SGN-1158 Introduction to Signal Processing

Exercise 3

3.1. How many bits are needed to represent the samples of one second of 2-channel stereo audio in the format used by a CD, when it stores samples with 16 bits/sample using a sampling rate of 44.1 kHz? (We ignore the fact that the disc carries also other information.)

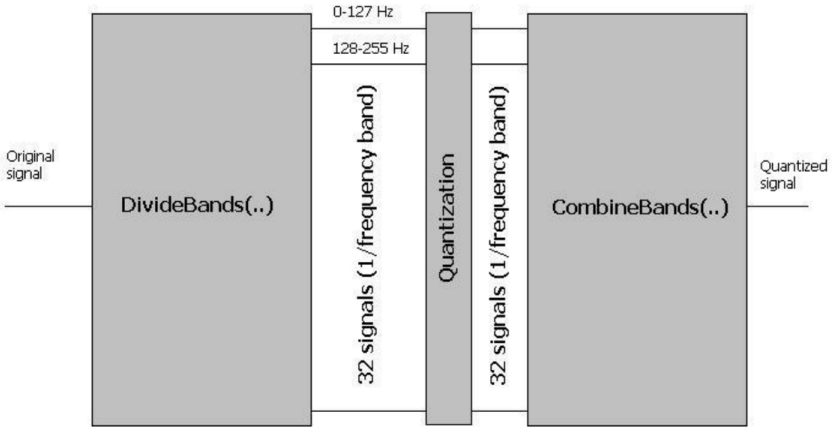
3.2. **a)** Why are A/μ-law compandings used in speech compression?

b) For the given compression equations, solve the expanding equations. (Solving means that you write more than just the final result.)

$$\text{A-law: } y(x) = \begin{cases} sign(x) \cdot \frac{A\|x\|}{1+\ln A}, & \|x\| \leq \frac{1}{A} \\ sign(x) \cdot \frac{1+\ln(A\|x\|)}{1+\ln A}, & \frac{1}{A} < \|x\| \leq 1 \end{cases}$$

$$\mu\text{-law: } y(x) = sign(x) \cdot \frac{\ln(1+\mu\|x\|)}{\ln(1+\mu)}, \quad -1 \leq x \leq 1.$$

3.3. `(Matlab, only this task do at home)` Get the `test.mat` signal and functions `DivideBands.m` and `CombineBands.m` from the course webpage. First one of these functions divides a signal into 32 frequency bands, and the second one combines them. The test signal is sampled with 8192 Hz, so the first extracted frequency band is 0–127 Hz, the second one 128–255 Hz, etc. Note that the signal has frequencies only up to 4096 Hz! Examine the extracted frequency bands (e.g. plot them, `plot(fB(1,:))` draws the time-domain representation of the first frequency band) and the spectrogram of the test signal. What is the length of the signals in time-domain? Which frequency bands have the most energy of the signal?



3.4. (Matlab) Get the same speech sample `toomuch`, and try to extract some parts of it, combine them and create the word "tooth". Does this work well? Why/why not?

3.5. (Matlab) Quantize the `toomuch` speech sample with 1 and 2 bits (`y=quant(x, 2^(-bits+1))`, this actually gives one extra quantization level, but we don't worry about it too much). Before quantization, scale the signal so that it uses the whole $[-1, 1]$ range. Listen to the results.

3.6. (Matlab) Perform μ-law compression for the `toomuch` speech sample and quantize the result with 1 and 2 bits. Expand the compressed signals and listen to the results. ($\mu = 255$)

3.7. (Matlab) Consider task 3.3 once again. When you are restricted to using less than 16 kbit/s, how would you allocate the bits for this signal? After you have decided, do it in Matlab and listen to the reconstructed signal.