ENEL 471 – Winter 2020

Assignment 5 - Solutions

Problem 6.3

The power of the modulated wave is 10W
The power of the noise at the input of the receiver is given by:

$$P_{Ni} = 2\int_{f_c-4kHz}^{f_c+4kHz} S_N\left(f\right)df = 0.008 \text{ W}$$

The SNR at the input is then:

$$SNR_{in} = CNR = \frac{10}{0.008} = 1250$$

The FOM for a DSB receiver is 1. Therefore, the SNR at the output is:

$$SNR_{out} = CNR = 1250$$

In logarithmic scale:

$$SNR_{out\_dB} = 10\log\left(SNR_{out}\right) = 10\log\left(1250\right) = 31 \text{ dB}$$

Problem 6.6

The power of the modulated wave is P_{s_in} = 80 kW + 2 .10 kW = 100 kW
The power of the noise at the input of the receiver is given by:

$$P_{Ni} = 0.001\cdot\left(2\cdot 4 \text{ kHz}\right) = 8 \text{ W}$$

The SNR at the input is then:

$$SNR_{in} = CNR = \frac{100000}{8} = 12500$$

In logarithmic scale:

$$SNR_{in\_dB} = 10\log\left(SNR_{in}\right) = 10\log\left(12500\right) = 41 \text{ dB}$$

For conventional AM receiver using envelope detector, the power of the demodulated signal is:

$$P_{so} = 2\left(20 \text{ kW}\right) = 40 \text{ kW}$$

And the power of the noise in baseband is:

$$P_{Ni} = 2 \cdot 0.001 \cdot \left(2 \cdot 4 \text{ kHz}\right) = 16 \text{ W}$$

The SNR at the output of the conventional AM receiver is then:

$$SNR_{out\_AM} = \frac{40000}{16} = 2500$$

In logarithmic scale:

$$SNR_{out\_AM\_dB} = 10\log\left(SNR_{out\_AM}\right) = 10\log\left(2500\right) = 34 \text{ dB}$$

The FOM for a DSB receiver is 1. Therefore, for the same input SNR (41 dB), the SNR at the output is:

$$SNR_{out\_DSB\_dB} = SNR_{in\_dB} = 41 \text{ dB}$$

The signal-to-noise ratio at the output of a conventional AM receiver is 7 dB below the signal-to-noise ratio at the output of a DSB receiver.

Problem 6.9

a)

In the case of a conventional AM modulation of a sinusoidal modulating signal with modulation efficiency μ , the FOM in a conventional AM receiver is given by:

$$FOM = \frac{SNR_O}{SNR_C} = \frac{\mu^2}{2+\mu^2}$$

For 80% modulation efficiency, the FOM is:

$$FOM = \frac{SNR_O}{SNR_C} = \frac{\mu^2}{2+\mu^2} = \frac{0.8^2}{2+0.8^2} = 0.2424$$

The carrier-to-noise ratio is then given by:

$$SNR_C = \frac{SNR_O}{0.2424}$$

Or in logarithmic scale:

$$SNR_{C\_dB} = SNR_{O\_dB} + 10\log\frac{1}{0.2424} = 30 + 6.15 = 36.15 \text{ dB}$$

b)

$\mu = 100\%$

In this case, the FOM is given by:

$$FOM = \frac{SNR_O}{SNR_{C\_100\%}} = \frac{\mu^2}{2+\mu^2} = \frac{1}{2+1} = 0.3333$$

The new carrier-to-noise ratio is then given by:

$$SNR_{C\_100\%} = \frac{SNR_O}{0.3333}$$

Or in logarithmic scale:

$$SNR_{C\_100\%\_dB} = SNR_{O\_dB} + 10\log\frac{1}{0.3333} = 30 + 4.77 = 34.77 \text{ dB}$$

The CNR can then be improved by:

$$SNR_{C\_dB} - SNR_{C\_100\%\_dB} = 36.15 - 34.77 = 1.38 \text{ dB}$$