

# **Observer Based Robot Arm Control System**

Functional Description and System Block Diagram

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## Introduction

Control systems exist in many applications today, from home thermostats and vehicle cruise controls to engine temperature regulation and missile-guidance systems. Many control system designs exist, and one of the newer, more sophisticated concepts in modern control systems is the concept of observers.

Observers are algorithms used to predict a system's response. The chief benefit to using observer control systems is cost. An observer can predict a system's response without using numerous sensors which can greatly reduce the cost of a system. The observer uses data collected from sensors to predict information that either cannot be measured or is too costly to measure. Also, because the data is derived from the observer and not read from a sensor, the factor of noise is eliminated. With this control method, we can control parameters that cannot be easily measured such as motor current or fluid flow rate. This project focuses on using observers to control the position of two robot arms which will pass an object back and forth.

## Goals

- Learn the Quanser software package and real time control via Simulink.
- Obtain a mathematical model for the pendulum arm and the horizontal arm.
- Design controllers for each system using classical control methods
- Design a controller for each that uses observers to predict the plant's response.
- Evaluate the performance of the two control methods and compare the result.

## Functional Description

The workstation for each robot arm consists of the following components:

- PC with Matlab and Simulink
- Motor with Quanser Control System
- Linear Power Amplifier
- Robot arm with Gripper
- SRV-02 Rotary Servo Plant
  - One robot arm will also contain a SRV-02 Rotary Flexible Joint to add another degree of freedom.
  - The inverted robot arm contains a rotary encoder, and the level robot arm contains a potentiometer to measure position.

One robot arm will be configured vertically in a pendulum-like fashion to incorporate the effects of gravity on the arm. The other robot arm will be placed horizontally and will have a flexible joint to add a second degree of freedom that is independent from the base of the system. A closed-loop PID control system will be implemented in Simulink and will use Quanser software to allow real-time control of the robot arms through Simulink.

System Inputs:

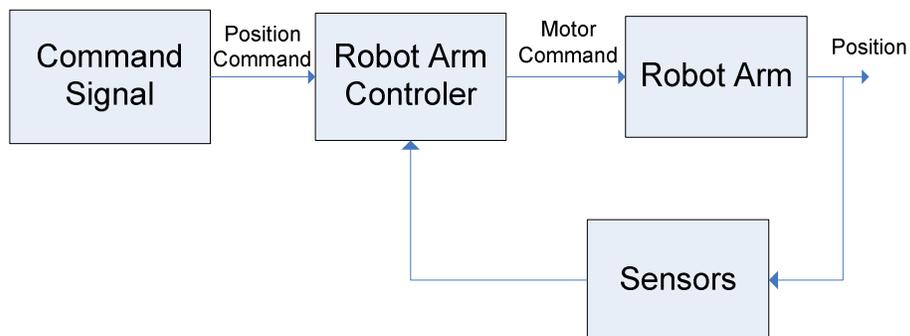
- Internal Commands
- Potentiometer
- Rotary Encoder

System Outputs:

- Position

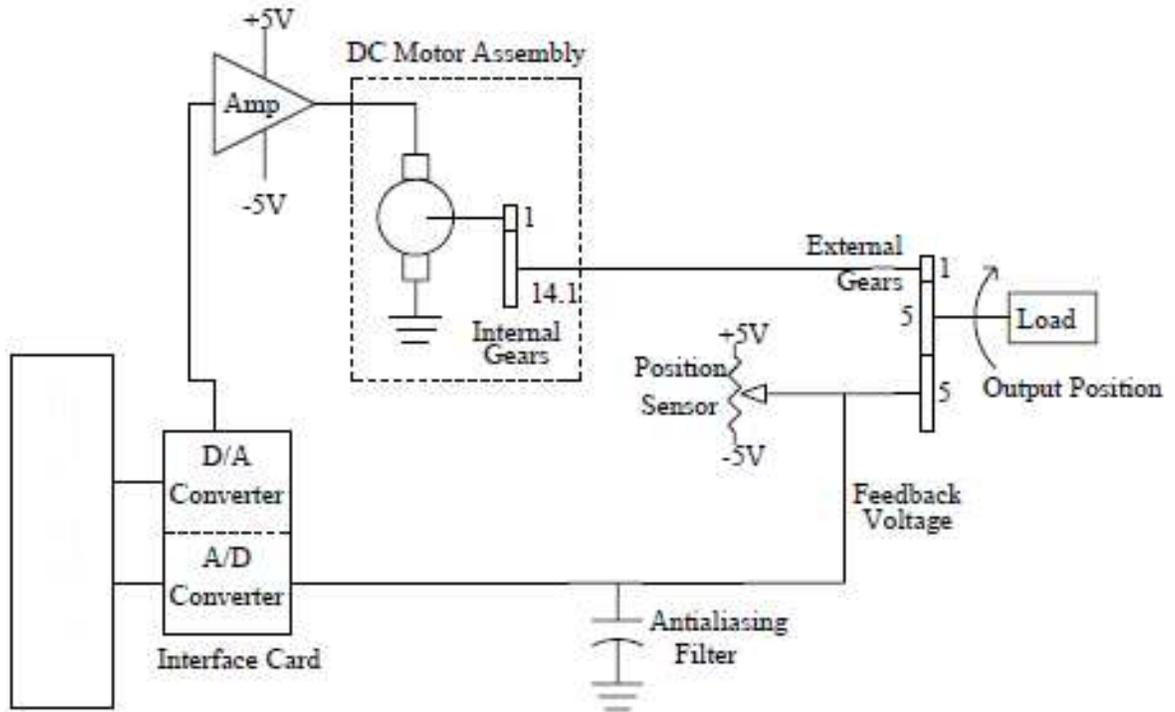
## Block Diagram

The High level block diagram for the project is shown in Figure 1. The command signal is set in simulink which then sends a signal to the implemented arm controller, which then sends the signal to the arm. Sensors connected to the arm then send feedback to the controller allowing closed loop control. The Power electronics involved with the robot arm controller, the robot arm itself and the sensors all introduce external disturbances including voltage source noise, changes in load due, friction, and quantization error.



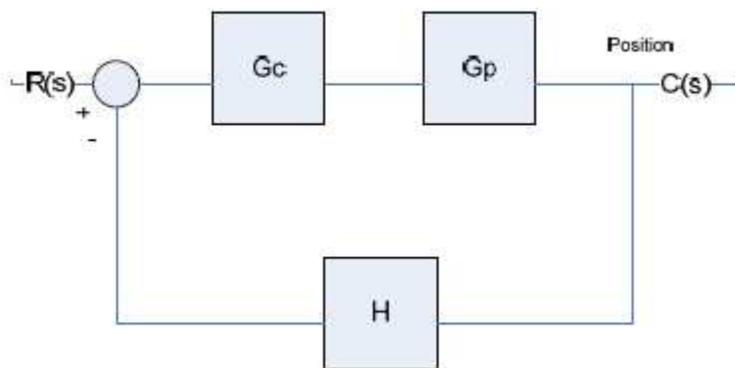
**Figure 1. High-Level Block Diagram**

Figure 2 shows a detailed view of the robot arm system, the sensors, and the power electronics involved in the control of the arm.

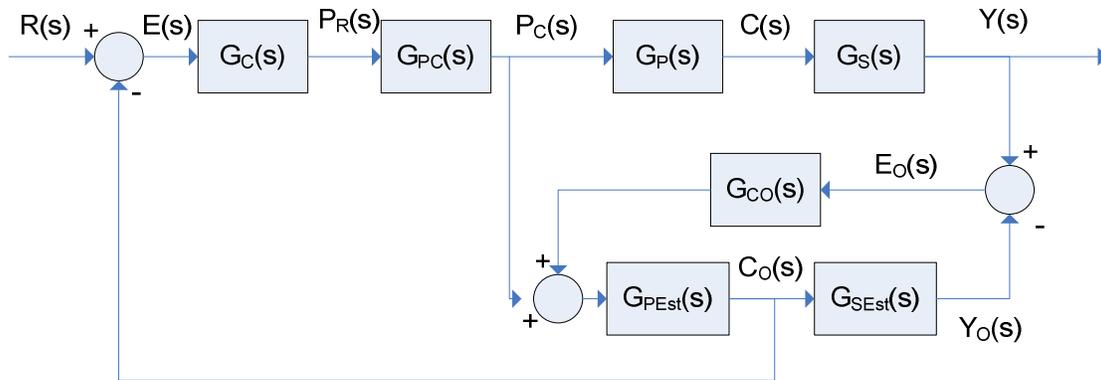


**Figure 2. Quanser Electromechanical Plant**

Figures 3 and 4 show robot arm controller systems that will be implemented and tested in this project. Figure 3 shows a classical single loop controller that will provide a basic control scheme to get us accustomed to the use of the system. Figure 4 shows the set up expected final set up for our system using the observer based control explained in George Ellis's Observers in Control Systems.



**Figure 3. Single Loop Controller**



**Figure 4. Proposed Observer Based Controller**

In Figure 4  $G_{pc}(s)$  represents the power electronics, anything with a subscript S is describing the sensor model, anything with a subscript P is describing the plant,  $G_{CO}(s)$  is a PID type controller forcing the system error to zero. The  $G_{PEst}(s)$  and  $G_{SEst}(s)$  are a model of the system run in software.  $C(s)$  will be the position of the robot arm anything with a subscript O represents the observers estimate of that signal, except for  $E_O(s)$  which represents the error of the model of the observer.

## References

- [1] Chris Edwards, Emberly Smith. "Design of Simulink-Based 2-DOF Robot Arm Control Workstation", Senior Project, Electrical and Computer Engineering Department, Bradley University, May 2005, <http://ee1.bradley.edu/projects/proj2007/twodofra/>
- [2] Gary Dempsey. "Observer based robot arm control system", Electrical and Computer Engineering Department, Bradley University, August 2011
- [3] George Ellis. "Observers in Control Systems", Academic Press, 2002