ON THE INFLUENCE OF PULSED JAMMING AND COLOURED NOISE IN UWB TRANSMISSION

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ABSTRACT

This paper compares the performances of an ultra wideband (UWB) system in additive white Gaussian noise (AWGN) channel in presence of a pulsed jamming or a coloured Gaussian noise allocated in the UMTS-FDD (FDD = Frequency Division Duplex) uplink band. Several modulation schemes have been implemented in order to analyze the efficiency and the robustness of different UWB systems when the studied interferences are present in the channel. Results showed that the particular UWB modulation scheme chosen doesn't affect effectively the degradation of performances introduced by the interference, giving a precise rank order for the different UWB concepts. Nevertheless, due to the band allocation of the interference, the pulsed jamming source worsens the performance of the system more significantly than the coloured noise for low interference power. For high values, instead, the behaviour is inverted.

1. INTRODUCTION

Due to the very large bandwidth of UWB systems, the effect of the interference coming from other sources occupying a part of the UWB signal band is an important subject in order to test the reliability and the efficiency of those systems. In this paper, the influence of a pulsed jamming (PJ) and a coloured Gaussian noise (CGN) in some UWB transmission environments have been performed.

The baseband UWB system performances are based on different modulation schemes in AWGN channel in the presence of interference. The UWB systems in the study are based on time hopping (TH) and direct sequence (DS) concepts [1].

In TH-mode the pulse transmission instant is defined by the pseudo random (PR) code. One data bit is spread over the multiple pulses to achieve a processing gain due to the pulse repetition. The processing gain is also increased by the low transmission duty cycle. In DS-mode a pseudo random code is used to spread the data bit into multiple chips like in conventional DS spread spectrum systems still having a chip waveform with a UWB spectrum.

In the study, several modulation techniques have been implemented. Binary amplitude modulation (BPAM) is performed in both TH and DS concepts. On the other hand, due to their intrinsic characteristics, pulse position modulation (PPM) has been implemented only for TH, and on-off keying (OOK) is used only in DS mode [2].

2. SYSTEM ENVIRONMENT

In order to have a fair comparison of the performance results, both the PJ and CGN sources have been given the same spectral allocation, in the UMTS-FDD uplink (UL) band which is located between 1.92 GHz - 1.98 GHz [3].

The pulsed jamming is modelled using a truncated sinc-pulse waveform that generates a rectangular spectrum in the assigned frequency band. The signal energy is evenly spread over the 60 MHz UMTS band [2].

The second interfering model is based on the generation of a coloured Gaussian noise in order to perform an interfering source in the band of interest. The CGN is obtained by filtering white Gaussian noise using a raised cosine waveform.

For the PPM modulation scheme, the optimum time shift (modulation index) [2] between the two data waveforms has been chosen in order to obtain the best performances for this modulation scheme in an AWGN channel.

3. SIMULATION RESULTS

In this chapter the simulation results for the UWB system performances in AWGN channel in the presence of jamming and interference are given. Bit error rates are studied as a function of signal-to-noise-ratio (SNR) and as a function of interference-to-signal power ratio (ISR).

During the simulations the signal power is fixed to 0 dBm and the UWB system processing gain is fixed to 20 dB. In TH-mode, 10 dB of the total processing gain is coming from the low duty cycle, and 10 dB from the pulse integration (pulse repetition). The processing gain in DS-UWB comes only from the pulse integration. When bit error rate (BER) is studied as a function of interference or jamming to signal ratio, the SNR is fixed to 8 dB. A summary of the main simulation parameters is depicted in Table 1.

***Table 1**. Simulation parameters.*

Parameter	Characteristics
Interference frequency band	1.92 – 1.98 GHz
Interference bandwidth	60 MHz
Pulsed jamming source (PJ)	Sinc waveform
Noise interfering source (CGN)	Coloured Gaussian Noise
Total average power for PJ or CGN	10 dBm
Data modulation schemes in UWB systems	DS-BPAM TH-BPAM TH-PPM DS-OOK
Radiated pulse waveforms	The 1^{st} and the 2^{nd} derivatives of the Gaussian pulse
UWB pulse lengths	0.5 ns, 1.0 ns, 1.5 ns

Corresponding BER simulations as a function of SNR in the UMTS FDD-UL band are represented in Figures 1a and 1b. The studied radiated pulse waveforms are related to the 1^{st} derivative of a Gaussian pulse. The power of the two interfering sources is fixed at 10 dB. From the Figure 1a it can be easily noted that the CGN gives better performances for both DS- and TH-BPAM schemes compared to PJ. On the other hand, in Figure 1b the same behaviour explained above can be seen only for the curves related pulses having pulse width t_p = 0.5 ns, while for the ones having t_p = 1.5 ns, no evident difference can be noticed between the two interfering models. This is due to the fact that the spectral allocation for that longer pulse avoids the interfering band defined in this study. Thus, neither the PJ nor the CGN source can worsen the performances of that UWB system. In BER point-of-view the rank order for the different UWB concepts is TH-BPAM, DS-BPAM, TH-PPM and DS-OOK. This is valid for both the interfering sources, although in the CGN case the difference in performances between TH- and DS-BPAM is negligible.

In Figures 2a and 2b BERs are presented for the first two Gaussian derivatives as a function of the interference-to-signal power ratio (ISR). In all the modulation schemes implemented, the performances of the UWB systems are better in case of CGN interference for low values of ISR, while the situation becomes the opposite when the ISR is high. However, the reciprocal performances of the different modulation schemes remain almost unchanged in all cases, meaning that this behaviour is strictly related to the interfering band allocation. A future work is already planned in order to analyze the performances of UWB systems in presence of interfering sources having a variable interfering band allocation. That study will also deal with the influence of the interfering sources as a function of their power.

Finally, it is important to note that, depending on the used UWB pulse waveform and its pulse width, the spectrum of the transmitted UWB signal is moving along the frequency axis. Thus, the system performances are subject to change depending on the frequency allocation of both the UWB signal and the interference.

4. CONCLUSIONS

This paper presents the performance comparison among different UWB modulation schemes in presence of two kinds of interference sources in AWGN channel.

The reciprocal performances of the different UWB modulation schemes are not affected by the interfering source present in the channel. Then, the rank order for the different UWB concepts is TH-BPAM, DS-BPAM, TH-PPM and DS-OOK. Nevertheless, the influence of the PJ interference model gives worse performances for low values of ISR, while for high values the CGN source prevails in deteriorating the UWB transmission. This effect is strictly related with the fixed band allocation chosen for the interfering signal and its influence on the UWB transmitted waveform.

5. ACKNOWLEDGEMENTS

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References

[1] M. Hämäläinen, J. Iinatti, V. Hovinen, M. Latva-aho, “In-band Interference Power Three Kind of UWB Signals in GPS L1-Band and GSM900 Bands,” in *Proc. IEEE PIMRC2001 Conf.*, 2001, pp. D 76-80.

[2] M. Hämäläinen, R. Tesi, J. Iinatti, V. Hovinen, ”On the Performance Comparison of Different UWB Data Modulation Schemes in AWGN Channel in the Presence of Jamming“, submitted to RAWCON 2002.

[3] H. Holma, A. Toskala (eds.) *WCDMA for UMTS: Radio Access for Third Generation Mobile Communications*. John Wiley & Sons, 2000.

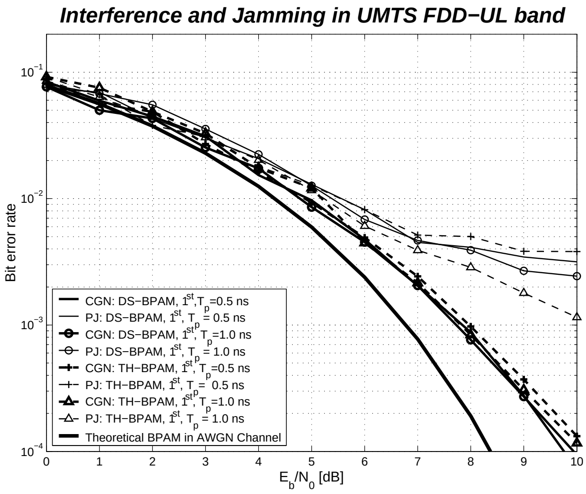

Figure 1a. *BER for TH- and DS-BPAM based UWB systems with ISR = 10 dB.*

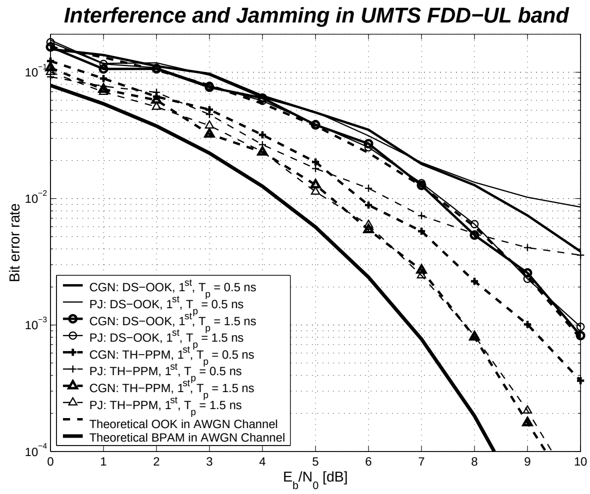

Figure 1b. *BER for TH-PPM and DS-OOK based UWB systems with ISR = 10 dB.*

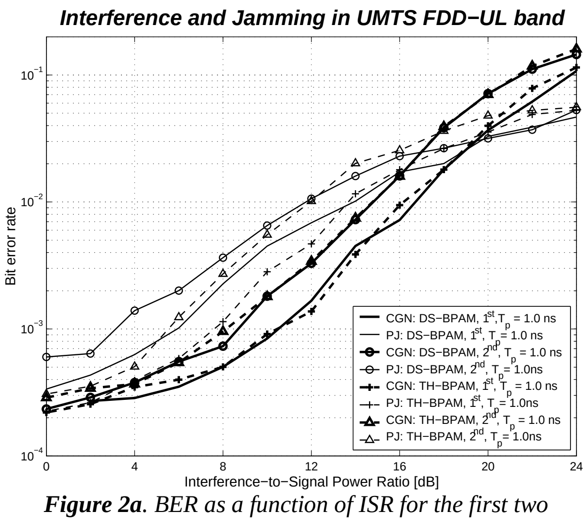

Figure 2a. *BER as a function of ISR for the first two derivatives of a Gaussian pulse for BPAM.*

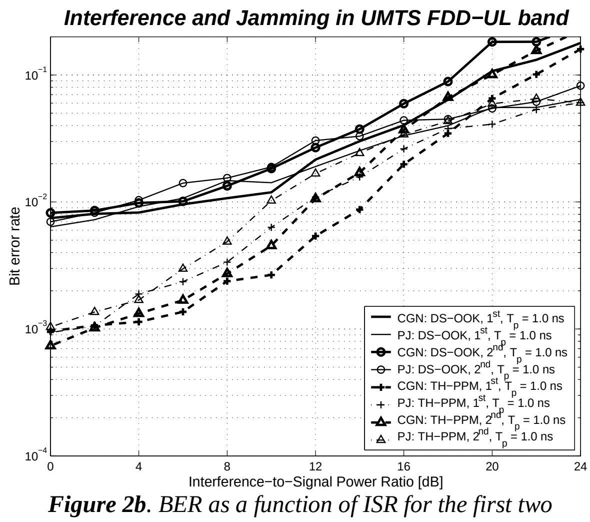

Figure 2b. *BER as a function of ISR for the first two derivatives of a Gaussian pulse for PPM and OOK.*