



B.Tech - Even Sem : End Semester Exam  
Academic Year:2021-2022  
**18EE4141 - BATTERY STATES ESTIMATION**  
Set No: 1

| Time: |                                                                                                                                                                                                                                                                                                                                                                                             | Max.Marks: 100 |         |         |     |
|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|---------|---------|-----|
| S.NO  | Answer All Questions                                                                                                                                                                                                                                                                                                                                                                        | Choice         | Options | Marks   | CO  |
| 1.    | Determine SOC from stoichiometry and prove that it cannot be easily determined from battery chemistry.                                                                                                                                                                                                                                                                                      | choice Q-2     |         | 10Marks | CO1 |
| 2.    | Briefly explain the current based SOC estimation method and support why it is termed as poor estimation method.                                                                                                                                                                                                                                                                             |                |         | 10Marks | CO1 |
| 3.    | Answer the following questions                                                                                                                                                                                                                                                                                                                                                              | choice Q-4     |         | 15Marks | CO1 |
| 3.A.  | Illustrate how the performance of Electric vehicle gets effected by accurate estimation of battery SOC.                                                                                                                                                                                                                                                                                     |                |         | 8Marks  | CO1 |
| 3.B.  | Consider random variable X having Gaussian distribution with mean of 3 and variance of 4, random variable Y having Gaussian distribution with mean of -1 and variance of 9. Consider random variable Z=2X+3Y. Determine i) Expected value of Z ii) Covariance of Z iii) If X and Y are uncorrelated determine expected value of Z conditioned upon X=1                                      |                |         | 7Marks  | CO1 |
| 4.    | Answer the following questions                                                                                                                                                                                                                                                                                                                                                              |                |         | 15Marks | CO1 |
| 4.A.  | Identify the condition for random variables to be called as independent and uncorrelated                                                                                                                                                                                                                                                                                                    |                |         | 8Marks  | CO1 |
| 4.B.  | Elaborate in detail the steps for solution of state estimation using sequential probabilistic inference                                                                                                                                                                                                                                                                                     |                |         | 7Marks  | CO1 |
| 5.    | Apply various matrix factorization methods we follow to generate correlated random vectors using octave code.                                                                                                                                                                                                                                                                               | choice Q-6     |         | 10Marks | CO2 |
| 6.    | Derive the prediction step of Kalman filter and Analyze the effect of each parameter on the estimation of state variable                                                                                                                                                                                                                                                                    |                |         | 10Marks | CO2 |
| 7.    | Answer the following questions                                                                                                                                                                                                                                                                                                                                                              | choice Q-8     |         | 15Marks | CO2 |
| 7.A.  | Describe the following terms with their symbols i) Predicted value of state variable ii) Estimated value of state variable iii) Predicted error of state variable                                                                                                                                                                                                                           |                |         | 8Marks  | CO2 |
| 7.B.  | Develop code in octave for step-2 of Kalman filter algorithm applied to the system given below with zero initial conditions<br>$\Sigma_{\tilde{w}} = \Sigma_{\tilde{v}} = 1$ $x_k = x_{k-1} + u_{k-1} + w_{k-1}$ $y_k = x_k + v_k$                                                                                                                                                          |                |         | 7Marks  | CO2 |
| 8.    | Answer the following questions                                                                                                                                                                                                                                                                                                                                                              |                |         | 15Marks | CO2 |
| 8.A.  | For the given cell model identify the input and output variable and model matrices. Consider $R_0=0.01, Q=100000/3600$ .<br>$z_{k+1} = 1 \cdot z_k - \frac{1}{3600 \cdot Q} i_k$ $\text{volt}_k = 3.5 + 0.7 \times z_k - R_0 i_k$                                                                                                                                                           |                |         | 8Marks  | CO2 |
| 8.B.  | For the given cell model<br>$z_{k+1} = 1 \cdot z_k - \frac{1}{3600 \cdot Q} i_k$ $\text{volt}_k = 3.5 + 0.7 \times z_k - R_0 i_k$ $\Sigma_{\tilde{w}} = \Sigma_{\tilde{v}} = 1, \hat{x}_0^+ = 0.5, \Sigma_{\hat{x}_0}^+ = 0$ Select any value of input and output values falling the range given Current $0.5 < i_k < 1$ and voltage $3.5 < v_k < 4$ . Determine $\hat{x}_1^+, \hat{x}_2^+$ |                |         | 7Marks  | CO2 |
| 9.    | Identify the cause of loss of symmetry of covariance and the procedure to deal with it so that robustness of Kalman Algorithm is improved?                                                                                                                                                                                                                                                  | choice Q-10    |         | 10Marks | CO3 |
| 10.   | Apply EKF to determine the correction steps of state estimation solution for non-linear systems                                                                                                                                                                                                                                                                                             |                |         | 10Marks | CO3 |
| 11.   | Answer the following questions                                                                                                                                                                                                                                                                                                                                                              | choice Q-12    |         | 15Marks | CO3 |
| 11.A. | Explain in which process the numeric robustness of Kalman filter tested?                                                                                                                                                                                                                                                                                                                    |                |         | 8Marks  | CO3 |
| 11.B. | Develop Wrapper code (load data, store in local variables) in Octave for implementing EKF for ESC model.                                                                                                                                                                                                                                                                                    |                |         | 7Marks  | CO3 |
| 12.   | Answer the following questions                                                                                                                                                                                                                                                                                                                                                              |                |         | 15Marks | CO3 |
| 12.A. | Enumerate the different techniques for estimating the state of charge (SOC) of non-linear system.                                                                                                                                                                                                                                                                                           |                |         | 8Marks  | CO3 |
| 12.B. | Consider a system having nonlinear state equation                                                                                                                                                                                                                                                                                                                                           |                |         | 7Marks  | CO3 |