



**Faculty of Engineering  
Department of Electrical & Computer Engineering (ECE)**

**Control Systems (ECE 331)**

**Experiment No: 04**

“Servo Motor Speed Control Using Proportional Controller”

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# Control Systems ECE 331

## Experiment 04

### Servo Motor Speed Control using a Proportional Controller

## Contents

<b>1</b>	<b>Introduction</b>	<b>2</b>
1.1	Limitation of Proportional Controller: . . . . .	3
<b>2</b>	<b>Modeling:</b>	<b>3</b>

# 1 Introduction

DC motors are used extensively in many control applications. Therefore, It is necessary to establish mathematical models for DC motors. The transfer function of a DC motor can be approximated by a first order model with unknown constants.

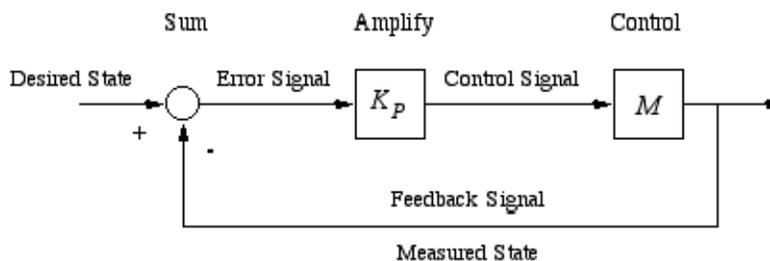


Figure 1: Basic Proportional Controller Model

A proportional control system is a type of linear feedback control system. Two classic mechanical examples are the toilet bowl float proportioning valve and the fly-ball governor. The proportional control system is more complex than an on-off control system like a bi-metallic domestic thermostat, but simpler than a proportional-integral-derivative (PID) control system used in something like an automobile cruise control. On-off control will work where the overall system has a relatively long response time, but can result in instability if the system being controlled has a rapid response time. Proportional control overcomes this by modulating the output to the controlling device, such as a continuously variable valve.

An analogy to on-off control is driving a car by applying either full power or no power and varying the duty cycle, to control speed. The power would be on until the target speed is reached, and then the power would be removed, so the car reduces speed. When the speed falls below the target, with a certain hysteresis, full power would again be applied. It can be seen that this looks like pulse-width modulation, but would obviously result in poor control and large variations in speed. The more powerful the engine; the greater the instability, the heavier the car; the greater the stability. Stability may be expressed as correlating to the power-to-weight ratio of the vehicle.

Proportional control is how most drivers control the speed of a car. If the car is at target speed and the speed increases slightly, the power is reduced slightly, or in proportion to the error (the actual versus target speed), so that the car reduces speed gradually and reaches the target point with very little, if any, "overshoot", so the result is much smoother control than on-off control.

## 1.1 Limitation of Proportional Controller:

[1] There are many times when you want the output of a system to be equal to the input value.

- The proportional controller amplifies the error and applies a control effort to the system that is proportional to the error.
- P-controller must have some error in order to provide control output.

[2] If you want better error performance, you might want to consider using an integral controller.

- In integral control, the control effort is proportional to the integral of the error.

## 2 Modeling:

The open loop transfer function for the dc motor is given by,

$$\begin{aligned} s(Js + b)\Theta(s) &= KI(s) \\ (Ls + R)I(s) &= V(s) - Ks\Theta(s) \\ P(s) = \frac{\Theta(s)}{V(s)} &= \frac{K}{(Js+b)(Ls+R)+K^2} \quad \frac{\text{rad/sec}}{V} \end{aligned}$$

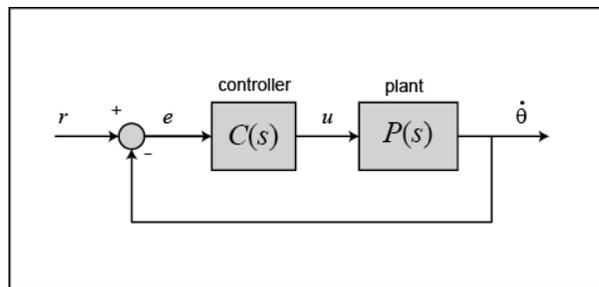


Figure 2: Modeling of DC Motor using Proportional Controller

For a 1 radian/second step reference, the design criteria are the following:

- Settling time less than 2 seconds
- Overshoot less than 5%
- Steady state error is less than 1%

Before going to make a .m file, please consider the following parameters used in the modeling:

```

J = 0.01;
b = 0.1
k = 0.01
R = 1;
L = 0.5;
s = tf('s');
Pmotor = K/(J * s + b)(L * s + R) + K^2);

```

Let's apply Proportional Controller with a gain of 100, that is,  $C(s) = 100$ . To determine the closed-loop transfer function, we use the feedback command,

So,

```

Kp = 100;
C = pid(kp)
syscl = feedback(C * Pmotor, 1);

```

Now examine the output graph for the given proportional controller.

The final script programme as under::

```

clc
clear all

J = 0.01;
b = 0.1;
K = 0.01;
R = 1;
L = 0.5;
s = tf('s');
Pmotor = K/((J*s+b)*(L*s+R)+K^2);

Kp = 100;
C = pid(Kp);
syscl = feedback(C*Pmotor, 1);

t = 0:0.01:5;
step(syscl, t)
grid
title('Step Response with Proportional Control')

```

The graph for the proportional controller as under:

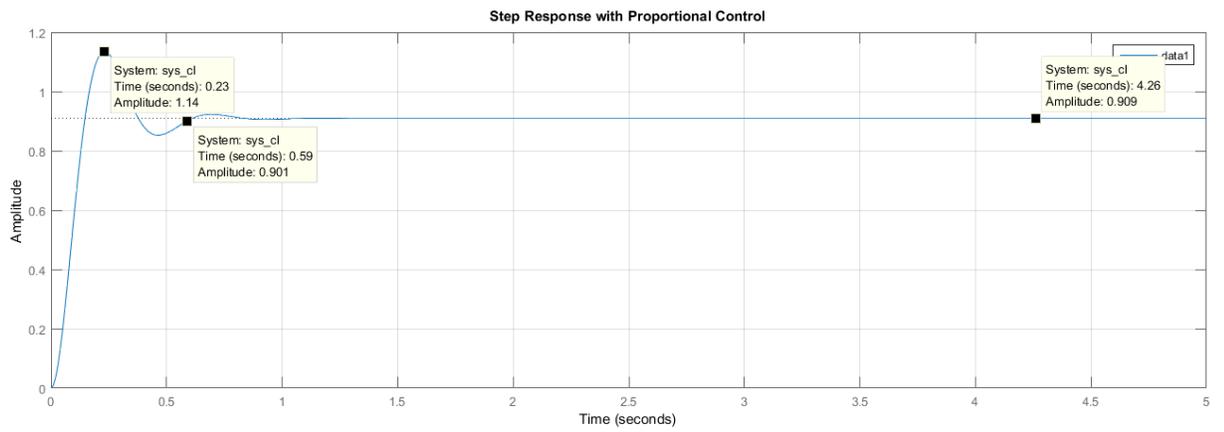


Figure 3: Step input for Proportional Controller