UNIVERSITY OF RUHUNA

Faculty of Engineering

Mid-Semester 7 Examination in Engineering: June 2015

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

[Two Hours]

[Answer all questions, each question carries 7.5 marks]

Q1 a) i) Compare and contrast linear power supplies and switch mode power supplies.

ii) What is the purpose of using high frequency transformers in power converters?

iii) What are the problems that a high frequency transformer can cause for a power converter?

[2 Marks]

b) Figure Q1 shows a circuit diagram of a forward converter.

i) Show that the voltage ratio is given by,

$$\frac{V_0}{V_d} = D\frac{N_2}{N_1}$$

where all the notations have their usual meanings.

ii) Assuming the complete demagnetizing of the core, draw the waveforms of V_1, i_m, i_3, i_1 and i_L for one switching cycle.

iii) Show that the maximum duty ratio for complete demagnetized operation is given by,

$$D_m = \frac{1}{1 + (N_3/N_1)}$$

iv) A forward converter having winding turns ratios $N_1 : N_2 : N_3 = 1 : 0.5 : 1$, is supplied with an input voltage of 48 V. Calculate the maximum output voltage that the converter can supply.

[5.5 Marks]

Q2 a) The fly-back converter shown in Figure Q2 operates in complete demagnetizing mode.

i) Obtain the maximum magnetizing inductance, L_m for fully demagnetizing mode of operation.

Hint: For a fly-back converter which operates in continuous conduction mode,

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

ii) Show that the voltage ratio of the converter is given by,

$$\frac{V_0}{V_d} = D\sqrt{\frac{R}{2\,L_m f_s}}$$

where all the notations have their usual meanings.

iii) A fly-back converter with a 1:1 turns ratio, 12 V input voltage, 24 V output voltage and a magnetizing inductance of 3 μH is operating at a switching frequency of 100 kHz. If the output power is 60 W, find the maximum duty ratio that ensures complete demagnetizing mode of operation.

[4.5 Marks]

b) An isolated fly-back converter operating in the continuous conduction mode at a frequency of 50 Hz is fed from 230 V, 50 Hz ac supply via a full wave rectifier and LC filters so as to maintain continuous supply current. The output voltage is 24 V and maximum duty cycle is limited to 60%. The main supply voltage varies from 180 V to 270 V. Calculate,

i) minimum voltage rating of the power switch if it is required to keep a safety margin of 100 V for voltage spikes due to leakage inductance effect.

ii) turns ratio of the fly back converter required to obtain the output voltage at 50 % duty cycle under normal mains conditions.

iii) range of operating duty cycle with the turns ratio obtained in ii).

[3 Marks]

Q3 a) Nonlinear loads are the main factor to produce power disturbances. Power disturbances can be minimized by using protective devices.

i) List five power disturbance types described in IEEE standards.

ii) Explain separately, why Uninterruptible Power Supply (UPS) is superior over the protective devices under above mentioned disturbance types.

iii) Draw the block diagram of standby (offline) UPS and mark the primary and backup path on it.

iv) Standby UPS can't use for the critical loads. Explain this statement by using the block diagram drawn in iii).

v) Explain briefly the operation of the delta conversion online UPS comparing with the double conversion online UPS with the help of block diagrams.

[5 Marks]

b) Power electronics give better solutions for the problems in conventional electronic systems.

i) Briefly explain the operation of conventional air conditioning system using the block diagram.

ii) What are the advantages of an air conditioning system with an Adjustable Speed Drive (ASD) over a conventional air conditioning system?

[2.5 Marks]

Q4 a) i) Explain the principle of induction cooking using a suitable block diagram.

ii) Induction heating is a clean, quick and efficient method. It allows a defined section of the work piece to be heated accurately. The induction frequency is selected based on the application. The penetration depth (δ) of the induced current is given by the equation,

$$\delta = k\sqrt{\frac{\rho}{f}}$$

where,

δ - penetration depth (m)

f -Induction frequency (Hz)

ρ - Resistivity of work piece (Ωm)

k - Constant; $k = {}^{1}/_{\sqrt{\pi\mu}}$

Parameters for the aluminum work piece are given below.

$\rho = 2.6548 \times 10^{-8}\ \Omega m$, $\mu_r = 1.00002$, $\mu_0 = 4\,\pi \times 10^{-7}\ H/m$

(I) Find the penetration depth of aluminum work piece for 1 MHz and 5 MHz frequencies.

(II) By using the above calculations, state and explain which frequency is suitable for melting the aluminum work piece.

[2.5 Marks]

b) i) Draw two detailed circuits in conventional electric arc welding. Assume that the single phase ac power supply is available as the input.

ii) Explain the problems associated with the two circuits drawn in i).

iii) With the help of a circuit diagram, explain how these problems can be eliminated using recent developments in power electronics.

[2.5 Marks]

c) Simple conventional fluorescent lamp mainly includes a tube, a starter and a ballast.

i) Describe the importance of the starter and the ballast used in fluorescent lamps.

ii) One drawback of the conventional ballast is its size and weight. Explain two other problems associated with the conventional ballasts.

iii) What is the importance of using a higher operating frequency in electronic ballast?

[2.5 Marks]

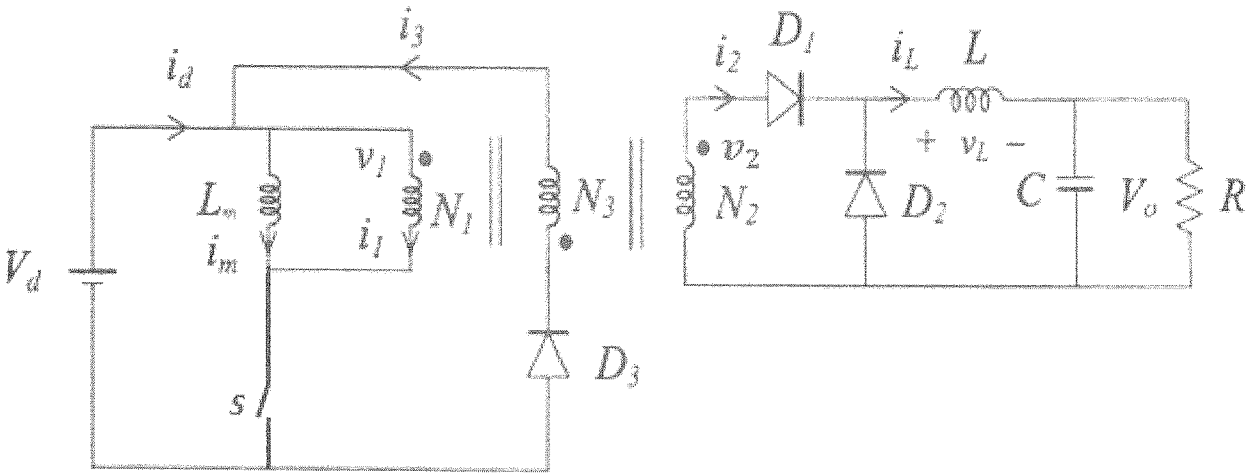

Figure Q1

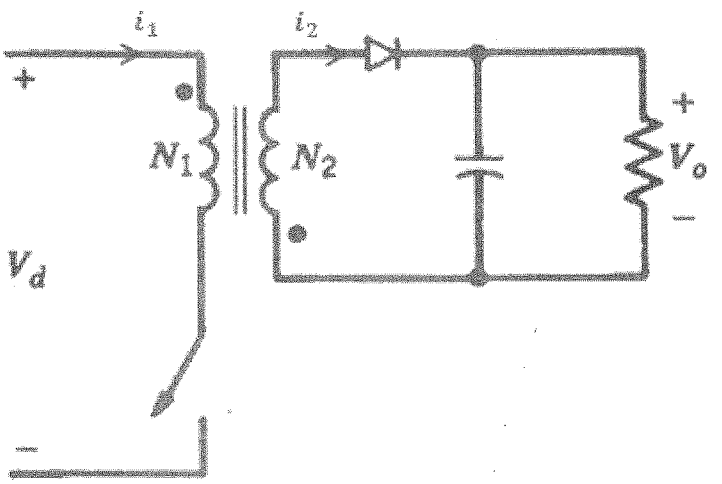

Figure Q2