MECH421 Midterm Exam

Feb. 25th 2019, 3pm-4pm

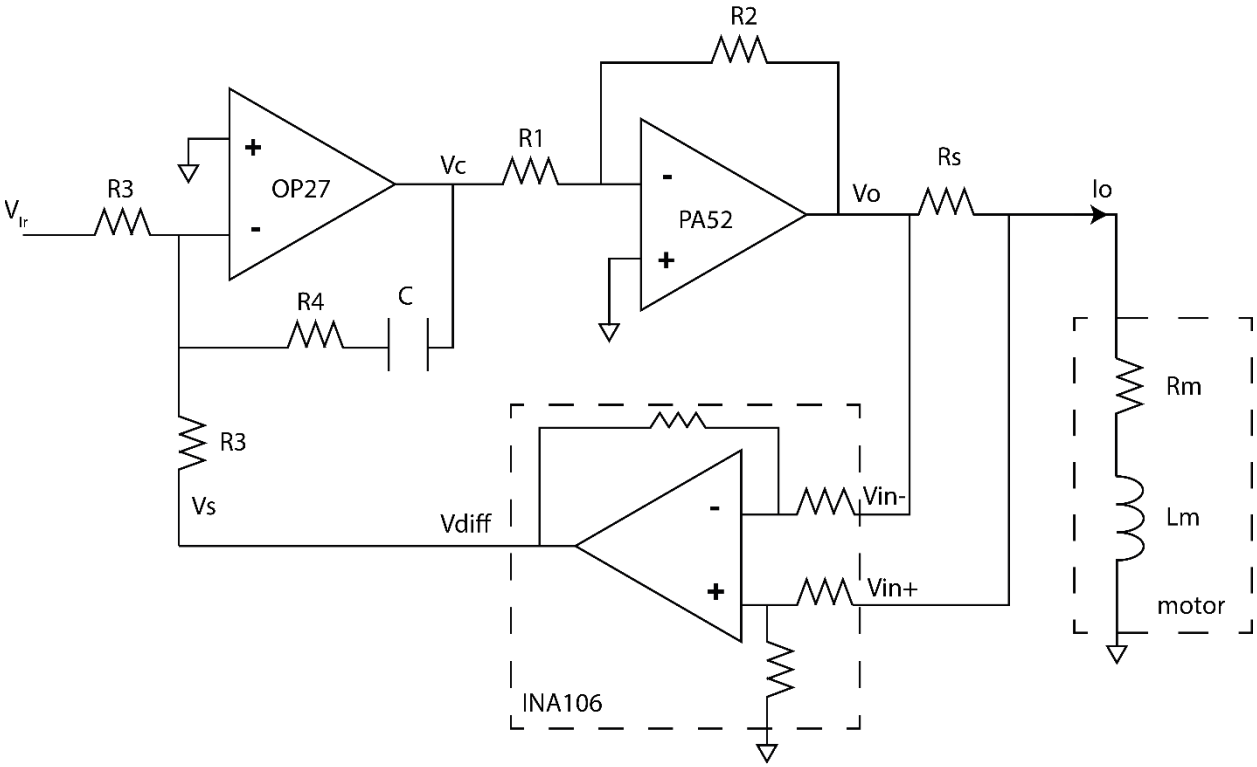

Figure 1: A motor power amplifier with a current controller.

In Figure 1, OP 27 is considered as an ideal op-amp to implement current controller. PA52 is a high power op-amp to drive the motor, and Figure 2 describes its frequency response. In this circuit PA52 is not an ideal op-amp. INA106 is a difference op-amp with a fixed gain of 10 (K_g=10), and its functions follow the equation: $\boldsymbol{V_{diff} = K_g(V_{IN+} - V_{IN-})}$. Lm and Rm are motor's inductance and resistance. Rs is the current sensing resistor. **Lm=6mH, Rm=3.9Ω, Rs=0.1Ω.**

1). (30 marks) Draw a block diagram for the whole circuit in Figure 1. Clearly label the following signals:

a) V_{Ir} (reference current command).

b) V_c (input voltage of PA52).

c) V_o (output voltage of PA52).

d) I_o (motor current).

e) V_s (current sensing signal).

2). (30 marks) Consider voltage stage only, which is an inverting amplifier circuit; the input is V_c and the output is V_o. PA52 frequency response is shown in Figure 2 below.

a) Design resistors R1 and R2 to set the DC gain from V_c to V_o is 9. (i.e. $|V_o/V_c|=9$).

b) Is this voltage stage stable? If yes, what is the negative loop transmission (NLT) crossover frequency, and what is the phase margin.

3). (40 marks) Consider the current controllor design with following objectives: 10kHz closed loop bandwidth; no steady-state error; at least 60 degree phase margin.

a) Select R3, R4 and C in the circuit to design a PI ($C(s) = K(1 + \frac{\omega_I}{s})$) controller to achieve above objectives. Make sure to show K and ω_I clearly.

b) Draw Bode plots of the controller only.

c) Draw Bode plots for the NLT of the whole system, and label the corner frequencies.

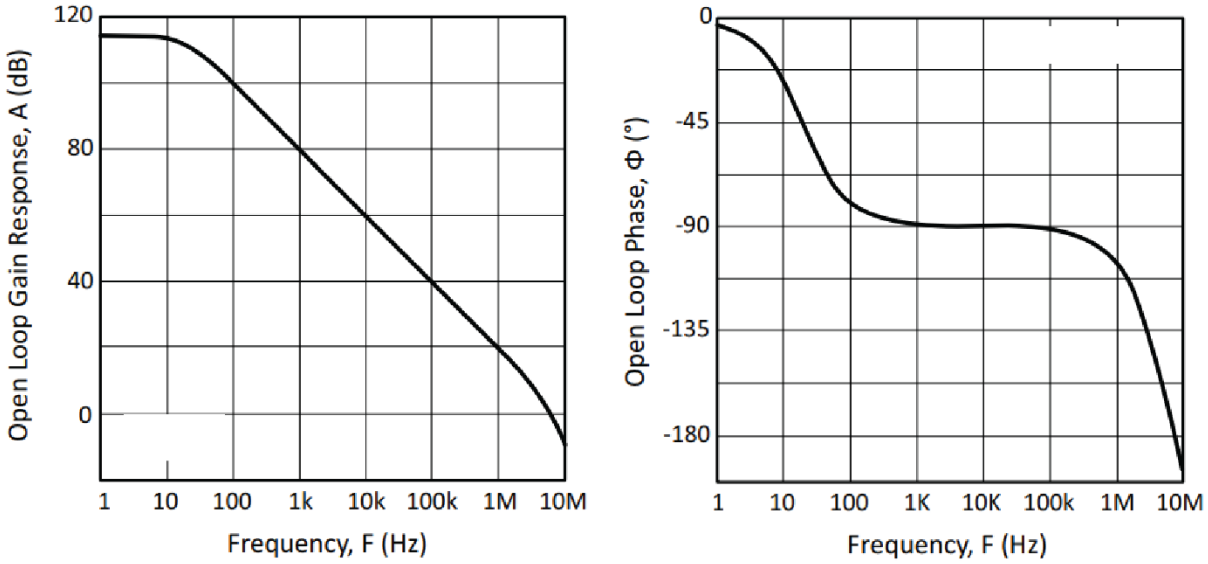

Figure 2: PA52 frequency response.