PROCEEDINGS OF SPIE VOLUME 8645

Broadband Access Communication Technologies VII

Editor(s): **Benjamin B. Dingel; Raj Jain; Katsutoshi Tsukamoto**

Published: **4 January 2013**; 200 pages; 22 papers; Softcover
ISBN: **9780819494146**

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WDM-PON budget extension techniques for Nx10 Gbit/s DPSK signals

Author(s): Ali Emsia; Quang T. Le; Dieter Briggmann; Franko Küppers

This paper shows optical power extension techniques for 10 Gbit/s per A. channel for WDM-PON DPSK systems. The scheme is based on semiconductor optical amplifiers. We present 56.5 dB total optical power budget enhancement using our configuration for the downstream scenario. The setup is cost effective in terms of optical components. Only one DLI (Delay Line Interferometer) is used to convert DPSK signals to OOK. We present experimentally as well as through simulations that our scheme has better performance than a single SOA as a power budget extender.

Next generation PON evolution

Author(s): Anand Srivastava

Passive optical network (PON) features a point-to-multi-point (P2MP) architecture to provide broadband access. The P2MP architecture has become the most popular solution for FTTx deployment among operators. PON-based FTTx has been widely deployed ever since 2004 when ITU-T Study Group 15Q2 completed recommendations that defined GPON system [ITU-T seriesG.984]. As full services are provisioned by the massive deployment of PON networks worldwide, operators expect more from PONs. These include improved bandwidths and service support capabilities as well as enhanced performance of access nodes and supportive equipment over their existing PON networks. The direction of PON evolution is a key issue for the telecom industry. Full Service Access Network (FSAN) and ITU-T are the PON interest group and standard organization, respectively. In their view, the next-generation PONs are divided into two phases: NG-PON1 and NG-PON2. Mid-term upgrades in PON networks are defined as NG-PON1, while NG-PON2 is a long-term solution in PON evolution. Major requirements of NG-PON1 are the coexistence with the deployed GPON systems and the reuse of outside plant. Optical Distribution Networks (ODNs) account for 70% of the total investments in deploying PONs. Therefore, it is crucial for the NGPON evolution to be compatible with the deployed networks. With the specification of system coexistence and ODN reuse, the only hold-up of the migration from GPON to NG-PON1 is the maturity of the industry chain. Unlike NG-PON1 that has clear goals and emerging developments, there are many candidate technologies for NG-PON2. The selection of NG-PON2 is under discussion. However, one thing is clear, NG-PON2 technology must outperform NG-PON1 technologies in terms of ODN compatibility, bandwidth, capacity, and cost-efficiency.

Chirp-managed lasers as cost-efficient transmitters for 10-Gbit/s WDM-PONs

Author(s): Quang Trung Le; Ali Emsia; Dieter Briggmann; Franko Küppers

Chirp-managed lasers (CML) are demonstrated as simple low-cost transmitter with high tolerance to chromatic dispersion. This manuscript proposes the use of CML as cost-effective downstream (DS) transmitters for next generation access networks. The laser chirp, which is the main drawback limiting the transmission performance of directly modulated lasers, is now used to generate differential phase-shift keying (DPSK) modulation format by direct modulation. The network architecture using CML as downstream DPSK transmitter is proposed. Bit error-rate measurement showed that an optical power budget of 36 dB could be obtained with direct phase-shift keying modulation ofCML which proves that the proposed solution is a strong candidate for future WDM-PONs. Budget-extended WDM-PON configuration is also demonstrated using Saturated Collision Amplifier, which is an amplification scheme that uses SOA saturation in order to maximize the output power and minimize the ASE noise and the polarization sensitivity. The extension scheme is demonstrated for four-wavelength 10 Gbit/s unidirectional downstream configuration with 60-dB maximum total optical budget for each wavelength.

Developments in photonic and mm-wave component technology for fiber radio

Author(s): Stavros Iezekiel

A review of photonic component technology for fiber radio applications at 60 GHz will be given. We will focus on two architectures: (i) baseband-over-fiber and (ii) RF-over-fiber. In the first approach, up-conversion to 60 GHz is performed at the picocell base stations, with data being transported over fiber, while in the second both the data and rum wave carrier are transported over fiber. For the baseband-over-fiber scheme, we examine techniques to improve the modulation efficiency of directly modulated fiber links. These are based on traveling-wave structures applied to series cascades of lasers. This approach combines the improvement in differential quantum efficiency with the ability to tailor impedance matching as required. In addition, we report on various base station transceiver architectures based on optically-controlled :tvfMIC self oscillating mixers, and their application to 60 GHz fiber

radio. This approach allows low cost optoelectronic transceivers to be used for the baseband fiber link, whilst minimizing the impact of dispersion. For the RF-over-fiber scheme, we report on schemes for optical generation of 100 GHz. These use modulation of a Mach-Zehnder modulator at V_{π} bias in cascade with a Mach-Zehnder driven by 1.25 Gb/s data. One of the issues in RF-over-fiber is dispersion, while reduced modulation efficiency due to the presence of the optical carrier is also problematic. We examine the use of silicon nitride micro-ring resonators for the production of optical single sideband modulation in order to combat dispersion, and for the reduction of optical carrier power in order to improve link modulation efficiency.

Seamless integration of 100-G wire line and 100-GHz wireless link system

Author(s): Ze Dong; Jianjun Yu; Xinying Li; Nan Chi

In this invited paper, we experimentally demonstrate a seamlessly integrated fiber-wireless system that delivers 108-Gb/s signal through 80-km fiber and 1-m wireless transport over free-space at 100 GHz, adopting polarization-divisionmultiplexing quadrature-phase-shift-keying (PDM-QPSK) modulation and heterodyning coherent detection. The X- and Y-polarization baseband components of the optical PDM-QPSK are simultaneously up-converted to 100-GHz wireless carriers by optical polarization-diversity heterodyne beating, and then independently transmitted and received by two pairs of transmitter and receiver antennas, which forms a 2x2 multiple-input multiple-output (MIMO) wireless link. At the wireless receiver, two-stage down conversion is performed with firstly done in analog domain based on balanced mixer and sinusoidal radio frequency (RF) signal, and then in digital domain based on digital signal processing (DSP). MIMO signal de-multiplexing combined with optical polarization multiplexing and free space MIMO crosstalk is realized by constant modulus algorithm (CMA) in digital signal processing (DSP) part at the receiver. The bit-error ratio (BER) for the 108-Gb/s PDM-QPSK signal is less than the pre-forward-error-correction (pre-FEC) threshold of 3.8×10^{-3} after both 1-m wireless delivery at 100 GHz and 80-km single-mode fiber-28 (SMF-28) transmission. To our knowledge, this is the first demonstration to realize 100-Gb/s signal delivery through both fiber and wireless links at 100GHz.

Effect of the degree of phase-correlation of laser sources on the transmission and optical coherent detection in radio-over-fibre systems

Author(s): Ramon Maldonado-Basilio; Ran Li; Sawsan Abdul-Majid; Hamdam Nikkhah; Kin-Wai Leong; Trevor J. Hall

The deployment of high capacity Radio-over-Fiber (RoF) systems rely, among many aspects, on the capability to efficiently generate, transport, and detect millimeter-wave carriers modulated at high data rates. Photonic approaches based on the heterodyne beating of two free-running laser sources have been proposed as an alternative to generate multi-Gbps quadrature phase modulated signals imposed on millimeter wave carriers. Implementing photonic approaches in the down-link avoids the need for electronic generation of high frequency carriers and decreases the requirements at the base band electronics. In addition, implementing complex modulation formats overcomes some of the typical issues found in intensity modulation direct detection approaches such as non linearity, receiver sensitivity and dynamic range. In this work, the performance improvement of a coherent RoF system carrying 10 Gbps QPSK signals is numerically analyzed in terms of both the frequency linewidth and the degree of phase correlation between the lasers utilised at the down-link (for the optical heterodyne beating) and at the up-link (for the optical coherent detection). Relative to phase correlated lasers featuring linewidths of 5 MHz, the peak power of the 60 G Hz carrier generated at the down-link is reduced by 8 dB for un-correlated lasers. In addition, the error vector magnitude of the received signal at the up-link is improved from over 20% (for un-correlated lasers and linewidths of 5 MHz) to around 15% (for correlated lasers) at an optical received power of -30 dBm. The results obtained reinforce the idea of using coherent comb laser sources with phase correlated modes located at the Central Office. It also motivates the eventual deployment of techniques to control the degree of phase correlation between the lasers used as signal and local oscillator at the optical coherent receivers.

Power consumption of communication systems employing radio-over-fiber distributed antenna systems for railway

Author(s): Tien Dat Pham; Atsushi Kanno; Tetsuya Kawanishi

Demand on high speed communication and broadband access connection for fast moving passengers is rapidly increasing. However, the current wireless access communication techniques for railway which are mainly based on GSM for rail, satellite, and macro-cell cellular networks cannot meet the requirement of communication on fast moving trains. Cellular networks with small cell size and high carrier frequencies can be realized as a promising

solution to overcome the current obstacles. In that situation, a radio-over-fiber distributed antenna system using WDM technology can be an attractive means to connect small base stations along the railway track to the control centers. However, considering a huge number of base stations placed along the railway track, power consumption will become one of the main concerns. In this paper, we investigate and optimize power consumption and energy efficiency of a Radio-over-Fiber distributed antenna system (RoF DAS) for railway. Based on the model, optimum system design in terms of remote antenna cell size and number of cells in a WDM ring are derived with respect to system energy consumption and efficiency. From the model we can also determine an appropriate scheme to upgrade a currently deployed conventional cellular network to a system employing RoF DAS technology. The power consumption and energy efficiency of the conventional and the upgraded systems are compared. The results demonstrate a significant save of power consumption and remarkable enhancement of energy efficiency when using a RoF DAS system.

Optical wireless applications: a solution to ease the wireless airwaves spectrum crunch

Author(s): Mohsen Kavehrad

Demands by the communications industry for greater and greater bandwidth push the capability of conventional wireless technology. Part of the Radio Spectrum that is suitable for mobility is very limited. Higher frequency waves above 30 GHz tend to travel only a few miles or less and generally do not penetrate solid materials very well. This offers a sustainable solution for the current Spectrum Crunch in the lower microwave bands. One mission of this paper is to demonstrate practical and usable networks that can select a self-limiting link distance, allowing spectrum reuse. The motivation for operators of such bands to actually choose to self-limit is that by doing so, they improve the signal-tonoise against competing users at a lower cost than trying to overcome interference. These characteristics of wave propagation are not necessarily disadvantageous as they enable more densely packed communications links. Thus, high frequencies can provide very efficient spectrum utilization through “selective spectrum reuse”, and naturally increase the security of transmissions. Optical systems and networks offer a far greater bandwidth. This means new devices and systems have to be developed. Semiconductor Light Emitting Diode (LED) is considered to be the future primary lighting source for buildings, automobiles and aircrafts. LED provides higher energy efficiency compared to incandescent and fluorescent light sources and it will play a major role in the global reduction of carbon dioxide emissions, as a consequence of the significant energy savings. Lasers are also under investigation for similar applications. These core devices have the potential to revolutionize how we use light, including not only for illumination, but as well; for communications, sensing, navigation, positioning, surveillance, and imaging.

Novel 60 GHz CPW array antennas with beam-forming features for indoor wireless over fiber networks

Author(s): Ioannis Petropoulos; Spiros Mikroulis; Adonis Bogris; Hercules Simos; Kostantinos Voudouris

In this study two types of coplanar waveguide (CPW) array antennas are designed and analyzed for use in a 60GHz Radio over Fiber indoor network. The first one is based on high permittivity Rogers 6010 and Indium Phosphide (InP) substrates incorporating slots as radiating elements. The second one utilizes stacked geometry based on the above substrates. Both arrays present more 1 GHz bandwidth and 10dBi gain. Furthermore they can provide beam-forming operation by properly adjusting the signal’s amplitude and phase. A Least Mean Square (LMS) algorithm is generated for this purpose and the radiation pattern is steered accordingly. At last, a photodiode is simulated using equivalent circuit and is adopted with the proposed arrays, and an optical beam forming scenario is discussed.

Investigation on a low-cost single wavelength converged wired-60 GHz wireless OFDM-based system employing a photonic patch antenna

Author(s): Spiros Mikroulis; Ivan Aldaya; Ioannis Petropoulos; Elias Giakoumidis; Kostantinos Voudouris; Ioannis Tomkos

A low cost converged wireline and 60GHz wireless hybrid system utilizing a single wavelength is proposed, employing two single electrode LiNbO3 modulators for all-optical mm-wave frequency up-conversion and baseband modulation, respectively. Additionally, a novel 15dBi, broadband, coplanar based, photonic patch array antenna is designed on a high dielectric substrate for application as an indoor compact photonic-wireless transceiver. In order to evaluate the fiber-wireless system performance a microwave/optical/wireless design is utilized, employing 3Gb/s orthogonal frequency division multiplexed (OFDM) broadband wireless and passive optical network (PON) signals, co-propagating in a single mode fiber (SMF). An acceptable performance is calculated for a 10m indoor wireless channel and a PON urban link in the order of up to 20km, respectively. At last, a comparison of alternative

RoF/PON photonic up conversion schemes is presented.

Proposal of adaptive wireless cell configuration for RoF-DAS over WDM-PON system

Author(s): Tatsuhiko Iwakuni; Kenji Miyamoto; Takeshi Higashino; Katsutoshi Tsukamoto; Shozo Komaki; Takayoshi Tashiro; Youichi Fukada; Jun-Ichi Kani; Naoto Yoshimoto; Katsumi Iwatsuki

Radio on fiber (RoF) - distributed antenna system (DAS) over wavelength division multiplexing - passive optical network (WDM-PON) with multiple - input multiple - output (MIMO) has been proposed as a next generation radio access network (RAN). This system employs optical time division multiplexing (OTDM) over one WDM channel to multiplex and transmit various types of wireless interfaces such as 3.9G, Wireless LAN and WiMAX. A combination of star and bus topologies has employed to cover a wider service area. The optical transmission loss is caused notably at remote base stations (RBSs) quipped on a WDM bus link. The loss is relatively small, but at the RBS far from the center station (CS), the RBS suffers the large accumulated loss, so the reduction of cell size provides the increasing of the number of RBSs, causes the degradation of the SNR of RoF link. This paper addresses this trade-off problem, and considers the application to the actual service area by the channel capacity investigation of RoF-DAS over WDM-PON with computer simulation. Then, this paper focuses on the flexibility of RoF-DAS over WDM-PON, considers the adaptive wireless cell configuration according to population fluctuations of day and night, or densely populated areas and sparsely populated areas, respectively.

QPSK modulation for AC-power-signal-biased visible light communication system

Author(s): Yu-Feng Liu; Chien-Hung Yeh; Chi-Wai Chow; Yang Liu

With the integration of light emitting diode (LED), visible light communication (VLC) can provide wireless communication link using the lightning system. Due to the consideration of power efficiency, AC-LED has the design of reducing energy waste with alternating current from the power outlet. In this work, we propose an AC-power-signalbiased system that provides communication on both DC-LED and AC-LED. The bias circuit is designed to combine ACpower signal and the message signal with QPSK format. This driving scheme needs no AC-to-DC converters and it is suitable for driving AC LED. Synchronization is completed to avoid threshold effect of LED.

Comparison of VLC-based indoor positioning techniques

Author(s): Weizhi Zhang; Mohsen Kavehrad

Indoor positioning based on visible light communication (VLC) technology has become a very popular research topic recently. This paper provides an overview of different VLC based indoor positioning techniques and their performance. Three schemes of location estimation together with their mechanisms are introduced. We then present a detailed comparison on their performances in terms of accuracy, space dimension and complexity. We further discuss a couple of factors that would affect the performance of each of these positioning systems, including multipath reflections and synchronization. Finally, conclusions and future prospects of research are addressed.

Demonstration of using digital FIR filter and matched filter to increase data rate in visible light communication

Author(s): Yu-Feng Liu; Chien-Hung Yeh; Chi-Wai Chow; Po-Yen Huang; Yang Liu

Using digital-filters in time domain are demonstrated to enhance the modulation-speed of 1 MHz bandwidth white LED communication. Digital FIR filter and matched filtering are used to reduce the inter-symbol-interference (ISI). Hence, 20-Mbps is achieved by using 4-ASK modulation.

Sensing RF signals with the optical wideband converter

Author(s): George C. Valley; George A. Sefler; Thomas J. Shaw

The optical wideband converter (OWC) is a system for measuring properties of RF signals in the GHz band without use of high speed electronics. In the OWC the RF signal is modulated on a repetitively pulsed optical field with a large wavelength chirp, the optical field is diffracted onto a spatial light modulator (SLM) whose pixels are modulated with a pseudo-random bit sequences (PRBSs), and finally the optical field is directed to a photodiode and the resulting current integrated for each PRBS. When the number of PRBSs and measurements equals the number of SLM pixels, the RF signal can be obtained in principle by multiplying the measurement vector by the inverse of the square matrix given by the PRBSs and the properties of the optics. When the number of measurements is smaller than the number of pixels, a compressive sensing (CS) measurement can be performed,

and sparse RF signals can be obtained using one of the standard CS recovery algorithms such as the penalized /1 norm (also known as basis pursuit) or one of the variants of matching pursuit. Accurate reconstruction of RF signals requires good calibration of the OWC. In this paper, we present results using the OWC for RF signals consisting of 2 sinusoids recovered using 3 techniques (matrix inversion, basis pursuit, and matching pursuit). We compare results obtained with orthogonal matching pursuit with nonlinear least squares to basis pursuit with an over-complete dictionary.

Overview of the performances of PMMA-SI-POF communication systems

Author(s): Stefano Straullu; Silvio Abrate

Poly-Methyl-MethAcrilate based optical fibers with Step-Index profile and 1 mm core diameter (PMMA-SI-POF) are widely deployed in automobile infotainment systems thanks to the MOST standards that adopt them as the preferred physical medium. However, thanks to their mechanical robustness and tolerance and their ease of installation, they make a suitable medium for local networking. Unfortunately, their good mechanical characteristics have to be paid in terms of performances, since PMMA-SI-POF based systems are severely limited in both bandwidth and attenuation. We will present a review of the best research results that have been obtained at the different speeds that are defined by the Ethernet standard: 10 Mb/s, 100 Mb/s and 1 Gb/s, showing that PMMA-SI-POF can easily overcome copper performances while being smaller, cheaper, easier to install in brownfield environment. To date, the following results have been obtained: 425 m at 10 Mb/s, 275 m at 100 Mb/s and 75 m at 1 Gb/s; these results have been obtained with commercial eye-safe components, and we believe that overcoming them requires in most cases the development of a new class of components. An overview of the different modulation formats that have been adopted, the most suitable equalization techniques and the best affordable components will be given. In the end, an overview of the current commercial systems performances and the road standardization procedures are taking will be given.

Precoding techniques for PAPR reduction in asymmetrically clipped OFDM based optical wireless system

Author(s): Bilal A. Ranjha; Mohsen Kavehrad

In this paper, we have analyzed different precoding based Peak-to-Average-Power (PAPR) reduction techniques for asymmetrically-clipped Orthogonal Frequency Division Multiplexing (OFDM) optical wireless communication systems. Intensity Modulated Direct Detection (IM/DD) technique is among the popular techniques for optical wireless communication systems. OFDM cannot be directly applied to IM systems because of the bipolar nature of the output signal. Therefore some variants of OFDM systems have been proposed for (IM/DD) optical wireless systems. Among them are DC-biased-OFDM, Asymmetrically-Clipped Optical OFDM (ACO-OFDM) [2] and Pulse Amplitude Modulated Discrete Multitone (PAM-DMT) [3]. Both ACO-OFDM and PAM-DMT require low average power and thus are very attractive for optical wireless systems. OFDM systems suffer from high PAPR problem that can limit its performance due to non-linear characteristics of LED. Therefore PAPR reduction techniques have to be employed. This paper analyzes precoding based PAPR reduction methods for ACO-OFDM and PAM-DMT. We have used Discrete Fourier Transform (DFT) coding, Zadoff-Chu Transform (ZCT) [8] and Discrete Cosine Transform (DCT) for ACOOFDM and only DCT for PAM-DMT since the modulating symbols are real. We have compared the performance of these precoding techniques using different QAM modulation schemes. Simulation results have shown that both DFT and ZCT offer more PAPR reduction than DCT in ACO-OFDM. For PAM-DMT, DCT precoding yields significant PAPR reduction compared to conventional PAM-DMT signal. These precoding schemes also offer the advantage of zero signaling overhead.

Minimalist-design, high-functionality, micro-ring resonator-based optical filter with narrow linewidth and low group delay using Looped Back Over- and Under-coupled Resonator (LOBOUR)

Author(s): Bo Ye; Benjamin B. Dingel; Weili Cui

We present a minimalist design but high functionality micro-ring resonator based optical filter with narrow linewidth and low group delay using a novel design we called LOBOUR for LOoped-Back Over- and Under- Coupled Resonator (LOBOUR). The characteristics of both narrow linewidth and low group delay (low chromatic dispersion) generally do not come together especially when using a single ring resonator. The Cascaded Over- and Under-Coupled Resonator (COUR) design was able to achieve this goal but introduced many practical fabrication issues. Here, we present an alternative design to COUR which uses only one ring resonator and without fabrication and manufacturing issues. It can achieve 50 dB extinction ratio and tens of ps performance. We also present important parameter selection mapping for LOBOUR.