



US 20160181690A1

(19) **United States**

(12) **Patent Application Publication**
Cooper et al.

(10) **Pub. No.: US 2016/0181690 A1**

(43) **Pub. Date: Jun. 23, 2016**

(54) **PENTABAND ANTENNA**

Publication Classification

(71) Applicant: **WIRELESS RESEARCH DEVELOPMENT**, Temecula, CA (US)

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

(72) Inventors: **Henry Cooper**, Temecula, CA (US);
Sheng Peng, Lynwood, WA (US)

(52) **U.S. Cl.**
CPC **H01Q 1/38** (2013.01); **H01Q 9/0414** (2013.01)

(21) Appl. No.: **14/429,716**

(22) PCT Filed: **Sep. 18, 2013**

(57) **ABSTRACT**

(86) PCT No.: **PCT/US13/60462**

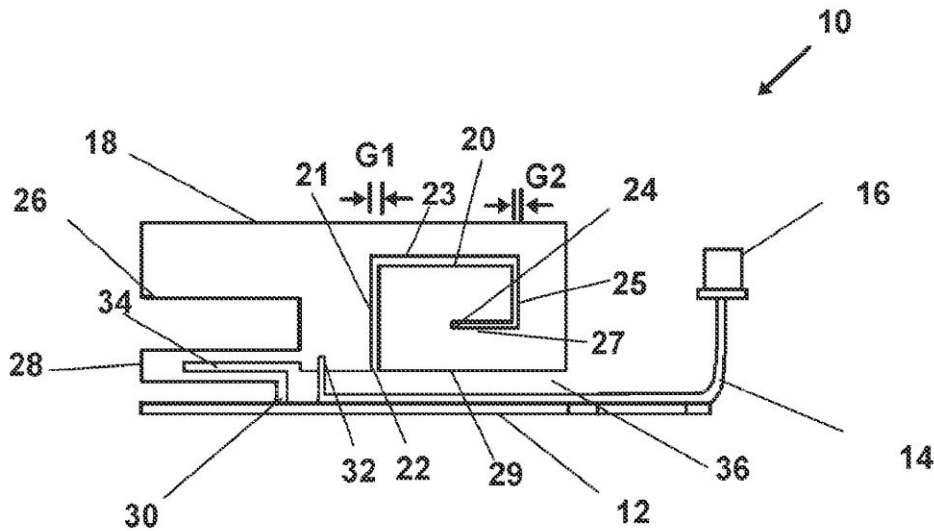
§ 371 (c)(1),

(2) Date: **Aug. 25, 2015**

An antenna element is disclosed which is formed in a unitary structure featuring a planar ground plane portion formed of electrically conductive material engaged with a perpendicular radiator element. One or a plurality of gaps formed into the radiator element provide one or a plurality of additional antenna elements which may be horizontally or vertically disposed for accommodating horizontally or vertically polarized RF transmission and reception.

Related U.S. Application Data

(60) Provisional application No. 61/703,083, filed on Sep. 19, 2012.





US 20160181694A1

(19) **United States**

(12) **Patent Application Publication**
CHEN et al.

(10) **Pub. No.: US 2016/0181694 A1**

(43) **Pub. Date: Jun. 23, 2016**

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

Publication Classification

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

(51) **Int. Cl.**
H01Q 5/10 (2006.01)

(72) Inventors: **JIN-BO CHEN**, New Taipei (TW);
CHENG-AN CHEN, New Taipei (TW);
WEN-YUAN CHEN, New Taipei (TW);
SHENG-CHIEH LIANG, New Taipei (TW)

(52) **U.S. Cl.**
CPC **H01Q 5/10** (2015.01)

(57) **ABSTRACT**

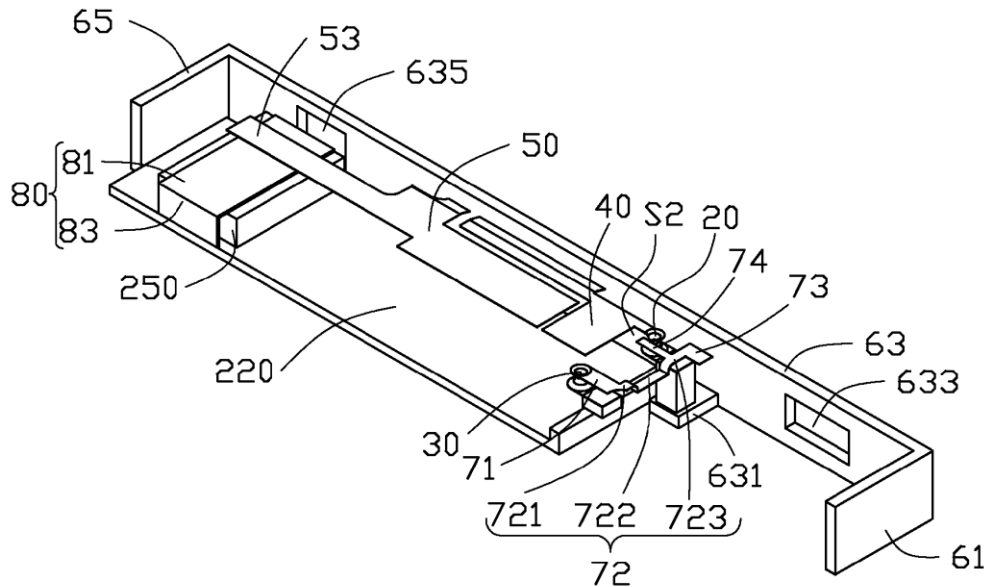
An antenna structure includes an antenna holder, a feed unit, a grounding unit, a first radiating unit, a second radiating unit, a third radiating unit, a parasitic unit, and a coupling unit. The feed unit and the grounding unit are positioned on the antenna holder and are spaced apart from each other. The first radiating unit and the third radiating unit are both electrically connected to the feed unit. The parasitic unit is electrically connected to the grounding unit. The first radiating unit couples with the second radiating unit and the parasitic unit. The second radiating unit further couples with the coupling unit and is grounded through the coupling unit.

(21) Appl. No.: **14/687,431**

(22) Filed: **Apr. 15, 2015**

(30) **Foreign Application Priority Data**

Dec. 23, 2014 (CN) 201410807376.3





US 20160181698A1

(19) **United States**

(12) **Patent Application Publication**
GOTO

(10) **Pub. No.: US 2016/0181698 A1**

(43) **Pub. Date: Jun. 23, 2016**

(54) **ANTENNA ELEMENT, ANTENNA DEVICE,
AND WIRELESS COMMUNICATION
EQUIPMENT USING THE SAME**

(52) **U.S. Cl.**
CPC . **H01Q 7/00** (2013.01); **H01Q 1/362** (2013.01)

(71) Applicant: **TDK Corporation, TOKYO (JP)**

(57) **ABSTRACT**

(72) Inventor: **Tetsuzo GOTO, TOKYO (JP)**

(73) Assignee: **TDK Corporation, TOKYO (JP)**

(21) Appl. No.: **14/963,105**

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

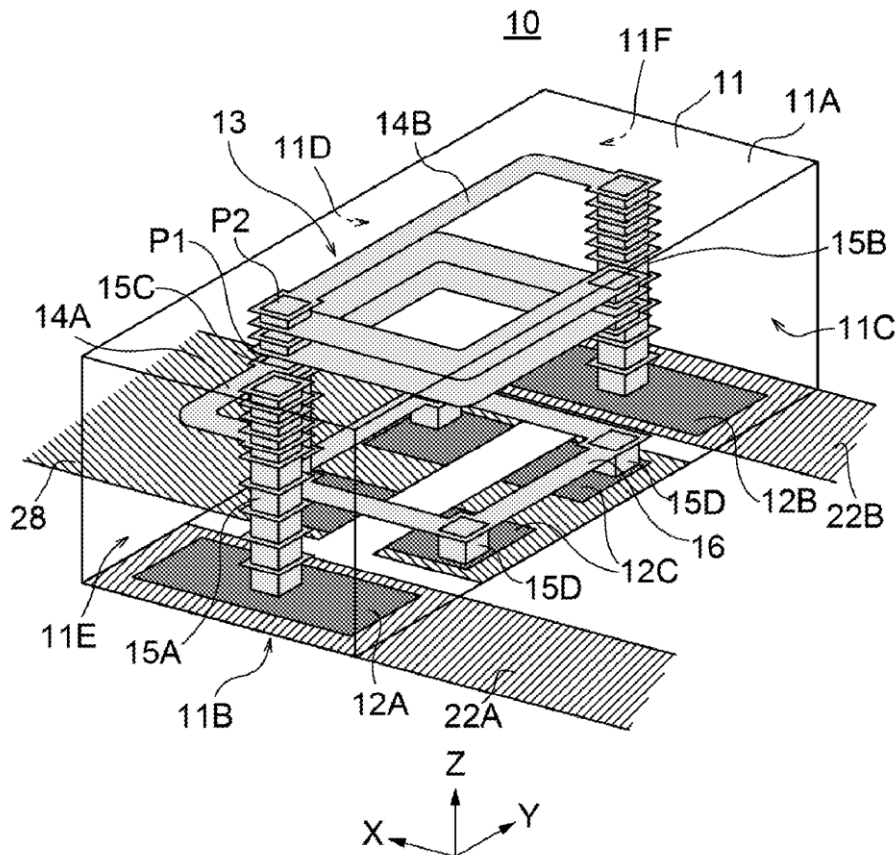
(30) **Foreign Application Priority Data**

Dec. 17, 2014 (JP) 2014-254714

Publication Classification

(51) **Int. Cl.**
H01Q 7/00 (2006.01)
H01Q 1/36 (2006.01)

An antenna element is provided with a substrate made of a dielectric body, first to third terminal electrodes formed on a bottom surface of the substrate, a helical coil pattern that is formed in the inside of the substrate, a first lead pattern connected to one end of the helical coil pattern or near the one end, a second lead pattern connected to the other end of the helical coil pattern or near the other end, a first through-hole conductor that connects the first terminal electrode and the first lead pattern, a second through-hole conductor that connects the second terminal electrode and the second lead pattern, and a third through-hole conductor that connects the third terminal electrode and the one end of the helical coil pattern.





US 20160181701A1

(19) **United States**

(12) **Patent Application Publication**
Sangaran et al.

(10) **Pub. No.: US 2016/0181701 A1**

(43) **Pub. Date: Jun. 23, 2016**

(54) **ANTENNA HAVING A REFLECTOR FOR IMPROVED EFFICIENCY, GAIN, AND DIRECTIVITY**

Publication Classification

(71) Applicants: **Pragash Sangaran**, Oakland, CA (US);
Ken Margon, Oakland, CA (US)

(51) **Int. Cl.**
H01Q 15/14 (2006.01)
H01Q 9/04 (2006.01)

(72) Inventors: **Pragash Sangaran**, Oakland, CA (US);
Ken Margon, Oakland, CA (US)

(52) **U.S. Cl.**
CPC . *H01Q 15/14* (2013.01); *H01Q 9/04* (2013.01)

(21) Appl. No.: **14/860,682**

(57) **ABSTRACT**

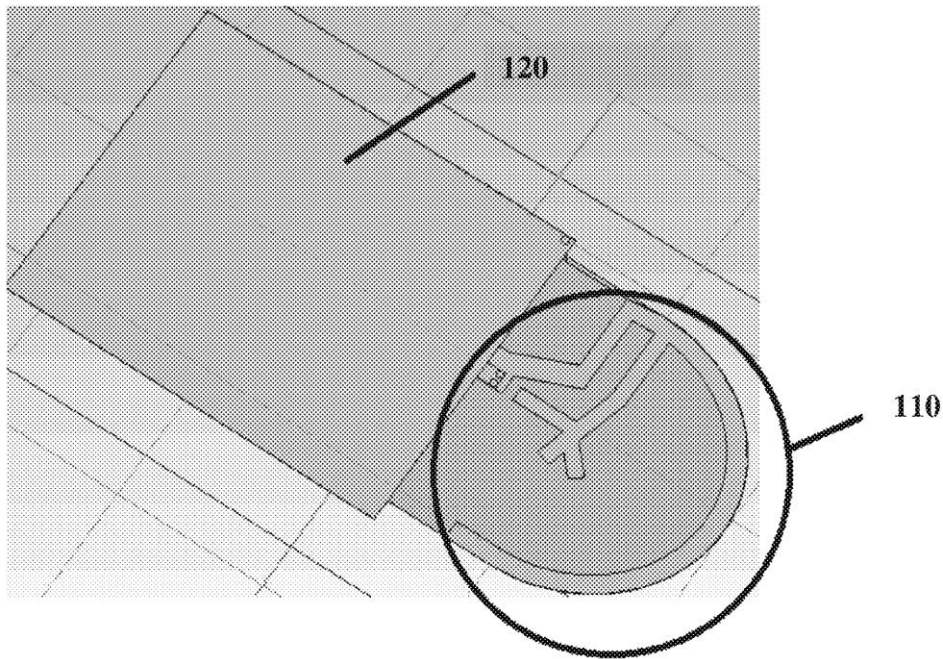
(22) Filed: **Sep. 21, 2015**

An antenna having at least one reflector for improving radiation efficiency, gain, and directivity is disclosed. The antenna may be formed on a substrate or be a standalone conductive material that is designed to operate in at least one band of frequency. The antenna includes a reflector for each band of frequency the antenna is designed to operate in. The reflector is positioned relative to the antenna to redirect electromagnetic radiation of the antenna away from surrounding materials or objects that affect, i.e., reflect, refract, diffract, absorb and scatter the antenna's electromagnetic radiation.

Related U.S. Application Data

(60) Provisional application No. 62/052,810, filed on Sep. 19, 2014.

100





US 20160182003A1

(19) **United States**

(12) **Patent Application Publication**
TESHIMA et al.

(10) **Pub. No.: US 2016/0182003 A1**

(43) **Pub. Date: Jun. 23, 2016**

(54) **IMPEDANCE CONVERSION CIRCUIT,
ANTENNA APPARATUS, AND WIRELESS
COMMUNICATION APPARATUS**

Publication Classification

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

(51) **Int. Cl.**
H03H 7/38 (2006.01)
H04B 1/3827 (2006.01)
H01Q 1/50 (2006.01)

(72) Inventors: **Yuichiro TESHIMA**, Nagaokakyo-shi
(JP); **Kenichi ISHIZUKA**,
Nagaokakyo-shi (JP)

(52) **U.S. Cl.**
CPC . *H03H 7/38* (2013.01); *H01Q 1/50* (2013.01);
H04B 1/3827 (2013.01)

(21) Appl. No.: **15/057,147**

(57) **ABSTRACT**

(22) Filed: **Mar. 1, 2016**

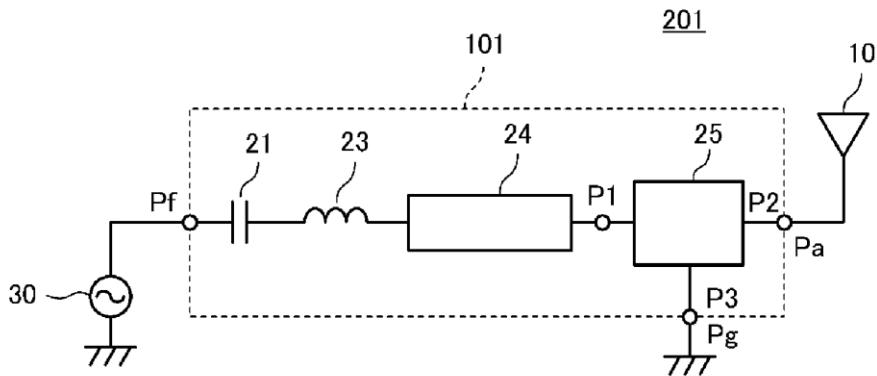
Related U.S. Application Data

(63) Continuation of application No. PCT/JP2014/064908,
filed on Jun. 5, 2014.

An impedance conversion circuit includes an auto-transformer circuit including a first inductor connected between a first port connected on a power supply portion side and a second port connected on an antenna side and a second inductor connected between a third port that is grounded and the second port; a first phase shifter with a first end connected to the first port; an inductor connected in series between a second end of the first phase shifter and the power supply portion; and a capacitor connected in series to the inductor and connected in series between the second end of the first phase shifter and the power supply portion.

Foreign Application Priority Data

Sep. 5, 2013 (JP) 2013-184176
Oct. 28, 2013 (JP) 2013-223464





US 20160182112A1

(19) **United States**

(12) **Patent Application Publication**
KIM et al.

(10) **Pub. No.: US 2016/0182112 A1**

(43) **Pub. Date: Jun. 23, 2016**

(54) **MOBILE TERMINAL**

Publication Classification

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

(51) **Int. Cl.**
H04B 1/388 (2006.01)
H04B 15/00 (2006.01)
H04M 1/02 (2006.01)

(72) Inventors: **Changil KIM**, Seoul (KR); **Dongjin KIM**, Seoul (KR); **Yeomin YOUN**, Seoul (KR); **Hyeongsik YOON**, Seoul (KR); **Jaegon LEE**, Seoul (KR); **Chisang YOU**, Seoul (KR)

(52) **U.S. Cl.**
CPC **H04B 1/388** (2013.01); **H04M 1/0274** (2013.01); **H04B 15/005** (2013.01)

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

(57) **ABSTRACT**

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

A mobile terminal, comprises: a case including a conductive metal part; a main board mounted inside the case and having a power supply part and a ground surface; a first antenna radiator disposed so as to be spaced from the power supply part to the first antenna radiator; a power supply line for electrically connecting the power supply part to the first antenna radiator and ground line for electrically connecting the ground surface to the metal part and the first antenna radiator, thereby preventing a decrease in the performance of an antenna since the formation of an electromagnetic field between the case of a metallic material and the main board can be minimized even if the metallic material is used for the case.

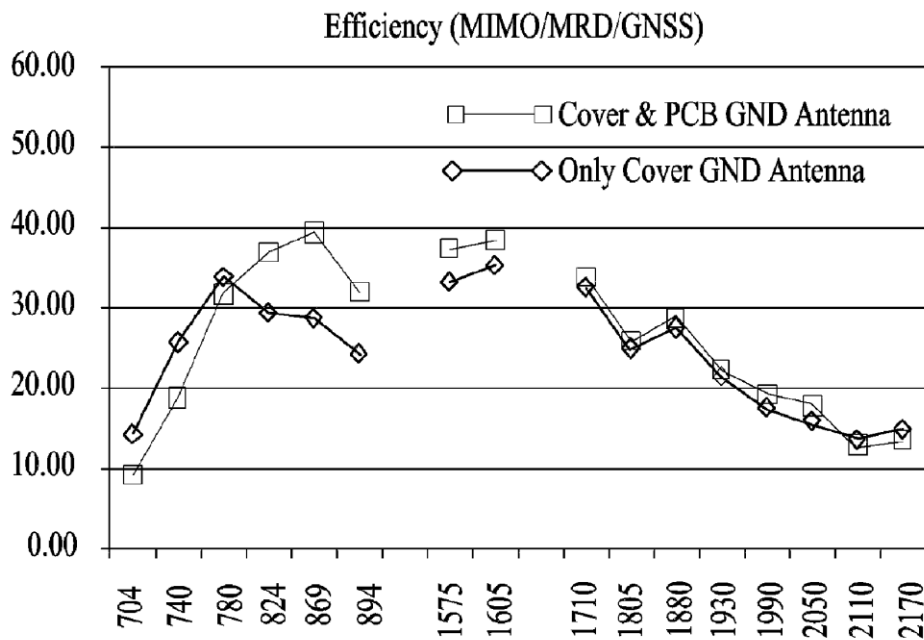
(22) PCT Filed: **Dec. 16, 2013**

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

§ 371 (c)(1),
(2) Date: **May 19, 2015**

(30) **Foreign Application Priority Data**

Jul. 5, 2013 (KR) 10-2013-0078880
Jul. 5, 2013 (KR) 10-2013-0078881





US 20160190699A1

(19) **United States**

(12) **Patent Application Publication**
YANG et al.

(10) **Pub. No.: US 2016/0190699 A1**

(43) **Pub. Date: Jun. 30, 2016**

(54) **MOBILE DEVICE**

Publication Classification

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

(51) **Int. Cl.**
H01Q 9/26 (2006.01)
H01Q 5/307 (2006.01)
H01Q 1/38 (2006.01)

(72) Inventors: **Chung-Wen YANG**, New Taipei City (TW); **Chuan-Chun WANG**, New Taipei City (TW); **Ching-Chi LIN**, New Taipei City (TW); **Kun-Sheng CHANG**, New Taipei City (TW); **Kuan-Jen CHUNG**, New Taipei City (TW)

(52) **U.S. Cl.**
CPC . *H01Q 9/26* (2013.01); *H01Q 1/38* (2013.01);
H01Q 5/307 (2015.01)

(57) **ABSTRACT**

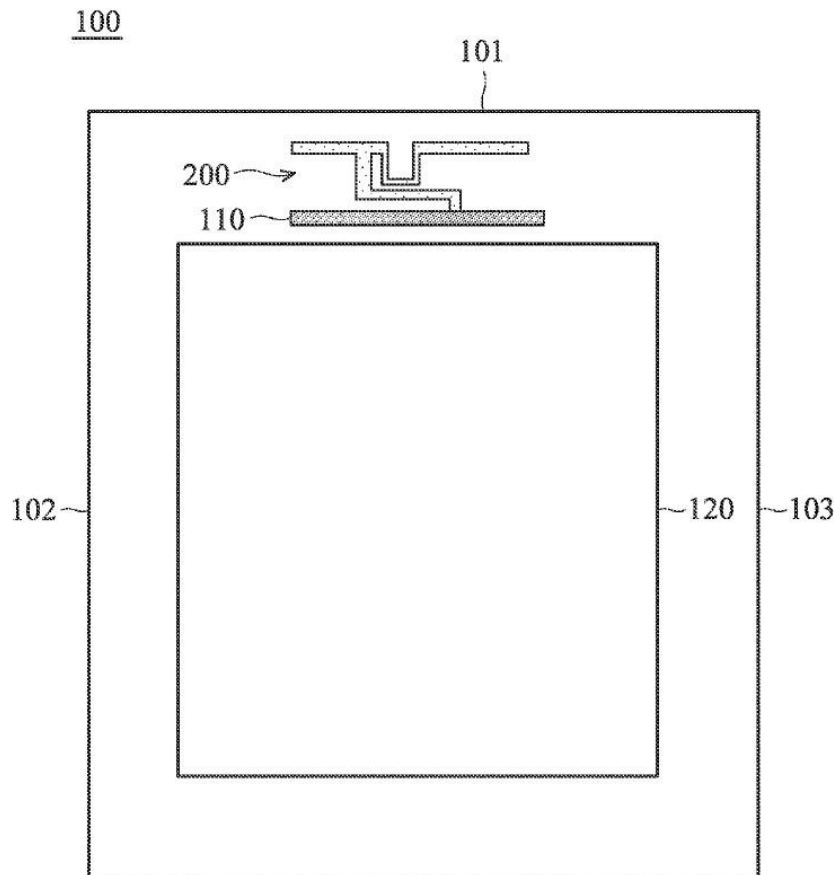
A mobile device includes a ground element and an antenna structure. The antenna structure includes a ground branch, a feeding branch, a low-frequency radiation branch, and a high-frequency radiation branch. The feeding branch is coupled through the ground branch to the ground element. The low-frequency radiation branch is coupled to the feeding branch. The high-frequency radiation branch is coupled to the feeding branch. The low-frequency radiation branch has a meandering structure for reducing the SAR (Specific Absorption Rate) of the antenna structure.

(21) Appl. No.: **14/679,159**

(22) Filed: **Apr. 6, 2015**

(30) **Foreign Application Priority Data**

Dec. 26, 2014 (TW) 103145711





US 20160190700A1

(19) **United States**

(12) **Patent Application Publication**
WANG et al.

(10) **Pub. No.: US 2016/0190700 A1**

(43) **Pub. Date: Jun. 30, 2016**

(54) **DUALBAND ANTENNA WITH ISOLATION ENHANCED AND METHOD THEREOF**

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

CPC *H01Q 9/26* (2013.01); *H01Q 5/307* (2015.01); *H01Q 1/38* (2013.01)

(71) Applicant: **REALTEK SEMICONDUCTOR CORP., HSINCHU (TW)**

(72) Inventors: **SY BEEN WANG, CHU PEI CITY (TW); CHING WEI LING, CHU PEI CITY (TW); CHIH PAO LIN, CHU PEI CITY (TW)**

(57)

ABSTRACT

(21) Appl. No.: **14/724,199**

(22) Filed: **May 28, 2015**

(30) **Foreign Application Priority Data**

Dec. 26, 2014 (TW) 103145730

Publication Classification

(51) **Int. Cl.**

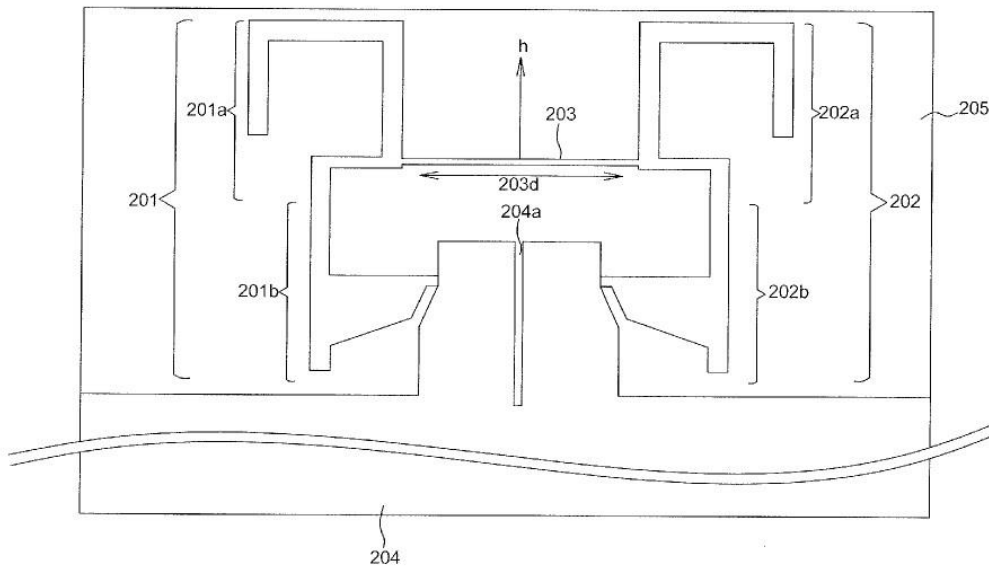
H01Q 9/26 (2006.01)

H01Q 1/38 (2006.01)

H01Q 5/307 (2006.01)

An antenna set includes a first antenna, a second antenna, and a neutralized line. Each of the first antenna and the second antenna has a low frequency resonant path and a high frequency resonant path. The neutralized line is couple to the low frequency resonant path of the first antenna and the low frequency resonant path of the second antenna. The low frequency resonant path of the first antenna and the low frequency resonant path of the second antenna correspond to a first frequency band, the high frequency resonant path of the first antenna and the high frequency resonant path of the second antenna correspond to a second frequency band, and the two low frequency resonant paths do not overlap the two high frequency resonant paths.

200





US 20160190705A1

(19) **United States**

(12) **Patent Application Publication**
Lee et al.

(10) **Pub. No.: US 2016/0190705 A1**

(43) **Pub. Date: Jun. 30, 2016**

(54) **MULTIBAND COMPOSITE RIGHT AND LEFT HANDED (CRLH) SLOT ANTENNA**

(60) Provisional application No. 61/159,694, filed on Mar. 12, 2009.

(71) Applicant: **Tyco Electronics Services GMBH**,
Schaffhausen (CH)

Publication Classification

(72) Inventors: **Cheng Jung Lee**, Santa Clara, CA (US);
Ajay Gummalla, Sunnyvale, CA (US);
Maha Achour, Encinitas, CA (US)

(51) **Int. Cl.**
H01Q 15/00 (2006.01)
H01Q 13/10 (2006.01)

(21) Appl. No.: **14/977,868**

(52) **U.S. Cl.**
CPC **H01Q 15/0086** (2013.01); **H01Q 13/10**
(2013.01)

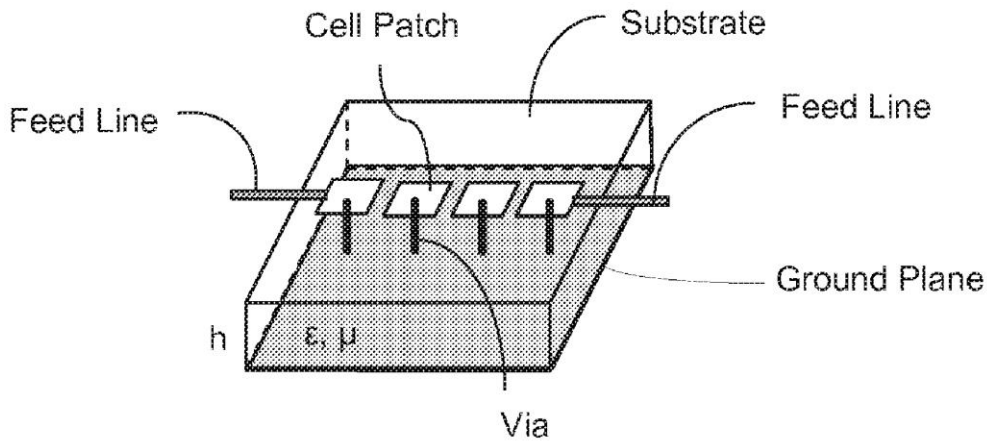
(22) Filed: **Dec. 22, 2015**

(57) **ABSTRACT**

Related U.S. Application Data

(63) Continuation of application No. 12/723,540, filed on Mar. 12, 2010, now Pat. No. 9,246,228.

This application relates to slot antenna devices based on Composite Right and Left Handed (CRLH) metamaterial (MTM) structures.





US 20160190709A1

(19) **United States**

(12) **Patent Application Publication**
Niu

(10) **Pub. No.: US 2016/0190709 A1**

(43) **Pub. Date: Jun. 30, 2016**

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

Publication Classification

(71) Applicant: **Lenovo (Beijing) Co., Ltd.**, Beijing (CN)

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

(72) Inventor: **Jiaxiao Niu**, Beijing (CN)

(52) **U.S. Cl.**
CPC **H01Q 21/28** (2013.01)

(73) Assignee: **LENOVO (BEIJING) CO., LTD.**, Beijing (CN)

(57) **ABSTRACT**

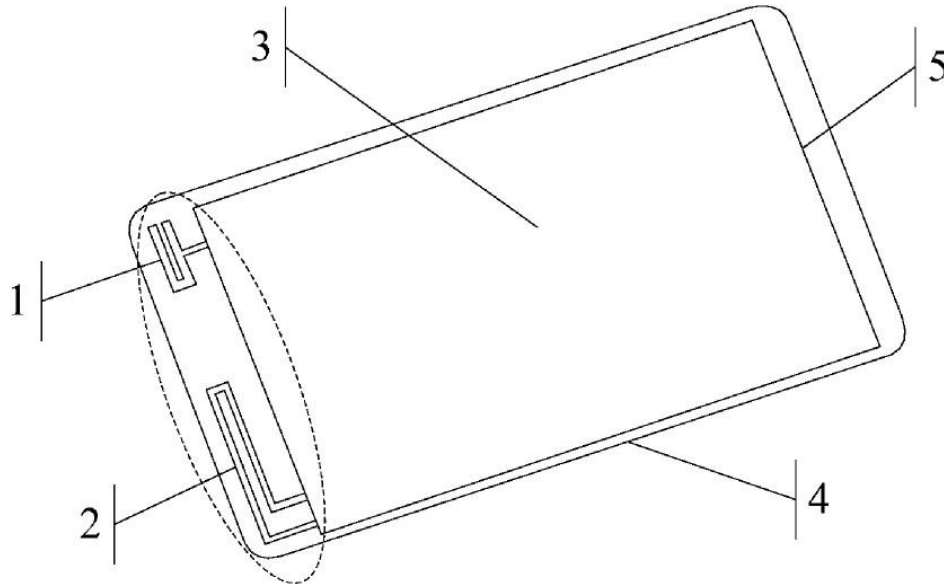
(21) Appl. No.: **14/673,008**

The present disclosure discloses an antenna system that includes a first antenna for transmitting and receiving data and having an electrical length that is equal to its resonant electrical length; a second antenna for receiving data and having an electrical length that is less than its resonant electrical length. The present disclosure also discloses a corresponding electronic apparatus.

(22) Filed: **Mar. 30, 2015**

(30) **Foreign Application Priority Data**

Dec. 31, 2014 (CN) 201410855064.X





US 20160191681A1

(19) **United States**

(12) **Patent Application Publication**
HAN et al.

(10) **Pub. No.: US 2016/0191681 A1**

(43) **Pub. Date: Jun. 30, 2016**

(54) **WIRELESS COMMUNICATION DEVICE WITH AN ANTENNA ADJACENT TO AN EDGE OF THE DEVICE**

Publication Classification

(71) Applicant: **Futurewei Technologies, Inc.**, Plano, TX (US)

(51) **Int. Cl.**
H04M 1/02 (2006.01)
H04B 1/3827 (2006.01)

(72) Inventors: **Chul Min HAN**, San Diego, CA (US);
Jorge Fabrega SANCHEZ, San Diego, CA (US)

(52) **U.S. Cl.**
CPC *H04M 1/026* (2013.01); *H04B 1/3827* (2013.01)

(73) Assignee: **Futurewei Technologies, Inc.**, Plano, TX (US)

(57) **ABSTRACT**

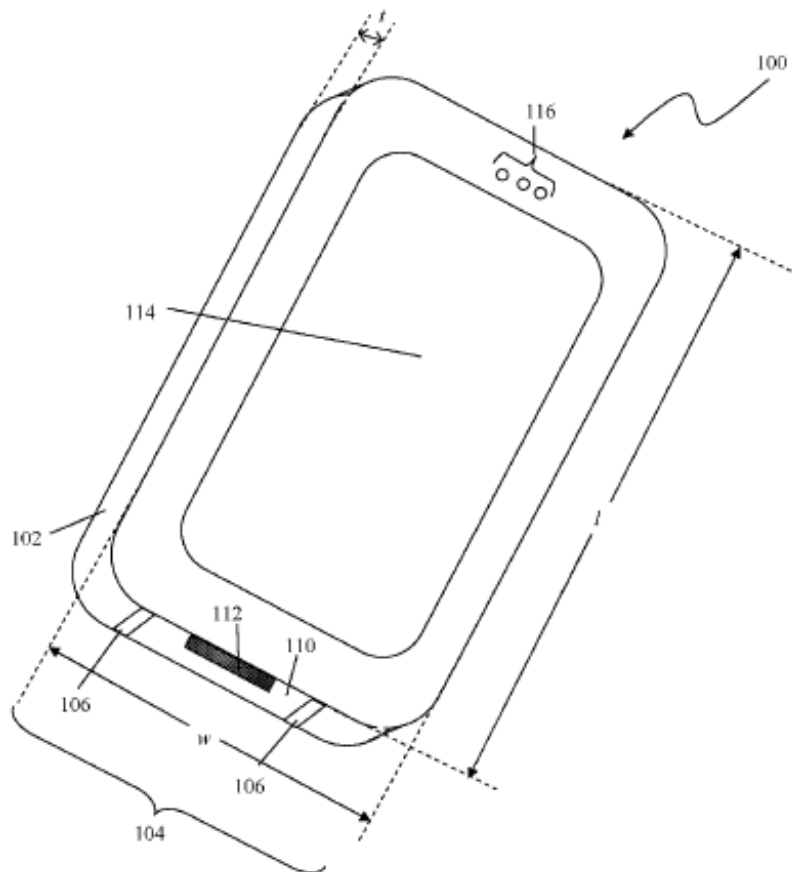
(21) Appl. No.: **15/059,588**

A wireless communication device comprising a housing comprising a plurality of edges and configured to serve as an external surface for the wireless communication device, and an antenna adjacent to at least a first edge of the housing, wherein the antenna comprises at least a conductive strip and at least one slot and wherein the antenna is configured to receive and transmit wireless signals, wherein the first edge of the housing is one of an edge of the housing nearest an ear piece and an edge of the housing that is opposite the edge of the housing nearest the ear piece, and wherein the conductive strip and the slot are adjacent to at least the first edge of the housing.

(22) Filed: **Mar. 3, 2016**

Related U.S. Application Data

(63) Continuation of application No. 13/278,836, filed on Oct. 21, 2011, now Pat. No. 9,300,033.





US 20160197401A1

(19) **United States**

(12) **Patent Application Publication**
Ouyang et al.

(10) **Pub. No.: US 2016/0197401 A1**

(43) **Pub. Date: Jul. 7, 2016**

(54) **ELECTRONIC DEVICE WITH SHARED ANTENNA STRUCTURES AND BALUN**

Publication Classification

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

(51) **Int. Cl.**
H01Q 3/24 (2006.01)
H01Q 7/00 (2006.01)

(72) Inventors: **Yuehui Ouyang**, Sunnyvale, CA (US);
Dean F. Darnell, Durham, NC (US);
Enrique Ayala Vazquez, Watsonville, CA (US);
Erica J. Tong, Pacifica, CA (US);
Hongfei Hu, Santa Clara, CA (US);
Matthew A. Mow, Los Altos, CA (US);
Mattia Pascolini, San Mateo, CA (US);
Ming-Ju Tsal, Cupertino, CA (US);
Nanbo Jin, Sunnyvale, CA (US);
Robert W. Schlub, Cupertino, CA (US)

(52) **U.S. Cl.**
CPC . **H01Q 3/247** (2013.01); **H01Q 7/00** (2013.01)

(57) **ABSTRACT**

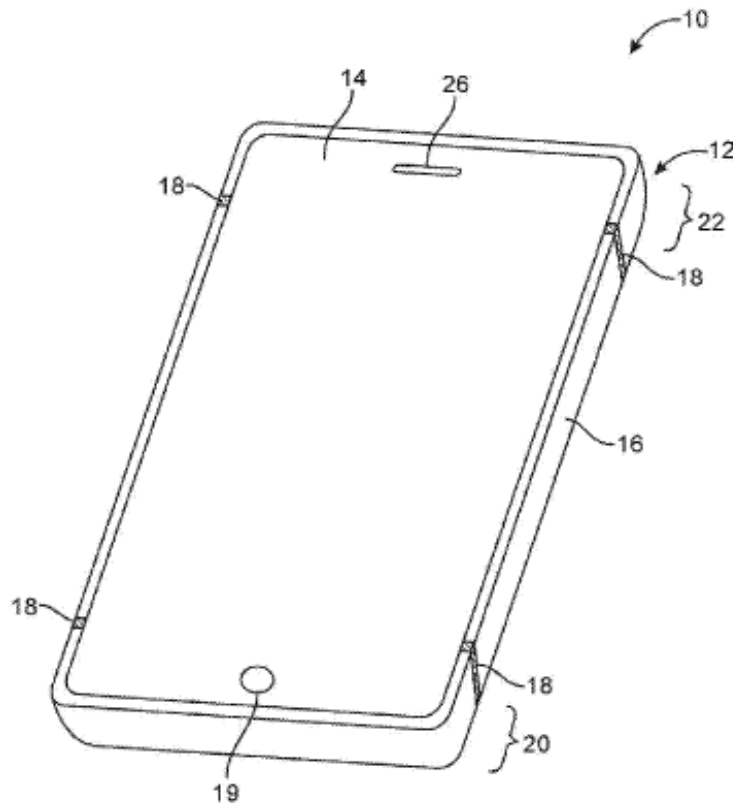
An electronic device may be provided with shared antenna structures that can be used to form both a near-field-communications antenna such as a loop antenna and a non-near-field communications antenna such as an inverted-F antenna. The antenna structures may include conductive structures such as metal traces on printed circuits or other dielectric substrates, internal metal housing structures, or other conductive electronic device housing structures. A main resonating element arm may be separated from an antenna ground by an opening. A non-near-field communications antenna return path and antenna feed path may span the opening. A balun may have first and second electromagnetically coupled inductors. The second inductor may have terminals coupled across differential signal terminals in a near-field communications transceiver. The first inductor may form part of the near-field communications loop antenna.

(21) Appl. No.: **15/071,795**

(22) Filed: **Mar. 16, 2016**

Related U.S. Application Data

(63) Continuation of application No. 14/195,130, filed on Mar. 3, 2014, now Pat. No. 9,325,080.





US 20160197403A1

(19) **United States**
(12) **Patent Application Publication**
CHOI et al.

(10) **Pub. No.:** US 2016/0197403 A1
(43) **Pub. Date:** Jul. 7, 2016

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

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

(72) Inventors: **Jaehyun CHOI**, Seoul (KR);
Hyengcheul CHOI, Seoul (KR);
Chisang YOU, Seoul (KR)

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

(21) Appl. No.: **14/868,138**

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

(30) **Foreign Application Priority Data**

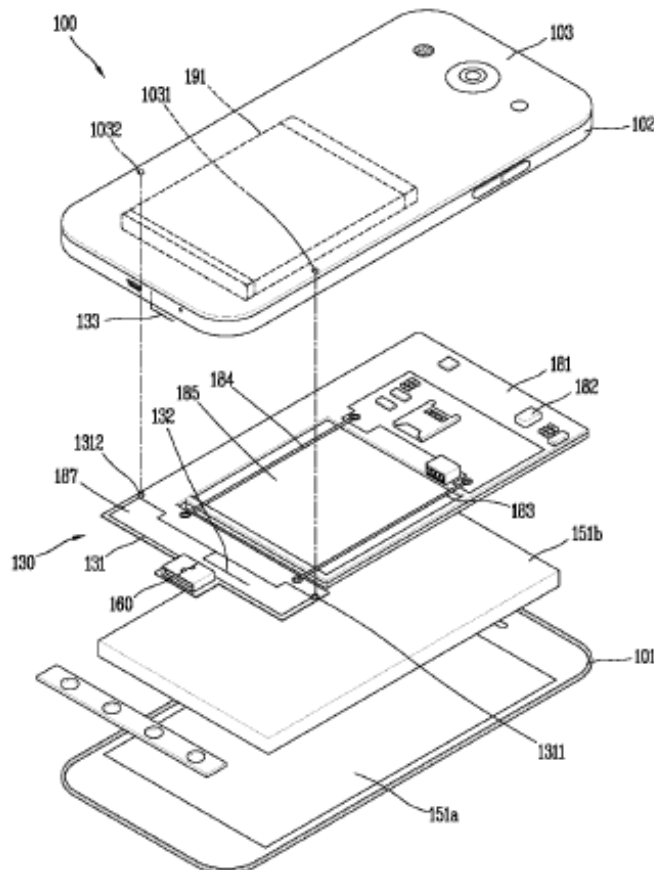
Jan. 5, 2015 (KR) 10-2015-0000772

Publication Classification

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/38 (2006.01)
(52) **U.S. Cl.**
CPC . **H01Q 9/045** (2013.01); **H01Q 1/38** (2013.01)

(57) **ABSTRACT**

Disclosed are an antenna module and a mobile terminal having the same. The antenna module includes a ground plate; a metal plate spaced apart from the ground plate by a distance such that a surface of the metal plate faces a surface of the ground plate; a first conductive member spaced apart from an edge of the ground plate by a distance, the first conductive member encompassing the edge; a feeding part formed on the ground plate; a second conductive member formed on the ground plate and coupled to the feeding part, wherein the second conductive member indirectly feeds the first conductive member and the metal plate; and a first connection member and a second connection member that couple the ground plate to the metal plate.





US 20160204499A1

(19) **United States**

(12) **Patent Application Publication**

Toh et al.

(10) **Pub. No.: US 2016/0204499 A1**

(43) **Pub. Date: Jul. 14, 2016**

(54) **MULTI-BAND ANTENNA ON THE SURFACE OF WIRELESS COMMUNICATION DEVICES**

(71) Applicant: **Futurewei Technologies, Inc.**, Plano, TX (US)

(72) Inventors: **Wee Kian Toh**, San Diego, CA (US);
Hongwei Liu, San Diego, CA (US);
Ping Shi, San Diego, CA (US)

(21) Appl. No.: **14/596,002**

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

Publication Classification

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/52 (2006.01)
H01Q 5/10 (2006.01)
H01Q 1/42 (2006.01)
H01Q 9/04 (2006.01)
H01Q 1/38 (2006.01)

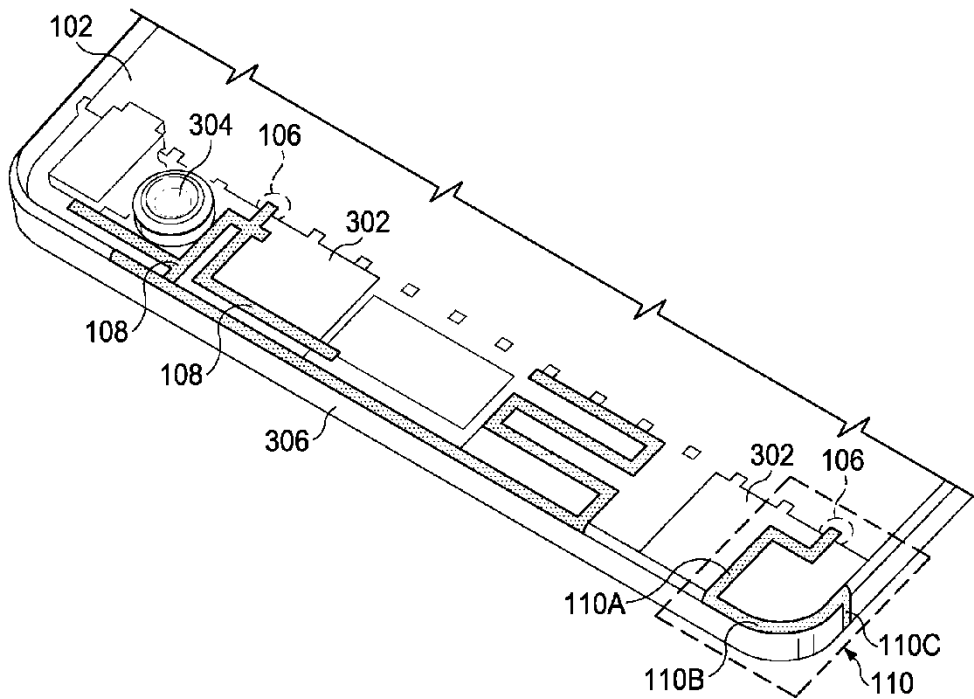
(52) **U.S. Cl.**

CPC *H01Q 1/24* (2013.01); *H01Q 9/0407* (2013.01); *H01Q 1/38* (2013.01); *H01Q 5/10* (2015.01); *H01Q 1/42* (2013.01); *H01Q 1/521* (2013.01)

(57)

ABSTRACT

An embodiment wireless communication device includes a circuit board and a cover having a back surface covering a portion of a first surface of the circuit board and an opening in the back surface. A top antenna is disposed within the cover and is electrically connected to the circuit board at a first feed point on a first edge of the circuit board. A secondary antenna disposed within the cover has a first antenna portion connected to the circuit board at a second feed point, and a second antenna portion of the second antenna extends laterally from a second edge of the circuit board over the first surface of the circuit board and between the back surface of the cover and the first surface of the circuit board such that at least a portion of the second antenna portion is exposed through the opening in the back surface.





US 20160204501A1

(19) **United States**

(12) **Patent Application Publication**
BRINGUIER et al.

(10) **Pub. No.: US 2016/0204501 A1**

(43) **Pub. Date: Jul. 14, 2016**

(54) **CLOSELY COUPLED RE-RADIATOR
COMPOUND LOOP ANTENNA STRUCTURE**

Publication Classification

(71) Applicant: **DockOn AG**, Zurich (CH)

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H04B 5/00 (2006.01)

(72) Inventors: **Jonathan Neil BRINGUIER**, Carlsbad, CA (US); **Eugene Yu-Giun REN**, San Marcos, CA (US); **Nan XU**, San Diego, CA (US)

(52) **U.S. Cl.**
CPC *H01Q 1/243* (2013.01); *H04B 5/0087* (2013.01)

(21) Appl. No.: **15/055,363**

(57) **ABSTRACT**

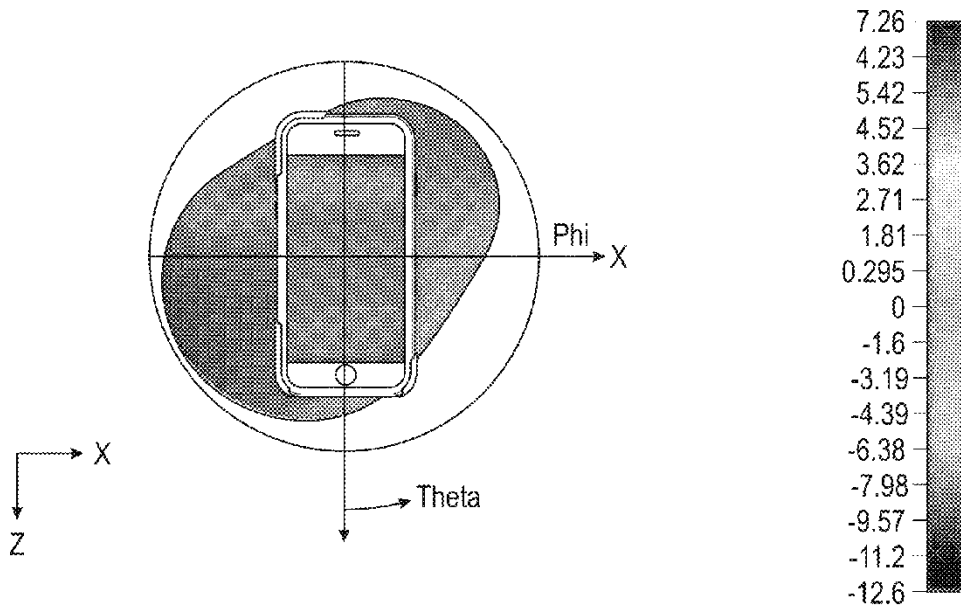
(22) Filed: **Feb. 26, 2016**

Source radio frequency energy (RF) is coupled wirelessly (no physical contact) between two compound loop (CPL) antennas or one CPL and another type of antenna across a variety of barriers such as plastic, human tissues, glass, and air. The compound coupling interface created between the two antennas is highly efficient in transferring the RF energy from a source antenna to a destination including a CPL antenna. A re-radiating structure including a further CPL antenna or a different type of antenna may be connected on the destination side to completely physically isolate the source side from the destination side. When the destination coupling antenna is removed, the source coupling antenna may operate as an efficient radiator at the desired operating frequencies. Likewise, the destination coupling antenna may operate as an efficient radiator in the absence of the source coupling antenna.

Related U.S. Application Data

(63) Continuation-in-part of application No. 14/712,804, filed on May 14, 2015, which is a continuation-in-part of application No. 14/103,684, filed on Dec. 11, 2013, which is a continuation-in-part of application No. 14/565,379, filed on Dec. 9, 2014.

(60) Provisional application No. 62/126,373, filed on Feb. 27, 2015, provisional application No. 61/996,773, filed on May 14, 2014, provisional application No. 61/913,789, filed on Dec. 9, 2013.





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(19) **United States**

(12) **Patent Application Publication**
MIYAKE

(10) **Pub. No.: US 2016/0204506 A1**

(43) **Pub. Date: Jul. 14, 2016**

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

Publication Classification

(71) Applicant: **Funai Electric Co., Ltd.**, Osaka (JP)

(51) **Int. Cl.**
H01Q 1/52 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)

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(52) **U.S. Cl.**
CPC *H01Q 1/521* (2013.01); *H01Q 1/48* (2013.01); *H01Q 1/243* (2013.01)

(73) Assignee: **Funai Electric Co., Ltd.**

(21) Appl. No.: **15/074,076**

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

(57) **ABSTRACT**

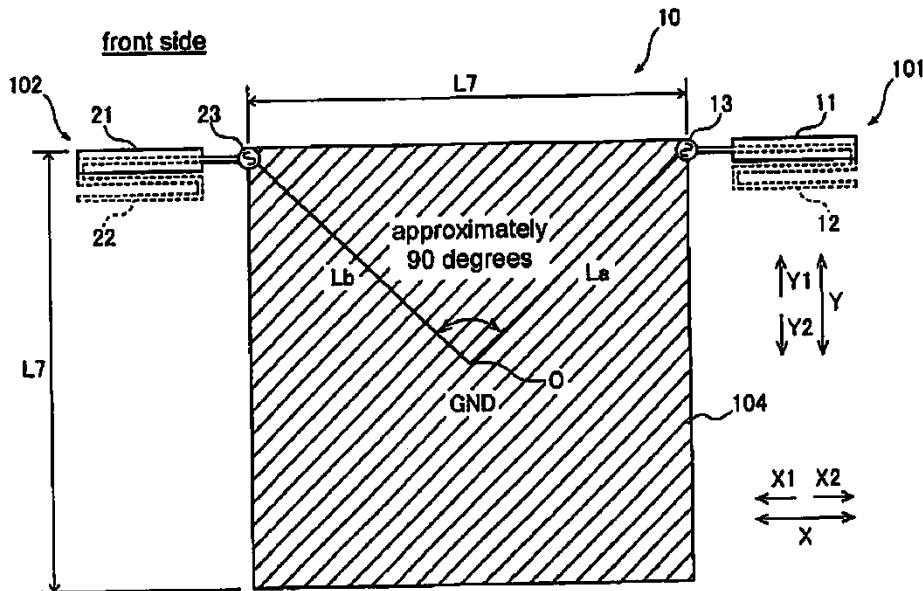
Related U.S. Application Data

(63) Continuation of application No. 14/077,755, filed on Nov. 12, 2013, now Pat. No. 9,306,277.

Foreign Application Priority Data

(30) Nov. 20, 2012 (JP) 2012-254225

A multi-antenna device includes a grounding plate, a first antenna and a second antenna. The first antenna includes a first feed element that is grounded to the grounding plate via a first feed point. The second antenna includes a second feed element that is grounded to the grounding plate via a second feed point. Polarization planes of the first and second antennas intersect at a predetermined angle.





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(19) **United States**

(12) **Patent Application Publication**
Zhai et al.

(10) **Pub. No.: US 2016/0204509 A1**

(43) **Pub. Date: Jul. 14, 2016**

(54) **COMBINATION ANTENNA ELEMENT AND ANTENNA ARRAY**

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

CPC *H01Q 5/55* (2015.01); *H01Q 9/0407* (2013.01); *H01Q 21/065* (2013.01)

(71) Applicants: **Wenyao Zhai**, Kanata (CA); **Halim Boutayeb**, Montreal (CA); **Vahid MirafTAB**, Kanata (CA)

(57)

ABSTRACT

(72) Inventors: **Wenyao Zhai**, Kanata (CA); **Halim Boutayeb**, Montreal (CA); **Vahid MirafTAB**, Kanata (CA)

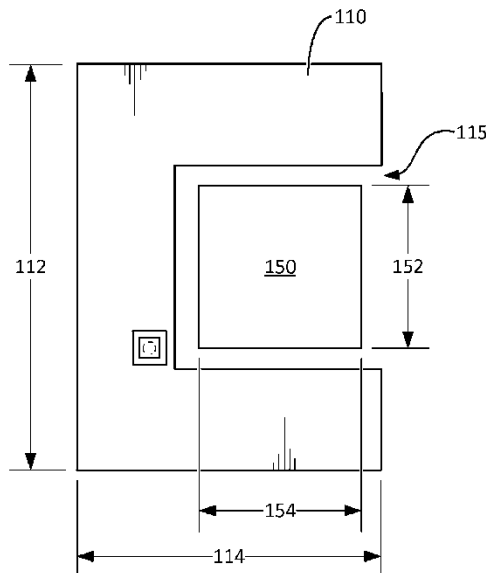
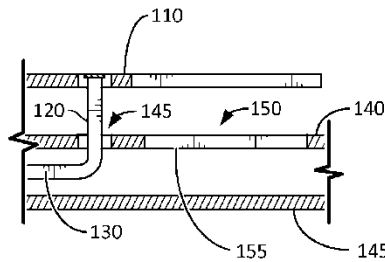
A combination antenna element is provided. A first antenna element, for example a waveguide antenna, may be coupled to a waveguide feed such as a Substrate Integrated Waveguide (SIW). The waveguide antenna may be formed as an aperture at a terminus of the SIW and disposed within a Printed Circuit Board (PCB) internal layer. A second antenna element, for example a microstrip patch antenna (MPA), may be provided on an outer PCB layer, the MPA defining an interior region, the interior region being positioned in line with the first antenna element. Also in some embodiments, the second antenna element is coupled to another antenna feed such as a transmission line feed which propagates signals in a different electromagnetic propagation mode than the waveguide. The transmission line feed may be a stripline located within the waveguide. An antenna array incorporating the combination antenna element is also provided.

(21) Appl. No.: **14/594,583**

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

Publication Classification

(51) **Int. Cl.**
H01Q 5/55 (2006.01)
H01Q 21/06 (2006.01)
H01Q 9/04 (2006.01)





US 20160204820A1

(19) **United States**

(12) **Patent Application Publication**
Mow et al.

(10) **Pub. No.: US 2016/0204820 A1**

(43) **Pub. Date: Jul. 14, 2016**

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

Publication Classification

(51) **Int. Cl.**
H04B 1/40 (2006.01)

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

(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)

(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.

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

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

Related U.S. Application Data

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

