Joint Distribution of Polarization-Multiplexed UWB and WiMAX Radio in PON

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***Abstract*—In this paper, the feasibility of the joint distribution of ultra-wideband (UWB) and WIMAX wireless using polarization multiplexing as a coexistence technique is proposed and experimentally demonstrated within the framework of passive optical networks (PON). Four single- and orthogonal-polarization multiplexing schemes are studied targeting to reduce the mutual interference when UWB and WiMAX are distributed jointly through standard single-mode fiber (SSMF) without transmission impairments compensation techniques and amplification. Experimental results indicate successful transmission up to 25 km, in SSMF exceeding the range in typical PON deployments. The radio link penalty introduced by optical transmission is also investigated in this paper.**

***Index Terms*—Integrated optical-wireless access, optical fiber communication, polarization division multiplexing, radio-over-fiber, ultra-wideband radio, WiMAX radio.**

I. Introduction

PASSIVE optical networks (PON) are a fiber-to-the-home (FTTH) access technology of special interest nowadays under deployment around the world [1]. PON access the customer premises employing repeater-less optical power splitting and standard single-mode fiber (SSMF). PON technology is preferred when areas with a larger number of users must be served [2]. PON leads to a more economical network deployment than other point-to-point optical access technologies due to several factors. (i) Transmission impairments, such as group-velocity dispersion (GVD) or polarization-mode dispersion (PMD), are not required to be compensated in most cases [3]. (ii) User aggregation is done by passive splicing new fibers, giving more flexibility and scalability than optical access networks with in-line amplification, which would require careful network planning [4]. (iii) Fiber breaks can be easily repaired, reducing maintenance costs. Nevertheless, the straightforward implementation in PON leads to a reach limitation in the optical transmission since amplification, regeneration and impairment compensation stages are eliminated along the optical link. Typical PON reach distances have been reported to be around 20 km [5].

The distribution of wireless standards in optical access networks, known as hybrid fiber-radio access [6], is an interesting approach that exhibits several advantages. (i) Optical access networks are capable to distribute wireless radio at frequencies above 60 GHz if external modulation is employed [7]. (ii) No trans-modulation is required at customer premises since the wireless signal is transmitted through the optical path in its native format. (iii) No frequency upconversion is required at customer premises. The wireless signal is photodetected, filtered, amplified and radiated in order to establish the wireless connection. (iv) Optical access networks are transparent to the specific modulation employed. This flexibility is of special interest for operators as wireless standards and regulation evolve at a fast rate.

Regarding current wireless standards, UWB radio transmission technology has been proved to be adequate for the distribution of uncompressed high definition audio/video in hybrid fiber-radio networks [8]. UWB targets short-range high-bitrate communications, potentially exceeding 1 Gbit/s [9]. Moreover, UWB is receiving increasing interest because its low self-interference, tolerance to multi-path fading and potential low-cost characteristics [10]. In the near future it is expected the pervasive presence of UWB transmitters supporting a broad range of applications, from wireless computer universal serial bus (WUSB) to home multimedia wireless communication systems, such as wireless high definition multimedia interface (HDMI) [11]. UWB is defined as a radio modulation technique with 500 MHz of minimum bandwidth or at least 20% greater than the center frequency of operation [12]. The modulated signal is required to fulfill stringent equivalent isotropic radiated power (EIRP) limits. Two specific UWB implementations are mainstream nowadays: impulse-radio (IR-UWB), which transmits data by short impulses (monopulses), and orthogonal frequency division multiplexing (OFDM-UWB), which divides the UWB spectrum into 14 channels of 528 MHz bandwidth (BW). In this last case, each channel is occupied by one OFDM signal composed by 128 carriers, and each carrier can be QPSK- or DCM-modulated [13].

WiMAX, worldwide interoperability for microwave access, is a wireless transmission technology targeting medium- to long-range data communications at bitrates up to 12 Mbit/s [14]. WiMAX is expected to replace large wireless local-area

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network installations [15], e.g., University campus, commercial areas, etc. Comparing the bitrate and expected range, WiMAX and UWB are complementary radio technologies expected to coexist in a near future.

The transmission of UWB radio for audio/video distribution was first proposed for FTTH networks with optical amplifier sections in [8], where a single wavelength signal without polarization multiplexing is distributed per user. Since UWB can be regarded as a low cost technology, a reduction of the overall network deployment costs is expected. Another advantage arises from the use OFDM-UWB as defined in WiMedia UWB [13], which is especially well suited for uncompensated and unamplified PON. Nevertheless, OFDM-UWB and QAM-WiMAX modulation formats require higher linearity on the radio over fiber (RoF) distribution system [16] than less complex modulations, such as on-off keying (OOK) modulation. UWB and WiMAX coexistence on low-cost multi-mode fiber (MMF) was reported in [17] for indoor applications. In this case, a single wavelength signal without any polarization multiplexing technique was employed.

To the best of our knowledge, this paper proposes by the first time the joint distribution of UWB and WiMAX radio over SSMF employing a polarization-multiplexing scheme. Different single- and orthogonal-polarization schemes are proposed and analyzed aiming to minimize the UWB and WiMAX mutual interference when distributed through SSMF and no amplification or transmission impairment compensation techniques are employed. The experimental results indicate successful transmission up to 25 km in SSMF, which exceeds the range in typical PON deployments [5]. Moreover, the impact of the optical transmission in the radio path for this PON distribution system is also reported in this paper.

This paper is structured as follows. Section II describes the polarization multiplexing joint distribution of UWB and WiMAX concept. Section III presents the experimental results of UWB transmission on a single polarization wavelength. This is the baseline performance for further comparison. Section IV describes the polarization multiplexing technique proposed. Three polarization multiplexing schemes are considered in the experiments and their performance on the joint UWB and WiMAX RoF distribution measured. Finally, the main conclusions are drawn in Section V.

II. UWB and WiMAX Radio Distribution in PON

The proposed technique for joint UWB and WiMAX radio distribution in PON is depicted in Fig. 1. This figure shows a central node (central office, CO), which can generate standard UWB and WiMAX wireless signals, indicated as generic Wireless 1 and Wireless 2 blocks in the figure. These radio signals are typically converted to the optical domain by external modulation. Both optical signals, after polarization adjustment, are combined by a polarization beam splitter/combiner (PBS) and distributed through a SSMF-based optical access network to a given number of subscribers. At the subscriber premises, the optical signal is adjusted in polarization to match the slow and fast axis of a reception PBS in order to separate the two orthogonal polarizations. Once each polarization

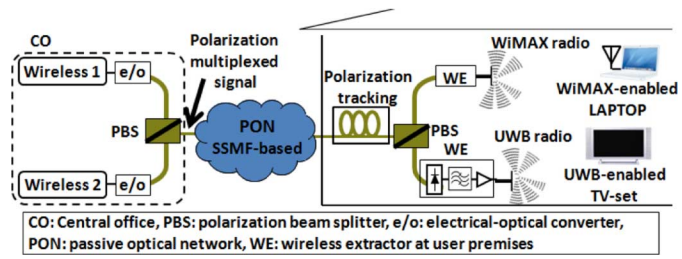

Fig. 1. Concept of joint wireless services distribution by polarization multiplexing in hybrid fiber-radio access on PON.

is splitted, the individual wireless signals are photodetected, filtered, amplified and directly radiated to the users present at the customer premises. This approach benefits from the high bitrate capabilities of UWB, supporting bitrates up to 1 Gbit/s at a few meters range [9], which can be extended to 30 m by multiple-input multiple-output (MIMO) processing [18]. Furthermore, the WiMAX radio complements UWB providing coverage to the whole home/building at a lower bitrate of 2 Mbit/s [14], [19].

The approach depicted in Fig. 1 permits a high spectral efficiency. Two polarizations are distributed per user, each one carrying UWB or WiMAX radio. Multi-user operation can be implemented by wavelength-division multiplexing (WDM) and/or sub-carrier multiplexing (SCM) techniques [20]. In our system, simultaneous UWB and WiMAX transmission in a single channel is analyzed for demonstration purposes. Both transmitted UWB and WiMAX signals are based on OFDM modulation with a spectral efficiency of 0.3788 bit/s/Hz and 0.634 bit/s/Hz, respectively. As shown in Section IV, this spectral efficiency is almost doubled when the polarization multiplexing technique is introduced.

III. Single Polarization UWB Distribution

Fig. 2 shows the experimental setup used to evaluate the performance of UWB radio distribution in PON SSMF path distances. The transmitted UWB signal follows the WiMedia OFDM-UWB standard [13]. This signal comprises two channels (generated by a Wisair DV9110 module) with 528 MHz bandwidth. Each channel bears one OFDM signal comprised by 128 QPSK-modulated carriers, 6 null carriers, and 12 pilot tones. The channel bitrate is 200 Mbit/s, providing an aggregated bitrate of 400 Mbit/s per user. Each channel is centered at 3.432 GHz (Ch 1) and 3.96 GHz (Ch 2), respectively (Fig. 3). The two UWB channels are modulated on a Mach–Zehnder electro-optical modulator (MZ-EOM in Fig. 2, $V_\pi = 4.5$ V) and are boosted by an optical erbium doped fiber amplifier (EDFA in Fig. 2, Amonics 30-B-FA) at the CO output and transmitted through 5, 10 and 25 km SSMF paths. These lengths correspond to the expected distances in PON access. The PMD effect associated to these SSMF lengths is negligible since the SSMF fiber used in this experiment shows a very low PMD factor (first-order approximation) of 0.08 ps/km$^{1/2}$. Other factors such as GVD and chromatic dispersion, reflected in the carrier suppression effect [21], are not limiting factors for the optical transmission distances under consideration. The OFDM-UWB signals are photodetected and amplified

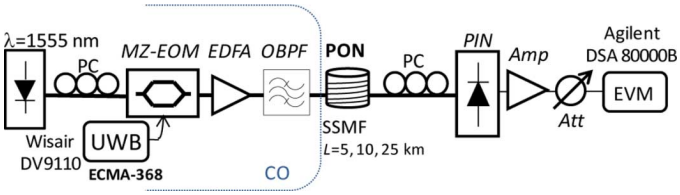

Fig. 2. Experimental setup for the performance analysis of UWB radio distribution on a single wavelength on SSMF at PON distances.

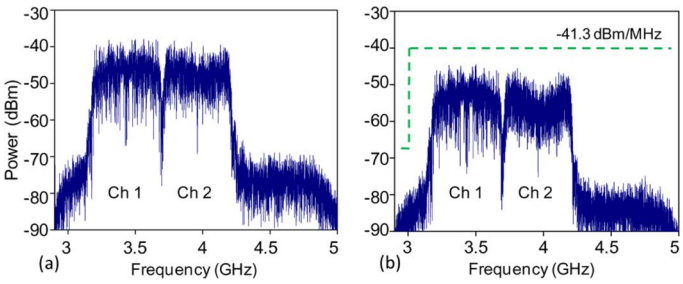

Fig. 3. PSD of the UWB spectrum distributed in single polarization, RBW = 1 MHz. (a) Before optical modulation. (b) After 25 km SSMF transmission, photodetection and amplification. The spectral UWB transmission PSD mask in current regulation [13] is depicted as a dashed line.

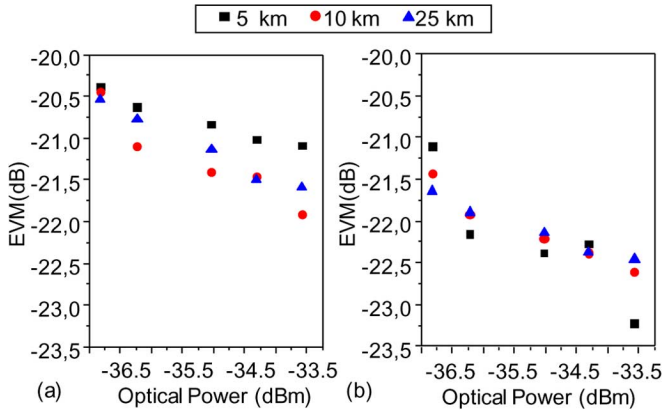

Fig. 4. UWB EVM versus fiber length transmission versus optical power before photodetection for (a) channel 1 and (b) channel 2.

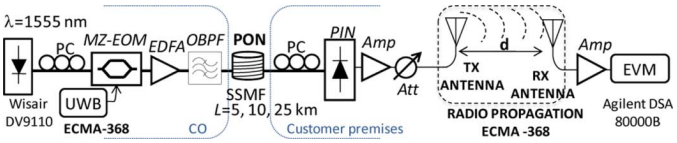

Fig. 5. Experimental setup for the analysis of UWB radio penalty introduced after 5 to 25 km SSMF optical transmission.

adjusting the EIRP to the −41.3 dBm/MHz level allowed in UWB regulation [12].

The error vector magnitude (EVM) is a figure of merit for assessing the quality of digitally modulated communication signals. EVM measurements have been performed on a digital signal analyzer (Agilent DSA 80000B) to evaluate the link degradation experienced by wireless services, in this case UWB, distribution over the system.

Fig. 3(b) shows the power spectrum density (PSD) of the two UWB channels where the degradation introduced by 25 km of optical transmission SSMF can be observed. It is important to point out that the received power meets in all the cases the PSD limit of −41.3 dBm/MHz, and the spectral mask in FCC regulation [12]. This guarantees that the received signal at costumer premises could be radiated just photodetecting, filtering and amplifying. The increase in the optical power at fiber distribution can be regulated using a variable attenuator, as shown in Fig. 2.

Fig. 4 shows the measured EVM for UWB Ch 1 and Ch 2 channels at different optical power levels measured at the PIN photodetector shown in Fig. 2. The EVM results shown in Fig. 4 indicate a soft EVM variation when the received optical power varies in the range under consideration. This UWB EVM variation ranges from −20.75 to −22 dB EVM for Ch 1, and from −21 to −23 dB EVM for Ch 2. The EVM results indicate the successful UWB transmission in the SSMF paths from 5 to 25 km, as EVM values are clearly below the −14.5 dB EVM UWB threshold defined in [13].

A. Radio Transmission Penalty

The impact of UWB distribution in SSMF on the radio path is evaluated in this section. This study aims to ensure that the fiber transmission at PON distances does not strongly affect the radio transmission. In this way, the received UWB signal could be radiated without special transmission impairments compensation algorithms in the OFDM modulation. The performance is studied measuring the UWB EVM at radio distances from 0 to 3 meters after optical transmission through SSMF spans of 5, 10, and 25 km.

Fig. 5 shows the experimental setup employed in this case including the radio transmission path previously discussed. After SSMF transmission, the level of OFDM-UWB signals is adjusted to the PSD regulated level of −41.3 dBm/MHz. Then, the UWB signal is photodetected, filtered, amplified and radiated by a 0 dBi gain omnidirectional antenna. This signal is detected with a 0 dBi antenna from the same model/manufacturer and its EVM is measured.

The EVM results are shown in Fig. 6. The EVM threshold limits the radio distance range after SSMF transmission to 1.5 m for Ch 1, after up to 10 km SSMF fiber propagation, or to 1 m for all fiber lengths. For Ch 2, the EVM threshold limits radio distance to 1 m in all SSMF paths. These distances are in line with the UWB performance, and hence, SSMF transmission does not strongly affect the radio range.

IV. Polarization Multiplexing Joint Distribution

Three different polarization strategies are analyzed for the joint distribution of UWB and WiMAX radio in this section. These strategies are depicted in Fig. 7(b)–(d). Fig. 7(b) shows the co-channel polarization multiplexing strategy where the UWB signal is allocated in the first and second UWB channels [13], marked as Ch 1 and Ch 2, and the WiMAX signal is distributed in the Pol. B shown in Fig. 7(a) at the center frequency of 3.5 GHz [22]. This is the most restrictive situation from the optical transmission point of view since UWB and WiMAX overlap in frequency but are transmitted in different polarizations. Three WiMAX bandwidths are considered (5,

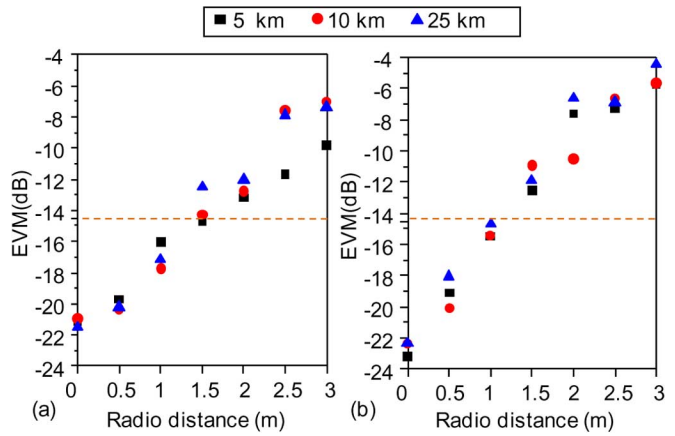

Fig. 6. UWB EVM versus fiber length versus wireless range for −34.305 dBm received optical power for (a) channel 1 and (b) channel 2.

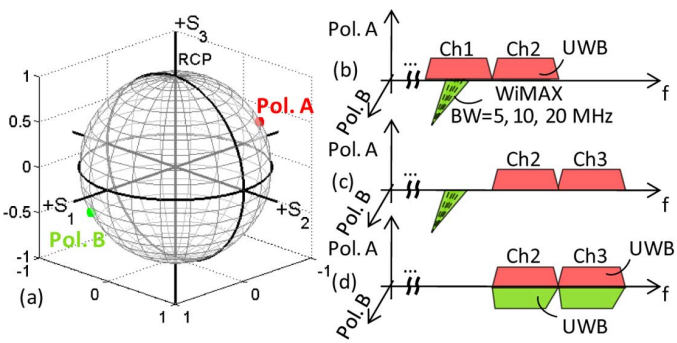

Fig. 7. (a) Orthogonal polarizations (measured) launched in the SSMF. (b) Co-channel polarization scheme. (c) Adjacent-channel polarization scheme. (d) UWB polarization multiplexing scheme.

10, and 20 MHz) in this case. The second strategy is shown in Fig. 7(c). Adjacent-channel polarization multiplexing. This approach is based on transmitting the UWB signal in the second and third UWB channels (Ch 2 and Ch 3). In this way, WiMAX and UWB mutual interference is reduced. The third case considered is when UWB radio is transmitted in both polarizations providing the maximum transmission bitrate of 800 Mbit/s per user. This approach is depicted in Fig. 7(d).

Fig. 8 shows the experimental setup employed for the polarization multiplexing transmission. Two different wireless services can be transmitted using the polarization diversity described in Fig. 7(a). The two generated signals, UWB or WiMAX, are modulated by a MZ-EOM at quadrature bias (QB) point. The UWB- and WiMAX-modulated optical signal at points (1) and (2) in Fig. 8, is adjusted with a polarization controller to linear-horizontal [LH, named Pol. A in Fig. 7(a)] and linear-vertical states [LV, named Pol. B in Fig. 7(a)], and combined by a PBS to generate the polarization-multiplexed (PM) signal. The PM signal is boosted by and EDFA (Amonics 30-B-FA) at the CO output and launched through SSMF ($L = 5$, 10, and 25 km). The EDFA output level remains constant to not improve the noise introduced by EDFA. However, the total optical power level in point (3) in Fig. 8 (optical launch power over PON) is adjusted with a variable attenuator from −3 to

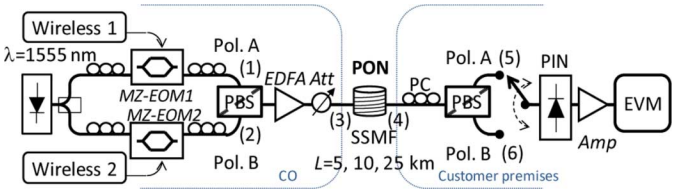

Fig. 8. Evaluation setup for optical polarization multiplexing distribution over PON links.

7 dBm, to investigate the PM performance from the customer point of view.

The PM signal is received at point (4) in Fig. 8, where the two polarizations are splitted, photodetected, filtered, amplified and should be radiated to the final user. No demodulation or upconversion stages are required with this technique. At the receiver, the state of polarization is manually adjusted by a polarization controller (PC). This controller would be an automatic polarizer stabilizer in an on-the-field deployment [23]. After the PC, a PBS resolves polarization A and B (Pol. A and Pol. B) at points (5) and (6), respectively. Each PM polarization signal is detected with a PIN photodetector (0.7 A/W responsivity), amplified and analyzed in order to evaluate the EVM of each signal.

A. Co-Channel Polarization Multiplexing

In this section, UWB and WiMAX distribution over a PON fiber deployment has been studied. The first case under study is in-band coexistence, where WiMAX and UWB signals coexist on the PON fiber deployment but they are transmitted over an orthogonal polarization in order to minimize mutual interference between them. The two orthogonal polarizations shown in Fig. 7(a) are employed in this case. The setup shown in Fig. 8 is used to analyze the co-channel polarization multiplexing scheme. Wireless service 1 (in Fig. 8) is a UWB signal that uses sub-band #1 and sub-band #2 (center frequencies of 3.432 GHz (Ch 1) and 3.96 GHz (Ch 2), respectively) and service 2 is a WiMAX signal operating in the 3.5 GHz band.

The setup for wireless service 1 comprises UWB multi-band-OFDM (MB-OFDM) signal generation by Wisair DV-9110 modules as described in the previous section. The UWB signal is generated following the WiMedia-defined UWB specification described in the ECMA-368 standard [13]. The wireless service 2 is a WiMAX signal that corresponds to a broadband wireless access (BWA) indoor terminal following IEEE 802.16e standard [14]. WiMAX utilizes scalable orthogonal frequency division multiple access (SOFDMA) QPSK modulation. The signal is centered at 3.5 GHz following the European regulation [22]. The main WiMAX signal parameters are summarized in Table I.

The WiMAX signal is synthesized by software (Agilent N7615B signal studio) and generated by a vector signal generator (Agilent ESG 4483C). Three possible bandwidths (5, 10, and 20 MHz) are considered in the transmission performance measurements.

Fig. 9 shows RF spectrum after 25 km SSMF transmission at point (5) and (6) of the setup depicted in Fig. 8. It should be noticed that rejection ratio between Pol. B and Pol. A of the PBS is around 30 dB. Fig. 9(a) is the RF spectrum with Pol. A that

TABLE I
WiMAX Signal Parameters

Center frequency	3.5 GHz		
Bandwidth	5 MHz	10 MHz	20 MHz
FFT-points	1024		
Subchannel spacing	5.46875 kHz	10.9375 kHz	21.875 kHz
Oversampling rate	24/28		
Guard period	1/8		
Symbol duration	182.86 µs	102.85 µs	57.14 µs
Modulation	QPSK (½ CTC)		
Downlink Data rate	3.17 Mbit/s	6.34 Mbit/s	12.68 Mbit/s

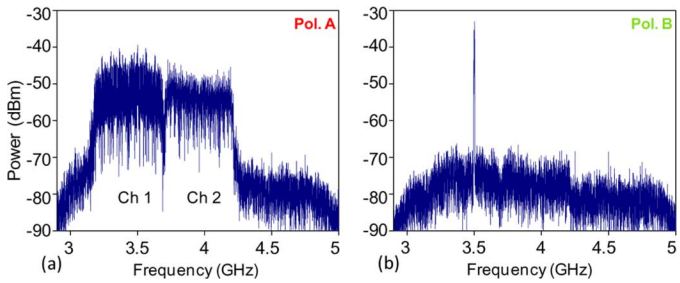

Fig. 9. RF received spectrum after 25 km SSMF transmission measured with in-band coexistence in (a) point (5) Pol. A, and (b) point (6) of Fig. 8 Pol. B. RBW = 1 MHz.

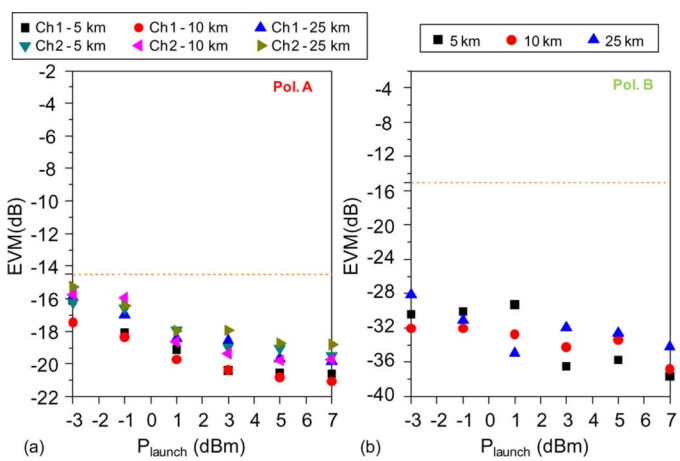

Fig. 10. EVM versus fiber length versus optical launch power for (a) UWB Ch 1 and Ch 2 in Pol. A, and (b) WiMAX (10 MHz BW) in Pol. B.

comprises a 400 Mbit/s aggregated MB-OFDM UWB signal. Fig. 9(b) shows the WiMAX 10 MHz bandwidth signal with Pol. B.

In Fig. 10, the EVM measured for each wireless service (UWB, WiMAX) and for each polarization (Pol. A, Pol. B) in the co-channel polarization multiplexing configuration is depicted. EVM results for UWB signal shows that at 25 km PON transmission, the UWB EVM threshold of −14.5 dB is always accomplished [13]. Therefore, as optical launch power over fiber increases, the UWB transmission quality is improved. The EVM results shown in Fig. 10(b) indicates that WiMAX distribution at 25 km PON distance is also feasible as the EVM −15 dB limit recommended in the standards [14] is always fulfilled in the experimental work.

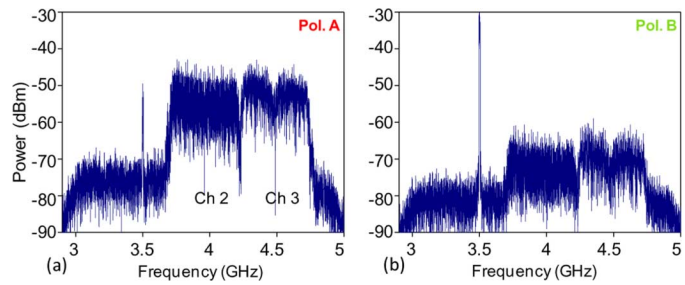

Fig. 11. RF received spectrum after 25 km SSMF transmission measured with out-of-band coexistence in (a) point (5) Pol. A, and (b) point (6) of Fig. 8 Pol. B. RBW = 1 MHz.

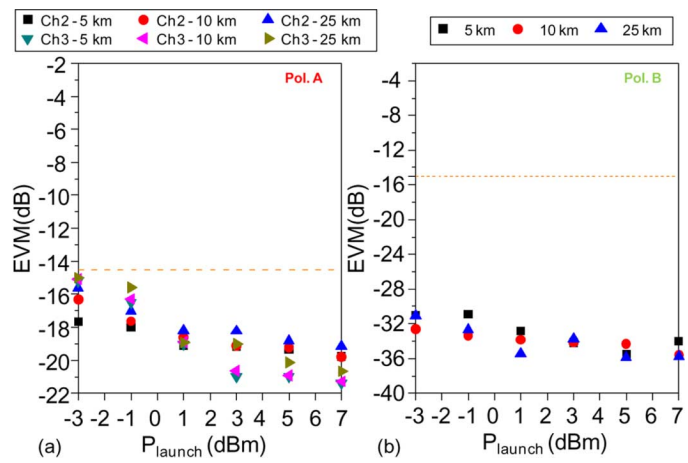

Fig. 12. EVM versus fiber length versus optical launch power for (a) UWB Ch 2 and Ch 3 in Pol. A, and (b) WiMAX (10 MHz BW) in Pol. B.

B. Adjacent-Channel Polarization Multiplexing

In this case, the adjacent-channel polarization multiplexing configuration already described in Fig. 7(c) is analyzed. In the setup shown in Fig. 8, the wireless service 1 is a UWB signal that uses sub-band #2 and sub-band #3 (center frequencies of 3.96 GHz (Ch 2) and 4.448 GHz (Ch 3), respectively) and the wireless service 2 is the WiMAX 3.5 GHz signal described in Table I. The two orthogonal polarizations shown in Fig. 7(a) are employed in this case.

Fig. 11 shows the RF spectrum after 25 km fiber transmission at point (5) and (6) of the setup. Fig. 11(a) shows the RF spectrum of the 400 Mbit/s MB-OFDM UWB transmission using Pol. A. It should be noticed that orthogonal polarization-multiplexed WiMAX signal appears as a cross-polarization residual crosstalk. Fig. 11(b) is the 10 MHz bandwidth WiMAX signal in Pol. B. In this case, rejection ratio between under-study signal and cross-polarization residual crosstalk is about 30 dB.

Fig. 12 shows the EVM measured for each wireless service for the adjacent-channel polarization multiplexing configuration. UWB (Pol. A) results are presented in Fig. 12(a) indicating that PON transmission at 25 km distance is feasible in all cases under study. However, for low optical power launch values, the EVM is close to −14.5 dB resulting in a poor transmission. On the other hand, WIMAX EVM results presented at Fig. 12(b) are always under the −15 dB EVM threshold in WiMAX, demonstrating the successful transmission.

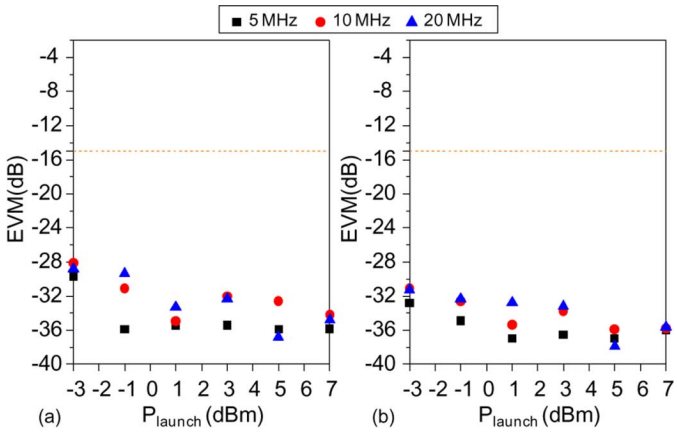

Fig. 13. WiMAX EVM versus WiMAX BW versus optical launch power at 25 km for (a) co-channel, and (b) adjacent-channel interferer case.

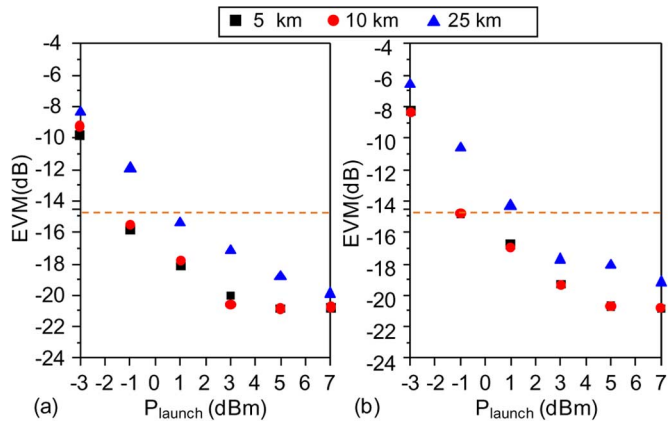

Fig. 14. EVM versus fiber length versus optical launch power when only one polarization is used for UWB (a) channel 2 and (b) channel 3.

In Fig. 13, the effect of different WiMAX BW on WiMAX EVM results is analyzed. Fig. 13(a) shows the co-channel configuration, and Fig. 13(b) the adjacent channel configuration WiMAX EVM measurements. These results confirm that adjacent-channel polarization multiplexing outperforms the co-channel polarization multiplexing scheme. this improvement is close to 2 dB EVM for each WiMAX BW. Otherwise, it should be noticed that EVM decreases with a larger WiMAX bandwidth. For example, the EVM value for WiMAX 5 MHz BW at -1 dBm optical power is close to -36 dB EVM, whereas for WiMAX 20 MHz BW at -1 dBm optical power is -29 dB EVM.

The study of the co-channel and adjacent-channel polarization multiplexing configurations indicates that PON distances of 25 km fiber transmission are feasible and that EVM values depend on optical launch power at fiber in all the cases. However, the adjacent-channel configuration outperforms co-channel configuration in terms of EVM. This is due to the residual polarization crosstalk, which appears in-band in the co-channel configuration. The same polarization crosstalk appears out-of-band in the adjacent-channel configuration, giving better performance. Comparing the EVM results with the single UWB distribution scheme presented at Fig. 4, the co-channel and the adjacent-channel PM configurations introduce an EVM penalty lower than 2.5 dB and 1.5 dB, respectively.

C. UWB Polarization Multiplexing

A dual-polarization multiplex with two UWB channels, of 528 MHz bandwidth each, is implemented and analyzed in this section. In this case, both wireless services 1 and 2, in Fig. 8, are generated by two full standard ECMA-368 OFDM-UWB signals, each comprising two channels using sub-band #2 and sub-band #3 (center frequencies of 3.96 GHz (Ch 2) and 4.488 GHz (Ch 3), respectively) at 200 Mbit/s per channel. Both services are modulated on the orthogonal polarization of this single wavelength signal as depicted in Fig. 8.

Fig. 14 shows the EVM performance when transmitting two MB-OFDM UWB channels using the same setup and the same fiber lengths but with only one polarization (no PM). In this case, the spectral efficiency is 0.3788 bit/s/Hz.

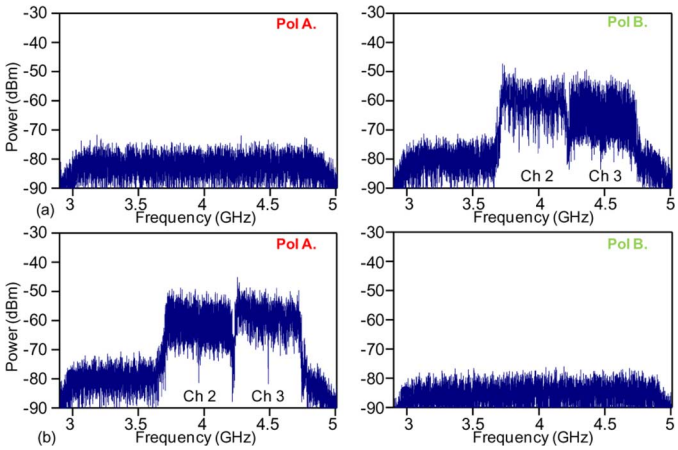

Fig. 15. (a) RF received spectrum after 25 km SSMF transmission measured in points (5) and (6) of Fig. 8, and (b) cross-polarization residual crosstalk, for Pol. A and Pol. B (top/bottom respectively). RBW = 1 MHz.

Fig. 15 shows RF spectrum after 25 km SSMF transmission at point (5) and (6) of the setup depicted in Fig. 8. Fig. 15(a) shows spectrums for UWB joint Ch 2 and Ch 3 Pol. B distribution configuration, whereas Fig. 15(b) corresponds to UWB Ch 2 and Ch 3 Pol. A distribution configuration. The cross-polarization residual crosstalk on the setup is around 30 dB for UWB Pol. B configuration distribution and 33 dB for UWB Pol. A configuration, as depicted in Fig. 15.

Fig. 16 shows EVM measurements for the received UWB signals using polarization diversity at points (5) and (6) in Fig. 8, achieving 0.7576 bit/s/Hz spectral efficiency. These results show the combined EVM for PM-UWB Ch 2 and Ch 3 after the SSMF links. EVM results indicate that both PM-UWB polarizations achieve the successful communication threshold of -14.5 dB EVM defined in ECMA-368 for distribution distances between 5 and 25 km for an optical launch power over 2 dBm at point (3) of Fig. 8.

Comparing the UWB EVM results using single polarization (Fig. 14), with the polarization-multiplexed approach (Fig. 16), it can be observed that the interference between orthogonal polarizations induces a maximum of 2 dB EVM penalty. The PM-UWB configuration doubles spectral efficiency, from 0.3788 bit/s/Hz to 0.7576 bit/s/Hz with a penalty of 2 dBm EVM.

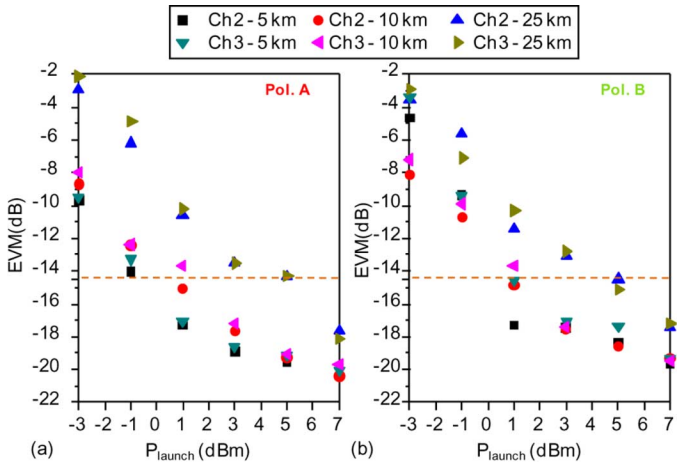

Fig. 16. EVM versus fiber length launch power versus optical launch power for joint PM-UWB Ch 2 and Ch 3 transmission for (a) Pol. A and (b) Pol. B.

V. Conclusion

In this paper, the feasibility of polarization-division schemes for the joint distribution of UWB and WiMAX radio has been evaluated considering four single- and orthogonal-polarization different schemes for the optical transmission co-existence.

First, a single-polarization UWB transmission with 0.3788 bit/s/Hz spectral efficiency is reported achieving 25 km reach with −21.5 dB EVM, which indicates the baseline performance. Second, the proposed co-channel polarization multiplexing scheme for UWB and WiMAX is measured. This scheme achieves 25 km reach with −17.5 dB EVM for UWB signal and −31 dB EVM for WiMAX signal. The UWB spectral efficiency obtained is 0.3788 bit/s/MHz. Third, the adjacent-channel UWB and WiMAX polarization multiplexing proposed scheme is demonstrated with 0.3788 bit/s/Hz spectral efficiency for UWB signal transmission. Adjacent-channel polarization multiplexing scheme achieves 25 km reach with −18 dB EVM for UWB signal and −32.5 dB EVM for WiMAX signal. Finally, the UWB orthogonal polarization multiplexing scheme is reported with 0.7576 bit/s/Hz spectral efficiency. This scheme achieves 25 km reach with 2 dB EVM penalty compared with UWB single-polarization distribution scheme.

The experimental results demonstrate the feasibility of the polarization-division technique proposed for typical PON distances. This technique enables the joint distribution of UWB and WiMAX. Adequate polarization tracking, photodection, filtering and amplification stages at the customer premises are required for on-the-field deployment.

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