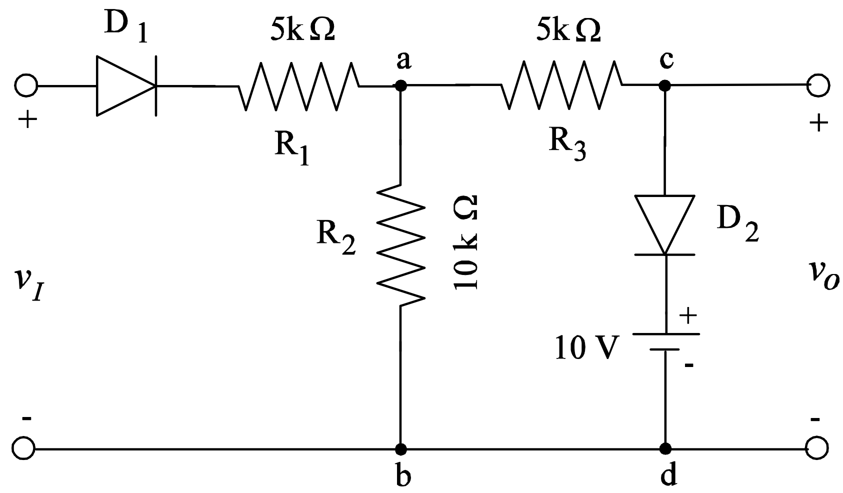
EE101
Tutorial-3(21 Aug 2014)

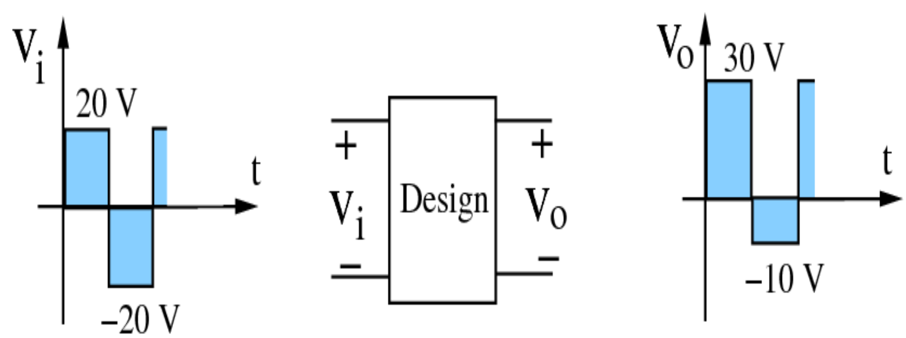
Q1. For the circuit shown in Figure, assume thatthe diodes are ideal.

(a) Sketch the transfer characteristic of the circuit for $-20\ V \leq v_I \leq 20\ V$.

(b) If the diode D_2 in the circuit is reversed, sketch the resulting transfer characteristics for $-20\ V \leq v_I \leq 20\ V$.



Q2. Design a clamper using a diode with forward voltage of 0.7 V to perform the wave shaping shown in Figure below. The frequency of the square-wave input is 1 kHz.



Q3. A transistor has $= 100$. Given that for this transistor base current I_B is set in such a way that $I_B = 10 \times I_{CO}$. If $I_B = 20\ \mu A$, find I_C and I_E.

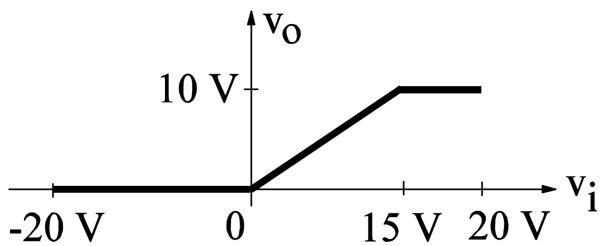
EE101
Tutorial-3 (21 Aug 2014)
Solutions

1. (a) For $-20\text{ V} \le \mathrm{v_I} < 0\ V$, both diodes D_1 and $D_2$are OFF, so $\mathrm{v_O} = 0\ V$.Now for $v_I > 0\ V$, D_1 starts conducting being an ideal diode, but D_2 be remain OFF till the voltage $V_{ab} < 10\ V$ .Thus for $v_I > 0\ V$ and till D_2 is OFF, we have

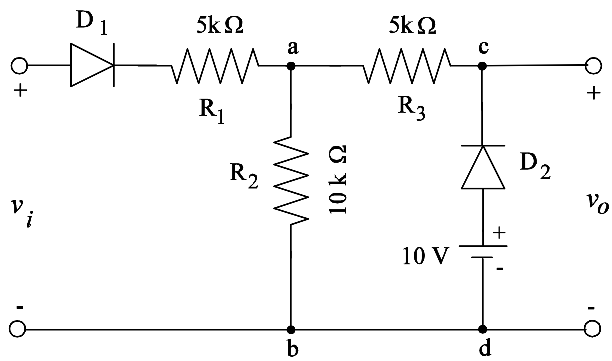
$$v_O = V_{ab} = \frac{R_2}{R_1 + R_2} v_I \quad \Longrightarrow \quad v_O = \frac{2}{3} v_I$$

Diode D_2 turns ON as soon as $V_{ab} = 10\ V$ or $v_I = \frac{3}{2} \times 10 = 15\ V$.

So for $v_I \ge 15\ V$, the diode D_2 conducts and $v_O = 10\ V$.The transfer characteristics of the given circuit is shown below,

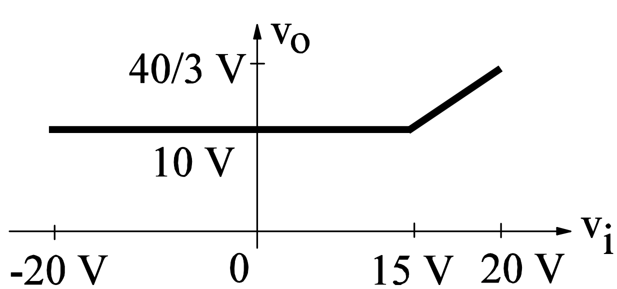


(b) The modified circuit is shown below.



As long as the voltage $V_{ab} < 10\ V$, the diode D_2 remains ON and $v_O = 10\ V$. Note$V_{ab} = 10\ V$ when $v_I = 15\ V$ as already calculated in part (a).So for $v_I \ge 15\ V$ we have $V_{ab} \ge 10\ V$ and D_2 is OFF, the output voltage would be proportional to the input voltage, i.e., $v_O = \frac{2}{3} v_I$

While for $-20\text{ V} \le \mathrm{v_I} < 15\ VandV_{ab} < 10\ V$,the diode D_2 remains ON and $v_O = 10\ V$.The transfer characteristics of modified circuit is shown below,



Q2. On comparing the input and output waveforms of the clamper, we can deduce that it is a positive clamper with negative bias.

The period of the square-wave input is 0.001 sec (= 1/ 1000 Hz).

For the faithful reproduction of the input waveform shape at the output, the time-constant of clamper circuit should at least 50 times that of the period of input signal.

Thus by choosing R= 100 kΩ and C=1 μF, we have time-constant RC = 0.1 sec and it satisfies that condition, well enough.

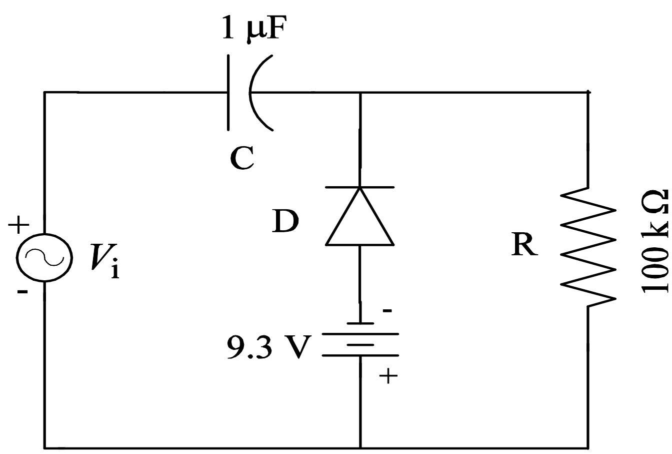
From given figure, the shift in the peak positive voltage is noted as

$$V_{shift} = V_{o\,max} - V_{i\,max} = 30 – 20 = 10\text{ V}$$

The required negative DC bias,

$$V_{dc} = V_{i\,max} - V_{shift} – V_{DO} = 20 – 10 -0.7 = 9.3\text{ V}$$

The overall design of clapper is shown as



Q3.

$$I_C = \alpha I_E + I_{CO}$$
$$I_E = I_C + I_B = \alpha I_E + I_{CO} + I_B$$
$$\beta = \frac{\alpha}{1-\alpha}$$
$$I_E = \frac{1}{1-\alpha}(I_{CO} + I_B) = (\beta+1)\times 1.1 I_B = 101\times 1.1\times 20 = 2222\ \mu A = 2.222\ mA$$
$$I_C = 2.222 - 0.02 = 2.202\ mA$$

Alternatively,

$$I_C = \beta I_B + (\beta+1) I_{CO} = 100\times 0.02 + 101\times\frac{0.02}{10} = 2.202\ mA$$