AMERICAN UINVERSITY OF BEIRUT
FACULTY OF ENGINEERING AND ARCHITECTURE
EECE 460 Control Systems
Fall 2005 - 2006
Quiz II ; Prof. Fouad Mrad
SOLUTION

Problem 1 (50 points):
An open loop frequency response test on an unknown system produced the following results:

W rad/s	**0.2**	**0.4**	**0.8**	**1.6**	**3.0**	**4.0**	**4.6**	**5**	**6**	**8**	**10**	**20**	**40**
Gain dB	28	22	16	10.7	7.5	7.3	7.0	6.0	0.9	-9.3	-28	-36	-54
Phase deg	-91	-92	-95	-100	-115	-138	-162	-180	-217	-244	-259	-262	-266

Approximate the Bode Plots on a semi-log paper and determine:
a) An estimate of the open loop transfer function
T.F.= 5/(s(0.04s2 + 0.1s +1))
b) Approximate values of GM and PM.
GM = -6 dB PM = -40 deg
c) The stability of the closed and open loop systems.
The closed loop is unstable because PM and GM are negative and Open loop is Min Phase (i.e stable since all poles are in Left Half Plane)
d) An estimate of the closed loop transfer function
CLTF = G/(1+G)= 5 / (0.04 s3 + 0.1 s2 + s = 5)
e) For the closed loop of part (c), approximate maximum gain Mp and bandwidth (the -3dB drop definition).
Mp = 6.82 dB Wb = 7 rad/sec

Problem 2 (50 points):
Consider a unity feedback system with open loop transfer function:

$$G(s) = \frac{K}{(s+5)(s+20)(s+50)}$$

a) If the gain K = 120,000; Determine:
i. Phase Margin PM = -6 deg
ii. Gain Margin GM = -2 dB
iii. These specs are Steady State or Transient? SS.
iv. These specs are for Closed or Open loop T.F.? Closed
b) Based on part (a), is the Open loop system stable? Why.
Open Loop is stable because all poles are in LHP
c) Based on part (a), is the closed loop system stable? Why.
Closed loop is unstable because PM and GM are negative
d) Assume that K is 1, Design a frequency response based Lead, Lag, or Lag-Lead **(if needed and justify your choice)** in order to obtain a
i. Static Position error constant of 2
ii. a phase margin of at least 90 deg
iii. a gain margin of at least 19 dB.
For Kp to be met, Gain of controller is 10,000
Once [10,000 G(s)] Bode plots are approximated, we find that the obtained PM = 92 deg and GM = 20 dB which means that the required specs were met by only a P controller of gain 10,000 without additional Poles or Zeros.