KineticSystems Company, LLC

FM7000 Stand Alone Servo Controller

February 17, 2003

Model 7030 Digital Servo Controller User's Manual for Standalone Operation

1.0 INTRODUCTION

The Cyber Systems Model 7030 Digital Servo Controller is built to control an electrohydraulic servo control loop. Its features are chosen to optimize the performance of the loop whose purpose is to control the force or displacement of a hydraulic actuator.

From the front panel of the dual channel controller the operator can enter setup data, control the command signal to the control loop, set protection limits, and monitor the progress of the test.

2.0 OVERVIEW

The controller has many performance features, which are enabled by the use of a dedicated microprocessor. These features include the following:

- Automated calibration of scaling and balance
- Numeric display of load in engineering units
- Numeric entry and display of control parameters
- LED meter display of loop signals
- Inner and outer error and limit testing
- Discrete outputs controlled by limits
- Front panel loop signal test points
- Internal command generation for cyclic testing
- Operator controlled load changes for static testing
- Oscillation detection and automatic loop gain reduction
- Adjustable Rate Compensation for dynamic optimization

- Integrator with adjustable time constant
- Actuator unequal area compensation
- Internal hydraulic load simulator
- Two channels in each plug in module

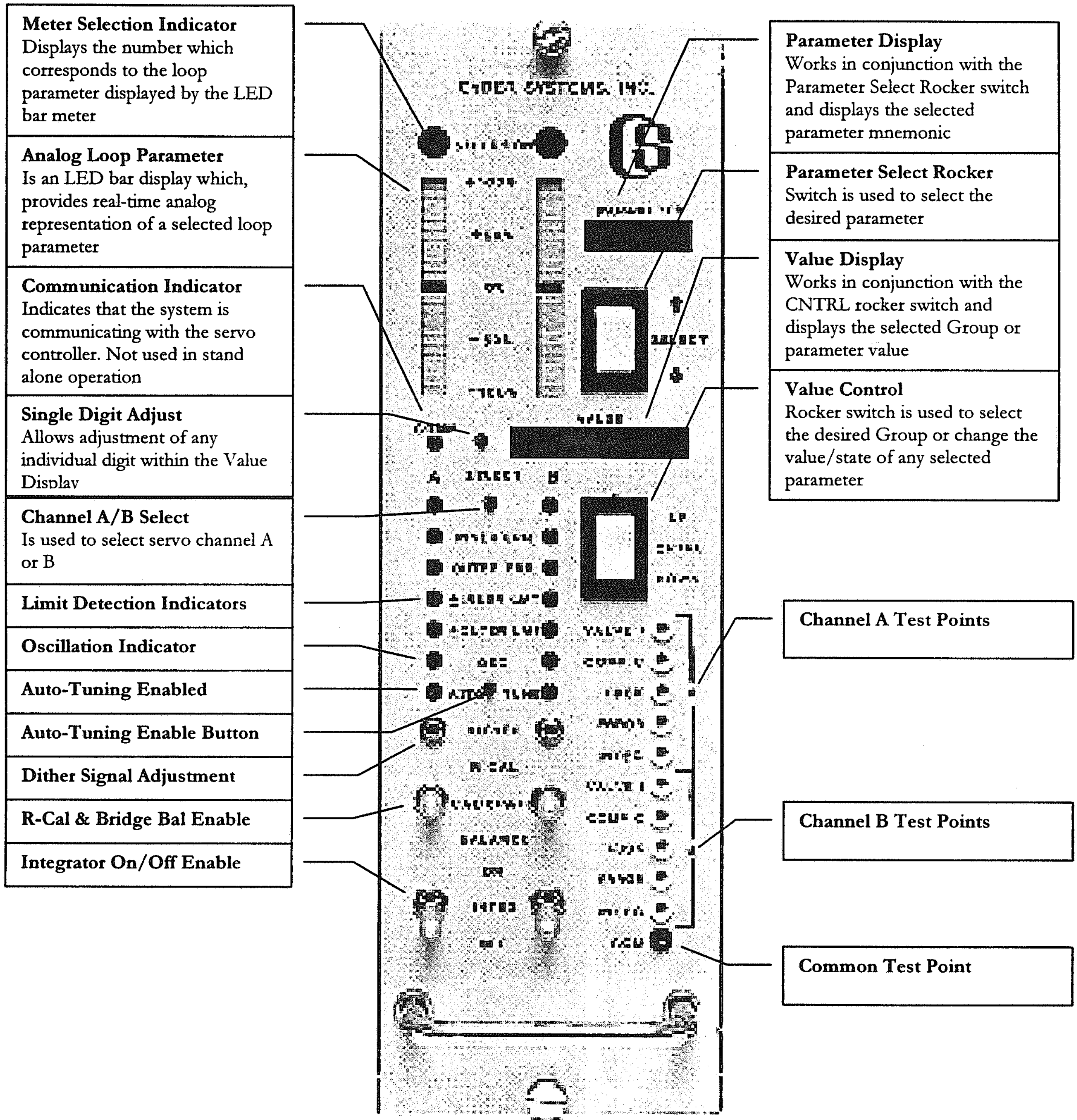

Figure 1. Model 7030 Digital Servo Controller Front Panel Layout

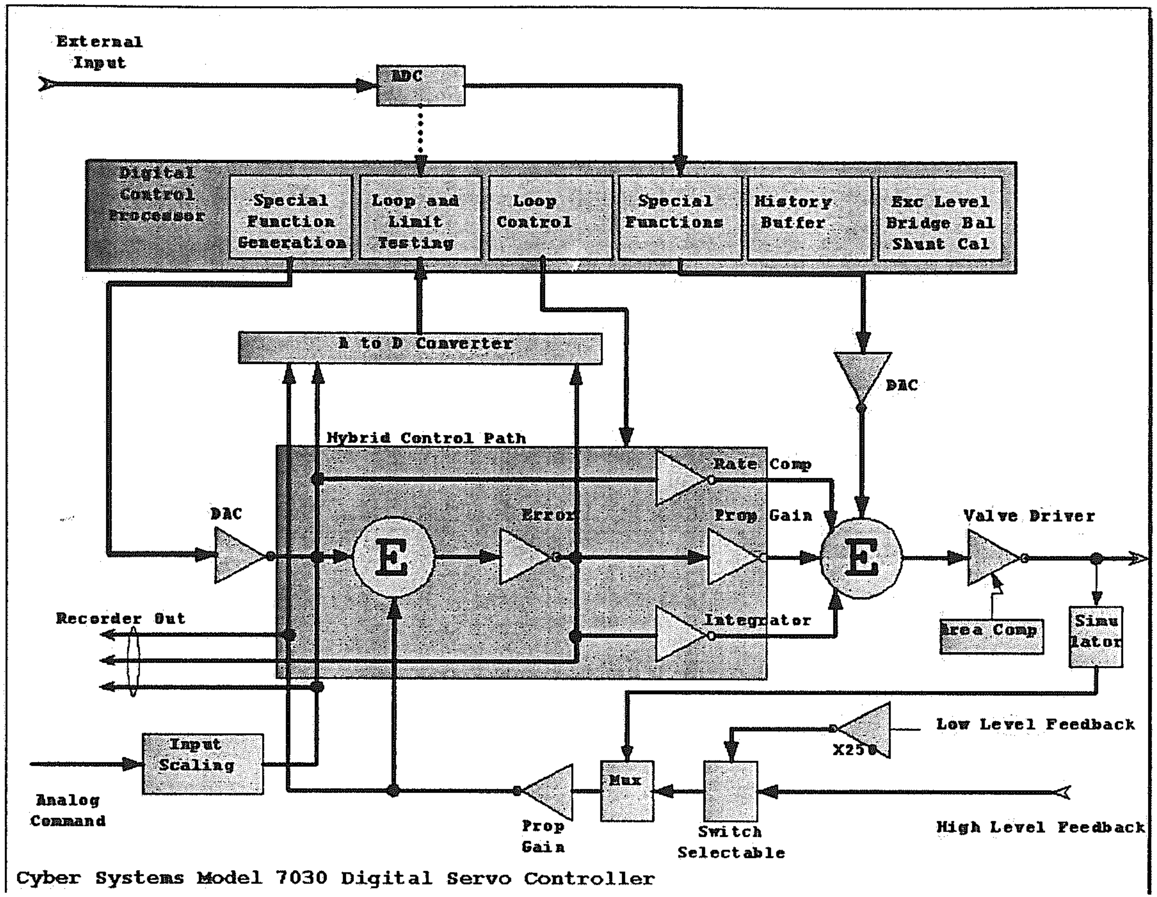

Figure 2 – Block Diagram of Model 7030 Digital Servo Controller

2.1 Model 7030 Specifications

The performance and other related specifications of the Model 7030 Hybrid Servo Controller are summarized below:

Command Input Scaling	0 to 100% Full Scale
Command Input Type	Analog or Digital
Command Input Sign	Positive or Negative
Static Offset Range	+100% to –100% of Full Scale
Open Loop Bandwidth	1000Hz +-1 dB (without rate compensation)
Feedback Gain	2 ranges (x 1to x40), (x250 to x10,000)
Proportional Gain	X0.03 to x128 in 4096 steps
Integration Time Constant	0.1 sec to 10 seconds
Dither Signal	0 to 20% of Full Scale peak to peak, 400Hz
Error Checking Update Rate	1,200 Hz

Feedback Amplifier Specifications

Full Scale Input Range	0 to 40mV in 4,096 steps
Automatic Bridge Balance	+-2 mV/Volt in 4,096 steps
Offset Stability	<1 uV/degree C
Bandwidth	Limited to 210 Hz by filter
Common Mode Rejection	110 dB
Amplifier Non-Linearity	0.01%
Input Impedance	100 Megohms
Gain Stability	0.002% FS/degC

Signal Conditioning Specifications

Wiring Standard	Western Regional Strain Gage Committee standard (8,6, or 4 Wire Configurations)
Excitation Voltage	0 to 15 Volts in 4,096 steps
Output Current	Up to 75mA
Line Regulation	0.005%
Load Regulation	0.02%
Noise	0.1mVrms
Fault Trigger	Excitation less than 2 volts
Output Stability	50 parts per million per degC

Limit Detection Levels

+/- Inner Feedback Limit	0 to 102.4% of Full Scale
+/- Outer Feedback Limit	0 to 102.4% of Full Scale
Inner Loop Error Limit	0 to 100% of Full Scale
Outer Loop Error Limit	0 to 100% of Full Scale
Oscillation Detection	1 to 10 sign reversals

Valve Driver

Current Ranges	7.5, 15, 20, 40 ma
Valve Coil Arrangement	Series or parallel
Compliance Voltage	+-12 volts
Valve Driver Mode	Current Mode
Valve Driver Polarity	Switch selectable

3.0 OPERATING THE FRONT PANEL

The Model 7030 servo controller front panel provides the operator the following features:

- Meter Display for each channel with choice of 7 functions
- Setting of control loop parameters with numeric entries from the panel.
- Readout of loop signals and parameters in engineering units on numeric displays
- Continuous analog loop signal test points of 5 signals for each channel
- Interlock switches to prevent accidental triggering of functions.
- Dither amplitude controls.

3.1 OPERATING THE NUMERIC READOUT CONTROLS

More than 35 functions can be brought up on the numeric readouts. Some control a loop parameter like proportional gain. Others monitor loop signals, and still others provide for triggering and internal software function.

These Functions are divided into six groups by what they do.

START	General functions
SETUPCAL	Loop scaling and calibration parameters
CONTROL	Loop performance parameters
LIMITS	Limit detector thresholds
TUNING	Anti-oscillation and auto-tuning parameters
MONITOR	Selection of functions for the meter and numeric readouts.
FUNCTION	Defining and running internally generated command functions
STATIC	Manual control of moving from one load level to another

Choose channel **A** or **B** by pressing the momentary button under **SELECT**. The **LED** should be ON under the desired **A** or **B** channel. The operations performed will then pertain to the selected channel.

3.2 TO MOVE TO ANOTHER FUNCTION

3.2.1 IN THE SAME GROUP

Push the upper **SELECT** rocker up or down until the abbreviated function title appears in the upper **PARAMETER** display. The lower **CONTROL** rocker will trigger the function or change the value if it is a controllable parameter. It may just display a signal value, as in the monitor functions.

3.2.2 IN A DIFFERENT GROUP

1. Press the upper **SELECT** rocker **UP** until the name of the **GROUP** appears in the lower display.
2. Press the lower **CONTROL** rocker up or down until the desired **GROUP** name appears in the lower **VALUE** display.
3. Press the upper **SELECT** rocker down until the desired function mnemonic appears in the upper **PARAMETER** display.
4. The lower display will show the present value or condition of that function.
5. If it is a triggerable or changeable parameter, the lower rocker switch will do it.
6. If a change is desired in a large numeric value, it is possible to affect only one digit at a time. To choose the digit, press the momentary button on the left of the value display until the desired digit is blinking. Now the **CONTROL** rocker will only affect that digit. When the value is correct, press the momentary button until no digits are blinking.

The various controller parameters or functions that can be displayed are in **Table 1**. They are also on the front panel of the controller power supply for easy reference.

When power is turned on, the values are restored to their previous value from nonvolatile **RAM** memory, except full scale and calibration equivalent.

All values can be set to the default values shown in **Table 1** by going to "***Set Servo Default Values***" in the **START** group. Press the **CONTROL** rocker to trigger setting the defaults.

Detail descriptions of the various parameters and functions are given in **Section 5**.

TABLE 1 - Servo Front Panel Parameter Guide

Servo Parameter	Parameter Display	Value Display	Default Value
Group Select	------	START	
Set Servo Default	SETD	Yes/No	No
Decimal Point Adjust	DPA	9.999999 to 99999999	99999999
Group Select	------	SETUPCAL	
Full Scale Value	FULL	0 to +/-999999	0
Calibration Equivalent	CLEQ	0 to 99999	0
Excitation Voltage	EXCV	0 to +15 Volts	+8 Volts
Feedback Bridge Bal	FBAL	Yes/No	No
Invoke Shunt Cal	RCAL	Yes/No	No
Valve Balance	VBAL	Yes/No	No
Command Scaling	SCAL	0 to 100%	100%
Command Offset	OFST	0 to +/-9999999	0
Valve Offset Adj	VLVO	+/- 100%	0
Group Select	------	CONTROL	
Forward Loop Gain	GAIN	0 to 127.9	1
Rate Comp Freq	RATE	0.5Hz to 100Hz	100 Hz
Integ Time Constant	INTC	0.1 to 10 Seconds	1 Second
Integ On/Off	INTE	On/Off	Off
Group Select	------	LIMITS	
Fault Clear	FCLR	Blank/Clear	Blank
Fault Set	FSET	Yes/No	No
Inner Loop Error	INLE	0 to 102%	5%
Outer Loop Error	OTLE	0 to 102%	20%
+Inner FDBK Limit	IFBH	0 to +/- 102%	80%
-Inner FDBK Limit	IFBL	0 to +/- 102%	-80%
+Outer FDBK Limit	OFBH	0 to +/- 102%	80%
-Outer FDBK Limit	OFBL	0 to +/- 102%	-80%
Fault Limit Debounce	FLDB	1 to 200 msec	100 msec
Group Select	------	TUNING	
Piston Area	AREA	0.5:1 to 1:1	1:1
Noise Band	NOIS	0 to 100%	2%
Oscillation Peak	OSPK	1 to 10	3
Phase Margin	PHAS	10 to 90 degrees	30%
Hyd Simulator	SIMU	On/Off	Off
Group Select	------	MONITOR	
Command	CMMD		
Feedback	FDBK		
Loop Error	ERROR		
Valve Current	VALV		
Meter Select	METR	See Note*	FEEDBACK
External Input	EXTN		

*Note: Meter Select (**METR**) allows the operator to select which loop parameter is displayed on the **LED** bar meter. Available parameters include Command, Feedback, Error, Valve Current, and External Input.

4.0 THE SETUP CONNECTIONS

The servo control loop is completed by connecting to the hydraulic servo valve and the feedback load cell. Command input signals from the external function generator must also be connected. Optional high-level feedback input and feedback recorder outputs may also be connected. The pin assignments and reference schematics of the connecting circuits are shown in Figures 3 through 8.

4.1 FEEDBACK LOAD CELL BRIDGE CONNECTIONS

The signal conditioning in the servo controller for the load Cell Bridge provides for a full eight-wire-plus-shield connection. The shield is grounded in the servo controller and should not be connected to any other ground. If eight-wire cable is used, make the connections as shown in Figure 3. The twisted pairs in the cable should be grouped as follows:

A – D

F – J

B – C

G – H

If two shielded cables with four wires in each are used put **A-D** and **F-J** in one cable, and **B-C** and **G-H** in the other. Connect both shields to shield pin **E**.

For Six wire operation, use the two extra wires to remote sense the **–sig** and **–exc** point of the bridge. In the backplane connector, eliminate the wire to pin **F** and connect pin **F** to pin **A**. Eliminate the wire to pin **G** and connect pin **G** to pin **B**.

If only four wires are run to the bridge, connect **A-F**, **B-G**, **J-D**, and **C-H** in the backplane connector. Connect the bridge balance, pin **G**, to the **+sig**. Side of the bridge, pin **B**. this is the side that goes positive when the load cell is put into tension.

For low level bridge feedback, jumper **W5** on the **13831** analog card of the servo controller must be in the 1-2 position for channel **A**. Jumper **W11** must be in position 1-2. This is the factory setting for channel **B**.

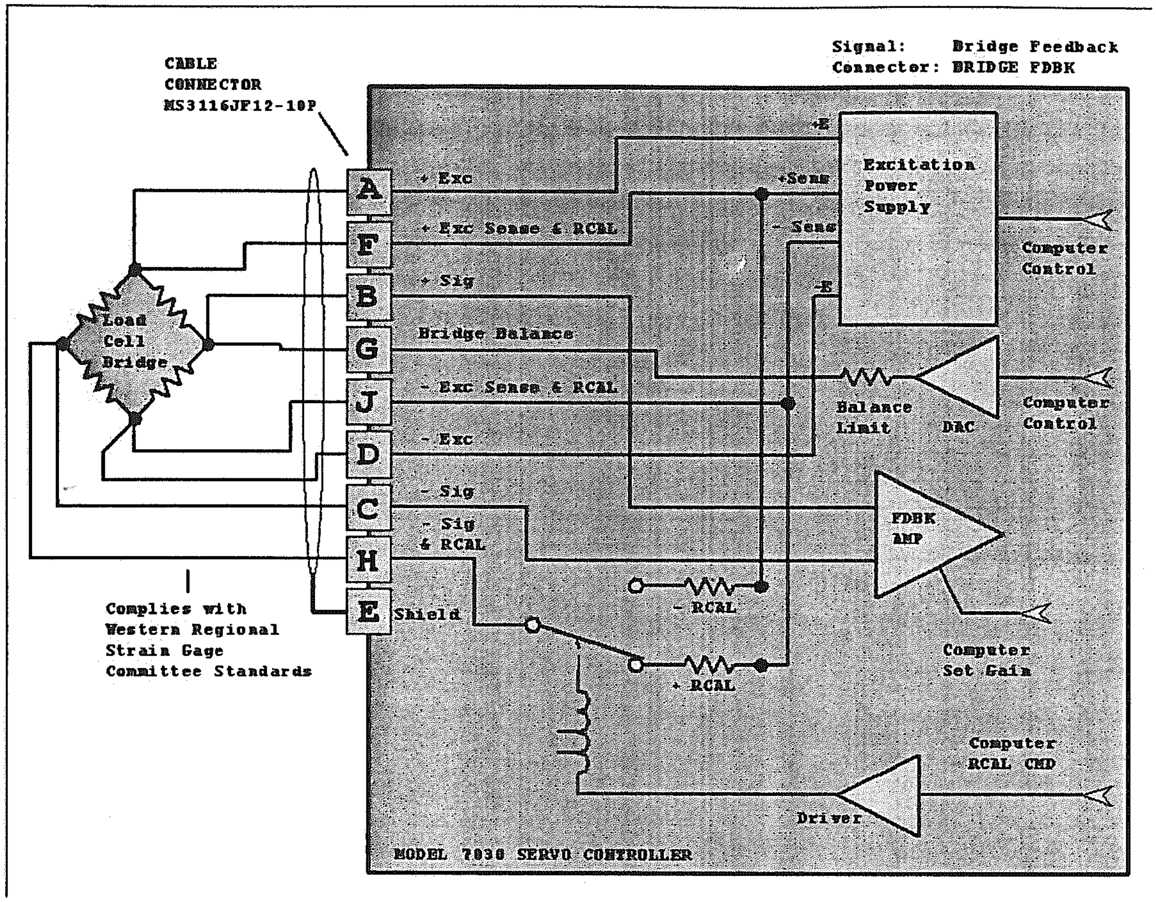

Figure 3 – Load Cell Connections

4.2 DETERMINING THE CALIBRATION VALUES FOR SHUNT CALIBRATION

Follow these steps to calibrate the servo control channel.

Step 1: Decide what the maximum load will be, based on the test to be performed.

Step 2: Choose a full-scale value that is equal to or slightly greater than the maximum load and is a rounded off number.

Step 3: If the metrology lab load cell calibration provides shunt resistor values, which are equivalent to specific forces, select the one which is less than but closest to the selected full scale. If necessary, raise full scale to the calibration load.

If a shunt resistor value is to be used which is not one of the resistor values given in the load cell calibration, the force corresponding to the new resistor value can be computed as follows:

$$F2 = \frac{F1 * (Rcal\#1 + 175)}{(Rcal\#2 + 175)}$$

Where: **F1** is the load at the given calibration point.

Rcal#1 is the shunt resistance corresponding to Load **F1,** in ohms.

Rcal#2 is the new shunt resistor value, in ohms, that will be used.

F2 is the load that is equivalent to shunt resistance **Rcal#2,** that will be entered as the **RCAL** equivalent value.

(This equation assumes a 350-ohm Bridge)

Step 4: Install a resistor of that value in the resistor carrier (Pomona Electronics Part Number 22440) and plug it into the +**RCAL** position on the proper channel of the servo controller backplane. The calibration will usually be done by shunting from minus signal to minus excitation on the bridge, but if the calibration lab specifically shunted the bridge from minus signal to plus excitation, plug the resistor into the –**RCAL** position.

Step 5: Enter the **Full Scale** and the **RCAL** equivalent load under "**FULL**" and "**CLEQ**" on the servo panel.

Step 6: If the wiring to the load cell bridge uses the eight wire or six wire connection method, the accuracy of the calibration will not be compromised by wire resistance, and long wires up to hundreds of feed can be used. If, however, a four-wire connection is used, an error of about 1.14% per ohm of wire resistance is introduced.

If the wire resistance is known, raise the RCAL equivalent value to compensate for this error.

The resistance of copper wire at 68 degF is as follows:

20 gage	.0102 ohm/ft
22 gage	.0161 ohm/ft
24 gage	.0257 ohm.ft
26 gage	.0408 ohm/ft

The wire resistance can be measured by connecting two wires together at the far end and measuring the loop resistance from the near end, and the divide by two.

Step 7: A balance limit resistor of 43.58K is used in the servo controller bridge conditioning and it is assumed the calibration lab also used a similar value. If no balance limit resistor was used in calibration, a 0.20% reduction in load cell sensitivity will occur in the servo controller. Raise the **RCAL** equivalent value to compensate for it.

When the **RCAL** calibration is initiated, the gain of the servo controller feedback amplifier is adjusted so the command corresponding the **RCAL** value is exactly balanced by the feedback signal due to the **RCAL** shunt. The system uses an iterative process to achieve this Null.

4.3 FEEDBACK DISPLACEMENT TRANSDUCER CONNECTIONS

To operate the servo controller in stroke control (displacement control), a displacement transducer is used in the servo feedback. It is normally an **LVDT**. The polarity of the feedback signal from the **LVDT** must be such that a positive load command results in a positive displacement signal.

An **LVDT** is normally used as a high level device. For high-level feedback operation, set the **FEEDBACK RANGE** accessible through the side panel to the "**HIGH LEVEL**" position.

The feedback signal comes into the servo backplane connector called "**HI LEVEL FDBK**". The connections are shown in **Figure 5**.

4.4 SETTING THE HIGH LEVEL FEEDBACK FULL SCALE VOLTAGE

The full-scale feedback voltage for stroke or preconditioned feedback signal can be set using the following procedure:

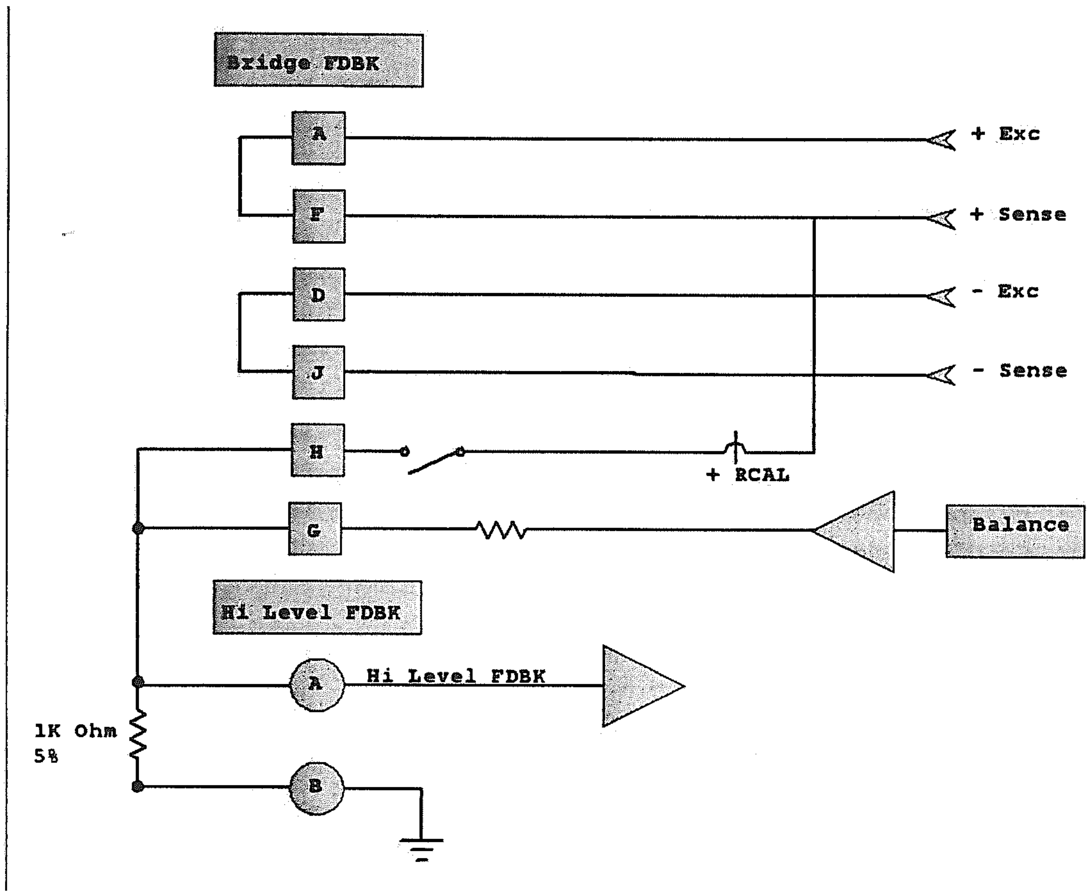

Figure 4 – Setting the Hi Level Feedback Full-Scale

1. Make the above connections. Install a jumper in the +**RCAL** position on the backplane. On the servo controller side panel, set the feedback Range to High Level.

2. Turn on power and set the Excitation to twice the desired full-scale voltage. The voltage form +**Exc** on Bridge Feedback pin **F** to ground on the **Hi Level Feedback** pin **B** will become the full scale feedback voltage.

3. Set the value of the **FULL SCALE** to the displacement corresponding to the full scale feedback voltage. Set the Cal equivalent (**CLEQ**) to the same as the **FULL SCALE**. See paragraph **5.2.1** and **5.2.3**

4. Set the Balance switch on the controller panel to balance. Set the display to show **FBAL** and trigger a balance. See paragraph **5.2.8**

5. Set the panel switch to **RCAL**. Set the display to show **RCAL**, and trigger the **RCAL**. See paragraph 6.**3**

6. The High-Level feedback voltage is now set to the +**Exc** level. The panel display will show the displacement in the full-scale displacement units.

7. Remove the wires from the **Bridge** Feedback and **Hi Level** Feedback connectors and connect the **Hi Level** Feedback transducer.

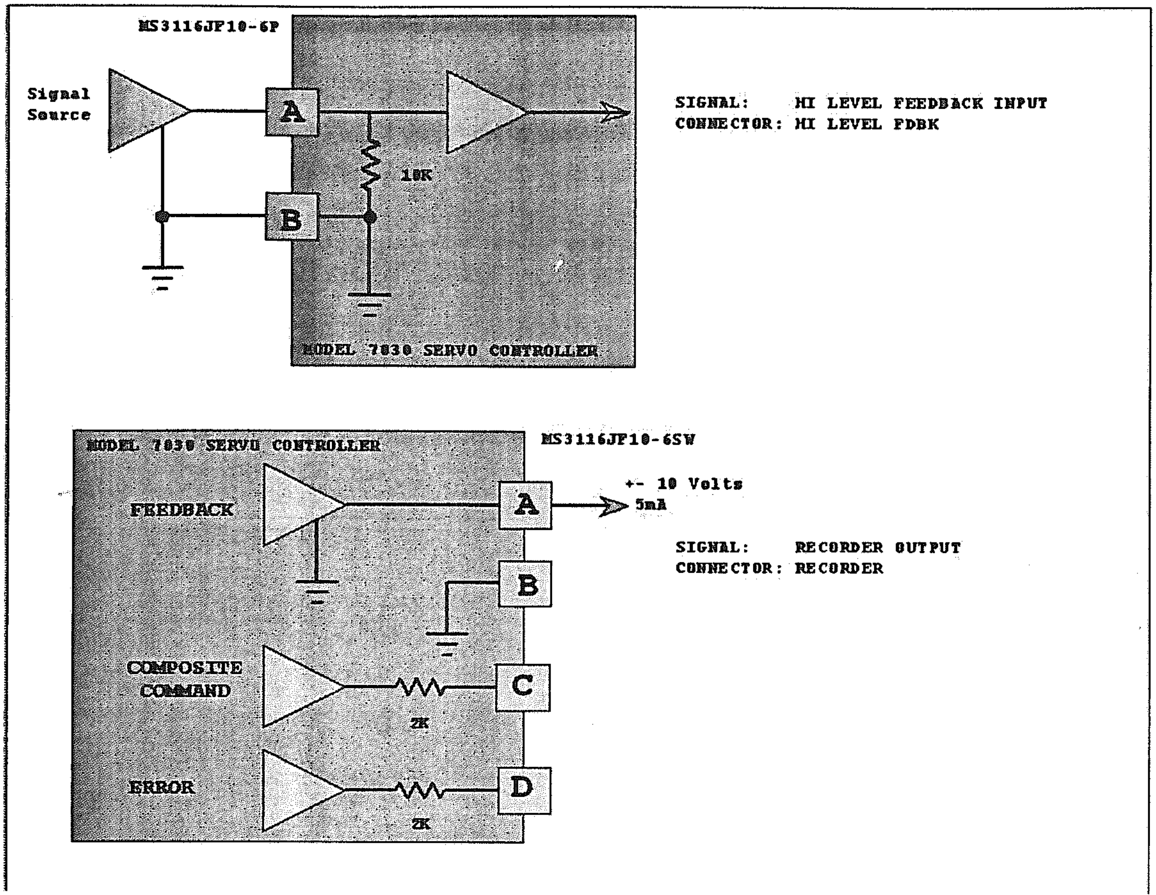

Figure 5 – Hi Level and Recorder Connections

4.5 HYDRAULIC SERVO VALVE CONNECTIONS

The hydraulic servo valve is a control valve, which controls the flow rate of the hydraulic fluid into the actuator, and does it in proportion to the current that flows in its input coils. Servo valves have a full scale input current rating. This is the current that makes the valve fully open.

The valve will therefore be driven fully open in either of the arrangements shown in **Figure** 6.

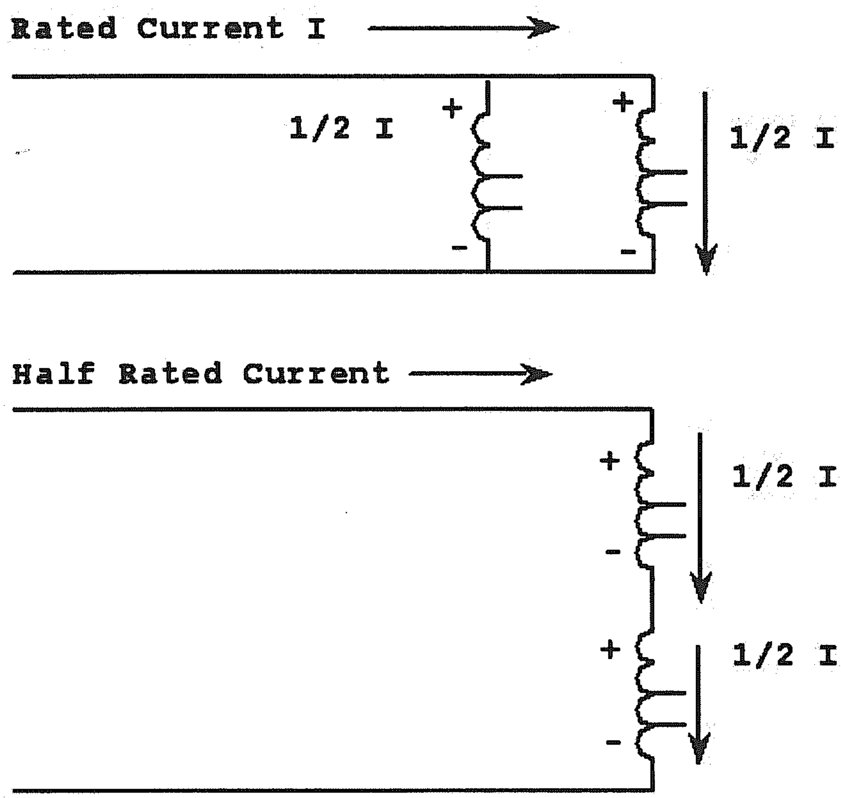

Figure 6 - Driving Hydraulic Valves Fully Open

The connections from the servo controller backplane connector to the servo valve coil are shown in **Figure** 7.

A **DIP** switch sets the full-scale current from the valve driver in the servo controller accessible through a hole in the side cover. Set the switch to correspond to the valve current rating and to the coil connection method bight used.

4.6 COMMAND INPUT

The command input is a plus or minus ten-volt signal brought into the servo controller from the users function generation equipment. The control loop will move to cause the load or stroke to be, that which corresponds to this voltage. Ten volts corresponds to the full-scale value entered as the "**FULL**" parameter in engineering units. See paragraph **5.2.1**.

Attenuation of this voltage can be done inside the servo controller. See paragraph **5,2,13**.

This input is differential to prevent ground voltage differences between the function generator and the servo controller from becoming part of the command signal. The signal source ground should be within plus or minus one volt from the servo controller ground.

The wiring connections are shown in **Figure 8.**

4.7 DISCRETE INPUTS

The discrete inputs provide single wire communication to the controller.

4.7.1 DISCRETE INPUT - HYDRAULICS ON

The servo controller has internal interlocks that are controlled by whether the hydraulic pressure is on, to prevent possible damage to the test article.

The way the controller knows whether to allow these functions is by the "HYD ON" discrete input for that channel on the controller chassis backplane.

Open circuit or a +5V input indicates that the hydraulic pressure is **OFF**. Driving the input to the common indicates hydraulic pressure is **ON**.

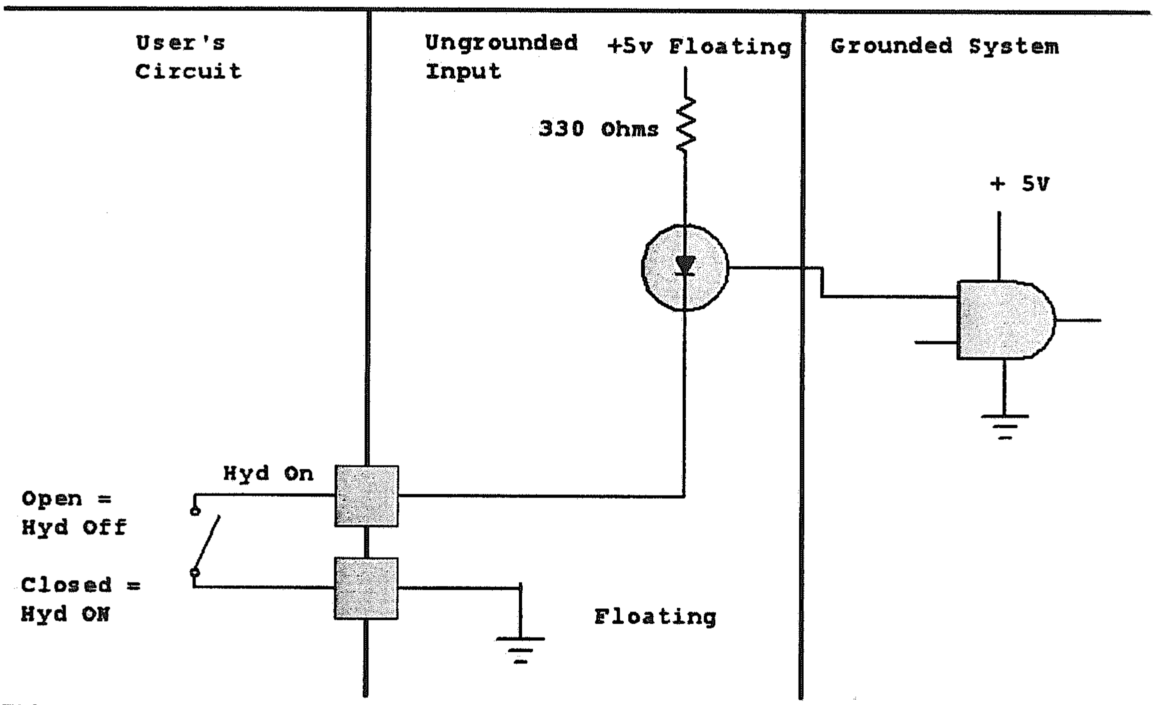

FIGURE 7 - Hyd On Wiring

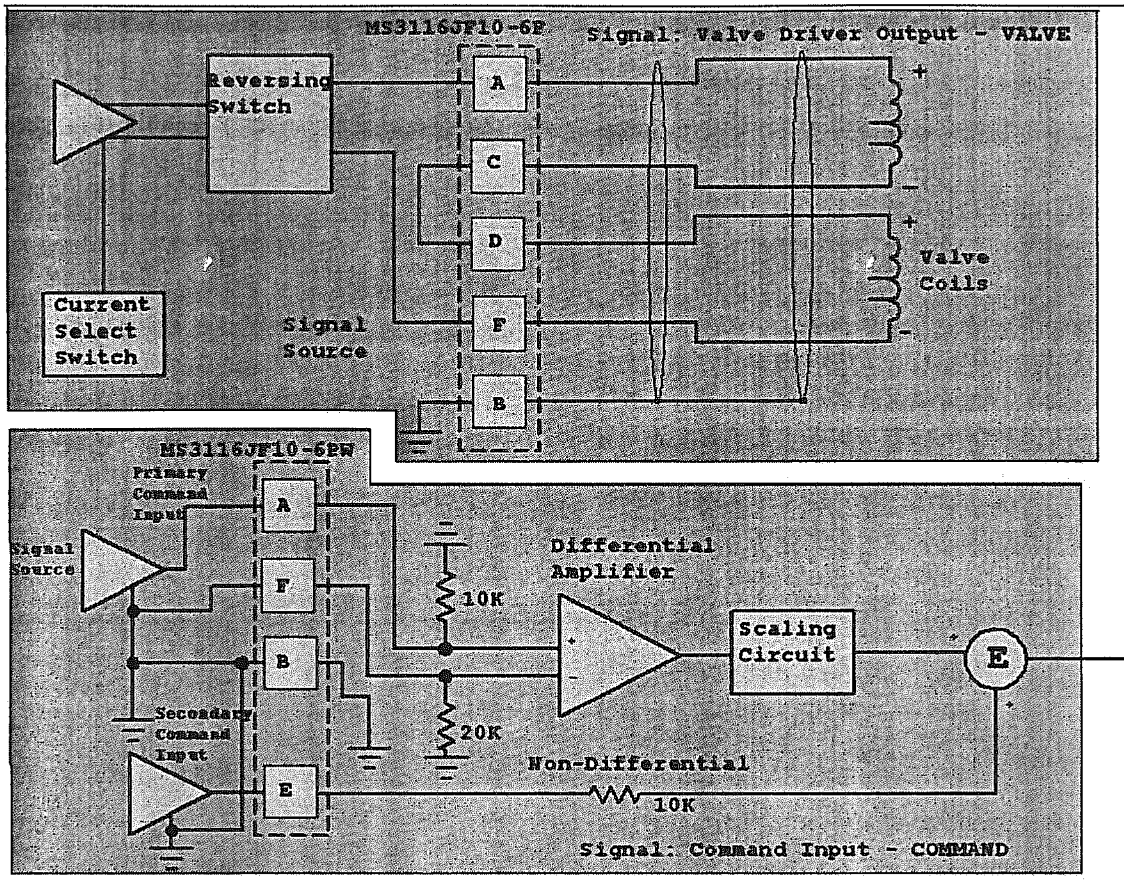

Figure 8 – Valve and Command Input Connections

4.7.2 OTHER DISCRETE INPUTS

The discrete inputs called **DISC 1**, **DISC 2**, and **RESET** are not used.

4.8 DISCRETE OUTPUTS

The discrete outputs provide single wire communication from the controller. The outputs are **NPN** transistor switches, which drive to the floating common output. All discrete inputs and outputs are isolated from the controller ground, but are all referenced to a floating ground within a single chassis. Each output has a 270K ohm pull up resistor to the floating five volts. The output is driven to the low state when the condition is true.

These discrete outputs can be connected together to form a "**Wired OR**" output, which means that the line is low if any of the outputs on the line are low.

4.8.1 DISCRETE OUTPUT – FAULT 1

If the **Outer Error** or plus or minus **Outer Limit** detectors are triggered, the **FAULT1** output is driven to the low state and the panel Outer Error **LED** will go on and stay on. It is latched there until it is reset by **Fault Clear**.

The **Fault 1** output is normally used to drive protective devices to prevent possible damage to the test article, such as dumping the pressure to the actuator.

The outputs can be used to drive large **AC** or **DC** loads using circuits shown in Figures 9 through 12.

Triggering the Outer Error detector with the Set Faults (FSET) item in the Limits group can test the Fault 1 output circuits. To reset, use **Clear Faults** (**FCLR**) in the **Limits** group.

4.8.2 DISCRETE OUTPUT FAULT 2

Exceeding an **Inner Error** or **Inner Limit** causes the **Fault 2** discrete output to be driven to the low state. The panel **Inner Error LED** is also turned on. The discrete output is latched on even if the condition goes away until reset by the **Fault Clear**. When the condition is gone, however, the panel **LED** will go off.

The discrete output circuit is the same as the other discrete outputs and can be used with the drivers shown in **Figures 9** through **12**.

4.8.3 DISCRETE OUTPUT LOCK AND DUMP

These discrete outputs are not used.

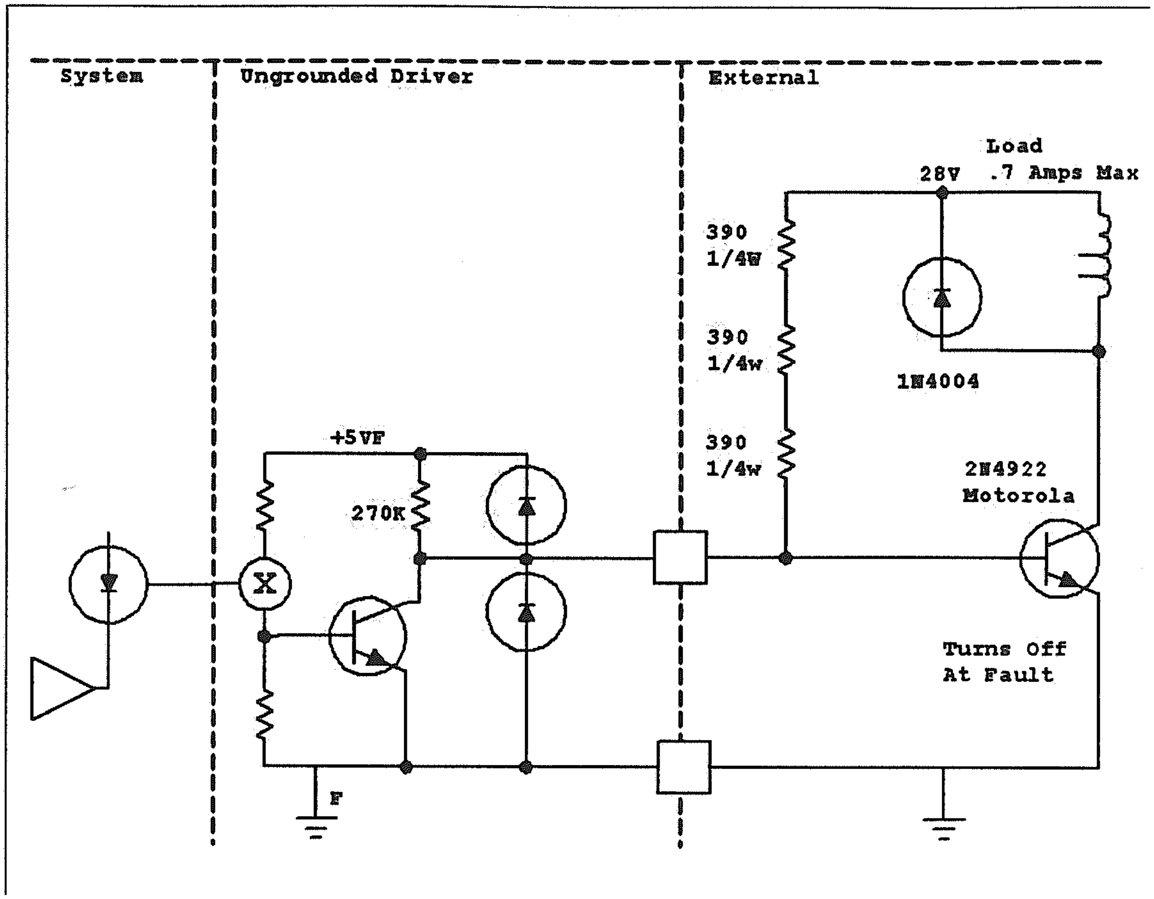

FIGURE 9 – Discrete Output Driver for 28 VDC Loads – Turns Off at Fault

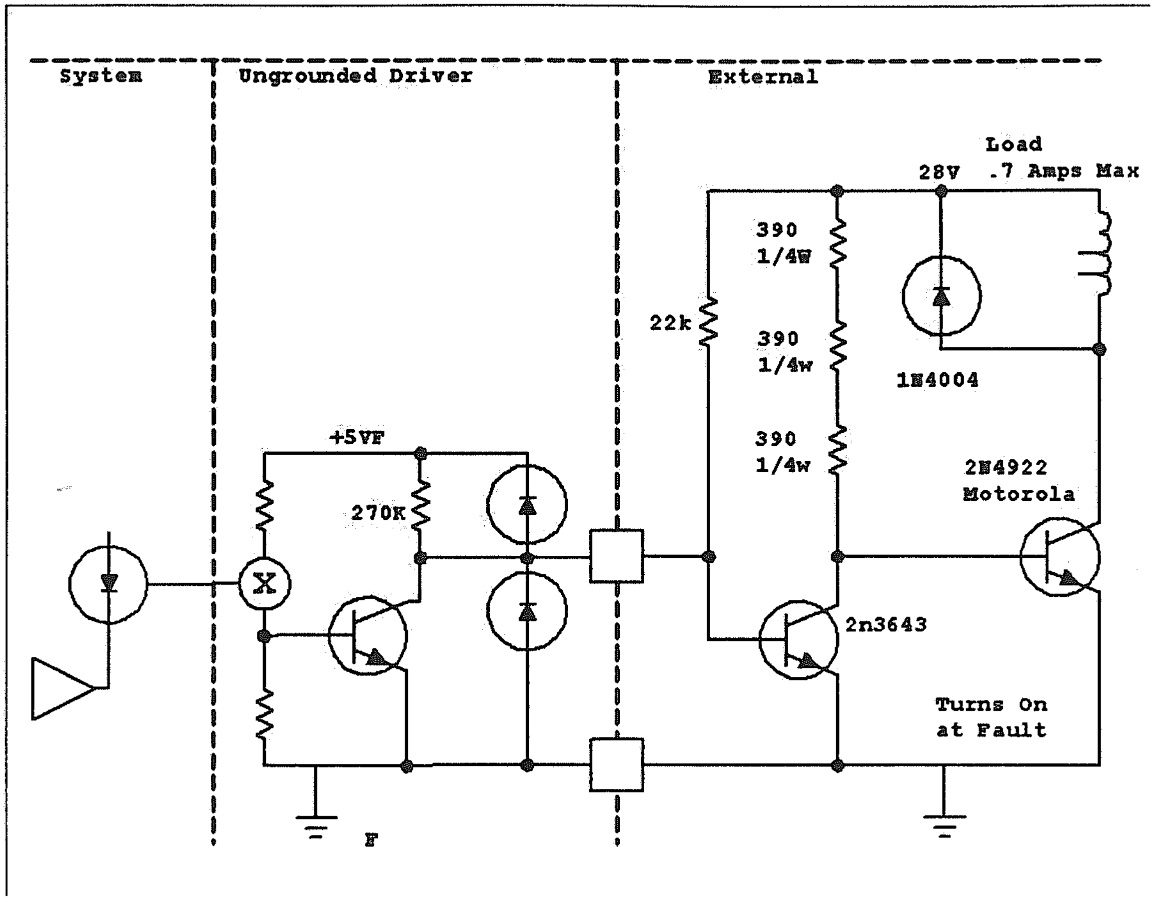

FIGURE 10 – Discrete Output Driver for 28 VDC Loads – Turns On at Fault

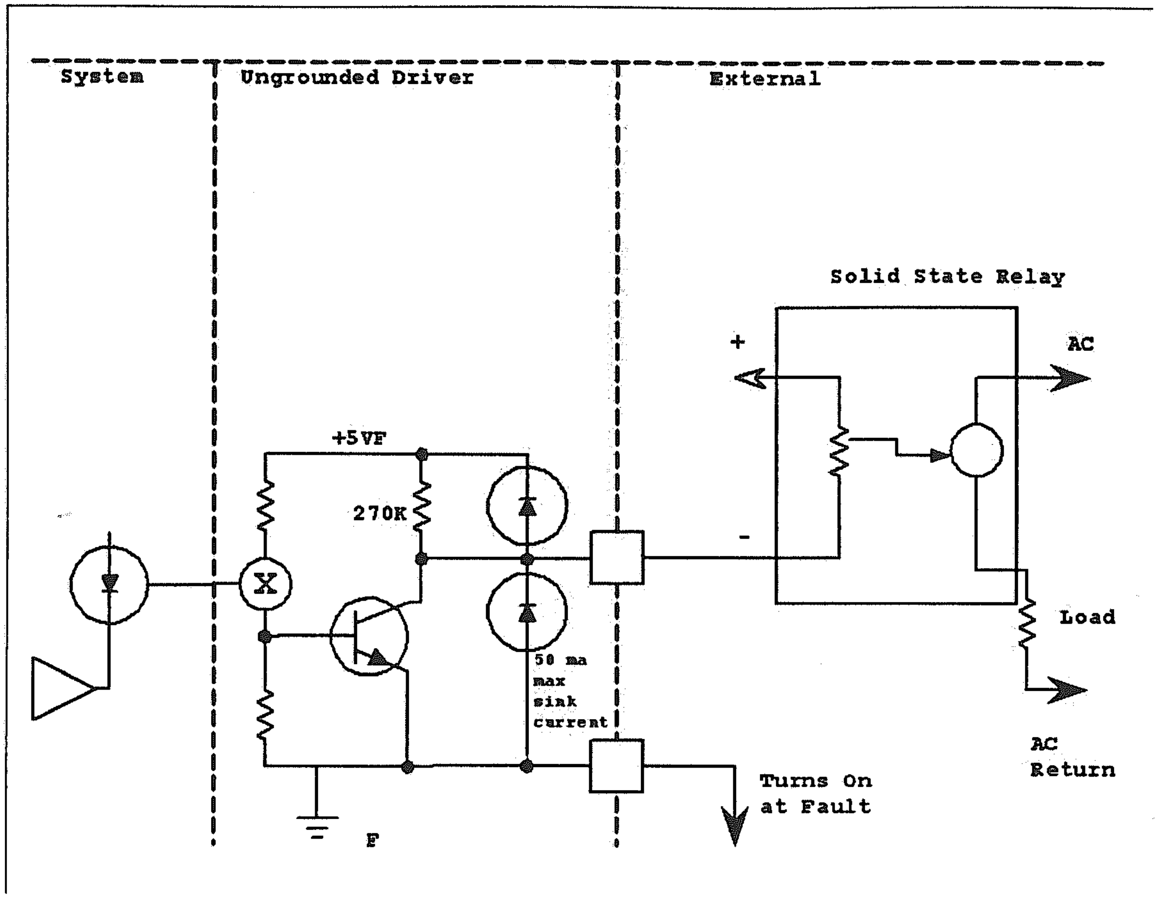

Figure 11 – Discrete Output Driver for AC Loads – Turns On at Fault

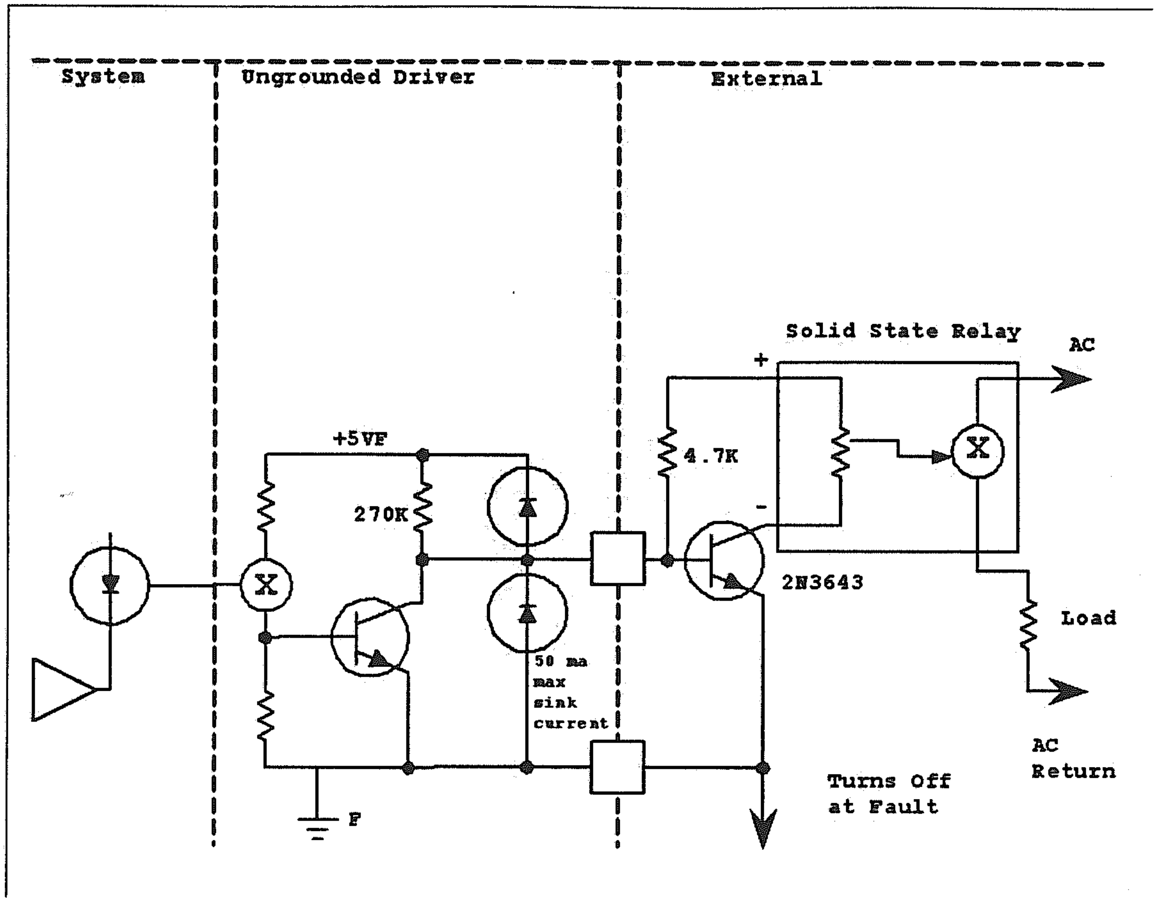

Figure 12 – Discrete Output Driver for AC Loads – Turns Off at Fault

4.0 PARAMETER SETUP AND CONTROL

This section describes the operator inputs to the servo controller from the front panel, which define the essential parameters for the operation of the controller. For detailed information on how to move around between the groups and to select a desired parameter, refer to **Section 3** of this manual.

All the parameter entry and loop control features of the servo controller have been arranged into eight categories. These are called Start, Setupcal, Control, Limits, Tuning, Monitor, Function, and Static.

5.1 START GROUP

5.1.1 SETUP DEFAULTS (SETD)

Whenever power is turned off on the servo controllers, the current value of all the parameters are written to nonvolatile **RAM** memory, so that upon restoring power the controller has the same setup. A set of default values for each parameter has been selected to provide typical settings. To load these default values, move to the Start group and the **SETD** parameter. Trigger the Control rocker switch to load the default values. The Value display will momentarily display **YES**.

5.1.2 TEST NUMBER (TEST)

This parameter is only used when the servo controller is part of a Cyber Load Control System.

5.1.3 DECIMAL POINT ADJUST (DPA)

The DPA setting controls this decimal point location for all engineering unit value inputs and displayed outputs. It allows the operator to use relatively small engineering unit values with fractional parts, or large values can be used where no fractional part is used.

To set the decimal point location, move to **DPA** in the **Start** group. With the Control rocker switch, move the decimal point to the desired location.

5.1.4 ENDPOINT COUNT (ENDN)

This parameter is only used when the servo controller is part of a Cyber Load Control System.

5.2 SETUPCAL GROUP

5.2.1 SETTING THE FULL SCALE (FULL)

The Full Scale is the maximum engineering unit value that the controller is going to be asked to achieve. This value will be made to correspond to 10 volts on the front panel test points of command and feedback.

Using the Select switch, go to the **SETUPCAL** group. Use the Control switch to go to **FULL** in the **Parameter** display. This means the controller is ready to receive the value of the Full Scale. Use the **Control** rocker switch to set the value to the engineering unit full scale. If the value is large, use the single digit adjust button which is just left of the value display. This allows the **Control** rocker switch to affect a particular digit of the value display. This allows large numbers to be entered in the value display in a short time.

If there is a question about the selection of the Full-Scale value, refer to **Section 4** under determining the calibration values for shunt calibration.

5.2.3 SETTING THE 100% LOAD (100%)

A **100%** load can be set which would be the rated load of the test article. This load would be less than the Full-Scale load, and would allow going to a load greater than the rated load. Limits set in the **LIMITS** group, which are given in percent would be of the **100%** load, not the Full Scale. The Full-Scale value always corresponds to 10 volts in the control loop and at the panel test points.

To set the **100%** load, move to **100%** in the **SETUPCAL** group. Using the **Control** rocker switch, enter the Engineering Unit value of the **100%** load.

5.2.3 ENTERING THE CALIBRATION EQUIVALENT VALUE (CLEQ)

The **Calibration Equivalent Value** is the engineering unit value that gives the same size signal as the shunt resistor. It is used to set the controller feedback amplifier gain in the **RCAL** routine.

Move to **CLEQ** in the **SETUPCAL** group and use the **Control** rocker switch to enter the engineering unit value of the shunt calibration resistor.

The single digit adjust button to the left of the Value display can be used to make the **Control** rocker switch affect a particular digit of the display, avoiding the need to make the display count up to large values.

If there is any question about the selection of the calibration equivalent value, refer to **paragraph 4.2** on determining the calibration values for shunt calibration.

5.2.4 EXTERNAL INPUT FULL SCALE (EXFS)

A signal can be brought into the controller for the purposes of monitoring. It would be brought into the **Auxiliary External Input**. The controller will convert this signal to engineering units and it can be displayed in the **Value** display or the **Bar Meter** display. See the **MONITOR** group description.

To set the **External Input Full Scale**, go to **EXCV** in the **SETUPCAL** group. Using the **Control** rocker switch, enter the engineering unit value that corresponds to 10 volts on the **Auxiliary External Input**.

5.2.5 EXCITATION VOLTAGE (EXCV)

The load cell bridge excitation voltage can be set to any voltage from zero to 15 volts.

To set the Excitation voltage, move to **EXCV** in the **SETUPCAL** group. Using the **Control** rocker switch set the desired level.

5.2.6 FEEDBACK FULL SCALE IN MILLIVOLTS (FSMV)

An alternative to letting the **RCAL** routine use the shut resistor to determine the feedback amplifier gain is to assign the Full Scale feedback voltage at the input of the feedback amplifier. This is the feedback voltage that will correspond to a 10-volt command. A value set into **FSMV** will overwrite any previously determined value, including those determined by the **RCAL** routine.

To set the feedback millivolt full scale, move to **FSMV** in the **SETUPCAL** group. Use the **Control** rocker switch to set the millivolt value into the **Value** display.

5.2.7 BRIDGE BALANCE - MANUAL (BBAL)

The load Cell Bridge can be manually balanced using the **BBAL** control. The feedback gain should have been set by either the **FSMV** or **RCAL** functions prior to using BBAL.

Set the front panel **Calibrate** interlock switch to **Balance** and connect a digital voltmeter to the Feedback test point on the controller front panel. Use the **Control** rocker switch while in the **BBAL** item of the **SETUPCAL** group to bring the feedback amplifier to zero or any tare value. If the load cell has some preload applied to it at the time of bridge balancing (tare load), either adjust the **BBAL** until the feedback amplifier is at the corresponding level, or set the command to the corresponding level and adjust **BBAL** until the front panel loop error is zero. Remember that at the panel test point, the feedback voltage corresponding to a positive command is negative.

5.2.8 BRIDGE BALANCE - AUTOMATIC (FBAL)

The bridge balance routine automatically adjusts the offset of the load cell bridge until the output voltage of the feedback amplifier is zero.

Bring the feedback load cell to a condition considered to be zero load. Set the Front Panel interlock toggle switch to **Balance**. Move to **FBAL** in the **SETUPCAL** group and trigger the Control rocker switch to initiate the balance routine. If an error message appears in the **Value** display, refer to **appendix A** for its meaning. Correct the fault and reinitiate the balance routine. The routine requires several seconds to complete.

See also **Tare Balance, TBAL**.

5.2.9 FEEDBACK GAIN SETTING - AUTOMATIC (RCAL)

The gain of the feedback amplifier is set by the **RCAL** function. The feedback signal change when applying the Rcal shunt resistor is made equal to the **Cal Equivalent** values proportion of a Full Scale 10 volt input.

The shunt resistor must be installed on the controller back plane and the front panel calibrate interlock switch must be in the **Balance** position. Values must have been entered for Full Scale (**FULL**) and Cal Equivalent (**CLEQ**).

To initiate the **RCAL** function, move to **RCAL** in the **SETUPCAL** group. Trigger the routine with the **Control** rocker switch. The routine takes several seconds to complete. If an error message appears in the **Value** display, refer to **Appendix A** for its meaning. The appearance of an error message means the routine did not successfully complete and a proper feedback gain was not found. Correct the problem indicated by the error message and repeat the **RCAL** routine.

5.2.10 ERROR BALANCE (EBAL)

Error Balance is provided so that hydraulic power can be turned on without an abrupt movement of the actuator. The routine causes the internally generated command signal to be equal to the feedback signal. This makes the loop error go to zero as long as the **External Command** is zero and the hydraulic valve will be closed. This internal generated command offset will remain and will be summed with the external command input.

To initiate the **Error Balance**, move to **EBAL** in the **SETUPCAL** group. Use the **Control** rocker switch to start the **EBAL** routine. Refer to **Appendix A** for any error messages that appear in the **Value** display.

5.2.11 TARE BALANCE (TBAL)

This routine is the same as the **Automatic Bridge Balance** routine except that rather than making the feedback go to zero, it makes it go to the value of the **Tare Offset** (**TARE**). If there is a known preload applied to the load cell at the time of the balance, rather that requiring its removal, its effect can be compensated. Enter its value in the **TARE** item in the **CONTROL** group and use the **Tare Balance** (**TBAL**) routine.

To initiate the routine, set the front panel **Calibrate** interlock switch to **Balance**. Go to **TBAL** in the **SETUPCAL** group and trigger with the **Control** rocker switch. See **Appendix A** for any error messages.

5.2.12 VALVE BALANCE (VBAL)

If the hydraulic valve requires a nonzero input current to be in the off position, this current must be supplied to hold a constant load. This current would typically be supplied from a nonzero loop error, which means the control accuracy is not very good. The **Valve Balance** routine injects an offset into the valve driver to supply the required valve offset current, thus removing the need for a steady state loop error and resulting in improved control accuracy.

This procedure requires that the hydraulic pressure in **ON** and so it is interlocked with the **Hyd ON** discrete input on the controller backplane. In the **VBAL** item in the **SETUPCAL** group, trigger this routine with **Control** rocker switch. See **Appendix A** for any error messages in the **Value** display.

5.2.13 ANALOG COMMAND INPUT SCALING (SCAL)

The external command to the control loop can be attenuated to provide scaling other than that of the signal source. The command, for example, could be adjusted so the signals in the control loop became 1000 pounds per volt for purposes of display and monitoring equipment.

The value entered is the percent of the input signal to be applied as a command to the control loop, and can range from zero to 100%. To set this value, move to the **SCAL** item in the **SETUPCAL** group. Use the **Control** rocker switch to bring the desired value to the **Value** display.

5.2.14 VALVE DRIVE OFFSET – MANUAL (VLVO)

For reasons described in **Valve Balance** above, it is desirable to provide the hydraulic valve offset current by an offset in the valve driver. This offset can be manually adjusted using the **VLVO** function while monitoring the control loop error with a digital voltmeter at the front panel test point. The hydraulic pressure must be **ON** so the control loop is active.

To adjust the offset, move to the **VLVO** item in the **SETUPCAL** group. Move the value using the Control rocker switch.

5.2.15 AUXILIARY EXTERNAL INPUT LIMIT CHECK (EXCK)

The signal brought in to be monitored on the **Auxiliary External Input** can have its limit checking turned **ON** and **OFF** by **EXCK**. If the limit on the **Auxiliary External Input** is exceeded, the **Fault 2** discrete output will be triggered.

To turn **ON** or **OFF** the limit checking of the **Auxiliary External Input**, go to the **EXCK** item of the **SETUPCAL** group and use the **Control** rocker switch to set the desired condition.

5.3 CONTROL GROUP

5.3.1 PROPORTIONAL GAIN (GAIN)

This parameter allows the operator to set the forward gain of the control loop. A higher value is desirable, however limitations due to oscillations prevent the use of excessively high gains.

The meaning of the gain value is that the error signal is multiplied by this gain to determine the size of the valve drive signal. A gain of 4 with a 10% of full-scale error signal would result in a 40% valve drive.

To set the **Proportional Gain**, move to the **GAIN** item in the **CONTROL** group. Use the **Control** rocker switch to set the desired gain in the **Value** display. A conservative starting value would be one.

5.3.2 COMMAND OFFSET (OFST)

The operator using **OFST** can set the internally generated command signal. This value is summed with the external analog command input and becomes a command offset. This value is entered in engineering units.

To set this value, move to the **OFST** item in the **CONTROL** group. Using the **Control** rocker switch, change the value shown in the **Value** display to the desired level. This value will be added to all subsequent external input command voltages. This value is not affected by command scaling.

5.3.3 RATE COMPENSATION (RATE)

Rate compensation can be used in dynamic testing to improve the response of the control loop. Loops that cannot be made wide band because of limitations in the setting of the loop gain can be made to appear to be more wide band by the use of **Rate Compensation**. A lower frequency in the rate compensation value means the compensation will begin at a lower frequency, which corresponds to more compensation. A high value means the compensation does not begin until a higher frequency, meaning that less compensation is being used.

This compensation is accomplished by injecting the derivative of the command input into the control loop as an additional command. It does not actually make the loop bandwidth higher but rather compensates the phase shift and attenuation associated with low bandwidth. This compensation works at any operating frequency, not just at the **Rate Compensation** frequency.

This frequency defaults to **100 HZ**, which means compensation does not occur until frequencies approaching **100 HZ**. To set the compensation, make the loop cycle at the desired rate. While watching the loop error with an oscilloscope or the panel bar display, cause the **RATE** frequency to come down. As the **RATE** frequency approaches the frequency where the hydraulic0mechanical gain is one, the loop error will go through a null. The best setting is where the loop error is a minimum.

Another way to set the **Rate Compensation** is to introduce a small square wave command. By observing the risetime and overshooting of the feedback signal a best **Rate Compensation** setting can be make. The shortest risetime with minimal overshoot is best.

To set the **Rate Compensation** frequency, move to the **RATE** item in the **CONTROL** group. Use the **Control** rocker switch to bring the desired value into the **Value** display.

5.3.4 INTEGRATOR ENABLE (INTE)

The integrator provides an integral term in the forward path of the control loop. It will provide valve current to drive the loop error to zero. Its time constant is adjustable by **INTC** and it can be enabled and disable by **INTE**.

To enable or disable the integrator, move to the **INTE** item in the **CONTROL** group. Use the **Control** rocker switch to set the integrator. The **Value** display will show **ON** or **OFF**. The integrator is interlocked with the **Hyd ON** discrete input on the controller back plane and the front panel Integrator interlock switch.

5.3.5 INTEGRATOR TIME CONSTANT (INTC)

The integrator is used to improve the static accuracy of the control loop. It's time constant can be set between 0.1 and 10 seconds.

To set the integrator time constant, move to the **INTC** item in the **CONTROL** group. Using the **Control** rocker switch set the value in the **Value** display. One second is a typical value. Using too short a time constant can cause instability in a control loop, so care should be taken in using short time constants.

5.3.6 DIGITAL COMMAND SCALING (ISCL)

When using the internally generated command functions, the amplitude of those commands can be scaled by the **ISCL** command. This is a percentage adjustment of the maximum and minimum values of the cyclic command waveforms and can be from zero to 100%.

To set the **Digital Command Scaling**, move to the **ISCL** item in the **CONTROL** group. With the **Control** rocker switch set the desired attenuation level in the Value display.

5.3.7 LAG RATIO (LAGR)

The proportional amplifier of the control loop can be made to have an extra high gain at **DC** with a **Lag Frequency** (pole) at a low frequency and a **Lead Frequency** positioned so that all higher frequencies have a gain set by the **Proportional gain**. This gives the loop extra high gain for tight control at static conditions and low frequency cycling without sacrificing control loop stability.

The amount of extra proportional gain at **DC** is set by the **Lag Ratio**, which is the ratio of the lag and lead frequencies in the transfer function. The **Lag Frequency** is the frequency where the gain begins to be reduced down to the **Proportional Gain**. The **Lead Frequency** will always be the **Lag Ratio** times the **Lag Frequency**, and should always be at least a factor of four below the bandwidth of the control loop.

To set the **Lag Ratio**, move to the **LAGR** item in the **CONTROL** group. Use the **Control** rocker switch to set a value in the **Value** display from zero to 31.9. Setting the **Lag Ratio** to zero disables the **Lag-Lead** feature.

5.3.8 LAG FREQUENCY (LAGF)

The **Lag Frequency** is the frequency where the **Lag-Lead** transfer function begins to roll off its extra gain. Refer to the **Lag Ratio** description in **5.3.7** above.

To set the **Lag Frequency**, move to the **LAGF** item in the **CONTROL** group. Use the **Control** rocker switch to set the **Lag Frequency** shown in the **Value** display to a value between 0.01 and 1.0 hertz.

5.3.9 TARE OFFSET (TARE)

A tare load is a preload of a load cell due to the weight of connecting linkages or test article. If this loaded condition is not to be considered zero load, it can be compensated for in the **Bridge Balance** routine. See **Tare Balance** in **5.2.11** above.

To set the value of the **Tare Offset**, move to the **TARE** item in the **CONTROL** group. Using the **Control** rocker switch set the value of the preload into the Value display in engineering units.

5.4 LIMITS GROUP

5.4.1 CLEAR FAULTS (FCLR)

If any outer limit or error condition has occurred, the **Outer Error Detector** will be triggered. This turns on the **Outer Error LED** on the front panel, and turns on the **Fault 1** discrete output on the controller back plane. Since this is a latching detector, it must be reset to clear it. It will not reset unless the fault condition has been removed.

To reset the **Outer Error Detector**, move to the **FCLR** item in the **LIMITS** group. Use the **Control** rocker switch to clear the fault. The front panel **LED** will go out.

5.4.2 SET FAULTS (FSET)

The **Outer Error** detector can be triggered to allow the testing of the hardware that is activated by the Fault 1 discrete output.

To set the **Outer Error** detector, move to the **FSET** item in the **LIMITS** group. Use the **Control** rocker switch to set the detector.

5.4.3 INNER LOOP ERROR LIMIT (INLE)

The control loop error is monitored and compared against a limit. Either polarity error can trigger this limit. If the **INNER LIMIT** is triggered, the **Fault 2** output on the back plane of the servo controller chassis will be driven to the low state. Refer to **Section 4** under **Discrete Outputs** for a complete description.

The inner error detector is non-latching. This means that if the error condition goes away, the **Fault 2** output will no longer be driven to the low state. Also the **inner error LED** on the front panel will turn on and off as the inner error limit is exceeded.

Move to the **LIMITS** group and select **INLE**, the inner loop error limit. Use the **Control** switch to set the value of the loop error limit. This value is in percent of the 100% load, not of Full Scale, and can be set between 0 and 102%. Typical values are in the 1 to 10% range.

5.4.4 OUTER LOOP ERROR LIMIT (OTLE)

The control loop error is compared to the **Outer Loop Error Limit**. Exceeding the limit causes the **Outer Error** detector to be triggered, the **Fault 1** discrete output to be driven on, and the front panel **Outer Error LED** to be turned on. The **Outer Error** detector latches on and must be manually cleared by the **Clear Faults** (**FCLR**) function.

Move to the **LIMITS** group and the **OTLE** item. Use the **Control** rocker switch to set the value to the limit desired, within the range of 0 to 102% of the 100% load. Errors of either polarity will trigger this detector. Typical values are in the 5 to 25% range.

5.4.5 PLUS INNER FEEDBACK LIMIT

The **Plus Inner Feedback Limit** is a tolerance set on the feedback signal of the control loop. This limit is used to assure the load or stroke of the controller does not exceed a specified value. The plus side limit corresponds to the displayed feed back moving in a positive direction. (The **FDBK** panel test point will be negative) This will occur when the command is positive and normally corresponds to tension.

To set this value, move to the **LIMITS** group and bring **IFBH** into the parameter display. Using the **Control** rocker switch set the value in the **Value** display to the desired limit between plus and minus 102% of the 100% load.

The **Inner Feedback** limit is a non-latching error detector and will turn off if the limit is no longer being exceeded.

When the inner feedback limit is exceeded, the **Fault 2** discrete output is driven to the low state.

5.4.6 MINUS INNER FEEDBACK LIMIT (IFBL)

The **Minus Inner Feedback Limit** is exactly the same as the **Plus Inner Feedback Limit** except it triggers on displayed feedback signals on the negative side. (The **FDBK** front panel test point will be positive.) These correspond to negative command signals and normally correspond to compression. Exceeding this limit triggers the **Fault 2** discrete output.

To set its value, move to the **LIMITS** group with **IFBL** in the parameter display. With the **Control** rocker switch set the value in the **Value** display to between zero and 102% of the 100% load.

5.4.7 PLUS OUTER FEEDBACK LIMIT (OFBH)

The **Plus Outer Feedback Limit** is a tolerance set on the feedback signal on the plus side. This normally corresponds to a tension load.

The **Outer Limit Detector** is a latching detector, so it will not reset if the feedback limit threshold is no longer exceeded. Triggering the outer feedback limit causes **Fault 1** discrete output to be driven to the low state.

The value for **Plus Outer Feedback Limit** is in percent of the 100% **load**, and can be from zero to 102%.

To set the **Plus Outer Feedback Limit**, move to the **LIMITS** group and use the **Control** rocker switch to bring **OFBH** to the parameter display. Use the **Control** rocker switch to set the value in the **Value** display to between zero and 102% of the 100% load.

5.4.8 MINUS OUTER FEEDBACK LIMIT (OFBL)

The **Minus Outer Feedback Limit** is the tolerance set on the feedback signal in the negative direction. This corresponds to a negative command, which is normally compression.

The outer feedback detector is a latching detector and can be reset by **Fault Clear** as in paragraph **5.4.1** if the feedback limit is no longer being exceeded. When this limit is exceeded, the **Fault 1** discrete output is driven to the low state.

Move to the **LIMITS** group and use the **Select** rocker switch to bring **OFBL** to the parameter display. Using the **Control** rocker switch set the desired limit into the **Value** display in percent of the 100% load.

5.4.9 PLUS EXTERNAL INPUT LIMIT (EXTH)

The signal brought into the **External Input** can be displayed and tested for limits. Exceeding the limit causes the **Fault 1** discrete output to trigger. The plus limit is on the more positive side of the input signal range. The limit is entered in percent of the **External Input Full Scale** entered in the **EXFS** item in the **SETUPCAL** group.

To set the limit, move to the **EXTH** item in the **LIMITS** group. Using the **Control** rocker switch set the desired limit in the **Value** display in percent.

5.4.10 MINUS EXTERNAL INPUT LIMIT (EXTL)

The **Minus External Input Limit** is exactly like the **Plus External Input Limit** except it is on the more negative side of the signal range. To set it, move to the **EXTL** item in the **LIMITS** group. With the **Control** rocker switch set the desired limit into the **Value** display.

5.4.11 FAULT LIMIT DEBOUNCE TIME

The **Fault Limit Debounce Time** is a delay, which is used to prevent short duration conditions from triggering the limit detectors. Narrow spikes which exceed the limits can be prevented from causing the limit detector to trigger by the use of the fault limit debounce delay. A limit condition must last longer than the **Debounce Time** before it is considered a fault.

To set the debounce delay, move to the **FLDB** item in the **LIMITS** group. Using the **Control** rocker switch set the desired delay into the **Value** display in milliseconds. A value of 10 provides a ten-millisecond delay.

5.5 TUNING GROUP

5.5.1 HYDRAULIC SIMULATOR (SIMU)

Built into the servo controller is a circuit whose function is to simulate the response of an external hydraulic load. It responds to the valve driver output and provides a feedback signal. When turned on, the controller will respond in a realistic fashion allowing operation of a test procedure or other system functions to verify that normal operation is occurring. Using low loop gain will cause sluggish loop response, and high loop gain will cause quick response.

To enable the hydraulic simulator, the hydraulic power to the actuator must be **OFF**. This is indicated by the **Hyd ON** discrete input being connected to common on the servo back plane, or on the Discrete input panel connected to the back plane.

To turn **ON** the hydraulic simulator, move to **SIMU** in the **TUNING** group. Use the **Control** rocker switch to set the simulator to **ON** or **OFF** as displayed in the **Value** display.

5.5.2 PISTON AREA RATIO (AREA)

In actuators where the rod does not come out of both ends, the effective area of the actuator piston is unequal on the two sides. This results in a different loop gain in the two directions of motion of the actuators, especially at higher loads. Setting a value into the piston Area Ratio parameter can compensate this.

To determine what setting to use, cause the loop to cycle between two typical loads. Examine the amplitude of the **Loop Error** signal when the load is increasing and decreasing. If they are not equal, adjust the **Area Ratio** to make them equal.

To set the **Area Ratio**, move to the **AREA** item in the **TUNING** group. Using the **Control** switch set the desired value into the **Value** display. The range of values is between 0.5 and 1.

5.5.3 OSCILLATION DETECTION AND CONTROL - HOW AUTOTUNING WORKS

In the **Autotuning** mode of the servo controller, the loop error signal is being analyzed to detect cycles of oscillation. When detected, the loop gain is automatically lowered to improve the stability of the control loop. As long as the oscillations are continuing to be detected, the gain will continue to be lowered until oscillations stop or the **Minimum Gain Cap** is reached. To lower the gain too far is to lose complete control of the applied load, so the operator chooses the lowest gain the loop is allowed to go.

Autotuning is enabled by the black front panel push button while **Autotuning by Time, ATTL**, is in the **ON** setting. The loop gain will slowly rise at a rate set by the **Gain Recovery Time, GNRT**. The **Gain Recovery Time** is the number of seconds to go from the gain of the last detected oscillation to the **Maximum Gain Cap**. The **Maximum Gain Cap** is the highest loop gain the operator wants to allow

Any loop will oscillate if the gain is made high enough. If the **Maximum Gain Cap** is made very high, the loop will stay near oscillation and the gain will be lowered every time oscillations are detected. The operator may, however, desire that the loop never oscillate. A lower **Maximum Gain Cap** would be used, and the oscillation detection would be used as insurance that if under some condition the loop began to oscillate, it would automatically be stopped.

5.5.4 NOISE MARGIN (NOIS)

When the servo controller is in the **Autotune** mode, the oscillation detector is evaluating the AC components of the loop error signal. The noise band is the percent of full-scale signal around zero that is allowed for noise and small AC signals without them being considered peaks of an oscillation. This **noise margin** can be set from 0 to 100% Full Scale.

In the **TUNINGS** group, use the **Select** rocker switch to bring **NOIS** into the parameter display. Use the **Control** rocker switch to set the desired margin in the **Value** display.

5.5.5 OSCILLATION PEAKS (OSPK)

This parameter allows the oscillation detector to decide how many peaks it takes for it to conclude an oscillation is occurring.

To set the **Number** of **Oscillation Peaks**, move to the **OSPK** in the **TUNING** group. Use the **Control** rocker switch to set the number beyond which oscillation is to be considered to be occurring. This number can be from 1 to 10.

5.5.6 AUTOTUNING BY TIME (ATTI)

To enable autotuning by allowing the loop gain to slowly rise, go to the **TUNING** group and select **ATTI**. Turn the **Autotuning LED** on the correct channel to **ON** by the black panel **Autotune** push button. This enables **ATTI** to be set to **ON** by the **Control** rocker switch.

5.5.7 AUTOTUNING BY END POINT (ATEP)

This feature is only used in the full Cyber load system operation.

5.5.8 MINIMUM GAIN CAP (MNGC)

This is the lowest loop gain allowed when operating in autotune mode. It should be set low enough to assure the loop will not oscillate, but high enough to still maintain control of the load. A gain of one is a typical number.

To set the **Minimum Gain Cap**, go to **MNGC** in the **TUNING** group and use the **Control** rocker to set the minimum gain.

A gain of one means a ten percent error signal will open the hydraulic valve ten percent.

5.5.9 MAXIMUM GAIN CAP (MXGC)

This is the maximum loop gain allowed when operating in autotune mode. This should be chosen according to how likely it is desired that an oscillation will occur. See the description in **5.5.3** above.

To set the **Maximum Gain Cap**, go to **MXGC** in the **TUNING** group and use the **Control** rocker to set the maximum gain in the **Value** display.

5.5.10 GAIN RECOVERY TIME (GNRT)

The gain recovery time is the number of seconds the loop gain is to take to go from the gain of the last detected oscillation to the **Maximum Gain Cap**. The range is from 0.1 to 127.9 seconds.

To set the **Gain Recovery Time**, go to **GNRT** item in the **TUNING** group. Use the **Control** rocker switch to set the time into the **Value** display.

5.6 MONITOR GROUP

The Monitor group controls those items that display data on the front panel Value display and the bar meter.

5.6.1 COMMAND DISPLAY (CMMD)

When selecting the **CMMD** item in the **MONITOR** group, the current value of the **Command** will be displayed in the **Value** display. It will be in engineering units. This is the sum of any internally generated command and any external command input. An external command input will include any attenuation scaling being applied by **SCAL**.

5.6.2 FEEDBACK DISPLAY (FDBK)

When selecting the **FDBK** item in the **MONITOR** group, the current value of the **Feedback** signal will be displayed in the **Value** display. It will be in engineering units.

5.6.3 ERROR DISPLAY (EROR)

When selecting **EROR** item in the **MONITOR** group, the current value of the **Loop Error** will be displayed in the **Value** display. The value will be in engineering units.

5.6.4 VALVE CURRENT DISPLAY (VALV)

When selecting the **VALV** item in the **MONITOR** group, the present value of the hydraulic **valve drive current** will be shown in the Value display. It will be in percent of full drive current. The actual valve full scale current is set by switches accessible on the side panel of the controller.

5.6.5 BAR METER SETTING (METR)

This allows any of seven functions to be displayed on the **Bar Meter** for continuous display. This function remains on the meter when the Value display has some other function in it. Move to the **METR** item in the **MONITOR** group.

Using the **Control** rocker switch bring any of the following functions to the **Value** display.

COMMAND	Total command input to the control loop
ERROR	Control loop error
FEEDBACK	Control loop feedback signal
-EXCITE	Minus side of the Excitation supply (its balanced about ground)
+EXCITE	Plus side of the Excitation supply
EXTERNAL	The value of the monitored external input
VALVE I	The percent of full scale drive to the hydraulic servo valve

5.6.5 EXTERNAL INPUT DISPLAY (EXTN)

This function displays the engineering unit value of the signal on the **External Input**. The engineering unit value is determined from the **External Input Full Scale** (**EXFS**) in the **SETUPCAL** group.

Move to the **EXTN** item in the **MONITOR** group. The present value of the **External Input** will be in the **Value** display.

5.6.6 CYCLE COUNT (CYCT)

When using internal command function generation, the number of cycles that have been performed can be displayed. This value will continue to increase as long as cycling continues. If cycling is stopped, the count will remain. When the cycling is started, the counter will be reset and begin counting again from zero. To stop cycling automatically at a particular count, see **Number of Cycles to Perform**, **NUMC**, in the **FUNCTION** group.

To display the **number of cycles** performed, move to the **CYCT** item in the **MONITOR** group. The **Value** display will show the number of cycles.

5.7 FUNCTIONS GROUP

This group pertains to the internal generation of commands.

5.7.1 INTERNAL CYCLING ON/OFF (CYCL)

The starting and stopping of the command function can be controlled from **CYCL**. When starting, it will do one cycle at 1/8 of normal amplitude, one at ¼ amplitude, one at ½ amplitude and followed by full amplitude cycles. When turning the cycling off, the command will continue to the coming peak or valley and then hold there. The recommended way to stop cycling is with the **Cycling Stop – Ramp to Zero**.

To start the cycling, move to the **CYCL** item in the **FUNCTION** group. With the **Control** rocker switch trigger the cycling to **ON**.

5.7.2 CYCLING STOP - RAMP TO ZERO (RAMP)

This is the preferred way to stop the command cycling. When triggered, the command will continue to the coming peak or valley and then do a two-second ramp to zero.

To stop cycling and ramp to zero, move to the **RAMP** item in the **FUNCTION** group. Using the **Control** rocker switch trigger the **Stop Cycling**.

5.7.3 NUMBER OF CYCLE TO PERFORM (NUMC)

To make the command function stop after a certain number of cycles, enter that value for **NUMC**. If this value is zero, the cycling will continue forever or when manually stopped.

To set the number of cycles, move to the **NUMC** item in the **FUNCTION** group. Using the **Control** rocker switch set the desired number of cycles in the **Value** display.

5.7.4 CYCLE PEAK (MAXL)

The **Cycle Peak** is the value of the most positive part of the command waveform and is entered in engineering units. It cannot be greater than Full Scale.

To enter the value, move to the **MAXL** item in the **FUNCTION** group. Using the **Control** rocker switch set the peak load in the **Value** display.

5.7.5 CYCLE VALLEY (MINL)

The **Cycle Valley** is the value of the most negative part of the command waveform.

To enter the value, move to the **MINL** item in the **FUNCTION** group. Use the **Control** rocker switch to set the Valley Load in the **Value** display.

5.7.6 CYCLING FREQUENCY (FREQ)

The **Cycling Frequency** can be from 0.1 to 100 hertz.

To enter the value, move to the **FREQ** item in the **FUNCTION** group. Use the **Control** rocker switch to set the frequency in the **Value** display.

5.7.7 CYCLING WAVEFORM (SHAP)

There are 3 waveform shapes that can be used for the command signal. The first is a triangle waveform where the transitions are made with pure ramp. The second is a haversine shape, which when joined for a continuous waveform makes a pure sine wave. The third is a modified sine wave. This waveform is a ramp from about the 10 to 90 percent points with a sine wave section to the endpoints.

To select the waveform, move to the **SHAP** item in the **FUNCTION** group. Using the **Control** rocker switch select from **TRIANGLE, SINUSOID** or **MODSIN** in the **Value** display.

5.7.8 FREQUENCY ADJUST (FADJ)

The **Frequency Adjust** function allows the cycling frequency to be adjusted by plus or minus ten percent while cycling is continuing. There are some limitations on its range.

To adjust the frequency, move to the **FADJ** item in the **FUNCTION** group. Using the **Control** rocker switch set the percent adjustment into the **Value** display.

5.8 STATIC GROUP

The functions in this section pertain to running a test where the operator decides to go to a particular load, enters the load, sets the time for the transition, and initiates the transition. Selecting the shape of the transition waveform, monitoring the feedback value, manually stopping the waveform, and ramping to zero are also available.

5.8.1 DESTINATION LOAD (LOAD)

To select the new load level, move to the **LOAD** item in the **STATIC** group. Using the **Control** rocker switch set the destination load in the **Value** display. This can be anywhere between plus and minus full scale engineering units.

5.8.2 TRANSITION TIME (TIME)

The time to go to the new load level is entered in the **TIME** item of the **STATIC** group. Use the **Control** rocker switch to enter the **Transition Time** in seconds into the **Value** display.

5.8.3 TRANSITION SHAPE (SHAP)

The shape of the transition waveform can be a ramp, a haversine, or a modified haversine. The modified haversine is a ramp between the 10 and 90 percent loads and haversine shapes at the ends.

To select the shape, move to the **SHAP** item in the **STATIC** group. Use the **Control** rocker switch to select between **RAMP**, **HAVERSINE**, and **MODSIN** in the **Value** display.

5.8.4 INITIATE TRANSITION (GO)

To start the transition to the new load level, move to the **GO** item in the **STATIC** group. Press the **Control** rocker switch to start the transition.

The load can be stopped where it is at during the transition by pressing the **Control** rocker switch again while in the **GO** item. Then pressing it again will cause it to resume the transition to the destination load.

The load can be immediately ramped to zero by moving down two clicks on the **Select** switch to the **RAMP** item, and pressing the **Control** switch. It will go to zero in the Transition time.

5.8.5 FEEDBACK VALUE (FDBK)

The value of the **Feedback** signal can be displayed by one down click of the **Select** rocker switch from the **GO** item that starts the transition.

5.8.6 RAMP TO ZERO (ZERO)

The **Command** signal can be made to transition to zero with the **ZERO** function. It moves in the **Transition** time (**TIME**) and with the shape selected in **SHAP**. It can be initiated while a transition is under way, or if the transition is in hold.

Move to the **ZERO** item in the **STATIC** group. Trigger a ramp to zero with the **Control** rocker switch.

5.0 SETTING UP THE TEST

When starting a new test, it is necessary to assure that certain conditions exist. This section will describe some of these checks

6.1 POLARITY OF GAIN

The servo control loop can only be stable if the error signal causes the feedback to move in such a direction as to reduce the error signal. A positive command signal should create tension in the actuator and the resulting signal that comes from the load cell or stroke transducer should cause the feedback signal to move in a positive direction (negative on the panel test point). This subtracts from the command and making the error go toward zero.

To assure that the load cell is wired in such a way as to provide negative feedback, connect a voltmeter or oscilloscope to the feedback test point on the front panel of the servo controller. Alternatively, the feedback can be shown in the Value display by moving to **FDBK** in the **MONITOR** group. With the excitation voltage set to its proper level, pull by hand on the load cell and observe the direction of the feedback signal. This signal should move in a negative direction at the test point or positive on the **FDBK** display in order for the polarity of gain in the control loop to be proper. If the load cell is of very large capacity, this signal will be quite small. Possibly requiring the use of sensitive digital voltmeter to detect the small signal. If the signal does not move in the right direction, it is necessary to reverse the plus and minus signal leads at the load cell. The load cell should give a positive output under tension.

Verify the polarity of the valve drive to the actuator by removing the pin that connects the actuator to the test article. With the pin removed and hydraulic power turned **ON**, use the command-offset control, **OFST** in the **CONTROL** group, to increase the command in a positive direction. The actuator should move in a direction as to create tension in the load cell, that is, to retract the actuator rod into the actuator. If the positive command signal does not cause the actuator rod to retract, then move the valve polarity switch, which is accessible through the side panel of the servo controller, to the other position. This reverses the drive current to the servo valve.

6.2 PINNING THE ACTUATOR

To move the actuator in order to install the pin that connects the actuator to the test article, turn on the hydraulic power. Using the command offset, **OFST** in the **CONTROL** group, move the actuator to the proper position that aligns the hole and allows the pin to be inserted.

6.3 BALANCE CALIBRATION

The servo controller must be calibrated to assure that the signals introduced as commands correspond to the proper loads or strokes. To achieve a 0-volt signal in the load cell for a zero load, turn off the hydraulic power. Three methods of bridge balancing are available.

The first is to assure that zero load is applied to the load cell. Move to the **FBAL** item in the **SETUPCAL** group. Set the front panel **Calibrate** interlock switch to **Balance**. Assure that the **HYD ON** discrete input is in the high state. With the **Control** rocker switch, trigger the automatic bridge balance routine. This routine requires several seconds to complete. If an error message number is displayed, refer to **Appendix A** for its meaning.

The second method is when the initial load on the load cell is not zero. If the amount of pre-load, or tare load, is known, enter it in the **TARE** item in the Control group. Then in the **TBAL** item in the **SETUPCAL** group, trigger the automatic **TARE Balance** Routine. The feedback signal will be made to go to a value that corresponds to the tare load as scaled by the Full-Scale value.

The third method is to manually move the bridge balance while monitoring the feedback signal. To manually control the bridge balance, move to the **BBAL** item in the **SETUPCAL** group. Use the Control rocker switch to move the feedback signal to the desired value.

6.4 SHUNT CALIBRATION

The second part of this calibration is the setting of the feedback amplifier gain. The shunt resistor, installed on the servo chassis back plane, is shunted across the load Cell Bridge to provide a signal that corresponds to the calibration equivalent value. This value is entered in the **CLEQ** item in the **SETUPCAL** group.

To initiate this calibration routine, move to the **RCAL** item in the **SETUPCAL** group. Set the front panel **Calibrate** interlock switch to the **RCAL** position. Make sure the hydraulic pressure to the actuator is off and that the **HYD ON** discrete input is in the high state. Trigger the **RCAL** routine using the Control rocker switch. This requires several seconds to complete. If an error message number is displayed, refer to **Appendix A** for its meaning. Set the Calibrate toggle switch back to the center position.

An alternate method for setting the feedback amplifier gain is to use the **FSMV** item in the **SETUPCAL** group. This allows the operator to set the millivolt value that will give ten volts at the amplifier output. It assumes that the feedback amplifier is set for low level operation by the servo side panel switch.

If a high level signal is being used and the side panel switch is set for high level, determine the input signal level that corresponds to the full scale engineering units entered in **FULL** in the **SETUPCAL** group. Divide this by 250 to determine the value to enter for **Feedback Full Scale Millivolts**.

6.5 THE HYDRAULIC ON DISCRETE INPUT

This discrete input must be controlled as described in **paragraph 4.6** for the servo controller interlocks to work properly. The load cell **Bridge Balance** and **RCAL** functions must be performed with the hydraulics off. This requires the **Hydraulic ON** discrete input to be in the open or high state.

When testing is to be started and hydraulic power is turned on, the **Hydraulic ON** discrete input must be driven to the low state. This enables the operator to choose to use the integrator and it also disables the use of **Bridge Balance** and **RCAL** functions.

6.6 CHOICE OF LOOP GAIN

Improper choice of the loop proportional gain will either cause very slow, sluggish loop performance or instability and oscillation of the control loop. Most control loops are stable at a loop gain of one and this is a conservative starting value. To set the loop gain, move to the **GAIN** item in the **CONTROL** group and use the **Control** rocker switch to set the gain in the **Value** display.

Hydraulic power can be turned on at this point and the loop can be driven by a command signal. Observing either the feedback signal or the loop error on the front panel test points can monitor the response of the loop. Both test points are scaled for 10 volts equals full scale. The loop gain can be manually raised and while cycling, the response of the control loop observed by an oscilloscope on the test points, watching for any indication of oscillation.

See also **section 5.5.3** on autotuning.

6.7 USE OF THE INTEGRATOR

The integrator is used in the controller to improve the accuracy of the applied load, especially in static conditions.

The time constant of the integrator is a measure of how quickly the correction will occur. The range of the time constant is from 0.1 to 10 seconds, where a typical value is 1 second. To set the integrator time constant, move to the **INTC** item in the **CONTROL** group. Using the **Control** rocker switch set the desired time constant in the **Value** display in seconds.

The integrator can be enabled and disabled from the front panel. The integrator cannot be enabled if the hydraulic power is not on, as determined by the **HYD ON** discrete input on the back panel. It must be in the high or open state. To enable the integrator, move to the **INTE** item in the **CONTROL** group. Using the Control rocker switch set the **Value** display to **ON** or **OFF** as desired.

6.7 SETTING RATE COMPENSATION

The rate compensator is used to improve the dynamic performance of the control loop. This is desirable in cyclic testing. It functions by boosting the valve drive during higher velocity parts of the command waveform.

To set the Rate Compensation value, move to the **RATE** item in the **CONTROL** group. Using the **Control** rocker switch set the desired peaking frequency in the **Value** display in hertz.

The best value for this is the frequency where the gain from the valve driver through the actuator and the load cell to the feedback amplifier is one. It can be found experimentally by changing the command frequency until the value current signal and the feedback signal are the same amplitude. Another way is to cycle at a modest frequency and lower the **RATE** frequency until a null occurs in the loop error signal. A third way is to command the loop with a small amplitude square wave and adjust the **RATE** frequency until the rise time is a minimum without significant overshoot thus giving the best squareness to the feedback signal. Once the best setting is found, it is the best setting for any cycling frequency.

The value starts out at a high value, 100 Hz. This means that very little compensation is occurring at lower frequency cycling. As the value is made lower the compensation begins at lower frequencies.

6.8 SETTING THE VALVE BALANCE

When there is offset in the hydraulic servo valve, a current is required into the valve to maintain zero flow. This current can be supplied by the integrator. If the integrator is not being used, a separate offset source can be adjusted in the valve driver thus preventing the need for a static error signal in the control loop. A static error signal means the accuracy of the loop control is poor.

To trigger the valve balance procedure, the hydraulic power must be on and the **HYD ON** discrete input must be low. Move to the **VBAL** item in the **SETUPCAL** group. Using the **Control** rocker switch trigger the **Valve Balance**. This procedure takes several seconds to complete. If an error message number is displayed, refer to **Appendix A** for its meaning.

6.9 USE OF AUTOTUNING

The proportional loop gain can be manually set and left fixed at that value for the duration of the testing.

The servo controller can also operate in the autotuning mode. In autotuning, the loop gain will rise to the **Maximum Gain Cap** value at a rate set by the **Gain Recovery Time**. If by examination of the loop error the controller determines that an oscillation is occurring, the loop gain will automatically be lowered until the oscillation stops. If the **Maximum Gain Cap** is set to a value determined to be a good gain, and the controller is set to the autotuning mode, the loop gain will stay at that gain but will be lowered to stop an oscillation if for any reason that should occur. See **section 5.5.3** through **5.5.10** on setting the parameters for autotuning.

To enable peak autotuning, press the autotune button on the front panel of the servo controller. The autotune **LED** will turn **ON**

6.0 MONITORING THE TEST

Three different ways are provided on the servo controller front panel for monitoring the key signals of the control loop. They are LED bar meters, the Value display which show a numeric value of the parameter, and the test points located on the front panel.

7.1 BAR METER DISPLAY

The Bar Meter Displays provide a course indication of the value of the selected parameter. This allows the monitoring of a loop value at a distance. Channels A and B have separate bar meter displays.

To select the function to be displayed on the bar meter, move to the **METR** item in the **MONITOR** group. Use the Control rocker switch to select the parameter to be displayed on the meter. The available functions are:

0	**Command**
1	**Loop Error**
2	**Feedback**
3	**Minus side of the excitation voltage**
4	**Plus side of the excitation voltage**
5	**The external input voltage**
6	**Valve current**

Full scale on the meter is either full scale in the control loop, or 10 volts. These 7 functions are numbered 0 through 6 as shown above. The number corresponding to each of these 7 functions is shown for reference on the Servo Controller front panel. This number is displayed in a one digit numeric display above each of the bar meters. This allows the operator to know what parameter is being displayed on the bar meter.

7.2 NUMERIC DISPLAYS

The value of any of five loop signals can be shown on the Value display.

7.2.1 COMMAND INPUT

To display the engineering unit value of the **Command** input in the **Value** display, move to the **CMMD** item in the **MONITOR** group. The engineering unit value of the total command input will be displayed in the Value display. This is the sum of internally generated commands and scaled external commands. This value can range from plus to minus the engineering value given as **Full Scale**.

7.2.2 FEEDBACK

The value of the **Feedback Signal**, in engineering units, can be displayed in the **Value** display. Move to the **FDBK** item in the **MONITOR** group. The engineering unit value of the feedback signal is shown in the **Value** display.

7.2.3 LOOP ERROR

For **Loop Error** to be shown in the **Value** display move to the **EROR** item in the **MONITOR** group. The loop error is shown in engineering units.

7.2.4 VALVE CURRENT

Valve Current can be shown in the **Value** display. Move to the **VAKV** item in the **MONITOR** group. The valve current will be shown in percent of full scale. A 100% value means the valve is driven to full open, as long as the valve driver current setting corresponds to the current rating of the hydraulic servo valve in use.

7.2.5 EXTERNAL INPUT

The engineering unit value of the **External Input** can be displayed. It has its own Full Scale, which is entered in the **EXFS** item in the **SETUPCAL** group. Move to the **EXTN** item in the **MONITOR** group. The External input is shown in the **Value** display.

7.2.6 FRONT PANEL TEST POINTS

The signals of the control loop can also be monitored with a voltmeter or an oscilloscope from the test points at the front panel.

7.2.6.1 VALVE CURRENT (VALVE I)

The valve current signal is a +/- 10 Volt signal, where 10 Volts corresponds to 100% drive to the hydraulic servo valve.

7.2.6.2 COMPOSITE COMMAND (COMP C)

This test point displays the net sum of the two components making up the Command signal. These components are the external command input, with attenuation if the input scaling is being used, and summed with the internally generated command voltage, if it is being used.

7.2.6.3 FEEDBACK (FDBK)

This test point is the output of the feedback amplifier with 10 volts equal to the Full-Scale engineering units. Its polarity will always be the opposite of the displayed feedback signal.

7.2.6.4 LOOP ERROR (ERROR)

This test point displays the loop error signal. Ten volts correspond to the engineering unit value of a 10-volt loop command signal. If the input scaling, **SCAL** is set for 50% for example, a 10-volt external command voltage will result in a 5-volt loop command signal.

7.2.6.5 INTEGRATOR (INTEG)

The integrator can correct for valve offsets of up to 25% of full valve drive. Therefore, a 10V signal at the integrator test point corresponds to a 25% of rated valve current. This signal is useful to monitor the amount of offset being corrected by the integrator.

Appendix A

Servo Controller Error Messages

During the course of performing the normal start up procedures and calibration procedures, problems may arise which are displayed as error codes on the servo front panel. This appendix provides a list of possible error codes, along with their individual meaning.

CODE #	MEANING
Error 1	No Full Scale defined
Error 2	Not presently defined
Error 3	"Balance" panel switch in the wrong position
Error 4	Integrator can't be turned on because hydraulics are **OFF** or because "Integrator" panel switch is in the wrong position
Error 5	Hydraulics are on, therefore can't turn on hydraulic load simulator
Error 6	Hydraulics or hydraulic load simulator is on, so can't do **FBAL** or **RCAL**
Error 7	"**RCAL**" panel switch is in the wrong position
Error 8	Pretune auto tune can't be run because neither hydraulics nor the load simulator is **ON**
Error 9	Not presently defined
Error 10	Excessive noise encountered during readings for **BALANCE** or **RCAL**
Error 11	Balance **DAC** has insufficient range after second try during reading in **BALANCE** or **RCAL**
Error 12	Balance DAC has insufficient range
Error 13	Readings have too much noise
Error 14	Readings have too much noise while deciding **RCAL** polarity
Error 15	Readings have too much noise during excitation tweak in **RCAL**
Error 16	Excitation DAC has insufficient range after second try in excitation tweak in RCAL

CODE #	MEANING
Error 17	Excitation DAC has insufficient range
Error 18	Reading has too much noise in excitation tweak in RCAL
Error 19	Can't do Valve Balance since Hydraulic Pressure is OFF
Error 20	Valve balance not able to be achieved
Error 21	Excessive noise in initial ADC Feedback samples
Error 22	Excessive noise in ADC Feedback samples
Error 23	Computed Bridge balance DAC value out of range
Error 24	Computed Feedback DAC value out of range
Error 25	Not Used
Error 26	Tare Balance failure
Error 27	Excessive noise in initial ADC Error samples
Error 28	Excessive noise in ADC Error sample
Error 29	Can't do Tare Balance. Either the hydraulics or simulator is ON
Error 30	Can't do Error Balance. Either the hydraulics or simulator is ON
Error 31	Error Balance failure
Error 32	Excessive noise in initial ADC External sample
Error 33	Excessive noise in ADC External sample
Error 34	Monitor Bridge Balance failure
Error 35	Excessive noise in ADC command sample
Error 36	Monitor RCAL failure
Error 37	Initial Cal Feedback is full scale
Error 38	Feedback with RCAL is full scale
Error 80	Tried to turn on command cycling while servo is assigned to a test (system usage only), or a segment initiated in the Static mode was not completed.

CODE #	MEANING
Error 81	Tried to Ramp from the panel while servo is assigned to a test (system usage only), or a segment initiated in the Static mode was not completed
Error 90	Tried to make minload greater (more positive) than maxload
Error 91	Tried to make maxload less (more negative) than minload
Error 92	Tried to do frequency adjust trim with frequency above 5.9 Hz
Error 93	If cycling, cannot do GO in the Static mode
Error 94	If cycling, cannot do Zero in the Static mode

APPENDIX B

ANALOG SERVO CARD OPERATION FROM BUTLER

Tests can be performed on the analog circuit card, which include setting the DACs and monitoring the readings of the ADC

To operate the analog servo card from a terminal, connect a terminal to **J1** on the Digital Servo Controller, 13829. The pin assignments are:

Pin	Function
1 (top)	Transmit
2	Receive
3	Ground

The terminal interface is 8N (8 data bits, no parity, one stop bit). The baud rate setting is 9600.

To start the Butler diagnostic editor, type control **B**. All address and data values are in hexadecimal format.

The Butler Menu is as follows:

D = Set NOVRAM for default values

M = Modify memory w/verification

P = Display process states (not applicable)

R = Loop on read

S = Set memory

W = Loop on write (not available)

X = Examine memory

(ESC) = To exit butler

OPERATION

To display the ADC readings, use the Butler commands as follows:

Examine from 40000 to 4001E

The output values are in two's complement hexadecimal format.

The eight functions across one line of the screen (after address) are Command, Feedback, Error, Valve Current, External Input, +Excitation P/S, -Excitation P/S and VLV drive.

SETTING DACs

To control a DAC, set memory from the first address given to the second, word length, and the hexadecimal value.

For example, to set input scaling of the B channel to 100% set memory from A0020 to A0021, W, FA0.

INPUT SCALING

Channel A	address A0000 to A0001
Channel B	address A0020 to A0021

Length is word

Scaling	Value
0%	0
50%	7D0
100%	FA0
102.375%	FFF

RATE COMPENSATION

Channel A	address A0002 to A0003
Channel B	address A0022 to A0023

Length is word

Setting	Value
100 Hz (off)	FFF
10 Hz	19A
1 Hz	29

PROPORTIONAL GAIN

Channel A	address A0004 to A0005
Channel B	address A0024 to A0025

Length is word

Prop gain	Value
x0 (off)	0
x1	20
x5	A0
x10	140
x20	280
x50	640
x128	FFF

INTEGRATOR TIME CONSTANT

Channel A	address A0006 to A0007
Channel B	address A0026 to A0027

Length is word

Time Constant	Value
.1 second	FFF
.5 second	333
1 second	19A
5 second	52

EXCITATION LEVEL

Channel A	address A0008 to A0009
Channel B	address A0028 to A0029

Length is word

Excitation	Value
0 volts	0
1 volt	111
2 volts	222
5 volts	555
8 volts	889
10 volts	AAB
15 volts	FFF

BRIDGE BALANCE

Channel A	address A000A to A000B
Channel B	address A002A to A002B

Length is word

Setting	Value	Setting	Value
0	800		
+.1 mv/v	866	-.1 mv/v	79A
+.5 mv/v	A00	-.5 mv/v	600
+1 mv/v	C00	-1 mv/v	400
+2 mv/v	FFF	-2 mv/v	0

FEEDBACK GAIN

Channel A	address A000C to A000D
Channel B	address A002C to A002D

Length is word

Full scale (gain)	Value
1 mV FS (x10,000)	66
2 mV FS (x5,000)	CD
5 mV FS (x2,000)	200
10 mV FS (x1,000)	400
20 mV FS (x500)	800
40 mV FS (x250)	FFF

UNEQUAL AREA

Channel A	address A000E to A000F
Channel B	address A002E to A002F

Length is word

Setting	Value
1.0	0
0.75	800
0.50	FFF

COMPUTER FUNCTION

Channel A	address A0010 to A0011
Channel B	address A0030 to A0031

Length is word

% FS Valve Current	Value	%FS Valve Current	Value
0	800		
+25	993	-25	66D
+50	B26	-50	4DA
+100	E4C	-100	1B4
+124	FFF	-124	0

COMPUTER COMMAND

Channel A	address A0014 to A0015
Channel B	address A0034 to A0035

Length is word

% FS Command	Value	% FS Command	Value
0	800	0	800
25	9F4	-25	60C
50	BE8	-50	418
80	E40	-80	1C0
100	FD0	-100	30
102.35	FFF	-102.4	0

DISCRETE OUTPUTS

Channel A	address D0010 to D0011
Channel B	address E0010 to E0011

Length is Byte

The value to be entered is the sum of the weighted values for the four discretes that control analog card functions. Add the weighted values of those functions to be turned ON. The entered value must be in hexadecimal.

Function	Weighted Value
Integrator ON	1
RCAL ON	2
Load simulator ON	4
Hydraulics are ON	8

For example to turn integrator ON, load simulator ON and Hydraulics are ON, weighted sum is decimal 13, which is hexadecimal D. Enter a value of D.

Common settings are:

Simulator ON, hydraulics OFF, RCAL OFF, integrator OFF --> 4

Simulator ON, hydraulics OFF, RCAL OFF, integrator ON --> 5

Simulator OFF, hydraulics ON, RCAL OFF, integrator OFF --> 8

SUMMARY SHEET

ADC values --> Examine 40000 to 4001E

Output --> address, Command, Fdbk, Error, Valve I, Ext.Input, +Exc, - Exc,

VLV drive

Input scaling - chan A A0000,1 chan B A0020,1 , length is word

0% --> 0, 50% --> 7D0 , 100% --> FA0 , 102.375% --> FFF

Rate Comp - chan A A0002,3 chan B A0022,3, length is word

100 Hz --> FFF , 10 Hz --> 19A , 1 Hz --> 29

Prop Gain - chan A A0004,5 chan B A0024,5 , length is word

xo --> 0 , x1--> 20 , x5 --> A0 , x10 --> 140 , x50 --> 640 , x128 --> FFF

Integrator Time Const - chan A A0006,7 chan B A0026,7 , word

.1sec --> FFF , .5sec --> 333 , 1sec --> 19A , 5sec --> 52

Excitation Level - chan A A0008,9 chan B A0028,9 , word

0V -- 0 , 1V --> 111 , 2V --> 222 , 5V --> 555 , 8V --> 889 , 15V --> FFF

Bridge Balance - chan A A000A,B chan B A002A,B , word

0 --> 800 , +.5 mv/v --> A00 , -.5 mv/v --> 600 , +1 mv/v --> C00 ,

-1 mv/v --> 400 , +2 mv/v --> FFF , -2 mv/v --> 0

Feedback Gain - chan A A000C,D chan B A002C,D , word

40 mv FS --> FFF , 20 mv FS --> 800 , 10 mv FS --> 400 , 5 mv FS --> 200

Unequal Area - chan A A000E,F chan B A002E,F , word

1.0 --> 0 , 0.75 --> 800 , 0.50 --> FFF

Computer Function - chan A A0010,1 chan B A0030,1 , word

0% --> 800 , +25% --> 993 , +50% --> B26 , +100% --> E4C , +124% --> FFF

-25% --> 66D , -50% --> 4DA , -100% --> 1B4 , -124% --> 0

Computer Command - chan A A0014,5 chan B A0034,5 , word

0% --> 800 , 25% --> 9F4 , 50% --> BE8 , 80% --> E40 , 100% --> FD0

-25% --> 60C , -50% --> 418 , -80% --> 1C0 , -100% --> 30

Discrete Output - chan A D0010,1 chan B E0010,1 , BYTE

integ ON +1 , RCAL ON +2 , simulator ON +4 , hydraulics ON +8

APPENDIX C

Cyber Systems Model 7030 Servo Controller

Metrology Calibration Procedure

Periodic metrology calibration of the Model 7030 Servo Controller should be performed at intervals of 6 months.

The calibration test requires the use of the following test equipment.

1. Digital VoltMeter - 5-1/2 digit resolution, .01% accuracy, or better.

2. DC voltage source - settable to +/- 10.000 volts +/-.001 volts

3. Computer terminal - RS232 interface

4. IC clips for easy access to signals.

To provide power to the servo controller and access to the signals on the analog card, remove all four-servo controllers from a servo controller chassis that is at a convenient working height. On the controller under test, remove the left side panel.

Plug the servo controller into the right hand slot of the chassis to provide easiest access.

Connect a computer terminal with an RS232 interface to connector **J1** on the front of the middle card **(13829)** of the servo controller. The pin assignments are as follows:

J1-1	TXD
J1-2	RXD
J1-3	GND

Set the terminal for 9600 baud and 8N, which is eight data bits, no parity and one stop bit.

Turn on power to the servo controller and the terminal. Start the Butler diagnostic editor by typing **control B**. **Appendix A** to this procedure provides instruction on the Butler.

ADC Gain and Offset

Connect the precision DC source to the ADC input at IC **U23-12** and the return to **U23-14**. Set the DC source to -10.000 +/- .001 volts.

To observe the ADC measurement of this input, type as follows:

R40008 enter

40009 enter

The output will be the address followed by the ADC value in hexadecimal format. The value should be **F82F**, **F830** or **F831** (-2000 +/- 1 decimal). If it is not, adjust pot **R184** for **F830**. If the pot is adjusted, type the above sequence again to get a new reading. Approximately one turn of the pot equals one count. (**note** hit **esc** to quit loop read mode on display)

Set the DC source to +10.000 +/- .001 volts. Type:

R40008 enter

40009 enter

The output, following the address, should be **7CF**, **7DO** or **7D1** (+2000 +/- 1 decimal). If it is not, adjust pot **R183**.

(**note** hit **esc** to quit loop read mode on display)

Set the discrete outputs by typing as follows:

SD0010 enter

D0011 enter

B8 enter

SE0010 enter

E0011 enter

B8 enter

Command DAC Gain and Offset - Channel A

Connect the digital voltmeter to **RN1-6** with the low side connected to **RN1-7**. This is the command DAC output for channel A.

Set the command DAC to -10V output by typing the following from the menu.

SA0014 enter

A0015 enter

W30 enter

The DVM should read -10.000 +/- .005 volts. Adjust pot **R7** for -10.000 volts.

Set the command DAC to +10V output by typing the following from the menu.

SA0014 enter

A0015 enter

WFD0 enter

The DVM should read +10.000 +/- .005 volts. Adjust pot **R4** for +10.000 volts.

Set the command DAC to zero output by typing as follows:

SA0014 enter

A0015 enter

W800 enter

The DVM should read zero +/- .005 volts. If more than +/- .005 volts, a problem exists with DAC **U52**. If not readjust pot **R7** for 0 +/- .003 volts.

Command DAC Gain and Offset - Channel B

Connect the DVM to **RN3-6** with the low side connected to **RN3-7**. This is the command DAC output for channel B.

Set the command DAC to -10V output by typing as follows:

SA0034 enter

A0035 enter

W30 enter

The DVM should read -10.000 +/- .005 volts. Adjust pot **R97** for -10.000 volts.

Set the command DAC to +10V output by typing as follows:

SA0034 enter

A0035 enter

WFD0 enter

The DVM should read +10.000 +/- .005 volts. Adjust pot **R94** for +10.000 volts.

Set the command DAC to zero output by typing as follows:

SA0034 enter

A0035 enter

W800 enter

The DVM should read zero +/- .005 volts. If more than +/- .005 volts, a problem exists with DAC **U53**. If not, readjust pot **R97** for 0 +/- .003 volts.

Computer Function DAC offset - Channel A

Connect the DVM to **U22-24** and the low side to **U22-23**.

Set the computer function DAC to zero by typing the following:

SA0010 enter

A0011 enter

W800 enter

The DVM should read zero +/- .005 volts. Adjust pot **R28** for zero.

Computer Function DAC Offset - Channel B

Connect the DVM to **U25-24** and the low side to **U25-23**.

Set the computer function DAC to zero by typing the following:

SA0030 enter

A0031 enter

W800 enter

The DVM should read zero +/- .005 volts. Adjust pot **R118** for zero.

Rate Compensation Offset - Channel A

Connect the DVM to **U43-8** with the low side on **U43-10**.

Set the Rate Compensator to 1 Hz by typing the following:

SA0002 enter

A0003 enter

W29 enter

The DVM should read less than +/- .005 volts. Adjust pot **R202** for zero.

Rate Compensation Offset - Channel B

Connect the DVM to **U45-8** with the return on **U45-10**. Set the Rate Compensator to 1 Hz by typing the following:

SA0022 enter

A0023 enter

W29 enter

The DVM should read less than +/- .005 volts. Adjust pot **R214** for zero.

Analog Command Gain and Proportional Gain Offset - Channel A.
Remove any connectors on the command input on the servo controller chassis backplane.

Connect the DC voltage source to **RN1-2** with the return on **RN1-3**. Connect another wire from the return on the DC source to the top pin of the lower card edge connector (**P12-C32**), which is ground. Connect a jumper from **U12-4** to **U12-2**. The DC source is providing an external command input.

Connect the DVM to **RN1-5** and the return to **RN1-7**.

Set the DC source to +10 +/- .001 volts.

Set the Input Scaling to 100% by typing the following:

SA0000 enter

A0001 enter

WFA0 enter

The DVM should read +10 +/- .005 volts. Adjust pot **R9** for +10.000 volts.

Move the DVM to read the Channel A **ERROR** test point on the front panel with the return still on **RN1-7**. Set the DC source to zero.

Set the Input Scaling to 1% by typing the following:

SA0000 enter

A0001 enter

W28 enter

Adjust the DC source so the error is zero +/- .0001 volts.

Set the Proportional Gain Amplifier gain to 10 by typing the following:

SA0004 enter

A0005 enter

W140 enter

Place the DVM high lead on **U43-14**.

The DVM should read zero +/- .050 volts. Adjust pot **R204** for zero.

Analog Command Gain and Proportional Offset - Channel B.

Connect the DC voltage source to **RN3-2** with the return on **RN3-3**. Connect another wire from the return on the DC source to the top pin of the lower card edge connector (**P12-C32**), which is ground. Connect a jumper from **U15-4** to **U15-2**. The DC source is providing an external command input.

Connect the DVM to **RN3-5** and the return to **RN3-7**.

Set the DC source to +10 +/- .001 volts.

Set the Input Scaling to 100% by typing the following:

SA0020 enter

A0021 enter

WFA0 enter

The DVM should read +10 +/- .005 volts. Adjust pot **R99** for +10.000 volts.

Move the DVM to read the Channel B **ERROR** test point on the front panel with the return still on **RN3-7**. Set the DC source to zero.

Set the Input Scaling to 1% by typing as follows:

SA0020 enter

A0021 enter

W28 enter

Adjust the DC source so the error is zero +/- .0001 volts.

Set the Proportional Gain Amplifier gain to 10 by typing as follows:

SA0024 enter

A0025 enter

W140 enter

Place the DVM high lead on **U45-14**.

The DVM should read zero +/- .050 volts. Adjust pot **R216** for zero.

APPENDIX D

External Hydraulic Load Simulator

A hydraulic load simulator is built into the servo controller, which allows the controller to operate as though it is controlling a real actuator. This simulator allows the testing of functions before actually turning on the hydraulic pressure. The internal simulator does not have a bridge to simulate a load cell, thus preventing the exercising of the **Balance** and **RCAL** functions.

The schematic in this appendix is of a simulator with a bridge so it can do balance and **RCAL** functions. It uses the excitation voltage to power an amplifier, which can be disabled providing a hydraulics off situation. If it is enabled, the loop responds as though hydraulic power is on.

The excitation voltage should be set to 10 volts.

Poles are included to simulate the valve response, which allow the loop to be made to oscillate by raising the loop gain. This allows system responses to be tested without using live hydraulic pressure.

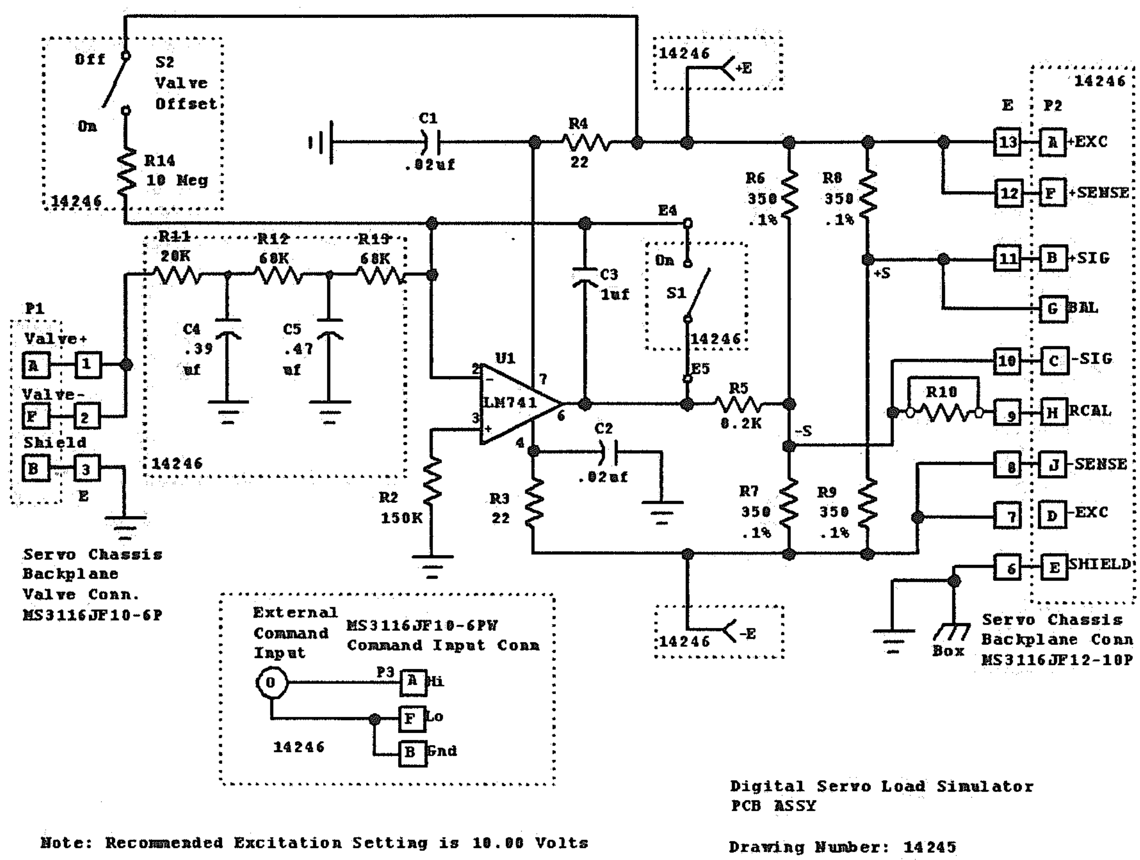

Figure 13 – Circuit Diagram for External Hydraulic Simulator Box

APPENDIX E

SERVO FRONT PANEL PARAMETER GUIDE

This appendix provides a quick reference guide for setting and displaying the various servo parameters from the servo front panel. The range of the value for each parameter is also shown.

GROUP	NAME	FUNCTION	RANGE
START			
	SETD	Set Default Values	YES/NO
	TEST	Test Number Assignment	(SYSTEM ONLY)
	DPA	Decimal Point Adjust	------------------------
	ENDN	Endpoint Count	(SYSTEM ONLY)
	MODE	Servo Mode	ANALOG/DIGITAL

GROUP	NAME	FUNCTION	RANGE
SETUPCAL			
	FULL	Full Scale Value	Up to 999999
	100%	100% Load	Up to 999999
	CLEQ	Calibration Equivalent Value	Up to +/- 999999
	EXFS	External Input EU Full Scale	0 to 999999
	EXCV	Excitation Voltage	0 to 15 Volts
	FSMV	Feedback Full Scale in MV	1.0 to 40.0
	BBAL	Manual Bridge Balance	+/- 100%
	FBAL	Automatic Bridge Balance	YES/NO
	RCAL	Automatic fdbk gain by Rcal	YES/NO
	EBAL	Zeros loop error	YES/NO
	TBAL	Tare balance of bridge	YES/NO
	VBAL	Automatic hydraulic valve balance	YES/NO
	SCAL	Analog command input scaling	0 to 100%
	VLVO	Manual valve driver offset	+/- 100%
	EXCK	External input limit check	YES/NO

GROUP	NAME	FUNCTION	RANGE
CONTROL			
	GAIN	Loop proportional gain	0.1 to 127.9
	OFST	Command Offset	+/- Full Scale
	RATE	Rate compensation	0.5 to 100.0
	INTE	Integrator enable	YES/NO
	INTC	Integrator time constant	0.1 to 10
	ISCL	Scaling of internal command	0 to 100%
	LAGR	Lag ratio	0 to 31.9
	LAGF	Lag frequency	0.01 to 1.0 Hz
	TARE	Tare offset load	+/- Full Scale

GROUP	NAME	FUNCTION	RANGE
LIMITS			
	FCLR	Clear fault detector	
	FSET	Set fault detector	
	INLE	Inner loop error limit	0.0 to 102.4 X FS
	OTLE	Outer loop error limit	0.0 to 102.4 X FS
	IFBH	Plus inner feedback limit	+/- 102.4% FS
	IFBL	Minus inner feedback limit	+/- 102.4% FS
	OFBH	Plus outer feedback limit	+/- 102.4% FS
	OFBL	Minus outer feedback limit	+/- 102.4% FS
	EXTH	Plus external input limit	+/- 100% EXTFS
	EXTL	Minus external input limit	+/- 100% EXTFS
	FLDB	Fault limit debounce time	0.01 to 99.99 secs

GROUP	NAME	FUNCTION	RANGE
TUNING			
	SIMU	Enable simulator	OFF/ON
	AREA	Actuator area ratio comp	0.5 to 1.0
	NOIS	Autotuning noise band	0 to 100
	OSPK	Number oscillation peaks	1 to 10
	ATTI	Autotuning by time	YES/NO
	ATEP	Autotuning by endpoint	(System Only)
	MINGC	Minimum gain cap	0.1 to 127.9
	MXGC	Maximum gain cap	0.1 to 127.9
	GNRT	Loop gain recovery time	0.1 to 127.9 secs

GROUP	NAME	FUNCTION	RANGE
MONITOR			
	CMMD	Display command	
	FDBK	Display feedback	
	EROR	Display loop error	
	VALV	Display valve drive	
	METR	Select meter function	Shown
	EXTN	Display external input	
	CYCT	Current cycle count	Up to 99999999
	COMM	Communication errors	(System Only)

GROUP	NAME	FUNCTION	RANGE
FUNCTION			
	CYCL	Turn cycling ON/OFF	ON/OFF
	RAMP	Stop cycling and ramp to zero	ON/OFF
	NUMC	Number of cycles to perform	0 to 10000000
	MAXL	Peak value	+/- Full Scale
	MINL	Valley value	+/- Full Scale
	FREQ	Cycling frequency	0.1 to 100 Hz
	SHAP	Transition waveform	Shown
	FADJ	Adjustment of cycling frequency	+/- 10%

GROUP	NAME	FUNCTION	RANGE
STATIC			
	LOAD	Next destination load	+/- Full Scale
	TIME	Transition time	0.1 to 999 secs
	SHAP	Transition shape	Shown
	GO	Initiate transition	Stopped/Running
	FDBK	Display the feedback value	+/- Full Scale
	ZERO	Ramp to Zero	Stopped/Running

APPENDIX B

ANALOG SERVO CARD OPERATION FROM BUTLER

Tests can be performed on the analog circuit card, which include setting the DACs and monitoring the readings of the ADC

To operate the analog servo card from a terminal, connect a terminal to **J1** on the Digital Servo Controller, 13829. The pin assignments are:

Pin	**Function**
1 (top)	Transmit
2	Receive
3	Ground

The terminal interface is 8N (8 data bits, no parity, one stop bit). The baud rate setting is 9600.

To start the Butler diagnostic editor, type control **B**. All address and data values are in hexadecimal format.

The Butler Menu is as follows:

D	=	Set NOVRAM for default values
M	=	Modify memory w/verification
P	=	Display process states (not applicable)
R	=	Loop on read
S	=	Set memory
W	=	Loop on write (not available)
X	=	Examine memory
(ESC)	=	To exit butler

OPERATION

To display the ADC readings, use the Butler commands as follows:

Examine from 40000 to 4001E

The output values are in two's complement hexadecimal format.

The eight functions across one line of the screen (after address) are Command, Feedback, Error, Valve Current, External Input, +Excitation P/S, -Excitation P/S and VLV drive.

SETTING DACs

To control a DAC, set memory from the first address given to the second, word length, and the hexadecimal value.

For example, to set input scaling of the B channel to 100% set memory from A0020 to A0021, W, FA0.

INPUT SCALING

Channel A	address A0000 to A0001
Channel B	address A0020 to A0021

Length is word

Scaling	Value
0%	0
50%	7D0
100%	FA0
102.375%	FFF

RATE COMPENSATION

Channel A	address A0002 to A0003
Channel B	address A0022 to A0023

Length is word

Setting	Value
100 Hz (off)	FFF
10 Hz	19A
1 Hz	29

PROPORTIONAL GAIN

Channel A	address A0004 to A0005
Channel B	address A0024 to A0025

Length is word

Prop gain	Value
x0 (off)	0
x1	20
x5	A0
x10	140
x20	280
x50	640
x128	FFF

INTEGRATOR TIME CONSTANT

Channel A	address A0006 to A0007
Channel B	address A0026 to A0027

Length is word

Time Constant	Value
.1 second	FFF
.5 second	333
1 second	19A
5 second	52

EXCITATION LEVEL

Channel A	address A0008 to A0009
Channel B	address A0028 to A0029

Length is word

Excitation	Value
0 volts	0
1 volt	111
2 volts	222
5 volts	555
8 volts	889
10 volts	AAB
15 volts	FFF

BRIDGE BALANCE

Channel A	address A000A to A000B
Channel B	address A002A to A002B

Length is word

Setting	Value	Setting	Value
0	800		
+.1 mv/v	866	-.1 mv/v	79A
+.5 mv/v	A00	-.5 mv/v	600
+1 mv/v	C00	-1 mv/v	400
+2 mv/v	FFF	-2 mv/v	0

FEEDBACK GAIN

Channel A	address A000C to A000D
Channel B	address A002C to A002D

Length is word

Full scale (gain)	Value
1 mV FS (x10,000)	66
2 mV FS (x5,000)	CD
5 mV FS (x2,000)	200
10 mV FS (x1,000)	400
20 mV FS (x500)	800
40 mV FS (x250)	FFF

UNEQUAL AREA

Channel A	address A000E to A000F
Channel B	address A002E to A002F

Length is word

Setting	Value
1.0	0
0.75	800
0.50	FFF

COMPUTER FUNCTION

Channel A	address A0010 to A0011
Channel B	address A0030 to A0031

Length is word

% FS Valve Current	Value	%FS Valve Current	Value
0	800		
+25	993	-25	66D
+50	B26	-50	4DA
+100	E4C	-100	1B4
+124	FFF	-124	0

COMPUTER COMMAND

Channel A address A0014 to A0015

Channel B address A0034 to A0035

Length is word

% FS Command	Value	% FS Command	Value
0	800	0	800
25	9F4	-25	60C
50	BE8	-50	418
80	E40	-80	1C0
100	FD0	-100	30
102.35	FFF	-102.4	0

DISCRETE OUTPUTS

Channel A	address D0010 to D0011
Channel B	address E0010 to E0011

Length is Byte

The value to be entered is the sum of the weighted values for the four discretes that control analog card functions. Add the weighted values of those functions to be turned ON. The entered value must be in hexadecimal.

Function	Weighted Value
Integrator ON	1
RCAL ON	2
Load simulator ON	4
Hydraulics are ON	8

For example to turn integrator ON, load simulator ON and Hydraulics are ON, weighted sum is decimal 13, which is hexadecimal D. Enter a value of D.

Common settings are:

Simulator ON, hydraulics OFF, RCAL OFF, integrator OFF --> 4

Simulator ON, hydraulics OFF, RCAL OFF, integrator ON --> 5

Simulator OFF, hydraulics ON, RCAL OFF, integrator OFF --> 8

SUMMARY SHEET

ADC values --> Examine 40000 to 4001E

Output --> address, Command, Fdbk, Error, Valve I, Ext.Input, +Exc, - Exc,

VLV drive

Input scaling - chan A A0000,1 chan B A0020,1 , length is word

0% --> 0, 50% --> 7D0 , 100% --> FA0 , 102.375% --> FFF

Rate Comp - chan A A0002,3 chan B A0022,3, length is word

100 Hz --> FFF , 10 Hz --> 19A , 1 Hz --> 29

Prop Gain - chan A A0004,5 chan B A0024,5 , length is word

xo --> 0 , x1--> 20 , x5 --> A0 , x10 --> 140 , x50 --> 640 , x128 --> FFF

Integrator Time Const - chan A A0006,7 chan B A0026,7 , word

.1sec --> FFF , .5sec --> 333 , 1sec --> 19A , 5sec --> 52

Excitation Level - chan A A0008,9 chan B A0028,9 , word

0V -- 0 , 1V --> 111 , 2V --> 222 , 5V --> 555 , 8V --> 889 , 15V --> FFF

Bridge Balance - chan A A000A,B chan B A002A,B , word

0 --> 800 , +.5 mv/v --> A00 , -.5 mv/v --> 600 , +1 mv/v --> C00 ,

-1 mv/v --> 400 , +2 mv/v --> FFF , -2 mv/v --> 0

Feedback Gain - chan A A000C,D chan B A002C,D , word

40 mv FS --> FFF , 20 mv FS --> 800 , 10 mv FS --> 400 , 5 mv FS --> 200

Unequal Area - chan A A000E,F chan B A002E,F , word

1.0 --> 0 , 0.75 --> 800 , 0.50 --> FFF

Computer Function - chan A A0010,1 chan B A0030,1 , word

0% --> 800 , +25% --> 993 , +50% --> B26 , +100% --> E4C , +124% --> FFF

-25% --> 66D , -50% --> 4DA , -100% --> 1B4 , -124% --> 0

Computer Command - chan A A0014,5 chan B A0034,5 , word

0% --> 800 , 25% --> 9F4 , 50% --> BE8 , 80% --> E40 , 100% --> FD0

-25% --> 60C , -50% --> 418 , -80% --> 1C0 , -100% --> 30

Discrete Output - chan A D0010,1 chan B E0010,1 , BYTE

integ ON +1 , RCAL ON +2 , simulator ON +4 , hydraulics ON +8

APPENDIX C

Cyber Systems Model 7030 Servo Controller

Metrology Calibration Procedure

Periodic metrology calibration of the Model 7030 Servo Controller should be performed at intervals of 6 months.

The calibration test requires the use of the following test equipment.

1. Digital VoltMeter - 5-1/2 digit resolution, .01% accuracy, or better.
2. DC voltage source - settable to ñ10.000 volts ñ.001 volts
3. Computer terminal - RS232 interface
4. IC clips for easy access to signals.

To provide power to the servo controller and access to the signals on the analog card, remove all four-servo controllers from a servo controller chassis that is at a convenient working height. On the controller under test, remove the left side panel.

Plug the servo controller into the right hand slot of the chassis to provide easiest access.

Connect a computer terminal with an RS232 interface to connector J1 on the front of the middle card (13829) of the servo controller. The pin assignments are as follows:

J1-1	TXD
J1-2	RXD
J1-3	GND

Set the terminal for 9600 baud and 8N, which is eight data bits, no parity and one stop bit.

Turn on power to the servo controller and the terminal. Start the Butler diagnostic editor by typing control B. Appendix A to this procedure provides instruction on the Butler.

ADC Gain and Offset

Connect the precision DC source to the ADC input at IC U23-12 and the return to U23-14. Set the DC source to -10.000 +/- .001 volts.

To observe the ADC measurement of this input, type as follows:

X40008 enter

40009 enter

The output will be the address followed by the ADC value in hexadecimal format. The value should be F82F, F830 or F831 (-2000 +/- 1 decimal). If it is not, adjust pot R184 for F830. If the pot is adjusted, type the above sequence again to get a new reading. Approximately one turn of the pot equals one count.

Set the DC source to +10.000 +/- .001 volts. Type:

X40008 enter

40009 enter

The output, following the address, should be 7CF, 7DO or 7D1 (+2000 +/- 1 decimal). If it is not, adjust pot R183.

Set the discrete outputs by typing as follows:

SD0010 enter

D0011 enter

B8 enter

SE0010 enter

E0011 enter

B8 enter

Command DAC Gain and Offset - Channel A

Connect the digital voltmeter to RN1-6 with the low side connected to RN1-7. This is the command DAC output for channel A.

Set the command DAC to -10V output by typing the following from the menu.

SA0014 enter

A0015 enter

W30 enter

The DVM should read -10.000 +/- .005 volts. Adjust pot R7 for -10.000 volts.

Set the command DAC to +10V output by typing the following from the menu.

SA0014 enter

A0015 enter

WFD0 enter

The DVM should read +10.000 +/- .005 volts. Adjust pot R4 for +10.000 volts.

Set the command DAC to zero output by typing as follows:

SA0014 enter

A0015 enter

W800 enter

The DVM should read zero +/- .005 volts. If more than +/- .005 volts, a problem exists with DAC U52. If not readjust pot R7 for 0 +/- .003 volts.

Command DAC Gain and Offset - Channel B

Connect the DVM to RN3-6 with the low side connected to RN3-7. This is the command DAC output for channel B.

Set the command DAC to -10V output by typing as follows:

SA0034 enter

A0035 enter

W30 enter

The DVM should read -10.000 +/- .005 volts. Adjust pot R97 for -10.000 volts.

Set the command DAC to +10V output by typing as follows:

SA0034 enter

A0035 enter

WFD0 enter

The DVM should read +10.000 +/- .005 volts. Adjust pot R94 for +10.000 volts.

Set the command DAC to zero output by typing as follows:

SA0034 enter

A0035 enter

W800 enter

The DVM should read zero +/- .005 volts. If more than +/- .005 volts, a problem exists with DAC U53. If not, readjust pot R97 for 0 +/- .003 volts.

Computer Function DAC offset - Channel A

Connect the DVM to U22-24 and the low side to U22-23.

Set the computer function DAC to zero by typing the following:

SA0010 enter

A0011 enter

W800 enter

The DVM should read zero +/- .005 volts. Adjust pot R28 for zero.

Computer Function DAC Offset - Channel B

Connect the DVM to U25-24 and the low side to U25-23.

Set the computer function DAC to zero by typing the following:

SA0030 enter

A0031 enter

W800 enter

The DVM should read zero +/- .005 volts. Adjust pot R118 for zero.

Rate Compensation Offset - Channel A

Connect the DVM to U43-8 with the low side on U43-10.

Set the Rate Compensator to 1 Hz by typing the following:

SA0002 enter

A0003 enter

W29 enter

The DVM should read less than +/- .005 volts. Adjust pot R202 for zero.

Rate Compensation Offset - Channel B

Connect the DVM to U45-8 with the return on U45-10. Set the rate compensator to 1 Hz by typing the following:

SA0022 enter

A0023 enter

W29 enter

The DVM should read less than +/- .005 volts. Adjust pot R214 for zero.

Analog Command Gain and Proportional Gain Offset - Channel A.

Remove any connectors on the command input on the servo controller chassis backplane.

Connect the DC voltage source to RN1-2 with the return on RN1-3. Connect another wire from the return on the DC source to the top pin of the lower card edge connector (P12-C32), which is ground. Connect a jumper from U12-4 to U12-2. The DC source is providing an external command input.

Connect the DVM to RN1-5 and the return to RN1-7.

Set the DC source to +10 +/- .001 volts.

Set the Input Scaling to 100% by typing the following:

SA0000 enter

A0001 enter

WFA0 enter

The DVM should read +10 +/- .005 volts. Adjust pot R9 for +10.000 volts.

Move the DVM to read the Channel A ERROR test point on the front panel with the return still on RN1-7. Set the DC source to zero.

Set the Input Scaling to 1% by typing the following:

SA0000 enter

A0001 enter

W28 enter

Adjust the DC source so the error is zero +/- .0001 volts.

Set the Proportional Gain Amplifier gain to 10 by typing the following:

SA0004 enter

A0005 enter

W140 enter

Place the DVM high lead on U43-14.

The DVM should read zero +/- .050 volts. Adjust pot R204 for zero.

Analog Command Gain and Proportional Offset - Channel B.

Connect the DC voltage source to RN3-2 with the return on RN3-3. Connect another wire from the return on the DC source to the top pin of the lower card edge connector (P12-C32), which is ground. Connect a jumper from U15-4 to U15-2. The DC source is providing an external command input.

Connect the DVM to RN3-5 and the return to RN3-7.

Set the DC source to +10 +/- .001 volts.

Set the Input Scaling to 100% by typing the following:

SA0020 enter

A0021 enter

WFA0 enter

The DVM should read +10 +/- .005 volts. Adjust pot R99 for +10.000 volts.

Move the DVM to read the Channel B ERROR test point on the front panel with the return still on RN3-7. Set the DC source to zero.

Set the Input Scaling to 1% by typing as follows:

SA0020 enter

A0021 enter

W28 enter

Adjust the DC source so the error is zero +/- .0001 volts.

Set the Proportional Gain Amplifier gain to 10 by typing as follows:

SA0024 enter

A0025 enter

W140 enter

Place the DVM high lead on U45-14.

The DVM should read zero +/- .050 volts. Adjust pot R216 for zero.

APPENDIX D

External Hydraulic Load Simulator

A hydraulic load simulator is built into the servo controller, which allows the controller to operate as though it is controlling a real actuator. This simulator allows the testing of functions before actually turning on the hydraulic pressure. The internal simulator does not have a bridge to simulate a load cell, thus preventing the exercising of the **Balance** and **RCAL** functions.

The schematic in this appendix is of a simulator with a bridge so it can do balance and **RCAL** functions. It uses the excitation voltage to power an amplifier, which can be disabled providing a hydraulics off situation. If it is enabled, the loop responds as though hydraulic power is on.

The excitation voltage should be set to 10 volts.

Poles are included to simulate the valve response, which allow the loop to be made to oscillate by raising the loop gain. This allows system responses to be tested without using live hydraulic pressure.

APPENDIX E

SERVO FRONT PANEL PARAMETER GUIDE

This appendix provides a quick reference guide for setting and displaying the various servo parameters from the servo front panel. The range of the value for each parameter is also shown.

GROUP	NAME	FUNCTION	RANGE
START			
	SETD	Set Default Values	YES/NO
	TEST	Test Number Assignment	(SYSTEM ONLY)
	DPA	Decimal Point Adjust	------------------------
	ENDN	Endpoint Count	(SYSTEM ONLY)
	MODE	Servo Mode	ANALOG/DIGITAL

GROUP	NAME	FUNCTION	RANGE
SETUPCAL			
	FULL	Full Scale Value	Up to 999999
	100%	100% Load	Up to 999999
	CLEQ	Calibration Equivalent Value	Up to +/- 999999
	EXFS	External Input EU Full Scale	0 to 999999
	EXCV	Excitation Voltage	0 to 15 Volts
	FSMV	Feedback Full Scale in MV	1.0 to 40.0
	BBAL	Manual Bridge Balance	+/- 100%
	FBAL	Automatic Bridge Balance	YES/NO
	RCAL	Automatic fdbk gain by Rcal	YES/NO
	EBAL	Zeros loop error	YES/NO
	TBAL	Tare balance of bridge	YES/NO
	VBAL	Automatic hydraulic valve balance	YES/NO
	SCAL	Analog command input scaling	0 to 100%
	VLVO	Manual valve driver offset	+/- 100%
	EXCK	External input limit check	YES/NO

GROUP	NAME	FUNCTION	RANGE
CONTROL			
	GAIN	Loop proportional gain	0.1 to 127.9
	OFST	Command Offset	+/- Full Scale
	RATE	Rate compensation	0.5 to 100.0
	INTE	Integrator enable	YES/NO
	INTC	Integrator time constant	0.1 to 10
	ISCL	Scaling of internal command	0 to 100%
	LAGR	Lag ratio	0 to 31.9
	LAGF	Lag frequency	0.01 to 1.0 Hz
	TARE	Tare offset load	+/- Full Scale

GROUP	NAME	FUNCTION	RANGE
LIMITS			
	FCLR	Clear fault detector	
	FSET	Set fault detector	
	INLE	Inner loop error limit	0.0 to 102.4 X FS
	OTLE	Outer loop error limit	0.0 to 102.4 X FS
	IFBH	Plus inner feedback limit	+/- 102.4% FS
	IFBL	Minus inner feedback limit	+/- 102.4% FS
	OFBH	Plus outer feedback limit	+/- 102.4% FS
	OFBL	Minus outer feedback limit	+/- 102.4% FS
	EXTH	Plus external input limit	+/- 100% EXTFS
	EXTL	Minus external input limit	+/- 100% EXTFS
	FLDB	Fault limit debounce time	0.01 to 99.99 secs

GROUP	NAME	FUNCTION	RANGE
TUNING			
	SIMU	Enable simulator	OFF/ON
	AREA	Actuator area ratio comp	0.5 to 1.0
	NOIS	Autotuning noise band	0 to 100
	OSPK	Number oscillation peaks	1 to 10
	ATTI	Autotuning by time	YES/NO
	ATEP	Autotuning by endpoint	(System Only)
	MINGC	Minimum gain cap	0.1 to 127.9
	MXGC	Maximum gain cap	0.1 to 127.9
	GNRT	Loop gain recovery time	0.1 to 127.9 secs

GROUP	NAME	FUNCTION	RANGE
MONITOR			
	CMMD	Display command	
	FDBK	Display feedback	
	EROR	Display loop error	
	VALV	Display valve drive	
	METR	Select meter function	Shown
	EXTN	Display external input	
	CYCT	Current cycle count	Up to 99999999
	COMM	Communication errors	(System Only)

GROUP	NAME	FUNCTION	RANGE
FUNCTION			
	CYCL	Turn cycling ON/OFF	ON/OFF
	RAMP	Stop cycling and ramp to zero	ON/OFF
	NUMC	Number of cycles to perform	0 to 10000000
	MAXL	Peak value	+/- Full Scale
	MINL	Valley value	+/- Full Scale
	FREQ	Cycling frequency	0.1 to 100 Hz
	SHAP	Transition waveform	Shown
	FADJ	Adjustment of cycling frequency	+/- 10%

GROUP	NAME	FUNCTION	RANGE
STATIC			
	LOAD	Next destination load	+/- Full Scale
	TIME	Transition time	0.1 to 999 secs
	SHAP	Transition shape	Shown
	GO	Initiate transition	Stopped/Running
	FDBK	Display the feedback value	+/- Full Scale
	ZERO	Ramp to Zero	Stopped/Running

WARRANTY

KineticSystems Company, LLC warrants its standard hardware products to be free of defects in workmanship and materials for a period of one year from the date of shipment to the original end user. Software products manufactured by KineticSystems are warranted to conform to the Software Product Description (SPD) applicable at the time of purchase for a period of ninety days from the date of shipment to the original end user. Products purchased for resale by KineticSystems carry the original equipment manufacturer's warranty.

KineticSystems will, at its option, either repair or replace products that prove to be defective in materials or workmanship during the warranty period.

Transportation charges for shipping products to KineticSystems shall be prepaid by the purchaser, while charges for returning the repaired warranty product to the purchaser, if located in the United States, shall be paid by KineticSystems. Return shipment will be made by UPS, where available, unless the purchaser requests a premium method of shipment at their expense. The selected carrier shall not be construed to be the agent of KineticSystems, nor will KineticSystems assume any liability in connection with the services provided by the carrier.

The product warranty may vary outside the United States and does not include shipping, customs clearance, or any other charges. Consult your local authorized representative or reseller for more information regarding specific warranty coverage and shipping details.

PRODUCT SPECIFICATIONS AND DESCRIPTIONS IN THIS DOCUMENT SUBJECT TO CHANGE WITHOUT NOTICE.

KINETICSYSTEMS SPECIFICALLY MAKES NO WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR ANY OTHER WARRANTY EITHER EXPRESSED OR IMPLIED, EXCEPT AS IS EXPRESSLY SET FORTH HEREIN. PRODUCT FAILURES CREATED BY UNAUTHORIZED MODIFICATIONS, PRODUCT MISUSE, OR IMPROPER INSTALLATION ARE NOT COVERED BY THIS WARRANTY.

THE WARRANTIES PROVIIDED HEREIN ARE THE PURCHASER'S SOLE AND EXCLUSIVE REMEDIES ON ANY CLAIM OF ANY KIND FOR ANY LOSS OR DAMAGE ARISING OUT OF, CONNECTED WITH, OR RESULTING FROM THE USE, PERFORMANCE OR BREACH THEREOF, OR FROM THE DESIGN, MANUFACTURE, SALE, DELIVERY, RESALE, OR REPAIR OR USE OF ANY PRODUCTS COVERED OR FURNISHED BY KINETICSYSTEMS INCLUDING BUT NOT LIMITED TO ANY CLAIM OF NEGLIGENCE OR OTHER TORTIOUS BREACH, SHALL BE THE REPAIR OR REPLACEMENT, FOB FACTORY, AS KINETICSYSTEMS MAY ELECT, OF THE PRODUCT OR PART THEREOF GIVING RISE TO SUCH CLAIM, EXCEPT THAT KINETICSYSTEMS' LIABILITY FOR SUCH REPAIR OR REPLACEMENT SHALL IN NO EVENT EXCEED THE CONTRACT PRICE ALLOCABLE TO THE PRODUCTS OR PART THEROF WHICH GIVES RISE TO THE CLAIM. IN NO EVENT SHALL KINETICSYSTEMS BE LIABLE FOR DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, INCLUDING LOSS OF PROFITS.

Products will not be accepted for credit or exchange without the prior written approval of KineticSystems. If it is necessary to return a product for repair, replacement or exchange, a Return Authorization (RA) Number must first be obtained from the Repair Service Center prior to shipping the product to KineticSystems. The following steps should be taken before returning any product:

1. Contact KineticSystems and discuss the problem with a Technical Service Engineer.
2. Obtain a Return Authorization (RA) Number.
3. Initiate a purchase order for the estimated repair charge if the product is out of warranty.
4. Include a description of the problem and your technical contact person with the product.
5. Ship the product prepaid with the RA Number marked on the outside of the package to:

KineticSystems Company, LLC
Repair Service Center
900 North State Street
Lockport, IL 60441

Telephone: (815) 838-0005
Facsimile: (815) 838-4424
Email: tech-serv@kscorp.com