

OFDM/VSF-CDMA for DVB-H Communications

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Abstract— Digital Video Broadcasting for Handheld Terminals (DVB-H) standard uses Orthogonal Frequency-Division Multiplexing (OFDM) technique which exhibits some major drawbacks, namely; the sensitivity to Doppler shift, the sensitivity to frequency synchronization and the high Peak to Average Power Ratio (PAPR). This paper proposes using OFDM/Variable Spreading Factor (VSF)-Code Division Multiple Access (CDMA) for DVB-H transmission. Simulation results show a Bit Error Rate (BER) performance enhancement of the proposal over the OFDM based traditional transmission. The drawbacks of the proposal are the requirements for a higher RF bandwidth and the relative higher complexity overhead.

Index Terms — DVB, DVB-H, OFDM, CDMA, VSF.

I. INTRODUCTION

OFDM technique is currently used for DVB-H standard [1], that's because of the advantage of OFDM over single-carrier schemes, namely; its ability to cope with severe channel conditions without the need for complex equalization filters.

But OFDM has some major drawbacks like, the sensitivity to Doppler shift, the sensitivity to frequency synchronization which causes inter-carrier interference (ICI) at the receiver and the high PAPR, [2] and these drawbacks cause major problems in the video broadcasting. So, these drawbacks limit the application of the OFDM technique.

This paper proposes using OFDM/VSF-CDMA for transmission in DVB-H communications. Through this proposal, the data will be distributed over subcarriers and codes instead of being distributed over sub-carriers only. This will minimize the number of required sub-carriers and hence will reduce the effect of the disadvantages of the OFDM technique. Also, using VSF will help to reduce the higher RF bandwidth caused by the employment of the CDMA when the channel conditions are better.

II. DVB-H SYSTEM ARCHITECTURE

The DVB-H is a transmission system has 3 modes of operation, namely; 2k, 4k and 8k mode. The functional block diagram of the DVB-H transmission system is shown in figure 1, [3].

In the functional block diagram given in figure 1, the block coder is Reed Solomon, the outer interleaver is convolutional interleaver, the inner encoder is convolutional encoder, the inner interleaver is block interleaver, the mapping is Quadrature Shift Keying (QPSK) or M-ary Quadrature Amplitude Modulation (QAM), specifically, 16 or 64 QAM. The values of the parameters of each block depend on the mode of operation and the used parameters set [3] [4].

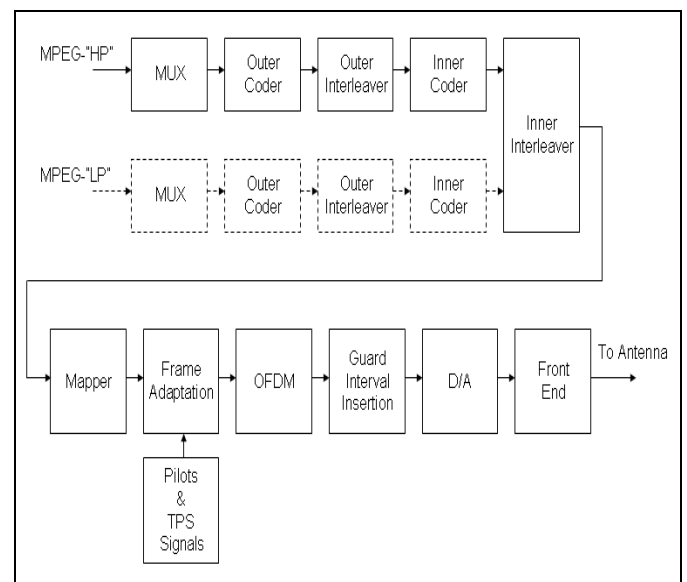


Figure 1: The functional block diagram of the DVB-H transmission system.

III. THE PROPOSED OFDM/VSF-CDMA

OFDM/VSF-CDMA is proposed to be used in DVB-H transmission system instead of using OFDM. The data is to be distributed over N OFDM sub-carriers and M

CDMA orthogonal codes generated using the H-matrix, that's instead of the distribution over $N \times M$ OFDM sub-carriers as the case of the regular OFDM transmission. So, each sub-carrier will have M orthogonal CDMA codes to be able to carry M independent data streams. The CDMA will use VSF to save the transmission bandwidth.

The proposed technique will minimize the number of OFDM sub-carriers needed for transmission and hence reduce all the disadvantages of the OFDM. Also, using VSF will help to reduce the higher RF bandwidth caused by the usage of the CDMA.

The SF value is specified based on the feedback of the change in the BER value at the receiver side, this feedback is sent via a control channel. When the channel conditions are better, i.e. when the BER is low, the Spreading Factor (S.F.) can be lowered to save the bandwidth and vice versa.

The proposal uses the change in the BER of the receiver, to select the S.F. value. Through a pilot or a separate control channel, the transmitter can get a frame quality indicator, namely; the average change in the BER, from the receiver and then according to the percentage change in the value of the BER, the transmitter chooses the S.F. according to the proposed values in table 1.

The reference BER is initially taken the first calculated BER and then this reference is regularly updated by the best BER that the receiver gets.

Table 1: The S.F. values for given changes in BER.

BER Change	S.F.
$\Delta BER < -10\%$	16
$-10\% \leq \Delta BER < -20\%$	4
$-20\% \leq \Delta BER$	1 (no spreading)

The ΔBER is averaged over 5 random frames then it is used for the switching of the next 95 frames.

IV. SIMULATION SCHEMES AND RESULTS

Simulation is performed to compare the proposed OFDM/VSF-CDMA based DVB-H system with the standard OFDM-based DVB-H system in the 3 modes of operations for DVB-H; namely; 2k, 4k and 8k. The simulation used the parameter set 3 and the propagation channel profiles as indicated in [4], [5]. The simulation is performed in Additive White Gaussian Noise (AWGN) channel, Rician channel, Rayleigh channel and Typical Urban 6 (TU6) channel as recommended by the DVB-H

project, [4]. In the simulations' scenarios, the whole results are averaged over 250 random channel realizations. Simulation is performed under the assumptions that, the channel fading is constant over the frame and independently distributed from one frame to the other. The simulation is performed using MATLAB R13.

The basic system parameters are presented in table 2. The parameters values for the channel models are described in details in [5]. The VSF values are as given in table 1.

Simulation results in the presence of AWGN channel are presented in figure 2, in the presence of Rician channel are presented in figure 3, in the presence of Rayleigh channel are presented in figure 4 and in the presence of TU6 channel are presented in figure 5.

Table 2: The basic system configurations

Parameter	Value
Peak ES bitrate	10 Mbps
Burst time/interleaving depth	200 ms
Transmission bitrate	10 Mbps
Parallel ESs	1 ES
MPE-FEC	2 M bit frame size (1024 rows)
Modulation Scheme	(16-QAM $\frac{1}{2}$)
Average SNR	0:30 dB
Average SNR increment	5 dB

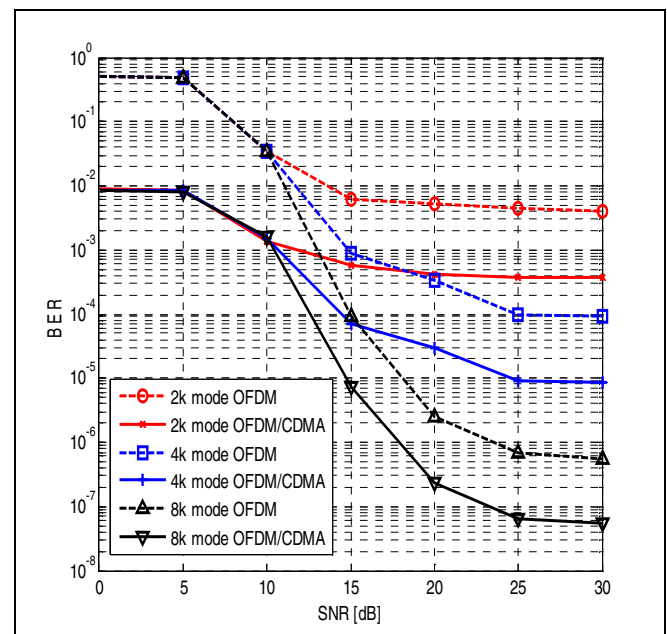


Figure 2: OFDM/VSF-CDMA-based DVB-H vs. OFDM-based DVB-H, in AWGN channel.

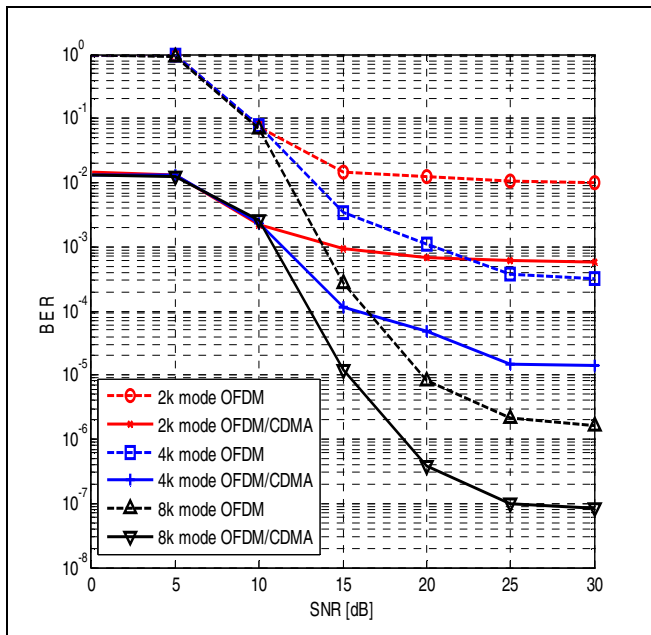


Figure 3: OFDM/VSF-CDMA-based DVB-H vs. OFDM-based DVB-H, in Rician channel.

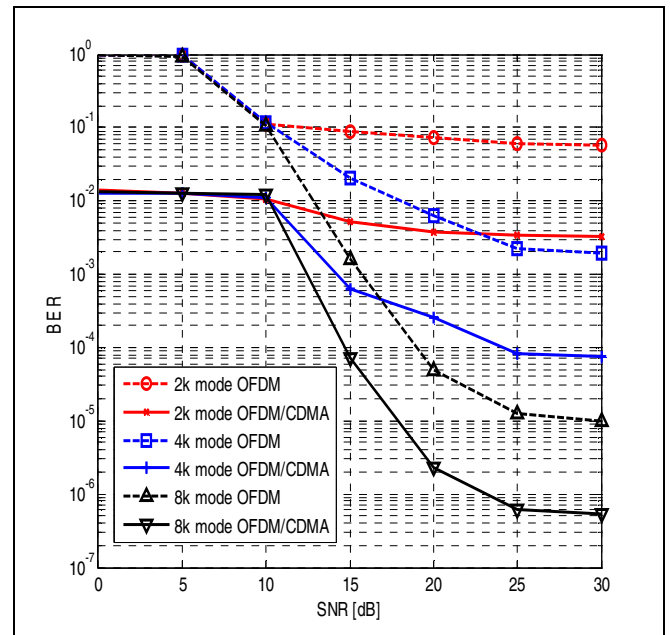


Figure 5: OFDM/VSF-CDMA-based DVB-H vs. OFDM-based DVB-H, in TU6 channel.

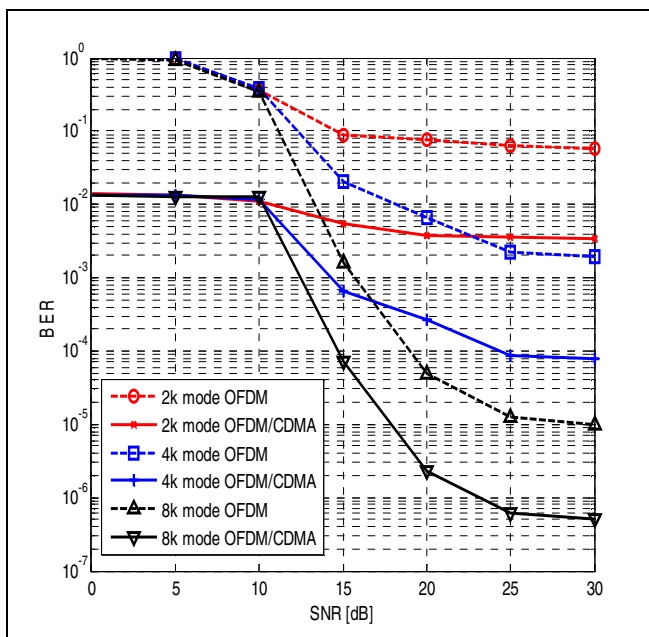


Figure 4: OFDM/VSF-CDMA-based DVB-H vs. OFDM-based DVB-H, in Rayleigh channel.

The simulation results showed that using OFDM/VSF-CDMA DVB-H gives a BER performance enhancement over the OFDM DVB-H in the considered channel models.

Also, the simulation results showed that using OFDM/VSF-CDMA DVB-H gives some smoothing to the BER-SNR curve, by lowering the BER difference for low SNR and high SNR, relative to the OFDM based one. This behavior is an important point in DVB transmission.

The OFDM/VSF-CDMA based DVB-H BER percentage enhancement over the OFDM based DVB-H is given in table 3.

Table 3: OFDM/VSF-CDMA based DVB-H BER percentage enhancement over the OFDM based DVB-H

Mode/CH.	AWGN	Rician	Rayleigh	TU6
2K	98%	98%	98%	98%
4K	98%	98%	98%	98%
8K	98%	99%	98%	98%

The analysis presented in table 3 shows a good BER enhancement of the proposed OFDM/VSF-CDMA over the OFDM based DVB-H. Also, it shows that the percentage enhancements, in the cases of Rician channel model, Rayleigh channel model and TU6 channel model are approximately the same as the AWGN (namely; 98%-99%) this is due to the fact that CDMA combat the interference.

The BER percentage changes of the proposed OFDM/VSF-CDMA technique in each considered environment over the AWGN environment, as a chosen reference channel, are presented in table 4.

Where, $\mu_{\% \Delta}$ is the mean of the percentage change and $\sigma_{\% \Delta}^2$ is the variance of the percentage change.

Table 4 shows that, the maximum percentage change in the mean is 0.4959% and the maximum percentage change in the variance is 0.0019, meaning that the percentage enhancement in case of Rician channel model, Rayleigh channel model and TU6 channel model are approximately the same as the AWGN, this is due to the same fact that CDMA combat the interference.

Table 4: The BER percentage change of the OFDM/VSF-CDMA DVB-H, in each considered environment, over the AWGN.

Mode	Δ	Rician	Rayleigh	TU6
2K	$\mu_{\% \Delta}$	0.1750	0.4959	0.4672
	$\sigma_{\% \Delta}^2$	0.0006	0.0006	0.0005
4K	$\mu_{\% \Delta}$	0.1239	0.2710	0.2446
	$\sigma_{\% \Delta}^2$	0.0006	0.0016	0.0014
8K	$\mu_{\% \Delta}$	0.1106	0.2565	0.2446
	$\sigma_{\% \Delta}^2$	0.0005	0.0019	0.0014

Taking the processing time as a measure for the complexity, the percentage complexity overhead of the OFDM/VSF-CDMA based DVB-H over the OFDM based DVB-H is presented in table 5.

Table 5: OFDM/VSF-CDMA based DVB-H percentage complexity overhead over the OFDM based DVB-H

Mode/CH.	AWGN	Rician	Rayleigh	TU6
2K	5%	6%	6%	7%
4K	6%	6%	7%	7%
8K	6%	7%	7%	7%

Table 5 shows that the OFDM/VSF-CDMA has a small percentage (5%-7%) of higher complexity overhead over the OFDM based DVB-H system in the considered environments.

The second drawback of the proposal is that the required RF bandwidth is higher than the normal OFDM based system. That's due to spreading the signal over the carrier, which is on the average around 7 times the original bandwidth.

V. CONCLUSIONS

The paper proposes using OFDM/VSF-CDMA for DVB-H transmission instead of OFDM only. Simulation results show that the BER performance of the proposal is better than the OFDM based technique. The simulation results show also that the proposal smoothens the BER vs. SNR curve for the considered environments namely; AWGN, Rician, Rayleigh and TU6. Also, the analysis of the results shows that the BER performance of the proposal is nearly the same for the considered environments. The drawbacks of the proposal are the relatively (5%-7%) higher computational complexity and the higher RF bandwidth requirements over the traditional OFDM, which is the main drawback due to the spreading of the signal.

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