作业4讲解

4 绘制开环传递函数的极坐标幅相特性

$$G(s)=\frac{K}{s\left(16s^2+6.4s+1\right)}$$

$$G(j\omega)=\frac{K}{j\omega\left(-16\omega^2+j6.4\omega+1\right)}$$

$$=-\frac{6.4K}{\left(1-16\omega^2\right)^2+\left(6.4\omega\right)^2}-j\frac{\left(1-16\omega^2\right)K}{\omega\left[\left(1-16\omega^2\right)^2+\left(6.4\omega\right)^2\right]}$$

起点和终点

$$G(j0)=-6.4K-j\infty$$

$$G(j\infty)=0$$

与实轴交点

$$\mathrm{Im}\left[G(j\omega)\right]=0$$

$$\rightarrow\omega_x=0.25,G(j\omega_x)=-2.5K$$

作业4讲解

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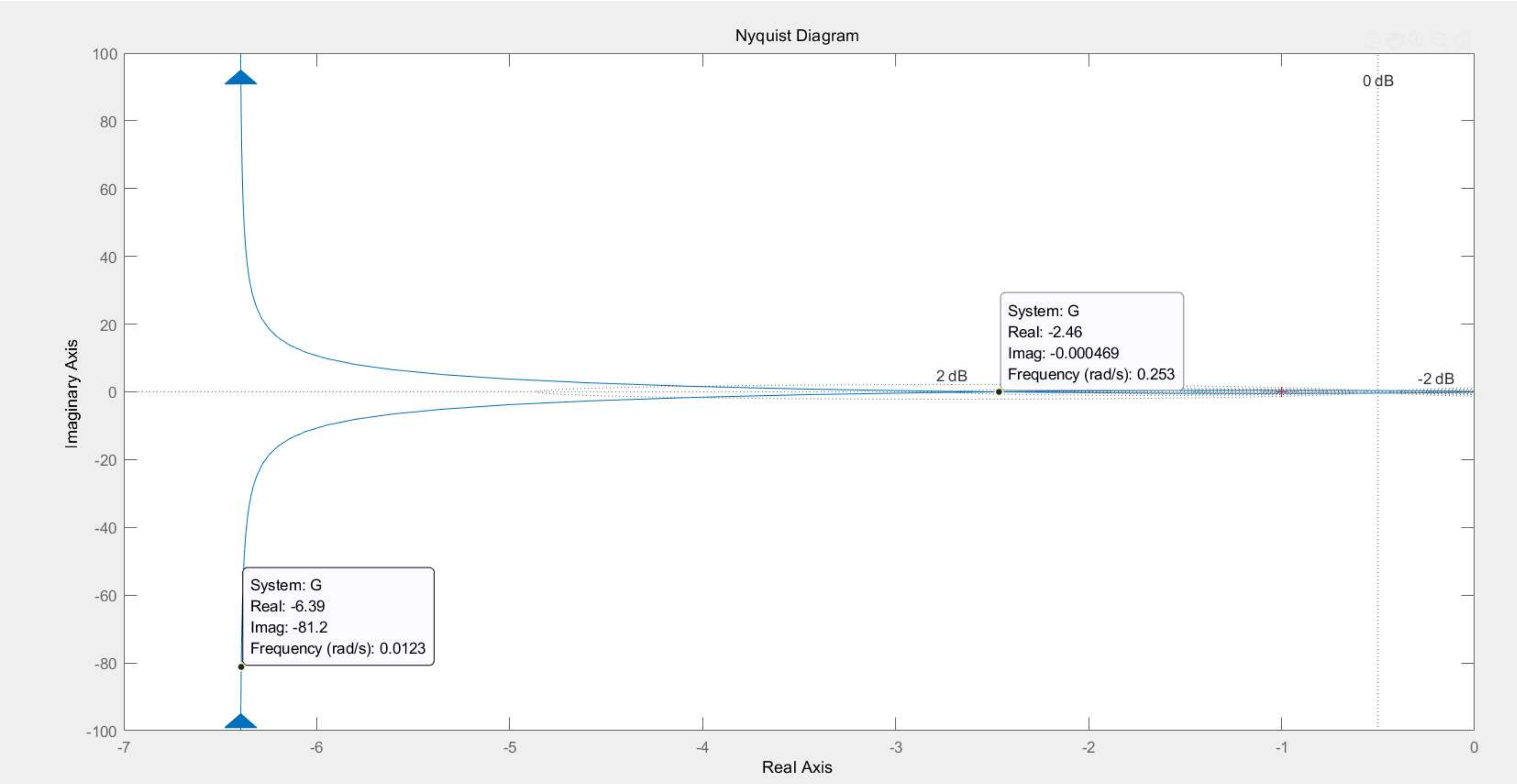
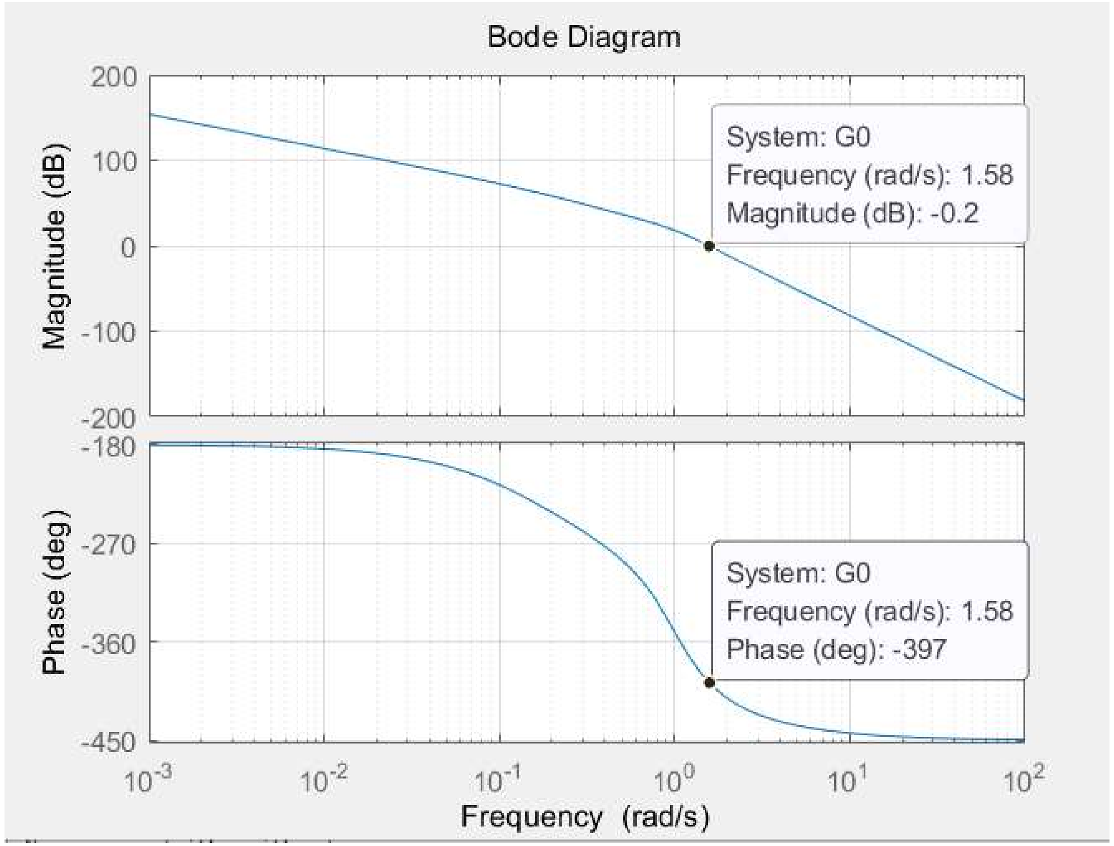

Nyquist Diagram
Imaginary Axis
Real Axis
100
80
60
40
20
0
-20
-40
-60
-80
-100
-7
-6
-5
-4
-3
-2
-1
0
0 dB
2 dB
-2 dB
System: G
Real: -2.46
Imag: -0.000469
Frequency (rad/s): 0.253
System: G
Real: -6.39
Imag: -81.2
Frequency (rad/s): 0.0123

5 绘制开环传递函数的博德图

$$G(s) = \frac{50}{s^2\left(s^2+s+1\right)\left(6s+1\right)}$$



作业4讲解

6 设单位负反馈系统开环传递函数如下，要求设计一串联校正网络，使校正后的系统开环增益K = 5，相角裕度不低于40度，幅值裕度不小于10dB

$$G(s)=\frac{K}{s(s+1)(0.5s+1)}$$

$k=5$ 对于校正前的系统

令$L(\omega)=0$，可得 $\omega_c=2.1544$

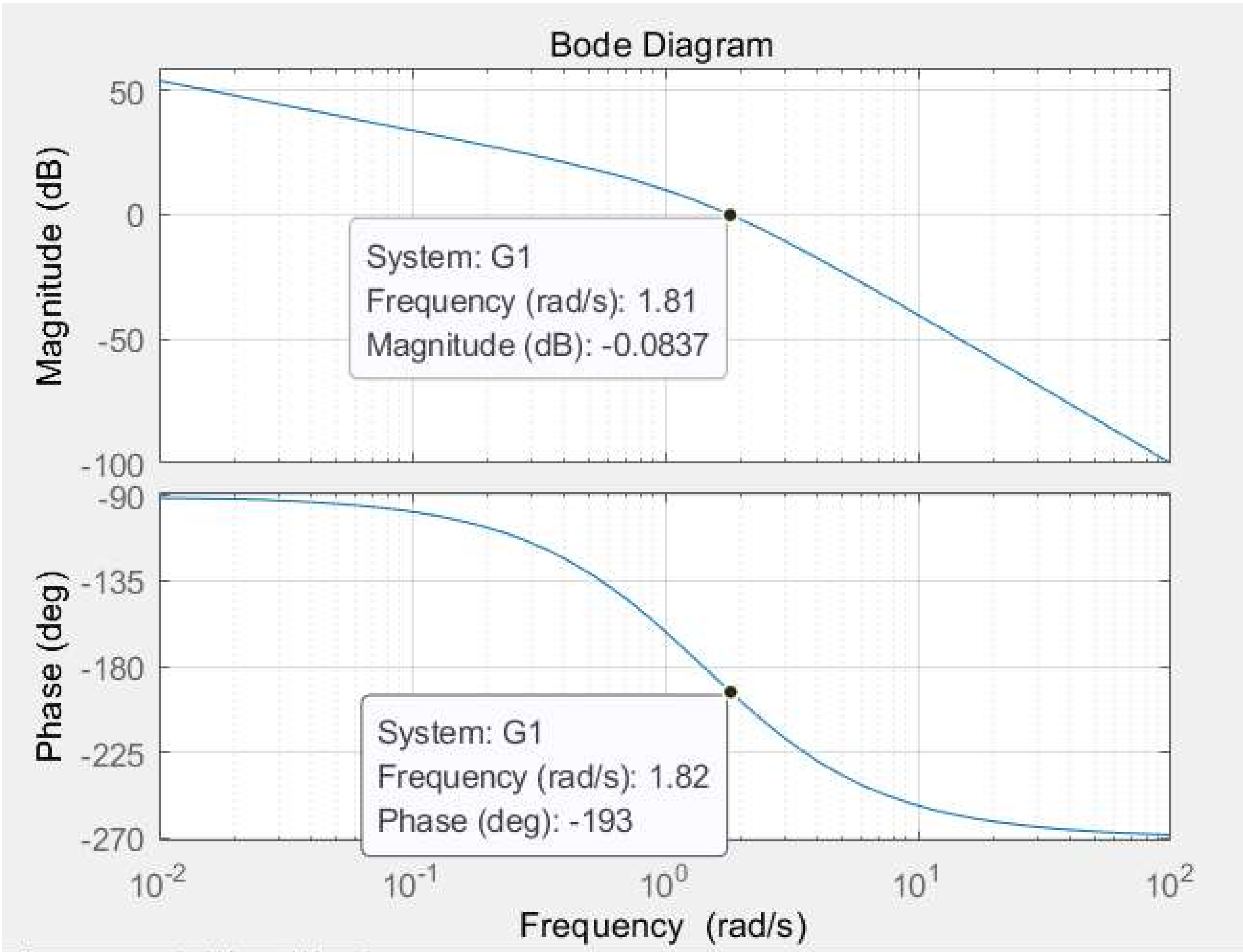
$$20\lg 5=40\lg 2+60\lg\frac{\omega_c}{2}$$

$$\gamma=180°-90°-\arctan\omega_c-\arctan(0.5\omega_c)=-22.23°<\gamma^*$$

系统不稳定，选用滞后校正

6

未校正的系统


Bode Diagram
Magnitude (dB)
50
0
-50
-100
System: G1
Frequency (rad/s): 1.81
Magnitude (dB): -0.0837
Phase (deg)
-90
-135
-180
-225
-270
System: G1
Frequency (rad/s): 1.82
Phase (deg): -193
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
Frequency (rad/s)

作业4讲解

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$$\varphi(\omega_c'') = \gamma^* + 5^\circ = 45^\circ$$

$$-90^\circ - \arctan\omega_c'' - \arctan(0.5\omega_c'') = 45^\circ$$

$$\arctan\omega_c'' + \arctan(0.5\omega_c'') = 45^\circ$$

$$\omega_c'' = 0.5$$

$$20\lg\beta + L(\omega_c'') = 0$$

$$\frac{1}{\beta T} = 0.1\omega_c''$$

$$\Rightarrow \quad \beta = \frac{1}{25}, \quad T = 500$$

用渐近线简化，也可以用准确值

$$G_c(s) = \frac{1+\beta Ts}{1+Ts} = \frac{1+20s}{1+500s}$$

$$G'(s) = G(s)G_c(s) = \frac{5}{s(s+1)(0.5s+1)} \cdot \frac{1+20s}{1+500s}$$

$$\gamma'' = 180^\circ + \phi_c(\omega_c'') + \phi(\omega_c'')$$

$$= 180^\circ + \arctan(20\omega_c'') - \arctan(500\omega_c'') - 90^\circ - \arctan\omega_c'' - \arctan(0.5\omega_c'') = 44^\circ$$

作业4讲解

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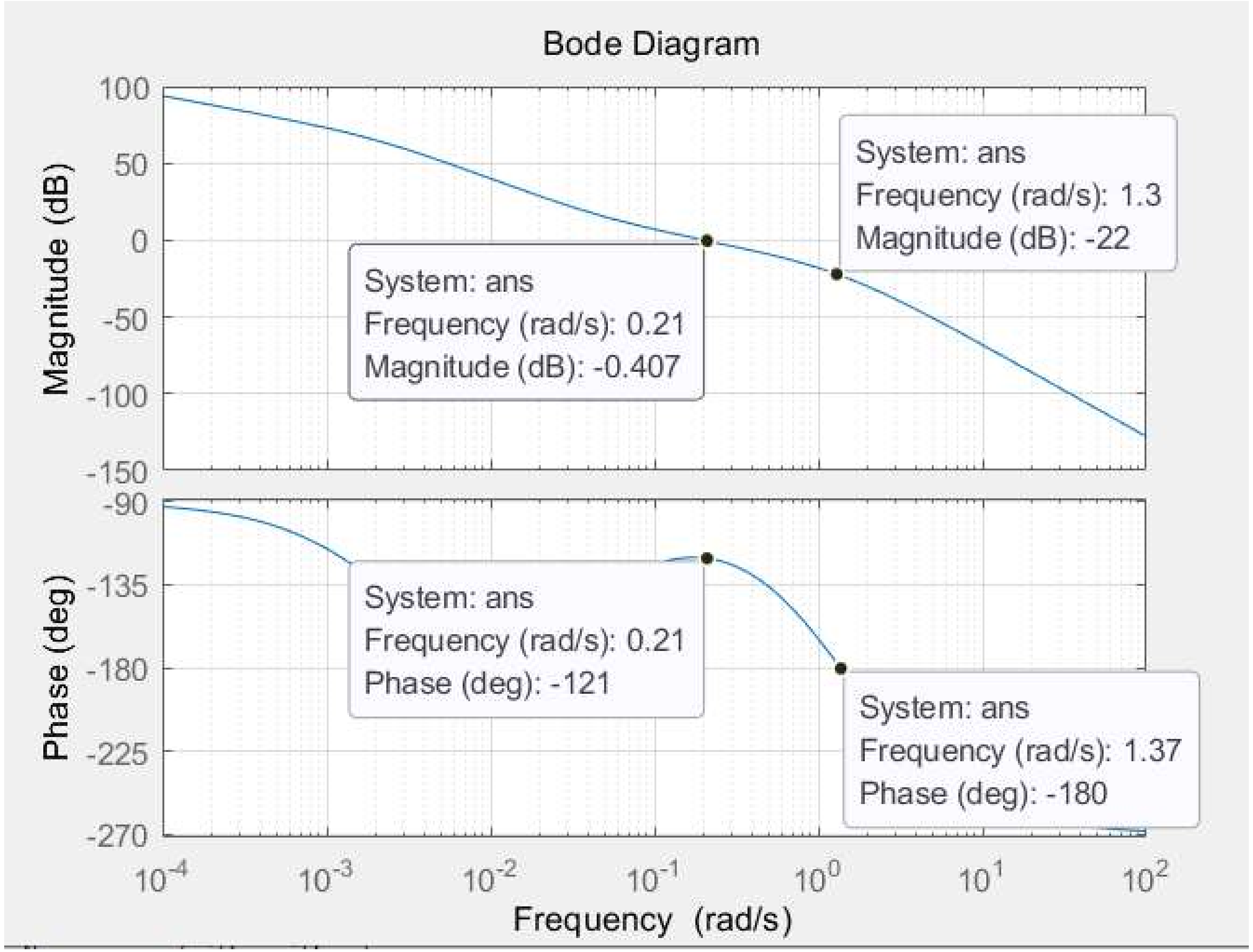
校正后的系统



偏差是由于渐近线引起