EE 112 End-Sem Exam (MBP)

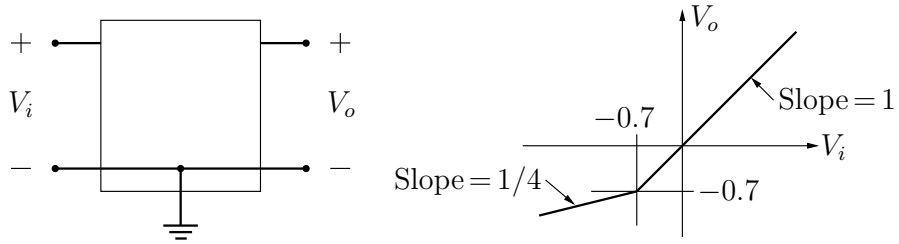
(April 23, 2016)

Note: (a) As far as possible, work in terms of symbols (like R_1, R_2, V_T), and substitute numbers at the end. This will make it easier for you to get partial credit. (b) Do not write numerical answers as fractions. For example, write 0.24 and not 6/25. You will lose some marks if the decimal format is not followed. (c) Use $V_T = kT/q = 25$ mV.

1. Implement the function $Y = A\,\overline{B} + \overline{A}\,B\,C$ using only two-input NOR gates. Justify your implementation. [6]

2. Let the binary number $A_3A_2A_1A_0$ denote a date in April 2016. For example, $A_3A_2A_1A_0 =$ `1011` denotes April 11, 2016. It is given that April 1, 2016 is a Friday. Using the K-map technique, obtain a minimal expression for a logical function Y which is `1` if the day corresponding to $A_3A_2A_1A_0$ is a Friday or a Saturday and `0` otherwise. *Consider dates from April 1, 2016 to April 14, 2016 only.*
(No partial marks if your K-map is wrong.) [8]

3. The V_o versus V_i relationship for a circuit is given in the figure. The circuit has one diode with $V_{\text{on}} = 0.7$ V, and two resistors R_1 and R_2. One of the resistances is 1 kΩ. Draw the circuit and find the other resistance. Justify your answer. [6]

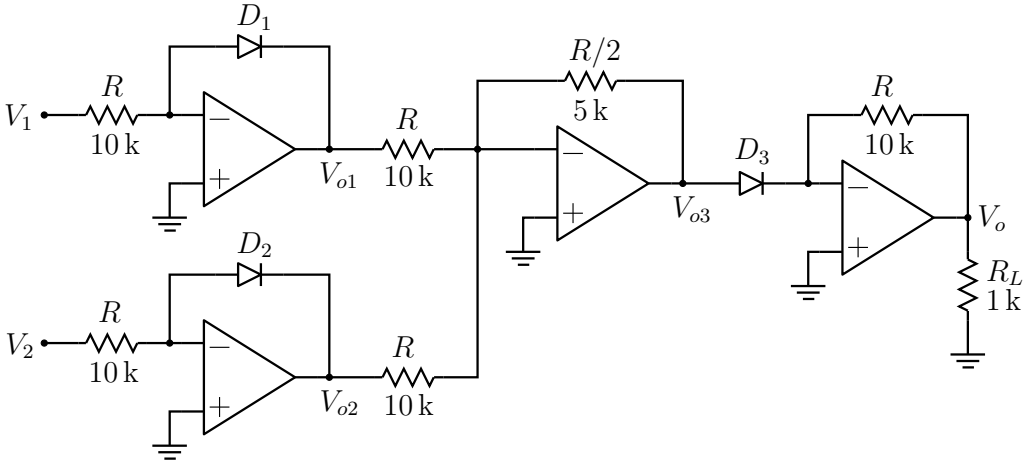


4. In the circuit shown in the figure, the diodes are identical, with $I_s = 0.5$ pA. The input voltages are $V_1 = 1$ V and $V_2 = 4$ V. Approximate the diode current (under forward bias) as $I = I_s\left(e^{V/V_T} - 1\right) \approx I_s\, e^{V/V_T}$. Assume that all op amps are working in their linear regions.

   (a) Find expressions for V_{o1} and V_{o2}, and their numerical values.
   Note: Specify V_{o1} and V_{o2} to at least five decimal places.

   (b) Repeat for V_{o3} and V_o.

   (c) What function is the circuit performing? [8]

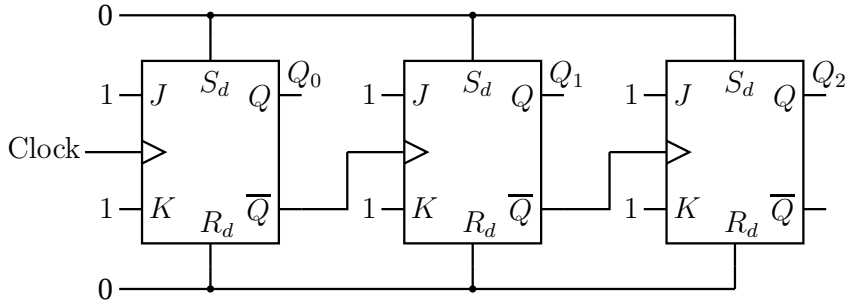


5. For the counter shown in the figure,

   (a) Starting with $Q_2Q_1Q_0 = \texttt{000}$, draw the clock, Q_0, Q_1, Q_2 waveforms for ten cycles. Draw clock on top, followed by Q_0 below it, then Q_1, and finally Q_2. Show alignment of the edges (`0` to `1`, `1` to `0`) in all waveforms clearly.

   (b) Keeping the J, K, and clock connections the same, modify the counter to get the sequence $2 \to 3 \to 4 \to 5 \to 6 \to 7 \to 2 \to 3 \ldots$ (i.e., $Q_2Q_1Q_0$ changing as $\texttt{010} \to \texttt{011} \to \texttt{100} \to \texttt{101} \to \texttt{110} \to \texttt{111} \to \texttt{010} \to \texttt{011} \to \ldots$)

   (c) Starting with $Q_2Q_1Q_0 = \texttt{010}$, draw the clock, Q_0, Q_1, Q_2 waveforms for the modified counter for ten cycles. [6]

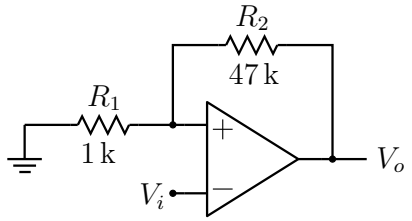


6. In the Schmitt trigger shown in the figure, the op amp has $\pm V_{\text{sat}} = \pm 12\,\text{V}$.

   (a) Calculate the threshold points (V_{TL} and V_{TH}).

   (b) Draw V_o versus V_i.

   (c) The Schmitt trigger is used as a comparator. What is the peak-to-peak noise permissible in the input signal without causing a spurious change of output voltage? Justify. [6]



7. Answer briefly (not more than half page each).

   (a) Compare flash ADC and dual-slope ADC with respect to all important figures of merit that you can think of (no figures are required). [4]

   (b) Consider the I-V curves for BJTs (I_C versus V_{CE} with I_B as a parameter) and MOSFETs (I_D versus V_{DS} with V_{GS} as a parameter). Comment on the similarities and differences between the two. [3]

   (c) Nine songs of an average duration of 8 minutes each occupy a total of about 700 Mbytes on a CD when stored in the stereo (two-channel) format with 16 bits per sample per channel. Estimate the sampling rate used while recording the songs. For simplicity, consider 1 kbyte to be 1,000 bytes (rather than 1,024). Explain your steps.

   Does your answer seem reasonable? Justify. (1 byte = 8 bits) [3]