Prof Anandarup Das

12/20 9/10/17

ELL 302 Power Electronics

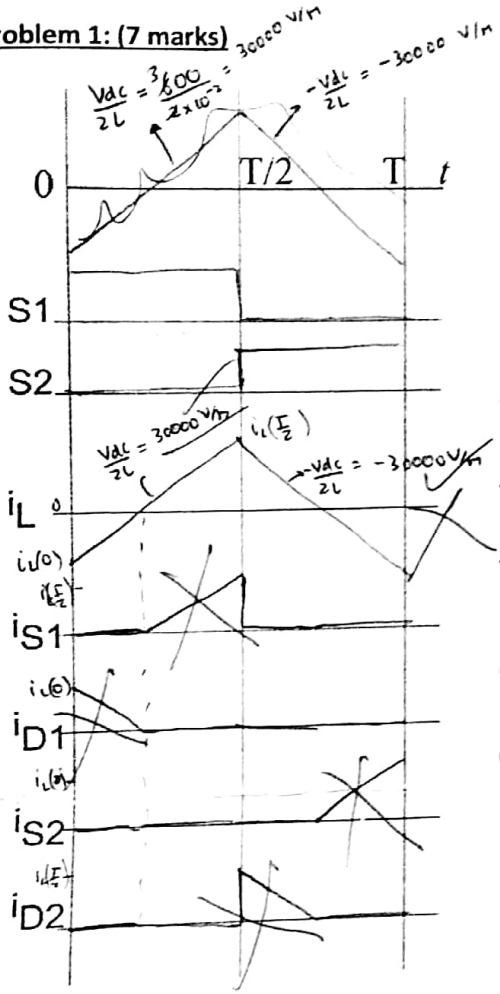
Minor 2 (Date: 05.10.2017), 9:30-10:30 AM, LH 108

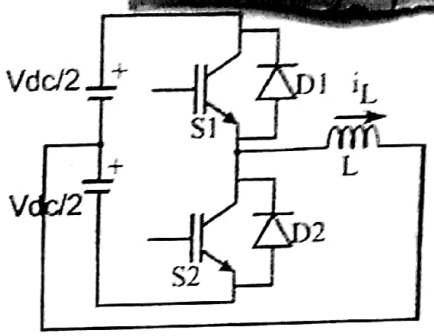
NAME: [redacted] **ENTRY NO** [redacted]

Marks: 20, Time: 60 minutes, Make suitable assumptions if necessary.

6

Problem 1: (7 marks)





Carefully study the half bridge converter feeding a pure inductive load. Assume switches S_1 and S_2 are operated with 50% duty ratio and the circuit has reached steady state operation.

Assume V_{dc}=600V, L= 10 mH and f = 50 Hz = (1/T).

(a) Sketch the inductor current waveform (i_L). Indicate the slopes of the waveform. (2)

(b) What is the average value of the inductor current? (2)

0

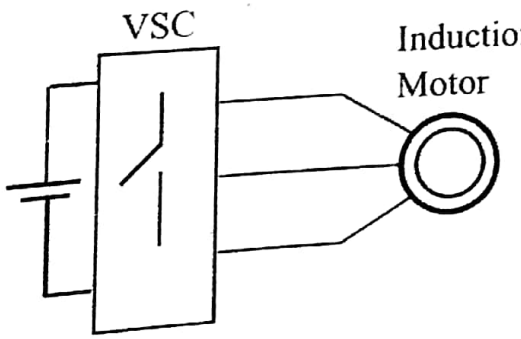
(c) Sketch the waveform of current flowing through S_1, S_2, D_1 and D_2. (4x0.5=2)

(d) What is the average value of the current through D2? $\frac{1}{2} \times I_L\left(\frac{T}{2}\right) \times \frac{T}{4} \Big/ T = \frac{I_L\left(\frac{T}{2}\right)}{8}$? (1)

0

3

Problem 2: (6 marks)



A 3-phase Voltage Source converter drives an induction motor load. The motor draws 2 MW active power and 600 kW reactive power at steady state operation. The motor terminal voltage is 6.6 kV (line to line).

(a) Calculate the current drawn by the motor (magnitude and phase). (2)

$3 \times \frac{V_{L-L}}{\sqrt{3}} \times I \times \cos\phi = 2000 \times 10^3$ W (V_{L-L} = 6.6 kV)

$\phi = \tan^{-1}\left(\frac{-3}{10}\right) = -16.699$

$\Rightarrow I = 182.657$ A → magnitude

$\angle I = \phi = -16.699°$

$\therefore \bar{I} = 182.657 \angle -16.699°$

2

(b) Calculate the dc bus voltage magnitude of the converter, if the converter is operated with sinusoidal PWM strategy and modulation index limited to 0.98. (2)

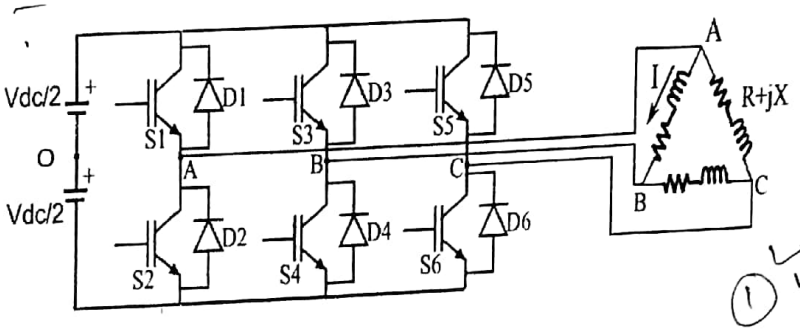
$V_{AB} = \frac{\sqrt{3}\, m_a V_d}{2} = 6.6 \times 1000 \Rightarrow V_d = 7.77\ kV$

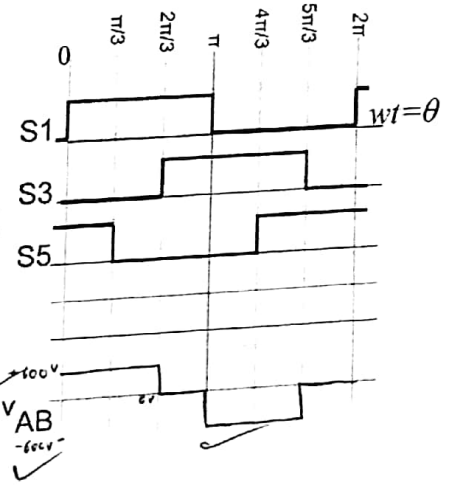
(c) Calculate the minimum voltage and current rating of the switches required in the converter. (2)

Voltage rating = 7.77 kV

I rating = 182.651 A

Problem 3 (7 marks)





A 3-phase Voltage Source converter drives a balanced delta connected R-L load. The gate pulses for the switches are given. R= 1.5 ohm, L=5 mH, f= 2π/w=50 Hz, V_{dc}=600V.

(a) Draw the v_{AB} waveform. Indicate magnitudes of voltages in the waveform. (1)

(b) Find out the magnitude of n^{th} harmonic component of voltage appearing across the load Z_{AB}? (3)

$a_0 = 0$ → DC value

$a_n = \frac{4V}{n2\pi} \cos\frac{7\pi n}{6} \sin\frac{3\pi n}{6}$ ⇒ $a_n = 0$ (for n = even)

$b_n = -\frac{4V}{n2\pi} \sin\frac{7n\pi}{6} \sin\frac{3\pi n}{6}$

$b_n = 0$ (for n = even)

→ For n^{th} harmonic we have: Magnitude = 0 if n = even

Magnitude = $\frac{4V}{n2\pi}\sqrt{2}$ otherwise = $\frac{2\sqrt{2}\,V}{n\pi}$ → 600V

$= \frac{540\sqrt{2}}{n}$

(2)

(d) Calculate the magnitude of 5^{th} harmonic current flowing through load Z_{AB}.

$\Rightarrow \frac{2\sqrt{2}\,V}{n\pi} \times \frac{1}{1.5 + 100\pi \times 5 \times 5 \times 10^{-3}}$

$= 11.554\ A$ → peak

RMS = 8.17

(1)

(c) Calculate the magnitude of 9^{th} harmonic current flowing through load Z_{AB}.

$\Rightarrow \frac{2\sqrt{2}\,V}{n\pi} \times \frac{1}{1.5 + 100\pi \times 5 \times 9 \times 10^{-3}}$

$= 3.838\ A$ → peak

RMS = 2.71 A