(15%) 1. Consider a filter function whose poles and zeros are plotted in s-plane shown in **Fig. P1**. Please specify

(a) which type of filters it is. (low-pass/ high-pass/ band-pass/ all-pass) Explain your reason. (10%)

(b) its filter order N. Explain your reason. (5%)

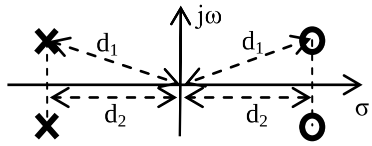

Fig. P1

(20%) 2. Consider an N^{th}-order Butterworth low-pass filter whose maximum allowed variation in passband is A_{max}, minimun required stopband attenuation is A_{min}, passband edge is ω_p, and stopband edge is ω_s. Find the required filter orders to meet the following specifications, respectively. (Butterworth magnitude function= $\dfrac{1}{\sqrt{1+\varepsilon^2(\frac{\omega}{\omega_p})^{2N}}}$)

(a) A_{max} = 1dB, A_{min} = 50dB, ω_p = 100kHz, and ω_s = 1MHz. (10%)

(b) A_{max} = 1dB, A_{min} = 50dB, ω_p = 100kHz, and ω_s = 200kHz. (10%)

(15%) 3. **Fig. P3** shows a switched-capacitor integrator and its two-phase clock.

(a) Express the equivalent time-constant for the integrator in terms of C_1, C_2, and T_c. (5%)

(b) Compared with an active-RC integrator, what are the benefits of a switched-capacitor integrator for on-chip implementation? (5%)

(c) Explain how stray capacitances affect the circuit. (5%)

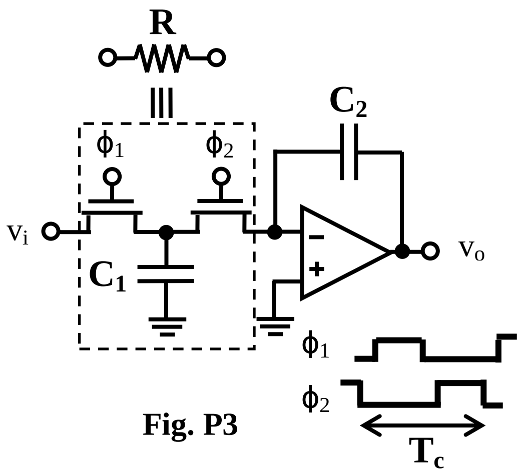

Fig. P3

(15%) 4. (a) Please describe the Barkhausen criterion. (10%)

(b) In **Fig. P4**, will the circuit start oscillation or not? Why? (5%)

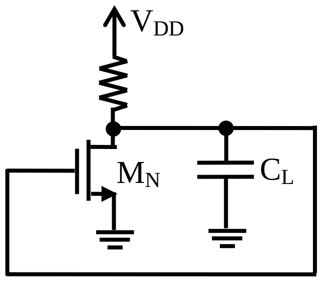

Fig. P4

(20%) 5. **Fig. P5a** and **Fig. P5b** are bistable circuits with inverting and non-inverting topologies, respectively. Both have output saturation vlotages $L_+ = -L_- = 12V$, and the threshold voltages $V_{TH} = -V_{TL} = 4V$.

(a) Please sketch the transfer characteristic curves of both inverting and non-inverting topologies, respectively (mark the L_+, L_-, V_{TH}, V_{TL}, and the direction of the transfer operation on your plots). (10%)

(b) Let $R_1 = 10k\Omega$, please find R_2 and R_3. (10%)

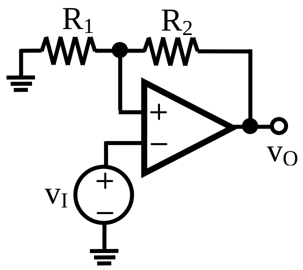

Fig. P5a

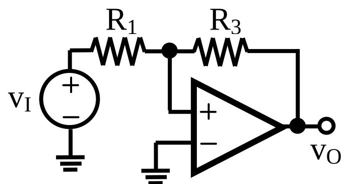

Fig. P5b

(15%) 6. **Fig. P6** shows a NOR-based multivibrator circuit and its waveforms. Assume R =100kΩ, C =1nF, and NOR's transition threshold voltage $V_T = 0.5V_{DD}$.

(a) Which type of multivibrator is it? (bistable/ astable/ monostable) (5%)

(b) Calculate the peak voltage of the V_X, which is labelled as $\mathbf{V_P}$. (5%)

(c) Calculate T_1. (Hint: RC circuit complete response: $v(t) = v(\infty)+[v(0)-v(\infty)]e^{-t/\tau}$) (5%)

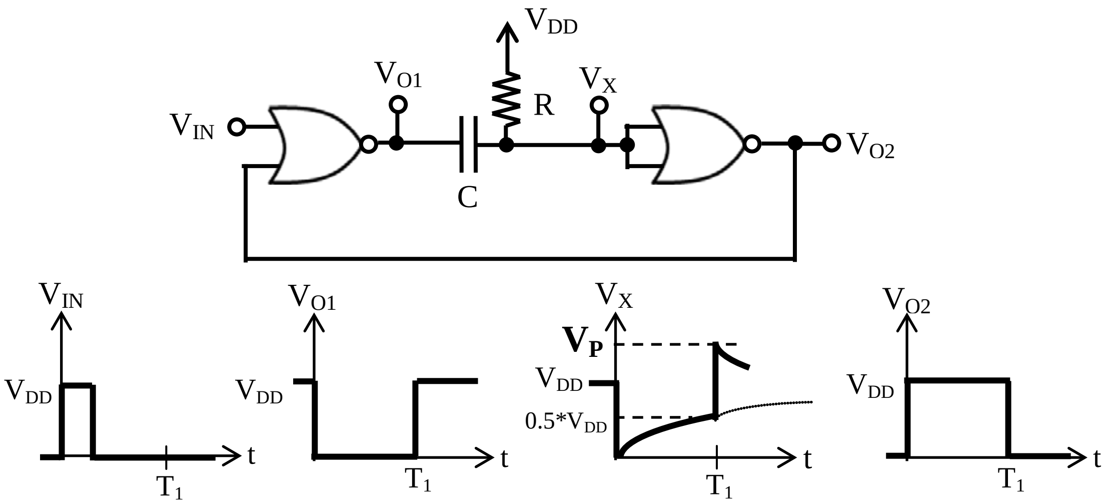

Fig. P6