First Semester Examination
Academic Session 2018/2019

December 2018/January 2019

EEE542 – Industrial Power Electronics

Duration : 3 hours

Please check that this examination paper consists of NINE (9) pages and appendix ONE (1) page of printed material before you begin the examination .

Instructions: This question paper consists **SIX (6)** questions. Answer FIVE (5) questions. All questions carry the same marks.

1. A three-phase full bridge twelve pulse rectifier is shown in Figure Q1. The three-phase source voltage available is 415 V, 50 Hz. The transformer winding ratio are nY : nY : nΔ = 1 : 1 : $\sqrt{3}$. Load is pure resistance R of 100 Ohm.

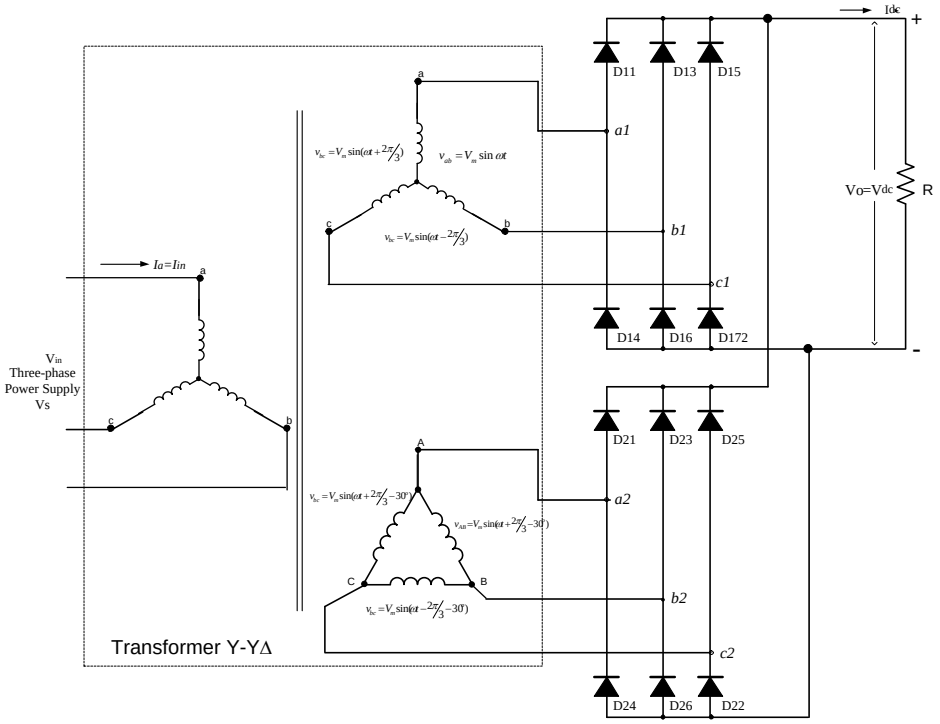

Figure Q1

(a) Draw waveforms of input voltage V_{in}, input current I_{in}, output voltage V_{dc} and output current I_{dc}.

(40 marks)

(b) Calculate the average output voltage VDC

(30 marks)

(c) If the rectifier is used as a charger system to feed the batteries set with constant terminal voltage of 200 V and total internal resistance of batteries are 10 Ohm, calculate the charge current flow into the batteries set.

(30 marks)

2. A controlled three-phase half wave rectifier connected with a delta-wye transformer such as shown in Figure Q2. The three-phase line voltage source is 415 V, 50 Hz. The transformer Voltage ratio is 1 to 10. Assumed that the rectifier is ideal with chuck inductor L is infinity (current is continuous). If the required output voltage V_{dc} is 1000 V and resistance of load is 10 Ohm.

   (a) Determine firing angle α of the rectifier

   (40 marks)

   (b) What is the function of the freewheeling diode D on that rectifier?, Explain, briefly.

   (20 marks)

   (c) Draw the waveforms of input voltage V_s (voltage source of line), output voltage (V_{dc}) and output current (I_{dc}).

   (40 marks)

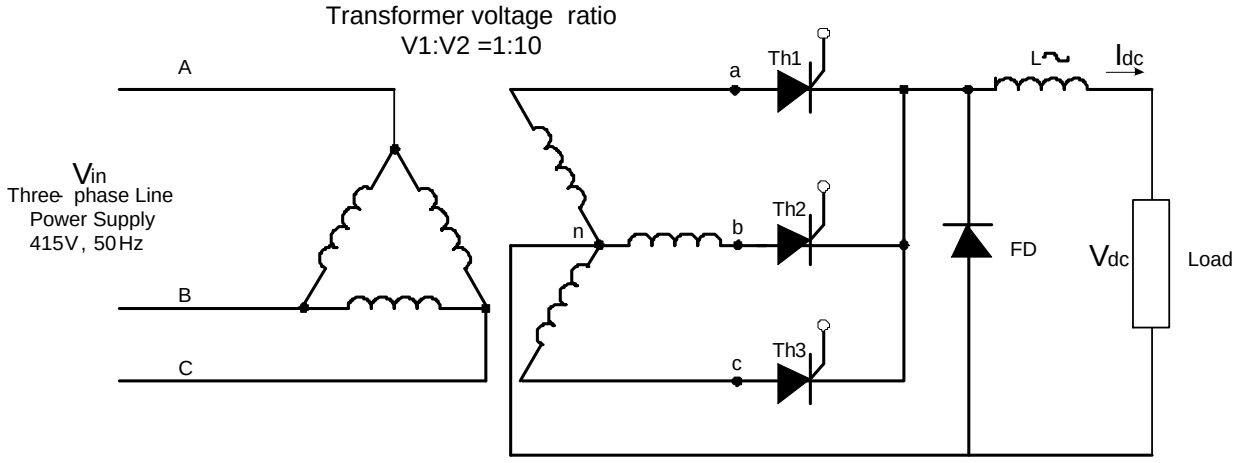

Figure Q2

3. (a) In a step-down DC-DC converter design, it is specified that the input voltage, V_g is to vary between 10 V to 40 V, and the desired output voltage is to be set to 5 V by regulating the switch duty cycle. The switching frequency is set at 50 kHz. The output voltage ripple must be less than 5 %. The output power is required to be minimum 5 W, and the converter is required to operate in a continuous conduction mode.

(i) Design an appropriate step-down converter that will meet the specifications. Your answer should include the calculation of duty cycle, average output current, minimum inductance and capacitance.

(45 marks)

(ii) Draw a circuit diagram illustrating the location of all the various passive circuit components which is used to implement this design.

(10 marks)

(b) A step-up chopper supplies 400 V to a 100 Ω load from a 100 V source. The capacitor is large enough that negligible load voltage ripple occurs; L = 2 mH and the switching frequency is 15 kHz. Find:

(i) duty cycle.

(15 marks)

(ii) maximum and minimum values of the inductor currents.

(30 marks)

4. (a) With the aid of current waveforms, explain the presence of harmonics in electrical system. (20 marks)

(b) Using circuit diagrams, describe how harmonics are generated in a distribution system.

(20 marks)

(c) A six-step inverter is used to supply a three-phase load using a DC voltage source. If the frequency at the load side is desired to be 400 Hz, calculate the conduction period of each switch for both 120° conduction mode and 180° conduction mode respectively.

(15 marks)

(d) A three-phase voltage-fed inverter bridge transfers power from an ideal DC supply voltage rail of V_{DC} = 600 V to a three-phase resistive load of R = 100 Ω per phase. The triggering mode to be used is where two switches will conduct simultaneously i.e. 120° conduction mode as can be seen in Figure Q4.

(i) Prove that the rms value of the fundamental component of the line voltage $V_{AB(rms)}$ across the load is 405.1 V.

(30 marks)

(ii) Given $V_{AB(rms)}$ = 424.26 V, calculate the T.H.D of the line voltage V_{AB}.

(15 marks)

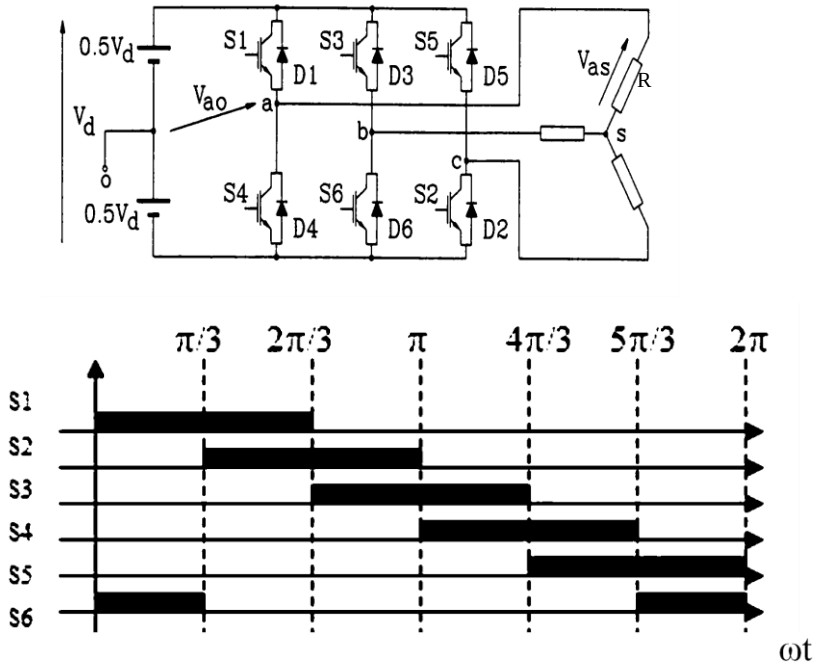

Figure Q4 A three-phase inverter bridge and the switching waveforms

5. (a) The series resonant inverter in Figure Q5(a) has $L_1 = L_2 = L = 50\ \mu H$, C = 6 µF and R = 2 Ω. The dc input voltage is V_s = 220 V and the frequency of output voltage is f_o = 7 kHz. The turn-off time of the transistor is t_{off} = 10 µs and the rms load current is 44.1 A.

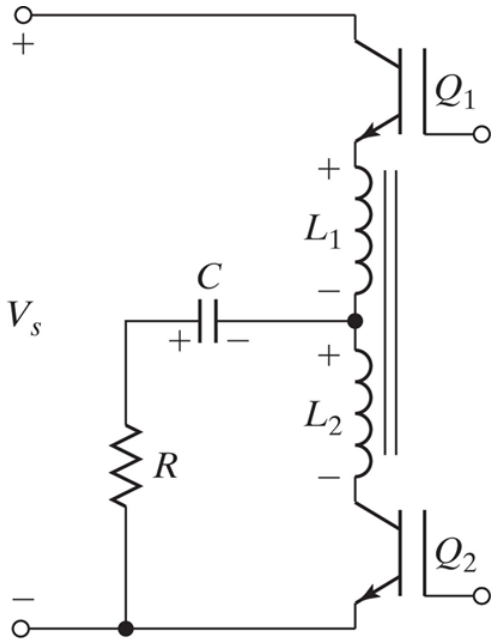

Figure Q5(a)

(i) Determine the circuit turn-off time, $t_{off.}$

(10 marks)

(ii) Determine the maximum permissible frequency, $f_{max.}$

(10 marks)

(iii) Determine the peak to peak capacitor voltage, $V_{pp.}$

(10 marks)

(iv) Determine the peak load current, $I_{p.}$

(10 marks)

(v) Determine the output power, $P_{o.}$

(5 marks)

(vi) Determine the average supply current, $I_{s.}$

(5 marks)

5. (b) A parallel resonant inverter as in Figure Q5(b) delivers a load power of P_L = 3 kW at a peak sinusoidal load voltage of V_p = 220 V and at resonance. The load resistance is R = 7.5 Ω. The resonant frequency is f_o = 30 kHz.

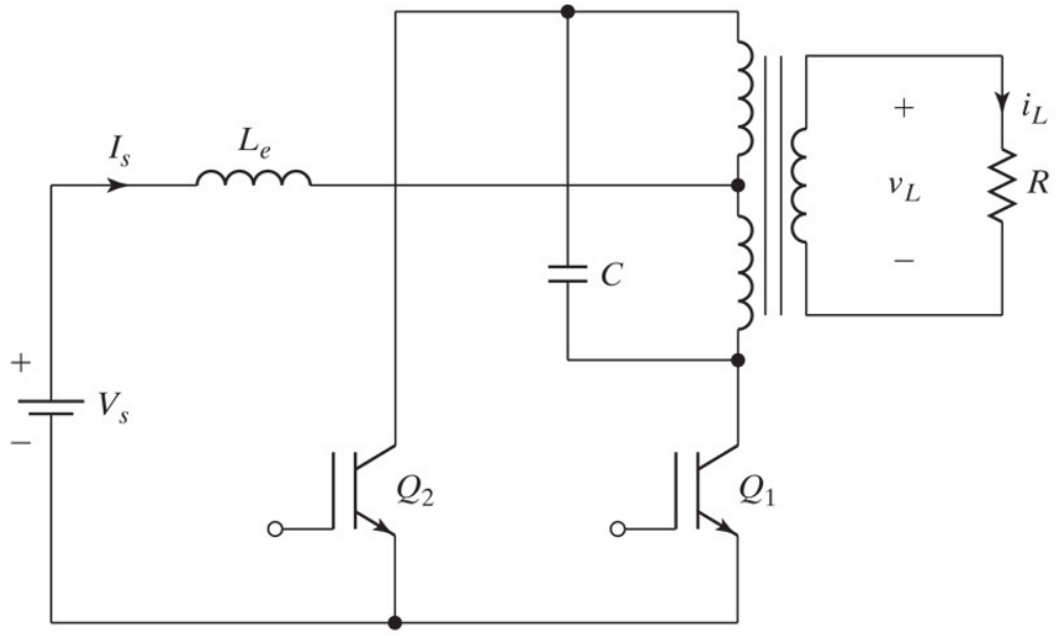

Figure Q5(b)

(i) Determine the dc supply input current, I_s.

(15 marks)

(ii) Determine the quality factor Q_p if it is required to reduce the load power to 1500 W by frequency control so that u = 1.25.

(15 marks)

(iii) Determine the capacitor C value.

(10 marks)

(iv) Determine the inductor L value.

(10 marks)

6. (a) Figure Q6(a) shows an example of flyback converter. There are two modes of operation: (1) mode 1 when switch Q_1 is turned on, and (2) mode 2 when switch Q_1 is turned off.

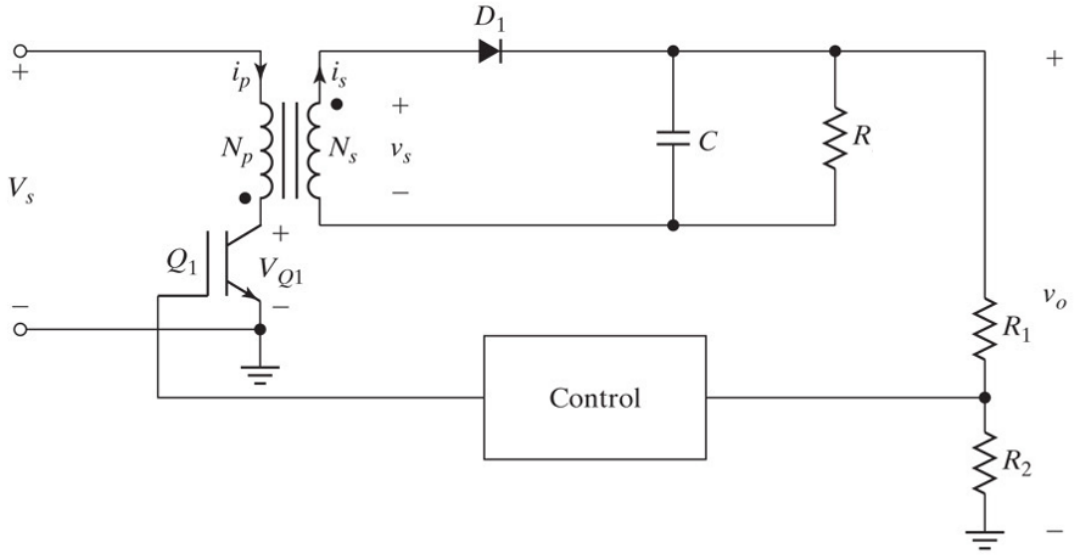

Figure Q6(a)

(i) Sketch waveforms of transistor Q_1 voltage V_{Q1}, secondary voltage V_s, primary current I_p, secondary current I_s and output voltage V_o

(25 marks)

(ii) A double-ended flyback converter is used when the voltage supply is too high and above voltage V_{Q1}. Draw a double-ended flyback converter by referring to Figure Q6(a).

(15 marks)

6. (b) Figure Q6(b) shows an example of a forward converter.

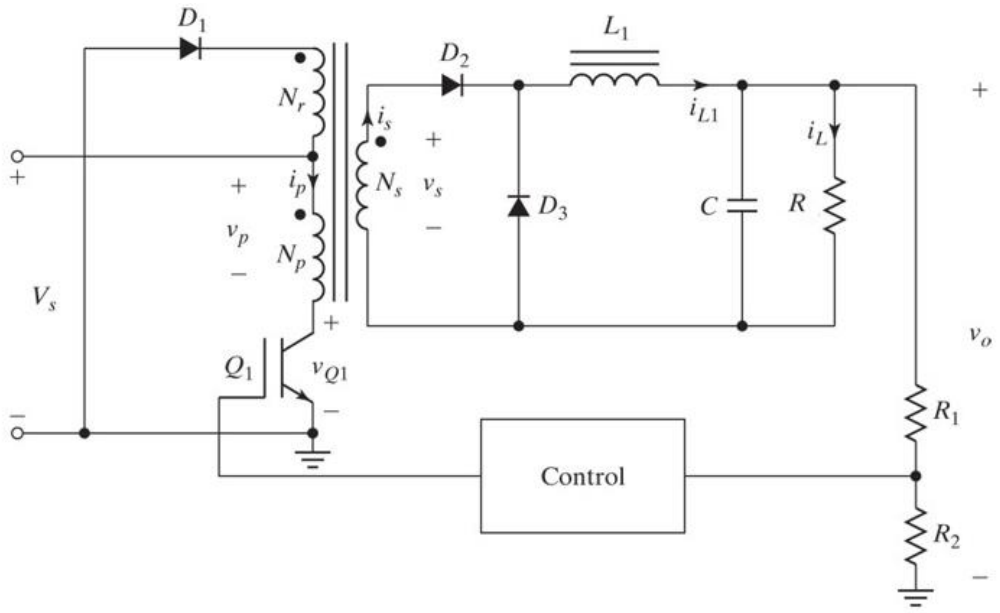

Figure Q6(b)

(i) Sketch waveforms of primary voltage V_P, transistor Q_1 voltage V_{Q1}, primary current I_p, current of diode D_3 I_{D3}, current of Inductor I_L and output voltage V_o

(30 marks)

(ii) Draw two configurations of commonly used in uninterruptible power supply or UPS systems.

(30 marks)

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Course Outcomes (CO) – Programme Outcomes (PO) Mapping
Pemetaan Hasil Pembelajaran Kursus – Hasil Program

Questions ***Soalan***	**CO**	**PO**
1	1	1
2	1	1
3	3	3
4	2	2
5	2	3
6	1	2