Given the need to simulate signals that approximate those actually used in Nuclear Magnetic Resonance experiments—and in some cases with distortions produced by the analog stages of real circuits—Application 2 was developed.

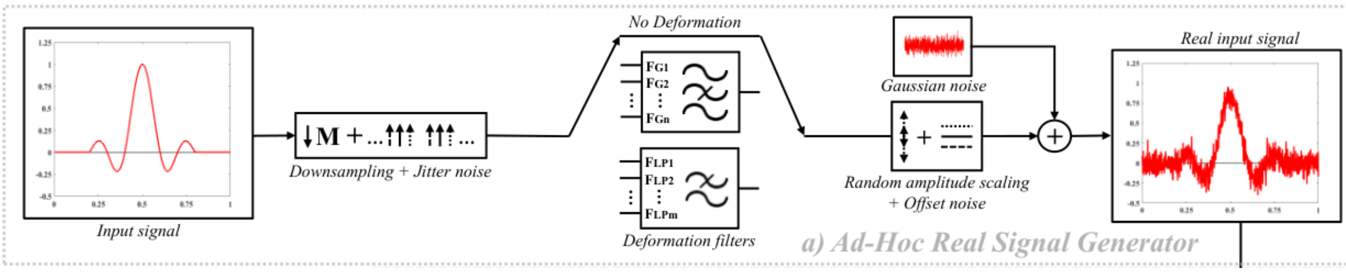


Figura 1: Block Diagram of the Ideal Signal Application (Application 1).

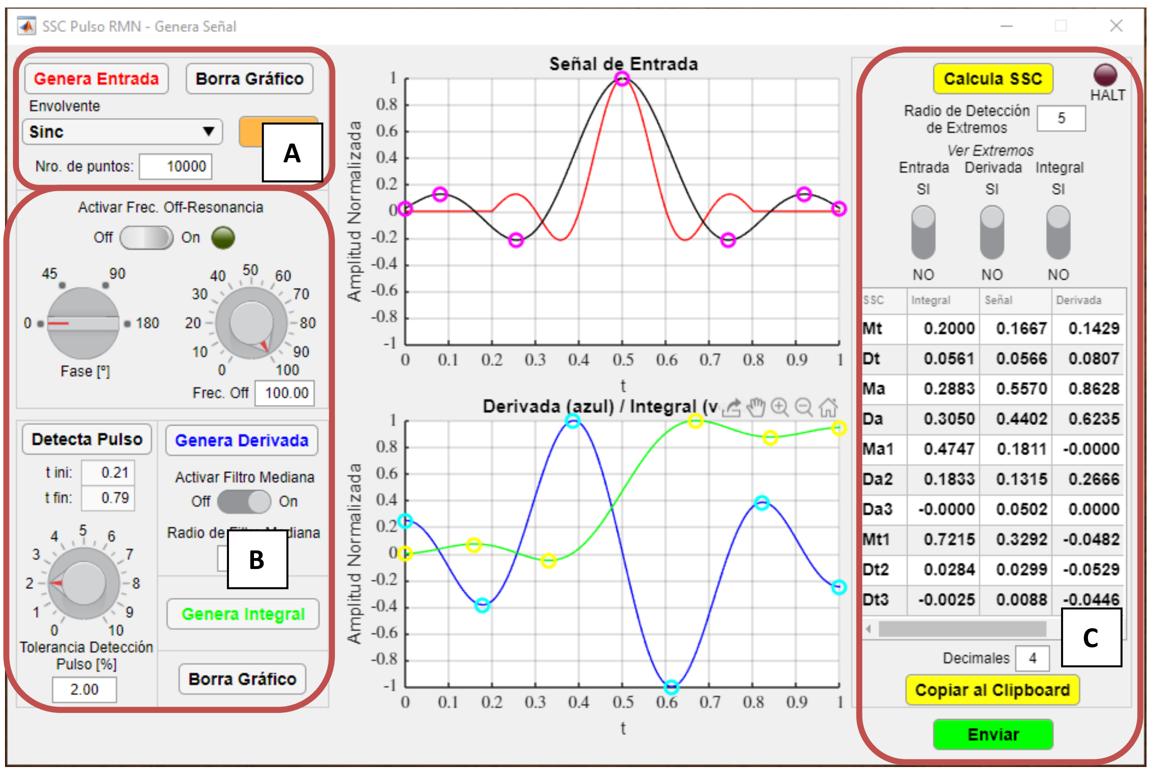


Figura 2: Interface of Application 1 that calculates the Extended SSC parameters for ideal signal values

Sección	Función
A	Menu with the list of signals available for simulation: Sinc, Gaussian, or Chirp
B	Allows configuration of phase shifts and pulse detection levels. Calculates the derivative and integral of the function.
C	Calculation of the ideal extended SSC parameters and the option to send the data to the second application to simulate a real signal.

Tabla 1: Descripción de las secciones principales de la *Aplicación 1*.

Its function is to provide the necessary information to form a real database for later use in training the classifier's neural network. As shown in the block diagram of Figure 3, this application has noise sources and distortion filters, which are necessary elements for forming the database with real signal information. Figure 4 and Table 2 show the most important blocks of the interface and their functionalities.

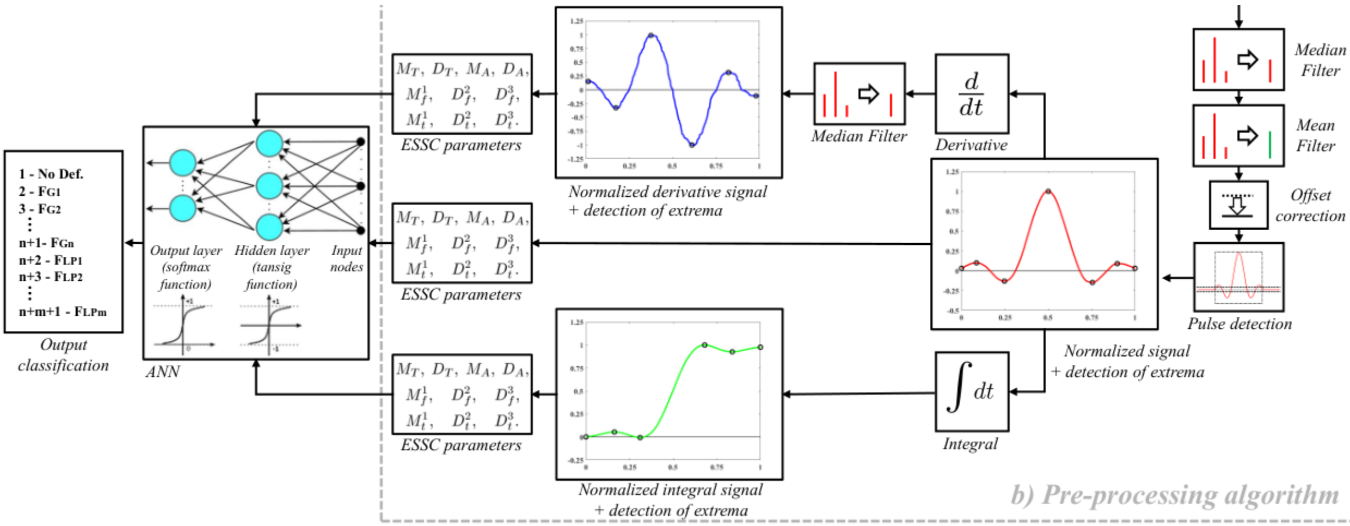


Figure 3: Block Diagram of the Real Signal Application (Application 2)

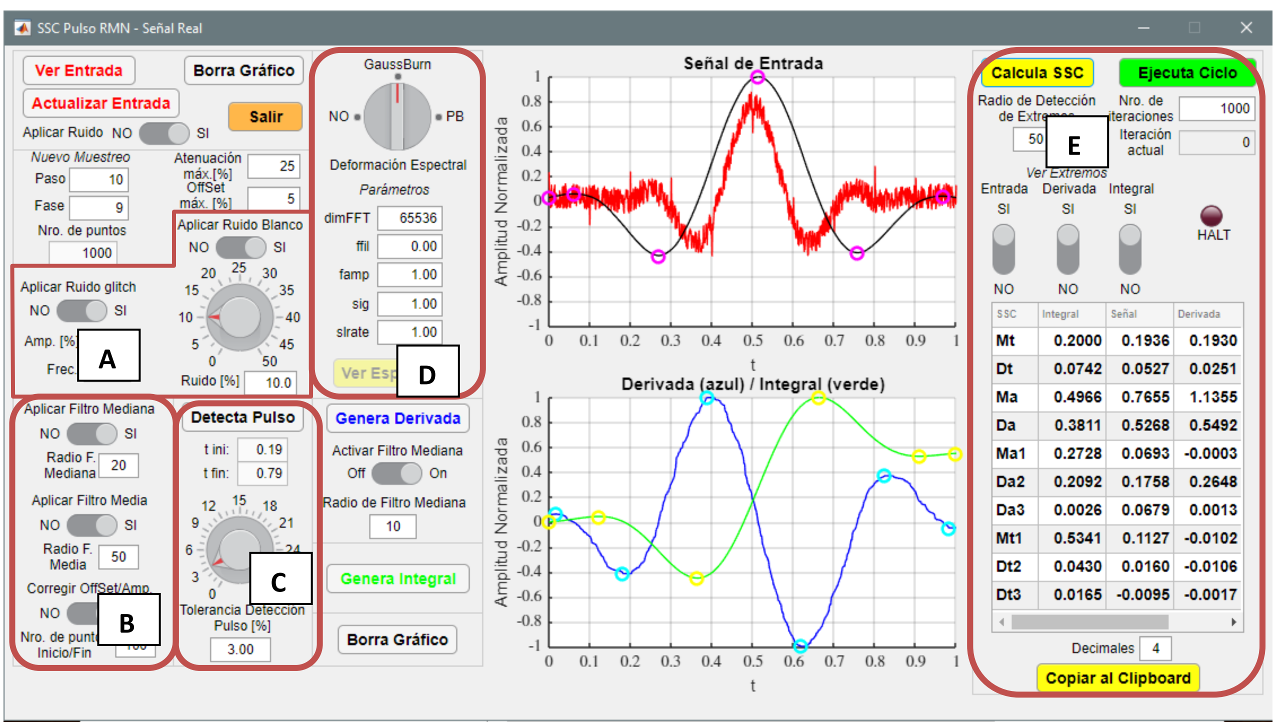


Figure 4: Interface of Application 2 that calculates the Extended SSC parameters for real signal values.

Section	Function
A	Configuration of the type of noise and its intensities to be added to the ideal signal from Application 1.
B	Configuration of Noise Filters: median and mean types, as well as detection of signal offset levels.
C	As in Application 1, it is possible to adjust the voltage levels from which signal detection is performed.
D	Filtros de deformación de señal. Selección del filtro y sus parámetros. Se disponen de dos tipos de filtros, uno Pasaba bajos y otro del tipo Gaussiano.
	Signal distortion filters: selection of the filter and its parameters. There are two types of filters available: low-pass and Gaussian. **Gaussian Filter Parameters:** - "ffil" is the central frequency - "famp" is the attenuation factor at the central frequency (between 0, no attenuation, and 1, full attenuation) - "sig" is the frequency width of the Gaussians (one for + freq and one for -freq) **Low-Pass Filter (Pb) Parameters:** - "ffil" is the central frequency - "slrate" is the attenuation profile or rate; if "slrate" is large, the profile is more square, and for small "slrate" the profile is smoother
E	Calculation of the extended SSC parameters for the real signal, and the "Run Cycle" function whose purpose is to generate N random signals based on the original.

Table 2: Description of the main sections of Application 2.

Each parameter matrix generated by Application 2 has a dimension of [10x3], as seen in Figure 4 section E, with a total of 30 values, where each column corresponds to the parameters of the integral signal, the signal without any operation, and the derivative signal. To form the database, each matrix is rearranged into a one-dimensional array of [30x1]. Each of these arrays belongs to a signal whose noise is updated randomly for each execution. For example, for #SubBatch 2 of Table 3, Application 2 generated 1000 Sinc-type signals, for a type of distortion performed with the Gaussian filter Figure 5, where each one-dimensional array of the data sub-batch differs from the others in the random noise. Finally, a database was generated with batches of 5000 arrays for each type of signal. This allows us to have a database to train a single classifier that identifies among three signals and 15 types of distortions, or an individual classifier for each type of signal and its 5 distortions.

Complete Batch				
Batch	**#SubBatch (1000 data each)**	**Filter Type**	**Nomination**	**Filter parameters**
Sinc Noise: 5% N_data_tot: 5000	1	No filter	**NoDef**	No deformation
	2	Gaussian 1	**Gauss1**	**ffil** = 0 ; famp = 0.4 ; sig = 2
	3	Gaussian 2	**Gauss2**	**ffil** = 3 ; famp = 0.4 ; sig = 2
	4	Low Pass 1	**PB1**	**ffil** = 2 ; Slew Rate = 0.5
	5	Low Pass 2	**PB2**	**ffil** = 5 ; Slew Rate = 0.5
Gaussian Noise: 5% N_data_tot: 5000	6	No filter	**NoDef**	No Deformation
	7	Gaussian 1	**Gauss1**	**ffil** = 0 ; famp = 0.4 ; sig = 2
	8	Gaussian 2	**Gauss2**	**ffil** = 3 ; famp = 0.4 ; sig = 2
	9	Low Pass 1	**PB1**	**ffil** = 3 ; Slew Rate = 0.5
	10	Low Pass 2	**PB2**	**ffil** = 4 ; Slew Rate = 0.5
Chirp Noise: 5% N_data_tot: 5000	11	No filter	**NoDef**	No Deformation
	12	Gaussian 1	**Gauss1**	**ffil** = 0 ; famp = 0.4 ; sig = 2
	13	Gaussian 2	**Gauss2**	**ffil** = 3 ; famp = 0.4 ; sig = 2
	14	Low Pass 1	**PB1**	**ffil** = 5 ; Slew Rate = 0.5
	15	Low Pass 2	**PB2**	**ffil** = 3 ; Slew Rate = 0.5
Ffil: Filter profile central frequency				

Table 3: Database for Sinc, Gaussian and Chirp with five types of distortions for each one, in this case at 25db of SNR.

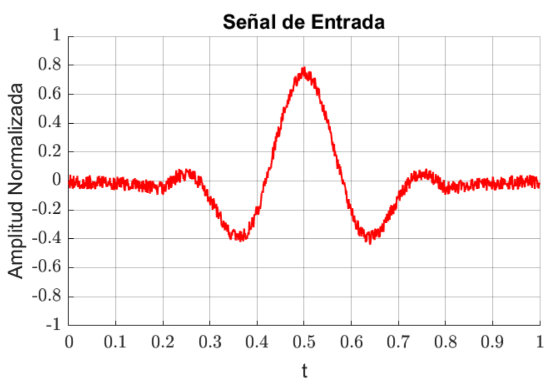


Fig. a: Sinc signal in the time domain with 5% white noise.

Fig. b: Frequency spectrum of the Sinc signal with noise.

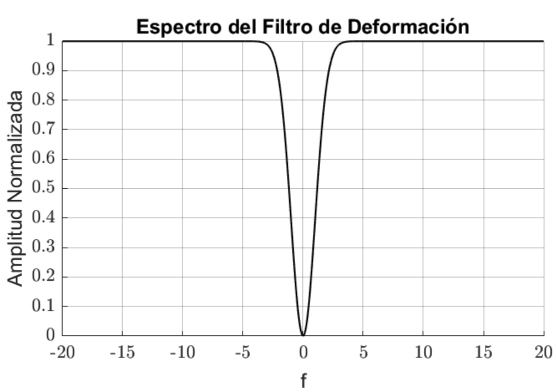


Fig. c: Profile of the Gaussian deformation filter.

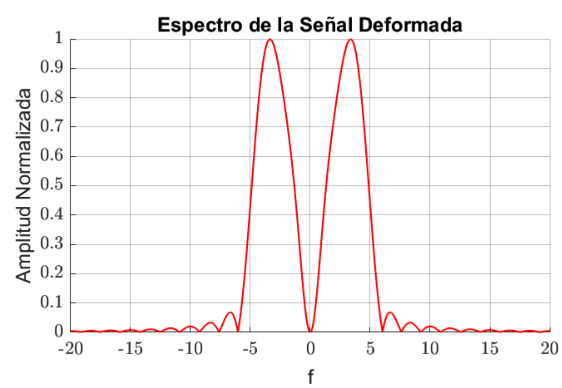


Fig. d: Spectrum of the Sinc signal deformed by the Gaussian filter, generating attenuation at the central frequency.

Figure 5: Sinc signal with noise and the deformation caused by the Gaussian filter.

Simulated Real Waveforms Samples generated by the app:

The visualizations illustrate waveform distortions induced by Gaussian and low-pass filtering. ***These examples probe the classifier's ability to resolve nuanced structural differences, emphasizing its discriminative sensitivity.***

Sinc:

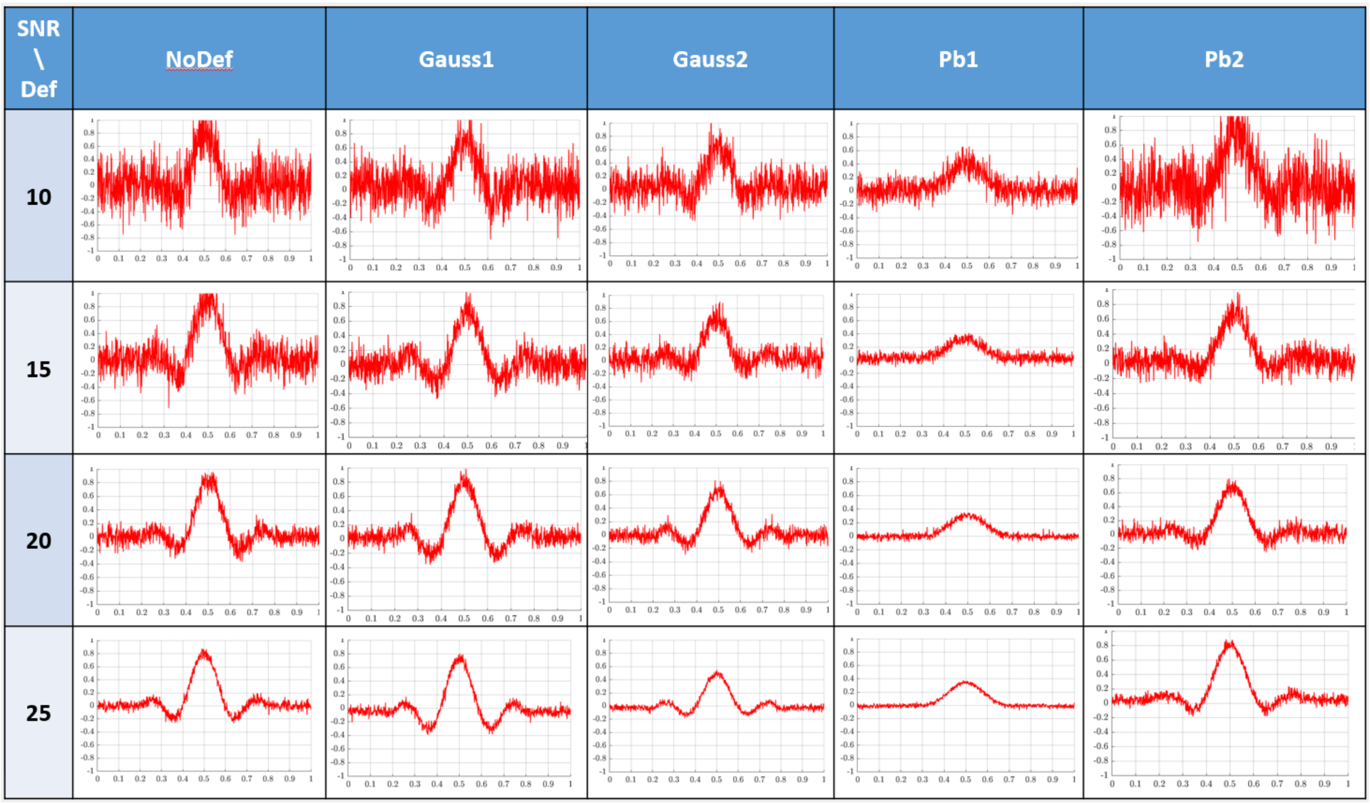


Figura 6: Sinc Waveform at different SNR noise level and filter profile deformation.

Gauss:

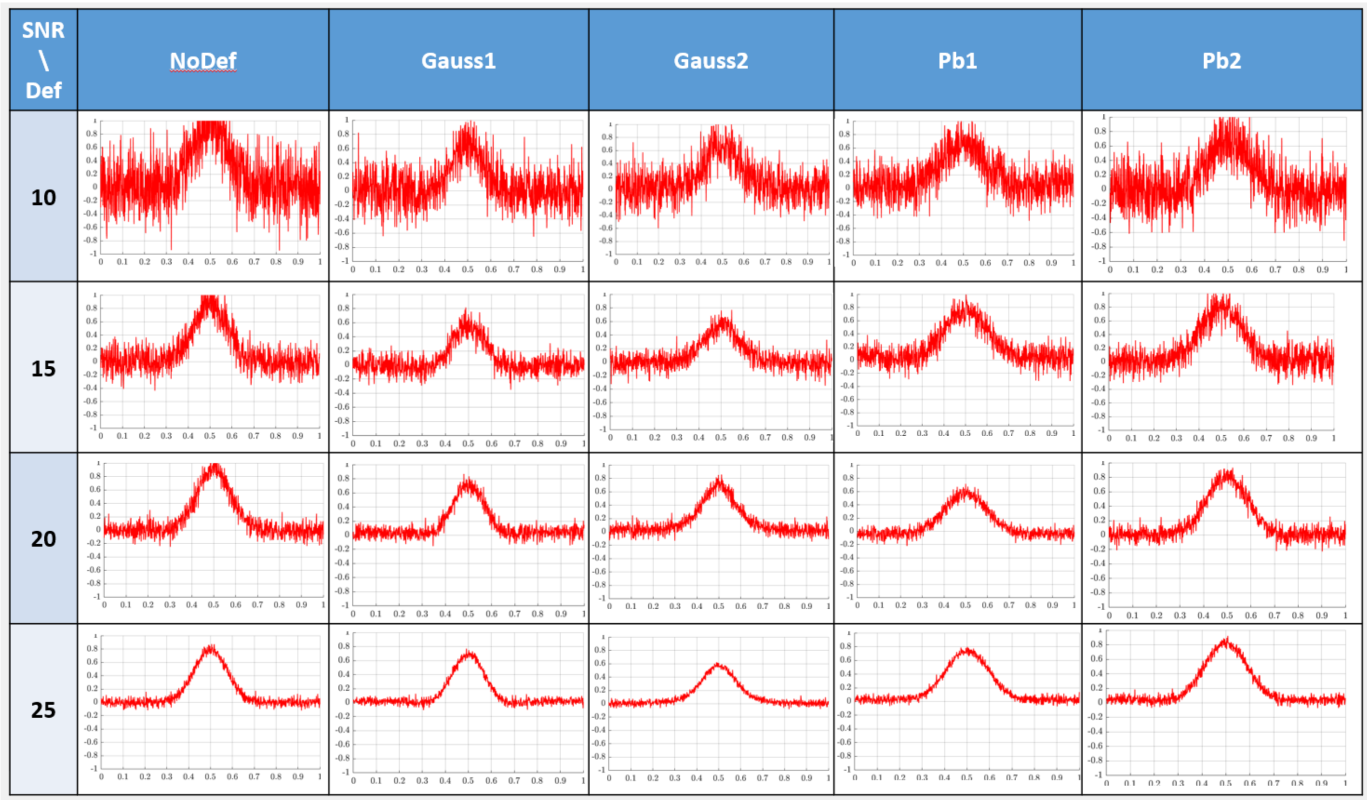


Figura 7: Gaussian Waveform at different SNR noise level and filter profile deformation.

<u>Chirp:</u>

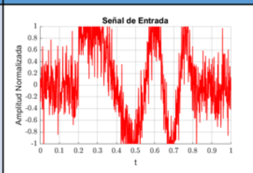
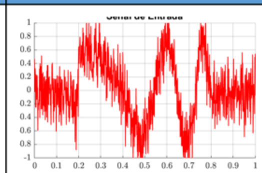
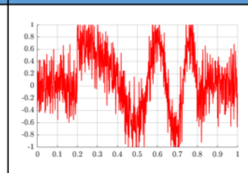
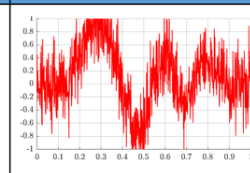
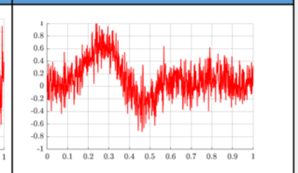
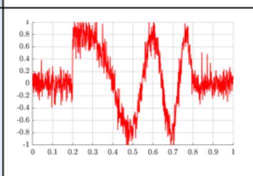
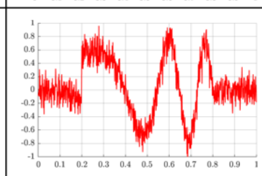
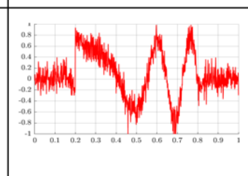
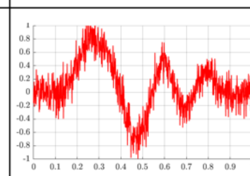
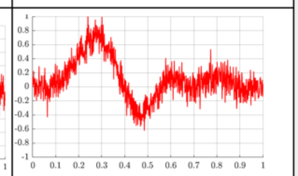
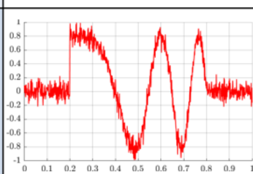
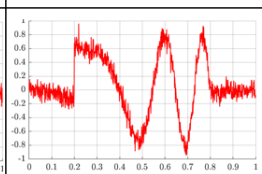
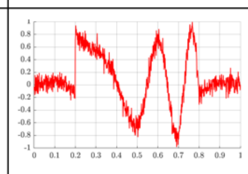
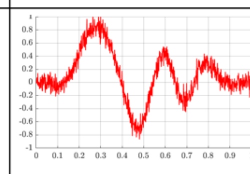
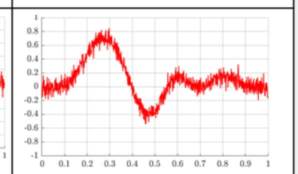
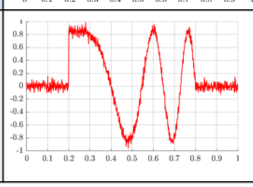
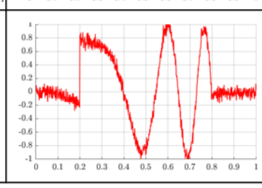
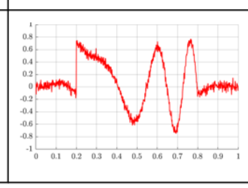
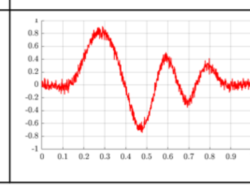
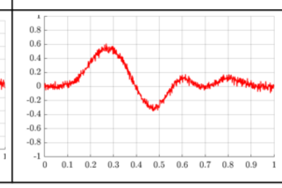
SNR \ Def	NoDef	Gauss1	Gauss2	Pb1	Pb2
10					
15					
20					
25					

Figura 8: Gaussian Waveform at different SNR noise level and filter profile deformation.