Student ID:____________

# Question 1, Cont'd

(c.) If the drive is operated at 50% of rated speed, find the fundamental current and the three highest switching frequency harmonic currents. *Assume that with constant V/Hz control the slip is also relatively constant (true for fan or pump load) and that under this condition the rotor current amplitude is 99% of the stator current amplitude and that at switching frequency and its harmonics the magnetizing reactance is nearly infinite.*

**Table 8-1** Generalized Harmonics of $v_{Ao}$ for a Large $m_f$.

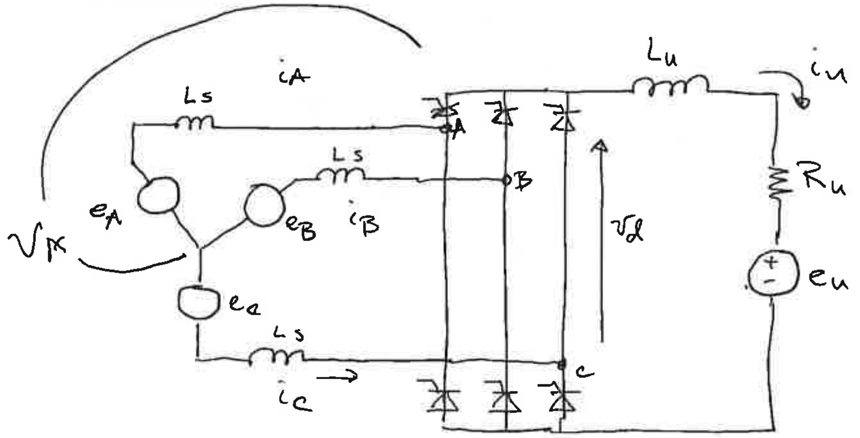
| $h$ \ $m_a$ | *0.2* | *0.4* | *0.6* | *0.8* | *1.0* |
|---|---|---|---|---|---|
| *1* *Fundamental* | *0.2* | *0.4* | *0.6* | *0.8* | *1.0* |
| $m_f$ | 1.242 | 1.15 | 1.006 | 0.818 | 0.601 |
| $m_f \pm 2$ | 0.016 | 0.061 | 0.131 | 0.220 | 0.318 |
| $m_f \pm 4$ | | | | | 0.018 |
| $2m_f \pm 1$ | 0.190 | 0.326 | 0.370 | 0.314 | 0.181 |
| $2m_f \pm 3$ | | 0.024 | 0.071 | 0.139 | 0.212 |
| $2m_f \pm 5$ | | | | 0.013 | 0.033 |
| $3m_f$ | 0.335 | 0.123 | 0.083 | 0.171 | 0.113 |
| $3m_f \pm 2$ | 0.044 | 0.139 | 0.203 | 0.176 | 0.062 |
| $3m_f \pm 4$ | | 0.012 | 0.047 | 0.104 | 0.157 |
| $3m_f \pm 6$ | | | | 0.016 | 0.044 |
| $4m_f \pm 1$ | 0.163 | 0.157 | 0.008 | 0.105 | 0.068 |
| $4m_f \pm 3$ | 0.012 | 0.070 | 0.132 | 0.115 | 0.009 |
| $4m_f \pm 5$ | | | 0.034 | 0.084 | 0.119 |
| $4m_f \pm 7$ | | | | 0.017 | 0.050 |

Note: $(\hat{V}_{Ao})_h/\frac{1}{2}V_d$ [= $(\hat{V}_{AN})_h/\frac{1}{2}V_d$] is tabulated as a function of $m_a$.

# Question 2, ElecEng 471, 575

**Additional EE 572 Question**

For the circuit below a synchronous generator is feeding a phase controlled rectifier operating as a DC motor drive. $L_u$ is very large and $L_u >> L_s$. The output voltage $v_d$ is adjusted using the firing angle $\alpha$ to control the motor speed (which is proportional to the back emf voltage $e_u$). Assume that the motor is loaded to a sufficient level of armature current to ensure that the phase controlled rectifier operates in continuous mode.




a.) Draw the waveshapes for $i_A$, $i_B$, $i_C$ and $v_d$. Be sure to include the effect of $L_s$ on the commutating waveforms.

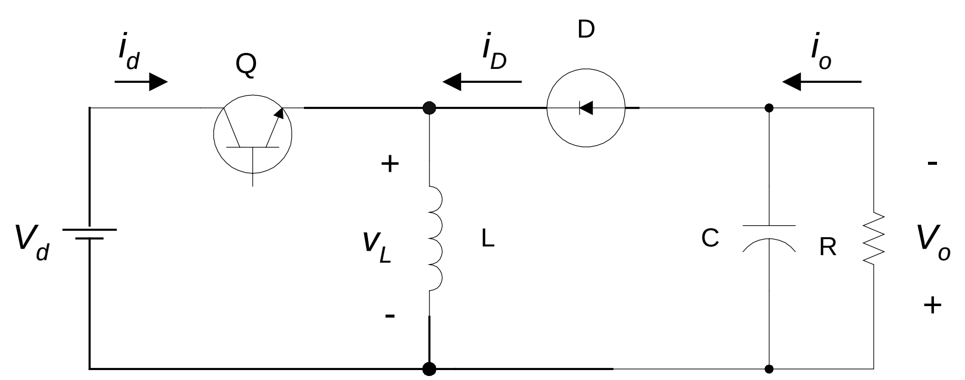
b.) Derive expressions for RMS line to neutral voltage, $v_A$, and average armature current, $i_u$, in terms of $v_d$, $e_u$, $\alpha$ and $R_u$. In this case it is okay to neglect the impact of $L_s$.

# Question 3, ElecEng 471, 575

A Buck-Boost converter is shown below.

(a) Applying the principles of volt-second balance, show the steps to derive the expression for the ratio of output voltage to input voltage as a function of duty cycle (D). *(Note that the output voltage is inverted from the input voltage)*

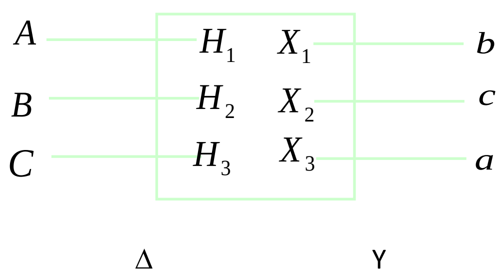
(b) If the Buck-Boost converter has an input of 10V and is to have an output of -20V supplying a 50W load. The switching frequency is 50kHz. Find the duty ratio and calculate the inductor inductance (L) such that the inductor current is no more than 10% of the average inductor current. Also, find the average load current ($i_o$) and input current ($i_d$).



# Question 4, ElecEng 471, 575

(a) A single phase transformer is rated 25KVA and 1300V/200V. Please (a) configure this transformer into a step-up auto-transformer 200V/1500V and (b) calculate the input and output currents of this auto-transformer

(b) A generator supplies the load through a standard Δ-Y transformer. If the symmetrical component currents from the Y side of the transformer to the load are $I_{a1}$= -j1.5, $I_{a2}$ = -j1.5, and $I_{a0}$ = -j2.5. Please find the line current $I_C$ on the Δ side.



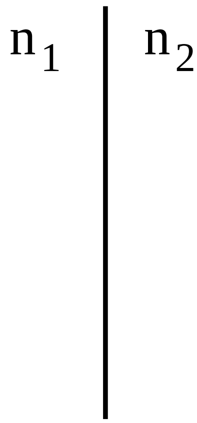
Final grade for this section: __________ out of 40 points

# Photonics

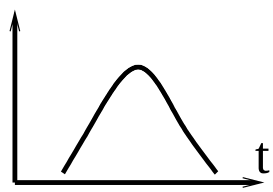
Student ID:____________

# Question 1, ElecEng 464, 565

The following three questions relate to the following diagram for an interface between two media with refractive indices $n_1$ and $n_2$. You can draw your answer on the diagram.




a) Assume $n_1 > n_2$. Draw an incident ray with angle of $\theta_i$ and a transmitted ray with refraction angle of $\theta_t$.
b) Draw the reflected ray
c) The ray direction is the propagation direction. Draw the electric and magnetic field directions for incident, transmitted and reflected waves for a **s-polarized** incident wave.
d) If dispersion parameter $D_\lambda > 0$, how does delay depend on frequency? Label in the following diagram the relative temporal position of low and high frequencies.



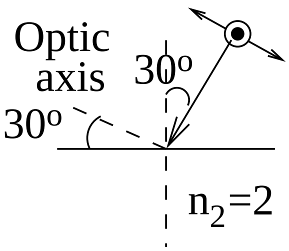

e) An 1mW Gaussian beam with beam radius W = 0.1 mm. Find its peak intensity.

g) Estimate power transmission of a wave traversing a thin layer of GaAs with refractive index of 3.5 which has air as its outside medium. Assume normal incidence of the wave.

Student ID:____________

# Question 2, ElecEng 565

a. Consider a crystal with $n_e = 1.553$ and $n_o = 2.052$ at wavelength $\lambda_o = 1\mu m$.
i. Draw the k surfaces for the ordinary wave and extraordinary wave.
ii. For an interface between the crystal and a medium with refractive index $n_2 = 2$ as show in the diagram. Find the angle $\theta_{2o}$ between the normal and the ordinary wave and the angle $\theta_{2e}$ between the normal and the extraordinary wave in the medium.




b. Design a optical modulator with a rotator and two polarizers. Be sure you specify the orientation of the polarizers and find the Jones matrix of the modulator. Show that the modulator can vary the intensity by changing the angle of polarization rotation.

Student ID:____________

# Question 3, ElecEng 464

A 2-km-length multimode fiber has a modal dispersion of 1 ns/km and a chromatic dispersion of 100 ps/km• nm. If it is used with an LED of linewidth 40 nm, (a) what is the total dispersion? (b) Calculate the bandwidth (BW) of the fiber.

Student ID:____________

# Question 4,ElecEng 464

A fiber has attenuation of 0.6 db/km at 1300nm and 0.3 dB/km at 1550nm. Suppose two optical signals are launched into the fiber simultaneously; an optical power of 150 μW at 1300nm and an optical power of 100 μW at 1550nm. What are the power levels in μW of these two signals after 8km propagation in the fiber. (10)