Sec 3
Medical Power electronics

Desired Characteristics In Controllable Switches

Mohan Book

In Ideal:

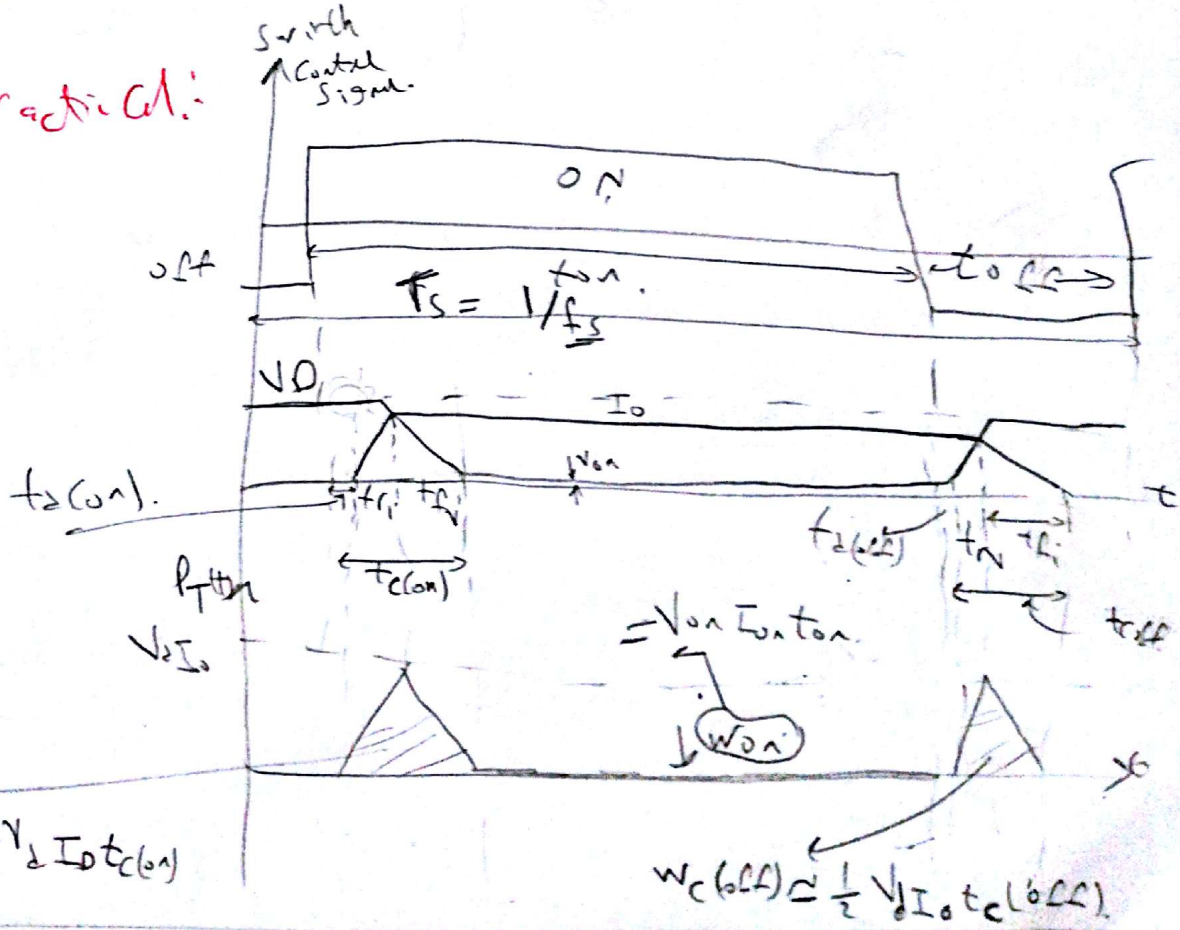
(1) Block arbitrarily large forward & reverse voltages with zero current flow when off

(2) Conduct arbitrarily large currents with zero voltage drop when on.

(3) Switch from on to off or vice versa instantaneously when triggered

(4) Small power required from control source to trigger the switch.

⇒ In practical:



⇒ Average Power losses During transition:

$$P_S = \frac{1}{2} V_d I_o f_s (t_{c(on)} + t_{c(off)})$$

$$P_{T(t)} = V_T i_T$$

$$P = \int_0^T V_t i_T \, dt \approx \frac{1}{2} V_d I_o f_s (t_{c(on)} + t_{c(off)})$$

$P \propto f_s$

⇒ In Ideal off-state, leakage current can be neglect.

Sheet (1)

(1)

$t_{ri} + t_{fv}$ $\qquad$ $t_{fi} + t_{rv}$

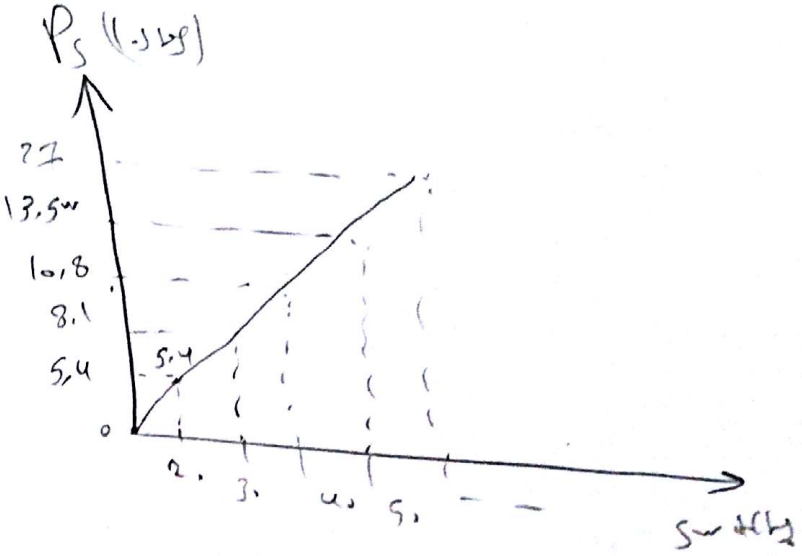
$$P_s \cong \frac{1}{2} V_d I_o f_s \left(t_{c(on)} + t_{c(off)} \right)$$

$$= \frac{1}{2} \times 300 * 4 \times \frac{1}{10 \times 10^{-6}} * \left(10 \times 10^{-9} + 50 \times 10^{-9} + 200 \times 10^{-9} + 150 \times 10^{-9} \right)$$

$$P_s = 27\ W$$

(2)

$P_s \propto f_s$



③ $V_{BD} = 2500\,V$

Req: $W_d = ?$ ← drift region $N_d = ??$ ↳ doping density.

Solution:

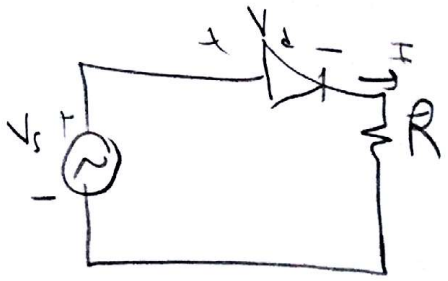
* $W_d = 10^{-5} * V_{B.D} \Rightarrow 10^{-5} * 2500 = 25\ mm$

for Non-Punch Through $= \frac{1}{2} * 25 = 12.5\ mm$

* $N_d \simeq \frac{1.3 * 10^{17}}{2500} = 5.2 * 10^{13}\ cm^{-3}$.

④ Given:

$V_s = 120\ V_{rms}$, $f = 60\ Hz$, $R = 5\ \Omega$



Req:

$V_{avg} = ?$, $I_{avg} = ?$, $P_{avg} = ?$, P.f = ?

Solution:

① $V_{avg} = \frac{V_m}{\pi} = \frac{120\sqrt{2}}{\pi} = 54.01\ V.$

② $I_{avg} = \frac{V_{avg}}{R} = \frac{54}{5} = 10.8\ A.$

③ $P_{avg} = I_{avg} \times V_{avg} = 54 * 10.8 = 583.40\ V.$

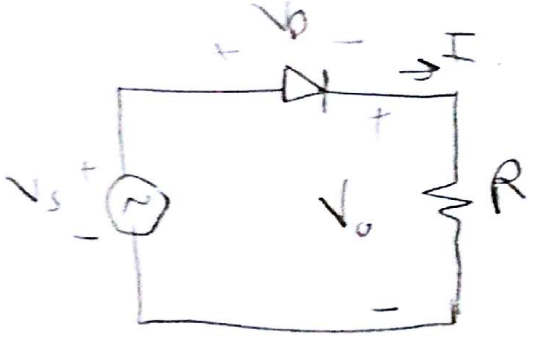
④ $P_f = \frac{V_{orms} I_{orms}}{V_{rms} . I_{rms}} = \frac{\frac{V_m}{2}}{\frac{V_m}{\sqrt{2}}} = \frac{\sqrt{2}}{2} = .707$

(5) Given:

$V_s = 220\ V\ (R.M.S)$, $R = 20\ \Omega$,

Req: a) $V_{o_{avg}}$ b) $V_{o_{rms}}$ c) $V_{ac_{rms}}$ d) Diode rating f) draw waveform

Solution:



a) $V_{o_{avg}} = \frac{V_m}{\pi} = \frac{\sqrt{2}V_{rms}}{\pi} =$

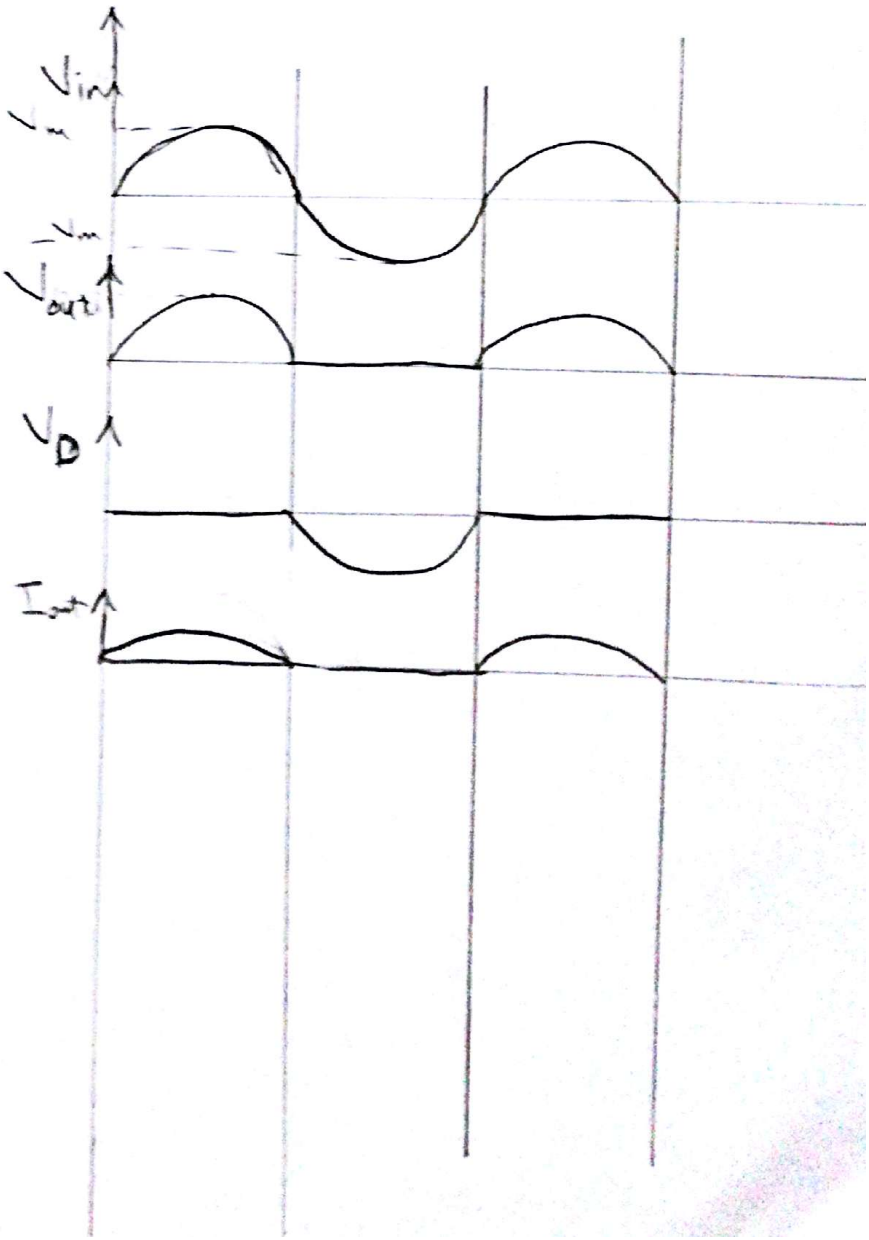
$= \frac{\sqrt{2} \times 220}{\pi} = 99.03\ V$

b) $V_{o_{rms}} = \frac{V_{max}}{2} = \frac{\sqrt{2} \times 220}{2} = 155.56\ V.$

c) $V_{ac} = \sqrt{V_{rms}^2 - V_{dc}^2}$

$= \sqrt{(155.56)^2 - (99.03)^2}$

$= 119.96\ V.$



d)

The Peak reverse voltage In diode = V_m.

⇒ To be In Safe IT must be greater $(1.5 \times V_m)$.

$I = \frac{V_{rms}}{R} = \frac{V_{max}}{2R}$

$= \frac{220\sqrt{2}}{2 \times 20} = 7.77A$

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Sheet (1)

1-For the circuit shown in Fig.(1), calculate the switching power loss if the switching time from the data sheet of the switching device are:
t_{ri}=100 ns t_{fi} =200 ns t_{rv}=100 ns t_{fv} =50 ns
and the V_d=300V , I_d=4 A , the switching period time is 10 us.

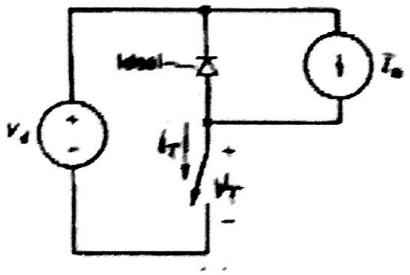

Fig. (1)

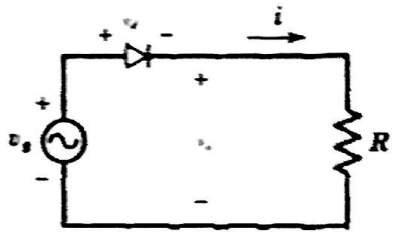

Fig.(2)

2- Plot the switching power loss as function of switching frequency from 20-100 KHz for the switching device in problem (1).

3- A power diode is designed to have a breakdown voltage of 2500 V, estimate the minimum width of the drift region (W_d), and the doping density of the drift region (N_d). Assuming that the diode is non-punch through type.

4- For the half-wave rectifier of Fig.(2), the source is a sinusoid of 120 V rms at a frequency of 60 Hz. The load resistor is 5 Ω. Determine (*a*) the average load current, (*b*) the average power absorbed by the load and (*c*) the power factor of the circuit.

5- If the voltage of problem (4) is 220 V and the load resistance is 20 Ω, find the a) average output voltage ,(b) the r.m.s of output voltage , (c)the r.m.s of ac components of the output voltage (d) the rating values of the diode , and (f) draw the different waveforms