuit board. The customizable trace may be customized to connect the pad to a desired one of a plurality of contacts associated with the conductive housing member to form a customized antenna feed terminal.

12 Claims, 12 Drawing Sheets





US009287629B2

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

(10) **Patent No.:** **US 9,287,629 B2**

(45) **Date of Patent:** **Mar. 15, 2016**

(54) **IMPEDANCE CONVERSION DEVICE,
ANTENNA DEVICE AND COMMUNICATION
TERMINAL DEVICE**

(71) Applicant: **Murata Manufacturing Co., Ltd.**,
Nagaokakyo-shi, Kyoto-fu (JP)

(72) Inventors: **Noboru Kato**, Nagaokakyo (JP);
Kenichi Ishizuka, Nagaokakyo (JP);
Noriyuki Ueki, Nagaokakyo (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 377 days.

(21) Appl. No.: **13/834,487**

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

(65) **Prior Publication Data**
US 2014/0266964 A1 Sep. 18, 2014

(51) **Int. Cl.**
H01Q 9/30 (2006.01)
H01Q 1/50 (2006.01)
H01Q 5/335 (2015.01)

(52) **U.S. Cl.**
CPC . **H01Q 9/30** (2013.01); **H01Q 1/50** (2013.01);
H01Q 5/335 (2015.01)

(58) **Field of Classification Search**
CPC H01Q 1/50; H01Q 5/335; H01Q 9/30
USPC 343/860
See application file for complete search history.

(56) **References Cited**

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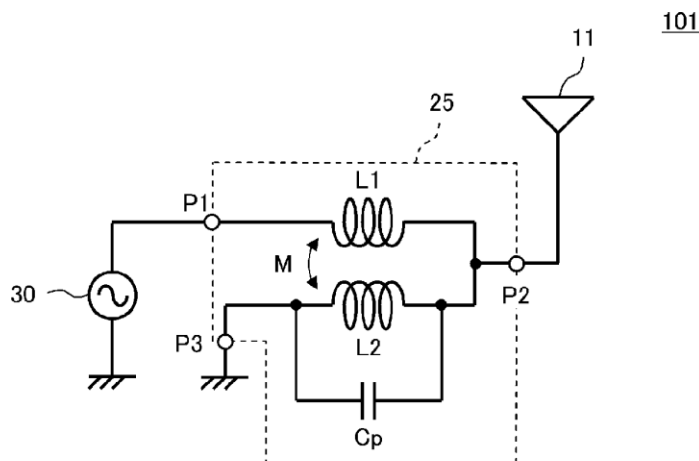
Primary Examiner — Hoang V Nguyen

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

(57) **ABSTRACT**

In a case in which a capacitor is not provided in parallel with a second inductance element, the impedance ratio between a first inductance element and the second inductance element is constant regardless of the frequency, but when a capacitor is provided, the parallel impedance of the capacitor and the second inductance element gradually increases at frequencies equal to and below the resonant frequency. Consequently, at frequencies equal to or below the resonant frequency, the higher the frequency becomes, the larger the value of the real portion of the impedance observed on a high-frequency-circuit side becomes. Therefore, by appropriately setting the values of the first inductance element, the second inductance element, and the capacitor, the frequency characteristics of the real portion of the impedance observed on the high-frequency-circuit side can be set to be similar to the frequency characteristics of the radiation resistance of the antenna.

17 Claims, 19 Drawing Sheets





US009287633B2

(12) **United States Patent**
Tseng

(10) **Patent No.:** **US 9,287,633 B2**
(45) **Date of Patent:** **Mar. 15, 2016**

(54) **DUAL FREQUENCY COUPLING FEED ANTENNA AND ADJUSTABLE WAVE BEAM MODULE USING THE ANTENNA**

(71) Applicant: **Industrial Technology Research Institute**, Hsinchu (TW)

(72) Inventor: **Wen-Jen Tseng**, Hsinchu (TW)

(73) Assignee: **Industrial Technology Research Institute**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 598 days.

(21) Appl. No.: **13/674,909**

(22) Filed: **Nov. 12, 2012**

(65) **Prior Publication Data**
US 2014/0062822 A1 Mar. 6, 2014

(30) **Foreign Application Priority Data**
Aug. 30, 2012 (TW) 101131577 A

(51) **Int. Cl.**
H01Q 21/00 (2006.01)
H01Q 9/16 (2006.01)
H01Q 21/26 (2006.01)
H01Q 9/26 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 21/26** (2013.01); **H01Q 9/16** (2013.01); **H01Q 9/26** (2013.01)
(58) **Field of Classification Search**
CPC H01Q 9/16; H01Q 9/26; H01Q 25/001; H01Q 9/065; H01Q 19/13
USPC 343/816, 797, 798, 834, 833
See application file for complete search history.

(56) **References Cited**

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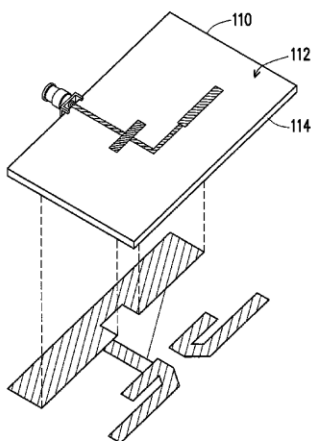
(Continued)

Primary Examiner — Dameon E Levi
Assistant Examiner — Ricardo Magallanes
(74) *Attorney, Agent, or Firm* — Jianq Office IP Office

(57) **ABSTRACT**

A dual frequency coupling feed antenna includes a substrate. There are an upper dipole radiative conductor, a lower dipole radiative conductor, a ground line and a ground reflective conductor disposed on the second surface of the substrate and the two dipole radiative conductors are not electrically connected to each other. The first surface of the substrate has a coupling conductor, a signal line and a feed-matching conductor. The coupling conductor extends parallel to the upper dipole radiative conductor. The ground reflective conductor is located at a side-edge of the dipole radiative conductor and the feed-matching conductor is located on the path of the signal line.

20 Claims, 10 Drawing Sheets





US009287919B2

(12) **United States Patent
Harper**

(10) **Patent No.:** **US 9,287,919 B2**
(45) **Date of Patent:** **Mar. 15, 2016**

(54) **MULTI-BAND ISOLATOR ASSEMBLY**

(71) Applicant: **Microsoft Corporation**, Redmond, WA (US)

(72) Inventor: **Marc Harper**, Issaquah, WA (US)

(73) Assignee: **Microsoft Technology Licensing, LLC**, Redmond, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 142 days.

(21) Appl. No.: **14/188,513**

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

(65) **Prior Publication Data**

US 2015/0244411 A1 Aug. 27, 2015

(51) **Int. Cl.**

H01Q 1/52 (2006.01)
H04B 1/44 (2006.01)
H04B 1/401 (2015.01)
H01Q 1/24 (2006.01)
H01Q 9/14 (2006.01)

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

CPC **H04B 1/44** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/521** (2013.01); **H01Q 9/14** (2013.01); **H04B 1/401** (2013.01)

(58) **Field of Classification Search**

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(57) **ABSTRACT**

An isolator assembly is configured to provide isolation in each of multiple non-overlapping frequency bands and includes a selection network to select one of the multiple non-overlapping frequency bands for an isolation operation. During the isolation operation, the isolator assembly prevents signal coupling between antennas that are positioned on opposite sides of the isolator assembly.

20 Claims, 11 Drawing Sheets

