2011 IEEE MTT-S International Microwave Workshop Series
on Innovative Wireless Power Transmission:
Technologies, Systems, and Applications

IMWS-IWPT 2011

May 12-13, 2011,
Oubaku Plaza, Uji Campus, Kyoto University, Uji, Kyoto, Japan

Final Program

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IMWS-IWPT2011 Program at a Glance

May 12 (THU)

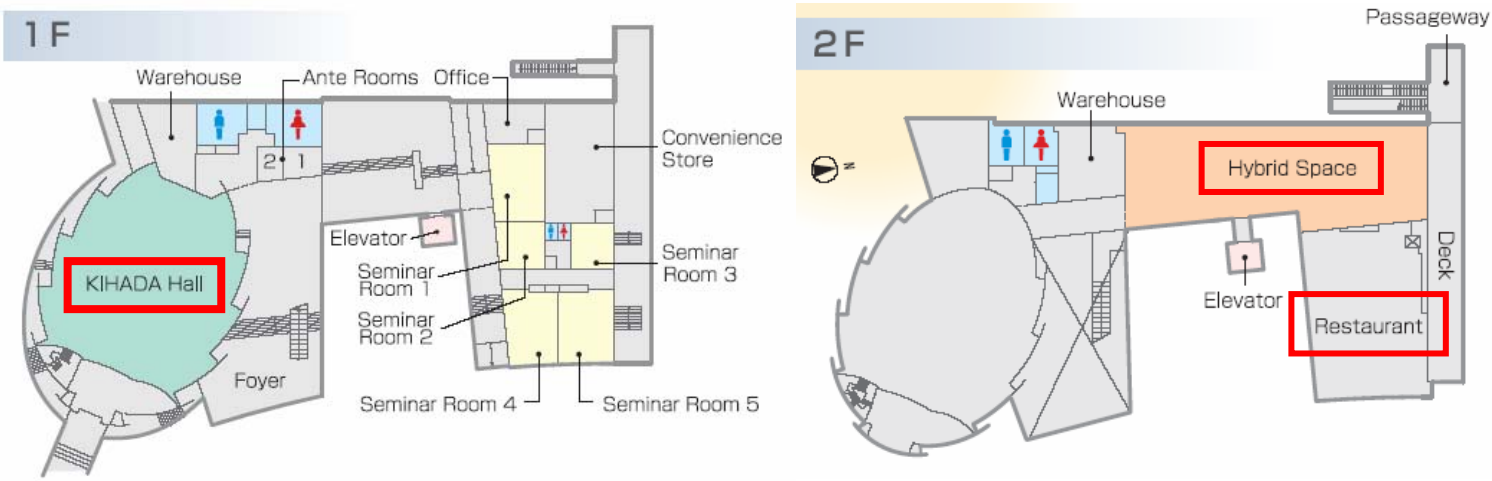
	KIHADA Hall	Hybrid Space
9:00	**Opening Remarks**	
9:20	**Keynote Speech 1**	
10:10	**Break**	
10:20	**Keynote Speech 2**	
11:10	**Keynote Speech 3**	
12:00	**Lunch**	
13:00	**Session 1:** Rectennas	
14:20	**Session 2:** Circuit and Device	
15:40	**Break**	
16:00	**Session 3:** Long Distance WPT Applications	
17:40	**Session 4:** Short Distance WPT Applications	
18:40		
19:00	**Banquet** (Restaurant)	
21:00		

May 13 (FRI)

	KIHADA Hall	Hybrid Space
8:50	**Session 5-1:** Radio Management and Regulations	
9:50	**Session 5-2:** Biological Effects and EMC Control	
11:10	**Break**	
11:30	**Session 6:** Coupling	
13:10	**Lunch**	**Poster Session (12:40-14:20)**
14:20	**Session 7:** Improved Antenna Design Considerations for New Applications	
15:20	**Session 8:** Phased Array	
16:40	**Break**	
17:00	**Session 9:** Other Applications	
18:00	**Session 10:** Microwave Rockets as a Low-Cost Interface to Space	
19:00		
19:20	**Closing**	
19:40		

CONFERENCE ROOMS

Oubaku Plaza



Message from the Workshop Co-Chairs

On behalf of the IMWS-IWPT2011 Organizing Committee, I am pleased to extend you a warm welcome and also an invitation to contribute to the IMWS-IWPT2011. This workshop is the fist IMS Workshop in Japan and the first workshop in which we mainly focus on the wireless power transmission (WPT) technologies and applications. We have plenary session, technical sessions, and poster session on state-of-the-art technologies and applications of the WPT presented by leading experts from around the world.

The WPT, especially microwave power transmission (MPT), has long technological history. There were a lot of researches and experiments of the MPT in the world. Especially, after proposal of the Space Solar Power Satellite (SPS) in 1968 which was biggest and most suitable MPT application, the MPT researches walked along the SPS. Based on the technological history, we have some kinds of new WPT technology like a resonant coupling and new applications suitable for the WPT in 21st century. 2011 is the first year of the innovative WPT technologies, systems and applications.

I hope you have a fruitful time in the IMWS-IWPT2011 and you find new knowledge of the MPT and the WPT.

Naoki SHINOHARA
Workshop Co-Chair

The microwave technology has been great progress in the field of wired and wireless telecommunication systems and a sensor system. As the third usage of the RF and microwave frequency, wireless power supply and energy transmission and the related energy harvesting have been paid much attention. The activities of the microwave power transmission (MPT) in Japan have been activated by the SSPS project.

The most significant point of MPT is the effective use of the carrier energy in the signal with various kinds of modulation. In addition, this concept can be used in a radar system. In accordance with this stream, its application has been extended into the communication and sensing systems. In this workshop, attractive active/passive microwave components, antennas and systems for MWPT are demonstrated. Standing this view point, we greatly expect the fruitful discussion.

Shigeo KAWASAKI
Workshop Co-Chair

Though I am a microwave engineer, some people do not think I am, because I have plunged into the field of power transmission. The microwave technology is so wide that it sometimes conceals the background of an engineer. In fact, I was inspired by the microwave concepts to deal with the resonator and/or line coupled WPT systems.

The development of WPT systems, however, has revealed the culture difference between the microwave and power electronics societies. Considering the importance of the present technology, we are expected to cooperate toward its earliest practical application. The warm atmosphere of cooperation over the world after the disaster in Japan will help improve the world-wide public welfare, not only the reconstruction of Japan.

Ikuo AWAI
Workshop Co-Chair

Message from the Technical Program Committee Chairs

Yohei ISHIKAWA
Technical Program Committee Co-Chair

Yoshiyuki FUJINO
Technical Program Committee Co-Chair

On behalf of the IMWS-IWPT2011 Technical Program Committee, it is an honor to welcome you to the IMWS-IWPT 2011 in Uji, Kyoto at the best season in Japan.

The TPC committee has prepared an advanced, exciting program that covered the whole from the system to the component technologies concerning the wireless power transmission technology.

So far, we have received a great number of papers from many countries, which is unusual and remarkable for an international conference in this field.

However, we are terribly sorry that we had to choose 46 oral presentations for regular sessions and 20 poster presentations out of all papers as a result of considering the program timelines and also placing the first priority on the mutual understanding among related specialized fields.

The plenary session is scheduled on May 12, Tuesday at 9:00 a.m. with the opening keynote speech entitled “Wireless Power Transmission Technologies for Solar Power Satellite" by Professor Susumu Sasaki from JAXA, Japan, Then, Professor Joungho Kim from KAIST, Korea will be presenting the second keynote speech entitled "Resonant Magnetic Field Technology for High Power and Enhanced Efficiency Wireless Power Transfer". The third keynote speech entitled "Cytogenetic Studies in Mammalian Somatic Cells Exposed to Electromagnetic Fields: A Meta-Analysis" will be given by Dr. Vijayalaxmi from the Texas Health Science University. We are confident that these speeches are outstanding study results on the most essential technology for practical use of the wireless power transmission systems. In addition, we invited five outstanding excellent researchers in each field.

The tragic catastrophe that had hit East Japan on March 11 made us realized again that the electric power networks and the communication network are the most important lifeline. Now we face the necessity of R&D for the technology that guarantees the high reliability and the fast restoration of the lifelines. Moreover, the inconvenience of the rolling blackout in big cities urges the people for the electric power saving and the further use of natural energy. We are certain the wireless power transmission technology has a great potential as a strong and flexible system against disasters.

The program for this year is intentionally designed with the serial sessions in which we hope there would be the effective interaction between sessions. Because we believed that R&D activities which technologies of each session are systematically organized are very important for the early practical use of each WPT system. We are looking forward to seeing you soon in Uji, Kyoto, and wish you an enjoyable and creative stay.

Yohei ISHIKAWA
Yoshiyuki FUJINO
Technical Program Committee Co-Chairs
IMWS-IWPT2011

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Technical Program

Thursday, 12 May, 2011

Plenary Session
KIHADA Hall 9:00 - 12:00
Thursday, 12 May, 2011

9:00-9:20

Opening Remarks: Naoki Shinohara, *Kyoto University, Japan*

Chair: Yohei Ishikawa, *Murata Corporation, Japan*

9:20-10:10
IWPT-PL-1 (Keynote Speech 1) **Wireless Power Transmission Technologies for Solar Power Satellite**
Susumu Sasaki, Koji Tanaka, and Advanced Mission Research Group, *JAXA, Japan*

10:20-11:10
IWPT-PL-2 (Keynote Speech 2) **Resonant Magnetic Field Technology for High Power and Enhanced Efficiency Wireless Power Transfer**
Joungho Kim, *KAIST, Korea*

11:10-12:00
IWPT-PL-3 (Keynote Speech 3) **Cytogenetic Studies in Mammalian Somatic Cells Exposed to Electromagnetic Fields: A Meta-Analysis**
Vijayalaxmi and Thomas J. Prihoda, *University of Texas Health Science Center, USA*

Session 1: Rectenna
KIHADA Hall 13:00 - 14:20
Thursday, 12 May, 2011

Chairs: Kenji Itoh, *Kanazawa Institute of Technology, Japan*
Shigeji Nogi, *Okayama University, Japan*

IWPT1-1 (Invited) **Innovative Antenna Systems for Efficient Microwave Power Collection**
Giorgio Franceschetti, Andrea Massa, and Paolo Rocca, *University of Trento, Italy*

IWPT1-2 **Efficiency and harmonics generation in microwave to DC conversion circuits of half-wave and full-wave rectifier types**
Shohei Imai, Shoichi Tamaru, Kazuhiro Fujimori, Minoru Sanagi, and Shigeji Nogi, *Okayama University, Japan*

IWPT1-3 **5.8GHz High Sensitivity Rectenna Array**
[1]Kazuhiro Nishida, [1]Yuhei Taniguchi, [1]Kenji Kawakami, [1]Yukihiro Homma, [1]Hiroyuki Mizutani, [1]Moriyasu Miyazaki, [1]Hiroshi Ikematsu, and [2]Naoki Shinohara, [1]*Mitsubishi Electric Corporation, Japan,* [2]*Kyoto University, Japan*

IWPT1-4 **An Improved Detector Topology for a Rectenna**
Steve Eden Fila Mbombolo and Chan Wang Park, *Université du Québec à Rimouski, Canada*

Session 2: Circuit and Device
KIHADA Hall 14:20 - 15:40
Thursday, 12 May, 2011

Chair: Yasuo Ohno, *Tokushima University, Japan*

IWPT2-1 **Distributed Class-F/Inverse Class-F Circuit Considering up to Arbitrary Harmonics with Parasitics Compensation**
Ryo Ishikawa and Kazuhiko Honjo, *The University of Electro–Communications, Japan*

IWPT2-2 **Power Transmission through Insulating Plate Using Open-Ring Resonator Coupling and GaN Schottky Diode**
Kenji Harauchi[1], Yuichi Iwasaki[1], Mami Abe[1], Jin-Ping Ao[1], Naoki Shinohara[2], Hiroshi Tonomura[3] and Yasuo Ohno[1], [1]*The University of Tokushima,Japan,* [2]*Kyoto University, Japan,* [3]*UD Trucks Corporation, Japan*

IWPT2-3 **Control of Turn-on Voltage in GaN Schottky Barrier Diode Using Zr/Al/Mo/Au Metal Stack**
H. Tokuda[1], F. Watanabe[1], A. Syahiman[1], M. Kuzuhara[1], and T. Fujiwara[2], [1]*University of Fukui, Japan* [2]*Sho Engineering Corp., Japan*

IWPT2-4 **Internally-matched GaN HEMT High Efficiency Power Amplifier for SPS**
Yoshinori Tsuyama[1] , Koji Yamanaka[1], Koji Namura[1] ,Shin Chaki[1], and Naoki Shinohara[2], [1]*Mitsubishi Electric Corporation, Japan,* [2]*Kyoto University, Japan*

Session 3: Long Distance WPT Applications
KIHADA Hall 16:00 - 17:40
Thursday, 12 May, 2011

Chair: Yoshiyuki Fujino, *NICT, Japan*

IWPT3-1 **Outline and Progress of the Japanese Microwave Energy Transmission Program for SSPS**
Yoshiharu Fuse[1], Takashi Saito[1], Shoichiro Mihara[1], Koichi Ijichi[1], Koji Namura[2], Yukihiro Honma[2], Takuro Sasaki[2], Yuichiro Ozawa[3], Eiichiro Fujiwara[3], and Teruo Fujiwara[3], [1]*Institute for Unmanned Space Experiment Free Flyer, Japan,* [2]*Mitsubishi Electric Co., Japan,* [3]*IHI Aerospace Co.,Ltd., Japan*

IWPT3-2 **Wireless Power Transmission using Modulated Microwave**
Mai Ishiba, Jun Ishida, Kimiya Komurasaki, and Yoshihiro Arakawa, *The University of Tokyo, Japan*

IWPT3-3 **Novel Wireless Impulsive Power Transmission to Enhance the Conversion Efficiency for Low Input Power**
Chun-Chih Lo, Yu-Lin Yang, Chi-Lin Tsai, Chieh-Sen Lee, and Chin-Lung Yang, *National Cheng Kung University, Taiwan, R.O.C.*

IWPT3-4 **New Phased Array and Rectenna Array Systems for Microwave Power Transmission Research**
Yukihiro Homma[1], Takuro Sasaki[1], Koji Namura[1], Fuminori Sameshima[1], Tsuyoshi Ishikawa[1], Hiroki Sumino[1], and Naoki Shinohara[2], [1]*Mitsubishi Electric Corporation, Japan*, [2]*Kyoto University, Japan*

IWPT3-5 **Study on a Microwave Power Transmitting System for Mars Observation Airplane**
Akihito Nagahama[1], Tomohiko Mitani[1], Naoki Shinohara[1], Naoki Tsuji[2], Keita Fukuda[2], Yoshitaka Kanari[2], and Koichi Yonemoto[2], [1]*Kyoto University, Japan,* [2]*Kyushu Institute of Technology, Japan*

Session 4: Short Distance WPT Applications
KIHADA Hall 17:40 - 18:40
Thursday, 12 May, 2011

Chairs: Hai-Young Lee, *Ajou University, Korea*
Tomohiro Seki, *NTT, Japan*

IWPT4-1 **Wireless Power Transmission System by Tightly Coupled Microstrip Line Overlay Resonators**
Hiroyuki Arai and Naoki Yoneyama, *Yokohama National University, Japan*

IWPT4-2 **High Efficiency Midrange Wireless Power Transfer System**
Jaime Garnica[1], Joaquin Cassanova[2], and Jenshan Lin[1], [1]*University of Florida, U.S.A.*, [2]*Conservation and Production Research Laboratory, USDA, U.S.A.*

IWPT4-3 **Power Transfer for a Running Automobile**
Masahiro Hanazawa[1] and Takashi Ohira[2], [1]*Toyota Central R & D Labs., Inc., Japan,* [2]*Toyohashi University of Technology, Japan*

Friday, 13 May, 2011

Session 5-1: Radio Management and Regulations
KIHADA Hall 8:50 - 9:50
Friday, 13 May, 2011

Chairs: Toshio Nojima, *Hokkaido University, Japan*
Junji Miyakoshi, *Kyoto University, Japan*

IWPT5-1-1 **Frequency Allocations of Solar Power Satellite and International Activities**
Kozo Hashimoto[1, 2], [1]*The Paleological Association of Japan, Inc., Japan,* [2]*Kyoto University, Japan*

IWPT5-1-2 **Issues and Initiatives for Practical Use of Wireless Power Transmission Technologies in Japan**
Hiroki Shoki, *Toshiba Corporation*

IWPT5-1-3 **Activities of Energy Harvesting Consortium in Japan**
Keiji Takeuchi, *NTT Data Institute of Management Consulting, Inc., Japan*

Session 5-2: Biological Effects and EMC Control
KIHADA Hall 9:50 - 11:10
Friday, 13 May, 2011

Chairs: Toshio Nojima, *Hokkaido University, Japan*
Junji Miyakoshi, *Kyoto University, Japan*

IWPT5-2-1 (Invited) **Possible EMC Regulations for Wireless Power Transmission Equipment**
Yukio Yamanaka and Akira Sugiura, *National Institute of Information and Communications Technology, Japan*

IWPT5-2-2 (Invited) **Practical method to evaluate electromagnetic interference in active implantable medical devices**
Takeshi Toyoshima, *Medtronic Japan Co., Ltd.,Japan*

IWPT5-2-3 **Microarray Analysis of Human-derived Glial Cells Exposed to 2.45 GHz Microwave**
Tomonori Sakurai[1], Eijiro Narita[1], Yukihisa Suzuki[2], Masao Taki[2], and Junji Miyakoshi[1], [1]*Kyoto University*, Japan, [2]*Tokyo Metropolitan University, Japan*

IWPT5-2-4 **Active Implantable Medical Device EMI Assessments for Electromagnetic Emitters Operating at various RF Bands**
Takashi Hikage[1], Yoshifumi Kawamura[1], Toshio Nojima[1], Ben Koike[2], Hiroshi Fujimoto[3], and Takeshi Toyoshima[3], [1]*Hokkaido University, Japan,* [2]*Japan Automatic Identification Systems Association, Japan,* [3]*Medtronic Japan Co., Ltd., Japan*

Session 6: Coupling
KIHADA Hall 11:30 - 13:10
Friday, 13 May, 2011

Chairs: Jenshan Lin, *University of Florida, USA*
Ikuo Awai, *Ryukoku University, Japan*

IWPT6-1 (Invited) **Classification and Characterization of Wireless Power Transfer Systems of Resonance Method Based on Equivalent Circuit Derived from Even and Odd Mode Reactance Functions**
Naoki Inagaki[1] and Satoshi Hori[2], [1]*Nagoya Institute of Technology, Japan,* [2]*Kojima Press Industry Co., Ltd., Japan*

IWPT6-2 **Broadband and Strong Coupling Metamaterial-Based Cavity Resonator Using Artificial Magnetic Surfaces**
Chong-Yi Liou, Chi-Jung Kuo, Jen-Chun Yeh, Yu-Zhi Chueh and Shau-Gang Mao, *National Taipei University of Technology, Taiwan, R.O.C.*

IWPT6-3 **Design and Experiment of Multi-stage Resonator-coupled WPT System**
Ikuo Awai, Takuya Komori and Toshio Ishizaki, *Ryukoku University, Japan*

IWPT6-4 **Efficiency of magnetic resonance WPT with two off-axis self-resonators**
Jin-Wook Kim, Hyeon-Chang Son, Do-Hyeon Kim, Kwan-Ho Kim, and Young-Jin Park, *University of Science & Technology (UST), Korea, Korea Electotechnology Research Institute (KERI), Korea*

IWPT6-5 **Wireless Power Transfer System with a Simple Receiver Coil**
Takashi Miyamoto, Shinji Komiyama, Hiroyuki Mita and Kenichi Fujimaki, *Sony Corporation, Japan*

Session 7: Improved Antenna Design Considerations for New Applications
KIHADA Hall 14:20 - 15:20
Friday, 13 May, 2011

Chair: Koichi Ogawa, *The University of Toyama, Japan*

IWPT7-1 (Invited) **Electromagnetic Field Focusing for Short-Range Wireless Power Transmission**
Ada S. Y. Poon, *Stanford University, USA*

IWPT7-2 **A Feasibility Study of Wireless Power Transmission System by using Two Independent Coupled Electric Fields**
Koichi Tsunekawa, *Chubu University, Japan*

IWPT7-3 **Design of Receiving Antenna for Microwave Power Transmission to Capsular Endoscope**
Toshihiro Kumagai, Kazuyuki Saito, Masaharu Takahashi, and Koichi Ito, *Chiba University, Japan*

Session 8: Phased Array
KIHADA Hall 15:20 - 16:40
Friday, 13 May, 2011

Chairs: Andrea Massa, *University of Trento, Italy*
Masanobu Yajima, *JAXA, Japan*

IWPT8-1 (Invited) **Innovative Array Designs for Wireless Power Transmission**
Paolo Rocca, Giacomo Oliveri, and Andrea Massa, *University of Trento, Italy*

IWPT8-2 **Study on Optimization of Microwave Power Beam of Phased Array Antenna for SPS**
Takaki Ishikawa and Naoki Shinohara, *Kyoto University, Japan*

IWPT8-3 **Development of Phased Array for High Accurate Microwave Power Transmission**
Tomohiro Takahashi[1], Tomohiro Mizuno[1], Manabu Sawa[1], Takuro Sasaki[1],Toru Takahashi[1], and Naoki Shinohara[2], [1]*Mitsubishi Electric Corporation, Japan*, [2]*Kyoto University, Japan*

IWPT8-4 **An FPGA Implementation of Complex Valued Independent Component Analysis for Real-Time Interference Canceler**
Hidehisa Shiomi, Shunsuke Fujio and Yasuyuki Okamura, *Osaka University, Japan*

Session 9: Other Applications
KIHADA Hall 17:00 - 18:00
Friday, 13 May, 2011

Chair: Kazuo Satoh, *Toyota Central R&D Laboratory, Inc., Japan*

IWPT9-1 **HEMS with Resonant-type Wireless Power Transmission**
Takashi Yoshikawa and Ikuo Awai, *Ryukoku University, Japan*

IWPT9-2 **Development of Highly Efficient Transducer for Wireless Power Transmission System by Ultrasonic**
Yusuke Shigeta, Yuki Hori, Kazuhiro Fujimori, Kenji Tsuruta, and Shigeji Nogi, *Okayama University, Japan*

IWPT9-3 **Efficiency Improvement of the Impulsive Wireless Power Transmission through Biomedical Tissues by Varying the Duty Cycle**
Yu-Lin Yang, Chin-Lung Yang, Chi-Lin Tsai, and Chieh-Sen Lee, *National Cheng Kung University, Taiwan, R.O.C.*

Session 10: Microwave Rockets as a Low-Cost Interface to Space
KIHADA Hall 18:00 - 19:00
Friday, 13 May, 2011

Chair: Kimiya Komurasaki, *The University of Tokyo, Japan*

IWPT10-1 **An Experimental Study on High Power Millimeter Wave Beam Transmission for Microwave Beaming Propulsion**
Yasuhisa Oda[1], Toshikazu Yamaguchi[2], Kimiya Komurasaki[2], Ken Kajiwara[1], Koji Takahashi[1], and Keishi Sakamoto[1], [1]*Japan Atomic Energy Agency, Japan*, [2]*The University of Tokyo, Japan*

IWPT10-2 **Development of Microwave Rocket as a Space Mass Transportation System**
Reiji Komatsu[1], Masafumi Fukunari[1], Toshikazu Yamaguchi[1], Kimiya Komurasaki[1], Yoshihiro Arakawa[1], Yasuhisa Oda[2], Keishi Sakamoto[2], Ikko Funaki[3], Hiroshi Katsurayama[4], [1]*The University of Tokyo, Japan,* [2]*Japan Atomic Energy Agency, Japan*, [3]*Japan Aerospace Exploration Agency, Japan* [4]*Yamaguchi University, Japan*

IWPT10-3 **Interaction between Shock Wave and Plasma Region Ionized by Millimeter Wave Beam and Its Application to Pulse Detonation System as a Microwave Rocket**
Toshikazu Yamaguchi[1], Reiji Komatsu[1], Kimiya Komurasaki[1], Yasuhisa Oda[2], Ken Kajiwara[2], Koji Takahashi[2], and Keishi Sakamoto[2], [1]*The University of Tokyo, Japan,* [2]*Japan Atomic Energy Agency, Japan*

Poster Session
Hybrid Space (2nd Floor) 12:40 - 14:20
Friday, 13 May, 2011

IWPT-P-1 **System Consideration of Solar Power Satellite using Functional Models**
Koji Tanaka[1], Tatsuhito Fujita[1], Satoshi Yamaguchi[2], Shintaro Hamada[3], Kengo Miyashiro[3], and Susumu Sasaki[1], [1]*Japan Aerospace Exploration Agency, Japan*, [2]*Tokyo Institute of Technology, Japan*, [3]*Tokyo University of Science, Japan*

IWPT-P-2 **Analysis on Transmission Efficiency of Wireless Energy Transmission Resonator Based on Magnetic Resonance**
Jaewon Choi, Jun-Kyung Cho, and Chulhun Seo, *Soongsil University, Korea*

IWPT-P-3 **One-Dimensional Proximity Power Transmission Using Ribbon-Like Waveguide and Bar-Type High-Q Resonant Receiver Coupler**
Akihito Noda and Hiroyuki Shinoda, *The University of Tokyo, Japan*

IWPT-P-4 **Acoustic Lens using Sonic Crystal for Energy-Transmission Applications**
Yusuke Kanno, Yuuki Kasai, Kenji Tsuruta, Kazuhiro Fujimori, Hideki Fukano, and Shigeji Nogi, *Okayama University, Japan*

IWPT-P-5 **Measurement of resonator parameters for wireless power transmission system**
Tetsuya Ishida, Ikuo Awai, and Issei Sugiyama, *Ryukoku University, Japan*

IWPT-P-6 **Effects of Exposure to A High-Frequency Electromagnetic Field at 2.45 GHz on Neurite Outgrowth in PC12VG Cells**
Eijiro Narita[1], Tomonori Sakurai[1] Yukihisa Suzuki[2], Masao Taki[2], and Junji Miyakoshi[1], [1]*Kyoto University, Japan*, [2]*Tokyo Metropolitan University, Japan*

IWPT-P-7 **A Numerical Study of Power Loss Factors in Resonant Magnetic Coupling**
Satoshi Shimokawa, Hiroyasu Kawano, Kiyoto Matsui, Akiyoshi Uchida and Masakazu Taguchi, *Fujitsu Laboratories Limited, Japan*

IWPT-P-8 **Arbitrarily-shaped-beam microstrip reflectarray based on phase-retrieval method**
A. Kobayashi, H. Deguchi, M. Tsuji, and S. Kurihara, *Doshisha University, Japan*

IWPT-P-9 **Development of High Accuracy Phase Control Method for Space Solar Power System**
Takanori Narita[1], Tomohisa Kimura[1], Kenichi Anma[1], Nobuhiko Fukuda[1], and Naoki Shinohara[2], [1]*Mitsubishi Heavy Industries, Japan*, [2] *Kyoto University, Japan*

IWPT-P-10 **Development Status of Beam Steering Control Subsystem for Microwave Power Transmission Ground Experiment**
Takehiro Miyakawa[1], Masanobu Yajima[1], Yasuyuki Fukumuro[1], Susumu Sasaki[1], Takuro Sasaki[2], Yukihiro Homma[2], and Koji Namura[2], [1]*Japan Aerospace Exploration Agency (JAXA)*, *Japan*, [2]*Mitsubishi Electric Corporation, Japan*

IWPT-P-11 **Array Calibration Techniques for DOA Estimation with Arbitrary Array Using Root-MUSIC Algorithm**
Yoshiki Takahashi, Hiroyuki Yamada and Yoshio Yamaguchi, *Niigata University, Japan*

IWPT-P-12 **Equivalent Circuit of Induction Fed Magnetic Resonant WPT System**
Hiroshi Hirayama, Yuki Okuyama, Nobuyoshi Kikuma, and Kunio Sakakibara, *Nagoya Institute of Technology, Japan*

IWPT-P-13 **A Novel Concept for 2-Dimensional Free-Access Wireless Power Transfer System Using Asymmetric Coupling Resonators with Different Sizes**
Toshio Ishizaki, Daisuke Fukada and Ikuo Awai, *Ryukoku University, Japan*

IWPT-P-14 **Optimal Designs for Wireless Resonant Energy Link with Symmetrical Coil Pair**
Hisayoshi Sugiyama, *Osaka City University, Japan*

IWPT-P-15 **Development of Class-F Load Rectennas**
Ken Hatano[1], Naoki Shinohara[1], Tomoniko Mitani[1], Kenjiro Nishikawa[2], Tomohiro Seki[2], and Ken Hiraga[2], [1]*Kyoto University, Japan*, [2]*NTT Corporation, Japan*

IWPT-P-16 **Fundamentals of the Bridge RF Rectifier with an impedance transformer**
Tsunehiro Saen[1], Kenji Itoh[1], Shin-ichi Betsudan[1], Shigeru Makino[1], Tetsuo Hirota[1], Keisukei Noguchi[1], and Mitsuhiro Shimozawa[2], [1]*Kanazawa Institute of Technology, Japan*, [2]*Mitsubishi Electric Corporation, Japan*

IWPT-P-17 **Metamaterial Microwave Transmission-Line on Si-Wafer Utilizing a Semiconductor Integration Technology for WPT Modules**
Daichi Hirahara, Hirofumi Noji, Masakazu Hori, Makoto Mita and Shigeo Kawasaki, *Japan Aerospace Exploration Agency (JAXA), Japan*

IWPT-P-18 **Phase Control System of SSPS -Automatic Correction of Phase Variations Generated at Power Amplifier-**
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IWPT-P-19 **High Power and High Efficiency GaN-HEMT for Microwave Communication Applications**
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IWPT-P-20 **Developing GaN HEMTs for High Efficiency**
Kazutaka Takagi, Keiichi Matsushita, Kazutoshi Masuda, Shinichiro Nakanishi, Tomohide Soejima, Hiroyuki Sakurai, Ken Onodera, Jeoungchill Shim, Hisao Kawasaki, Yoshiharu Takada, Mayumi Hirose and Kunio Tsuda, *Toshiba Corporation, Japan*