Electrical Machines

Assignment 2

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EE22BTECH11003

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Problem

Simulate DC shunt machine using dynamic equations and plot the variations for the following quantities:

1. Supply voltage
2. Load current
3. Field current
4. Speed

Solution

The dynamic equations for a DC shunt machine are given by:

$$V = E + I_a R_a + L_a \frac{dI_a}{dt}$$
$$E = K_m \omega$$
$$T_m = K_m \Phi I_a$$
$$T_f = J\frac{d\omega}{dt} + B\omega$$

Where:

$$
\begin{aligned}
V &= \text{Supply voltage} \\
E &= \text{Back emf} \\
I_a &= \text{Armature current} \\
R_a &= \text{Armature resistance} \\
R_f &= \text{Shunt field resistance} \\
L_a &= \text{Armature inductance} \\
T_m &= \text{Mechanical torque} \\
T_f &= \text{Friction torque} \\
K_m &= \text{Machine constant} \\
\Phi &= \text{Flux} \\
\omega &= \text{Speed} \\
J &= \text{Moment of inertia} \\
B &= \text{Coefficient of friction}
\end{aligned}
$$

The equivalent circuit of a DC shunt machine is shown below.

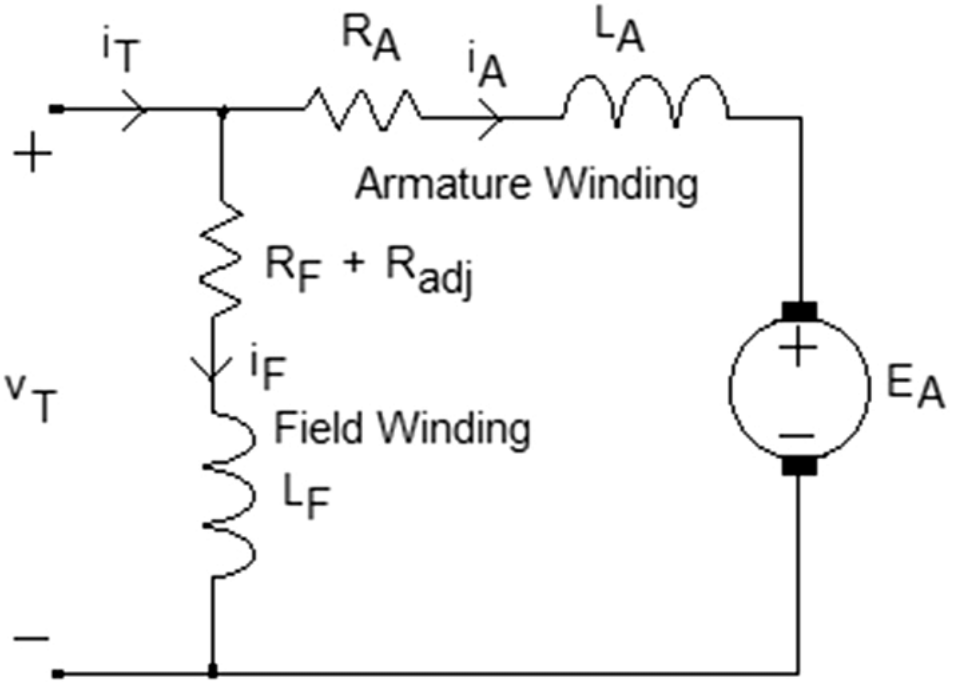


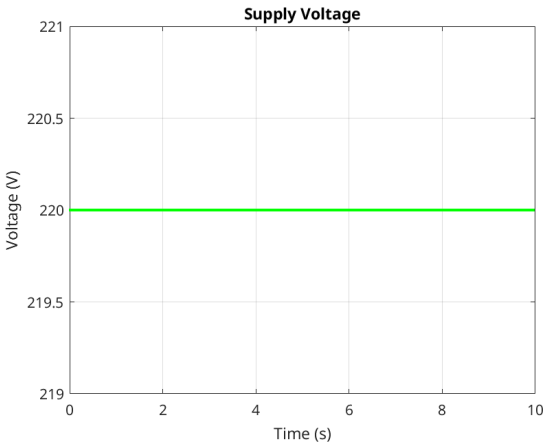
Figure 1: Equivalent circuit of a DC shunt machine

The above equations can be solved using numerical methods. The following code simulates the DC shunt machine and plots the variations of the quantities mentioned in the problem statement.

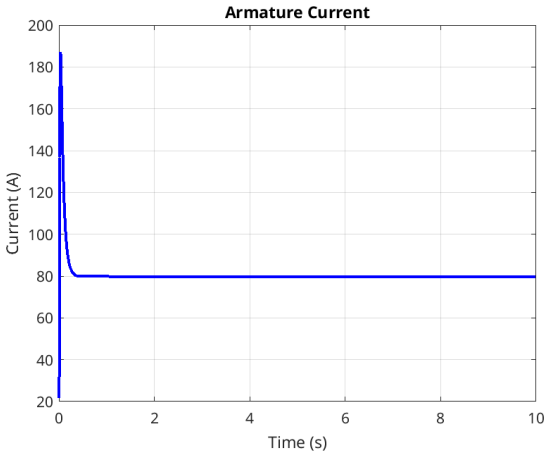
```
Vs = 220;
Ra = 1;
Rf = 200;
Km = 0.1;
La = 0.01;
J = 0.001;
B = 0.005;
T_load = 1;
Lf = 0.01;

t_max = 10;
dt = 0.001;

Ia = 0;
w = 0;
If = 1;

t = 0:dt:t_max-dt;

Ia_data = zeros(size(t));
w_data = zeros(size(t));
Vs_data = Vs * ones(size(t));
If_data = zeros(size(t));

for i = 1:length(t)
  dIa_dt = (Vs - Ra*Ia - Km*w) / La;
  Ia = Ia + dIa_dt * dt;

  dw_dt = (Km*Ia - B*w - T_load) / J;
  w = w + dw_dt * dt;

  dIf_dt = (Vs - Rf*If) / Lf;
  If = If + dIf_dt * dt;

  Ia_data(i) = Ia;
  w_data(i) = w;
  If_data(i) = If;
end

figure(1);
plot(t, Vs_data, 'g', 'LineWidth', 2);
xlabel('Time (s)');
ylabel('Voltage (V)');
title('Supply Voltage');
grid on;

figure(2);
plot(t, Ia_data, 'b', 'LineWidth', 2);
xlabel('Time (s)');
```

```
ylabel('Current (A)');
title('Armature Current');
grid on;

figure(3);
plot(t, w_data * (60/(2*pi)), 'r', 'LineWidth', 2);
xlabel('Time (s)');
ylabel('Speed (RPM)');
title('Speed');
grid on;

figure(4);
plot(t, If_data, 'm', 'LineWidth', 2);
xlabel('Time (s)');
ylabel('Current (A)');
title('Field Current');
grid on;
```

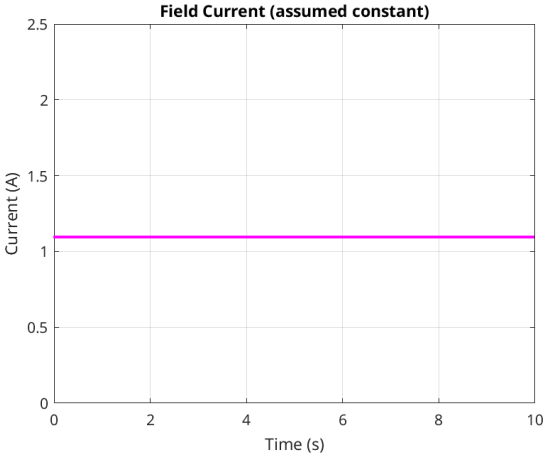
The above code simulates the DC shunt machine and plots the variations of the quantities mentioned in the problem statement. The following plots show the variations of the quantities over time.



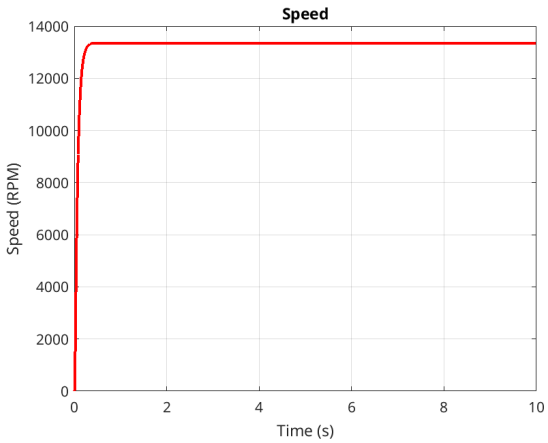
(a) Supply voltage



(b) Load current



(c) Field current



(d) Speed