

# ECE 842 Midterm

Due Date Nov 3

Assume the following model structure.

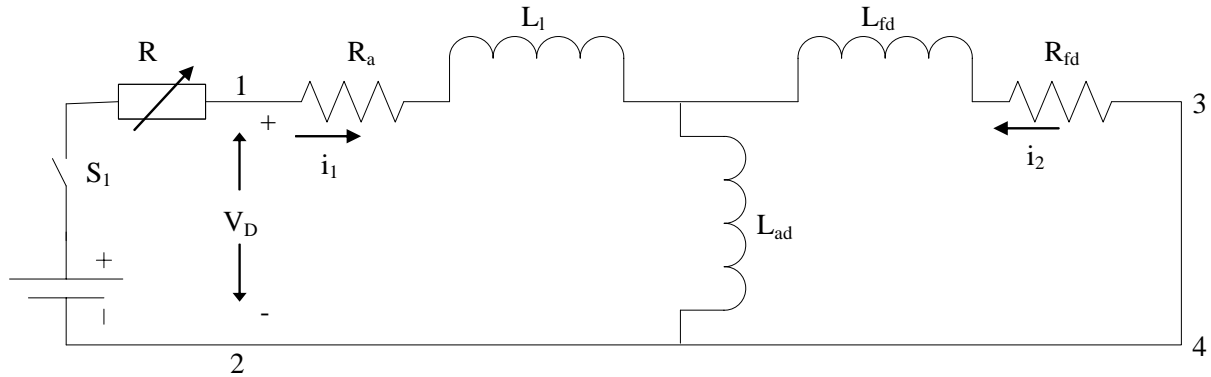


Fig 1

Where  $R_a = 0.4205 \Omega$   
 $L_1 = 0.0011 \text{ H}$   
 $R_{fd} = 0.5589 \Omega$   
 $L_{fd} = 0.020 \text{ H}$   
 $L_{ad} = 0.060 \text{ H}$

Write a matlab simulation test bed to perform the following:

Derive the continuous time state-space model

$$\dot{X} = AX + BU$$

And determine the matrices A and B.

Derive the discrete time state space model

$$X(k+1) = A^* X(k) + B^* UK(k)$$

- 1) Show simulation steps and selection of sample times. Make sample time 100 times smaller than the settling time.
- 2) Apply 120V dc voltage pulse to terminal (1) and (2) and limit the current to 150 Amp and record  $i_1$ ,  $i_2$  and  $u$ .
- 3) Use Matlab commands to convert the continuous time model to discrete-time model. Record  $i_1$ ,  $i_2$  and  $u$ .
- 4) Plot  $i_1$ ,  $i_2$  and  $u$  of part 2 and 3 and discuss the results.

- 5) Compute Eigen values of continuous time state space model.
- 6) Write a Matlab program to convert discrete-time state space model A\* and B\* to continuous time state space model A and B
- 7) Use Matlab command to convert A\* and B\* to A and B
- 8) Discuss the results of part 6 and 7.
- 9) Assume the model structure is given as shown in Fig 1. Also the model input output response data are known, however the model parameters are not known. Estimate the model parameters using the generated data and LSQ estimation. Your LSQ estimation program must be written in Matlab.
- 10) Assume the generated data are noise corrupted using the following procedure:

$$\tilde{V}_d(k) = V_d(k) + \alpha_1(k) v_1(k)$$

$$\tilde{I}_d(k) = I_d(k) + \alpha_2(k) v_2(k)$$

$$\tilde{I}_{fd}(k) = I_{fd}(k) + \alpha_3(k) v_3(k)$$

Where  $\tilde{V}_d(k)$ ,  $\tilde{I}_d(k)$  and  $\tilde{I}_{fd}(k)$  are noise corrupted quantities and  $V_d(\cdot)$ ,  $I_d(\cdot)$  and  $I_{fd}(\cdot)$  correspond to the noise-free terminal values.

Define 
$$\alpha_i(k) = \left| \frac{\text{signal}(k)}{S/N \text{ ratio}} \right|$$

Where signal (k) corresponds to the noise-free signal strength and the S / N ratio indicated the signal / noise ratio used in the noise corruption process.

$$S/N \text{ ratio} = \left| \frac{\sum_{k=0}^N \text{signal}^2(k)}{\sum_{k=0}^N \alpha_i v_i^2(k)} \right|^{1/2}$$

The sequence  $v_i(\cdot)$  in the above equation is Gaussian distributed with zero mean and unity variance.

Assume the following cases:

a)  $\frac{S}{N} = 2000 : 1$

b)  $\frac{S}{N} = 1000 : 1$

c)  $\frac{S}{N} = 200 : 1$

Write a Matlab LSQ estimator and estimate the parameters of the model from the noise corrupted data.

11) Use Matlab command for LSQ estimator and estimate the parameters of the model from the noise-corrupted data.