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Waveform Conformation in DSSS Systems for Wireless Optical Diffuse Indoor Data Communications

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Abstract: In this work, we study the effects of signal conformation over Wireless Optical DSSS systems.. We study the effect of conformation over the data signal, the code or the spreaded signal, Results show that these techniques produce an improvement on the process gain without a substantial reduction of performance

1.Introduction

Wireless Communications between portable devices, and wireless in-house communications in general, have been intensively studied in the last years. This interest has produced two main technologies for data transmission: Radio-frequency systems present a robust technology and wide operating zones, but they require legal procedures for frequency assignment and the cost of the devices can be high. On the other hand, optical communications systems are becoming more and more important for in-house wireless communications. They lack of for short operating areas but they provide high transmission speeds with low cost and size, making them suitable for integration on nearly all system, (including very small calculators or mobile telephones). Other important advantages for wireless optical networks are reduced installation complexity and high security versus intruders.Kahn has studied extensively [1] high-speed optical wireless. Spread Spectrum (SS) techniques[2] have been also used in order to improve the optical link characteristics in wireless communications [3,4].

In this work, we study the use of conformation techniques on Direct Sequence Spread Spectrum (DSSS) systems. This study is based on baseband, intensity modulated optical communications. We follow a guideline of studies over signal conformation for other modulation families as QAM, QPSK or GMSK [5] [6]. These results should can be directly applicable to ASK or PSK modulated radio-frequency systems..

2. DSSS systems over the optical infrared channel

As is well known, wireless diffuse optical channels present some different characteristics compared with the radio-frequency ones. First of all transmission losses are bigger than in radio-frequency , due to the electro-optical conversion of optical power into electrical current in optical receivers. Optical channels are also affected by several additional sources of noise [1]. They include radiation from natural an artificial illumination, introducing important interference signals. Indoor optical diffuse communications channels are also severely affected by multipath propagation. It is produced by the multiple reflections in walls and others obstacles of the transmitted signal. This phenomenon produces dispersion on the channel time-response, and inter symbol interference .

The use of SS signals introduces some advantages that can improve the performances of a wireless optical communications system. SS systems have a large narrowband interference signals rejection capability when these interferences are incorrelated with the spreaded data signal[7]. Some interferences in the infrared optical channel (as those produced by illumination or infrared remote controls) can be considered narrowband interferences. Another improvement introduced by SS techniques is the reduction over the multipath propagation effect. SS also allow several users to share the same channel at the same time and in the same frequencies, by means of Code Division Multiple Access (CDMA). All the advantages explained are lacked by the higher bandwidth required by SS schemes compared with conventional ones. If we use a traditional optical communication system we will be able to transmit higher bit rates, but using equalization stages [8].

3. Pulse Conformation in optical DSSS systems

Modifications over the waveform of a signal can be studied as a type of filtering. The signal conformation pursues to reduce both bandwidth and power consumption. There are several possibilities in the conformation process of DSSS signal, as can be seen in table 1.

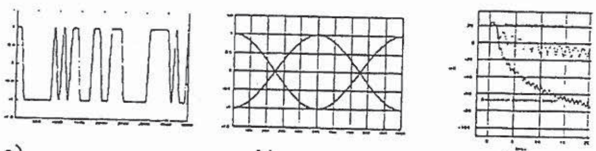
	Data	Code	Modulated signal
CONFOR.	YES	NO	NO
	NO	YES	NO
	NO	NO	YES
	YES	YES	NO

Table 1. Conformation possibilities

The conformation processes presented in this paper are obtained from those used on well-known modulation schemes, as could be FQPSK [9].

3.1. Sinusoidal Conformation

It consists in the substitution of the abrupt transitions between the transmission level of 1's and 0's by smother curves. They follow a sinusoidal function. In figure 1a we show the results over square pulses. Figure 1b shows the corresponding eye diagram. The comparison between the spectral power density of the conformed and not conformed signals is shown in figure 1c.



a) b) c)

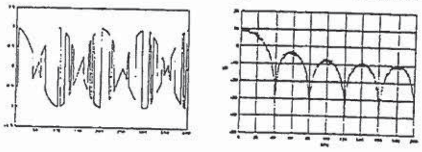
Figure1. Sinusoidal-conformed pulses

Filtered signal presents a reduction in its high frequency components, in comparison with the square pulse signal. Results of conformation of different DSSS conformation schemes obtained for each case on table 1 are shown below.

3.1.1 Data conformation

If we conform the data signal and using a non-conformed signal as spreading code, the resulting DSSS modulated signal and its spectral power density are represented in figure 2.

Figure 2. DSSS modulated signal for data conformation



As code signal is not conformed, its spectral components are unmodified, but data signal has a bandwidth reduction. This fact produce a the process gain (Gp)[10], whose expression is given in (1):

$$Gp = \frac{BW_{SD}}{BW_{DAT}} \qquad (1)$$

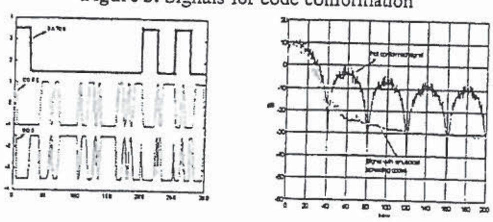
The Spreaded Signal bandwidth (BW_{SD}) can be considered to be equal to the code signal bandwidth. BW_{DAT} is the data signal bandwidth. As the data bandwidth has been reduced by conformation, we have higher process gains. The higher Gp the lower the signal to noise ratio (S/N), necessary for a correct demodulation in presence of narrow band interference.

Other advantage of conformed signal is the reduction of the high frequency components on the modulated signal. This produces an important reduction of the adjacent carrier interference (ACI) The simulation results were obtained from a 4 Mbps data signal and an 80 Mchips/s code signal. For not conformed signals the obtained process gain were Gp=20 (13dB) while for sinusoidal data conformation it was improved to 27 (14.3dB).

3.1.2 Code pulse sinusoidal conformation

Figure 3 shows the time and spectral representation of the conformed-code DSSS signal.

Figure 3. Signals for code conformation



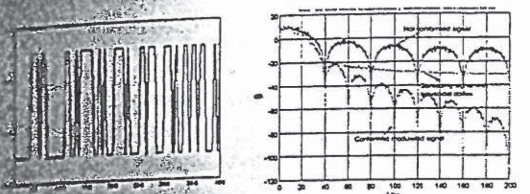
As it can be seen, the modulated signal presents some glitches, produced by simultaneous transitions in code and data signals.

In the SPD of the spreaded signal a high frequency components reduction have been produced, higher than for data conformation., It also improves the system ACI. But as the conformed-code signal bandwidth has been reduced while the data signal bandwidth is unmodified, the Gp value is reduced.

3.1.3 Sinusoidal conformation of the spread signal

In this point, we take the product of the data and code signal , and then we conform the resulting signal. It is presented on figure 4.

Figure 4. Conformed Spread signal,time and spectral representation

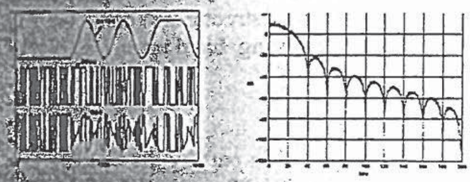


This scheme avoids glitches and the high-frequency component reduction is the highest of these three cases.

3.1.4 Sinusoidal conformation of the code and data signals

In figure 5 we show the resulting signals

Figure 5. Signals for code and data conformation Modulated signal SPD

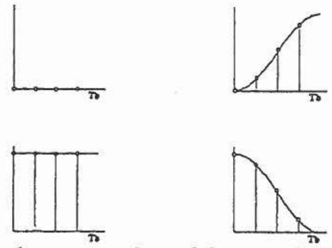


They both are similar to the data conformation [illegible]

In all cases, we have simulated the reception process with perfect synchronization of code signal. . In real systems, with real synchronization stages, the variations in the spreaded signal envelope can produce malfunctions in both acquisition and tracking processes of the receiver. These envelope variations will appear in [illegible] of data or code conformation, while for code conformation will also appear glitches in the spreaded signal. On the other hand, conforming both code and data will mean cost and complexity increase, because of the need of two codification modules. This complexity increase does not produce a proportionally [illegible] performance improvement. Therefore, the [illegible] conformation solution for us is the spreaded signal conformation, as it reduces the modulation bandwidth, [illegible] complexity to only one conformation module [illegible] synchronization stages in the receiver will not [illegible] modifications.

4. Conformation procedure

We have selected a digital implementation of waveforms generated in the conformation processes mentioned before. In this way, it is necessary to know the output curves of the conformation filters in order to quantify and store them in look-up tables. The conformed signal generation consists in a selection of the corresponding curve to put in the output and then, a



digital to analog conversion of the samples of that curve from the look-up table values.

Sinusoidal conformation consists in the substitution of transition slopes for sinusoidal function. In this way, only four curves have to be storage in the memories. Those curves are shown in the next figure.

Figure 6. Sinusoidal conformation curves

For 0-1 and 1-0 transitions we use two different sinusoidal functions and for no transition (0-0 and 1-1) we have to select from another to function. Time duration of each function is the same as the pulse interval (bit or codes pulses).

We have to study the input sequence in order to select, in each time interval, what function have to be put in the conformation output. In this case, it is necessary to analyze the value of two consecutive bits and select the function that determines the following table.

Before Bit	Following Bit	Function
0	0	Low level
0	1	Up sinusoidal
1	0	Down sinusoidal
1	1	High level

Table2. Curve selection logical function

So the correct function can be selected with a very simple logic circuit. It are composed by a flip-flop that implement a serial to parallel conversion of every two consecutive bits, as is shown in the figure 7.

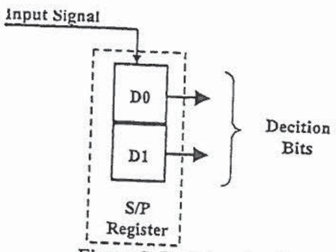


Figure 7. Decision circuit

The next step in conformation is the addressing in the look-up table, of each sample of the selected function. In order to simplify this process we can distribute the memory in four zones, which contain the samples of each function. In this way it is possible to implement an indexed addressing, the base direction determines the function to implement and the offset address each sample of that function. This is represented in the figure.

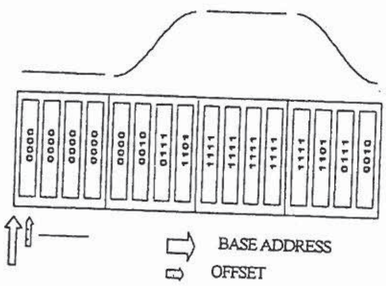


Figure 8. Indexed adressing

This system is implemented as follows: base direction is obtained from the decision circuit and a two bits counter generates the offset, as shows the following graphic.

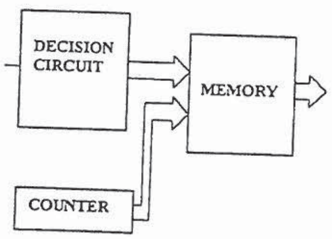


Figure 9. Look-up table control circuit

Conformation digital implementation allows the use of the same circuit to perform conformation for any frequency of the input sequence. We only have to change the system clock of the conformation circuit in order to accept the new sequence rate. The conformation circuit general scheme can be see in the figure below.

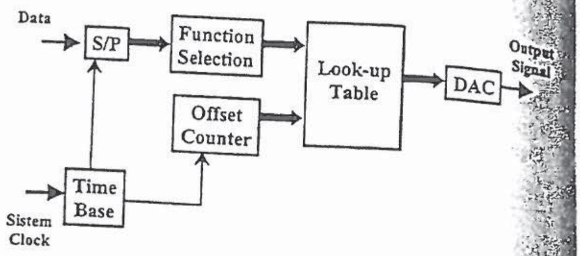


Figure 10. Digital conformation circuit

8. Conclusions

The use of conformation techniques for DSSS systems, introduces some advantages, as a lower bandwidth and power consumption. On the other hand, conformation requires more complex circuits. These modules have to be incorporated in the transmission devices, but not in the receivers, which does not require further modification to work. The conformation process is implemented by full-digital circuits. These circuits avoid the use of analog filters or expensive digital signal processors . They only need a logic decision circuit, a look-up table memory.and a digital to analog converter. All these structures can be easily implemented at our working baud rates.

Acknowledgements

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References

[2] J. M. Kahn, et al., "Non-Directed Infrared links for High-Capacity Wireless LANs", *IEEE Personal Communications*, Second Quarter 1994.

[1] R. L. Pickholtz, D. L. Schilling and L. B. Milstein, "Theory of Spread-Spectrum Communication", *IEEE Transactions on Communications*, vol. Com-30, n°.5, may 1982.

[3] F. Delgado et al. , *"Design of a FFFH-SS for wireless infrared communications"*, submitted to IEE Electronics Letters.

[4] R. Vento, J. Rabadán, R. Pérez-Jiménez, A. Santamaría, F. J. López-Hernández, "Experimental Characterization of a Direct Sequence Spread Spectrum System for In-House Wireless Infrared Communications", *IEEE Transactions on Consumer Electronics, vol. 45, n°. 4, November 1999.*

[5] R. Pérez-Jiménez et al., *"Design and evaluation of a 2 Mbps GMSK modem for short distance infrared wireless communication"*, Proceedings of optical