AWGN Channel

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Section Overview

An AWGN channel adds white Gaussian noise to the signal that passes through it. You can create an AWGN channel in a model using the `comm.AWGNChannel` System object, the AWGN Channel block, or the `awgn` function.

The following demos use an AWGN Channel: `QPSK Transmitter and Receiver` and `scattereyedemo`.

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AWGN Channel Noise Level

The relative power of noise in an AWGN channel is typically described by quantities such as

- Signal-to-noise ratio (SNR) per sample. This is the actual input parameter to the `awgn` function.
- Ratio of bit energy to noise power spectral density (EbNo). This quantity is used by BERTool and performance evaluation functions in this toolbox.
- Ratio of symbol energy to noise power spectral density (EsNo)

Relationship Between EsNo and EbNo

The relationship between EsNo and EbNo, both expressed in dB, is as follows:

$$E_s / N_0 \ (\mathrm{dB}) = E_b / N_0 \ (\mathrm{dB}) + 10\log_{10}(k)$$

where k is the number of information bits per symbol.

In a communication system, k might be influenced by the size of the modulation alphabet or the code rate of an error-control code. For example, if a system uses a rate-1/2 code and 8-PSK modulation, then the number of information bits per symbol (k) is the product of the code rate and the number of coded bits per modulated symbol: (1/2) $\log_2(8)$ = 3/2. In such a system, three information bits correspond to six coded bits, which in turn correspond to two 8-PSK symbols.

Relationship Between EsNo and SNR

The relationship between EsNo and SNR, both expressed in dB, is as follows:

$$E_s / N_0 \ (\mathrm{dB}) = 10\log_{10}\left(T_{sym} / T_{samp}\right) + SNR \ (\mathrm{dB}) \quad \text{for complex input signals}$$

$$E_s / N_0 \ (\mathrm{dB}) = 10\log_{10}\left(0.5T_{sym} / T_{samp}\right) + SNR \ (\mathrm{dB}) \ \text{for real input signals}$$

where T_{sym} is the signal's symbol period and T_{samp} is the signal's sampling period.

For example, if a complex baseband signal is oversampled by a factor of 4, then EsNo exceeds the corresponding SNR by 10 $\log_{10}(4)$.

Derivation for Complex Input Signals. You can derive the relationship between EsNo and SNR for complex input signals as follows:

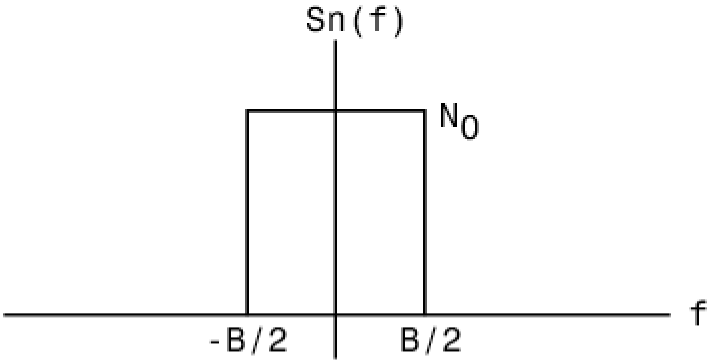
$$
\begin{aligned}
E_s / N_0 \ (\mathrm{dB}) &= 10\log_{10}\left((S \cdot T_{sym})/(N/B_n)\right) \\
&= 10\log_{10}\left((T_{sym}F_s)\cdot(S/N)\right) \\
&= 10\log_{10}\left(T_{sym}/T_{samp}\right) + SNR\ (\mathrm{dB})
\end{aligned}
$$

where

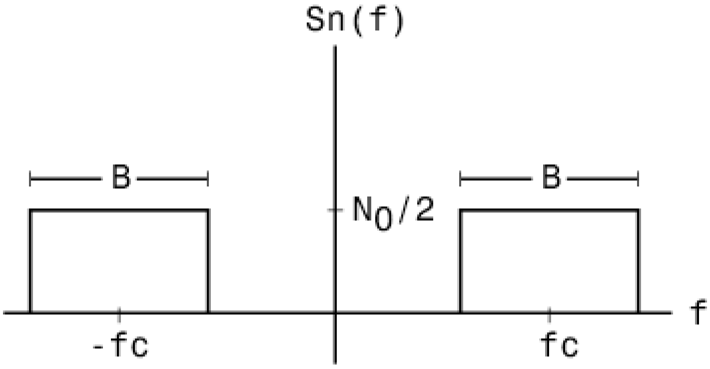
- S = Input signal power, in watts
- N = Noise power, in watts
- B_n = Noise bandwidth, in Hertz
- F_s = Sampling frequency, in Hertz

Note that $B_n = F_s = 1/T_{samp}$.

Behavior for Real and Complex Input Signals. The following figures illustrate the difference between the real and complex cases by showing the noise power spectral densities $S_n(f)$ of a real bandpass white noise process and its complex lowpass equivalent.



Complex Lowpass Noise Power Spectral Density



Real Bandpass Noise Power Spectral Density

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