First PEM International Workshop in Kyoto

27-28 November 2015

Venue: Doshisha University (Shinmachi Campus)

159-1 Konoeden Omote-cho, Imadegawa-agaru, Shinmachi-dori, Kamigyo-ku, Kyoto, Japan

Sponsor:

IEICE Technical committee on Photonics-applied Electromagnetic Measurement

Technical Co-sponsors:

Japanese Society for Electromagnetics in Biology and Medicine

Research Institute for Physical Measurement,

National Institute of Advanced Industrial Science and Technology (AIST)

National Institute of Information and Communications Technology (NICT)

The Laser Society of Japan, Kansai Section

Foreword

On behalf of the Organizing Committee, I would like to warmly welcome you to the first photonics applied electromagnetic measurement international conference, 'PEM 2015', in Kyoto, Japan.

For our conference program, 37 papers were submitted from PEM research experts include 2 plenary talk papers and 2 invited papers. Each paper was rigorously peer reviewed by the Technical Program Committee (TPC). The TPC finally accepted 9 papers for oral presentation, 10 papers for student poster presentation, 4 papers for regular poster presentations and 9 company poster presentations. The oral presentations have been scheduled into 4 sessions covering various topics of interests to the PEM community with a focus on present and future PEM technology, PEM related technologies, advanced EO technologies for PEM and PEM technology for Biology & Medicine. In addition there are three exhibition companies.

I would like to thank all the members of the organizing committee, TPC and PEM committee for their assistance with the first PEM2015 international conference. Thanks to their efforts we have a full and high-quality technical program. Finally, I express my gratitude and give my very special thanks to Prof. Hiroyuki Toda and Prof. Hiroshi Murata for their hard and remarkable organization work.

We hope you will enjoy the first PEM2015 and the beautiful season for the autumn colored leaves in Kyoto.

Dr. Satoru Kurokawa
AIST, Japan
PEM 2015 Kyoto Organizer

Workshop Committee

Workshop Organizer: Dr. Satoru Kurokawa (AIST, Japan)

Sub-Organizer: Dr. Teruo Onishi (NTT DOCOMO, Japan)

Organizing Committee: Prof. Hiroshi Murata (Osaka University, Japan)
Prof. Hiroyuki Toda (Doshisha University, Japan)
Dr. Maya Mizuno (NICT, Japan)
Dr. Nozomi Haga (Gunma University, Japan)
Dr. Michitaka Ameya (AIST, Japan)
Ms. Kozue Asai (AIST, Japan)

Technical Program Committee:
Prof. Hiroshi Murata (Osaka University, Japan)
Prof. Yukihisa Suzuki (Tokyo Metropolitan University, Japan)
Dr. Ai-ichiro Sasaki (NTT, Japan)
Dr. Atsushi Kanno (NICT, Japan)
Prof. Kiyotaka Sasagawa (NAIST, Japan)
Dr. Michitaka Ameya (AIST, Japan)
Prof. Shintaro Hisatake (Osaka University, Japan)

Exhibitors

VITEC GLOBAL ELECTRONICS CO., LTD.
AIST
RAPID

Workshop Date

27-28 November 2015

Venue

Rinkokan Room 207 (Oral sessions) / Room 204 (Poster sessions)

Doshisha University (Shimmachi Campus)

159-1 Konoeden Omote-cho, Imadegawa-agaru, Shinmachi-dori

Kamigyo-ku, Kyoto-shi 602-0047 Japan

Major Topic Areas

1. **Basic theory/techniques of photonics-applied electromagnetic measurement (PEM)**

   Microwave photonics, Fiber optics, Microwave engineering, Sensing technology, Antenna measurements, Electromagnetic compatibility (EMC) measurements, Electrical and electronic circuit measurements, Imaging and Radar

2. **PEM systems**

   Electromagnetic-field measurement systems, Optical measurement systems, EMC measurement systems, Optical sources, Probes and sensors, Remote sensing systems, Optical fiber systems

3. **Closely-related technologies of PEM**

   Optical signal transmission techniques, Signal restoring and reconstructing techniques, Image processing techniques

4. **New device/technology for PEM**

   Advanced electro-optic sensor, Antenna-coupled photonic device, High-speed photonic device, New antennas/probes for electromagnetic measurement

5. **New applications of PEM**

Student Best Presentation and PEM Visualization Awards

- The student best presentation award is awarded to a student for outstanding contributed papers, presented either as a poster or an oral talk in the PEM workshop 2015.
- The PEM visualization award is awarded to a researcher for a beautiful electromagnetic field image, presented as a poster in the PEM workshop 2015.

Registration Fees

	Regular	**Student**
Up to October 30	8,000 JPY	4,000 JPY
After October 31	10,000 JPY	5,000 JPY

Presentation Time (including discussion)

Plenary Talk: 45min.
Invited Talk: 30min.
Regular Talk: 15min.
Poster Preview: 5min. (Presentation only)
Poster Presentation: 120min. Core time: 60min.

Guidelines for Poster Preparations

- The size of the poster board is 1640 mm height × 830 mm width.
- A portrait (vertical) A0 (1189 mm height × 841 mm width) poster is recommended.
- During Session FB (Student Poster Preview), each author is required to present his/her poster in five minutes. Please prepare a couple of slides.

Program at-a-glance

PEM 2015 Kyoto Overview Program at-a-glance		
Time	2015/11/27 Friday	2015/11/28 Saturday
9:15		***Session SA*** PEM related technologies
10:00		Coffee break 30min.
10:30		***Session SB*** Advanced EO technologies for PEM
11:30		Lunch break 90min.
12:00	Registration Open	
13:00	***Session FA*** Plenary & Invited Papers -1 PEM Technology – Present & Future –	***Session SC*** Plenary & Invited Papers -2 PEM Technology for Biology & Medicine
14:30	Coffee break 30min.	***Closing session*** Award Ceremony
15:00	***Session FB*** *Student Poster Preview*	
16:00	***Sessions FCA, FCB & FCC*** *FCA: Student Poster Session* *FCB: Regular Poster Session* *FCC: Company Poster Session* 16:00-17:00 Core presentation time for Odd-number posters 17:00-18:00 Core presentation time for Even-number posters	
18:00	***Reception***	

Oral (Plenary:45min, Invited:30min, Regular:15min)
Poster Preview
Poster
Closing
Coffee/Lunch break

The First PEM International Workshop　Final Program

27 November 2015

13:00-14:30 **Rinkokan Room 207**

Session FA*:** ***Plenary & Invited Paper Session 1

PEM Technology – Present & Future –

Session Chair: Hiroshi Murata (Osaka University)

Opening Remark

FA-1 (Plenary) Photonic-applied electromagnetic measurement technologies for antenna measurement

○Satoru Kurokawa・Masanobu Hirose・Michitaka Ameya（AIST）

Abstract We have developed some antenna measurement systems using photonic-applied electromagnetic measurement technologies. Our measurement system can replace the metal coaxial cables and suppress the reflection waves from the coaxial cable. In this paper, we show some antenna measurement systems and measurement results.

FA-2 (Invited) Validated Reactive EM Near-field Phasor Measurement System Using Active Optical Sensors

○Sven Kuehn（IT'IS）・Serge Pfeifer・Eugene Grobbelaar・Peter Sepan・Beyhan Kochali（SPEAG）・Niels Kuster（IT'IS）

Abstract Correlation of close near-field measurements with radiated field patterns will mitigate test efforts for electromagnetic compatibility (EMC) testing and antenna characterization. A novel automated reactive near-field testbed based on photonic phasor probes is presented. The scanning system combines a large scanning volume with micrometer resolution. An optical surface reconstruction system allows the structure of the device under test (DUT) to be measured with better than 20 µm uncertainty, allowing scans at a precisely known distance above arbitrary electronic components. Miniaturized active microphotonic electric and magnetic field probes for the 0.01 – 6 GHz frequency range, combined with a high-speed vector signal analyzer, are applied to measure the electromagnetic (EM) phasor-field distribution with a dynamic range of >120 dB. The fully isolated probes eliminate perturbations of the EM fields generated by the DUT compared to electrically connected near-field probes and offer up to 60 dB better sensitivity than passive electro-optical probes. The testbed allows high-precision broadband near-field 3D scans for antenna characterisation to be performed with excellent inter-laboratory repeatability. The phasor measurement capability enables near- to-far-field transformation and thus direct correlation of near- field and radiated characteristics.

FA-3 A Novel Method to Measure Antenna Cut-Plane Patterns for EMC Antennas – Combination of Radio-on-Fiber Technique and 1-D CNFFFT –

○Masanobu Hirose・Satoru Kurokawa（AIST）

Abstract We propose a novel method to measure the far-field absolute-gain patterns in any cut planes for EMC antennas such as double-ridged waveguide horn (DRWH). The proposed method combines the Radio-on-Fiber technique and the 1-D Circular Near-Field to Far-Field Transformation (1-D CNFFFT) method. The Radio-on-Fiber technique realizes an ideal antenna pattern measurement. This means that there is no metallic cable such as coaxial cable to connect the antenna and the vector network analyzer. The 1-D CNFFFT method realizes rapid and accurate far-field absolute-gain pattern measurements in any 1-D cut plane at a few meter distance. We demonstrate the usefulness of our method by measuring a commercial DRWH.

14:30-15:00 Coffee break

15:00-15:50 **Rinkokan Room 207**

Session FB*: *Student Poster Preview

Session Chair: Atsushi Kanno (NICT)

FB-1 Evaluation of DAST Crystals for Nonpolarimetric Self-heterodyne Electro-optic Detection of Terahertz Waves

○Hai Huy Nguyen Pham・Shintaro Hisatake（Osaka Univ.）・Hirohisa Uchida（Arkray Inc.）・Tadao Nagatsuma（Osaka Univ.）

Abstract The use of a DAST crystal, an organic electro-optic (EO) material with a high EO coefficient, in a nonpolarimetric self-heterodyne EO detection system is studied. The comparison of the signal-to-noise ratio (SNR) and the measurement stability between DAST and ZnTe sensors is presented. The enhancement of the SNR of the amplitude measurement of about 9dB by the DAST sensor was achieved.

FB-2 Preliminary Measurement with Laser Microphone for Acoustic Noise Due to Electromagnetic Vibration

○Hajime Yoshino・Alfred Kik・Yukihisa Suzuki（Tokyo Metropolitan Univ.）

Abstract It is necessary that the method to measure sound waves generated from the magnetic field exposure system for biological experiment. Generally used microphones, such as dynamic-microphone and condenser-microphone, are not suitable for the measurement because they are affected by the magnetic field. Therefore the sound wave measurement method using optical system with laser is examined. We performed a preliminary experiment to detect sound waves emitted from a loudspeaker. Sound waves at 300 Hz and 80 dB SPL are detected by the sound wave measurement method using optical system with laser.

FB-3 Visualization of in situ spatial temperature distribution with transparent phantom containing thermo-chromic liquid crystals in millimeter waves exposure

○Fumiya Kobayashi・Alfred Kik・Yukihisa Suzuki（TMU）

Abstract

It is desired to evaluate the safety of millimeter-waves (MMWs) exposure to human bodies. Heating sources are induced within biological tissues by MMWs exposure. The influence of MMWs exposure to biological tissues is mainly based on this thermal effect. It is required to investigate the change of temperature distribution in biological tissues to operate MMWs safely. Accordingly, in this study, micro-encapsulated thermo-chromic liquid crystals (MTLCs) are introduced as temperature probes to observe the temperature distribution. We performed *in-vitro* experiments to visualize the temperature rise by 40 GHz MMWs exposure. In our presentation, we will show the results of temperature distribution with this non-destructive method.

FB-4 Microwave 180-degree Hybrid Formed on $LiNbO_3$ Substrate for Frequency Chirp Modulation by Electro-Optic Modulator

○Ryota Nakamura・Tadashi Kawai・Akira Enokihara（Univ. Hyogo）・Tetsuya Kawanishi（Waseda Univ.）

Abstract

A microwave rat-race (RR) circuit, which operates as the 180-degree hybrid, was designed with 2:1 power split ratio and fabricated on z-cut $LiNbO_3$ (LN) substrate. The property was confirmed by the experiment. An electro-optic modulator integrated with the RR circuit for frequency chirp modulation was designed on a single LN substrate.

FB-5 SAR calculations around an implanted cardiac pacemaker due to a mobile radio terminal for business in VHF band

○Ryota Akiyama・Kazuyuki Saito（Chiba Univ.）・Soichi Watanabe（NICT）・Koichi Ito（Chiba Univ.）

Abstract

Recently, various types of radio communication devices such as cellular phones have become common. Therefore, influence with the electromagnetic wave emitted from these equipments is widely concerned. In particular, electromagnetic interference of an implanted pacemaker induced by these equipments has been investigated. However, there are few studies of specific absorption rate (SAR) around the pacemaker by the mobile radio terminal. In this study, SAR due to a mobile radio terminal for business in very high frequency (VHF) band, which are used in police officers, airport employees etc., is investigated. As a result of calculations, possibilities of increasing the SAR around a pacemaker housing were observed.

FB-6 An EVM Evaluation for RF OFDM signal transmission over Radio on Optical OOK Fiber Link

○Kazuma Nishiyasu・Yuya Kaneko・Takeshi Higashino・Minoru Okada（NAIST）

Abstract

Analog radio over fiber (ARoF) is a candidate to construct mobile optical backhaul and fronthaul network that connects between wireless radio transceiver and remote antenna unit (RAU) because of its centralized signal processing capability and heterogeneous property of the optical fiber communication technologies. Its broad bandwidth for transmitting heterogeneous radio signal enables us to share single optical fiber infrastructure even if the

light source has single wavelength resource. There were some reports on the method for sharing the 10Gbps optical Ethernet infrastructure to transmit radio frequency (RF) signal without introducing extra light source. Previous paper has reported on the probability density function (pdf) of RF signal amplitude that modulates an optical OOK signal, and derived the bit error rate (BER) performance for the OOK signal. However, only the continuous wave (CW) was assumed as an RF signal in the last work. This paper proposes an application of frequency shift for transmitting the RF orthogonal frequency division multiplexing (OFDM) signal over fiber with optical On-Off Keying (OOK) in order to avoid serious interference. In this paper, the error vector magnitude (EVM) performance is evaluated by using computer simulation.

FB-7 Measurement of Microwave Propagation Characteristics along a Fiberglass-Reinforced Plastic Mortar Pipe Using an Electro-Optic Sensor

○Yoshiyuki Azuma・Fumiaki Ueno・Hiroshi Murata・Yasuyuki Okamura（Osaka Univ.）・Tadahiro Okuda・Masaya Hazama（Kurimoto LTD）

Abstract

We have proposed a new nondestructive inspection method for fiberglass-reinforced plastic mortar (FRPM) pipes using microwave guide-mode propagation and photonic techniques. This method is based on the precise measurement of a microwave guided-mode propagated along a FRPM pipe-wall by use of an electro-optic (EO) sensor. In the previous research, we have confirmed that microwave can propagate along the FRPM pipe-wall as a guided-mode, and the propagated microwave transmission characteristics through the FRPM pipe are affected by defects or cracks in FRPM pipes. By measuring electric field distributions by use of an EO sensor precisely, we believe that we can detect smaller defects or cracks in/on the FRPM pipe nondestructively.

FB-8 Novel Interference Voltage Sensor Using an Electro-Optic Converter for Active Implantable Medical Devices EMI Assessment

○Naoki Tanaka・Takashi Hikage・Toshio Nojima（Hokkaido Univ.）・Takahiro Iyama・Junji Higashiyama・Teruo Onishi（NTT DOCOMO, INC.）

Abstract

An interference voltage sensor for active implantable medical devices (cardiac pacemakers / ICDs) EMI assessment is newly developed by applying direct modulated Electrical to Optical (EO) converter. The sensor can be connected an actual pacemaker lead and measured induced voltage without disturbing electromagnetic fields emitted from tested RF device because I/O signal of the sensor are made through optical fiber. As one example, measurement of interference voltage due to a cellular base station antenna is demonstrated.

FB-9 Improvement of Modulation Efficiency of Electro-Optic Modulators with Gap-Embedded Patch Antenna Utilizing Stacked Structure

○Hironori Aya（Osaka Univ.）・Yusuf Nur Wijayanto・Atsushi Kanno・Tetsuya Kawanishi（NICT）・Hiroshi Murata・Yasuyuki Okamura（Osaka Univ.）

Abstract

In this report, we propose new electro-optic modulators using gap-embedded patch antennas with Yagi-antenna- like stacked structure. By utilizing the stacked structure, antenna gain and electric field Ez for optical modulation at the gap are increased with a shift of its resonance frequency toward the higher region. By tuning parameters of the patch antennas, the conversion efficiency from wireless millimeter-wave to lightwave signal is increased about 2 times compared with the modulator of non-stacked structure. The analysis and design of the device are reported.

FB-10 A Performance Comparison of Load Balancing among Radio-over-Fiber Indoor LTE Small Cells

○Withawat Tangtrongpairoj・Takeshi Higashino・Minoru Okada（NAIST）

Abstract Radio over Fiber (RoF) is a promising candidate for constructing 4G and 5G mobile optical network. The main feature of the RoF is heterogeneous and centralized processing for the radio resource. In this paper, we compared several algorithms as for the load-balancing scheme. The throughput performance and standard deviation (SD) are evaluated with the different schemes. As a result, it is found that the sorted-greedy achieves the highest throughput with minimum deviation.

16:00-18:00 **Rinkokan Room 204**

Session FCA, FCB & FCC: Poster Sessions

16:00-17:00 Core presentation time for Odd-number posters

17:00-18:00 Core presentation time for Even-number posters

18:00-20:00 **Reception**

Venue: "Hamac de Parad"

1st Floor in Kanbaikan, Muromachi Campus, Doshisha University.

28 November 2015

9:15-10:00 **Rinkokan Room 207**

Session SA*: *PEM related technologies

Session Chair: Shintaro Hisatake (Osaka University)

SA-1 High-Resolution Ultra-Wideband Radar Imaging using Kirchhoff Integral and F-K Migration with Boundary Scattering Transform

Takuya Sakamoto（Univ. of Hyogo）

Abstract This paper introduces a fast high-resolution imaging algorithm designed for ultra-wideband radar, and combines modified Kirchhoff migration and frequency-wavenumber (F-K) migration. The proposed algorithm also uses the texture method and inverse boundary scattering transform to calculate efficiently the integral arising in modified Kirchhoff migration, and thus enabling the integral in the F-K domain to be calculated within a short time.

SA-2 Experimental Demonstration of Interference Suppression in Radio over Fiber Simultaneously Transmitted with Optical On-Off Keying

○Yuya Kaneko・Takeshi Higashino・Minoru Okada（NAIST）

Abstract Radio frequency (RF) and optical on-off keying (OOK) signal can be simultaneously transmitted by using the radio over fiber (RoF) link. In this link, optical OOK signal is a carrier for transmitting the RF signal. However, the OOK modulation interferes with the RF signal at the receiving side. In this paper, biased half-wave rectification is implemented using an analog electronic circuit and demonstrates interference suppression for proof-of-concept. The experiment shows that the proposal improves SNR (signal-to-noise ratio).

SA-3 W-Band Wireless Access Systems using RoF Technologies – Toward Resilient Seamless Access Network –

Nobuhiko Shibagaki（HITACHI）

Abstract W-band wireless access systems using millimeter-wave RoF technologies are developed in the frequency range of 90-100 GHz. A data transmission of 10 Gbps using 16QAM has been successfully demonstrated using W-band RF and optical components. The W-band wireless link can provide a backup link of high-speed optical data link.

10:00-10:30 Coffee break

10:30-11:30 **Rinkokan Room 207**

Session SB*: *Advanced EO technologies for PEM

Session Chair: Ai-ichiro Sasaki (NTT)

SB-1 High-Power Millimeter-Wave Electromagnetic-Field Sensing Using Compact Slotted Patch-Antennas with Electro-Optic Modulator

○Yusuf Nur Wijayanto・Atsushi Kanno（NICT）・Hiroshi Murata（Osaka Univ.）・Tetsuya Kawanishi・Naokatsu Yamamoto（NICT）・Yasuyuki Okamura（Osaka Univ.）

Abstract We report a demonstration of high-power millimeter-wave electromagnetic-field (EMF) sensing using compact slotted patch-antennas with electro-optic (EO) modulator. The EMF can be detected by the patch-antennas and directly converted to lightwave through the Pockels effects of the EO crystal in this technique. The measured millimeter-wave EMF characteristics can be transferred through low-loss optical fibers with immune to the environmental noises. Magnitude and polarization of the millimeter-wave EMF can be observed and identified easily. Preliminary demonstration of this technique for 90GHz millimeter-wave frequency with 33dBm millimeter-wave power are discussed and reported.

SB-2 W-band Transmission Imaging by Photonics-Based Millimeter-Wave Synthesizer and High-Power Traveling-Wave-Tube Amplifier

○Atsushi Kanno・Norihiko Sekine・Akifumi Kasamatsu・Naokatsu Yamamoto（NICT）

Abstract We configure and demonstrate an electromagnetic-wave transmission imaging system with a photonics-based W-band synthesizer, traveling-wave tube amplifier (TWTA) and focal-plane transistor array. High-power TWTA with multi-watts output power will enhance the quality of obtained images.

SB-3 Electro-Optic Sampling Detection of CW-THz Signals Using MZM-Based Flat Comb Generator

○Isao Morohashi（NICT）・Mayu Kirigaya・Yuta Kaneko・Ikufumi Katayama（YNU）・Yoshihisa Irimajiri・Takahide Sakamoto・Norihiko Sekine・Akifumi Kasamatsu・Iwao Hosako（NICT）

Abstract We proposed and demonstrated 100 GHz-band spectrum measurement based on electro-optic (EO) sampling using a Mach-Zehnder-modulator-based flat comb generator (MZ-FCG). An Optical two-tone signal was extracted from a 10 GHz-spaced optical comb by a pair of optical bandpass filters, and was modulated on an EO crystal by 100 GHz-band signal generated from the frequency multiplier. As a result, the 100 GHz-band signal was successfully detected, which had SN ratio of greater than 20 dB.

SB-4 Optical E-field probe characterization in a TEM cell

○Takehiro Morioka（AIST）・Yoshikazu Toba・Jun Ichijo（SEIKOH GIKEN）・Satoru Kurokawa（AIST）

Abstract A well-defined E-field is necessary for the characterization of the E-field probes. A transverse electromagnetic (TEM) cell is a well-known instrument to generate the standard

E-field. However, the field distribution inside the cell is degraded by the higher-order modes and the upper usable frequency is limited based on the cross-sectional dimensions of the cell. A straightforward approach to extend the frequency range is to use a smaller cell and the optical E-field probe is a suitable choice for the installation into the space inside such a cell. Characterization of the optical E-field transfer probe is discussed in the present paper. The calibration factor is defined for the system characterization and sources that affect the results are carefully investigated.

11:30-13:00 Lunch break

13:00-14:30 **Rinkokan Room 207**

Session SC*: *Plenary & Invited Paper Session 2

PEM Technology for Biology & Medicine

Session Chair: Teruo Onishi (NTT DOCOMO)

SC-1 (Plenary) Advanced Physical Phantoms for Evaluation of Interactions between the Human Body and Electromagnetic Waves

Koichi Ito（Chiba University）

Abstract It is essential to evaluate interactions between the human body and electromagnetic waves radiated from antennas for mobile terminals or other wireless devices to be used in the vicinity of the human body. The "interactions" mean two different ways: an influence of the human body on the performance of the antenna or wireless device as well as an influence of electromagnetic waves on the human body. Such interactions are estimated by numerical simulation and/or experimental evaluation. Today, computational simulation with numerical human-body phantoms or models is a very powerful tool and many commercial softwares are available. However, results of numerical simulation should be validated with other techniques such as an experiment with physical phantoms. As conventional physical phantoms, tissue-equivalent liquid, gel, semi-hard (semi-solid) or solid phantoms have usually been employed according to the purposes or situations. In our laboratory, we have studied and developed different types of semi-hard phantoms for many years. This presentation introduces some examples of advanced physical phantoms including (a) inhomogeneous phantom to simulate different internal organs inside the human body, (b) UWB phantom which covers ultra-wide band (3.1-10.6 GHz) frequency range, and (c) dynamic phantom to simulate the movement of the human body.

SC-2 (Invited) Non-destructive 3D temperature measurement for dosimetries of the thermal dose due to high frequency electromagnetic field exposure with micro-encapsulated thermo-chromic liquid crystal

○Yukihisa Suzuki（Tokyo Metropolitan Univ.）・Masami Kojima（Kanazawa Medical Univ.）・Alfred Kik・Masao Taki（Tokyo Metropolitan Univ.）

Abstract A new method to measure the temperature distribution due to high frequency electromagnetic field (HF-EMF) power absorption is established. It is intend to develop for the specific absorption rate (SAR) measurement from the temperature elevation. A micro-encapsulated thermo-chromic liquid crystal (MTLC) is employed as the temperature

probe because of its nature of high resolution and high sensitivity. In this paper, we show the non-destructive temperature visualization with MTLC for the dosimetry of in vivo millimeter-wave exposure experiment. It is also shown that the quantification method of the temperature distribution from the visualization image within the cross-section of rabbit eyes and transparency gel phantoms.

SC-3 Electric Field Measurement Close to Antennas at an Upper Frequency in the SHF Band

○Kei Satoh・Teruo Onishi（NTT DOCOMO）・Ai-ichiro Sasaki・Hiroki Morimura・Akihiko Hirata（NTT）

Abstract

Since the next-generation mobile communication system, "5G (Fifth Generation)," requires more frequency bands to achieve ultra-high-speed communications, technical verification has been conducted above 6 GHz. However, there is no clear method for evaluating the electromagnetic exposure above 6 GHz. We present the first study comparing waveguide (WG) and electro-optic (EO) probes for use in an electric field distribution measurement method in the vicinity of super high frequency (SHF) band antennas. The results based on the EO probe measurements are closer to calculated results than those using the WG probe, which indicates that the EO probe is more effective in measuring the electric field strength of high SHF antennas.

14:30-15:00 **Rinkokan Room 207**

Closing Session

Award ceremony: Student Best Presentation Award
PEM Visualization Award

Closing remark

Poster Sessions

27 November 16:00-18:00 **Rinkokan Room 204**

16:00-17:00 Core presentation time for Odd-number posters

17:00-18:00 Core presentation time for Even-number posters

FCA: Student Poster Session

FCA-1 Evaluation of DAST Crystals for Nonpolarimetric Self-heterodyne Electro-optic Detection of Terahertz Waves

○Hai Huy Nguyen Pham・Shintaro Hisatake（Osaka Univ.）・Hirohisa Uchida（Arkray Inc.）・Tadao Nagatsuma（Osaka Univ.）

Abstract The use of a DAST crystal, an organic electro-optic (EO) material with a high EO coefficient, in a nonpolarimetric self-heterodyne EO detection system is studied. The comparison of the signal-to-noise ratio (SNR) and the measurement stability between DAST and ZnTe sensors is presented. The enhancement of the SNR of the amplitude measurement of about 9dB by the DAST sensor was achieved.

FCA-2 Preliminary Measurement with Laser Microphone for Acoustic Noise Due to Electromagnetic Vibration

○Hajime Yoshino・Alfred Kik・Yukihisa Suzuki（Tokyo Metropolitan Univ.）

Abstract It is necessary that the method to measure sound waves generated from the magnetic field exposure system for biological experiment. Generally used microphones, such as dynamic-microphone and condenser-microphone, are not suitable for the measurement because they are affected by the magnetic field. Therefore the sound wave measurement method using optical system with laser is examined. We performed a preliminary experiment to detect sound waves emitted from a loudspeaker. Sound waves at 300 Hz and 80 dB SPL are detected by the sound wave measurement method using optical system with laser.

FCA-3 Visualization of in situ spatial temperature distribution with transparent phantom containing thermo-chromic liquid crystals in millimeter waves exposure

○Fumiya Kobayashi・Alfred Kik・Yukihisa Suzuki（TMU）

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FCA-4 Microwave 180-degree Hybrid Formed on $LiNbO_3$ Substrate for Frequency Chirp Modulation by Electro-optic Modulator

○Ryota Nakamura・Tadashi Kawai・Akira Enokihara（Univ. Hyogo）・Tetsuya Kawanishi（Waseda Univ.）

Abstract

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FCA-5 SAR calculations around an implanted cardiac pacemaker due to a mobile radio terminal for business in VHF band

○Ryota Akiyama・Kazuyuki Saito（Chiba Univ.）・Soichi Watanabe（NICT）・Koichi Ito（Chiba Univ.）

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FCA-6 An EVM Evaluation for RF OFDM signal transmission over Radio on Optical OOK Fiber Link

○Kazuma Nishiyasu・Yuya Kaneko・Takeshi Higashino・Minoru Okada（NAIST）

Abstract

Analog radio over fiber (ARoF) is a candidate to construct mobile optical backhaul and fronthaul network that connects between wireless radio transceiver and remote antenna unit (RAU) because of its centralized signal processing capability and heterogeneous property of the optical fiber communication technologies. Its broad bandwidth for transmitting heterogeneous radio signal enables us to share single optical fiber infrastructure even if the light source has single wavelength resource. There were some reports on the method for sharing the 10Gbps optical Ethernet infrastructure to transmit radio frequency (RF) signal without introducing extra light source. Previous paper has reported on the probability density function (pdf) of RF signal amplitude that modulates an optical OOK signal, and derived the bit error rate (BER) performance for the OOK signal. However, only the continuous wave (CW) was assumed as an RF signal in the last work. This paper proposes an application of frequency shift for transmitting the RF orthogonal frequency division multiplexing (OFDM) signal over fiber with optical On-Off Keying (OOK) in order to avoid serious interference. In this paper, the error vector magnitude (EVM) performance is evaluated by using computer simulation.

FCA-7 Measurement of Microwave Propagation Characteristics along a Fiberglass-Reinforced Plastic Mortar Pipe Using an Electro-Optic Sensor

○Yoshiyuki Azuma・Fumiaki Ueno・Hiroshi Murata・Yasuyuki Okamura（Osaka Univ.）・Tadahiro Okuda・Masaya Hazama（Kurimoto LTD）

Abstract

We have proposed a new nondestructive inspection method for fiberglass-reinforced plastic mortar (FRPM) pipes using microwave guide-mode propagation and photonic techniques. This method is based on the precise measurement of a microwave guided-mode propagated along a FRPM pipe-wall by use of an electro-optic (EO) sensor. In the previous research, we have confirmed that microwave can propagate along the FRPM pipe-wall as a guided-mode, and the propagated microwave transmission characteristics through the FRPM pipe are affected by defects or cracks in FRPM pipes. By measuring electric field distributions by use of an EO sensor precisely, we believe that we can detect smaller defects or cracks in/on the FRPM pipe nondestructively.

FCA-8 Novel Interference Voltage Sensor Using an Electro-Optic Converter for Active Implantable Medical Devices EMI Assessment

○Naoki Tanaka・Takashi Hikage・Toshio Nojima（Hokkaido Univ.）・Takahiro Iyama・Junji Higashiyama・Teruo Onishi（NTT DOCOMO, INC.）

Abstract

An interference voltage sensor for active implantable medical devices (cardiac pacemakers / ICDs) EMI assessment is newly developed by applying direct modulated Electrical to Optical (EO) converter. The sensor can be connected an actual pacemaker lead and measured induced voltage without disturbing electromagnetic fields emitted from tested RF device because I/O signal of the sensor are made through optical fiber. As one example, measurement of interference voltage due to a cellular base station antenna is demonstrated.

FCA-9 Improvement of Modulation Efficiency of Electro-Optic Modulators with Gap-Embedded Patch Antenna Utilizing Stacked Structure

○Hironori Aya（Osaka Univ.）・Yusuf Nur Wijayanto・Atsushi Kanno・Tetsuya Kawanishi（NICT）・Hiroshi Murata・Yasuyuki Okamura（Osaka Univ.）

Abstract

In this report, we propose new electro-optic modulators using gap-embedded patch antennas with Yagi-antenna- like stacked structure. By utilizing the stacked structure, antenna gain and electric field Ez for optical modulation at the gap are increased with a shift of its resonance frequency toward the higher region. By tuning parameters of the patch antennas, the conversion efficiency from wireless millimeter-wave to lightwave signal is increased about 2 times compared with the modulator of non-stacked structure. The analysis and design of the device are reported.

FCA-10 A Performance Comparison of Load Balancing among Radio-over-Fiber Indoor LTE Small Cells

○Withawat Tangtrongpairoj・Takeshi Higashino・Minoru Okada（NAIST）

Abstract

Radio over Fiber (RoF) is a promising candidate for constructing 4G and 5G mobile optical network. The main feature of the RoF is heterogeneous and centralized processing for the radio resource. In this paper, we compared several algorithms as for the load-balancing scheme. The throughput performance and standard deviation (SD) are evaluated with the different schemes. As a result, it is found that the sorted-greedy achieves the highest throughput with minimum deviation.

FCB: Regular Poster Session

FCB-1 Development of Log-scale Comb-generator for EMC Emission Measurement less than 30 MHz Using FPGA-based Arbitrary Waveform Generator

○Michitaka Ameya・Satoru Kurokawa（AIST）

Abstract

In this paper, a log-scale comb-generator using FPGA-based arbitrary waveform generator are proposed. This comb-generator can be utilized for daily-checking of conducted and radiated emission measurement system. The proposed comb-generator can cover the frequency range of 9 kHz to 30 MHz and can generate almost-equal-space comb-like spectrum in frequency logarithmic scale. Additionally, the fine tuning of output level of each comb can be realized due to the use of FPGA architecture. After fine tuning for highly flatness of frequency response of comb spectrum, the output levels of 90 dBuV ±0.01 dB are achieved. The standard deviation of the output spectrum of the proposed comb-generator is less than 0.01 dB in the frequency less than 20 MHz, therefore the output spectrum of the proposed comb-generator is quite stable. By the use of this equipment, the amplitude of the electromagnetic fields radiated from this generator can be leveled off. Therefore, this signal generator can be used as a reference field generator. By the reference field generator, the RoF link system and the photonic electric field sensor system easily calibrated and realize more accurate electromagnetic field measurements. The measurement results by RoF link system will be presented in the poster session.

FCB-2 An Example of Millimeter-wave band Antenna Measurement System with Optical Fiber Link Technologies

○Yuanfeng She・Michitaka Ameya・Satoru Kurokawa（AIST）・Jiro Hirokawa・Makoto Ando（Tokyo Tech）

Abstract

This paper evaluates the effect of the facilities such as the connect jig and the measurement system. An example of the millimeter-wave band antenna system with optical fiber has been introduced. The radiation patterns of a 60 GHz small package antenna has been measured by the optical fiber link system.

FCB-3 Permittivity measurements using a microwave resonator with a sample insertion mechanism

○Yuto Kato・Masahiro Horibe（AIST）

Abstract

Recently a new resonant method has been proposed. This method uses a resonator with a sample insertion mechanism. By adjusting the sample volume in a cavity, the magnitudes of changes in resonant properties can be controlled. By using this method, the permittivity can be perturbatively measured and evaluated even for high-loss or high-permittivity samples. In this paper, we characterized a cyclic olefin copolymer (COC) at 6.5 –9.5GHzfrequency region by measuring TE_{10n} modes as a sample is inserted into the rectangular cavity, and quantitatively confirmed that the new method not only improved the accuracy but also reduced the uncertainty. This method is also expected to use for characterizing biomedical materials.

FCB-4 Recent Standardization Activities for Radio on Fiber Transmitter Within IEC TC103 WG6

○Satoru Kurokawa（AIST）・Junichiro Ichikawa（Sumitomo Osaka Cement）・Hiroyo Ogawa（NICT）

Abstract

This paper describes the outline of recent standardization activities for Radio over Fiber

transmitter by IEC TC103WG6. Radio over Fiber transmitter consists of optical fibers, electrical to optical converter, and optical to electrical converter. IEC TC103WG6 is working on standardization on measurement method of these devices, and technical report for some applications using Radio over Fiber transmitter. This paper overviews those standardization activities which are being developed by TC103WG6.

FCC: Company Poster Session

FCC-1 Broadband High Extinction Ratio Modulator for Optical Two-Tone Signal Generation

○Junichiro Ichikawa・Youichi Hosokawa・Kaoru Higuma・Satoshi Oikawa（Sumitomo Osaka Cement）

Abstract A high extinction ratio Mach Zehnder Modulator (MZM) is a key device for generating a pure optical two-tone signal. Characteristics of the high extinction ratio modulators were improved. A half-wavelength voltage was reduced down to 4.1 V_{pp} and a bandwidth (BW) was extended up to 27 GHz. A novel bias control method of the modulator was also developed.

FCC-2 Millimeter wave operation of optical modulator using electro-optic polymer containing donor-electron enhanced FTC-based chromophore

○Yoshizumi Ishikawa・Masayuki Motoya・Kaoru Higuma・Junichiro Ichikawa（Sumitomo Osaka Cement）

Abstract Electro Optic (EO) polymer modulators containing Donor-electron enhanced FTC-based chromophore were fabricated and evaluated. Phase modulators with 10 mm interaction length exhibited a wide bandwidth of 60GHz and a small half-wavelength voltage of 5.5 V. Mach-Zehnder (MZ) intensity modulators were also fabricated.

FCC-3 Improvement of optical millimeter wave by dual-parallel $LiNbO_3$ modulator and ALC-EDFA

○Kohei Toyoda・Naoki Nishikawa・Hidenori Iwai・Kazuya Ota・Naoshi Yamada（Trimatiz）

Abstract By using an improved $LiNbO_3$ modulator, it is possible to generate large second order harmonics with a lower carrier to noise ratio, leading to the production of a significantly improved optical millimeter wave. Furthermore, it is possible to improve the frequency characteristic of the optical millimeter wave by using an automatic level control amplifier.

FCC-4 Electric field sensing with EO probe and application of RoF

○Koji Uematsu・Yoshihiro Imajo・Hiroshi Noguchi（Stack Elec.）

Abstract We present our products, an electric field sensor utilizing electro-optic (EO) effect and device applied to radio over fiber (RoF) transmission. The name of the EO sensor we develop is LeoProbe which features small size, metal free structure and wide detectable frequency range. Products related to RoF technology are ROF-link that is a pair of electrical to optical (E/O) converter and optical to electrical (O/E) converter to transmit RF signal with analogue optical modulation. The standard type of ROF-link operates in the frequency range from 10MHz to 3GHz.

FCC-5 Introduction of R&S QPS100 Quick personal security scanner

– R&S millimeter body scanner –

Yuta Hoshina（Rhode & Schwarz）

Abstract The R&S QPS100 is a state-of-art millimeter-wave body scanner that automatically detects concealed items carried on the body or in clothing.

FCC-6 Radio over Fiber System for Electromagnetic Measurement

○Yoshiki Yanagisawa・Satoshi Suzuki・Natsuki Obara (TME)

Abstract This paper describes the outline of Radio over Fiber System. Additionally we will also introduce a microwave products. We "TAMAGAWA ELECTRONICS" is specialized in high frequency technology. Since our company was founded in 1968, we have been developing and producing systems and components designed for telecommunication, broadcasting, and so on.

FCC-7 Optical E-field Sensor for E-field Measurement System

Yoshikazu Toba（SEIKOH GIKEN）

Abstract We have developed the Optical Electric Field Sensor utilizing the Pockels effect of lithium niobate ($LiNbO_3$), and proposed it for EMC measurement system. This sensor can measure not only E-field strength but also frequency and phase. The feature of this sensor are: mitigating disturbance of the surrounding E-field, high-accuracy, elimination of common noise, small sensor head, measurement ability of any kinds of modulations such as AM, FM, CDMA and so on and wide frequency range such as 100kHz to 10GHz. In this report, we introduce system configuration and product lineup of the optical E-field sensors. And we describe the efforts of some of the future.

FCC-8 Kyosemi products

Kenji Nishikawa（Kyosemi）

Abstract Development of advanced industrial apparatus, such as High speed communication device, an encoder device, a bill identification device, ITS (intelligent transport system), image processing, a surveillance camera, a plant factory, sterilization, and gas analysis, is progressing. The scope of optical sensing has also Kyosemi is developing various products, such as LED, Photodiode, and Phototransistor, taking advantage of the technology corresponding to a broad domain from ultraviolet rays to infrared rays.

FCC-9 Technical support for small and medium enterprises using optical, millimeter-wave and microwave measurement instrument

○Masahiro Andachi, Masaki Hori, Yoichi Koyama, Satoshi Higashi (Kyoto Pref.), Satoru Kurokawa (AIST)

Abstract We support small and medium enterprises for communication, medical, analysis, sensing and various fields in Kyoto. We introduce optical, millimeter-wave and microwave measurement instrument in our Center.