# University of Toronto

## Department of Electrical and Computer Engineering

## ECE 356S – System and Signal Analysis II 1999

### Exp 1: IDENTIFICATION OF A PHYSICAL SYSTEM

# 1 Purpose

The first three labs in this course involve modelling a physical system, namely, a DC motor, designing a speed controller for it, and implementing the controller. The purpose of this first lab is to determine by experiment the parameters in the model. You'll use both time-domain and frequency-domain methods.

# 2 Introduction

The DC motor system in an open-loop configuration is a first-order system when the input is taken as the voltage $v_m$ applied to the power amplifier and the output as the motor speed $w$ in $rad/s$. The motor speed and the tachometer output voltage $v_t$ are related by the equation $v_t = K_t w$.

The block diagram of the DC motor system in open-loop configuration is shown here:

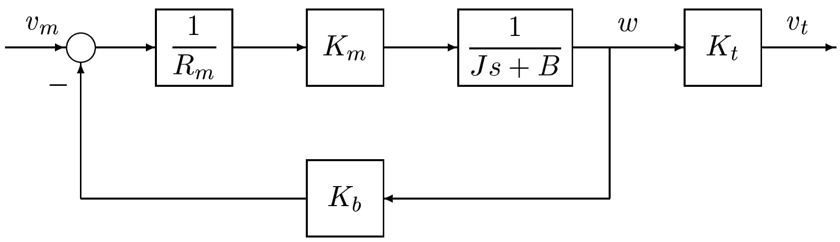


Figure 1: DC Motor System Block Diagram.

The transfer function $H(s)$ from $v_m$ to $v_t$ is first-order,

$$H(s) = \frac{K}{\tau s + 1}, \tag{1}$$

where $K$ is the DC gain and $\tau$ is the time constant. The identification problem amounts to determining $K$ and $\tau$ so that the mathematical model is as good a fit as possible. You will determine $K$ by a time-domain method and $\tau$ by a frequency-domain method.

# 3 Experimental Set-up

### Equipment

- RC-01 Rate Control Experiment DC Motor Kit
- Function Generator

- Oscilloscope

The experimental set-up is very simple. Connect the function generator to the terminal of the RC-01 marked $v_m$. The output of the system can be monitored from the terminal marked $v_t$. Then, both channels of the oscilloscope can be used to monitor voltages. For instance, Channel A can be used to observe $v_m$ and Channel B to observe $v_t$.

**Caution** So as not to saturate the power amplifier, you should limit the amplitude of the input $v_m$ to not more than 5 $V$ peak-to-peak.

# 4 Procedure

1. Record the number of your RC-01 DC motor. Use this one for Experiment 3 also.
2. Determine the DC gain by applying a suitable square wave input $v_m$.
3. Determine the time constant by applying a sinusoidal input $v_m$ and adjusting its frequency until the output amplitude equals 0.7 times the DC gain times the input amplitude. This frequency in $rad/s$ then equals $\tau^{-1}$.
4. Obtain about eight other frequency response points (magnitude and phase) for later checking. The most convenient way to do this is to display a Lissajous figure on the scope.
5. Add the inertia disc to the motor and repeat the above steps.

# 5 Preparation

Plan how to measure $K$ and $\tau$ by the methods outlined above. Read up on how to measure gain and phase from a Lissajous figure.

# 6 Your Report

1. Describe how you did the experiment.
2. Report the values you measured.
3. From the measured values of $K$ and $\tau$, draw the Bode plot of $H(s)$ (it's recommended to use MATLAB). On this plot, add the other frequency response points obtained. Comment on the match. What might be the sources of mismatch?
4. Given the motor manufacturers specs $K_t$=0.00955 $V/rad/s$, $K_m$=0.027 $Nm/A$, $K_b$=0.027 $V/rad/s$, and $R_m$=5.3 $Ohms$, find the values for the friction $B$, armature inertia $J_a$, and disc inertia $J_d$. (Note: When the system is unloaded, $J = J_a$ and when it is loaded $J = J_a + J_d$.)