Questions A

A1. Why bandwidth extension?

- What can (not) be improved using bandwidth extension?

A2. Principle of imaging

- Explain bandwidth extension using imaging.
- What is the reason for the sound distortions?

A3. Source-filter model

- Explain the principle of bandwidth extension based on linear prediction!
- What is the benefit of the band-stop filter (slide 17)?
- Why don't we use the completely synthesized signal $\hat{s}(n)$ as output signal?

A4. Modulation

- What problems do appear when bandwidth extension using modulation is applied?

Questions B

B1. Nonlinearities

- Which properties that are relevant for bandwidth extension does the convolution of a line spectrum with itself have?
- What has to be taken care of when applying bandwidth extension using nonlinearities?

B2. Neural networks

- Compare the approach based on neural networks with the system concepts on slides 5 and 6. Which system concept is being used?
- Which block in the system concept corresponds to the neural network?
- What effects complicate the application of neural networks?

B3. Bandwidth extension based on codebooks

- In the basic structure, there are two codebooks. For what reasons do these two codebooks contain different types of coefficients?
- What happens to the selected wide-band codebook vectors $\hat{\boldsymbol{a}}_{bb}(n)$?

Answers B

B1. Nonlinearities

- The harmonics are conserved and are continued in a natural way.
- See slides 23, 24: Removal of the unintentionally inserted DC components, adjustment of the output power, reduction of aliasing effects.

B2. Neural networks

- Usually, the approach without transmission of side information is used.
- The neural network corresponds to the block “a priori trained speech models” as well as partly to the block “bandwidth extension”.
- The predictor coefficients that are output by the neural network do not guarantee a stable IIR filter. Furthermore, the reaction of neural networks to unlearned input is uncertain (see slide 29).

B3. Bandwidth extension based on codebooks

- For the recognition of spectral envelopes, cepstral coefficients are suitable, because a distance function can easily be defined (compare part 4, feature extraction). But in order to recreate a spectral envelope, predictor coefficients are necessary.
- The wide-band codebook vectors feed the inverse prediction error filter (see slide 17).

Answers A

A1. Why bandwidth extension?

- An improvement of the sound quality at the receiver can be reached.
  But: Usually no improvement of speech intelligibility.

A2. Principle of imaging

- Explanation see slide 10; generation of imaging effects by oversampling and attenuation.
- Sound distortions are created by the non-natural continuation of the spectrum.
  - Harmonics are not continued correctly
  - Spectral envelope is not continued correctly

A3. Source-filter model

- See slide 17:
  - Remove the narrow-band envelope using a predictor-error filter
  - Upsampling, generation of an excitation signal
  - Apply the wide-band envelope using the inverse predictor-error filter
- In the frequency range of the narrow-band signal, only the original signal should be used.
- The resynthesized signal does not reach the quality of the original (narrow-band) signal.

A4. Modulation

- See slides 19 to 21.