

## **Safety Considerations**

The following safety rules **MUST BE FOLLOWED** to ensure safety in the laboratory.

### **General Considerations**

- No smoking, eating or drinking in the laboratory. Hydraulic oil in its vapor state can be flammable, and electronic components may be shorted by spilled beverages.
- Note the locations of the two fire extinguishers, first aid kit, and telephone.
- Use common-sense safety precautions. Do not work alone.
- Many hundreds of thousands of dollars have been invested in this laboratory. Treat it as if it were your own.

### **Hydraulic Trainer Stand Precautions**

- Power on the hydraulic system only after hydraulic circuitry has been checked by a qualified instructor!
- Verify that actuator (cylinders and motor) path is free of clothing, fingers, rags, hoses and all other objects.
- Check all guards and verify that they are securely in place.
- **Check reservoir oil level. Check for leaks.**
- Check all connections to valves and actuators, including quick connect couplings. Verify that they are securely connected and that the safety lock on the quick couplings is activated.
- Verify that the relief valve is set at 0 psi at start-up.
- Do not exceed a maximum system pressure of 500 psi.
- Stand clear of bench on initial start-up of the hydraulic system.

## **Trainer Stand Usage & Overview**

### *Reference:*

Bul. 0229 Industrial Hydraulic Trainer Stand Lab Manual, Parker Hannifin Corporation, 1981

This section is intended to familiarize you with the Parker Hannifin Hydraulic Trainer Stand. Read this thoroughly and complete the exercise at the end of this supplement BEFORE attempting any lab exercise.

### **Introduction**

The Parker Hannifin Industrial Hydraulic Trainer Stand is an educational tool. It is used in industry to train workers and engineers in the proper use of hydraulic equipment. It is also used to teach people how to diagnose problematic hydraulic systems. The Electro Hydraulic option, with which our trainer stands come equipped, is used to teach more advanced electronic motion control concepts.

In this laboratory, the stand will be used to demonstrate control ideas. Basic concepts such as plant identification and closed loop PID control can be taught on these stands, while nonlinear effects such as deadband and valve stiction exhibited by the components can be used to address advanced topics such as nonlinear and adaptive control.

EXTREME CAUTION should be followed when working with the components. Common sense safety practices should be followed and close attention paid to the instructor at all times. READ the safety guidelines sheet before attempting the exercise at the end of this handout.

### **Apparatus**

A diagram of the trainer stand appears in Figure 1. For this exercise we will be using the lever actuated directional control valve (43) to control the motor (41). A similar procedure would be followed if one were to use a different valve or actuator.

In a hydraulic system, the pump provides fluid pressure and flow. This flow and pressure can be converted by one of the actuators (motor or cylinder in our case) to do useful work. Directional valves, such as the one we will be using, simply direct the fluid flow in one direction or another. A proportional valve, such as the D1FS (38) will not only control the direction of the fluid flow, but also a percentage of the full pump flow rate in that direction.

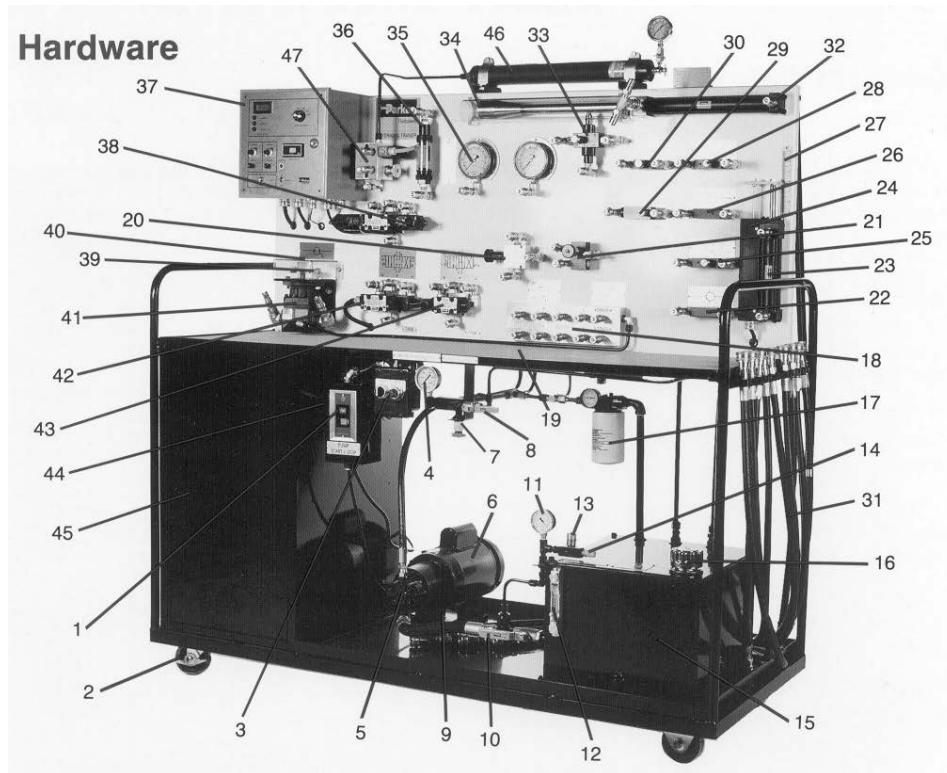


Figure 1 Parker Hannifin Hydraulic Trainer Stand Schematic

- Fused start-stop button
- Heavy duty castors (2 fixed, 2 swivel)
- Solenoid selector switch
- System pressure gage
- 3.5 GPM gear pump
- Electric motor, 115V, 1Hp
- System pressure relief valve
- Ball valve for venting system pressure relief valve
- Motor isolation mount
- Ball valve for demonstrating cavitation
- Vacuum gage
- Liquid level gage with thermometer
- Needle valve for demonstrating aeration
- Aeration filter
- 10 gallon reservoir
- Filler/breather
- 10 micron filter with indicator
- Pressure, drain and tank manifold
- Work bench
- Sequence valve
- Pressure reducing valve
- Check valve
- Hydraulic cylinder, 6" stroke
- Linear position sensor for cylinder rod
- Flow control
- Check valve
- 6" rod piston scale
- Flow control valve
- Pressure compensated flow control
- Needle valve
- 8 sets of hose assemblies with quick disconnect on an integral rack plus (2) tees and (1) cross
- Hydraulic cylinder w/ guard, 12" stroke
- Deceleration valve
- Tapered cam
- Pressure gage (2)
- Flow meter
- Electronic control box
- Electro hydraulic proportional control valve
- Hydraulic motor magnetic pickup
- Hydraulic motor sensing gear
- Hydraulic motor with guard
- Solenoid operate 4-way closed center directional control valve
- Lever operate 4-way open center directional control valve
- Electrical cord (not shown)
- Storage cabinet
- 1 quart accumulator with gas precharge pressure gage down block

The pump (5) draws hydraulic oil from the reservoir (15) and pumps it into the system. The oil passes through the relief valve (7) and into the manifold (18). A properly configured relief valve causes the system pressure never to exceed a preset limit. The manifold is a convenient interface for hose connections. It has pressure (from the pump) and drain (to the reservoir) couplings. The manifold is analogous to the battery in electronic circuits – the pressure couplings are the high potentials, and the drain couplings are the low potential. From the manifold, various valves and actuators can be connected in a circuit to produce the desired work effect.

For this exercise, we will not be using the electro hydraulic control box (37). It is used to control the electro hydraulic valve (38) only.

## Objective

Proper completion of this trainer exercise will require that you:

- Follow safety guidelines for using the hydraulic trainer stand.
- Learn the proper start up and shut down procedure for minimal pump stress and personal safety.
- Understand the basics of hydraulic circuitry.

## Experiment

The goal of the following steps is to enable the hydraulic motor. It will spin quickly when the system is powered on, so verify that the protective covering around the gear is secure.

Follow these steps:

**Connect the circuit.** Take a hose from the cabinet (45) and connect a high pressure outlet (18) to the “P” port on valve (42). Using another hose, connect the “T” port on valve (42) to one of the return couplings (18). Now, connect either the “A” or “B” port on the valve (42) to one port of the hydraulic motor (41). Connect the other port on the motor to the remaining valve coupling. **Caution:** Sometimes, it will matter which valve port “A” or “B” is connected to the actuator. In this case it does not.

**Check that the system pressure gauge (4) reading is almost 0 psi.** The pressure gauge will never actually reach 0 psi.

**Verify that the ball valve, relief vent (8) is completely on.** Steps (2) and (3) above make sure that the pump is unloaded when the system is started. With the current setup, the pump will simply return all fluid to the reservoir, and the manifold connections will be unpressured.

**Ask a qualified instructor to check the circuitry.** This step should always be followed.

The solenoid switch (3) should be in the off position before starting the system.

***Locate the pump pressure gage (4).*** Watch this gage closely. If it ever exceeds 500 psi, turn off the pump immediately.

***Locate the power switch (1).*** Stand clear of the trainer stand and turn it on. The pump pressure gage (4) should remain near zero psi.

***Close the ball valve, relief vent (8).*** All of the fluid is still being pumped into the reservoir. However, now the fluid must travel through the relief valve. The pump pressure should remain at zero.

***SLOWLY, start closing the relief valve (7).*** The pump pressure should increase. Set the pressure to be about 150 psi.

The system is powered up at this point, but the motor is not turning because the valve is shutting off all flow. Try switching the solenoid valve selector switch (3) from off to A, then to B. Observe the motor. Check the RPMs of the motor on the digital display on (37).

***NEVER exceed 500psi!*** Increase and decrease the pressure by opening and closing the relief valve (7) and observe the effect of pressure on the motor RPMs.

The solenoid switch (3) should be in the off position before shutting the system down.

***Slowly back out the relief valve all the way.*** The system pressure should be close to 0 psi.

***Open the ball valve, relief vent, all the way.*** The system is back to where it was before the pump was started.

***Turn off the pump.***

***Disconnect the quick coupling hoses and put them away.*** Neatly.

The steps in italics are the steps that should be followed whenever the trainer stand is used. Different valves and actuators may be used, but the startup and shutdown procedures remain the same, always.

If time permits, try connecting to the manual directional control valve (43) instead of the solenoid directional control valve (42). Follow the same procedure as before. Instead of two solenoids, the flow is controlled by the lever. ***Note:*** When setting the relief valve pressure (7) for the lever controlled valve, put the lever in position A or B while setting the pressure. If you leave it neutral, the pressure will never increase, as the off position of the valve is actually a short circuit. Ask the instructor for an explanation.

## **Computer Control and Data Acquisition**

### *Reference:*

Wincon 3.0 Manual

This section is intended to familiarize you with Wincon 3.0. Read it thoroughly and do the exercise at the end of this supplement BEFORE attempting any lab exercises.

### **Introduction**

Quanser Consulting produces a software and hardware package that allows a user to collect and generate real time electronic signals using a Windows based PC. The main strength of the system is that external signals can be used as inputs into a Simulink block diagram, manipulated, and then output as real signals.

The hardware portion consists of the MultiQ A/D and D/A (analog to digital and digital to analog) board. It fits into a standard PC expansion slot. An external terminal attaches via ribbon cable to the MultiQ card. The external terminal consists of coaxial cable connections. Signals are received and generated by the MultiQ board.

The software package that controls the hardware is called Wincon 3.0. Wincon 3.0 takes a Simulink block diagram, generates C code based on the diagram, and compiles the code. It then loads a user interface that looks much like a toolbar. This toolbar controls the starting and stopping of the controller, in addition to graphing and saving options.

### **Apparatus**

The MW2000 is a signal conditioning box that has been built about the MultiQ external terminal board. The box has 38 available connections, include 8 analog and digital inputs and outputs. It also has 6 optical encoder inputs. All cables must be plugged into this interface.

Matlab and Simulink are the two computer programs that provide the basis for the Wincon System. Knowledge of the two is essential in order to use Wincon.

### **Objectives**

Proper completion of this exercise will require that you:

- (1) Create a Simulink block diagram controller based on an available template.
- (2) Compile the block diagram.
- (3) Configure and start Wincon.
- (4) Modify controller parameters in real time.
- (5) Save data.

## Experiment

The goal of the following exercise is to record a signal that has been generated by Simulink.

Follow these steps:

- (1) **Start Matlab and Simulink. Open the Simulink model, N:\HydraulicsLab\ME460\template.mdl.** The template has certain compiler options that have been preset, in addition to some required Wincon blocks. It is recommended that you always start with this template, unless you want to figure out the compiler options yourself. This is not recommended! (The timer-block is always required in all block diagrams to be used with Wincon. The analog input and output block are not required – unless you need to use them. The Simulink library for these blocks can be retrieved by typing ‘winlib’ at the Matlab prompt.)
- (2) **Create the controller.** The controller has already been created for you. Configure the block titled *Sine Wave* to have an amplitude and frequency of your choosing.
- (3) **Set ADC and DAC options.** Double click on the analog input and analog output blocks. Select the desired channels in the ‘Channels to use’ section. In this case, use analog output channel 0 and analog input channel 4.
- (4) **Set the sampling interval.** Go to the menu item Wincon. Select Options. Click on the Solver tab. Enter the appropriate sample time for your application. In this case choose 0.005.
- (5) **Verify that the proper ODE solver is selected.** Choose Fixed step ODE (Euler) for this laboratory – in the same menu as Step 4. This solver will be adequate for most needs.
- (6) **Save the block diagram.** Make a directory with your alias in C:\ME460. Save the block diagram in this directory. Make sure that this directory matches the ‘Current Directory’ being called by Matlab.
- (7) **Compile the block diagram.** Go to the menu item Wincon. Select build. Various status messages will be printed in the Matlab window.
- (8) **Turn on the MW2000.** The power switch is in the very back of the blue box with the white front panel.
- (9) **Make physical connections.** Connect a coaxial cable between Channel 0 in Analog output and Channel 4 in Analog input. The signal generated in Channel 0 is now immediately read by Channel 4. Usually, the signal would be directed into some device which would use the output, and the input signal would be something you want to measure, like a tachometer signal.
- (10) **Open the desired plot windows.** This is done via the graph icon on the Wincon toolbar. Select the desired signal to plot.
- (11) **Select the variables to plot.** In the plot window, select the File menu and choose Variables. Pick as many variables as you want plotted in this window.
- (12) **Set buffer, axis and refresh options.** In general, pick the smallest buffer size (in seconds) that you need in order to capture all of your data. Set this under the Update menu, Buffer option. In some applications you may wish to select Freeze plot under the Update menu. This will cause Wincon to capture one screen full of data and then stop plotting. In this exercise, do not select this option. Finally set various axis range options.
- (13) **Start the controller.** Press the start button on the Wincon toolbar.
- (14) Modify the controller parameters by using the slider gain. Observe the effects.
- (15) **Stop the controller.**

- (16) *Save data as .m file.* The save option is under the File menu. Save in your directory in c:\ME460
- (17) *Turn off the MW2000.*

The steps in italics are the steps that should be followed whenever Wincon is used.

If time permits, try changing the channel number in the analog output or input block in the Simulink block diagram. Change the cables to match the changes in the block diagram. Recompile the code and run the controller using Wincon again. Observe differences, if any. Also try generating a sine wave of about 2000 HZ, and inputting it into Channel 7 in the Analog Inputs (you will have to change the block parameters and recompile). Change the sine wave's frequency to 1000 HZ. What's going on?