Vetenskapsrådet

Application

2015-03-31

2015-04968 **Pang, Xiaodan** **NT-13**

Information about applicant

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Project site: Netlab

Information about application

Call name: Forskningsbidrag Stora utlysningen 2015 (Naturvetenskap och teknikvetenskap)

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Focus: Fri

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Project title (english): Digital signal processing from radio domain conquers signal impairments in hybrid photonic-wireless systems

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Keywords: phase noise, digital signal processing, fiber-wireless convergence, advanced modulations, semiconductor laser

Funds applied for

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Descriptive data

Project info

Project title (Swedish)*

Digital signalbehandling i radiodomänen reducerar signaldistorsionen i radio-optiska hybridsystem

Project title (English)*

Digital signal processing from radio domain conquers signal impairments in hybrid photonic-wireless systems

Abstract (English)*

Seamless convergence of fiber-optic and wireless access networks enabled by highly spectral efficient photonic-wireless transmission systems is currently under intensive investigation. The fundamental limiting factors of such systems need to be studied in detail to provide optimal performance. In particular, as the photonic-wireless systems are subject to heavy influence of (laser) phase noise, it is imperative to choose system designs that minimize the phase noise influence. Moreover, the correlations of advanced modulation formats (nPSK, nQAM, OFDM, etc.), phase noise and other transmission impairments in both optical fibers and wireless channel need to be in detail investigated for an effective mitigation. Therefore, we plan a 4-year research project to perform a detailed investigation on these issues by combining the research efforts from both the optical and the radio communications. The project is planned to start from January 2016 and will be carried out at the Networking and Transmission Laboratory (Netlab), Acreo Swedish ICT AB in collaboration with the Optics and Photonics Group (OFO) and the Radio Systems Laboratory (RS-LAB) at KTH. The main methodology of the project is to adopt the advanced digital signal processing (DSP) algorithms from radio domain to the photonic-wireless system to recover distorted signal impaired during transmission. This stands upon a thorough understanding of both the fundamental properties of the impairments and the DSP algorithms. The project is believed to have significant impacts on both scientific research and industrial technology, in terms of providing guidelines for next generation hybrid fiber-wireless networks and extending the scientific insights of the laser noise influence in photonic-wireless transmission and detection. Besides the scientific significance, the project can contribute to the educational strategy in optics and photonics within the institute. It will also bring closer collaboration between the researchers from radio communications and optical communications.

Popular scientific description (Swedish)*

Under de senaste åren, drivet av det ökande antalet internetanvändare samt nya applikationer som HDTV, realtidsvideokonferenser, interaktiv online-spel, och e-hälsovårdstjänster på distans har efterfrågan på datakommunikation har ökat med en enorm hastighet. Ur användarnas synvinkel visar ett exponentiellt växande antal bärbara datorer, smartphones och surfplattor, att trådlösa anslutningar är att föredra framför fasta anslutningar, förutsatt att de har samma anslutningshastighet. I detta projekt kommer vi att genomföra forskning gentemot en lösning som möjliggör att ansluta optiska fibrer som jobbar med bithastigheter över 10 Gbit/s eller till och med över 100 Gbit/s till trådlösa anslutningar. För att uppnå detta mål krävs ett enkelt sätt att transparent omvandla optiska höghastighetssignaler till trådlöst format i stället för att med dagens metoder använda elektroniska komponenter som normalt har lägre bithastighet än fiberoptiken. Detta innebär att de trådlösa signalerna ursprungligen genereras med en laser i stället för med elektriska oscillatorer. Lasrar med acceptabelt pris har normalt mycket lägre stabilitet i frekvens/våglängd jämfört med elektriska oscillatorer. Denna instabilitet orsakar en distorsion av signalen då den överförs genom de optiska fibrerna och i luften. Detta försämrar den mottagna signalkvaliteten och kan orsaka fel i den mottagna signalen. Vår forskning är därför inriktad på att kombinera digital signalbehandlingserfarenhet från radiovärlden med den grundläggande förståelsen av de fysikaliska egenskaperna hos lasrar från den optiska forskarvärlden och sammanfoga dessa till en lösning för att förbättra kvaliteten på höghastighetssignaler som överförs genom hybridnät som består av fiber och trådlösa länkar.

Project period

Number of project years*

4

Calculated project time*

2016-01-01 - 2019-12-31

Classifications

Select a minimum of one and a maximum of three SCB-codes in order of priority.

Select the SCB-code in three levels and then click the lower plus-button to save your selection.

SCB-codes*

2. Teknik > 202. Elektroteknik och elektronik > 20205. Signalbehandling

2. Teknik > 202. Elektroteknik och elektronik > 20204. Telekommunikation

1. Naturvetenskap > 103. Fysik > 10302. Atom- och molekylfysik och optik

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Enter a minimum of three, and up to five, short keywords that describe your project.

Keyword 1*

phase noise

Keyword 2*

digital signal processing

Keyword 3*

fiber-wireless convergence

Keyword 4

advanced modulations

Keyword 5

semiconductor laser

Research plan

Ethical considerations

Specify any ethical issues that the project (or equivalent) raises, and describe how they will be addressed in your research. Also indicate the specific considerations that might be relevant to your application.

Reporting of ethical considerations*

This research does not raise any ethical issues

The project includes handling of personal data

No

The project includes animal experiments

No

Account of experiments on humans

No

Research plan

Digital signal processing from radio domain conquers signal impairments in hybrid photonic-wireless systems

1. Purpose and aims

In this research project we will study the **fundamental limiting factors** and possibility to improve the performance of highly spectral efficient photonic-wireless transmissions. Recent achievements in generation of high frequency radio signals with photonic technologies have developed a strong interest to photonic-wireless systems, which are currently under investigation for seamless convergence of fiber-optic and wireless links. Our research is based on a combined novel approach adapted from another scientific branch and focused at a major bottleneck of the systems with high spectral efficiency. A list of relevant literature is enclosed [1-36].

In the hybrid photonic-wireless systems the data are modulated onto an optical carrier and heterodyne mixing with a local oscillator (LO) laser at a fast-respond photodetector to generate radio signal at a high carrier frequency. Comparing to conversional wireless system where signals are generated by electrical oscillators and mixers, the photonic up-converted signals are not limited by the bandwidth of many electronic components. However, the signals suffer relatively higher phase noise that is directly translated from the laser sources. In addition, high spectral efficiency is also desired in such systems due to the limited spectral resources in both optical and radio domain. Therefore, **advanced multilevel modulations** for data transmission are required to boost the system capacity within the limited bandwidth. However, such advanced modulation formats are very sensitive to the signal quality: even minor imperfections in the coherence performance of the transmitter and LO laser sources become a strong limiting factor. Recently, digital signal processing- (DSP-) assisted optical coherent detection techniques have been intensively studied and can be utilized to mitigate various signal distortions, including signal phase noise. In principle, the commonly employed carrier phase estimation algorithms are sensitive to modulation formats and laser linewidths.

The main objective of the proposed research is to in detail investigate influence of the transmission impairments, particularly phase noise, in order to identify most efficient algorithms to minimize their impact. This is a crucial step to simplify an overall system layout including the selection of semiconductor lasers (in transmitters and LO) that will potentially avoid the need for an elaborated laser design, e.g. external cavity lasers (ECLs). This is important since the photonic-wireless systems will target densely populated high capacity access links, where cost and power consumption are important factors to consider. From another perspective, in the wireless domain, phase noise estimation and compensation have been extensively studied. Very efficient phase estimation techniques such as iterative turbo like estimation, statistical Bayesian estimation methods, etc. …, are implemented in the wireless systems. Therefore, it is worth to investigate the possibility of compensating laser phase noise influence by suitable *DSP techniques which are adopted from the equivalent radio frequency counterparts*. Thus, it is extremely important to understand the fundamentals of how the phase noise statistics are modified by the use of DSP in the radio world and which further considerations are needed to *transfer the radio principles into the optical transmission world*. In hybrid photonic-wireless systems the fiber dispersion manifests itself as a frequency dependent phenomenon in addition to being multipath dependent in radio. Impairments mitigation is a nontrivial fundamental task since the phase noise in the photonic-wireless systems with high signal constellations is not a simple additive noise with Gaussian statistics. Thus, all parts of the DSP (including filtering) need thorough communication theoretical consideration, where advanced filtering of statistical processes is a key feature to understand and deal with the system design.

2. Survey of the field

Data rates in both fiber-optic and wireless communications have been increasing exponentially over recent decades and no sign of the end of this trend is revealed based on the technology roadmap studies [1]. It is highly desirable that the future wireless links will possess the same capacity with fiber-optics to realize seamless convergence between fiber and wireless networks. Tremendous efforts have been put into increasing the capacity of photonic-wireless links and over 10 Gbit/s or even 100 Gbit/s transmissions have been demonstrated during the very recent years with various advanced modulations at different carrier frequency bands [2-7]. Among these works we have contributed with evaluations of feasibility and performance for employing different advanced modulation formats in the photonic-wireless systems, including quaternary phase shift keying (QPSK) [5], 16-ary quadrature amplitude modulation (QAM) [6] and orthogonal frequency division multiplexing (OFDM) [7]. Narrow linewidth ECLs are employed in these works to minimize the impact of phase noise. Further research efforts are essential to relax this requirement in selection of semiconductor lasers with relatively high phase noise for both the transmitter and LO. A phase noise insensitive optical heterodyne detection technique was proposed for the radio-over-fiber system however requiring an additional coherent detector for phase extraction [12]. It is worth to investigate solutions that can maintain the hardware configuration and mitigation only taking place in the digital domain. For this purpose, the experiences from the coherent optical transmissions could be consulted and adopted since similar issues have been intensively investigated.

Digital coherent optical systems - based upon heterodyne detection and mainly analog signal processing in the optical receiver - was extensively studied from 1985-95. Our contribution to these studies gave especially new insight into the fundamental influence of phase noise and provided ways of eliminating such an impact by proper use of optical and electronic filtering [9]. Currently, a number of advanced modulation formats are under intensive investigation, such as n-ary PSK (nPSK), n-ary QAM (nQAM), and optical OFDM with nPSK or nQAM modulation on each multiplexed optical frequency. An important feature of the new generation of high-constellation optical coherent systems is that, in principle, all system impairments (in both optical and electronic domains) can be potentially mitigated using electronic DSP techniques in the optical transmitter and/or receiver. DSP can be used to eliminate the influence of chromatic dispersion in the optical fiber [10], to extract a reference carrier phase [11,12] and to - at least in principle - eliminate the influence of fiber nonlinearities [13,14]. All systems use semiconductor lasers as transmitters and local oscillators. These lasers have phase noise which influences the system behavior in causing bit-error-ratio (BER) floors [15-17]. For systems to be practical, such BER floors have to be below the order of 10^{-3} to 10^{-4}. The purpose of the current study is to investigate ways of achieving this performance either by choosing specific modulation/demodulation methods for a given amount of the laser phase noise or by eliminating the phase noise influence fully or partly.

In the radio domain, due to the reduction in cost of computation and communication in the last decades, the use of wireless communication has reached an unprecedented level. Along with high data rate demand, people also expect increased mobility and high quality of service for these new multi-media applications. In order to meet these stringent requirements, reliable receiver design is needed. These receivers need to deal with the stochastic nature of the wireless medium and interference. Phase noise or phase jitter is a key element in wireless communications systems as it can significantly affect the performance of systems especially when OFDM with bandwidth efficient, high order signal constellations is employed. Phase noise occurs due to the Doppler effects of wireless links and it is present in the up-conversion

and down-conversion oscillators. OFDM is very sensitive to any synchronization errors and any phase impairment can introduce inter-carrier interference. To deal with the effects of phase noise, several algorithms have been designed to make the system more robust to RF imperfections and Doppler effects [18-23]. Adaptive algorithms that combine equalization and phase corrections have been proposed and studied [24]. Our contribution to these studies has provided a possible solution for reducing the effects of phase noise on OFDM signals [25, 26]. The problem of phase noise has been extensively studied in the wireless area and some mature solutions do exist. The most promising are the ones that combine data detection and phase estimation with soft exchange of information [27-29]. It will be interesting to see how we can adapt these techniques to the optical communications world especially multilevel, high capacity photonic-wireless systems as its implementation is still in its infant stage.

Our initial research of the influence of laser phase noise on the system performance (see references [9-10, 15-17] provides the basis for comprehensive and fundamental (in statistical sense) understanding of the effect for different system implementations taking advantage of the novel approaches provided by the development of DSP technology. We have at Acreo (including collaborative projects with KTH) unique background in this field, have educated one PhD and have four PhD projects and two Post Doc projects ongoing and expect to generate new research knowledge of essential importance. The expected results can be published and used directly by the leading industry (involved in the branch) in order to improve significantly the design of such high capacity systems and must probably make the use of semiconductor lasers more relaxed than nowadays.

3. Project description

In this project the fundamental limiting factors of highly spectral efficient photonic-wireless transmissions will be detailed investigated and significant performance improvement can be expected. The key issue induced by the transparent convergence of the optical and wireless links is that the signal impairments from both optical domain and wireless domain are correlated, including laser phase noise, fiber nonlinearities and wireless channel fading, etc. Meanwhile the DSP-based mitigation methods are sensitive to modulation formats, particularly for compensating phase noise. Therefore, we plan for a 4-year project and expect to involve 1 full-time PhD student to address these issues with analytical studies, system simulations and experimental validations. The project consists of 4 work packages (WP):

- WP 1 Phase noise analysis for signals with photonic heterodyne generation;
- WP 2 Fiber-optic and wireless transmission link modeling;
- WP 3 Identify and test methodologies from the radio world to compensate for the phase noise influence;
- WP 4 Performance evaluation by system simulations and experiments.

WP 1: Phase noise analysis for signals with photonic heterodyne generation

The focus in this work package is placed on the phase noise analysis and characterization of the photonic-wireless signals with different modulations (nPSK, nQAM, OFDM) generated by photonic heterodyne process. This study will create fundamental new knowledge regarding the influence of phase noise. Since phase noise originates in the signal field phase, and not as a simple additive Gaussian noise term, the detailed account for the influence of phase noise (including for instance effects of filtering) is a complex analysis task. This task will - as a starting point - take into account previous knowledge derived regarding filtering of statistical processes and make this approach applicable in the DSP context of today's system implementations [9, Chapter 3] and [30-32]. This WP will be mainly performed by Dr. Xiaodan Pang (Netlab, ACREO) and the new employed PhD student under the guidance

of Prof. Gunnar Jacobsen (Netlab, ACREO), who has extensive experience in laser phase noise studies for optical communications and will be a participating researcher in this project. In addition, Dr. Richard Schatz from KTH FMI could be consulted for his research experience in phase noise analysis of semiconductor lasers.

WP 2 Fiber-optic and wireless transmission link modeling

In the photonic-wireless system, transmitted signals can be impaired in the optical fibers, during the photonic up-conversion as well as in the wireless channel. In optical fibers, chromatic dispersion and the nonlinear Kerr effect can distort the signal and need to be compensated at the DSP-based receiver. The photonic up-conversion is a nonlinear mixing process occurring in a high-speed photodetector, which ideally though should transparently convert the signal to the radio carrier frequency band. However, signal distortion can be induced by the third-order inter-modulation distortion products (IMD3) of the photodetector and succeeding amplifiers, depending on their spurious-free dynamic range (SFDR). In the wireless channel, certain transmission issues such as frequency selective fading, Doppler shift and so on will also need to be considered. These impairments may correlate with the laser phase noise and impose possible requirements on the DSP algorithms selection for carrier recovery and mitigation. Therefore, this work package will focus on modeling the key blocks of the photonic-wireless system taking the main transmission issues into consideration. Dr. Xiaodan Pang, Dr. Oskars Ozolins (Netlab, ACREO) and Assoc. Prof. Sergei Popov (OFO, KTH) will contribute their expertise to the optical fiber and components modeling and Assoc. Prof. S. Ben Slimane (COS RS-LAB, KTH) will provide guidance for the wireless channel model.

WP 3 Identify and test methodologies from the radio world to compensate for the phase noise influence

There are a number of phase noise compensation methods in the radio world that have been heavily investigated. Based on the analytical studies in WP 1, in this work package different methods that may result in full or partial elimination of the phase noise impact and be realized with different schemes will be explored and identified. The system model developed in WP 2 will also be used for investigation of phase noise tolerance for this work package. A list of possible methods that are interested for investigation is presented as follow:

- Soft-decision directed phase noise estimation algorithm in combination with iterative block decision feedback equalization [18].
- Non-iterative phase mitigation using a known cyclic prefix in single carrier frequency domain equalization. This is pilot type phase estimation [19].
- Bayesian approach for the estimation of phase noise in SC-FDE schemes. This consists of determining the a posteriori pdf of the phase state conditioned on all measurement data, which provides the possibility to compute an optimal estimate with respect to MMSE or any other criterion [20, 24]
- Iterative decision-directed phase noise estimation. An iterative feed-forward decision-directed phase noise estimation based on the estimating the phase by some linear process [21].
- Phase noise tracking based on pilot symbols followed by soft decision directed mode [22]. Decision-directed phase noise compensation for millimeter-wave single carrier systems with iterative frequency-domain equalization [23].
- Joint data detection and phase noise estimation based on iterative turbo equalization/decoding with soft exchange of information [27-29]. These methods have shown good results in wireless communications and it requires proper adaptation to optical communications.

In this WP the PhD student will perform literature study and transfer knowledge from radio world to optical communications. Assoc. Prof. S. Ben Slimane will provide research guidance.

WP 4 Performance evaluation by system simulations and experiments

In WP 4 the results obtained from the first 3 work packages will be combined to carry out performance evaluation in the system level. Comparison of different carrier extraction techniques, including both commonly used algorithms in coherent optical systems (DDPLL, Viterbi-Viterbi, blind phase search, etc.) and the adapted techniques from the radio domain will be performed. System simulation with MATLAB/VPItransmissionMaker^{TM} and detailed theoretical BER formulation will also be implemented for nPSK/nQAM/OFDM receivers in order to incorporate radio based DSP principles for carrier phase noise elimination/reduction. In addition, link characterization and performance evaluation will be experimentally performed in the ACREO/KTH Kista High Speed Transmission Lab. Dr. Xiaodan Pang and Dr. Oskars Ozolins will supervise the PhD student for the simulations and laboratory works.

This project is planned to start from Jan. 2016 and last for four years. The work plan is as follow:

	Activities	***1st year***				***2nd year***				***3rd year***				***4th year***			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	***WP 1***																
	Study and understanding of filtering of statistical processes	■	■														
	Phase noise analysis for different modulation formats in photonic heterodyne process	■	■	■	■												
2	***WP 2***																
	Study of fiber dispersion and nonlinearities, system SFDR analysis and wireless channel properties			■	■	■	■										
	Photonic-wireless system modeling					■	■	■	■								
3	***WP 3***																
	Study of phase noise compensation methods in radio systems							■	■	■	■						
	Develop DSP algorithms and adapt to photonic-wireless signals									■	■	■	■				
4	***WP 4***																
	Performance comparison of phase noise estimation methods with system simulations and experimental validation									■	■	■	■	■	■		
5	***Dissemination***					■	■	■	■	■	■	■	■	■	■	■	■
6	***Thesis writing and dissertation***													■	■	■	■

4. Significance

The proposed initiative is believed to have a significant impact on the research community. First of all it will provide guidelines and engineering rules for practical implementation of next generation hybrid fiber-wireless networks, in terms of selection of laser sources, modulation formats and DSP routines for the transceivers. In addition to its significance for technology advances and society impacts, it is furthermore a fundamental study of the laser phase noise influence that requires detailed understanding of fundamental statistical processes when influencing multilevel transmitters and receivers. This asks for detailed work around filtering and other analog operations on statistical processes - see [9, 30-32]. Moreover, this project provides new insight into theoretical understanding, simulation and experimental investigation of laser phase noise and its system impact in different photonic-wireless configurations. As the state of the art, the study regarding practical implementation of seamless photonic-wireless communication systems is still in its infant stage. Many different configurations have been initially studied in simulations and experiments up to a total system capacity in the order of 10-400 Gbit/s. The systems have been implemented in n-level PSK or QAM formats and/or using OFDM technologies for effective frequency multiplexing. When going beyond simple amplitude shift-keying (ASK) modulation, it is obvious that laser phase

noise becomes a crucial factor to incorporate in the system as a limiting feature. As discussed in Sec. 3, different strategies need deep exploration in order to find ways of minimizing the laser phase noise influence on the system performance. The understanding of the phase noise influence (see [21-26]) is currently premature and much more detailed study is needed in order to:

- Differentiate the system implementation (among nPSK, nQAM, OFDM) with respect to the phase noise influence;
- Identify and test methodologies from the radio world to compensate for the phase noise influence.

Besides the scientific significance, the project can successfully contribute to the educational strategy in optics and photonics within the institute, such as the teaching of optics, photonics, and quantum electronics courses, and to the international Master's Programs on Photonics run in KTH Kista. It provides an excellent experimental base and experience for MSc. projects, unique national competence, advanced topics for M.Sc. projects.

- Parts of the project related to numerous physical problems create a number of topical MSc projects in this multidisciplinary area. Also, the various tasks of the research will contribute to the improvement of our different educational programs.
- Modeling techniques used and developed in the project can be applied during exercise sessions for certain university courses. Particular tasks can be considered by students to instructively demonstrate a considerable difference between classical and near-field approach in the fundamentals of optics, electromagnetic theory, and their applications.
- Bringing the modeling details to the students' attention can assist their understanding of the formulation and clear definition of complex physical tasks, especially involving interdisciplinary problems.
- The results of the theoretical investigations and modeling can be employed to develop advanced courses in senior and graduate levels in applied subjects, e.g., on Information and Communication aspects, including fundamentals and applications.

The project will contribute to more collaboration between the radio communication systems group (COS RS-LAB), the Optics/Photonics division (OFO), both at KTH, and the Networking and Transmission Laboratory (Netlab) at ACREO, which creates excellent possibilities for scientific/academic interaction in research complex problems.

5. Preliminary results

The ability of the research group of Acreo Netlab as well as COS and OFO, KTH-Kista to execute the proposed program is based on the demonstrated experience, both experimental and theoretical, in the various subjects of the investigation. Recent results and achievements have been published in internationally recognized journals in the fields related e.g. to coherent system design and fundamental understanding of noise influence in the systems, diffractive optics, dye lasers, polarization of light, and fiber optics. Part of the research regarding high capacity coherent optical communication systems prior to this application has been performed in parallel with the proposed research has been ongoing within the EU ITN projects GRIFFON (Green Initiative for Future Optical Networks) and ICONE (Allied Initiative for Training and Education in Coherent Optical Networks).

The main applicant, Dr. Xiaodan Pang is currently a postdoctoral researcher at ACREO Netlab. He received his PhD degree in optical communication from Technical University of Denmark in 2013. Dr. Pang has been working on fiber-optic communications and fiber-wireless convergence since his PhD research, when he coordinated the first demonstration of a 100 Gbit/s photonic-wireless link in 2011 [6]. Since then he has been researching on

various relevant issues, including employing distributed-feedback laser with electro-absorption modulator (DFB-EAM) and vertical cavity surface emitting laser (VCSEL) for ASK photonic-wireless transmissions [33], nonlinearity and phase noise tolerant OFDM radio-over-fiber link [34], modulation optimization for laser phase noise tolerance [35] and carrier recovery algorithms for non-white laser frequency noise compensation [36]. Through these analytical, simulation and experimental works the applicant has established solid prerequisite knowledge and skills for carrying out the proposed research project.

The co-applicant, Dr. Oskars Ozolins is a postdoctoral researcher at ACREO Netlab. He received his Doctor of Engineering Science in 2013 from the Riga technical University. His main research experiences are in the area of coherent systems with advanced multilevel modulation formats, subsystems for all-optical signal processing, optical filtering and modulation format conversion, nonlinear optical effects in the optical fibers and highly non-linear fibers for optical signal regeneration and amplification. Dr. Ozolins contributes to the supervision of the system simulations and experiments within the project.

The co-applicant, Prof. Gunnar Jacobsen has acquired professional experience in the optical and photonics fields during his work in well-established research institutions. His research interests have been within the area of coherent optical communication systems since 1981 and he has published more than 250 peer-reviewed papers and one monograph in this field over the years. Prof. Jacobsen will provide insights and supervision on understanding of the laser phase noise properties in this project.

The co-applicant, Assoc. Prof. Ben Slimane is with KTH COS RS-LAB. He has been involved in teaching modern radio communications and carrying out research projects. His research interest is in the area of wireless communications with special emphasis on digital communication techniques for fading channels, channel coding, access methods, cooperative communications, energy efficient wireless communications, and cognitive radio communications. Assoc. Prof. Slimane will contribute to the explanations of DSP algorithms principles in the wireless systems within the project.

The co-applicant, Assoc. Prof. Sergei Popov is with KTH OFO. His most recent research interests and accomplishments are concentrated around diffractive and micro-optics, polarization properties of fiber optical amplifiers, as well as the fundamentals of near-field optical phenomena and their applications in nonlinear fiber optics (including micro-structured fibers). Earlier, Assoc. Prof. Popov was actively involved in the research related to solid-state (polymer-based) dye lasers, theoretical and technical optics, as well as the coherence and polarization properties of light. He coordinates the project execution and is being involved in both modeling and experimental realization of the various tasks.

6. Equipment

Acreo/KTH Kista High Speed Transmission Lab is available for the project tasks. The lab is equipped with state-of-the-art high speed transmission setup, including 60 Gbaud bit pattern generator, 50 GSa/s arbitrary waveform generator, 32 Gbaud 4-bit digital to analog converter (DAC), RF signal generator up to 67 GHz, 44 GHz coherent receiver and digital storage oscilloscope up to 80 GSa/s, a 100 GHz DFB-EAM and a 100 GHz photodetector, high power ECLs, optical and electrical spectrum analyzers (https://www.acreo.se/groups/kista-high-speed-transmission-lab).

7. Independent line of research

For successful realization of the proposal, there exists excellent background in terms of well recognized competence. Significant competence support is provided by ongoing EU projects GRIFFON and ICONE within the Marie-Curie program. Currently there are 4 PhD students

and 2 Post Docs are working within the projects, addressing different issues in high-speed coherent optical communication systems, including modulation formats optimization, advanced DSP algorithm design, noise suppression of distributed Raman amplification schemes, forward error correction coding and so on. There will be clear synergies between the proposed research project and the ongoing projects without overlap. If funded, the PhD student could benefit from the team's research experience on coherent optical transmissions.

8. National and international collaboration

In addition to the close collaboration between Acreo and KTH, the applicants have established extensive international collaborations, such as Aston University, UK (Prof. Sergei K. Turitsyn), Technical University of Denmark (Assoc. Prof. Darko Zibar and Prof. Leif K. Oxenløwe), Huazhong University of Science & Technology, China (Assoc. Prof. Lei Deng and Prof. Deming Liu), VPIphotonics, Germany (Dr. Hadrien Louchet). Potential research collaborations are envisaged within the proposed project in the form of joint experimental activities.

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17. E. Vanin and G. Jacobsen, "Analytical estimation of laser phase noise induced BER floor in coherent receiver with digital signal processing," *Opt. Exp.,* vol.18, pp.4246-4259, 2010.
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19. M. Asim et al., "Mitigation of phase noise in single carrier frequency domain equalization systems," *IEEE WCNC* 2012.
20. P. Pedrosa et al., "Bayesian approach for the estimation of phase noise in sc-fde schemes," *IEEE GlobecOM'11*, pp. 1-5, 2012.
21. J. Bhatti et al., "Performance analysis of iterative decision-directed phase noise estimation," Future Network Mobile Summit, 2010.
22. L. Benvenuti et al., "Code-aware carrier phase noise compensation on turbo-coded spectrally- efficient high-order modulations," *8-th Intern. Workshop on Signal Processing for Space Commun.*, pp.177–184, September 2003.
23. S. Suyama et al., "Decision-directed phase noise compensation for millimeter-wave single carrier systems with iterative frequency-domain equalization," *Int. J. Microw. Wirel. T,* pp.399-408, 2010.
24. P. Pedrosa et al., "Joint equalization and phase noise tracking for doubly selective channels," *21st ICCCN 2012,* pp.1-7, Aug. 2012.
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29. A. Barbieri et al., "Joint iterative detection and decoding in the presence of phase noise and frequency offset," *IEEE Trans. Communications,* vol.55, pp.171- 179, 2007.
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Interdisciplinarity

My application is interdisciplinary

☐

An interdisciplinary research project is defined in this call for proposals as a project that can not be completed without knowledge, methods, terminology, data and researchers from more than one of the Swedish Research Councils subject areas; Medicine and health, Natural and engineering sciences, Humanities and social sciences and Educational sciences. If your research project is interdisciplinary according to this definition, you indicate and explain this here.

Click here for more information

Scientific report

Scientific report/Account for scientific activities of previous project

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Budget and research resources

Project staff

Describe the staff that will be working in the project and the salary that is applied for in the project budget. Enter the full amount, not in thousands SEK.

Participating researchers that accept an invitation to participate in the application will be displayed automatically under Dedicated time for this project. Note that it will take a few minutes before the information is updated, and that it might be necessary for the project leader to close and reopen the form.

Dedicated time for this project

	Role in the project	Name	Percent of full time
1	Applicant	Xiaodan Pang	20
2	Participating researcher	Oskars Ozolins	20
3	PhD Student	PhD student	100
4	Participating researcher	Gunnar Jacobsen	10
5	Participating researcher	Slimane Ben Slimane	10
6	Participating researcher	Sergei Popov	10
7	Participating researcher	Sergei Popov	

Salaries including social fees

	Role in the project	Name	Percent of salary	2016	2017	2018	2019	Total
1	Applicant	Xiaodan Pang	20	170,000	174,000	178,000	183,000	705,000
2	Participating researcher	Oskars Ozolins	20	170,000	174,000	178,000	183,000	705,000
3	PhD Student	PhD student	100	546,000	601,000	661,000	727,000	2,535,000
4	Participating researcher	Gunnar Jacobsen	0	0	0	0	0	0
5	Participating researcher	Slimane Ben Slimane	0	0	0	0	0	0
6	Participating researcher	Sergei Popov	0	0	0	0	0	0
	Total			886,000	949,000	1,017,000	1,093,000	3,945,000

Other costs

Describe the other project costs for which you apply from the Swedish Research Council. Enter the full amount, not in thousands SEK.

Premises

Type of premises	2016	2017	2018	2019

Running Costs

	Running Cost	Description	2016	2017	2018	2019	Total
1	Conference, Workshops	Attend conferences and workshops	60,000	60,000	60,000	60,000	240,000
2	Publications	Publication fees	30,000	30,000	30,000	30,000	120,000
3	PC & Licenses	PC and licenses for simulation platforms	60,000	40,000	40,000	40,000	180,000
	Total		150,000	130,000	130,000	130,000	540,000

Depreciation costs

	Depreciation cost	Description	2016	2017	2018	2019	Total
1	Computer	depreciation cost for computer	5,000	5,000	5,000	5,000	20,000
	Total		5,000	5,000	5,000	5,000	20,000

Total project cost

Below you can see a summary of the costs in your budget, which are the costs that you apply for from the Swedish Research Council. Indirect costs are entered separately into the table.

Under Other costs you can enter which costs, aside from the ones you apply for from the Swedish Research Council, that the project includes. Add the full amounts, not in thousands of SEK.

The subtotal plus indirect costs are the total per year that you apply for.

Total budget

Specified costs	2016	2017	2018	2019	Total, applied	Other costs	Total cost
Salaries including social fees	886,000	949,000	1,017,000	1,093,000	3,945,000	0	3,945,000
Running costs	150,000	130,000	130,000	130,000	540,000	0	540,000
Depreciation costs	5,000	5,000	5,000	5,000	20,000	0	20,000
Premises					0	0	0
Subtotal	1,041,000	1,084,000	1,152,000	1,228,000	4,505,000	0	4,505,000
Indirect costs	408,400	433,600	460,800	491,200	1,794,000	0	1,794,000
Total project cost	1,449,400	1,517,600	1,612,800	1,719,200	6,299,000	0	6,299,000

Explanation of the proposed budget

Briefly justify each proposed cost in the stated budget.

Explanation of the proposed budget*

The requested funding will mainly cover the PhD student as well as a minor part of salaries for the project leader and co-applicants. The main part of the co-applicants' financing is planned from other sources. All salaries are subject to social security costs and local Acreo and KTH overheads. Regular annual increase is also included in the calculation.

Inside VR project financing is 20% of the salary for Dr. Xiaodan Pang, 20% of the salary for Dr. Oskars Ozolins, and 100% of 1 PhD student salaries over 4 years. Outside VR project financing is 80% of Dr. Xiaodan Pangs salary, 80% of Dr. Oskars Ozolins salary, 100% of Gunnar Jacobsens salary, 100% of Ben Slimanes salary and 100% of Sergei Popovs salary.

VR financing includes beyond salaries 1 high performance PC to be used by the PhD student (20 kSEK) and 4 years licenses for the use of VPItransmissionMaker^{TM} simulation software (40 kSEK/year) in total 180 kSEK. Travels and publication costs for PhD students are also included at an estimated 360 kSEK over 4 years. Travel costs are aimed at participation each year for one or two persons in the leading conferences and workshops in the research area. Such participation is essential in order to be able to closely follow and take direct advantage of the newest research results in the field. The recent trend in introducing of charges for publications in leading professional journals also leads to additional costs in the table.

Depreciation of the computer cost is also considered in the budget.

Other funding

Describe your other project funding for the project period (applied for or granted) aside from that which you apply for from the Swedish Research Council. Write the whole sum, not thousands of SEK.

Other funding for this project

Funder	Applicant/project leader	Type of grant	Reg no or equiv.	2016	2017	2018	2019

CV

Curriculum Vitae of Dr. Xiaodan Pang

Name, Surname: Xiaodan, Pang

E-mail: xiaodan.pang@acreo.se

Tel: +46 70 53 97 161

1. **Higher education qualification(s):**

   Sep. 2008: B.Sc. Optical Information Science and Technology, Shandong University, China

   Jul. 2010: M.Sc. Photonics Engineering, Royal Institute of Technology (Kungliga Tekniska Högskolan), Stockholm, Sweden

2. **Doctoral degree:**

   Sep. 2013: Ph.D. Photonics Engineering, Metro-Access & Short Range System Group, DTU Fotonik, Technical University of Denmark, Kgs. Lyngby, Denmark

   (Thesis entitled "High-Capacity Hybrid Optical Fiber-Wireless Communication Links in Access Networks", supervised by Prof. Idelfonso Tafur Monroy)

3. **Postdoctoral positions:**

   Oct. 2013 - present: Networking and Transmission Laboratory, ACREO Swedish ICT AB

4. **Qualification required for appointments as a docent:**

   Not applicable.

5. **Current position:**

   Oct. 2013 - present: Networking and Transmission Laboratory, ACREO Swedish ICT AB

   Post Doc Researcher working on digital signal processing-based impairments mitigation for high-speed fiber-optic communications. Specific research areas include laser phase noise mitigation; distributed Raman amplified transmission links, etc. The work is performed within the EU Marie Curie project GRIFFON.

6. **Previous positions and periods of appointment:**

   - **Feb. 2012 - Aug. 2012:** Valencia Nanophotonics Technology Center (VNTC), Polytechnic University of Valencia, Valencia, Spain

     Visiting researcher working on DWDM fiber-wireless networks in the V-band

   - **Jun. 2009 - Mar. 2010:** ERICSSON TELECOM AB (Stockholm, Sweden)

     Thesis project worker, thesis title "Investigation of Techniques for Long-reach Passive Optical Networks" (Supervised by: Mr. Einar In De Betou, Dr. Stefan Dahlfort)

   - **Sep. 2007 - Jun. 2008:** Communication Networks Group (ComNets), University of Bremen, Germany

     Visiting researcher on Investigation of open Wireless Networking Simulator (openWNS)

7. **Interruption in research:**

   Not applicable.

8. **Supervision:**

   Not applicable

9. Other merits of relevance to the application:

- 1 tutorial lecture on "Carrier Phase Estimation for Coherent high order QAM Systems", Annual Intensive PhD Training Course in frame of the Marie-Curie project ICONE, Fraunhofer Heinrich-Hertz-Institute, Berlin, Jan. 2015.
- Active member of IEEE, OSA, SPIE
- Active reviewer for IEEE/OSA Journal of Lightwave Technology, OSA Optics Express, OSA Optics Letters, IEEE Journal of Quantum Electronics, IEEE Photonics Technology Letters, IEEE/OSA Journal of Optical Communications and Networking, Elsevier Optical Fiber Technology, Elsevier Optical Communications and more.
- TPC member for:
    - 2nd International Conference on Digital Signal Processing (MIC-SigProc2014), Dubai, UAE, Oct. 3-5, 2014
    - 1st International Conference on Wireless Communications and Computing Networks (WCCN2015), Beijing, Jul. 20-21, 2015
- Supervision of 1 M.Sc. thesis projects, KTH/Acreo, 2014
- Winner of the 1st prize in the Best Student Paper Competition, Asia Communications and Photonics Conference (ACP), Shanghai, China, Nov. 2011.
- Research travel grants from Otto Mønsteds Fond, Oticon Fonden

Curriculum Vitae of Dr. Oskars Ozolins

Name, Surname: Oskars Ozolins

E-mail: oskars.ozolins@acreo.se

1. **Higher education qualification(s):**
   - **2007** Bachelor of Science and Electrical Engineering (B.Sc.Ing.), Riga Technical University (RTU), Latvia
   - **2009** Master of Engineering Sciences in Telecommunications with distinction (M.Sc.Ing.), RTU, Latvia
2. **Doctoral degree:**
   - **2013** Doctor of Engineering Science (telecommunications) (Dr.Sc.Ing), RTU, Latvia, "Analysis and Realization of Wavelength Filters in Fiber Optic Transmission Systems", Professor Ģirts Ivanovs
3. **Postdoctoral positions:**
   - **Jun. 2014 - Jul. 2014** Visiting researcher, FOTON Laboratory (CNRS UMR 6082), ENSSAT, University of Rennes 1
   - **Feb. 2015 - present** ACREO Swedish ICT AB
4. **Qualification required for appointments as a docent:**
   Not applicable.
5. **Current position:**
   Feb. 2015 - present Postdoctoral researcher ACREO Swedish ICT AB
   The research (100%) is focused on long distance transmission of coherent systems with advanced multi-level modulation formats. The work is performed within the EU Marie Curie project ICONE.
6. **Previous positions and periods of appointment:**
   - **Jan. 2008 – Nov. 2008** Network monitoring center engineer. Tele2, Latvia
   - **Jan. 2008 – Jun. 2014** Lecturer, RTU, Latvia
   - **Sep. 2007 – Jan. 2015** Researcher, RTU, Latvia
   - **Jan. 2012 – Apr. 2012** Visiting researcher, DTU FOTONIK High-Speed Optical Communications Group (under supervision of Professor Christophe Peucheret)
   - **May 2014 – Jan. 2015** Assistant Professor (in Latvian „**DOCENTS**"), elected on 09.05.2014 for 6 years.
   - **Jun. 2014 – Jul. 2014** Visiting researcher, FOTON Laboratory (CNRS UMR 6082), ENSSAT, University of Rennes 1
7. **Interruption in research:**
   Not applicable.
8. **Supervision:** Not applicable for PhD students and Postdoctoral. Has supervised 11 Master level students (Related to field of **Fiber Optics**).
9. **Other merits of relevance to the application:**
   a. **Participation in organizations:**
      - **Latvian Council of Science expert** till 02.09.2016. Committee: Engineering and computer science, Scientific direction: **Electronics and Telecommunications**.

- Student representative in RTU Faculty of Electronics and Telecommunications council 2011-2013.
- Institute of Electrical and Electronics Engineers (IEEE) member since 2008.
- Latvian Optical Society (LOS) member since 2009.
- European Optical Society (EOS) member since 2009.
- Optical Society of America (OSA) member since 2009.
- Student Corporation „Fraternitas Lettica" member since 2005.

b. Designated reviewer at international journals:

- Fiber and Integrated Optics, Publisher: Taylor and Francis Inc. Publication type: Journals. ISSN: 01468030, 10964681, h index: 18.
- International Journal of Physical Sciences, Publisher: Academic Journals Inc. Publication type: Journals. ISSN: 19921950, h index: 13.
- Chinese Optics Letters, Publisher: Science Press. Publication type: Journals. ISSN: 16717694, h index: 19.
- Optics Express, Publisher: The Optical Society. Publication type: Journals. ISSN: 10944087, H Index: 143

c. Reviewer at international conferences (TPC member):

- Third International Symposium on Intelligent Informatics (ISI'14), Sep. 24-27, 2014 in Greater Noida, India.
- 2014 IEEE Symposium on Computer Applications & Industrial Electronics (ISCAIE 2014), Apr. 7 - 8 2014 in Penang, Malaysia.
- 2013 IEEE Symposium on Wireless Technology & Applications (ISWTA), Sep. 22 - 25, 2013, Pullman Kuching Hotel, Malaysia.
- 2014 IEEE Symposium on Wireless Technology & Applications (ISWTA), Sep. 28 -Oct. 1, 2014 Kota Kinabalu, Sabah, Malaysia.
- Global Summit on Computer & Information Technology (GSCIT' 2014), 14th to 16th Jun. 2014, Sousse, Tunisia.

d. Awards and scholarships:

- Iras un Petera Bolsaitis scholarship from Vitolu fund 2005 -2007,
- „2nd level of Samsung Electronics Annual Grant" for bachelor studies 2007,
- „Werner von Siemens Excellence Award" for master thesis „ Investigation of Bragg grating applications in perspective WDM systems" 2009,
- Erasmus practice scholarship in 2012 to visit DTU Fotonik,
- ESF scholarship for PhD studies 2009.-2013.,
- „Werner von Siemens Excellence Award" for doctoral thesis „ Analysis and Realization of Wavelength Filters in Fibre Optic Transmission Systems" 2014.
- Erasmus practice scholarship in 2014 to visit CNRS UMR FOTON.

Short Curriculum Vitae of Prof. Gunnar Jacobsen

Name, Surname: Gunnar Jacobsen

E-mail: gunnar.jacobsen@acreo.se

1. Higher education qualification(s):

1976 MSc, Engineering (Electro Physics), Danish Technical University, Denmark

2. Doctoral degree:

1981 PhD, Optical Communications, DTU, Supervisor Professor Palle Jeppesen

1988 Dr. technices, Coherent Optical Communication Systems, DTU. (This was the only Dr. techn. degree which was awarded in 1988.), Supervisor Professor Palle Jeppesen

3. Postdoctoral positions: Not applicable.

4. Qualification required for appointments as a docent: Not applicable.

5. Current position:

2008 - Present	Adjunct Professor in Optical Communication Systems, KTH
Apr. 2006 - present	Deputy Department Head, Chief Technical Officer Broadband, Photonics Department, ACREO Swedish ICT AB

6. Previous positions and periods of appointment:

Aug. 2002 - Dec. 2006	Operative Manager and Project Manager VINNOVA Broadband Communication Project, ACREO AB
Aug. 2005 - Apr. 2006	Acting Department Head, Photonics Department, ACREO AB
Aug. 2002 - Aug. 2005	Manager Optical Systems and Networks Lab, ACREO AB
Jun. 2000 - Jul. 2002	Manager Optical Networks Research Labs (ONER), ERICSSON Telecom AB, Stockholm
Jun. 1998 - Jul. 2000	Deputy Manager Optical Networks Research Labs (ONER), ERICSSON Telecom AB, Stockholm
Jan. 1997 - Jun. 1998	Expert, optical communication systems, Transport Network Application Lab (TNAL), ERICSSON Telecom AB, Stockholm
1990 - 1996	Adjunct Professor in Physics, Aarhus University
Jan. 1996 - Dec. 1996	Section Chief for the section: Access Networks under the department: Network Technologies in Tele Danmark R&D
1990 - 1996	Project Supervisor, Tele Danmark Research
1993	three months guest professor at the STARLAB, Department of Electrical Engineering, Stanford University, California, USA
1987	three months consultant at Bellcore, Navesink Research and Engineering Center, New Jersey, USA
1990	three months consultant at NEC Opto Electronics Research Laboratories, Miyazakidai, Japan
1984 - 1990	Staff Member, Tele Denmark Research.

1981 – 1984	Associate Professor, Electromagnetics Institute, DTU
1977 - 1981	PhD Student, Electromagnetics Institute, DTU

7. Interruption in research:

Not applicable.

8. Supervision:

Supervision of 30 PhD projects in my research areas in cooperation with Danish Universities, Royal Institute of Technology and with University of Eindhoven in the Netherlands. International cooperation: EURESCOM, RACE, COST, Heinrich Hertz Institute (Germany), Bellcore (USA), NEC Central Research Lab (Japan), Stanford Univ. (USA), Univ. Eindhoven (Netherlands), Beijing Univ. of Posts & Telecommunications (China), Peking Univ. (China), Technion (Israel).

9. Other merits of relevance to the application:

a. Networks in academia and industry

Most important international and national cooperation partners over time: COM department, Technical University of Denmark, Stanford University (USA), University of Eindhoven in the Netherlands, Heinrich Hertz Institute (Germany), Bellcore (USA), Kungliga Tekniska Högskolan (Sweden), Univ. Eindhoven (Netherlands), Beijing Univ. of Posts & Telecommunications (China), Peking Univ. (China), Technion (Israel).

b. Scientific Review Activities

I have regularly served as a reviewer for Optics Express, IET Electronics Letters, IET Photonics & Electro-Optics, IEEE Photonics Technology Letters, IEEE/OSA Journal of Lightwave Technology, IEEE Transactions on Communications, IEEE Transactions on Information Theory, Journal of Optical Communications, the European Conference on Optical Communication (ECOC), the Conference on Lasers and Electro-Optics (CLEO) and the Optical Fiber Communication Conference (OFC).

I have served as external evaluator for about 25 PhD projects.

I have reviewed candidates for Professor appointments at universities in the US and in Europe.

I have reviewed research proposals for NATO and the Framework Programmes for the European Community.

c. Publications

More than 250 papers in peer reviewed journals and at leading international conferences

I have written one monograph: `Noise in Digital Optical Transmission Systems', Artech House, inc., Boston, USA, pp 1 - 387, Jul. 1994. h-index is 25 (Using Google Scholar and ISI Web of knowledge).

d. Patents

I have one patent (together with British Telecom) regarding the implementation of tuned (band-pass type) optical receivers and two patents at Ericsson regarding dynamic control of optical (EDFA-type) optical amplifiers.

e. Personal Data

Citizen of Denmark. Born in Copenhagen on Apr. 14, 1952.

Curriculum Vitae for Associate Professor Ben Slimane

Name: Slimane Ben Slimane
Address: Electrum 229, 164 40 KISTA, Sweden
Phone/Fax: +46 8 790 9353 / +46 8 790 9370
Email: slimane@kth.se

1. **Higher education qualification(s):**

   Master of Engineering: in Electrical and Computer Engineering (Telecommunications), Concordia University, Montreal, Canada, Nov. 1987.
   Dissertation: Bandwidth-Efficient Constant-Envelope Differential PSK Signals.

   Bachelor of Engineering: in Electrical Engineering, Université de Quebec à Trois-Rivières, Québec, Canada, Apr. 1985.

2. **Doctoral degree:**

   Doctor of Philosophy: in Electrical and Computer Engineering, Concordia University, Montreal, Canada, Jun 1994. (Dissertation: Maximum Likelihood Sequence Estimation of Quadrature Pulse-Overlapping Modulated Signals.)

3. **Postdoctoral positions:** Not applicable.

4. **Docent level (year):**

   Title of Docent: in Radio Communication Systems, KTH, Stockholm, Sweden (2000)

5. **Current position:**

   Oct. 2013-present: Member in the Academic Appointments Board, ICT, KTH
   Jun. 2012-present: Director of Area Doctoral studies, Department of Communication Systems, ICT, KTH
   Apr. 2001-present: Associate Professor, Radio Communication Systems, Department of Communication Systems, ICT, KTH

6. **Previous positions and periods of appointment:**

   Oct. '95-Apr. 2001: Assistant Professor, Radio Communication Systems, Department of Communication Systems, KTH, Stockholm, Sweden.
   Jun. '93-Aug. '95: Research associate and part-time instructor, Concordia University, Montreal, Canada.
   Jan. '85-May '93: Research Assistant, Concordia University, Montreal, Canada.

7. **Interruption in research:** Not applicable.

8. **Supervision:**

   - Serveh Shalmashi
   - Mohammed Hamid
   - Javier Ferrer Coll
   - Tafzeel ur Rahman Ahsin, graduated 2012 (Tek. Ph.D.)
   - Omar Al-Askary, graduated 2006 (Tek. Ph.D.)
   - Afif Osseiran, graduated 2006 (Tek. Ph.D.)
   - Mikael Gidlund, graduated 2004 (Tek. Licentiate)
   - Kai-Erik Sunell (jointly with Prof Zens Zander), Graduated in 2000 (Tek. Licentiate)
   - Göran Malmgren (jointly with Prof Jens Zander), Graduated in 1998 (Tek. Ph.D.)

9. **Other merits of relevance to the application:**

Honors:

Sep. '81-Dec. '87: The Scientific Mission of Tunisia and the Canadian Agency for International Development.

Sep. '85-May '93: Canadian Institute for Telecommunication Research (CITR) and the National Center of Excellence in Telecommunications.

1993: Nominated for the NSERC Doctoral Prize given to the best Canadian student completing a doctoral degree in Engineering at Canadian Universities.

Some Activities

Aug. 12-Present: Involved in the FP7 European METIS (Mobile and Wireless Communications Systems for 2020 Information Society) project

Aug. 08-Jun. 12: Involved in the VINNOVA cooperation project "IMT-Advanced" between Sweden and China. Our project activities has as subject Modulation and Coding Techniques, Spectrum and Propagation

Jan. 00-Dec. '03: Involved in the European SATURN project, concerned with the investigation of "Smart" antenna technology for application to wireless communications systems with special emphasis on HIPERLAN/2 and WCDMA.

Oct. '95-Sept. '97: Involved in the European ACTS program FRAMES, targeted at proposing radio interfaces for 3rd generation Universal Mobile Communication Systems (UMTS).

Mar. '96-Nov. '97: Involved in the development of an interactive computer based introductory course in mobile radio communication in cooperation with Ericsson Radio Systems AB.

Jun. '93-Aug. '95: - Modeling for self-similar traffic data, design and implementation of carrier recovery for multi-level modulation schemes, performance of coded modulation schemes in memory channels.

- Modem design and implementation using XILINX Programmable Gate Array.

Jan. '85-May '93: - Design and implementation of Quadrature Amplitude Modulation (QAM) modems and TCM 8PSK schemes using a TMS320C25 digital signal processor board.

- Developed link level simulation programs for different digital communication systems using C Language.

Master Students Supervision: An average of five (5) master students per year.

Professional Memberships and Activities:

- Senior Member of the IEEE
- Member of the IASTED Technical Committee on "Telecommunications"
- Session chair in some international conferences
- Secretary of the IEEE VT/COM Chapter, Swedish section, 1996, 1999
- Chairman of the IEEE VT/COM Chapter, Swedish section, 1998
- Reviewer to several international journals and conferences
- Co-chair of the IEEE VTC2005-Spring, Stockholm, Sweden, May 2005
- Editor to the ETRI Journal.

Curriculum Vitae for Associate Professor Sergei Popov

Address: School of ICT, KTH, Electrum 229, 164 40 Kista, Sweden; email: sergeip@kth.se

1. Higher education degree (discipline/subject area).

M.Sc.: Applied Physics, Moscow Institute of Physics and Technology, Russia, 1987
M.Sc.: Computer Sciences, Zhukovsky Air Force Engineering Academy, Russia, 1989

2. Doctoral degree (year, discipline/subject area, dissertation title and supervisor).

Ph.D.: Applied and Engineering Physics, Helsinki University of Technology, Finland, 1998 ("*Diffractive Axicons with Fully and Partially Coherent Light"* supervisor Prof. Ari Friberg).

3. Postdoctoral position (year and placement). Not applicable.

4. Docent level (year)
Docent in Optics, the Royal Institute of Technology, Stockholm, 2008

5. Present position, period of appointment, percentage of research in the position

2011 - Present: Optics group, ICT School, Royal Institute of Technology, Sweden.
Position: Associate Professor (universitetslektor), full time.

6. Previous positions and periods of appointment

- 1987 - 1991 Research engineer, Zhukovsky Air Force Engineering Academy, Russia.
- 1991 - 1993 Researcher, General Physics Institute, Russia.
- 1993 - 1998 PhD student, Helsinki University of Technology, Finland.
- 1999 - 2002 Research scientist, Ericsson Telecom AB, Sweden.
- 2002 - 2003 Research scientist, Acreo AB, Sweden.
- 2003 - 2011 Researcher, Royal Institute of Technology, Sweden.

7. Interruptions in research. Not applicable.

8. Individuals who have completed their doctoral degree under my supervision or postdoctoral period under my main supervision

- 2012 - Lin Dong, PhD
- 2012 - Srinivasan Iyer, PhD
- 2013 - Tianhua Xu, postdoc
- 2014 - Timo Hassinen, postdoc
- 2015 - Oskars Ozolins, postdoc
- 2012 - Tianhua Xu, PhD
- 2014 - Miu Yoong Leong, PhD
- 2011 - Jun Hu, postdoc
- 2015 - Xiaodan Pang, postdoc

9. Additional information

Supervision of MSc thesis projects: 2003 - 2015 over 50 students

International collaboration

- Aalto University, Finland
- University of Eastern Finland, Finland
- Aston University, UK
- University College London, UK
- Imperial College London, UK
- Aristotle University, Greece
- Technical University of Denmark, Denmark
- CSIC-Institute of Optics, Spain
- VPI Photonics GmbH, Germany
- X-Tera plc, UK

Publications

Author/co-author of 200+ papers and conference presentations and reports, including over 20 invited and post-deadline talks; 2 book chapters; 11 patents on fiber optical communication, optics, and lasers

Research grants

Phase noise influence and mitigation in terabit capacity coherent optical communication systems
Swedish Research Council 2012-2014 2 460 000 SEK, Project co-leader

Electromagnetic Coherence: Physical Effects and Applications
Swedish Research Council 2013-2015 3 450 000 SEK**,** Principal investigator

Green Initiative for Future Optical Network
EU Marie-Curie action, IAAP program 2013-2016 3 170 000 SEK, Principal investigator

Allied Initiative for Training and Education in Coherent Optical Network
EU Marie-Curie action, ITN program 2014-2017 5 700 000 SEK, Principal investigator

Editorial boards, award committees, and others

- Associate editor - Springer "Photonic Network Communications Journal"
- Associate editor - "Journal of European Optical Society - Rapid Publications" (JEOS:RP)
- Associate editor - "De Gruyter publisher" (Physics section)
- Senior member of OSA (Optical Society of America)
- Board member of committee "David Richardson Medal" OSA (Optical Society of America)
- Leader of WorkGroup 7 (Research and Education), PhotonicSweden

Member of program committee, session chair, workshop organizer etc. in conferences:

- Optical Security Systems, SPIE Congress 2005, Warsaw, Poland, 09-2005
- Fiber lasers and applications (FILAS2012), San Diego, USA, 02-2012
- Progress in Electromagnetics Research (PIERS2012), Moscow, Russia, 08-2012
- Progress in Electromagnetics Research (PIERS2014), Guangzhou, China, 08-2014
- Asia Communication and Photonics conference (ACP2014), Shanghai, China, 11-2014
- Progress in Electromagnetics Research (PIERS2015), Prague, Czech Republic, 07-2015
- Northern Optics and Photonics 2015 (NOP2015), Lappeenranta, Finland, 06-2015
- International Symposium on Photonics and Optoelectronics 2015 (SOPO2015), Shanghai, China, 08-2015
- International Conference on Transparent Optical Networks 2015 (ICTON2015), Budapest, Hungary, 07-2015

Other professional activities

Reviewer for journals:

Optics Express, Applied Optics, Optics Letters, JOSA A, JOSA B

New Journal of Physics, Optics Communications, Optical Engineering

EOS Journal of Optics: Pure and Applied Optics

IOP Journals: Applied Physics, Applied Physics Letters

Membership in scientific societies

Optical Society of America, Swedish Optical Society, Finnish Optical Society

Publication list

List of Publications for Xiaodan Pang

(* 5 most relevant publications)

Citation info uses "Google Scholar".

1. Peer-reviewed original articles:

1. M. B. Othman, L. Deng, X. Pang, J. Caminos, W. Kozuch, K. Prince, X. Yu, J. Jensen, and I. Tafur Monroy, "MIMO-OFDM WDM PON with DM-VCSEL for femtocells application," Opt. Express, 19, B537-B542, 2011. Citations: 9
2. Y. Zhao, L. Deng, X. Pang, X. Yu, X. Zheng, H. Zhang, and I. Tafur Monroy, "Digital predistortion of 75–110 GHz W-band frequency multiplier for fiber wireless short range access systems," Opt. Express, 19, B18-B25, 2011. Citations: 1
3. Y. Zhao, X. Pang, L. Deng, X. Yu, X. Zheng, B. Zhou, and I. Tafur Monroy, "High accuracy microwave frequency measurement based on single-drive dual-parallel Mach-Zehnder modulator," Opt. Express, 19, B681-B686, 2011. Citations: 1
4. * X. Pang, A. Caballero, A. Dogadaev, V. Arlunno, R. Borkowski, J. S. Pedersen, L. Deng, F. Karinou, F. Roubeau, D. Zibar, X. Yu, and I. Tafur Monroy, "100 Gbit/s hybrid optical fiber-wireless link in the W-band (75–110 GHz)," Opt. Express, 19(25), 24944-24949, 2011. Citations: 100
5. L. Deng, X. Pang, Y. Zhao, M. B. Othman, J. Jensen, D. Zibar, X. Yu, D. Liu, I.T. Monroy, "2x2 MIMO-OFDM Gigabit fiber-wireless access system based on polarization division multiplexed WDM-PON," Opt. Express, 20(4), 4369-4375, 2012. Citations: 13
6. L. Deng, M. Beltrán, X. Pang, X. Zhang, V. Arlunno, Y. Zhao, A. Caballero, A. Dogadaev, X. Yu, R. Llorente, D. Liu, I. Tafur Monroy, "Fiber Wireless Transmission of 8.3 Gb/s/ch QPSK-OFDM Signals in 75-110 GHz Band," IEEE Photon. Technol. Lett., 24(5), 383-385, 2012. Citations: 24
7. Y. Zhao, X. Pang, L. Deng, X. Yu, X. Zheng, I. Tafur Monroy, "Ultra-Broadband Photonic Harmonic Mixer Based on Optical Comb Generation," IEEE Photon. Technol. Lett., 24, no.1, 16-18, 2012. Citations: 8
8. X. Pang, A. Caballero, A. Dogadaev, V. Arlunno, L. Deng, R. Borkowski, J. S. Pedersen, D. Zibar, X. Yu, and I. Tafur Monroy, "25 Gbit/s QPSK Hybrid Fiber-Wireless Transmission in the W-Band (75–110 GHz) With Remote Antenna Unit for In-Building Wireless Networks," IEEE Photon. J., 4(3), 691-698, 2012. Citations: 28
9. X. Pang, X. Yu, Y. Zhao, L. Deng, D. Zibar, I. Tafur Monroy, "Experimental characterization of a hybrid fiber-wireless transmission link in the 75 to 110 GHz band," Optical Engineering, 51, 045004, 2012. Citations: 7
10. * L. Deng, D. Liu, X. Pang, X. Zhang, V. Arlunno, Y. Zhao, A. Caballero, A. Dogadaev, X. Yu, I. T. Monroy, M. Beltran, and R. Llorente, "42.13 Gbit/s 16QAM-OFDM Photonics-Wireless Transmission in 75-110 GHz Band," Progress In Electromagnetics Research, 126, 449-461, 2012. Citations: 17
11. M. Beltrán, L. Deng, X. Pang, X. Zhang, V. Arlunno, Y. Zhao, X. Yu, R. Llorente, D. Liu, I.T. Monroy, "Single- and Multiband OFDM Photonic Wireless Links in the 75−110 GHz Band Employing Optical Combs," IEEE Photon. J., 4(5), 2027-2036, 2012. Citations: 7
12. X. Zhang, X. Pang, L. Deng, D. Zibar, I. Tafur Monroy, R. Younce, "High phase noise tolerant pilot-tone-aided DP-QPSK optical communication systems," Opt. Express, 20, 19990-19995, 2012. Citations: 5
13. X. Pang, L. Deng, A. Dogadaev, X. Zhang, X. Yu, I. Tafur Monroy, "Uplink transmission in the W-band (75-110 GHz) for hybrid optical fiber-wireless access networks," Microwave and Optical Technology Letters, 55, 1033-1036, 2013. Citations: 4

14. A. Lebedev, J.J. Vegas Olmos, X. Pang, S. Forchhammer, I. Tafur Monroy, "Demonstration and comparison study for V-and W-band real-time high-definition video delivery in diverse fiber-wireless infrastructure," Fiber and Integrated Optics, 32, 93-104, 2013. Citations: 5

15. A. Lebedev, X. Pang, J.J. Vegas Olmos, M. Beltran, R. Llorente, S. Forchhammer, I. Tafur Monroy, "Feasibility Study and Experimental Verification of Simplified Fiber-Supported 60-GHz Picocell Mobile Backhaul Links," IEEE Photon. J., 5, 7200913-7200913, 2013. Citations: 5

16. A. Lebedev, X. Pang, J.J. Vegas Olmos, S. Forchhammer, I. Tafur Monroy, "Gigabit close-proximity wireless connections supported by 60 GHz RoF links with low carrier suppression," Optics Express, 21, 24574-24581, 2013. Citations: 1

17. L. Deng, Y. Zhao, X. Pang, M. Tang, P. Shum, D. Liu, "All-VCSEL Transmitters with Remote Optical Injection for WDM-OFDM-PON," IEEE Photon. Technol. Lett., 26, 461-464, 2014. Citations: 0

18. X. Pang, M. Beltrán, J. Sánchez, E. Pellicer, J.J. Vegas Olmos, R. Llorente, I. Tafur Monroy, "Centralized optical-frequency-comb-based RF carrier generator for DWDM fiber-wireless access systems," IEEE J. Opt. Commun. Netw. 6, 1-7, 2014. Citations: 4

19. A. Lebedev, X. Pang, J.J. Vegas Olmos, S. Forchhammer, I. Tafur Monroy, "Simultaneous 60 GHz RoF Transmission of Lightwaves Emitted by ECL, DFB, and VCSEL," IEEE Photon. Technol. Lett., 26, 733-736, 2014. Citations: 1

20. L. Deng, X. Pang, I. Tafur Monroy, M. Tang, P. Shum, D. Liu, "Experimental Demonstration of Nonlinearity and Phase Noise Tolerant 16-QAM OFDM W-Band (75–110 GHz) Signal Over Fiber System," J. Lightw. Technol., 32, 1442-1448, 2014. Citations: 1

21. A. Lebedev, J.J. Vegas Olmos, X. Pang, I. Tafur Monroy, K. Larsen, S. Forchhammer, "Low complexity source and channel coding for mm-wave hybrid fiber-wireless links," Optics Communications, 318, 142-146, 2014. Citations: 1

22. J.J. V. Olmos, X. Pang, I. Tafur Monroy, "E-and W-Band High-Capacity Hybrid Fiber-Wireless Links," IEICE Trans. Commun., 97, 1290-1294, 2014. Citations: 0

23. J.J. V. Olmos, X. Pang, A. Lebedev, M. Sales, I. Tafur Monroy, "Wireless and Wireline Service Convergence in Next Generation Optical Access Networks—The FP7 WISCON Project," IEICE Trans. Commun., 97, 1537-1546, 2014. Citations: 0

24. X. Pang, A. Lebedev, J.J. Vegas Olmos, I. Tafur Monroy, "Multigigabit W-Band (75-110 GHz) Bidirectional Hybrid Fiber-Wireless Systems in Access Networks," J. Lightw. Technol., 32, 3983-3990, 2014. Citations: 0

25. * S. Ortega Zafra, X. Pang, G. Jacobsen, S. Popov, S. Sergeyev, "Phase noise tolerance study in coherent optical circular QAM transmissions with Viterbi-Viterbi carrier phase estimation," Opt. Express, 22, 30579-30585, 2014. Citations: 0

2. Peer-reviewed conference papers:

1. Y. Zhao, X. Pang, L. Deng, X. Yu, X. Zheng, H. Zhang and I. T. Monroy, "Digital Predistortion of 75-110GHzW-Band Frequency Multiplier for Fiber Wireless Short Range Access Systems," *In Proc. ECOC'11,* Geneva, 2011, paper Tu.5.A.3. Citations: 1

2. Y. Zhao, L. Deng, X. Pang, X. Yu, X. Zheng, H. Zhang and I. T. Monroy, "High Accuracy Microwave Frequency Measurement Based on Single-Drive Dual-Parallel Mach-Zehnder Modulator," *In Proc. ECOC'11,* Geneva, 2011. Citations: 1

3. M. Othman, L. Deng, X. Pang, J. Caminos, W. Kozuch, K. Prince, J. Jensen, I. Monroy, "Directly-Modulated VCSELs for 2x2 MIMO-OFDM Radio over Fiber in WDM-PON," *In Proc. ECOC'11,* Geneva, 2011, Paper We.10.P1.119. Citations: 3

4. X. Pang, Y. Zhao, L. Deng, M. B. Othman, X. Yu, J. B. Jensen D. Zibar and I. T. Monroy, "Seamless Translation of Optical Fiber PolMux-OFDM into a 2×2 MIMO Wireless Transmission Enabled by Digital Training-Based Fiber-Wireless Channel Estimation," *In Proc. ACP'11,* Shanghai, China, vol. 8309, pages: 83090C, 2011. (**Best Student Paper**) Citations: 0
5. X. Pang, Y. Zhao, L. Deng, M. B. Othman, X. Yu, J. B. Jensen and I. T. Monroy, "A Spectral Efficient PolMux-QPSK-RoF System with CMA-Based Blind Estimation of a 2×2 MIMO Wireless Channel," *In Proc. IPC'11*, Arlington, USA, 2011. Citations: 1
6. L. Deng, Y. Zhao, X. Pang, X. Yu, J. B. Jensen, D. Liu and I. T. Monroy, "Colorless ONU Based on All-VCSEL Sources with Remote Optical Injection for WDM-PON," *In Proc. IPC'11,* Arlington, USA, 2011. Citations: 1
7. X. Pang, Y. Zhao, L. Deng, X. Yu and I. T. Monroy, "A Novel Reconfigurable Ultra-broadband Millimeter-wave Photonic Harmonic Down-converter," *In Proc. MWP'11,* Singapore, 2011. Citations: 0
8. X. Pang, X. Yu, Y. Zhao, L. Deng, D. Zibar and I. T. Monroy, "Channel Measurements for an Optical Fiber-Wireless Transmission System in the 75-110 GHz Band," In Proc. MWP'11, Singapore, 2011. Citations: 4
9. Y. Zhao, X. Pang, L. Deng, X. Yu, X. Zheng, H. Zhang and I. T. Monroy, "Experimental Demonstration of 5-Gb/s Polarization-Multiplexed Fiber-Wireless MIMO Systems," *In Proc. MWP'11,* Singapore, 2011. Citations: 2
10. L. Deng, Y. Zhao, X. Pang, X. Yu D. Liu and I. T. Monroy, "Intra and Inter-PON ONU to ONU Virtual Private Networking using OFDMA in a Ring Topology," *In Proc. MWP'11,* Singapore, 2011. Citations: 4
11. D. Zibar, A. Caballero, X. Yu, X. Pang, A.K. Dogadaev, I.T. Monroy, "Hybrid optical fibre-wireless links at the 75–110 GHz band supporting 100 Gbps transmission capacities," *In Proc. MWP'11,* Singapore, pp.445-449, 18-21 Oct. 2011. (**Invited**) Citations: 11
12. X. Zhang, M. B. Othman, X. Pang, J.B. Jensen, I. Tafur Monroy, "Bi-directional Multi Dimension CAP Transmission for Smart Grid Communication Services," *In Proc. ACP'12,* Guangzhou, China, 2012, paper AS3C.4. Citations: 0
13. L. Deng, X. Pang, M. Beltrán, X. Zhang, V. Arlunno, Y. Zhao, X. Yu, R. Llorente, D. Liu, I. Tafur Monroy, "38.2-Gb/s Optical-Wireless Transmission in 75-110 GHz Based on Electrical OFDM with Optical Comb Expansion," *In Proc. OFC'12,* Los Angeles, CA, USA 2012. Citations: 6
14. X. Zhang X. Pang, A. Dogadaev, I. Tafur Monroy, D. Zibar, R. Younce, "High Spectrum Narrowing Tolerant 112 Gb/s Dual Polarization QPSK Optical Communication Systems Using Digital Adaptive Channel Estimation," *In Proc. OFC'12,* Los Angeles, CA, USA 2012. Citations: 0
15. X. Yu, Y. Zhao, L. Deng, X. Pang, I. Tafur Monroy, "Existing PON Infrastructure Supported Hybrid Fiber-Wireless Sensor Networks," *In Proc. OFC'12,* Los Angeles, CA, USA 2012. Citations: 4
16. A. Lopez, J.J. Vegas Olmos, F. Karinou, I. Roudas, L. Deng, X. Pang, I. Tafur Monroy, "Optical Switching for Dynamic Distribution of Wireless-over-Fiber Signals," *In Proc. ONDM'12,* London, UK, 2012. Citations: 2
17. X. Pang, J.J. Olmos, A. Lebedev, I. Tafur Monroy, "A 15-meter multi-gigabit W-band bidirectional wireless bridge in fiber-optic access networks," *In Proc. MWP'13,* Alexandria, VA, USA, 2013, pp. 37-40. Citations: 2
18. X. Pang, J.J. Olmos, A. Lebedev, I. Tafur Monroy, "A Multi-Gigabit W-Band Bidirectional Seamless Fiber-Wireless Transmission System with Simple Structured Access Point," *In Proc. ECOC'13,* London, UK, 2013, paper P.6.11. Citations: 2

19. X. Pang, A. Caballero, L. Deng, X. Yu, R. Borkowski, V. Arlunno, A. Dogadaev, D. Zibar, L. Suhr, J.J. Vegas Olmos, I. Tafur Monroy, "100-Gbps hybrid optical fiber-wireless transmission," *In Proc. OECC'13,* Kyoto, Japan, 2013, paper ThP3 (**Invited**). Citations: 3
20. X. Pang, A. Lebedev, J.J. Vegas Olmos, I. Tafur Monroy, "Seamless Optical Fiber-Wireless Millimeter-Wave Transmission Link for Access Networks," *In Proc. OECC'13,* Kyoto, Japan, 2013, paper TuPP_12. Citations: 2
21. J.J. Vegas Olmos, X. Pang, A. Lebedev, I. Tafur Monroy, "VCSEL sources for optical fiber-wireless composite data links at 60GHz," *In Proc. OECC'13,* Kyoto, Japan, 2013, paper TuPP_10. Citations: 0
22. X. Pang, A. Lebedev, M. Beltrán, J.J. Vegas Olmos, R, Llorente, I. Tafur Monroy, "Performance Evaluation for DFB and VCSEL-based 60 GHz Radio-over-Fiber System," *In Proc. ONDM'13,* Brest, France, 2013, pp. 252-256. Citations: 3
23. A. Lebedev, X. Pang, J.J. Vegas Olmos, M. Beltrán, R. Llorente, S. Forchhammer, I. Tafur Monroy, "Fiber-supported 60 GHz mobile backhaul links for access/metropolitan deployment," *In Proc. ONDM'13,* Brest, France, 2013. Citations: 4
24. X. Pang, M. Beltrán, J. Sánchez, E. Pellicer, J.J. Vegas Olmos, R, Llorente, I. T. Monroy, "DWDM Fiber-Wireless Access System with Centralized Optical Frequency Comb-based RF Carrier Generation," *In Proc OFC'13,* Anaheim, USA 2013, paper JTh2A.56. Citations: 4
25. J.J. Vegas Olmos, X. Pang, A. Lebedev, Idelfonso Tafur Monroy, "Multi-Gigabit Capacity W-band Hybrid Wireless-Photonic Transmission Link," *In Proc. ACP'13,* Beijing, China, 2013, paper ATh3G. 1. Citations: 0
26. A. Lebedev, X. Pang, J.J.Vegas Olmos, Idelfonso Tafur Monroy, Soren Forchhammer, "Tunable photonic RF generator for dynamic allocation and multicast of 1.25 Gbps channels in the 60 GHz unlicensed band," *In Proc. IEEE MTT-S IMS'13,* Seattle, WA, USA 2013, pp. 1-3. Citations: 3
27. L. Deng, X. Pang, X. Zhang, X. Yu, D. Liu, I. Tafur Monroy, "Nonlinearity and Phase Noise Tolerant 75-110 GHz Signal over Fiber System Using Phase Modulation Technique," In Proc OFC'13, Anaheim, USA 2013, paper JTh2A.55. Citations: 2
28. A. Dogadaev, X. Pang, L. Deng, S. Ruepp, L. Dittmann, H. Christiansen, "Experimental and simulation analysis of the W-band SC-FDMA hybrid optical-wireless transmission," In Proc. IPC'14, San Diego, CA, USA, 2014, pp.77-78. Citations: 0
29. M. I. Olmedo, X. Pang, A. Udalcovs, R. Schatz, D. Zibar, G. Jacobsen, S. Popov, I. T. Monroy, "Impact of Carrier Induced Frequency Noise from the Transmitter Laser on 28 and 56 Gbaud DP-QPSK Metro Links," *In Proc. ACP'14,* Shanghai, China, Nov. 2014, paper ATh1E.1. Citations 2
30. X. Pang, A. El-Taher, R. Schatz, G. Jacobsen, S. Popov, S. Sergeyev, "Characterization of Distributed Raman Amplification-induced Amplitude and Phase Impairments on Unrepeated Coherent Transmission Links," *In Proc. ACP'14,* Shanghai, China, Nov. 2014, paper AF2D.4. Citations 1
31. M. Iglesias Olmedo, X. Pang, R. Schatz, D. Zibar, I. Tafur Monroy, G. Jacobsen, S. Popov; "Digital signal processing approaches for semiconductor phase noise tolerant coherent transmission systems," *In Proc. SPIE 9388, Optical Metro Networks and Short-Haul Systems VII,* Feb. 2015, paper 93880A. Citations 0
32. * M. Iglesias Olmedo, X. Pang, M. Piels, R. Schatz, G. Jacobsen, S. Popov, I. Tafur Monroy, and D. Zibar, "Carrier Recovery Techniques for Semiconductor Laser Frequency Noise for 28 Gbd DP-16QAM," *In Proc. OFC'15,* Los Angeles, CA, USA, Mar. 2015, paper Th2A.10. Citations 0

33. M. Piels, M. Iglesias Olmedo, X. Pang, R. Schatz, G. Jacobsen, S. Popov, D. Zibar, “Rate Equation-Based Phase Recovery for Semiconductor Laser Coherent Transmitters,” *In Proc. OFC’15,* Los Angeles, CA, USA, Mar. 2015, paper W1E.7. Citations 1

34. A. El-Taher, X. Pang, R. Schatz, G. Jacobsen, S. Popov, and S. Sergeyev, "Noise Characterization and Transmission Evaluation of Unrepeated Raman Amplified DP-16QAM Link," *In Proc. OFC’15,* Los Angeles, CA, USA, Mar. 2015, paper Th2A.31. Citations 0

3. Monograph

1. * X. Pang, S. Forchhammer, J.J. Vegas Olmos, I. Tafur Monroy, “High-Capacity Hybrid Optical Fiber-Wireless Communications Links in Access Networks,” Ph.D. Thesis, ISBN 978-87-93089-07-05, pp.157, DTU Fotonik, Denmark, 2013. Citations 1

Five Most Cited Publications:

26. X. Pang, A. Caballero, A. Dogadaev, V. Arlunno, R. Borkowski, J. S. Pedersen, L. Deng, F. Karinou, F. Roubeau, D. Zibar, X. Yu, and I. Tafur Monroy, “100 Gbit/s hybrid optical fiber-wireless link in the W-band (75–110 GHz),” Opt. Express, 19(25), 24944-24949, 2011. Citations: 100

27. X. Pang, A. Caballero, A. Dogadaev, V. Arlunno, L. Deng, R. Borkowski, J. S. Pedersen, D. Zibar, X. Yu, and I. Tafur Monroy, “25 Gbit/s QPSK Hybrid Fiber-Wireless Transmission in the W-Band (75–110 GHz) With Remote Antenna Unit for In-Building Wireless Networks,” IEEE Photon. J., 4(3), 691-698, 2012. Citations: 28

28. L. Deng, M. Beltrán, X. Pang, X. Zhang, V. Arlunno, Y. Zhao, A. Caballero, A. Dogadaev, X. Yu, R. Llorente, D. Liu, I. Tafur Monroy, “Fiber Wireless Transmission of 8.3 Gb/s/ch QPSK-OFDM Signals in 75-110 GHz Band,” IEEE Photon. Technol. Lett., 24(5), 383-385, 2012. Citations: 24

29. L. Deng, D. Liu, X. Pang, X. Zhang, V. Arlunno, Y. Zhao, A. Caballero, A. Dogadaev, X. Yu, I. T. Monroy, M. Beltran, and R. Llorente, “42.13 Gbit/s 16QAM-OFDM Photonics-Wireless Transmission in 75-110 GHz Band,” Progress In Electromagnetics Research, 126, 449-461, 2012. Citations: 17

30. L. Deng, X. Pang, Y. Zhao, M. B. Othman, J. Jensen, D. Zibar, X. Yu, D. Liu, I. T. Monroy, “2x2 MIMO-OFDM Gigabit fiber-wireless access system based on polarization division multiplexed WDM-PON,” Opt. Express, 20(4), 4369-4375, 2012. Citations: 13

List of Publications for Oskars Ozolins for 2007-2015

(* 5 most relevant publications)

Citation info uses "Google Scholar".

1. Peer-reviewed original articles:

1. I. Lasuks, A. Scemelevs, O. Ozolins, "Investigation of spectrum-sliced WDM system," Elektron. Elektrotech. **85**(5), 45-48 2008. Citations: 4
2. O. Ozolins, G. Ivanovs, "Realization of Optimal FBG Band–Pass Filters for High Speed HDWDM," Elektron. Elektrotech. 92(4), 41-44 2009. Citations: 10
3. V. Bobrovs, O. Ozolins, G. Ivanovs, "Investigation into the Potentialities of Quasi-Rectangular Optical Filters in HDWDM Systems," LJPTS **47**(1), 13-25 2010. Citations: 0
4. V. Bobrovs, O. Ozolins, G. Ivanovs, J. Porins, "Realization of HDWDM Transmission System" // Int. J. Phys. Sci. **5**(5) 452-458 2010. Citations:16
5. O. Ozolins, V. Bobrovs, G. Ivanovs, "Efficient Wavelength Filters for DWDM Systems," LJPTS **47**(6) 47-58 2010. Citations: 14
6. O. Ozolins, G. Ivanovs, "Evaluation of Band-Pass Filters Influence on NRZ Signal in HDWDM Systems," Elektron. Elektrotech. **100**(4), 65-68 2010. Citations: 6
7. O. Ozolins, V. Bobrovs, G. Ivanovs, "DWDM Transmission Based on the Thin-Film Filter Technology," LJPTS **48**(3), 55-65 2011. Citations: 5
8. O. Ozolins, V. Bobrovs, G. Ivanovs, I. Lasuks, "New-Generation Optical Access System Based on the Thin Film Filter Technology" Int. J. Phys. Sci. **6**(35) 7926-7934 2011. Citations: 4
9. O. Ozolins, G. Ivanovs, "Estimation of DWDM Transmission for Broadband Access with FBG Technology," Elektron. Elektrotech. **111**(5), 11-14 2011. Citations: 4
10. * M. Xiong, O. Ozolins, Y. Ding, B. Huang, Y. An, H. Ou, C. Peucheret, and X. Zhang, "Simultaneous RZ-OOK to NRZ-OOK and RZ-DPSK to NRZ-DPSK format conversion in a silicon microring resonator," Opt. Express **20**(25), 27263-27272 (2012). Citations: 10
11. * O. Ozolins, V. Bobrovs, G. Ivanovs, "Cascadability of Uniform Fibre Bragg Grating for 40 Gbit/s RZ-OOK to NRZ-OOK Conversion," OPJ **3**(2B) 950-9552013. Citations: 1
12. * O. Ozolins, I. Trifonovs, R. Parts, V. Bobrovs, "All-Optical NRZ-to-PRZ Format Conversion Limitations Using Notch Filters," Elektron. Elektrotech. **21**(1), 64-69 2015. Citations: 0

2. Peer-reviewed conference papers:

1. O. Ozolins, V. Bobrovs, G. Ivanovs, "Efficient Bandwidth Measurements of Thin Film Filters for Next-Generation Optical Access," in *Proc. of the PGNet2011* (LJMU, 2011), pp.275-280. Citations: 1
2. V. Bobrovs, A. Udalcovs, S. Spolitis, O. Ozolins, G. Ivanovs, "Mixed Chromatic Dispersion Compensation Methods for Combined HDWDM Systems," in *Proc. of the BWCCA2011* (IEEE, 2011), pp. 313-319. Citations: 12
3. O. Ozolins, V. Bobrovs, G. Ivanovs, "Efficient Bandwidth of 50 GHz Fiber Bragg Grating for New-Generation Optical Access," in *Proc. of the TELFOR2011* (IEEE, 2011), pp. 816-819. Citations: 0
4. O. Ozolins, V. Bobrovs, G. Ivanovs, "DWDM-Direct Access System Based on the Fiber Bragg Grating Technology," in *Proc. of the CSNDSP2012* (IEEE, 2012), pp. 1-4. Citations: 2

5. * M. Xiong, O. Ozolins, Y. Ding, B. Huang, Y. An, H. Ou, C. Peucheret, X. Zhang "41.6 Gb/s RZ-DPSK to NRZ-DPSK Format Conversion in a Microring Resonator," in *Proc. of the OECC2012* (IEEE, 2012), pp. 891 - 892. Citations: 1
6. O. Ozolins, Y. An, Z. Lali-Dastjerdi, Y. Ding, V. Bobrovs, G. Ivanovs, C. Peucheret, "Cascadability of Silicon Microring Resonators for 40 Gbit/s OOK and DPSK Optical Signals," in *Proc. of the ACP2012* (OSA, 2012), pp. 1 - 3. Citations: 2
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List of Publications for Gunnar Jacobsen for 2007-2015

(* 5 most relevant publications)

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1. Peer-reviewed original articles:

1. G. Jacobsen, A. Aurelius, A. Berntson, "BER Model for Rx ISI Effects in WDM Systems Accounting for General LPF Impulse Responses and for Correlation of Quadrature and Polarization Noise Contributions," Journal of Optical Communications, 28, 52-57, 2007. Citations: 5
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5. H. Olesen, G. Jacobsen, “A theoretical and experimental analysis of modulated laser fields and power spectra,” IEEE J. Quantum Electron., QE-18, 2069-2080, 1982. Citations: 58

List of Publications for Ben Slimane for 2007 – 2015

(* 5 most relevant publications)

Citation info uses "Google Scholar".

1. Peer-reviewed original articles:

1. M. Hamid, N. Björsell, and S. Ben Slimane, "Energy and Eigenvalue-Based Combined Fully-Blind Self-Adapted Spectrum Sensing Algorithm," IEEE Transactions on Vehicular Technology, 2015. Citations: 0.
2. M. Hamid, N. Björsell, and S. Ben Slimane, "Signal Bandwidth impact on Maximum-minimum Eigenvalue Detection," IEEE Communications Letter, Vol. 19, No. 3, pp. 395-398, March 2015. Citations: 1.
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3. * S. Shalmashi and S. Ben Slimane, "Cooperative device-to-device communications in the downlink of cellular networks," *IEEE WCNC,* April 2014. *Citations: 1*.
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2. S. Popov, "Dye photodestruction in a solid-state dye laser with a polymeric gain medium", ***Applied Optics*** 37 (27), 6449-6455 (1998). (Citations: 67)

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CV

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Research education

Dissertation title (swe)

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Dissertation title (en)

High-Capacity Hybrid Optical Fiber-Wireless Communications Links in Access Networks

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Technical University of Denmark, Denmark Not Sweden - Higher Education institutes	DTU Fotonik	Idelfonso Tafur Monroy

Subject doctors degree	ISSN/ISBN-number	Date doctoral exam
20204. Telekommunikation	978-87-93089-07-05	2013-09-02

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Dissertation title (swe)
Diffractive Axicons with Fully and Partially Coherent Light

Dissertation title (en)
Diffractive Axicons with Fully and Partially Coherent Light

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10399. Annan fysik		1998-12-18

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Evanescent wave theory describing propagation in guiding environments

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Dissertation title (swe)
Maximum Likelihood Sequence Estimation of Quadrature Pulse-Overlapping Modulated Signals

Dissertation title (en)
Maximum Likelihood Sequence Estimation of Quadrature Pulse-Overlapping Modulated Signals

Organisation	Unit	Supervisor
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Research education

Dissertation title (swe)
ANALYSIS AND REALIZATION OF WAVELENGTH FILTERS IN FIBER OPTIC TRANSMISSION SYSTEMS

Dissertation title (en)
ANALYSIS AND REALIZATION OF WAVELENGTH FILTERS IN FIBER OPTIC TRANSMISSION SYSTEMS

Organisation	Unit	Supervisor
Riga Technical University, Latvia Not Sweden - Higher Education institutes	Faculty of Electronics and Telecommunications	GIRTS IVANOVS

Subject doctors degree	ISSN/ISBN-number	Date doctoral exam
20204. Telekommunikation	978-9934-10-409-1	2013-05-23

Publications

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Pang, Xiaodan has not added any publications to the application.

Publications

Name: Sergei Popov	**Doctorial degree:** 1998-12-18
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Popov, Sergei has not added any publications to the application.

Publications

Name: Gunnar Jacobsen	**Doctorial degree:** 1981-03-04
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Jacobsen, Gunnar has not added any publications to the application.

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Ben Slimane, Slimane has not added any publications to the application.

Publications

Name: Oskars Ozolins	**Doctorial degree:** 2013-05-23
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Ozolins, Oskars has not added any publications to the application.

Register

Terms and conditions

The application must be signed by the applicant as well as the authorised representative of the administrating organisation. The representative is normally the department head of the institution where the research is to be conducted, but may in some instances be e.g. the vice-chancellor. This is specified in the call for proposals.

The signature*from the applicant*confirms that:

- the information in the application is correct and according to the instructions form the Swedish Research Council
- any additional professional activities or commercial ties have been reported to the administrating organisation, and that no conflicts have arisen that would conflict with good research practice
- that the necessary permits and approvals are in place at the start of the project e.g. regarding ethical review.

The signature *from the administrating organisation* confirms that:

- the research, employment and equipment indicated will be accommodated in the institution during the time, and to the extent, described in the application
- the institution approves the cost-estimate in the application
- the research is conducted according to Swedish legislation.

The above-mentioned points must have been discussed between the parties before the representative of the administrating organisation approves and signs the application.

Project out lines are not signed by the administrating organisation. The administrating organisation only sign the application if the project outline is accepted for step two.

Applications with an organisation as applicant is automatically signed when the application is registered.