

# Advance Program

## Polarization Division Multiplexed Optical Transmission Systems

**Monday, 19 July 2010**

**ALL SESSIONS WILL BE HELD IN MIMOSA 1**

**09.00 - 10.00**

**Session MA1: HIGH CAPACITY PDM-TRANSMISSION I**

**Session Chair:** Sebastien Bigo, *Alcatel-Lucent, Marcoussis Cedex, France*

**MA1.1 09.00 - 09.30 (Invited)**

**Polarization Multiplexed Transmission for Undersea Applications**, A. N. Pilipetskii, *Tyco Telecommunications Laboratories, Eatontown, NJ, USA*

The deployment of 10 Gb/s RZ-DBPSK transponders has led to high capacity transoceanic systems with large repeater spacing. To satisfy future capacity demand high spectral efficiency systems that operate at 40 G and 100 G rates using polarization multiplexing will be required.

**MA1.2 09.30 - 10.00 (Invited)**

**Advanced Modulation Formats and its Application in Optical Label Switching Systems**, T. Miyazaki, *National Institute of Information and Communications Technology, Tokyo, Japan*

Features of multi-level modulation format based on polarization multiplexed pilot-carrier have been introduced. Then the application of various advanced modulation or multiplexing techniques to optical label switched networks are summarized.

**10.00 – 10.30**

**COFFEE BREAK**

**10.30 - 12.00**

**Session MA2: NONLINEARITIES I**

**Session Chair:** Chongjin Xie, *Alcatel-Lucent, Holmdel, NJ, USA*

**MA2.1 10.30 - 11.00 (Invited)**

**Cross-Polarization Modulation in Polarization-Division Multiplexed Transmission Systems**, M. Winter, D. Kroushkov and K. Petermann, *Technical University Berlin, Berlin, Germany*

We introduce the concept of stochastic degrees of freedom to semi-analytically approximate the distribution of nonlinear degree of polarization reduction values observed in numerical simulations as result of cross-polarization modulation.

**MA2.2 11.00 - 11.30 (Invited)**

**XPM Induced Nonlinear Polarization Crosstalk and Mitigation in Optical Dual Polarization Systems**, Z. Tao, L. Liu, L. Li, W. Yan, *Fujitsu Research & Development Center, Beijing, China*, S.-I. Oda, T. Hoshida and J. C. Rasmussen, *Fujitsu Laboratories Ltd., Kawasaki, Japan*

An analytical model of XPM induced nonlinear polarization crosstalk is proposed and experimentally verified. Based on this model, various polarization crosstalk mitigation methods including coherent receiver DSP and transmission system design are reviewed.

**MA2.3 11.30 - 12.00 (Invited)**

**SPM Compensation of No-Guard-Interval PDM Co-OFDM for Optical Transport Network**, E. Yamazaki, *NTT Corporation, Yokosuka, Kanagawa, Japan*

Experimental performance evaluation of SPM compensation and its application in optical transport network is introduced. Experimental results show transmission distances of 100Gbps signal reaches 16,340 and 12,015 km in single-channel and 10-ch WDM conditions respectively.

**12.00 – 13.30**

**LUNCH BREAK**

13.30 - 15.00

**Session MA3: PMD AND PDL EFFECTS**

**Session Chair:** Magnus Karlsson, *Chalmers University of Technology, Göteborg, Sweden*

**MA3.1 13.30 - 14.00 (Invited)**

**Polarization Tracker and PMD Compensator for 100Gb/s Direct-Detect RZ-DQPSK PDM Systems**, Y. Shen, X. Liu, S. Zhong, J. Veselka, P. Kim, J. Ferment and H. P. Sardesai, *Ciena Corporation, Linthicum, MD, USA*

The design of a polarization tracker and a PMDC for direct-detect RZ-DQPSK PDM systems is reviewed. The error signals are analyzed and their application spaces are identified. Experimental results are demonstrated to verify the designs.

**MA3.2 14.00 - 14.15**

**MLSE-Based PMD Mitigation in On-Off Keying Polarization Multiplex Direct Detection Systems**, D. Goelz, F. Pohl, and P. Meissner, *Technical University Darmstadt, Darmstadt, Germany*

MLSE has proven to work as PMD mitigator in standard direct detection transmission systems. We present and discuss a new approach which enables MLSE detection to work in an optical on-off keying direct detection polarization multiplex systems.

**MA3.3 14.15 - 14.45 (Invited)**

**The Role of Polarization Dependent Loss in Polarization Multiplexed Transmission**, M. Shtaf and A. Andrusier, *Tel Aviv University, Tel-Aviv, Israel*

A formalism for describing the effect of polarization dependent loss on coherent polarization multiplexed systems is described. Performance penalties are assessed in a variety of cases, emphasizing fundamental limits.

**MA3.4 14.45 - 15.00**

**Measurements of the Polarization Dependent Loss of Multiple WDM Channels in an Installed, Long-Haul Terrestrial Link**, L. E. Nelson, M. Birk, P. Magill, *AT&T, Middletown, NJ, USA*, A. Schex and L. Rapp, *Nokia Siemens Networks, Munich, Germany*

We report continuous, multiple-day measurements of polarization-dependent loss (PDL) of several C-band channels on an installed 1800-km terrestrial link. The PDL varies on a time-scale of hours, and the PDL of adjacent channels often track.

15.00 – 15.30

COFFEE BREAK

15.30 - 17.00

**Session MA4: ALGORITHMS AND DSP**

**Session Chair:** Peter J. Winzer, *Alcatel-Lucent, Holmdel, NJ, USA*

**MA4.1 15.30 - 16.00 (Invited)**

**Techniques and Algorithms in Coherent Detection**, H. Nakashima, T. Tanimura, C. Ohshima, S.-I. Oda, *Fujitsu Laboratories Ltd., Kawasaki, Japan*, Z. Tao, *Fujitsu Research & Development Center, Beijing, China*, T. Hoshida, *Fujitsu Laboratories Ltd., Kawasaki, Japan* and J. C. Rasmussen, *Fujitsu Laboratories Ltd., Kawasaki, Japan*

The influence of the electrical skew of intradyne front-end and laser phase noise for digital coherent detection with chromatic dispersion compensation are shown and thus to propose practical algorithm and technique of coherent receiver.

**MA4.2 16.00 - 16.30 (Invited)**

**DSP Techniques for 16-QAM Coherent Optical Systems**, I. Fatadin and S. J. Savory, *University College London, London, UK*

Coherent detection, a field revived by advances in DSP, has recently received renewed interest in optical communication systems with spectrally efficient modulation formats. We review DSP techniques for 16-QAM which is one of the most promising modulation formats for next-generation communication systems.

**MA4.3 16.30 - 17.00 (Invited)**

**Implementation Challenges of 100G Coherent Transponders**, Y. K. Lize, C. Malouin, E. Ibragimov, B. Zhang and T. Schmidt, *Opnext, Inc., Los Gatos, CA, USA*

We present challenges associated with taking a proof of concept to a commercial transponder suitable for field deployment requires design decisions to optimize performance, margin, power consumption and manufacturing cost.

17.30 – 18.30

Welcome Reception

**Tuesday, 20 July 2010**

**09.00 - 10.00**

**Session TUA1: TUTORIAL SESSION**

**Session Chair:** Mark Shtaif, *Tel Aviv University, Tel-Aviv, Israel*

**TuA1.1 09.00 - 10.00 (Tutorial)**

**The Onsager Relations and Birefringence in Optical Fibers**, C. R. Menyuk, *University of Maryland Baltimore County, Baltimore, MD, USA*

The physical reason that the intrinsic (material) birefringence of optical fibers is linear is traced to the Onsager relations and their extension to waveguides. Limitations due to extrinsic (waveguide) effects are discussed. In the absence of helicity, the Onsager relations still hold.

**10.00 – 10.30**

**COFFEE BREAK**

**10.30 - 12.00**

**Session TUA2: LONG-HAUL TRANSMISSION**

**Session Chair:** Lynn E. Nelson, *AT&T, Middletown, NJ, USA*

**TuA2.1 10.30 - 11.00 (Invited)**

**PDM-QPSK Transmission Experiments Over Transoceanic Distance**, S. Bigo, *Alcatel-Lucent, Marcoussis Cedex, France*

We compare two transmission experiments using polarization-multiplexed coherent channels at 100Gbit/s and discuss the impact of fiber arrangements and amplifier scheme on the propagation distance.

**TuA2.2 11.00 - 11.30 (Invited)**

**Long-Haul Optical Transmission using 100-Gb/s Polarization-Multiplexed QPSK Modulation**, M. Alfiad, *Eindhoven University of Technology, Eindhoven, The Netherlands*, D. van den Borne, T. Wuth, *Nokia Siemens Networks, Munich, Germany*, M. Kuschnerov, *Federal Armed Forces University, Neubiberg, Germany*, M. B. Astruc, P. Sillard, *Draka Comteq, Marcoussis, France* and H. de Waardt, *Eindhoven University of Technology, Eindhoven, The Netherlands*

We study the tolerance of 111-Gb/s POLMUX-RZ-DQPSK to nonlinear impairments and show the advantage of using non-dispersion managed links and large effective area fibers in ultra long-haul transmission.

**TuA2.3 11.30 - 12.00 (Invited)**

**Experimental Studies of Polarization-Multiplexed Optical OFDM Superchannel Transport**, R. Dischler, *Alcatel-Lucent, Stuttgart, Germany*

Different schemes for generation of OFDM superchannels beyond 100 Gb/s capacity are introduced and recent experimental results of the transmission of OFDM superchannels over field deployed fibers are reported.

**12.00 – 13.30**

**LUNCH BREAK**

**13.30 - 15.00**

**Session TUA3: NONLINEARITIES II**

**Session Chair:** Zhenning Tao, *Fujitsu Research & Development Center, Beijing, Beijing, China*

**TuA3.1 13.30 - 14.00 (Invited)**

**Impact of Fiber Nonlinearity on Tb/s PDM-OFDM Transmission**, X. Liu and S. Chandrasekhar, *Alcatel-Lucent, Holmdel, NJ, USA*

We discuss the impact of fiber nonlinearity on a recently-demonstrated 1.2-Tb/s polarization-division-multiplexed (PDM) coherent optical OFDM superchannel in long-haul transmission over 7200 km of ultra-large-area fiber. The improvement obtained by nonlinearity compensation is also discussed.

**TuA3.2 14.00 - 14.15**

**Inter-Channel Nonlinearities in Hybrid OOK and Coherent PDM-QPSK Transmission Systems with Dispersion Management**, C. Xie, *Alcatel-Lucent, Holmdel, NJ, USA*

We show that in dispersion-managed systems with co-propagating 10-Gb/s OOK and coherent PDM-QPSK channels, it is the inter-channel XPM from the 10-Gb/s OOK channels that significantly degrades the performance of the coherent PDM-QPSK channels.

**TuA3.3 14.15 - 14.45 (Invited)**

**Nonlinear Limits in Single- and Dual-Polarization Transmission**, A. Bononi, P. Serena and N. Rossi, *University of Parma, Parma, Italy*

The dominant nonlinear effects in single- and dual-polarization multichannel dispersion-managed optical transmissions are reviewed through an exhaustive simulation study of the nonlinear threshold with nonlinearity separation.

**TuA3.4 14.45 - 15.00**

**Dispersion Map Optimization of Single and Dual-Pol QPSK in the Presence of Adjacent Aggressor Channels**, A. Stark, Y.-T. Hsueh, T. F. Detwiler, *Georgia Institute of Technology, Atlanta, GA, USA*, M. Filer, S. Tibuleac, *ADVA Optical Networking, Norcross, GA, USA*, A. McCurdy, *OFS Laboratories, Atlanta, GA, USA*, R. L. Lingle, *OFS Laboratories, Norcross, GA, USA*, G.-K. Chang and S. E. Ralph, *Georgia Institute of Technology, Atlanta, GA, USA*

Optimum and robust dispersion maps are experimentally determined from a range of pre- and inline-dispersion compensation for a 56 Gb/s RZ-DQPSK hybrid linear link, and then investigated using 112 Gb/s Dual-Pol QPSK with coherent detection.

## Wednesday, 21 July 2010

**09.00 - 10.00**

**Session WA1: DIGITAL SIGNAL PROCESSING RECEIVERS**

**Session Chair:** Curtis R. Menyuk, *University of Maryland Baltimore County, Baltimore, MD, USA*

**WA1.1 09.00 - 09.30 (Invited)**

**MAP Detection for Linear and Nonlinear ISI Mitigation in Long-Haul Coherent Detection Systems**, Y. Cai, *Tyco Telecommunications Laboratories, Eatontown, NJ, USA*

We investigate the performance of a maximum-a-posteriori-probability (MAP) detection scheme for linear and nonlinear inter-symbol interference compensation. We show that MAP detection can help to increase spectral efficiency and improve nonlinearity tolerance in longhaul transmissions.

**WA1.2 09.30 - 10.00 (Invited)**

**Demultiplexing via a Dual-Polarization Coherent Receiver**, L. E. Nelson and S. L. Woodward, *AT&T, Middletown, NJ, USA*

We review recent studies of the detection of a 46Gb/s dual-polarization quadrature phase-shift-keyed (DP-QPSK) channel using a single-ended intradyne receiver when multiple channels are incident, and we explain the scaling of the coincident channel interference.

**10.00 – 10.30**

**COFFEE BREAK**

**10.30 - 12.00**

**Session WA2: HIGH CAPACITY PDM-TRANSMISSION II**

**Session Chair:** Alexei N. Pilipetskii, *Tyco Telecommunications Laboratories, Eatontown, NJ, USA*

**WA2.1 10.30 - 11.00 (Invited)**

**High Speed Coherent Detection at High Spectral Efficiencies**, P. J. Winzer and A. H. Gnauck, *Alcatel-Lucent, Holmdel, NJ, USA*

ABSTRACT NOT AVAILABLE

**WA2.2 11.00 - 11.15**

**Offset QPSK for 112 Gb/s Coherent Optical Links**, T. F. Detwiler, A. Stark, Y.-T. Hsueh, S. M. Searcy, *Georgia Institute of Technology, Atlanta, GA, USA*, R. L. Lingle, *OFS Laboratories, Norcross, GA, USA*, B. Basch, *Verizon, Waltham, MA, USA*, G.-K. Chang and S. E. Ralph, *Georgia Institute of Technology, Atlanta, GA, USA*

Offset QPSK (OQPSK) is a linear modulation format possessing low fluctuations in intensity. This feature may be exploited for avoiding nonlinear refraction effects in optical fiber. Here we examine the use of OQPSK for coherent optical links, present implementation strategies and preliminary results.

**WA2.3 11.15 - 11.45 (Invited)**

**High Capacity Coherent PDM-WDM Transmission System Demonstrations**, X. Zhou, *AT&T, Middletown, NJ, USA* and J. Yu, *ZTE USA Inc., Iselin, NJ, USA*

We review and discuss two ultra-high-capacity optical transmission experiments recently demonstrated by using PDM-M-QAM modulation formats and DSP enabled intradyne detection techniques. They are 33.9Tb/s over 580km at SE=4.2b/s/Hz and 64Tb/s over 320km at SE=8b/s/Hz.

**WA2.4 11.45 - 12.00**

**Modified Progressive Edge-Growth Algorithm based LDPC Coded-Modulation for 400 Gb/s Optical Transport**, I. B. Djordjevic, *University of Arizona, Tucson, AZ, USA*

We propose a polarization-multiplexed iterative polar quantization (IPQ)-based LDPC-coded-modulation scheme suitable for beyond 400 Gb/s serial optical transmission. The component LDPC codes are designed using modified progressive edge-growth (MPEG) algorithm. The proposed scheme employs 32-IPQ-based-modulation.

**END OF PROGRAM**