**SECOND SEMESTER EXAMINATIONS 2014/2015**

**FIFTH YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING**

**FEE 542: POWER ELECTRONICS AND VARIABLE SPEED-DRIVES B**

**DATE: APRIL 20, 2015**  **TIME: 08.30 A.M. - 10.30 A.M.**

INSTRUCTIONS TO CANDIDATES

1. Answer any **THREE** of the following Five questions.
2. All questions carry equal marks.
3. Show all working clearly in the answer sheets.
4. Do ***NOT*** attempt more than **three** questions.

**QUESTION 1**

Figure Q1 shows a three-phase dc-to-ac converter (inverter). It employs a three-SCR conduction-module such that each SCR conducts for an angle of 180o,where Q1, Q2, Q3 are positive-conducting SCRs and Q4, Q5, Q6 are negative-conducting SCRs.



1. By drawing the conducting periods of positive-conducting and negative-conducting

 SCRs, derive the three-SCR conducting sequence and show the gate-firing sequence. **( 4 Marks )**

(b) Derive the phase-voltage waveforms of the load voltages eao, ebo respectively. **( 5 Marks )**

(c) Hence, derive the line-to-line voltage waveform of the load voltage Vab **( 3 Marks )**

(d) By applying Fourier analysis, show that amplitude of the ***phase-voltage*** of any nth  harmonic is given by **( 4 Marks )**



(e) Given that Vd = 300 V, determine the values for eao(rms) for; ( all answers to zero decimal place )

 i) the fundamental,

 ii) the second harmonic,

 iii) the third harmonic. **( 4 Marks )**

**QUESTION 2**

1. An HVDC transmission scheme has the following specifications between station-A and station-B:

***Station-A***: 3-phase, 900 kV, 50Hz is the ac input to the rectifier-inverter bridge, 720 kVdc is the dc output voltage of the rectifier-module.

***Station-B***: 3-phase, 1,080 kV, 60 Hz is the ac output of the inverter-rectifier bridge at station-B.

The dc-wire resistance of the transmission line is 20 Ω.

1,800 Mw of power is to be transmitted from station-A to station-B.

By means of a neat block diagram of the dual-link scheme, determine;

1. the firing angle αa of the rectifier-module at station-A,
2. the firing angle βb of the inverter-module at station-B. ( **12 Marks** )
3. If 1,200 MW of power is now transmitted from station-B to station-A with 480 kVdc

being the dc output voltage of the rectifier-module at station-B, determine;

1. the firing angle αb of the rectifier-moduleat station-B,
2. the firing angle βa of the inverter-module at station-A ( **8 Marks** )

**QUESTION 3**

1. From the operation and characteristics of dc motors, show from first principles that; for a separately-excited dc motor,
2. the power developed by the armature is given by

 Pd = ω x Ia x If x Kt  = ω2 B + ω TL,watts

1. the operating speed is expressed as

$N = \frac{30 Rf \left( Va-Ia Ra \right)}{π Kv Vf} ,$ rpm ( **10 Marks** )

1. A 22.5-Hp, 360-V, 1800-rpm separately-excited dc motor controls a mechanical load requiring a torque of TL = 75 N-m at a speed of 1,200 rev/min. The field circuit resistance is Rf = 135 Ω, the armature circuit resistance is Ra = 0.20 Ω, and the voltage constant of the motor is Kv = 0.7032 V/(A-rad/s). The field voltage is

Vf = 360 V. Assume that the viscous friction and the no-load losses are negligible, and also that the armature current is continuous and ripple free. Determine;

1. the back emf voltage, Eg
2. the required armature voltage, Va ,
3. the rated armature current, Ia of the motor ( **10 Marks** )

**QUESTION 4**

1. With the aid of neat circuit diagrams and suitable waveforms, describe;
2. single-phase semi-converter drive
3. single-phase dual-converter drive ( **6 Marks** )
4. The speed of a separately-excited dc motor is controlled by a single-phase semi-converter drive. The field current is also controlled from another semi-converter drive and the value of field current is set to the maximum. The ac supply to the armature converter and the field converter is single-phase, 240 V, 50 Hz. The armature resistance is Ra = 0**.**225Ω, the field resistance is Rf = 325 Ω and motor voltage constant is Kv = 1**.**050 V/(A-rad/s). The load torque is TL = 125 N-m at a speed of 1,350 rev/min. The armature current and field current are continuous and ripple free. Determine;
5. the value of field current If ,
6. the delay angle, αa of the converter in the armature circuit,
7. the input power factor ( PF ) of the armature circuit. ( **8 Marks** )
8. With suitable neat circuit diagrams and waveforms, describe;
9. 3-phase, semiconverter drive,
10. 3-phase, dual-wave converter drive, ( **6 Marks** )

**QUESTION 5**

(a). With the aid of a neat, simple block diagram, explain the basic operation of a variable speed drive. **( 6 Marks )**

(b). Give the benefits of using a variable speed-drive. **( 4 Marks )**

(c). A three-phase, 11.2 kW, 1750-rpm, 460-V, 50-Hz, star-connected induction motor has the following parameters:



The motor is controlled by varying both the voltage and frequency. The volts/hertz ratio, which corresponds to the rated voltage and rated frequency, is maintained constant.

(i). Calculate the maximum torque *Tm* and the corresponding speed *ωm* for 50 Hz and 25 Hz.

(ii). Repeat (i) if *Rs* is negligible. **( 10 Marks )**