EE160 Lab Assignment-7

Lab section 1A

Rotating Magnetic Field

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Objectives:

Create and execute a Matlab Program that simulates:

(a) Rotating Magnetic Field

If a three-phase set of currents, each of equal magnitude and differing in phase by 120^o, flows in a three-phase winding, then it will produce a rotating magnetic field of constant magnitude.

Observe the following:

(i) What will happen when the current in any two of the three coils is swapped?

(ii) What would be the effect of variation of the amplitude of currents in each phase?

(iii) What would be the effect of variations in phase angles?

(iv) What would be the effect of increasing / decreasing the value of electrical frequency?

(v) What would be the effect of incorporating more sets of three-phase winding, i.e., increasing the number of magnetic poles?

(b) Interaction of the magnetic field produced by a current carrying one-loop rotor with the rotating magnetic field of the three-phase stator windings.

Observe the following:

(i) Is the loop's magnetic field trying to align with the rotating magnetic field?

(ii) If yes then what is the mechanical speed of the loop's magnetic field?

(iii) What would be the effect of variations in the initial mechanical angle between the two fields?

Code

part(A)

_AB Drive/lab7.m

```
% M-file, mag_field.m
% M-file to calculate the net magnetic field produced
% by a three-phase stator.

% Set up the basic conditions
bmax = 1; % Normalize bmax to 1
freq = 50; % 60 Hz
w = 2*pi*freq; % angular velocity (rad/s)

% First, generate the three component magnetic fields
t = 0:1/6000:1/10;
Baa = sin(w*t) .* (cos(0) + 1j*sin(0));
Ebb = sin(w*t - 2*pi/3) .* (cos(2*pi/3) + 1j*sin(2*pi/3));
Ecc = sin(w*t + 2*pi/3) .* (cos(-2*pi/3) + 1j*sin(-2*pi/3));

% Calculate Enet
Enet = Baa + Ebb + Ecc;

% Calculate a circle representing the expected maximum
% value of Enet
circle = 1.5 * (cos(w*t) + 1j*sin(w*t));

% Plot the magnitude and direction of the resulting magnetic
% fields. Note that Baa is black, Ebb is blue, Ecc is magenta,
% and Enet is red.
for ii = 1:length(t)
    % Plot the reference circle
    plot(circle, 'k');
    hold on;

    % Plot the four magnetic fields
    plot([0 real(Baa(ii))], [0 imag(Baa(ii))], 'k', 'LineWidth', 2);
    plot([0 real(Ebb(ii))], [0 imag(Ebb(ii))], 'b', 'LineWidth', 2);
    plot([0 real(Ecc(ii))], [0 imag(Ecc(ii))], 'm', 'LineWidth', 2);
    plot([0 real(Enet(ii))], [0 imag(Enet(ii))], 'r', 'LineWidth', 3);

    axis square;
    axis([-2 2 -2 2]);
    drawnow;
    hold off;
end
```

Code:

part(b)

_AB Drive/lab72.m

```
% M-file, mag_field.m
% M-file to calculate the net magnetic field produced
% by a three-phase stator.
% Set up the basic conditions
bmax = 1; % Normalize bmax to 1
freq = 100; % 60 Hz
w = 2 * pi * freq; % angular velocity (rad/s)
% First, generate the three component magnetic fields
t = [0:1/6000:1/60]; % Time vector from 0 to 1/60 with step 1/6000
O = 0; % Angle offset, set to 0 for simplicity
Baa = sin(w * t) .* (cos(O) + 1i * sin(O));
% M-file, mag_field.m
% M-file to calculate the net magnetic field produced
% by a three-phase stator.
% Set up the basic conditions
bmax = 1; % Normalize bmax to 1
freq = 100; % 60 Hz
w = 2 * pi * freq; % angular velocity (rad/s)
% First, generate the three component magnetic fields
t = 0:1/6000:1/1; % Time vector from 0 to 1/60 with step 1/6000
O = 0; % Angle offset, set to 0 for simplicity
Baa = sin(w * t) .* (cos(O) + 1i * sin(O));
Ebb = sin(w * t - 2*pi / 3) .* (cos(2*pi / 3) + 1i * sin(2*pi / 3));
Ecc = sin(w * t + 2* pi / 3) .* (cos(-2 * pi / 3) + 1i * sin(-2 * pi / 3));
% Calculate Enet
Enet = Baa + Ebb + Ecc;
Bloop =(cos(w*t+O) + 1i * sin(w*t+O));
% Calculate a circle representing the expected maximum value of Enet
circle = 1.5 * (cos(w * t) + 1i * sin(w * t));
% Plot the magnitude and direction of the resulting magnetic fields.
% Note that Baa is black, Ebb is blue, Ecc is magenta, and Enet is red.
for ii = 1:length(t)
    % Plot the reference circle
    plot(circle, 'k');
    hold on;
    % Plot the four magnetic field
    plot([0 real(Enet(ii))], [0 imag(Enet(ii))], 'r', 'LineWidth', 3);
    plot([0 real(Bloop(ii))], [0 imag(Bloop(ii))], 'r', 'LineWidth', 3);
    axis square;
    axis([-2 2 -2 2]);
    drawnow;
    hold off;
end
```

Observations:

(a)

(i) Reversing the current in any two of the three coils will result in a reversal of the magnetic field's rotation direction.

(ii) The strength of the rotating magnetic field is directly proportional to the amplitude of the currents. Enhancing the current amplitudes will lead to a more powerful magnetic field, whereas reducing the amplitudes will result in a weaker magnetic field.

(iii) The relative timing of the currents in each coil is determined by the phase angles. Altering the phase angles will change the initial positions of the rotating magnetic field. The magnetic field will still rotate, but its starting position and rotational speed may be modified.

(iv) The speed of rotation of the magnetic field is determined by the electrical frequency. Increasing the frequency will accelerate the rotation, while decreasing the frequency will slow it down.

(v) Increasing the number of magnetic poles will decrease the rotational speed and impact the torque and speed characteristics of the motor.

(b)

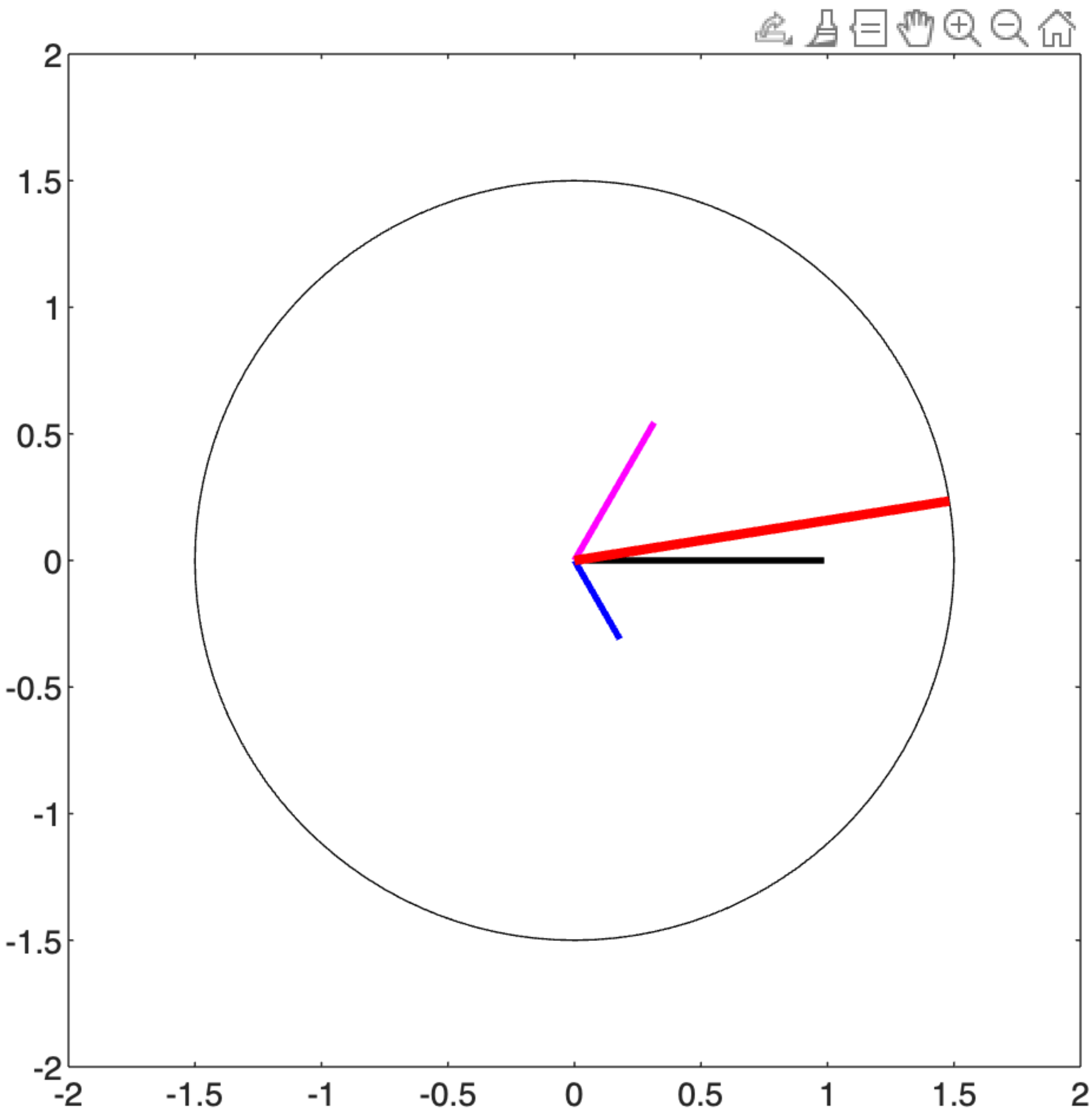
(i) The magnetic field generated by the single-loop rotor will attempt to align itself with the rotating magnetic field.

(iii) The rotational speed of the rotor's magnetic field can be determined by dividing the electrical frequency by the number of magnetic poles.

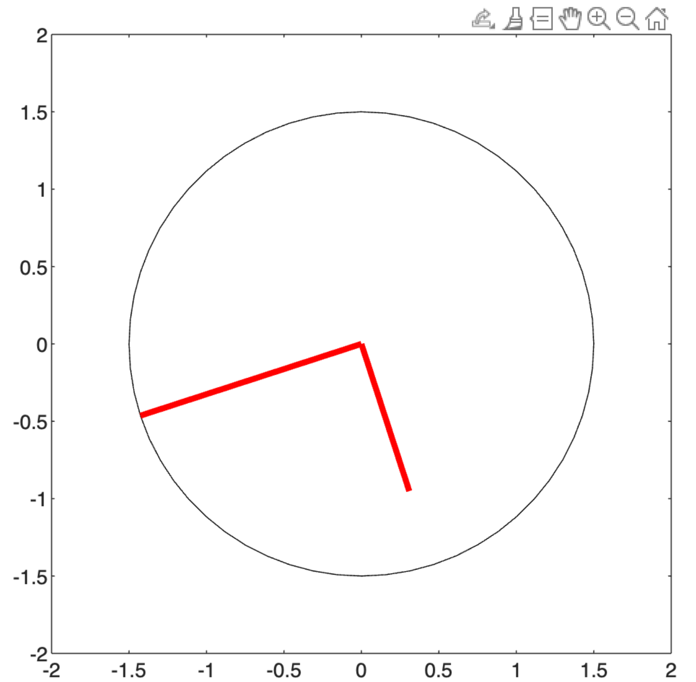
(iv) Changes in the initial mechanical angle between the two fields lead to a phase shift or misalignment between them. The interaction and alignment of the fields depend on the specific initial mechanical angle.

Results:

part(a) B_{net} is of constant magnitude



part(b)



B_{loop} is chasing B_{net} .

1. Swapping the current in any two of the three coils reverses the direction of the rotating magnetic field.
2. Increasing the amplitude of the currents strengthens the rotating magnetic field, while decreasing the amplitude weakens it.
3. Changing the phase angles alters the starting position and speed of rotation of the magnetic field.
4. Increasing the electrical frequency speeds up the rotation of the magnetic field, while decreasing it slows down the rotation.
5. Incorporating more sets of three-phase windings or magnetic poles decreases the speed of rotation and affects motor characteristics.
6. The magnetic field of a one-loop rotor aligns with the rotating magnetic field.
7. The mechanical speed of the loop's magnetic field is determined by dividing the electrical frequency by the number of magnetic poles.
8. Variations in the initial mechanical angle between the two fields result in phase shifts or misalignment between them.