**Oct. 5-9, 2010**

**MontrÉal, QuÉbec, Canada**

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**MWP 2010**

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**2010 IEEE International Topical Meeting on microwave photonics**

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*Afshin S. Daryoush Beatrice Cabon Ke Wu*

*General Chair General Co-chair General Co-chair*

*Drexel University, Philadelphia Ecole Polytechnique, Grenoble Ecole Polytechnique, Montreal*

*USA France Canada*

Join us for the 2010 IEEE International Topical Meeting on Microwave Photonics (MWP2010) in the beautiful city of Montreal, Quebec, CANADA from 5- 8 October 2010. The MWP2010 conference follows tradition of many other successful MWP conferences and this meeting is jointly sponsored by two prominent IEEE societies of the Microwave Theory and Techniques (MTT) and the Photonics Society (formerly LEO). Throughout the life of the MWP meetings since its inception in 1996, this is the second time that MWP is being held in Canada. This year the European Optical Society has sponsored this conference for the first time, manifesting a broad and diverse representation of various technical communities. We are also pleased to welcome delegates from 20 countries to the technical conference, which is organized in the Hilton Montreal Bonaventure Hotel.

The MWP meetings focus on the intersection between microwave devices and optical components, which creates a unique forum for engineers to discuss hardware design and system performance of the state-of-the-art microwave photonic systems that are applied to wireless communication, radar and imaging systems, remote sensing and medical imaging. The conference starts with a workshop on Tuesday October 5 and followed with single technical oral and interactive sessions starting Wednesday October 6 and ends on Friday October 8. The submitted papers were equally distributed among Americas, Europe and the Middle East, and Asia-Pacific regions.

One of the advantages of having our meeting in the Montreal is the close proximity to leading microwave and photonics companies in Canada and a large number of universities and research institutes. We would like to acknowledge sponsorship of Canadian Institute for Photonic Innovations (CIPI), Discovery Semiconductors Inc., Photline, Teraxion, and Quebec Photonic Network of this conference. With quality technical conference and a number of commercial exhibitions, the MWP2010 provides opportunities for learning about the state of the art in all the technical and commercial aspects of the rapidly changing microwave photonics. The conference hotel is located in the heart of Montreal, a city with its world renowned international cuisine and very close proximity to beautiful mountains during the beautiful fall foliage season of Quebec. We hope that our delegates could take advantage of both technical and cultural features that this rich multi-cultural region of Canada offers. Your feedback is greatly appreciated to help us organizing better future meetings.

We look forward to seeing you in Montreal!

# Welcome Address

***MWP 2010 Organizing Committee***

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# Message from the Technical Program Committee

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| *Jianping Yao*  *TPC Chair*  *University of Ottawa, Canada* | *Thas A. Nirmalathas*  *TPC Co-Chair*  *University of Melbourne, Australia* | *Jean Chazelas*  *TPC Co-Chair*  *Thales, France* |

On behalf of Technical Program Committee, we would like to warmly welcome you to MWP 2010. MWP 2010 will begin with a workshop on photonic radio-frequency arbitrary waveform generation on October 5, and proceed with two and half days of oral and poster sessions, on October 6, 7 and 8.

Of the 139 papers, including three plenary talks and eight invited talks, submitted to this year’s conference through the conference website, the committee accepted a total of 107 papers for either oral or poster presentations. The oral presentations have been grouped into eight sessions that will focus on topics of interest to the microwave photonics community, namely, Microwave Photonics Devices, Microwave Photonics Transmission Techniques, Photonic Generation of Microwave and THz Signals, Radio over Fiber Techniques, Microwave Signal Generation and Clock Recovery, Signal Processing for Radar, Communications and Sensor Applications, and Microwave Photonics Filtering and Beamforming Techniques. The poster presentations are grouped into two sessions, namely, Microwave Photonics Devices and Systems, and Photonic Generation, Processing and Measurement of Microwave Signals.

Besides the regular oral and poster sessions, the technical program of MWP 2010 features plenary presentations by three world leaders in the area, namely, Larry A. Coldren on “Photonic Integrated Circuits for Microwave Photonics”, Masayuki Izutsu on “MWP and Terahertz Technology”, and Andreas Stöhr on “Photonic Millimeter-Wave Generation and its Applications in High Data Rate Wireless Access”.

The technical program will conclude with oral presentation of post-deadline papers, reviewed and accepted by the Technical Program Committee.

We hope you enjoy the technical program of MWP 2010.

# International Steering Committee

Technical conference is planned at Hilton Montreal

Bonaventure, where all the technical session and majority of social events are to be held and located 900 Rue de la Gauchetière Ouest, Montréal, QC H5A.



Hilton Montreal Bonaventure is located truly at the heart of Montreal; it is in short walking distance to a number of restaurants, shopping, and public transportation centers, which provides many sightseeing opportunities to Montreal and surrounding points of interests. The hotel is recognized for its excellent service; its concierge desk is daily available to arrange for sightseeing tour. Hotel staff and its many amenities are at your disposal so your stay at the Hilton Hotel and visit to Montreal becomes truly a memorable experience.



Montreal Pierre Elliott Trudeau Airport (YUL), originally known as Dorval International Airport, is only 12km away (about 20 minutes drive) from the conference hotel. A number of transpiration services are available from the International Airport to Hilton Montreal Bonaventure Hotel. A taxi service is to cost about CAN$ 38, a bus service is also available for CAN$ 7.

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# Conference venue

# Technical Committee

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| **16:00 - 17:30** *Verdun/Lachine/Lasalle Ballroom*  **Session TU1:** ***Photonic Radio-Frequency Arbitrary Waveform Generation Workshop*** *II*  Session Co-Chairs:  *Andrew M. Weiner, Purdue University, United States*  *Lawrence Chen, McGill University, Canada* |

**TU2-1 16:00-16:30**

Advanced Fiber Bragg Gratings for Photonic Generation and Processing of Arbitrary Microwave Waveforms

*Chao Wang and Jianping Yao, University of Ottawa, Canada*

Photonic generation and processing of microwave arbitrary waveforms has been a topic of interest recently. Compared with the electronic techniques, photonics techniques provide the capabilities of generating and processing high frequency and large-bandwidth microwave waveforms which cannot be fulfilled by the electronic techniques, In this paper, techniques to generate and process microwave arbitrary waveforms in the optical domain using advanced fiber Bragg gratings (FBGs) are reviewed, with an emphasis on the system architectures in which FBGs are employed as spectral shapers or optical filters. The challenges in using FBGs for microwave arbitrary waveform generation and processing are also discussed.

**TU2-2 16:30-17:00**

On-chip Programmable RF Waveform Generation

*Minghao Qi, Hao Shen, Li Fan, Leo T. Varghese, Jian Wang, Ben Niu, Daniel Leaird, and Andrew M. Weiner****,*** *Purdue University, United States*

We demonstrate thermo-optically tunable multiple-channel micro-ring resonators as an ultracompact on-chip spectral shaper, and tunable multiplering all-pass filters as variable delay lines for photonic radio-frequency waveform generation. High quality radio-frequency pulsed signals were achieved.

**TU2-3 17:00-17:30**

Incoherent Frequency-to-Time Mapping Method for Pulse Shaping and RF Signal Generation

*Víctor Torres-Company[1], Jesús Lancis[2], and Pedro Andres [3], [1] McGill University, Canada, [2] Universitat Jaume, Spain, [3] Universidad de Valencia, Spain*

The capabilities for RF-AWG in terms of waveform fidelity for three different incoherent photonic methods are revised and discussed: incoherent frequency-to-time mapping, incoherent MWP filtering with *N* discrete taps, and multiwavelength pulse compression.

**Tuesday October 5, 2010**

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| **13:30 - 15:15** *Verdun/Lachine/Lasalle Ballroom*  **Session TU1:** ***Photonic Radio-Frequency Arbitrary Waveform Generation Workshop*** *I*  Session Co-Chairs:  *Andrew M. Weiner, Purdue University, United States*  *Jose Azana, INRS, Canada* |

**13:30-13:45** **Introduction to the Workshop**

Andrew M. Weiner, Purdue University, United States

**TU1-1 13:45-14:15**

Programmable Electromagnetic Pulse Shaping

*Jason D. McKinney, U.S. Naval Research Laboratory, United States*

This paper provides an overview of reprogrammable arbitrary-waveform generation (electromagnetic pulse shaping) enabled by optical pulse shaping technology. Here, generation of wideband millimeter-wave signals, ultra-broadband radiofrequency and microwave waveforms, as well as tunable continuous-wave microwave tones are discussed. Example waveforms exhibiting user-defined temporal and spectral structure at center frequencies from < 1 - >50 GHz and fractional bandwidths ranging over % BW = 0 - ~170 % are provided. Several applications are also briefly discussed.

**TU1-2** **14:15-14:45**

Low Jitter Optical and Microwave Waveform Synthesis with Frequency Combs

*Scott Diddams, National Institute of Standards and Technology, United States*

An optically-stabilized femtosecond laser optical frequency comb can serve as a source of optical and microwave waveforms with absolute integrated timing jitter on the scale of a few femtoseconds. This ultralow jitter is due to the stability of a passive optical cavity, which is the frequency reference for the system. We will present recent results in the generation of low phase noise 10 GHz signals and will discuss our progress towards the synthesis of more complicated waveforms.

**TU1-3** **14:45-15:15**

100+ GHz Transistor Electronics: Present and Projected Capabilities

*Mark Rodwell, University of California Santa Barbara, United States*

Design principle and the present status of high-frequency transistors and integrated circuits are reviewed. Given presently-demonstrated process and material parameters, bipolar transistors having ~3 THz power-gain cutoff frequencies are feasible. Demonstration of field-effect transistors having similar bandwidth requires development of high-capacitance-density gate dielectrics of adequately low leakage current, and high-K oxide gate barriers may therefore be necessary. Transistors of such bandwidths would enable e.g. ~1.5 THz radio transmitters and receivers; classical electron device and circuit techniques are feasible over most of the sub-millimeter-wave (0.3-3 THz) spectrum.

**◄ 15:15-16:00 Coffee Break ►**

***Le Portage & Terrace***

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| **10:30-12:30** *Verdun/Lachine/Lasalle Ballroom*  **Session WE2:** ***Microwave Photonics Devices***  Session Co-Chairs:  *Andreas Stöhr, Universität Duisburg-Essen, Germany*  *Jonathan Klamkin, MIT Lincoln Laboratory, United States* |

**WE2-1 10:30-11:00**

Low-cost Sub-Millimeter-Wave/THz Integrated System Technologies (Invited)

*M. Neshat[1], N. Ranjkesh[1], M. Basha[1], K. Bayat[2], S. Chaudhuri[1], S. Safavi-Naeini[1], [1]University of Waterloo, Canada, [2]South Dakota State University, United States*

Three approaches will be presented for low-cost submillimeter/THz integrated circuits and systems. Multi-layer planar line monolithic integration, dielectric waveguide hybrid technology, and SOI-based photonic-crystal technique will be described and recent progresses and typical developed integrated devices will be discussed.

**WE2-2 11:00 -11:15**

Voltage-Dependent Nonlinearities in Uni-Traveling Carrier Directional Coupled Photodiodes

*M. N. Draa[1], J. Bloch[2], W. S. Chang[2], P. K. Yu[2], D. C. Scott[3], K. J. Williams[4], S. B. Chen[3], N. Chen[3], [1]Global Defense Technology & Systems, Inc., United States, [2]University of California San Diego, United States, [3]Archcom Technology, United States, [4]U.S. Naval Research Laboratory, United States*

Voltage-dependent responsively nonlinearities are characterized experimentally and analytically for uni-traveling carrier directional coupled photodiodes (DCPD) with two types of design variations. OIP3 data follows the voltage-dependent responsively predictions for both MMI width and PD width variations of the baseline DCPD. A maximum OIP3 of 39dBm was achieved for a device with a 3 μm wide PD at 20mA and 4V.

**WE2-3 11:15 -11:30**

Optoelectronic Mixer Based on High Power Modified Uni-Traveling-Carrier Photodiode

*Z. Li, H. Pan, Y. Fu, J. Campbell, and Z. Li, University of Virginia, United States*

We demonstrate for the first time an optoelectronic mixer with an up-converted power > 0 dBm. A high up-converted power of 0.7 dBm has been achieved with a low conversion loss of -3.2 dB at 60 GHz.

**WE2-4 11:30 -11:45**

Monolithically Integrated Programmable Photonic Microwave Filter with Tunable Inter-Ring Coupling (Student Paper Finalist)

R. *S. Guzzon, E. J. Norberg, J. S. Parker, L. A. Johansson, L. A. Coldren, University of California Santa Barbara, United States*

The design and operation of a coupled-ring programmable photonic microwave filter architecture are described. RF measurements of flat-topped bandpass filters with bandwidths of 3 GHz-7.4 GHz are presented. A stop-band extinction of 40 dB is obtained.

**Wednesday October 6, 2010**

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| **8:00-10:00** *Verdun/Lachine/Lasalle Ballroom*  **Session WE1:** ***Plenary Session***  Session Co-Chairs:  *Ampalavanapillai Nirmalathas, University of Melbourne, Australia*  *Jean Chazelas, Thales, France* |

**8:00-8:15 Welcome remarks**

**WE1-1 8:15-8:50**

Photonic Integrated Circuits for Microwave Photonics (Plenary)

*Larry A. Coldren, University of California Santa Barbara, United States*

InP-based Photonic Integrated Circuits (PICs) have found applications in the telecommunication and sensing arena because they have offered improvements in cost and function as well as size, weight and power. For microwave photonics applications, it has been found that some analog functions such as optical-phase locked loops (OPLLs) can be greatly improved and enabled with PIC technology. Primary reasons are significantly reduced path lengths that enable much higher loop bandwidths and very stable optical paths enabling low noise coherent summing of optical signals. In this paper significant advances in PIC technology will be summarized. Integrated PIC coherent receivers and phase-locked transmitter arrays using OPLLs will be reviewed. Programmable PIC microwave photonic filters will also be briefly discussed.

**WE1-2 8:50-9:25**

MWP and Terahertz Technology (Plenary)

*Masayuki Izutsu, Tokyo Institute of Technology, Japan*

The importance will be emphasized to involve terahertz spectrum in the microwave photonic technologies of the next stage.

**WE1-3 9:25-10:00**

Photonic Millimeter-Wave Generation and its Applications in High Data Rate Wireless Access (Plenary)

*Andreas Stöhr, Universität Duisburg-Essen, Germany*

Microwave Photonics is widely considered as a disruptive technology for high data rate wireless communications. This paper discusses technological trends in enabling photonic solutions for high data rate wireless access systems operating in the millimeter-wave regime. Besides technical achievements, a focus is also put on worldwide regulations for wireless communications in the E-band (60-90 GHz).

**◄ 10:00-10:30 Coffee Break ►**

***Fontaine GH***

**WE2-5 11:45-12:00**

An Ultra-Compact Integrated Coherent Receiver for High Linearity RF Photonic Links (Student Paper Finalist)

*U. Krishnamachari, S. Ristic, A. Ramaswamy, L. Johanssen, C. Chen, J. Klamkin, M. Piels, M. Rodwell, A. Bhardwaj, J. Bowers, L. Coldren, University of California Santa Barbara, United States*

We demonstrate a novel photonic integrated circuit (PIC) that combines an ultra compact trench beam splitter with monolithically integrated photodetectors and modulators. A coherent receiver is realized by flip chip bonding of this PIC with an electronic integrated circuit (EIC). Preliminary system results yield a third-order intermodulation distortion suppression of 46 dB at a signal frequency of 300 MHz.

**WE2-6 12:00-12:15**

Demonstration of a Linear Ultra-Compact Integrated Coherent Receiver (Student Paper Finalist)

*A. Ramaswamy[1], L. A. Johansson[1], U. Krishnamachari[1], S. Ristic[1], C. Chen[1], M. Piels[1], A. Bhardwaj[1], L. A. Coldren[1], M. J. Rodwell[1], J. E. Bowers[1], R. Yoshimitsu[2], D. W. Scott[2], R. L. Davis[2], [1]University of California Santa Barbara, United States, [2]Northrop Grumman AeroSpace Systems, United States*

We demonstrate the operation of an ultra-compact coherent receiver for linear optical phase demodulation. The receiver, based on a broadband optical phase-locked loop (OPLL) has a bandwidth of 1.5 GHz. Physical delay in the feedback path is dramatically reduced by incorporating novel photonic and electronic components. Using the receiver in an analog link experiment, a spurious free dynamic range of 122dBHz2/3 is measured at 300 MHz. Additionally, the link loss is -2dB at low frequencies.

**WE2-7 12:15-12:30**

Compact Electro-optic Modulator for Direct Integration into an X-band Antenna Array Front-end

*D. Yap, O. M. Efimov, K. Geary, J. H. Schaffner, HRL Laboratories, United States*

A compact electro-optic modulator comprising a waveguide grating formed on a small piece of lithium niobate can be integrated directly into an X-band antenna array element. A prototype link with this modulator was demonstrated.

**◄ Lunch Break 12:30-13:30 ►**

***Le Portage & Terrace***

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| **13:30-15:30** *Verdun/Lachine/Lasalle Ballroom*  **Session WE3:** ***Microwave Photonics Transmission Techniques***  Session Co-Chairs:  Dalma Novak, Pharad LLC, United States  Kun Xu, Beijing University of Posts and Telecommunications, China |

**WE3-1 13:30-14:00**

Class-A Semiconductor Lasers for the Transport and Generation of Optically Carried RF Analog Signals for Radar Applications (Invited)

*F. Bretenaker[1], G. Baili[2], M. Alouini[3], L. Morvan[2], D. Dolfi[2], I. Sagnes[4],*

*[1]Laboratoire Aimé Cotton, France,*

*[2]Thales Research and Technology, France,*

*[3]Institut de Physique de Rennes, France,*

*[4]Laboratoire de Photonique et Nanostructure, France*

Class-A operation of VECSELs is obtained. Such shot noise limited sources are used for the transport of RF signals and the generation of radar local oscillators via two-frequency operation.

**WE3-2 14:00-14:15**

Terahertz Wireless Communications Link at 300 GHz

*H. Song[1], K. Ajito[1], A. Wakatsuki[1], Y. Muramoto[1], N. Kukutsu[1], T. Nagatsuma[2], Y. Kado[1], [1]NTT Corporation, Japan, [2]Osaka University, Japan*

We present a terahertz wave wireless link operating at 300 GHz which has a potential for use in ultra fast future wireless services in short range. Terahertz wave was generated and modulated with photonic technologies in the transmitter, allowing us to use radio on fiber system concept as well. For the receiver, we used a Schottky barrier diode detector integrated with a planar antenna. With the link, error free data transmission at 12.5 Gbps was experimentally demonstrated. Taking the performance margin of the transmitter and receiver into consideration, we believe that even up to 20-Gbps data can be transmitted.

**WE3-3 14:15-14:30**

20-Gb/s On-off-keying Wireless Data Transmission by Using Bias Modulation of NBUTC-PD Based W-Band Photonic Transmitter-Mixer

*J. Shi[1], F. Kuo[1], H. Tsai[1], Y. Hsin[1], N. Chen[2], H. Chiang[3], H. Chuang[3], C. Huang[3], C. Pan[3], [1]National Central University, Taiwan, [2]Yuan Ze University, Taiwan, [3]National Tsing-Hua University, Taiwan*

We demonstrated near-ballistic uni-traveling-carrier photodiode based broadband photonic transmitter-mixers with quasi-Yagi radiators fed horn antennas. By adopting a novel design in the intermediate-frequency (IF) port of such device, we can further extend the IF (bias) modulation bandwidth of NBUTC-PD to over 14GHz. Wireless data transmission with record-high on-off keying date rate as 20-Gb/s via bias modulation of such novel device has been successfully achieved.

**WE3-4 14:30-14:45**

Digitized Multi-channel ISDB-T Signals Transportion over an Optical 10-Gbps IP/Ethernet Link

*Y. Shoji, Y. Takayama, M. Toyoshima, H. Ohta, National Institute of Information and Communications Technology, Japan*

Transportations of digitized multi-channel ISDB-T (Japanese digital broadcasting) signals over an optical 10-Gbit IP/Ethernet link are demonstrated. Prototyped Microwave/IP packets converters, which can convert any type of microwave into optical IP/Ethernet packets, are detailed.

**WE3-5 14:45-15:00**

A Dispersion-Insensitive UWB over Fiber System Based on a Photonic Microwave Bandpass Filter

*S. Pan, J. Yao, University of Ottawa, Canada*

A novel technique to generate and distribute UWB signals over optical fiber that is insensitive to fiber dispersion is proposed and demonstrated. The entire system is equivalent to a photonic microwave bandpass filter with a constant frequency response for a different distribution distance. The proposed system is evaluated by a numerical simulation and verified by an experiment. The dispersion insensitivity makes it suitable for integration into a WDM-PON network.

**WE3-6 15:00-15:15**

Consolidation of Signal Processing Functions in WDM-Based mm-Wave Fiber Wireless Links using a LCoS-Based Programmable Optical Processor

*C. Lim[1], C. Pulikkaseril[2], K. Lee[1], A. Nirmalathas[1], M. Roelens[2],*

*[1]The University of Melbourne, Australia,*

*[2]Finisar Australia, Australia*

We propose a scheme for simplifying the architecture of a fiber-wireless remote node using a LCoS-based programmable optical processor, capable of processing optical single sideband signal with improved carrier-to-sideband ratio, as well as demultiplexing multiple WDM mm-wave fiberwireless channels.

**WE3-7 15:15-15:30**

Non-Linear Distortions in Electro-Optical Phase Modulators

*R. Tavlykaev and G. Gopalakrishnan, Independent Consultants, United States*

Non-linear distortions induced by the voltage dependence of the guided mode field in electro-optical phase modulators are studied and quantified. Under very large signal modulation conditions, such distortions could impact analog link performance.

**◄ 15:30-16:00 Coffee Break ►**

***Fontaine GH***

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| **16:00-17:30** *Fontaine H*  **Session WE4: *Poster Session I – Microwave Photonics Devices and Systems***  Session Co-Chairs:  Arye Rosen, Drexel University, United States  Asher Madjar, M2 Microwaves LLC, United States |

**WE4-2**

Bidirectional Transmission of Digital Signals in a WDM-PolMUX Optical Access Network

*F. Grassi, J. Mora, B. Ortega, J. Capmany, Universidad Politécnica de Valencia, Spain*

We present a WDM optical access network based on polarization multiplexing technique where light-source provisioning and polarization control is centralized at the central office. The architecture is suitable for bidirectional SMF transmission of digital signals.

**WE4-3**

Performance Evaluation of MB-OFDM Ultra-Wideband over Fiber Transmission Using a Low Cost Electro-Absorption Modulator Integrated Laser

*C. Sui[1], B. Hraimel[1], X. Zhang[1], K. Wu[2], B. Hraimel[2], T. Liu[3], T. Xu[3], Q. Nie[3],*

*[1]Concordia University, Canada,*

*[2]Ecole Polytechnique de Montreal, Canada,*

*[3]Ningbo University, China*

The performance of Multiband-Orthogonal Frequency Division Multiplexing (MB-OFDM) Ultra-WideBand (UWB) signal over single mode fiber system using a low cost Electro-Absorption Modulator (EAM) integrated laser (EML) is studied experimentally. Error Vector Magnitude (EVM) measurement is carried out to evaluate the system performance considering the effect of bias voltage, bias current temperature and optical modulation index of the EML, and fiber length. The experiment results showed that by using an EML, the UWB signal transmission over fiber can be cost effectively implemented.

**WE4-4**

Vertical-Cavity Surface-Emitting Laser: Modelling and Applications for Microwave Signal Generation

*A. Rissons, A. Bacou, A. Hayat, M. Varon-Duran, J. Mollier, ISAE, France*

**WE4-5**

Optical Distribution of Microwave Signals for Earth Observation Satellites

*R. Palacio, F. Deborgies, P. Piironen, European Space Agency, Netherlands*

Optical distribution of signals is playing a key role in

ESA Earth Observation satellite SMOS (Soil Moisture and Ocean Salinity). This paper is describing a possible evolution of the optical harness in which the Local Oscillator, the calibration microwave signal and the clock reference are distributed in a single fiber thanks to Wavelength Division Multiplexing (WDM). Due to the high sensitivity of the on-board RF Frontends, degradation effects induced by the optical link can severely affect the overall performance. Therefore, system level requirements like signal isolation or phase noise are to be taken into account. Preliminary test measurements have shown that isolation over 70dB can be obtained in the RF domain.

**WE4-6**

High Power Microwave Pulse Impact on an All-Dielectric Lithium Niobate Modulator

*J. H. Schaffner[1], K. Geary[1], D. Yap[1], O. Efimov[1], D. A. White[2], M. L. Stowell[2], C. G. Brown[2], J. S. Levine[3],*

*[1]HRL Laboratories, LLC, United States,*

*[2]Lawrence Livermore National Laboratories, United States,*

*[3]L-3 Communications/Pulse Sciences, United States*

Measurements and multiphysics simulations of alldielectric LiNbO3 grating modulators exposed to high power microwave pulses were conducted. Thinned substrate devices exposed to 180kV/cm fields show no significant degradation in measured optical spectrum or link gain.

**WE4-12**

Performance Characterization and Limitation of Coherence Multiplexing Technique in Radio over Fiber Systems

*Y. Pei[1], B. Hraimel[2], Y. Shen[2], X. Zhang[2], K. Xu[1], X. Sun[1], J. Wu[1], J. Lin[1],*

*[1]Beijing University of Posts and Telecommunications, China,*

*[2]Concordia University, Canada*

Coherence multiplexing (CM) based Radio-over-Fiber (RoF) system is experimentally investigated for the first time for both single tone RF signal and ultra-wideband orthogonal frequency division multiplexing (UWB-OFDM) signal. The impact of received optical power, linewidth of the optical source, input RF power and fiber length are considered. It is found that the system is seriously limited by beat noise and fiber dispersion.

**WE4-13**

Experimental Evaluation of High Speed Impulse Radio UWB Interference on WiMAX Narrowband Systems

*X. Yu[1], X. Yin[2], I. Tafur Monroy[1],*

*[1]DTU Fotonik, Denmark,*

*[2]School of Electronic Engineering, China*

Interference of high speed impulse radio ultra-wideband (IR-UWB) on 5.735GHz single carrier 64/256-QAM WiMAX narrowband signals is experimentally investigated. The experimental results indicate that the coexistence of 625Mbps and 2Gbps IR-UWB signals causes penalties of 3dB and 0.5dB respectively to the WiMAX channel. At higher bit rates, IR-UWB technology is therefore expected to reduce its interference on WiMAX signals. This work serves as further motivation for the exploration of IR-UWB systems with higher speed and higher capacity.

**WE4-14**

Timing Jitter Reduction of a Mode-Locked VECSEL Using an Optically Triggered SESAM

*G. Baili[1], L. Morvan[1], M. Alouini[3], D. Dolfi[1], A. Khadour[2], S. Bouchoule[2], J. Oudar[2],*

*[1]Thales R&T, France,*

*[2]Laboratoire de Photonique et Nanostructures, France,*

*[3]Institut de Physique de Rennes, France*

A technique, using optically triggered Semiconductor Saturable Absorber Mirror (SESAM), for active stabilizing the repetition rate of mode-locked VECSEL is presented. Experimental demonstration shows jitter reduction from 8 ps to 423 fs for a 1.68 GHz repetition rate laser.

**WE4-7**

Broadband Microwave and mm-Wave Dispersion Using Periodic Structures

*J. D. Schwartz[1], Q. Zhuge[2], Y. Zhu[2], J. Azaña[1], D. V. Plant[2],*

*[1]Institution National de la Recherche Scientifique (INRS), Canada,*

*[2]McGill University, Canada*

We describe a passive planar waveguide electromagnetic bandgap (EBG) structure yielding linear dispersion for microwave and mm-wave (60 GHz) signals. We also propose a recirculating architecture for increasing the effective dispersion of existing EBG structures.

**WE4-9**

Behavioral Modeling of Radio-over-Fiber Links Using Memory Polynomials

*L. C. Vieira[1], N. J. Gomes[1], A. Nkansah[1], F. van Dijk[2],*

*[1]University of Kent, United Kingdom,*

*[2]Alcatel-Thales III-V Lab, France*

A behavioral, nonlinear radio-over-fiber (RoF) link model considering memory effects with low complexity is presented. Model validation against experimental results is demonstrated, with the effect of the memory length on the fitting accuracy being studied.

**WE4-10**

Equivalent λ/4 Phase Shift to Improve the Single Longitudinal Mode Property of Asymmetric Sampled Bragg Grating Semiconductor Laser

*Y. Zhou, Y. Shi, S. Li, J. Li, X. Chen, Nanjing University, China*

A special sampled Bragg grating (SBG) configuration, which consists of two sections with same length and different effective refractive index, is proposed. Because an equivalent λ/4 phase shift based on reconstruction equivalent chirp (REC) technology is introduced, the asymmetric structure can effectively suppress the lasing in its 0th channel, and then its single longitudinal mode (SLM) property is improved. This proposed method can also be used to fabricate high performance multiwavelength laser array (MLA) with high yield.

**WE4-11**

Mitigation of RF Power Degradation in Dispersion-Based Photonic True Time Delay Systems

*X. Xue, X. Zheng, H. Zhang, B. Zhou, Tsinghua University, China*

Photonic true time delay (TTD) systems based on optical dispersive devices suffer from RF power degradation induced by dispersion. When the dispersion value is 100 ps/nm, the -3 dB bandwidth are limited to 17.6 GHz and 4.4 GHz for systems using lasers and broadband light sources, respectively. A multichannel chirped fiber grating is used to mitigate the RF power degradation in a dispersion-based TTD link for the first time. Both the experimental and theoretical results show that the degradation can be completely eliminated by using this method.

**WE4-15**

Integration of Traveling-Wave Photodetector and Coplanar-Fed Log-Periodic Antenna for Terahertz Generation

*E. Mortazy[1], K. Wu[1], H. Liu[2],*

*[1]Ecole Polytechnique, Canada,*

*[2]National Research Council, Canada*

In this paper, integration of high-power travellingwave photodetector (TWPD) and broadband log-periodic antenna with coplanar waveguide (CPW) fed is proposed and designed for terahertz (THz) generation. In this integrated device, THz signal is generated and radiated by optical signals coming from telecommunication lasers in the range of 1550-nm. Design and analysis of the edge illuminatedPIN-type TWPD up to 1 THz are studied and then phase velocity and loss of the device are compared with the measured results. Also, two bandwidth limitation factors of the TWPD including optical and microwave phase velocity mismatch as well as carrier driftvelocity are discussed. In addition, the structure of conventional log-periodic antenna with coplanar strip (CS) fed is modified and integrated with the CPW output of the TWPD. Design and analysis of this broadband complementary CPW-fed antenna are presented in the paper.

**WE4-16**

High Linearity Photodiode Array with Monolithically Integrated Wilkinson Power Combiner

*Y. Fu, H. Pan, Z. Li, J. C. Campbell, University of Virginia, United States*

We demonstrate the first high linearity four-element photodiode array with monolithically integrated Wilkinson power combiner. A high third-order intercept point (OIP3) of 47 dBm is achieved at 20 GHz and 80 mA photocurrent level.

**WE4-17**

Eliminating Gain Transience in RoF Signals in Dynamic WDM Networks Using a Transient-Suppressed-EDFA with Additional Gain-Stabilization *Y. Awaji, T. Kawanishi, B. J. Puttnam, K. Inagaki, N. Wada, National Institute of Information and Communications Technology, Japan*

We demonstrated that supplementary gain-stabilization in combination with a transient-suppressed-EDFA is quite effective to improve RoF signal impaired by gain transience, introduced by EDFAs, and switched traffic accommodated in WDM networks with RoF channel.

**WE4-18**

Frequency Dependence in RF Gain Resonance by Negative Photocurrent Resistance of Electroabsorption Modulator

*D. Shin, Hanyang University, Republic of Korea*

Negative differential photocurrent resistance of the electroabsorption modulator can enhance the RF gain by inducing ‘resonance’ in the voltage drop across the junction at very high optical power. In this paper, it is examined that the maximum RF gain value enhanced by the negative photocurrent resistance reduces as the modulation frequency is increased. For the modulator capacitance of 1 pF, as the frequency is increased from 0.5 to 1.0 and 2.0 GHz, the maximum RF gain is reduced from 21 to 15 and 9 dB, respectively.

**WE4-19**

Quasi-static Approach to Optimize RF Modulation of Vertical-Cavity Surface-Emitting Lasers

*Z. Bouhamri, Y. Le Guennec, J. Duchamp, G. Maury, B. Cabon, Institut de Microélectronique, Electromagnétisme et Photonique - Laboratoire d’Hyperfréquences et de Caractérisation, France*

This paper presents a new experimental study of vertical-cavity surface-emitting lasers (VCSELs) in a low-cost radio-over-fiber (RoF) application. This study shows the achievable advantages of optimizing VCSELs modulation thanks to a new “quasi-static” laser characterization.

**WE4-20**

Novel Fiber RF Antenna with Coaxial Structure

*X. Shi, S. Zheng, H. Chi, X. Jin, X. Zhang, Zhejiang University, China*

A novel fiber RF antenna technology is proposed. With the coaxial structure, optical waveguide, surface Plasmon waveguide and radio frequency waveguide are combined together. The modulation of the antenna received radio frequency signal on optical carrier is implemented based on the surface plasmon polaritons.

**WE4-21**

4 Channels Subcarrier Multiplexing Optical Link Using an RSOA Modulator

*Zhansheng Liu, Manuel Violas and Mojtaba Sadeghi, Instituto de Telecommunicações, Universidade de Aveiro, 3810-193 Aveiro, Portugal,*  *Guilhem de Valicourt, Alcatel-Thalès III-V labs Route départementale 128, 91767 Palaiseau Cedex, France*

We experimentally demonstrated the performance of a reflective semiconductor optical amplifier (RSOA) used as an external modulator for optical uplink in radio over fiber (RoF) systems. The transmission performances for single and four channels were compared by error vector magnitude (EVM). The experimental results show that a little bit degradation for four channels was obtained when compared to single channel’s one.

**WE4-22**

Design and Realization of an Integrated Optical Frequency Modulation Discriminator for a High Performance Microwave Photonic Link

*D. Marpaung[1], C. Roeloffzen[1], R. Timens[1], A. Leinse[2], M. Hoekman[2], [1]University of Twente, Netherlands, [2]LioniX BV, Netherlands*

This paper reports the design, fabrication and the characterization of an integrated optical filter for an FM discriminator. The filter is based on optical ring resonator structures which are fully reconfigurable using thermo-optical tuning. The desired characteristic, which is a linear slope with zero in a particular region, is demonstrated. This characteristic is needed in a high performance microwave photonics link with increased spurious free dynamic range.

**WE4-23**

Electromagnetic Modeling of SPP Resonance for Low Noise RF Magnitude Modulation of Optical Carriers

*C. Tripon-Canseliet, S. Faci, Electronics and Electromagnetism Laboratory, France*

In this paper, light modulation efficiency using surface plasmon polariton (SPP) excitation in metal/electro-optic material interface is investigated by electromagnetic simulations. The propagation constant of the plasmon wave are controlled by an electric field applied across the electro-optic layer and thus modulates in magnitude the reflected light.

**WE4-24**

60GHz CMOS-APD Optoelectronic Mixers with Optimized Conversion Efficiency

*J. Kim, M. Lee, W. Choi, Yonsei University, Republic of Korea*

A harmonic optoelectronic mixer based on CMOS avalanche photodiode is designed for optimized conversion efficiency in 60-GHz band. By reducing P-N junction capacitance in the avalanche photo-detection region and parasitic n-well/substrate capacitance, the supplied 30-GHz LO is efficiently converted to the 60-GHz harmonic LO signal and generates up-converted RF signals from optical IF. In addition, the silicide layer under the metal contact reduces the parasitic resistance and enhances the mixer conversion efficiency.

**WE4-25**

Calibration Method of Optoelectronic Frequency Response Using Mach-Zehnder Modulator

*K. Inagaki, T. Kawanishi, National Institute of Information and Communications Technology, Japan*

A new calibration method of optoelectronic frequency response for optical-to-electrical (O/E) conversion devices is proposed. The method is based on a conventional heterodyne measurement principle, but utilizes a Mach-Zehnder modulator for generating two-tone lightwaves as standard stimulus signals. Four requirements needed for such signals are given and the techniques to satisfy them are discussed. Trial calibration results are also demonstrated. The proposed method is simpler and easier than the conventional method utilizing a complex two-laser system phase-locked with each other.

**◄ 19:00-20:30 *Reception*****►**

*A Reception open to the conference attendees is organized at Ecole Polytechnique. See directions in p21.*

**Thursday October 7, 2010**

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| **8:00-10:00** *Verdun/Lachine/Lasalle Ballroom*  **Session TH1:** ***Photonic Generation of Microwave and THz Signals***  Session Co-Chairs:  *Alwyn Seeds, University College London, United Kingdom*  *Idelfonso Tafur Monroy, DTU Fotonik, Denmark* |

**TH1-1 8:00-8:30**

Application of THz Sensing to Analysis of Works of Art for Conservation (Invited)

*K. Fukunaga[1], I. Hosako[1], M. Picollo[2], Y. Kohdzuma[3],*

*[1]National Institute of Information and Communications Technology, Japan,*

*[2]Istituto di Fisica Applicata Nello Carrara, Italy,*

*[3]Nara National Research Institute for Cultural Properties, Japan*

Terahertz (THz) spectroscopy and THz imaging techniques are expected to have great potential for the noninvasive analysis of works of art. THz waves can penetrate opaque materials and have the potential to non-destructively create three-dimensional maps of materials by spectroscopic imaging. Satisfactory results using model samples have been obtained by many institutions.

We have succeeded in the first ever noninvasive cross-sectional imaging of a tempera masterpiece by Giotto, which revealed that the artwork was painted by the medieval technique. Moreover, the material mapping of an east Asian mural painting revealed that two materials were used to make the same colour. These examples prove that THz technology is of great practical use for art conservation science.

**TH1-2 8:30-8:45**

A Compact Tunable Coherent Terahertz Source Based on an Hybrid Integrated Optical Phase-lock Loop

*L. Ponnampalam[1], R. J. Steed[1], M. J. Fice[1], C. C. Renaud[1], D. C. Rogers[2], D. G. Moodie[2], G. D. Maxwell[2], I. F. Lealman[2], M. J. Robertson[2], L. Pavlovic[3], L. Naglic[3], M. Vidmar[3], A. J. Seeds[1], [1]University College London, United Kingdom,*

*[2]CIP Technologies Ltd., United Kingdom,*

*[3]University of Ljubljana, Slovenia*

A tunable terahertz source based on the first hybrid integrated optical phase-lock loop is presented. Generated signals have linewidth <1kHz and phase noise <-80dBc/Hz at 10kHz offset. The measured output power at 300GHz was -22dBm.

**TH1-3 8:45-9:00**

Phase Noise Measurements of a Dual-Wavelength Brillouin Fiber Laser (Student Paper Finalist)

*P. T. Callahan, M. C. Gross, M. L. Dennis, Johns Hopkins University Applied Physics Laboratory, United States*

We present phase-noise measurements of microwave signals generated by our dual-wavelength Brillouin fiber laser that approach the performance of commercially available frequency synthesizers. We demonstrate the invariance of the phase-noise spectrum with respect to carrier frequency. Methods for further improving performance are also discussed.

**TH1-4 9:00-9:15**

Phase Stability of Optical Self-Heterodyned Microwave Signals with Nd:YVO4 Laser

*G. Kovacs[1], P. R. Herczfeld[1], T. Berceli[2],*

*[1]Drexel University, United States,*

*[2]Budapest University of Technology and Economics, Hungary*

This paper concerns the phase stability of an optoelectronic QAM-over-Fiber transmitter, which generates complex modulated radio signals directly in the optical domain. The transmitter is based on a single wavelength tunable Nd:YVO4-LiNbO3 electro-optic microchip laser and a simple self-heterodyne fiber optic arrangement without phase stabilization feedback. Using a narrow, 10 kHz linewidth laser and high-pass phase-noise filtering of the time-delay selfheterodyne (TDSH) arrangement provides for excellent microwave signal quality.

**TH1-5 9:15-9:30**

Stabilization of New Generation Solid-state Dual-frequency Laser at 1.5 µm for Optical Distribution of High Purity Microwave Signals

*G. Pillet[1], L. Morvan[1], D. Dolfi[1], J. Schiellein[2], T. Merlet[2],*

*[1]Thales Research and Technology, France,*

*[2]Thales Air Systems S.A., France*

We report on a compact and ruggedized dualfrequency laser at 1.5 μm delivering widely tunable (0-13 GHz) optically-carried microwave signals with a high stability (phase and amplitude noise below -120 dBc/Hz @10 kHz).

**TH1-6 9:30-9:45**

Reconfigurability and Tunability of a Chirped Microwave Photonic Pulse Generator

*M. Bolea, J. Mora, B. Ortega, J. Capmany, Universidad Politécnica de Valencia, Spain*

We propose and demonstrate a microwave chirped pulse generator which is based on the effects of the dispersion slope over the propagation of an optical broadband signal. A complete reconfigurability of the generated signal waveform is easily achieved by a suitable adjustment of the optical source power distribution profile. Moreover, large frequency tuning range and TBWP control of the pulse generated have been also experimentally demonstrated.

**TH1-7 9:45-10:00**

Optical Fiber System for Real-Time Fourier Transformation of Nanosecond-Long Broadband Microwave Waveforms

*Y. Park, J. Azana, Institut National de la Recherche Scientifique (INRS), Canada*

We experimentally achieve microwave dispersions approaching 24ns/GHz (equivalent to the dispersion of ~185,000- km of standard single-mode fiber) using a fiber-optic incoherent processing setup. The scheme is used for real-time Fourier transformation of nanosecond-long microwave waveforms with bandwidths over 20 GHz.

**◄ 10:00-10:30 Coffee Break ►**

***Fontaine GH***

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| **10:30-12:30** *Verdun/Lachine/Lasalle Ballroom*  **Session TH2:** ***Radio over Fiber Techniques***  Session Co-Chairs:  *Christina Lim, Centre for Ultra-Broadband Information Networks, Australia*  *Ed Ackerman, Photonic Systems, Inc., United States* |

**TH2-1 10:30-11:00**

Photonic Time-Stretch: from World’s Fastest Digitizer to the World’s Fastest Camera (Invited)

*B. Jalali, K. Goda, University of California Los Angeles, United States*

We review the progress in time-stretched ADC technology and how this quintessential microwave photonic technology has spun off into ultrafast imaging that is being used for early detection of cancer.

**TH2-2 11:00-11:15**

Bit Resolution Enhanced Digitized RF-over-Fiber Link (Student Paper Finalist)

*Y. Yang, C. Lim, A. Nirmalathas, Centre for Ultra-Broadband Information Networks, Australia*

In this paper, we propose a bit resolution enhancement technique employing oversampling and decimation for digitized radio-over-fiber (DRoF) transport. This technique reduces the overall bit rate for the optical link as well as reduces the hardware requirements on optoelectronics devices in the DRoF link. By using bit resolution enhanced DRoF technique, the overall data rate can be reduced from 4 Gbps to 1.5 Gbps while maintaining similar EVM performance for transporting the same wireless signals.

**TH2-3 11:15-11:30**

Dynamic Capacity Allocation in Radio-over-fiber Links

*H. Yang, Y. Shi, C. Okonkwo, E. Tangdiongga, T. Koonen, COBRA Research Institute, Netherlands*

We present the experimental study on dynamic capacity allocation in radio-over-fiber based on SOA optical routing. One-dimensional dynamics using optical routing as well as two-dimensional dynamics by optical routing and electrical SCM are demonstrated.

**TH2-4 11:30-11:45**

Influence of Optical Filtering on Nonlinearities in SOA-based Slow and Fast Light Microwave Phase Shifter

*P. Berger[1], J. Bourderionnet[1], D. Dolfi[1], S. O Duill[2], G. Eisenstein[2], F. Bretenaker[3], M. Alouini[4],*

*[1]Thales Research & Technology, France,*

*[2]Technion, Israel,*

*[3]Laboratoire Aimé Cotton, France,*

*[4]Institut de Physiques de Rennes, France*

We present an experimental and numerical investigation of the influence of filtering the red-shifted modulation on the linearity of a microwave-photonics link with a CPO-based phase shifter. Different behavior versus SOA bias current are evidenced.

**TH2-5 11:45-12:00**

Phase Modulated Radio-Over-Fiber Link with Linearized Electrooptic Downconversion

*V. R. Pagán[1], B. M. Haas[1], T. E. Murphy[2], [1]Laboratory for Physical Sciences, United States, [2]Institute for Research in Electronics & Applied Physics, United States*

We demonstrate a technique for optically relaying and downconverting microwave signals. The system uses phase modulation in the transmitter and re-modulation and optical filtering in the receiver. Intermodulation distortion is suppressed by adjusting the amplitude of the local oscillator.

**TH2-6 12:00-12:15**

Frequency Interleaved Directly Detected Optical OFDM for Next-Generation Optical Access Networks (Student Paper Finalist)

*L. Mehedy, M. Bakaul, A. Nirmalathas, NICTA Victoria Research Laboratory, Australia*

We theoretically analyze and demonstrate that spectral efficiency of a conventional direct detection based optical OFDM system (DDO-OFDM) can be improved significantly using frequency interleaving of adjacent DDOOFDM channels in future optical access systems.

**TH2-7 12:15-12:30**

Analog Pulse-position Modulation for Free-space Optical Transmission of Microwave Signals

*D. Yap[1], O. M. Efimov[1], M. L. Minden[2], [1]HRL Laboratories, United States, [2]Cold Canyon Associates, United States*

A pulse-position modulated optical link with chirped electro-optic waveguide grating modulator and semiconductor optical amplifier based demodulator has multi-gigahertz bandwidth and spur free dynamic range exceeding 85 dB.Hz4/5.

**◄ Lunch Break 12:30-13:30 ►**

***Le Portage & Terrace***

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| **13:30-15:30** *Verdun/Lachine/Lasalle Ballroom*  **Session TH3:** ***Microwave Signal Generation and Clock Recovery***  Session Co-Chairs:  *Yifei Li, University of Massachusetts Dartmouth, United States, Yannis Le Guennec, INPG, France* |

**TH3-1 13:30-14**:**00**

All-Optical Clock Recovery Using a Quantum-Dash Fabry-Perot Laser (Invited)

*J. C. Cartledge[1], X. Tang[1], M. Yanez[1], A. Shen[2], A. Akrout[2], G. Duan[2], [1]Queen's University, Canada, [2]Alcatel-Thales III-V Laboratory, France*

The performance of a quantum-dash Fabry-Pérot laser is experimentally characterized for 40 Gb/s RZ-DPSK and NRZ-DPSK clock recovery, 40 Gb/s RZ-OOK all-optical 3R regeneration, and 160 Gb/s OTDM sub-harmonic clock recovery.

**TH3-2 14:00-14:15**

Generation of 1.4 THz Clock by Filtering a 42.7 GHz Actively Mode-locked Quantum Dash Fabry-Perot Laser

*A. Lagrost[1], M. CostaeSilva[1], L. Bramerie[1], P. Besnard[1], A. Shen[2], G. Duan[2], [1]UEB CNRS Foton, France, [2]Alcatel-Thales III-V Laboratory, France*

We report on the generation of an optical clock up to 1.4 THz using a spectral filtering from a Quantum Dash Fabry- Perot laser. We show that it is possible to recover high speed clock by converting their rate down to 42.7 GHz.

**TH3-3 14:15-14:30**

A Frequency Shift Keying Transmitter Based on Incoherent Frequency-to-Time Mapping for Free-Space Optical Communications

*H. Mu, H. Xia, J. Yao, University of Ottawa, Canada*

A novel frequency shift keying (FSK) transmitter for free-space optical communications based on incoherent frequency-to-time mapping is proposed and demonstrated. In the proposed system, an incoherent broadband optical source is spectrally shaped by an optical filter that has a sinusoidal frequency response and a tunable free spectral range (FSR), and then modulated at a temporal gate. The temporally gated optical signal is sent to a dispersive device to realize frequency-to-time mapping. By switching the FSR of the optical tunable filter that is controlled by a data sequence, a temporal sinusoidal signal with FSK modulation is thus generated after frequency-to-time mapping. The proposed transmitter is experimentally demonstrated. An FSK signal at a bit rate of 700 Mbits/s is experimentally generated.

**TH3-4 14:30-14:45**

Highly Flat and Stable Optical Frequency Comb Generation Using Intensity and Phase Modulators Employing Quasi-Quadratic Phase Modulation (Student Paper Finalist)

*R. Wu, V. Supradeepa, C. M. Long, D. E. Leaird, A. M. Weiner, Purdue University, United States*

We present an optical frequency comb with, to the best of our knowledge, unprecedented flatness, high stability and a large number of spectral lines, which allows for high quality pulse compression using single mode fiber**.**

**TH3-5 14:45-15:00**

Signal Generation Schemes for Millimeter-wave Radio-over-fiber System based on Heterodyned Unlocked Light Sources and RF Homodyned Receiver (Student Paper Finalist)

*A. Islam[1], M. Bakaul[1], A. Nirmalathas[2], G. E. Town[3], [1]NICTA Victoria Research Laboratory, Australia, [2]University of Melbourne, Australia, [3]Macquarie University, Australia*

Two millimeter-wave radio-over-fiber signal generation schemes are demonstrated by heterodyning unlocked-lasers and homodyning the detected RF-carrier to cancel phase-noise effects at baseband. The proposed schemes avoid phase/frequency locking, high-speed modulators and local-oscillators at CS and BSs*.*

**TH3-6 15:00-15:15**

Broadening of Comb Bandwidth by Multiple Modulation using Feedback Loop in Mach-Zehnder-Modulator-Based Flat Comb Generator

*I. Morohashi[1], T. Sakamoto[1], N. Yamamoto[1], H. Sotobayashi[2], T. Kawanishi[1], I. Hosako[1], [1]National Institute of Information and Communications Technology, Japan, [2]Aoyama-Gakuin University, United States*

We demonstrated broadening of the comb bandwidth by constructing a feedback loop in a Mach-Zehnder modulator based flat comb generator. By multiple-modulation using the feedback loop, a broadband comb signal was generated.

**TH3-7 15:15-15:30**

Opto-Electronic Dual-Loop 50 GHz Oscillator with Wide Tunability and Low Phase Noise

*S. Fedderwitz, A. Stöhr, S. Babiel, V. Rymanov, D. Jäger, Universität Duisburg-Essen, Germany*

We propose and demonstrate a 50 GHz opto-electronic dual-loop oscillator with low phase noise of -95 dBc/Hz at 10 kHz offset from a 50 GHz carrier and a frequency tunability of more than 100 MHz.

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| **16:00-17:30** **Fontaine H**  Session HT4: **Poster Session II – Photonic Generation, Processing and Measurement of Microwave Signals**  Session Co-Chairs:  Arye Rosen, Drexel University, United States  Asher Madjar, M2 Microwaves LLC, United States |

**TH4-1**

Phase Drift Detection in Fiber Ring Lasers using an Optical Delay Line Filter

*R. Herschel, C. G. Schaeffer, Helmut Schmidt University, Germany*

This paper presents an all optical approach for phase drift detection in a phase locked fiber ring laser using a first order optical delay line filter. Its principle is discussed and the performance verified experimentally.

**TH4-2**

40 GHz Photonic Synthesizer Using a Dual-polarization Microlaser

*A. Rolland[1], L. Frein[1], M. Vallet[1], M. Brunel[1], F. Bondu[1], T. Merlet[2], [1]Université de Rennes, France, [2]Thales Air Systems, France*

An optically-carried microwave synthesis working at 40 GHz is demonstrated by using a two-frequency microchip laser inside a digital phase-locked loop. We report relative frequency stability better than 2.5×10−11. Different frequency sweeping formats are programmed.

**TH4-3**

Multi-channel RoF Signal Generation Using a Reciprocating Optical Modulator

*T. Kawanishi[1], T. Sakamoto[1], M. Izutsu[2], [1]National Institute of Information and Communications, Japan, [2]Tokyo Institute of Technology, Japan*

We propose a novel multi-channel radio-on-fiber signal generation technique, using a reciprocating optical modulator. Each component can be individually modulated by a millimeter-wave.

**TH4-4**

Broadband Linearization and its Application to Photonic Time-Stretch ADC

*A. Fard[1], S. Gupta[2], B. Jalali[1], [1]University of California Los Angeles, United States, [2]IIT Bombay, India*

We propose a post-compensation technique to suppress distortions added to a wideband signal by any nonlinear system. Experimentally, broadband linearization of the photonic time-stretch analog-to-digital converter (TSADC) is demonstrated and dynamic range improvement of >10 dB is achieved.

**TH4-5**

Fiber System for DC-Free Microwave Pulse Generation with Full Frequency and Chirp Reconfigurability

*R. Ashrafi, Y. Park, J. Azaña, Institut National de la Recherche Scientifique – Énergie, Matériaux et Télécommunications (INRS-EMT), Canada*

We propose and demonstrate an optical fiber-based scheme for GHz-frequency microwave pulse generation with full frequency and linear chirp reconfigurability. The scheme incorporates a balanced photo detection strategy to achieve dc free microwave pulses with significantly improved noise figures.

**TH4-6**

Instantaneous Frequency Measurement System with Tunable Measurement Range Utilizing Fiber-based Incoherent Microwave Photonic FiltersJ. *Dai, K. Xu, X. Sun, Y. Li, J. Niu, Q. Lv, J. Wu, X. Hong, J. Lin, Beijing University of Posts and Telecommunications, China*

A photonic approach for microwave frequency measurement was proposed based on incoherent microwave photonic filters. The fiber employed is short that performs good real-time response and the implementation owns the stability and tunable measurement range.

**TH4-7**

Laser Synthesizer of the ALMA Telescope: Design and Performance

*S. Ayotte[1], A. Babin[1], P. Poulin[1], M. Poulin[1], A. Jeanneau[1], M. Picard[1], D. Poulin[1], C. Davidson[1], M. Aubé[1], I. Alexandre[1], F. Costin[1], F. Pelletier[1], J. Cliche[1], M. Têtu[1], B. Shillue[2], [1]TeraXion, Canada, [2]National Radio Astronomy Observatory, United States*

The Laser Synthesizer of the Atacama Large Millimeter Array telescope in Chile has been designed and built by TeraXion. We present the design and performance achieved with this instrument.

**TH4-8**

Effect of Laser Decorrelation on the Phase Noise of RF Signals Generated by Optical Mixing of Modulation Sidebands

*M. Poulin, C. Latrasse, M. Morin, S. Ayotte, F. Costin, TeraXion, Canada*

The generation of RF signals by mixing sidebands generated by phase modulation of an optical carrier is discussed. In particular, the effect of source decorrelation on the RF signal phase noise is analyzed. Very low noise RF signals are produced with a proper path length adjustment.

**TH4-9**

Instantaneous Microwave Frequency Measurement with Improved Measurement Range and Resolution Based on a Polarization Modulator

*Z. Li[1], H. Chi[2], X. Zhang[2], J. Yao[1], [1]Microwave Photonics Research Laboratory, Canada, [2]Zhejiang University, China*

We propose a novel photonic approach to implementing instantaneous microwave frequency measurement with improved measurement range and resolution. A polarization modulator (PolM) is employed, which functions with a polarizer as an intensity modulator (IM) in one channel, and with a length of polarization-maintaining fiber as a two-tap photonic microwave bandpass filter (PMBF) in another channel. A linear amplitude comparison function (ACF) that relates the microwave frequency and the microwave powers at the outputs of the two channels is obtained, which ensures an improved frequency measurement range and resolution. An experiment is performed. A measurement range of 0.5-40 GHz with a resolution of ±0.5 GHz under different input microwave power levels is realized.

**TH4-10**

2.5V RF Arbitrary Waveform Generation in the UWB-band with High Power Handling, Highly Linear Photodiodes

*D. E. Leaird[1], A. M. Weiner[1], A. Joshi[2], S. Datta[2], [1]Purdue University, United States, [2]Discovery Semiconductor, Inc., United States*

We demonstrate for the first time 2.5V RF arbitrary waveform generation, at frequencies of interest to ultrawideband (UWB) applications, enabled by high power handling photodiodes. The effect of the photodiodes’ amplitude & phase linearity is also explored.

**TH4-11**

Novel Approach for Microwave Frequency Measurement Based on Optical Power Monitoring

*X. Zou, W. Pan, B. Luo, L. Yan, Southwest Jiaotong University, China*

An approach using a single laser source and two optical comb filters is proposed to performing microwave frequency measurement. In the proposed system, two filters with quadrature comb filtering responses are firstly constructed. The light wave of the laser source is modulated by a microwave signal under the carrier-suppression and single sideband modulation condition. The single sideband of the modulated light wave is simultaneously coupled into the two comb filters, at the outputs of which two optical powers having a quadrature relationship are detected. The microwave frequency to be measured is then estimated from the two quadrature power ratios (i.e., the sine-form and the cosine-form ratios), which are derived from a comparison between the two detected optical powers and a reference optical power. Since the ambiguity can be eliminated by using the two quadrature power ratios, the measurement range is enlarged from half free spectral range (FSR) to full FSR of the comb filtering responses. Thus the proposed approach using a single laser source can provide a larger measurement range, and especially a potential solution to the cascaded or parallel configurations.

**TH4-12**

Multichannel Photonic Temporal Differentiator for Wavelength-Division-Multiplexed Signal Processing Using a Single Fiber Bragg Grating

*M. Li, J. Yao, Microwave Photonics Research Laboratory, Canada*

A multichannel photonic temporal differentiator implemented based on a single multichannel fiber Bragg grating (FBG) for wavelength-division-multiplexed (WDM) signal processing is proposed for the first time to our knowledge. The multichannel FBG is designed using the discrete layer peeling (DLP) algorithm together with the spatial sampling technique. The DLP algorithm is used to design the spectral response of an individual channel, while the spatial sampling is employed to generate a multichannel response. The key feature of the proposed temporal differentiator is that WDM signals at multiple optical wavelengths can be simultaneously processed. Two sampling techniques, the phase-only and the amplitude only sampling, are employed to design a 45-channel and a 3- channel first-order temporal differentiator, respectively. A proof-of-concept experiment is then carried out. A 3-channel first-order differentiator with a bandwidth of 33.75 GHz and a channel spacing of 100 GHz is fabricated. The use of the fabricated 3-channel FBG to perform first-order temporal differentiation of a 13.2-GHz Gaussian-like optical pulse with different optical carrier wavelength is demonstrated.

**TH4-13**

A Photonic Approach to Broadband Microwave Frequency Measurement

*Y. Gu, S. Li, X. Han, X. Luo, J. Hu, P. Wu, M. Zhao, Dalian University of Technology, China*

A novel photonic approach to microwave frequency measurement based on interference effect of microwave signals is proposed. In the simple measurement system, an unknown microwave signal is modulated simultaneously on two optical carriers with different wavelengths through a Mach-Zehnder modulator (MZM). The optical output from the MZM propagates in a dispersive medium, leading to different phase shifts. By scanning the wavelength of one optical carrier, the frequency of the microwave signal can be obtained directly through analyzing the interference intensity of the microwave signal from the photodetector. The validity of the proposed approach is demonstrated experimentally by obtaining the unknown microwave frequency from 1 to 15GHz.

**TH4-14**

Hybrid Optical Beamformers and their Robustness Against Group Delay Ripples Errors

*P. Q. Thai, A. Alphones, Nanyang Technological University, Singapore*

In this paper, the negative effect of group delay ripples on optical beamformers using chirped grating is investigated. A promising solution in the form of hybrid approach for optical beamformer is also presented. Both transmitting and receiving systems using this approach have been demonstrated and examined against the group delay fluctuations.

**TH4-15**

Phase Modulated Coherent Optical OFDM by Phase Restoration of Optical Field

*Z. Wu, H. Wen, X. Zheng, H. Zhang, Y. Guo, State Key Laboratory on Integrated Optoelectronics, Tsinghua National Laboratory for Information Science and Technology, China*

We introduced phase modulator into coherent optical

OFDM system and retrieved the electrical signal by phase restoration of optical field. This system proved to ameliorate some of the disadvantages of conventional coherent optical OFDM systems.

**TH4-16**

12.8-GHz-Bandwidth Frequency Chirp Signal Generation with High-Extinction-Ratio Optical Modulator by Optical Frequency Doubling Technique

*A. Kanno[1], S. Honda[2], H. Sotobayashi[2], T. Kawanishi[1], [1]National Institute of Information and Communications Technology, Japan, [2]Aoyama Gakuin University, Japan*

We successfully demonstrated ultra-wideband frequency chirp signal generation using the DSB-SC modulation technique with pulse duration of 0.5 μs. A high extinction ratio optical modulator helps realize clear signals with no filters.

**TH4-21**

Millimeter-Wave Signal Generation Device Based on Difference Frequency Generation in a LiTaO3 Rectangular Waveguide

*Q. H. Ngo, H. Murata, Y. Okamura, Osaka University, Japan*

We have proposed a new DFG-based signal generation device in a LiTaO3 rectangular waveguide. 15 GHz signal was successfully generated from the fabricated device. In this paper, its application for higher-frequency signal generation is discussed.

**TH4-22**

PMD Impact on True Time Delay Lines in Optical Beamforming Networks Based on Photonic Crystal Fibers

*Y. Li, State Key Laboratory on Integrated Optoelectronics, China*

Polarization-dependent RF delay and amplitude due to PMD in OBFNs are investigated. Delay deviation and amplitude fluctuations in each delay line cause a major degradation of the OBFNs radiation pattern.

**TH4-23**

Photonic Generation of Various Modulation Formats in High Speed UWB over Fiber System

*P. Li, S. Wang, H. Chen, M. Chen, S. Xie, Tsinghua University, China*

We firstly propose one system configuration for generating three kinds of modulation formats used in high-speed ultra-wide-band (UWB) over fiber application. 2Gbps UWB signal transmission over 20km single mode fiber without any compensation is experimentally demonstrated.

**TH4-24**

Highly-Tunable Optoelectronic Microwave Oscillator *G. Pillet, L. Morvan, D. Dolfi, J. Huignard, Thales Research and Technology,, France*

We report on a tunable optoelectronic microwave oscillator stabilized with an optical frequency-locked loop. The microwave signal is generated by heterodyning two crosspolarized optical waves. Its frequency is then locked with an electrooptical frequency discriminator realized with a 100 m long optical fiber delay line. The tunability is obtained by thanks to a birefringent optical phase modulator and a polarizer. We implemented this principle with a dual frequency laser at 1.5 μm and we obtained a chirp over a 1 GHz bandwidth with a 1 kHz precision and an average chirp rate of 500 MHz/ms.

**TH4-17**

Microwave Photonic Filtering Scheme for BB84 Subcarrier Multiplexed Quantum Key Distribution

*J. Mora, A. Ruiz-Alba, W. A. Amaya, V. Garcia-Munoz, A. Martinez, J. Capmany, Universidad Politecnica de Valencia, Spain*

A high performance microwave photonic filter stage is designed and experimentally tested for the implementation of a BB84 Subcarrier Multiplexed Quantum Key Distribution systems SCM-QKD. Results both in the classical and quantum regime show the feasibility of SCM-QKD obtaining visibility values at least 98 % as required for the successful operation of these systems.

**TH4-18**

Novel Architectures for RF Phase Shifters and Optical Delay Lines Based on Slow and Fast Light in SOAs

*P. Berger[1], J. Bourderionnet[1], D. Dolfi[1], G. de Valicourt[2], R. Brenot[2], F. Bretenaker[3], M. Alouini[4], [1]Thales Research & Technology, France, [2]Alcatel-Thales III-V Laboratory, France, [3]Laboratoire Aimé Cotton, France, [4]Institut de Physiques de Rennes, France*

We show that forced coherent population oscillations (CPO) constitute an alternative set-up to conceive a controllable

RF phase shifter, and that wave-mixing in SOAs opens the possibility to conceive optical tunable delay lines beyond the carrier lifetime limit.

**TH4-19**

Arbitrary UWB Waveform Generator Supporting OOK, PPM and PSK Modulation Formats

*M. Abtahi, L. A. Rusch, Université Laval, Canada*

We propose an arbitrary ultra-wideband (UWB) waveform generator that supports various modulation formats. An optimized UWB waveform for monopole antenna with two steps is generated at 1GB/s and modulated using OOK, BPPM, QPPM and PSK modulation formats.

**TH4-20**

Photonic Generation of Millimeter-Waves Using Two Cascaded Electro-Absorption Modulators in Radio-over-Fiber Systems

*L. Wu[1], B. Hraimel[1], X. Zhang[1], M. Mohamed[1], C. Sui[1], K. Wu[2], T. Liu[3], T. Xu[3], Q. Nie[3], [1]Concordia University, Canada, [2]Polygrames Research Group, Ecole Polytechnique , Canada, [3]Ningbo University, China*

We propose a novel photonic millimeter-wave (mmwave) generation technique using two cascaded Electro-Absorption Modulators (EAMs). The two cascaded EAMs are driven by the same low radio frequency (RF) signal but with certain phase shift to suppress odd-order optical sidebands and enhance second order sidebands to obtain frequency doubling and quadrupling. It is shown that RF modulation voltage, phase shift between the two EAMs, and their bias voltages are the keys to be adjusted to efficiently generate high quality mm-wave signal. Experimental proof of concept is also demonstrated.

**TH4-25**

UWB Radio over Perfluorinated GI-POF for Low-Cost In-Building Networks

*J. M. Oliveira, S. Silva, L. M. Pessoa, D. Coelho, H. M. Salgado, J. C. Castro, INESC Porto / Faculdade de Engenharia da Universidade do Porto, Portugal*

This paper presents a performance evaluation of a multiband-orthogonal frequency division multiplexing (MBOFDM) ultra-wideband (UWB) signal transmission over two types of perfluorinated graded-index polymer optical fibers (PFGI-POFs) with diameters of 62.5 μm and 120 μm, using a lowcost optical transceiver. Experimental measurements of packet error rate (PER) and minimum transmitted powers to achieve the maximum allowed PER show that it is possible to have a viable transmission at data rates of 480 Mbps, 200 Mbps and 53.3Mbps over 100, 150 and 200 meters of PF-GI-POF, respectively, preceded by a 1 meter wireless link.

**TH4-26**

Dispersion Induced Fading Frequency Shifting Technology in Radio-over-Fiber Link

*S. Li, X. Zheng, H. Zhang, B. Zhou, Tsinghua University, China*

We theoretically and experimentally demonstrated that the dispersion-induced fading frequency of a Radio-over- Fiber link can be shifted by tuning one of the biases in a single drive dual parallel Mach-Zehnder Modulator.

**TH4-27**

Multiple Low Speed Receiving in 400-Gb/s Multi-band CO-OFDM System

*L. Cheng, H. Wen, X. Zheng, H. Zhang, Y. Guo, B. Zhou, Tsinghua University, China*

We propose a method to reduce the sampling rate of ADCs in optical OFDM systems with pre-distortion and aliasing, and demonstrate it in an experiment of 400-Gb/s multi-band CO-OFDM.

**TH4-28**

On the Noise Performance of Slow Light SOA-based Microwave Photonic Phase Shifters

*J. Lloret, F. Ramos, J. Sancho, I. Gasulla, S. Sales, J. Capmany, Universidad Politécnica de Valencia, Spain*

Herein, numerical and experimental results of the noise properties of slow light microwave photonic phase shifters based on coherent population oscillations in semiconductor optical amplifiers are presented. The main dependencies of the noise spectral density on key parameters accounting for phase shift tunability in this sort of devices are reported. Finally, discussions are given when considering the cascade of several phase shifting stages.

**TH4-29**

Link Quality Based MIMO Antenna Selection in RoF Ubiquitous Antenna

*T. Higashino, T. Yamakami, K. Tsukamoto, S. Komaki, Osaka University, Japan*

Recently, multi-antenna technology is used in almost new radio communication technology such as MIMO (multiple–input multiple-output). The centralized signal processing is one of features of the Radio-on-Fiber distributed antenna application. This paper proposes a link quality based antenna selection in Radio-on-Fiber ubiquitous antenna system. In this system, the channel state information is gathered by the centralized control station (CCS). Proposed scheme selects an antenna element with high SNR for multi-user (MU-) MIMO parallel transmission at outdoor radio propagation channel in the presence of shadowing. Proposed scheme improves BER performance with suppressing SNR gap among received MIMO signals compared with the system without using RoF remote antenna.

**TH4-30**

A Real-Time Radio Frequency Spectrum Analyzer

*B. H. Hamel-Bissell, V. Torres Company, L. R. Chen, McGill University, Canada*

We use OptiSystem to demonstrate a technique to make Real-Time Radio Frequency Spectrum measurements through the combination of cross phase modulation, and the time domain analog to Fraunhofer Diffraction.

**TH4-31**

Numerical Simulation of Multi-Channel Crosstalk in a DWDM Millimeter-Wave-Band Radio-over-Fiber

*K. Nitta[1], H. Toda[1], T. Kuri[2], K. Kitayama[3], [1]Doshisha University, Japan, [2]National Institute of Information and Communications Technology (NICT), Japan, [3]Osaka University, Japan*

In this paper, we numerically investigate the influence of multi interchannel optical crosstalk in a 25-GHz spaced dense-wavelength division multiplexing (DWDM) millimeterwave- band radio-over-fiber (RoF) downlink system. Up to 31 undesired RoF signals were intentionally mixed as the crosstalk with the desired RoF signal. We define the suppression ratio of the crosstalk as the ratio of the mm-wave power of the desired channel to the undesired channels which are estimated from optical spectrum of the detected RoF signal. The simulation results show that the receiver sensitivity degradation due to the crosstalk can be fairly well predicted with the measurable suppression ratio regardless of the total DWDM channel number.

**TH4-32**

Multimode Fiber Transmission of Up-Converted MB-OFDM UWB Employing Optical Frequency Multiplication

*Y. Shi[1], H. Yang[1], C. M. Okonkwo[1], D. Visani[1], G. Tartarini[2], E. Tangdiongga[1], T. Koonen[1], [1]COBRA Research Institute, Netherlands, [2]Dipartimento di Elettronica Informatica e Sistemistica (DEIS), Italy*

We demonstrated an all-optical up-conversion of Multiband OFDM UWB signal employing optical frequency multiplication technique. After transmission over multimode fiber, the performance of the spectral mask and error vector magnitude are compliant with ECMA standard.

**Friday October 8, 2010**

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| **8:00-10:00** *Vurden/Lachine/Lasalle Ballroom*  **Session FR1:** ***Signal Processing for Radar, Communications and Sensor Applications***  Session Co-Chairs:  *Jose Capmany, Universidad Politécnica de Valencia, Valencia, Spain*  *Xiaoke Yi, University of Sydney, Australia* |

**FR1-1 8:00-8:30**

Serial Optical Communications and Ultra-Fast Optical Signal Processing of Tbit/s Data Signals (Invited)

*L. K. Oxenløwe, M. Galili, H. Hu, H. Ji, E. Palushani, J. L. Areal, J. Xu, H. H. Mulvad, A. Clausen, P. Jeppesen, Technical University of Denmark, Denmark*

This paper reviews our recent advances in ultra-highspeed serial optical communications. It describes Tbit/s optical signal processing and various materials allowing for this, as well as network scenarios embracing this technology.

**FR1-2 8:30-8:45**

A Monolithic Programmable Optical Filter for RF-Signal Processing

*E. J. Norberg, R. S. Guzzon, J. S. Parker, L. A. Johansson, L. A. Coldren, University of California Santa Barbara, United States*

A monolithic programmable optical filter suitable for dynamic pre-filtering of wide bandwidth RF signal-bands is presented. Bandpass filters have a passband tunable in bandwidth (3-14GHz) and center frequency (0-40GHz). Cascaded filter sections have stopband rejection exceeding 35dB.

**FR1-3 8:45-9:00**

Orthogonally Polarized Optical Modulation for Microwave Photonics Processing Using Stimulated Brillouin Scattering

*M. Sagues, A. Loayssa, Universidad Publica de Navarra, Spain*

We present a novel technique to generate orthogonally polarized optical single sideband modulated signals. The modulation scheme is based on all optical stimulated Brillouin scattering processing of the optical carrier of an OSSB modulated signal, by means of the polarization state dragging induced by this non-linear effect. This modulation scheme is required in applications such as antenna beamforming or microwave photonics filters. In order to perform a proof-of-concept experiment, the orthogonal modulator is deployed for the implementation of an RF phase-shifter.

**TH4-33**

Optical Distribution of UWB: Low Complexity Pulse Generation Supporting OOK and PSK

*M. Mirshafiei, M. Dastmalchi, M. Abtahi, S. Larochelle, L. A. Rusch, Université Laval, Canada*

Optical transport of UWB signals extends the reach of these power-limited signals. We propose and experimentally demonstrate a simple, low-cost method to generate UWB pulses in optics. Unlike other methods, we use the minimal hardware configuration (source/modulator/photodetector) without requiring RF pulse shaping. A novel combination of data and a sinusoidal signal modulates the intensity of a continuous wave laser to create various UWB pulses. For impulse radio UWB, on-off keying (OOK) or phase-shift-keying is accomplished simply by adjusting the data and the sinusoidal signal amplitudes. Multiband UWB signals with OOK can also be realized by this technique.

**TH4-34**

MAC Layer Performance Evaluation of IEEE 802.16e Radio-over-Fiber Networks

*P. Sklikas, M. Mjeku, N. J. Gomes, University of Kent, United Kingdom*

This paper investigates the performance of the IEEE 802.16e Medium Access Control (MAC) in 802.16e Radio-over- Fiber (RoF) networks, in terms of MAC Data Rate (MDR). It is shown that the accommodation of the extra propagation delay induced by the optical fiber links increases the protocol overheads and reduces the protocol’s efficiency.

**TH4-35**

Development Challenges of Brain Functional Monitoring using Untethered Broadband Frequency Modulated fNIR System

*K. Manseta[1], E. Sultan[1], A. M. Khwaja[1], K. Pourrezaei[1], A. Joshi[2], L. Najafizadeh [3], A. Gandjbakhche[3], A. S. Daryoush[1], [1]Drexel University, United States, [2]Discovery Semiconductors, United States, [3]National Institute of Health, United States*

Spectroscopic measurements of brain matter is considered at near infra-red region, where optical properties are characterized by the refractive index n, absorption coefficient μa, modified scattering coefficient μ's, and anisotropy factor g. Development of a free space optical system over broadband is optimized in terms of improved signal to noise ratio. The data collected by sensor is communicated to a remote processor using an ultra wideband communication system to provide wireless access and full mobility.

**TH4-36**

Instantaneous Frequency Measurement using Optical Coherence and DC Photodetection

*L. A. Bui, A. Mitchell, RMIT University, Australia*

A novel instantaneous frequency measurement using optical coherence and DC detection is presented. A proof of concept demonstration between DC and 40 GHz shows the ability of the proposed technique for broad bandwidth measurements.

**◄ 19:00-21:00 Banquet ►**

***Jardins-Le Castillon  & Terrace***

**FR1-4 9:00-9:15**

Complete Pulse Characterization Based on Temporal Interferometry Using An Unbalanced Temporal Pulse Shaping System (Student Paper Finalist)

*C. Wang, J. Yao, University of Ottawa, Canada*

In this paper, we demonstrate a simple method for the full characterization of an ultrashort optical pulse based on temporal interferometry using an unbalanced temporal pulse shaping (UB-TPS) system. The UB-TPS system is functioning togenerate and stretch two time-delayed replicas of the input pulse.The magnitude and phase information of the input pulse is reconstructed from the recorded temporal interference of the two time-delayed and dispersed pulses based on a Fourier transform algorithm.

**FR1-5 9:15-9:30**

Interrogating Fiber Bragg Grating Sensors Based on Single Bandpass Microwave Photonic Filtering

*M. Comanici[1], L. R. Chen[1], P. Kung[2], [1]McGill University, Canada, [2]QPS Photronics, Canada*

We demonstrate an approach for interrogating fiber

Bragg grating sensors based on single bandpass microwave photonic filtering. The FBG sensor is a twin-grating structure and different temperature sensitivities are obtained at different RF frequencies.

**FR1-6 9:30-10:00**

Terahertz Bandwidth Waveform Spectrum Analysis (Invited)

*M. Pelusi, T. Vo, B. Eggleton, University of Sydney, Australia*

We review the recent demonstrations of the waveform power spectrum (WPS) analysis of high-speed optical signals based on using the ultra-fast Kerr effect in an optical medium. Experiments with highly nonlinear planar waveguides have highlighted the technique’s capability to achieve a multiterahertz measurement bandwidth that far surpasses the limits of electronics by over an order of magnitude. This has enabled the WPS measurement of pulses as short as 260 fs, and for signals with bit-rates as high as 1.28 Tb/s. Furthermore, the broadband WPS of high bit-rate signals has been effectively used to retrieve the signal autocorrelation waveform via an inverse Fourier Transform operation. This in turn has provided a novel approach for characterizing the signal in terms of quantifying distortions such as dispersion, timing jitter and noise. The critical design features of the nonlinear waveguide for application to short pulses and high-speed signals are discussed.

**◄ 10:00-10:30 Coffee Break ►**

***Network café***

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| **10:30-12:30** *Vurden/Lachine/Lasalle Ballroom*  **Session FR2:** ***Microwave Photonics Filtering and Beamforming Techniques***  Session Co-Chairs:  *Nathan Gomes, University of Kent, UK*  *Tetsuya Kawanishi, NCIT, Japan* |

**FR2-1 10:30-11:00**

Recent Advancement of Slow Light in Microwave Photonics Applications (Invited)

*L. Thévenaz, S. Chin, EPFL Swiss Federal Institute of Technology, Switzerland*

A complete realization of an optically tunable true time delay, generated through the combination of a photonic RF phase shifter and a Brillouin slow light element is presented. Illustration through a dynamic microwave photonic filter is demonstrated.

**FR2-2 11:00-11:15**

Elimination of Dispersion-Induced RF Distortion in Spectrum Sliced Microwave Photonic Filters

*X. Yi, L. Li, T. X. Huang, R. A. Minasian, The University of Sydney, Australia*

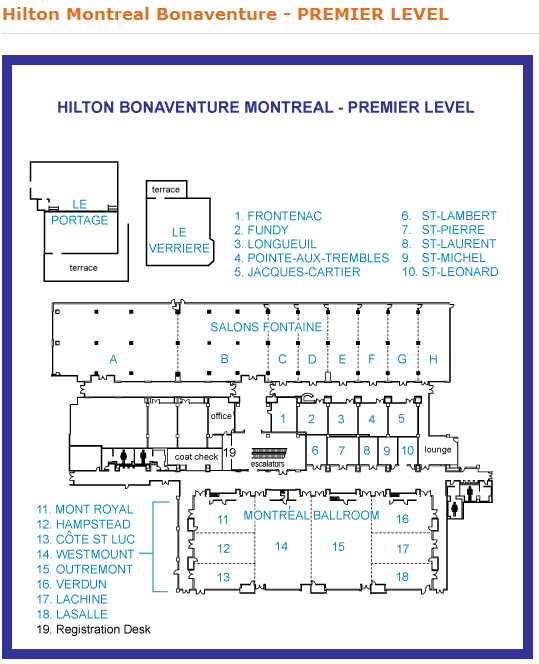
A new technique that can overcome the dominant dispersion-induced RF distortion in spectrum sliced photonic signal processors, is presented. It is based on the concept of the staircase optical delay line. Experimental results demonstrate the elimination of high frequency limitations in both tunable and multi-tap spectrum sliced microwave photonic filters.

**FR2-3 11:15-11:30**

Tunable Radio Frequency Photonic Filter based on Intensity Modulation of Optical Combs (Student Paper Finalist)

*E. Hamidi, R. Wu, V. Supradeepa, C. M. Long, D. E. Leaird, A. M. Weiner, Purdue University, United States*

We demonstrate tunable programmable microwave photonic filters based on optical frequency combs. The utilization of optical comb enables to scale multi tap filters to large number of taps. By using optical line-by-line pulse shaping to program tap weights, we shape the filter’s bandpass. In contrast to our previous work, we demonstrate a much simplified technique based on intensity modulator biased at its minimum transmission which results in double sideband with carrier suppression. We use a programmable optical delay line to uniformly tune the bandpass filter center frequency uniquely across half of the free spectral range. Our new scheme is very simple and easily implementable which provides filters with arbitrary tap weights. As an example we implement a filter with Gaussian apodized tap weights which we tune over 0-5.2 GHz with sidelobe suppression in the range 26-31 dB.



**FR2-4 11:30-11:45**

Variable Spot Scanning Antenna Using an Optically Controlled Beam Forming Network

*H. Matsuzawa[1], T. Akiyama[1], H. Sumiyoshi[1], T. Iguchi[1], M. Nagase[1], Y. Shoji[2], Y. Fujino[2], A. Akaishi[2], R. Suzuki[2],*

*[1]Mitsubishi Electric Corporation, Japan,*

*[2]National Institute of Information and Communications Technology, Japan*

An Optically controlled beam forming network has been developed, which has capacity of steering 2 beams and exciting 64 antenna elements. Using it, beam steering and beam width control is possible in parallel.

**FR2-5 11:45-12:00**

Squint-Free Beamsteering Demonstration using a Photonic Integrated Beamformer Based on Optical Ring Resonators

*M. Burla[1], M. R. Khan[1], D. A. Marpaung[1], C. G. Roeloffzen[1], P. Maat[2], K. Dijkstra[2], A. Leinse[3], M. Hoekman[3], R. Heideman[3],*

*[1]University of Twente, Netherlands,*

*[2]ASTRON, Netherlands,*

*[3]LioniX B.V., Netherlands*

The squint-free beamsteering capability of a photonic integrated beamformer based on continuously tunable optical ring resonators has been demonstrated by showing, for the first time, its generated radiation patterns. The paper demonstrates a beamsteering of 16 degrees over an instantaneous bandwidth of at least 450 MHz.

**FR2-6 12:00-12:15**

Post-deadline Paper 1

**FR2-7 12:15-12:30**

Post-deadline Paper 2

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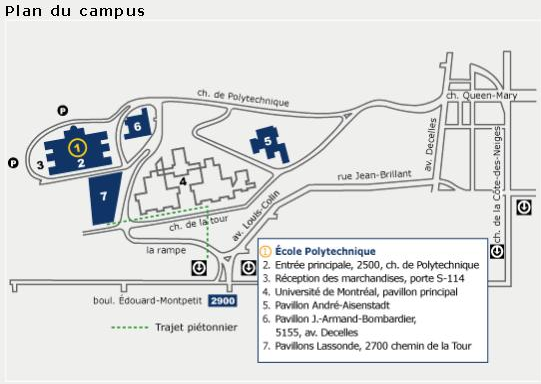
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# Reception Event Information



**SP-6**

Bit Resolution Enhanced Digitized RF-over-Fiber Link

*Yizhuo Yang,*

*University of Melbourne*

**SP-7**

[Frequency Interleaved Directly Detected Optical OFDM for Next-Generation Optical Access Networks](http://www.mtt-tpms.org/symposia_v6/MWP2010/fileuploads/178-KF2A6KEvFlSl-1.pdf)

*Lenin Mehedy,*

*University of Melbourne*

**SP-8**

[Tunable Radio Frequency Photonic Filter based on Intensity Modulation of Optical Combs](http://www.mtt-tpms.org/symposia_v6/MWP2010/fileuploads/116-KELNVDHmJuYx-1.pdf)

*Ehsan Hamidi,*

*Purdue University*

**SP-9**

[Highly Flat and Stable Optical Frequency Comb Generation Using Intensity and Phase Modulators Employing Quasi-Quadratic Phase Modulation](http://www.mtt-tpms.org/symposia_v6/MWP2010/fileuploads/145-KERXkDTfDuGo-1.pdf)

*Rui Wu,*

*Purdue University*

**SP-10**

Signal Generation Schemes for Millimeter-wave Radio-over-fiber System based on Heterodyned Unlocked Light Sources and RF Homodyned Receiver

*A.H.M. Razibul Islam,*

*University of Melbourne*

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**Ecole Polytechnique Campus Map**

**SP-1**

[An Ultra-Compact Integrated Coherent Receiver for High Linearity RF Photonic Links](http://www.mtt-tpms.org/symposia_v6/MWP2010/fileuploads/225-KF3GsvKkCgAd-1.pdf)

*Uppiliappan Krishnamachari,*

*University of California - Santa Barbara*

**SP-2**

Monolithically Integrated Programmable Photonic Microwave Filter with Tunable Inter-Ring Coupling

*Robert S. Guzzon,*

*University of California - Santa Barbara*

SP-3

[*Demonstration of a Linear Ultra-Compact Integrated Coherent Receiver*](http://www.mtt-tpms.org/symposia_v6/MWP2010/fileuploads/173-KF1RmWOfKqVh-1.pdf)

*Anand Ramaswamy,*

*University of California - Santa Barbara*

**SP-4**

Complete Pulse Characterization Based on Temporal Interferometry Using An Unbalanced Temporal Pulse Shaping System

*Chao Wang,*

*University of Ottawa*

**SP-5**

Phase Noise Measurements of a Dual Wavelength Brillouin Fiber Laser

*Patrick T. Callahan,*

*Johns Hopkins University*

**When:** 19:00-20:30,Wednesday October 6, 2010

**Address:**

Atrium Lorne M. Trottier, 3rd floor, Pavillon Lassonde

2500, chemin de Polytechnique  
Montréal (Québec), H3T 1J4, Canada

**Transportation:**

~25 minutes (using Montreal Metro services).

*Departure Metro Station: Bonaventure (Orange Line) – Hilton Hotel*

*Arrival Metro Station: Université-de-Montréal (Blue Line)- Ecole Polytechnique de Montréal*

# Student Paper Competition

**Montréal Botanical Gardens**:  Located in Olympic Park (the site of the 1976 Olympics) the gardens have over 20,000 different plan species in 31 specialized gardens.



**Biodome de Montréal**:  Housed in a former Olympic stadium used in 1976 the Biodome consists of 4 different ecological habitats:  rain forest, polar, marine and forest - where visitors can see the plants and animals native to each ecosystem.



# Montreal Points of Interest

**Place des Arts**:  Montréal's top performance hall features music, drama and much more



**Casino de Montréal:** Definitely for the adults, this casino on the Ile Notre-Dame is the largest in Quebec and one of the ten largest in the world in terms of the amount of gaming equipment.

