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UWB wireless coexistence by fibre-based photonic ADC interference monitoring

Marta Beltran, Maria Morant, Joaquin Perez, and Roberto Llorente

Nanophotonics Technology Center, Universidad Politecnica de Valencia,
C/ Camino de Vera, s/n; Valencia, 46022, Spain

Phone: +34 963879768, Fax: +34 963877827, Email: {marbelra, mmorant, joapeso, rllorent}@ntc.upv.es

Abstract –The interference monitoring of UWB wireless picocell clusters through an in-house fibre installation is proposed and evaluated in a proof-of-concept experiment. UWB clusters enable range extension of UWB technology providing Gbit/s communications in home or office buildings. Coexistence of a large number of UWB clusters with other wireless services is guaranteed by a photonic analog-to-digital converter employing the in-house optical fiber installation.

Introduction – UWB technology targets low-cost short-range high bitrate applications like high-definition (HD) audio/video cabling replacement or wireless universal serial bus (USB) data transmission. A large number of HD audio/video link solutions based on UWB technology have been very recently reported [1]. UWB data transmission has been reported in point-to-point wireless communication at 480 Mbit/s bitrate [2], and has been further extended to 1 Gbit/s single user bitrate in record indoor demonstrations [3]. Several interesting characteristics are driving UWB market introduction: (a) The extremely low power spectral density employed, minimising interference; (b) The high spectral efficiency due to its carrier-less signal transmission; (c) Capability for providing more than 1 Gbit/s bitrate per user [4] in its actual implementation. UWB technology targets short-range communications with limited reach. Several technology demonstrations have been reported so far targeting to maximise the UWB reach, achieving 100 Mbit/s bitrate at 10 m [5] and 50 Mbit/s bitrate at 60 m range [6]. An UWB cellular architecture has been proposed in the European project FP7-ICT-1-216785 “UCELLS” [7] to provide indoor Gbit/s communications in wider areas employing standard low-cost UWB transceivers. The presence of a large number of UWB transmitters, despite its low average transmitted power, requires interference monitoring to guarantee coexistence due to the extreme bandwidth allocated in current UWB regulation, from 3.1 to 10.6 GHz [8]. Interference monitoring by a Photonic analogue-to-digital converter (Ph-ADC) employing the in-house standard single-mode fibre (SSMF) infrastructure is proposed in this paper.

UWB cluster Ph-ADC concept – Fig. 1 depicts the UWB cluster concept altogether the Ph-ADC infrastructure. Fig. 1 shows a set of UWB transceivers arranged in different UWB picocells which can establish peer-to-peer communications inside the cell between UWB transceivers or can connect to an UWB access node, if required. A large number of UWB transmitters in simultaneous operation are expected in the cluster arrangement.

Proper UWB cluster operation requires spectral coexistence in the UWB bandwidth (3.1-10.6 GHz). Coexistence requirements make necessary UWB spectrum monitoring. We propose a Ph-ADC to monitor the spectrum over the whole UWB band in real

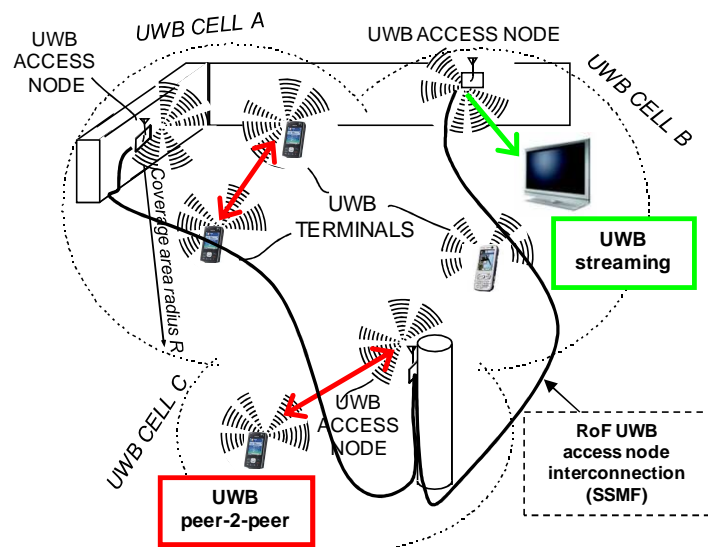


Fig. 1. UWB picocell cluster. The in-house RoF connects access nodes.

time. Ph-ADC spectrum monitoring advantages are: 1) Sampling the whole UWB band; 2) Dynamic range enough to accommodate UWB low-power signals in presence of high transmission levels from other wireless interferers; 3) Good spectral resolution, and 4) Feasible fast probing of the “air channel” due to its real-time implementation. The Ph-ADC is based on a radio-over-fibre SSMF infrastructure.

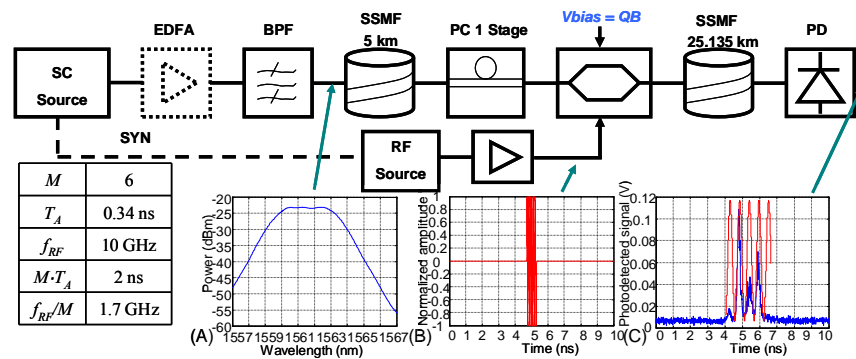


Fig. 2. Ph-ADC experimental set-up. The table contains system parameters used in the proof-of-concept experiment as well as measured pulsewidth and bandwidth of the stretched signal (C). SC: Supercontinuum, BPF: Bandpass filter, PC: Polarization controller, QB: Quadrature Bias, PD: Photodetector, SYN: Synchronization.

340 ps and chirped by propagation through 5 km SSMF fibre. Inset (A) shows the measured super-continuum (SC) spectrum (4 nm -3 dB BW), and Inset (C) shows the measured time-stretched RF signal superimposed to ideal stretched RF signal. The electrical UWB signal received from the antenna would be modulated by an electro-optical modulator on the chirped SC pulses. In the proof-of-concept experiment, the UWB signal is a RF pulse comprising 6 cycles 100 ps period, shown in Inset (B). The UWB modulated signal is time-stretched in a second spool of fibre (25.135 km) before photodetection. The UWB RF signal is effectively slowed down prior to its conversion, as shown in Inset (C). This optical process relaxes the requirements of the ADC required in processing; A stretch factor of 6 is achieved in the proof-of-concept experiment implying the whole UWB can be digitized using a 1.8 GSamples/s electronic ADC.

Conclusion – In this paper, a spectrum monitor based on a time-stretching Ph-ADC architecture has been proposed as a suitable approach for UWB monitoring in real-time employing an in-house radio-over-fibre infrastructure. This approach has been validated in a proof-of-concept experiment, in which the time-stretch of a 600 ps UWB pulse by a factor of 6 employing SSMF radio-over-fibre, and its further photodetection and capturing is demonstrated.

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Ph-ADC UWB monitoring proof-of-concept experiment

The Ph-ADC comprises two spans of fibre from the RoF links shown in Fig. 1. Fig. 2 shows the time-stretching Ph-ADC proof-of-concept experimental set-up. This set-up targets to demonstrate time-stretching Ph-ADC operation on UWB signals. Fig. 2 Inset (B) shows the ideal input UWB monopulse under analysis. Ph-ADC operation is as follows: The SC source generates optical pulses, which are stretched to