# PE-1
# August 2017 QE



You must show work for credit

Problem 1. 33 pts. The torque of a magnetically linear single-phase electromechanical device may be expressed

$$T_e = 8\cos(4\theta_{rm})i^2$$

When the rotor position is zero, the inductance is 5 H. What is the flux linkage equation for the device?

Problem 2. 33 pts. The $a$-phase conductor density of a machine is given by

$$n_{as} = -6\cos(4\phi_{sm})$$

where $\phi_{sm}$ is position measured relative to the stator. The radial flux density at the stator inner radius is given by

$$\mathrm{B}(\phi_{rm}) = \frac{2}{3}\cos(4\phi_{rm})$$

where $\phi_{rm}$ is position measured relative to the rotor. The machine is 0.1 m long. With the stated flux density, and neglecting winding resistance and leakage inductance, it is desired that the $a$-phase voltage is a 100 V zero-to-peak sinewave when the mechanical rotor speed is $1000/\pi$ rad/s. What should be the radius (stator inner radius) of the machine?

Handy Fact: $2\sin A\cos B = \sin(A+B)+\sin(A-B)$

Problem 3. 34 pts. Transform the following flux linkage equation to the rotor reference frame:

$$\lambda_{abcs} = \begin{bmatrix} 4 & -1 & -1 \\ -1 & 4 & -1 \\ -1 & -1 & 4 \end{bmatrix} i_{abcs} + 2\begin{bmatrix} \cos(\theta_r) \\ \cos(\theta_r - 2\pi/3) \\ \cos(\theta_r + 2\pi/3) \end{bmatrix}$$

Handy facts:

$$\cos(x)+\cos(x-2\pi/3)+\cos(x+2\pi/3)=0$$
$$\sin(x)+\sin(x-2\pi/3)+\sin(x+2\pi/3)=0$$
$$\cos(x)\cos(y)+\cos(x-2\pi/3)\cos(y-2\pi/3)+\cos(x+2\pi/3)\cos(y+2\pi/3)=\frac{3}{2}\cos(x-y)$$
$$\sin(x)\sin(y)+\sin(x-2\pi/3)\sin(y-2\pi/3)+\sin(x+2\pi/3)\sin(y+2\pi/3)=\frac{3}{2}\cos(x-y)$$
$$\sin(x)\cos(y)+\sin(x-2\pi/3)\cos(y-2\pi/3)+\sin(x+2\pi/3)\cos(y+2\pi/3)=\frac{3}{2}\sin(x-y)$$

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