Department of Mechanical Engineering
The University of British Columbia
MECH 421: Mechatronic System Instrumentation
Feb 27, 2017, 3:00pm--4:00pm
Mid-term exam (2 pages total)

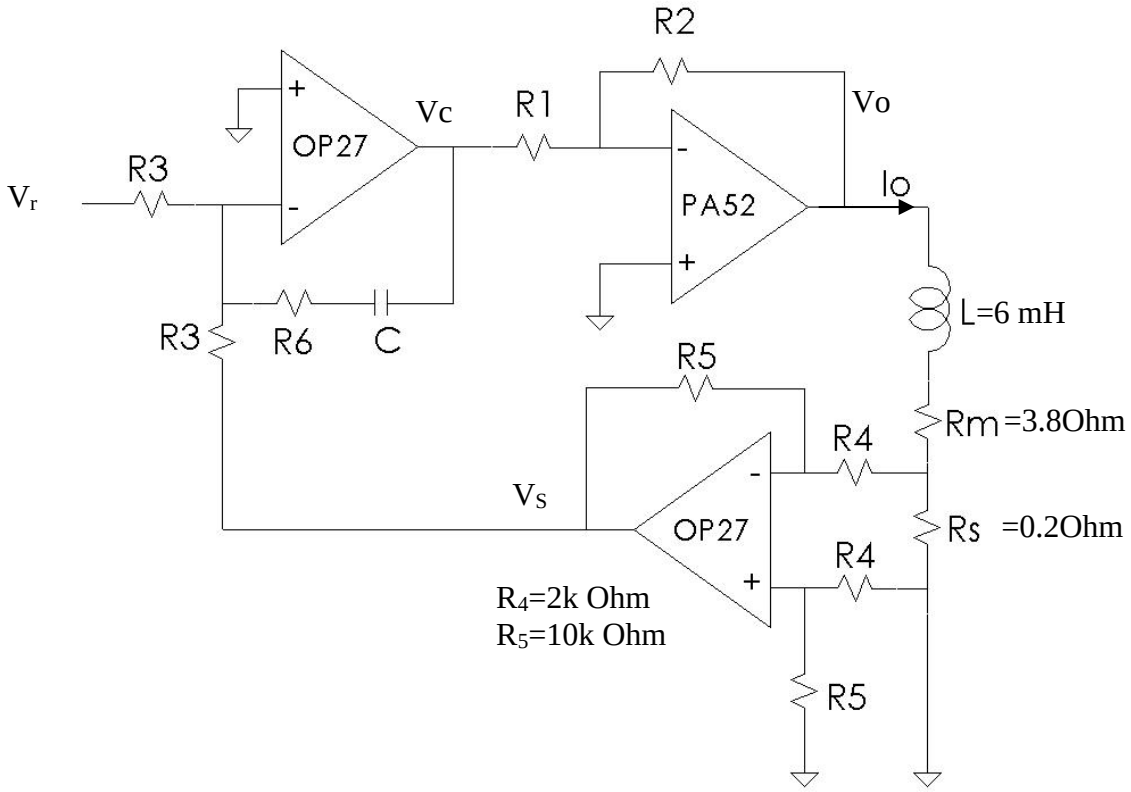

Figure 1: Current amplifier schematic diagram

The following questions are centered on the electrical circuit shown in Figure 1. In the following questions, assuming OP27 is an ideal Op-Amp with infinite gain for all frequencies. PA52 is a power device with frequency response shown in Figure 2. L and Rm are the motor inductance and resistance. The current-sensing resistor Rs has a resistance value of 0.2 Ohm. R4=2k Ohm. R5=10k Ohm. Rm=3.8 Ohm. L=6 mH.

(1) (30 marks) Draw a block diagram for the whole circuit in Figure 1. Clearly label the following signals in your block diagram:
   a. Vr (current reference command),
   b. Vc (Voltage stage input command),
   c. Vo (PA52 output voltage),
   d. Io (motor current),
   e. Vs (current sensing signal).

(2) (30 marks) Looking at the voltage stage only, with input Vc and output Vo.

a. Design resistors R1 and R2 so that the voltage stage DC gain is: Vo=-9Vc at DC.

b. Is this voltage stage stable? If yes, what's the negative loop transmission crossover frequency of the voltage stage, and what's its phase margin?

(3) (40 marks) This section investigates the current controller design. The goal is to design a current controller with 10 kHz bandwidth. To simplify the current controller design process, the voltage stage is simplified as a constant gain element (Vo=-9Vc) for all frequencies.

a. Select R3, R6, and C so that the overall system is stable with 10kHz bandwidth and at least 60 degree phase margin.

b. Draw Bode plots for the current controller transfer funciton from Vs to Vc.

c. Draw Bode plots for the current loop NLT(negative loop transmission).

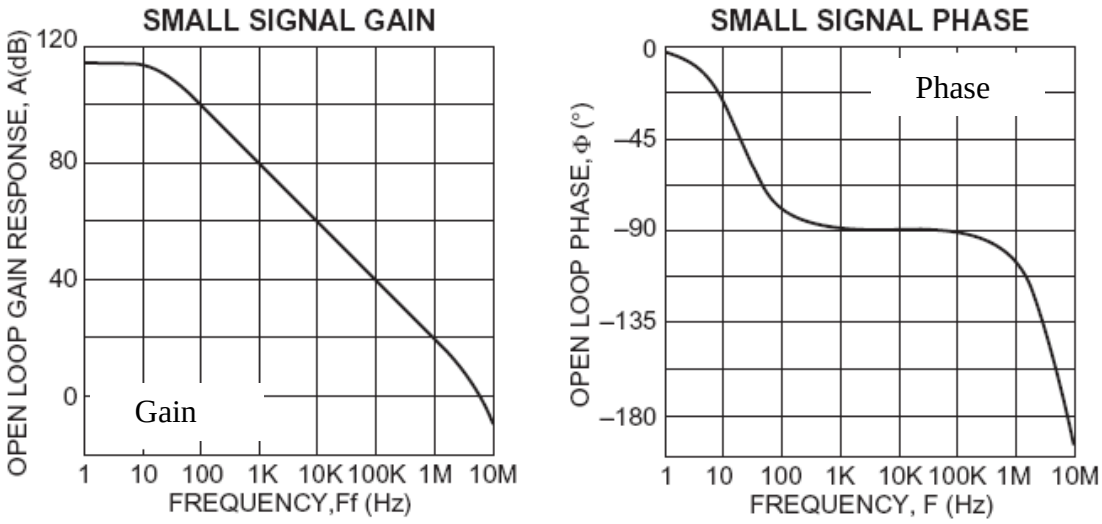

Figure 2: PA52 open loop frequency response.