



US009478846B2

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

(10) **Patent No.:** **US 9,478,846 B2**
(45) **Date of Patent:** **Oct. 25, 2016**

(54) **ANTENNA DEVICE**

(71) Applicant: **Murata Manufacturing Co., Ltd.**,
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(72) Inventors: **Kengo Onaka**, Nagaokakyo (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 57 days.

(21) Appl. No.: **14/709,837**

(22) Filed: **May 12, 2015**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No.
PCT/JP2013/071549, filed on Aug. 8, 2013.

(30) **Foreign Application Priority Data**

Nov. 13, 2012 (JP) 2012-248927

(51) **Int. Cl.**

H01Q 1/22 (2006.01)

H01Q 5/378 (2015.01)

H01Q 1/44 (2006.01)

H01Q 21/28 (2006.01)

H01Q 9/40 (2006.01)

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

CPC **H01Q 1/2266** (2013.01); **H01Q 1/44**
(2013.01); **H01Q 5/378** (2015.01); **H01Q 9/40**
(2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**

USPC 343/881, 882, 902
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,414,643 B2 * 7/2002 Cheng H01Q 1/084
343/702

9,136,590 B2 * 9/2015 Hotta H01Q 1/243
2003/0134669 A1 7/2003 Byun et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CN 102544699 A 7/2012
JP 2007/214740 A 8/2007

(Continued)

OTHER PUBLICATIONS

International Search Report for PCT/JP2013/071549 date, of mail-
ing Nov. 12, 2013.
Written Opinion of the International Searching Authority for PCT/
JP2013/071549, date of mailing Nov. 12, 2013.

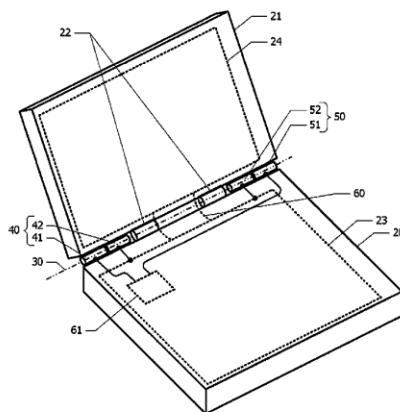
Primary Examiner — Howard Williams

(74) *Attorney, Agent, or Firm* — Arent Fox LLP

(57) **ABSTRACT**

A first housing includes a first conductor plate, and a second housing includes a second conductor plate. A rotation mechanism openably and closably attaches the second housing to the first housing. A first driven element and a second driven element are arranged along a rotation axis of the rotation mechanism. Between the first driven element and the second driven element, a continuity structure intersects the rotation axis to establish direct-current or high-frequency continuity between the first conductor plate and the second conductor plate. An antenna device can be provided which can ensure sufficient isolation between a plurality of driven elements.

20 Claims, 17 Drawing Sheets





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

(10) **Patent No.:** **US 9,478,847 B2**

(45) **Date of Patent:** **Oct. 25, 2016**

(54) **ANTENNA SYSTEM AND METHOD OF
ASSEMBLY FOR A WEARABLE
ELECTRONIC DEVICE**

(56) **References Cited**

U.S. PATENT DOCUMENTS

(71) Applicant: **GOOGLE TECHNOLOGY
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(US)

4,612,669	A	9/1986	Nossen	
4,631,543	A	12/1986	Brodeur	
4,754,285	A *	6/1988	Robitaille	H01Q 1/44 343/718

(Continued)

(72) Inventors: **Michael E. Russell**, Lake Zurich, IL
(US); **Katherine H. Coles**, Geneva, IL
(US); **Abu T. Sayem**, Gurnee, IL (US)

FOREIGN PATENT DOCUMENTS

(73) Assignee: **Google Technology Holdings LLC**,
Mountain View, CA (US)

CN	1762137	4/2006
CN	1859656	11/2006

(Continued)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 33 days.

OTHER PUBLICATIONS

European Patent Office, International Search Report and the Written
Opinion in International Patent Application PCT/US2015/031328
(Aug. 12, 2015).

(21) Appl. No.: **14/339,476**

(Continued)

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

(65) **Prior Publication Data**

US 2015/0349410 A1 Dec. 3, 2015

Primary Examiner — Trinh Dinh

(74) *Attorney, Agent, or Firm* — Wolfe-SBMC

Related U.S. Application Data

(57) **ABSTRACT**

(60) Provisional application No. 62/006,316, filed on Jun.
2, 2014, provisional application No. 62/016,884, filed
on Jun. 25, 2014.

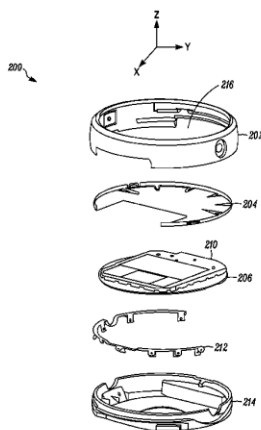
An antenna system for a wearable electronic device includes
a first conductive surface constructed from a segment of
outer housing of the wearable electronic device. The first
conductive surface spans a first axis through the wearable
electronic device. The antenna system also includes a second
conductive surface that spans the first axis. The second
conductive surface is constructed from a set of contacting
metal components that are internal to the wearable electronic
device. The first and second conductive surfaces are sepa-
rated by a space. The antenna system also has a contact
element having a feeding element that connects the first
conductive surface to the second conductive surface along a
plane that is normal to the first conductive surface.

(51) **Int. Cl.**
H01Q 13/10 (2006.01)
H01Q 1/27 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/273** (2013.01); **G04G 21/04**
(2013.01); **H01Q 13/10** (2013.01); **G04R**
60/06 (2013.01); **Y10T 29/4902** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 1/273; H01Q 13/10; G04R 60/06
See application file for complete search history.

20 Claims, 9 Drawing Sheets





US009478851B2

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

(10) **Patent No.:** **US 9,478,851 B2**

(45) **Date of Patent:** **Oct. 25, 2016**

(54) **ANTENNA STRUCTURE**

(71) Applicant: **Arcadyan Technology Corporation**,
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(72) Inventors: **Shin-Lung Kuo**, Kaosiung (TW);
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Keng-Chih Lin, Taipei (TW);
Yu-Hsiang Chang, Yilan County (TW);
Shih-Chieh Cheng, Tainan (TW)

(73) Assignee: **ARCADYAN TECHNOLOGY CORPORATION**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 433 days.

(21) Appl. No.: **14/140,117**

(22) Filed: **Dec. 24, 2013**

(65) **Prior Publication Data**

US 2014/0354504 A1 Dec. 4, 2014

Related U.S. Application Data

(60) Provisional application No. 61/828,240, filed on May 29, 2013.

(51) **Int. Cl.**
H01Q 1/48 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/36 (2006.01)
H01Q 5/392 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 1/48** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 5/392** (2015.01); **H01Q 9/36**
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/392; H01Q 9/36
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2007/0152885 A1 * 7/2007 Sorvala H01Q 1/243
343/700 MS
2008/0204328 A1 * 8/2008 Nissinen H01Q 5/00
343/700 MS

(Continued)

FOREIGN PATENT DOCUMENTS

CN 102859791 A 1/2013
EP 1198027 A1 4/2002

(Continued)

OTHER PUBLICATIONS

Gyubok Park et al., "The Compact Quad-band Mobile Handset Antenna for the LTE700 MIMO Application" IEEE Antennas and Propagation Society International Symposium, 2009.

(Continued)

Primary Examiner — Hoang V Nguyen

Assistant Examiner — Michael Bouizza

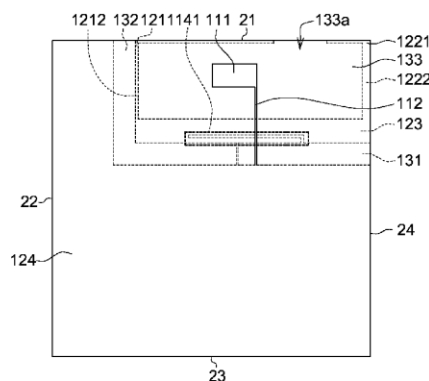
(74) *Attorney, Agent, or Firm* — Rabin & Berdo, P.C.

(57) **ABSTRACT**

An antenna structure comprising a substrate and an antenna is provided. The substrate comprises an upper surface and an under surface. The antenna comprises a first metal pattern and a second metal pattern. The first metal pattern is disposed on the upper surface. The first metal pattern comprises a feeding portion and a transmission line connected to the feeding portion. The second metal pattern is disposed on the under surface, and comprises a first parasitic grounding arm, a second parasitic grounding arm, a connecting arm, a grounding plane and a grounding strip. The connecting arm has a parasitic slot, and connects the first parasitic grounding arm and the second parasitic grounding arm. The grounding strip connects the connecting arm and the grounding plane.

19 Claims, 11 Drawing Sheets

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US009478852B2

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

(10) **Patent No.:** **US 9,478,852 B2**
(45) **Date of Patent:** **Oct. 25, 2016**

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

(71) Applicant: **The Penn State Research Foundation,**
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(72) Inventors: **Douglas H. Werner**, State College, PA
(US); **Zhihao Jiang**, State College, PA
(US)

(73) Assignee: **The Penn State Research Foundation,**
University Park, PA (US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 214 days.

(21) Appl. No.: **14/462,780**

(22) Filed: **Aug. 19, 2014**

(65) **Prior Publication Data**

US 2015/0054696 A1 Feb. 26, 2015

Related U.S. Application Data

(60) Provisional application No. 61/868,836, filed on Aug.
22, 2013.

(51) **Int. Cl.**
H01Q 1/48 (2006.01)
H01Q 1/27 (2006.01)
H01Q 1/52 (2006.01)
H01Q 15/00 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/48** (2013.01); **H01Q 1/273**
(2013.01); **H01Q 1/52** (2013.01); **H01Q**
15/0013 (2013.01); **H01Q 15/0086** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/273; H01Q 1/48; H01Q 15/0013;
H01Q 15/0086; H01Q 1/52
USPC 343/700 MS, 718, 770, 848, 909
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,700,197 A	10/1987	Milne	
5,407,075 A	4/1995	Descalzo	
7,450,077 B2 *	11/2008	Waterhouse	H01Q 1/273 343/700 MS
7,461,444 B2	12/2008	Deaett et al.	
7,592,957 B2 *	9/2009	Achour	H01Q 1/38 343/700 MS
7,629,934 B2	12/2009	Rhodes et al.	
7,952,526 B2 *	5/2011	Lee	H01Q 1/38 343/700 MS
8,193,973 B2 *	6/2012	Morton	H01P 1/2005 29/600

(Continued)

FOREIGN PATENT DOCUMENTS

EP	1630898 A1	3/2006
EP	2355243 A1	8/2011
KR	20120094418 A	8/2012

OTHER PUBLICATIONS

"Flexible and Compact AMC Based Antenna for Telemedicine Applications" Haider R. Raad et al., IEEE Transactions on Antennas and Propagation, IEEE Service Center, Piscataway, NJ, US, vol. 61, No. 2 (Feb. 1, 2013).

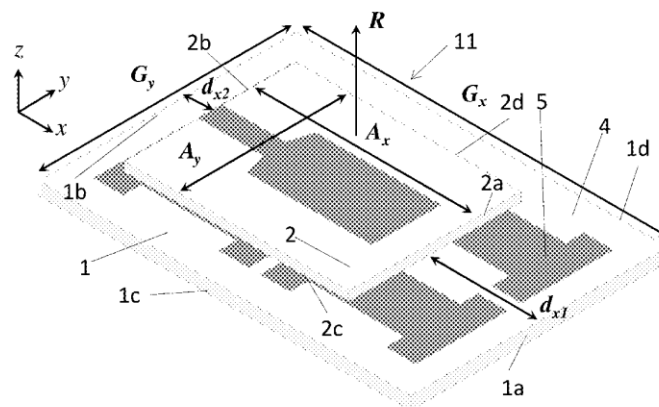
(Continued)

Primary Examiner — Tho G Phan
(74) *Attorney, Agent, or Firm* — Buchanan Ingersoll &
Rooney PC

(57) **ABSTRACT**

An antenna includes a first body having an array of resonators; a spacer adjacent to the first body, and a second body adjacent to the spacer such that the spacer is between the first and second bodies. The first body can be configured as an artificial metasurface ground plane and the second body can be configured as a monopole.

20 Claims, 15 Drawing Sheets





US009478859B1

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

(10) **Patent No.:** **US 9,478,859 B1**

(45) **Date of Patent:** **Oct. 25, 2016**

(54) **MULTI-BAND COMPACT PRINTED
CIRCUIT ANTENNA FOR WLAN USE**

(71) Applicants: **Deepu Vasudevan Nair**,
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Ramchandani**, Kota (IN); **Partha
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(IN)

7,742,006 B2	6/2010	Villarroel et al.	
8,284,115 B2	10/2012	Nysen et al.	
8,344,959 B2	1/2013	Autti et al.	
8,587,491 B2	11/2013	Badaruzzaman et al.	
2003/0016177 A1 *	1/2003	Deguchi	H01Q 1/242 343/702
2003/0098812 A1 *	5/2003	Ying	H01Q 1/243 343/702
2009/0128425 A1 *	5/2009	Kim	H01Q 1/243 343/702

(72) Inventors: **Deepu Vasudevan Nair**,
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Sarathy Murali**, San Jose, CA (US);
Suresh Kumar Vagvala, Hyderabad
(IN)

FOREIGN PATENT DOCUMENTS

EP 1351334 A1 * 10/2003 H01Q 9/0421

OTHER PUBLICATIONS

Sun, Liu, Cheung, Yuk, "Dual-Band Antenna With Compact Radiator for 2.4/5.2/5.8 GHz WLAN Applications".

* cited by examiner

(73) Assignee: **Redpine Signals, Inc.**, San Jose, CA
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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 169 days.

Primary Examiner — Sue A Purvis

Assistant Examiner — Jae Kim

(74) *Attorney, Agent, or Firm* — File-EE-Patents.com; Jay A. Chesavage

(21) Appl. No.: **14/176,127**

(22) Filed: **Feb. 9, 2014**

(51) **Int. Cl.**
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H01Q 5/00 (2015.01)
H01Q 1/48 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/0027** (2013.01); **H01Q 1/48**
(2013.01); **H01Q 5/0093** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 13/206; H01Q 9/0407
USPC 343/700 MS, 848, 722, 745, 749, 793
See application file for complete search history.

(56) **References Cited**

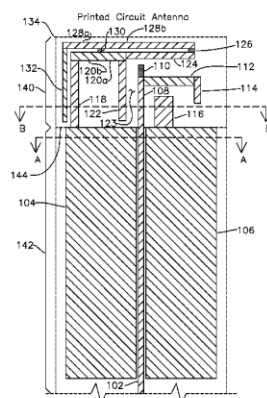
U.S. PATENT DOCUMENTS

7,403,160 B2 7/2008 Chiang et al.
7,586,452 B2 9/2009 Li et al.

(57) **ABSTRACT**

A printed circuit tri-band antenna has a feedline region and a radiating structure region which provides RF emissions in a lowband (LB) RF frequency, a lower highband (HB-L) frequency, and an upper highband (HB-U) frequency. The feedline region is formed of conductors on an upper plane, the conductors including a feedline which is edge coupled to left and right ground structures. The feedline couples directly to a HB-U radiating structure, and includes a stub. The HB-U structure and stub also provide edge coupling through a gap for coupling RF into a combined HB-L and LB radiation structure, which provides frequency-dependent paths for radiating RF energy at the HB-L and LB frequencies. The antenna is preferably used with 2.35 Ghz LB, 5.07 GHz HB-L, and 5.57 GHz HB-H.

18 Claims, 5 Drawing Sheets





US009478860B2

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

(10) **Patent No.:** **US 9,478,860 B2**

(45) **Date of Patent:** **Oct. 25, 2016**

(54) **MULTIBAND ANTENNA**

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

(72) Inventors: **Te-Chang Lin**, New Taipei (TW);
Cho-Kang Hsu, New Taipei (TW)

(73) Assignee: **Chiun Mai Communication Systems, 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 446 days.

(21) Appl. No.: **14/018,553**

(22) Filed: **Sep. 5, 2013**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jun. 28, 2013 (TW) 102123338

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 5/00 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 5/0058** (2013.01); **H01Q 5/0062**
(2013.01); **H01Q 9/0414** (2013.01); **H01Q**
9/0421 (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/04

USPC 343/700 MS

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2010/0315294 A1 * 12/2010 Chang H01Q 1/38
343/700 MS

* cited by examiner

Primary Examiner — Dameon E Levi

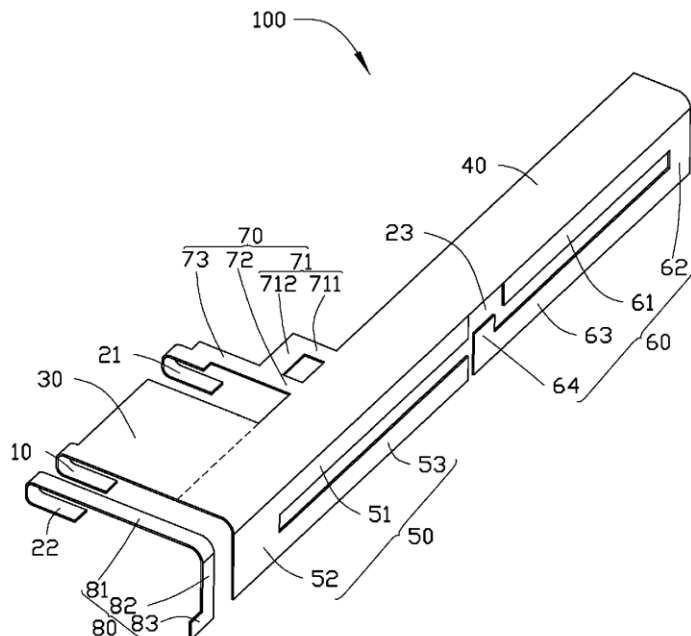
Assistant Examiner — Andrea Lindgren Baltzell

(74) *Attorney, Agent, or Firm* — Zhigang Ma

(57) **ABSTRACT**

A multiband antenna includes a feed end, a first grounding end, a first main portion connected to the feed end, a second main portion, a first radiating portion, a second radiating portion, and a third radiating portion. The second main portion is coplanar with and connected to the first main portion. The first radiating portion is connected to a first edge of the second main portion opposite to the first main portion. The second radiating portion is connected to the first edge of the second main portion and spaced from the first radiating portion. The third radiating portion is connected to a second edge of the second main portion opposite to the first radiating portion. The first grounding end is connected to the third radiating portion.

18 Claims, 2 Drawing Sheets





US009478862B2

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

(10) **Patent No.:** **US 9,478,862 B2**

(45) **Date of Patent:** **Oct. 25, 2016**

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

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

(72) Inventors: **Wei-Cheng Su**, New Taipei (TW);
Yen-Hui Lin, New Taipei (TW)

(73) Assignee: **Chiun Mai Communication Systems, 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 148 days.

(21) Appl. No.: **14/463,880**

(22) Filed: **Aug. 20, 2014**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Aug. 22, 2013 (CN) 2013 2 05127565 U

(51) **Int. Cl.**

H01Q 11/12 (2006.01)

H04B 1/04 (2006.01)

H01Q 5/35 (2015.01)

H01Q 1/24 (2006.01)

H01Q 5/314 (2015.01)

H01Q 5/335 (2015.01)

H04B 1/00 (2006.01)

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

CPC **H01Q 5/35** (2015.01); **H01Q 1/243** (2013.01); **H01Q 5/314** (2015.01); **H01Q 5/335** (2015.01); **H04B 1/005** (2013.01); **H04B 1/0458** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/242; H01Q 1/243; H01Q 5/30; H01Q 5/335; H01Q 5/392; H01Q 9/0442; H04B 1/005; H04B 1/0458

USPC 455/120, 121, 123, 553.1, 575.7, 132

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,255,994 B1 *	7/2001	Saito	H01Q 1/38
			343/700 MS
2001/0054981 A1 *	12/2001	Boyle	H01Q 5/00
			343/702
2003/0174092 A1 *	9/2003	Sullivan	H01Q 1/243
			343/702
2004/0132487 A1 *	7/2004	Kearns	H04B 1/005
			455/552.1
2005/0128155 A1 *	6/2005	Fukuda	H01Q 1/242
			343/745
2006/0139211 A1 *	6/2006	Vance	H01Q 9/0421
			343/700 MS
2008/0018541 A1 *	1/2008	Pang	H01Q 1/243
			343/702
2012/0112969 A1 *	5/2012	Caballero	H01Q 1/243
			343/702
2012/0295554 A1 *	11/2012	Greene	H04B 1/0458
			455/77
2012/0319918 A1 *	12/2012	Ramachandran	H01Q 9/0442
			343/852
2013/0127674 A1 *	5/2013	Korva	H01Q 1/243
			343/702
2013/0201067 A1 *	8/2013	Hu	H01Q 1/243
			343/745
2014/0333495 A1 *	11/2014	Vazquez	H01Q 9/06
			343/745

* cited by examiner

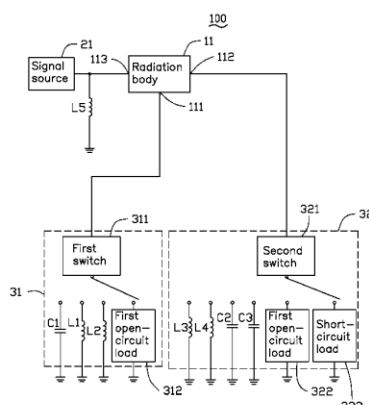
Primary Examiner — Duc M Nguyen

(74) *Attorney, Agent, or Firm* — Zhigang Ma

(57) **ABSTRACT**

A wireless communication device includes a substrate and a tunable antenna. The substrate has a signal source. The tunable antenna includes a metal cover and at least one matching circuit. The metal cover serves as a cover of the wireless communication device, and includes a radiation body, a main body, and a dielectric member coupled between the radiation body and the main body. The radiation body is coupled to the signal source and dielectric relative to the main body. The at least one matching circuit is configured to switch between multiple working mode to enable the radiation body to receive and send wireless signals at different frequency bands.

20 Claims, 6 Drawing Sheets





US009484619B2

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

(10) **Patent No.:** **US 9,484,619 B2**

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

(54) **SWITCHABLE DIVERSITY ANTENNA APPARATUS AND METHODS**

4,028,652 A 6/1977 Wakino et al.
4,031,468 A 6/1977 Ziebell et al.
4,054,874 A 10/1977 Oltman

(Continued)

(75) Inventors: **Heikki Korva**, Tupos (FI); **Ari Raappana**, Kello (FI); **Petteri Annamaa**, Oulunsalo (FI)

FOREIGN PATENT DOCUMENTS

(73) Assignee: **PULSE FINLAND OY** (FI)

CN 1387688 A 12/2002
CN 1954460 A 4/2007

(Continued)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1125 days.

OTHER PUBLICATIONS

(21) Appl. No.: **13/333,588**

"An Adaptive Microstrip Patch Antenna for Use in Portable Transceivers", Rostbakken et al., Vehicular Technology Conference, 1996, Mobile Technology for the Human Race, pp. 339-343.

(22) Filed: **Dec. 21, 2011**

(Continued)

(65) **Prior Publication Data**

US 2013/0162486 A1 Jun. 27, 2013

Primary Examiner — Dameon E Levi

Assistant Examiner — Collin Dawkins

(74) *Attorney, Agent, or Firm* — Gazdzinski & Associates, PC

(51) **Int. Cl.**

H01Q 1/38 (2006.01)

H01Q 1/24 (2006.01)

H01Q 21/24 (2006.01)

H01Q 21/30 (2006.01)

H01Q 5/378 (2015.01)

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

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(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/38; H01Q 9/0421
USPC 343/700 MS, 702, 876, 725
See application file for complete search history.

(57) **ABSTRACT**

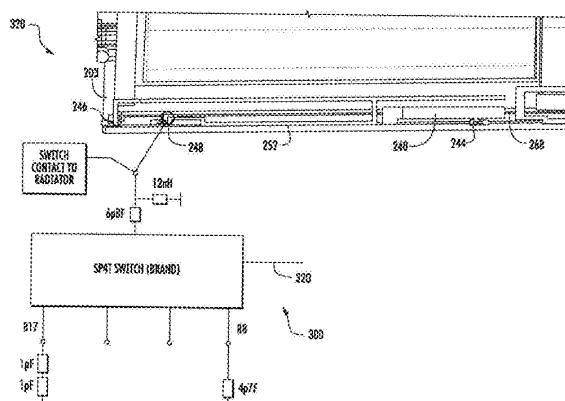
An active diversity antenna apparatus and methods of tuning and utilizing the same. In one embodiment, the active diversity antenna is used within a handheld mobile device (e.g., cellular telephone or smartphone), and enables device operation in several low frequency bands (LBs). The exemplary implementation of the active LB diversity antenna comprises a directly fed radiator portion and a grounded (coupled fed) radiator portion. The directly fed portion is fed via a feed element connected to an antenna feed. The coupled fed portion of the LB antenna is grounded, forming a resonating part of the low frequency band. A gap between the two antenna portions is used to adjust antenna Q-value. Resonant frequency tuning is achieved by changing the length of the grounded element. The LB feed element is disposed proximate the feed element of a high band diversity antenna, thus reducing transmission losses and improving diplexer operation.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,745,102 A 5/1956 Norgorden
3,938,161 A 2/1976 Sanford
4,004,228 A 1/1977 Mullett

21 Claims, 15 Drawing Sheets





US009484622B2

(12) **United States Patent**
Tai

(10) **Patent No.:** **US 9,484,622 B2**

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

(54) **MULTI-BAND ANTENNA**

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

(72) Inventor: **Lung-Sheng Tai**, 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 214 days.

(21) Appl. No.: **14/073,884**

(22) Filed: **Nov. 7, 2013**

(65) **Prior Publication Data**

US 2014/0125527 A1 May 8, 2014

(30) **Foreign Application Priority Data**

Nov. 7, 2012 (TW) 101141447 A

(51) **Int. Cl.**

H01Q 1/30 (2006.01)

H01Q 9/42 (2006.01)

H01Q 1/24 (2006.01)

H01Q 1/48 (2006.01)

H01Q 5/364 (2015.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/364** (2015.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/04; H01Q 1/243; H01Q 9/42; H01Q 5/364; H01Q 21/30
USPC 343/702, 770, 767, 700 MS, 846
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,274,297 B2 * 9/2007 Kodukula et al. 340/572.7
7,362,277 B2 * 4/2008 Su H01Q 1/243
343/700 MS
7,642,967 B2 * 1/2010 Wang H01Q 1/243
343/702

7,903,036 B2 * 3/2011 Takaki H01Q 9/42
343/700 MS
8,035,566 B2 * 10/2011 Tsai H01Q 1/243
343/700 MS
8,054,231 B2 * 11/2011 Ahn et al. 343/702
8,144,062 B2 * 3/2012 Ke H01Q 1/36
343/700 MS
2007/0120753 A1 * 5/2007 Hung H01Q 1/243
343/702
2009/0066583 A1 * 3/2009 Hung H01Q 9/0407
343/700 MS
2009/0256779 A1 * 10/2009 Wang H01Q 1/2266
343/893
2010/0194652 A1 * 8/2010 Chiang H01Q 9/04
343/745
2011/0094666 A1 * 4/2011 Sun B29C 45/14
156/245
2011/0122042 A1 * 5/2011 Huang H01Q 1/243
343/860
2012/0169555 A1 * 7/2012 Tsou H01Q 5/364
343/749
2012/0262342 A1 * 10/2012 Lee H01Q 5/35
343/700 MS

FOREIGN PATENT DOCUMENTS

CN 202405415 * 12/2011
CN 202405415 8/2012
CN 202423539 9/2012

* cited by examiner

Primary Examiner — Dameon E Levi

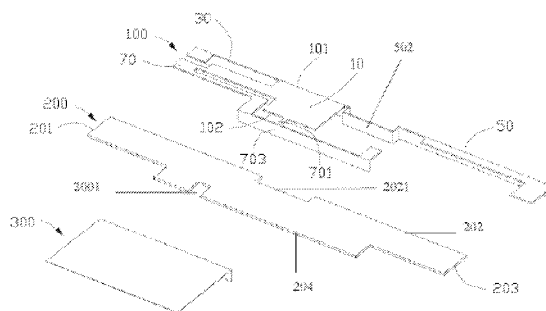
Assistant Examiner — Awat Salih

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

(57) **ABSTRACT**

An multi-band antenna includes a base section including a first end and a second end opposite to each other, a first radiating arm and a second radiating arm extending opposite to each other from the first end and locating on two opposite sides of the base section in a longitudinal direction, and a loop conductive portion extending from the base section. The loop conductive portion includes a grounding portion locating adjacent to the second end of the base section and a connecting portion extending in the longitudinal direction. The connecting portion is located on the same side of the base section with the first radiating arm.

12 Claims, 4 Drawing Sheets





US009484623B2

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

(10) **Patent No.:** **US 9,484,623 B2**

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

(54) **ANTENNA DEVICE OF MOBILE TERMINAL**

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

(72) Inventors: **Sang Bong Sung**, Gyeongsangbuk-do
(KR); **In Jin Hwang**,
Gyeongsangbuk-do (KR)

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

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

This patent is subject to a terminal dis-
claimer.

(21) Appl. No.: **14/731,801**

(22) Filed: **Jun. 5, 2015**

(65) **Prior Publication Data**

US 2015/0270602 A1 Sep. 24, 2015

Related U.S. Application Data

(63) Continuation of application No. 13/962,483, filed on
Aug. 8, 2013, now Pat. No. 9,054,419, which is a
continuation of application No. 13/458,453, filed on
Apr. 27, 2012, now Pat. No. 8,531,342, which is a
continuation of application No. 12/489,044, filed on
Jun. 22, 2009, now Pat. No. 8,188,930.

(30) **Foreign Application Priority Data**

Jun. 20, 2008 (KR) 10-2008-0058619

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

(Continued)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/24**
(2013.01); **H01Q 1/48** (2013.01); **H01Q 9/42**
(2013.01); **H04M 1/026** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/24; H04M 1/026
USPC 343/702, 700 MS, 846, 848
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,028,555 A 2/2000 Harano
6,446,931 B1 9/2002 Hayashi

(Continued)

FOREIGN PATENT DOCUMENTS

KR 1020060022485 3/2006
KR 1020060062969 6/2006

(Continued)

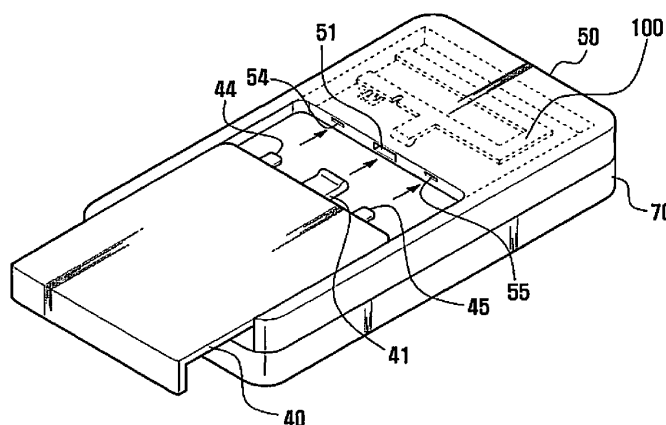
Primary Examiner — Hoanganh Le

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

(57) **ABSTRACT**

Various mobile communication terminals, apparatuses, and
methods having antenna improvements are discussed. An
apparatus is described which includes an outer front side
having a display disposed therein; an outer rear side a
conductive part and a non-conductive part; a battery dis-
posed between the outer front side and the outer rear side;
and an antenna including a radiation unit capable of receiv-
ing a signal, at least a portion of the radiation unit being
disposed between the outer front side and the non-conduc-
tive part of the outer rear side, a feeding unit which
electrically connects the radiation unit to a circuit board, and
a ground part which electrically connects the radiation unit
to the conductive part of the outer rear side.

20 Claims, 7 Drawing Sheets





US009484631B1

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

(10) **Patent No.:** **US 9,484,631 B1**

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

(54) **SPLIT BAND ANTENNA DESIGN**

USPC 343/702, 850, 852
See application file for complete search history.

(71) Applicant: **Amazon Technologies, Inc.**, Seattle,
WA (US)

(56) **References Cited**

(72) Inventors: **Adrian Napoles**, Cupertino, CA (US);
Ulf Jan Ove Mattsson, Saratoga, CA
(US); **Anuj Dron**, San Jose, CA (US);
Tzung-I Lee, San Jose, CA (US);
Daejong Kim, Sunnyvale, CA (US);
Morris Yuanhsiang Hsu, Sunnyvale,
CA (US); **Seng Chin Tai**, Rocklin, CA
(US)

U.S. PATENT DOCUMENTS

7,859,468 B2 * 12/2010 Ali H01Q 1/243
343/702
7,917,096 B2 * 3/2011 Wilcox H04B 1/0458
333/124
8,791,864 B2 * 7/2014 Merz H01Q 1/243
343/702
8,890,753 B1 * 11/2014 Lee H01Q 1/243
343/702
2015/0054701 A1 * 2/2015 Kim H01Q 9/0442
343/750

(73) Assignee: **Amazon Technologies, Inc.**, Seattle,
WA (US)

* cited by examiner

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 58 days.

Primary Examiner — Hoang V Nguyen

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

(21) Appl. No.: **14/557,423**

(57) **ABSTRACT**

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

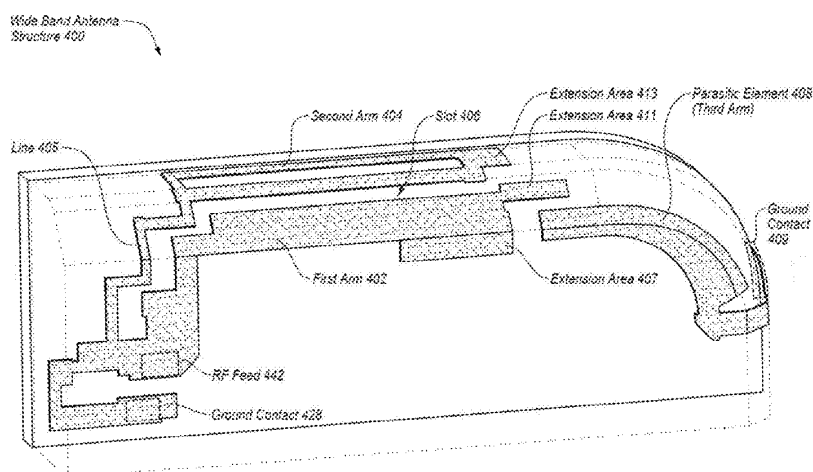
Antenna structures and methods of operating the same of an
electronic device are described. One apparatus includes a
single radio frequency (RF) feed and a folded monopole
element coupled to the single RF feed. The folded monopole
element is an integrated WAN/GNSS antenna that receives
electromagnetic energy in a first frequency band and
receives electromagnetic energy in a second frequency band.
The first frequency band is a wireless area network (WAN)
frequency band and the second frequency band is a global
navigation satellite system (GNSS) frequency band. The
apparatus further includes an impedance matching circuit
coupled to the single RF feed. The impedance matching
circuit includes a diplexer to extract out GNSS frequency
signals received by the folded monopole element from WAN
signals received by the folded monopole element.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/50 (2015.01)
H01Q 5/307 (2015.01)
H01Q 5/22 (2015.01)
H01Q 5/20 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 5/50** (2015.01); **H01Q 1/243**
(2013.01); **H01Q 5/20** (2015.01); **H01Q 5/22**
(2015.01); **H01Q 5/307** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 5/30; H01Q 5/307; H01Q 1/243;
H01Q 1/50

18 Claims, 27 Drawing Sheets





US009484633B2

(12) **United States Patent**
Oh

(10) **Patent No.:** **US 9,484,633 B2**

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

(54) **LOOP ANTENNA HAVING A
PARASITICALLY COUPLED ELEMENT**

(71) Applicant: **Nokia Technologies Oy**, Espoo (FI)

(72) Inventor: **Sung-Hoon Oh**, Cupertino, CA (US)

(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 0 days.

(21) Appl. No.: **14/438,476**

(22) PCT Filed: **Oct. 26, 2012**

(86) PCT No.: **PCT/IB2012/055928**

§ 371 (c)(1),

(2) Date: **Apr. 24, 2015**

(87) PCT Pub. No.: **WO2014/064490**

PCT Pub. Date: **May 1, 2014**

(65) **Prior Publication Data**

US 2015/0295314 A1 Oct. 15, 2015

(51) **Int. Cl.**
H01Q 21/00 (2006.01)
H01Q 19/00 (2006.01)
H01Q 7/00 (2006.01)
H01Q 1/24 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 7/00** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 5/378** (2015.01); **H01Q 9/42**
(2013.01); **H01Q 21/0006** (2013.01); **H01Q**
21/0087 (2013.01)

(58) **Field of Classification Search**
CPC H01Q 7/00; H01Q 1/243; H01Q 5/378;
H01Q 21/0087

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,808,442 B2 * 10/2010 Chiu H01Q 1/243

343/826

8,552,919 B2 * 10/2013 Hsieh H01Q 1/243

343/722

(Continued)

FOREIGN PATENT DOCUMENTS

CN 102122760 A 7/2011

CN 102255134 A 11/2011

WO 2010122220 A1 10/2010

OTHER PUBLICATIONS

International Search Report and Written Opinion received for corresponding Patent Cooperation Treaty Application No. PCT/IB2012/055928, dated Jun. 18, 2013, 9 pages.

(Continued)

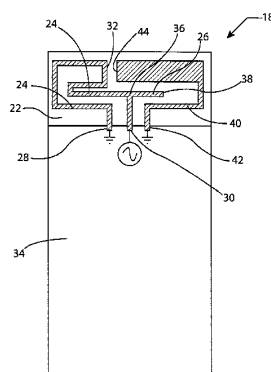
Primary Examiner — Trinh Dinh

(74) *Attorney, Agent, or Firm* — Nokia Technologies Oy

(57) **ABSTRACT**

An antenna, a portable electronic device incorporating an antenna and a method of operation are provided to enable both wide and multiple frequency band response. The antenna may include a feeding arm and a parasitic element. The feeding arm may include a conductive loop antenna and a conductive excitation arm portion. The loop antenna portion may extend from a first end that is configured to be grounded to a second end that is configured to be driven by radio frequency circuitry. The excitation arm may be coupled at a first end to the loop antenna portion and extend outwardly therefrom to an open end. The parasitic element may extend from a first end is configured to be grounded to a second end that is open. The parasitic element may extend along opposite sides of the excitation arm portion so as to be coupled thereto.

17 Claims, 10 Drawing Sheets





US009484978B2

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

(10) **Patent No.:** **US 9,484,978 B2**

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

(54) **SYSTEM AND METHOD FOR
COMMUNICATION WITH ADJUSTABLE
SIGNAL PHASE AND POWER**

(71) Applicant: **HTC Corporation**, Taoyuan (TW)

(72) Inventors: **Tiao-Hsing Tsai**, Taoyuan (TW);
Chien-Pin Chiu, Taoyuan (TW);
Wei-Yang Wu, Taoyuan (TW);
Hsiao-Wei Wu, Taoyuan (TW);
Chih-Chin Su, Taoyuan (TW);
Li-Yuan Fang, Taoyuan (TW)

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

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

(21) Appl. No.: **14/668,539**

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

(65) **Prior Publication Data**

US 2016/0285500 A1 Sep. 29, 2016

(51) **Int. Cl.**
H04B 1/44 (2006.01)
H04M 1/00 (2006.01)
H04W 16/28 (2009.01)

(52) **U.S. Cl.**
CPC **H04B 1/44** (2013.01); **H04W 16/28**
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0442
USPC 455/575.5, 73
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,529,988 A *	7/1985	James		H01Q 3/26	342/379
5,107,273 A *	4/1992	Roberts		H01Q 3/2611	342/375
5,233,359 A	8/1993	Panaretos			
6,731,920 B1 *	5/2004	Iwai		H01Q 1/243	343/702
7,937,051 B2	5/2011	Väisänen			
8,515,365 B2	8/2013	Pan et al.			
2004/0178862 A1 *	9/2004	Kaplan		H01Q 25/00	333/117

FOREIGN PATENT DOCUMENTS

TW	I306338	2/2009
TW	I382693	1/2013
TW	201349788	12/2013
TW	201442339 A	11/2014

* cited by examiner

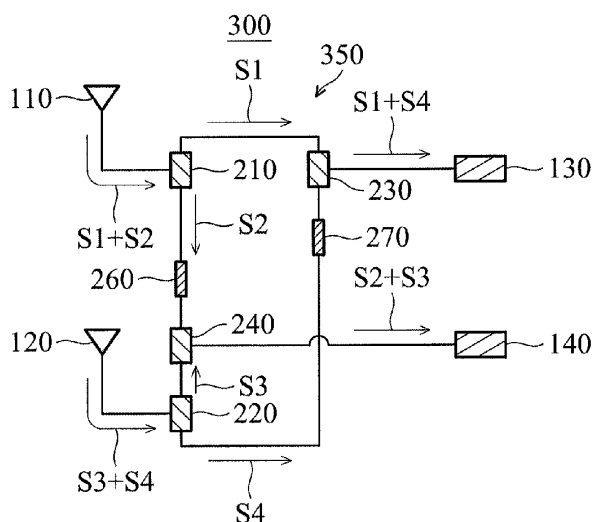
Primary Examiner — Tilahun B Gesesse

(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch
& Birch, LLP

(57) **ABSTRACT**

A communication system includes a first antenna, a second antenna, a first transceiver, a second transceiver, and a phase and power distribution transform circuit. The phase and power distribution transform circuit is coupled between the first antenna, the second antenna, the first transceiver, and the second transceiver. The phase and power distribution transform circuit is configured to adjust the phase and power of each signal from the first antenna, the second antenna, the first transceiver, and/or the second transceiver, thereby improving the communication quality of the communication system.

21 Claims, 9 Drawing Sheets





US009490536B2

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

(10) **Patent No.:** **US 9,490,536 B2**
(45) **Date of Patent:** **Nov. 8, 2016**

(54) **MULTI-BAND ANTENNA**

- (71) Applicant: **Amazon Technologies, Inc.**, Reno, NV (US)
(72) Inventors: **Cheng-Jung Lee**, San Jose, CA (US);
Tao Zhou, San Jose, CA (US)
(73) Assignee: **Amazon Technologies, Inc.**, Seattle, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 374 days.

(21) Appl. No.: **14/108,564**

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

(65) **Prior Publication Data**

US 2015/0171518 A1 Jun. 18, 2015

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 5/00 (2015.01)

H01Q 5/378 (2015.01)

H01Q 9/42 (2006.01)

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

CPC **H01Q 5/378** (2015.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/378; H01Q 9/42
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2005/0259031 A1	11/2005	Sanz et al.	
2006/0119526 A1	6/2006	Gilbert et al.	
2009/0015507 A1 *	1/2009	Hong et al.	H01Q 9/42 343/873
2012/0313830 A1	12/2012	Lee	
2013/0057442 A1	3/2013	Brown et al.	

OTHER PUBLICATIONS

International Search report for PCT/US14/69440.

* cited by examiner

Primary Examiner — Hoang V Nguyen

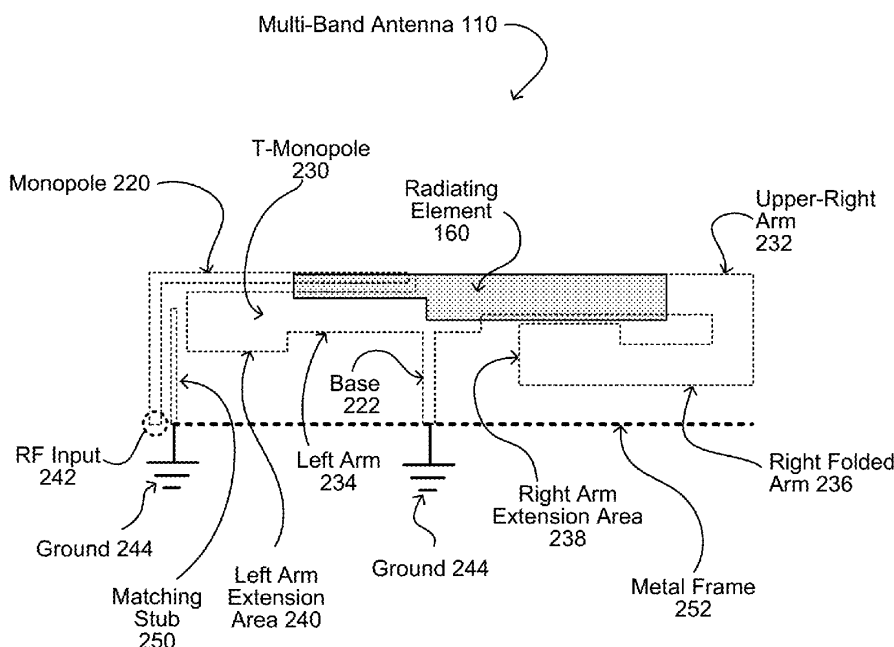
Assistant Examiner — Michael Bouizza

(74) *Attorney, Agent, or Firm* — Seyfarth Shaw LLP; Ilan N. Barzilay; David A. Klein

(57) **ABSTRACT**

A multiband antenna for mobile devices that includes both energized and parasitically-coupled resonant elements. An energized element is fed radio frequency energy and resonates at a first frequency. A first parasitic element, arranged on a same surface as the energized element, is parasitically coupled to the energized element and resonates with at least a second frequency. A second parasitic element, arranged on a surface opposite the energized element resonates at a third frequency.

25 Claims, 13 Drawing Sheets





US009490885B1

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

(10) **Patent No.:** **US 9,490,885 B1**
(45) **Date of Patent:** **Nov. 8, 2016**

(54) **PROXIMITY SENSOR AND ANTENNA SYSTEM ARRANGEMENT FOR METAL HOUSING**

(71) Applicant: **Amazon Technologies, Inc.**, Seattle, WA (US)

(72) Inventors: **Ming Zheng**, Cupertino, CA (US);
Adrian Napoles, Cupertino, CA (US)

(73) Assignee: **AMAZON TECHNOLOGIES, INC.**, Seattle, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 25 days.

(21) Appl. No.: **14/702,197**

(22) Filed: **May 1, 2015**

(51) **Int. Cl.**
H04B 7/06 (2006.01)
H04W 52/18 (2009.01)

(52) **U.S. Cl.**
CPC **H04B 7/0608** (2013.01); **H04W 52/18** (2013.01)

(58) **Field of Classification Search**
CPC H04B 7/0608; H04W 52/18
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,798,695 B1 8/2014 Zheng et al.
2008/0051165 A1* 2/2008 Burgan H04W 52/0254
455/575.6

2011/0250928 A1* 10/2011 Schlub H01Q 1/243
455/550.1
2012/0164962 A1* 6/2012 Lin G06F 1/1684
455/127.1
2012/0214412 A1* 8/2012 Schlub G01B 7/023
455/41.1
2013/0029625 A1* 1/2013 Park H01Q 1/243
455/272
2013/0217342 A1* 8/2013 Abdul-Gaffoor H03K 17/955
455/77
2014/0087786 A1* 3/2014 Tani H04M 1/026
455/556.1
2015/0044977 A1* 2/2015 Ramasamy H04B 7/0404
455/77
2015/0303979 A1* 10/2015 Shin H04B 1/74
455/78
2015/0357702 A1* 12/2015 Tani H01Q 5/321
343/904
2016/0036474 A1* 2/2016 Broyde H01Q 1/242
455/77
2016/0056853 A1* 2/2016 You H04B 15/00
455/73

* cited by examiner

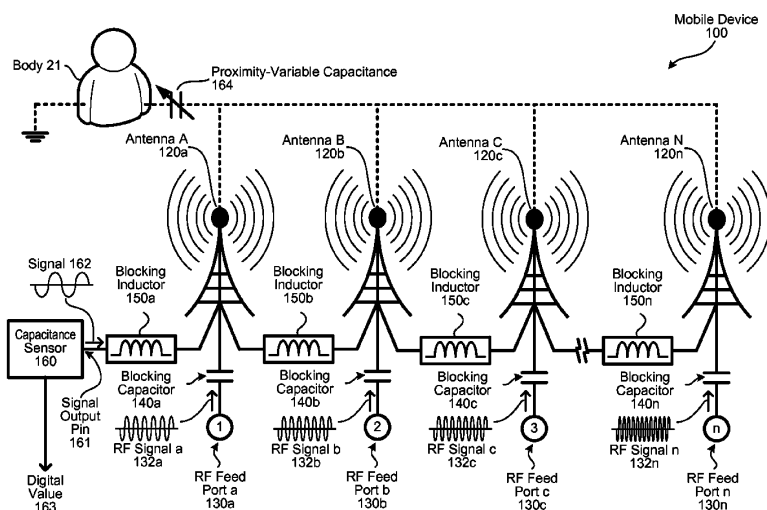
Primary Examiner — Nathan Mitchell

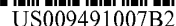
(74) Attorney, Agent, or Firm — Seyfarth Shaw LLP; Ilan N. Barzilay; David A. Klein

(57) **ABSTRACT**

A unified proximity sensor including multiple physically separated radio antenna structure for mobile electronic devices that senses proximity of a person to the antennae. Changes in capacitances of the antennae are detected based on a low frequency signal output by a single capacitance sensor. As a human body approaches any of the antennae, this capacitance increases. Based on the increase in capacitance, the transmission powers of radio signals emitted by the antennae are reduced.

20 Claims, 16 Drawing Sheets





(10) **Patent No.:** US 9,491,007 B2
(45) **Date of Patent:** Nov. 8, 2016

- H04B 1/3833; H04B 1/18; H04B 3/03;
H04L 25/0278; H04M 1/0274; H04M
2250/12

- See application file for complete search history.

- (56)
- References Cited**

- U.S. PATENT DOCUMENTS

- (Continued)

- FOREIGN PATENT DOCUMENTS

- | | | |
|----|---------|---------|
| CN | 1762137 | 4/2006 |
| CN | 1859656 | 11/2006 |

- (Continued)

- US 2015/0312058 A1 Oct. 29, 2015

- ## OTHER PUBLICATIONS

- European Patent Office, International Search Report and the Written Opinion of the International Patent Application PCT/US2015/027872 (Jul. 15, 2015).

- ### Related U.S. Application Data

- (Continued)

- (60) Provisional application No. 61/984,927, filed on Apr. 28, 2014.

- Primary Examiner — Lewis West

- (51) **Int. Cl.**
H04L 25/02 (2006.01)
H04B 1/18 (2006.01)
 (Continued)

- (74) *Attorney, Agent, or Firm* — Wolfe-SBMC

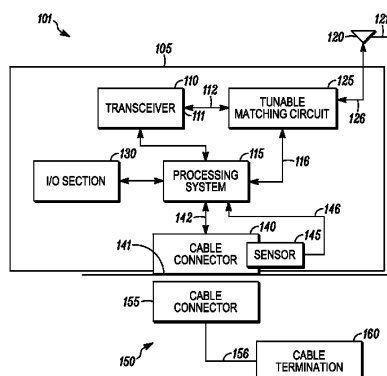
- (52) **U.S. Cl.**
CPC *H04L 25/0278* (2013.01); *H01Q 1/242*
(2013.01); *H01Q 1/50* (2013.01);
(Continued)

- (57) **ABSTRACT**

- (58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/242; H01Q 1/50;
H01Q 1/52; H01Q 21/28; H03H 11/30;
H03H 7/40; H04B 17/103; H04B 1/0458;

- A method and apparatus are for performing antenna matching and include determining a cable connection state of a cable connector, generating a cable detection signal that indicates the cable connection state, and modifying impedance transform of a tunable matching circuit in response to the cable detection signal. The cable detection signal indicates one of a presence and an absence of a cable connector. The tunable matching circuit couples a transceiver and an antenna. The tunable matching circuit couples the selected impedance transform between the transceiver and the antenna. The apparatus is a radio communication device that includes a transceiver, a processing system, an antenna, a tunable matching circuit, an input/output section, a cable connector, and a sensor.

- 20 Claims, 7 Drawing Sheets**





US009496603B2

(12) **United States Patent**
Sato

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

(54) **ELECTRONIC APPARATUS**

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H01Q 1/22 (2006.01)

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CPC **H01Q 1/243** (2013.01); **G06F 1/1601**
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G06F 1/169 (2013.01); **G06F 1/1654**
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CPC **H01Q 1/241**; **H01Q 1/242**; **H01Q**

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G06F 1/1605

USPC 361/679.21–679.3, 679.01–679.2,

361/679.55–679.59; 343/702

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,642,892 B2 * 11/2003 Masaki **H01Q 1/2266**
343/700 MS
6,853,336 B2 * 2/2005 Asano **H01Q 1/22**
343/702
7,043,209 B2 * 5/2006 Hirota **G06F 1/1616**
343/725
7,167,726 B2 * 1/2007 Ghosh **G06F 1/1616**
342/162
7,522,109 B2 * 4/2009 Shimasaki **G06F 1/1616**
343/700 MS
8,310,825 B2 * 11/2012 Schlesener **G06F 1/1616**
343/702

(Continued)

FOREIGN PATENT DOCUMENTS

JP 2009-231952 10/2009
JP 2013-247613 12/2013
JP 2014-115989 6/2014

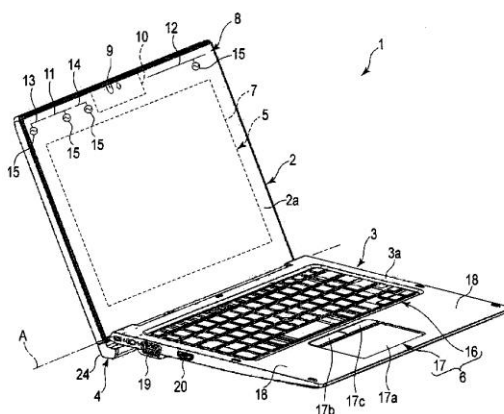
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(57) **ABSTRACT**

An electronic apparatus in one embodiment is brought to a
tablet state, in which a first housing having antennas and a
display unit is placed over a second housing having an
electrically conductive member and allows input from the
display unit. In the tablet state, a part of one of the antennas
is over the electrically conductive member.

10 Claims, 6 Drawing Sheets





US009496614B2

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

(10) **Patent No.:** **US 9,496,614 B2**

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

(54) **ANTENNA SYSTEM USING CAPACITIVELY COUPLED COMPOUND LOOP ANTENNAS WITH ANTENNA ISOLATION PROVISION**

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(65) **Prior Publication Data**

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(58) **Field of Classification Search**
USPC 343/729, 700 MS, 702
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,952,982 A 9/1999 Jorgenson et al.
6,307,509 B1 10/2001 Krantz

7,289,068 B2 * 10/2007 Fujio H01Q 9/0407 343/700 MS
8,009,119 B2 * 8/2011 Hung H01Q 1/38 343/702
8,144,065 B2 3/2012 Brown
8,149,173 B2 4/2012 Brown
8,164,532 B1 4/2012 Brown et al.
8,350,770 B1 1/2013 Dawson
2005/0243005 A1 11/2005 Rafi et al.
2010/0060528 A1 * 3/2010 Chiu H01Q 1/243 343/700 MS

(Continued)

FOREIGN PATENT DOCUMENTS

EP 1753080 A1 2/2007
WO WO 2009/118565 A1 10/2009

OTHER PUBLICATIONS

International Patent Application No. PCT/US2014/69627; Int'l Preliminary Report on Patentability; dated Dec. 11, 2015; 19 pages.

(Continued)

Primary Examiner — Hoang V Nguyen

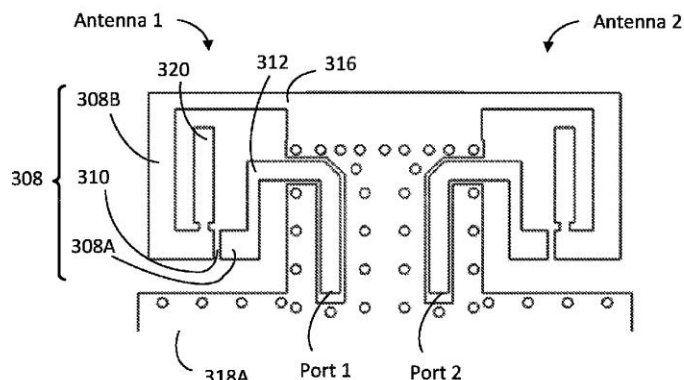
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(57) **ABSTRACT**

An antenna system is provided, including a first antenna, a second antenna, a ground plane, and a resonant isolator coupled to the first and second antennas. Each of the antennas is configured to be a capacitively-coupled compound loop antenna, and the resonant isolator is configured to provide isolation between the two antennas at resonance. The two antennas may be symmetrical or asymmetrical and include a first element that emits a magnetic field and a second element that generates an electrical field that is orthogonal to the magnetic field. The radiating element of the second element may be capacitively coupled to the remainder of the second element. The resonant isolator may be comprised of a single conductive element or two conductive elements that are capacitively coupled.

22 Claims, 15 Drawing Sheets





US009496616B2

(12) **United States Patent**
Toyao

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(54) **ANTENNA AND ELECTRONIC DEVICE**

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(73) Assignee: **NEC CORPORATION**, Tokyo (JP)

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§ 371 (c)(1),
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(30) **Foreign Application Priority Data**

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USPC 343/741, 767, 866, 700 MS, 867
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,197,545 A 4/1980 Favaloro et al.
4,792,809 A 12/1988 Gilbert et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CN 101389998 A 3/2009
GB 2 245 784 A 1/1992

(Continued)

OTHER PUBLICATIONS

Chinese Office Action dated Jan. 6, 2015 with an English translation thereof.

(Continued)

Primary Examiner — Sue A Purvis

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(74) *Attorney, Agent, or Firm* — McGinn IP Law Group, PLLC

(57) **ABSTRACT**

An antenna includes: a first conductor layer including a first split ring part surrounding a first opening part, the first split ring part having a first split part provided at a portion in a circumferential direction, the first split ring part being continuous in an approximate C-shape; a second conductor layer including a second split ring part opposing the first split ring part, the second split ring part surrounding a second opening part, the second split ring part having a second split part at a portion in a circumferential direction, the second split ring part being continuous in an approximate C-shape; a plurality of conductor vias provided with an interval in a circumferential direction of the first split part and the second split part, the conductor vias electrically connecting the first split ring part and the second split ring part; and a power feed line provided on a conductor layer different from the first conductor layer, the power feed line having a first end and second end, the first end being electrically connected to at least one of the conductor vias, the second end spanning the first and the second opening parts and extending to a region opposing the first split ring part.

11 Claims, 18 Drawing Sheets

