5to Foro de TV Digital

Comparative analysis of advanced modulation techniques used in the next generation of TDT

Universidad de Oriente
Facultad de Ingeniería Eléctrica
Departamento de Telecomunicaciones
Noviembre, 2017

AUTHORS :

MSC. YANELA VARELA MÉNDEZ

MSC. FIDEL GIRÓ URIBAZO

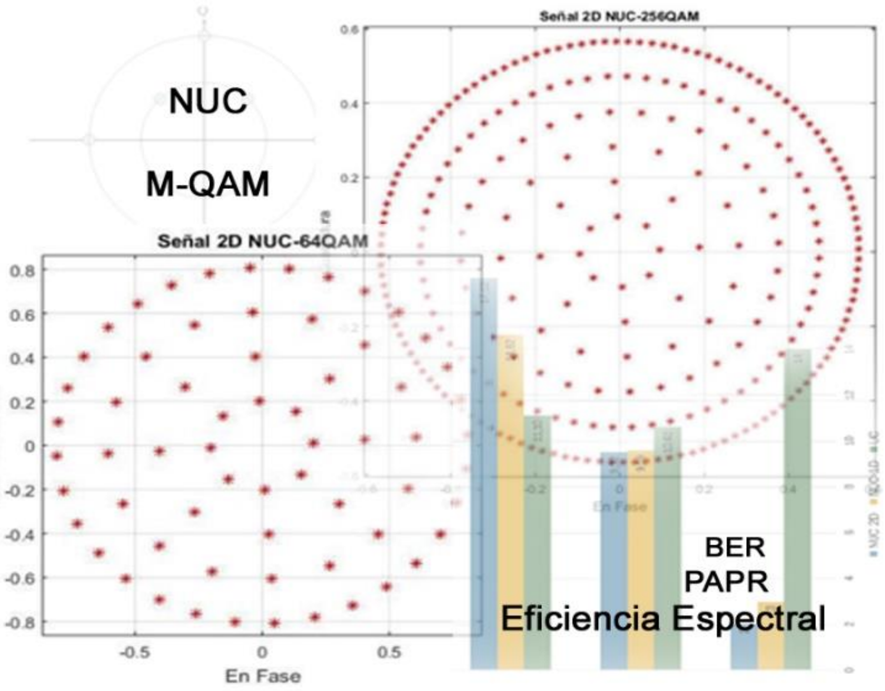
Summary

- Introduction
- Theoretical fundament
- Non-Uniform Constellations (NUC)
- Analysis and Validation of results
- Conclusions

General objective

Make a comparative analysis of the uniform modulation (UC) versus non-uniform (NUC) modulation used in the new TDT standards.

Introduction

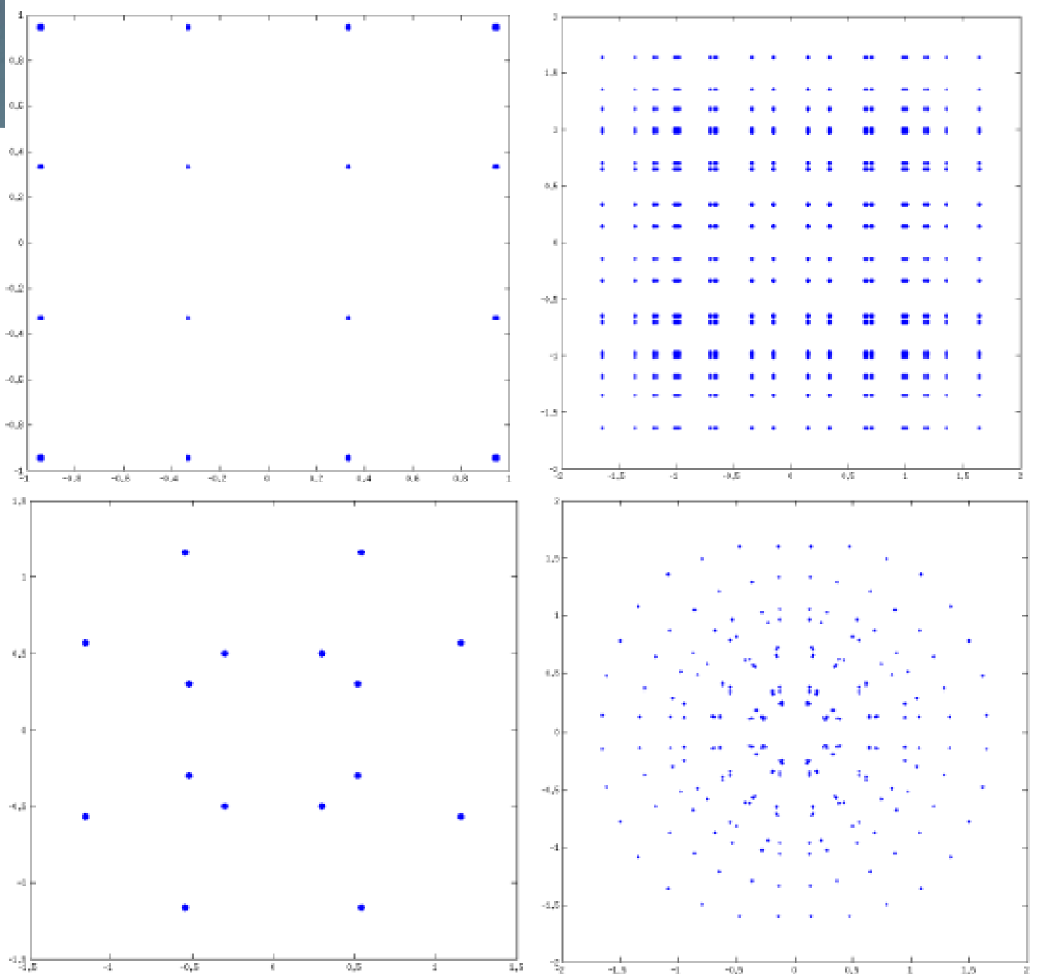


Non-Uniform Constellation

Non-Uniform Constellation (NUC)

1 Dimension ➡

2 Dimension ➡



New generation of systems TDT

NGB-W

(China)

ATSC 3.0

(EUA)

MIMO

4K ULTRAHD

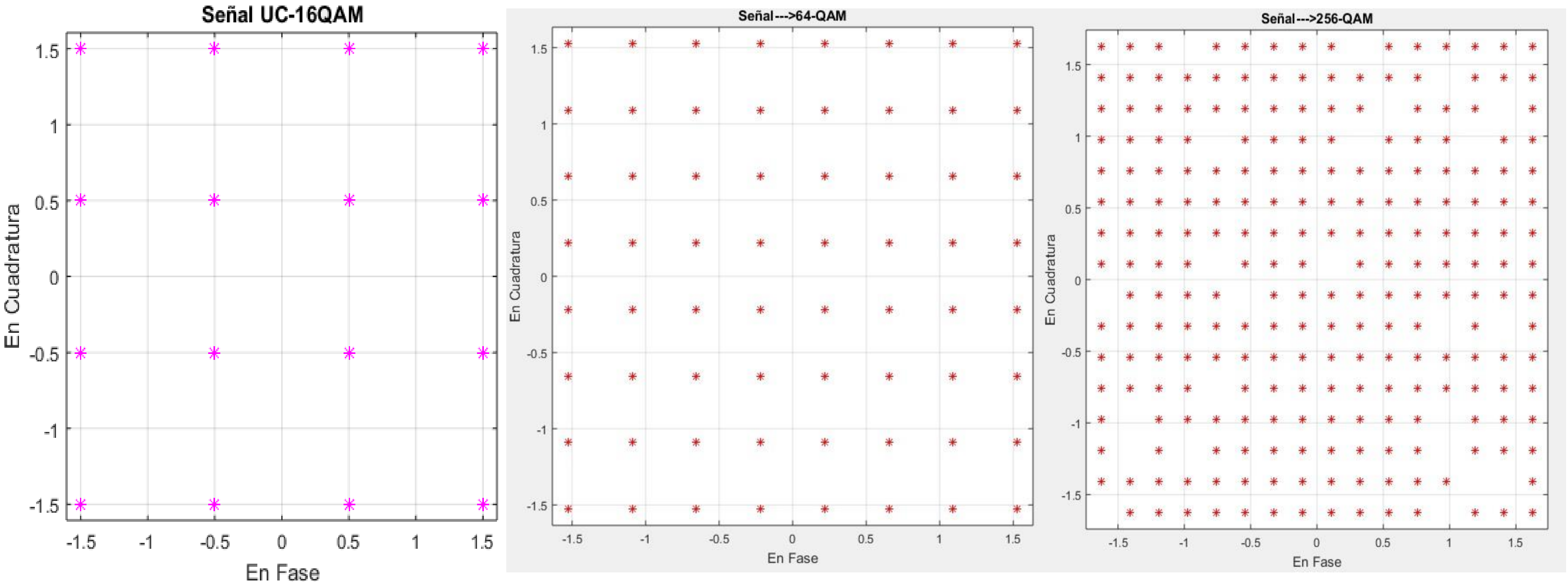
Uniform Constellation

$$s(t) = \underbrace{\sum_{i=-\infty}^{i=+\infty} a_i p(t - iTs)\cos(2\pi f_{ct})}_{\text{ASK(I)}} + \underbrace{\sum_{i=-\infty}^{i=+\infty} b_i p(t - iTs)\sin(2\pi f_{ct})}_{\text{ASK(Q)}}$$

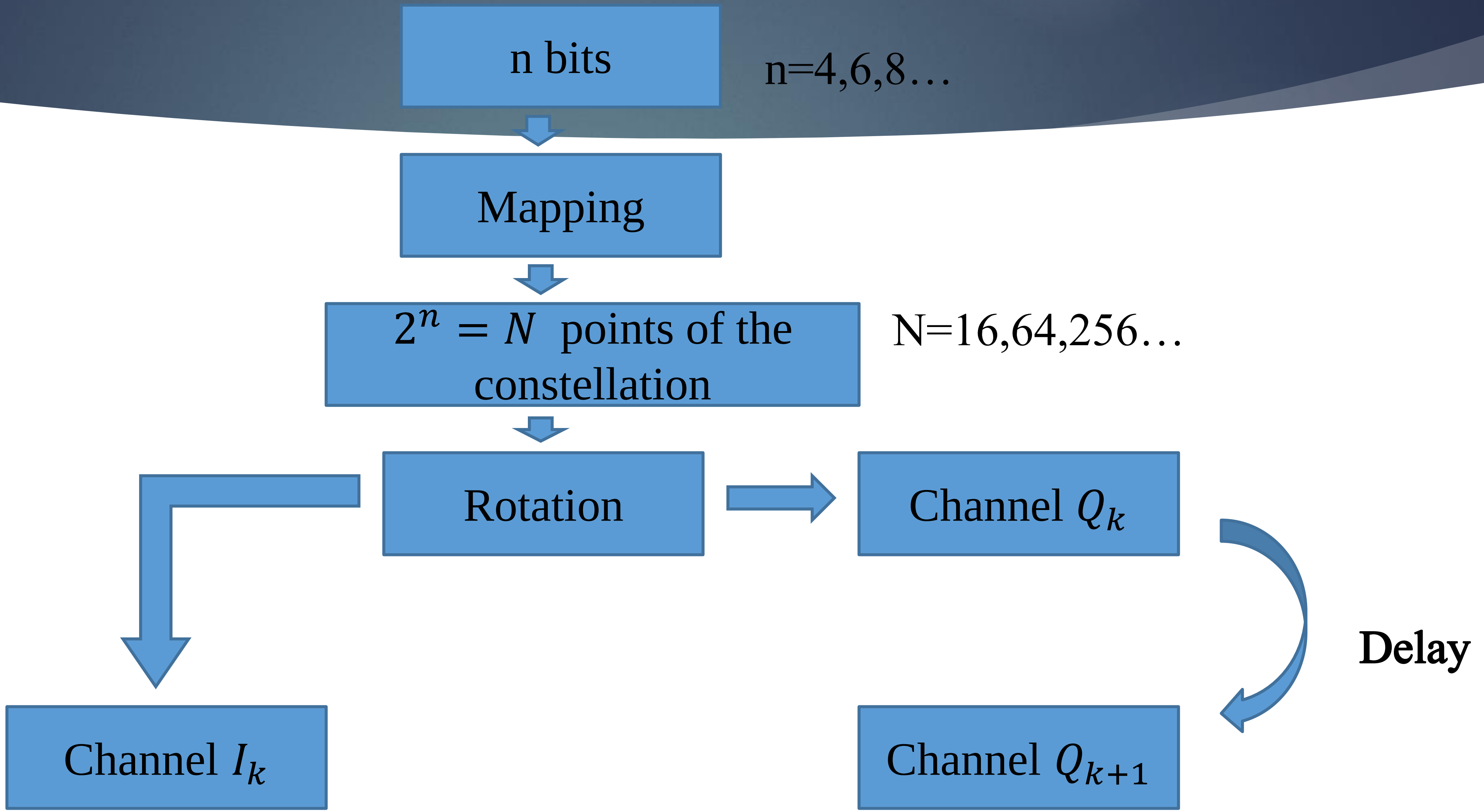
Where p(t) is the pulse and is equal:

$$p(t) = \begin{cases} 1, & 0 < t < Ts \\ 0, & ohther \end{cases} \qquad \begin{matrix} a_i = \mp 1 \\ b_i = \mp 1 \end{matrix}$$

Uniform Constellation



Mapping, rotation and delay



Non-Uniform Constellation

$$[p^R i \;\; p^R q] = [pi + pq] * \begin{bmatrix} \cos(\theta) & -\sin(\theta) \\ \sin(\theta) & \cos(\theta) \end{bmatrix}$$

$$x_i = a_i \cos(\theta) + b_i \sin(\theta)$$

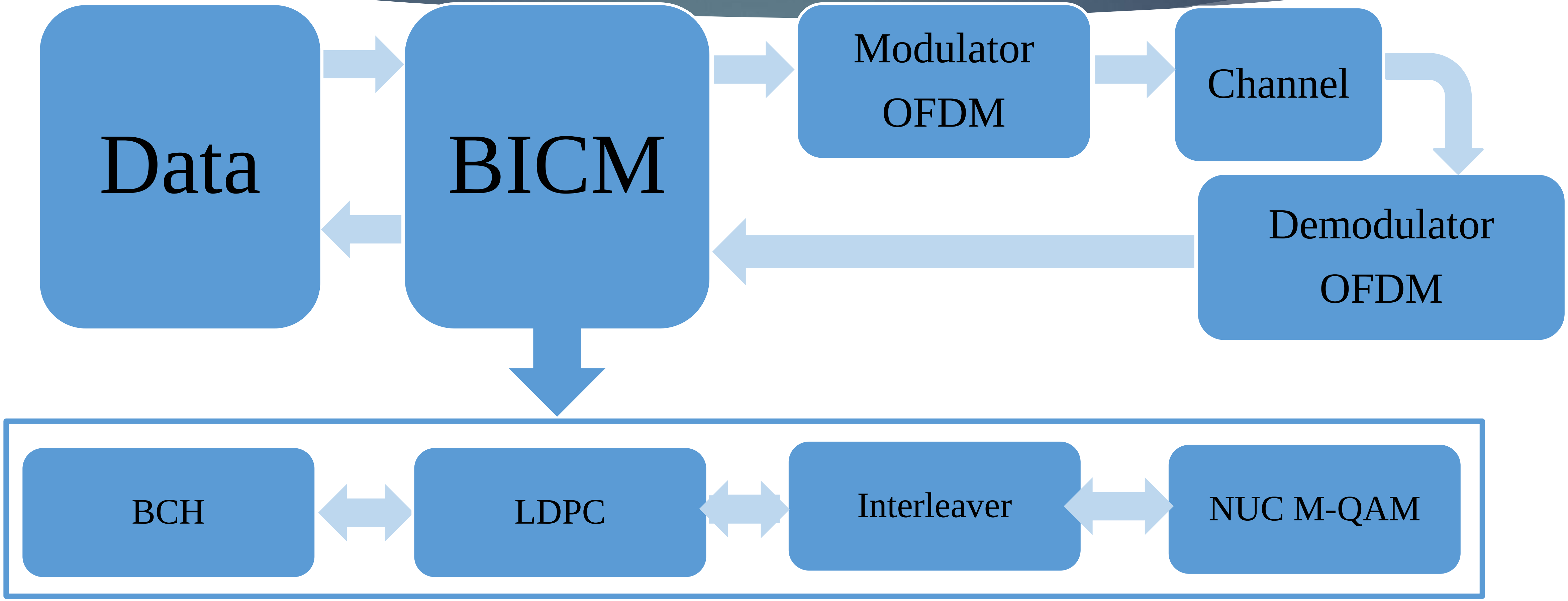
$$y_i = -(a_i) \sin(\theta) + b_i \cos(\theta)$$

$$s(t) = \sum_{i=-\infty}^{i=+\infty} x_i p(t - iTs)\cos(2\pi f_{ct}) + \sum_{i=-\infty}^{i=+\infty} k y_i p(t - iTs)\sin(2\pi f_{ct})$$

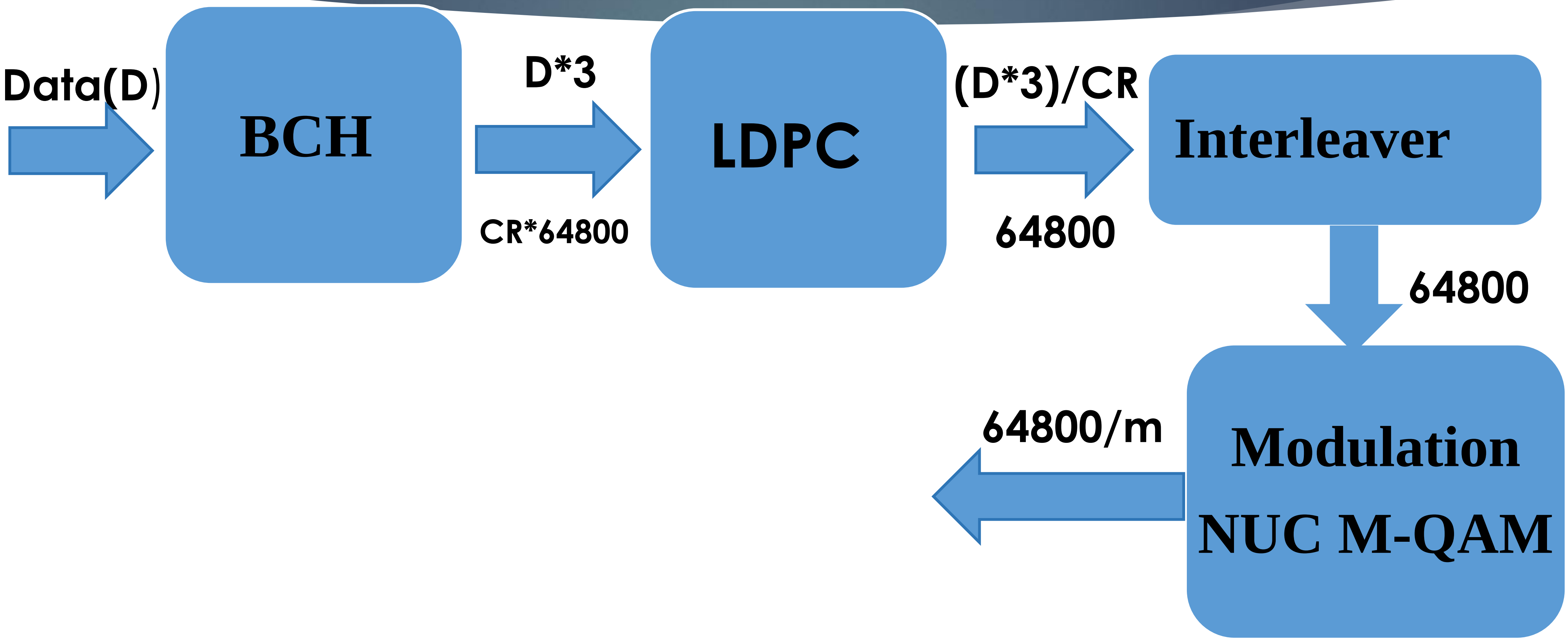
Rotation angles

Modulation	16-QAM	64-QAM	256-QAM
θ (degree)	16.8	8.6	atan(1/16)

Performance



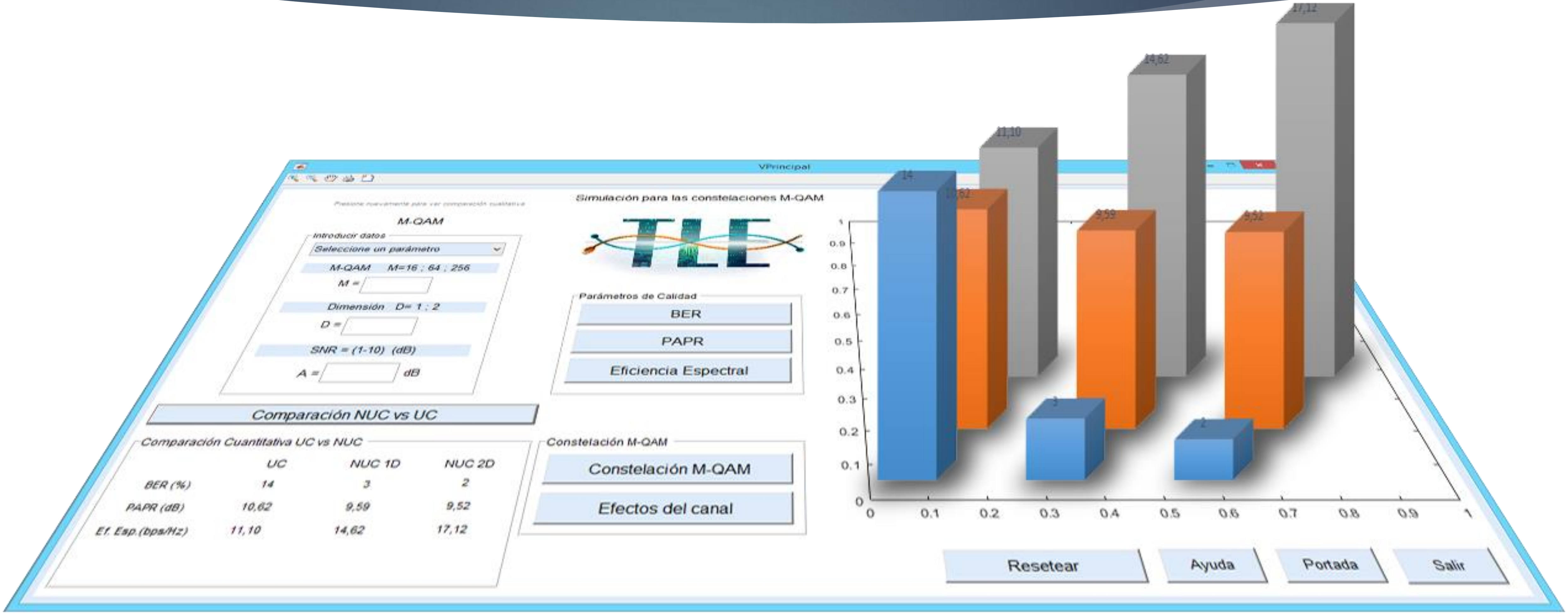
Coding, Modulation, and Interleaved

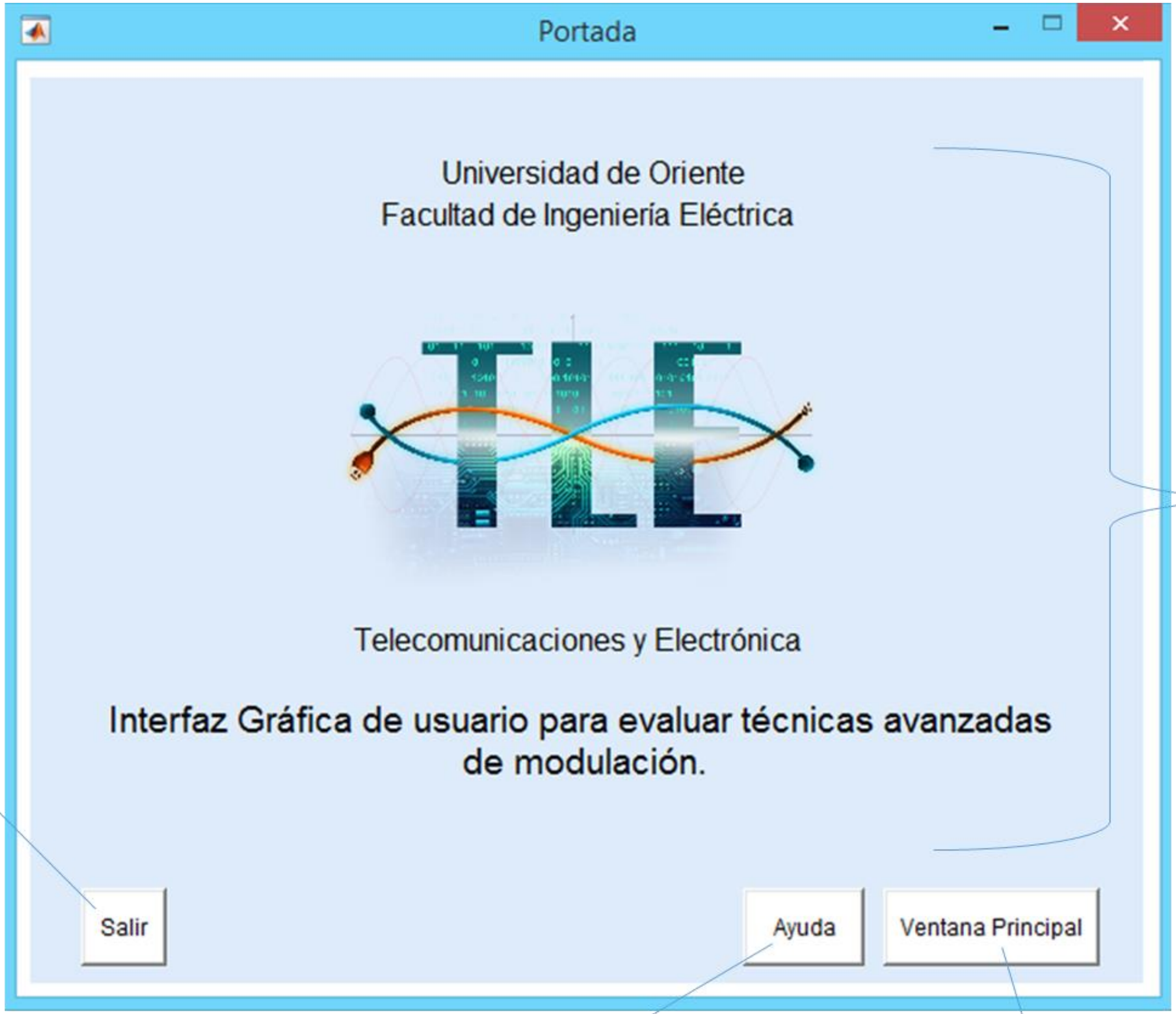


Performance

Software	**MATLAB (R2014 y R2015)**
Channels	AWGN , Rayleigh
Constellation	NUC 16-QAM,64-QAM,256-QAM
Dimension of the constellation	1,2
CR	12/15

Analysis and validation of results





Static Texts y Axes con los datos de presentación de la interfaz

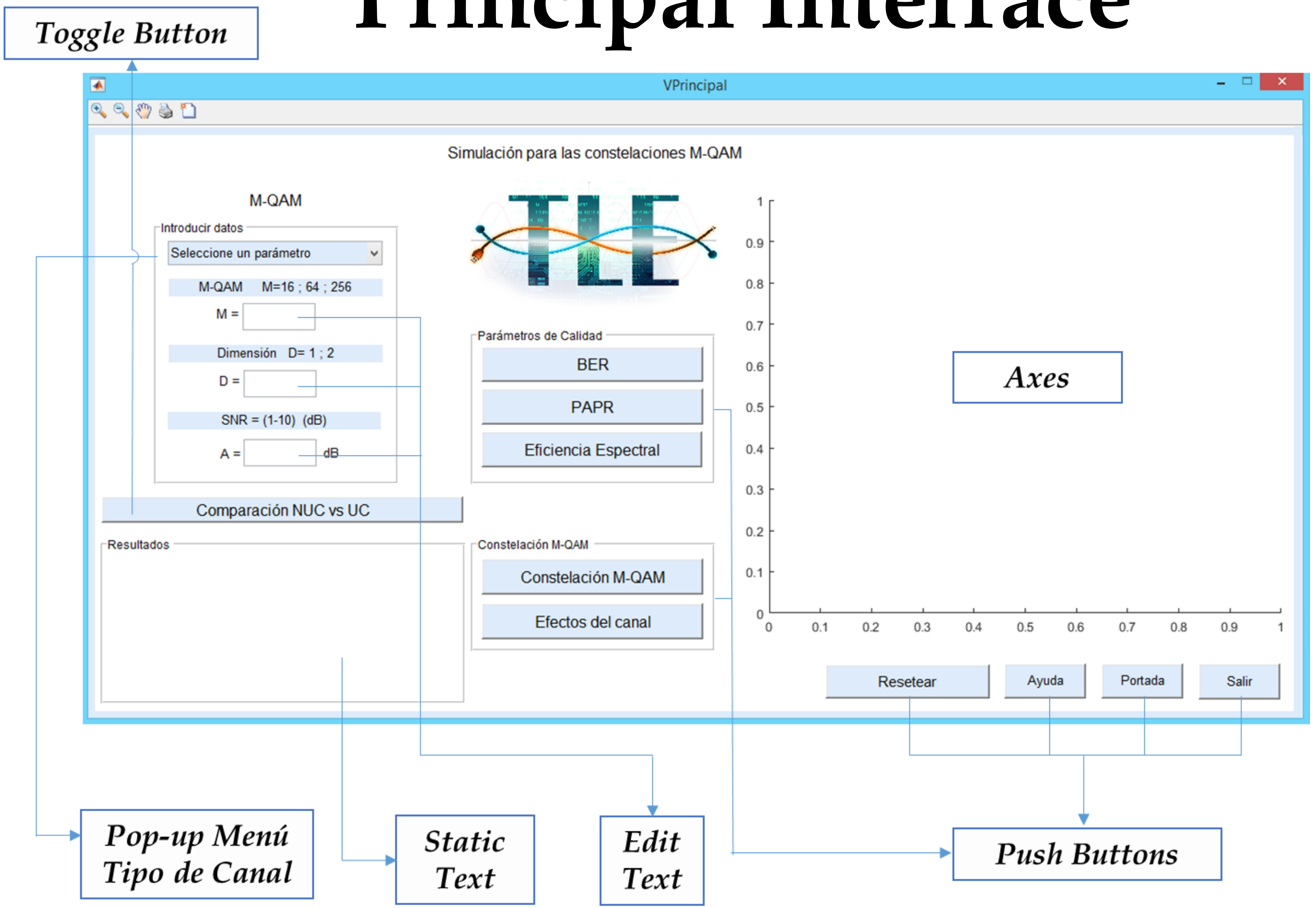
Push Button Salir

Push Button Ayuda

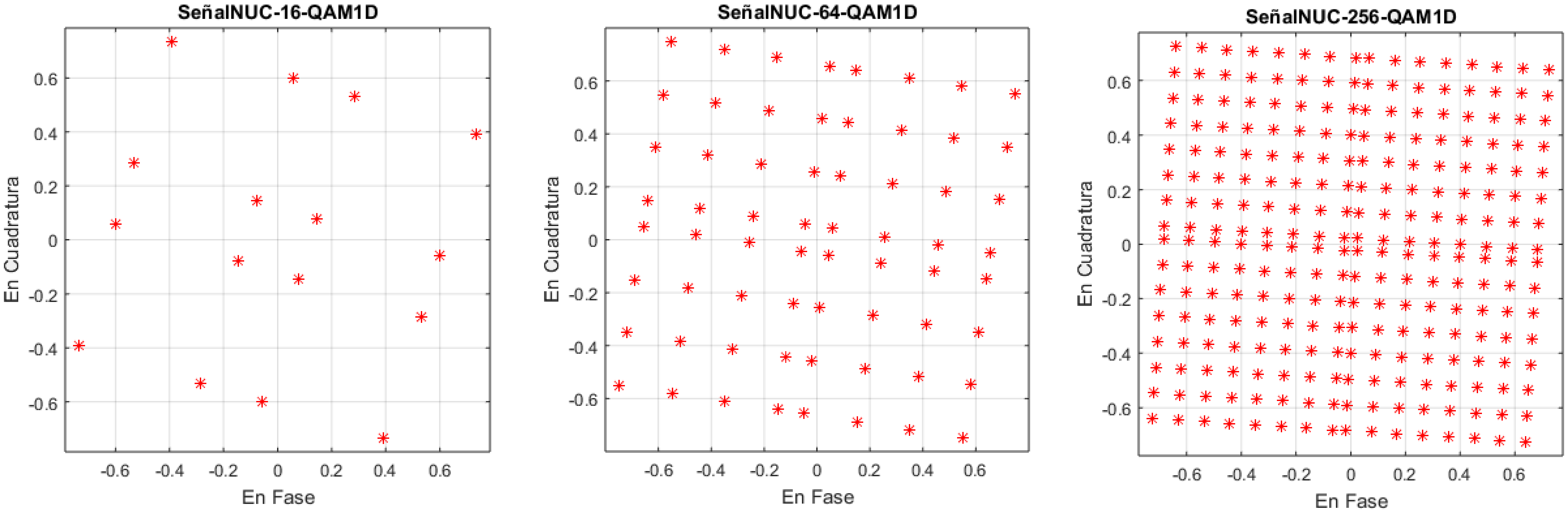
Push Button Ventana Principal

Front Interface

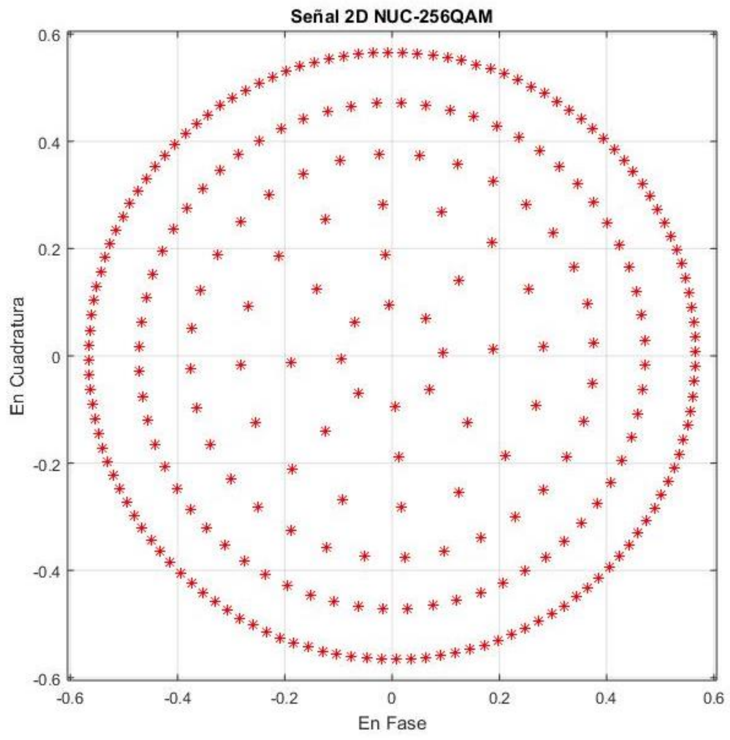
Principal Interface

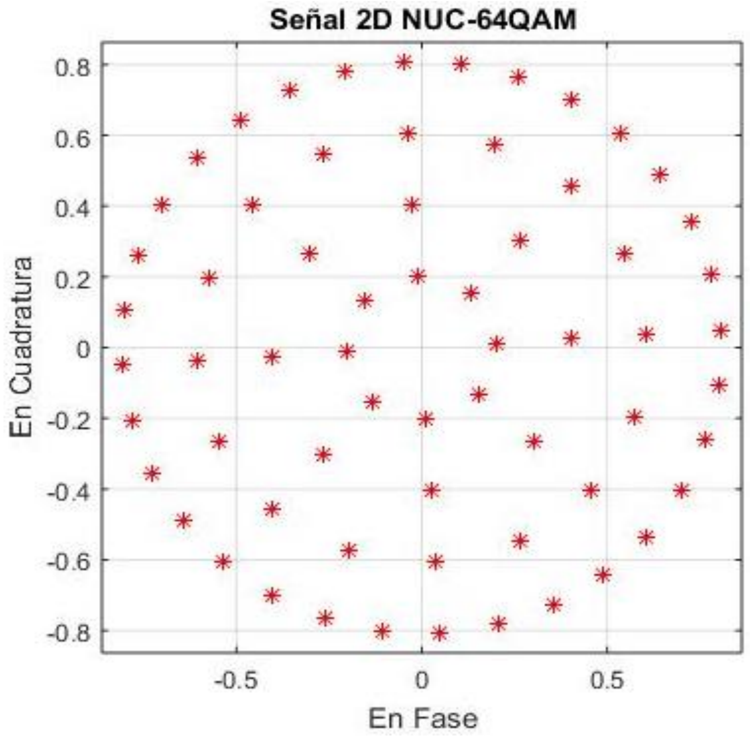


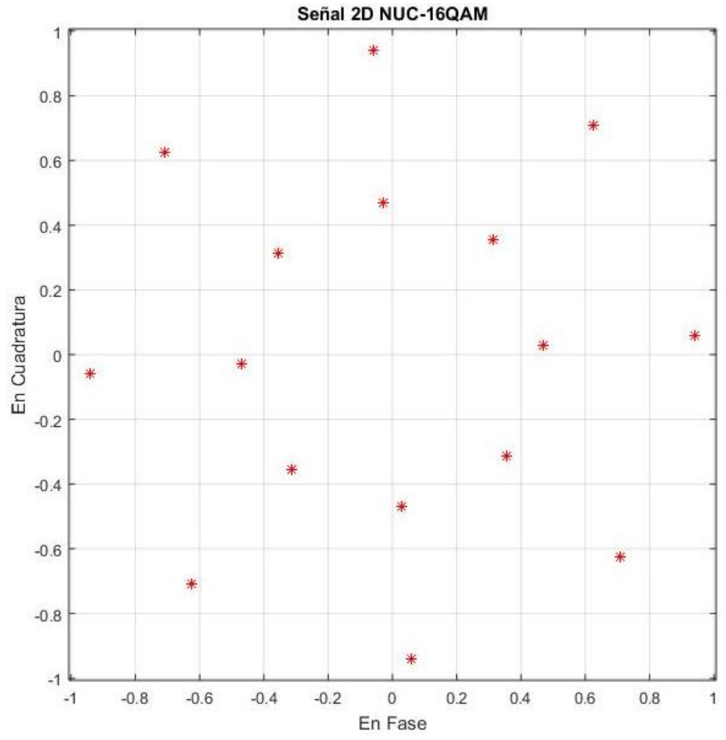
Non-Uniform Constellation 1D



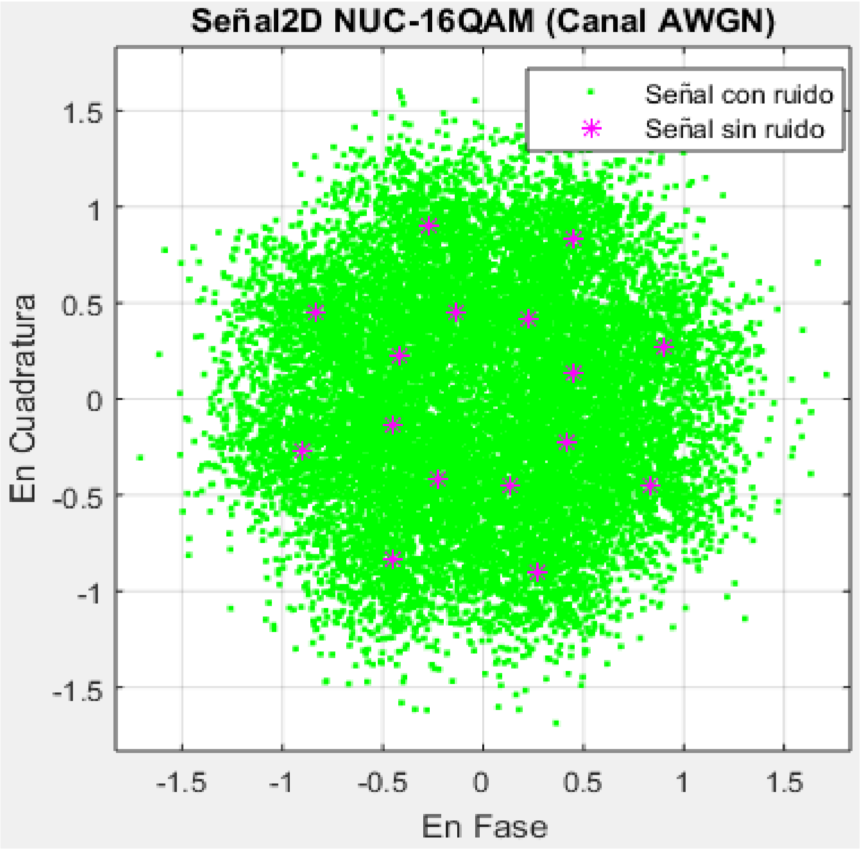
Non-Uniform Constellation 2D



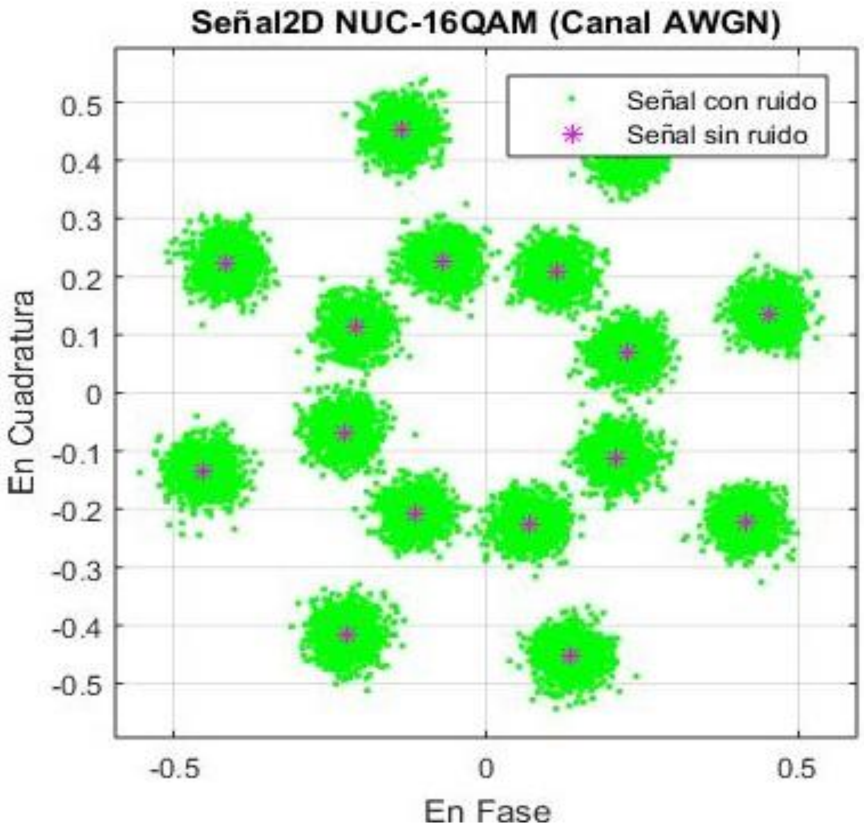




AWGN Channel



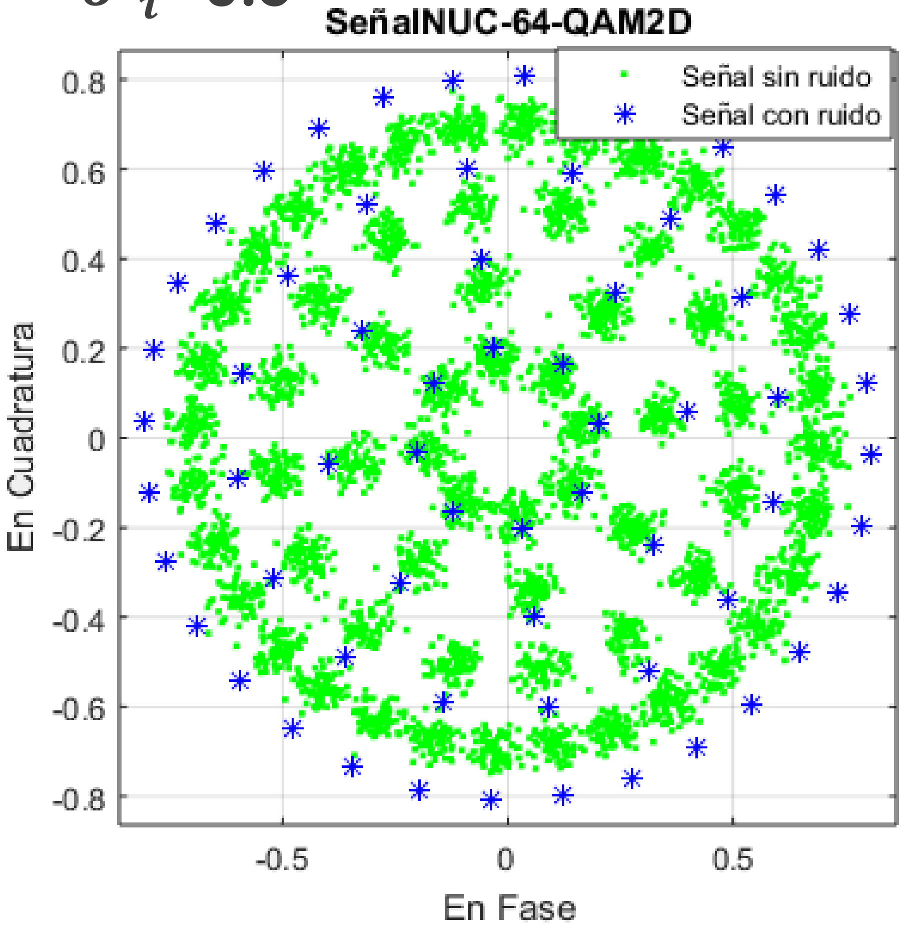
SNR=3dB.



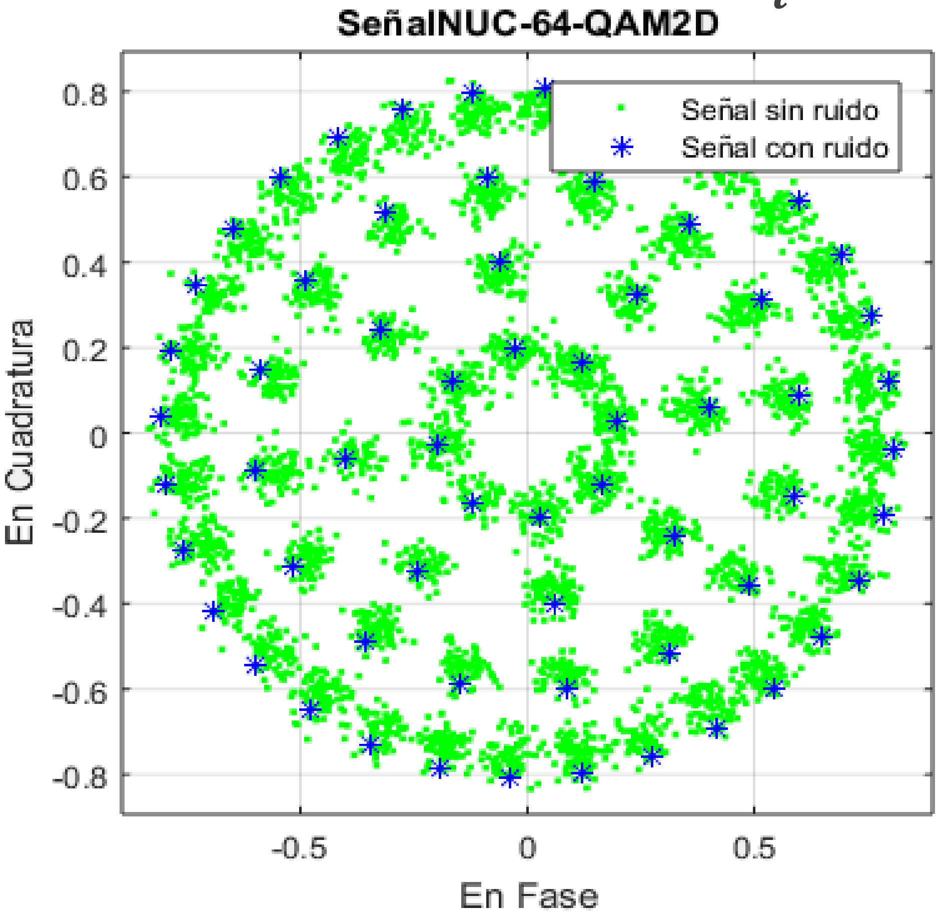
SNR=9dB.

Rayleigh Channel

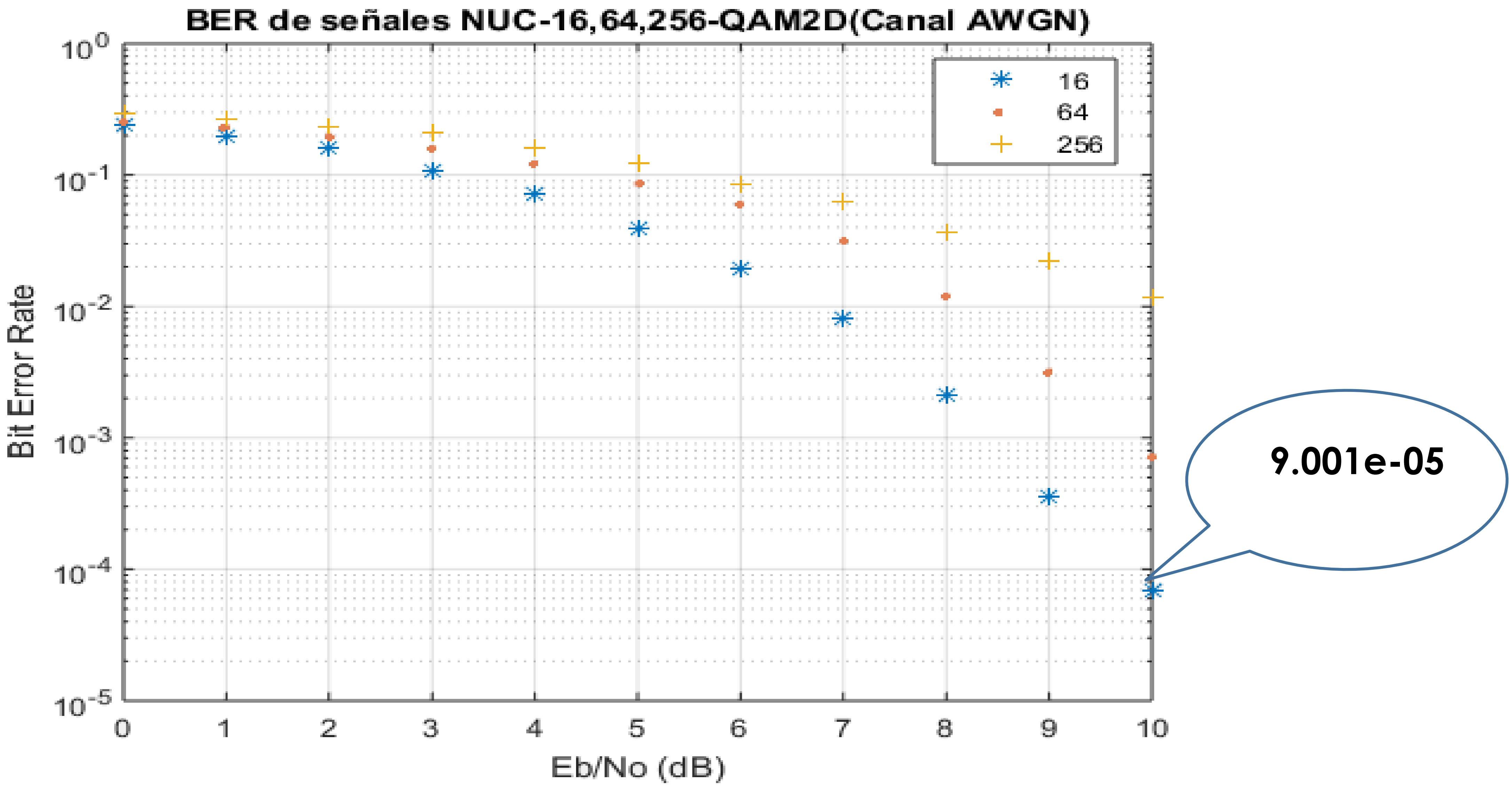
σ_{τ}=0.5



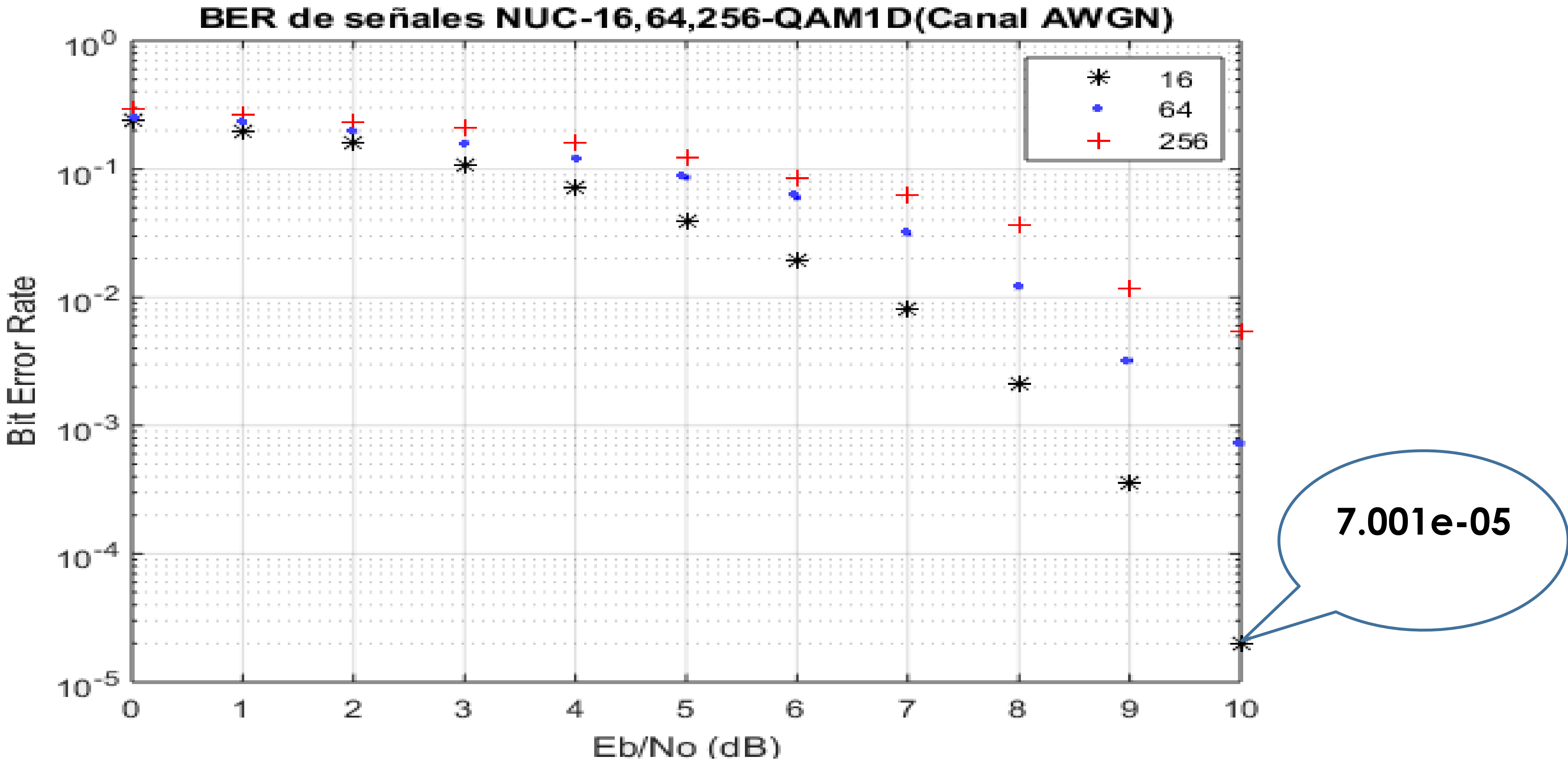
σ_{τ}=0.1



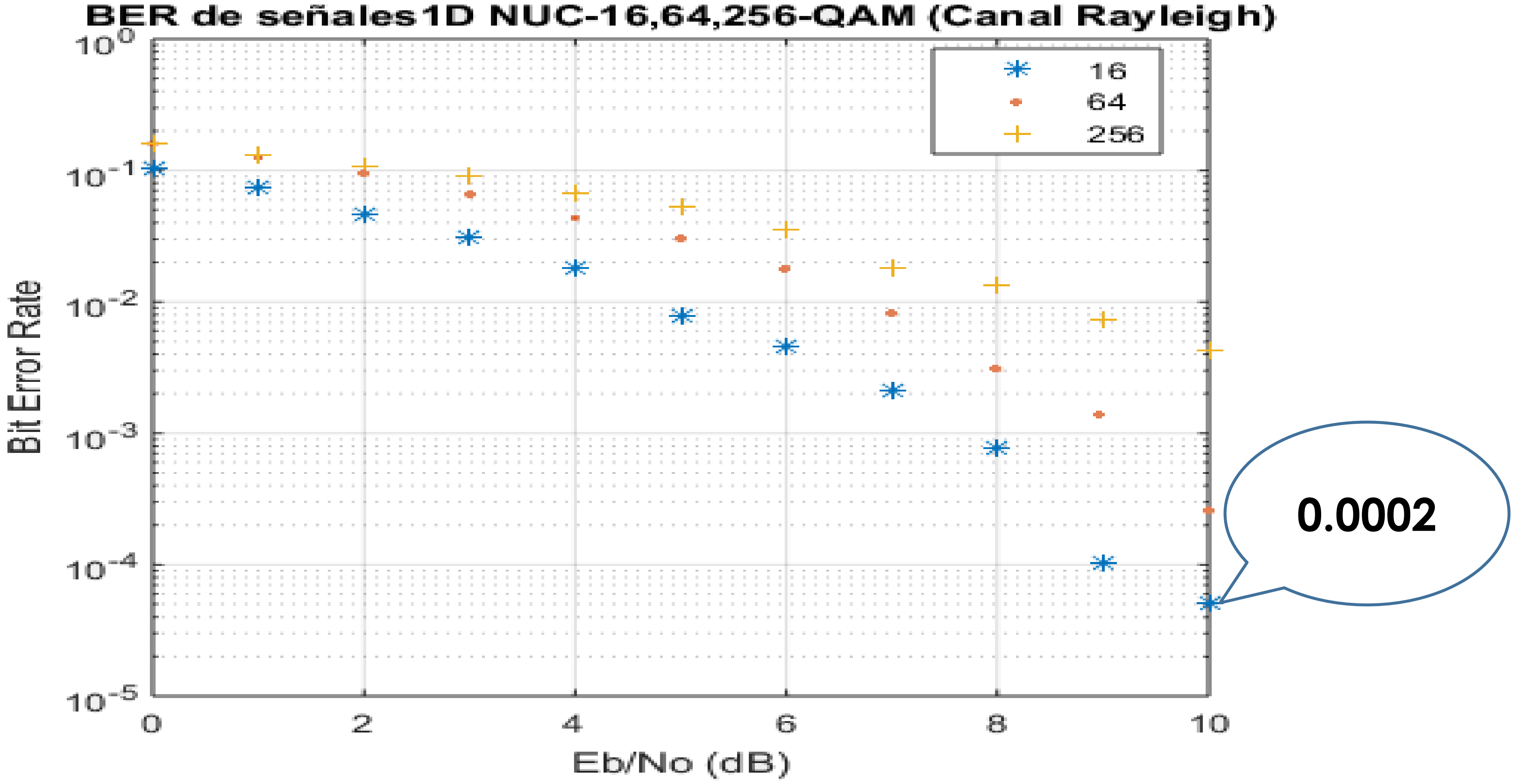
Bits Error Rate (BER)



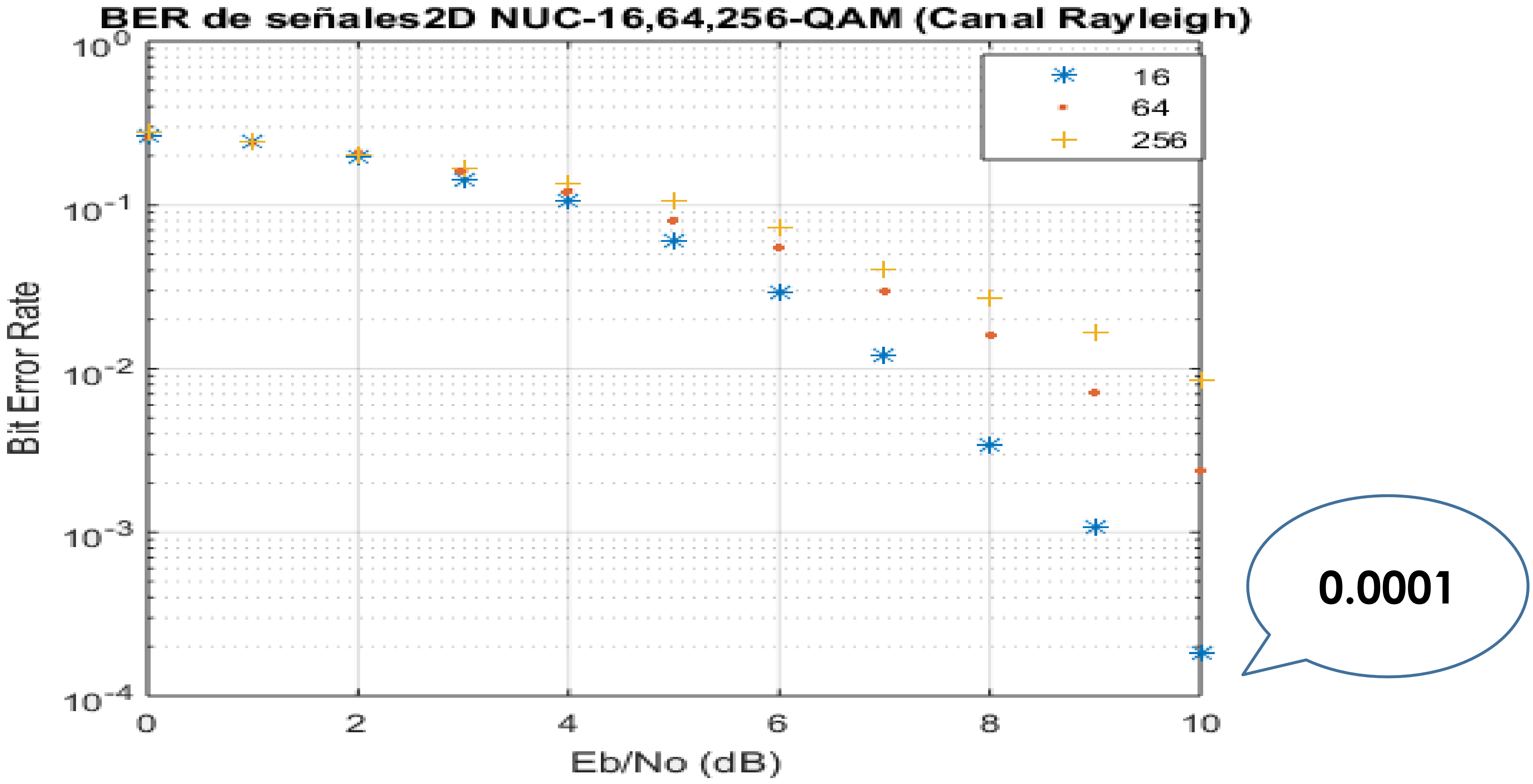
Bits Error Rate (BER)



Bits Error Rate (BER)



Bits Error Rate (BER)

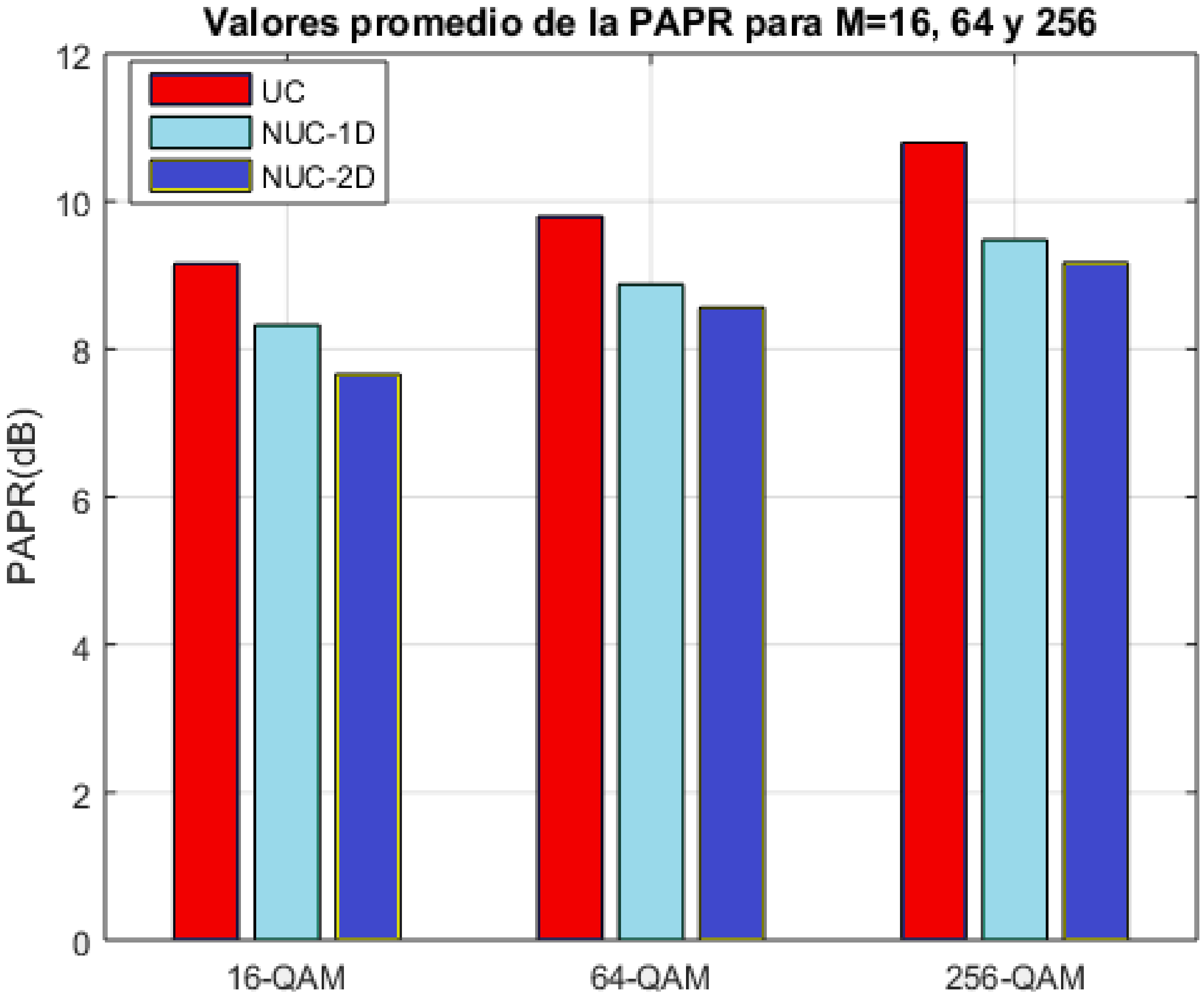


Comparison of the NUC´s vs UC´s

AGWN	16-QAM			64-QAM			256-QAM		
SNR(dB)	UC	1D	2D	UC	1D	2D	UC	1D	2D
0	0,1412	0,0892	0,2149	0,1990	0,1675	0,3207	0,2540	0,2150	0,1209
5	0,0419	0,0057	0,0139	0,1000	0,0369	0,1336	0,1590	0,1033	0,0860
10	0,0018	9e-5	7e-5	0,0265	0,0010	0,0038	0,0786	0,0156	0,0307

Rayleigh	16-QAM			64-QAM			256-QAM		
SNR(dB)	UC	1D	2D	UC	1D	2D	UC	1D	2D
0	0.1437	0.1037	0.2355	0.2025	0.1906	0.1638	0.2890	0.2344	0.1248
5	0.0448	0.0090	0.0272	0.1032	0.0587	0.0828	0.2047	0.1162	0.0969
10	0.0027	0.0001	0.0002	0.0289	0.0015	0.0067	0.1242	0.0247	0.0476

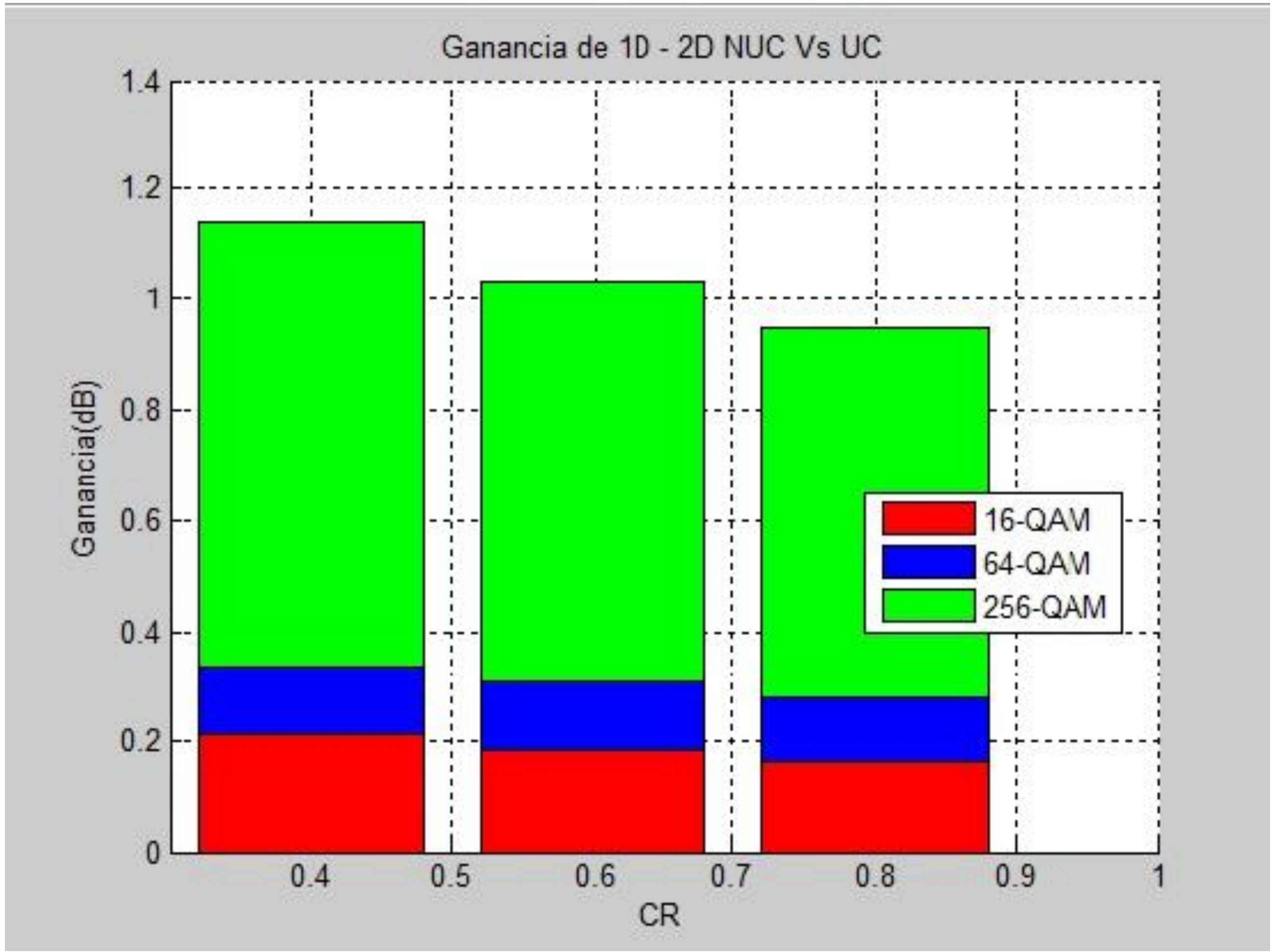
PAPR Analysis



$$PAPR = \frac{\max[\,[y[k]]^2\,]}{E[\,[y[k]]^2\,]}$$

Modulation	UC(dB)	NUC 1D(dB)	NUC 2D(dB)
16-QAM	9.095448	8.036107	7.806945
64-QAM	10.626976	9.175798	8.970163
256-QAM	11.294440	9.683567	9.634040

Spectral Efficiency Analysis



$$\frac{R}{W} = \frac{V_t}{AB} \qquad bit/s/Hz$$

Tamaño FFT	16 QAM	64 QAM	256 QAM
4k	5.0515	6.8124	8.0618
8k	5.5090	7.2699	8.5193
16k	5.7573	7.5182	8.7676
32k	5.8869	7.6478	8.897260

Conclusions

A GUI was implemented in MATLAB, using a simple simulation language to any user, it enables the understanding and implementation of theoretical and technical knowledge about advanced modulation techniques.

Uniform and non-uniform constellations were simulated and this permitted to highlight the advantages and disadvantages of non-uniform versus uniform constellations in relation to PAPR, BER and spectral efficiency parameters.

The values of the BER for an AWGN and Rayleigh channel were calculated, they decrease as the values of the SNR increase. In addition the results obtained for an AWGN channel are better than for a channel Rayleigh.

Conclusions

The spectral efficiency achieves better results as the modulation order and the number of FFT points increases, which favors the performance of the communications systems.

The PAPR was calculated for uniform and non-uniform constellations of 1 and 2 dimensions, obtaining that the non-uniform constellations presented better results than the uniform, although in general it was observed that, as the number of carriers increases, PAPR increase too.

Thanks