WIRELESS OPTICAL SPREAD SPECTRUM COMMUNICATIONS. DATA SECURITY IMPROVEMENT IN WIRELESS LINKS

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ABSTRACT

This paper introduces new techniques for improving the security level of the wireless optical systems. In this way, we are going to use modulation schemes based on spread spectrum theory. These techniques had been developed for military applications in order to obtain reliable and secure communications, so they seem to be a good candidate for our systems. Spread spectrum systems perform a data encryption in the modulation process, and they are able to work in presence of high level interference and intentional jamming signals. On the other hand, these schemes can be also applied to optical barriers and perimeter control systems, because the spread spectrum signal improves the robustness and invulnerability of the security barriers.

1. INTRODUCTION

From security point of view, transmission media are the most vulnerable points of data and control networks, mainly in the case of wireless communications, as we deal with a totally incontrollable and accessible media. In this work, different transmission and modulation techniques for wireless communications security and integrity are presented, proposed systems are based on infrared radiation and wireless optical systems. These systems have some characteristics, which improve the link security. Firstly, optical radiation is confined for the room walls, so there is no radiation outside. This is an important difference from radio systems, easily detected from external reception equipment. Secondly, for outdoor links, wireless optical system can assure confidentiality by means of the reduction of emitters and receivers radiation patterns in a very simple and cheap way.

Wireless optical spread spectrum systems [1] consist of conventional wireless optical communications devices with an additional circuitry, which performs the processes associated to the spreading techniques. Therefore, the presented prototypes introduce new interesting capabilities, but they are simple to implement and have low cost.

Wireless optical systems present different configurations [2], as can be seen in figure 1. Diffuse links allow communications from any point of the room. Point to point links need an accurate alignment between emitter and receiver. This is the most secure configuration because communications are very difficult to intercept. Finally, quasy-diffuse links are an intermediate environment, where transceivers have to be oriented to a common reflection area.

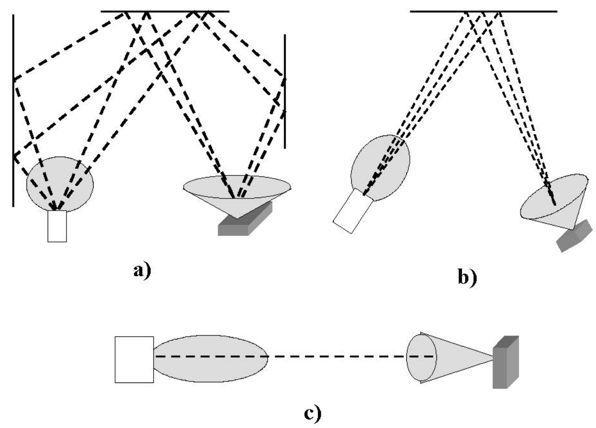

Figure 1. Wireless optical links configurations: a) diffuse, b) quasy-diffuse, c) point to point

As we said below, by means of spread spectrum techniques we introduce a code in the modulation process [3]. This code makes more difficult the access from external agent to the transmitted data, as these agents do not know the code. In this work we present two different alternatives for using spread spectrum system in the wireless optical links.

2. SYSTEM DESIGN

2.1. Direct Squence Spread Spectrum (DSSS)

This kind of systems uses the code signal as a special random carrier of the data. The basic scheme is shown in figure 2.

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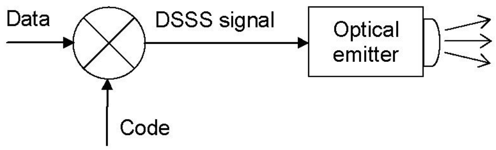

Figure 2. DSSS modulation

In figure 3 we present the general scheme of a optical DSSS receiver. It mainly consists in a multiplier (as in transmission) and a synchronization recovery block which assures that the code signal is a exact replica of the code signal used in the modulation process.

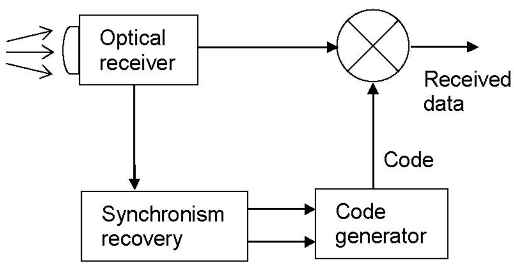

Figure 3. DSSS demodulation

Figure 4 shows a prototype implemented for DSSS optical communications that follows the proposed schemes. It is based on programmable logic devices and discrete analog circuits. The DLL (Delay Locked Loop) and SSC (Sliding Series Correlator) blocks perform the synchronization process and they are the most complex blocks of the system.

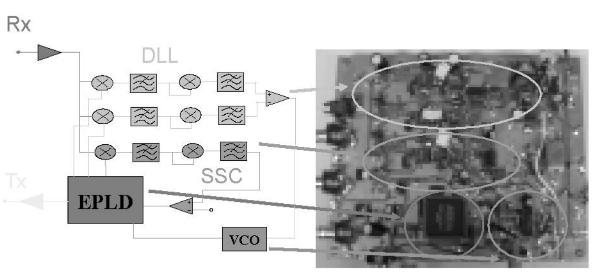

Figure 4. DSSS transceiver

In this work we also propose a new synchronization scheme that introduces a significant complexity reduction in the receiver. Proposed techniques are based on pilot signals, which make easier and more reliable the synchronization process and improve the spread spectrum receiver performance. This pilot signal consists on a square signal (digital carrier) at a frequency multiple of the code rate [4]. Besides, it is phase modulated (BPSK, Binary Phase Shift Keying) by a square signal with a period of twice the codeword length [4]. In this way we have information about both code frequency and phase, necessary for generate an exact replica of the code in the receiver.

The synchronization stage is then reduced to a simple BPSK receiver to extract a flag indicating the starting point of the code signal and the digital carrier. These outputs are used for generating the code in the receiver in order to be correlated with the received signal. The simplified blocks diagrams of the pilot generator and receiver are shown in figure 5.

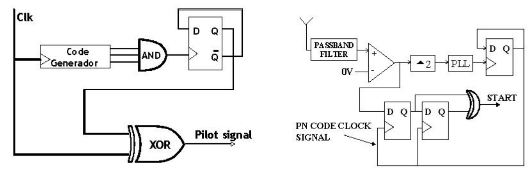

Figure5. Pilot signal generator and recovery block diagrams

2.2. Frequency Hopping Spread Spectrum (FHSS)

Frequency Hopping Spread Spectrum (FHSS) is a more complex option, because it uses the code signal to determinate the frequency of the transmitted data carriers. In figure 6 we can see the block diagram of a FHSS sistem where the pilot signal is included.

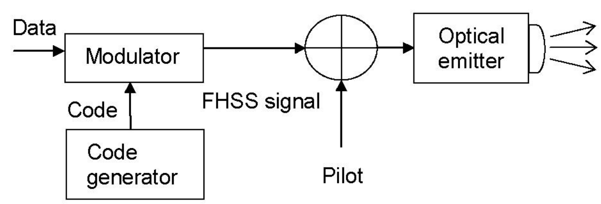

Figure 6. FHSS modulation

In figure 7 we present the general scheme of a FHSS receiver. This diagram shows the synchronization blocks, which are critical for the correct reception process.

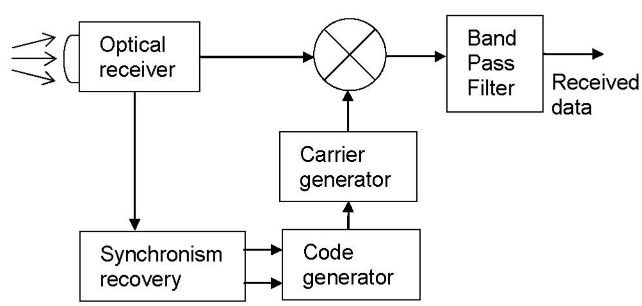

Figure 7. FHSS receiver

3. RESULTS

As we have said before spread spectrum systems introduce a codification in the transmitted signal. For the proposed systems in this work we have two possibilities. First, a base band codifications in the case of DSSS are shown in figure 8.

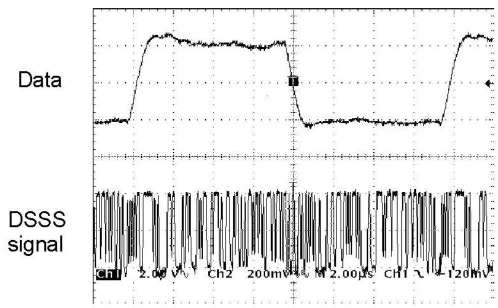

Figure 8. DSSS data signal codification

On the other hand, a frequency codification is possible in FHSS systems, as we can see in figure 9. In this figure we can also appreciate the pilot signal corresponding to the proposed synchronization technique.

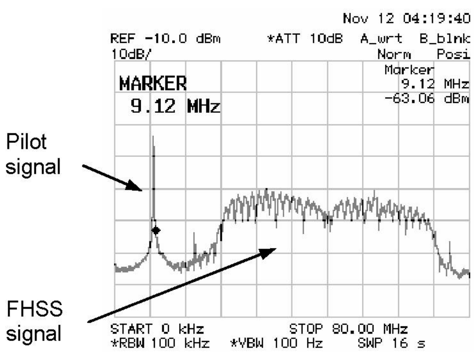

Figure 9. Power Spectral Density of pilot signal and FHSS signal

Furthermore, spread spectrum systems also reduce interference. As an example of this, we present in figure 10 a fluorescent light interference and the reduction effect produced by a DSSS receiver. As we can see the interference level have been reduced considerably.

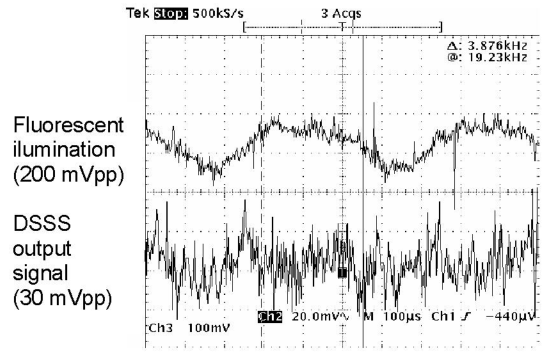

Figure 10. Fluorescent illumination interference reducction

4. CONCLUSIONS

As summary, this work presents some systems to improve the security level of the wireless optical links. In this way, we have introduced modulations schemes based on spread spectrum techniques. The main advantages of these wireless spread spectrum systems are the introduction of a codification of data in the modulation process, and the rejection to interference and intentional jamming, and its capability of sharing the media with other optical systems without disturbing them. Besides they are robust to the optical multipath distortion, present in indoors environments.

5. REFERENCES

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