Quantization

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Amplitude Qunatization

Definition

the process of transforming the sample amplitude $m(nT_s)$ of a baseband signal $m(t)$ at time $t = nT_s$into a discrete amplitude $v(nT_s)$ taken from a finite set of possible levels

- instantaneous quantization (at time $t = nT_s$)
- memoryless quantization (not affected by previous samples)

Quantizer Index

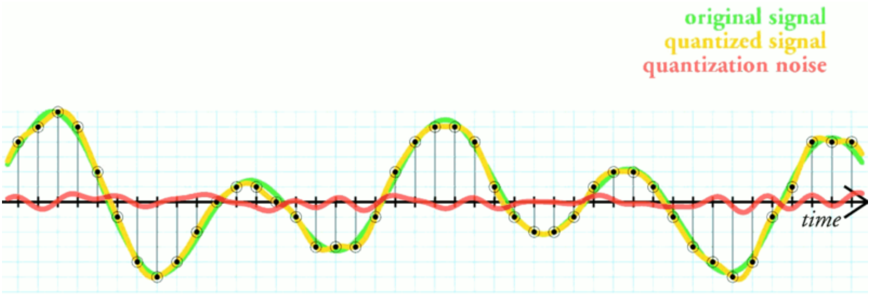
$m \equiv m(nT_s)$

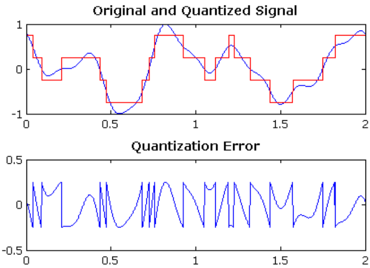
- the signal amplitude$m(t)$ is specified by the index k if it lies in the interval I_k
- $I_k : \{m_k < m \leq m_{k+1},\}\ k = 1, 2, ..., L$
- L: the total number of amplitude levels used in the quantizer
- $\{m_1, m_2, ..., m_L\}$:decision levels (decision thresholds)

Quantizer Output

- at the quantizer output, the index $k$is transformed into an amplitude v_k
- $\{v_1, v_2, ..., v_L\}$: representation levels (reconstruction levels)
- $(v_{k+1} - v_k)$: the spacing between two adjacent representation levels : quantum (step-size)
- if the input signal sample$m$ belongs to the interval I_k, then the quantizer output becomes v_k

Quantization Error





Types of Quantizers

Uniform / Non-uniform

- the representation levels are uniformly spaced (a uniform quantizer)
- the representation levels are non-uniformly spaced (a non-uniform quantizer)

Midtread / Midrise

- ... $-\Delta$, 0, $+\Delta$.... (Midtread)
- ... $-\Delta/2$, $+\Delta/2$.... (Midrise)

Non-Uniform Quantizer

the ratio of peaks of loud voice to that of weak voice
is in the order of 1000

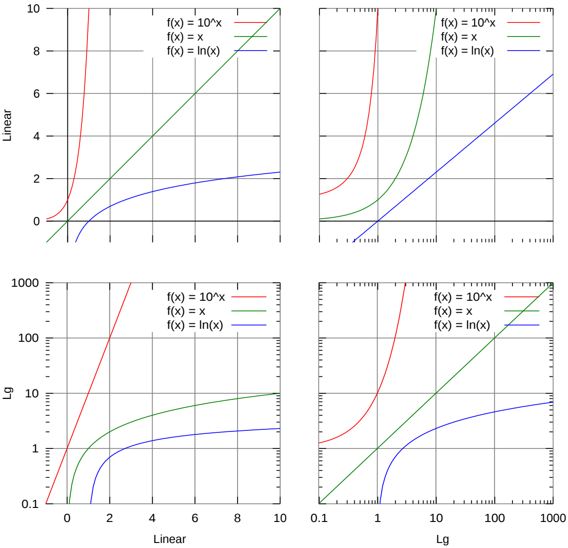
- Uniform Quantizer:

  relatively large step size over the weak voice

- Non-uniform Quantizer:

  smaller step size for the weak voice (fine resolution)
  larger step size for the loud voice (coarse resolution)

Logarithmic Scale



Mu-law

After a Compressor, then a uniform quantizer

- μ-law

$$|v| = \frac{ln(1+\mu|m|)}{ln(1+\mu)}$$

inear if $\mu|m| \ll 1$
logarithmic if $\mu|m| \gg 1$

- A-law

$$|v| = \frac{A|m|}{(1+A)}, \qquad (1 \leq |m| \leq 1/A)$$

$$|v| = \frac{1+ln(A|m|)}{(1+ln(A))}, \qquad (1/A \leq |m| \leq 1)$$

Reference

[1] S. Haykin, M Moher, “Introduction to Analog and Digital Communications”, 2ed