A schematic for the position control of a d.c. motor is shown in Figure 1.

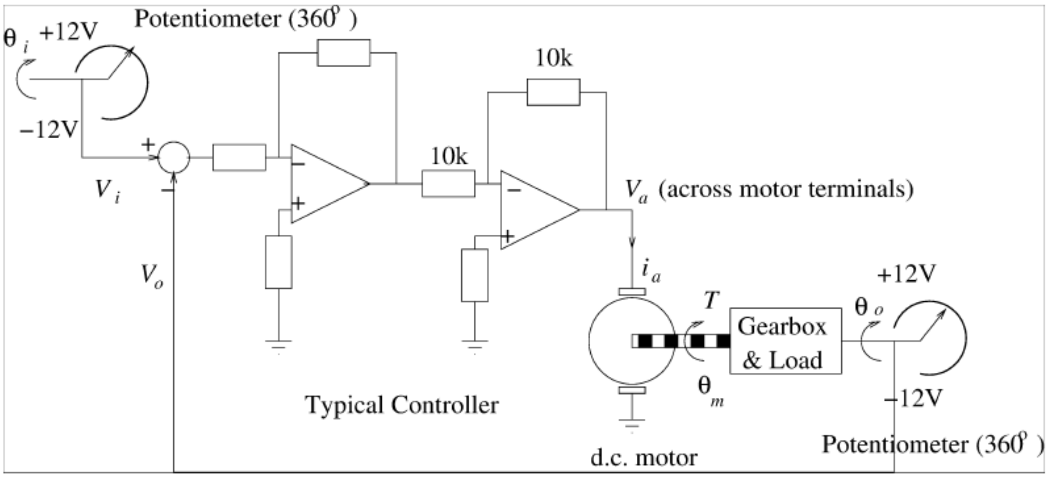

Figure 1: d.c. Motor Position Control

The specification of the system parameters is:

Motor	Armature resistance	20.8Ω
	Field constant	15×10^{-3} Nm/A
	Back e.m.f. constant	1.6 V/1000 r.p.m.
Step down Gearbox	Ratio	1:320
Load (referenced to d.c. motor shaft)	Inertia	6.26×10^{-7} kgm^2
	Viscous friction	3.125×10^{-6} Nm (rad s^{-1})$^{-1}$

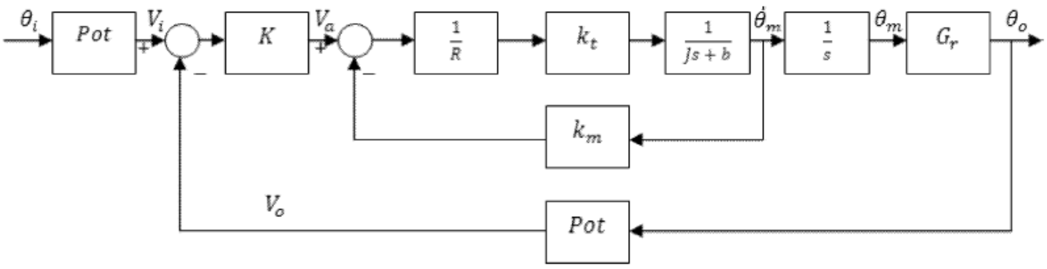

Figure 2: Block Diagram of d.c. Motor Position Control

Task 1

Use the information in the schematic of Figure 1, the provided system parameters, and the block diagram of Figure 2 to find an expression for the open-loop motor transfer function $G(s) = \frac{\theta_o(s)}{V_a(s)}$.

Figure 2 shows a closed-loop configuration, the controller is intended to be a general unknown transfer function at this stage. Do not attempt to deduce what form it should take from the presence of op-amp elements in the schematic of Figure 1, these are for illustrative purposes only.

Find an expression for the overall closed-loop transfer function $G_{cl}(s) = \frac{\theta_o(s)}{\theta_i(s)}$ in terms of a general controller transfer function, $K(s)$, or a general controller gain k if you prefer.

Hint: be careful with units.

If you prefer to work with a unity feedback structure, you can manipulate the block diagram to achieve this provided of course you do it correctly.

If the controller is a proportional amplifier, of variable gain, investigate the effect of varying the gain on the closed-loop performance of the system, and propose a suitable controller gain based on your observations and predictions. Use MATLAB (or other software) as appropriate.

Hint: this is an open investigation, there is no set specification to meet.

Hint: in tackling this activity in the past, students have demonstrated a great desire to produce a high volume of very detailed mathematical analysis, with literally pages of working, and manipulation of equations and algebra. This is very time consuming to produce, and often rather tedious to read. It certainly adds little or no insight into the students understanding of the problem, merely demonstrating they can crunch some numbers.

The objective of the report is to be able to reflect on the design method, the performance criteria selected, and to compare and contrast the various solutions obtained. You should include sufficient detail to demonstrate that you can treat controller design as an analytical problem, rather than merely taking a 'trial and error'approach in MATLAB, but you should not produce a number of detailed designs just for the sake of crunching the numbers.

Task 2

Describe how additional velocity feedback, from a tachogenerator, may be incorporated into the closed-loop system, and simulate the system with MATLAB. Investigate the effect of integrating such a scheme with the proportional amplifier approach of Task 1. Propose a suitable P+D controller, based on your observations and predictions. Similar comments about the use of MATLAB to support the activity, and the need to reflect on the design process as a whole, apply as for Task 1.

Task 3

Instead of using velocity feedback, improved closed-loop performance may be achieved by the introduction of an in series compensator (filter) in the forward path. Investigate how the parameters of such a compensator maybe designed, and how they affect the performance characteristics of the closed-loop system, compared with the results of Tasks 2 and 3. Propose a suitable compensator. Similar comments about the use of MATLAB to support the activity, and the need to reflect on the design process as a whole, apply as for Task 1.