Dylan.Z

Problem set 2 due 2/14/25

Probability and statistics, Noise

2.

a) $\frac{50\ KHz}{500KHz} = 1/10 = 50\ KHz$

b) $\frac{250\ KHz}{500\ KHz} = 1/2 = 250\ KHz$

c) $\frac{750\ KHz}{500\ KHz} = 2 = 0$

3.

$$A = \frac{Vout}{Vin} = \frac{0.33}{3.3} = 0.1$$

$$A = \frac{1}{\sqrt{1 + (2\pi fRC)^2}}$$

$$RC = \frac{1}{2\pi f}\sqrt{\frac{1}{A^2} - 1}$$

$$RC = \frac{1}{2\pi \times 25 \times 10^6}\sqrt{\frac{1}{0.1^2} - 1}$$

$$\frac{1}{0.1^2} - 1 = 100 - 1 = 99$$

$$RC \approx \frac{1}{157 \times 10^6} \times 9.95 \approx 6.34 \times 10^{-8}\ s$$

$$C = \frac{RC}{R} = \frac{6.34 \times 10^{-8}}{10 \times 10^3} = 6.34 \times 10^{-12}\ F = 6.34\ pF$$

4.

$$A = \frac{Vout}{Vin} = \frac{0.33}{3.3} = 0.1$$

$$A = \frac{1}{\sqrt{1 + \left(\frac{1}{2\pi fRC}\right)^2}}$$

$$= \frac{1}{\sqrt{1 + \left(\frac{1}{2\pi RC}\right)}} = 0.1$$

$$= 0.01$$

$$= \frac{1}{1 + \left(\frac{1}{2\pi fRC}\right)}$$

$$= \left(\frac{1}{2\pi fRC}\right)^2 = 99$$

$$= \frac{1}{2\pi fRC} = \sqrt{99}$$

$$= \frac{1}{2\pi (10\times10^6)(10\times10^3)C} = 9.95$$

$$C = \frac{1}{2\pi (10^6) \times 9.95}$$

$$C = \frac{1}{6.25 \times 10^9}$$

$$C \simeq 1.6 \times 10^{-10} F = 160\ pF$$

3. ADC and DAC

1. ADC

a) $\Delta V = \frac{2.55 - 0}{256} = \frac{2.55}{256} = 0.00996\ V \simeq 9.96\ mV$

b) $\Delta V = \frac{4.095}{4096} = 0.001\,V = \boxed{1\,mV}$

c) $\Delta V = \frac{12}{2^N} < 0.001$

$2^N > \frac{12}{0.001} = 12000$

$N = \log_2(12000) \approx 13.55$

14 bits (16,384 levels) required for $\Delta V < 1\,mV$

d) $\Delta V = \frac{5}{2048} = 0.00244\,V = 2.44\,mV$ per level

$Counts = \frac{2.52}{\Delta V} = \frac{2.52}{0.00244} \approx 1033$

1033 Counts for a 2.52 V signal

DAC

a) $V = 256 \times 9.8\,mV$

$V = 256 \times 0.0098$

$V = 2.5088\,V \simeq 2.51\,V$

b) $\Delta V = \frac{5}{4095} = 0.00122V = 1.22mV$

$V = 2048 \times 0.00122$

$V \simeq 2.5\,V$

c) $\Delta V = \frac{V_{max}}{511}$

$V_{max} = \frac{0.25 \times 511}{128}$

$V_{max} = \frac{127.75}{128} \simeq 1.0\,V$