



TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Engineering and Technology

Department of Electrical & Electronic Engineering

UNIVERSITY EXAMINATION FOR:

Diploma in Technology in Power Engineering

Diploma in Technology in Telecommunication & Information Engineering

ECI 2301: Control Systems II

END OF SEMESTER EXAMINATION

SERIES: NOVEMBER 2024

TIME: 2 HOURS

DATE: NOVEMBER 2024

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of **FIVE** Questions; Attempt **QUESTION ONE** and any **TWO** Questions.

Do not write on the question paper.

QUESTION ONE (COMPULSORY)

a) Define the following terms as applied in control engineering:

- I) Frequency response
- II) Time response
- III) Marginally stable system
- IV) Conditionally Stable System
- V) Characteristic equation
- VI) Poles
- VII) Zeros

ii) Determine and plot on the S-plane the poles and Zeros of

$$F(s) = \frac{(s+1)(s+2)}{(s+4)(s+5)(s+8)}$$

b) State Routh-Hurwitz Stability Criterion

(12 Marks)

c) i) State and explain any **Three** techniques for finding poles and zeros in a transfer function

ii) List the **Two** conditions that a Linear Time-Invariant (LTI) system must satisfy to be stable.

(8 Marks)

QUESTION TWO

- a) i) State the **TWO** difficulties encountered while applying Routh Stability criterion
- ii) The transfer function of the forward path of a unity feedback system is found to be $\frac{K}{s(s^2+s+1)(s+4)+k}$. Using the Routh-Hurwitz stability criterion:
- Determine the characteristic equation
 - Form Routh Array
 - Calculate the minimum positive values of K at which the system becomes unstable
 - Determine the range of values of K for which the system is stable
- (10 Marks)
- b) Find the stability of the control system whose characteristic equations are given below
- $2s^5 + 2s^4 + 4s^3 + 4s^2 + 6s + 10 = 0$
 - $2s^5 + 6s^4 + 2s^3 + 6s^2 + 2s + 6 = 0$
- (10Marks)

QUESTION THREE

- State Nyquist stability criterion
- With respect to the Nyquist polar plot define the following
 - Phase cross-over
 - Gain cross-over

(8 Marks)

A system has the following open-loop frequency response:

W(rad/s)	2	3	4	5	6	8	10	30
Gain	.2.8	1.9	1.3	0.9	0.68	0.4	0.26	0.12
θ (degrees)	-120	-130	-140	-149	-157	-170	-180	-300

Plot the Nyquist diagram and determine:

- Phase Margin
 - Gain Margin
 - Deduce from these values, whether the system is stable or unstable giving reasons for your answer.
- (12 Marks)

QUESTION FOUR

- a) i) State why compensation is often needed in a control system
- ii) Draw the circuit and give a clearly labeled diagram showing the frequency and phase characteristics of
- Phase-lead compensator
 - Phase-lag compensator
- (8Marks)
- iii) Prepare Nichols chart for the open loop transfer function for $0.2 \leq \omega \leq 4.0$
- $$G(s) = \frac{20}{s(s+2)(s+5)}$$
- b) ii) From the Nichols chart in (a) determine:
- Phase margin
 - Gain margin
- (12Marks)

QUESTION FIVE

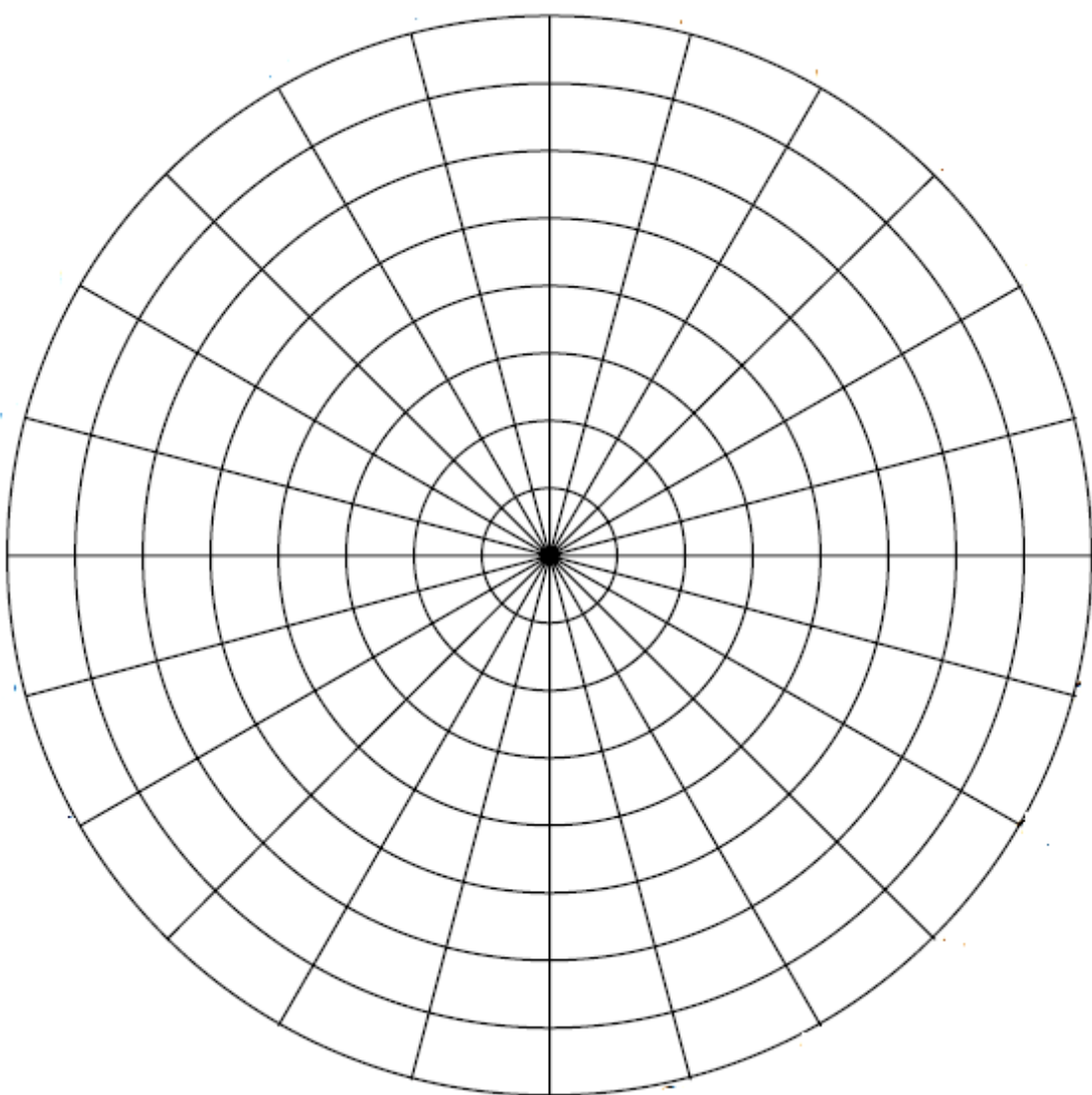
- a) Construct the bode plots on a semilog graph paper for a unity feedback system whose open loop transfer function is given by:

$$G(s) = \frac{10}{s(s+1)(1+0.02s)}$$

From the Bode plot determine:

- I) Gain and phase crossover frequency
 - II) Gain and phase Margin. And
 - III) Stability of the closed loop system
- (10Marks)
- b) For any given point $G(s) = x + jy$ of a polar plot $G(j\omega)$ show that constant M-circles are circles given by in the complex plane with radius:

$$r = \frac{m}{1+m^2} \text{ centered at } \left(\frac{m^2}{1+m^2}, y = 0 \right) \quad (10\text{Marks})$$



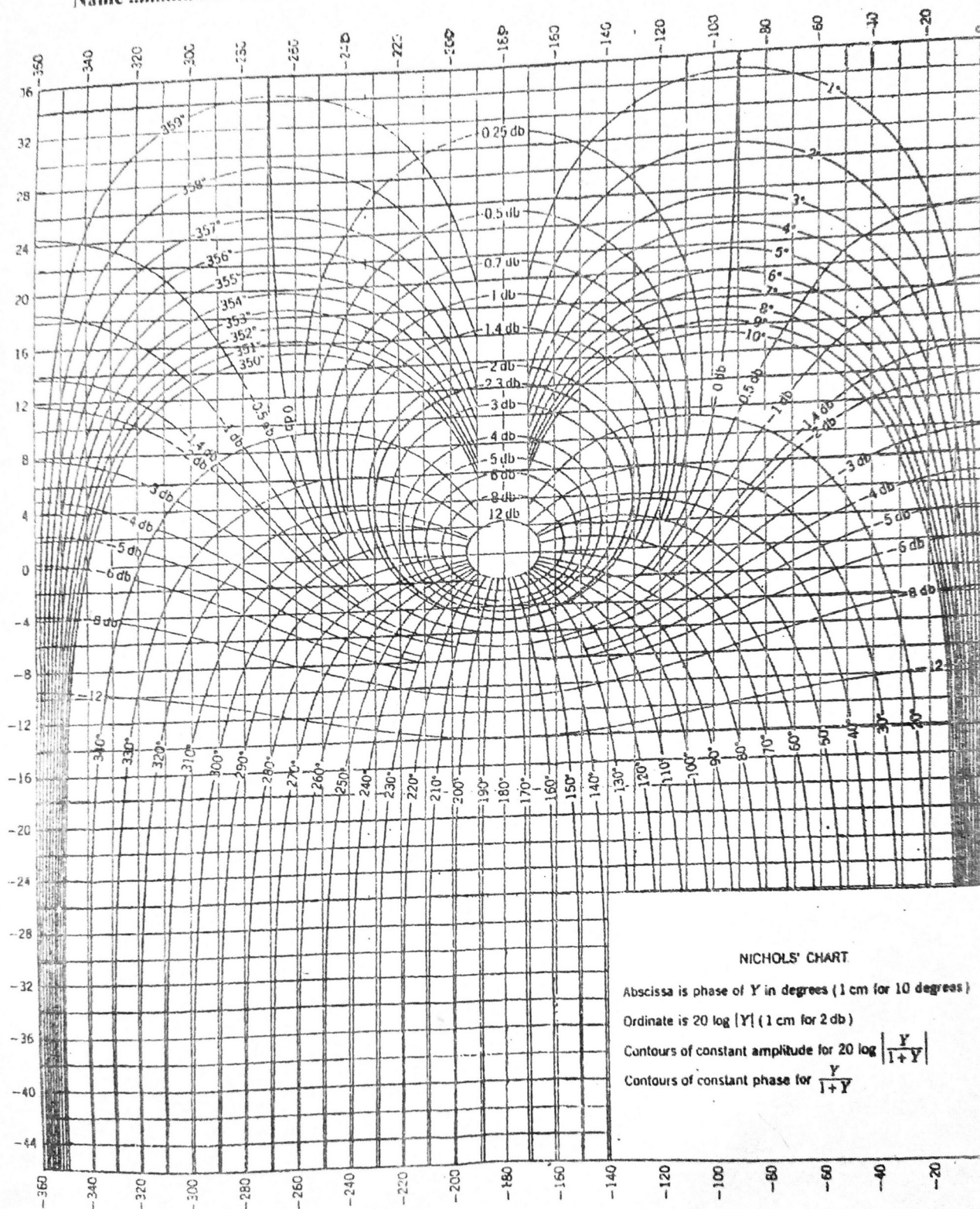


Figure 3. Bode, Nyquist, and Nichols Plots for Control Systems