C/N & E_b/N_o

Modified from: Signal-to-Noise, Carrier-to-Noise, Eb/No on Signal Quality Ratios by Wolfgang Damm, Noisecom, https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwi6-cfDnP_LAhUlk4MKHV1uCbQQFggfMAA&url=http%3A%2F%2Fwww.noisecom.com%2F~%2Fmedia%2FNoisecom%2FWebinars%2FSN%2520CN%2520EbNo.ashx&usg=AFQjCNEOfVqyY7EAwN1sOHwITcV9DndxsQ&sig2=44wvCGu-W9l6oTZv1gG0oA

Carrier to Noise Ratio (C/N)

What is it?

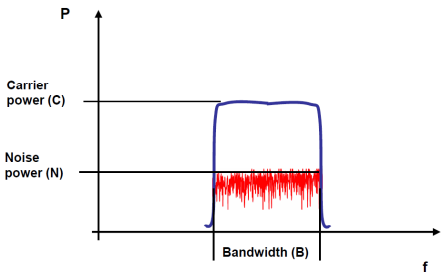
C/N is the ratio of the relative power level to the noise level in the bandwidth of a system.

Why:

Allows to analyze if a carrier can still be recognized as such, or if it is obliterated by ambient and system noise. C/N Provides a value for the quality of a communication channel.

How:

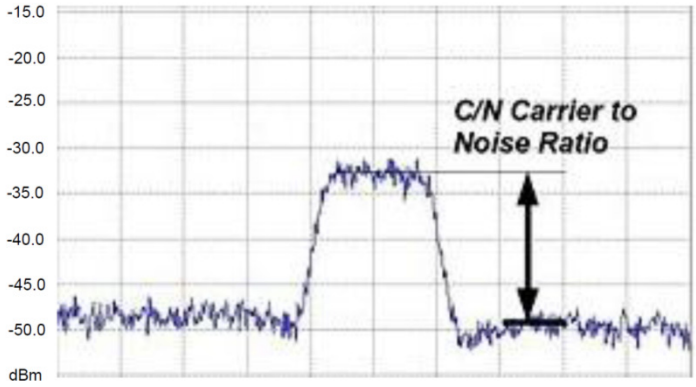
The quality of the system is usually determined through BER plots against C/N.



C and **N** may be measured in watts or in volts squared

Modified from: Signal-to-Noise, Carrier-to-Noise, Eb/No on Signal Quality Ratios by Wolfgang Damm, Noisecom, https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwi6-cfDnP_LAhUlk4MKHV1uCbQQFggfMAA&url=http%3A%2F%2Fwww.noisecom.com%2F~%2Fmedia%2FNoisecom%2FWebinars%2FSN%2520CN%2520EbNo.ashx&usg=AFQjCNEOfVqyY7EAwN1sOHwITcV9DndxsQ&sig2=44wvCGu-W9l6oTZv1gG0oA

C/N Example



Example: Spectrum of a QPSK signal interfered by ambient white noise. The horizontal axis shows the frequency in Hertz, and the vertical axis the power in dBm In this example, the C/N is (−32.5 dBm) − (−48 dBm) = 15.5

Modified from: Signal-to-Noise, Carrier-to-Noise, Eb/No on Signal Quality Ratios by Wolfgang Damm, Noisecom, https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwi6-cfDnP_LAhUlk4MKHV1uCbQQFggfMAA&url=http%3A%2F%2Fwww.noisecom.com%2F~%2Fmedia%2FNoisecom%2FWebinars%2FSN%2520CN%2520EbNo.ashx&usg=AFQjCNEOfVqyY7EAwN1sOHwITcV9DndxsQ&sig2=44wvCGu-W9l6oTZv1gG0oA

Carrier to Noise Spectral Density Ratio (C/No)

What is it?

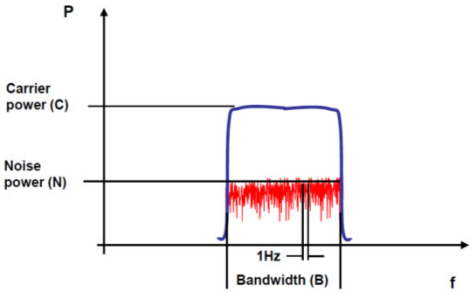
C/No is the ratio of the power level to the noise power spectral density (normalized noise level relative to 1 Hz) in a system.

Why:

Similar as C/N but C/No does not factor the actual noise bandwidth in. This simplifies analysis of systems where variation of the (utilized) BW may apply.

How:

As C/N, C/No is usually determined through BER plots.



Modified from: Signal-to-Noise, Carrier-to-Noise, Eb/No on Signal Quality Ratios by Wolfgang Damm, Noisecom, https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwi6-cfDnP_LAhUlk4MKHV1uCbQQFggfMAA&url=http%3A%2F%2Fwww.noisecom.com%2F~%2Fmedia%2FNoisecom%2FWebinars%2FSN%2520CN%2520EbNo.ashx&usg=AFQjCNEOfVqyY7EAwN1sOHwITcV9DndxsQ&sig2=44wvCGu-W9l6oTZv1gG0oA

Energy per Bit (E_b)

What is E_b?

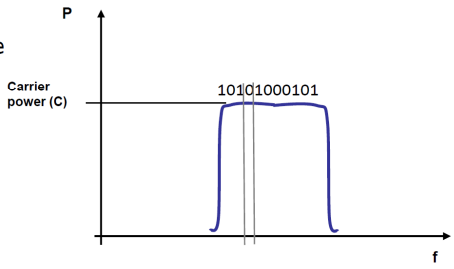
Energy per information bit (i.e. the energy per bit net of FEC overhead bits). Carrier power divided by actual information bits.

$$E_b = C / R$$

where

C is the carrier power, and

R is the actual information bit rate.



Simplified depiction of E_b. Bits in modulation schemes are not as shown directly linked to a certain frequency.

Why?

Using the Eb rather than overall carrier power (C) allows comparing different modulation schemes easily.

Unit of E_b is:

Joules [J], Watts/Hz [W/Hz] or Watts * s [Ws].

All three units express the very same metric..

Modified from: Signal-to-Noise, Carrier-to-Noise, Eb/No on Signal Quality Ratios by Wolfgang Damm, Noisecom, https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwi6-cfDnP_LAhUlk4MKHV1uCbQQFggfMAA&url=http%3A%2F%2Fwww.noisecom.com%2F~%2Fmedia%2FNoisecom%2FWebinars%2FSN%2520CN%2520EbNo.ashx&usg=AFQjCNEOfVqyY7EAwN1sOHwITcV9DndxsQ&sig2=44wvCGu-W9l6oTZv1gG0oA

Energy per Bit to Noise Spectrum Density (E_b/N_o)

What is it?

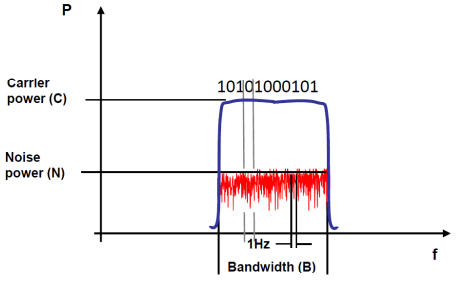
E_b/N_o is the ratio of the Energy per Bit divided by the noise power density.

Why:

Allows comparing bit error rate (BER) performance (effectiveness) of different digital modulation schemes. Both factors are normalized, so actual bandwidth is no longer of concern.

How:

Modulation schemes are compared through BER plots against E_b/N_o.



E_b / N_o is a dimensionless ratio.

Modified from: Signal-to-Noise, Carrier-to-Noise, Eb/No on Signal Quality Ratios by Wolfgang Damm, Noisecom, https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwi6-cfDnP_LAhUlk4MKHV1uCbQQFggfMAA&url=http%3A%2F%2Fwww.noisecom.com%2F~%2Fmedia%2FNoisecom%2FWebinars%2FSN%2520CN%2520EbNo.ashx&usg=AFQjCNEOfVqyY7EAwN1sOHwITcV9DndxsQ&sig2=44wvCGu-W9l6oTZv1gG0oA

Correlation: C/N, C/N_o and E_b/N_o

C/N, C/No and Eb/No are correlated

$$C / N = C / (N_o * B) = (E_b / N_o) * (R / B)$$

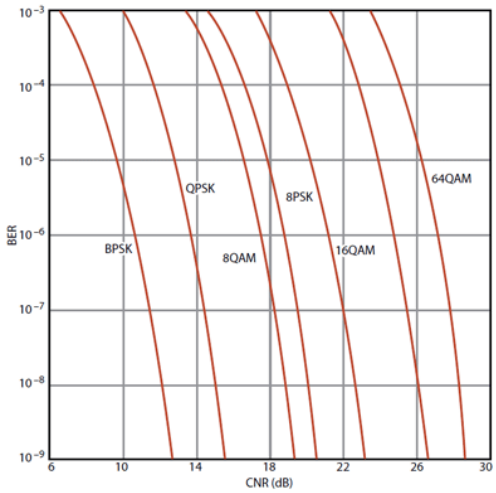
$$E_b / N_o = (C / N) * (B / R)$$

$$N_o = (N * E_b * R) / B * C$$

$$C / N_{dB} = 10 \log (Eb/No) + 10 \log (R / B)$$

R information rate in bits per second;
B channel bandwidth in Hertz;
C total carrier power
N total noise power in the bandwidth.

Modified from: Signal-to-Noise, Carrier-to-Noise, Eb/No on Signal Quality Ratios by Wolfgang Damm, Noisecom, https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwi6-cfDnP_LAhUlk4MKHV1uCbQQFggfMAA&url=http%3A%2F%2Fwww.noisecom.com%2F~%2Fmedia%2FNoisecom%2FWebinars%2FSN%2520CN%2520EbNo.ashx&usg=AFQjCNEOfVqyY7EAwN1sOHwITcV9DndxsQ&sig2=44wvCGu-W9l6oTZv1gG0oA



From: http://electronicdesign.com/communications/understanding-modern-digital-modulation-techniques