Delta Modulation (DM)

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Preliminaries

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- When those correlated samples are encoded like in PCM system, resulting signal contains redundant information
- BW in PCM $\propto$ bit rate $\uparrow$ with sampling rate

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- Differential pulse code modulation (PCM): a variation of PCM
  - Difference between actual samples $x(nT_s)$ and an estimate of it, $\hat{x}_{nT_s}$, is quantized, encoded and then transmitted
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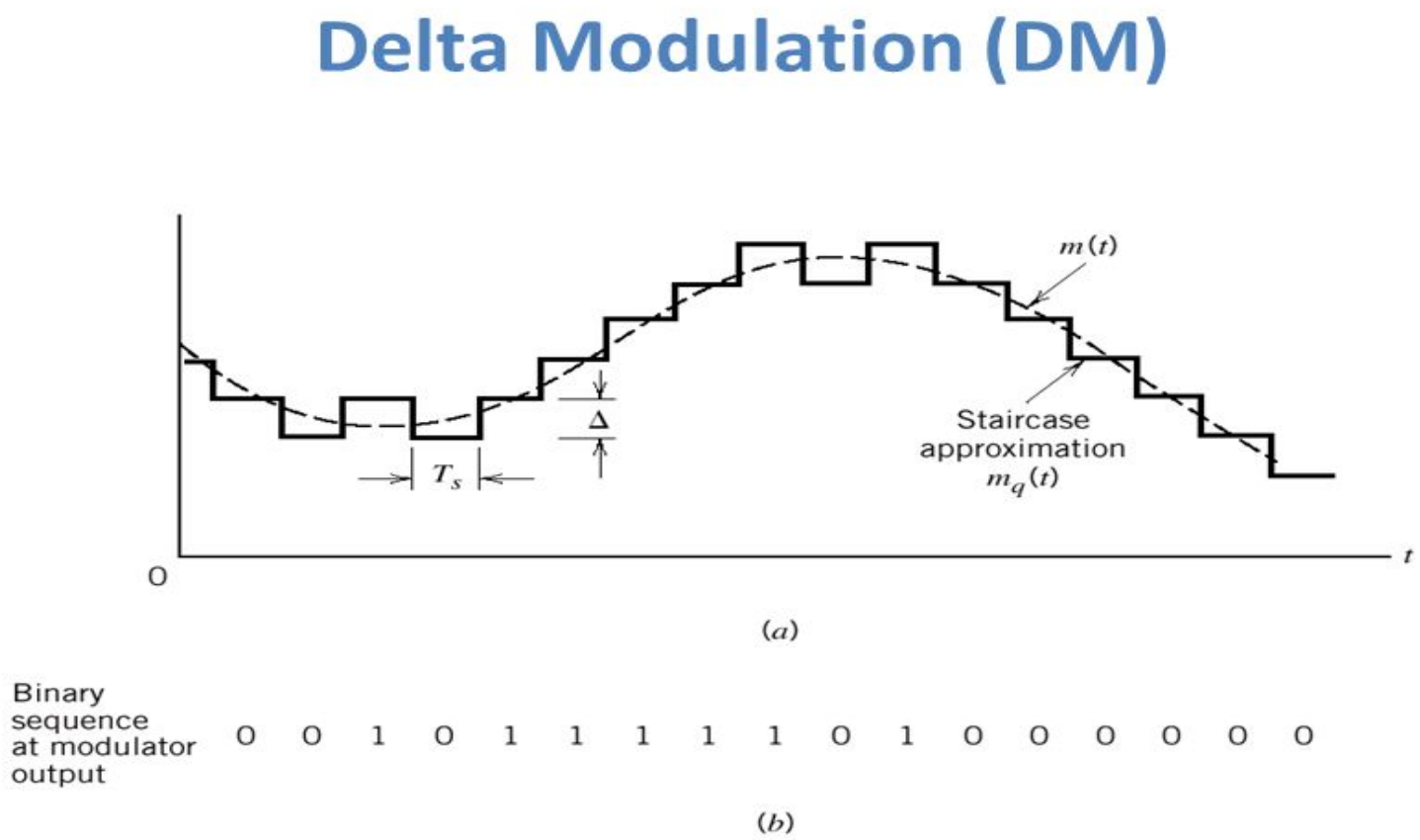
- Application of DPCM
  - JPEG (Joint Photographic Experts Group)- an image compression standard
  - Adaptive DPCM

Delta Modulation (DM)

- Simplified variant of DPCM which uses 1−bit (2−level) quantizer
- Developed for voice telephony application
- Principle of DM:



Slope Overload Distortion & Granular Noise

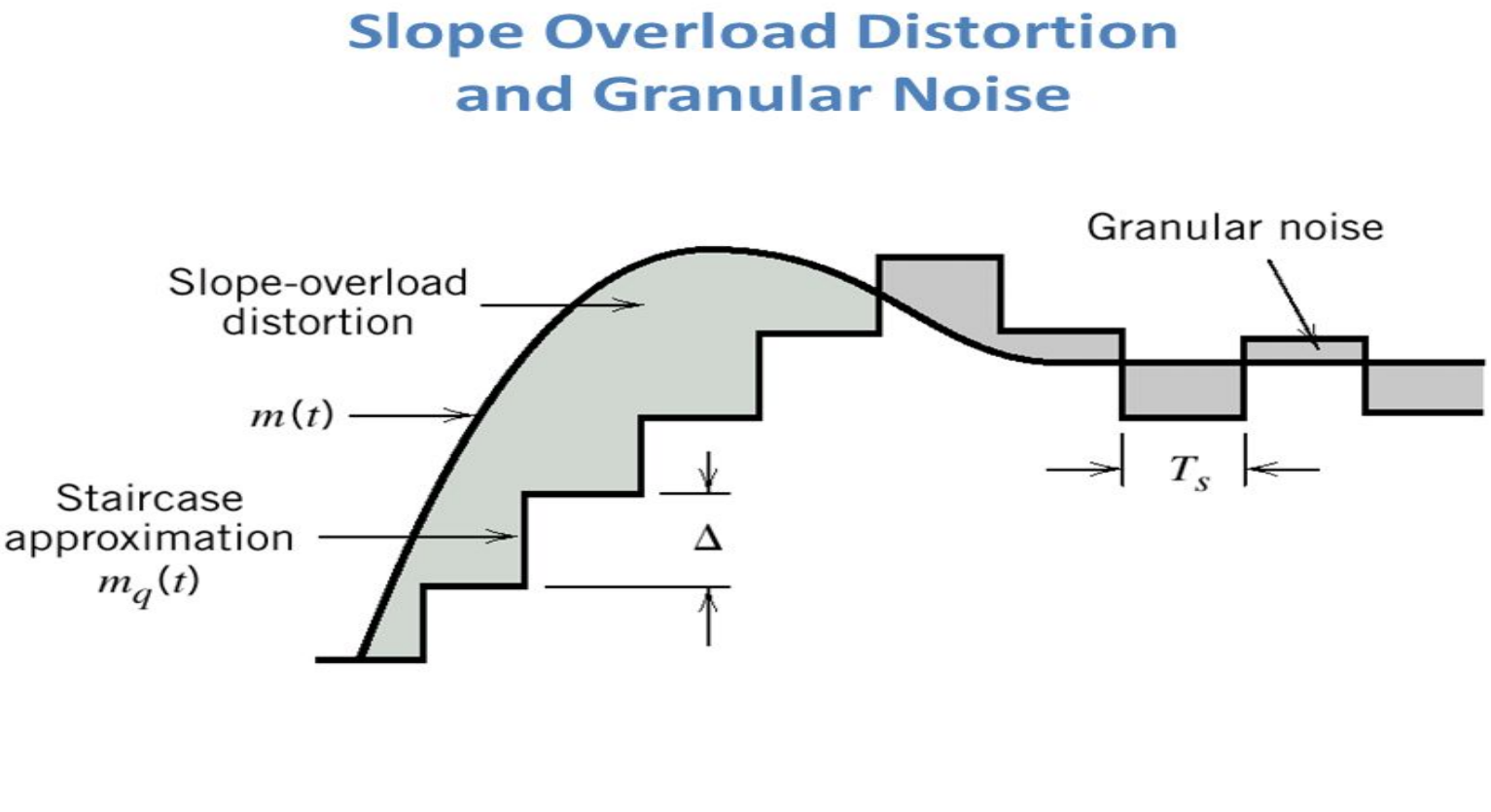


Figure: Very small step size causes slope overload distortion.
Very large step size causes granular noise.

Important Instructions

- Try to complete all tasks within 2 hours. After 2 hrs, evaluation starts.
- For each subtask, create mfiles (eg. CT_HT.m) and save them with suitable name.
- Prepare a word document naming your name and ID. In it, save all results including plots.
- In all plots, put x-label, y-label, legend, font 'Arial'(Size = 10), and, Width '2'.

Task 1: Designing of Δ

- Let $m(t)$ continuous-time (CT) message signal
- Slope of the signal $\mathcal{S} = \frac{dm(t)}{dt}$
- Single tone modulation: $m(t) = A_m \cos\left(2\pi f_m t - \frac{\pi}{2}\right)$
- Question (1). (a): Find Δ such that $\frac{\Delta}{T_s} = \max \mathcal{S}$, where T_s is sampling duration
- Question (1). (b): Let $m(t) = \cos\left(t - \frac{\pi}{2}\right)$.
  - Find Δ such that $\frac{\Delta}{T_s} = \max \mathcal{S}$

Task 2: Delta Modulation & Demodulation

- Make use of the following
  - Message signal's peak amplitude $A_m = 1$ volt;
  - Sample duration $T_s = 0.045$ sec.
  - Time vector $t = 0 : T_s : 9$;
  - Message signal $m(t) = A_m \sin t$;
  - Choose $\Delta = T_s$;
  - Initialize $m_q = 0$;
  - Modulation: For each sample, do the following:
    - Compare message sample and m_q
    - If message amplitude is higher than m_q, bit $b = 1$ and $m_q \rightarrow m_q + \Delta$. Otherwise, bit = 0 and $m_q \rightarrow m_q - \Delta$
  - Demodulation: For each bit, use similar logic to generate demodulated signal

Task 2: Delta Modulation & Demodulation

- Question 2. (a): Write a program to plot the following
  1. Original message signal $m(t)$
  2. Delta modulated signal (Hint: use 'stairs' command).
  3. Demodulated signal
  4. Difference signal $d = |m - m_q|$
     - Show all in single plot. In the plot, provide x-label, y-label, title, and legend.
- Question 2. (b):
  - Using MATLAB, compute sum of squared error between message and staircase approximation
- Question 2. (c):
  - What is the bit duration?
  - What is the bit rate?

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Explore More..

- Explore on DM of triangular pulse?
  - Design of Δ
  - Modulation & demodulation
- Explore on DM for double-tone signal?
  - Design of Δ
  - Modulation & demodulation