Department of Electrical Engineering

Assignment

Page 1 **Date: 20/04/2020**

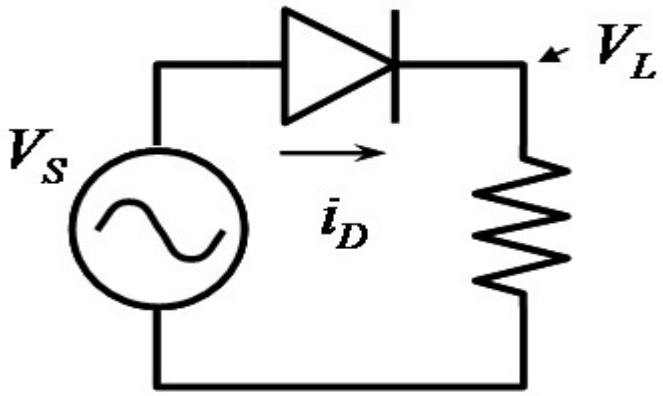
Course Details

Course Title: Power Electronics **Module:** 4rth

Instructor: Engr, Amir Amaan **Total Marks:** 30

Student Details

Name: AZHAD NIAZ **Student ID:** 15493

Q1.	(a)	In some applications, power semiconductor diodes are required to conduct several kilo amperes of current in the forward direction with very little power loss while blocking several kilo volts in the reverse direction. Explain the main differences of constructional features of a power diode and a signal diode. Illustrate your answer with the help of sketches to make a clear difference between the two.	Marks 10 CLO 1
Q2.	(a)	Explain operational features of the power MOSFET. Support your explanation using MOSFET operation as a switch. Also, illustrate the conditions to derive power MOSFET in the different regions of operation.	Marks 10 CLO 1
Q3.	(a)	 Consider Vs = 220Sin2wt, R = 1000kΩ and 1N4004 uncontrolled rectifier diode for the circuit shown above. Find i) V_{avg} ii) I_{oavg} iii) V_{rms} iv) I_{orms} v) Output Power	Marks 10 CLO 2

		vi) Input Power Factor vii) Conduction angle of a diode viii) Extension angle of diode ix) Comparison of both conduction angle and extension angle of diode x) Peak Inverse Voltage xi) Circuit turnoff time, t_c xii) By putting inductor of your own choice repeat all the findings and compare both circuits result and comment.	

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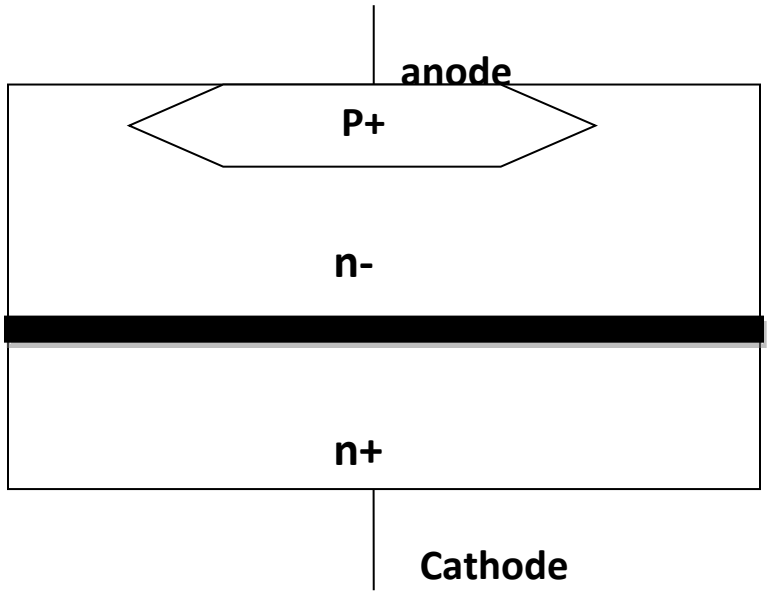
Q1 (A): In some applications, power semiconductor diodes are required to conduct several kilo amperes of current in the forward direction with very little power loss while blocking several kilo volts in the reverse direction. Explain the main differences of constructional features of a power diode and a signal diode. Illustrate your answer with the help of sketches to make a clear difference between the two.

ANS:

Signal diode:

- In signal diode it is just PN junction device which made by combining P type and N type semiconductors
- It is two terminal two layer device
- Signal diode is made up of silicon and germanium
- The main application of signal diode is fly back diode or freewheeling diode
- The PN junction of signal diode is usually fabricated in glass or plastic case and generally has black or red band at cathode end of the terminal.
- Signal diode enables current up to 100 milliamps

Power Diode



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Definition:

Power diodes has two terminal like anode & cathode two layers like PN and Junction used in power electronics This type of circuit is known is power diode .

This type of diode is more complex in construction as wells in operating because low power device has to change to make them appropriate in higher power applications

In power electronics it work as rectifier in converter circuit voltage regulation

Construction:

- The construction of this diode contain three layers as show in upper figure
- Like P+ layer n- layer& n+ layer.
- The top one is P+ it is heavily doped
- the middle one is n- layer which is lightly doped
- The last layer is n+ it is heavily doped.
- P+ layer act as anode the level of doping is $10^{19}cm^{-3}$
- The n+ layer act as cathode the level of doping is $10^{19}cm^{-3}\backslash$
- The n- middle layer is drift layer which is mainly depending on breakdown voltage. the level of doping is $10^{14}cm^{-3}$.

Q2(A) Explain operational features of the power MOSFET. Support your explanation using MOSFET operation as a switch. Also, illustrate the conditions to derive power MOSFET in the different regions of operation.

ANS: Power MOSFET:

Power MOSFET is type of metal oxide semiconductor field effect transistor it is designed to handle high level powers it is constructed in V configuration that's why it V- MOSFET, VFET

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Switching characteristics of MOSFET:

In power conversion a MOSFET is used as switch as MOSFET switching characteristics the turn on delay time $T_{d(on}$ rise time t turn off delay time $t_{d(off}$ and fall time t are generally indicated for example the turn- on/off delay time may be called the on/off delay time and the rise /fall time delay may be the rising/falling time and so on

Turn on delay time from 10% of rise of Vgs until 10% of the rise of Vds

Rise time: time from 10% to 90% of rise of Vds

Turn-off delay time: time from 90% of the fall of Vgs until 90% of the fall of Vds

Fall time: time from 90% to 105 of the fall of Vds

Regions for MOSFET:

CUT OFF REGION: **(**n-mos)

$$V_{gs} < V_{th}$$

$$I_d = 0$$

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Linear region: (n-mos)

$$V_{gs} < V_{th}$$

$$V_{DS} > V_{GS} - V_{th}$$

$$I_d = \mu_n \, \text{Cox} \frac{W}{L} \left[(V_{GS} - V_{th})V_{ds} - \frac{Vds^2}{2}\right]$$

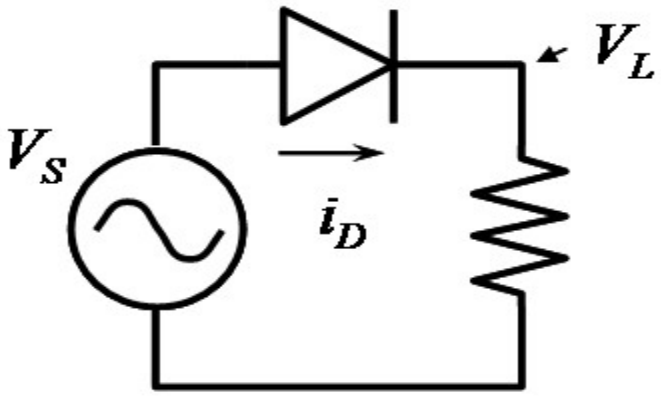
Saturation region: (n-mos)

$$V_{gs} > V_{th}$$

$$V_{DS} > V_{GS} - V_{th}$$

$$I_d = \frac{1}{2} \mu n \, \text{cox} \frac{W}{L} \, (V_{GS} - V_{th})^2$$

Q3 (A):



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Consider Vs = 220Sin2wt, R = 1000kΩ and 1N4004 uncontrolled rectifier diode for the circuit shown above. Find

i) V_{avg}
ii) I_{oavg}
iii) V_{rms}
iv) I_{orms}
v) Output Power
vi) Input Power Factor
vii) Conduction angle of a diode
viii) Extension angle of diode
ix) Comparison of both conduction angle and extension angle of diode
x) Peak Inverse Voltage
xi) Circuit turnoff time, t_c
xii) By putting inductor of your own choice repeat all the findings and compare both circuits result and comment.

ANS:3(a)

1) $V_{avg} = \frac{V_{peak}}{\pi} = \frac{220}{\pi} = 70.02v$

2) $I_{oavg} = \frac{V_{avg}}{R} = \frac{70.02}{1000k} = 70\mu A$

3) $V_{rms} = \frac{V_{peak}}{2} = \frac{220}{2} = 110\mu A$

4) $I_{RMS} = \frac{V_{rms}}{R} = \frac{110}{100k} = 110\mu A$

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5) Output power

$$Po = I_{rms}^2 R = (110\mu A)^2 \times 1000k\cap$$

$$P = 0.0121w$$

6) Input Power factor, $\cos\theta = \frac{V_{rms}}{V_{peak}} \cos\theta$

$$= \frac{110}{220} = \frac{1}{2} = 0.5$$

7) Diode is conducting only for first half therefore conduction angular, $r_p = \pi$

8) Extension angle of diode

Diode is conducting up to π
(first cycle)
So, B = π

9) In all diode rectifier circuits ;
Conduction extension

Angle (r) = angle (b)

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10) Peak inverse value (PIV)

During negative half cycle diode acts as open circuit And therefore all voltage appears across diode

Thus, PIV = Vpeak = 220v

11) Circuit turn-off time t_c

$$Wt_c = \pi$$

$$t_c = \frac{\pi}{w} \quad ; \text{assume that f=50Hz}$$

$$t_c = \frac{\pi}{2\pi f} = 0.01\text{sec}$$

12) By putting inductor of your own choice repeat all the findings and compare both circuits result and comment.

70.02v/70µA /110µA/110µA/0.0121w/0.5/ π/ π