UNIVERSITY OF RUHUNA

Faculty of Engineering

Mid-Semester 7 Examination in Engineering: June 2014

Module Number: EE7235 **Module Name: Power Electronic Applications**

[Two Hours]

[Answer **all questions**, each question carries **10 marks**]

Q1 a) i) Switch mode power supplies are mostly used in both analog and digital electronic systems. State the advantages of using the switch mode power supplies.

ii) Explain the importance of the electrical isolation between the input and the output of a power supply.

iii) Explain why it is preferred to keep the switching frequency of a switch mode power electronic converter as higher as possible.

iv) What are the problems associated with high frequency switching?

v) What is the functionality of the dissipative snubber of a switch mode power electronic converter?

[5 Marks]

b) i) What are the advantages of using a DC link over an AC link at higher power transmitting?

ii) Draw the circuit diagram of 12 pulse converter and explain the significance of using the 12 pulse converter for converting the AC voltage to the DC voltage in HVDC systems.

iii) A three phase 12 pulse rectifier is fed from transformers having an effective voltage ratio of 0.4. If the transformers are connected to the grid having V_{LL} (rms) is 220 kV and each converter operates at a firing angle of 15°, calculate the operating voltage of the DC transmission line assuming commutating inductance is negligible.

Hint:

For a six pulse converter DC output voltage given by

$$V_d = \frac{3\sqrt{2}}{\pi} V_{LL} \cos\alpha - \frac{3\omega L_\omega I_d}{\pi}.$$

[5 Marks]

Q2 An equivalent circuit of a Fly-Back converter and its parameters are shown in Figure Q2.

a) i) Assuming the converter is operated in continuous conduction mode, draw the waveforms of V_1, V_2, i_1, i_{sw}, i_m and i_c stating the axis values clearly.

ii) Show that output voltage of the Fly-Back converter V_0 is given by

$$V_0 = \frac{D}{(1-D)} \frac{N_2}{N_1} V_d.$$

[4 Marks]

b) i) Show that the minimum magnetizing current i_{m0} in the core of the Fly-Back converter is given by

$$i_{m0} = \frac{N_2}{N_1} I_0 \frac{1}{(1-D)} - \frac{V_d}{2L_m} DT_s .$$

ii) Suppose that the parameters of a Fly-Back converter with a 1:1 turns ratio, are V_o = 12 V, V_d = 24 V, P_{load} = 60 W and the switching frequency f_s = 200 kHz. Calculate the maximum value of the magnetizing inductance L_m that can be used if the converter is always required to be operated in a complete demagnetization.

iii) If the converter is operated in the continuous conduction mode and requires a complete demagnetization (i.e. i_{m0} = 0), show that the average magnetizing current $i_{m.avg}$ is given by

$$i_{m,avg} = \frac{DV_d}{2L_m} .$$

[6 Marks]

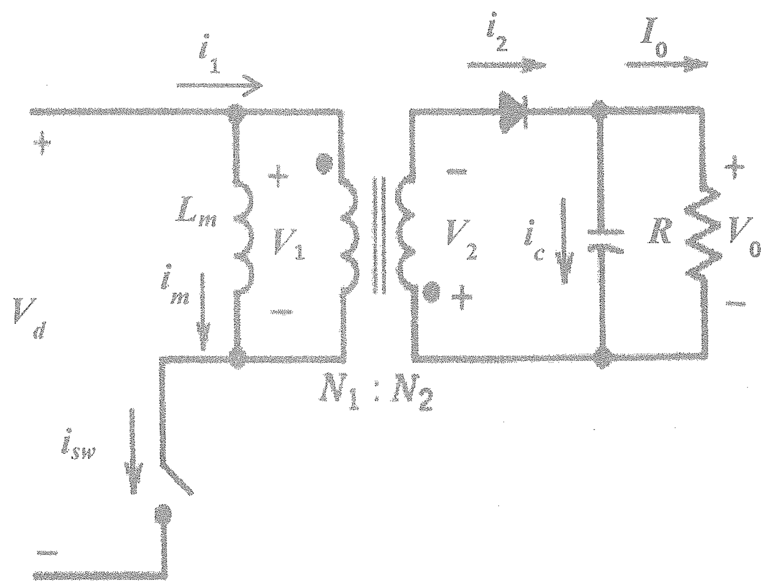

Figure Q2: An equivalent circuit of a Fly-Back converter

Q3 a) i) Briefly explain the importance of the demagnetizing winding of a forward converter.

ii) Assuming Forward converter shown in Figure Q3 is operated in the complete demagnetizing conduction mode, draw the waveforms of v_1, i_m, i_3 and i_L stating the relevant expressions. Define the parameters used in your analysis.

iii) If $N_3/N_1 = 1$, calculate the maximum possible duty ratio D of the forward converter.

[4 Marks]

b) The parameters of a forward converter shown in Figure Q3 are $V_d = 240$ V, $V_0 = 4$ V, $f_s = 100$ kHz, $L_m = 10$ mH, and $L = 0.05$ mH.

i) If D = 0.3, calculate the turns ratio N_1:N_2.

ii) Calculate the maximum magnetizing current $i_{m,max}$.

iii) For the value N_1:N_2 calculated in part i), what is the lowest input voltage permissible if V_o is to kept equal to 4 V ?

iv) What is the average voltage across the smoothing inductor? Give the reasons for your answer.

v) Calculate the maximum voltage across the switch assuming $N_1/N_3 = 1$.

[6 Marks]

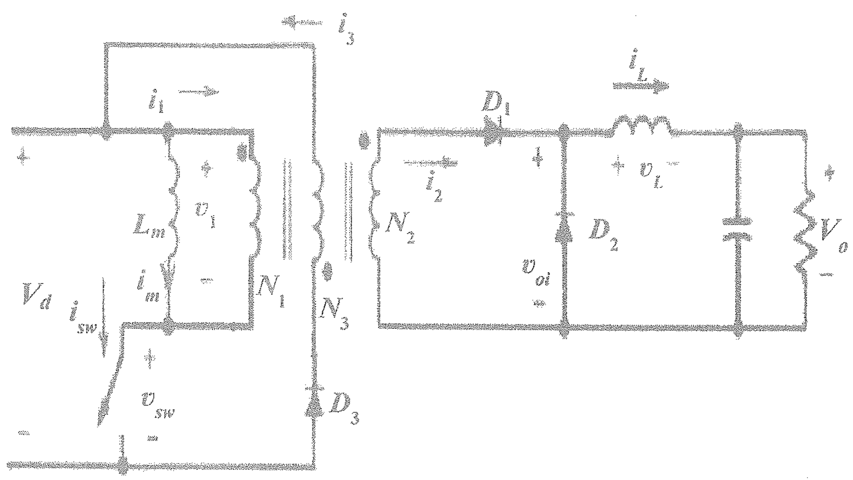

Figure Q3: An equivalent circuit of a Forward converter