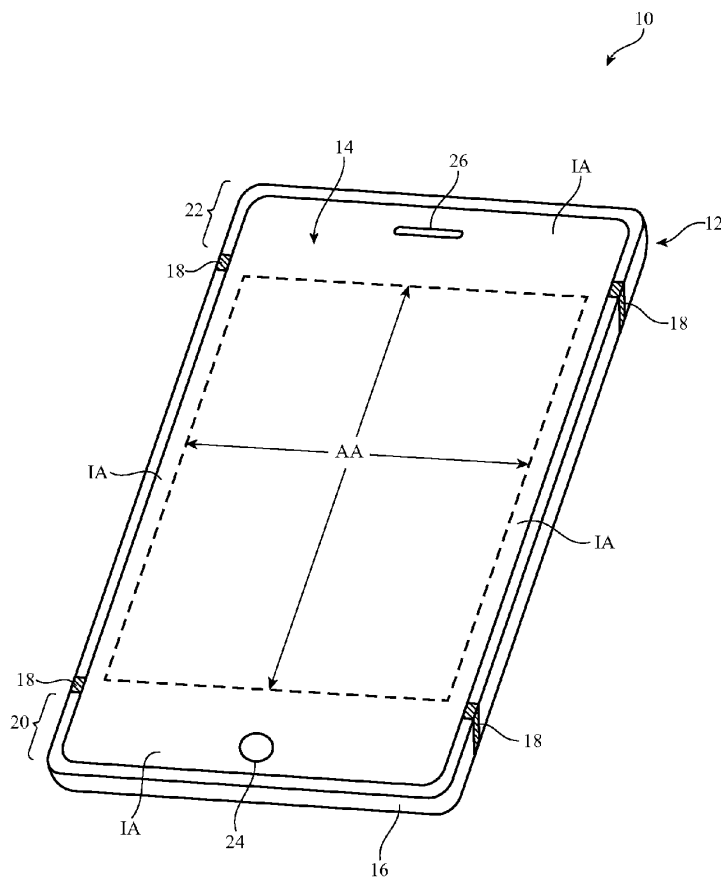




US 20170054196A1

(19) **United States**(12) **Patent Application Publication**
Hu et al.(10) **Pub. No.: US 2017/0054196 A1**(43) **Pub. Date: Feb. 23, 2017**(54) **ELECTRONIC DEVICE ANTENNA WITH
EMBEDDED PARASITIC ARM****Publication Classification**(51) **Int. Cl.**
H01Q 1/24 (2006.01)(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01)(71) Applicant: **Apple Inc.**, Cupertino, CA (US)(72) Inventors: **Hongfei Hu**, Santa Clara, CA (US);
Benjamin Shane Bustle, Cupertino, CA
(US); **Enrique Ayala Vazquez**,
Watsonville, CA (US); **Nanbo Jin**,
Milpitas, CA (US); **Miguel Christophy**,
San Francisco, CA (US); **Erdinc Irci**,
Santa Clara, CA (US); **Salih Yarga**,
Sunnyvale, CA (US); **Erica Tong**,
Pacifica, CA (US); **Anand**
Lakshmanan, San Jose, CA (US);
Mattia Pascolini, San Francisco, CA
(US); **Tyler Cater**, Cupertino, CA (US);
Christopher T. Cheng, Los Altos, CA
(US)(57) **ABSTRACT**

An electronic device may have wireless circuitry with antennas. An antenna resonating element arm for an antenna may be formed from peripheral conductive structures running along the edges of a device housing. The peripheral conductive structures may form housing sidewalls. A slot may be machined into a metal housing that separates the housing sidewalls from a planar rear housing portion that forms a ground for an antenna. The slot may be filled with plastic filler. A parasitic antenna resonating element arm that supports an antenna resonance at high band frequencies may be embedded within the plastic filler. The parasitic antenna resonating element may be formed from a portion of the planar rear housing portion.

(21) Appl. No.: **14/829,008**(22) Filed: **Aug. 18, 2015**



US 20170054199A1

(19) **United States**

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

(10) **Pub. No.: US 2017/0054199 A1**

(43) **Pub. Date: Feb. 23, 2017**

(54) **MOBILE TERMINAL**

Publication Classification

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

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

(72) Inventors: **Cheolgu GANG**, Seoul (KR); **Hyunsuk YANG**, Seoul (KR); **Jongmo Kang**, Seoul (KR); **Jinho Jang**, Seoul (KR)

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

(73) Assignee: **LG Electronics Inc.**

(21) Appl. No.: **15/241,605**

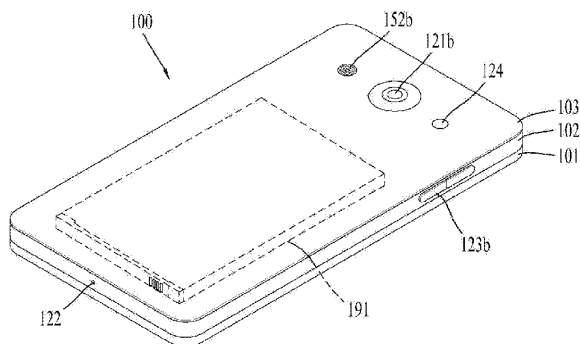
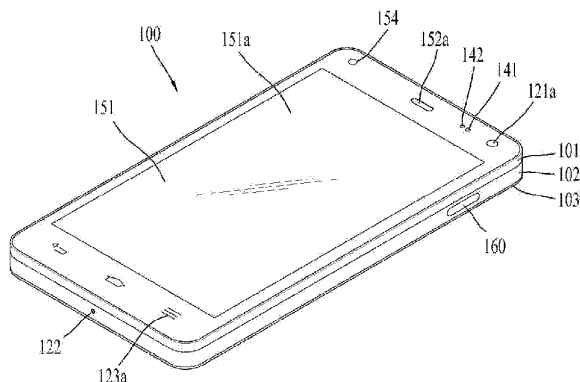
(22) Filed: **Aug. 19, 2016**

(30) **Foreign Application Priority Data**

Aug. 20, 2015 (KR) 10-2015-0117416

(57) **ABSTRACT**

Disclosed is a mobile terminal, by which extensibility of an antenna pattern and radiation efficiency of an antenna can be increased. The present invention includes a display, a frame configured to support a back of the display, a first antenna to be provided to at least one side of a top portion and a bottom portion of the frame, a rear case to attach to a back of the frame, a second antenna provided to at least one of an inner side and an outer side of the rear case, and a third antenna configured in a beam shape to be attached to at least one of a right lateral side and a left lateral side of the frame, the third antenna configured to be electrically connected to either the first antenna or the second antenna.





US 20170054200A1

(19) **United States**

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

(10) **Pub. No.: US 2017/0054200 A1**

(43) **Pub. Date: Feb. 23, 2017**

(54) **MOBILE TERMINAL**

Publication Classification

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

(72) Inventors: **Yunmo KANG**, Seoul (KR); **Kangjae JUNG**, Seoul (KR); **Sungjoon HONG**, Seoul (KR); **Byungwoon JUNG**, Seoul (KR); **Sungjung RHO**, Seoul (KR)

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)
H01Q 1/50 (2006.01)
H01Q 7/00 (2006.01)
H01Q 13/10 (2006.01)
H01Q 9/26 (2006.01)
H01Q 1/38 (2006.01)
H01Q 5/50 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/50** (2015.01); **H01Q 7/00** (2013.01); **H01Q 13/10** (2013.01); **H01Q 9/26** (2013.01); **H01Q 1/50** (2013.01)

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

(21) Appl. No.: **15/346,505**

(22) Filed: **Nov. 8, 2016**

Related U.S. Application Data

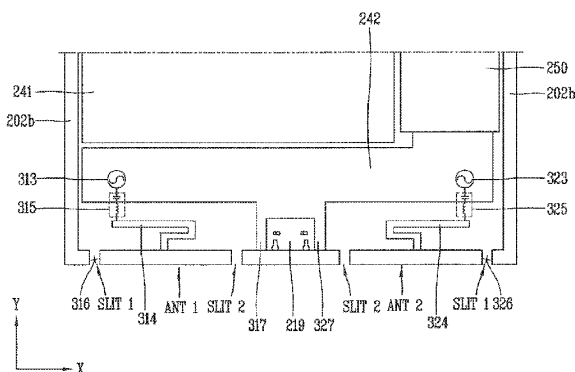
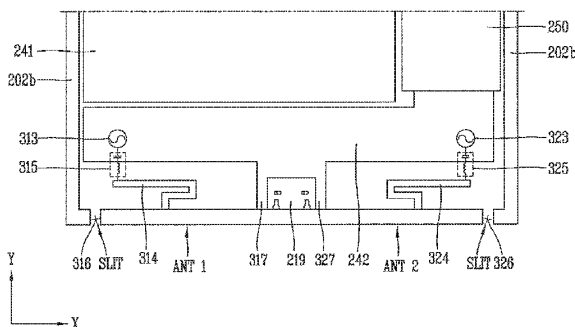
(63) Continuation of application No. 14/010,900, filed on Aug. 27, 2013.

(30) **Foreign Application Priority Data**

Sep. 19, 2012 (KR) 10-2012-0104152

(57) **ABSTRACT**

A mobile terminal comprises: a terminal body; and a first antenna device and a second antenna device disposed at one side of the terminal body in an adjacent manner, and formed to operate at different frequency bands, wherein the first antenna device and the second antenna device are provided with conductive members each having a slit at one side thereof, and wherein the conductive members form part of an appearance of the terminal body.





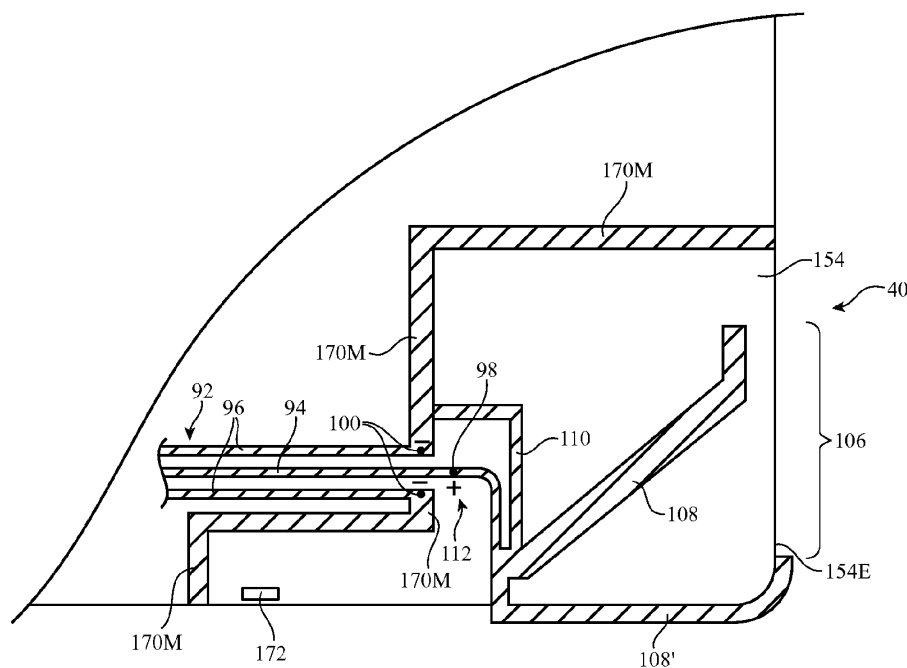
US 20170062906A1

(19) **United States**(12) **Patent Application Publication**
McAuliffe et al.(10) **Pub. No.: US 2017/0062906 A1**(43) **Pub. Date: Mar. 2, 2017**(54) **ANTENNAS FOR ELECTRONIC DEVICE
WITH HEAT SPREADER**(52) **U.S. Cl.**CPC **H01Q 1/24** (2013.01); **H01Q 9/04**
(2013.01); **H01Q 1/38** (2013.01); **H01Q 1/06**
(2013.01)(71) Applicant: **Apple Inc.**, Cupertino, CA (US)(72) Inventors: **Erin A. McAuliffe**, Campbell, CA
(US); **James W. Jervis**, Santa Clara,
CA (US); **Andrea Ruaro**, Copenhagen
(DK); **Mattia Pascolini**, San Francisco,
CA (US); **Jerzy S. Guterman**,
Mountain View, CA (US)

(57)

ABSTRACT

An electronic device may have wireless circuitry with antennas. The electronic device may have a dielectric housing. A printed circuit board with electrical components may be mounted in the dielectric housing. Heat spreader structures may be used to dissipate heat from the electrical components. The heat spreader structures be configured to form antenna cavities. The antennas in the electronic device may be formed from the antenna cavities and may have antenna resonating elements formed on the printed circuit. An electrical component such as a light-emitting diode may be mounted in one of the antenna cavities. Each antenna element may be an inverted-F antenna resonating element with short and long arms. The short arm of each antenna resonating element may be formed from edge plated metal traces on an edge of the printed circuit.

(21) Appl. No.: **14/839,619**(22) Filed: **Aug. 28, 2015****Publication Classification**(51) **Int. Cl.****H01Q 1/24** (2006.01)**H01Q 1/38** (2006.01)**H01Q 1/06** (2006.01)**H01Q 9/04** (2006.01)



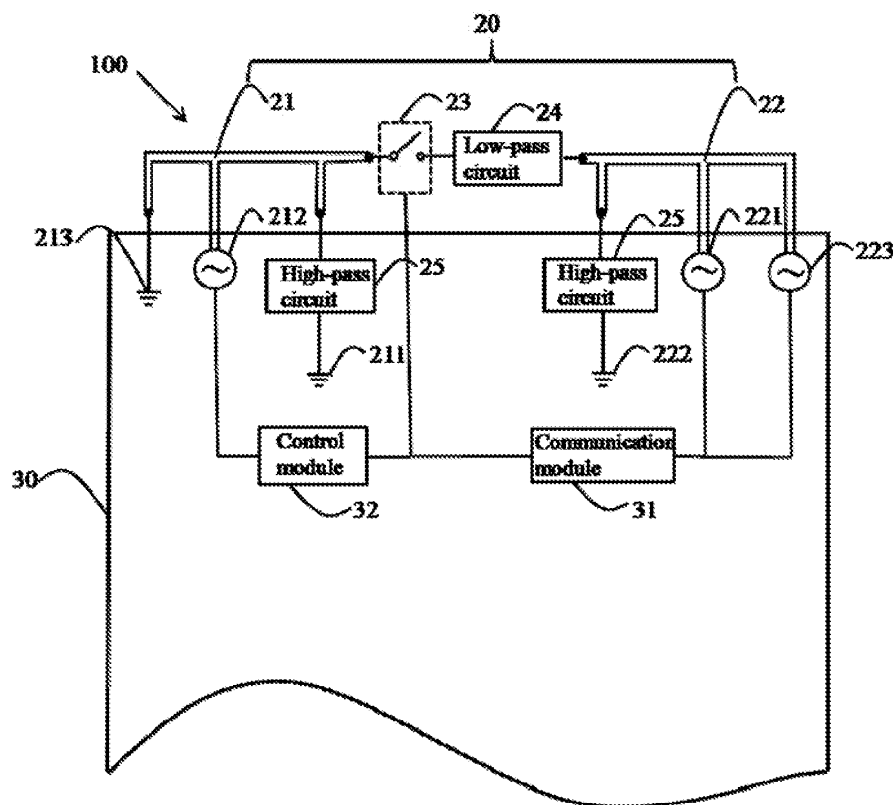
US 20170062930A1

(19) **United States**(12) **Patent Application Publication**
CHEN et al.(10) **Pub. No.: US 2017/0062930 A1**(43) **Pub. Date: Mar. 2, 2017**(54) **ANTENNA FOR ELECTRONIC DEVICE**(52) **U.S. CL.**CPC . **H01Q 5/30** (2015.01); **H01Q 9/16** (2013.01)(71) Applicant: **HON HAI PRECISION INDUSTRY CO., LTD.**, New Taipei (TW)(57) **ABSTRACT**(72) Inventors: **WEI-YU CHEN**, New Taipei (TW);
YUEH-CHU LIN, New Taipei (TW)

An electronic device includes a control module, a first antenna frame, and a second antenna frame. A first ground point, a first feed point, and a second ground point are respectively located on the first antenna frame. A second feed point, a third ground point, and a third feed point are respectively located on the second antenna frame. A switching unit and a low-pass circuit being electrically coupled between one end portion of the first antenna frame and one end portion of the second antenna frame, wherein the switching unit is controlled by the control module to selectively connect the first antenna frame and the second antenna frame. If the switching unit is closed, an antenna element formed between the first ground point and the third feed point is enabled, and the antenna element is operated to receive and/or transmit low frequency signal.

(21) Appl. No.: **14/920,613**(22) Filed: **Oct. 22, 2015**(30) **Foreign Application Priority Data**

Aug. 31, 2015 (CN) 201510546222.8

Publication Classification(51) **Int. Cl.**
H01Q 5/30 (2006.01)
H01Q 9/16 (2006.01)



US 20170062932A1

(19) **United States**

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

(10) **Pub. No.: US 2017/0062932 A1**

(43) **Pub. Date: Mar. 2, 2017**

(54) **COMPOUND LOOP ANTENNA SYSTEM
WITH ISOLATION FREQUENCY AGILITY**

H01Q 5/307 (2006.01)

H01Q 1/38 (2006.01)

(71) Applicant: **DOCKON AG, ZURICH (CH)**

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

CPC *H01Q 7/00* (2013.01); *H01Q 1/38*
(2013.01); *H01Q 1/48* (2013.01); *H01Q 5/307*
(2015.01)

(72) Inventors: **Matthew Robert FOSTER**, San Diego,
CA (US); **Jonathan Neil BRINGUIER**,
Carlsbad, CA (US); **Ryan James ORSI**,
San Diego, CA (US); **Forrest James
BROWN**, San Diego, CA (US);
Alexandre DUPUY, San Diego, CA
(US)

(57)

ABSTRACT

An antenna system is provided, including a first antenna, a second antenna, a ground plane, and a resonant isolator located proximate to the first antenna and the second antenna. The resonant isolator is coupled to the ground plane at or proximate to one current null point created by a first antenna and at or proximate to a second current null point created by a second antenna, and is configured to isolate the first antenna from the second antenna at a resonance. In some cases, the resonant isolator may include at least two conductive portions that may be substantially parallel to one another. The resonant isolator may also include an active tuning element that may change the resonance at which the resonant isolator de-couples the two antennas. In some cases, each of the antennas may be a capacitively-coupled compound loop antenna.

(21) Appl. No.: **15/351,300**

(22) Filed: **Nov. 14, 2016**

Related U.S. Application Data

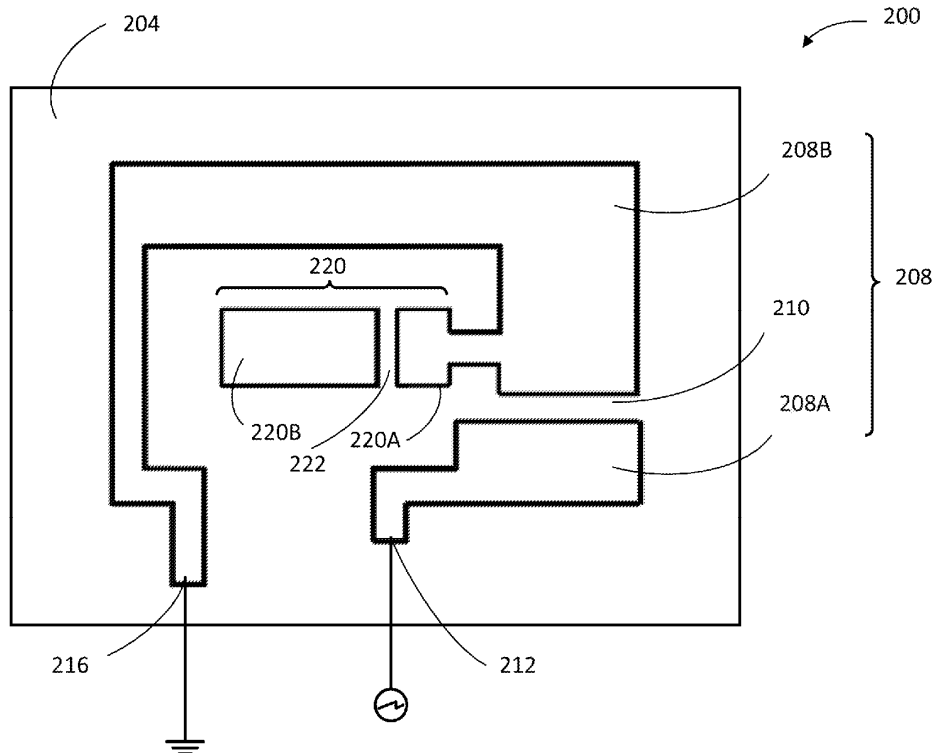
(63) Continuation-in-part of application No. 14/253,678,
filed on Apr. 15, 2014, now Pat. No. 9,496,614.

Publication Classification

(51) **Int. Cl.**

H01Q 7/00 (2006.01)

H01Q 1/48 (2006.01)





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

(43) **Pub. Date:** **Mar. 2, 2017**

(52) U.S. Cl.

CPC *H04M 1/026* (2013.01); *H04B 1/3827*
(2013.01)

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

(72) Inventors: **Kun-Sheng Chang**, New Taipei City (TW); **Shih-Ting Huang**, New Taipei City (TW); **Ching-Chi Lin**, New Taipei City (TW)

(57) **ABSTRACT**

A communication device including a ground plane and an antenna element is provided. The antenna element includes a feeding portion, a first radiation portion, a second radiation portion and an adjusting portion. The first radiation portion and the feeding portion form a first resonant path, and the first radiation portion includes a first portion and a second portion. The first portion faces a first edge of the ground plane and the second portion, and the second portion extends from a second edge of the ground plane. The second radiation portion and the feeding portion form a second resonant path. The antenna element operates in a first band and a second band through the first resonant path and the second resonant path. The adjusting portion and part of the first radiation portion form a current-dividing path to adjust impedance of the antenna element operating in the second band.

(21) Appl. No.: 14/951,511

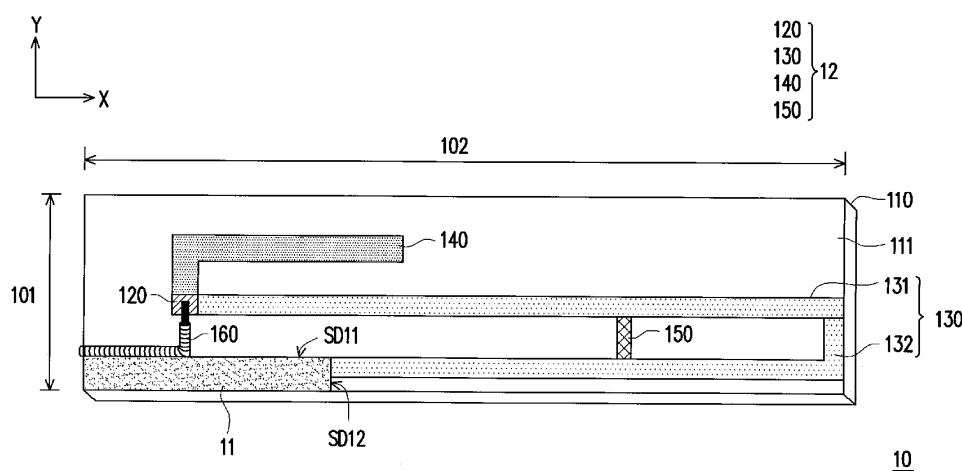
(22) Filed: **Nov. 25, 2015**

(30) **Foreign Application Priority Data**

Aug. 26, 2015 (TW) 104127828

Publication Classification

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





US 20170069954A1

(19) **United States**

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

(10) **Pub. No.: US 2017/0069954 A1**

(43) **Pub. Date: Mar. 9, 2017**

(54) **ELECTRONIC DEVICE HAVING ANTENNA
ON GROUNDED SPEAKER BOX**

(52) **U.S. CL.**

CPC **H01Q 1/243** (2013.01); **H01Q 1/38**
(2013.01)

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

(57)

ABSTRACT

(72) Inventors: **Timothy S. Lui**, San Jose, CA (US);
Robert F. Meyer, Palo Alto, CA (US);
Stoyan P. Hristov, San Jose, CA (US);
Ashley E. Fletcher, Cupertino, CA
(US)

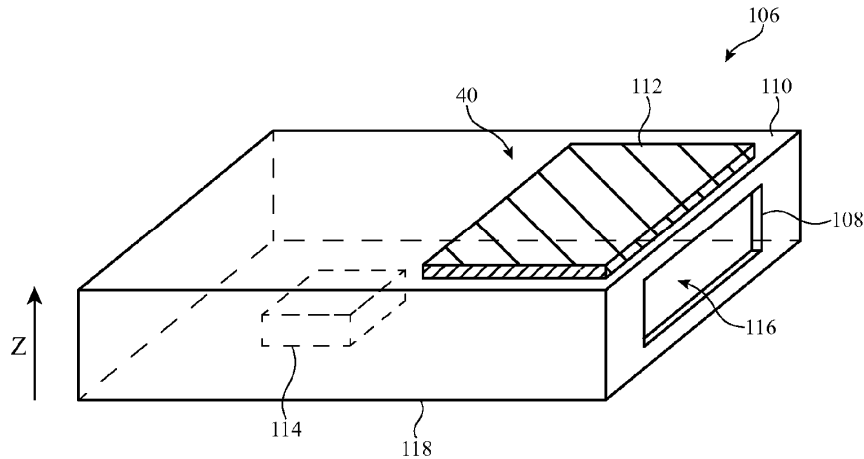
An electronic device may be provided with a housing in which electrical components are mounted. The housing may include a metal portion that serves as ground. An antenna for the electronic device may be formed from metal traces on an antenna support such as a flexible printed circuit. The flexible printed circuit may be mounted to a speaker box. The speaker box may have one or more walls formed from metal plates. A metal plate in a speaker box may be coupled to a metal clip. The metal clip may be shorted to a metal stiffener that overlaps a tail portion of the flexible printed circuit. The metal stiffener may have an opening that is aligned with an opening in the metal clip. A metal fastener such as a screw may pass through the openings to short the metal clip, stiffener, and metal plate to ground.

(21) Appl. No.: **14/844,911**

(22) Filed: **Sep. 3, 2015**

Publication Classification

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

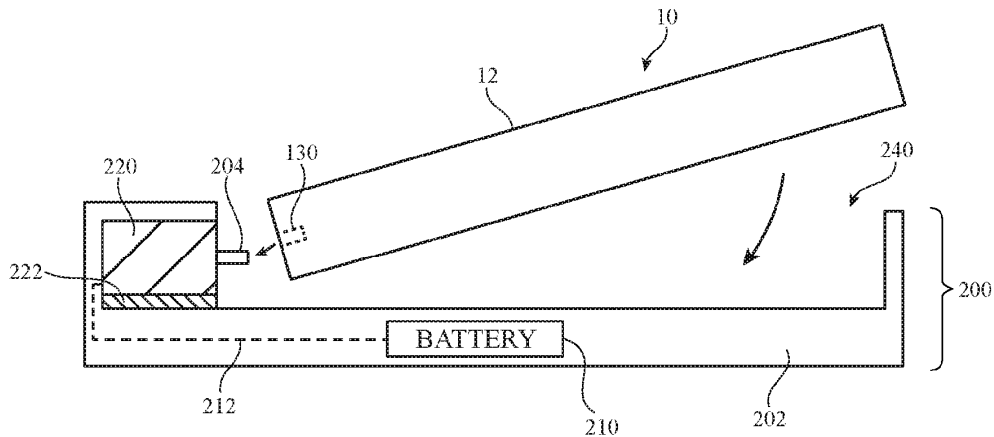




US 20170069955A1

(19) **United States**(12) **Patent Application Publication**
Kasar et al.(10) **Pub. No.: US 2017/0069955 A1**(43) **Pub. Date: Mar. 9, 2017**(54) **BATTERY CASE WITH SUPPLEMENTAL
ANTENNA FEATURES FOR CELLULAR
TELEPHONE**(52) **U.S. CL.**
CPC **H01Q 1/243** (2013.01); **H01Q 9/0442**
(2013.01)(71) Applicant: **Apple Inc.**, Cupertino, CA (US)(72) Inventors: **Darshan R. Kasar**, San Francisco, CA
(US); **Kirill Kalinichev**, San Francisco,
CA (US); **Ian P. Colahan**, Menlo Park,
CA (US); **Timothy J. Rasmussen**,
Sunnyvale, CA (US)(21) Appl. No.: **14/848,034**(22) Filed: **Sep. 8, 2015****Publication Classification**(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/04 (2006.01)(57) **ABSTRACT**

A removable case may receive an electronic device. A male connector in the case may mate with a female connector in the device. A battery in the case may supply power to the device through the male connector. The electronic device may have an antenna. The case may have a supplemental antenna that compensates for variations in performance in the antenna when the device is received within the case. The supplemental antenna may be a parasitic antenna resonating element that is formed from metal traces on a flexible printed circuit. The flexible printed circuit, a metal trim structure, and a plastic support structure may form portions of a connector support structure in the case.





US 20170077599A1

(19) **United States**

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

(10) **Pub. No.: US 2017/0077599 A1**

(43) **Pub. Date: Mar. 16, 2017**

(54) **MULTI-ANTENNA AND RADIO APPARATUS INCLUDING THEREOF**

Publication Classification

(71) Applicant: **ASAHI GLASS COMPANY, LIMITED**, Chiyoda-ku (JP)

(51) **Int. Cl.**

H01Q 1/52 (2006.01)

H01Q 21/28 (2006.01)

H01Q 1/48 (2006.01)

(72) Inventors: **Toshiki Sayama**, Chiyoda-ku (JP);
Ryuta Sonoda, Chiyoda-ku (JP); **Koji Ikawa**, Chiyoda-ku (JP)

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

CPC **H01Q 1/52** (2013.01); **H01Q 1/48** (2013.01); **H01Q 21/28** (2013.01)

(73) Assignee: **ASAHI GLASS COMPANY, LIMITED**, Chiyoda-ku (JP)

(57)

ABSTRACT

(21) Appl. No.: **15/361,920**

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

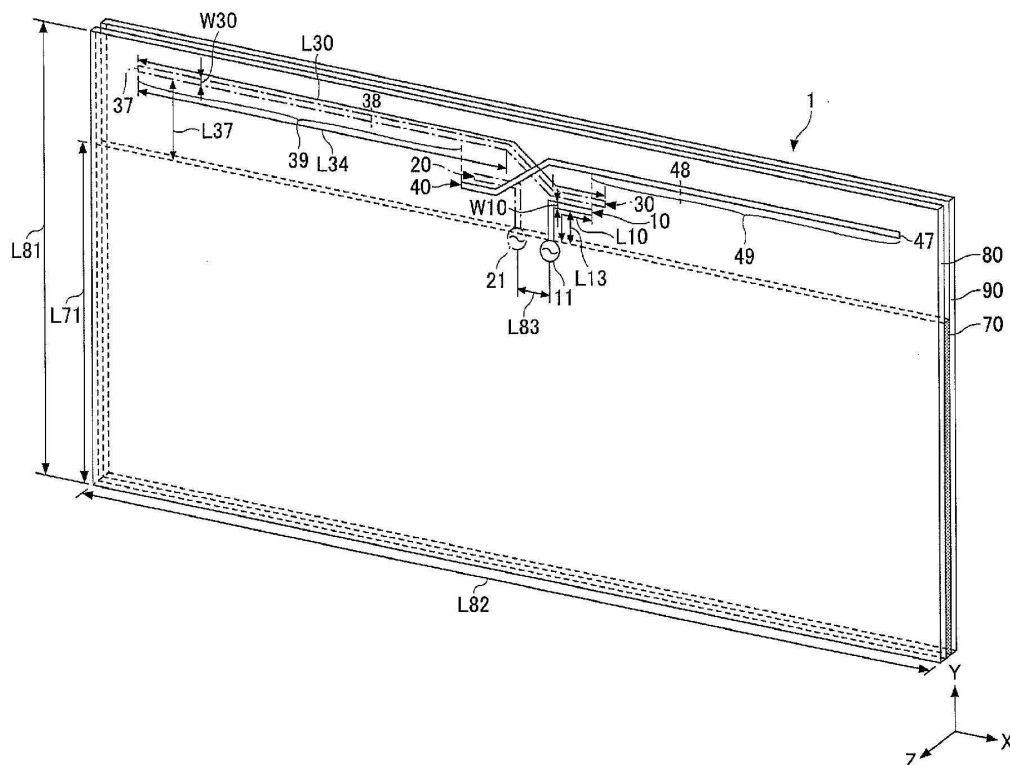
Related U.S. Application Data

(63) Continuation of application No. PCT/JP2015/065315, filed on May 27, 2015.

Foreign Application Priority Data

May 30, 2014 (JP) 2014-113074

A multi-antenna includes a ground plane; a first feeding point; a second feeding point that is different from the first feeding point; a first feed element that is connected to the first feeding point; a second feed element that is connected to the second feeding point, a cancellation electric current being generated in the second feed element; and a radiating element that functions as a radiation conductor when power is supplied by establishing electromagnetic field coupling with the first feed element and the second feed element.





US 20170077603A1

(19) **United States**

(12) **Patent Application Publication**
Krogerus

(10) **Pub. No.: US 2017/0077603 A1**

(43) **Pub. Date: Mar. 16, 2017**

(54) **MULTI-ANTENNA ISOLATION
ADJUSTMENT**

(71) Applicant: **Microsoft Technology Licensing, LLC,**
Redmond, WA (US)

(72) Inventor: **Joonas Krogerus, Espoo (FI)**

(21) Appl. No.: **14/854,353**

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

Publication Classification

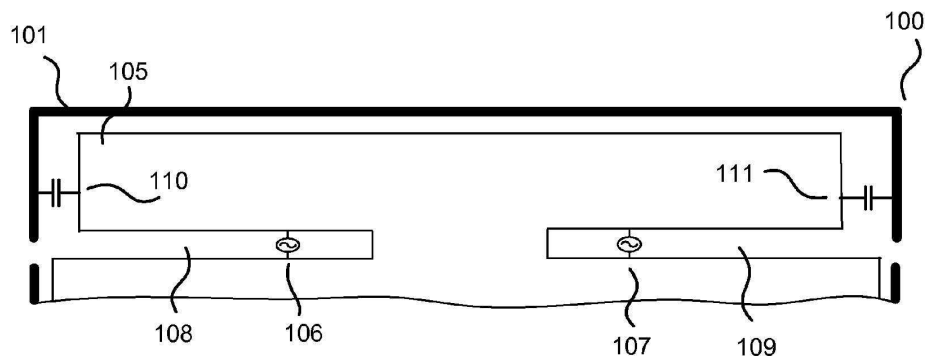
(51) **Int. Cl.**
H01Q 5/30 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/50 (2006.01)
H01Q 5/328 (2006.01)
H01Q 5/10 (2006.01)
H01Q 1/38 (2006.01)

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

CPC **H01Q 5/30** (2015.01); **H01Q 5/10**
(2015.01); **H01Q 1/38** (2013.01); **H01Q 1/50**
(2013.01); **H01Q 5/328** (2015.01); **H01Q 1/24**
(2013.01)

(57) **ABSTRACT**

In an embodiment, isolation between antennas of a multi antenna system is disclosed. According to another embodiment, a device is disclosed comprising a conductive portion of a cover of the device; a first antenna feed configured to a first radio frequency band; a second antenna feed configured to a second radio frequency band; at least two slots of a printed wiring board, feeds being coupled to the slots and slots being coupled to the conductive portion; a first capacitive component; a second capacitive component; wherein the first and the second capacitive component are configured between the printed wiring board and the conductive portion.





US 20170077604A1

(19) **United States**

(12) **Patent Application Publication**
Krogerus

(10) **Pub. No.: US 2017/0077604 A1**

(43) **Pub. Date: Mar. 16, 2017**

(54) **ENHANCED MULTI-BAND MULTI-FEED
ANTENNAS AND A WIRELESS
COMMUNICATION APPARATUS**

(71) Applicant: **Microsoft Technology Licensing, LLC,**
Redmond, WA (US)

(72) Inventor: **Joonas Krogerus, Espoo (FI)**

(21) Appl. No.: **14/854,570**

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

Publication Classification

(51) **Int. Cl.**
H01Q 5/30 (2006.01)
H04B 1/40 (2006.01)
H01Q 5/10 (2006.01)
H01Q 1/50 (2006.01)
H01Q 1/38 (2006.01)

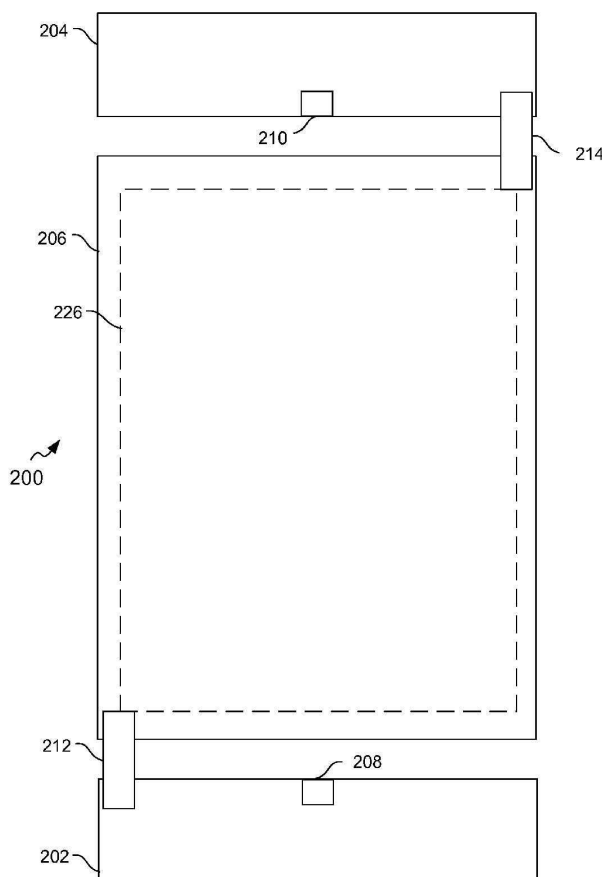
(52) **U.S. Cl.**

CPC **H01Q 5/30** (2015.01); **H01Q 1/50**
(2013.01); **H01Q 1/38** (2013.01); **H01Q 5/10**
(2015.01); **H04B 1/40** (2013.01)

(57)

ABSTRACT

In one example, a multi-band multi-feed antenna comprises a first conductive end portion having a first antenna feed point located in a substantially middle area of the first conductive end portion; a second conductive end portion having a second antenna feed point located in a substantially middle area of the second conductive end portion; a conductive middle portion configured between the first and second conductive end portions; a first lower ground member at a first corner area of the first conductive end portion, configured to interconnect the first conductive end portion and a ground plane of the conductive middle portion; and a second upper ground member at a second corner area of the second conductive end portion, configured to interconnect the second conductive end portion and the ground plane. The first lower ground member and the second upper ground member are configured at substantially diagonally opposite positions.





US 20170077605A1

(19) **United States**

(12) **Patent Application Publication**
Wonterghem

(10) **Pub. No.: US 2017/0077605 A1**

(43) **Pub. Date: Mar. 16, 2017**

(54) **ANTENNA ARRANGEMENT**

H01Q 9/04 (2006.01)

H01Q 1/24 (2006.01)

(71) Applicant: **Microsoft Technology Licensing, LLC**,
Redmond, WA (US)

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

CPC *H01Q 5/378* (2015.01); *H01Q 1/243*
(2013.01); *H01Q 5/385* (2015.01); *H01Q*
9/0442 (2013.01)

(72) Inventor: **Jari Van Wonterghem**, Tampere (FI)

(21) Appl. No.: **14/855,905**

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

(57)

ABSTRACT

Publication Classification

(51) **Int. Cl.**

H01Q 5/378 (2006.01)

H01Q 5/385 (2006.01)

An apparatus comprises a parasitic radiative element, a tuning element having a galvanic coupling to the parasitic radiative element, and a driven radiative element having a non-galvanic coupling to the parasitic radiative element.

