

Real-time control laboratory

Introduction

This laboratory is established to enhance the quality of undergraduate education in control systems and to reinforce the concepts that are covered in lectures. The real-time control laboratory would also open up research activities for graduate students projects. The laboratory is fully equipped with state-of-the-art computer aided control for analog and digital control systems simulations, design and analysis.

The undergraduate experiments give students the opportunity to tie theoretical classroom concepts with practical hands-on experiments. The objective is to provide undergraduate students with computer-based control and introduce them to concepts such as client-server environment, visual instrumentation, automatic code generation, and the modern techniques needed for the design and implementation of automatic control systems. The student is first introduced to the basics of the MATLAB and SIMULINK used for the analysis and simulation of the dynamic system, controller design and simulation of the compensated system. Next, the student implements the developed control system in one of the laboratory test bench, and control the system in real-time in accordance to the design specifications.

Laboratory Equipment

The lab contains ten stations, providing a flexible computing environment for the study of real-time control systems. Each station comprises the Quanser SRV02-ET Servo plant, UPM1503-240V Power Module, ISA MultiQ-2E Data Acquisition and Control Board (DACB), several mechatronic components, an AB industrial micro PC referred to as the *host computer*, which contain data acquisition board and network interface card.



Figure 1

In addition to MATLAB and SIMULINK software we have the MATLAB Real-Time Workshop®, and the Quanser real-time data acquisition and control program called WinCon.

MATLAB Real-Time Workshop

Real-Time Workshop generates optimized, portable, and customizable ANSI C code from Simulink models. The code generated by Real-Time Workshop is processor-independent and represents your model exactly and is carefully commented. It includes block names and signal labels from the Simulink model, enabling you to trace the code back to the model. A separate target-dependent run-time interface is used to execute this code. Real-Time Workshop supports all Simulink features, including 8-bit, 16-bit, and 32-bit integer, floating-point, and custom (fixed-point) data types. It allows for extensive customization of the generated code.

WinCon

WinCon handles data transfer between MATLAB and the servo system. WinCon program consists of two components named WinCon client and WinCon server. The WinCon client is installed on the host computer. The student laptops contain MATLAB, SIMULINK and the Real-Time Workshop.

The students perform all their design work on their laptops. They connect their laptops to the host computer via an Ethernet cable; generate the real-time code on their laptops, which is downloaded automatically to the host computer. The control is executed on the host computer and data is streamed to the laptop for on-line parameter tuning. The WinCon provides useful GUI-based controls for on-the-fly controller tuning and for plotting real-time data.

WinLib

This is a library of Quanser DACB drivers accessible from SIMULINK. Some commonly used blocks of MultiQ3 library are analog input (ADC), analog output (DAC) and encoder input.

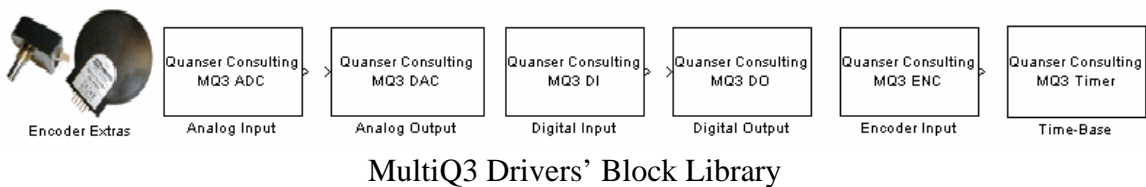
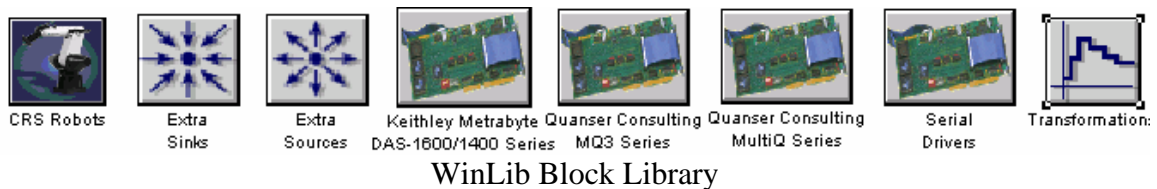


Figure 2 Library of Quanser DACB drivers

MultiQ3 DACB

The MultiQ3 terminal board shown in Figure 3 is the interface between the MultiQ-2E DACB inside the computer, and all of the I/O needed for implementing a control system. The DACB measures signals from sensors on the plant and converts them to digital signals, which can be acquired and processed by the computer. The WinCon provides a user-friendly graphical User Interface (GUI) for implementing Simulink-based real-time control on MultiQ-2E DACB. The control program residing in the computer performs the operations required for these signals and computes output voltages that are written to the DACB. The DACB outputs are connected to amplifiers, which in turn drive the actuator in the system.

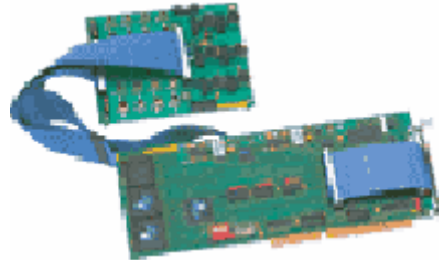


Figure 3 ISA MultiQ data acquisition and control board

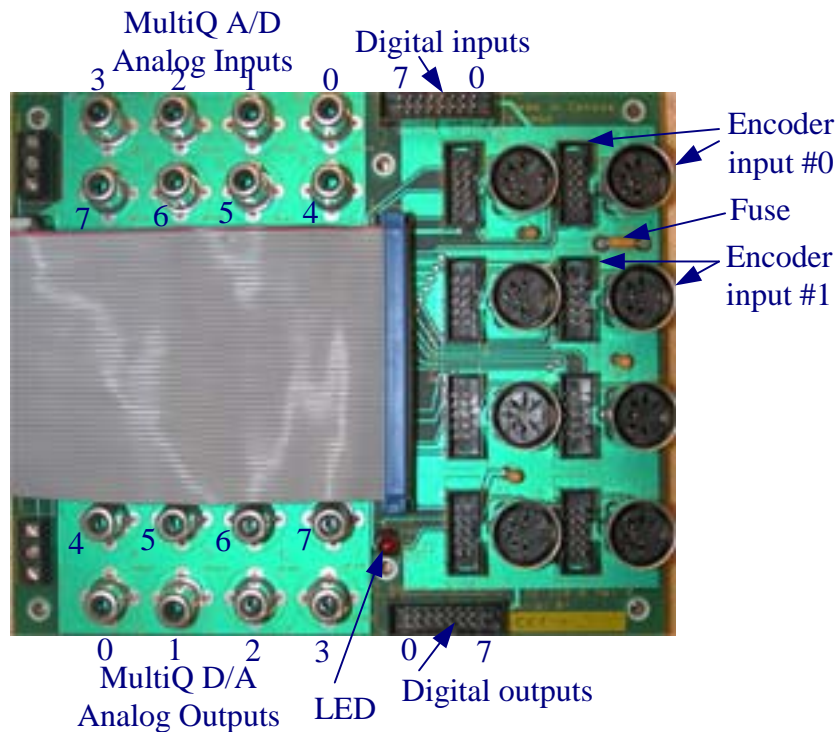


Figure 4 MultiQ3 terminal board

The connector I/O has the following I/O capabilities:

- 8 multiplexed analog inputs, +/- 5 Volts range
- 8 analog outputs, +/- 5 Volts range
- 8 Digital inputs
- 8 Digital outputs
- 8 optical encoder inputs
- 3 Real-time clocks that can tie to interrupts on the bus
- Terminal board with standard connectors and sockets

Power Module

Each servomotor requires a power amplifier to drive it. The power module consists of a regulated dual output ± 12 VDC power supply and a linear power operational amplifier. The top section labeled “DC Power Supply” has three binding posts set at ± 12 VDC with maximum current rating of 1 Ampere. The lower section labeled “Power Amplifier” has four binding posts. It can be used in any standard op-amp configuration. Its two inputs are labeled (-) for the inverting input and (+) for the noninverting input. The output is also labeled and a binding point adjacent to it is labeled GND. The power section is powered via a differential power supply with the following ratings: Maximum power output 45W, Maximum current output 3 A, maximum output voltage 15 V, power bandwidth 60 KHz, small signal bandwidth 700 KHz, slew rate 9 V/ μ sec .

The power modules have several connectors referred to as “Quick Connect System”. The output of the desired D/A channel is connected to the Power amplifier input “From D/A”. The signal from the analog sensor is connected to the ”From sensors to Analog inputs A/D”. The output of the power amplifier labeled “To Motor” is connected to the Servomotor terminals.



Figure 5 The Universal Power Module UPM 1503

SRV02-ET Servomotor

This is a high quality DC servomotor mounted in a solid aluminum frame. The motor drives a built-in 14:1 gearbox, whose output drives an external gear. The motor gear drives a gear attached to an independent output shaft that rotates in a precisely machined aluminum ball bearing block. The output shaft is equipped with a 1024 count quadrature encoder. The second gear on the output shaft drives an anti-backlash gear connected to a potentiometer. The potentiometer is used to measure the output angle. The external gear ratio can be changed from 1:1 to 5:1 using various gears. Two inertial loads are supplied with the system in order to examine the effect of changing inertia on closed loop performance. Various components such as rotary inverted pendulum can be fitted to the servomotor.

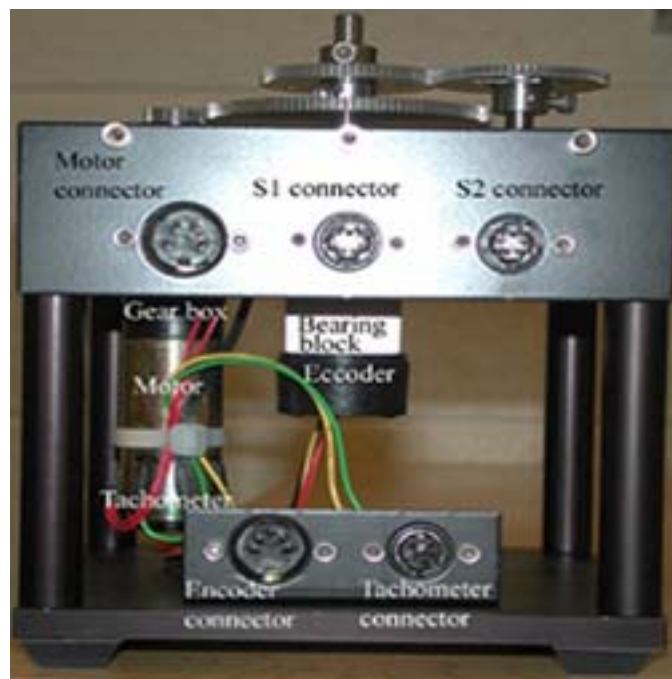


Figure 6 SRV02-ET Servo Plant

Nomenclature Refer to Figure 7 for details

1 Top plate	13 Tachometer
2 Bottom plate	14 Bearing block
3 Posts	15 S1 connector
4 Standard motor gear - 72 teeth	16 S2 connector
5 Output gear	17 Encoder Connector
6 Potentiometer anti-backlash gear	18 Tachometer connector
7 Anti-backlash springs	19 Motor Connector
8 Output shaft	20 Motor gear - 24 teeth
9 Motor	21 Large gear - 120 Teeth
10 Gearbox	22 Circular load
11 Potentiometer	23 Bar Load
12 Encoder	

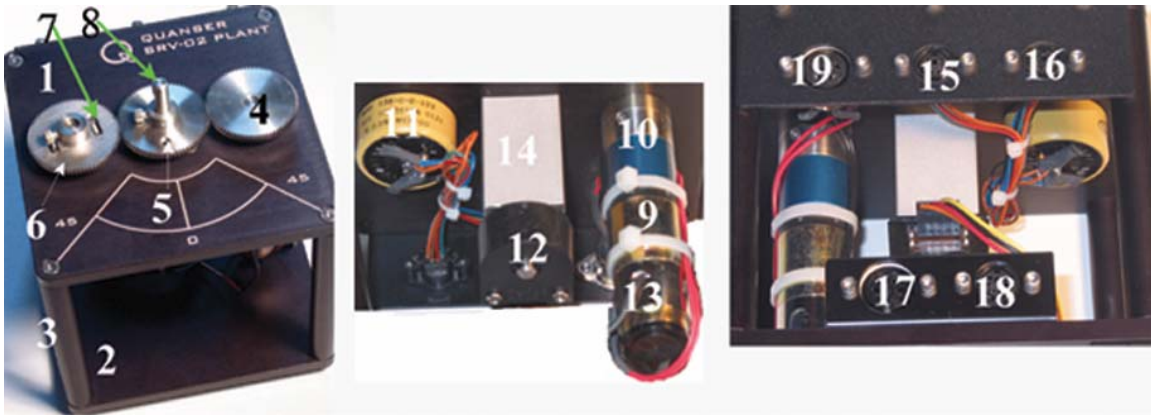


Figure 7

Configurations

The external gear can be reconfigured into two configurations:

Low gear ratio

This is the recommended configuration to perform position control experiments and rate control experiment with no other modules attached to the output. The only loads that are recommended for this configuration are the bar and circular loads supplied with the system.



Figure 8 Low gear ratio configuration

High gear ratio

This is the recommended configuration for all other experiments that require additional modules such as the ball and beam, gyro, rotary inverted pendulum etc.



Figure 9 High gear ratio configuration

Changing gear ratios

In order to change gear ratios, use the appropriate Allen key to loosen the screws on the gear hubs and remove them from the shafts. You then insert the new gears as shown in the photos and tighten the screws again. Note that the potentiometer gear is an **anti-backlash** gear and in order to insert it properly you must rotate its two faces against each other such that the springs are partially preloaded. Do not fully extend the springs when you preload the gears.

Attaching external loads

External loads should only be attached to the load gear using the supplied 8-32 screws. Do not apply a load greater than 5Kg. Make sure the screws are tightened.

