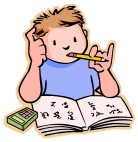
CIRCUITS WITH D, ZD, LED



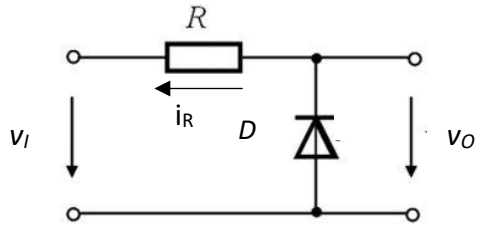
PREPARATION

To revisit:

- Diodes – operating regions, states, diode's equations for the constant voltage drop model
- Zener diodes – operating regions, states
- LEDs – operating regions, difference between diodes and LEDs

P1.

Assume the constant voltage drop model for D, with $v_{D,\,on} = 0.7$ V, and R = 2 kΩ.



a) Deduce and plot the VTC $v_O(v_I)$ for $v_I \in [-10, 10]$ [V]. What is the application of the circuit?

b) Plot $v_I(t)$ and $v_O(t)$ for $v_I(t) = 10\sin\omega t$ [V]. Specify the state of the diode (on/off) on the plot.

c) Mark v_R on the circuit. Plot $v_I(t)$, $i_R(t)$ and $v_R(t)$.

d) Compute v_O, v_R and i_R for $v_I = 5$ V. What is the state of D in this case? Justify your answer.

e) Assume D is replaced with a resistor, R_1, and $R_1 = R$. Find the new expression of $v_O(t)$. Draw $v_I(t)$ and $v_O(t)$ for $v_I(t) = 10\sin\omega t$ [V].

P2.

Assume the constant voltage drop model for diodes, with $v_{D,\,on} = 0.7$ V, and $v_I(t) = 7\sin\omega t$ [V].

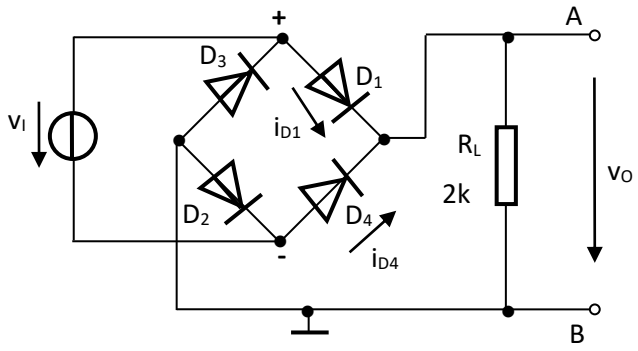
a) Deduce the expression $v_O(v_I)$. What is the application of the circuit?

b) Plot $v_I(t)$ and $v_O(t)$. Specify the states of the diodes (on/off) on the plot.

c) Plot $v_I(t)$, $i_{D1}(t)$ and $i_{D4}(t)$.

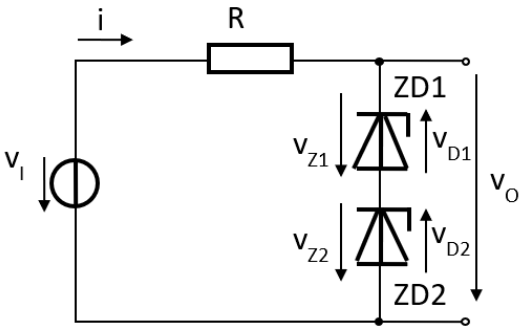
d) What is the minimum amplitude of $v_I(t)$ for which $i_{D1}(t)$ and $i_{D4}(t)$ exist (are not zero)? Justify your answer.

e) Assume D_4 – open circuit. Redraw $v_I(t)$ and $v_O(t)$.



P3.

V_{Z1} = 3.3 V, V_{Z1} = 7.5 V, $V_{D1,on}$ = $V_{D2,on}$ = 0.7 V, $v_I(t) = 12\sin\omega t$ [V].



a) What are the minimum and maximum values of $v_O(t)$? Specify the operating region of the Zener diodes (forward/ reverse bias/ breakdown) for each case.

b) Deduce and plot the VTC $v_O(v_I)$.

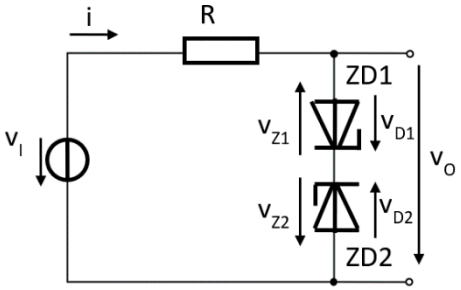
c) Mark $v_R(t)$ on the circuit. Plot $v_I(t)$, $v_O(t)$ and $v_R(t)$.

d) Compute v_O and specify the states of both Zener diodes for v_I = - 7 V and v_I = 5 V.

e) Replace ZD2 with a regular diode. Draw the new circuit. Compute the new minimum and maximum values of the output voltage.

P4.

V_{Z1} = 5.4 V, V_{Z1} = 8.2 V, $V_{D1,on}$ = $V_{D2,on}$ = 0.7 V, $v_I(t) = 15\sin\omega t$ [V].



a) What are the minimum and maximum values of $v_O(t)$? Specify the operating region of the Zener diodes (forward/ reverse bias/ breakdown) for each case.

b) Deduce and plot the VTC $v_O(v_I)$.

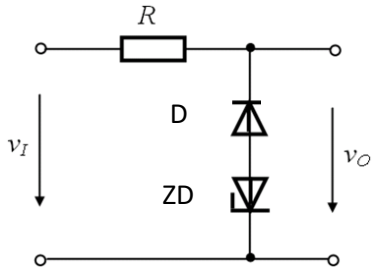
c) Mark $v_R(t)$ on the circuit. Plot $v_I(t)$, $v_O(t)$ and $v_R(t)$.

d) Compute v_O and specify the states of both Zener diodes for v_I = - 7 V and v_I = 5 V.

e) Reverse the orientation of ZD2. Draw the new circuit. Compute the new minimum and maximum values of the output voltage.

P5.

R = 1 kΩ, ZD8V2, $V_{ZD,on}$ = $V_{D,on}$ = 0.7 V, $v_I(t) = 12\sin\omega t$ [V].



a) What are the minimum and maximum values of $v_O(t)$? Specify the states of D (on/off) and ZD (forward/reverse bias) for each case.

b) Deduce and plot the VTC $v_O(v_I)$.

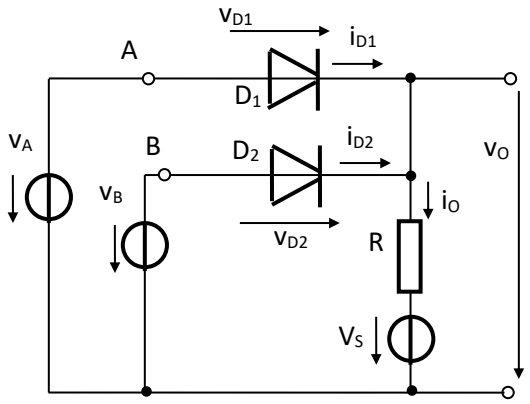
c) Mark $v_R(t)$ on the circuit. Plot $v_I(t)$, $v_O(t)$ and $v_R(t)$.

d) Compute v_O and specify the states of both diodes for v_I = - 7.5 V and v_I = 7.5 V.

e) Reverse the orientation of D. Draw the new circuit. Compute the new minimum and maximum values of the output voltage, for $v_I(t) = 12\sin\omega t$ [V].

P6.

Assume the constant voltage drop model for diodes, with $v_{D,\,on} = 0.7$ V.



a) What is the expression $v_O(v_A, v_B, V_S)$? What is the relation between v_A, v_B, V_S to have D_1 – on?

b) For $v_A = -5$ V and $v_B = 2$ V, determine V_S so that $v_O = 4$ V. Specify the state of each diode (on/off). Justify your answer.

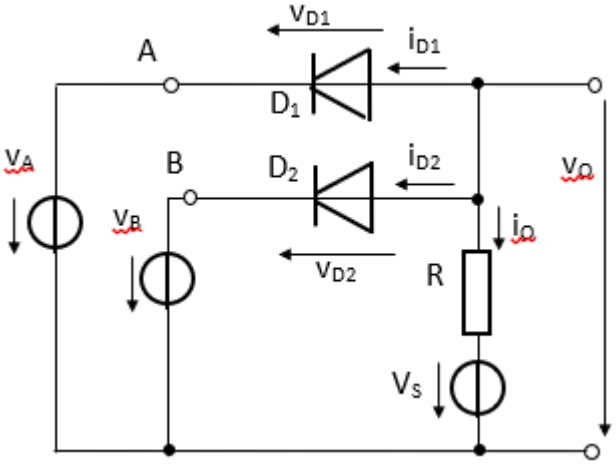
c) For $v_A, v_B \in \{0\text{ V}, 10\text{ V}\}$ and $V_S = 0$ V, fill in the electric operating table of the circuit, including the states of the diodes (on/off), for every possible combination of values.

d) Size R so that i_O does not exceed 10 mA, for $v_A, v_B \in \{0$ V, 10 V$\}$ and $V_S = 5$ V. For what combination of values for v_A, v_B is the maximum i_O obtained? What are the states of the diodes in this case?

e) For $v_A(t) = -5\sin\omega t$ [V], $v_B(t) = 10\sin\omega t$ [V], $V_S = 3$ V, plot $v_A(t)$, $v_B(t)$, V_S, $v_O(t)$, $i_O(t)$.

P7.

Assume the constant voltage drop model for diodes, with $v_{D,\,on} = 0.7$ V, and $V_S = 10$ V.



a) What is the expression $v_O(v_A, v_B, V_S)$? What is the relation between v_A, v_B, V_S to have D_2 – on?

b) For $v_A = 4$ V, $v_B = -3$ V, what is the value of v_O? Specify the state of each diode (on/off). Justify your answer.

c) For $v_A, v_B \in \{0$ V, 10 V$\}$, fill in the electric operating table of the circuit, including the states of the diodes (on/off), for every possible combination of values.

d) Size R so that i_O does not exceed 10 mA, for $v_A, v_B \in \{0$ V, 10 V$\}$. For what combination of values for v_A, v_B is the maximum i_O obtained? What are the states of the diodes in this case?

e) For $v_A(t) = 5\sin\omega t$ [V], $v_B(t) = -10\sin\omega t$ [V], plot $v_A(t)$, $v_B(t)$, V_S, $v_O(t)$, $i_O(t)$.