Communications Theory

Questions for lab Session 4: Communications

Theory

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Grade

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Q1. Two scaled versions of the signal are modulated and, afterwards, properly demodulated using the above algebra. Look at the pictures noting the scale of the vertical axis. Can you guess which one is going to sound OK? If not sure, just play both of them for a few seconds. Which one sounds fine? Why not so much the other?

By looking at the pictures we could not tell which ones is going to be better, although the amplitude of the first one is about 10 times larger than the second one. The second signal is **normalized**, meaning its absolute value does not go past 1 at any point, which is a condition for correct demodulation, since if the signal becomes negative, it can no longer be recovered from its envelope.

When we hear both signals, the first one sounds distorted near the zones with high amplitude, while the second one has a much more consistent sound.

Q2. Provide values for *Am* and *Ac* that cause overmodulation. What do you notice in the plot? Why doesn’t it affect the whole signal?

Whenever the ratio between *Am* and *Ac* is big, for example *Am* = 10 and *Ac* = 0.10, the modulation index grows.

According to the conditions for correct demodulation, we need . Since our (hopefully) normalized signal should have amplitude bounded by , we only need to make sure stays between 0 and 1, meaning . **Whenever , we’ll have overmodulation**.

As we have seen, the condition is on being greater than , so this only affects those parts of the signal that would make , that is, when . The effect of this in the plot is that the signal is **only affected at points lower than** , which depends on our choice of and . The larger we make , the more the signal is affected. If we enforce and use our normalized signal, this will never happen.

Q3. Test the effects of overmodulation on our ears. Can you pick a pair of values for *Am* and *Ac* such that overmodulation happens but doesn’t cause a noticeable degradation on the perceived sound quality? Above which (approximate) value of the modulation index, *m*, do you start noticing glitches in the audio?

In the range plotted by default, that is not possible, at least when using headphones or other semi-reliable audio playback methods. However, by shifting the plotted range to the range where the highest peaks occur (interval\_of\_interest = range(87\_600, 89\_000)), and using a value of 5 by setting and , one can see overmodulation in the plot while keeping the audible distortion almost imperceptible.

Q4. Below which value of the SNR is the sound not perceived as sharp (clear) anymore? 10 dBs is usually considered a pretty good SNR in high quality radio (see, e.g., the last paragraphs in these notes). According to that, is AM noise-resilient or not?

In our own (subjective) tests, at around 35 dB the white noise was already perceptible. In comparison to the 10 dB mark mentioned, we can easily conclude that this AM system is **not** very noise resilient. At that SNR, the noise vastly overpowers the signal, as the original sound is buried and barely audible.

Q5. What is the power of the signal for an SNR of about 20 dBs?

A computer code with numbers and symbols

Description automatically generated with medium confidence

By adding a print statement at the end of this cell, we can see that the signal power is close to . With this SNR of , the noise power should be 100 times less than this: