Ref. No.: Ex/EE/PE/B/T/421D/2023

B. E. ELECTRICAL ENGINEERING 4TH YEAR 2ND SEMESTER EXAMINATION, 2023

SUBJECT: - ADVANCED INSTRUMENTATION-II

Time: Three hours

Full Marks 100
(50 marks for each part)

Use a separate Answer-Script for each part

No. of Questions	PART I	Marks
	Answer all the questions.	
1. (a)	How does an adaptive noise canceller operate with correlated noise in the reference input? How is this scheme modified in absence of an external reference input? Explain the significance of decorrelation delay in this context. Show that the mean square error for an *M*-th order adaptive FIR filter is a quadratic function of the filter coefficients. (CO3)	12
	OR	
	Draw the block diagram of a discrete Wiener filter and derive the expression for its mean square error. What will be this mean square error with optimal filter coefficients? Show that the frequency response of this optimal Wiener filter is: $H(\omega)=\dfrac{S_{ss}(\omega)}{S_{ss}(\omega)+S_{nn}(\omega)}$ where each symbol has its usual meaning. (CO3)	12
(b)	Prove that, in an *M*-th order adaptive FIR filter, the time constant of the *p*th mode in the adaptation process can be approximately represented as inversely proportional to the *p*th eigenvalue of the matrix *R*, where *R* has its usual meaning. (CO3)	10
	OR	
	Present a detailed step-by-step procedure of developing a recursive least square (RLS) algorithm, where the filter coefficients are adapted following the rule: $H_n = H_{n-1} + \Delta H_{n-1}$ (each symbol has its usual meaning). In this context, elaborate the significance of computing *a priori* error and *a posteriori* error. (CO3)	10
2.	Justify or correct ***any two*** of the following statements with suitable reasons/derivations, in brief. (CO4)	05×02 =10
(a)	For a digital controller to be physically realizable, the constraint of causality must be satisfied.	

[Turn over

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No. of Questions	PART I	Marks
2. (b)	In sliding mode control, a sliding mode will exist for a system when, near the switching surface, the state vector is directed away from this surface.	
(c)	Compared to model following design, the control weighting design for predictive controllers adopts a more generalized performance criterion for optimization purpose.	
3.	Why is predictive control so named? Prove that, in a predictive controller designed using an incremental form of the predictor, the feedback path, in steady state, becomes independent of the estimated plant parameters. (CO4)	06
	OR	
	How is the method of equivalent control employed in designing a switching surface in sliding mode control? Derive the dynamics of a system on a linear switching surface so designed, after sliding mode is established. (CO4)	06
4. (a)	A first-order plant, controlled by a Dahlin's controller, is given as: $$G_p(s)=\frac{5\exp(-6s)}{(1+30s)}$$ Direct Synthesis Method is employed to design this Dahlin's controller. The sampling interval is chosen as 10% of the time constant of the plant. Choose the closed loop time constant suitably and justify your choice. First, derive the pulse transfer function of this first order plant. Then, determine the z-T.F. of the Dahlin's controller. Comment on the possible closed loop response and nature of the variation of the control signal for this system. (CO5)	12

Ref. No. Ex/EE/PE/B/T/421D/2023

B.E. Electrical Engineering Fourth Year Second Semester Examination, 2023

Advanced Instrumentation-II

Time: Three Hours **Full Marks: 100**

(50 Marks for each part)

Use a separate Answer Script for each Part

PART-II

Answer *All* Questions

Q.1a) How the orientation of defects does affect magnetic particle testing? What are the main variables that affects eddy current signals in test piece? What frequencies should be to detect surface and subsurface flaws in eddy current testing and why? Mention the different types of sensors used in ultrasonic testing and their characteristic features.

2+2+2+2

OR

Explain the principle of radiographic non- destructive testing method. Define radiographic sensitivity and mention the different factors that affects radiographic contrast?
What type of developer is used in liquid inspection testing to obtain the highest sensitivity test results and why? **3+3+2**

b) What do you mean by physical vapor deposition process? Briefly describe the PECVD process for thin film deposition of silicon nitride. What is the Bosch process and explain the different process steps involved in it. What is photoresist stripping and why it is done?

2.5+2.5+5+2

OR

Why Development and Hard Bake is necessary after transferring pattern on to the substrate?

[Turn over

Explain lift-off process with process flow diagram to realize ametallic pattern on silicon wafer. What is the basic difference between this process with etching? Mention the functionality of different components used in LIGA fabrication process. **2+4+2+4**

Q.2a) What are the factors involved in the selection of the best K_e (the state observer gain matrix)? **4**

OR

What is the impact of state feedback on linear dynamic system? "Duality plays an important role in the design of a state observer" – explain. **4**

b) The system state and output equations are given by

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 3 & 0 & -5 \\ -2 & 1 & 5 \\ 0 & 0 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 2 & 0 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix}$$

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} 4 & 1 & -3 \\ 3 & 2 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

Is the above system completely state controllable and observable? Explain what causes the apparent difference in the controllabilityandobservability of the same system. **4**

c) Explain "separation principle". **2**

Q.3a) Explain the Kalman filter algorithm? How the algorithm estimates the state of a linear dynamic system? Mention one application of the filter. **6**

OR

Derive the expression for Kalman filter gain. **6**

b) Why Kalman filter is known as optimal linear estimator? How process noise and measurement noise is related with the estimation of state by this filter? **2+2**

Q. 4. The system state and output equations are defined by

$$\dot{\mathbf{x}} = \mathbf{Ax} + \mathbf{Bu}$$

$$\mathbf{y = Cx}$$

Where $A = \begin{vmatrix} -8 & 1 & 0 \\ -17 & 0 & 1 \\ -10 & 0 & 0 \end{vmatrix}$, $B = \begin{vmatrix} 0 \\ 1 \\ 4 \end{vmatrix}$, $C = [1 \ 0 \ 0]$

Design an observer to respond ten timesfaster than the closed loop system design. The system poles are located at **-10** and **-1±j2**. **10.**

OR

The system state and output equations are defined by

$$\mathbf{\dot{x} = Ax + Bu}$$

$$\mathbf{y = Cx}$$

Where $A = \begin{vmatrix} -6 & -11 & -6 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{vmatrix}$, $B = \begin{vmatrix} 1 \\ 0 \\ 0 \end{vmatrix}$, .

By using state feedback control **u = -Kx**, it is desired to place the closed loop poles at **s_1=-3, s_2=-4 and s_3=-5**. Determine the state feedbackgain matrix **K** by using i) transformation matrix and ii) direct substitution method. How the location for desired closed loop poles can be chosen to obtain the best system performance? **10**