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: AUGUST 2024

TIME: **2 HOURS**

DATE: AUGUST 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:

I) Determine the characteristic equation

II) Form Routh Array

III) Calculate the minimum positive values of K at which the system becomes unstable

IV) 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

I) $2s^5+2s^4+4s^3+4s^2+6s+10=0$

II) $2s^5+6s^4+2s^3+6s^2+2s+6=0$ **(10Marks)**

QUESTION THREE

i) State Nyquist stability criterion

ii) With respect to the Nyquist polar plot define the following

I) Phase cross-over

II) 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:

i) Phase Margin

ii) Gain Margin

iii) 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

I) Phase-lead compensator

II) Phase-lag compensator **(8Marks)**

iii) Prepare Nichols chart for the open loop transfer function for 0.2≤w≥4.0

$$G(s)=\frac{20}{s(s+2)(s+5)}$$

b) ii) From the Nichols chart in (a) determine:

i) Phase margin

ii) 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:

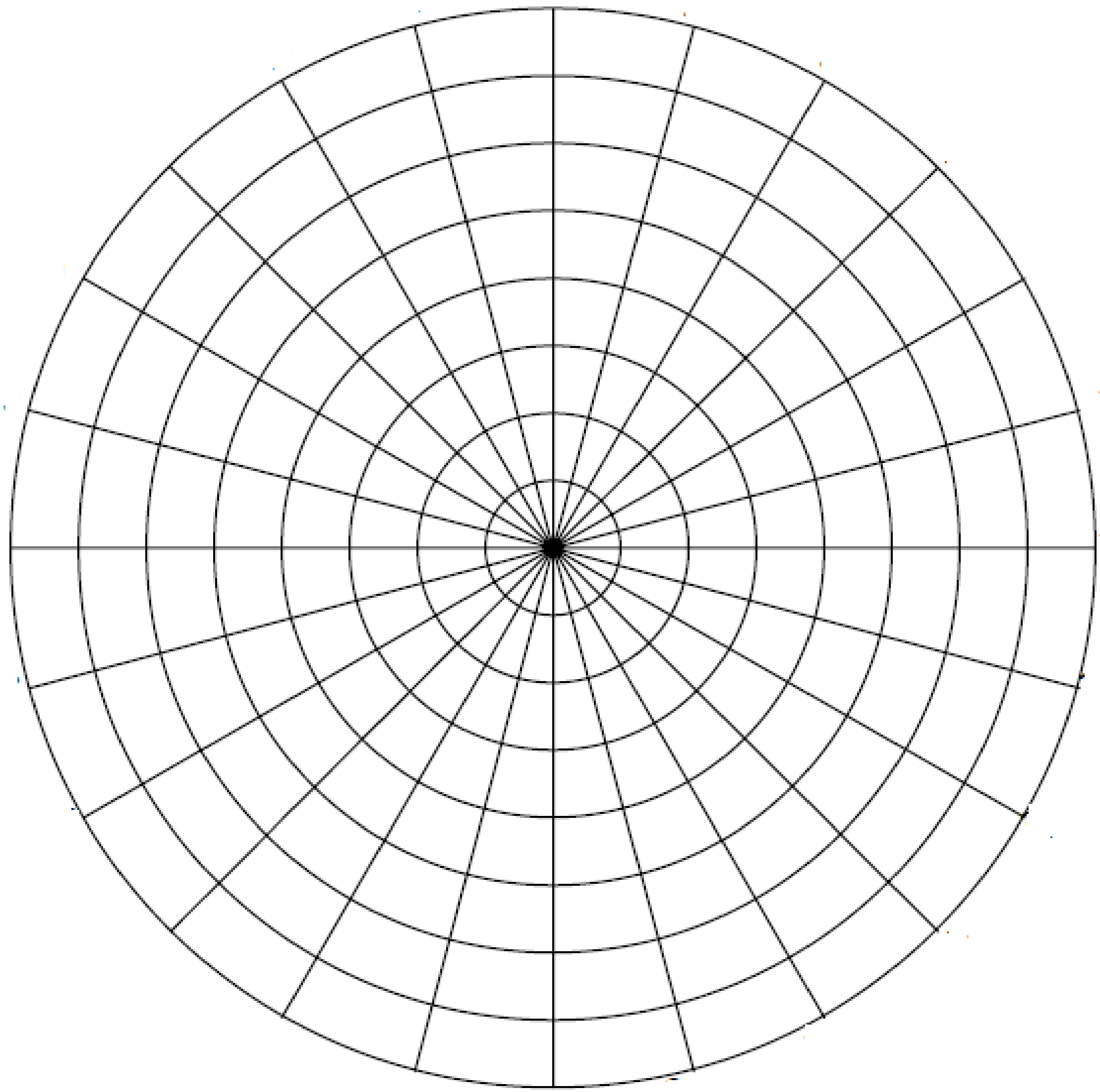
I) Gain and phase crossover frequency

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(jw) show that constant M-circles are circles given by in the complex plane with radius:

$r = \frac{m}{1+m^2}$ centered at ($x = \frac{m^2}{1+m^2}$, y = 0) **(10Marks)**



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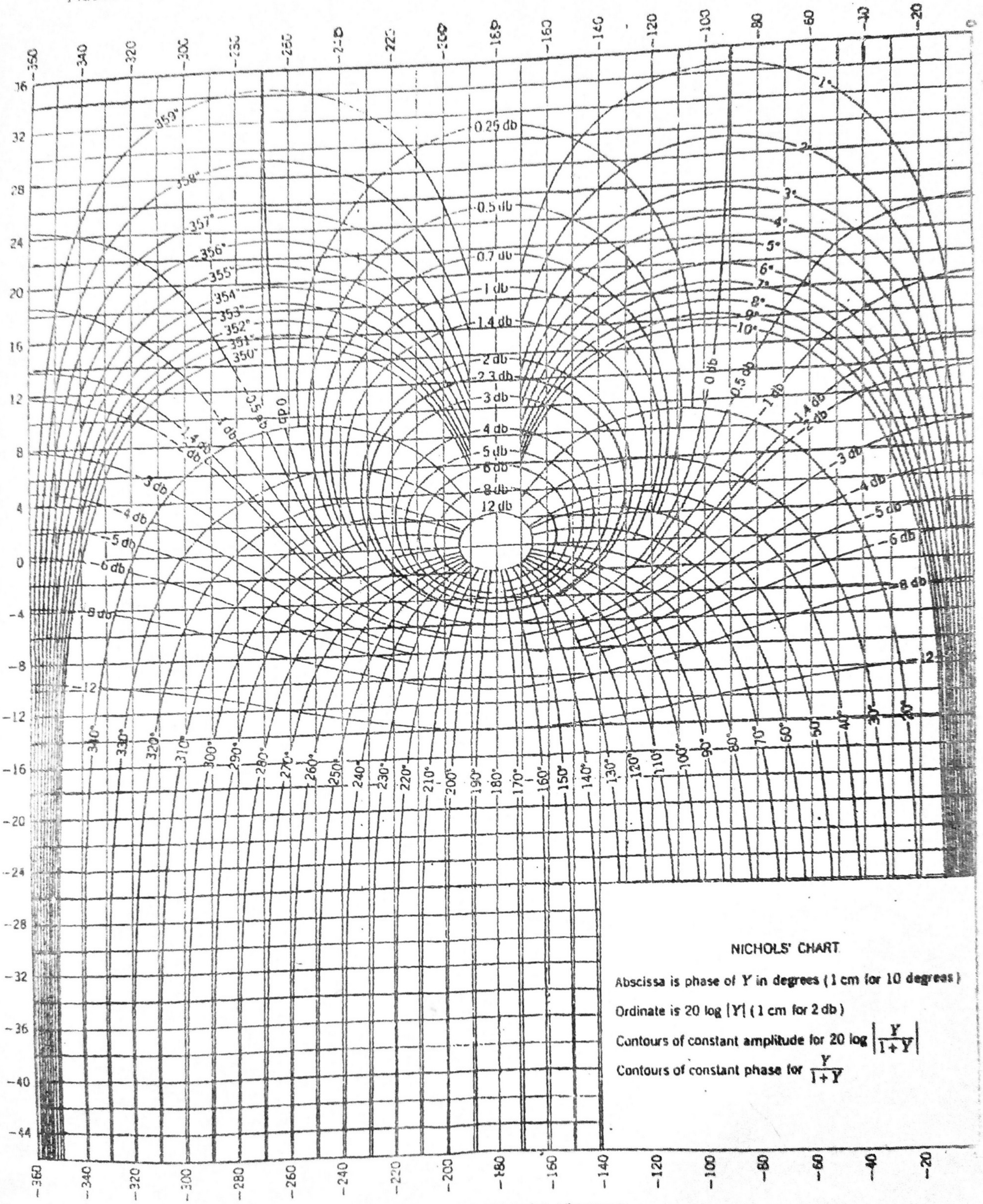

[illegible] Gille, Pelegrin, and DeCaulne: Feedback Control Systems