A Polar-Based demapper of 8PSK demodulation for DVB-S2 systems

Anthony Barré[1], Emmanuel Boutillon[1], Neysser Blas[2], Daniel Diaz[2]

[1]Université Européenne de Bretagne, UBS, Lab-STICC CNRS UMR 6285// [2]INICTEL-UNI, San Borja, Lima, Peru

INTRODUCTION

In DVB-S2, the demodulation is done in four steps which are successively : time synchronization followed by frequency synchronization, phase correction and the generation of the Log Likelihood Ratio (LLR) of the transmitted bits [1]. In [2], we presented a synchronization method using polar coordinates. In this paper, we present the extension of the polar representation to the LLR generation of 8-PSK modulation. The exact computation of the LLR is given by:

$$L^i(b) = \log \frac{\sum_{c \in C_i^0} e^{-\frac{(c-y)^2}{2\sigma^2}}}{\sum_{c \in C_i^1} e^{-\frac{(c-y)^2}{2\sigma^2}}} \qquad (1)$$

where C_i^0 (respectively C_i^1) is the subset of the points of the constellation so that the ith bit, $i \in 0, 1, 2$ is equal to $b_i = 0$ (respectively, $b_i = 1$), y is the received point from the channel and σ^2 is the variance of the noise. We propose to approximate (1) in the polar domain by using the module ρ and the phase θ of the received point.

Figure 1 presents the steps of the quantification process. From an y received, an optimal $\overline{L}^i$ is computed from its exact and quantified polar coordinates. We propose to compute an approximate LLR ($\tilde{L}^i$) from quantified polar coordinates.

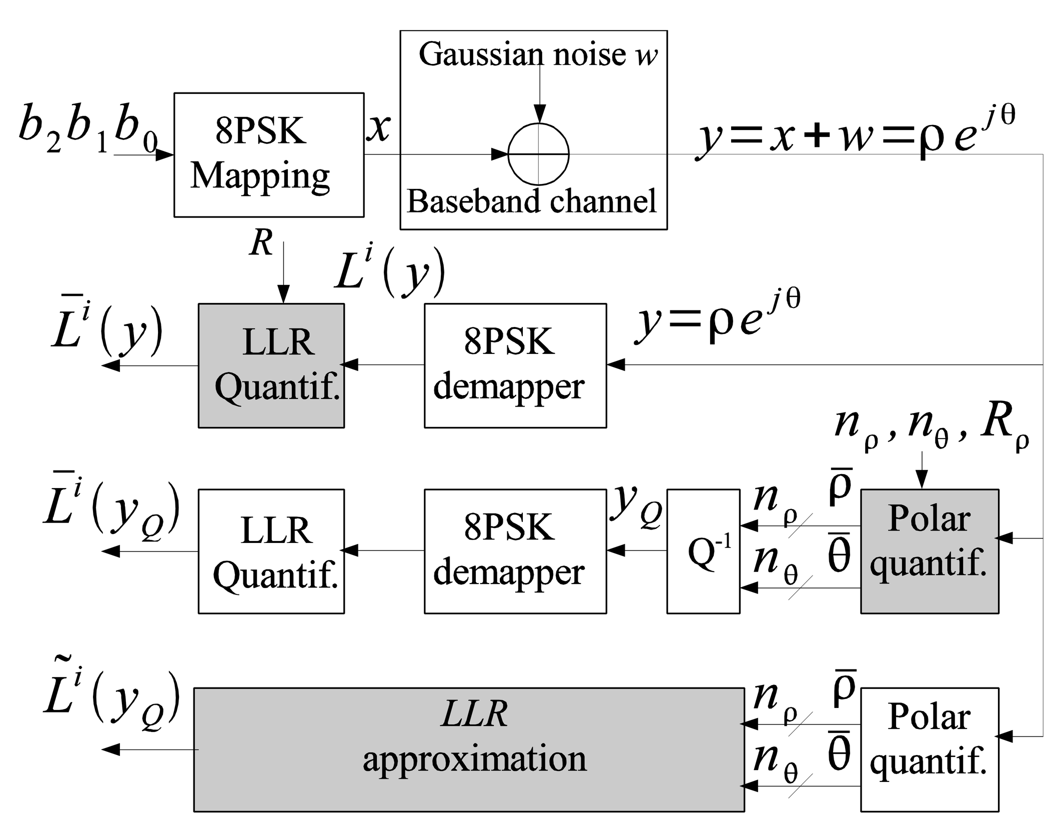

Figure 1 : The 3 steps of the quantification process

MATERIALS AND METHODS

APPROXIMATION OF LLR COMPUTATION

Figure 2 shows the quantified value of $\overline{L}^i_{i=0,1,2}(y_q)$ on 5 bits computed in figure 1. It has a very regular periodic triangular shape that can be easily interpolated. We can see that it can be approximated by a piecewise linear function. To avoid the direct computation of the LLRs, we propose to compute it with :

$$\tilde{L}^i = \lfloor s_i(\bar{\theta}) \min((\bar{\rho} \min(h_i(\bar{\theta}),30)\alpha_i) + 0.5, 15) \rfloor$$

Where $s_i(\bar{\theta})$ is a function that defines the sign of the LLR, $h_i(\bar{\theta})$ performs translation and/or symmetry on $\bar{\theta}$ and α_i is a scaling factor that depends on the LDPC code rate. Figure 3 shows the steps of the quantization process to compute $\tilde{L}^0$. The same architecture will be conceived to compute $\tilde{L}^0$ and $\tilde{L}^1$. Since $\alpha_0 = \alpha_1$, only one multiplier is required to obtain $\bar{\rho}\alpha_0$ and $\bar{\rho}\alpha_1$. We also know that $s_i(\bar{\theta}) = \pm 1$, then no multiplier is required for this step. To calculate $\tilde{L}$ for a whole symbol, 5 multipliers should be implemented.

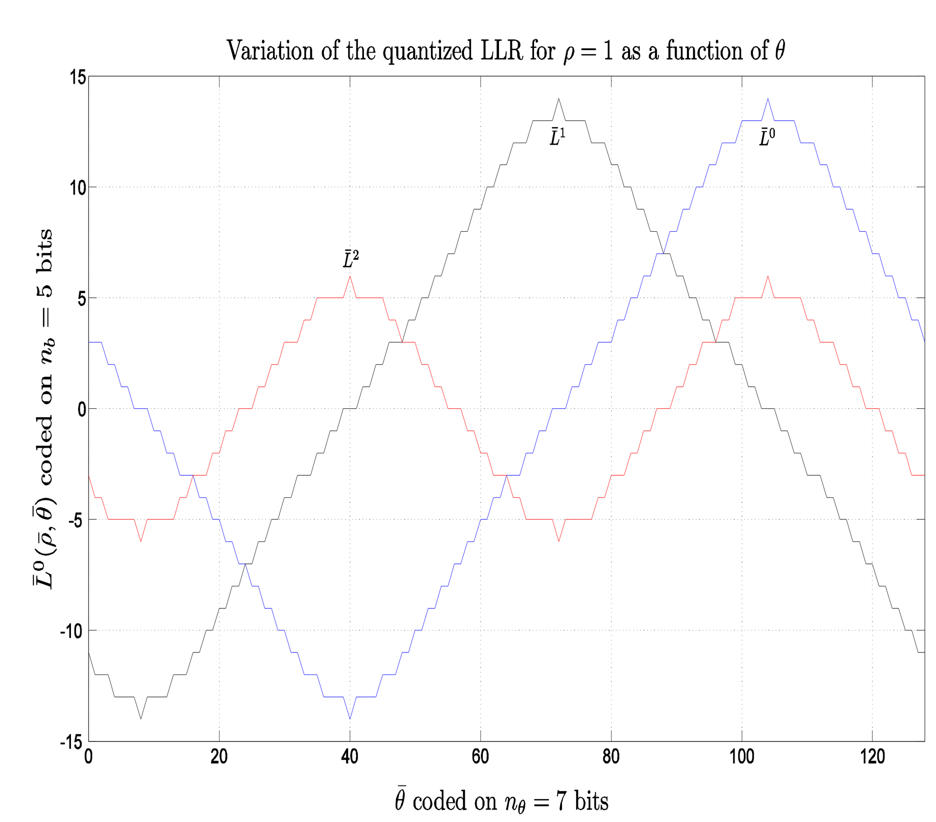

Figure 2 : Quantization of LLR for ρ = 1 as a function of θ

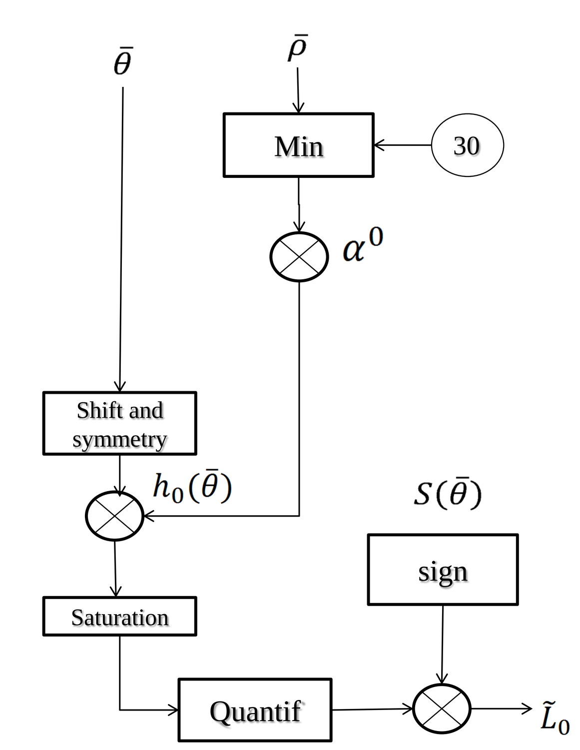

Figure 3 : Architecture of computation of $\tilde{L}_0$

SIMULATION RESULTS

Figure 4 shows the BER as a function of the SNR for a 2/3 and a 3/4 LDPC code rate (short frames N = 16200 bits). The performance is only reduced by 0.02 dB compared to the optimal LLR computation. Table 1 shows that compared to state of art's methods, the proposed linear approximation offers an interesting compromise between the simplicity and the performances.

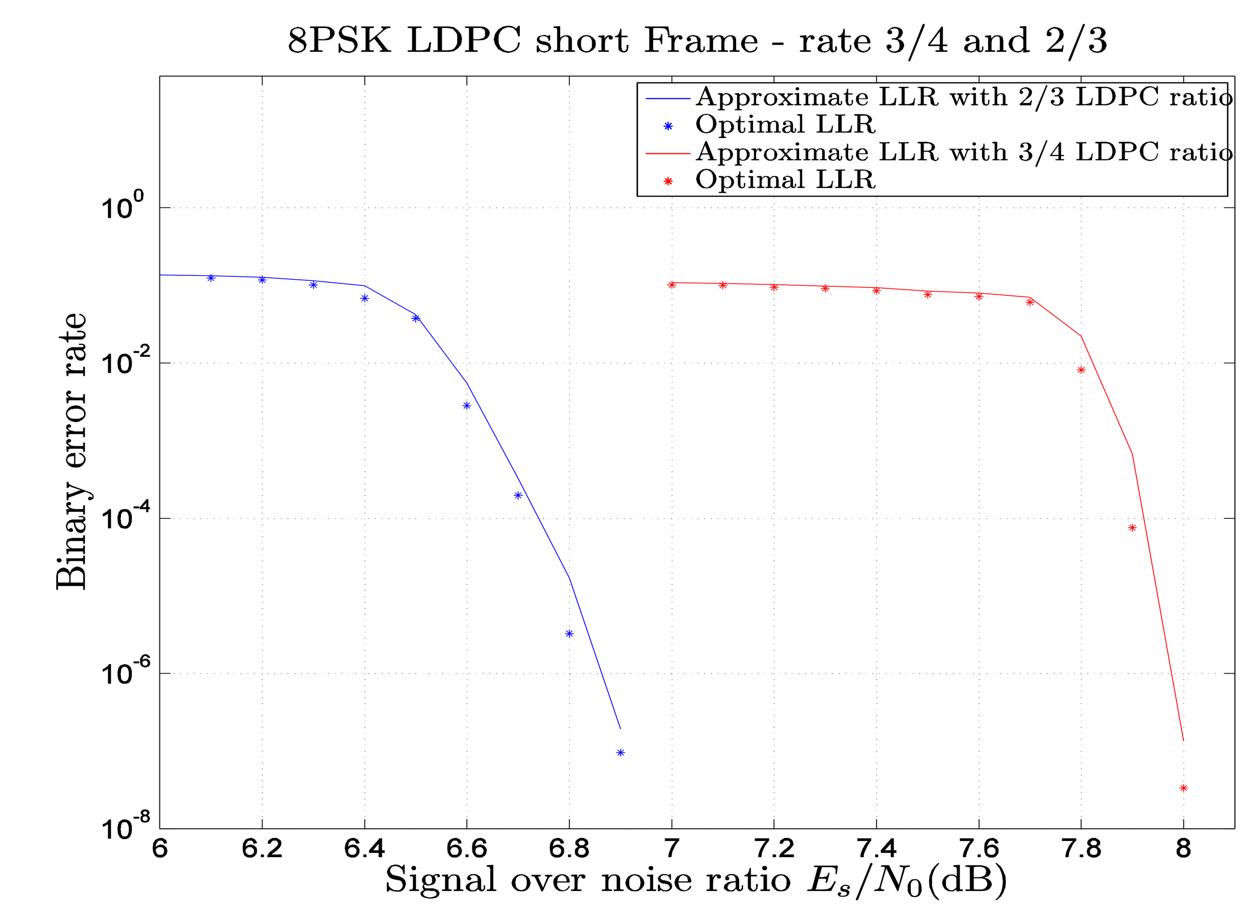

Figure 4 : Error rate as a function of the signal to noise ration for LDPC rate 2/3 and 3/4

Method	Max [4]	Re-injection of I and Q [5]	Proposed
Required multipliers	16	4	5
MSE	0.94	1.54	0.89

Table 1 : Number of multipliers required to implement different methods of approximation and Mean Square Error (MSE) between approximated LLR and exact quantified LLR.

CONCLUSIONS

This paper proposes a different approach of two aspects of demapping an 8PSK modulation for DVB-S2 standard. The first one is about using polar coordinates. The preceding step of synchronization can be done in that system of coordinates [2], we thereby save a CORDIC [3] (COordinate Rotation Digital Computer) changing computation. The second aspect concerns the approximation of the LLR using a geometric approach. This method is very simple to implement and allows us to obtain a better reliability than the-state-of-the-art methods.

We can go further by extending the proposed method to the 16-APSK modulation.

REFERENCES

[1] ETSI EN 302 307, v. 1.1.2 *Digital Video Broadcasting (DVB); Second generation framing structure, channel coding and modulation systems for broadcasting, interactive services, news gathering and other broadband satellite applications, June 2006.*

[2] E. Boutillon; P. Kim; C. Roland; D.-G. Oh, *Efficient Multiplierless Architecture for Frame Synchronization in DVB-S2 Standard, SISP 2011, Oct. 2011, Beirut*

[3] J. E. Volder, "The CORDIC Trigonometric Computing Technique", IRE Transactions on Electronic Computers, Sept. 1959.

[4] Jang Woong Park; Myung Hoon Sunwoo; Pan Soo Kim; Dae-Ig Chang, *Low Complexity Soft-Decision Demapper for High Order Modulation of DVB-S2 system SoC Design* Conference, ISOCC '08. International, vol 02, p. II- 37 - II-40, 2008.

[5] Michael K. Cheng; Dariush Divsalar; Stephanie Duy, *Structured Low-Density Parity-Check Codes with Bandwidth Efficient Modulation, Proc. SPIE 7349, Wireless* Sensing and Processing IV, Orlando, April 13 2009.