

BITS, Pilani – Dubai
International Academic City – Dubai
III year EEE/ EIE, IInd Semester 2008-09
Course Title - Power Electronics (EEE C461/INSTR C 461)
Comprehensive Exam Date—02/06/2009
Full Marks – 80 (Weight age 40 %) Duration—3 hours
Note: Part A and Part B in separate answer books

PART A

1. a) For a p-i-n diode, the peak reverse current (I_{rr}) at a temperature of 22 degree centigrade is 11 amperes. Breakdown voltage is (V_{BR}) = 840 volts. Forward current of the diode is 22 amperes for a considerable span of time. Calculate reverse recovery time (t_{rr}) of the diode. The other data are
 $k = 1.4 \times 10^{-23}$ Joules / Degree Kelvin
 $q =$ charge of an electron = 1.6×10^{-19} coulomb
 $\mu_n = 1325 \text{ cm}^2/\text{V-sec}$
 $\mu_p = 455 \text{ cm}^2/\text{V-sec}$
 $E_{BR} = 210 \text{ kV/cm}$ [6M]

- b) In context to a power diodes, explain “Conductivity modulation” or “Turn –On Transient” with necessary diagram, graph and equations. [4M]

2. a) Derive the expression for the channel resistance of an n-channel MOSFET, starting from fundamentals with necessary diagram. [7M]

- b) Explain any one of the “design aspects” (or “trade off aspects”) of a Schottky Barrier Diode writing the concerned equations in detail. [5M]

3. The delayed voltage pulse signal as shown in Figure 1 is injected to the gate of a MOSFET. In context to its turn on phenomenon, derive from the fundamentals, the expression for gate to source voltage ($V_{gs}(t)$) as a function of time using the method of Laplace Transform or any other method. Use the equivalent circuit of mode -1 of Turn –On Phenomenon for the above said analysis in addition to the following assumptions (need to be incorporated):
 Gate to drain capacitance is realistic and it is a parallel combination of ideal capacitor (C_{gd}) and a resistor (R_{gd}) &
 Gate to source capacitance is realistic and it is a parallel combination of ideal capacitor (C_{gs}) and resistor (R_{gs}) [8M]

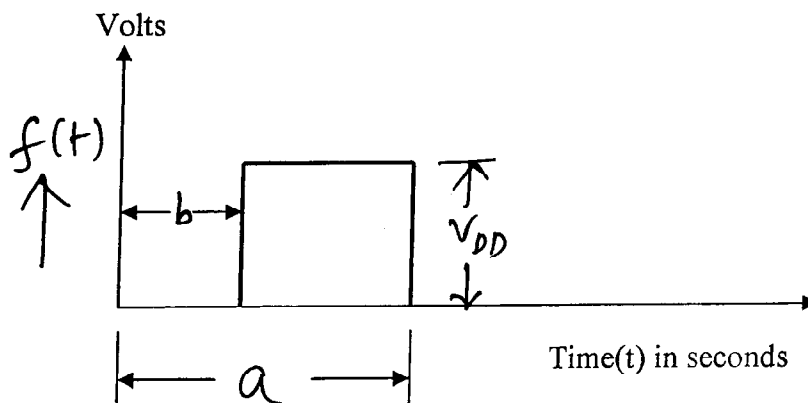


Figure 1

4. a) In connection with the circuit of impulse commutation of Thyristor, the capacitor is pre charged to -160 volts. $C=7 \mu\text{F}$ and Thyristor turn off time is $25 \mu\text{s}$. Calculate the value of constant load current (I_o), with the concerned switch closed. (Within the concerned circuit) [5M]

b) In context to part (a) question, if a resistor of 5 ohm is connected in parallel with the same capacitor, calculate the new turn -off time of the Thyristor. The load current remains same as part (a) of the question, initial voltage across the capacitor remains same i.e -160 volts. [5M]

PART B

5. a) Explain the operation of a full bridge DC-DC Converter with bipolar switching, showing the circuit diagram and equivalent circuits of all modes and the detailed expressions for " V_o/ V_s " and ΔI_o [5M]

b) A DC-DC Boost converter operating in continuous conduction mode has the following data: $V_s=5$ volts, $L=275\mu\text{H}$, Load resistance (R_L) =20 ohm, $C= 480 \mu\text{F}$, switching frequency (f_s) = 20kHz and $D=0.6$

Calculate

(i) Average output voltage, (ii) Peak to peak voltage ripple in the output

(iii) value of I_{OB}

[5M]

6. Consider the resonant tank shown in Figure 2, loaded with a current sink in voltage excitation. Starting from the fundamentals develop the state plane trajectory of the above said configuration. Detailed analysis using Laplace Transform should be presented. The normalized state variables should be used. [10M]

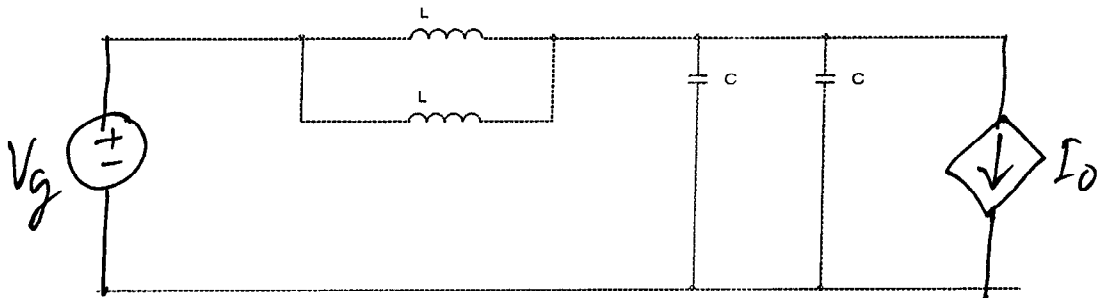


Figure 2

7. Write Short notes on any two of the following (with block diagram/circuit diagram/necessary equations/plots):

a) H.V.D.C

b) Static VAR Compensators

c) Protection of Semiconductor devices against surge voltage

d) Variable frequency square wave VSI drive

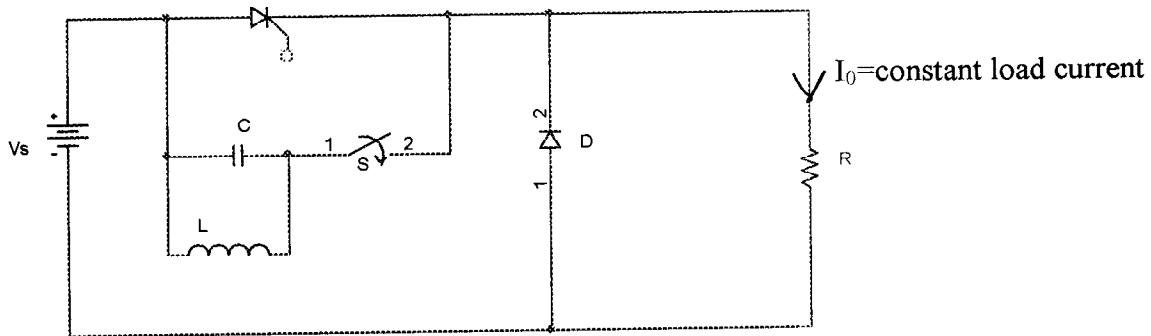
[5 + 5 M]

8. Explain the operation of a full bridge Inverter with square wave switching with necessary circuit diagrams and waveforms. [10M]

BITS, Pilani – Dubai
International Academic City – Dubai
III year EEE/ EIE, IInd Semester 2008-09
Course Title - Power Electronics (EEE C461/INSTR C 461)
TEST 2 Open Book Date—03/05/2009
Full Marks – 20 (Weight age 20%) Duration—50 min.

1. a) In connection with the impulse commutation of a Thyristor, an inductor is connected in parallel with the capacitor as shown in the following figure. The capacitor is pre charged with a value “ $V_c(0)$ ” . $t = 0$ is counted when the switch “S” is closed. The initial value of current through the inductor is neglected. Prove that the “turn off” time of the Thyristor can be expressed as

$$t_{off} = \sqrt{LC} \tan^{-1} \left(\frac{-V_c(0)\sqrt{C/L}}{I_0} \right) \quad [7M]$$



b) In context with Part -a question, calculate the value of t_{off} for the data given below $C=1.5$ micro farad, $L=1$ micro Henry, $V_c(0)=-160$ volts, $I_0=12$ amps [1M]

2. a. Determine the value of duty ratio in a full bridge DC-DC converter with bipolar switching such that average ^{Output} capacitor voltage becomes zero. [2M]

b. Why is the polarity of diode made reversed in Buck –Boost converter as compared to that in Boost converter?---- explain [2M]

c. Under what condition the assumption of inductor current in any DC-DC converter to be linear with respect to time is valid?----explain [1M]

3. Consider a DC-DC converter for which duty ratio varies from 0.462 to 0.706. The average output voltage is fixed to be 24 volts. The switching frequency is 50 kHz. Maximum output power is rated at 100Watts. The operation is CCM. Value of inductor is 20 micro Henry and it is in

a. What type of converter is it? *Parallel with the source when switch is closed.* [2M]

b. Derive the value of the Duty cycle for which I_{OB} is maximum [3M]

c. Calculate the maximum value of I_{OB} [2M]

BITS, Pilani – Dubai
International Academic City – Dubai
III year EEE/ EIE, IInd Semester 2008-09
Course Title - Power Electronics (EEE C461/INSTR C 461)
TEST 1 Date—29/03/2009
Full Marks – 25 (Weight age 25 %) Duration—50 min.

- 1 Explain switching characteristics of a Power Diode (Turn -on and turn-off transients, both) , with necessary diagrams and equations. [9M]

2. Draw the basic structure and equivalent circuit of a basic IGBT cell and explain its operation. [9M]

3. Consider a MOSFET (in Modes 1 and 2) having the following data: [7M]
 $V_{DD} = 15.0$ Volts ;
 $I_0 = 40.0$ Amps ;
 $V_T = 3.0$ Volts ;
 $C_{gs} = 2500 \times 10^{-12}$ Farads ;
 $C_{gd} = 350 \times 10^{-12}$ Farads ;
 $g_m = 25.0$ Siemens ;
 $R_g = 10.0$ Ohms .

Calculate the following:
 - (i) The time instant at which the current through the clamping diode will be HALF OF THE LOAD CURRENT .
 - (ii) Duration of mode 1 and mode 2
 - (iii) Based on part (ii), the time instant at which the current through the clamping diode will be ZERO

SURPRISE QUIZ 3
POWER ELECTRONICS
EEE C461

Name:

ID:

Answer the first ten questions for 0.5marks each. Transfer the best answers to the below Table.

Overwritten answers will not be evaluated.

1	2	3	4	5
6	7	8	9	10

1. What kind of output rectifier and filter circuit is used in a fly back converter?
 - (a) a four-diode bridge rectifier followed by a capacitor
 - (b) a single diode followed by an inductor-capacitor filter
 - (c) a single diode followed by a capacitor
 - (d) will require a center-tapped secondary winding followed by a full wave rectifier and a output filter capacitor.

2. A fly-back converter operates in discontinuous conduction mode with fixed ON duration of the switch in each switching cycle. Assuming input voltage and the resistive load at the output to remain constant, how will the output voltage change with change in switching frequency? (Assume discontinuous conduction through out and neglect circuit losses.)
 - (a) Output voltage varies directly with switching frequency.
 - (b) Output voltage varies inversely with switching frequency.
 - (c) Output voltage varies directly with square root of switching frequency.
 - (d) Output voltage is independent of switching frequency.

3. A fly-back converter has primary to secondary turn's ratio of 15:1. The input voltage is constant at 200 volts and the output voltage is maintained at 18 volts. What should be the snubber capacitor voltage under steady state?
 - (a) More than 200 volts but less than 270 volts.
 - (b) Less than 18 volts
 - (c) More than 270 volts.
 - (d) Not related to input or output voltage.

4. If the turns ratio of the primary and tertiary windings of the forward transformer are in the ratio of 1:2, what is the maximum duty ratio at which the converter can be operated?

- (a) $3/3$
- (b) $2/3$
- (c) $1/3$ and
- (d) 1

5. Find maximum voltage stress of the switch in the primary winding and diode in the tertiary winding if the converter-transformer has 10 primary turns and 15 tertiary turns and the maximum input dc voltage is 300 volts.

- (a) 600V and 700V
- (b) 800V and 650V
- (c) 500V and 750V
- (d) 400V and 730V

(6) What function does the diode 'D1' of circuit in forward converter have?

- (a) rectifies secondary voltage
- (b) blocks back propagation of secondary voltage to transformer
- (c) both (i) and (ii)
- (d) protects diode 'D2' from excessive reverse voltage

7. TVV in a buck converter in continuous mode is gives as

- (a) D
- (b) $1-D$
- (c) $1/D$
- (d) $D-1$

8. TVV in a buck converter in discontinuous mode is gives as

- (a) $D(1-\delta)$ (b) $1-D$
- (c) $D/(1-\delta)$ (d) D

9. TVV in a boost converter in continuous mode is gives as

- (a) D
- (b) $1+D$
- (c) $1-D$
- (d) $D-1$

10. TVV in a boost converter in continuous mode is gives as

- (a) $(D-1)/D$
- (b) $D/(1+D)$
- (c) $D/(1-D)$
- (d) $D-1$

Surprise Quiz –II
Power Electronics
EEE

Name :

ID:

1. Draw the structure of a power MOSFET cell.
2. What are the parasitic components that MOSFET has.
3. Draw the equivalent circuit of High frequency MOSFET.
4. What is the condition by which the maximum operating frequency is determined.
5. Which points determine the safe operating Area.

3rd Year EEE

POWER ELECTRONICS

QUIZ 1

24-02-2009

Name:

ID:

1. What are the types of power diodes? [1M]

2. What are the components of leakage current in power diode? [1M]

3. Define High Level injection [1M]

5. Draw the switching characteristics waveform of power diode. [1M]

7. Show the constructional concept of the following with a neat sketch [6 M]

PN junction

Bipolar JUNCTION Transistor

FET

DEPLETION MOSFET

ENHANCEMENT MOSFET

Schottky Barrier Diode

(3rd yr, EIE)

BITS, Pilani-Dubai

SEFA

International Academic City

Course Title - POWER ELECTRONICS

Course No. - ENSTR C461

Max. Marks :- 10

Quiz-3 (Weightage 5%)

Set-A

Date of Exam :- 29/04/09

Name -----

Id No. ---

1) In context to the internal structure of a thyristor, the typical dopant density in the "p" layer near to the Anode = D_1 (say) and that in the "p" layer away from the Anode = D_2 (say).
Then :-

- (a) $D_1 = D_2$ (b) $D_1 < D_2$ (c) $D_1 > D_2$

1 Mark

2) After the gate pulse is injected, the complete conduction of a Thyristor can be looked upon as a :-

- (a) Highly Negative Feedback action (b) Moderately Negative Feedback action (c) Neither of (a) and (b) (d) Regenerative Action

1 Mark

3) In some triggering circuits of Thyristor, DOUBLE DIODES are used for the reasons such as :-

- (a) Development of low value of on-state current of the device
(b) To determine the overshoot in current i_G
(c) To control on-state voltage drop

1 Mark

4) In connection with the Impulse Commutation of Thyristors, initial voltage across the "CAPACITOR" is :-

- (a) $+2V_c$ (b) $-V_c$ (c) ZERO

1 Mark

5) In "DCM" of a Buck Converter, " $\frac{V_o}{V_s}$ " becomes :-

- (a) $\frac{D}{D^2+1}$ (b) $\frac{D}{1-D-A}$ (c) $\frac{D}{1-A}$ (d) $\frac{D}{(1+2D)A}$

1 Mark

P.T.O

3rd yr, EEE

BITS, Pilani-Dubai
International Academic City

SET-B

Course Title - Power Electronics (INSTR 461)

Unit-3 (Weightage 5%)
Max. Marks - 10

Set-B

Date of Exam - 29/04/09

Id No. - - - - -

Name - - - - -

(1) Principle of operation of a Thyristor can be looked upon as a :-

1 Mark

(i) One Transistor and One MOSFET combination

(ii) Two Transistor Analogy, (iii) Three Transistor Analogy

(2) When, with reference to a Thyristor (internal structure), current gains α_1 and α_2 have a relation, $\alpha_1 + \alpha_2 \approx 1$, then the anode current, I_A becomes :-

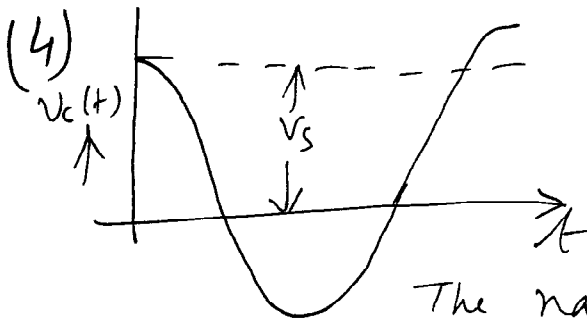
1 Mark

(a) Half of Maximum current (b) zero (c) Infinity
(d) None of them

(3) In connection with the "Impulse Commutation" of Thyristor :- (a) $t_{off} = \frac{1}{2} \frac{C V_c}{I_0}$ (b) $t_{off} = \frac{1}{2} \frac{C (V_c)^2}{(I_0)^2}$

(c) $t_{off} = \frac{1}{4} \frac{C V_c}{I_0}$ (d) $t_{off} = \frac{C V_c}{I_0}$

1 Mark



The figure shows the "Voltage versus time" for the capacitor used in a particular Commutation Circuit of a Thyristor.

1 M

The name of this ~~Commutation~~ Method of Commutation is _____
(Fill in the blank)

P-T.O.

BITS, Pilani-Dubai

International Academic City / Dubai

IInd Semester, 2008-09

(SET-A)

III yr, (EIE) / Course Title - POWER ELECTRONICS
(INSTR C461)

Duration
- 10 min.

Quiz-2

Date - 25-03-2009

Full Marks - 8 (Weightage 5%)

Set-A

(Instruction: If necessary, back side of this page can be used)

Name - - - - -

Id No. - - - - -

1.) Threshold voltage (V_T) has no role in the operation of MOSFET (involving Gate) - TRUE or FALSE?

1 Mark

2.) In a MOSFET, the channel resistance (R_{ch}) is:- (a) Proportional to "L" (b) Inversely proportional to "L" (c) Proportional to "L²"

2 Marks

3.) In a MOSFET, the thickness of the INVERSION LAYER :-

2 Marks

- (a) Increases with higher gate voltage
- (b) Decreases with higher gate voltage
- (c) Is independent on magnitude of gate voltage

4.) Draw the equivalent circuit of Mode 1 for "TURN-ON TRANSIENTS" of "MOSFET" and write the expression for $V_{gs}(t)$

2+1 Marks

BITS, Pilani – Dubai
International Academic City – Dubai
III year EIE, IInd Semester 2008-09

Course Title - Power Electronics (INSTR C 461)

Quiz 1(Set—A) [Use the back side of this page,if necessary]

Full Marks – 10 (Weight age 5 %) Duration—10 min.

Date: 25-02-2009[Q1 to Q8---1 Mark each and Q9—2 Marks]

Name-----

Id No.-----

-
- 1) The area of P-N junction in power diode, as compared to a normal diode (or, signal diode) is : (a) smaller (b) equal (c) large
- 2) High level injection occurs in : (a) Normal diode (b) Power diode (c) Transistor
- (3) High reverse breakdown voltage of a power diode can be achieved:
(a) By decreasing the width of the intrinsic layer
(b) By increasing the width of the intrinsic layer
(c) By changing the reverse leakage current
- (4) It is given that with reference to a power diode:
 I_{rP^+} = The diffusion leakage current in the p^+ region
 I_{rN^+} = The diffusion leakage current in the n^+ region
 I_{ri} = The space charge leakage current in the intrinsic region
 I_r = Leakage current in the power diode
Which is correct?
(a) $I_r = I_{rP^+} + I_{rN^+} - I_{ri}$ (b) $I_r = I_{rP^+} - I_{rN^+} - I_{ri}$ (c) $I_r = I_{rP^+} + I_{rN^+} + I_{ri}$
- (5) Resistance of the n^- region of a Schottky Barrier Diode (R_D) varies with reverse blocking voltage (V_{BR}) as given by:
(a) Proportional to $(V_{BR})^3$ (b) Proportional to $(V_{BR})^{3.5}$ (c) Proportional to $(V_{BR})^{2.5}$
- (6) Thyristor is level triggered device whereas MOSFET is a pulse triggered device?--
-TRUE or FALSE
- (7) An induction motor is driven by a power electronic circuit. The power circuit current of the concerned power electronic device is I_P and the control circuit current of the same device is I_C . Out of the following, which is correct?:
(a) $I_C = (2.0) I_P$ (b) $I_C = (20) I_P$ (c) $I_C = (200) I_P$ (d) $I_C = (0.1) I_P$
- (8) "In context to the Turn-off Transient of a Power Diode, the stored charge Q_f does not change appreciably until the current direction reverses."----- With reference to this statement, what is the name of the concerned property of the device ?
- (9) Draw the Turn-on and Turn-off characteristics(Current versus time only) of a Power Diode(with proper labeling)

BITS, Pilani - Dubai
International Academic City
III yr EEE, Ind Sem./2008-09

SET-B

Course Title - Power Electronics (INSTR
c461)

Quiz 1 (set B)

Full Marks - 10 (Weightage 5%)

Duration - 10 min, Date - 25-02-2009

[Q1 to Q8 --- 1 Mark each and Q-9 - 2 Marks]

Name ----- Id No. -----

- 1) The area of P-N junction in normal diode, compared to a Power Diode is ; (a) Smaller (b) equal (c) larger
- 2) In context to a Power Diode, High Level Injection occurs in :- (a) p^+ layer (b) Intrinsic layer (c) n^+ layer
- 3) High reverse breakdown voltage of a power diode can be achieved :- (a) By increasing the width of intrinsic layer (b) By decreasing the above said width (c) By changing reverse leakage current
- 4) In context to a Power Diode :- (a) $V_d = V_{j1} + V_{j2} - V_i$
(b) $V_d = V_{j1} + V_{j2} + [(V_i)/2]$ (c) $V_d = V_{j1} + V_{j2} + V_i$
- 5) An induction motor is driven by a power electronic device used as a switch. This device has a power circuit current = I_p and control circuit current = I_c .
Then :- (a) $I_c = 4 I_p$ (b) $I_p = 40 I_c$ (c) $I_c = 350 I_p$
- 6) "Gate" of a MOSFET is similar (analogous) to "Emitter" of a Transistor \rightarrow TRUE or FALSE?
- 7) With reference to Turn-off Transients of Power Diode :-
(a) $Q_f = I_{rr} t_{rr}/4$ (b) $Q_f = I_{rr} t_{rr}$ (c) $Q_f = I_{rr} t_{rr}/2$
- 8) In a Schottky Barrier Diode, if ϕ_b is increased then :-
(a) V_f & $I_s \rightarrow$ both increases (b) Nothing happens to each of V_f and I_s (c) V_f/I_s - ratio increases (d) V_f/I_s - ratio decreases
- 9) Draw the Turn-on and Turn-off characteristic ("Voltage versus time" only) of a Power Diode, with proper labelling.

(Use the back side page, if necessary)