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L1 signaling mobility performance in the DVB-T2 receivers intercarrier interference cancellation method applied to L1 signaling

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ABSTRACT

In this paper, DVB-T2 mobility performance for both payload and signaling is analyzed and a method to improve the L1 signaling behavior in a mobile scenario is presented by means of applying an intercarrier interference (ICI) cancellation algorithm. This method allows the signaling to support a higher Doppler spread and widening the set of configurations that can be supported.

1. Introduction

Initially, the Second Generation Terrestrial Digital Video Broadcasting (DVB-T2) standard [1] was conceived with the aim of transmitting high definition digital television (HDTV) services to fixed and portable devices.

This standard has been designed to achieve high transmission rates and to offer a performance very close to the channel capacity established by Shannon. This has been obtained mainly with the introduction of the low density parity check (LDPC) codes, as well as different diversity techniques. Other aspects have been taken from the previous experience like the application of time interleavers which can be found in the Digital Video Broadcasting Satellite to Handhelds (DVB-SH) standard [2]. All these features make the DVB-T2 standard able to support high data rates as well as to offer a very robust broadcast system in a great set of unfavorable propagation conditions.

The DVB-T2 standard is based on the orthogonal frequency division multiplexing (OFDM) modulation technique. Its signaling structure is frame based, that is, each frame is constituted by preamble symbols and a configurable number of data symbols. The preambles carry signaling information required to the reception of services, and its transmission scheme is different from the data path. Both paths have been designed to be highly robust and even able to support services within a severe propagation environment. However, in mobile scenarios, DVB-T2 presents an important limitation due to the layer 1 (L1) signaling, which is essential for the correct signal detection but it is sometimes less robust than the payload because of the T2 framing structure. The non-distributed structure of the L1 signaling, in addition to the lack of a time interleaving within these preamble symbols, make the L1 signaling an unprotected part against the channel time variations.

In this paper we firstly analyze the robustness of the L1 signaling. Then, we present a method to improve its performance in mobile environments based on canceling the intercarrier interference (ICI) caused by Doppler spread produced in time-variant channels.

This paper is organized as follows. In Section 2, the structure of the L1 signaling and its main drawbacks are presented. An introduction to the ICI problem is explained in Section 3. Section 4 presents a hardware efficient algorithm for the ICI cancellation and its application to the DVB-T2 signaling symbols. Simulation results are presented in Section 5. Finally, Section 6 draws some conclusions.

2. L1 signaling in DVB-T2

In DVB-T2, a new scheme to transmit the data associated to each service has been included. The physical layer data are divided into logical entities, called physical layer pipes (PLPs) that can transmit one or more services. Services mapping can be mainly carried out in two ways, as it is defined in the standard [1]:

– Mode A or “single PLP”: information is only transmitted over one PLP. The same modulation and coding is applied on all services.

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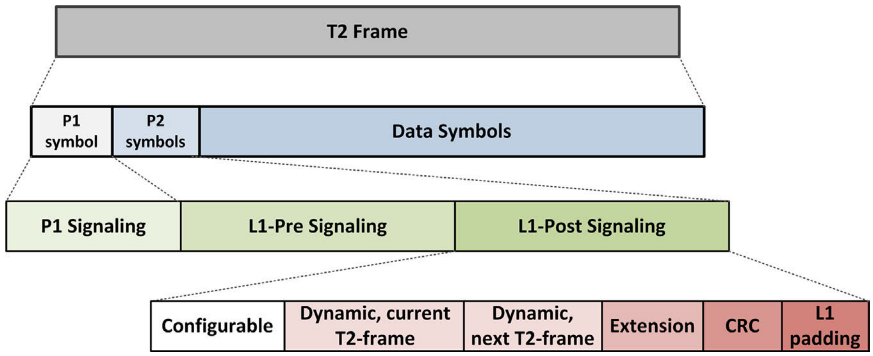

Fig. 1. T2 frame structure and L1 signaling.

Table 1
P2 symbols in a T2 frame.

Transmission mode (FFT size)	1K	2K	4K	8K	16K	32K
Number of P2 symbols in a T2 frame	16	8	4	2	1	1

– Mode B or "multiple PLPs", where several PLPs are transmitted. The configuration (coding, modulation and interleaving) of each service can be chosen depending on the required coverage level. Thus each service is transmitted with different robustness and quality.

In order to make the independent PLPs detection possible, L1 signaling is defined within the DVB-T2 standard, which contains the necessary information for the receiver to be able to decode each transmitted PLP. Therefore, L1 signaling transmission must be even more robust than the payload (data) transmission.

In the DVB-T2 standard, L1 signaling information is transmitted over the preamble symbols P1 and P2. These symbols are located at the beginning of the T2 frame (see Fig. 1). Additionally, L1 signaling is clearly divided in three parts as it is also shown in Fig. 1: the P1 signaling, the L1-pre signaling and L1-post signaling.

The P1 signaling, which is only transmitted within the P1 symbol, is composed by seven bits that provide the receiver information to distinguish the preamble format, and hence the frame type, as well as to rapidly identify the basic transmission parameters, as they are

– Transmission mode or Fast Fourier Transform (FFT) mode of the transmitted data signal: 1K, 2K, 4K, 8K, 16K, 32K.
– Partial information about the guard interval of the transmitted signal.
– Type of selected transmission: Multiple Input Single Output (MISO) or Single Input Single Output (SISO).

The knowledge of the FFT mode makes the P2 symbols reception possible which carry the remaining signaling (L1-pre and L1-post). The number of P2 symbols in a T2 frame depends on the FFT size of the data signal (see Table 1). Note that these symbols use the same FFT size as the data symbols.

The L1-pre signaling enables the reception of the L1-post signaling, which contains the parameters needed by the receiver to access the desired PLPs. Therefore, the transmission of the L1-pre signaling must be extremely robust. That is why L1-pre uses a BPSK (Binary Phase Shift Keying) constellation, the lowest order constellation available in the DVB-T2 standard. In addition, this L1 signaling part is protected by a concatenation of BCH outer code and a LDPC inner code with code rate 1/4.

As mentioned before, the information required for the reception of the PLP data is included in the L1-post signaling part. Therefore, the performance of this signaling must be also more robust than the data symbols. The DVB-T2 standard defines four modulation schemes for the L1-post signaling: BPSK, QPSK, 16-QAM and 64-QAM. In addition, it is protected by a code rate of 1/2 applying a short LDPC code concatenated with a BCH code.

As shown in Fig. 1, the L1-post signaling consists of two types of parameters, configurable and dynamic, plus an optional extension field. Additionally, the L1-post signaling is protected with 32-bit error detection code CRC. Finally, a variable-length field is inserted in the end to ensure that multiple LPDC blocks of the L1-post signaling have the same information size.

The configurable field of the L1-post signaling carries information that changes when the network transmission parameters are changed, for example, PLPs are added or removed. The dynamic field carries information about the mapping of PLPs in the T2-frame. The robustness of the dynamic part can be increased if this information is repeated in the preambles of two successive T2-frames.This is called repetition of the L1-post signaling.

The robustness of the L1-post signaling transmission compared to the data symbols is appropriate in ideal propagation conditions, as an AWGN channel, or in a static propagation environment, as a Rayleigh channel [3]. However, the results presented in [3] show the performance of the L1-post signaling with respect to data in time varying channels, typical of mobile scenarios, is not as good as in the static environment. Nevertheless, the results in [3] were simulated in ideal conditions (ideal channel estimation and genie aided demapping), and therefore the performance will be even worse if real conditions are assumed.

In this paper, we analyze the performance of the L1-post signaling in mobile propagation channels employing real channel estimation and a Max-Log demapping process. In addition, we propose to apply an ICI cancellation algorithm to L1-post signaling in order to improve its performance.

3. Intercarrier interference in the L1-post signaling

OFDM systems are sensitive to two main phenomena that occur under time varying multipath channels: intersymbol interference (ISI), due to the time delay spread, and intercarrier interference (ICI), caused by the time varying nature of the channel.

Since in OFDM systems the symbol duration is usually much longer than the delay spread introduced by the propagation channel, the OFDM modulation technique intrinsically reduces the effects added by the ISI. Moreover, OFDM systems usually include a guard interval, or so called cyclic prefix, which allows to completely remove the delay spread effects. For the guard interval to be functional, the maximum delay of the channel must be shorter than the guard interval duration. Summarizing, intersymbol interference can be easily canceled in OFDM systems by simply carrying out an appropriate design.

However, in a mobile environment, OFDM systems are quite sensitive to time selective fadings, which take place due to channel variations because of the relative movement between the receiver and the transmitter. Channel characteristics variation is the origin of the Doppler spread, which produces a loss of orthogonality between the subcarriers. This loss is called intercarrier interference (ICI).

As the L1 signaling is transmitted over P1 and P2 preambles, which are OFDM symbols, the Doppler spread presented in a mobile scenario can affect considerably the L1 signaling performance.

The OFDM symbols received after being transmitted over a time varying multipath channel and affected by ICI can be expressed as

$$Y_m = H_m S_m + I_{ICI_m} + N_m \quad 0 \le m \le N-1 \tag{1}$$

where Y_m represents the output of the FFT at the mth subcarrier, H_m is the channel distortion caused only by the frequency selective fading in the mth subcarrier, I_{ICI_m} represents the intercarrier interference at the mth subcarrier due to the rest of subcarriers, N_m denotes the DFT of the additive white Gaussian noise over this subcarrier, and N is the number the active subcarriers per OFDM symbol [4]. In the particular case of a time invariant channel, I_{ICI_m} is zero.

The I_{ICI_m} term, which can be modeled as an additive and Gaussian process when N is large enough [5], can be expressed mathematically as (2), where $H_k^{(1)}$ represents the first time derivative of the channel frequency response, S_k is the transmitted symbol, T_e is the sampling period, and χ_{k-m}, which can be denoted as χ_Δ with $\Delta = k-m$, are the complex leakage coefficients defined in (3) that depend on the transmission mode (N_{FFT}). Thus, χ_{k-m} and $H_k^{(1)}$ determine the contribution of the ICI at the mth subcarrier due to the kth subcarrier.

$$I_{ICI_m} = T_e \sum_{k=0}^{N-1} S_k \chi_{k-m} H_k^{(1)} \quad \text{with } m = 0, \ldots, N-1 \tag{2}$$

$$\chi_{k-m} = \chi_\Delta = \begin{cases} -\dfrac{1}{\left[1-\exp\left(\frac{j2\pi\Delta}{N_{FFT}}\right)\right]} & \text{for } \Delta \ne 0 \\ 0 & \text{for } \Delta = 0 \end{cases} \tag{3}$$

Eq. (2) can be rewritten as (4) using matrix notation, where I_{ICI} is now a $N \times 1$ vector, S is the transmitted symbol vector of size $N \times 1$, $diag(H^1)$ is a diagonal matrix containing the first temporal derivative $N \times 1$ vector H^1, and Ψ is a constant Toeplitz Hermitian matrix of size $N \times N$ with zero elements on the main diagonal, called leakage matrix.

$$I_{ICI} = T_e \Psi \operatorname{diag}(H^1) S \quad \text{where} \quad \Psi = \begin{bmatrix} 0 & \chi_1 & \cdots & \chi_{N-1} \\ \chi_{-1} & 0 & \ddots & \vdots \\ \vdots & \ddots & \ddots & \chi_1 \\ \chi_{-N+1} & \cdots & \chi_{-1} & 0 \end{bmatrix} \tag{4}$$

The received symbol using matrix notation can be expressed as shown in (5), where $diag(H^0)$ is a diagonal matrix containing the channel transfer function vector of size $N \times 1$, and N_{AWGN} is an $N \times 1$ vector that represents the additive white Gaussian noise.

$$Y = \operatorname{diag}(H^0) S + I_{ICI} + N_{AWGN} \tag{5}$$

3.1. ICI cancellation algorithms

According to (4), the ICI term can be estimated if the transmitted signal and the first derivative of the channel are known. However computing (4) is not straightforward since it requires the multiplication of an $N \times N$ matrix by an $N \times 1$ vector, which is prohibitively complex for the typical number of subcarriers used in DVB standards.

In order to reduce the hardware complexity, several methods have been proposed in the literature to mitigate the effect of the ICI. Among all the proposed methods, ICI cancellation schemes based on adaptive equalization methods have proven to be very effective. However these techniques theoretically require the inversion of large matrices, although the band structure of the frequency channel matrix can be exploited reducing the complexity [6]. This technique is called MMSE equalizer. Although this ICI cancellation method is less complex than the direct implementation of (4), the hardware complexity of MMSE equalizer is still high.

Another well-known solution, the Decision Feedback Equalization (DFE) technique [7], is based on implementing the product of the leakage matrix Ψ with $diag(H^1)S$ by means of two FFT processors. Although the DFE technique presents a reduced hardware complexity in comparison to the direct implementation of (4), the FFT processing is quite intensive in both, silicon area consumption (memories) and processing time. Therefore, the DFE technique is still complex, especially for large values of N_{FFT}.

In conclusion, the implementation of these ICI cancellation methods to improve the mobility performance of the L1-post signaling is not recommended.

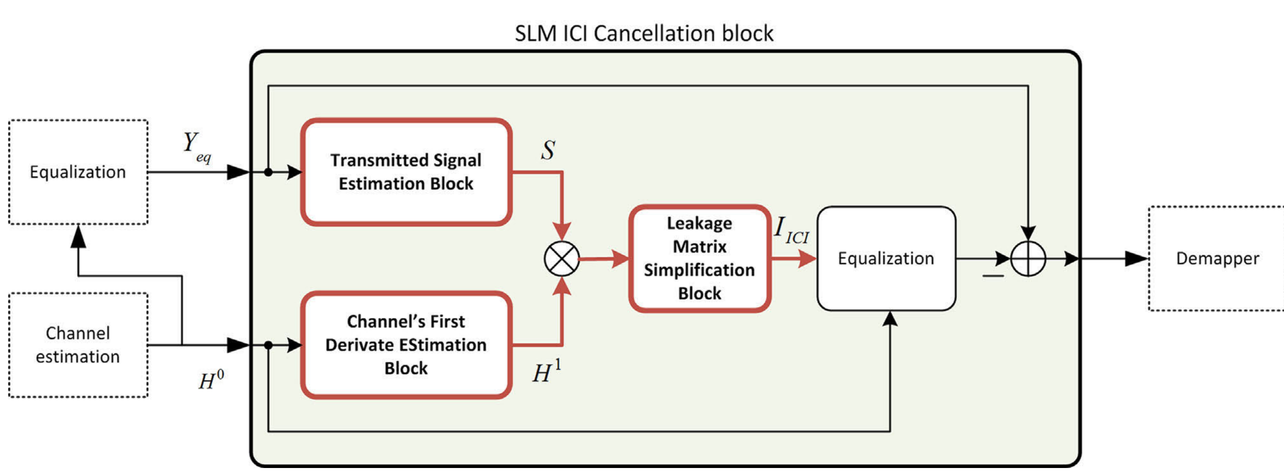

Fig. 2. SLM ICI cancellation scheme.

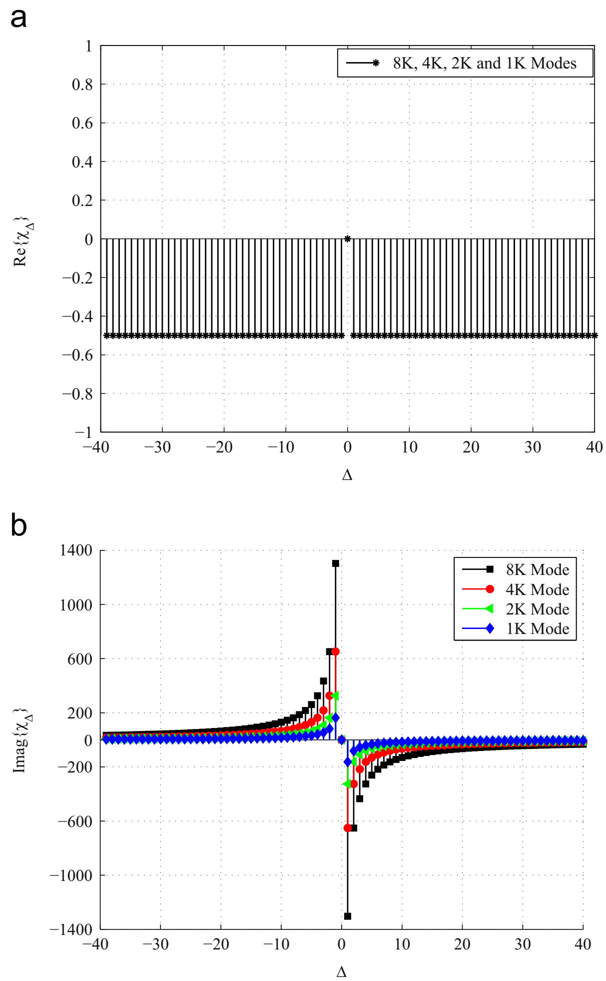

Fig. 3. Leakage coefficients for different transmission modes. (a) Real part. (b) Imaginary part.

4. Proposed method

In order to improve the mobility performance of the L1-post signaling, and therefore to allow the reception of TV services with DVB-T2 receivers in mobile scenarios, we propose applying a modification of the Simplified Leakage Matrix (SLM) ICI cancelation algorithm, that we proposed in [8,9], to L1-post signaling. This technique has proven to considerably reduce the complexity of the ICI term estimator.

The SLM algorithm takes the received and equalized signal Y_{eq} and the frequency response channel estimation H^0 in order to subtract the estimated ICI term to the received signal, as shown in Fig. 2. Note that for the ICI estimation from (2) the transmitted signal S, the first derivative of the channel response H^1, and the coefficients χ_{k-m} are required. Therefore, these variables must be computed before calculating the ICI term.

4.1. Transmitted signal estimation

First, the receiver needs to know the transmitted signal, which can be estimated using a demapped/mapped version of the equalized signal. Before demapping, the incoming signal is properly equalized by the static term of the channel response H^0, and then a hard decision demapping process is used. As shown later in the simulation results (Section 5), excellent performance can be obtained using a hard decision demapper, avoiding the use of a soft decision demapper (which would require to compute and process soft metrics made of several bits) and so reducing the requirements in terms of hardware complexity.

4.2. First time derivative of the channel estimation

As stated before, the receiver needs to calculate H^1, that is, the first time derivative of the channel frequency response. This term is computed using the channel estimation H^0, which is previously calculated like in any coherent OFDM receiver [10]. The process of computing H^1 must be modified with respect to [8,9], that is, it must be adapted to the number of P2 symbols contained in a T2 frame according to the selected transmission mode. In [8,9], H^1 was computed using the channel estimation of the previous and next symbols, something that is not possible in the case of the L1-post signaling in all transmission modes. Note that, for example, in the 8K mode, only two symbols are available.

Except for the last P2 symbol of the L1-post signaling, we propose to calculate the first time derivative of the channel frequency response in the all P2 symbols following (6), that is, using the channel estimation of the present P2 symbol and the next P2 symbol, where $H_{k,s}^{(0)}$ denotes the channel estimation at the kth carrier and sth OFDM symbol, N is the number of subcarriers in an OFDM symbol, and T_e is the sampling period. In the case of the last P2 symbol of the L1-post signaling, the previous and present P2 symbol will be applied to compute $H_{k,s}^{(1)}$, as expressed in (7). This form of first time derivative calculation presents the similar performance than the method presented in [8,9] but it is more efficient in the resources consumption, considering that it is only necessary a memory size of $2N$ positions instead of $3N$.

$$H_{k,s}^{(1)} = (H_{k,s+1}^{(0)} - H_{k,s}^{(0)})/NT_e \tag{6}$$

$$H_{k,s}^{(1)} = (H_{k,s}^{(0)} - H_{k,s-1}^{(0)})/NT_e \tag{7}$$

4.3. Computation of the leakage coefficients X_Δ

Finally, in order to estimate the ICI term the coefficients χ_{k-m} must be also computed. In [6,7], we indicated that the ICI over a specific subcarrier m is mainly generated from the L adjacent and closest carriers contribution (taking $L \ll N$). To demonstrate this statement we rewrite (3) into (8) using trigonometric equivalent expressions

$$\chi_\Delta = -1/2 - j/(2\ \tan(\pi\Delta/N_{FFT})) \quad \text{for } \Delta \neq 0 \tag{8}$$

Eq. (8) shows that the real part of the complex coefficients χ_Δ is constant but the imaginary part depends on the transmission mode. Its absolute value rapidly decreases when $|\Delta|/N_{FFT}$ increases. That is, closer subcarriers contribute more to the ICI. Note also that the modulus of real part is very small in comparison with the absolute value of the imaginary part, especially for low values of Δ (see Fig. 3).

On the one hand the effect of the rest of subcarriers $(N-L)$ is neglected. On the other hand, the contribution of the real part of the leakage coefficients is insignificant. In conclusion, only the calculation of L coefficients χ_{k-m} and their imaginary parts are required. As we will see in Section 5, only four coefficients $(L=4)$ are required to reach the same performance when compared to the ideal DFE method of [7].

In a practical implementation, the leakage matrix simplification block in Fig. 2 is designed as shown in Fig. 4, where only $2L$ complex multipliers and $2L-1$ complex adders are needed. Moreover, note that the complex multipliers can be further simplified due to the fact that the χ_Δ coefficients have been reduced to their imaginary parts. Additionally and as shown in Fig. 3b, the leakage

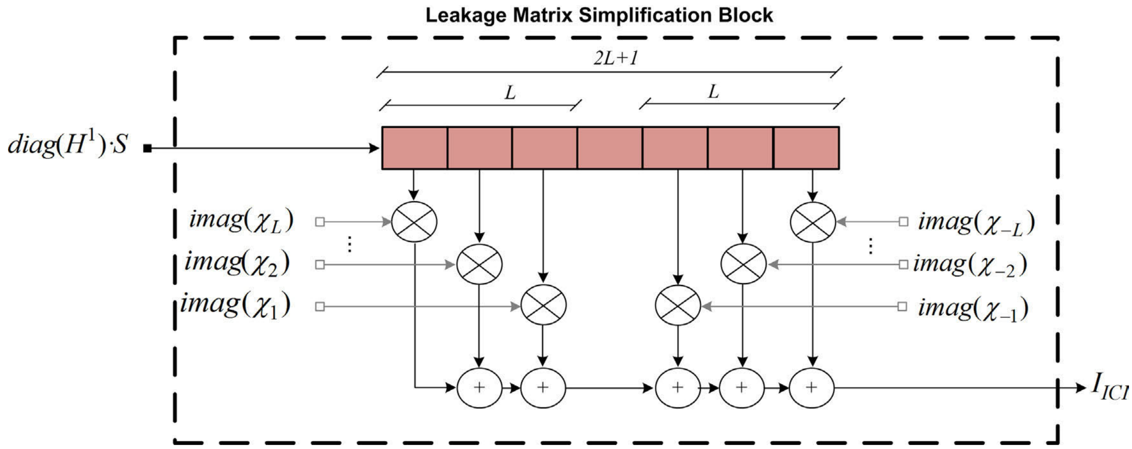

Fig. 4. Hardware implementation of the leakage matrix simplification block.

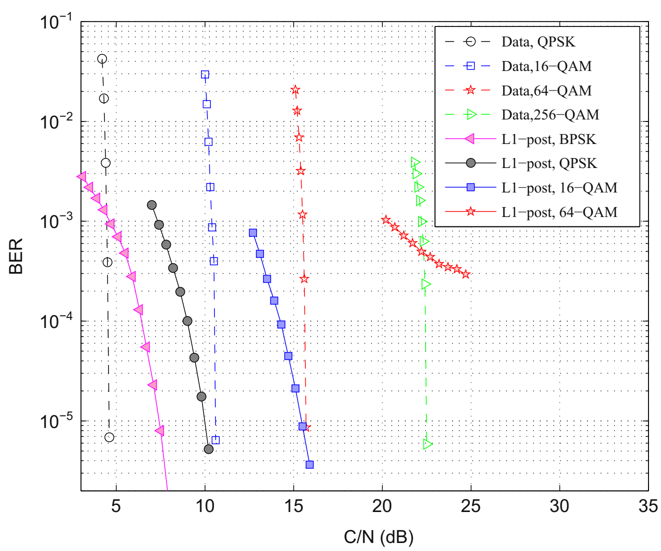

Fig. 5. Data and L1-post signaling performance in a TU6 channel, with a maximum Doppler frequency of 110 Hz. Data and L1-post signaling configured with a code rate of 1/2.

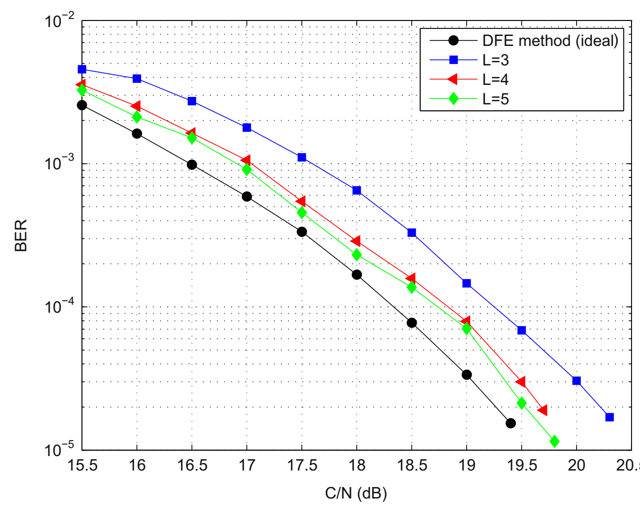

Fig. 6. L1-post signaling with ICI cancellation, 64-QAM constellation and a code rate of 1/2 using the DFE technique and the proposed SLM method for three values of L.

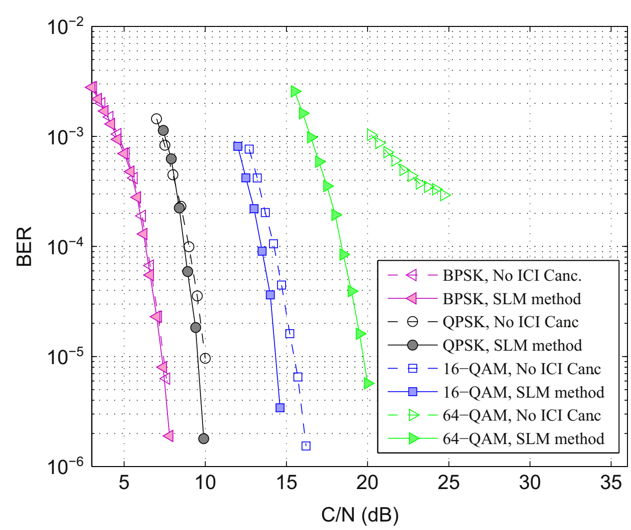

Fig. 7. L1-post signaling performance in a TU6 channel, with a maximum Doppler frequency of 110 Hz, with and without ICI cancellation. Data and L1-post signaling configured with a code rate of 1/2.

coefficients of all transmission modes (8K, 4K, 2K and 1K) can be derived from the coefficients of the 1K by means of multiplying (shifting) them by 8, 4, and 2, respectively. Therefore, only the L coefficients of the 1K mode are computed off-line and stored in a ROM memory.

The hardware resources reduction of the proposed SLM method when compared to the DFE method is significant. The proposed method avoids the large amount of memories to store the data between butterfly iterations in the FFT processors, as well as the FFT processing time.

5. Simulation results

In order to evaluate the performance of the payload and L1-post signaling of a DVB-T2 receiver in a mobile scenario, we have considered a DVB-T2 system configured with an 8K mode, a cyclic prefix size of 1/4 and all the possible constellations defined in [1].

To analyze the worst situation, we have considered all the code rates available in the DVB-T2 specification, from 1/2 to 5/6, for the data. Note that the only code rate available for the L1 signaling is 1/2. In addition, we have simulated the system in real conditions, that is, the PP1 pilot pattern, a real channel estimation (1-D estimation, using only frequency interpolation) and a Max-Log demapping process.

Table 2
Suitable modulation of L1-post signaling for each feasible data configuration in a TU6 channel with a maximum Doppler frequency of 110 Hz.

Data Configuration		Modulation scheme of the L1-post signaling							
Constellation	CR	BPSK		QPSK		16-QAM		64-QAM	
		Standard	SLM	Standard	SLM	Standard	SLM	Standard	SLM
QPSK	1/2	–	–	–	–	–	–	–	–
	3/5	X	X	–	–	–	–	–	–
	2/3	X	X	–	–	–	–	–	–
	3/4	X	X	X	X	–	–	–	–
	4/5	X	X	X	X	–	–	–	–
	5/6	X	X	X	X	–	–	–	–
16-QAM	1/2	X	X	X	X	–	–	–	–
	3/5	X	X	X	X	–	–	–	–
	2/3	X	X	X	X	–	**X**	–	–
	3/4	X	X	X	X	X	X	–	–
	4/5	X	X	X	X	X	X	–	**X**
64-QAM	1/2	X	X	X	X	X	X	–	–
	3/5	X	X	X	X	X	X	–	**X**
256-QAM	1/2	X	X	X	X	X	X	–	**X**

All the simulation results have been obtained for the Typical Urban (TU6) channel model defined by the COST 207 project for GSM [11], with a maximum Doppler frequency of 110 Hz. This channel was shown to give an accurate description of the mobile radio channel.

First, we will show the mobility performance of the L1-post signaling compared to the information data when both use the code rate of 1/2. Then, this analysis will be extended to all remaining code rates.

Simulation results for the 1/2 code rate are shown in the Fig. 5, where bit error rate (BER) curves versus the carrier to noise ratio (C/N) for both data and L1-post signaling are depicted. From the results presented in Fig. 5 it can be derived that there are some modulation schemes for the L1-post signaling that are less robust than the data, that is, if these configurations are used the PLPs will not be correctly retrieved and decoded. Indeed, focusing on the data performance for a QPSK constellation, it can be observed that all the configurations of the L1-post signaling (BPSK, QPSK, 16-QAM, 64-QAM) are less robust than the data.

Considering a safe margin of 1 dB for the performance of the L1-post signaling over the performance of the data to ensure the correct decoding of the PLPs, the feasibility of the different signaling configurations can be found. For example, in the case a 256-QAM and a code rate 1/2 for the data, all the configurations of the L1-post signaling can be used except 64-QAM.

Summarizing, it can be concluded that one of the main limitations for the DVB-T2 standard to support mobility is the L1-post signaling due to lack of robustness when compared to the data.

5.1. ICI cancellation results

The performance of the L1-post signaling can be improved if the modified SLM ICI cancellation algorithm is implemented. Firstly, simulations have been run to select the optimum value for L, that is, the minimum value which gives the best performance. Fig. 6 depicts the BER curve versus C/N for the L1-post signaling with the proposed SLM ICI cancellation method, 64-QAM constellation and a code rate of 1/2 for three values of L ($L=5$, $L=4$, and $L=3$). For comparison purposes the same simulation has been run using the DFE method (ideal curve). From Fig. 6, it can be concluded that a value of $L=4$ is enough to achieve almost the performance that is provided by the DFE technique. Therefore, for the rest of this paper, the SLM simulations have been run using $L=4$.

In order to analyze the improvement provided by the proposed SLM algorithm, BER vs. C/N simulations, with and without ICI cancellation, have been carried out for the L1-post signaling. The results for the 1/2 code rate in data and signaling are depicted in Fig. 7, where curves for the four possible constellations of the L1-post have been obtained. From Fig. 7, it can be observed that the proposed SLM method applied to the L1-post signaling provides better performance for all cases. Note that the main contribution is produced in the least robust constellations. For example, in QPSK, a gain of around 0.5 dB is achieved whereas in the 16-QAM case, a gain of 1 dB can be obtained. Moreover, when a 64-QAM constellation is used, the application of this method overcomes the error floor which made impossible the demodulation without the utilization of the ICI cancellation method. The main conclusion is that the proposed ICI cancellation method increases the set of feasible signaling modes.

An exhaustive study similar to the one described above has been carried out when the data are configured with all the remaining code rates (3/5, 2/3, 3/4, 4/5 and 5/6). The main aim is to analyze all the feasible configurations in L1-post signaling with and without ICI cancellation implementation. The main simulation results are summarized in Table 2, where suitable modulations of the L1-post signaling for each feasible data configuration are indicated. In this table, a letter "X" indicates that the L1-post signaling is at least 1 dB more robust than the data, whereas a symbol "–" indicates L1-post signaling is at least 1 dB less robust than the data. The "standard" label means implementation without ICI cancellation method and the "SLM" label means implementation of the proposed SLM ICI cancellation technique with $L=4$.

It must be remarked that those code rates that are not shown in Table 2 are not supported in the higher order constellations for the simulated mobility conditions (a Doppler frequency of 110 Hz in 8K mode). Note that in Table 2 the cases where the proposed SLM ICI cancellation method allows using a new L1-post signaling scheme has been shaded.

In Table 2 the L1-post signaling repetition was not used. When using repetition, a gain of roughly 2.5 dB is obtained in the BER curve of the L1-post signaling [3]. Thus the use of L1-post repetition brings the performance of the L1-post dynamic signaling close to the performance of the data path. However in many cases it is not enough. Therefore, it is possible to implement the

Table 3
Suitable modulation of L1-post for each feasible data configuration in a TU6 channel with a maximum Doppler frequency of 110 Hz when repetition of L1-post signaling is implemented.

Data configuration		Modulation scheme of the L1-post signaling							
Constellation	CR	BPSK		QPSK		16-QAM		64-QAM	
		Standard	SLM	Standard	SLM	Standard	SLM	Standard	SLM
QPSK	1/2	X	X	–	–	–	–	–	–
	3/5	X	X	–	**X**	–	–	–	–
	2/3	X	X	X	X	–	–	–	–
	3/4	X	X	X	X	–	–	–	–
	4/5	X	X	X	X	–	**X**	–	–
	5/6	X	X	X	X	X	X	–	–
16-QAM	1/2	X	X	X	X	–	–	–	–
	3/5	X	X	X	X	X	X	–	–
	2/3	X	X	X	X	X	X	–	–
	3/4	X	X	X	X	X	X	–	**X**
	4/5	X	X	X	X	X	X	–	**X**
64-QAM	1/2	X	X	X	X	X	X	–	–
	3/5	X	X	X	X	X	X	–	**X**
256-QAM	1/2	X	X	X	X	X	X	–	**X**

proposed SLM ICI cancellation scheme to further improve the mobility performance of the L1-post signaling. The obtained results are summarized in Table 3, where it has been carried out the same analysis that in Table 2, but using repetition of L1-post signaling. From Table 3 it can be concluded that if we add the contribution of the proposed ICI cancellation method and the repetition of L1-post signaling the set of feasible signaling modes gets increased. Thus six new cases can be used for the L1-post, which have been shaded in Table 3.

6. Conclusions

In this paper it has been shown how the performance of the L1 signaling is a limiting factor for the DVB-T2 systems in mobile scenarios. Since the L1 signaling does not benefit from the time and frequency diversity of the data, its robustness is severely affected in mobile scenarios.

This problem, which only takes place in mobile environments, becomes especially serious in the case of multiple PLP transmission or mode B, where the L1 signaling carry the information required to correctly retrieve and demodulate the PLPs data.

By applying the SLM ICI cancellation algorithm some of the intrinsic weaknesses of the L1 signaling are overcome and the set of available configurations that can be used for the L1 signaling are increased.

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