EE 462 – Utilization of Electric Energy

2018-2019 Spring Semester

Homework 2

Deadline: April 3th Wednesday 5 pm

1. Show that we can produce a rotating field in a five-phase system.

   a. Draw the winding diagram of a 2-pole 10-slot 5-phase stator structure, show positive and negative coil sides of each phase. What is the spatial phase shift between phases?

   b. Write down the phase currents assuming that Phase A has the following current. What is the electrical phase shift between phase currents?

   $$I_A = I_{max}\, cos(\omega_e t)$$

   c. Write down the positive and negative MMF sequences created by each phase. Assume that Phase A creates the following MMF waveform. Where ω_e is the electrical frequency and α is the spatial position.

   $$Acos(\omega_e t)\sin(\alpha)$$

   d. Show that we can create a rotating fields rotating both in positive and negative directions. How do we change the direction of the rotating field.

   e. Draw MMF space vectors created by each phase on $\alpha\beta - plane$ and show the resultant rotating MMF space vector **at time equal to 0**.

   f. What is the amplitude of the resultant rotating field in terms of A? Compare it with a 3-phase system discussed during lectures.

2. For amplitude invariant space vector transformation (Clarke's Transformation), show that power of 3-phase system is 3/2 times the power of the 2-phase system.

   $p_{3-phase} = v_1\, i_1 + v_2\, i_2 + v_3\, i_3 = \mathrm{Re}\{v\, i^*\}$

   $p_{2-phase} = \mathrm{Re}\{(v_\alpha + j\, v_\beta)\,(i_\alpha - j\, i_\beta)\} = v_\alpha\, i_\alpha + v_\beta\, i_\beta$

   $\rightarrow p_{3-phase} = 3/2\, p_{2-phase}$

3. Implement amplitude invariant space vector and coordinate transformations using either Matlab or Matlab/Simulink. Do not use ready to use blocks. Use the following time functions as your inputs in abc coordinates or 3-phase coordinates.

   $x_1 = 100\ cos(\omega_e t)$

   $x_2 = 100\ cos\left(\omega_e t - \frac{2\pi}{3}\right)$

   $x_3 = 100\ cos\left(\omega_e t + \frac{2\pi}{3}\right)$

   a. Plot the inputs $x_1, x_2\ and\ x_3$ as a function of time.

   b. Calculate $x_\alpha\ and\ x_\beta$ and plot them as a function of time.

   c. Calculate $x_d\ and\ x_q$ and plot them as a function of time.

   d. Comment on the advantages of abc → dq transformation.

   Please share your code or Simulink block contents.

Note: If you copy your homework from other students, your grade will be multiplied by -1.