EE361 Homework 3 Part I

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```
% Preliminary Definitions.
P_mec = 250; %W

Va_rated = 48; %V

R_a = 73e-3; %ohm
L_a = 120e-6; %Henry
K_a = 0.3416; %V/(rad/sec)

J_a = 0.0130; %kg*m^2
```

Step A)

The rated current, input power and rated power of the motor is calculated and given in the following code output.

```
%% step a)


I_rated_roots = roots([R_a -Va_rated P_mec]);

I_rated = I_rated_roots(2);%The first root is not a realistic one
I_rated
```

```
I_rated = 5.2503
```

```
P_in = I_rated .* Va_rated;
P_in
```

```
P_in = 252.0123
```

```
Ea = P_mec ./ I_rated;
Ea
```

```
Ea = 47.6167
```

```

omega_rated = Ea/K_a; %rad/sec
omega_rated
```

```
omega_rated = 139.3932
```

```

omega_rated_rpm = omega_rated *  60/(2*pi)
```

```
omega_rated_rpm = 1.3311e+03
```

Step B)

The loss is calculated through following snippet and the efficiency is calculated afterwards.

```
%step b)

P_loss = 7.8 + 0.2*omega_rated + 0.002076* omega_rated^2 ;
P_loss
```

```
P_loss = 76.0163
```

```

P_out = P_mec  - P_loss;
P_out
```

```
P_out = 173.9837
```

```

efficiency = P_out/P_in;
efficiency
```

```
efficiency = 0.6904
```

Step C)

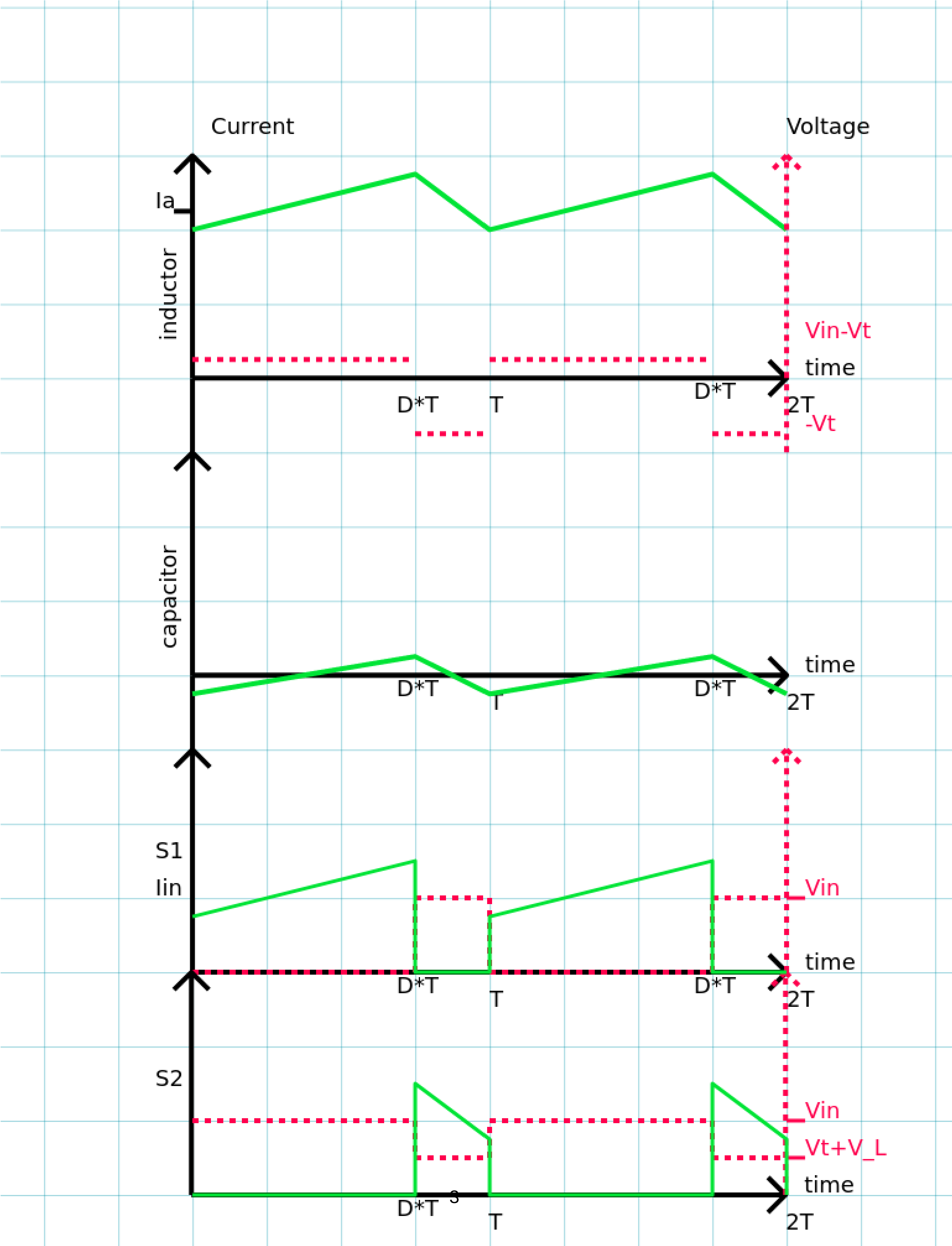
The velocity is calculated from the angular speed than it is converted to km/h scale.

```
%%step c)
diameter = 10e-2;

speed_ms = omega_rated*diameter/2;

speed_kmh = speed_ms*3.6;
speed_kmh
```

```
speed_kmh = 25.0908
```

Step D)

For the substeps the subplot given in Figure 1 is sketched.


Current
Voltage
Ia
inductor
Vin-Vt
time
D*T
T
D*T
2T
-Vt
capacitor
time
D*T
T
D*T
2T
S1
Iin
Vin
time
D*T
T
D*T
2T
S2
Vin
Vt+V_L
time
D*T
T
2T

```
%%step d)
time = linspace(0,2);

V_bat = 52; %V

D = Va_rated/V_bat;
```

v.)

Maximum Instantaneous Voltage for S1: Vin = 52V

Maximum Instantaneous Voltage for S2: Vin = 52V

Maximum Instantaneous Current for S1: $I_a + \frac{(V_{in} - V_T)DT}{2L}$

Maximum Instantaneous Current for S2: $I_a + \frac{(V_{in} - V_T)DT}{2L}$

Therefore they are same.

Step E)

The range of duty cycle is calculated and displayed in the following snippet.

```
%% step e)

max_D_cycle = D * 100 ;%Percent
min_D_cycle = 0 ;%Percent
disp("Range of duty cycle is [0," + max_D_cycle +"]");
```

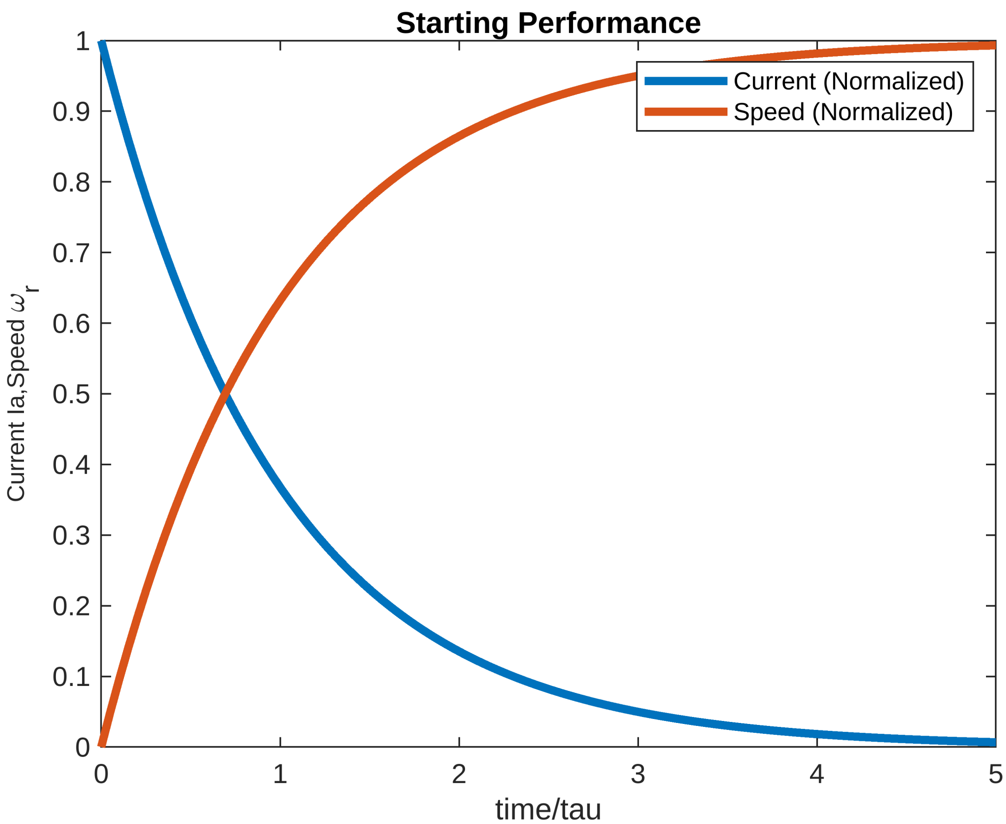
```
Range of duty cycle is [0,92.3077]
```

Step F)

The starting status of the motor is calculated through. The plot is obtained through a normalization of the data in order not to have L shaped small graph.

```
%% step f)

time_f = linspace (0,5);

tau = (R_a*J_a)/K_a^2;

Ia0 = Va_rated/R_a;

motor_current = Ia0*exp(-time_f/tau) + I_rated;

normalized_motor_current = exp(-time_f);
figure;
plot(time_f,normalized_motor_current,"LineWidth",3);
hold on;
```

```
omega_0 = Va_rated/K_a;
omega = omega_0*(1-exp(-time_f/tau));
normalized_omega = 1-exp(-time_f);
plot(time_f,normalized_omega,"LineWidth",3);
title("Starting Performance")
xlabel("time/tau");
ylabel("Current Ia,Speed \omega_r");
legend("Current (Normalized)","Speed (Normalized)")
```



Step F)

At the beginning of the start procedure very high amount of current pass through the motor. That is in general not a big deal for small motors so they can withstand the high current for short amount of time intervals. However for some motors high current may be dangerous and can damage all the power circuitry with motor. One can adress this problem with the following techniques.

- An inductor can be connected series to the motor so that the sudden current changes can be prevented.
- Duty cycle can be increased slowly starting from 0.
- Any current limitation can be done via a power electronics circuitry.