| Electrical Engineer Candidate Exam | | | |
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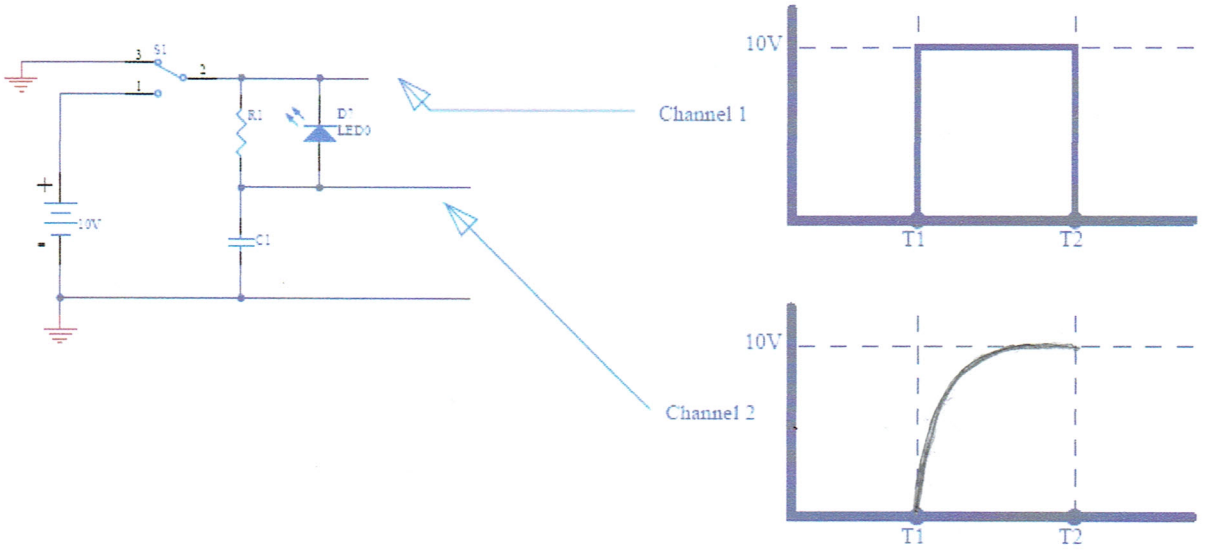
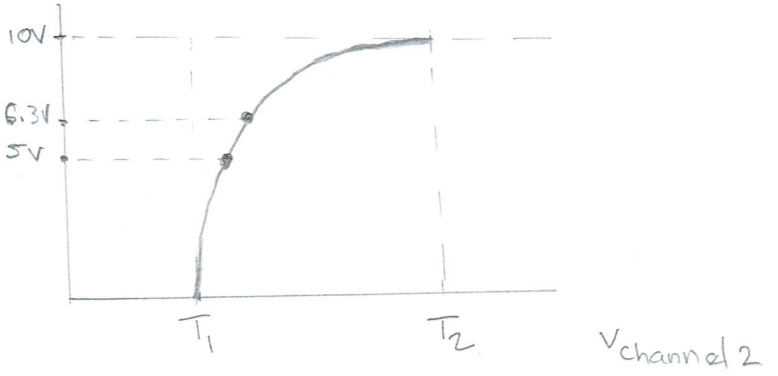
## Instructions

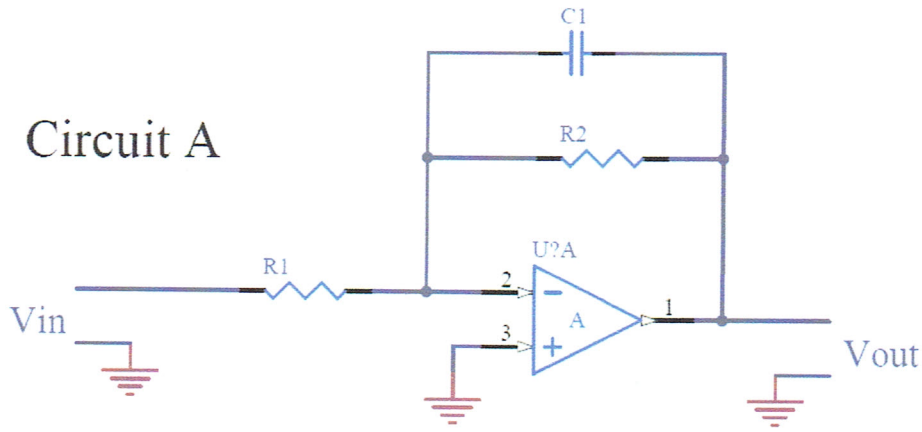
Please attempt to answer all questions and show your work and comment when applicable. The test will be scored out of 100, with 60 possible points for the analog section, and 40 possible points in the digital section.

## 1.0 Analog Questions (60 points)




1.1) Given the channel 1 oscilloscope waveform for the circuit above, draw the Channel 2 waveform. (20 points)






1.2a) Derive the expression for DC gain of this circuit. What values of R1 and R2 would give a DC gain of 10? Also, for your choice of R1 and R2, briefly describe why you wouldn't use significantly lower or higher values. (15 points)

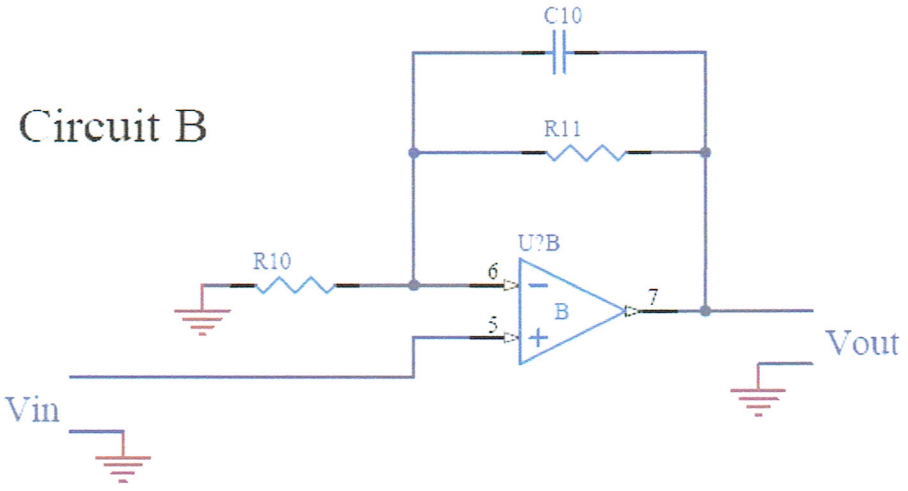
$\frac{V_o}{V_{in}} = \frac{-R_2}{R_1} \rightarrow$ $R_2 = 100\,K\Omega$, $R_1 = 10K\Omega$ Inverting Active Low-pass filter

As a good practice, Active Low-pass filter resistor values must be selected to fall into $10K\Omega - 100k\Omega$ region because The output impedance increases with increasing frequency. keeping Resistor values in this range will help with the overall performance.

1.2b) What value of C1 will reduce the output voltage by 3dB at 10 kHz? (10 point)

$10KHz = \frac{1}{2\pi \cdot C \cdot R_2}$ $\therefore$ $C = \frac{1}{2\pi \cdot 10KHz \cdot R_2}$

$C \approx 159.2pF$




1.3a) How does the phase of Vout compare to that of the circuit in 2.2? (5 points)

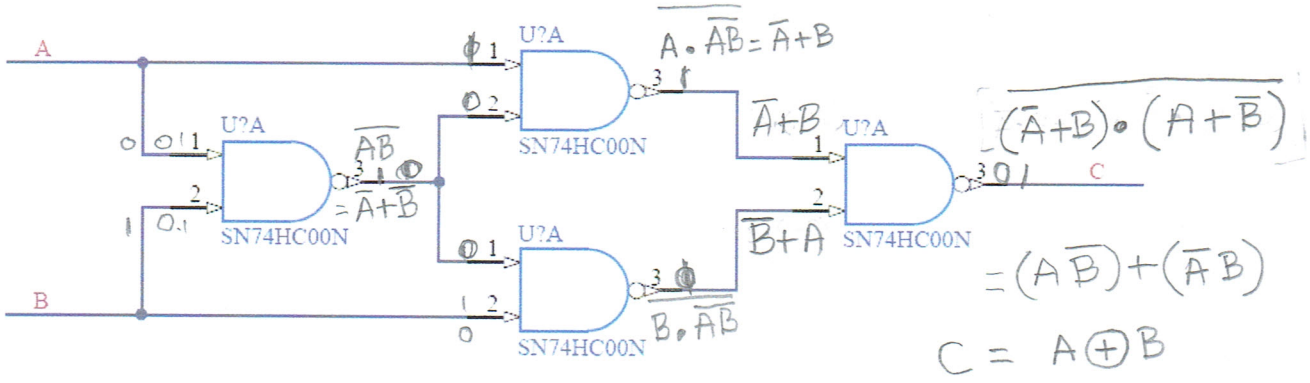
Comparing previous circuit to this one, which is a Non-Inverting Active Low-pass filter circuit, Vout of this Circuit will be 180° out-of-phase with respect to Previous circuit. But $V_{out} = A_{CL} \cdot V_{in}$ for this circuit

1.3b) Derive the expression for DC gain. What is the magnitude of Vout compared to Vin if R10=R11? (10 points)

$\Rightarrow \frac{V_o}{V_{in}} = \left(1 + \frac{R_{11}}{R_{10}}\right)$ = Transfer function.

$\Rightarrow$ When $R_{10} = R_{11}$, $V_o = V_{in}\left(1 + 1\right) \therefore V_o = 2V_{in}$

## 2.0 Digital Questions (40 points)

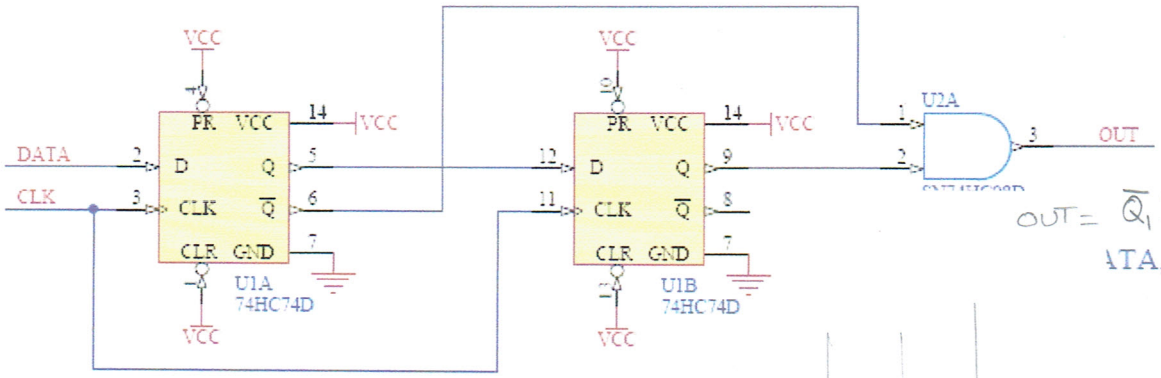


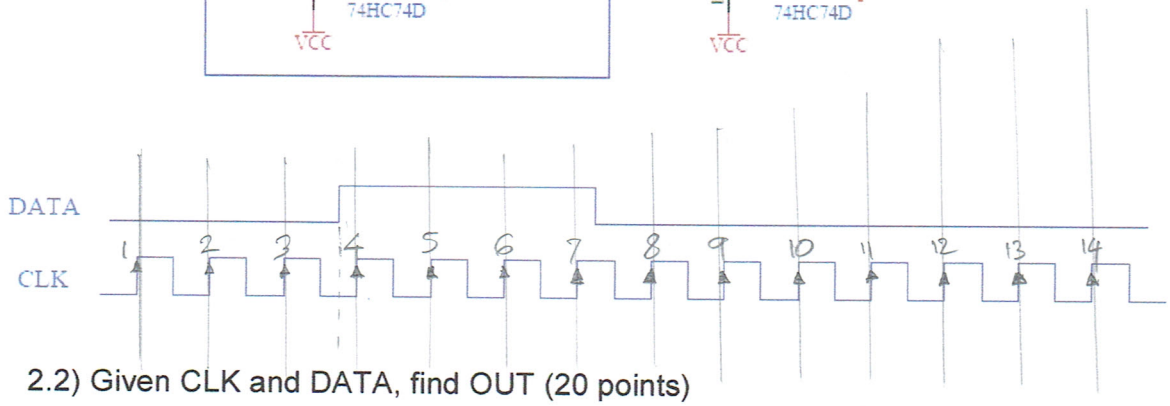

2.1) Find C in terms of A and B. (20 points)

$$C = A \oplus B$$

Truth Table

| A | B | C |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |




2.2) Given CLK and DATA, find OUT (20 points)

| $\overline{PRE}$ | $\overline{CLR}$ | CLK | D | Q | $\overline{Q}$ |
|---|---|---|---|---|---|
| L | H | X | X | H | L |
| H | L | X | X | L | H |
| L | L | X | X | H | H |
| H | H | ↑ | H | H | L |
| H | H | ↑ | L | L | H |
| H | H | ↓ | X | Q | $\overline{Q}$ |

| CLK | $Q_1$ | $\overline{Q}_1$ | $Q_2$ | $\overline{Q}_2$ | OUT |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | L | H | L | H | L |
| 3 | L | H | L | H | L |
| 4 | H | L | H | L | L |
| 5 | H | L | H | L | L |
| 6 | H | L | H | L | L |
| 7 | H | L | H | L | L |
| 8 | L | H | L | H | L |
| 9 | L | H | L | H | L |
| 10 | L | H | L | H | L |
| 11 | L | H | L | H | L |
| 12 | L | H | L | H | L |
| 13 | L | H | L | H | L |
| 14 | L | H | L | H | L |

→ OUT is always LOW