



Technical Program



## 9th Kansai Microwave Meeting for Young Engineers

Kyoto Institute of Technology, Matsugasaki Campus, Kyoto

July 2, 2016

Organized by IEEE Microwave Theory and Techniques Society Kansai Chapter

Supported by Kyoto Institute of Technology

### TIME SCHEDULE

9:25-9:30	Opening
9:30-10:35	Session MTT16-A
10:35-10:45	Break time
10:45-11:50	Session MTT16-B
11:50-13:00	Lunch time
13:00-14:05	Session MTT16-C
14:05-14:15	Break time
14:15-15:20	Session MTT16-D
15:20-15:30	Break time
15:30-16:22	Session MTT16-E
16:22-16:30	Break time
16:30-17:22	Session MTT16-F
18:00-20:00	Banquet

**Session MTT16-A 9:30- Chair:**

**9:30-9:43**

**(MTT16-A-1) Demonstration of Circularly-Polarized Leaky Wave Antenna Based on Pseudo-Traveling Wave Resonance**

(o)Kubo Yuki, Keisuke Ninomiya, Tetsuya Ueda, Andrey Porokhnyuk, Tatsuo Itoh  
Kyoto Institute of Technology

**9:43-9:56**

**(MTT16-A-2) Study on Re-radiation Characteristics of Rectenna Harmonics for a Harmonics Based Retrodirective System**

(o)Shogo Kawashima  
Kyoto University

**9:56-10:09**

**(MTT16-A-3) Multistep rectangular horn loading grooves with elliptical beam for dual-polarization**

(o)Reiko Omi, Mikio Tsuji, Hiroyuki Deguchi  
Doshisha University

**10:09-10:22**

**(MTT16-A-4) Studies on a Fabric Feed Line Sewn to a Flexible Slot Antenna**

(o)Yuto Ishii  
Kyoto Institute of Technology

**10:22-10:35**

**(MTT16-A-5) Linear-to-circular polarization reflectarray with arbitrarily shaped elements**

(o)Hiroki Yamada, Hiroyuki Deguchi, Mikio Tsuji  
Doshisha University

**Break time 10:35-10:45**

**Session MTT16-B 10:45- Chair:**

**10:45-10:58**

**(MTT16-B-1) Study on Operational-Amplifier-Based Negative Impedance Converters to Realize non-Foster Elements**

(o)Shoji Yamanaka, Yasushi Horii  
Kansai University

**10:58-11:11**

**(MTT16-B-2) Equivalent Circuit Model of Planar Meta-atoms with Retarded Electromagnetic Coupling**

(o)Ryoma Nakata, Tohlu Matsushima, Takashi Hisakado, Osami Wada  
Kyoto University

**11:11-11:24**

**(MTT16-B-3) Study on Linvill's Negative Impedance Converters for Generation of Pure Non-Foster Reactance**

(o)Kenichi Matsumoto, Yasushi Horii  
Kansai University

**11:24-11:37**

**(MTT16-B-4) Considerations for Loss Mechanism and Improvement of Artificial Dielectric Resonator**

(o)Yulin Song, Toshio Ishizaki  
Ryukoku University

**11:37-11:50**

**(MTT16-B-5) Study on Equivalent Circuit Models for Helmholtz Resonators for Design of Future Acoustic Metamaterials**

(o)Yuki Utoku, Yasushi Horii  
Kansai University

**Lunch time 11:50-13:00**

**Session MTT16-C 13:00- Chair:**

**13:00-13:13**

**(MTT16-C-1) Excitation Circuit with Variable Capacitors for Resonator-Coupled WPT System**

(o)Takehiro Toi, Tetsuya Ishida, Toshio Ishizaki  
Ryukoku University

**13:13-13:26**

**(MTT16-C-2) Study on a Rectifier for Microwave Power Transfer with Intermittent Input Signal**

(o)Takashi Hirakawa, Naoki Shinohara  
Kyoto university

**13:26-13:39**

**(MTT16-C-3) Switchable Power Receiving Unit for Mobile WPT System Providing Power to Multiple Vehicles**

(o)Kohei Yamamoto  
Ryukoku University

**13:39-13:52**

**(MTT16-C-4) Multiple-Input Multiple-Output Dynamic Charging Using Multiple Parallel Line Feeders**

(o)Brou William-Fabrice, Duong Quang Thang, Minoru Okada  
Nara Institute of Science and Technology

**13:52-14:05**

**(MTT16-C-5) Power Transfer Experiment of Magnetically Coupled WPT System for EVs through Tires**

(o)Yuki Kawazoe, Yangjun Zhang, Ikuo Awai  
Ryukoku University

**Break time 14:05-14:15**

**Session MTT16-D 14:15- Chair:**

**14:15-14:28**

**(MTT16-D-1) Proposal and basic study of a transparent water shield for the magnetically coupled WPT system -Toward resolution of EMC problems-**

(o)Kentaro Kawabe  
Ryukoku University

**14:28-14:41**

**(MTT16-D-2) Effect of Bush Growth on Radio Wave Propagation in 920 MHz Band**

(o)Ryosuke Yoshimura  
Kyoto Institute of Technology

**14:41-14:54**

**(MTT16-D-3) Study on Conductive Effects of Water for a WPT system Applied for Robot Fish**

(o)Tatuya Hiraiwa  
Ryukoku University

**14:54-15:07**

**(MTT16-D-4) Signal Interference Analysis Model In Near-Field Coupling Communication**

(o)Ryo Takeuchi  
Kyoto Institute of Technology

**15:07-15:20**

**(MTT16-D-5) Miniaturized Amplifier Module for Millimeter-wave Wireless Communication and Power Transfer System**

(o)Hayato Matsuo  
Ryukoku University

**Break time 15:20-15:30**

**Session MTT16-E 15:30- Chair:**

**15:30-15:43**

**(MTT16-E-1) A Small-Sized Oscillator Using Dielectric Resonator for Microwave Surgical Instruments**

(o)Yosuke Yokoyama  
Ryukoku University

**15:43-15:56**

**(MTT16-E-2) Study on Characteristics of a Single-Mode Resonator for Microwave Heating**

(o)Daichi Nishio, Tomohiko Mitani  
Kyoto University

**15:56-16:09**

**(MTT16-E-3) High Efficient Microwave Heating System with GaN-HEMT Power Amplifier**

(o)Masakazu Takahashi  
Ryukoku University

**16:09-16:22**

**(MTT16-E-4) Study on a 5.8GHz Power-Variable Phase-Controlled Magnetron**

(o)Bo Yang, Naoki Shinohara  
Kyoto University

**Break time 16:22-16:30**

**Session MTT16-F 16:30- Chair:**

**16:30-16:43**

**(MTT16-F-1) Improvement of Passband Characteristics Based on Physical Mechanism in GA-designed UWB Filter**

(o)Yuta Takeuchi, Mikio Tsuji, Hiroyuki Deguchi  
Doshisha University

**16:43-16:56**

**(MTT16-F-2) Frequency Chirp Modulation by Electro-Optic Modulator Integrated with Microwave Race Circuit**

(o)Naoki Maeda, Katsuyuki YAMAMOTO, Tadashi KAWAI, Akira ENOKIHARA, Naokatsu YAMAMOTO, Tetsuya KAWANISHI  
University of Hyogo

**16:56-17:09**

**(MTT16-F-3) Design Method of Attenuation Poles for Electromagnetically-coupled Half-Wavelength Resonator Filters**

(o)Ayaka Shimizu  
Ryukoku University

**17:09-17:22**

**(MTT16-F-4) Compensation of Third-Order Intermodulation Distortion of Electro-Optic Modulator by Using Frequency Chirp Modulation**

(o)Kosuke Takase, Sachiko Maeda , Tadashi Kawai, Akira Enokihara, Naokatsu Yamamoto, Tetsuya Kawanishi  
University of Hyogo

**Banquet 18:00-20:00**

**(MTT16-A-1) Title:** Demonstration of Circularly-Polarized Leaky Wave Antenna Based on Pseudo-Traveling Wave Resonance

**Author:** (o)Kubo Yuki, Keisuke Ninomiya, Tetsuya Ueda, Andrey Porokhnyuk, Tatsuo Itoh

**Affiliation:** Kyoto Institute of Technology

**Abstract:** A circularly-polarized leaky-wave radiation from metamaterial-inspired antenna based on pseudo-traveling wave resonance was demonstrated for the first time. The resonant structure was short-ended transmission line resonator and composed of a phase-nonreciprocal composite right/left handed transmission line fabricated on the circumference of a normally magnetized polycrystalline yttrium iron garnet disc. At both ends of the phase-nonreciprocal CRLH transmission line section there are two different reflectors, and the longer reflector was directly connected to a feed line for impedance matching. The resonator operates as zeroth-order resonator if there is no DC magnetic field and the gradient of the phase of field profiles along the transmission line of this structure was appropriately selected by tuning the dc magnetic field externally applied to the ferrite disc so that the phase difference for one circulation corresponds to 360 deg when an appropriate DC magnetic field is applied. Measured results clearly showed that the radiation from the Antenna is circularly-Polarized and rotation direction of the circular polarization was successfully switched by changing the direction of the applied dc magnetic field.

**Keywords:** Electromagnetic metamaterials, transmission lines, leaky wave antennas

**(MTT16-A-2) Title:** Study on Re-radiation Characteristics of Rectenna Harmonics for a Harmonics Based Retrodirective System

**Author:** (o)Shogo Kawashima

**Affiliation:** Kyoto University

**Abstract:** A harmonics-based retrodirective system (HBRS) is proposed for microwave power transmission to an airplane for weight saving. In the HBRS, re-radiation of rectenna harmonics is adopted for the pilot signal. It is necessary for actualizing the HBRS to evaluate harmonic re-radiation from rectennas. In this presentation, we fabricated a rectenna which are on a thin and lightweight substrate, and conducted simulations and experiments of harmonic re-radiation patterns. In electromagnetic simulations, we obtained radiation patterns of the 2nd and the 3rd harmonics which were similar to the theoretical patterns of a dipole antenna and a dipole antenna. From the experiments, the 2nd and the 3rd harmonic re-radiation patterns were measured, and they were agreed with the simulations. Re-radiation of array of two rectenna was also measured, and the null points were increased from the patterns of a single rectenna. Calculating array factor in the assumption that two rectenna re-radiates in same phase, we obtained calculation patterns. They were in consistent with the measurement results. This showed that two rectennas re-radiates in same phase in experiment. Comparing a past study and our results, we examined with the realization of HBRSI. It is considered to be a problem that arraying rectennas caused the increase of null points.

**Keywords:** Microwave Power Transmission, Rectenna, Harmonics, Retrodirective

**(MTT16-A-3) Title:** Multistep rectangular horn loading grooves with elliptical beam for dual-polarization

**Author:** (o)Reiko Omi, Mikio Tsuji, Hiroyuki Deguchi

**Affiliation:** Doshisha University

**Abstract:** An elliptical-shaped beam antenna is required for efficient coverage of a specified region. Such a beam has been realized by using reflectors with elliptical shape and primary feeds with desired edge illumination level. The elliptical-shaped horns are useful for reduction of a spill-over loss and a gain loss due to the illumination distribution. This paper proposes a new rectangular horn for orthogonal polarized elliptical beams. This consists of two sectoral horns, of which sidewalls have grooves its design is performed by optimization based on the mode-matching method. As a design example, we present a horn with -10 dB beam widths of  $33^\circ \times 100^\circ$  at 10 GHz. Effectiveness of the designed horn is verified numerically and experimentally.

**Keywords:** elliptical beam, orthogonal dual polarizations, groove, rectangular horn

**(MTT16-A-4) Title:** Studies on a Fabric Feed Line Sewn to a Flexible Slot Antenna

**Author:** (o)Yuto Ishii

**Affiliation:** Graduate School of Science and Technology, Kyoto Institute of Technology

**Abstract:** A flexible textile antenna has been fabricated using a polyester fabric as a substrate of the feed line to the antenna and studied in bending cases. The antenna is a cavity-backed slot antenna (CBSA) made of conductive textiles. The substrate of the feed line is also a textile sheet rather than conventional material in order to make the antenna more flexible. Moreover, the feed line is fixed by sewing directly to the CBSA to prevent a gap between the feed line and the antenna. The antenna performances in 2.4-GHz band have been measured depending on the radius of curvature of the antenna and compared with those fixing the feed line by adhesive tape in the previous study. The results revealed that the -10 dB bandwidth in the sewing case is wider than that by the previous case. Thus, we suggest that the antenna characteristics can be improved by the reduction of unnecessary deformation of the feed line and the antenna.

**Keywords:** Conductive textile, microwave, cavity-backed slot antenna, feed line, polyester fabric, flexibility

**(MTT16-A-5) Title:** Linear-to-circular polarization reflectarray with arbitrarily shaped elements

**Author:** (o)Hiroki Yamada, Hiroyuki Deguchi, Mikio Tsuji

**Affiliation:** Doshisha University

**Abstract:** This paper proposes arbitrary shaped elements for linear-to-circular polarizer for reflectarray. We optimized the resonant elements with orthogonal two axial symmetry by the genetic algorithm (GA). Moreover, the effectiveness of the proposed elements is verified by discussing radiation characteristics of a fabricated offset reflectarray numerically and experimentally.

**Keywords:** reflectarray, genetic algorithm, arbitrary shape

**(MTT16-B-1) Title:** Study on Operational-Amplifier-Based Negative Impedance Converters to Realize non-Foster Elements

**Author:** (o)Shoji Yamanaka, Yasushi Horii

**Affiliation:** Graduate School of Informatics, Kansai University

**Abstract:** With recent progress of the Things of Internet (IoT), wireless communication tools should be designed more compact and highly functional. However, electrically small antennas cannot provide broadband operation due to their high Q-factor. Therefore, innovative technologies are required to meet the demand. In such a situation, negative capacitance and negative inductance are collecting a lot of attentions recently. These negative elements are realized by using negative impedance converters (NIC) that make capacitors or inductors sign-reversed. These elements are called Non-Foster elements for convenient. Non-Foster matching is expected to improve the performance of electrically small antennas by canceling antenna reactance in a wide frequency range. In this presentation, I focus on OP-amp-based NICs. Comparing with BJT-based NICs, the number of circuit elements used for the NIC circuit is reduced drastically, leading to simplifying the circuit configuration. However, we have experienced serious errors between simulations and measurements, that is, in some cases, non-Foster behavior was not obtained as theory. In this presentation, I verify following three points to realize Non-Foster characteristic. (1) Look for conditions to realize Non-Foster characteristics, (2) analyze the influence of parasitic inductance induced on the PCB by utilizing ADS and Momentum simulations, and (3) fabricate smaller NIC circuits in order to reduce parasitic inductance. Subsequently, I fabricate a new model and compare its performance with the conventional one.

**Keywords:**

**(MTT16-B-2) Title:** Equivalent Circuit Model of Planar Meta-atoms with Retarded Electromagnetic Coupling

**Author:** (o)Ryoma Nakata, Tohlu Matsushima, Takashi Hisakado, Osami Wada

**Affiliation:** Kyoto University

**Abstract:** Metamaterials are artificial structures composed of meta-atoms made from conductors or dielectrics and show electromagnetic phenomena which cannot happen in natural materials. It is necessary to know the electromagnetic behavior of meta-atoms to analyze the electromagnetic phenomena that the whole metamaterials show. For analysis of the metamaterials, electromagnetic field analysis is used frequently. However, the calculations need a lot of time for the analysis. Therefore as more systematic one, analysis using equivalent circuit models of metamaterials has been considered. In those examinations, the retardation of the electromagnetic field is shown to be an important factor in equivalent circuit models. Then, our purpose is to observe the influence of the retardation of the electromagnetic field in the metamaterials by experiments. To experiment easily we handle planar meta-atoms having the structure of connected thin conductor disks by thin conductor lines. We build the equivalent circuit model of the planar meta-atoms including retardation and compare it with the experiment and evaluate the influence of the retardation of the electromagnetic field. When we consider retardation, the magnitude relation of the resonant even mode and odd mode frequencies of coupled two planar meta-atoms varies by the distance between them. We express this phenomenon by equivalent circuit model including retardation and demonstrate it by experiment.

**Keywords:** equivalent circuit model, retarded electromagnetic coupling, resonant frequency

**(MTT16-B-3) Title:** Study on Linvill's Negative Impedance Converters for Generation of Pure Non-Foster Reactance

**Author:** (o)Kenichi Matsumoto, Yasushi Horii

**Affiliation:** Graduate School of Informatics, Kansai University

**Abstract:** In recent years, miniaturized high performance antennas for wireless communications have been studied intensively. Among various new technologies, we have focused on non-Foster matching including negative capacitors and negative inductors. Such a non-Foster element is generated by a negative impedance converter (NIC). In this presentation, I overview the principle and typical performance of Linvill's NIC, and then, point out a serious problem that ""the NIC generates an undesired resistance by itself, and most of the input RF power is absorbed by the NIC itself, instead of being radiated from the antenna"". To solve this problem, I design a new NIC whose undesired resistance is self-canceled by a negative resistance generated by the same NIC circuit. This strategy has a great advantage in terms of DC power consumption, that is, additional DC power consumption can be ignored even if negative resistance is generated together with the negative capacitance. In the experimental demonstration, measured DC power consumption of the NICs with and without self-cancellation mechanism is 10 mW for both cases at 2.2V biasing and 20mW at 3.5V biasing for the input RF frequency of 300 MHz. Based on this idea, a pure non-Foster reactance will be realized.

**Keywords:**

**(MTT16-B-4) Title:** Considerations for Loss Mechanism and Improvement of Artificial Dielectric Resonator

**Author:** (o)Yulin Song, Toshio Ishizaki

**Affiliation:** Ryukoku University

**Abstract:** Due to the recent increase of data traffic, much more cellular base stations are required to be installed. Miniaturization and cost reduction of base station filter is strongly expected. In this study, a novel filter was developed by using artificial dielectric with high dielectric constant and anisotropy. To realize high unloaded Q, loss caused by circulating current should be reduced, because it does not contribute to dielectric constant. Dumbbell-shaped metal strips were investigated to reduce the circulating current. By optimizing number of tracks and gap between tracks, magnetic flux became easily go through the body of artificial dielectric and loss caused by circulating current was decreased by 15%.

**Keywords:** Artificial dielectric, Microwave filter, Dumbbell-type strip, Unloaded Q

**(MTT16-B-5) Title:** Study on Equivalent Circuit Models for Helmholtz Resonators for Design of Future Acoustic Metamaterials

**Author:** (o)Yuki Utoku, Yasushi Horii

**Affiliation:** Graduate School of Informatics, Kansai University

**Abstract:** Similar to the RF distributed constant circuits, acoustic systems can also be expressed by an equivalent circuit model with inductors " $L$ " and capacitors " $C$ " based on acoustic parameters such as air densities, sound velocities, and volumes of cavities. This transmission-line-theory-like approach is quite useful to understand and design complicated acoustic systems. Prof. Sam Hyeon Lee, for instance, proposed equivalent circuit models of acoustic metamaterials and demonstrated successfully. In this presentation, I explain the mechanism of Helmholtz resonators composed of a cavity and a narrow pipe portion (a neck) first, and then, give an equivalent circuit model expressed by a series connection of a capacitor and an inductor, which correspond to the cavity and the neck of the resonator, respectively. Following that, analytically estimated resonant frequency of the resonator is compared with full-wave acoustic simulations by Comsol Multiphysics 5.1. When the cavity length is varied from 30 mm to 80 mm, both analytical and simulated results show good agreements with each other within an acceptable range of errors of about 5% in a frequency range from 0 to 600 Hz. I believe that this transmission-line-theory-like approach will be a great help for designing and developing attractive future acoustic metamaterials.

**Keywords:**

**(MTT16-C-1) Title:** Excitation Circuit with Variable Capacitors for Resonator-Coupled WPT System

**Author:** (o)Takehiro Toi<sup>1</sup>, Tetsuya Ishida<sup>2</sup>, Toshio Ishizaki<sup>1</sup>

**Affiliation:** <sup>1</sup>Ryukoku University, <sup>2</sup>Wave Technology Inc.

**Abstract:** The objective of this study is to develop a variable impedance matching circuit for realizing a stable transmission, while transmission distance is varied. The matching circuit is constructed by variable capacitors, comprising SPST switches using PIN diodes and bank of fixed capacitors. It was confirmed that a switched excitation circuit with variable capacitors showed higher transmission efficiency than that of fixed system in the simulation. Further, although there was a suitable distance for the case, where only Tx-side was matched, a better efficiency at an arbitrary desired distance could be achieved by appropriately tuning Rx-side matching simultaneously.

**Keywords:** Wireless power transfer, Matching circuit, Variable capacitor, PIN diode

**(MTT16-C-2) Title:** Study on a Rectifier for Microwave Power Transfer with Intermittent Input Signal

**Author:** (o)Takashi Hirakawa, Naoki Shinohara

**Affiliation:** Research Institute for Sustainable Humanosphere, Kyoto University

**Abstract:** High-efficiency rectifier circuit is required for microwave power transfer. In this paper, we studied on the operation of a rectifier circuit with intermittent input signal. Intermittent signal is useful signal for coexistence with communication and has high peak-to-average power ratio. We can expect an improvement of RF-DC conversion efficiency by using intermittent input signal. But the output of a rectifier circuit with intermittent input becomes pulse wave or DC whose ripple content is very high. Frequently, such outputs are not useful and can damage on machines. However, the operation of a rectifier circuit after the input stopped is not discussed enough. Therefore, we analyzed the operation of a rectifier circuit by considering the time constants. As a result of this study, we revealed that the operation of a rectifier circuit can be analyzed by using time constants in some conditions. We also calculated RF-DC conversion efficiency and ripple content by using such a condition.

**Keywords:** Rectifier, Intermittent, High peak to average, power ratio

**(MTT16-C-3) Title:** Switchable Power Receiving Unit for Mobile WPT System Providing Power to Multiple Vehicles

**Author:** (o)Kohei Yamamoto

**Affiliation:** Ryukoku University

**Abstract:** For wireless power transfer system providing power for moving electric vehicles, it might be necessary for providing power for multiple vehicles. For this purpose, the authors are developing a new receiving unit, which allows to receive power in an assigned time slot by switching. Resonators of receiving unit are switched to perform selective power receiving. For this unit, it is important to avoid an additional loss due to the switch circuit and keep the efficiency of the system. In this study, in order to achieve low loss and keep efficiency, the switching circuit is designed by optimizing circuit pattern of transistor switch based on simulated performances of multiple power supply system. As a result, it was confirmed by experiment that power was successfully supplied to two toy cars.

**Keywords:** Wireless power transfer, Multiple power supply, Switchable receiving unit

**(MTT16-C-4) Title:** Multiple-Input Multiple-Output Dynamic Charging Using Multiple Parallel Line Feeders

**Author:** (o)Brou William-Fabrice, Duong Quang Thang, Minoru Okada

**Affiliation:** Graduate School of Information, Nara Institute of Science and Technology

**Abstract:** This paper proposes a multiple-input multiple-output dynamic charging system for electric vehicles (EVs) using more than one parallel line feeders and pick-ups. In a charging system using one single feeder, because the feeder length is not negligible compared to the wavelength, the electric current along the feeder follows a standing wave pattern, resulting in a fluctuation in output power when the EV moves. Therefore, the proposed system exploits pattern diversity by using multiple feeders with different current standing wave patterns to stabilize the output power. A multiplexing effect is also utilized to improve the output power in order to satisfy the requirement for high output power while keeping the input power low for safety reasons in each feeder. The effectiveness of the proposed system is verified by theoretical analysis and experiments on a system of three feeders and three pick-ups operating at 13.56 MHz.

**Keywords:** Multiple-input multiple-output, dynamic charging, parallel line feeder, diversity, multiplexing, standing wave

**(MTT16-C-5) Title:** Power Transfer Experiment of Magnetically Coupled WPT System for EVs through Tires

**Author:** (o)Yuki Kawazoe, Yangjun Zhang, Ikuo Awai

**Affiliation:** Ryukoku University

**Abstract:** In recent years, applications using wireless power supply system are widely studied. However, for electric vehicle, there are still many problems to be solved. For example, charge time is too long, and it must be shorted. The distance that can be run by one charge must be long enough etc. In this study, we try to develop a system to realize a wireless power charge by using a magnetic field coupled resonator system via the tire. The power is transmitted from the assumed coil resonator which is embedded in the road, and received by two resonators via the tire (road-wheel-body). We have made many demonstration experiments and investigated the efficiency to transfer the power. With respect to the power transmission resonator, we compared two kinds of spiral resonators with different structures. Also to obtain an impedance matching, we calculate the input impedance using the equivalent circuit, and compare it with the measured value. I also made a system using a toy car which is four-wheel drive tool kit. We check our research results with this toy system. It is shown the results are good.

**Keywords:** WPT, EV, Magnetic field coupling

**(MTT16-D-1) Title:** Proposal and basic study of a transparent water shield for the magnetically coupled WPT system -Toward resolution of EMC problems-

**Author:** (o)Kentaro Kawabe

**Affiliation:** Ryukoku University

**Abstract:** We propose here a transparent electromagnetic shield using tap water. We have obtained a big shield effect for the leakage electric field from the WPT system by using the reflection due impedance mismatching between the water sheet and the free space where there is a wave source. In addition, the loss to a system is quite small by its selective shield effect that hardly influences the magnetic field used for power transfer. Aiming that this shielding method could be adopted widely, we will show the simulation and measurement of the effect of the present selective shield method which uses water for the EMC solution to a WPT system for the robot fish which our study group is now developing.

**Keywords:** Wireless power transfer System, Tap water, Electromagnetic shield, EMC, Spiral resonator with capacitor, water shield

**(MTT16-D-2) Title:** Effect of Bush Growth on Radio Wave Propagation in 920 MHz Band

**Author:** (o)Ryosuke Yoshimura

**Affiliation:** Graduate School of Science and Technology, Kyoto Institute of Technology

**Abstract:** The change of the radio wave propagation loss in 920-MHz band was examined as bushes in a farm grew higher. Received Signal Strength Indicator (RSSI) was measured as a function of the distance between the transmitting antenna (Tx) and the receiving antenna (Rx) in a 50 x 50 m mulberry field. Tx and Rx were placed at a height of 1.5 m. Moreover, the horizontal and vertical polarizations were measured. The results revealed that the path loss increased in both horizontal and vertical polarizations as bushes grew up and that the horizontal polarization could be less affected by bushes than the vertical polarization.

**Keywords:** Radio wave propagation, path loss, 920-MHz, wireless sensor network, bushes

**(MTT16-D-3) Title:** Study on Conductive Effects of Water for a WPT system Applied for Robot Fish

**Author:** (o)Tatuya Hiraiwa

**Affiliation:** Ryukoku University

**Abstract:** A coupled-resonator-type wireless power transfer system applied for robot fish in aquarium is investigated. For the system, there is a problem that the system does not work well depending on the sites, where the tap water is acquired. Thus, dependency on conductivity of various tap water is studied. Also, a solution for this problem is considered. It was confirmed that the resonance frequency did not change by conductivity of water. On the other hand, unloaded Q was decreased and loss was increased by conductivity of water. However, the conductivity becomes larger, the influence becomes smaller, at least in the conductivity variations of tap water. To suppress the influence, large capacitor is connected in parallel to the resonator so that electric energy is confined in the capacitor. Unloaded Q became not affected by conductivity. As a result, a resonator which was not influenced by conductivity was developed successfully.

**Keywords:** Coupled-resonator WPT System, Conductivity, Underwater feeding

**(MTT16-D-4) Title:** Signal Interference Analysis Model In Near-Field Coupling Communication

**Author:** (o)Ryo Takeuchi

**Affiliation:** Graduate School of Science and Technology, Kyoto Institute of Technology

**Abstract:** Near-field coupling communication (NFCC) is a technology that uses the surface of the human body as a transmission path. To suppress the radiation signal from the human body, NFCC devices use a carrier frequency of less than 10 MHz. Because the radiation signal has the potential to disturb the other NFCC links, the radiation signal from other devices needs to be suppressed to ensure stable NFCC links. This study describes our investigation of the interfering mechanism in NFCC systems to put the systems into practical use, such as at a ticket gate in the train station. We measured interference signal losses depending on the distance between two phantoms, regarded as human bodies. Based on the experimental and simulated results, an equivalent circuit of the signal interference was proposed. From the interference analytical model, we identified the capacitance that caused the interference problem and found that weakening the effects of this capacitance was important to achieve a stable NFCC link.

**Keywords:** Near-field coupling communication, Electrically isolated measurement, Path/Signal loss, interference problem.

**(MTT16-D-5) Title:** Miniaturized Amplifier Module for Millimeter-wave Wireless Communication and Power Transfer System

**Author:** (o)Hayato Matsuo

**Affiliation:** Ryukoku University

**Abstract:** In Millimeter-wave Wireless Communication and Power Transfer (WiCoPT) system, energy is sent from control terminal to battery-less sensors wirelessly. Then, sensors send back information to control terminal by using received energy. Objective of this study is to miniaturize the transmitting amplifier module in the control system. Because the control system adopt an active integrated antenna to make a spot beam, space between adjacent antenna elements is severely limited to avoid grating lobes. Thus, miniaturized amplifier modules are required to being installed for respective antenna elements one by one on the back-side of antenna substrate. The amplifier module was miniaturized, for example, by shrinking bias circuit using the curved lines for RF choke circuit. Almost the same performance with that of conventional circuit was obtained even for the miniaturized module.

**Keywords:**

**(MTT16-E-1) Title:** A Small-Sized Oscillator Using Dielectric Resonator for Microwave Surgical Instruments

**Author:** (o)Yosuke Yokoyama

**Affiliation:** Ryukoku University

**Abstract:** Microwave surgical instruments heat cells by irradiating microwaves, and stop bleeding by congealing cells. Existing microwave signal sources for portable surgical instrument are still large and heavy. Operators often feel difficulty due to poor operability. Thus, it is necessary to reduce the size of signal source, especially the sizes of power amplifier and oscillator. To reduce the size, the authors developed compact GaN power amplifier by using LTCC technology and small-sized oscillator. In this report, the development of small-sized oscillator using dielectric resonator will be explained. Frequency stability for supply voltage and temperature satisfied the target values by using dielectric coaxial resonator.

**Keywords:**

**(MTT16-E-2) Title:** Study on Characteristics of a Single-Mode Resonator for Microwave Heating

**Author:** (o)Daichi Nishio, Tomohiko Mitani

**Affiliation:** Research Institute of Sustainable Humansphere, Kyoto University

**Abstract:** Recently, single-mode resonators are used for chemical experiments assisted by microwave heating. For easy designing equipment for microwave heating, we need relations of the Q factor and impedance of a single-mode resonator to an iris width and a heating sample temperature. However their relations are unclear. Therefore we investigate relations with simulations and experiments. We designed a resonator to heat pure water as a sample using a simulator, HFSS. The resonator length was 220 mm. In this condition, the antinode position of electric field matched the center of the sample. As a result, the relation between the Q factor and the sample temperature had a positive correlation. We find that the tendency was explainable using the sample dielectric tangent. Furthermore we find that the relations of the impedance of the resonator to the sample temperature and the iris width also was explainable using the sample relative permittivity and the iris impedance formula.

**Keywords:** Microwave Heating, Single-Mode, Resonator

**(MTT16-E-3) Title:** High Efficient Microwave Heating System with GaN-HEMT Power Amplifier

**Author:** (o)Masakazu Takahashi

**Affiliation:** Ryukoku University

**Abstract:** So far, magnetron is widely used for microwave heating, such as microwave oven and biomass material production. However, magnetron has many demerits. For example, it has short life time, large size and the signal is very noisy. However, recently, a new excellent solid-state device, Gallium Nitride (GaN) transistor, which has a high power capability in microwave range, has been developed. It comes a possibility that magnetrons are replaced by GaN transistors. Frequency, phase and power of generated microwave can easily be controlled for solid-state amplifier. In this report, the effectiveness of heating by controlling these parameters was investigated. High efficiency was obtained by optimizing these parameters.

**Keywords:** GaN power amplifier, Microwave heating system, High efficiency

**(MTT16-E-4) Title:** Study on a 5.8GHz Power-Variable Phase-Controlled Magnetron

**Author:** (o)Bo Yang, Naoki Shinohara

**Affiliation:** Graduate Research Institute for Sustainable Humanosphere, Kyoto University

**Abstract:** Power -Variable Phase- Controlled Magnetron (PVPCM) has been developed for several years by our research group. In 2000, the first PCM has been developed which utilizes injection locking method and anode current control phase locked loop method. In 2011, our research group has developed a new method which controls the phase of 2.45GHz magnetron output by phase shifter without anode current control phase locked loop. The new method needn't special frequency characteristics of the magnetron which was necessary to be required on the old method. Therefore the new method could control the power of magnetron by controlling anode current of magnetron. The old method control the power by controlling a magnetic field of magnetron which made the PVPCM system more complex. The objective of the present study is to develop a 5.8GHz microwave power transmission system for airplane. We suggest a PVPCM array antenna for the microwave source of the transmission system by applying the new method. First, we confirmed feasibility of the PVPCM and succeeded in controlling the phase with digital control circuit. However the digital control circuit was cost nearly 150ms to lock the phase of magnetron output. Finally, we made an analog phase control circuit whose response time was less than 1ms, faster enough for beam forming of array antenna.

**Keywords:**

**(MTT16-F-1) Title:** Improvement of Passband Characteristics Based on Physical Mechanism in GA-designed UWB Filter

**Author:** (o)Yuta Takeuchi, Mikio Tsuji, Hiroyuki Deguchi

**Affiliation:** Doshisha University

**Abstract:** A compact ultra-wideband (UWB) filter with defected ground structure (DGS) is presented. We previously proposed the UWB filter consisting of genetic algorithm (GA)-optimized conductor patch and slot shapes. Although the optimized filter had the desired passbands in the low and the high frequency ranges (3.4-4.8GHz, and 7.25 and 10.25GHz), the return losses there were not so low (about 10dB). Therefore, we first clarified resonant mechanism of the UWB filter optimized by the GA. Then, new conductor patch and DGS shapes based on this resonant mechanism are proposed to improve characteristics of the dual-band filter. As a result the return losses in two pass-band regions are suppressed less than 20dB.

**Keywords:** UWB, genetic algorithm, dualband, DGS

**(MTT16-F-2) Title:** Frequency Chirp Modulation by Electro-Optic Modulator Integrated with Microwave Rat-Race Circuit

**Author:** (o)Naoki Maeda<sup>1</sup>, Katsuyuki Yamamoto<sup>1</sup>, Tadashi Kawai<sup>1</sup>, Akira Enokihara<sup>1</sup>, Naokatsu Yamamoto<sup>2</sup>, Tetsuya Kawanishi<sup>2,3</sup>

**Affiliation:** <sup>1</sup>Graduate School of Engineering, University of Hyogo, <sup>2</sup>National Institute of Information and Communications Technology, <sup>3</sup>Faculty of Science and Engineering, Waseda University

**Abstract:** A Mach-Zehnder electro-optic modulator (MZM) generates intensity-modulated light with frequency chirp by introducing asymmetry in the interference. The frequency chirp modulation is applicable to the flat optical comb signal generation or the pre-chirp modulation. Here, we show the frequency chirp modulator using a rat-race circuit (RR) which operates as a 180-degree hybrid of an asymmetric power split for preparing two modulation signals with different power. The RR is integrated with the MZM on the same substrate to directly feed the two signals to the modulation electrodes. Thereby, frequency chirp modulation is realized by a compact and single-chip configuration with single-input operation. The RR of a power split ratio of 4.5:1 was designed on a LiNbO<sub>3</sub> substrate at 10 GHz using the parallel ring circuit structure, which is effective for line impedance control, and was directly connected to the modulation electrodes of the MZM. The modulator was fabricated and the modulation operation at 1550 nm wavelength was confirmed by observing output light spectra. Moreover, frequency chirping in the modulated light was directly measured by using the chromatic dispersion of optical fibers of which length was from 0 to 80 km. The chirp parameter of 0.47 was obtained from the fiber length where power penalty in the detected microwave signals was observed.

**Keywords:** frequency chirp, electro-optic modulator, rat-race circuit, LiNbO<sub>3</sub>, chromatic dispersion

**(MTT16-F-3) Title:** Design Method of Attenuation Poles for Electromagnetically-coupled Half-Wavelength Resonator Filters

**Author:** (o)Ayaka Shimizu

**Affiliation:** Ryukoku University

**Abstract:** In recent years, data traffic is increasing with the spread of smart-phones. So, it is required to install much more base stations. Thus, size and cost reductions of base station filter are strongly requested. By providing the attenuation pole near the pass band, high-selectivity with large attenuation outside the pass band can be obtained. In this study, design theory of attenuation poles for half-wavelength resonator filter is investigated. It was confirmed that the attenuation pole frequency could be designed by simplifying the circuit transfer functions expressed by equations. As a result, the filter was able to be designed by analytically using these formulae. A half-wavelength electromagnetically-coupled resonator filter was designed successfully.

**Keywords:**

**(MTT16-F-4) Title:** Compensation of Third-Order Intermodulation Distortion of Electro-Optic Modulator by Using Frequency Chirp Modulation

**Author:** (o)Kosuke Takase<sup>1</sup>, Sachiko Maeda<sup>2</sup>, Tadashi Kawai<sup>1</sup>, Akira Enokihara<sup>1</sup>, Naokatsu Yamamoto<sup>3</sup>, Tetsuya Kawanishi<sup>4</sup>

**Affiliation:** <sup>1</sup>Graduate School of Engineering, University of Hyogo, <sup>2</sup>School of Engineering, University of Hyogo, <sup>3</sup>National Institute of Information and Communications Technology, <sup>4</sup>Faculty of Science and Engineering, Waseda University

**Abstract:** Mach-Zehnder electro-optic modulator (MZM) has nonlinearity in properties of the modulation responses. The third-order intermodulation distortion (IMD3), which is induced near the signal frequency, may seriously degrade performance of signal transmission with analogue light modulation, such as radio on fiber systems. In this report, we propose a novel method to optically compensate the IMD3 components in detected electric signals, where a dual parallel Mach-Zehnder modulator (DPMZM) that consists of two MZMs inducing frequency chirping of opposite signs with each other is used. This compensation operation does not depend on modulation signal frequency. The IMD3 suppression of the proposed modulator was estimated by numerical calculations. When the output light modulated by a two-tone electric signal is detected by a photo-detector, the power ratio of a signal to the IMD3 in the detected output was calculated as a function of modulation index. In the case of using DPMZM that consisting of two MZMs with  $\pm 0.5$  chirp parameters, respectively, more than 30dB IMD3 suppression compared with a conventional MZM was obtained at the modulation index of  $0 \sim 0.2 \pi$ rad. Moreover, we fabricated the DPMZM on the LiNbO<sub>3</sub> substrate. The operation of the IMD3 suppression was confirmed by the experiment.

**Keywords:** electro-optic modulator, nonlinearity, distortion, third-order intermodulation, frequency chirp