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H.w#2

3.1 ADC and DAC

(a) ΔV for 8-bit ADC (0-2.55V, 255 levels): $\Delta V = 2.55 / 255 = 0.0100$ V/level

(b) ΔV for 12-bit ADC (0-4.095V, 4095 levels): $\Delta V = 4.095 / 4095 = 0.001000$ V/level

(c) Bits required for $\Delta V < 1$mV in 0-12V: 12 / 0.001 = 12000 levels => ceil(log2(12000)) = 14 bits

(d) Digital amplitude of 2.52V in 2048 levels over 0-5V: Value = (2.52 / 5) * 2047 ≈ 1032 counts

(e) DAC amplitude for 256 counts at 9.8mV/level: 256 * 0.0098 = 2.5088 V

(f) DAC amplitude for 2048 counts, 0-5V, 4095 max: (2048 / 4095) * 5 = 2.5024 V

(g) Max voltage when output = 0.25V, 128 counts out of 511: Vmax = 0.25 * (511 / 128) = 1.00 V

3.2 Digital Signal Frequency

(a) f_analog = 50kHz: f_digital = |50k - 0 * 500k| = 50,000 Hz

(b) f_analog = 250kHz: f_digital = |250k - 1 * 500k| = 250,000 Hz

(c) f_analog = 750kHz: f_digital = |750k - 2 * 500k| = 250,000 Hz

(d) f_analog = 1000kHz: f_digital = |1000k - 2 * 500k| = 0 Hz

3.3 Low-Pass RC Filter

Given: A_in = 3.3V, A_out = 0.33V, f = 25 MHz, R = 10kΩ

Gain = 0.33 / 3.3 = 0.1

C = sqrt(1/G^2 - 1) / (2πfR) ≈ 6.33 pF

3.4 High-Pass RC Filter

Given: A_in = 3.3V, A_out = 0.33V, f = 10 MHz, R = 10kΩ

Gain = 0.1

$C = (G / \mathrm{sqrt}(1 - G^2)) / (2\pi fR) \approx 0.16$ pF

3.5 Bonus: Phase Shift Introduced

Low-pass filter phase shift = -84.26°

High-pass filter phase shift = +84.26°