

Solutions

Examination in Integrated A/D and D/A Converters, ETI220

8.00-13.00, Saturday, Dec. 19, 2009

I. Basic questions about A/D converters

- a) Windowing helps in the case of non-coherent sampling. See textbook and lecture.
- b) It is caused by the charge redistribution of the charges in the channel of the (MOS) switch during commutation from on-state to off-state. It is non-linear, so it may cause distortion.
- c) For a conversion up to Nyquist (OSR=1), the SNR is $SNR=6.02 \cdot 10 + 1.76 = 61.96\text{dB}$. If OSR=8, there is only 1/8 of the q-noise in the signal band, and the SNR is improved by $10 \cdot \log_{10}(8) = 9.03\text{dB} \rightarrow SNR=70.99\text{dB}$.
- d) See textbook and lecture.

II. Specific questions about converters

- a) NTF and STF:
$$X \left(\frac{z^{-1}}{1 - z^{-1}} \right)^2 - Y \left(\frac{z^{-1}}{1 - z^{-1}} + \frac{z^{-1}}{1 - z^{-1}} \right) + \varepsilon = Y$$
$$Y = z^{-1}X + \frac{1}{1 - z^{-1}} \varepsilon = STF \cdot X + NTF \cdot \varepsilon$$

Delta-Sigma converters are very popular because their SNR is not dependent on matching between components \rightarrow very high number of bits possible; also very good linearity.

- b)
 1. See textbook and lecture.
 2. Assume a triangular glitch. Glitch area = $\frac{1}{2} 100m \cdot 50p = 2.5p$

$$\text{Area of 1 LSB: } \frac{1V}{2^{10}} \cdot \frac{1}{500 \cdot 10^6} = 1.95p$$

Glitch noise = 1.28LSB

If the glitch is 19.6ps long, then its area is 0.5LSB.

c) See textbook and lecture.

d)

1. See textbook and lecture.
2. See textbook and lecture.

$$3. \text{ Mismatch} = \frac{1}{2} LSB = \frac{1}{2} \frac{1}{2^{12}} = 0.122 \cdot 10^{-3}$$

4. See textbook and lecture.

e) See textbook and lecture.

f) See lecture.

g) The negative part of the wave is quantized in exactly the same way as the positive part. This means that the q-noise samples in the negative part is perfectly correlated to the q-noise in the positive part. More specifically, for each q-error sample in the positive part there is the same q-error sample (with inverted sign) in the negative part. Thus, all even bins are empty, and the q-noise is found only in the odd bins.