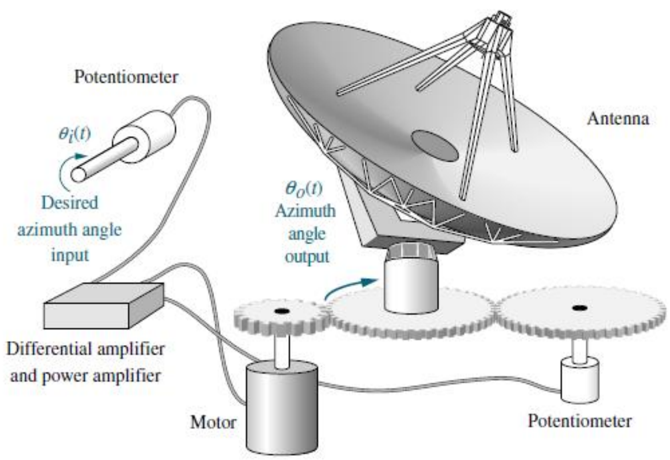
Cairo University **Faculty of Engineering** **Elect. Power Engineering Dept.**		**Second year** **EPEG204: Signals and Systems** **Term Project, 2025/2026**

Antenna Azimuth position control project

Note: All figures and data in this report description are taken from Control systems engineering by N. Nise.



Project description:

For the antenna Azimuth position control application (shown in figure 1 and Table 1), please do the following parts:

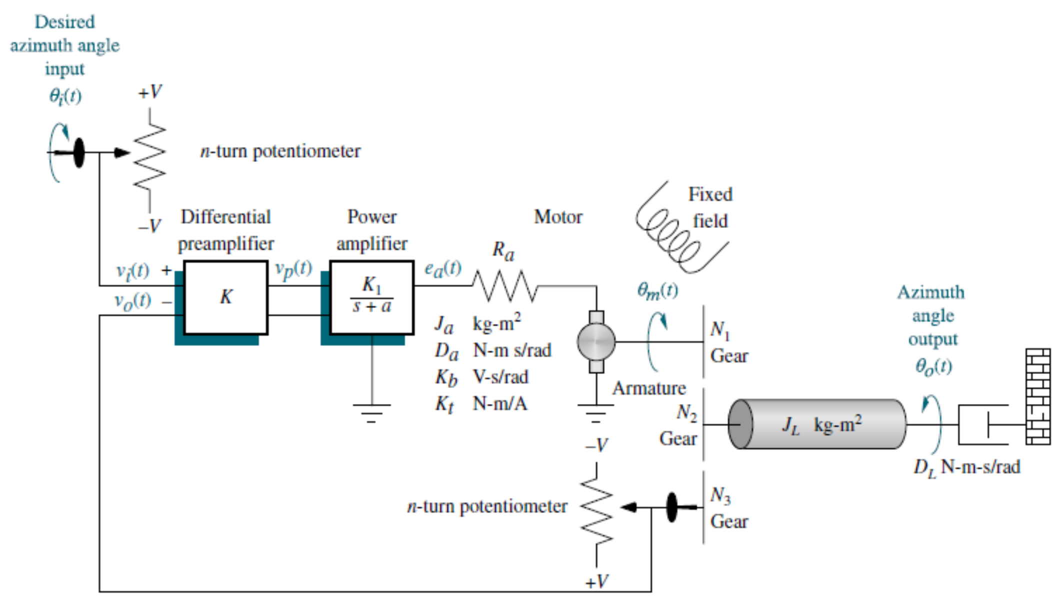


Figure 1

Table 1: schematic parameters

Parameter	Configuration 1	Configuration 2	Configuration 3
V	10	10	10
n	10	1	1
K	—	—	—
K_1	100	150	100
a	100	150	100
R_a	8	5	5
J_a	0.02	0.05	0.05
D_a	0.01	0.01	0.01
K_b	0.5	1	1
K_t	0.5	1	1
N_1	25	50	50
N_2	250	250	250
N_3	250	250	250
J_L	1	5	5
D_L	1	3	3

Part A:

Find the transfer function for each subsystem of the antenna azimuth position control system schematic shown in figure 1. **Use Configuration 2**. The required subsystems are listed in the table below.

Subsystem	Input	Output
Input potentiometer	Angular rotation from user, $\theta_i(t)$	Voltage to preamp, $v_i(t)$
Preamp	Voltage from potentiometers, $v_e(t) = v_i(t) - v_0(t)$	Voltage to power amp, $v_p(t)$
Power amp	Voltage from preamp, $v_p(t)$	Voltage to motor, $e_a(t)$
Motor	Voltage from power amp, $e_a(t)$	Angular rotation to load, $\theta_0(t)$
Output potentiometer	Angular rotation from load, $\theta_0(t)$	Voltage to preamp, $v_0(t)$

Part B:

For the schematic of the azimuth position control system shown in figure 1, **Configuration 2**, assume an open-loop system (feedback path disconnected).

a. Predict, by inspection, the form of the open-loop angular velocity response of the load to a step-voltage input to the power amplifier.
b. Find the damping ratio and natural frequency of the open-loop system.
c. Derive the complete analytical expression for the open-loop angular velocity response of the load to a step-voltage input to the power amplifier, using transfer functions.
d. Use MATLAB to obtain a plot of the open-loop angular velocity response to a step-voltage input.

Part C:

For the antenna azimuth position control system shown in figure 1, **Configuration 2**, do the following:

a. Find the closed-loop transfer function using block diagram reduction.
b. Replace the power amplifier with a transfer function of unity and evaluate the closed-loop peak time, percent overshoot, and settling time for K = 1000.
c. For the system of “b”, derive the expression for the closed-loop step response of the system.
d. For the simplified model of “b”, find the value of K that yields a 10% overshoot.

Part D:

For the antenna azimuth position control system shown in figure 1, **Configuration 2**. Find the range of preamplifier gain required to keep the closed-loop system stable.

Part E:

Consider the transfer function derived in **Part C-b**, use a Simulink simulation to

1- Check the following properties: a) linearity b) time invariance c) causality (Your report should include the responses of the system)
2- Plot the unit-step and unit-impulse response of the transfer function in **Part C-b**.
3- Integrate the unit-impulse response in **Part E-2** and compare the result with its unit-step response in **Part E-2**. Comment on your results.
4- Draw the system response when its input is sinusoidal with fixed magnitude and different frequencies (Use three frequencies). Manually calculate the magnitude and phase angle of the system in each of the previous cases and compare them to the Simulink results. Comment on your results.
5- You can use the command c2d (continuous to discrete) to convert the continuous transfer function in **Part C-b** to discrete using sampling periods of 0.01, 0.1 and 1 second.
6- For each of the resulting discrete systems, use the Simulink to display the discrete unit step response. Compare your results with **Part E-2**. Comment on your results.

Project instructions, deadline and submission:

- This is an individual project.
- Prepare a report with all your calculations and plots in a single pdf file.
- Your report should have a cover page with all necessary details like your name, section and bench numbers…etc.
- The deadline to submit the project is Thursday December 18th.
- The project is to be uploaded to the class’s Google Classroom.