Design of Simulink® -based Electromechanical Control Workstation for Load Disturbance Testing

Functional Requirements List and Performance Specifications

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Introduction

       The goal of this project is to design in Simulink® an electromechanical control workstation to examine the effects of load disturbance on the GM9236C534-R2 Pittman DC-geared motor. The motor is to be modeled in SimMechanics® as well as Simulink®, using both parameter values found in the Pittman motor datasheets, and those determined experimentally. The controller's response to various load disturbances will be tested by coupling a second motor to the first to act as a DC generator. The electronic coupler and second motor will also be modeled in SimMechanics®. Upon completion of the controller and modeling, a GUI will be developed to allow for easy variation of system parameters, command signals, and loads.
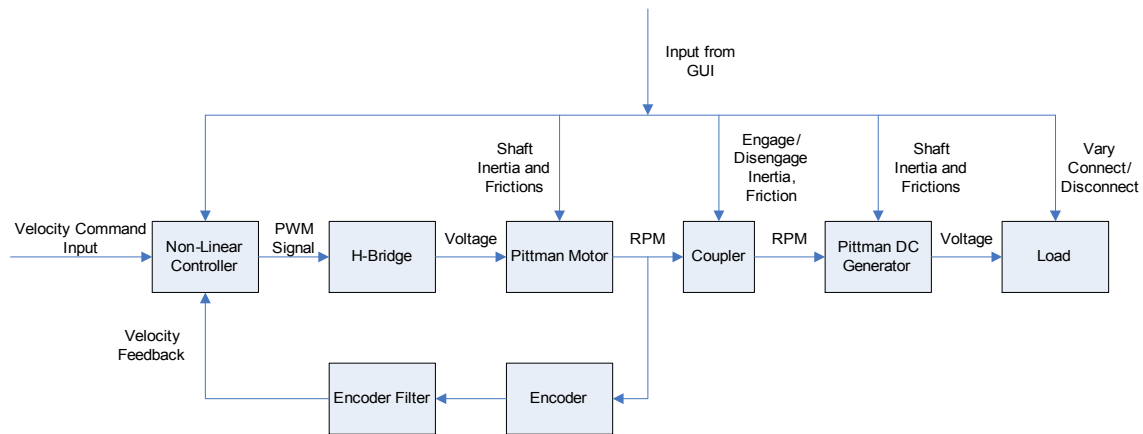

Figure 1: Complete System Block Diagram

       In the above block diagram the inputs to the system are the various motor, coupler, and load parameters, as well as the command velocity. Other command signals of interest might include position, acceleration, torque, or current consumption. Outputs to be analyzed consist of motor position, velocity, acceleration, torque, and current. The blocks of significance will be described briefly below.

The Graphical User Interface

       This interface will allow the user to modify key characteristics of the system such as motor friction, inertia, speed-voltage constant, winding inductance and resistance, torque constant; coupler friction, inertia, spring constant, and coupler status: engaged or disengaged; size of load; controller parameters: gain, encoder and pulse width modulation resolution.

Non-Linear Controller

       This differs greatly from the linear controller designed in the EE450 product design course. The non-linear controller will take into account the non-linear characteristics of the DC motor. The inputs to this block are the command signal, the

velocity feedback and the GUI. It outputs a PWM signal which regulates the motor speed.

DC Motor

This motor will be regulated by a PWM input. The starting point for the non-linear modeling for the Pittman motor will be the linear model developed in the mini-project. The model is detailed below.
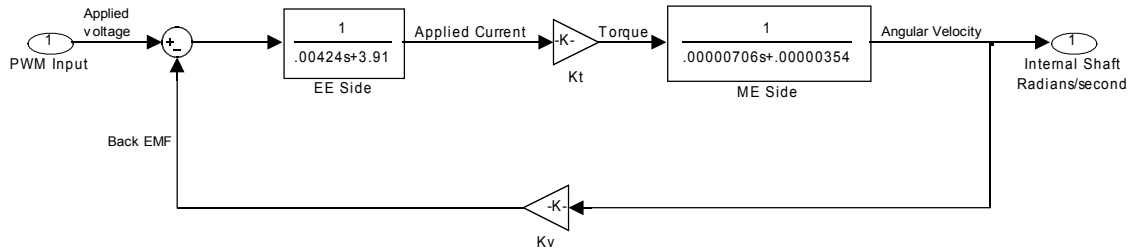

Figure 2: Linear DC Motor Model

The non-linear model will take into account the effects of the non-linear frictions present which are most evident between 0rpm and 25rpm. The figures below detail the nature of the frictions mentioned above.
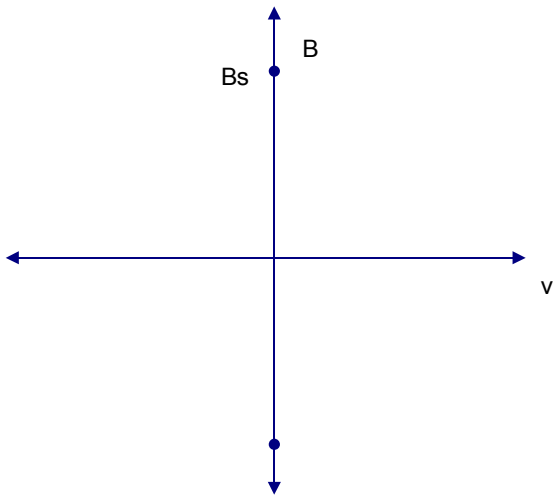

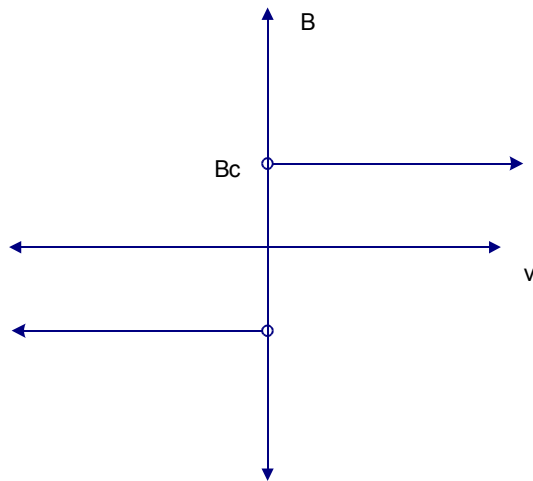Figure 3: Static Friction vs Motor Velocity
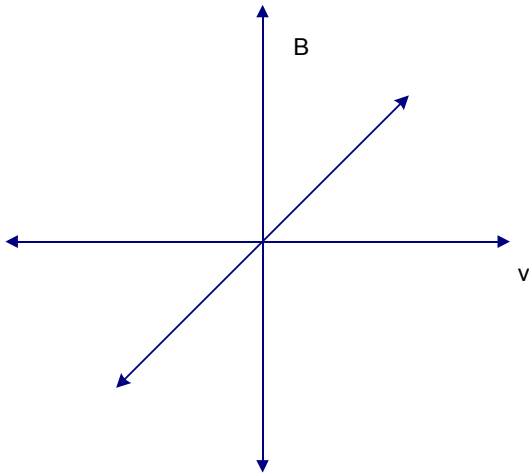
Figure 4: Coulomb Friction vs Motor Velocity

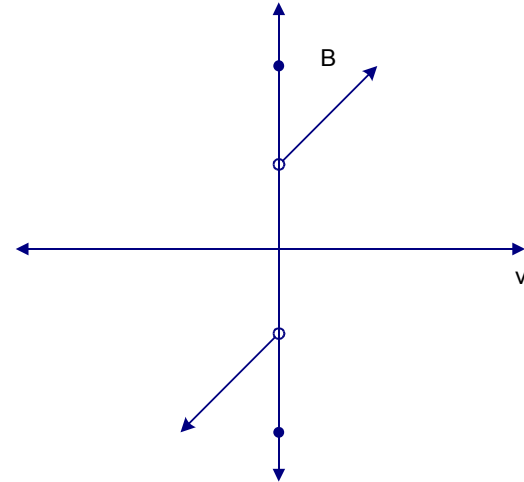Figure 5: Viscous Friction vs Motor Velocity   Figure 6: Combined Friction vs Motor Velocity

The Coupler (or Clutch)

This is an external device that is used as a clutch to couple two DC motors together. The EC15 Clutch from REELL Precision Manufacturing Company is the clutching device selected for this application. The clutch will enable the primary DC motor to drive DC generator which is also a DC motor.

Figure 7: EC15 Clutch

The DC Generator

This is a DC motor with the shaft coupled to the shaft of the first motor. It is driven by the shaft velocity of the first motor and generates a DC voltage output. It is not powered by an input voltage. A resistive load connected across the motor terminals can be varied to analyze the effects of load disturbance on the controller, a critical objective of the project.

Functional Requirements and Performance Specifications of Subsystem Components	
Subsystem	Primary Objectives
Controller	- Nonlinear characteristics of motor must be accounted for. - X% overshoot with Y load. ___ settling time with Y load. ___ rise time with Y load. - Regulation range: 0rpm – 500rpm.
DC Motor Model	- Initial model parameters accurate. - Motor model based on measured parameters accurate to within X% (velocity, current). - All model parameters should be variable using GUI, including all nonlinear frictions, shaft inertias, etc.
Clutch	- Experimental rise time accurately depicted in clutch model. - Clutch model engaged/disengaged through GUI. - Model only works in one direction. - All model parameters should be variable using GUI, including inertia, friction, and spring constant.
DC Generator Model	- Initial model parameters accurate - Generator model based on measured parameters accurate to within X% (voltage, current). - All model parameters should be variable using GUI, including all non linear functions, gear inertias, etc. - Load varied/connected/disconnected through GUI.
GUI	- Aesthetically pleasing and intuitive layout. - Outputs of interest displayed and graphed.

References

Manufacturer Site and Clutch Datasheet
http://www.reell.com/products/ec15.htm

Pittman Motor Datasheet
http://blackboard.bradley.edu/courses/1/EE450_01_06FA/content/_390613_1/gm9000_pittman.pdf

Pittman Servo Motor Application Notes
http://blackboard.bradley.edu/courses/1/EE451_01_06FA/content/_455117_1/220000ALL.pdf