Recitation (Δ Modulation)

Q.1) $m(t) = A_m \cos(2\pi f_m t)$

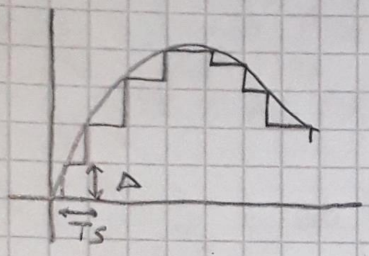
Slope of $m(t) = -2\pi f_m A_m \sin(2\pi f_m t)$

max slope of $m(t) = 2\pi f_m A_m$

max avg slope of the approximating signal $m_a(t)$ produced by the ΔM

$\dfrac{\Delta}{T_s}$

$$2\pi f_m A_m > \frac{\Delta}{T_s}$$



$$A_m > \frac{\Delta}{2\pi f_m T_s}$$

staircase approximation

$\dfrac{\Delta}{T_s}$ değeri (anlık slope) $m(t)$'den daha düşükse modulasyon yakalanmış demektir. cos sinyali için durum bu

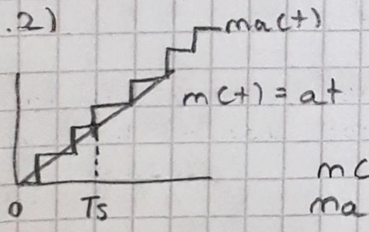
Assumming 1Ω load

The transmitted power $A_m^2/2$

$$A_m < \frac{\Delta}{2\pi f_m T_s} \quad \text{(no slope overload distortion)}$$

$$P_{max} = \frac{\Delta^2}{8\pi^2 f_m^2 T_s^2}$$

Q.2)



approximating signal $m_a(t)$

$m(t) \longrightarrow aT_s$

$m_a(t) \longrightarrow \Delta$

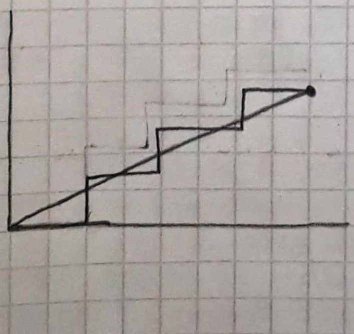
$aT_s > \Delta$

(slope overload distortion)

a) $\Delta = 0.75\, aT_s$ (still slope overload)

b) $\Delta = aT_s$

c) $\Delta = 1.25\, aT_s$ (no slope overload)



After 4 jumps $4\Delta = 5aT_s$

Q.3) $f_s = 10\, f_{Nyquist}$ $\qquad f_{Nyquist} = 6.8 \text{ kHz}$

$f_s = 68 \text{ kHz}$

$T_s = 1/f_s = 0.0147 \text{ ms}$

$m(t) = A_m \cos(2\pi f_m t)$ where $f_m = 1 \text{ kHz}$

$\frac{dm(t)}{dt} = -2\pi f_m A_m \cos(2\pi f_m t)$

$$\frac{\Delta}{T_s} > \max \left| \frac{dm(t)}{dt} \right|$$

$\Delta = 100 \text{ mV}$

$$A_m < \frac{\Delta}{2\pi f_m T_s} = \frac{100 \text{ mV}}{2\pi 10^3 . (0.0147) 10^{-3}} = 1.0827 \text{ V}$$

Midterm Q.3

$s(t) = 10 \cos(2\pi f_c t + 0.3 \sin(2\pi f_m t))$

$10 = A_c \qquad 0.3 = \beta$

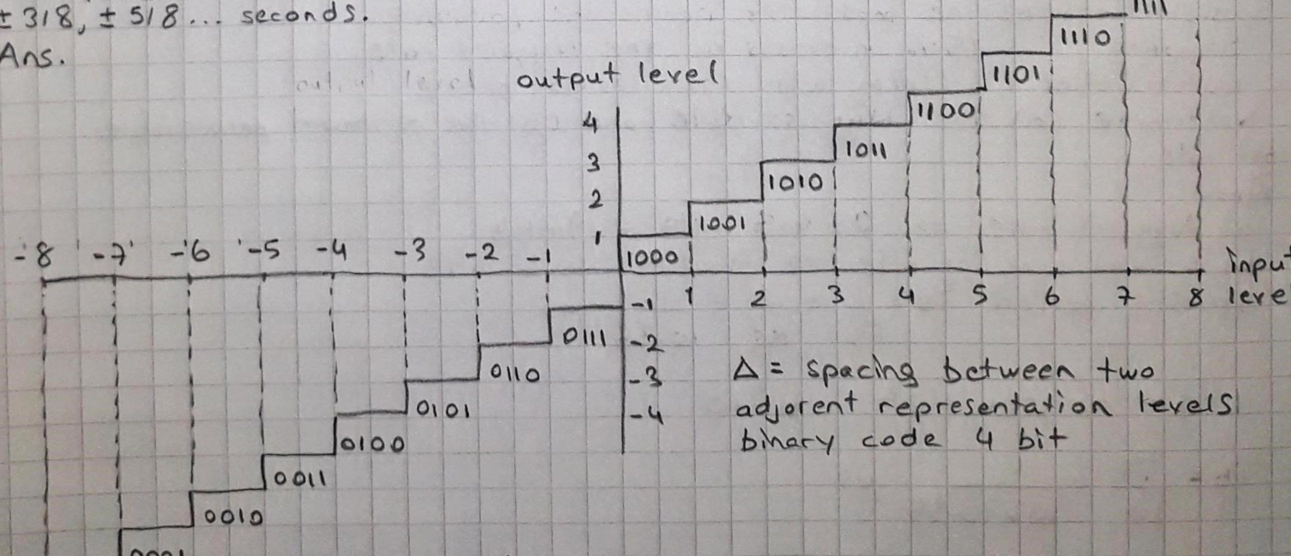
$$\int_0^t A_m \cos(2\pi f_m \tau)\, d\tau = \frac{A_m \sin(2\pi f_m \tau)}{2\pi f_m} \Big|_0^t = \frac{A_m}{2\pi f_m} \sin(2\pi f_m t)$$

$$s(t) = A_c \cos\left(2\pi f_c t + \frac{2\pi k_f A_m}{2\pi f_m} \sin(2\pi f_m t)\right)$$

Recitation #2 (PCM)

5.17 $m(t) = 6 \sin(2\pi t)$ V is transmitted using a 4-bit binary PCM system. The quantizer is of the midrise type, with a step size of 1 volt. Sketch the resulting PCM wave for one complete cycle of the input. Assume a sampling rate of four samples per second, with samples taken at $t = \pm 1/8$, $\pm 3/8$, $\pm 5/8$ ... seconds.

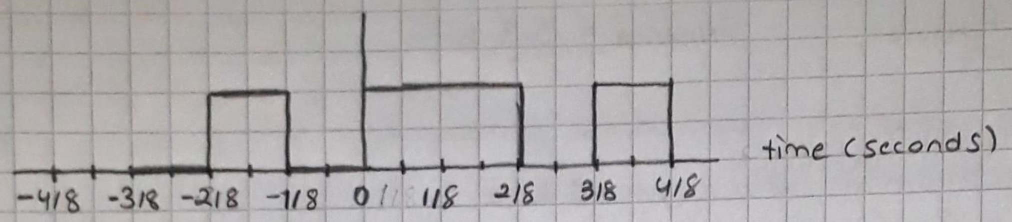
Ans.



Δ = spacing between two adjorent representation levels
binary code 4 bit

t	$m(t)$	code
$-3/8$	-4.24	0011
$-1/8$	-4.24	0011
$+1/8$	4.24	1100
$+3/8$	4.24	1100

assuming on-off signalling, coded waveform is



5.18 Consider a compact disc that uses pulse-code modulation to record audio signals whose band-with $W = 15$ kHz. Spesifications of the modulator include the following:

Quantization : uniform with 512 levels
Encoding : binary

Determine (a) Nyquist Rate, and (b) the minimum permissible bit rate.

Ans.

a) Nyquist Rate = min. sampling rate permissible
sampling rate $\Rightarrow 2W = 30$ kHz
samples / sec
Fs

b) We require a binary code with k bits to accomodate 512 quantization levels

$L = 2^k \Rightarrow 512 = 2^k \qquad k = 9$

$T_s = \frac{1}{F_s} = \frac{1}{30}$ ms (Ts must be divided into 9 bits)

5.19 This problem adresses the digitization of a television signal using pulse-code modulation. The signal bandwidth is 4.5 mHz. Spesifications of the modulator include the following:

Sampling : 15% in excess of the Nyquist rate
Quantization : uniform with 1024 levels binary

Determine (a) the Nyquist Rate, and (b) the minimum permissible bit rate

Ans.

a) Nyquist rate $\Rightarrow 2 \times 4.5$ mHz $= 9$ mHz
b) actual sampling rate $\Rightarrow 9 \times 1.15 = 10.35$ mHz
Sampling period $T_s = \frac{1}{F_s} = \frac{1}{R_s} = \frac{1}{10.35}$ μs

$L = 2^k \Rightarrow 1024 = 2^k \qquad k = 10$

$T_b = \frac{T_s}{10} = \frac{1}{10 \times 10.35}$ μs

$T_b = \frac{1}{103.5}$ μs $\Rightarrow R_b = 103.5$ megabits / sec