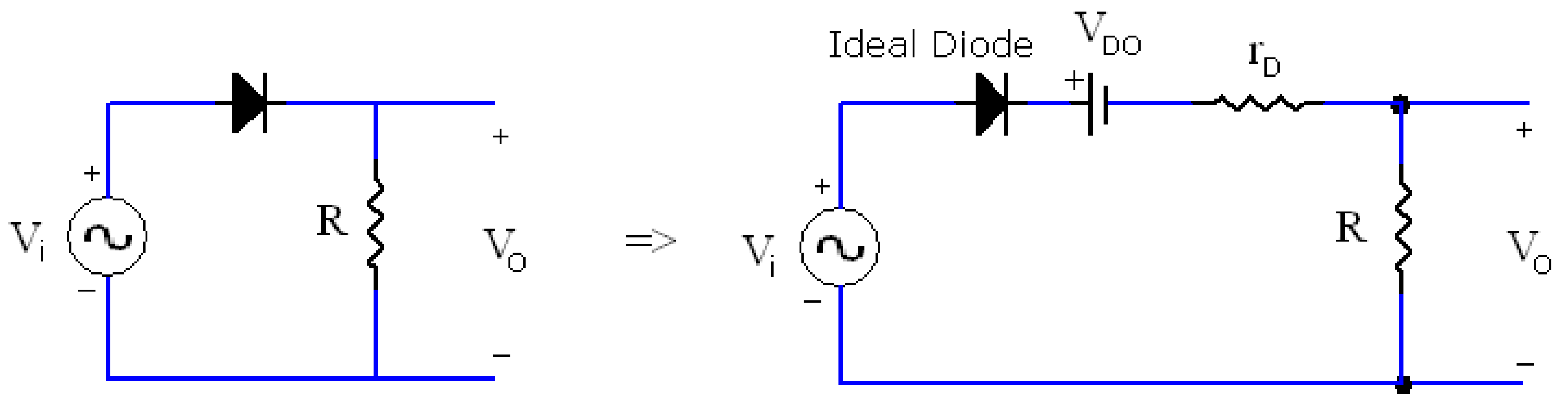
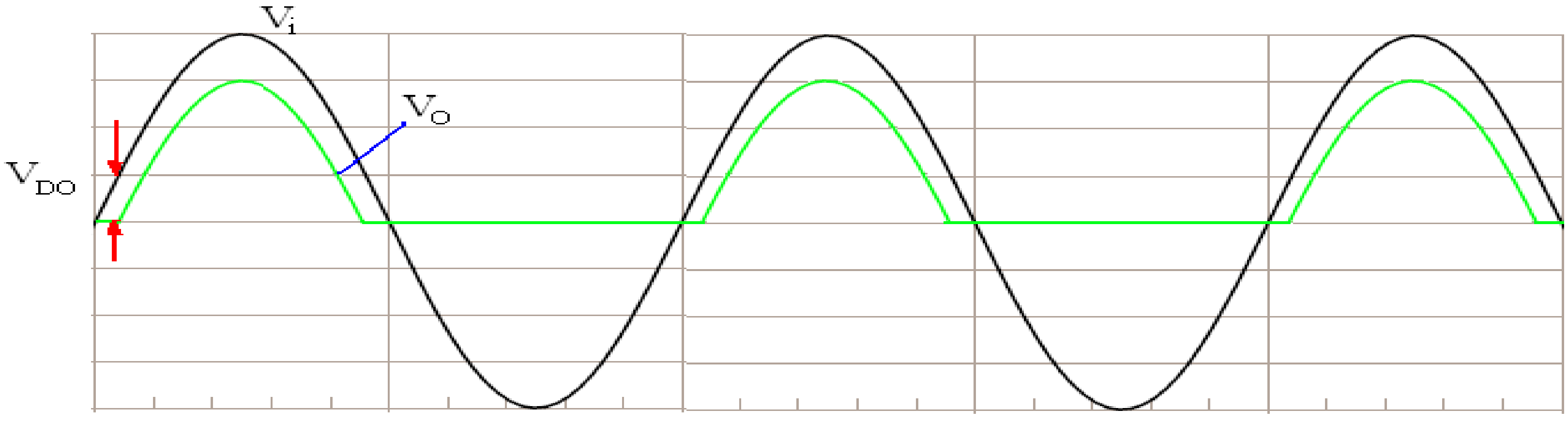
Rectifier Circuits

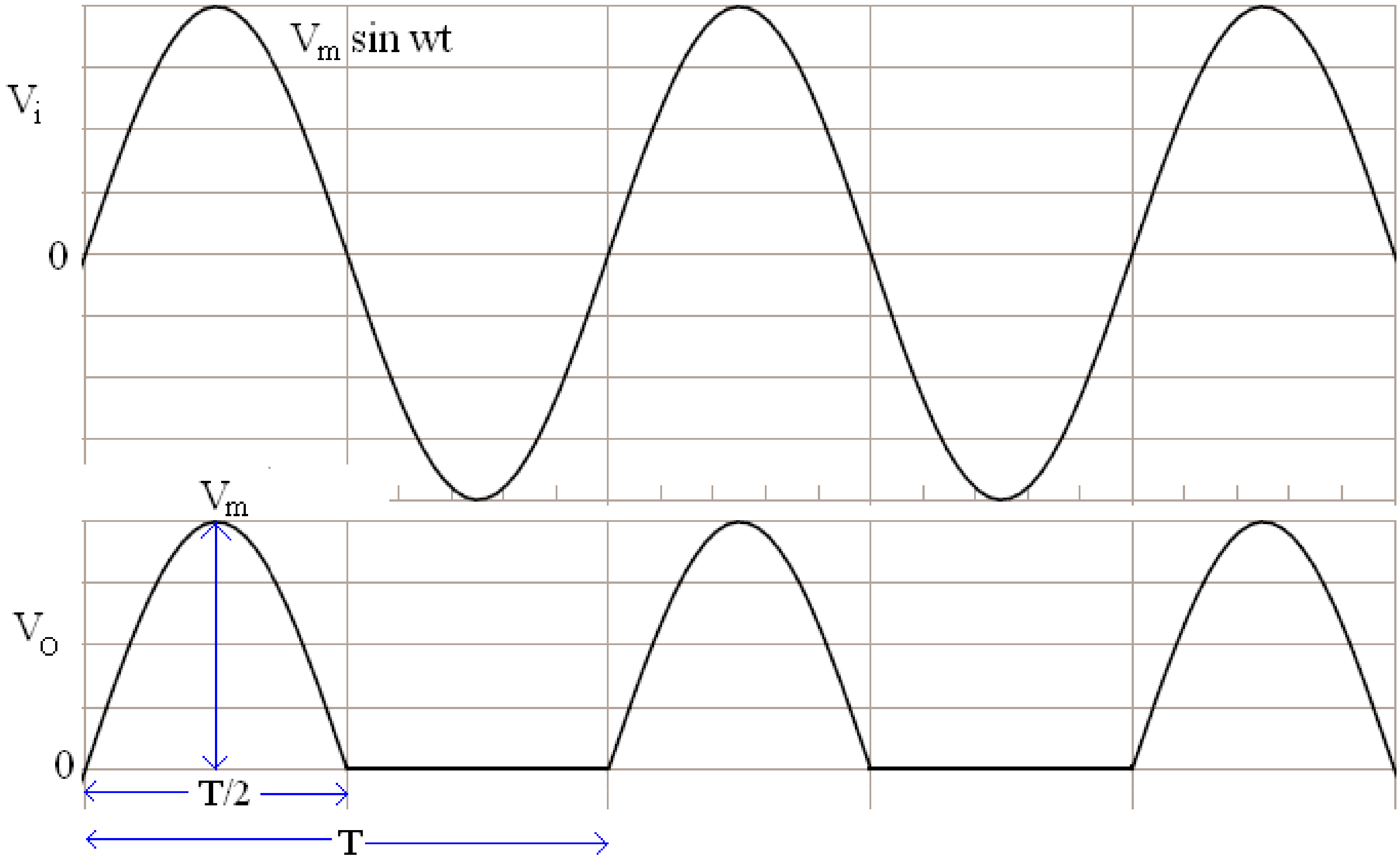
Half-wave rectifier (HWR)





Input & output waveforms, assuming $r_D << R$

Considering the diode to be ideal



V_{DC}

$$V_{DC} = \frac{1}{T}\int_0^{T/2} V_m \sin\varpi t\,dt \qquad \frac{2\pi}{\varpi} = T$$

$$= \frac{-V_m}{\varpi T}\left[\cos\varpi t\right]_0^{T/2}$$

$$= \frac{V_m}{\pi}$$

V_{DC}=0.318V_m

If Si diode is used, $V_K = 0.7V$

$$\& \ V_o = V_i - V_K$$

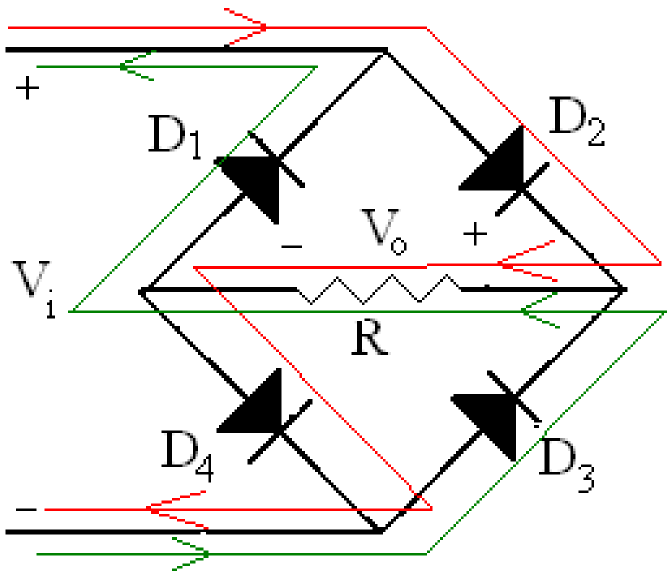
The effect is reduction of area above the axis, which reduces the resulting DC voltage level.

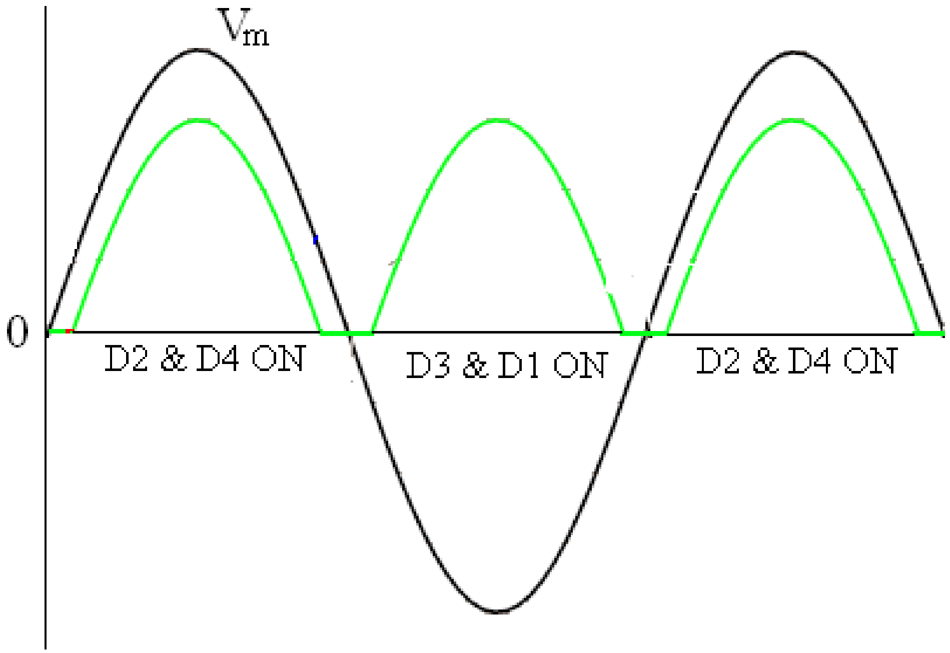
For $V_m >> V_K$, we can write

$$V_{DC} = 0.318\ (V_m - V_K) \quad \text{(approx.)}$$

Full Wave Rectifier (FWR)

1. Bridge Network



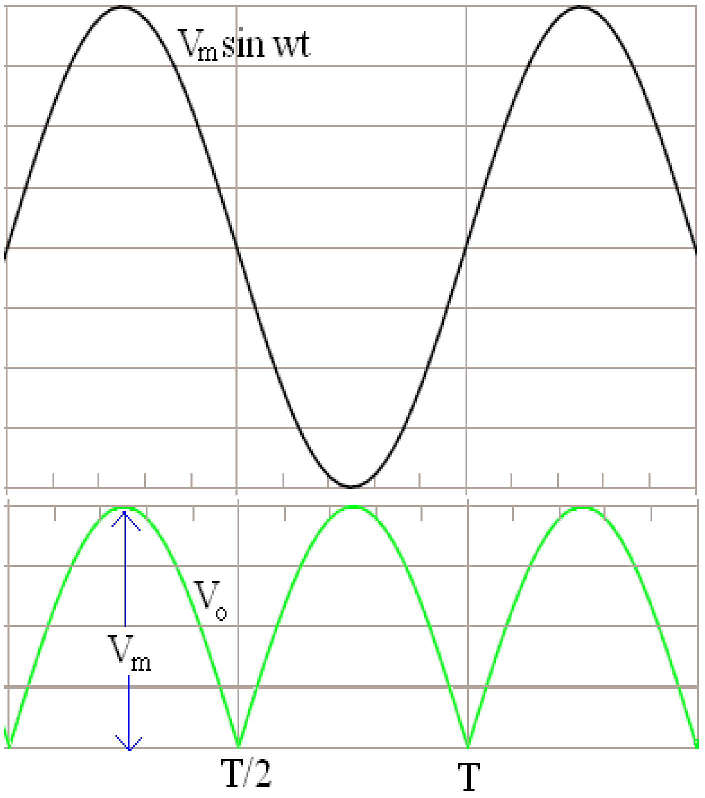


Assuming ideal diode,

$$V_{DC} = \frac{2}{T}\int_0^{T/2} V_m \sin \varpi t dt$$

$$= \frac{-2V_m}{\varpi T}\left[\cos \varpi t\right]_0^{T/2}$$

$$= \frac{2V_m}{\pi}$$



Assuming ideal diode

$$V_{dc}=0.636V_m$$

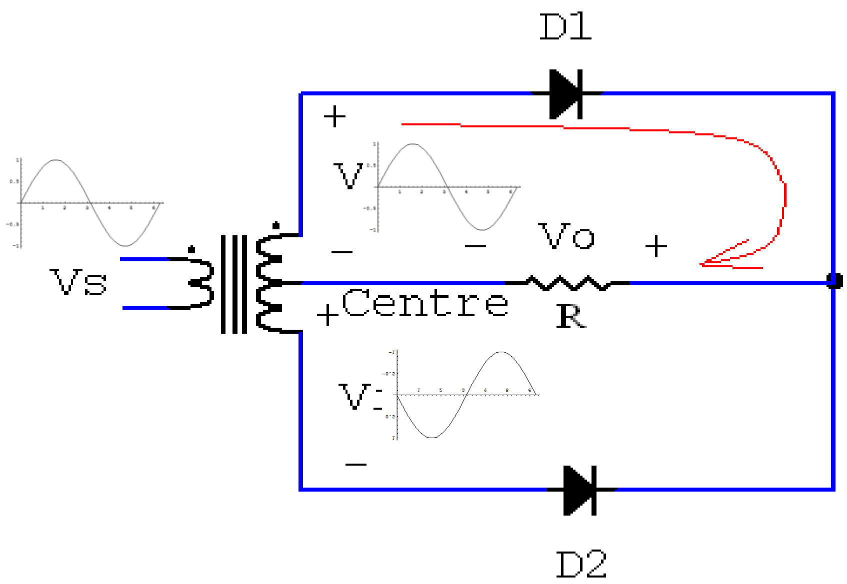
Peak value of the output voltage

$$V_{0max}=V_m-2V_k$$

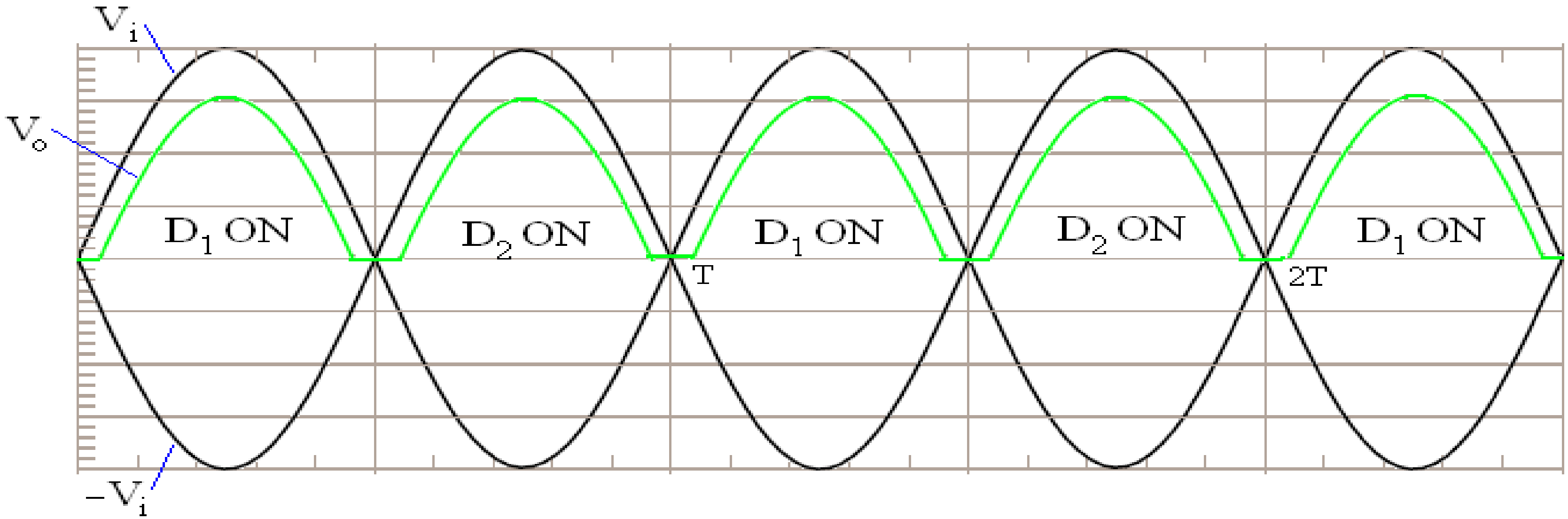
For $V_m>>2V_k$, $V_{dc}\approx 0.636(V_m-2V_k)$

$PIV\geq V_m-V_k$

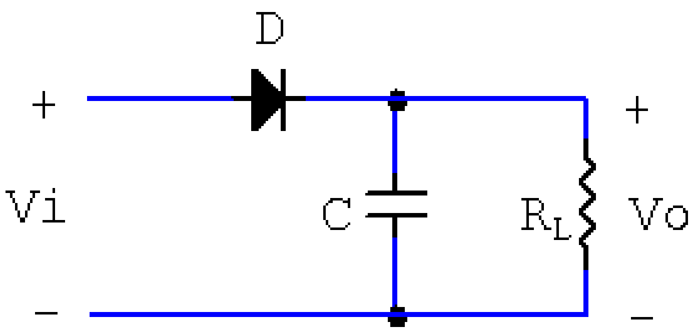
Using Centre-Tapped Transformer

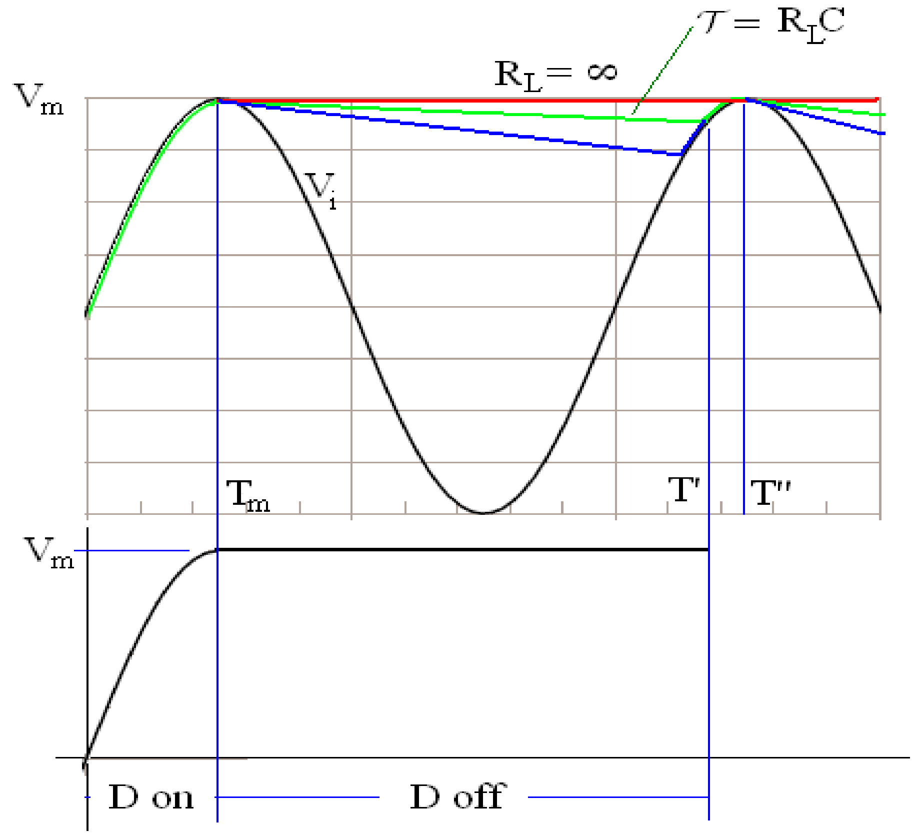


PIV across each diode is $2V_m$ - V_k



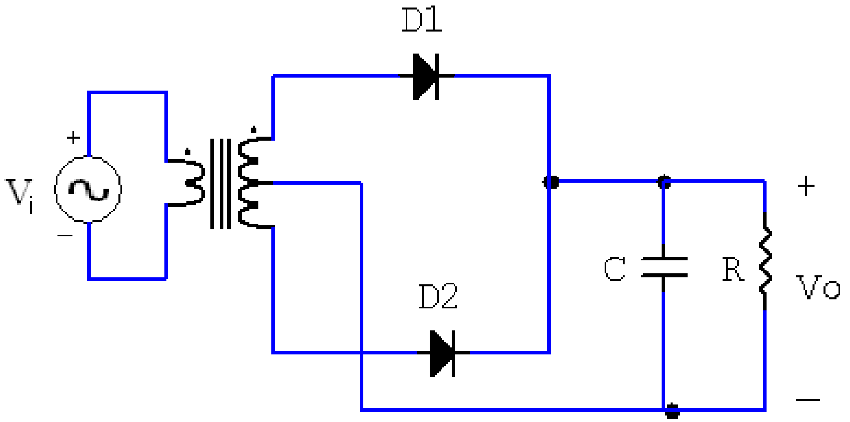
HWR with Capacitor Filter





Assuming ideal diode for simplicity, $V_D = 0$, $R_f = 0$

FWR with Capacitor Filter

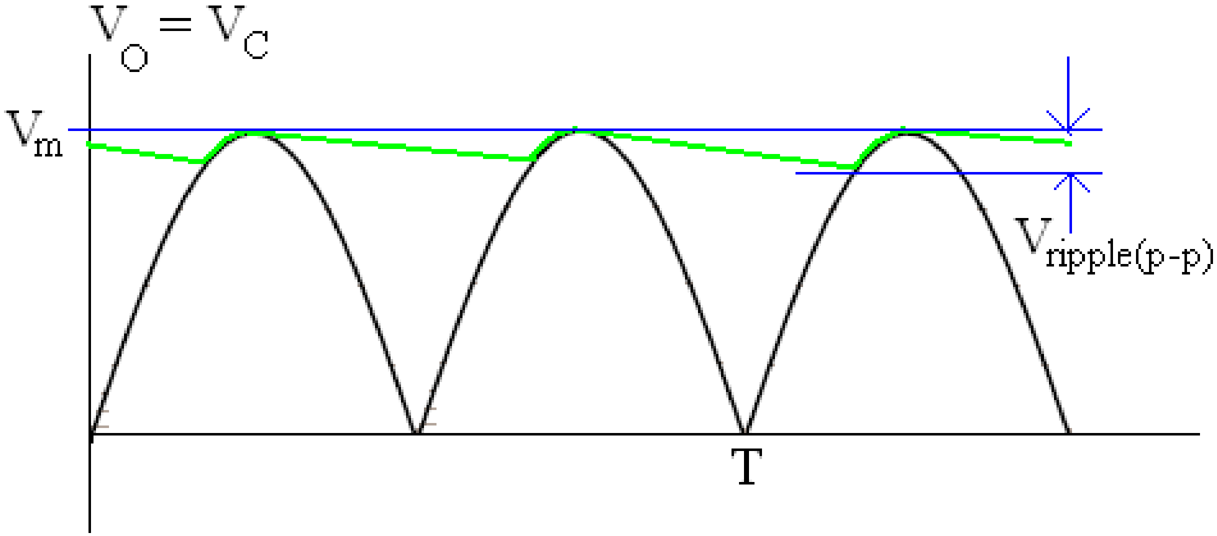


Assuming triangular ripple waveform,

V_o (dc) = $V_m - V_{r(p\text{-}p)}/2$

Ripple factor r

$= V_{r(rms)}/V_{dc}$

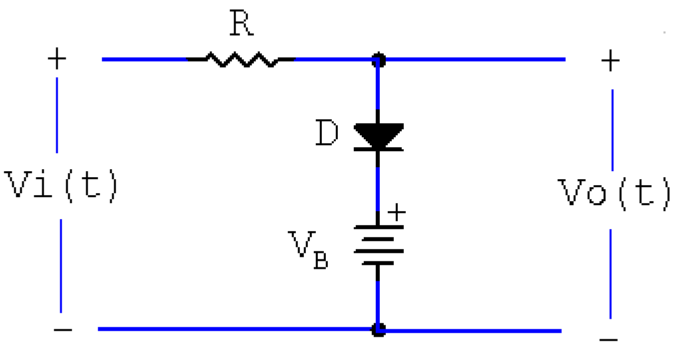


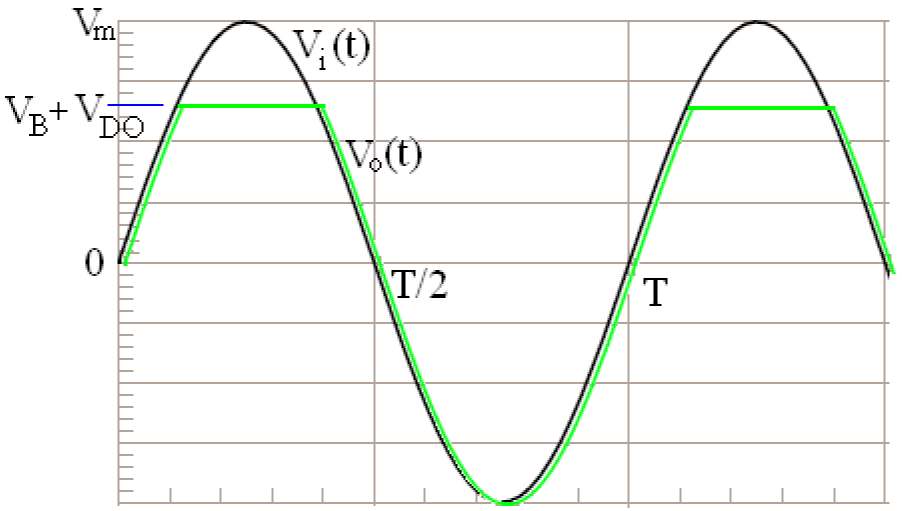
Wave Shaping Circuits

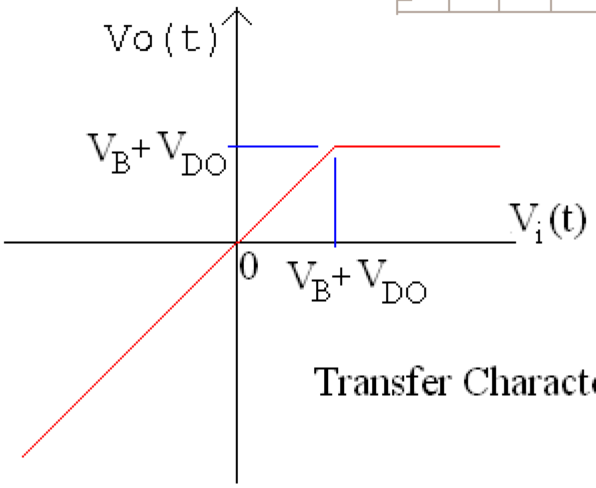
Diodes can be used in waveshaping circuits that either limit or “clip” portions of a signal, or shift the dc voltage level. These circuits are called clippers and clampers respectively.

Clippers are networks that employ diodes to clip away a portion of the input signal without distorting the remaining part of the applied waveform

Example 1: Clipper Circuit

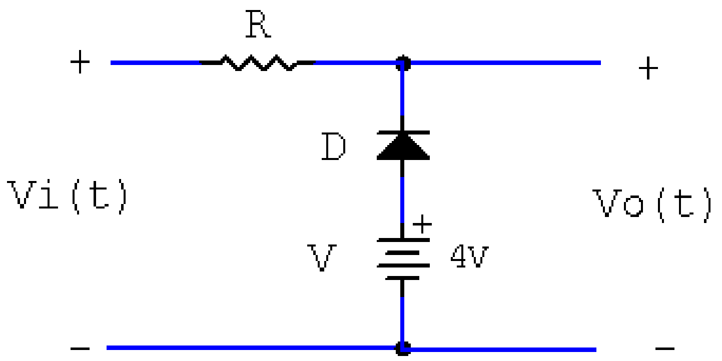


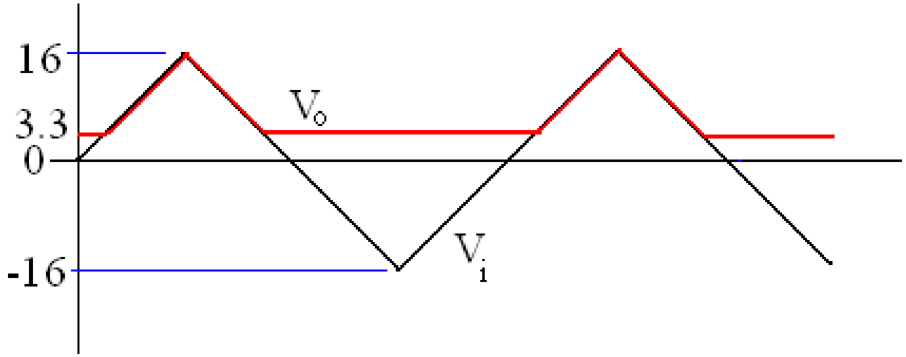


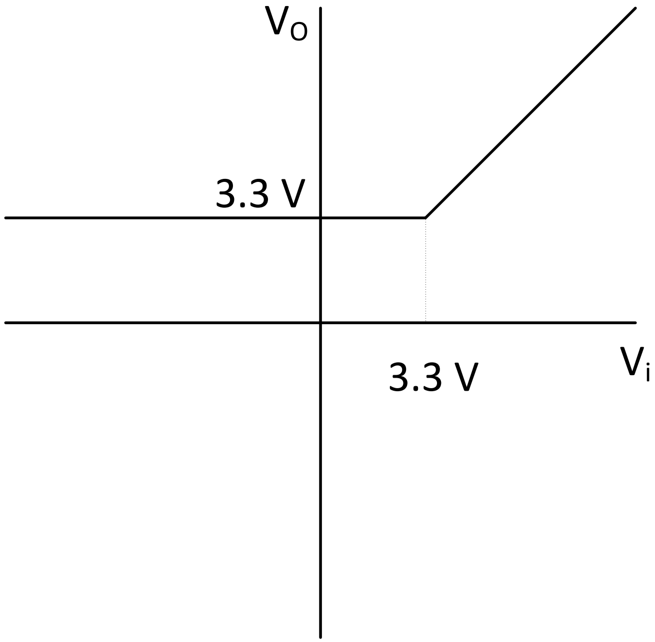


Transfer Characteristic

Example 2





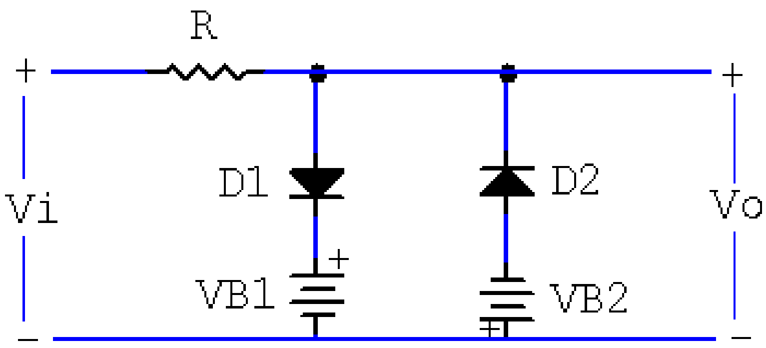


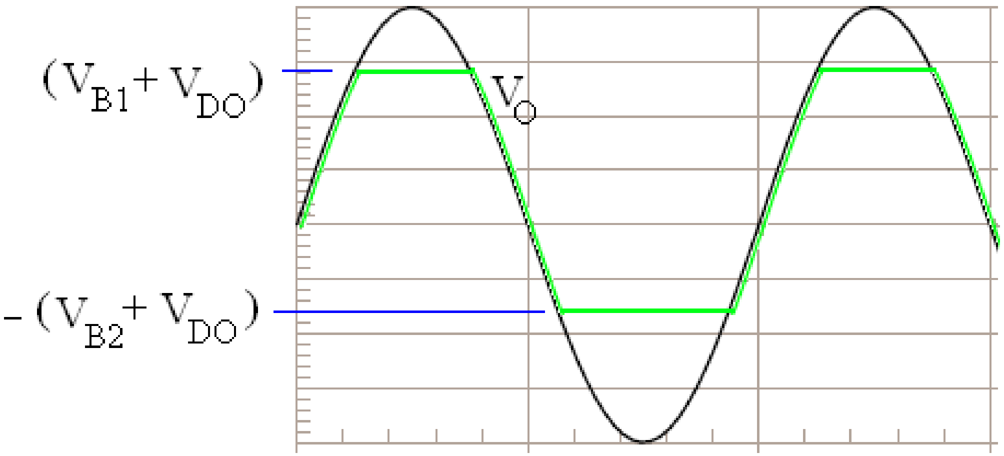
V_{DO} = 0.7V

V_o = (4 – 0.7)V

= 3.3V

Example 3

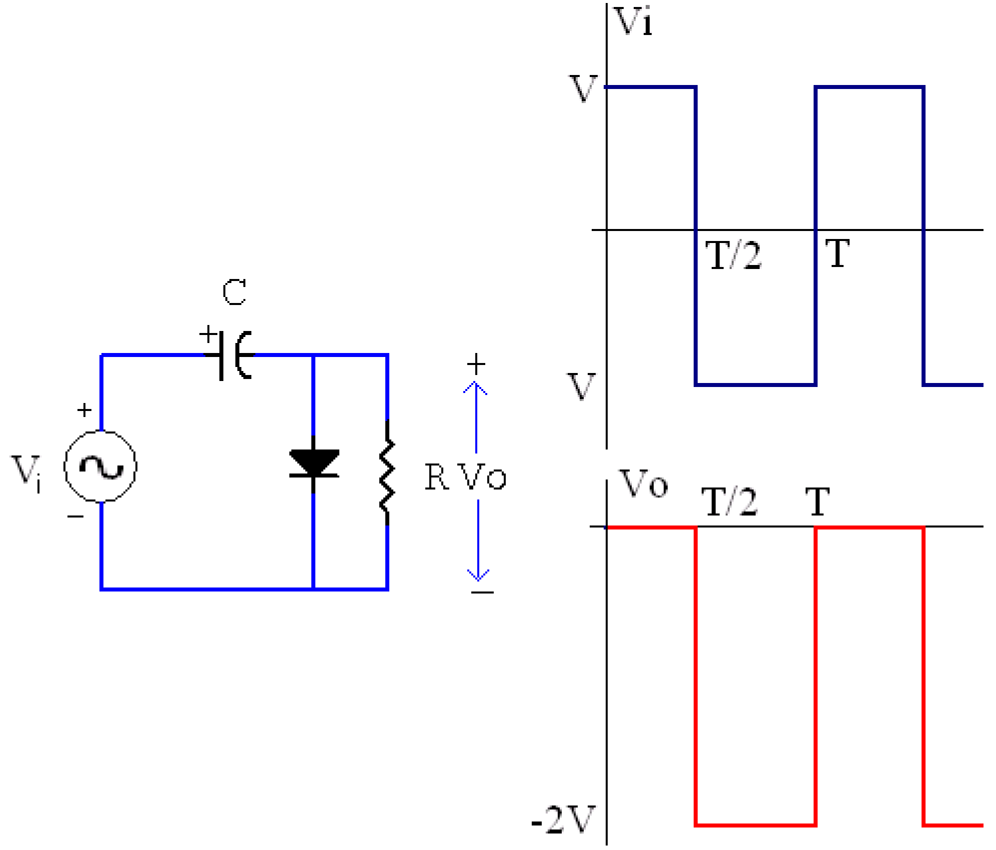




Clampers

A clamper is a network constructed of a diode, a resistor and a capacitor that shifts a periodic waveform to a different DC level without changing the appearance of the applied signal.

Example



Clampers

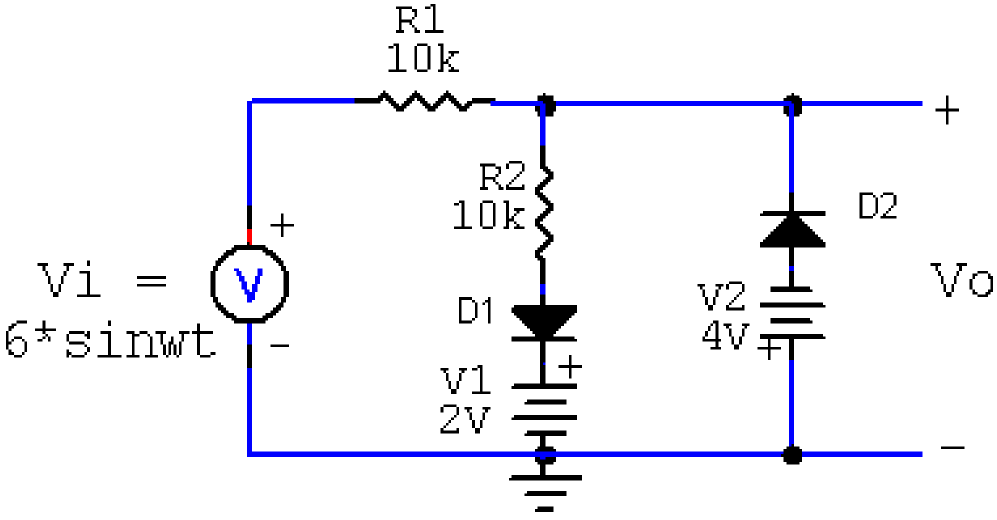
Try the following on your own –

1. Reverse the direction of the diode
   Signal is now clamped to positive levels

2. Add a battery in series with the diode – try both polarities of the battery
   Clamping level is now decided by the battery voltage

3. See what happens when the input is a **sine wave** (or any arbitrary waveform)
   We still get clamping action

Example 4



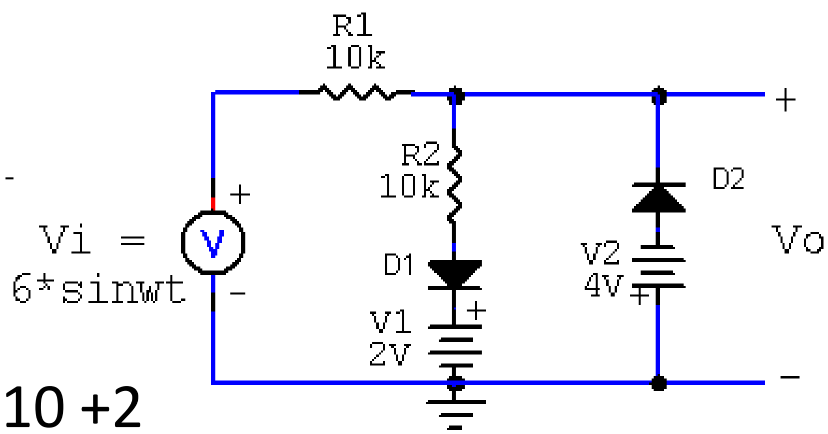
Find V_o

Assume ideal diodes, i.e.
$V_{DO}=0$, $R_f=0$ for both diodes.

Solution:

For $0<V_i<2V$, D_1 & D_2 are OFF as these are reverse biased.

Therefore, $V_o = V_i$



For $V_i > 2V$, D_1 turns ON and

$$i_1 = (V_i - 2)/(10+10)$$

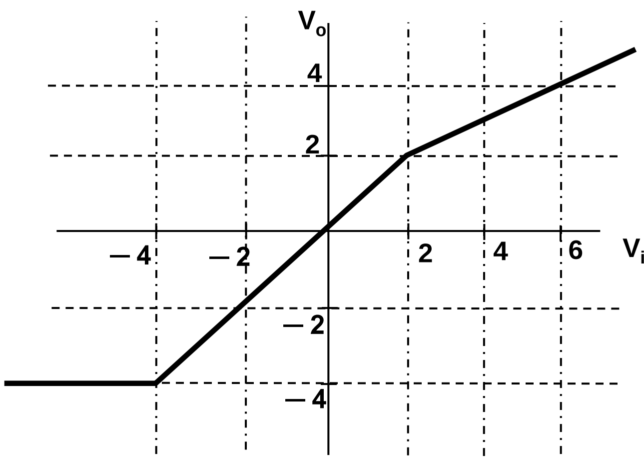
Also, $V_o = i_1R_2 + 2 = (V_i - 2)/20 \times 10 + 2$

$$= V_i/2 - 1 + 2 = V_i/2 + 1$$

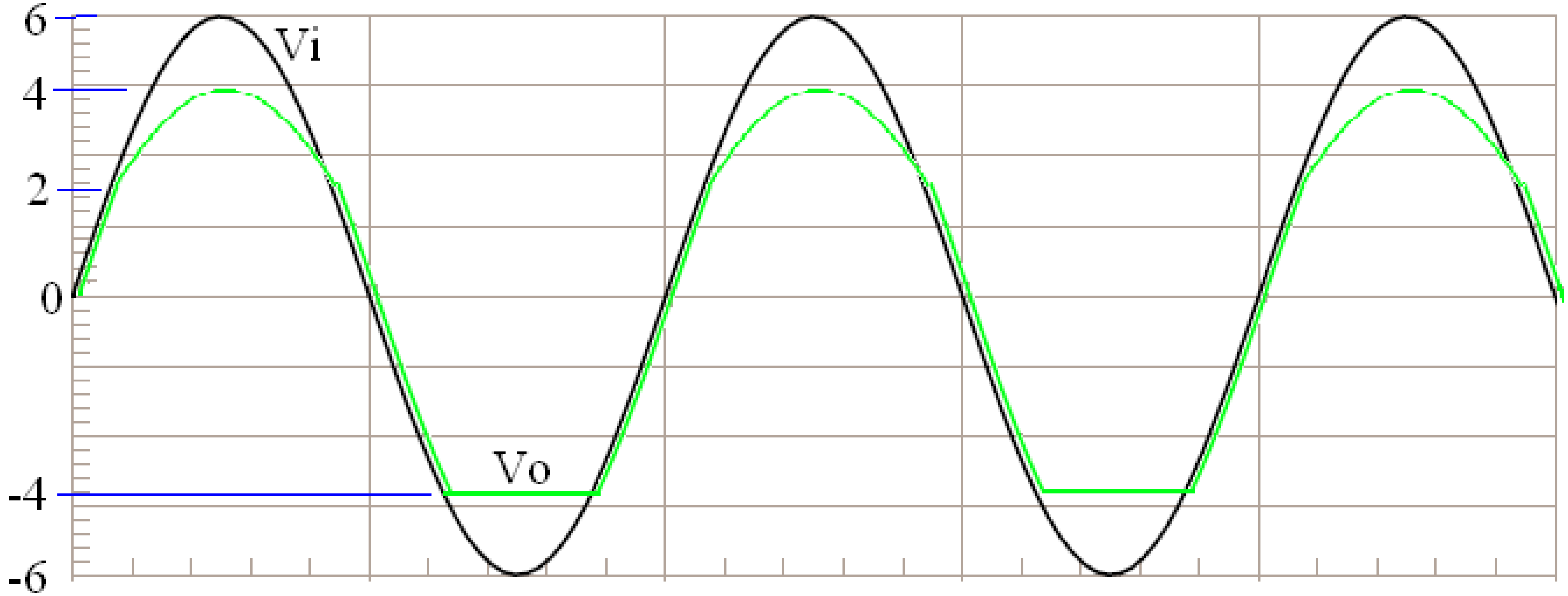
(e.g. If $V_i = 6V$, $V_o = 6/2 + 1 = 4V$)

For $-4<V_i<0$, both D_1 & D_2 are OFF

$$\& \; V_o = V_i$$



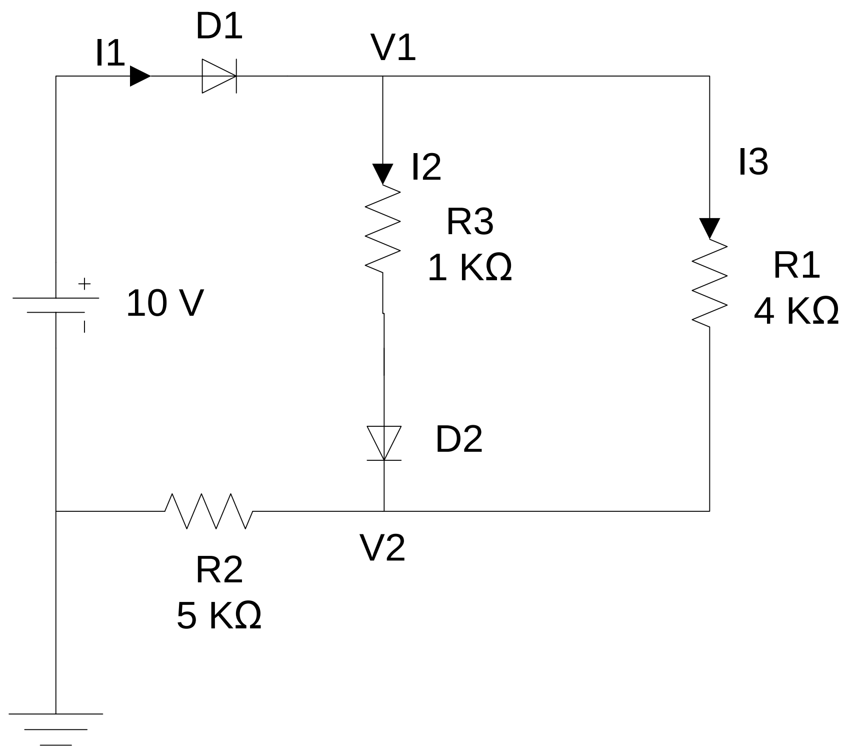
For $V_i < -4V$, D_2 turns ON and $V_o = -4V$



6
4
2
0
-4
-6
Vi
Vo

Example 5

For the circuit shown, find the voltages V1 and V2 and the currents I1, I2 and I3. Assume the diodes to be ideal with a forward voltage drop of 0.7 V.



Answer: (D1 and D2 ON)

V1=9.3 V V2=7.53 V
I1=1.51 mA I2 =1.07 mA
I3=0.44 mA

Check to see what happens if you assume D1 is ON but D2 is OFF

Will get V1=9.3V & V2=5.17 which is clearly impossible as then D2 will be ON

What will be the states (ON/OFF) of the two diodes, D1 and D2?

Find the currents I_{D1} and I_{D2}

Try all combinations of D1 and D2 ON/OFF. Only one combination will give logically consistent results. That one is the one which will be the correct choice

ANSWER:

D1 ON & D2 OFF

ID1=0.953 mA   ID2=0