

SUBJECT: - ADVANCED INSTRUMENTATION-II

Time: Three hours

Full Marks 100

No. of
Questions

Marks

Answer ALL questions.

1. Answer any three questions. (CO3-K3) 12×3
=36
- (a) Draw the schematic of a discrete Wiener filter and explain its operating principle. Then prove that its minimum mean square error condition is given by the relation:

$$\sum_{m=0}^{N-1} h_m R_{xx}(m-j) = R_{xd}(j), \quad j = 0, 1, \dots, (N-1),$$
 where each symbol has its usual meaning. Next, determine an equivalent form of this relation relating the data auto-correlation matrix, a cross-correlation vector and the optimum filter coefficients vector.
- (b) Prove that, for an M -weight adaptive digital FIR filter, the mean square error (ξ) is given as: $\xi = E[P_n^2] - 2P^T H + H^T R H$. Plot the mean square error surface as a function of two filter coefficients and describe how the method of steepest descent can be employed to seek minimum mean square error. Hence prove that the gradient matrix (∇) can be expressed as: $\nabla = 2R\mathbf{V}$. Each symbol used in this question has its usual meaning.
- (c) Prove that, in Widrow-Hoff LMS algorithm for adaptive digital filters, each k th weight is adapted as: $h_{k(n+1)} = h_{k(n)} + 2\mu E_n R_{n-k}$, where each symbol has its usual meaning. Why does excess mean square error appear in practical applications of LMS algorithms? Discuss the similarities and dissimilarities between leaky LMS method and RLS method.

[Turn over

SUBJECT: - ADVANCED INSTRUMENTATION-II

Time: Three hours

Full Marks 100

No. of
Questions

Marks

1. (d) A given row of an image matrix comprises pixel intensity values as:

18	13	19	15	21	13	16	6	36	28
----	----	----	----	----	----	----	---	----	----

What will be corresponding digital approximation of first derivative and second derivative for this single-row intensity profile of an image? Explain in detail how Laplacian can be used to implement second derivative filters for image sharpening. What are the four mask variants developed using this method? How can this method be modified to preserve the original background features and yet perform sharpening operation?

2. Justify or correct any four of the following statements with suitable reasons/derivations, in brief. 05×4
(CO4-K4) =20
- (a) For a digital controller to be physically realizable, causality should be ensured.
- (b) In sliding mode control, the method of equivalent control can be applied only when the state trajectory of the plant is on the sliding surface.
- (c) Chattering in sliding mode control can be reduced by introducing a boundary layer surrounding the origin of the phase plane drawn for the state-space model of the system.
- (d) In fuzzy systems, Mamdani-type of inferencing uses equations in the THEN parts of the fuzzy rules and Sugeno-type of inferencing uses fuzzy sets/membership functions in the THEN parts of the fuzzy rules.
- (e) In control weighting design of predictive controllers, if the controller pole is moved closer to the origin, the forward path gain also increases.

SUBJECT: - ADVANCED INSTRUMENTATION-II

Time: Three hours

Full Marks 100

No. of Questions		Marks
3.	Write short notes on <u>any two</u> : i) Magnetic field orientation and flaw detectability in magnetic particle testing ii) Transformer model and factors affecting response in eddy current based non-destructive testing methodology iii) Ultrasonic inspection in non-destructive testing	(CO1-K1) 10×2 =20
4.	Answer <u>any two</u> questions: (a) Derive the alternative form of the condition for complete state controllability of an n -state system defined as: $\dot{\mathbf{x}} = \mathbf{Ax} + \mathbf{Bu}$, where each symbol has its usual meaning. (b) Determine whether the following systems are completely observable or not: (i) $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}, y = \begin{bmatrix} 0 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$ (ii) $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 2 & 1 & 0 \\ 0 & 2 & 1 \\ 0 & 0 & 2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}, \begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} 3 & 0 & 0 \\ 4 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$ (c) How are the <i>prediction</i> stage and the <i>measurement update</i> stage employed in a Kalman filter? Derive the expression for covariance matrix $\mathbf{P}_{t t-1}$, in terms of $\mathbf{P}_{t-1 t-1}$ and $\mathbf{Q}_t$, used in the <i>prediction</i> stage of Kalman filter, where each symbol has its usual meaning.	(CO2-K2) 08×2 =16

[Turn over

SUBJECT: - ADVANCED INSTRUMENTATION-II

Time: Three hours

Full Marks 100

**No. of
Questions****Marks**

5. A first-order plant, controlled by a Dahlin's controller, is given as: 08

$$G_p(s) = \frac{5 \exp(-6s)}{(1 + 30s)}$$

The Dahlin's controller is designed by Direct Synthesis Method. Choose the sampling interval as 10% of the time constant of the plant. Make a suitable choice of the closed loop time constant, with proper justification. Determine the z-T.F. of the Dahlin's controller for this first-order plant. In comparison to a dead beat controller designed for the same plant, how will this Dahlin's controller perform, in terms of closed loop response and nature of the variation of the control signal for this system? (CO5-K5)