PART - I

1) Three phase 400V (line-to-line rms), 50Hz is used to energize a resistive load by using a three phase diode rectifiers.

Analytical derivation

a. Derive and calculate the average DC voltage output of the rectifier.
b. What would be the resistance of the resistive load if the average power of the load is 3kW.
c. What is voltage ripple at the output of rectifier?

Simulation

Note**:** Assume that all components are ideal, without any losses.

d. By using the provided template, simulate the rectifier with 3kW resistive load.
e. Obtain and plot three phase input current waveforms for 2 fundamental periods on the same plot.
f. Obtain output voltage waveform of the rectifier.
g. Obtain average DC voltage output of the rectifier from your plot. Does your analytical average voltage calculation match with your simulation result? Comment on any differences, if any.
h. Suggest a method to reduce voltage ripple at the output of the rectifier.

PART - II

2) Consider a permanent magnet DC motor driven by a buck converter. Input voltage of the buck converter is 300V. Switching frequency of the buck converter is 10kHz. There is no capacitor and inductor at the end of the buck converter. Parameters of the motor are shown in table below. Ignore friction forces.

Parameter Name	**Value**
Machine constant (Vs/rad) (or Torque Constant (Nm/A))	2
Inertia of the Motor (kgm^2)	0.5
Armature Resistance (mΩ)	700
Armature Inductance (mH)	20
Load Torque (Nm)	$0.0026*\omega^2$

The DC motor will drive a fan load with the given characteristics in the table. Note that the load torque is proportional with the square of the speed, ω^2. The unit for speed in this expression is rad/s.

Analytical derivation

a. Duty cycle of the buck converter is adjusted as 50% and motor is running in motoring mode. Find steady state armature current, torque and speed of the motor. Ignore the inductance in your derivation.
b. Assume that we want to have output power of 3kW for the fan load. Calculate the required duty cycle for this operation. Ignore the inductance in your derivation.

Simulation

Note**:** Assume that all components are ideal, without any losses.

c. By using the provided template, simulate motor drive system. Obtain armature current, motor speed, torque, waveforms for 50%, 75% and 100% duty cycles. Comment on the results.
d. Plot 10ms average efficiency waveform of motor drive system from zero speed to steady state speed (buck converter and DC motor). Comment on the result.
   Hint 1: You need to use mean block to obtain average input and average output of the system.
   Hint 2: Note that switch is ideal, all motor losses are ignored except for armature conduction losses.
e. Explain why there is no need to add an additional inductor and capacitor at the end of the buck converter.

3) (Bonus) In the model, change the switching frequency to 25kHz. Plot the current waveforms and comment on the differences with Part (2c) 50% duty cycle.

Note: In order to get full credit, make sure that your plots have white background, visible traces, and large axis font size. Also, put legends for plots with multiple lines. See the sample plot below.

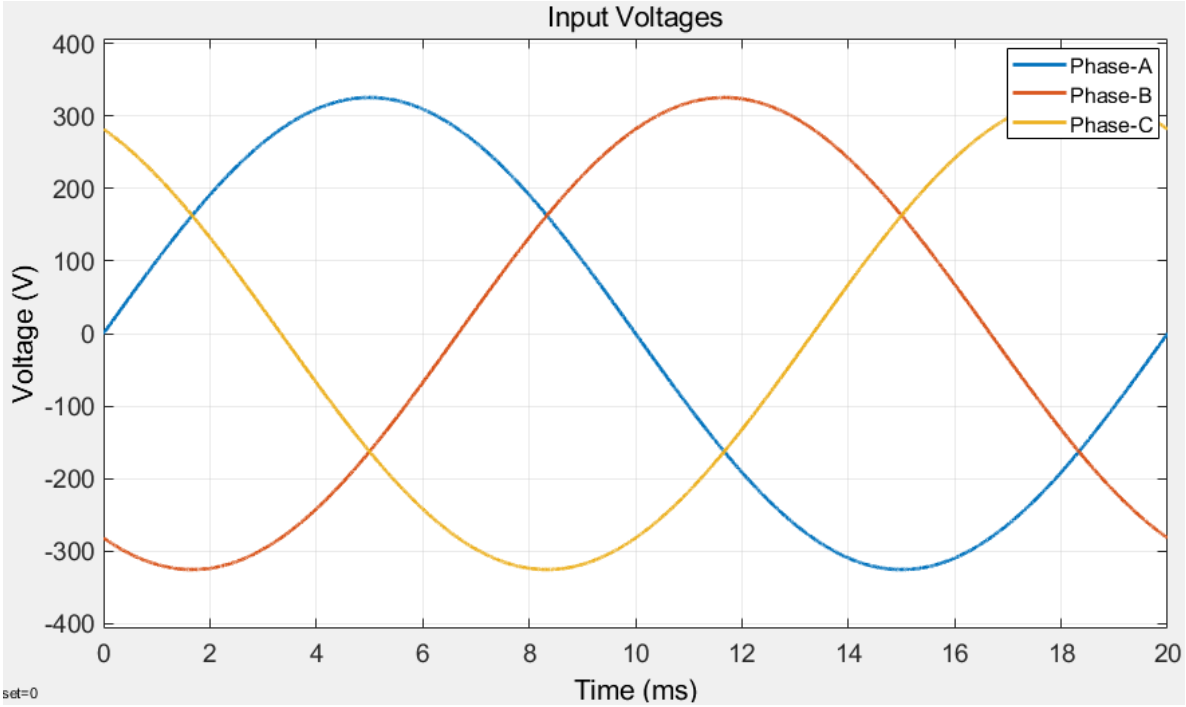

Fig. Sample plot