Problem Set 2

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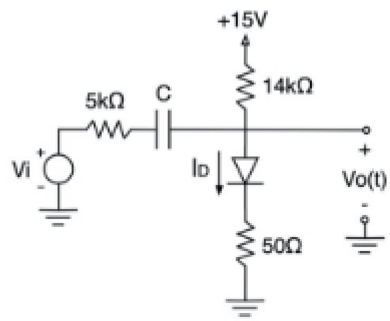
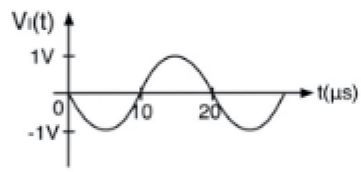
September 26, 2023

1. For the diode attenuator circuit and input waveform shown below, sketch the output voltage waveform, $v_o(t)$. Clearly label all key points on the graph. Assume that the diode has a forward-bias voltage of 0.7V when conducting a current of 1mA, and thermal voltage $V_T = 25\text{mV}$ at room temperature. Assume also that capacitor C has a very large value. (Hint: it can be shown that the small-signal diode model is valid here.)





Solution: We start with DC analysis. This is because for the AC analysis, we need to use a small signal approximation.
We can ignore the left hand side, since there is no current through a capacitor when voltage is constant. The voltage drop at the diode is 0.7V. Solving for current,

$$I_D = \frac{15 - 0.7}{14 + 0.05} \approx 1\text{mA}$$

which justifies the assumption of a 0.7V voltage drop.
For AC analysis, the resistance of the linear model is

$$r_d = \frac{V_T}{I_D} = \frac{25 \times 10^{-3}}{1 \times 10^{-3}} = 25\Omega$$

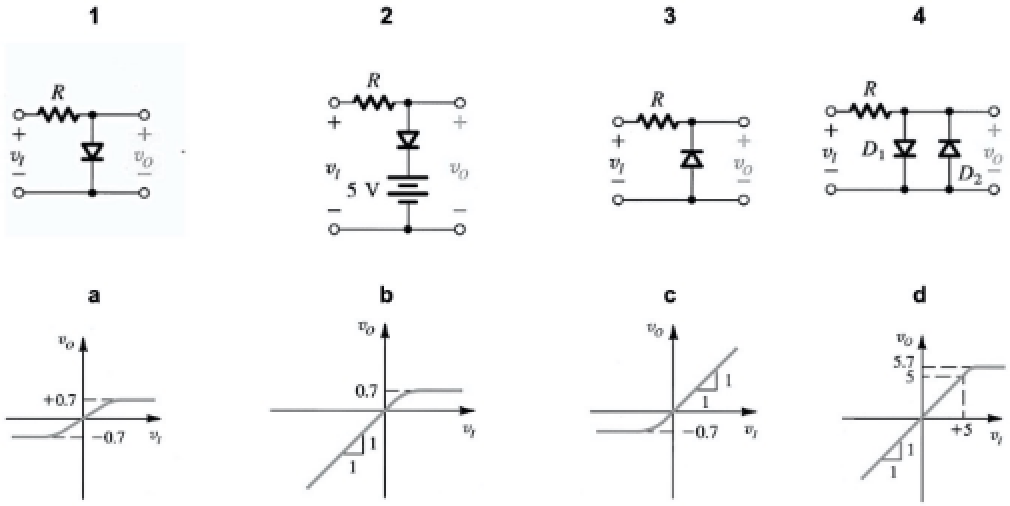
We assume the capacitor shorts, since we are only concerned with a DC circuit. We turn off the 15V source, and approximate the 14k resistor as an insulator. This becomes a voltage divider, so the amplitude becomes

$$1 \times \frac{25 + 50}{25 + 50 + 5000} = 15 \times 10^{-3}\text{V}$$

By superposition,

$$V_0 = 0.7 \pm 15 \times 10^{-3}$$

2. For each circuit (1-4) shown below, circle the matching voltage transfer characteristic (a-d)



Solution: For 1, consider when the diode is off. Then $v_o = v_i$, and its behaviour at negative v_i would be $y = x$. When the diode is on, $v_o = 0.7$V, which happens when v_i is 0.7 or more. Hence the answer is b.

For 2, the diode is off for $v_i \leq 5$V. If it is on, adding 5 to the voltage drop 0.7, we have $v_o = 5.7$V when $v_i \geq 5.7$V. Hence the answer is d.

For 3, when the diode is off, $v_i = v_o$. This is when $v_i > -0.7$T. If it is on, then $v_o = -0.7$V. The answer is then c.

For 4, the diodes are off when voltage difference is not yet 0.7 across the diodes. Hence for $|v_i| \leq 0.7$V, then $v_o = v_i$. With greater voltages, voltage drop is 0.7V, so $v_o = 0.7$V. Similarly, for lower voltages, $v_o = -0.7$V. The answer is hence a.