注意：考試開始鈴響前，不得翻閱試題，
並不得書寫、畫記、作答。

國立清華大學 112 學年度碩士班考試入學試題

系所班組別：動力機械工程學系
乙組(電機控制組)

科 目 代 碼 ：1202

考 試 科 目 ：控制系統

—作答注意事項—

1. 請核對答案卷（卡）上之准考證號、科目名稱是否正確。
2. 考試開始後，請於作答前先翻閱整份試題，是否有污損或試題印刷不清，得舉手請監試人員處理，但不得要求解釋題意。
3. 考生限在答案卷上標記「由此開始作答」區內作答，且不可書寫姓名、准考證號或與作答無關之其他文字或符號。
4. 答案卷用盡不得要求加頁。
5. 答案卷可用任何書寫工具作答，惟為方便閱卷辨識，請儘量使用藍色或黑色書寫；答案卡限用 2B 鉛筆畫記；如畫記不清（含未依範例畫記）致光學閱讀機無法辨識答案者，其後果一律由考生自行負責。
6. 其他應考規則、違規處理及扣分方式，請自行詳閱准考證明上「**國立清華大學試場規則及違規處理辦法**」，無法因本試題封面作答注意事項中未列明而稱未知悉。

國立清華大學 112 學年度碩士班考試入學試題

系所班組別：動力機械工程學系碩士班　乙組(電機控制組)

考試科目（代碼）：控制系統(1202)

　　*請在【答案卷、卡】作答

Q1. The differential equation $\ddot{y} + \dot{y} = 2v_a - 2\dot{v}_a + w$ represents the relationship shown in below block diagram. Assume v_a is computed by using the control low $v_a = k\ e$ where $e = r - y$

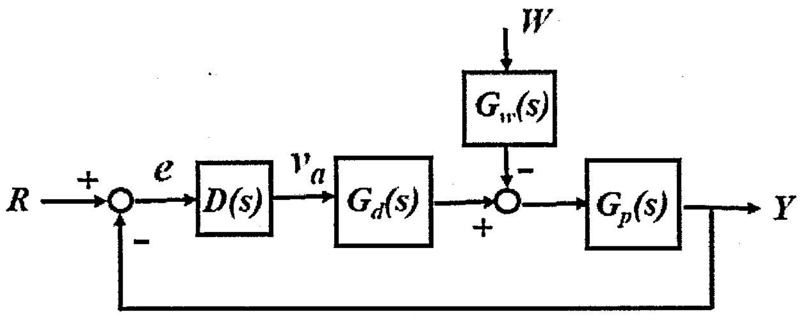

Figure 1

(a) k is a variable (0→ infinity). Draw the Root Locus. (5 pts)

(b) For the case of k=1, draw the Nyquist plot of $D(s)G_d(s)G_p(s)$. (5 pts)

(c) Use Nyquist criterion (Z=N+P) to decide the closed-loop system stability of case (b) (10 pts)

(**Notes:** (b) must be correct and you need to give the values of N, Z, P to get points for (c)!)

(d) What is the Gain Margin ($G.M.$) of case (b)? (5 pts)

(e) What is the Phase Margin($P.M.$) of case (b)? (**Notes:** $-180° < P.M. < 180°$) (5 pts)

Q2. The differential equations

$y(t) = 0 \qquad t < 2$

$\dot{y}(t) = 2v_a(t-2) + w(t) \quad t \geq 2$

represent the relationship shown in below block diagram.

Hint: For answering the following (a) and (b), you must use Padé approximant for delay of *T* seconds:

$$e^{-Ts} \cong \frac{1-\frac{Ts}{2}}{1+\frac{Ts}{2}}$$

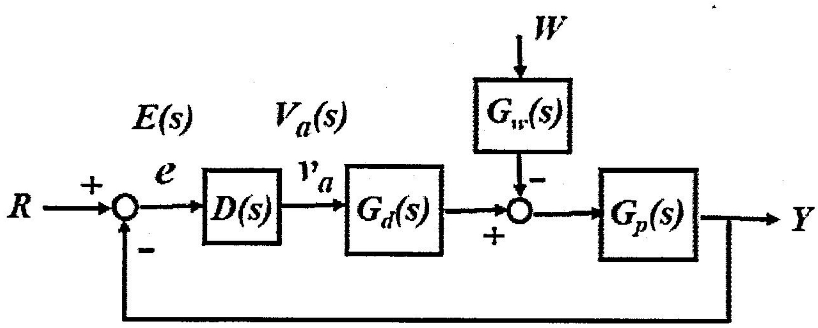

Figure 2

Assume v_a is computed by using the control low $V_a(s) = D(s)\ E(s)$

(a) Design a controller *D(s)*=*K* (s+z)/(s+p) to approach a Phase Margin of 40 degrees with the gain crossover frequency at 1 rad/s. What are (*K*, p, z)? (15 pts)

(b) What is the steady-state error of (*r*(*t*)-*y*(*t*)) responding to unit ramp input on *R(s)* for controller case shown in (a)? (5pts)

Q3. Consider the circuit of Figure 3.

(a) Using $i(t)$ as the input and $v(t)$ as the output, write the state equations and output equation with the voltages in the capacitors $(v_1(t), v_2(t))$ as the state variables. (5 pts) Find the transfer function *V(s)/I(s)* for this circuit. (5 pts)

(b) Examine the controllability and observability for the cases $C_1 \neq C_2$ and $C_1 = C_2$. Provide physical explanation if uncontrollability and/or unobservability exist. (10 pts)

(c) Show that $C_1 = C_2$ reduces the transfer function *V(s)/I(s)* to first order. (5 pts)

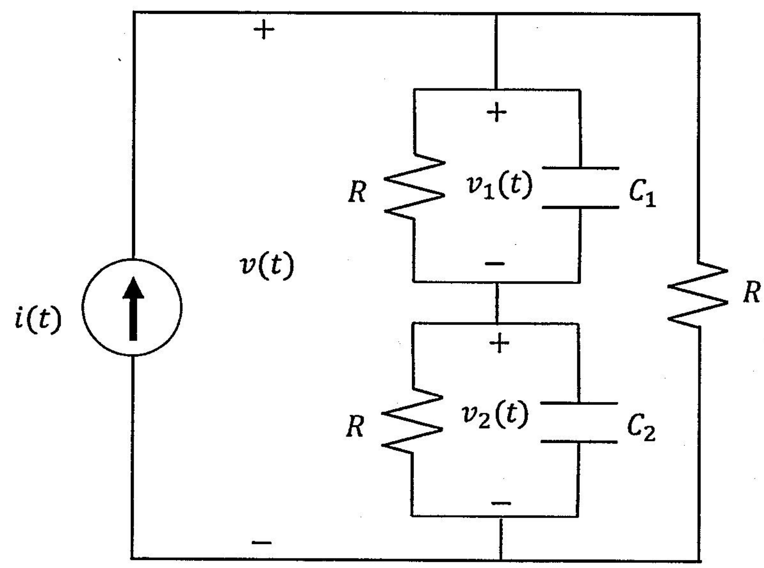

Figure 3

Q4. Consider a plant with input $u(t)$, input disturbance $d(t)$, and output $y(t)$ as shown in Figure 4.

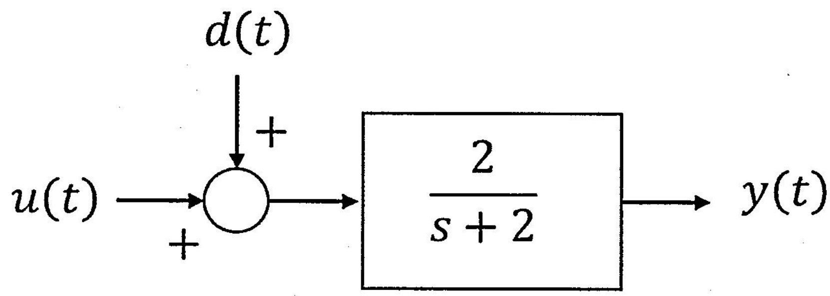

Figure 4

(a) Assume that the disturbance is constant but unknown (i.e. $\dot{d} = 0$). Using $\begin{bmatrix} y \\ d \end{bmatrix}$ as the state vector and $u(t)$ as the input, derive the state equation and output equation of the system. (5 pts)

(b) Using the results in (a), build a full-order observer that generates estimates for y and d. The observer polynomial should be chosen as $E(s) = s^2 + 16s + 64$. (7 pts)

(c) Use the results in (b) to implement state-estimate feedback control in the form

$$u(t) = -k_1\hat{y}(t) - \hat{d}(t)$$

where $\hat{y}(t)$ and $\hat{d}(t)$ are the estimates from the observer. Determine the numerical value for k_1 so that the closed-loop poles are located at -4 and -8, -8. What is the controller's transfer function $\frac{U(s)}{Y(s)}$? (13 pts)