



US009370886B2

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

(10) **Patent No.:** **US 9,370,886 B2**
(45) **Date of Patent:** **Jun. 21, 2016**

(54) **RADIATOR FRAME HAVING ANTENNA PATTERN EMBEDDED THEREIN, ELECTRONIC DEVICE INCLUDING THE SAME, AND MOLD FOR MANUFACTURING THE SAME**

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

(72) Inventors: **Sang Woo Bae**, Gyeonggi-do (KR); **Dae Ki Lim**, Gyeonggi-do (KR)

(73) Assignee: **Samsung Electro-Mechanics Co., Ltd.**, Suwon-si (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 196 days.

(21) Appl. No.: **14/039,560**

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

(65) **Prior Publication Data**

US 2014/0168016 A1 Jun. 19, 2014

(30) **Foreign Application Priority Data**

Dec. 14, 2012 (KR) 10-2012-0146589

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
B29C 45/14 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **B29C 45/14073** (2013.01); **B29C 45/14639** (2013.01); **B29C 45/14778** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC ... H01Q 1/243; H01Q 9/0407; H01Q 9/0421; H01Q 5/371
USPC 343/702, 700 MS
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,068,067 B2 * 11/2011 Hong H01Q 1/1207 343/702

8,773,314 B2 * 7/2014 Hong B29C 45/1671 343/702

2010/0271272 A1 10/2010 Sung et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CN 102170041 A 8/2011

KR 10-2010-0090574 A 8/2010

(Continued)

OTHER PUBLICATIONS

Chinese Office Action issued on Jun. 26, 2015 in counterpart Chinese Application No. 201310689400.3 (16 pages with English translation).

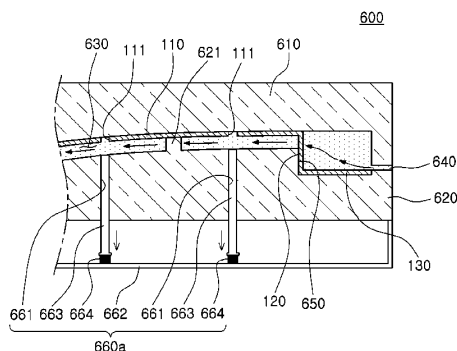
Primary Examiner — Hoang V Nguyen

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

(57) **ABSTRACT**

A radiator frame having an antenna pattern embedded therein, an electronic device including the same, and a mold for manufacturing thereof. The radiator frame includes a radiator including an antenna pattern part transmitting or receiving a signal and a terminal connection portion electrically connecting the antenna pattern part and a circuit substrate, and a molded frame formed by injection-molding a material to incorporate the radiator so that the terminal connection portion is exposed at a first surface of the molded frame and the antenna pattern part is exposed at a second surface of the molded frame opposite to the first surface, wherein the antenna pattern part includes one or more supporting holes arranged to fix the antenna pattern part to an injection-molding mold, and the supporting holes are at least partially filled with the molded frame material extending from the second surface of the molded frame.

6 Claims, 11 Drawing Sheets





US009373883B2

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

(10) **Patent No.:** **US 9,373,883 B2**
(45) **Date of Patent:** **Jun. 21, 2016**

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

USPC 343/720
See application file for complete search history.

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

(56) **References Cited**

(72) Inventors: **Soon-Ho Hwang**, Seoul (KR);
Sung-Koo Park, Suwon-si (KR);
Kyung-Jae Lee, Seoul (KR); **Joon-Ho**
Byun, Yongin-si (KR)

U.S. PATENT DOCUMENTS

6,937,196	B2 *	8/2005	Korva	343/702
8,581,799	B2 *	11/2013	Choi et al.	343/845
8,606,195	B2 *	12/2013	Suetake et al.	455/82
2005/0017909	A1	1/2005	Carpenter et al.	
2008/0316118	A1 *	12/2008	Baliarda et al.	343/702
2009/0073059	A1 *	3/2009	Ikegaya	343/702
2010/0001909	A1	1/2010	Nielsen	
2010/0164835	A1	7/2010	Tai et al.	
2010/0271264	A1	10/2010	Li et al.	
2011/0183633	A1	7/2011	Ohba et al.	

(Continued)

(21) Appl. No.: **13/937,725**

FOREIGN PATENT DOCUMENTS

(22) Filed: **Jul. 9, 2013**

EP 1 619 749 A1 1/2006
EP 1703586 A1 9/2006

(65) **Prior Publication Data**

US 2014/0210675 A1 Jul. 31, 2014

(Continued)

Primary Examiner — Sue A Purvis

Assistant Examiner — Patrick Holecek

(30) **Foreign Application Priority Data**

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

Jan. 30, 2013 (KR) 10-2013-0010477

(57) **ABSTRACT**

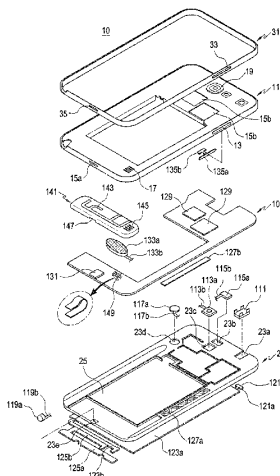
(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/44 (2006.01)
H01Q 13/10 (2006.01)

An antenna device of a portable terminal including conductive components is provided. The antenna device includes a first radiator connected to a power feeding unit of the portable terminal and a second radiator connected to each of the power feeding unit and a ground part of the portable terminal. At least one of the conductive components is connected to at least one the first radiator and the second radiator. The conductive components may be used as a radiator of the antenna device such that the antenna device may be easily installed within an inner space of a miniaturized and lightened portable terminal and the inner space of the portable terminal may be efficiently used.

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/44**
(2013.01); **H01Q 13/10** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/44; H01Q 1/24; H01Q 1/241;
H01Q 1/242; H01Q 1/243; H01Q 5/30;
H01Q 5/307; H01Q 5/314; H01Q 5/321;
H01Q 5/328; H01Q 5/335; H01Q 9/30;
H01Q 9/42

24 Claims, 6 Drawing Sheets





US009373889B2

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

(10) **Patent No.:** **US 9,373,889 B2**
(45) **Date of Patent:** **Jun. 21, 2016**

(54) **ULTRA-WIDEBAND ANTENNA AND
TERMINAL**

(75) Inventors: **Yajun Chen**, Shenzhen (CN); **Shougang
Cheng**, Shenzhen (CN); **Jun Shen**,
Shenzhen (CN); **Yu Qin**, Shenzhen (CN)

(73) Assignee: **ZTE Corporation**, Shenzhen,
Guangdong (CN)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 444 days.

(21) Appl. No.: **14/118,531**

(22) PCT Filed: **Apr. 24, 2012**

(86) PCT No.: **PCT/CN2012/074624**

§ 371 (c)(1),
(2), (4) Date: **Nov. 18, 2013**

(87) PCT Pub. No.: **WO2013/000331**

PCT Pub. Date: **Jan. 3, 2013**

(65) **Prior Publication Data**

US 2014/0104129 A1 Apr. 17, 2014

(30) **Foreign Application Priority Data**

Jun. 29, 2011 (CN) 2011 1 0178840

(51) **Int. Cl.**
H01Q 5/25 (2015.01)
H01Q 5/378 (2015.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/0017** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 1/38** (2013.01); **H01Q 5/25**
(2015.01); **H01Q 5/378** (2015.01); **H01Q 9/40**
(2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/0017; H01Q 5/25; H01Q 5/378;
H01Q 5/385; H01Q 9/40; H01Q 1/38
USPC 343/850
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,603,429 B1 * 8/2003 Bancroft H01Q 1/243
343/700 MS
7,042,414 B1 * 5/2006 Lee H01Q 1/243
343/795

(Continued)

FOREIGN PATENT DOCUMENTS

CN 101145635 A 3/2008
CN 201035603 Y 3/2008

(Continued)

OTHER PUBLICATIONS

International Search Report in international No. PCT/CN2012/
074624, mailed on Aug. 9, 2012. (2 pages—see entire document).

(Continued)

Primary Examiner — Dameon E Levi

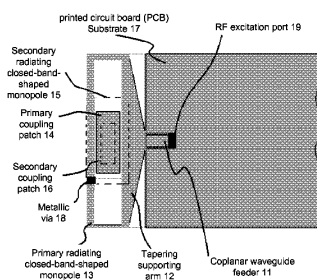
Assistant Examiner — Jennifer F Hu

(74) *Attorney, Agent, or Firm* — Oppedahl Patent Law Firm
LLC

(57) **ABSTRACT**

The present disclosure discloses an ultra-wideband antenna, including: a coplanar waveguide feeder connected to a Radio Frequency (RF) excitation port on the PCB substrate at one end and to a tapering supporting arm at the other end; the tapering supporting arm connected to the coplanar waveguide feeder at one end and to a primary radiating closed-band-shaped monopole at the other end; the primary radiating closed-band-shaped monopole connected to the tapering supporting arm; a primary coupling patch located in the area closed by the closed band of the primary radiating closed-band-shaped monopole; a secondary radiating closed-band-shaped monopole connected to the primary radiating closed-band-shaped monopole through a metallic via; and a secondary coupling patch located in the area closed by the closed band of the secondary radiating closed-band-shaped monopole. The present disclosure also discloses an ultra-wideband terminal. With the antenna and the terminal of the present disclosure, space usage is reduced, facilitating development of an ultrathin terminal and widening bandwidth, and thus allowing the terminal to operate in the range of an ultra-wide band.

12 Claims, 3 Drawing Sheets





US009373890B2

(12) **United States Patent
Park**

(10) **Patent No.: US 9,373,890 B2**
(45) **Date of Patent: Jun. 21, 2016**

(54) **ANTENNA**

(56) **References Cited**

(71) Applicant: **LG INNOTEK CO., LTD.**, Seoul (KR)

U.S. PATENT DOCUMENTS

(72) Inventor: **Young Hun Park**, Seoul (KR)

3,319,141	A *	5/1967	Cariou et al.	361/323
4,741,214	A *	5/1988	Vidmantas	73/708
5,262,792	A	11/1993	Egashira	
5,349,365	A *	9/1994	Ow et al.	343/895
2003/0160726	A1	8/2003	Grant et al.	
2004/0051675	A1	3/2004	Inoue	
2005/0264461	A1 *	12/2005	Sugimoto et al.	343/713
2006/0077115	A1	4/2006	Oh et al.	
2006/0227052	A1	10/2006	Tavassoli Hozouri	
2007/0285335	A1 *	12/2007	Bungo et al.	343/895
2011/0043427	A1	2/2011	Lee et al.	

(73) Assignee: **LG INNOTEK CO., LTD.**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 189 days.

(21) Appl. No.: **13/631,435**

FOREIGN PATENT DOCUMENTS

(22) Filed: **Sep. 28, 2012**

EP	1 091 445	A2	4/2001
JP	2006/115448	A	4/2006
KR	10-2009-0104333	A	10/2009
KR	10-2011-00841479	A	7/2011

(65) **Prior Publication Data**

US 2013/0076588 A1 Mar. 28, 2013

OTHER PUBLICATIONS

(30) **Foreign Application Priority Data**

Sep. 28, 2011 (KR) 10-2011-0098610

"Antenna Theory: A Review," Balanis, Proc. IEEE vol. 80 No. Jan. 1, 1992.*

* cited by examiner

(51) **Int. Cl.**

H01Q 1/50	(2006.01)
H01Q 9/16	(2006.01)
H01Q 9/04	(2006.01)
H01Q 7/00	(2006.01)
H01Q 5/40	(2015.01)

Primary Examiner — Graham Smith

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

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

CPC **H01Q 9/0421** (2013.01); **H01Q 5/40** (2015.01); **H01Q 7/00** (2013.01); **H01Q 9/045** (2013.01)

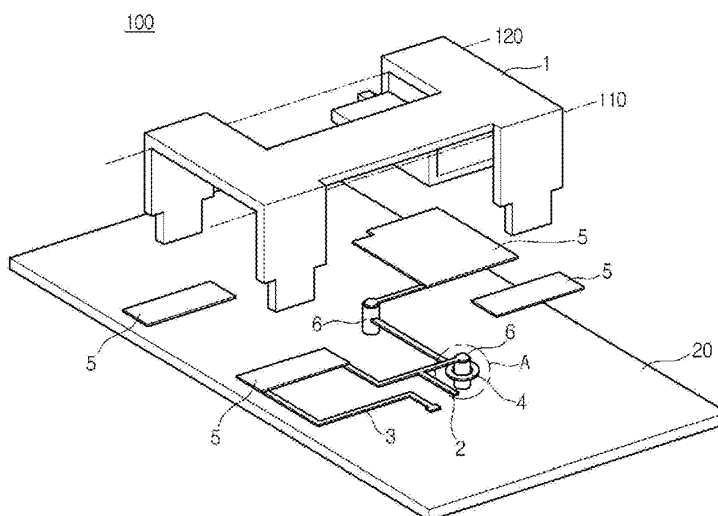
(57) **ABSTRACT**

Disclosed is an antenna. The antenna includes a first radiating part bent in a predetermined direction, a second radiating part under the first radiating part, a conductive member connected to the second radiating part, and a coupling part spaced apart from the conductive member while surrounding a lateral side of the conductive member.

(58) **Field of Classification Search**

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

13 Claims, 4 Drawing Sheets





US009374126B2

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

(10) **Patent No.:** **US 9,374,126 B2**
(45) **Date of Patent:** **Jun. 21, 2016**

(54) **MULTIBAND ON GROUND ANTENNA WITH A DUAL RADIATOR ARRANGEMENT**

(71) Applicant: **Nokia Corporation**, Espoo (FI)

(72) Inventors: **Niels Bonne Larsen**, Encinitas, CA (US); **Aycan Erentok**, Sunnyvale, CA (US); **Marko Olavi Kupari**, Kempele (FI)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 19 days.

(21) Appl. No.: **14/092,179**

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

(65) **Prior Publication Data**

US 2015/0147980 A1 May 28, 2015

(51) **Int. Cl.**

H04B 1/40 (2015.01)

H04B 1/50 (2006.01)

H01Q 21/30 (2006.01)

H01Q 5/314 (2015.01)

H01Q 5/321 (2015.01)

H01Q 5/328 (2015.01)

H01Q 5/378 (2015.01)

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

CPC **H04B 1/50** (2013.01); **H01Q 5/314** (2015.01); **H01Q 5/321** (2015.01); **H01Q 5/328** (2015.01); **H01Q 5/378** (2015.01); **H01Q 21/30** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 21/28; H01Q 9/42; H01Q 1/245; H01Q 3/24; H01Q 7/00; H01Q 1/521; H01Q 9/0442; H01Q 1/36; H01Q 1/38; H01Q 1/52; H01Q 9/14; H01Q 25/04; H04B 15/02; H04B 1/3833; H04B 5/0081; H04B 7/0825; H04B 7/10; H04B 1/0053; H04B 1/3838

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,757,267	B1 *	6/2004	Evans	H04B 7/0615	342/374
7,274,340	B2	9/2007	Ozden et al.		343/860
2007/0052599	A1 *	3/2007	Shimizu et al.		343/702
2009/0058554	A1	3/2009	Ozden		333/129
2009/0278755	A1 *	11/2009	Shoji	H01Q 1/24	343/745
2011/0116423	A1 *	5/2011	Rousu	H01Q 1/242	370/297
2011/0183633	A1	7/2011	Ohba et al.		
2011/0234469	A1	9/2011	Shoji		
2012/0046003	A1 *	2/2012	Ying	455/90.2	
2013/0038494	A1	2/2013	Kuonanoja	343/746	
2013/0088404	A1 *	4/2013	Ramachandran et al.	343/853	
2013/0169490	A1 *	7/2013	Pascolini et al.	343/702	

FOREIGN PATENT DOCUMENTS

WO WO-2010/039087 A1 4/2010
WO WO-2013/103564 A1 7/2013

* cited by examiner

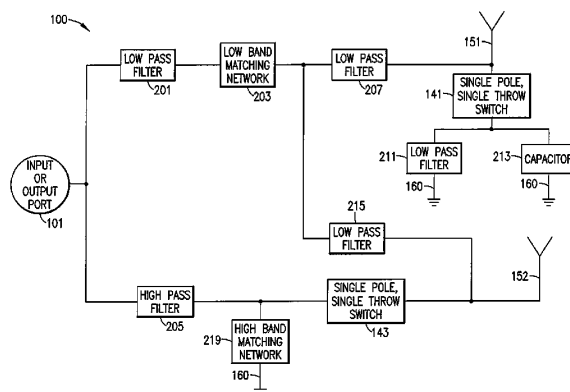
Primary Examiner — Golam Sorowar

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

(57) **ABSTRACT**

An antenna arrangement includes a switch having an open state and a closed state, a first antenna that operates as a first active driven element in a first frequency band in response to the switch being in the open state, and a second antenna that operates as a second active driven element in a first frequency band in response to the switch being in the open state. The closed state configures the first antenna and the second antenna to operate in a second frequency band different from the first frequency band by operatively coupling a first impedance between the first antenna and a radio frequency ground, and by operatively coupling a second impedance between the second antenna and the radio frequency ground. The first antenna functions as a parasitic element in the second frequency band and the second antenna functions as an active driven element in the second frequency band.

32 Claims, 11 Drawing Sheets





US009379427B2

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

(10) **Patent No.:** **US 9,379,427 B2**
(45) **Date of Patent:** **Jun. 28, 2016**

(54) **METHODS FOR MANUFACTURING AN ANTENNA TUNING ELEMENT IN AN ELECTRONIC DEVICE**

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

(72) Inventors: **Hao Xu**, Cupertino, CA (US); **Jayesh Nath**, Milpitas, CA (US); **Peter Bevelacqua**, San Jose, CA (US); **Daniel W. Jarvis**, Sunnyvale, CA (US); **Jared M. Kole**, San Jose, CA (US); **Jennifer M. Edwards**, San Francisco, CA (US); **Mattia Pascolini**, Campbell, CA (US); **Richard H. Dinh**, San Jose, CA (US); **Robert W. Schlub**, Cupertino, CA (US); **Ruben Caballero**, San Jose, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 347 days.

(21) Appl. No.: **13/871,996**

(22) Filed: **Apr. 26, 2013**

(65) **Prior Publication Data**

US 2014/0323063 A1 Oct. 30, 2014

(51) **Int. Cl.**
H04B 1/38 (2015.01)
H01Q 1/24 (2006.01)
H01Q 9/04 (2006.01)
H04B 1/18 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 9/0442** (2013.01); **H04B 1/18** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H03J 5/28; H03H 5/006; H01P 3/006
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,188,369 B1	2/2001	Okabe et al.	
8,482,467 B2	7/2013	Jarvis et al.	
2006/0114159 A1 *	6/2006	Yoshikawa	H01Q 1/24 343/702
2008/0316117 A1 *	12/2008	Hill et al.	343/702
2012/0119955 A1	5/2012	Milosavljevic et al.	

FOREIGN PATENT DOCUMENTS

EP	1962372	10/2010
WO	2006043543	4/2006
WO	2012039465	3/2012

OTHER PUBLICATIONS

Jin et al., U.S. Appl. No. 13/041,934, filed Mar. 7, 2011.
Jin et al., U.S. Appl. No. 13/041,905, filed Mar. 7, 2011.

* cited by examiner

Primary Examiner — Wesley Kim

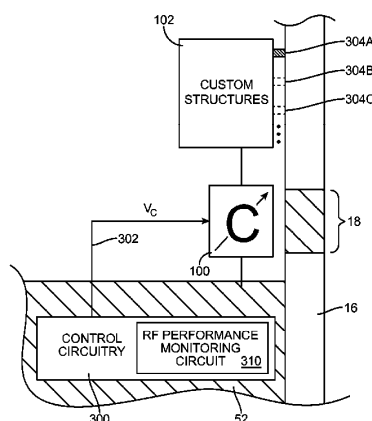
Assistant Examiner — Richard Chan

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

(57) **ABSTRACT**

Custom antenna structures may be used to improve antenna performance and to compensate for manufacturing variations in electronic device antennas. An electronic device antenna may include an antenna tuning element and conductive structures formed from portions of a peripheral conductive housing member and other conductive antenna structures. The antenna tuning element may be connected across a gap in the peripheral conductive housing member. The custom antenna structures may be used to couple the antenna tuning element to a fixed custom location on the peripheral conductive housing member to help satisfy design criteria and to compensate for manufacturing variations in the conductive antenna structures that could potentially lead to undesired variations in antenna performance. Custom antenna structures may include springs and custom paths on dielectric supports.

16 Claims, 12 Drawing Sheets





US009379428B2

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

(10) **Patent No.:** **US 9,379,428 B2**

(45) **Date of Patent:** **Jun. 28, 2016**

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

(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 316 days.

(21) Appl. No.: **14/050,942**

(22) Filed: **Oct. 10, 2013**

(65) **Prior Publication Data**

US 2014/0320350 A1 Oct. 30, 2014

(30) **Foreign Application Priority Data**

Apr. 30, 2013 (TW) 102115325 A

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 1/36 (2006.01)

H01Q 9/04 (2006.01)

H01Q 5/328 (2015.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/36** (2013.01); **H01Q 5/328** (2015.01); **H01Q 9/0414** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/38; H01Q 9/26; H01Q 1/243; H01Q 9/0421

USPC 343/702, 878, 700 MS, 806
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2010/0271282 A1 * 10/2010 Eom H01Q 1/48 343/873

2011/0267245 A1 * 11/2011 Park H01Q 1/243 343/722

2011/0298669 A1 * 12/2011 Rao H01Q 1/243 343/702

2012/0013511 A1 * 1/2012 Sumi H01Q 1/243 343/702

* cited by examiner

Primary Examiner — Dameon E Levi

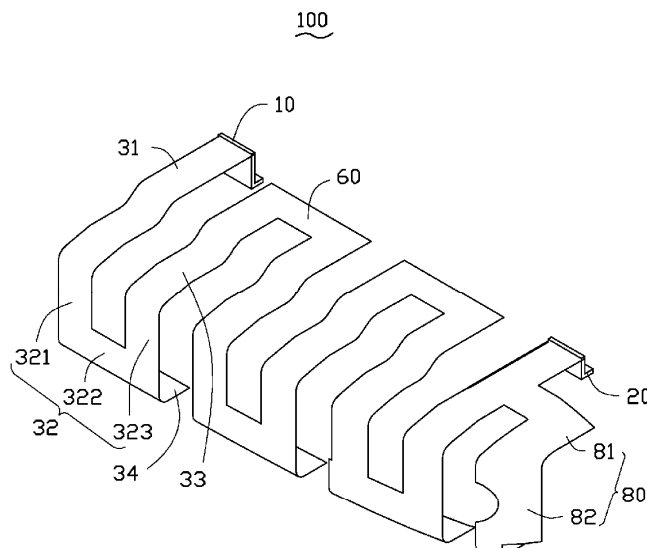
Assistant Examiner — Collin Dawkins

(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

An antenna structure includes a feed end, a ground end, a number of antenna units, and a number of connection sections corresponding to the antenna units. The antenna units are positioned side by side. Each connection section is positioned between two adjacent antenna units and interconnects the two adjacent antenna units to form a zigzag-shaped antenna structure. The feed end and the ground end are perpendicularly connected to two antenna units positioned at two ends of the interconnected antenna units.

11 Claims, 3 Drawing Sheets





US009379429B2

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

(10) **Patent No.:** **US 9,379,429 B2**
(45) **Date of Patent:** **Jun. 28, 2016**

(54) **ANTENNA ASSEMBLY AND WIRELESS COMMUNICATION DEVICE USING THE SAME**

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

(72) Inventors: **Chi-Sheng Liu**, New Taipei (TW);
Chih-Yang Tsai, New Taipei (TW);
Chuan-Chou Chi, New Taipei (TW);
Hao-Ying Chang, New Taipei (TW);
Chao-Wei Ho, New Taipei (TW);
Pai-Cheng Huang, New Taipei (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 208 days.

(21) Appl. No.: **14/296,629**

(22) Filed: **Jun. 5, 2014**

(65) **Prior Publication Data**
US 2014/0361930 A1 Dec. 11, 2014

(30) **Foreign Application Priority Data**
Jun. 7, 2013 (TW) 102120249 A

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

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

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 9/04; H01Q 9/42
USPC 343/700 MS, 702, 829, 846
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,467,097 A *	11/1995	Toko	.....	H01Q 1/244
				343/702
7,639,187 B2 *	12/2009	Caballero	.....	H01Q 1/088
				343/702
8,228,239 B2 *	7/2012	Lagnado	.....	G06F 1/1616
				343/702
8,325,095 B2 *	12/2012	Nishikido	.....	H01Q 1/243
				343/700 MS
8,742,997 B2 *	6/2014	Nickel	.....	G01R 31/2822
				343/700 R

* cited by examiner

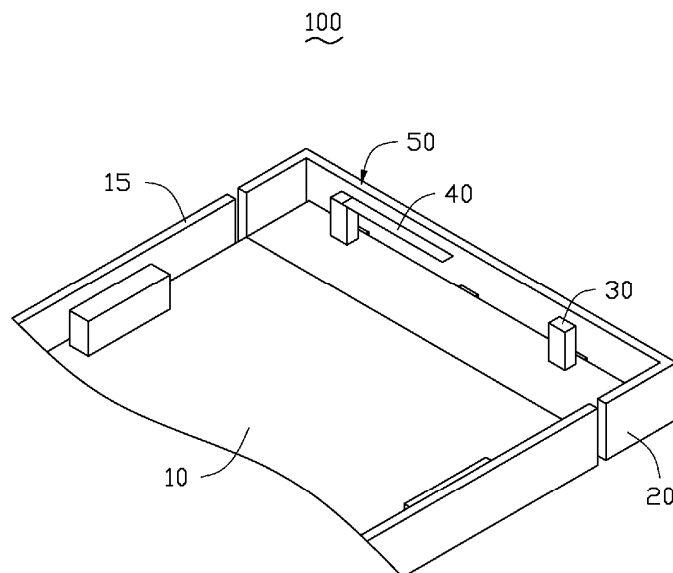
Primary Examiner — Tho G Phan

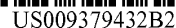
(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

An antenna assembly includes a first antenna, a second antenna, and at least one connecting member. The first antenna includes a radiator and at least one connecting portion connected to the radiator, and the radiator is a part of a housing of a wireless communication device. The at least one connecting member is connected to the at least one connecting portion to fix the first antenna to the wireless communication device to feed current to the first antenna and the second antenna.

10 Claims, 3 Drawing Sheets





(10) **Patent No.:** US 9,379,432 B2
(45) **Date of Patent:** Jun. 28, 2016

USPC 343/848, 846
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,448,933	B1 *	9/2002	Hill et al.	343/702
8,115,686	B2 *	2/2012	Mumbru et al.	343/702
2007/0001911	A1	1/2007	Fujio et al.	
2008/0278384	A1	11/2008	Shimasaki et al.	
2010/0238079	A1 *	9/2010	Ayatollahi et al.	343/729
2013/0241792	A1 *	9/2013	Ishikawa et al.	343/848

FOREIGN PATENT DOCUMENTS

JP	2003-332834	A	11/2003
JP	2006-352293	A	12/2006

(Continued)

OTHER PUBLICATIONS

Extended Search Report issued in European Patent Application No.
13 15 8004, mailed Jun. 20, 2013, 7 pages.

(Continued)

Primary Examiner — Michael C. Wimer

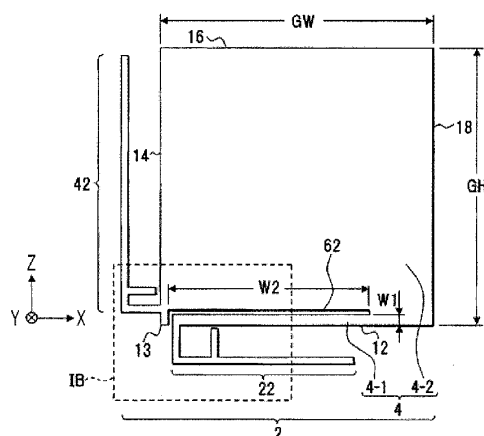
Assistant Examiner — Noel Maldonado

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

- (57) **ABSTRACT**

An antenna device, includes: a ground plate to which first and second antennas, each including a radiating element and a ground terminal, are connected, with one of the first and second antennas being powered, the ground plate including: a first slit extending from a portion where the ground terminal of one antenna of the first and second antennas is connected to the ground plate, in a direction along to the ground terminal, and a second slit extending from the tip of the first slit in a direction along to the radiating element.

12 Claims, 33 Drawing Sheets





US009379440B2

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

(10) **Patent No.:** **US 9,379,440 B2**
(45) **Date of Patent:** **Jun. 28, 2016**

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

(71) Applicant: **MURATA MANUFACTURING CO., LTD.**, Kyoto (JP)

(72) Inventors: **Kengo Onaka**, Kyoto (JP); **Hiroya Tanaka**, Kyoto (JP)

(73) Assignee: **Murata Manufacturing Co., Ltd.**, Kyoto-fu (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 106 days.

(21) Appl. No.: **14/286,176**

(22) Filed: **May 23, 2014**

(65) **Prior Publication Data**

US 2014/0300517 A1 Oct. 9, 2014

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2012/080007, filed on Nov. 20, 2012.

(30) **Foreign Application Priority Data**

Nov. 25, 2011 (JP) 2011-257023

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/00 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/0027** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/307** (2015.01); **H01Q 5/378** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 5/307; H01Q 5/378; H01Q 1/243
USPC 343/702, 700 MS
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,026,999 B2 * 4/2006 Umehara H01Q 1/243
343/700 MS
7,557,761 B2 * 7/2009 Iwai H01Q 9/30
343/702

(Continued)

FOREIGN PATENT DOCUMENTS

JP S63-62402 A 3/1988
JP 2002-076735 A 3/2002

(Continued)

OTHER PUBLICATIONS

Written Opinion of the International Searching Authority; PCT/JP2012/080007; Feb. 5, 2013.

(Continued)

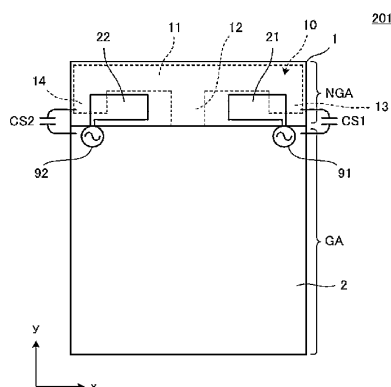
Primary Examiner — Hoang V Nguyen

(74) *Attorney, Agent, or Firm* — Studebaker & Brackett PC

(57) **ABSTRACT**

A first radiation electrode is formed on a bottom surface of a no-ground conductor formation area of a board, and second radiation electrodes are formed on a top surface of the no-ground conductor formation area. A longitudinal electrode of the first radiation electrode is electrically continuous with a ground conductor. A first end portion and a second end portion of a transverse electrode of the first radiation electrode extend toward the ground conductor. The transverse electrode of the first radiation electrode operates as a radiation element for radiating a signal at a first frequency. The second radiation electrodes each operate as a radiation element for radiating a signal at a second frequency, and also as a capacitive feed electrode for the first radiation electrode. This enables to strengthen directivity toward an antenna portion side (forward direction) of the board, and further enables multiband use.

6 Claims, 13 Drawing Sheets





US009379445B2

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

(10) **Patent No.:** **US 9,379,445 B2**
(45) **Date of Patent:** **Jun. 28, 2016**

(54) **ELECTRONIC DEVICE WITH SATELLITE
NAVIGATION SYSTEM SLOT ANTENNAS**

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

(72) Inventors: **Jiang Zhu**, Sunnyvale, CA (US); **Harish
Rajagopalan**, San Jose, CA (US);
Rodney A. Gomez Angulo, Sunnyvale,
CA (US); **Qingxiang Li**, Mountain View,
CA (US); **Robert W. Schlub**, Cupertino,
CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 43 days.

(21) Appl. No.: **14/180,866**

(22) Filed: **Feb. 14, 2014**

(65) **Prior Publication Data**

US 2015/0236426 A1 Aug. 20, 2015

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 13/10 (2006.01)

H01Q 1/22 (2006.01)

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

CPC **H01Q 13/10** (2013.01); **H01Q 1/2266**
(2013.01); **H01Q 1/243** (2013.01); **H01R**
2201/02 (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 13/10; H01R 2201/02
USPC 343/702, 767, 860, 906
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,016,490 A 4/1977 Weckenmann et al.
4,614,937 A 9/1986 Poujois
5,337,353 A 8/1994 Boie

5,410,497 A 4/1995 Viletto
5,463,406 A 10/1995 Vannatta et al.
5,650,597 A 7/1997 Redmayne
5,826,458 A 10/1998 Little
5,854,972 A 12/1998 Pennock et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CN 1343380 4/2002
CN 1543010 11/2004

(Continued)

OTHER PUBLICATIONS

Liu et al., MEMS-Switched, Frequency-Tunable Hybrid Slot/PIFA
Antenna; IEEE Antennas and Wireless Propagation Letters, vol. 8,
2009: p. 311-314.

(Continued)

Primary Examiner — Joseph Lauture

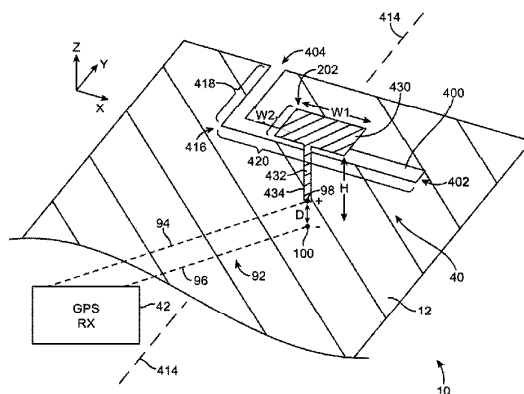
(74) Attorney, Agent, or Firm — Treyz Law Group, P.C.; G.
Victor Treyz; Michael H. Lyons

(57)

ABSTRACT

An electronic device may be provided with a satellite posi-
tioning system slot antenna. The slot antenna may include a
slot in a metal housing. The slot may be directly fed or
indirectly fed. In indirectly fed configurations, the antenna
may include a near-field-coupled antenna feed structure that
is near-field coupled to the slot. The near-field-coupled
antenna feed structure may be formed from a planar metal
structure. The planar metal structure may be a metal patch that
overlaps the slot and that has a leg that protrudes towards the
metal housing. A positive antenna feed terminal may be
coupled to the leg and a ground antenna feed terminal may be
coupled to the metal housing.

16 Claims, 16 Drawing Sheets





US009379452B2

(12) **United States Patent**
Andrenko

(10) **Patent No.:** **US 9,379,452 B2**
(45) **Date of Patent:** **Jun. 28, 2016**

(54) **ANTENNA APPARATUS HAVING FOUR
INVERTED F ANTENNA ELEMENTS AND
GROUND PLANE**

(71) Applicant: **FUJITSU LIMITED**, Kawasaki-shi,
Kanagawa (JP)

(72) Inventor: **Andrey S. Andrenko**, Kawasaki (JP)

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

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 105 days.

(21) Appl. No.: **14/218,754**

(22) Filed: **Mar. 18, 2014**

(65) **Prior Publication Data**

US 2015/0048995 A1 Feb. 19, 2015

(30) **Foreign Application Priority Data**

Aug. 13, 2013 (JP) 2013-168239

(51) **Int. Cl.**
H01Q 21/00 (2006.01)
H01Q 1/22 (2006.01)
H01Q 9/04 (2006.01)
H01Q 9/42 (2006.01)
H01Q 21/24 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 21/00** (2013.01); **H01Q 1/2216**
(2013.01); **H01Q 9/0421** (2013.01); **H01Q 9/42**
(2013.01); **H01Q 21/24** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/00; H01Q 21/24; H01Q 21/26;
H01Q 1/2216; H01Q 9/0421; H01Q 9/42
USPC 343/893
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,297,776 B1 * 10/2001 Pankinaho H01Q 1/243
343/700 MS
2002/0047807 A1 * 4/2002 Talvitie H01Q 9/0421
343/702

(Continued)

FOREIGN PATENT DOCUMENTS

EP 0 450 881 A2 10/1991
EP 1 052 723 A2 11/2000

(Continued)

OTHER PUBLICATIONS

European Search Report dated Jun. 1, 2015; Application No.
14160495.9.

(Continued)

Primary Examiner — Sue A Purvis

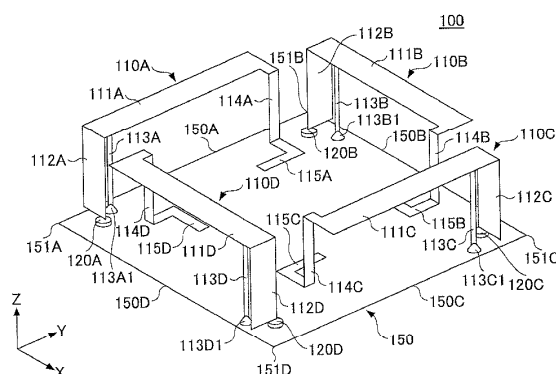
Assistant Examiner — Ab Salam Alkassim, Jr.

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

(57) **ABSTRACT**

An antenna apparatus includes a ground plane having a rect-
angular shape in plan view, and four inverted F antenna ele-
ments configured to be placed on a surface of the ground
plane and to be arranged in a symmetrical manner with
respect to the central point of the ground plane in plan view,
wherein each of the four inverted F antenna elements includes
a short strip extending from one end of a main strip to the short
end, a feeding strip, an open strip configured to extend toward
the open end from the other end of the main strip to a position
placed at a second height lower than the first height, and an
end strip configured to extend from a distal end of the open
strip to the open end and placed parallel to the ground plane at
the second height.

9 Claims, 12 Drawing Sheets





US009379455B2

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

(10) **Patent No.:** **US 9,379,455 B2**
(45) **Date of Patent:** **Jun. 28, 2016**

(54) **ANTENNA CIRCUIT USING MULTIPLE
INDEPENDENT ANTENNAS
SIMULTANEOUSLY THROUGH A SINGLE
FEED**

(71) Applicants: **STMICROELECTRONICS SA**,
Montrouge (FR);
**STMICROELECTRONICS
(CROLLES 2) SAS**, Crolles (FR)

(72) Inventors: **Florence Sonnerat**, St ferreol (FR);
Romain Pilard, Goncelin (FR);
Frédéric Giancesello, Saint Pierre
d'Albigny (FR); **Cédric Durand**, St
Martin d Heres (FR)

(73) Assignees: **STMICROELECTRONICS SA**,
Montrouge (FR);
**STMICROELECTRONICS
(CROLLES 2) SAS**, Crolles (FR)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 301 days.

(21) Appl. No.: **14/058,515**

(22) Filed: **Oct. 21, 2013**

(65) **Prior Publication Data**

US 2014/0145897 A1 May 29, 2014

(30) **Foreign Application Priority Data**

Nov. 23, 2012 (FR) 12 61159

(51) **Int. Cl.**
H01Q 11/00 (2006.01)
H04B 1/40 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 21/30** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 5/371** (2015.01); **H01Q 9/42**
(2013.01);

H01Q 21/0087 (2013.01); **H01Q 21/28**
(2013.01); **H04B 1/0057** (2013.01); **Y10T**
29/49018 (2015.01)

(58) **Field of Classification Search**
CPC H04B 1/0057; H01Q 21/30
USPC 343/853; 29/601; 333/24; 455/208;
370/297
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2003/0201939 A1 10/2003 Reece et al.
2011/0014958 A1 * 1/2011 Black H01Q 1/243
455/575.7

FOREIGN PATENT DOCUMENTS

EP 1732160 12/2006
EP 1983609 10/2008
GB 2422723 8/2006

OTHER PUBLICATIONS

Ikonen et al. ("Multi-feed RF front-ends and cellular antennas for
next generation smartphones" 2011 EPCOS AG and Pulse Electron-
ics) Slideshow.*

(Continued)

Primary Examiner — Dameon E Levi

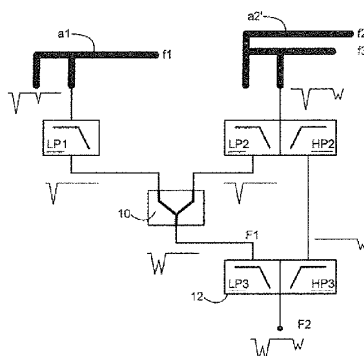
Assistant Examiner — Ricardo Magallanes

(74) *Attorney, Agent, or Firm* — Allen, Dyer, Doppelt,
Milbrath & Gilchrist, P.A.

(57) **ABSTRACT**

An antenna circuit includes a first antenna tuned to a first
fundamental frequency and a second antenna tuned to a sec-
ond fundamental frequency different from the first funda-
mental frequency. A first filter has a first terminal connected to
the first antenna and attenuates the frequency components
outside of a band defined by the first fundamental frequency
or its harmonics. A second filter has a first terminal coupled to
the second antenna and attenuates the frequency components
outside of a band defined by the second fundamental fre-
quency or its harmonics. A passive recombination element
couples the second terminals of the two filters to a common
terminal.

12 Claims, 3 Drawing Sheets





US009381688B2

(12) **United States Patent**
Lim

(10) **Patent No.:** **US 9,381,688 B2**

(45) **Date of Patent:** **Jul. 5, 2016**

(54) **ANTENNA PATTERN FRAME HAVING
ANTENNA PATTERN EMBEDDED THEREIN,
ELECTRONIC DEVICE INCLUDING THE
SAME, METHOD AND MOLD FOR
MANUFACTURING THE SAME**

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

(72) Inventor: **Dae Ki Lim**, Gyeonggi-do (KR)

(73) Assignee: **Samsung Electro-Mechanics Co., Ltd.**,
Suwon-si (KR)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 210 days.

(21) Appl. No.: **14/039,774**

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

(65) **Prior Publication Data**

US 2014/0168017 A1 Jun. 19, 2014

(30) **Foreign Application Priority Data**

Dec. 14, 2012 (KR) 10-2012-0146588

(51) **Int. Cl.**

H01Q 1/22 (2006.01)

B29C 45/14 (2006.01)

H01Q 1/12 (2006.01)

H01Q 1/24 (2006.01)

H01Q 1/40 (2006.01)

B29L 31/34 (2006.01)

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

CPC **B29C 45/14065** (2013.01); **B29C 45/14639**
(2013.01); **H01Q 1/1207** (2013.01); **H01Q**
1/243 (2013.01); **H01Q 1/40** (2013.01); **B29L**
2031/3437 (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/40; H01Q 1/243; H01Q 1/22;
H01Q 1/1207; B29C 45/14065

USPC 343/702, 700 MS, 873, 872
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,068,067 B2 * 11/2011 Hong H01Q 1/1207
343/702

8,773,314 B2 * 7/2014 Hong B29C 45/1671
343/702

2011/0205141 A1 8/2011 Hong et al.

FOREIGN PATENT DOCUMENTS

KR 10-0932079 B1 12/2009
KR 2011-0097415 A 8/2011

* cited by examiner

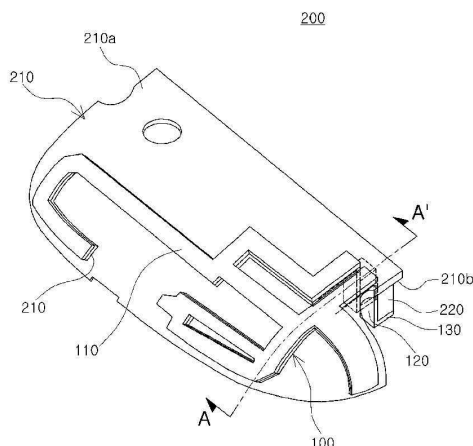
Primary Examiner — Hoang V Nguyen

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

(57) **ABSTRACT**

An antenna pattern frame having an antenna pattern embed-
ded therein, an electronic device including the same, a
method of manufacturing the same, and a mold for manufac-
turing the same. The antenna pattern frame includes a radiator
including an antenna pattern part transmitting or receiving a
signal and a terminal connection portion electrically connect-
ing the antenna pattern part and a circuit substrate; a radiator
frame formed by injection-molding to incorporate the radi-
ator so that the terminal connection portion is exposed at a first
surface of the radiator frame and the antenna pattern part is
exposed at and protrudes from a second surface of the radiator
frame opposite to the first surface; and a cover frame injec-
tion-molded so that the antenna pattern part is embedded
between the radiator frame and the cover frame.

7 Claims, 9 Drawing Sheets





US009385417B2

(12) **United States Patent**
Lin

(10) **Patent No.:** **US 9,385,417 B2**

(45) **Date of Patent:** **Jul. 5, 2016**

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

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

(72) Inventor: **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 199 days.

(21) Appl. No.: **14/065,595**

(22) Filed: **Oct. 29, 2013**

(65) **Prior Publication Data**

US 2014/0191908 A1 Jul. 10, 2014

(30) **Foreign Application Priority Data**

Jan. 9, 2013 (TW) 102100667 A

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 13/16 (2006.01)
H01Q 5/371 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01); **H01Q 13/16** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,552,919 B2 * 10/2013 Hsieh et al. 343/833
2008/0106478 A1 * 5/2008 Hill 343/702

* cited by examiner

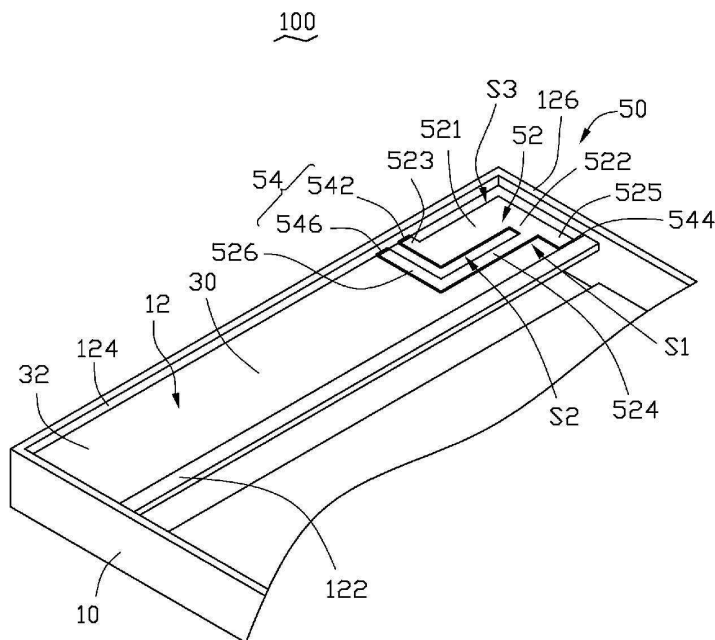
Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

A broadband antenna is mounted in a metal piece and includes a radiating portion, a ground portion, and a feed portion. The radiating portion includes a main portion and a plurality of radiating arms extending from the main portion in multiple directions, the radiating arms extend to contact the metal piece. The main portion, the radiating arms, and the metal piece enclose several slots. The ground portion is connected to a plurality of end portions of the radiating arms. The feed portion is connected to the metal piece and is adjacent to the radiating portion. The feed portion, the ground portion, the main portion, and the plurality of radiating arms form different current paths, thus to form different resonance nodes, thereby tender the broadband antenna to work at multi frequency bands. A wireless communication device employing the broadband antenna is also described.

4 Claims, 5 Drawing Sheets





(10) **Patent No.:** US 9,385,418 B2
(45) **Date of Patent:** *Jul. 5, 2016

(52) **U.S. Cl.**
CPC *H01Q 1/243* (2013.01); *H01Q 1/44*
(2013.01); *H01Q 21/28* (2013.01); *H01Q 21/29*
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 21/28
USPC 343/702, 700 MS, 846, 848
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,048,118 A 9/1991 Brooks et al.
8,270,914 B2 9/2012 Pascolini et al.
8,842,048 B2 9/2014 Kim et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CN 101814649 A 8/2010
CN 202353552 U 7/2012

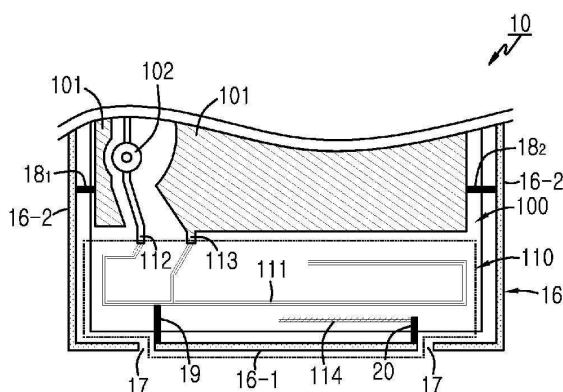
(Continued)

Primary Examiner — Hoanganh Le
(74) *Attorney, Agent, or Firm* — Cha & Reiter, LLC

(57) **ABSTRACT**

An antenna apparatus for a portable terminal having a main board is provided. The antenna apparatus includes a main antenna that electrically connects to a feed line of the main board. A metal frame is constructed as part of a case frame forming an exterior of the portable terminal. The metal frame is divided into first and second parts that are separated. The first part electrically connects to the main antenna or to the main board feed line, and is designed to radiate. The second part electrically connects to a ground surface of the main board. The metal frame enhances overall antenna performance rather than causing degradation through interference.

18 Claims, 4 Drawing Sheets





US009385419B2

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

(10) **Patent No.:** **US 9,385,419 B2**

(45) **Date of Patent:** **Jul. 5, 2016**

(54) **WRIST-WORN COMMUNICATION DEVICE**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

(72) Inventors: **Kin-Lu Wong**, New Taipei (TW);
Hung-Jen Hsu, New Taipei (TW)

6,765,846 B2 * 7/2004 Saitou H01Q 1/08
343/718

7,903,034 B2 * 3/2011 Anguera H01Q 1/243
343/700 MS

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

8,692,728 B2 * 4/2014 Jenwatanavet H01Q 1/242
343/702

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 268 days.

2010/0214175 A1 * 8/2010 Hui H01Q 1/243
343/700 MS

2010/0309070 A1 * 12/2010 Wong H01Q 9/30
343/749

2013/0169504 A1 7/2013 Jenwatanavet

* cited by examiner

(21) Appl. No.: **14/060,628**

(22) Filed: **Oct. 23, 2013**

(65) **Prior Publication Data**

US 2015/0070226 A1 Mar. 12, 2015

Primary Examiner — Sue A Purvis

Assistant Examiner — Patrick Holecek

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

(30) **Foreign Application Priority Data**

Sep. 10, 2013 (TW) 102132605 A

(57) **ABSTRACT**

(51) **Int. Cl.**
H01Q 1/27 (2006.01)
H01Q 1/48 (2006.01)
H01Q 5/00 (2015.01)
H01Q 5/314 (2015.01)
H01Q 9/30 (2006.01)

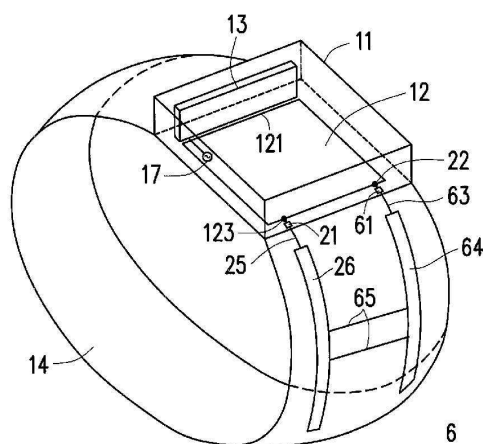
A communication device, including a device casing, an external connection element, and a first metal element, is provided. A ground element and an antenna element are disposed in the device casing. The ground element has a first edge, a second edge, and a first connection point. The first edge and the second edge are opposite to each other. The first connection point is disposed near or at the second edge. The antenna element is disposed near the first edge. The external connection element is formed by a non-conductive material and is outside the device casing. The external connection element has a belt-like structure and is combined with the device casing to substantially form a loop structure. The first metal element is supported by the external connection element and is coupled to the first connection point of the ground element.

(52) **U.S. Cl.**
CPC **H01Q 1/273** (2013.01); **H01Q 1/48**
(2013.01); **H01Q 5/314** (2015.01); **H01Q 9/30**
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/273; H01Q 1/48; H01Q 5/30;
H01Q 5/314; H01Q 5/321; H01Q 5/357;
H01Q 5/364; H01Q 5/371; H01Q 9/16;
H01Q 9/20; H01Q 9/30; H01Q 9/40

See application file for complete search history.

8 Claims, 4 Drawing Sheets





US009385421B2

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

(10) **Patent No.:** **US 9,385,421 B2**
(45) **Date of Patent:** **Jul. 5, 2016**

(54) **ANTENNA AND ELECTRONIC DEVICE FOR CLOSE PROXIMITY WIRELESS COMMUNICATION**

USPC 343/702, 729, 730, 726, 752, 802, 803,
343/804, 806, 808, 809, 843; 455/41.1,
455/41.2

See application file for complete search history.

(71) Applicant: **Kabushiki Kaisha Toshiba**, Minato-ku,
Tokyo (JP)

(56) **References Cited**

(72) Inventors: **Motochika Okano**, Tokyo (JP); **Toshiki Miyasaka**, Saitama (JP)

U.S. PATENT DOCUMENTS

(73) Assignee: **Kabushiki Kaisha Toshiba**, Tokyo (JP)

2,283,938 A * 5/1942 McKesson H01Q 9/26
343/733
2,888,678 A * 5/1959 Weiss H01Q 5/49
343/802

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 195 days.

(Continued)

(21) Appl. No.: **14/321,253**

FOREIGN PATENT DOCUMENTS

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

JP 4908576 B2 4/2012
JP 5058356 * 10/2012

(65) **Prior Publication Data**

US 2015/0263416 A1 Sep. 17, 2015

(Continued)

(30) **Foreign Application Priority Data**

Mar. 13, 2014 (JP) 2014-049679

Primary Examiner — Dameon E Levi

Assistant Examiner — Awat Salih

(74) *Attorney, Agent, or Firm* — White & Case LLP

(51) **Int. Cl.**
H01Q 9/30 (2006.01)
H01Q 1/36 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/24 (2006.01)

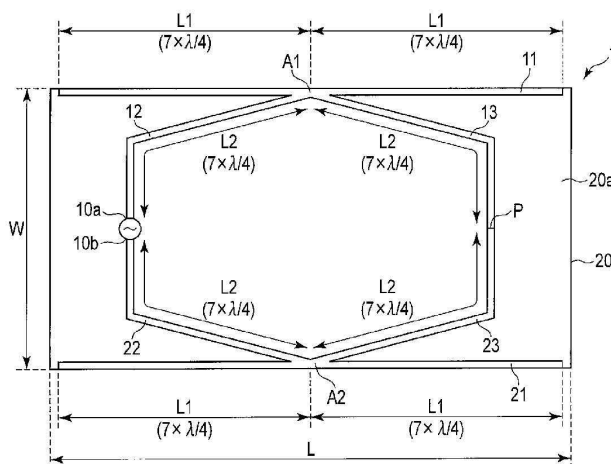
(52) **U.S. Cl.**
CPC . **H01Q 1/36** (2013.01); **H01Q 1/243** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/36; H01Q 23/24;
H01Q 9/285; H01Q 9/16; H01Q 21/20;
H01Q 9/42; H04B 7/0689; H04B 5/0075;
H04B 7/0602; H04W 52/0251; H05K 1/16;
Y02B 60/50

(57) **ABSTRACT**

According to one embodiment, an antenna includes first and second coupling elements and first to fourth connecting elements. An electrical length between a middle point of the first coupling element and each of both open ends thereof is a first electrical length which is an odd multiple of $\frac{1}{4}$ of a wavelength λ corresponding to a frequency used for close proximity wireless communication. An electrical length between a middle point of the second coupling element and each of both open ends thereof is the first electrical length. An electrical length of each of the first to fourth connecting elements is a second electrical length which is an odd multiple of $\frac{1}{4}$ of the wavelength λ .

11 Claims, 17 Drawing Sheets





US009385425B2

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

(10) **Patent No.:** **US 9,385,425 B2**

(45) **Date of Patent:** **Jul. 5, 2016**

(54) **ANTENNA DEVICE**

(71) Applicant: **TDK CORPORATION**, Tokyo (JP)

(72) Inventors: **Yasuyuki Hara**, Tokyo (JP); **Kenji Endou**, Tokyo (JP); **Tetsuya Shibata**, Tokyo (JP)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 334 days.

(21) Appl. No.: **13/896,594**

(22) Filed: **May 17, 2013**

(65) **Prior Publication Data**

US 2013/0335289 A1 Dec. 19, 2013

(30) **Foreign Application Priority Data**

Jun. 14, 2012 (JP) 2012-135037

(51) **Int. Cl.**
H01Q 1/52 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
H01Q 21/28 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/52** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/521** (2013.01); **H01Q 21/28** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/52; H01Q 1/521
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,830,329	B2	11/2010	Fukushima et al.	
2003/0189519	A1	10/2003	Ruttfors et al.	
2009/0237319	A1 *	9/2009	Fukushima et al.	343/848
2011/0136447	A1	6/2011	Pascolini et al.	
2012/0218157	A1 *	8/2012	Endou et al.	343/741

FOREIGN PATENT DOCUMENTS

CN	1441978	A	9/2003
CN	102110873	A	6/2011
WO	WO 2007/055232	A1	5/2007

* cited by examiner

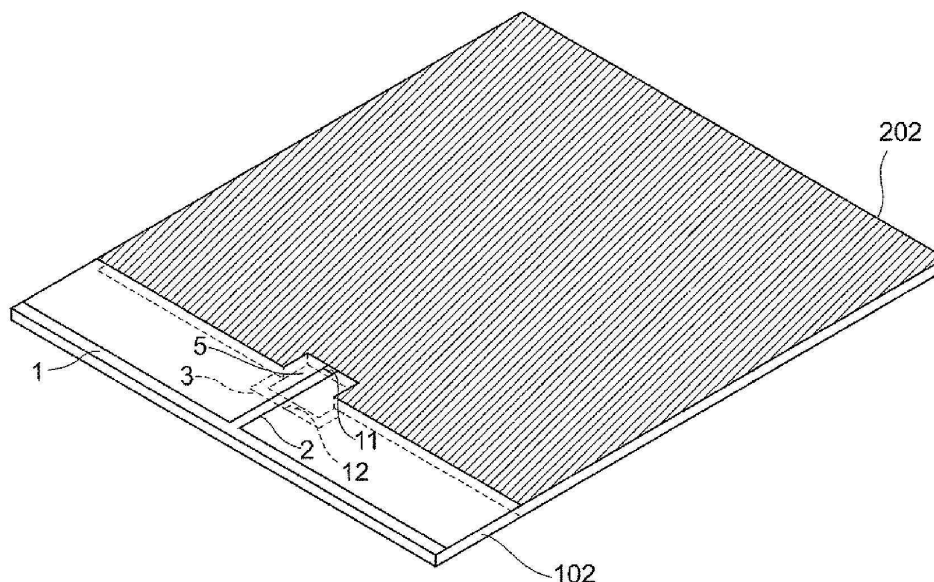
Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — Oliff PLC

(57) **ABSTRACT**

The present invention is to provide an antenna device with the isolation among feedpoints being further improved. In order to achieve this goal, the present invention provides an antenna device provided with a substrate having a ground area, and a first conductor, a second conductor and a third conductor. In the antenna, one end of the second conductor is connected to the ground area via a first feedpoint and the other end of the second conductor is connected to the first conductor. A second feedpoint is included serially in the third conductor at any position. Further, at least part of the third conductor is disposed opposite to the first conductor, and both ends of the third conductor are connected to the ground area.

2 Claims, 9 Drawing Sheets





US009385427B2

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

(10) **Patent No.:** **US 9,385,427 B2**
(45) **Date of Patent:** **Jul. 5, 2016**

(54) **MULTI-BAND ANTENNA AND WIRELESS COMMUNICATION DEVICE EMPLOYING SAME**

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

(72) Inventors: **Yi-Chieh Lee**, 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 157 days.

(21) Appl. No.: **14/087,087**

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

(65) **Prior Publication Data**

US 2014/0354508 A1 Dec. 4, 2014

(30) **Foreign Application Priority Data**

Jun. 3, 2013 (TW) 102119559 A

(51) **Int. Cl.**
H01Q 1/50 (2006.01)
H01Q 5/00 (2015.01)
H01Q 1/48 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/0093** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/0058** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243
USPC 343/860
See application file for complete search history.

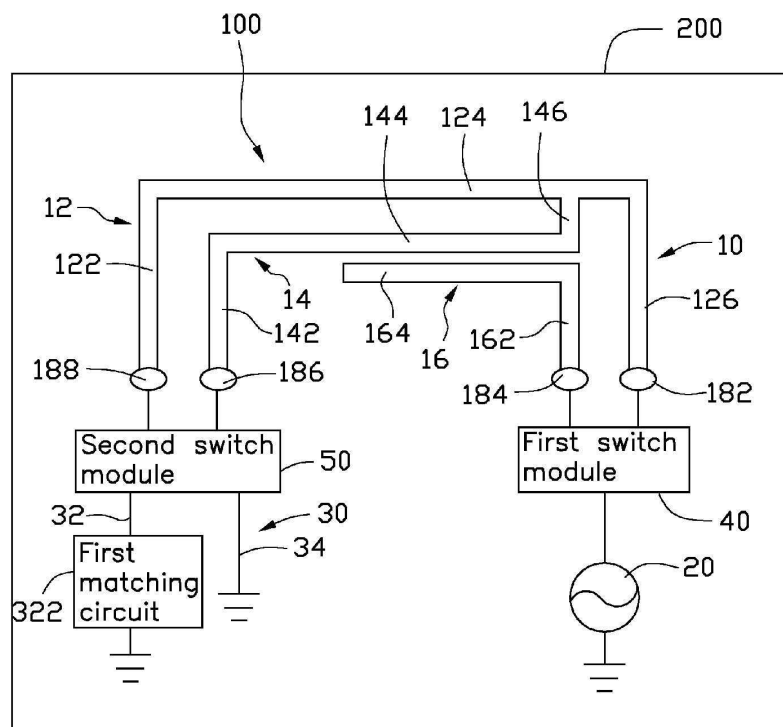
Primary Examiner — Graham Smith

(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

A multi-band antenna includes a radiating portion, a feed portion, a ground portion, a first switch module, and a second switch module. The radiating portion includes a plurality of connecting ends. The ground portion includes two ground sections with different impedances. The first switch module connects the feed portion to a first connecting end or a second connecting end, and the second switch module connects one of the ground sections to a third connecting end or a fourth connecting end. A wireless communication device employing the multi-band antenna is also disclosed.

6 Claims, 2 Drawing Sheets





US009385429B2

**(12) United States Patent
Zhang****(10) Patent No.: US 9,385,429 B2****(45) Date of Patent: Jul. 5, 2016****(54) PENTA-BAND INTERNAL ANTENNA AND
MOBILE COMMUNICATION TERMINAL
THEREOF****(75) Inventor: Lian Zhang**, Guangdong (CN)**(73) Assignee: HUIZHOU TCL MOBILE
COMMUNICATION CO., LTD.**,
Huizhou, Guangdong (CN)**(*) Notice:** Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 368 days.**(21) Appl. No.: 13/816,217****(22) PCT Filed: Nov. 5, 2011****(86) PCT No.: PCT/CN2011/081835**§ 371 (c)(1),
(2), (4) Date: **Feb. 8, 2013****(87) PCT Pub. No.: WO2012/071967**PCT Pub. Date: **Jun. 7, 2012****(65) Prior Publication Data**

US 2013/0141298 A1 Jun. 6, 2013

(30) Foreign Application Priority Data

Dec. 1, 2010 (CN) 2010 1 0568427

(51) Int. Cl.
H01Q 1/24 (2006.01)
H01Q 9/04 (2006.01)
(Continued)**(52) U.S. Cl.**
CPC **H01Q 9/0414** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 1/245** (2013.01); **H01Q 1/48**
(2013.01); **H01Q 5/364** (2015.01); **H01Q 5/385**
(2015.01); **H01Q 9/0421** (2013.01)**(58) Field of Classification Search**CPC H01Q 1/243; H01Q 1/245; H01Q 9/0414;
H01Q 5/0065; H01Q 9/0421; H01Q 5/0055;
H01Q 5/364; H01Q 5/385
USPC 343/700 MS, 702, 725, 767, 770
See application file for complete search history.**(56) References Cited**

U.S. PATENT DOCUMENTS

4,800,392 A * 1/1989 Garay H01Q 1/243
343/700 MS
4,968,984 A * 11/1990 Kato H01Q 1/32
343/713

(Continued)

FOREIGN PATENT DOCUMENTS

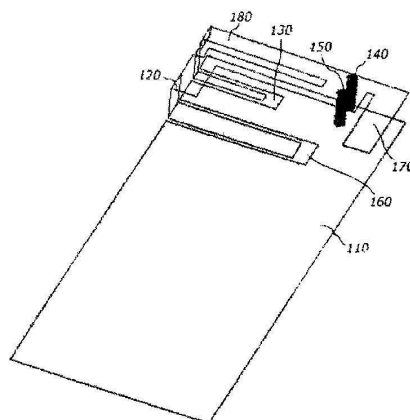
CN 1357163 A 7/2002
CN 1495966 A 5/2004

(Continued)

OTHER PUBLICATIONS

Kin-Lu Wang, Yun-Wen Chi, and Shu Yang Tu, Internal multiband
printed folded slot antenna for mobile phone application, Microwave
and Optical Technology Letters, Aug. 31, 2007, p. 1833-37, vol. 49,
issue 8.

(Continued)

Primary Examiner — Michael C Wimer*(74) Attorney, Agent, or Firm* — Shimokaji IP**(57) ABSTRACT**A penta-band internal antenna and a mobile communication
terminal may include: a first high-frequency branch, a second
high-frequency branch, and a low-frequency branch of an
antenna radiating element, and a first slotted hole and a sec-
ond slotted hole arranged on a printed circuit board. The first
slotted hole may be arranged along a direction substantially
perpendicular to the current flow direction of the printed
circuit board. The open-circuit end of the low-frequency
branch may be fitted into the first slotted hole and the open-
circuit end of the second high-frequency branch may be fitted
into the second slotted hole.**20 Claims, 3 Drawing Sheets**



US009385433B2

(12) **United States Patent**
Stoytchev

(10) **Patent No.:** **US 9,385,433 B2**

(45) **Date of Patent:** **Jul. 5, 2016**

(54) **MULTIBAND HYBRID ANTENNA**

(56) **References Cited**

(71) Applicant: **GALTRONICS CORPORATION LTD.**, Tiberias, IL (US)

U.S. PATENT DOCUMENTS

(72) Inventor: **Marin Stoytchev**, Chandler, AZ (US)

2,719,919	A *	10/1955	Enslein	343/803
3,605,103	A *	9/1971	Simons	343/812
6,094,177	A	7/2000	Yamamoto	
6,323,820	B1	11/2001	Haunberger	
2003/0020656	A1	1/2003	Shor	
2005/0107042	A1	5/2005	De Graauw	
2008/0204343	A1	8/2008	Kildal	
2010/0231462	A1	9/2010	Tran	
2013/0002503	A1 *	1/2013	Tan	343/803

(73) Assignee: **GALTRONICS CORPORATION, LTD.**, Tiberias (IL)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 158 days.

FOREIGN PATENT DOCUMENTS

(21) Appl. No.: **14/168,249**

WO 2014/118784 8/2014
OTHER PUBLICATIONS

(22) Filed: **Jan. 30, 2014**

U.S. Appl. No. 61/758,335, filed Jan. 30, 2013.
An International Search Report and Written Opinion both dated May 13, 2014, which issued during the prosecution of Applicant's PCT/IL2014/050111.

(65) **Prior Publication Data**

US 2014/0210680 A1 Jul. 31, 2014

* cited by examiner

Related U.S. Application Data

Primary Examiner — Jean B Jeanglaude
(74) *Attorney, Agent, or Firm* — Ingrassia Fisher & Lorenz, P.C.

(60) Provisional application No. 61/758,335, filed on Jan. 30, 2013.

(51) **Int. Cl.**
H01Q 9/16 (2006.01)
H01Q 9/26 (2006.01)
H01Q 5/342 (2015.01)
H01Q 5/364 (2015.01)

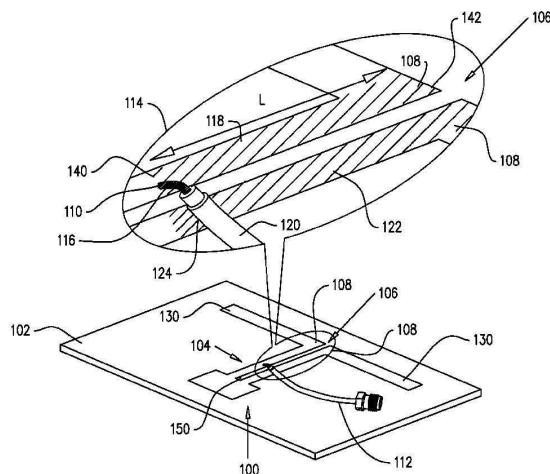
(52) **U.S. Cl.**
CPC **H01Q 9/26** (2013.01); **H01Q 5/342** (2015.01); **H01Q 5/364** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 9/26; H01Q 5/342; H01Q 5/364
USPC 343/803, 812, 806
See application file for complete search history.

(57) **ABSTRACT**

An antenna including a high band generating assembly having a first end and a second end, the high band generating assembly including a feed point and a bifurcated conductive element coupled to the feed point and having an angularly bent tip, the feed point defining the first end of the high band generating assembly, the angularly bent tip defining the second end of the high band generating assembly, at least one low band generating assembly, the at least one low band generating assembly including the high band generating assembly and at least one pair of dipole arms extending from the bifurcated conductive element, and a balun portion coupled to the feed point.

21 Claims, 9 Drawing Sheets





US009391362B1

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

(10) **Patent No.:** **US 9,391,362 B1**
(45) **Date of Patent:** **Jul. 12, 2016**

(54) **CONFIGURABLE ANTENNA**

(71) Applicant: **AMAZON TECHNOLOGIES, INC.**,
Reno, NV (US)

(72) Inventors: **Cheol Su Kim**, San Jose, CA (US); **In Chul Hyun**, San Jose, CA (US);
Tzung-I Lee, San Jose, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 325 days.

(21) Appl. No.: **13/764,217**

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

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

(52) **U.S. Cl.**
CPC **H01Q 1/36** (2013.01)

(58) **Field of Classification Search**
CPC . H01Q 1/2258; H01Q 1/2266; H01Q 1/2275;
H01Q 1/2291; H01Q 1/241; H01Q 1/242;
H01Q 1/38; H01Q 5/314; H01Q 5/321;
H01Q 5/328; H01Q 5/364; H01Q 5/371;
H01Q 5/378; H01Q 5/392; H01Q 5/40;
H01Q 9/30; H01Q 9/42
USPC 343/700 MS, 702, 724, 833, 834, 850,
343/860, 876

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,420,599	A *	5/1995	Erkocevic	343/828
7,129,907	B2 *	10/2006	Lin et al.	343/876
7,760,150	B2 *	7/2010	Sato	343/724

OTHER PUBLICATIONS

Koo, Gwan-Bon, "Application Note: AN-4147 Design Guidelines for RCD Snubber of Flyback Converters," Fairchild Semiconductor (2006).

* cited by examiner

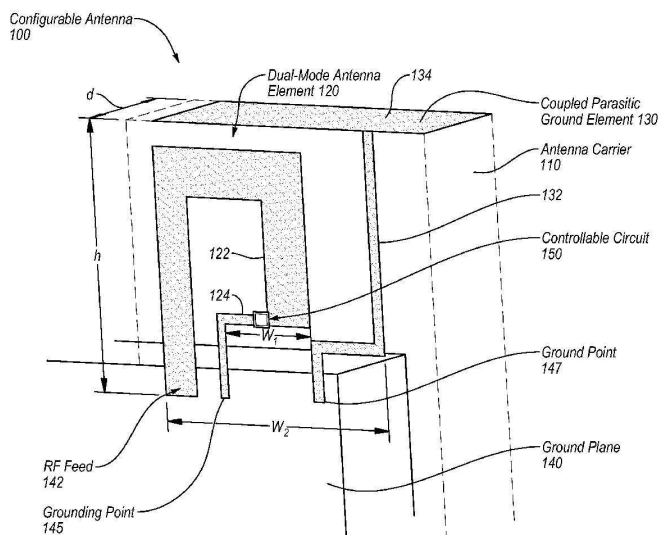
Primary Examiner — Michael C Wimer

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

(57) **ABSTRACT**

Antenna structures and methods of operating the same of a configurable antenna of an electronic device are described. A configurable antenna includes a first antenna element coupled to a radio frequency (RF) feed, a controllable circuit coupled to the first antenna element and a second antenna element coupled to the controllable circuit. The controllable circuit is configured to electrically isolate the first antenna element and the second antenna element to configure the antenna structure to operate in a first antenna configuration having a first length and to electrically connect the first antenna element and the second antenna element to configure the antenna structure to operate in a second antenna configuration having a second length.

23 Claims, 8 Drawing Sheets





US009391364B2

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

(10) **Patent No.:** **US 9,391,364 B2**
(45) **Date of Patent:** **Jul. 12, 2016**

(54) **MOBILE COMMUNICATION DEVICE WITH
IMPROVED ANTENNA PERFORMANCE**

(75) Inventors: **Pekka Ikonen**, Espoo (FI); **Juha Ellä**,
Halikko (FI)

(73) Assignee: **EPCOS AG**, Munich (DE)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 556 days.

(21) Appl. No.: **13/885,671**

(22) PCT Filed: **Nov. 25, 2010**

(86) PCT No.: **PCT/EP2010/068225**

§ 371 (c)(1),
(2), (4) Date: **Aug. 1, 2013**

(87) PCT Pub. No.: **WO2012/069086**

PCT Pub. Date: **May 31, 2012**

(65) **Prior Publication Data**

US 2014/0009360 A1 Jan. 9, 2014

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/50 (2006.01)
H01Q 1/52 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/50** (2013.01); **H01Q 1/242**
(2013.01); **H01Q 1/521** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/242; H01Q 1/50; H01Q 1/521
USPC 343/700 MS, 702, 850, 852, 853, 876,
343/725

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,924,237 A * 5/1990 Honda H01Q 1/243
343/702
5,784,032 A * 7/1998 Johnston H01Q 1/243
343/702
6,731,920 B1 5/2004 Iwai et al.
6,985,113 B2 1/2006 Nishimura et al.
7,116,271 B2 10/2006 Kostanic et al.
7,162,284 B2 1/2007 Kobayashi et al.
7,180,464 B2 * 2/2007 Chiang H01Q 1/242
343/702
7,505,001 B2 * 3/2009 Deavours G06K 19/07749
340/572.7
7,505,006 B2 3/2009 Ollikainen et al.
7,528,783 B2 5/2009 Takagi

(Continued)

FOREIGN PATENT DOCUMENTS

DE 10 2009 004 720 A1 7/2010
DE 10201001411 A1 9/2011

(Continued)

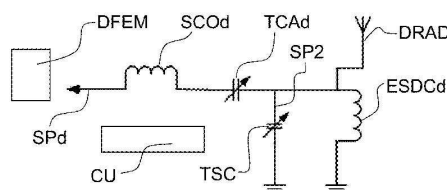
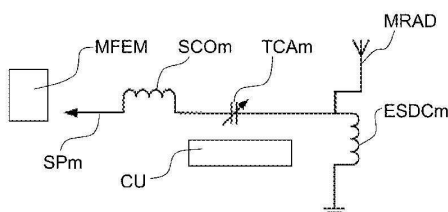
Primary Examiner — Tho G Phan

(74) Attorney, Agent, or Firm — McDermott Will & Emery
LLP

(57) **ABSTRACT**

The present invention concerns a mobile communication device comprising a ground plane, a main antenna comprising a main radiator (MRAD) that can couple electromagnetically to the ground plane and to a first signal path (SPm), a diversity antenna comprising a diversity radiator (DRAD), a reconfigurable input matching circuit that couples the diversity radiator (DRAD) to the ground plane and to a second signal path (SPd), and a control unit (CU) coupled to the reconfigurable input matching circuit and adapted to change the coupling of the diversity radiator (DRAD) to the ground plane during operation. The present invention further concerns to a method to enhance the performance of the device.

15 Claims, 3 Drawing Sheets





US009391371B2

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

(10) **Patent No.:** **US 9,391,371 B2**

(45) **Date of Patent:** **Jul. 12, 2016**

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

(71) Applicants: **TDK Corporation**, Tokyo (JP); **TDK Dalian Corporation**, Liaoning (CN)

(72) Inventors: **Tetsuzo Goto**, Tokyo (JP); **Naoaki Utagawa**, Tokyo (JP); **Yongshuai Zheng**, Liaoning (CN)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 114 days.

(21) Appl. No.: **14/445,792**

(22) Filed: **Jul. 29, 2014**

(65) **Prior Publication Data**

US 2015/0035713 A1 Feb. 5, 2015

(30) **Foreign Application Priority Data**

Aug. 5, 2013 (JP) 2013-162455

(51) **Int. Cl.**
H01Q 9/00 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/50 (2015.01)
H01Q 1/38 (2006.01)

(52) **U.S. Cl.**
CPC . **H01Q 9/42** (2013.01); **H01Q 5/50** (2015.01);
H01Q 1/38 (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0407; H01Q 5/50; H01Q 9/42;
H01Q 1/38
USPC 343/745, 749, 750, 700 MS
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,969,680 A *	10/1999	Tsuru	.....	H01Q 9/0421	343/700 MS
8,212,731 B2 *	7/2012	Bungo	.....	H01Q 1/243	343/700 MS
8,279,121 B2 *	10/2012	Ishizuka	.....	H01Q 1/243	343/700 MS
2010/0103057 A1 *	4/2010	Harihara	.....	H01Q 1/243	343/702
2011/0102268 A1	5/2011	Watanabe et al.	.....		
2013/0088398 A1 *	4/2013	Utagawa	.....	H01Q 1/38	343/745

FOREIGN PATENT DOCUMENTS

JP	2008-252506	10/2008
JP	4973700	2/2011

* cited by examiner

Primary Examiner — Dameon E Levi

Assistant Examiner — Hasan Islam

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

(57) **ABSTRACT**

An antenna device 1 has a capacitive coupling element 10 mounted on a printed circuit board 20. Strip patterns 21 to 23 are provided in a grand clearance region 20A defined on one principal surface of the printed circuit board 20. The strip pattern 21 is connected to a feeding line 29 after extending in a first direction from the connecting point with the capacitive coupling element 10. The strip pattern 22 is connected to a feeding line 30 after extending in a second direction, that is an opposite to the first direction, from the connecting point. The strip pattern 23 is connected to a ground pattern 24 after extending in a third direction from the connecting point. The capacitive coupling element 10 is disposed with an offset toward the first direction. The strip pattern 21 is shorter in length than the strip pattern 22.

7 Claims, 11 Drawing Sheets

