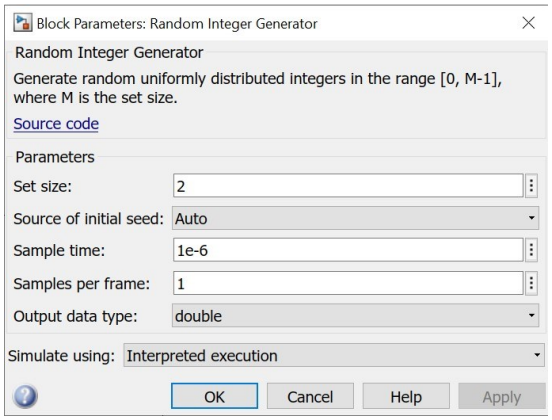
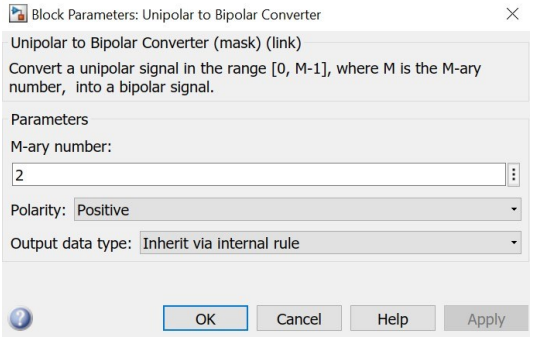
Simulink Model

In the simulation done using Simulink, we played a BLE transmission using the following blocks:

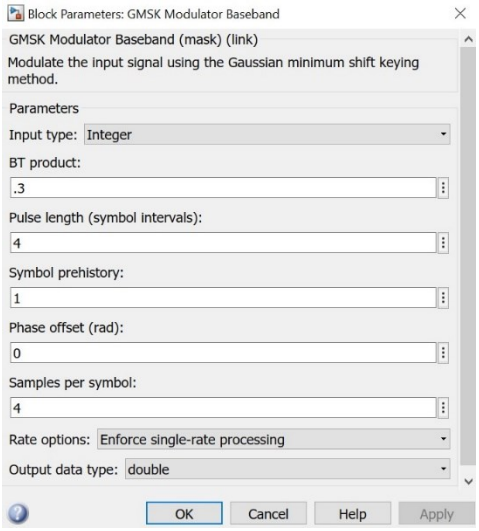
- *Random Integer,* with this block it is possible to create a random sequence of integers, in this way we were able to simulate the transmission of a completely random information. Among the fundamental parameters, it is necessary to set a sample time equal to the PHY field of the link layer you want to simulate (for example, with LE1M the sample time is equal to 1e-6).



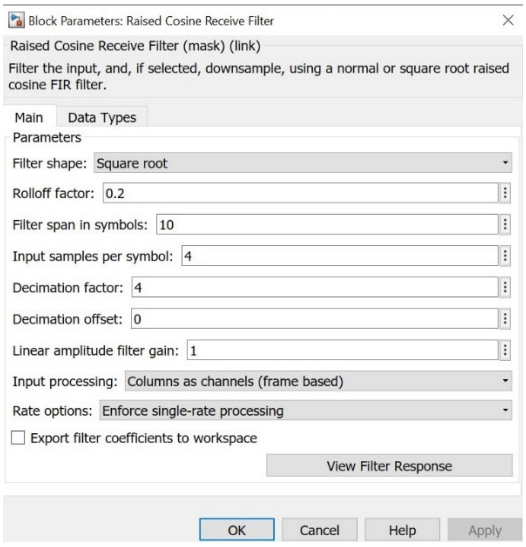
- *Unipolar to Bipolar Converter*, the information is changed from unipolar (symbols 0 and 1) to polar (symbols 1 and -1).



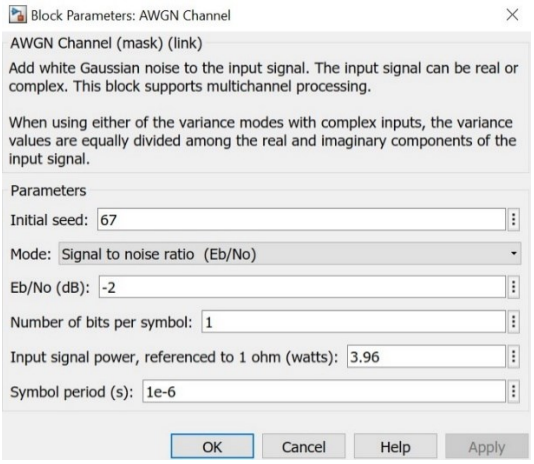
- *GMSK Modulator*, with this block the square wave information is transformed into a GMSK modulation.



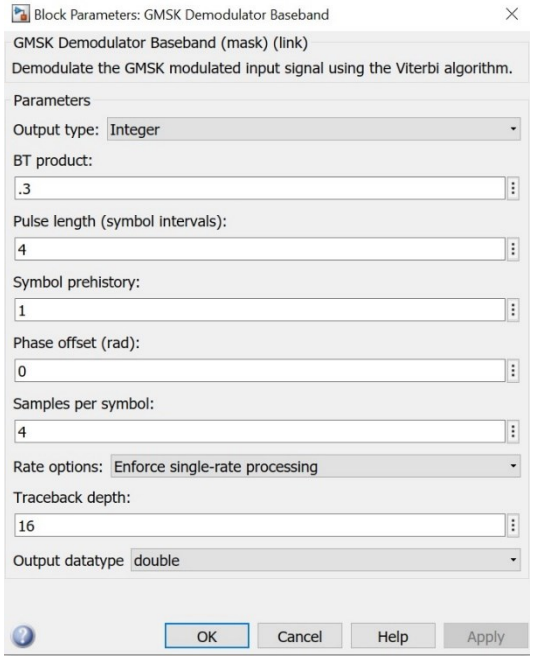
- *Square root*, respecting the Nyquist criterion, this block is inserted in order to eliminate any problems due to ISI effects. In particular, it has a roll-off factor of 0.2 typical of the media and a linear gain of 1. The block is placed in both transmit and receive.



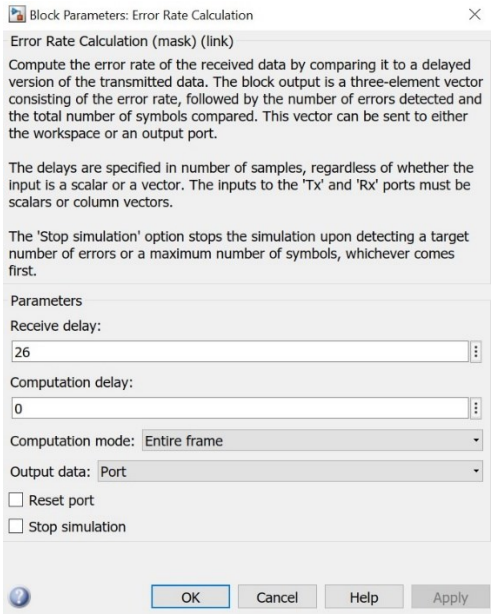
- *Running VAR,* block used to calculate the average strength of the transmitted signal.
- *AWGN,* white Gaussian additive noise such as that given by the thermal noise typical of communication systems. Among the necessary parameters to be defined in this block are: the SNR given by $E_b/N0$ (which we have modified from time to time to obtain the different probabilities of bad bit), the signal power input calculated with the previously described block, the symbol period that varies according to the simulated PHY (as already mentioned 1e-6 in the case of LE1M).



- *GMSK Demodulator*, a block necessary to demodulate the received signal and convert it back into a square wave signal.

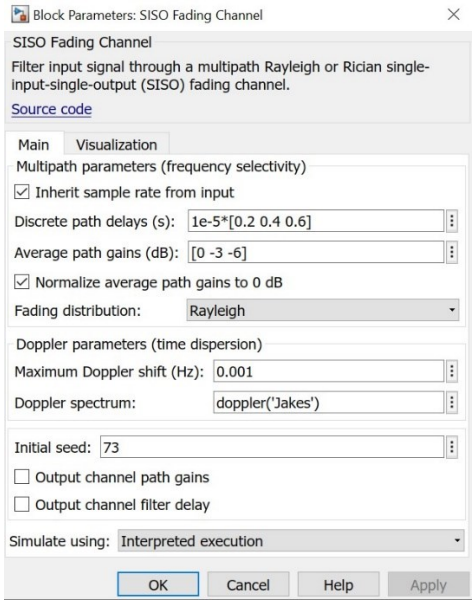


- *Error Rate Calculation*, a block that compares the signal transmitted at the start and the signal received and demodulated and calculates how many symbols were not received correctly. The fundamental parameter is *the receive delay* (in our case 26), given by the fact that the comparison between transmitted and received signal must not be instantaneous but must have a delay due to the processing of the information.



In case you reference a channel with Rayleigh fading then more blocks are added:

- *SISO fading channel*, in this way there will be three paths without having a dominant one.



- The Complex Phase Difference*,* Complex Phase Shift *and Gain blocks* are used to eliminate the phase shift caused by the Doppler effect due to the displacement of the receiver and/or transmitter.