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(54) **SYSTEMS AND METHODS FOR CONTROLLING COMMUNICATIONS DURING WIRELESS TRANSMISSION OF POWER USING APPLICATION PROGRAMMING INTERFACES**

(71) Applicant: **Energous Corporation**, Pleasanton, CA (US)

(72) Inventors: **Douglas Bell**, Pleasanton, CA (US); **Michael Leabman**, San Ramon, CA (US)

(73) Assignee: **Energous Corporation**, San Jose, CA (US)

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(56) **References Cited**

U.S. PATENT DOCUMENTS

787,412 A 4/1905 Tesla
3,167,775 A 1/1965 Guertler
(Continued)

FOREIGN PATENT DOCUMENTS

CN 203826555 U 9/2014
CN 104090265 A 10/2014
(Continued)

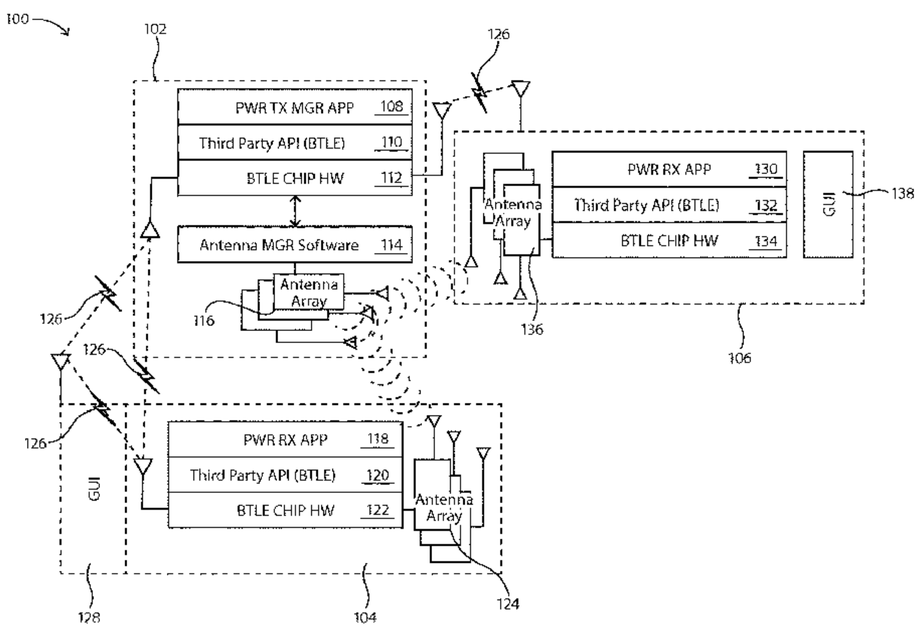
OTHER PUBLICATIONS

International Search Report dated Sep. 12, 2014 corresponding to International Patent Application No. PCT/US2014/037072, 3 pages.
(Continued)

Primary Examiner — Thomas J Hiltunen
(74) *Attorney, Agent, or Firm* — Morgan, Lewis & Bockius LLP

(57) **ABSTRACT**

An example system includes: a wireless power transmitter with (i) a processor running a power transmitter manager application; (ii) a wireless communication hardware having a transmitter application programming interface (API), the transmitter API operatively coupled with the power transmitter manager application and controlling the wireless communication hardware; and (iii) a transmitter antenna array that creates pockets of energy near a wireless power receiver, and the transmitter antenna array is partially responsive to instructions from the power transmitter manager application. The transmitter API calls the power transmitter manager application through a transmitter callback function, and the transmitter callback function sends a callback when a communication connection begins, a communication connection ends, a communication connection is attempted, or a message is received. The system also includes the wireless power receiver: running a power receiver application and including receiver wireless antenna
(Continued)



array that receives and uses wireless power from the pockets of energy.

19 Claims, 2 Drawing Sheets

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(56) **References Cited**

U.S. PATENT DOCUMENTS

3,434,678	A	3/1969	Brown et al.	
3,696,384	A	10/1972	Lester	
3,754,269	A	8/1973	Clavin	
4,101,895	A	7/1978	Jones, Jr.	
4,360,741	A	11/1982	Fitzsimmons et al.	
4,944,036	A	7/1990	Hyatt	
4,995,010	A	2/1991	Knight	
5,200,759	A	4/1993	McGinnis	
5,211,471	A	5/1993	Rohrs	
5,548,292	A	8/1996	Hirshfield et al.	
5,556,749	A	9/1996	Mitsuhashi et al.	
5,568,088	A	10/1996	Dent et al.	
5,646,633	A	7/1997	Dahlberg	
5,697,063	A	12/1997	Kishigami et al.	
5,712,642	A	1/1998	Hulderman	
5,936,527	A	8/1999	Isaacman et al.	
5,982,139	A	11/1999	Parise	
6,046,708	A	4/2000	MacDonald, Jr. et al.	
6,127,799	A	10/2000	Krishnan	
6,127,942	A	10/2000	Welle	
6,163,296	A	12/2000	Lier et al.	
6,289,237	B1	9/2001	Mickle et al.	
6,329,908	B1	12/2001	Frecska	
6,421,235	B2	7/2002	Ditzik	
6,437,685	B2	8/2002	Hanaki	
6,456,253	B1	9/2002	Rummeli et al.	
6,476,795	B1	11/2002	Derocher et al.	
6,501,414	B2	12/2002	Amdt et al.	
6,583,723	B2	6/2003	Watanabe et al.	
6,597,897	B2	7/2003	Tang	
6,615,074	B2	9/2003	Mickle et al.	
6,650,376	B1	11/2003	Obitsu	
6,664,920	B1	12/2003	Mott et al.	
6,798,716	B1	9/2004	Charych	
6,803,744	B1	10/2004	Sabo	
6,853,197	B1	2/2005	McFarland	
6,856,291	B2	2/2005	Mickle et al.	
6,911,945	B2	6/2005	Korva	
6,960,968	B2	11/2005	Odendaal et al.	
6,967,462	B1 *	11/2005	Landis	H02J 17/00 320/101
6,988,026	B2	1/2006	Breed et al.	
7,003,350	B2	2/2006	Denker et al.	
7,027,311	B2	4/2006	Vanderelli et al.	
7,068,234	B2	6/2006	Sievenpiper	
7,068,991	B2	6/2006	Parise	
7,183,748	B1	2/2007	Unno et al.	
7,191,013	B1	3/2007	Miranda et al.	
7,196,663	B2	3/2007	Bolzer et al.	
7,205,749	B2	4/2007	Hagen et al.	
7,222,356	B1	5/2007	Yonezawa et al.	
7,274,334	B2	9/2007	o'Riordan et al.	
7,274,336	B2	9/2007	Carson	
7,351,975	B2	4/2008	Brady et al.	
7,359,730	B2	4/2008	Dennis et al.	
7,392,068	B2	6/2008	Dayan	
7,403,803	B2	7/2008	Mickle et al.	
7,443,057	B2	10/2008	Nunally	
7,451,839	B2	11/2008	Perlman	
7,463,201	B2	12/2008	Chiang et al.	
7,471,247	B2	12/2008	Saily	
7,535,195	B1	5/2009	Horovitz et al.	
7,614,556	B2	11/2009	Overhultz et al.	
7,639,994	B2	12/2009	Greene et al.	
7,643,312	B2	1/2010	Vanderelli et al.	
7,652,577	B1	1/2010	Madhow et al.	
7,679,576	B2	3/2010	Riedel et al.	
7,702,771	B2	4/2010	Ewing et al.	
7,786,419	B2	8/2010	Hyde et al.	
7,812,771	B2	10/2010	Greene et al.	
7,830,312	B2	11/2010	Choudhury et al.	
7,844,306	B2	11/2010	Shearer et al.	
7,868,482	B2	1/2011	Greene et al.	
7,898,105	B2	3/2011	Greene et al.	
7,904,117	B2	3/2011	Doan et al.	
7,911,386	B1	3/2011	Ito et al.	
7,925,308	B2	4/2011	Greene et al.	
7,948,208	B2	5/2011	Partovi et al.	
8,055,003	B2	11/2011	Mittleman et al.	
8,070,595	B2	12/2011	Alderucci et al.	
8,072,380	B2	12/2011	Crouch	
8,092,301	B2	1/2012	Alderucci et al.	
8,099,140	B2	1/2012	Arai	
8,115,448	B2	2/2012	John	
8,159,090	B2	4/2012	Greene et al.	
8,159,364	B2	4/2012	Zeine	
8,180,286	B2 *	5/2012	Yamasuge	H04B 5/0037 307/104
8,228,194	B2	7/2012	Mickle	
8,234,509	B2	7/2012	Gioscia et al.	
8,264,101	B2	9/2012	Hyde et al.	
8,264,291	B2	9/2012	Morita	
8,276,325	B2	10/2012	Clifton et al.	
8,278,784	B2	10/2012	Cook et al.	
8,284,101	B2	10/2012	Fusco	
8,310,201	B1	11/2012	Wright	
8,338,991	B2	12/2012	Von Novak et al.	
8,362,745	B2	1/2013	Tinaphong	
8,380,255	B2	2/2013	Shearer et al.	
8,410,953	B2	4/2013	Zeine	
8,411,963	B2	4/2013	Luff	
8,432,062	B2	4/2013	Greene et al.	
8,432,071	B2	4/2013	Huang et al.	
8,446,248	B2	5/2013	Zeine	
8,447,234	B2	5/2013	Cook et al.	
8,451,189	B1	5/2013	Fluhler	
8,452,235	B2	5/2013	Kirby et al.	
8,457,656	B2	6/2013	Perkins et al.	
8,461,817	B2	6/2013	Martin et al.	
8,467,733	B2	6/2013	Leabman	
8,497,601	B2	7/2013	Hall et al.	
8,497,658	B2	7/2013	Von Novak et al.	
8,552,597	B2	10/2013	Song et al.	
8,558,661	B2	10/2013	Zeine	
8,560,026	B2	10/2013	Chanterac	
8,604,746	B2	12/2013	Lee	
8,614,643	B2	12/2013	Leabman	
8,621,245	B2	12/2013	Shearer et al.	
8,626,249	B2 *	1/2014	Ungari	H02J 7/00 235/492
8,629,576	B2	1/2014	Levine	
8,653,966	B2	2/2014	Rao et al.	
8,674,551	B2	3/2014	Low et al.	
8,686,685	B2	4/2014	Moshfeghi	
8,712,355	B2	4/2014	Black et al.	
8,712,485	B2	4/2014	Tam	
8,718,773	B2	5/2014	Wills et al.	
8,729,737	B2	5/2014	Schatz et al.	
8,736,228	B1	5/2014	Freed et al.	
8,760,113	B2	6/2014	Keating	
8,770,482	B2	7/2014	Ackermann et al.	
8,772,960	B2	7/2014	Yoshida	
8,823,319	B2	9/2014	Von Novak, III et al.	

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,832,646	B1	9/2014	Wendling	
8,854,176	B2	10/2014	Zeine	
8,860,364	B2	10/2014	Low et al.	
8,897,770	B1	11/2014	Frolov et al.	
8,903,456	B2	12/2014	Chu et al.	
8,917,057	B2	12/2014	Hui	
8,923,189	B2	12/2014	Leabman	
8,928,544	B2	1/2015	Massie et al.	
8,937,408	B2	1/2015	Ganem et al.	
8,946,940	B2	2/2015	Kim et al.	
8,963,486	B2	2/2015	Kirby et al.	
8,970,070	B2	3/2015	Sada et al.	
8,989,053	B1	3/2015	Skaaksrud et al.	
9,000,616	B2	4/2015	Greene et al.	
9,001,622	B2	4/2015	Perry	
9,006,934	B2	4/2015	Kozakai et al.	
9,021,277	B2	4/2015	Shearer et al.	
9,030,161	B2	5/2015	Lu et al.	
9,059,598	B2	6/2015	Kang et al.	
9,059,599	B2	6/2015	Won et al.	
9,077,188	B2 *	7/2015	Moshfeghi	H02J 7/0027
9,083,595	B2	7/2015	Rakib et al.	
9,088,216	B2	7/2015	Garrity et al.	
9,124,125	B2	9/2015	Leabman et al.	
9,130,397	B2	9/2015	Leabman et al.	
9,130,602	B2	9/2015	Cook	
9,142,998	B2	9/2015	Yu et al.	
9,143,000	B2	9/2015	Leabman et al.	
9,143,010	B2	9/2015	Urano	
9,178,389	B2	11/2015	Hwang	
9,225,196	B2	12/2015	Huang et al.	
9,240,469	B2 *	1/2016	Sun	H01L 29/7394
9,242,411	B2	1/2016	Kritchman et al.	
9,244,500	B2	1/2016	Cain et al.	
9,252,628	B2	2/2016	Leabman et al.	
9,270,344	B2	2/2016	Rosenberg	
9,282,582	B1	3/2016	Dunsbergen et al.	
9,294,840	B1	3/2016	Anderson et al.	
9,297,896	B1	3/2016	Andrews	
9,318,898	B2	4/2016	John	
9,368,020	B1	6/2016	Bell et al.	
9,401,977	B1	7/2016	Gaw	
9,409,490	B2	8/2016	Kawashima	
9,438,045	B1	9/2016	Leabman	
9,438,046	B1	9/2016	Leabman	
9,444,283	B2	9/2016	Son et al.	
9,450,449	B1	9/2016	Leabman et al.	
9,461,502	B2	10/2016	Lee et al.	
9,520,725	B2	12/2016	Masaoka et al.	
9,520,748	B2	12/2016	Hyde et al.	
9,522,270	B2	12/2016	Perryman et al.	
9,537,354	B2	1/2017	Bell et al.	
9,537,357	B2	1/2017	Leabman	
9,537,358	B2	1/2017	Leabman	
9,538,382	B2	1/2017	Bell et al.	
9,544,640	B2	1/2017	Lau	
9,559,553	B2	1/2017	Bae	
9,564,773	B2	2/2017	Pogorelik et al.	
9,571,974	B2	2/2017	Choi et al.	
9,590,317	B2	3/2017	Zimmerman et al.	
9,590,444	B2	3/2017	Walley	
9,620,996	B2	4/2017	Zeine	
9,647,328	B2	5/2017	Dobric	
9,711,999	B2 *	7/2017	Hietala	H02J 50/10
9,723,635	B2	8/2017	Nambord et al.	
9,793,758	B2	10/2017	Leabman	
9,793,764	B2	10/2017	Perry	
9,806,564	B2	10/2017	Leabman	
9,819,230	B2	11/2017	Petras et al.	
9,866,279	B2	1/2018	Bell et al.	
2001/0027876	A1	10/2001	Tsukamoto et al.	
2002/0001307	A1	1/2002	Nguyen et al.	
2002/0024471	A1	2/2002	Ishitobi	
2002/0028655	A1	3/2002	Rosener et al.	
2002/0034958	A1	3/2002	Oberschmidt et al.	
2002/0054330	A1	5/2002	Jinbo et al.	
2002/0065052	A1	5/2002	Pande et al.	
2002/0072784	A1	6/2002	Sheppard et al.	
2002/0095980	A1	7/2002	Breed et al.	
2002/0103447	A1	8/2002	Terry	
2002/0133592	A1	9/2002	Matsuda	
2002/0172223	A1	11/2002	Stilp	
2003/0005759	A1	1/2003	Breed et al.	
2003/0058187	A1	3/2003	Billiet et al.	
2003/0076274	A1	4/2003	Phelan et al.	
2003/0179152	A1	9/2003	Watada et al.	
2003/0179573	A1	9/2003	Chun	
2003/0192053	A1	10/2003	Sheppard et al.	
2004/0019624	A1	1/2004	Sukegawa	
2004/0020100	A1	2/2004	O'Brian et al.	
2004/0036657	A1	2/2004	Forster et al.	
2004/0066251	A1	4/2004	Eleftheriades et al.	
2004/0107641	A1	6/2004	Walton et al.	
2004/0113543	A1	6/2004	Daniels	
2004/0119675	A1	6/2004	Washio et al.	
2004/0130425	A1	7/2004	Dayan et al.	
2004/0130442	A1	7/2004	Breed	
2004/0142733	A1	7/2004	Parise	
2004/0145342	A1	7/2004	Lyon	
2004/0196190	A1	10/2004	Mendolia et al.	
2004/0203979	A1	10/2004	Attar et al.	
2004/0207559	A1	10/2004	Milosavljevic	
2004/0218759	A1	11/2004	Yacobi	
2004/0259604	A1	12/2004	Mickle et al.	
2004/0263124	A1	12/2004	Wieck et al.	
2005/0007276	A1	1/2005	Barrick et al.	
2005/0030118	A1	2/2005	Wang	
2005/0046584	A1	3/2005	Breed	
2005/0055316	A1	3/2005	Williams	
2005/0093766	A1	5/2005	Turner	
2005/0116683	A1	6/2005	Cheng	
2005/0117660	A1	6/2005	Vialle et al.	
2005/0134517	A1	6/2005	Gottl	
2005/0171411	A1	8/2005	KenKnight	
2005/0198673	A1	9/2005	Kit et al.	
2005/0227619	A1	10/2005	Lee et al.	
2005/0232469	A1	10/2005	Schofield	
2005/0237249	A1	10/2005	Nagel	
2005/0237258	A1	10/2005	Abramov et al.	
2005/0282591	A1	12/2005	Shaff	
2006/0013335	A1	1/2006	Leabman	
2006/0019712	A1	1/2006	Choi	
2006/0030279	A1	2/2006	Leabman et al.	
2006/0033674	A1	2/2006	Essig, Jr. et al.	
2006/0071308	A1	4/2006	Tang et al.	
2006/0092079	A1	5/2006	de Rochemont	
2006/0094425	A1	5/2006	Mickle et al.	
2006/0113955	A1	6/2006	Nunally	
2006/0119532	A1	6/2006	Yun et al.	
2006/0136004	A1	6/2006	Cowan et al.	
2006/0160517	A1	7/2006	Yoon	
2006/0183473	A1	8/2006	Ukon	
2006/0190063	A1	8/2006	Kanzius	
2006/0192913	A1	8/2006	Shutou et al.	
2006/0199620	A1	9/2006	Greene et al.	
2006/0238365	A1	10/2006	Vecchione et al.	
2006/0266564	A1	11/2006	Perlman et al.	
2006/0266917	A1	11/2006	Baldis et al.	
2006/0278706	A1	12/2006	Hatakayama et al.	
2006/0284593	A1	12/2006	Nagy et al.	
2006/0287094	A1	12/2006	Mahaffey et al.	
2007/0007821	A1	1/2007	Rossetti	
2007/0019693	A1	1/2007	Graham	
2007/0021140	A1	1/2007	Keyes	
2007/0060185	A1	3/2007	Simon et al.	
2007/0070490	A1	3/2007	Tsunoda et al.	
2007/0090997	A1	4/2007	Brown et al.	
2007/0093269	A1	4/2007	Leabman et al.	
2007/0097653	A1	5/2007	Gilliland et al.	
2007/0103110	A1	5/2007	Sagoo	
2007/0106894	A1	5/2007	Zhang	
2007/0109121	A1	5/2007	Cohen	
2007/0139000	A1	6/2007	Kozuma	
2007/0149162	A1	6/2007	Greene et al.	

(56) **References Cited**

U.S. PATENT DOCUMENTS

2007/0164868	A1	7/2007	Deavours et al.	
2007/0173196	A1	7/2007	Gallic	
2007/0173214	A1	7/2007	Mickle et al.	
2007/0178857	A1	8/2007	Greene et al.	
2007/0178945	A1	8/2007	Cook et al.	
2007/0182367	A1	8/2007	Partovi	
2007/0191074	A1	8/2007	Harrist et al.	
2007/0191075	A1	8/2007	Greene et al.	
2007/0197281	A1	8/2007	Stronach	
2007/0210960	A1	9/2007	Rofougaran et al.	
2007/0222681	A1	9/2007	Greene et al.	
2007/0257634	A1	11/2007	Leschin et al.	
2007/0273486	A1	11/2007	Shiotsu	
2007/0296639	A1	12/2007	Hook et al.	
2007/0298846	A1	12/2007	Greene et al.	
2008/0014897	A1	1/2008	Cook et al.	
2008/0024376	A1	1/2008	Norris et al.	
2008/0048917	A1	2/2008	Achour et al.	
2008/0062062	A1	3/2008	Borau et al.	
2008/0062255	A1	3/2008	Gal	
2008/0067874	A1	3/2008	Tseng	
2008/0074324	A1	3/2008	Puzella et al.	
2008/0089277	A1	4/2008	Aledander et al.	
2008/0110263	A1	5/2008	Klessel et al.	
2008/0113816	A1	5/2008	Mahaffey et al.	
2008/0122297	A1	5/2008	Arai	
2008/0123383	A1	5/2008	Shionoiri	
2008/0129536	A1	6/2008	Randall et al.	
2008/0140278	A1	6/2008	Breed	
2008/0169910	A1	7/2008	Greene et al.	
2008/0197802	A1	8/2008	Onishi	
2008/0204342	A1	8/2008	Kharadly	
2008/0204350	A1	8/2008	Tam et al.	
2008/0210762	A1	9/2008	Osada et al.	
2008/0211458	A1	9/2008	Lawther et al.	
2008/0233890	A1	9/2008	Baker	
2008/0248758	A1	10/2008	Schedelbeck et al.	
2008/0248846	A1	10/2008	Stronach et al.	
2008/0258993	A1	10/2008	Gummalla et al.	
2008/0266191	A1	10/2008	Hilgers	
2008/0278378	A1	11/2008	Chang et al.	
2008/0309452	A1	12/2008	Zeine	
2009/0002493	A1	1/2009	Kates	
2009/0019183	A1	1/2009	Wu et al.	
2009/0036065	A1	2/2009	Siu	
2009/0047998	A1	2/2009	Alberth, Jr.	
2009/0058354	A1	3/2009	Harrison	
2009/0058361	A1	3/2009	John	
2009/0058731	A1	3/2009	Geary et al.	
2009/0067208	A1	3/2009	Martin et al.	
2009/0096412	A1	4/2009	Huang	
2009/0096413	A1	4/2009	Partovi	
2009/0102292	A1	4/2009	Cook et al.	
2009/0102296	A1	4/2009	Greene et al.	
2009/0108679	A1	4/2009	Porwal	
2009/0122847	A1	5/2009	Nysen et al.	
2009/0128262	A1	5/2009	Lee et al.	
2009/0157911	A1	6/2009	Aihara	
2009/0200985	A1	8/2009	Zane et al.	
2009/0206791	A1	8/2009	Jung	
2009/0207090	A1	8/2009	Pettus et al.	
2009/0207092	A1	8/2009	Nysen et al.	
2009/0218884	A1	9/2009	Soar	
2009/0218891	A1	9/2009	McCollough	
2009/0219903	A1	9/2009	Alamouti et al.	
2009/0243397	A1	10/2009	Cook et al.	
2009/0264069	A1	10/2009	Yamasuge	
2009/0280866	A1	11/2009	Lo et al.	
2009/0281678	A1	11/2009	Wakamatsu	
2009/0284082	A1	11/2009	Mohammadian	
2009/0284083	A1	11/2009	Karalis et al.	
2009/0284220	A1	11/2009	Toncich et al.	
2009/0284227	A1	11/2009	Mohammadian et al.	
2009/0284325	A1	11/2009	Rossiter et al.	
2009/0286475	A1	11/2009	Toncich et al.	
2009/0291634	A1	11/2009	Saarisalo	
2009/0299175	A1	12/2009	Bernstein et al.	
2009/0312046	A1	12/2009	Clevenger et al.	
2009/0315412	A1	12/2009	Yamamoto et al.	
2009/0322281	A1	12/2009	Kamijo et al.	
2010/0001683	A1	1/2010	Huang et al.	
2010/0007307	A1	1/2010	Baarman et al.	
2010/0007569	A1	1/2010	Sim et al.	
2010/0019686	A1	1/2010	Gutierrez, Jr.	
2010/0019908	A1	1/2010	Cho et al.	
2010/0026605	A1	2/2010	Yang et al.	
2010/0027379	A1	2/2010	Saulnier et al.	
2010/0029383	A1	2/2010	Dai	
2010/0033021	A1*	2/2010	Bennett	H02J 17/00 307/104
2010/0033390	A1	2/2010	Alamouti et al.	
2010/0034238	A1	2/2010	Bennett	
2010/0041453	A1	2/2010	Grimm, Jr.	
2010/0044123	A1	2/2010	Perlman et al.	
2010/0054200	A1	3/2010	Tsai	
2010/0060534	A1	3/2010	Oodachi	
2010/0066631	A1	3/2010	Puzella et al.	
2010/0075607	A1	3/2010	Hosoya	
2010/0079005	A1	4/2010	Hyde et al.	
2010/0082193	A1	4/2010	Chiappetta	
2010/0087227	A1	4/2010	Francos et al.	
2010/0090524	A1	4/2010	Obayashi	
2010/0090656	A1	4/2010	Shearer et al.	
2010/0109443	A1	5/2010	Cook et al.	
2010/0117926	A1	5/2010	DeJean, II	
2010/0119234	A1	5/2010	Suematsu et al.	
2010/0123618	A1	5/2010	Martin et al.	
2010/0123624	A1	5/2010	Minear et al.	
2010/0127660	A1	5/2010	Cook et al.	
2010/0142418	A1	6/2010	Nishioka et al.	
2010/0142509	A1	6/2010	Zhu et al.	
2010/0148723	A1	6/2010	Cook et al.	
2010/0151808	A1	6/2010	Toncich et al.	
2010/0156721	A1	6/2010	Alamouti et al.	
2010/0156741	A1	6/2010	Vazquez et al.	
2010/0164296	A1	7/2010	Kurs et al.	
2010/0164433	A1	7/2010	Janefalker et al.	
2010/0171461	A1	7/2010	Baarman et al.	
2010/0174629	A1	7/2010	Taylor et al.	
2010/0176934	A1	7/2010	Chou et al.	
2010/0181961	A1	7/2010	Novak et al.	
2010/0181964	A1	7/2010	Huggins et al.	
2010/0194206	A1	8/2010	Burdo et al.	
2010/0201189	A1	8/2010	Kirby et al.	
2010/0201201	A1	8/2010	Mobarhan et al.	
2010/0201314	A1	8/2010	Toncich et al.	
2010/0207572	A1	8/2010	Kirby et al.	
2010/0210233	A1	8/2010	Cook et al.	
2010/0213895	A1	8/2010	Keating et al.	
2010/0214177	A1	8/2010	Parsche	
2010/0225270	A1	9/2010	Jacobs et al.	
2010/0227570	A1	9/2010	Hendin	
2010/0231470	A1	9/2010	Lee et al.	
2010/0237709	A1	9/2010	Hall et al.	
2010/0244576	A1	9/2010	Hillan et al.	
2010/0256831	A1	10/2010	Abramo et al.	
2010/0259110	A1	10/2010	Kurs et al.	
2010/0259447	A1	10/2010	Crouch	
2010/0264747	A1	10/2010	Hall et al.	
2010/0277003	A1	11/2010	Von Novak et al.	
2010/0277121	A1	11/2010	Hall et al.	
2010/0279606	A1	11/2010	Hillan et al.	
2010/0289341	A1	11/2010	Ozaki et al.	
2010/0295372	A1	11/2010	Hyde et al.	
2010/0308767	A1	12/2010	Rofougaran et al.	
2010/0309079	A1	12/2010	Rofougaran et al.	
2010/0309088	A1	12/2010	Hyvonen et al.	
2010/0315045	A1	12/2010	Zeine	
2010/0316163	A1	12/2010	Forenza et al.	
2010/0327766	A1	12/2010	Recker et al.	
2010/0328044	A1	12/2010	Waffenschmidt et al.	
2010/0332401	A1	12/2010	Prahlad et al.	
2011/0013198	A1	1/2011	Shirley	
2011/0018360	A1	1/2011	Baarman et al.	

(56) **References Cited**

U.S. PATENT DOCUMENTS

2011/0028114	A1	2/2011	Kerselaers	
2011/0031928	A1	2/2011	Soar	
2011/0032149	A1	2/2011	Leabman	
2011/0032866	A1	2/2011	Leabman	
2011/0034190	A1	2/2011	Leabman	
2011/0034191	A1	2/2011	Leabman	
2011/0043047	A1	2/2011	Karalis et al.	
2011/0043163	A1	2/2011	Baarman et al.	
2011/0043327	A1	2/2011	Baarman et al.	
2011/0050166	A1	3/2011	Cook et al.	
2011/0055037	A1	3/2011	Hayashigawa et al.	
2011/0056215	A1	3/2011	Ham	
2011/0057607	A1	3/2011	Carobolante	
2011/0062788	A1	3/2011	Chen et al.	
2011/0074342	A1	3/2011	MacLaughlin	
2011/0074349	A1	3/2011	Ghovanloo	
2011/0074620	A1	3/2011	Wintermantel	
2011/0078092	A1	3/2011	Kim et al.	
2011/0090126	A1	4/2011	Szini et al.	
2011/0109167	A1	5/2011	Park et al.	
2011/0114401	A1	5/2011	Kanno et al.	
2011/0115303	A1	5/2011	Baarman et al.	
2011/0115432	A1	5/2011	El-Maleh	
2011/0115605	A1	5/2011	Dimig et al.	
2011/0121660	A1	5/2011	Azancot et al.	
2011/0122018	A1	5/2011	Tarng et al.	
2011/0122026	A1	5/2011	DeLaquil et al.	
2011/0127845	A1	6/2011	Walley et al.	
2011/0127952	A1	6/2011	Walley et al.	
2011/0133655	A1	6/2011	Recker et al.	
2011/0133691	A1	6/2011	Hautanen	
2011/0148578	A1	6/2011	Aloi et al.	
2011/0151789	A1	6/2011	Viglione et al.	
2011/0154429	A1	6/2011	Stantchev	
2011/0156494	A1	6/2011	Mashinsky	
2011/0156640	A1	6/2011	Moshfeghi	
2011/0163128	A1	7/2011	Taguchi et al.	
2011/0175455	A1	7/2011	Hashiguchi	
2011/0175461	A1	7/2011	Tinaphong	
2011/0181120	A1	7/2011	Liu et al.	
2011/0182245	A1	7/2011	Malkamaki et al.	
2011/0184842	A1	7/2011	Melen	
2011/0188207	A1	8/2011	Won et al.	
2011/0194543	A1	8/2011	Zhao et al.	
2011/0195722	A1	8/2011	Walter et al.	
2011/0199046	A1	8/2011	Tsai et al.	
2011/0215086	A1	9/2011	Yeh	
2011/0217923	A1	9/2011	Ma	
2011/0220634	A1	9/2011	Yeh	
2011/0221389	A1	9/2011	Won et al.	
2011/0222272	A1	9/2011	Yeh	
2011/0243040	A1	10/2011	Khan et al.	
2011/0243050	A1	10/2011	Yanover	
2011/0244913	A1	10/2011	Kim et al.	
2011/0248573	A1	10/2011	Kanno et al.	
2011/0248575	A1	10/2011	Kim et al.	
2011/0249678	A1	10/2011	Bonicatto	
2011/0254377	A1	10/2011	Widmer et al.	
2011/0254503	A1	10/2011	Widmer et al.	
2011/0259953	A1	10/2011	Baarman et al.	
2011/0273977	A1	11/2011	Shapira et al.	
2011/0278941	A1	11/2011	Krishna et al.	
2011/0279226	A1	11/2011	Chen et al.	
2011/0281535	A1	11/2011	Low et al.	
2011/0282415	A1	11/2011	Eckhoff et al.	
2011/0285213	A1	11/2011	Kowalewski	
2011/0286374	A1	11/2011	Shin et al.	
2011/0291489	A1	12/2011	Tsai et al.	
2011/0302078	A1	12/2011	Failing	
2011/0304216	A1	12/2011	Baarman	
2011/0304437	A1	12/2011	Beeler	
2011/0304521	A1	12/2011	Ando et al.	
2012/0013196	A1	1/2012	Kim et al.	
2012/0013198	A1	1/2012	Uramoto et al.	
2012/0013296	A1	1/2012	Heydari et al.	
2012/0019419	A1	1/2012	Prat et al.	
2012/0043887	A1	2/2012	Mesibov	
2012/0051109	A1	3/2012	Kim et al.	
2012/0051294	A1	3/2012	Guillouard	
2012/0056486	A1	3/2012	Endo et al.	
2012/0056741	A1	3/2012	Zhu et al.	
2012/0068906	A1	3/2012	Asher et al.	
2012/0074891	A1	3/2012	Anderson et al.	
2012/0080957	A1	4/2012	Cooper et al.	
2012/0086284	A1	4/2012	Capanella et al.	
2012/0095617	A1	4/2012	Martin et al.	
2012/0098350	A1	4/2012	Campanella et al.	
2012/0098485	A1	4/2012	Kang et al.	
2012/0099675	A1	4/2012	Kitamura et al.	
2012/0103562	A1	5/2012	Clayton	
2012/0104849	A1	5/2012	Jackson	
2012/0105252	A1	5/2012	Wang	
2012/0112532	A1	5/2012	Kesler et al.	
2012/0119914	A1	5/2012	Uchida	
2012/0126743	A1	5/2012	Rivers, Jr.	
2012/0132647	A1	5/2012	Beverly et al.	
2012/0133214	A1	5/2012	Yun et al.	
2012/0146426	A1	6/2012	Sabo	
2012/0146576	A1	6/2012	Partovi	
2012/0146577	A1	6/2012	Tanabe	
2012/0147802	A1	6/2012	Ukita et al.	
2012/0149307	A1	6/2012	Terada et al.	
2012/0150670	A1	6/2012	Taylor et al.	
2012/0153894	A1	6/2012	Widmer et al.	
2012/0157019	A1	6/2012	Li	
2012/0161531	A1	6/2012	Kim et al.	
2012/0161544	A1	6/2012	Kashiwagi et al.	
2012/0169276	A1	7/2012	Wang	
2012/0169278	A1	7/2012	Choi	
2012/0173418	A1	7/2012	Beardsmore et al.	
2012/0179004	A1	7/2012	Roesicke et al.	
2012/0181973	A1	7/2012	Lyden	
2012/0182427	A1	7/2012	Marshall	
2012/0187851	A1	8/2012	Huggins et al.	
2012/0193999	A1	8/2012	Zeine	
2012/0200399	A1	8/2012	Chae	
2012/0201153	A1	8/2012	Bharadia et al.	
2012/0201173	A1	8/2012	Jian et al.	
2012/0206299	A1	8/2012	Valdes-Garcia	
2012/0212072	A1	8/2012	Miyabayashi et al.	
2012/0214462	A1	8/2012	Chu et al.	
2012/0214536	A1	8/2012	Kim et al.	
2012/0228956	A1	9/2012	Kamata	
2012/0231856	A1	9/2012	Lee et al.	
2012/0235636	A1	9/2012	Partovi	
2012/0242283	A1	9/2012	Kim et al.	
2012/0248886	A1	10/2012	Kesler et al.	
2012/0248888	A1	10/2012	Kesler et al.	
2012/0248891	A1	10/2012	Drennen	
2012/0249051	A1	10/2012	Son et al.	
2012/0262002	A1	10/2012	Widmer et al.	
2012/0265272	A1	10/2012	Judkins	
2012/0267900	A1	10/2012	Huffman et al.	
2012/0268238	A1	10/2012	Park et al.	
2012/0274154	A1	11/2012	DeLuca	
2012/0280650	A1	11/2012	Kim et al.	
2012/0286582	A1	11/2012	Kim et al.	
2012/0292993	A1	11/2012	Mettler et al.	
2012/0293021	A1	11/2012	Teggatz et al.	
2012/0293119	A1*	11/2012	Park	H02J 7/025 320/108
2012/0299389	A1	11/2012	Lee et al.	
2012/0299540	A1	11/2012	Perry	
2012/0299541	A1	11/2012	Perry	
2012/0299542	A1	11/2012	Perry	
2012/0300588	A1*	11/2012	Perry	H04B 11/00 367/135
2012/0300592	A1	11/2012	Perry	
2012/0300593	A1	11/2012	Perry	
2012/0306705	A1	12/2012	Sakurai et al.	
2012/0306707	A1	12/2012	Yang et al.	
2012/0306720	A1	12/2012	Tanmi et al.	
2012/0309295	A1	12/2012	Maguire	
2012/0309308	A1	12/2012	Kim et al.	

(56) **References Cited**

U.S. PATENT DOCUMENTS

2012/0309332	A1	12/2012	Liao	
2012/0313449	A1	12/2012	Kurs	
2012/0313835	A1	12/2012	Gebretnsae	
2012/0326660	A1	12/2012	Lu et al.	
2013/0002550	A1	1/2013	Zalewski	
2013/0024059	A1	1/2013	Miller et al.	
2013/0026981	A1	1/2013	Van Der Lee	
2013/0026982	A1	1/2013	Rothenbaum	
2013/0032589	A1	2/2013	Chung	
2013/0033571	A1	2/2013	Steen	
2013/0038124	A1	2/2013	Newdoll et al.	
2013/0038402	A1	2/2013	Karalis et al.	
2013/0043738	A1	2/2013	Park et al.	
2013/0044035	A1	2/2013	Zhuang	
2013/0049471	A1	2/2013	Oleynik	
2013/0049475	A1	2/2013	Kim et al.	
2013/0049484	A1	2/2013	Weissentern et al.	
2013/0057078	A1	3/2013	Lee	
2013/0057205	A1	3/2013	Lee et al.	
2013/0057210	A1	3/2013	Negaard et al.	
2013/0057364	A1	3/2013	Kesler et al.	
2013/0063082	A1	3/2013	Lee et al.	
2013/0063143	A1	3/2013	Adalsteinsson et al.	
2013/0069444	A1	3/2013	Waffenschmidt et al.	
2013/0077650	A1	3/2013	Traxler et al.	
2013/0078918	A1	3/2013	Crowley et al.	
2013/0082651	A1	4/2013	Park et al.	
2013/0082653	A1	4/2013	Lee et al.	
2013/0083774	A1	4/2013	Son et al.	
2013/0088082	A1	4/2013	Kang et al.	
2013/0088090	A1	4/2013	Wu	
2013/0088192	A1	4/2013	Eaton	
2013/0088331	A1	4/2013	Cho	
2013/0093388	A1	4/2013	Partovi	
2013/0099389	A1	4/2013	Hong et al.	
2013/0099586	A1	4/2013	Kato	
2013/0106197	A1	5/2013	Bae et al.	
2013/0107023	A1	5/2013	Tanaka et al.	
2013/0119777	A1	5/2013	Rees	
2013/0119929	A1	5/2013	Partovi	
2013/0120217	A1	5/2013	Ueda et al.	
2013/0132010	A1	5/2013	Winger et al.	
2013/0134923	A1	5/2013	Smith	
2013/0137455	A1	5/2013	Xia	
2013/0141037	A1	6/2013	Jenwatanavet et al.	
2013/0148341	A1	6/2013	Williams	
2013/0149975	A1	6/2013	Yu et al.	
2013/0154387	A1	6/2013	Lee et al.	
2013/0155748	A1	6/2013	Sundstrom	
2013/0157729	A1	6/2013	Tabe	
2013/0169061	A1	7/2013	Microshnichenko et al.	
2013/0169219	A1	7/2013	Gray	
2013/0169348	A1	7/2013	Shi	
2013/0171939	A1	7/2013	Tian et al.	
2013/0175877	A1	7/2013	Abe et al.	
2013/0178253	A1	7/2013	Karaoguz	
2013/0181881	A1	7/2013	Christie et al.	
2013/0190031	A1	7/2013	Persson et al.	
2013/0193769	A1	8/2013	Mehta et al.	
2013/0197320	A1	8/2013	Albert et al.	
2013/0200064	A1	8/2013	Alexander	
2013/0207477	A1	8/2013	Nam et al.	
2013/0207604	A1	8/2013	Zeine	
2013/0207879	A1	8/2013	Rada et al.	
2013/0210357	A1	8/2013	Qin et al.	
2013/0221757	A1	8/2013	Cho et al.	
2013/0234530	A1	9/2013	Miyauchi	
2013/0234536	A1	9/2013	Chemishkian et al.	
2013/0234658	A1	9/2013	Endo et al.	
2013/0241306	A1	9/2013	Aber et al.	
2013/0241468	A1	9/2013	Moshfeghi	
2013/0241474	A1	9/2013	Moshfeghi	
2013/0249478	A1	9/2013	Hirano	
2013/0249479	A1	9/2013	Partovi	
2013/0254578	A1	9/2013	Huang et al.	
2013/0264997	A1	10/2013	Lee et al.	
2013/0268782	A1	10/2013	Tam et al.	
2013/0270923	A1	10/2013	Cook et al.	
2013/0278209	A1	10/2013	Von Novak	
2013/0285477	A1	10/2013	Lo et al.	
2013/0285606	A1	10/2013	Ben-Shalom et al.	
2013/0288600	A1*	10/2013	Kuusilinna	H02J 7/0004 455/41.2
2013/0293423	A1	11/2013	Moshfeghi	
2013/0307751	A1	11/2013	Yu-Juin et al.	
2013/0310020	A1	11/2013	Kazuhiro	
2013/0311798	A1	11/2013	Sultenfuss	
2013/0328417	A1	12/2013	Takeuchi	
2013/0334883	A1	12/2013	Kim et al.	
2013/0339108	A1	12/2013	Ryder et al.	
2013/0343251	A1	12/2013	Zhang	
2014/0001846	A1	1/2014	Mosebrook	
2014/0001875	A1	1/2014	Nahidipour	
2014/0001876	A1	1/2014	Fujiwara et al.	
2014/0006017	A1	1/2014	Sen	
2014/0008992	A1	1/2014	Leabman	
2014/0008993	A1	1/2014	Leabman	
2014/0009108	A1	1/2014	Leabman	
2014/0009110	A1	1/2014	Lee	
2014/0011531	A1	1/2014	Burstrom et al.	
2014/0015336	A1	1/2014	Weber et al.	
2014/0015344	A1	1/2014	Mohamadi	
2014/0021907	A1	1/2014	Yu et al.	
2014/0021908	A1	1/2014	McCool	
2014/0035524	A1	2/2014	Zeine	
2014/0035526	A1	2/2014	Tripathi et al.	
2014/0035786	A1	2/2014	Ley	
2014/0043248	A1	2/2014	Yeh	
2014/0049422	A1	2/2014	Von Novak et al.	
2014/0054971	A1	2/2014	Kissin	
2014/0055098	A1	2/2014	Lee et al.	
2014/0057618	A1	2/2014	Zirwas et al.	
2014/0062395	A1	3/2014	Kwon et al.	
2014/0082435	A1	3/2014	Kitgawa	
2014/0086125	A1	3/2014	Polo et al.	
2014/0086592	A1	3/2014	Nakahara et al.	
2014/0091756	A1	4/2014	Ofstein et al.	
2014/0091968	A1	4/2014	Harel et al.	
2014/0103869	A1	4/2014	Radovic	
2014/0111147	A1	4/2014	Soar	
2014/0113689	A1	4/2014	Lee	
2014/0117946	A1	5/2014	Muller et al.	
2014/0118140	A1	5/2014	Amis	
2014/0128107	A1	5/2014	An	
2014/0132210	A1	5/2014	Partovi	
2014/0133279	A1	5/2014	Khuri-Yakub	
2014/0139034	A1	5/2014	Sankar et al.	
2014/0139039	A1	5/2014	Cook et al.	
2014/0139180	A1	5/2014	Kim et al.	
2014/0141838	A1	5/2014	Cai et al.	
2014/0142876	A1	5/2014	John et al.	
2014/0143933	A1	5/2014	Low et al.	
2014/0145879	A1	5/2014	Pan	
2014/0145884	A1	5/2014	Dang et al.	
2014/0152117	A1	6/2014	Sanker	
2014/0159651	A1	6/2014	Von Novak et al.	
2014/0159652	A1	6/2014	Hall et al.	
2014/0159662	A1	6/2014	Furui	
2014/0159667	A1	6/2014	Kim et al.	
2014/0169385	A1	6/2014	Hadani et al.	
2014/0175893	A1	6/2014	Sengupta et al.	
2014/0176054	A1	6/2014	Porat et al.	
2014/0176061	A1	6/2014	Cheatham, III et al.	
2014/0177399	A1	6/2014	Teng et al.	
2014/0184148	A1	7/2014	Van Der Lee et al.	
2014/0184155	A1	7/2014	Cha	
2014/0184163	A1	7/2014	Das et al.	
2014/0184170	A1	7/2014	Jeong	
2014/0191568	A1	7/2014	Partovi	
2014/0194092	A1	7/2014	Wanstedt et al.	
2014/0194095	A1	7/2014	Wanstedt et al.	
2014/0206384	A1	7/2014	Kim et al.	
2014/0210281	A1	7/2014	Ito et al.	
2014/0217955	A1	8/2014	Lin	

(56) **References Cited**

U.S. PATENT DOCUMENTS

2014/0217967	A1	8/2014	Zeine et al.	
2014/0225805	A1	8/2014	Pan et al.	
2014/0232320	A1	8/2014	Ento July et al.	
2014/0232610	A1	8/2014	Shigemoto et al.	
2014/0239733	A1	8/2014	Mach et al.	
2014/0241231	A1	8/2014	Zeine	
2014/0245036	A1	8/2014	Oishi	
2014/0246416	A1	9/2014	White	
2014/0247152	A1	9/2014	Proud	
2014/0252813	A1	9/2014	Lee et al.	
2014/0252866	A1	9/2014	Walsh et al.	
2014/0265725	A1	9/2014	Angle et al.	
2014/0265727	A1	9/2014	Berte	
2014/0265943	A1	9/2014	Angle et al.	
2014/0266025	A1	9/2014	Jakubowski	
2014/0273892	A1	9/2014	Nourbakhsh	
2014/0281655	A1	9/2014	Angle et al.	
2014/0292090	A1	10/2014	Cordeiro et al.	
2014/0300452	A1	10/2014	Rofe et al.	
2014/0312706	A1	10/2014	Fiorello et al.	
2014/0325218	A1	10/2014	Shimizu et al.	
2014/0327320	A1	11/2014	Muhs et al.	
2014/0327390	A1	11/2014	Park et al.	
2014/0346860	A1	11/2014	Aubry et al.	
2014/0354063	A1	12/2014	Leabman et al.	
2014/0354221	A1	12/2014	Leabman et al.	
2014/0355718	A1	12/2014	Guan et al.	
2014/0357309	A1	12/2014	Leabman et al.	
2014/0368048	A1	12/2014	Leabman	
2014/0368161	A1	12/2014	Leabman et al.	
2014/0368405	A1	12/2014	Ek et al.	
2014/0375139	A1	12/2014	Tsukamoto	
2014/0375253	A1	12/2014	Leabman et al.	
2014/0375255	A1	12/2014	Leabman et al.	
2014/0375258	A1	12/2014	Arkhipenkov	
2014/0375261	A1	12/2014	Manova-Elssibony et al.	
2014/0376646	A1	12/2014	Leabman et al.	
2015/0001949	A1	1/2015	Leabman et al.	
2015/0002086	A1	1/2015	Matos et al.	
2015/0003207	A1	1/2015	Lee et al.	
2015/0008980	A1	1/2015	Kim et al.	
2015/0011160	A1	1/2015	Uurgovan et al.	
2015/0015180	A1	1/2015	Miller et al.	
2015/0015182	A1	1/2015	Brandtman et al.	
2015/0015192	A1	1/2015	Leabamn	
2015/0015194	A1	1/2015	Leabman et al.	
2015/0015195	A1	1/2015	Leabman et al.	
2015/0021990	A1	1/2015	Myer et al.	
2015/0022008	A1	1/2015	Leabman et al.	
2015/0022009	A1	1/2015	Leabman et al.	
2015/0022010	A1	1/2015	Leabman et al.	
2015/0023204	A1	1/2015	Wil et al.	
2015/0028688	A1	1/2015	Masaoka	
2015/0028694	A1	1/2015	Leabman et al.	
2015/0028697	A1	1/2015	Leabman et al.	
2015/0028875	A1	1/2015	Irie et al.	
2015/0029397	A1	1/2015	Leabman et al.	
2015/0035378	A1	2/2015	Calhoun et al.	
2015/0035715	A1	2/2015	Kim et al.	
2015/0041459	A1	2/2015	Leabman et al.	
2015/0042264	A1	2/2015	Leabman et al.	
2015/0042265	A1	2/2015	Leabman et al.	
2015/0044977	A1	2/2015	Ramasamy et al.	
2015/0046526	A1	2/2015	Bush et al.	
2015/0061404	A1	3/2015	Lamenza et al.	
2015/0076917	A1	3/2015	Leabman et al.	
2015/0076927	A1	3/2015	Leabman et al.	
2015/0077036	A1	3/2015	Leabman et al.	
2015/0077037	A1	3/2015	Leabman et al.	
2015/0091520	A1	4/2015	Blum et al.	
2015/0091706	A1	4/2015	Chemishkian et al.	
2015/0097663	A1	4/2015	Sloo et al.	
2015/0102681	A1	4/2015	Leabman et al.	
2015/0102764	A1	4/2015	Leabman et al.	
2015/0102769	A1	4/2015	Leabman et al.	
2015/0102973	A1	4/2015	Hand et al.	
2015/0108848	A1	4/2015	Joehren	
2015/0109181	A1	4/2015	Hyde et al.	
2015/0115877	A1	4/2015	Aria et al.	
2015/0115878	A1	4/2015	Park	
2015/0123483	A1	5/2015	Leabman et al.	
2015/0123496	A1	5/2015	Leabman et al.	
2015/0128733	A1	5/2015	Taylor et al.	
2015/0130285	A1	5/2015	Leabman et al.	
2015/0130293	A1	5/2015	Hajimiri et al.	
2015/0148664	A1	5/2015	Stolka et al.	
2015/0155737	A1	6/2015	Mayo	
2015/0155738	A1	6/2015	Leabman et al.	
2015/0162751	A1	6/2015	Leabman et al.	
2015/0162779	A1	6/2015	Lee et al.	
2015/0171513	A1	6/2015	Chen et al.	
2015/0171656	A1	6/2015	Leabman et al.	
2015/0171658	A1	6/2015	Manova-Elssibony et al.	
2015/0171931	A1	6/2015	Won et al.	
2015/0177326	A1	6/2015	Chakraborty et al.	
2015/0180133	A1	6/2015	Hunt	
2015/0188352	A1	7/2015	Peek et al.	
2015/0199665	A1	7/2015	Chu	
2015/0207333	A1	7/2015	Baarman et al.	
2015/0207542	A1	7/2015	Zeine	
2015/0222126	A1	8/2015	Leabman et al.	
2015/0236520	A1	8/2015	Baarman	
2015/0244070	A1	8/2015	Cheng et al.	
2015/0244187	A1	8/2015	Horie	
2015/0244201	A1	8/2015	Chu	
2015/0244341	A1	8/2015	Ritter et al.	
2015/0249484	A1	9/2015	Mach et al.	
2015/0255989	A1	9/2015	Walley et al.	
2015/0263534	A1	9/2015	Lee et al.	
2015/0263548	A1*	9/2015	Cooper	H02J 7/0027 320/108
2015/0270741	A1	9/2015	Leabman et al.	
2015/0280484	A1	10/2015	Radziemski et al.	
2015/0288438	A1	10/2015	Maltsev et al.	
2015/0311585	A1	10/2015	Church et al.	
2015/0312721	A1	10/2015	Singh	
2015/0318729	A1	11/2015	Leabman	
2015/0326024	A1	11/2015	Bell et al.	
2015/0326025	A1	11/2015	Bell et al.	
2015/0326063	A1	11/2015	Leabman et al.	
2015/0326068	A1	11/2015	Bell et al.	
2015/0326069	A1	11/2015	Petras et al.	
2015/0326070	A1	11/2015	Petras et al.	
2015/0326072	A1	11/2015	Petras et al.	
2015/0326142	A1	11/2015	Petras et al.	
2015/0326143	A1	11/2015	Petras et al.	
2015/0327085	A1	11/2015	Hadani	
2015/0333528	A1	11/2015	Leabman	
2015/0333529	A1	11/2015	Leabman	
2015/0333573	A1	11/2015	Leabman	
2015/0333800	A1	11/2015	Perry et al.	
2015/0340759	A1	11/2015	Bridgelall et al.	
2015/0340903	A1	11/2015	Bell et al.	
2015/0340909	A1	11/2015	Bell et al.	
2015/0340910	A1	11/2015	Petras et al.	
2015/0340911	A1*	11/2015	Bell	H02J 50/80 307/104
2015/0341087	A1	11/2015	Moore et al.	
2015/0349574	A1	12/2015	Leabman	
2015/0358222	A1	12/2015	Berger et al.	
2015/0365137	A1	12/2015	Miller et al.	
2015/0365138	A1	12/2015	Miller et al.	
2016/0005068	A1	1/2016	Im et al.	
2016/0012695	A1*	1/2016	Bell	G08B 13/2402 340/572.1
2016/0013656	A1	1/2016	Bell et al.	
2016/0013677	A1*	1/2016	Bell	H02J 7/025 307/104
2016/0013678	A1	1/2016	Bell et al.	
2016/0013855	A1	1/2016	Campos	
2016/0020636	A1	1/2016	Khlat	
2016/0020649	A1	1/2016	Bell et al.	
2016/0020830	A1*	1/2016	Bell	H04B 5/0037 307/104

(56) **References Cited**

U.S. PATENT DOCUMENTS

2016/0042206	A1	2/2016	Pesavento et al.	
2016/0054395	A1	2/2016	Bell et al.	
2016/0054396	A1	2/2016	Bell et al.	
2016/0054440	A1	2/2016	Younis	
2016/0056635	A1	2/2016	Bell	
2016/0056640	A1*	2/2016	Mao	H02J 50/80 307/104
2016/0056669	A1	2/2016	Bell	
2016/0056966	A1	2/2016	Bell	
2016/0065005	A1	3/2016	Won et al.	
2016/0079799	A1	3/2016	Khlat	
2016/0087483	A1	3/2016	Hietala et al.	
2016/0094091	A1	3/2016	Shin et al.	
2016/0094092	A1	3/2016	Davlantes et al.	
2016/0099601	A1	4/2016	Leabman et al.	
2016/0099602	A1	4/2016	Leabman et al.	
2016/0099609	A1	4/2016	Leabman et al.	
2016/0099610	A1	4/2016	Leabman et al.	
2016/0099611	A1	4/2016	Leabman et al.	
2016/0099612	A1	4/2016	Leabman et al.	
2016/0099613	A1	4/2016	Leabman et al.	
2016/0099614	A1	4/2016	Leabman et al.	
2016/0099755	A1	4/2016	Leabman et al.	
2016/0099756	A1	4/2016	Leabman et al.	
2016/0099757	A1	4/2016	Leabman et al.	
2016/0099758	A1	4/2016	Leabman et al.	
2016/0100124	A1	4/2016	Leabman et al.	
2016/0100312	A1	4/2016	Bell et al.	
2016/0126752	A1	5/2016	Vuori et al.	
2016/0126776	A1	5/2016	Kim et al.	
2016/0141908	A1	5/2016	Jakl et al.	
2016/0164563	A1	6/2016	Khawand et al.	
2016/0181849	A1	6/2016	Govindaraj	
2016/0181854	A1	6/2016	Leabman	
2016/0181867	A1	6/2016	Daniel et al.	
2016/0181873	A1	6/2016	Mitcheson et al.	
2016/0191121	A1	6/2016	Bell	
2016/0204622	A1	7/2016	Leabman	
2016/0204642	A1	7/2016	Oh	
2016/0238365	A1	8/2016	Wixey et al.	
2016/0299210	A1	10/2016	Zeine	
2016/0323000	A1	11/2016	Liu et al.	
2016/0336804	A1	11/2016	Son et al.	
2016/0339258	A1	11/2016	Perryman et al.	
2016/0359367	A1	12/2016	Rothschild	
2016/0380464	A1	12/2016	Chin et al.	
2017/0005481	A1	1/2017	Von Novak, III	
2017/0005516	A9	1/2017	Leabman et al.	
2017/0005524	A1	1/2017	Akuzawa et al.	
2017/0005530	A1	1/2017	Zeine et al.	
2017/0025903	A1*	1/2017	Song	H02J 50/40
2017/0026087	A1*	1/2017	Tanabe	H04B 5/0037
2017/0043675	A1	2/2017	Jones et al.	
2017/0047784	A1	2/2017	Jung et al.	
2017/0077735	A1	3/2017	Leabman	
2017/0077736	A1	3/2017	Leabman	
2017/0077764	A1	3/2017	Bell et al.	
2017/0077765	A1	3/2017	Bell et al.	
2017/0077995	A1	3/2017	Leabman	
2017/0085120	A1	3/2017	Leabman et al.	
2017/0085437	A1	3/2017	Condeixa et al.	
2017/0092115	A1	3/2017	Sloo et al.	
2017/0110887	A1	4/2017	Bell et al.	
2017/0110914	A1	4/2017	Bell	
2017/0134686	A9	5/2017	Leabman	
2017/0163076	A1	6/2017	Park et al.	
2017/0179763	A9	6/2017	Leabman	

FOREIGN PATENT DOCUMENTS

DE	2000216655	U1	2/2002
EP	1028482	A2	8/2000
EP	1081506	A1	3/2001
EP	2397973	A1	6/2010
EP	2346136	A1	7/2011
EP	2545635	A0	9/2011
GB	2404497	A	2/2005
JP	2006157586	A	6/2006
JP	2007043432	A	2/2007
JP	2008167017	A	7/2008
KR	20060061776	A	6/2006
KR	20070044302	A	4/2007
KR	100755144	B1	9/2007
KR	20110132059	A	12/2011
KR	20110135540	A1	12/2011
KR	20120009843	A	2/2012
KR	20120108759	A	10/2012
KR	1020130026977	A	3/2013
WO	9952173	A2	10/1999
WO	WO 200111716	A1	2/2001
WO	2004077550	A1	9/2004
WO	2003091943	A1	11/2006
WO	WO 2006122783		11/2006
WO	2008156571	A2	12/2008
WO	2010022181	A1	2/2010
WO	WO 2010039246	A1	4/2010
WO	WO 2010138994	A1	12/2010
WO	2011112022	A2	9/2011
WO	WO 2012177283	A1	12/2012
WO	2013035190	A1	3/2013
WO	WO 2013031988	A1	3/2013
WO	WO 2013038074	A2	3/2013
WO	WO 2013042399	A1	3/2013
WO	WO 2013052950	A1	4/2013
WO	WO 2013105920	A2	7/2013
WO	WO 2014075103	A1	5/2014
WO	WO 2014132258	A1	9/2014
WO	WO 2014182788	A2	11/2014
WO	WO 2014182788	A3	11/2014
WO	WO 2014197472	A1	12/2014
WO	WO 2014209587	A1	12/2014
WO	WO 2015038773	A1	3/2015
WO	WO 2015097809	A1	7/2015
WO	WO 2015161323	A1	10/2015
WO	WO 2016024869	A1	2/2016
WO	WO 2016048512	A1	3/2016
WO	WO 2016187357	A1	11/2016

OTHER PUBLICATIONS

International Search Report dated Jan. 27, 2015 corresponding to International Patent Application No. PCT/US2014/037170, 4 pages.
International Search Report dated Oct. 16, 2014 corresponding to International Patent Application No. PCT/US2014/041546, 4 pages.
International Search Report dated Oct. 13, 2014 corresponding to International Patent Application No. PCT/US2014/041534, 4 pages.
International Search Report dated Nov. 12, 2014 corresponding to International Patent Application No. PCT/US2014/046956, 4 pages.
Written Opinion of the International Searching Authority dated Nov. 12, 2014 corresponding to International Patent Application No. PCT/US2014/046956, 6 pages.
Energous Corp., Written Opinion, PCT/US2014/037170 , dated Sep. 15, 2014, 7 pgs.
Energous Corp., IPRP, PCT/US2014/037170, dated Nov. 10, 2015, 8 pgs.
Energous Corp., Written Opinion, PCT/US2014/041534, dated Oct. 13, 2014, 6 pgs.
Energous Corp., IPRP, PCT/US2014/041534, dated Dec. 29, 2015, 7 pgs.
Energous Corp., IPRP, PCT/US2014/046956, dated Jan. 19, 2016, 7 pgs.
Energous Corp., Written Opinion, PCT/US2014/037072, dated Sep. 12, 2014, 5 pgs.
Energous Corp., IPRP, PCT/US2014/037072, dated Nov. 10, 2015, 6 pgs.
Energous Corp., ISRWO, PCT/US2014/068568, dated Mar. 20, 2015, 10 pgs.
Energous Corp., IPRP, PCT/US2014/068568, dated Jun. 14, 2016, 8 pgs.

(56) **References Cited**

OTHER PUBLICATIONS

Energous Corp., ISRWO, PCT/US2014/055195, dated Dec. 22, 2014, 11 pgs.
Energous Corp., IPRP, PCT/US2014/055195, dated Mar. 22, 2016, 9 pgs.
Energous Corp., ISRWO, PCT/US2015/067291, dated Mar. 4, 2016, 10 pgs.
Energous Corp., IPRP, PCT/US2015/067291, dated Jul. 4, 2017, 4 pgs.
Energous Corp., ISRWO, PCT/US2015/067242, dated Mar. 16, 2016, 9 pgs.
Energous Corp., IPRP, PCT/US2015/067242, dated Jun. 27, 2017, 7 pgs.
Energous Corp., ISRWO, PCT/US2015/067243, dated Mar. 10, 2016, 11 pgs.
Energous Corp., IPRP, PCT/US2015/067243, dated Jun. 27, 2017, 7 pgs.
Energous Corp., ISRWO, PCT/US2014/037109, dated Apr. 8, 2016, 12 pgs.
Energous Corp., IPRP, PCT/US2014/037109, dated Apr. 12, 2016, 9 pgs.
Energous Corp., ISRWO, PCT/US2015/067275, dated Mar. 3, 2016, 8 pgs.
Energous Corp., IPRP, PCT/US2015/067275, dated Jul. 4, 2017, 7 pgs.
Energous Corp., ISRWO, PCT/US2015/067245, dated Mar. 17, 2016, 8 pgs.
Energous Corp., IPRP, PCT/US2015/067245, dated Jun. 27, 2017, 7 pgs.
Energous Corp., ISRWO, PCT/US2014/041546, dated Oct. 16, 2014, 12 pgs.
Energous Corp., IPRP, PCT/US2014/041546, dated Dec. 29, 2015, 9 pgs.
Energous Corp., ISRWO, PCT/US2015/67250, dated Mar. 30, 2016, 11 pgs.
Energous Corp., IPRP, PCT/US2015/67250, dated Mar. 30, 2016, 10 pgs.
Energous Corp., ISRWO, PCT/US2015/067325, dated Mar. 10, 2016, 9 pgs.
Energous Corp., IPRP, PCT/US2015/067325, dated Jul. 4, 2017, 8 pgs.
Energous Corp., ISRWO, PCT/US2014/040697, dated Oct. 1, 2014, 12 pgs.
Energous Corp., IPRP, PCT/US2014/040697, dated Dec. 8, 2015, 9 pgs.
Energous Corp., ISRWO, PCT/US2014/040705, dated Sep. 23, 2014, 8 pgs.
Energous Corp., IPRP, PCT/US2014/040705, dated Dec. 8, 2015, 6 pgs.
Energous Corp., ISRWO, PCT/US2015/067249, dated Mar. 29, 2016, 8 pgs.
Energous Corp., IPRP, PCT/US2015/067249, dated Jun. 27, 2017, 7 pgs.
Energous Corp., ISRWO, PCT/US2015/067246, dated May 11, 2016, 18 pgs.
Energous Corp., IPRP, PCT/US2015/067246, dated Jun. 27, 2017, 9 pgs.
Energous Corp., ISRWO, PCT/US2014/059317, dated Feb. 24, 2015, 13 pgs.
Energous Corp., IPRP, PCT/US2014/059317, dated Apr. 12, 2016, 10 pgs.
Energous Corp., ISRWO, PCT/US2014/049669, dated Nov. 13, 2014, 10 pgs.
Energous Corp., IPRP, PCT/US2014/049669, dated Feb. 9, 2016, 8 pgs.
Energous Corp., ISRWO, PCT/US2014/041323, dated Oct. 1, 2014, 10 pgs.
Energous Corp., IPRP, PCT/US2014/041323, dated Dec. 22, 2015, 8 pgs.
Energous Corp., ISRWO, PCT/US2014/048002, dated Nov. 13, 2014, 11 pgs.
Energous Corp., IPRP, PCT/US2014/048002, dated Feb. 12, 2015 8 pgs.
Energous Corp., ISRWO, PCT/US2014/062682, dated Feb. 12, 2015, 10 pgs.
Energous Corp., IPRP, PCT/US2014/062682, dated May 3, 2016, 8 pgs.
Energous Corp., ISRWO, PCT/US2014/049666, dated Nov. 10, 2014, 7 pgs.
Energous Corp., IPRP, PCT/US2014/049666, dated Feb. 9, 2016, 5 pgs.
Energous Corp., ISRWO, PCT/US2014/046961, dated Nov. 24, 2014, 16 pgs.
Energous Corp., IPRP, PCT/US2014/046961, dated Jan. 19, 2016, 8 pgs.
Energous Corp., ISRWO, PCT/US2015/067279, dated Mar. 11, 2015, 13 pgs.
Energous Corp., IPRP, PCT/US2015/067279, dated Jul. 4, 2017, 7 pgs.
Energous Corp., ISRWO, PCT/US2014/041342, dated Jan. 27, 2015, 10 pgs.
Energous Corp., IPRP, PCT/US2014/041342, dated Dec. 15, 2015, 8 pgs.
Energous Corp., ISRWO, PCT/US2014/046941, dated Nov. 6, 2014, 11 pgs.
Energous Corp., IPRP, PCT/US2014/046941, dated Jan. 19, 2016, 9 pgs.
Energous Corp., ISRWO, PCT/US2014/062661, dated Jan. 27, 2015, 12 pgs.
Energous Corp., IPRP, PCT/US2014/062661, dated May 3, 2016, 10 pgs.
Energous Corp., ISRWO, PCT/US2014/059871, dated Jan. 23, 2015, 12 pgs.
Energous Corp., IPRP, PCT/US2014/059871, dated Apr. 12, 2016, 9 pgs.
Energous Corp., ISRWO, PCT/US2014/045102, dated Oct. 28, 2014, 14 pgs.
Energous Corp., IPRP, PCT/US2014/045102, dated Jan. 12, 2016, 11 pgs.
Energous Corp., ISRWO, PCT/US2014/059340, dated Jan. 15, 2015, 13 pgs.
Energous Corp., IPRP, PCT/US2014/059340, dated Apr. 12, 2016, 11 pgs.
Energous Corp., ISRWO, PCT/US2015/067282, dated Jul. 5, 2016, 7 pgs.
Energous Corp., IPRP, PCT/US2015/067282, dated Jul. 4, 2017, 6 pgs.
Energous Corp., ISRWO, PCT/US2014/041558, dated Oct. 10, 2014, 8 pgs.
Energous Corp., IPRP, PCT/US2014/041558, dated Dec. 29, 2015, 6 pgs.
Energous Corp., ISRWO, PCT/US2014/045119, dated Oct. 13, 2014, 11 pgs.
Energous Corp., IPRP, PCT/US2014/045119, dated Jan. 12, 2016, 9 pgs.
Energous Corp., ISRWO PCT/US2014/045237, dated Oct. 13, 2014, 16 pgs.
Energous Corp., IPRP , PCT/US2014/045237, dated Jan. 12, 2016, 12 pgs.
Energous Corp., ISRWO , PCT/US2014/054897, dated Feb. 17, 2015, 10 pgs.
Energous Corp., IPRP , PCT/US2014/054897, dated Mar. 15, 2016, 8 pgs.
Energous Corp., ISRWO , PCT/US2015/067334, dated Mar. 3, 2016, 6 pgs.
Energous Corp., IPRP , PCT/US2015/067334, dated Jul. 4, 2017, 5 pgs.
Energous Corp., ISRWO , PCT/US2014/047963, dated Nov. 7, 2014, 13 pgs.
Energous Corp., IPRP , PCT/US2014/047963, dated Jan. 26, 2016, 10 pgs.

(56) **References Cited**

OTHER PUBLICATIONS

Energous Corp., ISRWO , PCT/US2014/054891, dated Dec. 18, 2014, 12 pgs.
Energous Corp., IPRP , PCT/US2014/054891, dated Mar. 15, 2016, 10 pgs.
Energous Corp., ISRWO , PCT/US2014/054953, dated Dec. 4, 2014, 7 pgs.
Energous Corp., IPRP , PCT/US2014/054953, dated Mar. 22, 2016, 5 pgs.
Energous Corp., ISRWO , PCT/US2015/067294, dated Mar. 29, 2016, 7 pgs.
Energous Corp., IPRP , PCT/US2015/067294, dated Jul. 4, 2017, 6 pgs.
Energous Corp., ISRWO , PCT/US2014/062672 dated Jan. 26, 2015, 11 pgs.
Energous Corp., IPRP , PCT/US2014/062672 dated May 10, 2016, 8 pgs.
Energous Corp., ISRWO , PCT/US2014/044810 dated Oct. 21, 2014, 12 pgs.
Energous Corp., IPRP , PCT/US2014/044810, dated Jan. 5, 2016, 10 pgs.
Energous Corp., ISRWO , PCT/US2015/067271, dated Mar. 11, 2016, 6 pgs.
Energous Corp., IPRP , PCT/US2015/067271, dated Jul. 4, 2017, 5 pgs.
Energous Corp., ISRWO , PCT/US2014/040648, dated Oct. 10, 2014, 11 pgs.
Energous Corp., IPRP , PCT/US2014/040648, dated Dec. 8, 2015, 8 pgs.
Energous Corp., ISRWO , PCT/US2014/049673, dated Nov. 18, 2014, 10 pgs.
Energous Corp., IPRP , PCT/US2014/049673, dated Feb. 9, 2016, 6 pgs.
Energous Corp., ISRWO , PCT/US2014/068282, dated Mar. 19, 2015, 13 pgs.
Energous Corp., IPRP, PCT/US2014/068282, dated Jun. 7, 2016, 10 pgs.
Energous Corp., ISRWO, PCT/US2014/068586, dated Mar. 20, 2015, 11 pgs.
Energous Corp., IPRP, PCT/US2014/068586, dated Jun. 14, 2016, 8 pgs.
Energous Corp., ISRWO, PCT/US2016/068504, dated Mar. 30, 2017, 8 pgs.
Energous Corp., ISRWO, PCT/US2016/068495, dated Mar. 30, 2017, 9 pgs.
Energous Corp., ISRWO, PCT/US2015/067287, dated Feb. 2, 2016, 8 pgs.
Energous Corp., IPRP, PCT/US2015/067287, dated Jul. 4, 2017, 6 pgs.
Energous Corp., ISRWO, PCT/US2016/068551, dated Mar. 17, 2017, 8 pgs.
Energous Corp., ISRWO, PCT/US2016/068498, dated May 17, 2017, 8 pgs.
Energous Corp., ISRWO, PCT/US2016/068993, dated Mar. 13, 2017, 12 pgs.
Energous Corp., ISRWO, PCT/US2016/068565, dated Mar. 8, 2017, 11 pgs.
Energous Corp., ISRWO, PCT/US2016/068987, dated May 8, 2017, 10 pgs.
Energous Corp., ISRWO, PCT/US2016/069316 , dated Mar. 16, 2017, 15 pgs.
Energous Corp., ISRWO, PCT/US2018/012806 , dated Mar. 23, 2018, 9 pgs.
Energous Corp., ISRWO, PCT/US2017/046800 , dated Sep. 11, 2017, 13 pgs.
Energous Corp., ISRWO, PCT/US2017/065886, dated Apr. 6, 2018, 13 pgs.
Order Granting Reexamination Request Control No. 90013793 Aug. 31, 2016, 23 pgs.
Ossia Inc. vs. *Energous Corp.*, PGR2016-00023-Institution Decision, Nov. 29, 2016, 29 pgs.
Ossia Inc. vs. *Energous Corp.*, PGR2016-00024-Institution Decision, Nov. 29, 2016, 50 pgs.
Ossia Inc. vs. *Energous Corp.*, PGR2016-00024-Judgement-Adverse, Jan. 20, 2017, 3 pgs.
ReExam Ordered Control No. 90013793 Feb. 2, 2017, 8 pgs.
Ossia Inc. vs *Energous Corp.*, Declaration of Stephen B. Heppe in Support of Petition for Post-Grant Review of U.S. Pat. No. 9,124,125, PGR2016-00024, May 31, 2016, 122 pgs.
Ossia Inc. vs. *Energous Corp.*, Petition for Post-Grant Review of U.S. Pat. No. 9,124,125, dated May 31, 2016, 92 pgs.
Ossia Inc. vs. *Energous Corp.*, Patent Owner Preliminary Response, Sep. 8, 2016, 95 pgs.
Ossia Inc. vs. *Energous Corp.*, Petition for Post Grant Review of U.S. Pat. No. 9,124,125, May 31, 2016, 86 pgs.
Ossia Inc. vs. *Energous Corp.*, Declaration of Stephen B. Heppe in Support of Petition for Post-Grant Review of U.S. Pat. No. 9,124,125, PGR2016-00023, May 31, 2016, 144 pgs.
Supplementary European Search Report, EP Patent Application No. EP14818136-5, Jul. 21, 2016, 9 pgs.
European Search Report, EP Patent Application No. EP16189052.0, dated Jan. 31, 2017, 11 pgs.
European Search Report, EP Patent Application No. EP16189319-3, dated Feb. 1, 2017, 9 pgs.
European Search Report, EP Patent Application No. EP14822971, dated Feb. 1, 2017, 9 pgs.
European Search Report, EP Patent Application No. EP16189987, dated Feb. 1, 2017, 8 pgs.
European Search Report, EP Patent Application No. 16196205.5, dated Mar. 28, 2017, 7 pgs.
European Search Report, EP Patent Application No. 16189300, dated Feb. 28, 2017, 4 pgs.
European Search Report, EP Patent Application No. 16189988.5, dated Mar. 1, 2017, 4 pgs.
European Search Report, EP Patent Application No. 16189982.8, dated Jan. 27, 2017, 9 pgs.
European Search Report, EP Patent Application No. 16189974, dated Mar. 2, 2017, 5 pgs.
European Search Report, EP Patent Application No. 16193743, dated Feb. 2, 2017, 5 pgs.
European Search Report, EP Patent Application No. 14868901.1, dated Jul. 7, 2017, 5 pgs.
European Search Report . EP15876036, dated May 3, 2018, 8 pgs.
European Search Report . EP15874273, dated Apr. 27, 2018, 7 pgs.
L.H. Hsieh et al. Development of a Retrodirective Wireless Microwave Power Transmission System, IEEE, 2003 pp. 393-396.
B.D. Van Veen et al., Beamforming: A Versatile Approach to Spatial Filtering, IEEE, ASSP Magazine, Apr. 1988, pp. 4-24.
Leabman, Adaptive Band-partitioning for Interference Cancellation in Communication System,. Thesis Massachusetts Institute of Technology, Feb. 1997, pp. 1-70.
Panda, SIW based Slot Array Antenna and Power Management Circuit for Wireless Energy Harvesting Applications, IEEE APSURSI, Jul. 2012, 2 pgs.
Singh, Wireless Power Transfer Using Metamaterial Bonded Microstrip Antenna for Smart Grid WSN: In Fourth International Conference on Advances in Computing and Communications (ICACC), Aug. 27-29, 2014, Abstract 299.
T. Gill et al. "A System for Change Detection and Human Recognition in Voxel Space using the Microsoft Kinect Sensor" 2011 IEEE Applied Imagery Pattern Recognition Workshop. 8 pgs.
J. Han et al. Enhanced Computer Vision with Microsoft Kinect Sensor: A Review, IEEE Transactions on Cybernetics vol. 43, No. 5. pp. 1318-1334, Oct. 3, 2013.
Zhai, "A Practical wireless charging system based on ultra-wideband retro-reflective beamforming" 2010 IEEE Antennas and Propagation Society International Symposium, Toronto, ON 2010, pp. 1-4.
Mao: BeamStar: An Edge-Based Approach to Routing in Wireless Sensors Networks, IEEE Transactions on Mobile Computing, IEEE Service Center, Los Alamitos, CA US, vol. 6, No. 11, Nov. 1, 2007, 13 pgs.

(56) **References Cited**

OTHER PUBLICATIONS

Smolders—Institute of Electrical 1-15 and Electronics Engineers: "Broadband microstrip array antennas" Digest of the Antennas and Propagation Society International Symposium. Seattle, WA Jun. 19-24, 1994. Abstract 3 pgs.
Paolo Nenzi et al; "U-Helix: On-chip short conical antenna", 2013 7th European Conference on Antennas and Propagation (EUCAP), ISBN:978-1-4673-2187-7, IEEE, Apr. 8, 2013, 5 pgs.
Adamiuk G et al; "Compact, Dual-Polarized UWB-Antanna, Embedded in a Dielectric" IEEE Transactions on Antenna and Propagation, IEEE Service Center, Piscataway, NJ, US vol. 56, No. 2, ISSN: 0018-926X, abstract; Figure 1, Feb. 1, 2010, 8 pgs.
Mascarenas et al.; "Experimental Studies of Using Wireless Energy Transmission for Powering Embedded Sensor Nodes." Nov. 28, 2009, Journal of Sound and Vibration, pp. 2421-2433.
Li et al. High-Efficiency Switching-Mode Charger System Design Considerations with Dynamic Power Path Management, Mar./Apr. 2012 Issue, 8 pgs.

* cited by examiner

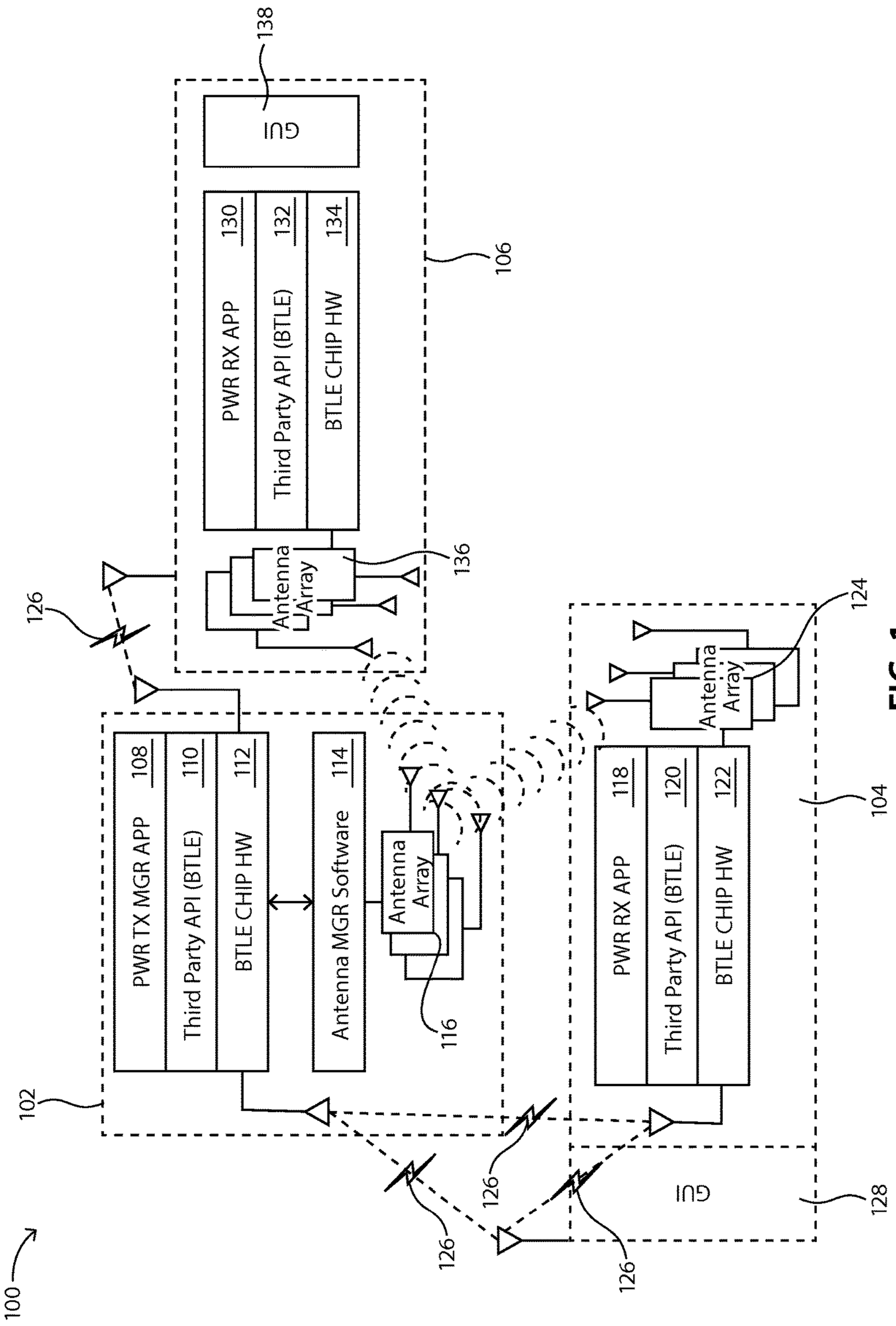

138
GUI
130
132
134
PWR RX APP
Third Party API (BTLE)
BTLE CHIP HW
106
Antenna Array
136
126
PWR TX MGR APP
108
Third Party API (BTLE)
110
BTLE CHIP HW
112
Antenna MGR Software
114
Antenna Array
116
102
100
126
126
126
PWR RX APP
118
Third Party API (BTLE)
120
BTLE CHIP HW
122
Antenna Array
124
104
GUI
128

FIG. 1

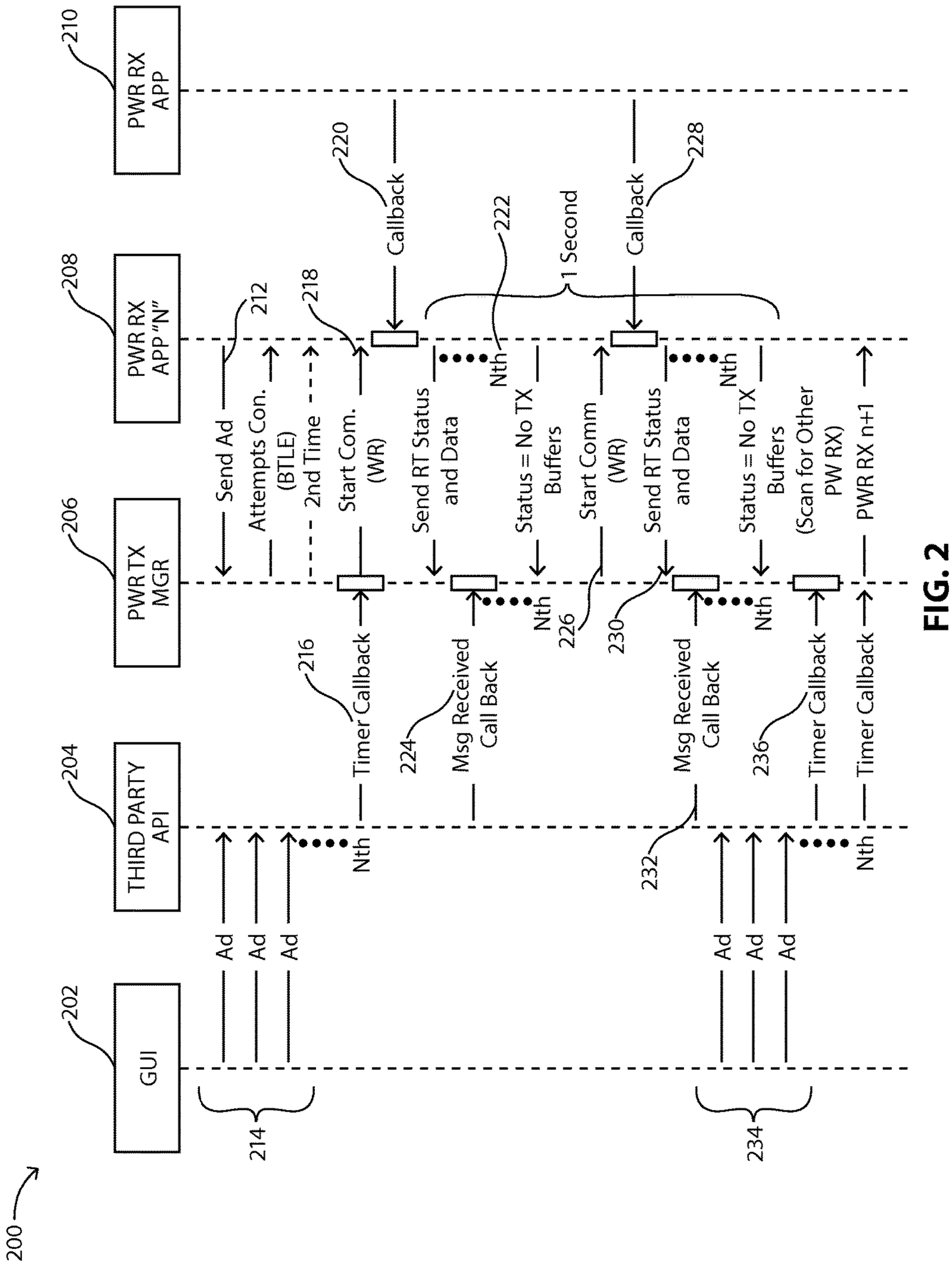

200
202
GUI
204
THIRD PARTY API
206
PWR TX MGR
208
PWR RX APP "N"
210
PWR RX APP
Ad
Ad
Ad
214
Send Ad
212
Attempts Con. (BTLE)
2nd Time
218
Start Com. (WR)
216
Timer Callback
Nth
Msg Received Call Back
224
Send RT Status and Data
Nth
Status = No TX Buffers
220
Callback
222
1 Second
Start Comm (WR)
226
Send RT Status and Data
Nth
Status = No TX Buffers
228
Callback
230
Msg Received Call Back
232
Nth
Timer Callback
236
(Scan for Other PW RX)
PWR RX n+1
Timer Callback
Nth
Ad
Ad
Ad
234

FIG. 2

SYSTEMS AND METHODS FOR CONTROLLING COMMUNICATIONS DURING WIRELESS TRANSMISSION OF POWER USING APPLICATION PROGRAMMING INTERFACES

CROSS-REFERENCE TO RELATED APPLICATIONS

The present disclosure is related to U.S. non-provisional patent application Ser. No. 13/891,430 entitled "Methodology for Pocket-forming"; U.S. non-provisional patent application Ser. No. 13/925,469 entitled "Methodology for Multiple Pocket-Forming"; U.S. non-provisional patent application Ser. No. 13/946,082 entitled "Method for 3 Dimensional Pocket-forming"; U.S. non-provisional patent application Ser. No. 13/891,399 entitled "Receivers for Wireless Power Transmission"; and U.S. non-provisional patent application Ser. No. 13/891,445 entitled "Transmitters for Wireless Power Transmission," all of which are invented by Michael Leabman, and all of which are incorporated herein by reference in their respective entireties.

BACKGROUND

Field of the Disclosure

The present disclosure relates generally to software embedded on a chip, and more specifically to software embedded on a chip that controls the communication between a wireless power transmitter and one or more wireless power receivers in real time.

Background Information

Electronic devices such as laptop computers, smartphones, portable gaming devices, tablets and so forth require power for performing their intended functions. This may require having to charge electronic equipment at least once a day, or in high-demand electronic devices more than once a day. Such an activity may be tedious and may represent a burden to users. For example, a user may be required to carry chargers in case his electronic equipment is lacking power. In addition, users have to find available power sources to connect to. Furthermore, users must plug into a wall or other power supply to be able to charge their electronic device. However, such an activity may render electronic devices inoperable during charging. Some approaches to this problem may include inductive pads which may employ magnetic induction or resonating coils. Nevertheless, such a solution may still require that electronic devices may have to be placed in a specific place for powering. Thus, electronic devices during charging may not be portable.

Other approach may include using RF waves through suitable power transmission techniques such as pocket-forming. This approach may provide wireless power transmission while eliminating the use of wires or pads for charging devices which may require tedious procedures such as plugging to a wall, and may turn devices unusable during charging. In addition, electronic equipment may require less components as typical wall chargers may not be required. In some cases, even batteries may be eliminated as a device may fully be powered wirelessly.

Although the latter approach may significantly solve the problem of using wires or pads for charging devices, the communication controls among wireless power devices using this approach may demand a real time communication (high transfer rate) and may not be easily achieved. There are a few off-the-shelf solutions that allow the fast communication between these devices, however these solutions may encounter a limited number of packets sent per second, hence a real time communication may not be reached. For the foregoing reasons, there is a need for a system and method that allows real time communication among wireless power devices so as to have a better control of them.

SUMMARY

Embodiments in the present disclosure may be directed to provide systems and methods for real time communication between wireless power transmitters and wireless power receivers based on software embedded on a microprocessor.

In one aspect of the present disclosure, a system architecture that may enable the communication controls between wireless power transmitter and one or more wireless power receivers is disclosed. Wireless powered receivers may include covers and customer pocket-forming enabled devices.

In one aspect, a wireless power transmitter may include a microprocessor that integrates a power transmitter manager app (PWR TX MGR APP) which may include a database for storing relevant information from wireless power receivers, and a third party application programming interface (Third Party API) for a Bluetooth Low Energy chip (BTLE CHIP HW). The wireless power transmitter may also include antenna manager software (Antenna MGR Software) to control an RF antenna array that may be used to form controlled RF waves which may converge in 3-D space and create pockets of energy on wireless power receivers (covers and customer pocket-forming enabled devices).

In another aspect, a cover may include a power receiver app (PWR RX APP), a third party application programming interface (Third party API) for a Bluetooth Low Energy chip (BTLE CHIP HW), and a radio frequency (RF) antenna array which may be used to receive and utilize the pockets of energy sent from wireless power transmitter.

As used herein, a customer pocket-forming enabled device may refer to a wireless device such as a smartphone, tablet, or the like that may include an integrated wireless power receiver chip (not shown in FIG. **1**) for wireless power charging. Customer pocket-forming enabled devices may include a power receiver app (PWR RX APP), and a third party application programming interface (Third Party API) for a Bluetooth Low Energy chip (BTLE CHIP HW). Customer pocket-forming enabled devices may also include an RF antenna array which may be used to receive and utilize pockets of energy sent from wireless power transmitter. GUI may be downloaded from any suitable application store and may run on any suitable operating system such as iOS and Android, among others.

In another aspect of the present disclosure, a sequence diagram that illustrates the interactions between the GUI, third party API and power manager app in the power transmitter board, and power receiver app and power receiver API in the power receiver board, is disclosed.

In one embodiment, power transmitter manager app may scan for ads emitted from power receivers and GUI. Power receiver ads may send data to power transmitters that may include a unique ID, and at the same time GUI may also send data to power transmitters that may include a list of power receivers to track and to be charged. Once power transmitter manager app reads and processes the data received from both, the power receiver and the GUI, it may attempt connection with the power receiver. Once the connection is established, a connection callback is sent to the power transmitter manager app in order to start communication

with the power receiver to which is connected. Thereafter, the power transmitter manager app may send a start communication write request message to the power receiver app. Power receiver API may immediately send a call back to the power receiver app in order to start sending messages back to the power transmitter manager app. In an embodiment, the messages may be sent up to a rate of about 100 packets per second, however in other embodiments the transfer rate may go even up to 400 packets per second or more. These messages may include status and data from the power receiver board such as battery levels, charging status, and antenna voltage among others.

When the power transmitter manager app receives said messages, an immediate call back from the third party API of the power transmitter board is sent to the power transmitter manager app stating that the message has been received. There may be a callback for each message received. However, the power receiver API, after a certain period of time, may run out of transmit buffers, and hence the power receiver app may call a function in the API to get the status of transmit buffers. Then the power receiver app may indicate this in the status of the next message to the power transmitter manager app. Subsequently, the power transmitter manager app may immediately send a start communication write request message back to the power receiver app to restore the transmit buffers. As a result, transmit buffers may be restored and the power receiver API may call again the power receiver app to send status and data messages to the power transmitter manager app until it runs out of buffers. However, the power transmitter manager app, at this point may stop sending a start communication write request message again to restore the transmit buffers. Instead, the power transmitter manager app may do another scan to listen for ads from other wireless power receivers and the GUI. GUI may then tell the power transmitter manager app which wireless power receivers to track and to be charged. Finally the negotiation process to establish a real time communication with the next wireless power receiver may repeat again. Thereafter periodically, such as every one second, the power transmitter manager app may search for other wireless power receivers so as to keep its information of all wireless power receivers around its radio updated.

The above described systems and methods may allow wireless power transmitters to communicate with one or more wireless power receivers in real time within intervals of one second. The systems and methods described here may enable full control of the wireless power receivers by letting the user decide which wireless power receivers to charge, when to charge them, and set priorities and charging schedules among other functions. In other embodiments, the systems and methods described here may allow the wireless power transmitters to communicate with wireless power receivers simultaneously by adding multiple BTLE chips on the power transmitter board.

Numerous other aspects, features and benefits of the present disclosure may be made apparent from the following detailed description taken together with the drawing figures.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure can be better understood by referring to the following figures. The components in the figures are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the disclosure. In the figures, reference numerals designate corresponding parts throughout the different views.

FIG. **1** shows a system architecture in which one or more embodiments of the present disclosure may operate.

FIG. **2** shows a sequence diagram of real time communication between wireless power transmitters and wireless power receivers, according to an embodiment.

DETAILED DESCRIPTION

The present disclosure is here described in detail with reference to embodiments illustrated in the drawings, which form a part here. Other embodiments may be used and/or other changes may be made without departing from the spirit or scope of the present disclosure. The illustrative embodiments described in the detailed description are not meant to be limiting of the subject matter presented here.

Definitions

As used here, the following terms may have the following definitions:

"Real time communication" refers to communicating the status of data at the receiver at the continuing present time, where a proprietary algorithm may read the present state of important information at the receiver continually and rapidly with only 1/100 of a second of delay.

"Transmitter" may refer to a device, including a chip which may generate two or more RF signals, at least one RF signal being phase shifted and gain adjusted with respect to other RF signals, substantially all of which pass through one or more RF antennas such that focused RF signals are directed to a target.

"Receiver" may refer to a device including at least one antenna element, at least one rectifying circuit and at least one power converter, which may utilize pockets of energy for powering or charging an electronic device.

"Pocket-forming" may refer to generating two or more RF waves which converge in 3-D space, forming controlled constructive and destructive interference patterns.

"Pockets of energy" may refer to areas or regions of space where energy or power may accumulate in the form of constructive interference patterns of RF waves.

"Ad" may refer to one or more Bluetooth Low Energy (BTLE) advertisement messages transmitted from a BTLE device.

Reference will now be made to the exemplary embodiments illustrated in the drawings, and specific language will be used here to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended. Alterations and further modifications of the inventive features illustrated here, and additional applications of the principles of the inventions as illustrated here, which would occur to one skilled in the relevant art and having possession of this disclosure, are to be considered within the scope of the invention.

FIG. **1** shows a system architecture **100** in which one or more embodiments of the present disclosure may operate. System architecture **100** may enable the communication controls between wireless power transmitter **102** and one or more wireless power receivers. Wireless power receivers may include covers **104** and customer pocket-forming enabled devices **106**.

In one embodiment, wireless power transmitter **102** may include a microprocessor that integrates a power transmitter manager app **108** (PWR TX MGR APP), and a third party application programming interface **110** (Third Party API) for a Bluetooth Low Energy chip **112** (BTLE CHIP HW). Wireless power transmitter **102** may also include an antenna

manager software **114** (Antenna MGR Software) to control an RF antenna array **116** that may be used to form controlled RF waves which may converge in 3-D space and create pockets of energy on wireless power receivers (covers **104** and customer pocket-forming enabled devices **106**). In an embodiment, Bluetooth Low Energy chip **112** may be replaced by another type of wireless protocol such as WiFi or the like.

Power transmitter manager app **108** may store relevant information from wireless power receivers such as, identifiers, voltage ranges, location, signal strength and/or any relevant information from a wireless power receivers. For example, the power transmitter app **108** may store the relevant information in a database (not shown).

Power transmitter manager app **108** may call third party application programming interface **110** for running a plurality of functions such as start a connection, end a connection, and send data among others. Third party application programming interface **110** may command Bluetooth Low Energy chip **112** according to the functions called by power transmitter manager app **108**.

Third party application programming interface **110** at the same time may call power transmitter manager app **108** through a callback function which may be registered in the power transmitter manager app **108** at boot time. Third party application programming interface **110** may have a timer callback that may go for ten times a second. Third party application programming interface **110** may send callbacks every time a connection begins, a connection ends, a connection is attempted, or a message is received.

Covers **104** may include a power receiver app **118** (PWR RX APP), a third party application programming interface **120** (Third party API) for a Bluetooth Low Energy chip **122** (BTLE CHIP HW), and a RF antenna array **124** which may be used to receive and utilize the pockets of energy sent from wireless power transmitter **102**.

Power receiver app **118** may call third party application programming interface **120** for running a plurality of functions such as start a connection, end the connection, and send data among others. Third party application programming interface **120** may have a timer callback that may go for ten times a second and may send callbacks every time a connection begins, a connection ends, a connection is attempted, or message is received.

Covers **104** may be paired to a wireless device such as a smartphone, or tablet via a BTLE connection **126** by using a graphical user interface (GUI **128**) that may be downloaded from any suitable application store and may run on any suitable operating system such as iOS and Android, among others. Covers **104** may also communicate with wireless power transmitter **102** via a BTLE connection **126** to send important data such as an identifier for the device as well as battery level information, antenna voltage, geographic location data, or other information that may be of use for the wireless power transmitter **102**.

In other embodiments, GUI **128** may also be installed on a wireless device (smartphones or tablets) that may not have the cover **104**. GUI **128** may perform operations to communicate with power transmitter manager app **108** via BTLE connection **126** or any other wireless communication protocols such as WiFi among others.

Customer pocket-forming enabled devices **106** may refer to a wireless device such as smartphones, tablets, or any of the like that may include an integrated wireless power receiver chip (not shown in FIG. **1**) for wireless power charging. Customer pocket-forming enabled devices **106** may include a power receiver app **130** (PWR RX APP), and a third party application programming interface **132** (Third Party API) for a Bluetooth Low Energy chip **134** (BTLE CHIP HW). Customer pocket-forming enabled devices **106** may also include an RF antenna array **136** which may be used to receive and utilize pockets of energy sent from wireless power transmitter **102**. GUI **138** may be downloaded from any suitable application store and may run on any suitable operating system such as iOS and Android, among others.

Power receiver app **130** may call third party application programming interface **132** for running a plurality of functions such as start a connection, end the connection, and send data among others. Third party application programming interface **132** may have a timer callback that may go for ten times a second and may send callbacks every time a connection begins, a connection ends, a connection is attempted, or message is received.

Customer pocket-forming enabled devices **106** may also communicate with wireless power transmitter **102** via a BTLE connection **126** to send important data such as an identifier for the device as well as battery level information, antenna voltage, geographic location data, or other information that may be of use for the wireless power transmitter **102**.

FIG. **2** shows a sequence diagram **200** for a real time communication between wireless power transmitters and wireless power receivers, according to an embodiment.

Sequence diagram **200** illustrates the interactions between objects or roles that allow the real time communication between a wireless power transmitter and one or more wireless power receivers. The objects or roles described here may include, but is not limited to, a GUI **202**, a third party API **204** that controls a BTLE chip embedded on the power transmitter board, a power transmitter manager app **206**, a power receiver app **208**, and a power receiver API **210** that controls a BTLE chip embedded on a wireless power receiver board.

Power transmitter manager app **206** may first scan for power receivers ads every one second as long as its radio receiver is on. Power receiver app **208** may continuously broadcast ads **212** around its radio until a power transmitter manager app **206** intercepts these ads **212**. Ads **212** may include data such as unique IDs that may allow power transmitter manager app **206** to identify the wireless power receiver to which is about to establish a connection. Once power transmitter manager app **206** intercepts ads **212**, it may attempt connection one or more times until it gets connected. GUI **202**, at the same time, may continuously send ads **214** to third party API **204** on the transmitter board until it causes an add detection callback that may initiate timer callback **216** in the third party API **204**. Ads **214** may include data such as a list of power receivers to be tracked and which to be charged.

Timer callback **216** may then trigger power transmitter manager app **206** where power transmitter manager app **206** may respond by sending a start communication **218** write request message to power receiver app **208** to initiate real time communication with power receiver app **208**. Then power receiver API **210** may respond with a callback **220** sent to power receiver app **208** which may immediately trigger power receiver app **208** by sending multiple messages including status and data **222** of the wireless power receiver, at a rate of about 100 packets per second, to the power transmitter manager app **206**. Status and data **222** may include data such as antenna voltage of the wireless power receiver, battery levels, and charging status among

others. In other embodiments, the transfer rate may go up to 400 packets per second but there may be problems of communication at that rate.

After status and data **222** is received at power transmitter manager app **206**, third party API **204** sends a message received call back **224** to power transmitter manager app **206**. Then power transmitter manager app **206** processes the status and data **222** message. This process may repeat every time a status and data **222** is received. After a certain period of time, power receiver app **208** may send a status indicating that power receiver API **210** is running out of transmit buffers. Subsequently, power transmitter manager app **206** may restore the buffers by sending back a start communication **226** write request message to the power receiver app **208**. Once the buffers are restored, a callback **228** from the power receiver API **210** is sent to the power receiver app **208**, triggering the software to send status and data **230** again back to power transmitter manager app **206** at a rate of about 100 packets per second. Status and data **230** may continue to send updates about antenna voltage of the wireless power receiver, battery levels, and charging status among others.

After status and data **230** is received at power transmitter manager app **206**, third party API **204** sends a message received call back **232** to power transmitter manager app **206**. Then power transmitter manager app **206** processes the status and data **230** message. This process may repeat every time a status and data **222** is received. After a certain period of time, power receiver app **208** may send a status indicating that power receiver API **210** is running out of transmit buffers. However, at this point, power transmitter manager app **206** may check the time and realize that one second has gone since it started communication with power receiver app **208**, hence it may be time to check if there are other wireless power receivers that may need charge. Power transmitter manager app **206** may then stop restoring buffers on power receiver API **210** and set on a scanning mode where it listens for ads coming from GUI **202** and power receiver APP **208**. Subsequently, GUI **202** may send ads **234** to third party API **204** which my trigger a timer callback **236**. Ads **234** may include data such as a list of power receivers to be tracked and which to be charged. Power transmitter manager app **206** may then process ads **234** and establish a real time communication with the next wireless power receiver available within a period of one second.

The above described systems and methods may allow wireless power transmitters to communicate with one or more wireless power receivers in real time within intervals of one second. The systems and methods described here may enable full control of the wireless power receivers by letting the user decide which wireless power receivers to charge, when to charge them, and set priorities and charging schedules among other functions. In other embodiments, the systems and methods described here may allow the wireless power transmitters to communicate with wireless power receivers simultaneously by adding multiple BTLE chips on the power transmitter board.

The foregoing method descriptions and the process flow diagrams are provided merely as illustrative examples and are not intended to require or imply that the steps of the various embodiments must be performed in the order presented. As will be appreciated by one of skill in the art the steps in the foregoing embodiments may be performed in any order. Words such as "then," "next," etc. are not intended to limit the order of the steps; these words are simply used to guide the reader through the description of the methods. Although process flow diagrams may describe the operations as a sequential process, many of the operations can be performed in parallel or concurrently. In addition, the order of the operations may be re-arranged. A process may correspond to a method, a function, a procedure, a subroutine, a subprogram, etc. When a process corresponds to a function, its termination may correspond to a return of the function to the calling function or the main function.

The various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the embodiments disclosed here may be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and steps have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present invention.

Embodiments implemented in computer software may be implemented in software, firmware, middleware, microcode, hardware description languages, or any combination thereof. A code segment or machine-executable instructions may represent a procedure, a function, a subprogram, a program, a routine, a subroutine, a module, a software package, a class, or any combination of instructions, data structures, or program statements. A code segment may be coupled to another code segment or a hardware circuit by passing and/or receiving information, data, arguments, parameters, or memory contents. Information, arguments, parameters, data, etc. may be passed, forwarded, or transmitted via any suitable means including memory sharing, message passing, token passing, network transmission, etc.

The actual software code or specialized control hardware used to implement these systems and methods is not limiting of the invention. Thus, the operation and behavior of the systems and methods were described without reference to the specific software code being understood that software and control hardware can be designed to implement the systems and methods based on the description here.

When implemented in software, the functions may be stored as one or more instructions or code on a non-transitory computer-readable or processor-readable storage medium. The steps of a method or algorithm disclosed here may be embodied in a processor-executable software module which may reside on a computer-readable or processor-readable storage medium. A non-transitory computer-readable or processor-readable media includes both computer storage media and tangible storage media that facilitate transfer of a computer program from one place to another. A non-transitory processor-readable storage media may be any available media that may be accessed by a computer. By way of example, and not limitation, such non-transitory processor-readable media may comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other tangible storage medium that may be used to store desired program code in the form of instructions or data structures and that may be accessed by a computer or processor. Disk and disc, as used here, include compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk, and Blu-ray disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers. Combinations of

the above should also be included within the scope of computer-readable media. Additionally, the operations of a method or algorithm may reside as one or any combination or set of codes and/or instructions on a non-transitory processor-readable medium and/or computer-readable medium, which may be incorporated into a computer program product.

The preceding description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the present invention. Various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined here may be applied to other embodiments without departing from the spirit or scope of the invention. Thus, the present invention is not intended to be limited to the embodiments shown here but is to be accorded the widest scope consistent with the following claims and the principles and novel features disclosed here.

The invention claimed is:

1. A system for controlling communication between a wireless power transmitter and at least one wireless power receiver, the system comprising:

a wireless power transmitter that includes:

a first processor running a power transmitter manager application;

a first wireless communication hardware having a transmitter application programming interface (API), the transmitter API operatively coupled with the power transmitter manager application and controlling the first wireless communication hardware;

a transmitter wireless antenna array that transmits controlled wireless power waves that converge to create pockets of energy in the space proximate at least one wireless power receiver, wherein:

the transmitter wireless antenna array is at least partially responsive to instructions from the power transmitter manager application, and

the transmitter API calls the power transmitter manager application through a transmitter callback function, and the transmitter callback function sends a callback when a communication connection begins, a communication connection ends, a communication connection is attempted, or a message is received; and

the at least one wireless power receiver that includes:

a second processor running a power receiver application;

a second wireless communication hardware having a receiver API, the receiver API operatively coupled to the power receiver application and controlling the second wireless communication hardware;

a receiver wireless antenna array that receives and uses wireless power from the pockets of energy created by the wireless power transmitter, wherein the receiver wireless antenna array is at least partially responsive to instructions from the power receiver application.

2. The system of claim **1**, wherein a communication protocol used by the first wireless communication hardware and the second wireless communication hardware is one of Bluetooth Low Energy (BTLE) and WiFi.

3. The system of claim **1**, wherein the power transmitter manager application stores information obtained from the at least one wireless power receiver to facilitate communications between the first wireless communication hardware of the wireless power transmitter and the second wireless communication hardware of the at least one wireless power receiver.

4. The system of claim **3**, wherein the information includes an identifier and information used to determine a location of the at least one wireless power receiver.

5. The system of claim **1**, wherein:

a communication connection is a connection between the first wireless communication hardware and the second wireless communication hardware, and

the message is received by the first wireless communication hardware from the second wireless communication hardware.

6. The system of claim **1**, wherein the transmitter API commands the first wireless communication hardware according to a plurality of functions called by the power transmitter manager application, the plurality of functions including respective functions that cause the transmitter API to command to the first wireless communication hardware to start a communication connection with the second wireless communication hardware, end a communication connection with the second wireless communication hardware, and send data.

7. The system of claim **1**, wherein the callback is sent at least ten times per second.

8. The system of claim **1**, wherein the at least one wireless power receiver is at least one of an energy consuming electronic device and a cover of an energy consuming electronic device.

9. The system of claim **1**, wherein the power receiver application calls the receiver API to start a connection, end a connection, and send data.

10. The system of claim **1**, wherein the receiver API calls the power receiver application through a receiver callback function.

11. The system of claim **10**, wherein the receiver callback function sends a callback to the power receiver application when a connection begins, a connection ends, a connection is attempted, or a message is received.

12. The system of claim **11**, wherein the receiver API sends the callback to the power receiver application at least ten times per second.

13. The system of claim **8** wherein the energy consuming device downloads the power receiver application from an application store, the power receiver application including a GUI to allow the energy consuming device to communicate with the power transmitter manager application.

14. The system of claim **1**, wherein the wireless power waves are radio frequency (RF) waves.

15. A method for controlling wirelessly transmitted power comprising:

at a wireless power transmitter that includes a first processor, a first wireless communication hardware having a transmitter application programming interface (API), and a transmitter wireless antenna array:

running, by the first processor, a power transmitter manager application that is operatively coupled with the transmitter API;

causing, by the power transmitter manager application using the transmitter API, the wireless communication hardware to begin a communication connection with a second wireless communication hardware of at least one wireless power receiver,

wherein the transmitter API calls the power transmitter manager application through a transmitter callback function, and the transmitter callback function sends a callback when the communication connection

begins, the communication connection ends, the communication connection is attempted, or a message is received; and

instructing, by the power transmitter manager application, the transmitter wireless antenna array to transmit controlled wireless power waves that converge to create a pocket of energy near a location of the at least one wireless power receiver; and

at the at least one wireless power receiver that includes a second processor, the second wireless communication hardware having a receiver API, and a receiver wireless antenna array:

running, by the second processor, a power receiver application that is operatively coupled with the receiver API, wherein the receiver API is configured to control the second wireless communication hardware; and

instructing, by the power receiver application, the receiver wireless antenna array to receive and use wireless power from the pocket of energy created by the wireless power transmitter.

16. The method of claim **15**, further comprising:

receiving ads from the second wireless communication hardware of the at least one wireless power receiver, wherein the ads include an identifier of the wireless power receiver;

receiving, by the wireless power transmitter, at least one of the ads; and

initiating, by the wireless power transmitter, the communication connection with the wireless power receiver.

17. The method of claim **16**, further comprising:

maintaining, by the wireless power transmitter, information identifying a plurality of wireless power receivers being tracked by the wireless power transmitter and which of the tracked wireless power receivers are to be charged; and

instructing, by the power transmitter manager application, the transmitter wireless antenna array to transmit respective wireless power waves to create respective pockets of energy to each of the tracked wireless power receivers that are to be charged.

18. The method of claim **15**, further comprising:

before the instructing, receiving, from the second wireless communication hardware of the at least one wireless power receiver and via the communication connection, information that is used to determine the location of the at least one wireless power receiver.

19. The method of claim **15**, further comprising:

determining whether the wireless power receiver is to be charged by the wireless power transmitter,

wherein the instructing includes:

in accordance with determining that the wireless power receiver is to be charged, instructing the transmitter wireless antenna array to transmit the controlled wireless power waves that converge to create the pocket of energy near the location of the at least one wireless power receiver.

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