

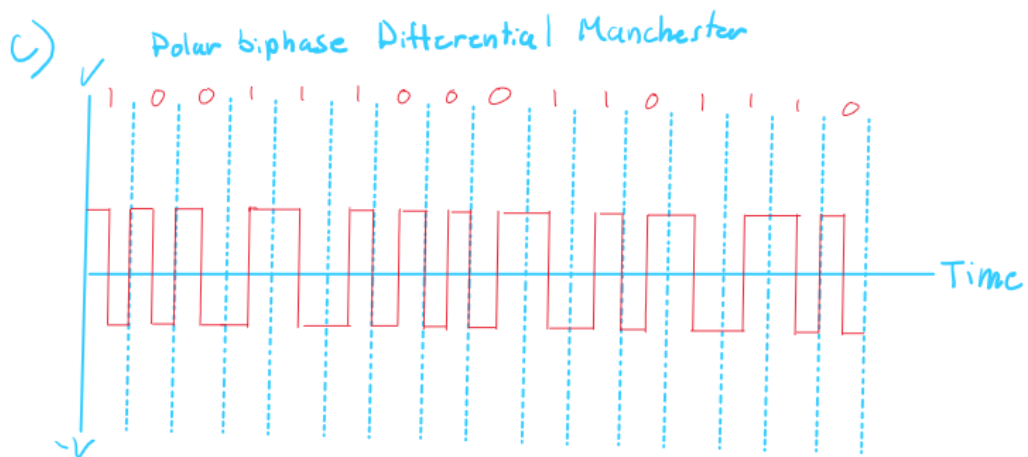
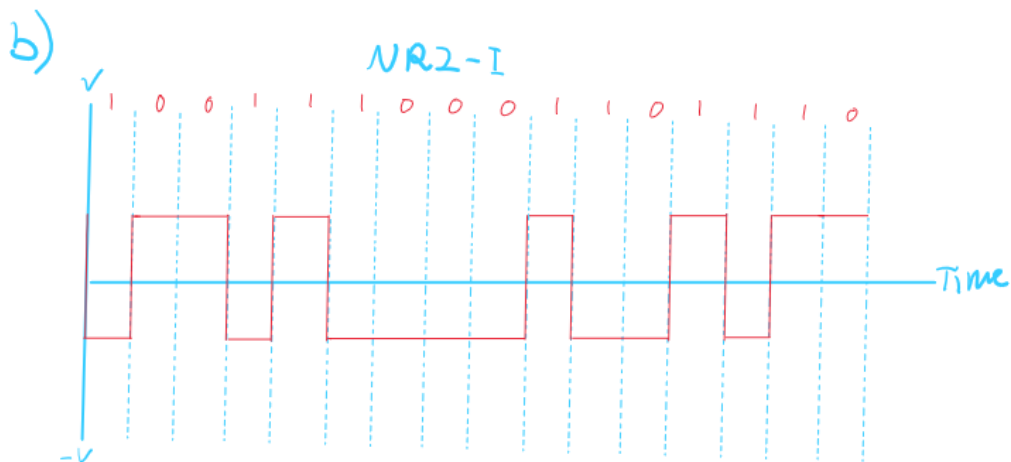
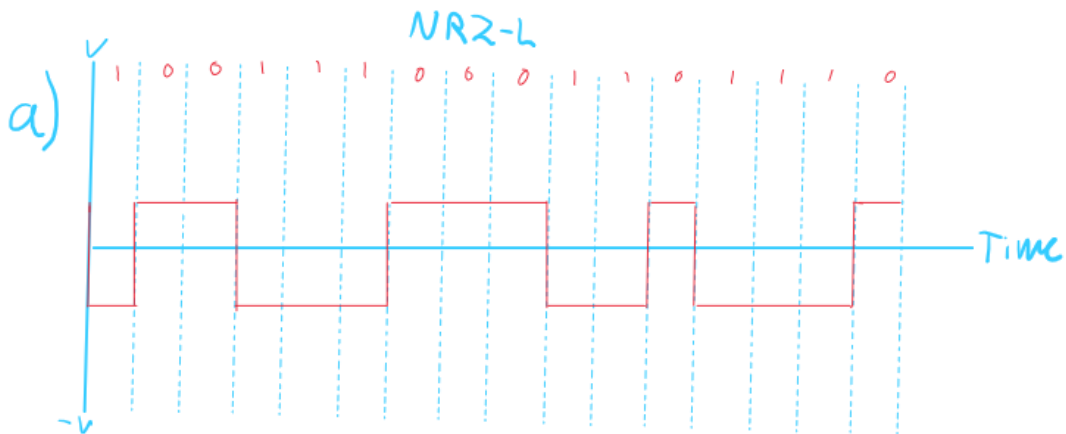
Assignment 2

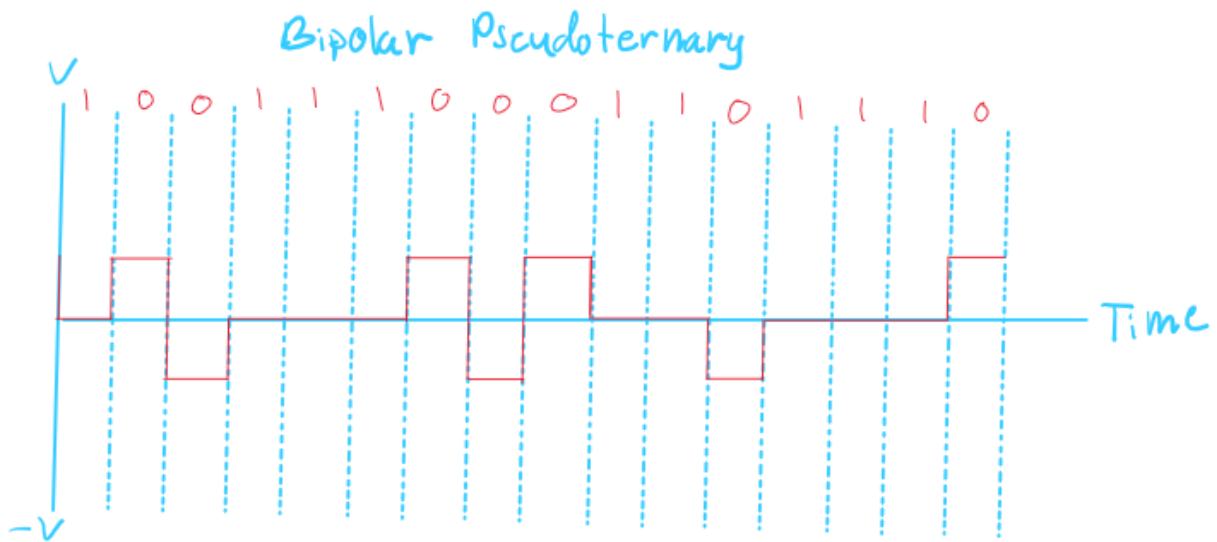
Markus Afonso A01333486

COMP 3725

Set: Friday

1) 100110001101110





$$2) \quad s(t) = \sin(2\pi ft) + \frac{1}{3} \sin(6\pi ft) + 0.2 \sin(10\pi ft)$$

a) max sampling rate of $s(t)$:

$$\frac{10\pi ft}{\pi ft} = \frac{2 \times \pi ft}{\pi ft}, \quad \frac{6\pi ft}{\pi ft} = \frac{2 \times \pi ft}{\pi ft}, \quad x = 1$$

$$10 = 2x \qquad 6 = 2x$$

$$5 = x \qquad 3 = x$$

so, we have f , $3f$, $5f$

the highest frequency of 5 with bandwidth of 240 kHz .

$$\text{so } f_{\max} = 240 \text{ kHz}.$$

$$\therefore \text{Sampling rate} = 2 \times f_{\max}$$

$$= 2 \times 240 \text{ kHz}$$

$$= 480 \text{ kHz}$$

$$b) \text{ Bitrate} = f_s \times n_b$$

$$n_b = \log_2 L$$

$$n_b = \log_2 16$$

$$n_b = 4$$

$$\text{Bitrate} = 480,000 \times 4$$

$$= 1,920,000 \text{ bps}$$

$$c) \text{ SNR}_{\text{dB}} = 10 \log_{10} \text{SNR}$$

$$\text{Capacity} = \text{bandwidth} \times \log_2(1 + \text{SNR})$$

$$\text{Capacity} = 1,920,000 \text{ bps}$$

$$\text{Bandwidth} = 0.5 \text{ MHz} = 500,000 \text{ Hz}$$

$$C = B \log_2(1 + \text{SNR})$$

$$\frac{1,920,000}{500,000} = \frac{500,000 \log_2(1 + \text{SNR})}{500,000}$$

$$3.84 = \log_2(1 + \text{SNR})$$

$$2^{3.84} = 1 + \text{SNR}$$

$$14.3204 = 1 + \text{SNR}$$

$$13.32 = \text{SNR}$$

$$\text{SNR}_{\text{dB}} = 10 \log_{10} \text{SNR}$$

$$\text{SNR}_{\text{dB}} = 10 \log_{10} 13.32$$

$$\boxed{\text{SNR}_{\text{dB}} = 11.25 \text{ dB}}$$

$$d) 1,420,000 \times 2 = 3,840,000$$

$$SNR_{db} = 10 \log_{10} SNR$$

$$C = B \log_2 (1 + SNR)$$

$$\frac{3,840,000}{500,000} = \frac{500,000 \log_2 (1 + SNR)}{500,000}$$

$$7.68 = \log_2 (1 + SNR)$$

$$2^{7.68} = 1 + SNR$$

$$SNR = 204.07$$

$$SNR_{db} = 10 \log_{10} SNR$$

$$SNR_{db} = 10 \log_{10} 204.07$$

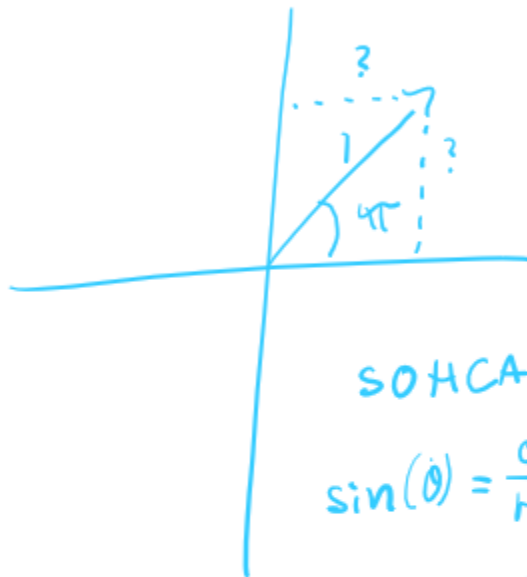
$$SNR_{db} = 23.10$$

$$23.10 - 11.25 = 11.85$$

increase at 11.85 db

3) a) 000

$$\cos(2\pi f_c t + \pi)$$



SOHCAHTOA

$$\sin(\theta) = \frac{O}{H} \quad \cos(\theta) = \frac{A}{H} \quad \tan = \frac{O}{A}$$

H = Amplitude, θ = phase shift

$$\cos(\theta) = \frac{A}{H} \quad \sin(\theta) = \frac{O}{H}$$

$$H \cos(\theta) = A, \quad H \sin(\theta) = O$$

$$\cos(2\pi f_c t + \pi)$$

$$I = \cos(\pi) \quad Q = \sin(\pi)$$

$$I = -1 \quad Q = 0$$

x axis = I (in-phase carrier) y axis = Q (Quadrature carrier)

$$000 = (-1, 0)$$

$$001 / 3 \cos(2\pi f_c t + \pi)$$

$$I = 3 \cos(\pi) \quad Q = 3 \sin(\pi)$$

$$I = -3 \quad Q = 0$$

$$001 = (-3, 0)$$

$$010 / \cos(2\pi f_c t + \frac{3\pi}{2})$$

$$I = \cos(\frac{3\pi}{2}) \quad Q = \sin(\frac{3\pi}{2})$$

$$I = 0 \quad Q = -1$$

$$010 = (0, -1)$$

$$011 / 3 \cos(\pi + \frac{3\pi}{2})$$

$$I = 3 \cos(\frac{3\pi}{2}) \quad Q = 3 \sin(\frac{3\pi}{2})$$

$$I = 0 \quad Q = -3$$

$$011 = (0, -3)$$

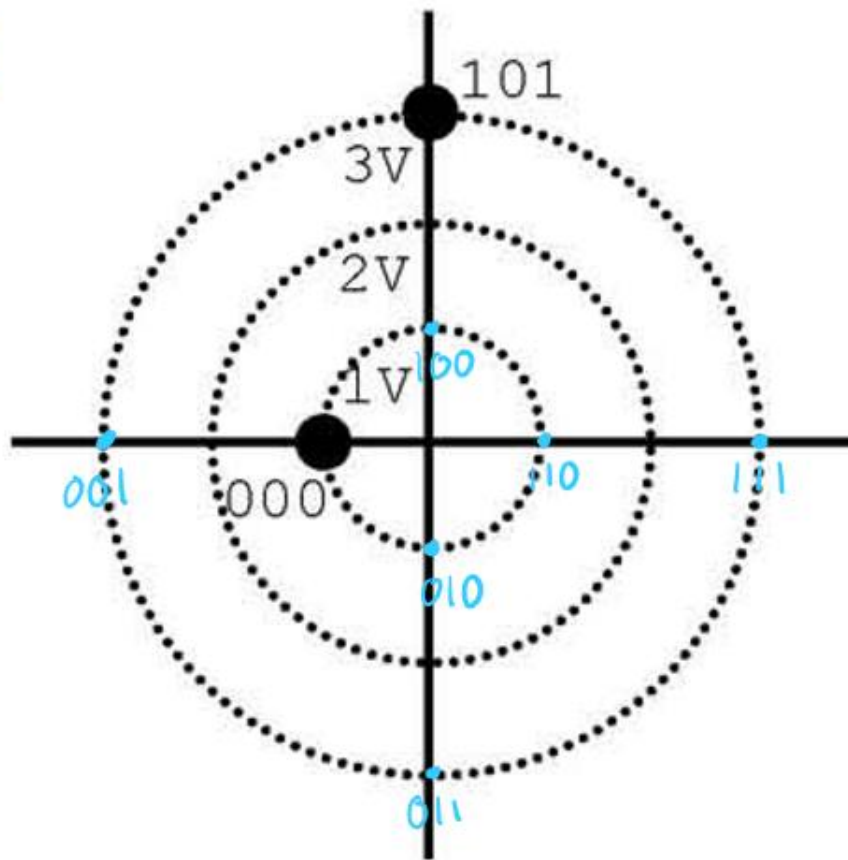
$$\begin{aligned}
 &100 / \cos(2\pi f_c t + \frac{\pi}{2}) \\
 &I = \cos(\frac{\pi}{2}) \quad Q = \sin(\frac{\pi}{2}) \\
 &I = 0 \quad Q = 1 \\
 &100 = (0, 1)
 \end{aligned}$$

$$\begin{aligned}
 &101 / 3\cos(2\pi f_c t + \frac{\pi}{2}) \\
 &I = 3\cos(\frac{\pi}{2}) \quad Q = 3\sin(\frac{\pi}{2}) \\
 &I = 0 \quad Q = 3 \\
 &101 = (0, 3)
 \end{aligned}$$

$$\begin{aligned}
 &110 / \cos(\wedge + 0) \\
 &I = \cos(0) \quad Q = \sin(0) \\
 &I = 1 \quad Q = 0 \\
 &110 = (1, 0)
 \end{aligned}$$

$$\begin{aligned}
 &111 / 3\cos(2\pi f_c t + 0) \\
 &I = 3\cos(0) \quad Q = 3\sin(0) \\
 &I = 3 \quad Q = 0 \\
 &111 = (3, 0)
 \end{aligned}$$

a)



b)

$$T = \frac{1}{f}$$

$$T = \frac{1}{8}$$

$$T = 0.125s$$

c)

$$T_s = \frac{1}{f_s}$$

$$T_s = \frac{1}{4}$$

$$T_s = 0.25s$$

d) 4 symbols/s

8 Hz

$$\underbrace{101}_{3\cos(2\pi f_c t + \frac{\pi}{2})} \quad \underbrace{110}_{\cos(2\pi f_c t)} \quad \underbrace{000}_{\cos(2\pi f_c t + \pi)} \quad \underbrace{111}_{3\cos(2\pi f_c t)}$$

$$f_c = 8 \text{ Hz}$$

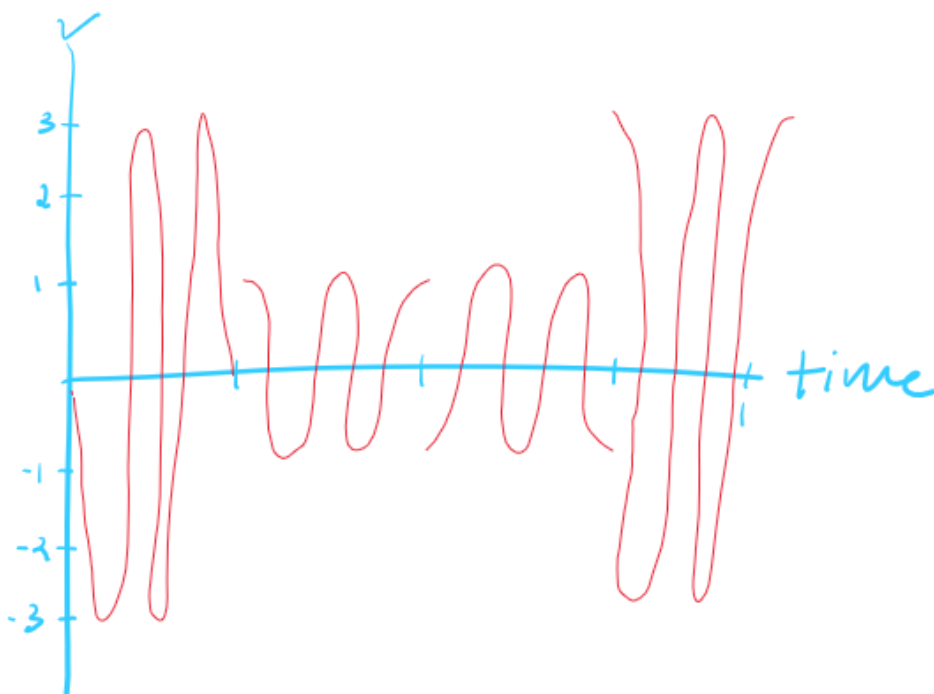
$$\underbrace{101}_{3\cos(2\pi 8t + \frac{\pi}{2})}$$

$$3\cos(16\pi t + \frac{\pi}{2})$$

$$\underbrace{110}_{\cos(16\pi t)}$$

$$\underbrace{000}_{\cos(16\pi t + \pi)}$$

$$\underbrace{111}_{3\cos(16\pi t)}$$



$$c) \quad \text{Bit rate} = f_s \times n_b$$

$$\text{bit rate} = 4 \times 3$$

$$\boxed{\text{bit rate} = 12 \text{ bps}}$$

4)

Quantization Levels

$$[-8, 8]v$$

$$\frac{8+8}{8} = 2v \text{ per level}$$

so, $-8, -6v$ is level 0 or 000 $-6, -4$ is level 1 or 001 $-4, -2$ level 2 or 010 $-2, 0$ level 3 or 011 $0, 2$ level 4 or 100 $2, 4$ level 5 or 101 $4, 6$ level 6 or 110 $6, 8$ level 7 or 111

sampling rate = 400 samples/s or 0.0025s

starting at $t_1 = 0.001$ $\uparrow + 0.0025$
 $t_2 = 0.0035$

$t_3 = 0.006$

$t_4 = 0.0085$

~~$t_5 = 0.011$~~

