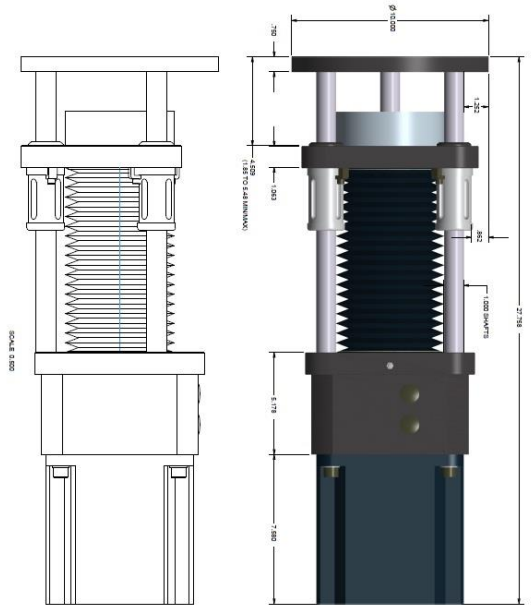
INTERACTIVE INSTRUMENTS



Model 5K/10K/15K Servo Load Frame and Creep Controller

Instruction Manual

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Introduction

The 5K-10K-15K Servo Creep Controller is capable of continuous or cyclic loads up to 5,000, 10,000 and 15,000 lbs depending on the servo load frame. The unit is capable of maintaining constant load conditions for days, months and even years with minimal maintenance requirements. The Servo system is also capable of sustained cyclic motion as well. Cyclic motion is programmable from as low as 10^{-300} Hz up to 10 Hz and beyond (under limited test conditions). The higher the test frequency runs the shorter the actuator stroke due to the servos limited actuator rate. Optimal cyclic control rate is typically less than 5 Hz.

Safety Information

The Servo is capable automatically moving the actuator with very high forces, very quickly. It is important to observe and follow all safety information in this manual. While working on the servo load frame is important to disable the servo controller by powering down the system and prevent other operators from intentionally or unintentionally powering up the system while someone is working on or around the load frame.
Remember, even of the load is programmed to control a low force, the actuator is still capable of forces in excess of 10,000 lbs. so safety must be exercised at all times especially while working on or around the load frame.

Important Servo Maintenance Requirement

Note: A limitation of the Servo system is that when operating cyclic loads over 300,000 cycles the bearings need to be maintained on a regular bases. When the actuator approaches 300,000 cycles it is very important to remove the system load and cycle the actuator over the entire stroke range for several cycles to redistribute the grease. It is also important to lubricate the system with the recommended grease as well. The main bearing (and Model 15K roller screw) is not covered under the limited warranty agreement and would require the load frame be sent to Interactive Instruments for repair.

Model 5K/10K Lubrication

Bearing Grease

The main thrust bearing must be lubricated periodically or the bearing will fail. Attach a standard grease gun loaded with the recommended grease (see below) to the fitting on the motor thrust plate above the motor. It is recommended to lubricate the bearing every half million to a million cycles by squeezing the grease gun handle 10 times. Once the grease is injected it should be redistributed by moving the actuator over the full range of stroke.

NEW Grease (after 12/1/18):
Systems purchased after 12/1/18 (Model 5K serial 260, Model 10K serial 130) will be lubricated with a Molybdenum (moly) grease (Lucas X-TRA Heavy Duty NLGI #2) which has a much longer shelf life than the original lithium grease used previously. Lucas grease can be purchased from many locations (www.lucasoil.com). It is not recommended to substitute different grease unless the original grease is removed.

Original Grease (before 12/1/18):
The original grease was a special lithium grease called "Lithium Complex EP Grease" and it can be purchased from Dieco (www.dieco.us).

Ball screw Grease

The actuator ball screw can be inspected by pulling down the bellows near the load cell to expose the screw assembly. Add the same grease to the ball screw to keep it lubricated and re-attach the bellows to keep dirt and debris from contaminating the screw assembly.

Model 15K Lubrication

Bearing Oil

The main thrust bearing must be properly lubricated or the bearing will fail. To refill the oil reservoir, remove the black oil cap from the side of the load frame and carefully pour oil into the opening allowing time for the oil to enter the main housing. The housing requires between a half and 1 quart to fill completely.

The recommended oil is a special synthetic oil called "Mobile SHC 634".

Roller Screw Grease

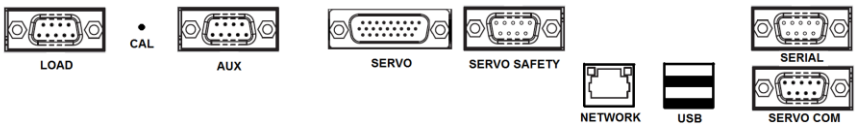
The roller screw has a zerk grease fitting on it that should be greased periodically to extend the life of the roller screw. Access to the roller screw by extending the actuator to its farthest position. Lift the bellows from the frame by lightly tapping one of the two black bellows mounting rings with a soft mallet to release the ring from the rubber seal. Once loose, the bellow can be lifted to expose the roller screw threads. If the grease appears to be dark or not properly coating the threads, it may be a good time to reapply grease. Remove any old grease if it has dried out and lost most of the oil and apply 8 to 10 pumps from a grease gun with "Molybdenum (moly) grease". Exercise the actuators position to re-distribute the grease and re-check the roller screw threads. If necessary remove the old grease again and re-apply until the grease is clean, soft and well distributed.

Servo Heat

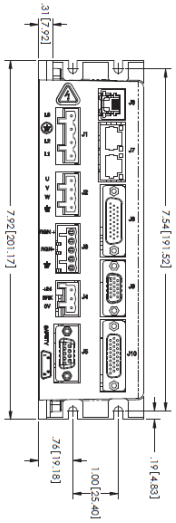
The servo motor can get very hot at times especially when operating near the load capabilities. If you plan on operating the load frame in high load conditions for more than a few hours, it would help to direct a fan onto the motor and/or heat sinks to help keep the bearings and servo motor cool. If excessive heat is detected by the servo drive, the drive may reduce the maximum allowed current (possibly disable the drive entirely) which will significantly reduce the load frames capabilities.

Installation and Setup

On the bottom of the Servo controller panel you will find several connectors as shown below. Follow the steps below to prepare the system before powering up the load frame.



Bottom of Servo Controller Panel



Rear of Copley Xenus Plus XPL-230 Servo Drive

1) Mount the servo drive panel (with the red/yellow power switch) and the servo control panel (with keypad) into a 19" rack. It is preferable for the servo drive to be mounted close to the bottom of the rack keeping the servo drive as cool as possible so heat from panels below it don't increase the ambient heat of the servo driver. The two servo motor cables will also have to reach the load frame so placing the panel close to the ground is usually the best position. The servo control panel should be placed at or below eye level to make it easy to read the LCD and press the keys on the keypad. The interconnecting cables are only 6 foot long so be sure the controller is close to the servo drive panel.

2) Install the load frame firmly to a stationary platform. The actuator is capable of rapid motion so be sure the load frame is securely mounted before operating. Check to make sure the two servo motor connectors are easily accessible. If the servo load frame is mounted horizontally, be sure to support the weight of the load frame. The top mounting ring has 3 mounting holes that are 0.531" equally spaced on a 7.5" diameter bolt circle. The load cell has a 1-14 UNS thread interface. **Note: Be careful when using the mounting bolts, if the bolt head is high, it may damage the load cell connector when operating the actuator fully extended. Note: When threading into the load cell, be sure to stop at least ¼ inch before hitting the bottom to prevent interference between the load cell and the actuator plate.**

3) Plug the 26 pin high density controller cable connector into the bottom of servo control panel labeled SERVO and plug the other end into the mating connectors located on the Copley servo drive (J8). The 26 pin cable is used to exchange high speed digital position commands between the servo controller and drive. Secure the ends of the cable with shell screws.

4) Plug a standard 9 pin cable into the Copley servo drive port J5 and the other end into the male 9 pin port on the servo controller panel labeled "SERVO SAFETY". This cable is used to supply power to the servo driver as well as enable the driver. Secure the ends of the cable with shell screws. **DO NOT PLUG THE SAFETY CABLE INTO THE SERVO COMMUNICATIONS PORT (also a DB9) OR THE SERVO DRIVER WILL BE DAMAGED.**

5) Plug the RJ11 (telephone) connector into the Copley J6 port and into the RJ11 to DB9 adapter attached to the servo controllers Servo COM port (Right side of driver). This cable is used to communicate serially between the servo controller and drive. **NOTE:** Some older controllers use a DB9 cable instead of the RJ11 cable. If so plug a standard 9 pin cable into the Copley servo drive panel (Right side of driver) and the other end into the matching port on the bottom of the servo controller panel labeled SERVO COM. Secure the ends of the cable with shell screws. **Be sure not to mistake the servo com cable for the safety cable (both DB9) as noted in the previous step.**

6) In many installations it is helpful to install a grounding wire between the servo controller and the load frame load cell to reduce load feedback noise. Attach a 22 AWG or larger stranded wire or a grounding strap between the servo controller panel and a screw on the servo motor connectors can significantly reduce load cell electrical noise. Many installations can also benefit by connecting a wire from the servo driver panel to the load cell as well. Each installation is different so try one or both methods to minimize load noise. Be sure to evaluate noise at various loads because the servo driver output changes as loads change.

7) **NOTE: The servo drive may not operate properly if any of the cables are improperly seated.**

8) If a network is available, it is advised to plug a RJ45 Ethernet cable between the servo controller port (bottom of controller panel) and your local network switch or hub. The network can be used to monitor the servo system and can be used to update the system firmware. The servo controller can operate without the use of a local network but it is helpful to have a DHCP on the local network to make IP network address configurations easier.

9) Plug the servo motor feedback cable (high density DB26) into the rear of the servo driver port labeled "J10" and secure the connector with the two screws. Plug the other end of the cable into the round mating connector (with narrow pins) on the servo motor. This cable sends the rotational position feedback to the servo driver and to the servo controller. You should not use any tools to tighten the connectors, only tighten by hand. Align the connector before tightening the connector housing. Carefully rotate the connector until it aligns with the motors mating connector. Once the connector aligns, it will drop in and begin to make contact. Thread the connector barrel until the connection is snug, securing it into place. As the barrel is tightened, be sure to press in on the connector until it can't be pressed further and the barrel is snug. The connector has an O ring seal to keep the connection clean so you will feel some resistance before the connection is fully seated. ***Note: If the cable comes loose while the system is operating, the system will produce unpredictable motion and possibly shut down so it is important that the cable is properly secured.***

10) Plug the round servo motor power cable from the rear of the servo drive panel into the mating connector (with thick pins) on the servo motor. It's important that the connector is fully seated or the system will not operate properly. You should not use any tools to tighten the connectors, only tighten by hand. Align the connector before tightening the connector housing. Rotate the connector until it aligns with the motors mating connector. Once the connectors align, they will drop in and begin to make contact. Thread the connector barrel until the connection is snug, securing it into place. As the barrel is tightened, be sure to press in on the connector until it can't be pressed further and the barrel is tight. The connector has an O ring seal to keep the connection clean so you will feel resistance before the connection is fully seated. The servo power cable should have a large ferrite core added to minimize load cell noise. One core may be used for the Model 5K and two cores may help for the Model 10K and the Model 15K load frames.

11) Connect the round end of the load cell cable into the load cell and gently rotate it to align the connectors until it is allowed to push in slightly. Then rotate the outer connector barrel while pushing in to lock it in place. Connect the other end of the load cell cable into the load cell port (Port A) on the bottom of the servo control panel. Be sure to secure the cable to the control panel using the two screws on the connector shell. The Cal button (recessed) can be pressed to verify the calibration of the load cell attached to port A. See Port connection for more information about using shunt cal. **Note:** A small ferrite core added to the load cell cable to minimize electrical noise generated by the servo motor/driver. The load cell cable should run through the core three times (two loops) for maximum effectiveness. If the ferrite core is not installed on the load cell cable, contact Interactive Instruments for help.

12) Plug the power cord socket attached to the servo drive panel into the rear of the servo control panel. The Servo controller gets its power from the servo drive panel so only one power cord is needed for the system.

13) If your unit has a separate power entry module at the rear of the servo driver panel requiring a detachable power cord, securely plug the main power cord into the servo driver panel below the power entry switch. Be sure the power entry power switch is in the ON position.

14) Plug the main power cord plug into a 120 volt (**or 240V if designated**) grounded wall outlet. Avoid GFI (ground fault interrupt) protected outlets because the servos electrical noise on the ground line may falsely trip the breaker.

15) Inspect the load frame, control panel, servo drive panel and cables for shipping damage. If any damage was caused in shipping, please contact Interactive Instruments immediately. ***Operating a damaged unit may result in additional damage or personal injury.***

16) Check all of the cables to make sure they are properly connected and secured. Verify the servo driver communication and safety cables go to the proper connectors to prevent damage to the driver.

17) Check that the servo drive is enabled. The enable button on the front servo control panel should be pushed in or the drive will not operate. ***Any time someone works on the near the load frame while under power be sure to disable or unplug the servo drive to prevent unexpected motion.***

18) Verify the actuator is free of obstruction before applying power.

19) Power up the unit by rotating the Main Switch on the servo driver panel to the On position. The controllers operating system will require about 12 seconds to boot up, in that time the LCD will display 2 black bars.

20) As the unit is booting up, the controller will access the DHCP server if available and automatically use the assigned network address. If a DHCP server is not available, a static network address can be assigned.

21) ***Note: After powering down the controller, be sure to wait 5 to 10 seconds before applying power again. If the load feedback appears incorrect, turn off the controller power, wait 10 seconds and restore power.***

Servo System Power Requirements

The servo controller and load frame doesn't require a lot of power to operate. Below is a table of approximate required power for a 110 volt 60 Hz system. As you can see a relatively small uninterruptible power supply (UPS) could relatively easily supply power to one or more units, maintaining a controllable load throughout a power outage.

Load Frame Power (approx.)

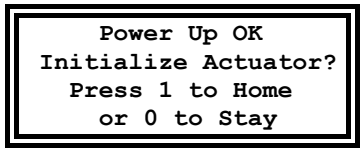
Load	Power
0 lbs	35 watt (Model 5K)
1000 lbs	50 watt (Model 5K)
2000 lbs	65 watt (Model 5K)
3000 lbs	80 watt (Model 5K)
4000 lbs	110 watt (Model 5K)
5000 lbs	130 watt (Model 5K)
6000 lbs	180 watt (Model 5K)
7000 lbs	210 watt (Model 5K)
8000 lbs	260 watt (Model 10K)
9000 lbs	330 watt (Model 10K)
10,000 lbs	400 watt (Model 10K)
12,000 lbs	200 watt (Model 15K)
14,000 lbs	270 watt (Model 15K)
16,000 lbs	340 watt (Model 15K)
18,000 lbs	430 watt (Model 15K)
20,000 lbs	550 watt (Model 15K)

Types of UPS systems

There are generally two types of UPS units, online and offline. The less expensive offline UPS will work but some power line disturbances pass through to the UPS disrupting the controller. More expensive Online UPS is a better choice for critical applications when you can't afford to lose load control.

Power up

If the controller diagnostics pass all internal tests, the LCD will then prompt:

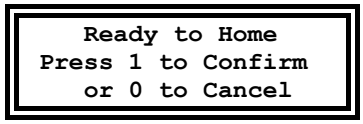


Press the 1 key on the front of the control panel to locate the home switch or press 0 to maintain the same actuator position. Since the actuator position is stored in memory, the actual position may be different than the stored position if the actuator moves while powered down.

Note: Before the actuator moves to locate the home position be sure the test are is free of test specimens or the specimen may be damaged.

Actuator Initialization

Pressing 1 displays a confirmation prompt below. Pressing 1 a second time and the actuator moves down to locate the lowest position (closest to the servo). This is done by slowly moving the actuator and waiting for the servo motor to stop at the bottom most position. Once the actuator stops moving it assumes it is the lowest possible position. If an object blocks the actuator from moving, the home position may be incorrect and it is best to relocate the proper end position.



Note: It is preferred to locate the home location after power up but if a specimen is already mounted then it is better to assume the current position. If the actual and stored position is off by more than 1/4" the actuator can bottom out internally causing the servo to stall and release the load.

While the controller is active or in control, the status LED on the control panel will blink to indicate possible servo activity. The same LED will indicate an error condition by flashing at a faster rate and will be on steady if the actuator is stopped.

Note: The servo controller will ignore serial and network commands until the controller is active (LED blinks continuously). This is a safety feature to prevent automated programs from taking control of the actuator so the operator is in complete control after power up.

Servo Controller Overview

The servo controller software is the front end program that contains the user interface to the actuator control and the waveform generator. The servo controllers main job is to determine where the actuator should be positioned to maintain minimal control error while monitoring various system limits and conditions. The actuator is controlled by sending digital position commands to a servo driver program which is responsible for controlling and monitoring the servo motor. As the servo motor is repositioned, the servo motor feedback is returned to the servo driver as a digital signal which updates the servo control program. The digital position command and feedback allows for high speed positioning and reliable noise free response over a wide dynamic range.

Actuator Controller

One of the requirements of the actuator controller is to be able to precisely position the actuator over a wide range of speeds. The servo controller sends a constant stream of pulses to the servo drive to control the actuator position. A separate line is used to control the direction of the motion so the actuator can be controlled up and down at a controlled rate. Each controller pulse sent to the driver moves the actuator a fixed distance, the smaller the distance, the finer the control motion. The servo driver is programmed to input 524,288 pulses for every inch of actuator travel so the effective positioning resolution is 1.90735e-6 inches per pulse. The fine position control resolution allows for very precise load stroke and strain control.

A programmable timer is used to adjust the speed of the pulses to control the actuator between very slow rates to the maximum allowed system actuator rate. Unlike a servo hydraulic system, the servo electric system is able to control the maximum allowed actuator rate to suit test requirements. Typical servo hydraulic systems are pre-configured for one rate only, fast or slow.

The servo controllers maximum actuator rate is a programmable limit that prevents the actuator from operating too fast. Some tests such as high cycle fatigue test require very fast rates where control accuracy isn't as much an issue. Long term creep strain tests sometimes require very slow actuator rates for smoother control and improved control accuracy. The servo controller is able to fill both requirements with the same piece of equipment. The typical actuator rate is set to a value that would be acceptable for most test conditions or about 20 inches per minute for moderate control response. The waveform generator is then used to control the actuator load, stroke or strain control. The control error is calculated and the actuator rate is adjusted up to the maximum actuator rate to reduce the control error back to near zero. Some test such as long term creep tests require precise smooth control, so a slower actuator rate is used instead of the typical 20 inch per minute rate. As the waveform adjusts the control point, the actuator ramp is clamped to prevent rapid actuator motion from disrupting the sensitive test environment. Actuator rates as low as 0.00001 in/min are possible for the finest actuator control so actuator adjustment will be dampened significantly. Select an maximum actuator rate that would be fast enough to maintain minimal control error. A good rule is to use a rate at least twice the required rate, to make sure the actuator can move fast enough to minimize control error. Some experimentation may be necessary for load control applications to determine an acceptable actuator rate.

High cycle fatigue may require a faster rate than 20 in/min. Setting the actuator rate to 75 in/min will greatly improve the cyclic frequency response at the expense of control accuracy. The higher rates will permit speeds approaching servo hydraulic testers at a fraction of the system and maintenance cost.

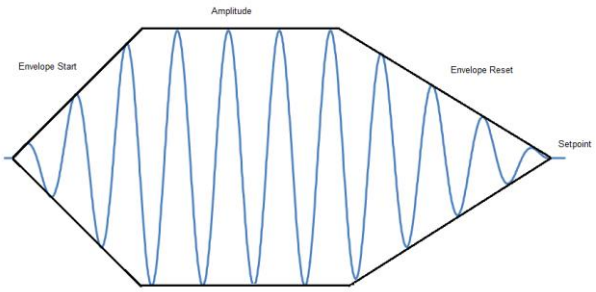
Note: Care must be taken when operating the load frame at high cyclic rates for long periods of time. See the section ***Important Servo Maintenance Requirements*** above.

Waveform Generator

The waveform generator can be programmed to manipulate the control point over a wide range of frequencies and amplitudes. The waveform generator is capable of controlling the current control channels, load, stroke or strain. The generator is capable of generating cyclic frequencies as low as 10^{-300} Hz on up to 30 Hz. It is also capable of controlling ramps from 10^{-300} units/minute up to 10^{+300} units/minute (units are load units, stroke units or strain units depending on the control channel). Although the waveform generator is capable of 30 Hz, it is unlikely it will be able to reliably support that rate. The waveform generator output is updated up to 1000 times a second and the waveform output is added to the current setpoint to generate the new control point which the controller will attempt to control. The waveform generator is open loop so it can't guarantee the control error will be near zero, that is up to the test conditions and the servo controller settings. The actuator rate should be adjusted in conjunction with the waveform generator and control accuracy requirements. Faster cyclic tests and ramps will require fast actuator rates while slower waveforms may require slow actuator rates. As the waveform generator updates the control point, the actuator controller will attempt minimize the error by moving the actuator rate slowly (for small errors) up to the maximum actuator rate (for large errors). This is why it may be important to consider the actuator rate for every test condition.

Envelope Control

The waveform generator has the ability to slowly increase and decrease the waveform amplitude over a period of time. Controlling the start and reset time is useful when applying high amplitude or high frequency waveforms. Start and reset times can be programmed form 0.001 to 100.000 seconds for each of the three independent waveform generators. The envelope control is only available for cyclic bipolar and unipolar waveforms such as sine, haversine etc.



Envelope Waveform Control

External Waveform Generator

An external waveform can be used to control the load or stroke channel using an analog control signal. The analog signal can be scaled to a desired range to best represent the analog control signal. The control signal is received on the AUX channel analog input and scaled internally and added to the load or stroke channel. For example you can program the controller to create a 0 to 2000 lb. waveform with a 0 to 10 volt signal. The analog voltage will modify the setpoint depending on the voltage on the AUX port. This is useful if the test waveform can't be duplicated with the internal waveform generator.

Programmable Waveform Generator

Custom waveforms can be downloaded into the controller to create a unique sequence of ramp segments. Once loaded, the waveforms amplitude and frequency can be further adjusted by the user interface for added flexibility. Waveforms are programmed by loading a list of amplitude values and optional ramp segment times (one segment per line). From 1 to 1000 ramp segments can be programmed to perform smooth sequential list of ramps to emulate virtually any waveform. Using Excel or other spreadsheet programs, complex waveforms can be created and exported to a text file rather easily. The structure of the waveform file is very simple and easy to create. Each line represents a waveform segment and contains an amplitude value which is typically of the range +1.0 to -1.0 but can be any value. The amplitude values are used to control the overall shape of the waveform. Once a waveform is loaded, the controller automatically normalizes the amplitude values so the waveforms true amplitude is controlled by the waveform generators amplitude. The waveform amplitude value is multiplied by half the waveform generator amplitude to create the waveform generator output for the specific control channel. A stored waveform can be reused for stroke or load control since each channel can has a different waveform generator amplitude. Once a waveform is downloaded, it is available for any control channel just by selecting the programmable waveform.

Each waveform segment text line can also have an optional time value (in seconds) separated by a comma. The time controls how long it would take to ramp from the previous segment value to the current value. A time of 0.5 would generate a ramp that transitions to the new amplitude in 1/2 second while a value of 2.0 would perform the ramp in 2 seconds. The time value allows for long constant hold times or fast ramp segments if needed. If the time entry is zero or not included on the segment line, the duration is automatically set based on the current waveform frequency and the number of segments in the file. For example, loading a 10 segment waveform with the waveform frequency set to 0.125 hz will program each segment time to 0.8 seconds (1.0/(0.125*10) = 0.8 sec) so the waveform cycles every 8 seconds. Simple waveforms can be loaded by using a file of amplitude values (one entry per line) and the servo controller calculates each segment time automatically. This way complex waveforms can be easily loaded by using a simple list of amplitudes.

Waveforms are loaded using USB flash memory drives. The waveforms are stored in a text file with the extension ".WAV" and are loaded into the controller when Programmable Wave is chosen and the waveform file is selected. The waveform file should be saved to a USB flash drive then plugged into one of the two USB connectors on the bottom of the servo controller. Once a waveform file is loaded into the controller, the USB flash is no longer needed and can be safely removed. Any further changes to the waveform are performed on the locally controller copy.
Note: You can use a standard USB extension cable to extend the USB port to a more convenient position.

Multiple waveforms can be stored on the USB device at one time, the waveform menu interface will display a list of ".WAV" waveform entries for you to select between. When a waveform is loaded which is found to have programmed segment times, the waveform frequency is automatically set to accommodate the total of all segment times. This value can be overridden by programming another frequency, the controller then scales each time entry to arrive at the to the new frequency. Reloading the original waveform from a file will restore the time segments to the original values and the original frequency.

Programmable Waveform File Format

The waveform file is an editable format that can be created using Notebook or any ASCII text editor. The file name must end in ".WAV" and can have from 1 to 1000 line entries, one for each ramp segment. Each segment should be terminated with a carriage return. The first line is special and can contain a descriptive name of the waveform such as "LoadProfile-2" or "Log Sweep-2X". The optional waveform name will be automatically truncated to 20 characters to fit on the display. The name should begin with a letter to prevent it from getting confused with a waveform value. If the waveform name is not available, the USB file name will be used instead. The name is displayed whenever the programmable waveform type is viewed.

The examples below represent two different types of waveforms. Example #1 is a 14 segment bipolar waveform (both +/- values) with constant segment times. Since the amplitudes don't have time durations associated with the segments, the time is based on the waveforms cycle frequency. Example #2 is a similar waveform but programmed unipolar (positive values only). Notice each line has two values, the first being the amplitude and the second (separated by a comma) is the time in seconds the generator takes to ramp to the value. Even though example #2 amplitude is half of example #1, both waveforms will have the same amplitude since the values are normalized internally. Example #3 shows how easy it is to create a simple triangle waveform. With up to 1000 entries, virtually any waveform can be customized.

Waveform Example #1

```
Custom Wave-1
0.1
0.9
1.0
1.0
0.9
0.1
0.0
-0.1
-0.9
-1.0
-1.0
-0.9
-1.0
0.0
```

Waveform Example #2

```
Custom Wave-2
0.1,1.0
0.9,2.0
1.0,1.0
1.0,0.5
0.9,1.0
0.1,2.0
0.0,1.0
0.0,0.5
```

Waveform Example #3

```
Triangle Wave
1.0
-1.0
```

Data Acquisition

The controller has an internal data acquisition feature that will allow you to sample up to 3 internal system or channel parameters synchronously or asynchronously for up to 10,000 samples. The data acquisition feature is only accessible with remote commands due to the amount of data involved.

The default data channels sampled are load, stroke, AUX feedback values but any 3 channel or system parameter can be programmed to be acquired.

Synchronous sampling is performed by programming the sample rate in samples per second. Once set the sampling is performed automatically until the sampling is suspended or the acquisition memory fills. Sampling rates can be programmed from as fast as 1000 samples per second to as slow as 1e-300 samples per second.

Asynchronous sampling is performed by sending a sample command to the controller whenever data is to be sampled.

Once the data is collected or even as data is being collected, the data samples can read from memory. You can read from 1 to all 10,000 data sample sets using remote commands.

Note: At times the controller is too busy to acquire a data sample when sampling at rates over 200 samples per second. Missing data samples will be replaced by duplicating the following data sample. The time stamp will reflect the missing entry by indicating duplicate time stamps.

Guide to the Servo Controller

Before starting a test

- Verify that the load frame controller and servo drive are properly setup (***see* Installation and Setup**)
- Power up the controller by switching the power switch located on the Servo drive panel
- Wait 10 to 15 seconds for the controller to boot up and begin displaying information on the LCD
- Press the ↵ (enter) or ▤ (menu) key to locate the home switch or stay. The LCD will prompt with the feedback display.

Resetting the Controller

The controller stores some of the control parameters in nonvolatile memory. To reset all control parameters (and actuator position) back to the factory default settings, power up the controller with the 0 key held down and keep it pressed until the display reply's with a prompt to reset the controller. The LCD will prompt with a confirmation message. Press 1 to confirm or 0 to cancel.

LCD Menu options

Press the ▤ (menu) key to display the Main Menu.

Note: When entering a parameter value with the keypad the ▤ button will first delete characters one at a time if one or more digits have been entered and then cancel the numeric entry if ▤ is pressed after all characters are deleted. Pressing the ▤ key will also exit from the menus, and return to the feedback display.

```
      Main Menu
➔1) Mode Control
 2) Setpoint
 3) Waveform
```

Pressing the UP/Down arrows on the keypad will move the pointer through the list of menu options. The list includes:

Mode Control	(Select between load, stroke or aux control)
Setpoint	(Set the desired control setpoint)
Waveform	(Configure and control the waveform generator)
View Max/Min	(View the Max and Min feedback values in real time)
View Control	(View the actuator control, feedback and error)
View Servo Stat.	(View the status of the servo motor)
Setup	(Configure the System and Channel parameters)
Network Config.	(Configure and view Network configuration)
About	(View the Software Version)
System Menu	(System updates and management)

Note: While the display is not showing the feedback screen and a key isn't pressed in 60 seconds, the display automatically returns to the feedback screen.

Mode Control is used to select which channel (load, stroke or auxiliary) is in control. Two options are available when transferring control to another channel. Option 1 is to automatically set the setpoint to the measured feedback of the selected control channel (Immediate) or option 2 is to go to a programmed setpoint immediately after the transfer is complete (Go To).

Setpoint is used to program the current setpoint value (or reference point) all waveforms are applied to. If the waveform is not active, the actuator controls to the programmed setpoint.

Waveform selects the waveform generator configuration and control options menu. Configurations include selecting the waveform type such as sine, square, triangle, haversine, haversquare, havertriangle, single ramp, dual ramp and trapezoid along with the required parameters. An external waveform is also available using the AUX analog input channel. The waveform control options are available to start, hold, finish, reset and stop the waveform generator.
The constant amp option allows the controller to fine tune the waveform generator output in real time to make sure the waveform reaches the desired maximum, minimum and midpoint values as programmed into the waveform generator. Constant amplitude control is helpful when operating at faster cyclic rates.
You can also program the Cycle Cnt Limit as well which tells the controller how many cycles to perform before automatically finishing. For example, if you intend to apply 1000 sinewave cycles to a specimen, modify the Cycle Count Limit to 1000 before starting the waveform. See **Cycle Cnt Limit** below for more information.
Each control channel maintains separate set of waveform parameters so the parameters don't require reprogramming if the mode control is changed back and forth. Waveform commands are also preserved after power up for each control channel.

View Max/Min View a channels maximum and minimum feedback values in real time. The display will indicate the overall max and min values since the waveform was started along with the max and min values for the previous waveform cycle. The values are evaluated and updated appropriately. The feedback amplitude and mean value can be monitored in real time as well using the down arrow. Pressing the up arrow will re-display the max/mins.

View Control View the current control value (waveform + setpoint) along with the control feedback value and the current control error. The bar graph on the top of the display represents the relative control error.

View Servo Stat. View the Servos drive current, drive temperature, status and load. These indicators are a good way of determining how hard the servo motor is working and whether the servo is being overstressed. With the Servo Status page displayed, press the down arrow to view the servo motor position for the controller and the servo driver. This is useful to debug possible position contingencies between the servo controller and the servo driver. Pressing the down arrow again will display the percentages of the time the controller samples the control channel feedback value only (when this information is displayed). Nosier feedback results will spread the feedback over a wider range so it is helpful to view the stability of the load, stroke or aux feedback in real time.

Setup Display the setup menu for configuring the system and channel setup parameters.

`Network Config.` Displays a list of menu items to view and modify the current network configuration. The network can be configured as a DHCP or Static network. If your local network has a DHCP server, the controller can request a valid IP address for your network. A static IP address can be selected if DHCP is not available or if a static IP is desired. If the servo controller is not plugged into a local network, ignore this menu.

`About` Views the software version and copyright notice.

`System Menu` The controller firmware can be updated using a USB flash memory stick. Other menu options are available to restart the control software or reboot the servo controller.

Mode Control

The controller can be programmed to control load, stroke or auxiliary (analog sensor). To change from the current control mode into a new control mode select the Mode Control menu item. The display will prompt with a list of control channels. Select one of the channels by entering 1, 2 or 3 to select Load, Stroke or Aux. The display then prompts with options on how the control change will take place. For Aux control, be sure an appropriate sensor is installed in the Aux analog port and is properly scaled and calibrated.

Immediate

The first option (Immediate) will quickly transfer control to the new channel and set the current setpoint to the control channel feedback value. As long as the new feedback channel is stable the transition should have minimal effect on the actuator position.

Go To

The second option (Go To) allows a new setpoint to be programmed immediately after the transfer of control is performed. This is an efficient method of switching control and programming the new setpoint in one operation. For example, while in stroke control you can switch to load control at 100 lbs. by selecting Go To 100 lbs.

Setpoint

Programs the setpoint to a new value. The setpoint is the mean value of the of the maximum and minimum excursions of the controlling waveform. On normal cyclic waveforms (sine, square, triangle) it is the center point which the waveform swings. On haver waveforms it is the starting and end point.
All setpoint transitions are made as quickly as possible. The actual rate depends on the selected actuator rate.
The default setpoint is the current setpoint. Pressing Enter (or menu) without entering a new value re-selects the current setpoint.
The setpoint can be changed at any time even while a waveform is running.

Note: The setpoint can't be changed if the actuator is stopped. Restart the actuator by pressing and holding the '.' key for a second while in the feedback display mode, then set the new setpoint.

Waveform

Each control channel has a programmable waveform generator with separate parameters providing a command signal to drive the servo system when that channel is in control. Only one set of waveform parameters are enabled at a time allowing the load, stroke or auxiliary to be controlled while monitoring the independent feedback channels.
The waveform parameters are saved in non-volatile storage for each channel, if the controller is powered down, the parameters will be preserved so the same waveform can resume by just selecting the menu option Start from the waveform menu.
Internal waveforms fall into three groups: bipolar waveforms comprising sine, triangle and square, unipolar waveforms comprising haversine, havertriangle and haversquare, and ramps which can be connected and repeated to form single ramps, dual ramps and trapezoidal waveforms.

Note: See the Important Servo Maintenance Requirement section above for long term high cycle testing.

Constant Amplitude Control

Constant amplitude control is available for trapezoid, sine, square, triangle and the haver cycle and programmable waveforms. The constant amplitude controller option can be enabled to greatly improves the actuators frequency response for multiple cycle testing. This option can be turned on and off remotely or by the keypad. When enabled the waveform generator monitors the previous cycle feedback peaks and the results fine tune the waveform generators output amplitude to adapt to the desired amplitude. The constant amplitude control also monitors the feedback midpoint value and compares it to the desired mean and adjusts the setpoint to adapt to the desired mean for each cycle. Neither of these controls modify the operators amplitude and setpoint values, they are temporarily tweaked using internal variables. Constant amplitude control only works for sine, square, triangle and haver and programmable waveforms which are primarily used for fast cycle control, ramps are not impacted even when constant amplitude is enabled. Enabling this feature allows the actuator frequency response to be pushed much farther. Turning constant amplitude control off (and after power up), the waveform generator returns to the original waveform control.

Effort was made to adapt the waveform output closely to the waveform parameters. In some cases the constant amplitude control can go outside the bounds of the parameters but this was typically when the waveform parameters (amplitude, setpoint, wave type etc.) are adjusted dramatically manually by the operator. In most cases, the constant amplitude control does a very good job of matching the waveform parameters as long as they are within the servos performance range.

Note: To minimize the constant amplitude control adjustment errors while significantly modifying the waveform parameters, it may be better to temporarily disable the feature, change the parameters and wait an appropriate amount of time to stabilize control, then re-enable.

Cyclic Waveforms

Bipolar

Bipolar waveforms are cyclic waveforms that start at a setpoint, proceed to a peak amplitude (positive or negative), reverse direction pass through the setpoint to the opposite peak amplitude and then return to the setpoint. When selecting bipolar waveforms, you must specify the set point, amplitude, frequency and the starting direction (amplitude sign) of the waveform.

Unipolar

Unipolar waveforms have the same shape as bipolar waveforms but are offset by the cyclic mean value form the setpoint. The cyclic mean is the mean level of the peak-to-peak amplitude. This means that the waveform excursions take place entirely above or below the setpoint. This feature is useful when you wish to start your test with a pre-load on your specimen then have the specimen load cycling take place entirely above or below that pre-load without unloading the specimen.

Note: When the waveform generator output is added to the current setpoint. The +/- sign in the upper left corner of the feedback display signals that a waveform output is modifying the current setpoint. When the sign is blank, the waveform output is zero, and not impacting the setpoint.

Waveform Envelope Start Control

The startup can be controlled for cyclic waveforms to softly start a test. A programmable timer can be set to quickly or slowly ramp the waveform amplitude up to maximum amplitude. The timer can be adjusted from 1 millisecond up to 100.000 seconds before reaching full amplitude. Each of the three internal waveform generators can be programmed to have different start ramp times. Pausing the waveform will suspend the start envelope timer as well but restarting the waveform will restart the envelope timer to zero but start at the current amplitude. If the amplitude of the waveform is modified, the internal envelope start cycle will automatically reset to slowly increase or decrease to the new waveform amplitude.

Note: The start envelope is only available for cyclic waveforms, ramping functions are not impacted by the envelope control.

Waveform Envelope Reset Control

The waveform reset can be controlled for cyclic waveforms to softly stop a test. A programmable timer can be set to quickly or slowly ramp the waveform amplitude down to zero amplitude. The timer can be adjusted from 1 millisecond up to 100.000 seconds before reaching zero amplitude. Each of the three waveform generators can be programmed to have different reset ramp times. Pausing the waveform will suspend the reset envelope timer as well but restarting the waveform will restart the envelope timer to zero but start at the current amplitude. The reset envelope is only available for cyclic waveforms, ramping functions are not impacted by the envelope control. Once a waveform is finished resetting, the waveform will be placed in “End” mode.

Ramping Waveforms

Single Ramp

Ramp waveforms are linear functions which have a ramp rate and an end amplitude. The reason it is called an end amplitude instead of an endpoint is because the final control point is the programmed endpoint plus the setpoint which makes it an end amplitude.
Single ramps do not automatically return to the setpoint. To return back to the setpoint (as fast as the actuator allows) use the waveform "Reset" function.
Select the finish command to set the setpoint to the current control point (setpoint + ramp control) and the ramp control is set to zero. This in effect establishes the end of the first ramp as the start of a second ramp.

Note: The direction of the ramp (towards tension or compression) is denoted by the sign of the amplitude.

Dual Ramp

A dual ramp is a conjunction of two ramps of differing slope and end amplitudes. The reason it is called an end amplitude instead of an end point is because the final control point is the endpoint plus the setpoint which makes it an amplitude. Since the second point can be non-zero it would be incorrect to call it an amplitude.
The first and second end amplitude values are completely independent of sign and/or magnitude. For example the first point can be a tension value while the second can be compression. The first point can also be greater in amplitude than the second as well.
A typical use for a dual ramp is during a tensile test in which a different tensile rate is required once the plastic yield point of the specimen has been reached.
Once the dual ramp reaches the second end amplitude, the ramp control point does not reset back to zero but holds the second end amplitude like the single ramp. To return back to the setpoint (as fast as the actuator allows) use the waveform "Reset" function.
Select the finish command to set the setpoint to the current control point (setpoint + ramp control) and the ramp control is set to zero. This in effect establishes the end of the dual ramp as the start of a second ramp.

Note: The direction of the ramps (towards tension or compression) are denoted by the sign of each amplitude.

Trapezoid

A trapezoid waveform is made up from two segments, each of which comprises a ramp followed by a hold time. The first ramp slope, amplitude and hold time, and the second ramp slope, and hold time all must be specified along with a setpoint value. Since the trapezoid waveform is offset by the setpoint the trapezoid starts from the setpoint and ramps to the amplitude (plus the setpoint) and begins the first hold. The second segment ramps back to the setpoint for the second hold.

Note: The direction of the trapezoid (towards tension or compression) is denoted by the sign of the amplitude.

External Control

An external waveform can be controlled using the analog voltage on the AUX input channel. Selecting the "External Control" waveform will prompt for the maximum range of the AUX waveform control. For example to program a 0 to 10 volt signal for 0 to 2000 lbs, program the External Range to 2000. This range will be programmed into the AUX channel range so the AUX feedback will be used as the external waveform value. The AUX channel will be read 1000 samples per second and the value will be used as the waveform value to be added to the current setpoint. Since the external control signal is a waveform command, it is added to the current setpoint so if you would like the AUX channel to control the load exactly, make sure the setpoint is set to zero so the waveform output is the same as the control point. Be sure to start the waveform to enable the external waveform control. You can also pause the waveform by pressing the "." On the keypad which will suspend the waveform update and maintain the last value.

The External Control waveform is very flexible and can be used to control the load or stroke setpoint.

The analog signal is input on the AUX channel DB9 connector on the bottom of the servo controller on pin 4 with ground on pin 8. See "Analog Port Connection" for more information.

Note: The AUX port defaults to a +/- 10 volt input if the range resistor is open circuit. To fine tune the analog input signal you may want to use a range resistor so you can calibrate the analog signal. See the section "Analog Port Connection" for more information on selecting an appropriate ranging resistor.

An offset can be programmed into the AUX signal as well. Program the offset using the AUX channel offset command under the "Setup", "Setup Channels", "Channel Offset" menu item. Any changes to the AUX input channel such as digital filtering will impact the External Control feature. Even though the AUX channel is used to adjust the setpoint, the control channel (load or stroke) identifies which set of PID parameters are active.

When you are done with the external control feature, set the AUX range to 0 in the Setup Channel menu. This disables the AUX channel and allows more time for the main application.

Note: The resolution of the AUX channel doesn't have to match the load or stroke channel, scaling is performed internally. You can program an external control range of 100 lbs. while the load range is set for 7500 lbs. The analog input will be able to add or subtract up to 100.00 lbs. from the current setpoint.

Waveform Type

To specify a cyclic or ramp waveform use the following procedure. Select Waveform Type from the Waveform menu. Select which control channel waveform is to be modified.

```
  Select Channel
→1) Load
 2) Stroke
 3) Aux
```

The next selection is the type of waveform. Scroll through the list by using the up/down arrows and press ↵(enter) to select.

```
   Waveform Type
→1) Sine
 2) Square
 3) Triangle
```

Depending on the selected waveform, the display prompts for the required parameters. The first line of each parameter prompt identifies the parameter to be entered. The second line prompts with the default value. To modify a parameter, key in the new number on the keypad and press ↵. Pressing ▤ will delete back one character then cancel the prompt once all characters have been removed. The up arrow can be used for entering numbers in exponential format. To enter 0.000012 type 1.2↑-5 or 1.2e-5.

Once the last parameter is entered all parameters are programmed at once for that specific control channel. Pressing ▤ before entering the last parameter cancels all parameter entries.

The display then prompts for the Start Envelope Time which is the amount of time required to ramp to the final amplitude. The time can be adjusted from 0.001 sec to 100.0 sec. After entering a time, the display prompts for the Reset Envelope Time as well. This is the time it takes to ramp from the current amplitude down to 0 when the Waveform Reset command is issued.
The last display shows the summary of the selected waveform and parameters.

Once the waveform parameters are entered the waveform must be started before it begins to operate.

Start

After programming the waveform generator for the current control channel the waveform can be started. For cyclic waveforms, the waveform ramps from zero to the chosen amplitude. If the setpoint is programmed to be a value other than zero the waveform starts at the setpoint and adds the waveform amplitude to the setpoint. When the output of the waveform generator is negative, the control point (setpoint + waveform output) can track below the setpoint. Once started the cycle counter, waveform timer and the total max/min values for all channels are reset.
If a Start Envelope time value is programmed for the selected channel, the waveform amplitude will ramp from 0 to the desired amplitude over the time period.

The first line of the feedback display prompts with "**Run:**" while the function generator is running. The symbol in the upper left corner identifies the status of the current waveform output. A '+' or '-' identifies the sign of the controlling waveform output value. A blank (not '+' or '–') identifies the waveform output as zero so the control point is the same as the setpoint.

Hold

Hold the waveform generator at the current control point. The feedback display prompt changes from "**Run:"** to "**Pause:**". Select Start from the Waveform menu to restart the waveform without resetting the time, cycle count or total max/min's.
Holding a waveform during a start or reset envelope will also suspend the respective envelope timer as well. Releasing the hold by selecting Start or Reset will also restart the envelope timer so the cycle time will require the full time but from the current amplitude.
Note: Pressing the ↵ (enter) key and holding it for a second while displaying the feedback display will also pause the function generator displaying "**Pause:**". Pressing ↵ a second time and holding it pressed restarts the generator.

Finish

For a cyclic waveform, complete the current cycle then hold at the setpoint in the current control mode. For a ramp function, the ramping is halted and the setpoint is set to the current control point (amplitude + setpoint). The actuator will move at the fastest rate allowed (See Actuator Rate command). Once the waveform stops, the feedback display prompt changes from "**Run**" to "**End**".

Reset to Setpt

For a cyclic waveform, ramp to the setpoint from the current waveform value at the maximum actuator rate (see Actuator Rate command). For cyclic waveforms if the Reset Envelope time value is set, the waveform amplitude will reduce to zero over the programmed time period. Once the reset cycle is complete, the feedback display prompt changes from "**Run:**" to "**End:**".

Stop

Transfers the controller to stroke control and halts the actuator at the current stroke feedback and the waveform generator output resets to zero. The feedback display prompt changes from "**Run:**" to "**Stop:**". At this time the servo controller is halted until restarted, any change in setpoint will not alter the actuator. To resume control, press and hold the '.' key to restart the controller.

Constant Amp

Waveform constant amplitude control can be enabled or disabled with this menu option. When enabled, the waveform amplitude and mean value are controlled more closely. This option is typically used for fast cycle tests or if the specimen is very compliant. This control will work with all cyclic waveforms, not ramps.

Cycle Cnt Limit

A limit of the number of waveform cycles generated by the waveform generator before automatically terminating. Select waveform menu "Cycle Cnt Limit" and enter an integer greater than 0 to program the waveform generator to cycle N cycles before finishing. As the cycle counter increments, the cycle count limit counts down to 1 and the generator automatically issues a finish command to terminate after the last cycle completes. Setting the count to zero (default) allows the waveform generator to cycle indefinitely. Each control channel waveform has an independent counter that only decrements if the waveform is operating on that channel. The cycle count limit can be modified at any time even when the waveform is already cycling.

View Max/Min

This menu item displays the maximum and minimum channel feedback results, updated in real time. Selecting this option prompts with the Select Channel menu. Once the desired channel is selected the total (overall) and cycle maximum and minimum values are displayed. The controller continuously updates these values 1000 times a second so even if the display is not fast enough to show the peak value, this viewer will. Pressing the down arrow will display the measured waveform amplitude (max – min) and mean (max-min/2) value in real time. Pressing the up arrow returns to displaying the max/min values for the selected channel.

The Total max/min values are reset when a waveform is first started. Pressing the (enter) key while viewing the Max/Mins will reset the total peaks as well.

Peak Detector

The controller continuously monitors the load, stroke and auxiliary feedback values 1000 times a second. Any time a value exceeds the currently stored value the new value is recorded in its place. Cycle peaks are maintained on a cycle by cycle bases. Once a cycle completes (determined by the waveform generator), the current cycle peak results are saved and the current peak detector is reset to the current feedback values. This method requires two sets of registers. The first set used to establish the current cycle peaks and the second is used to display the previous cycle peak results once the cycle is complete.

To exit press the (menu) key.

View Control

The controller's main responsibility is to minimize the error between the control value and the selected control channels measured feedback. The "View Control" menu selection displays the control point value (setpoint + waveform amplitude) along with the feedback value. The difference represents the control error. The smaller the error the better the controller is at positioning the actuator. The control error is displayed on the bottom line.

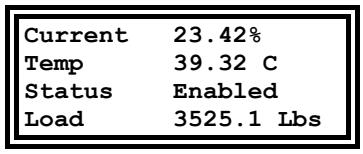
The top line of the display is a bar graph representing the absolute value of the control error. The default bar graph scale is 1:10 or every horizontal pixel = feedback display * 10. Pressing the 0 to 9 keys rescale the bar graph from 1:1 (key 0) to 1:1000 (key 9). Select a range that displays a reasonably scaled bar graph.

To exit press the (menu) key.

The compliance of the specimen and the speed of the loading significantly affect the size of the control error. As the compliance reduces and loading speed increases, the controller has a difficult time reducing the control error. This is why it is sometimes necessary to reprogram the control parameters for varying specimens and test condition. To minimize the control error, try adjusting the maximum actuator rate and/or the PID parameters. These two items significantly change how the controller reacts to the control error. No one setting can be used for all test conditions but typically one set of parameters can in general be used for a wide range of conditions.

View Servo Stat.

The servo drive has limitations that must be monitored to prevent it from becoming overheated and reduce system performance or disable the servo entirely. The View Servo Stat. Menu item is a good tool for monitoring the status of the servo motor and the system. Below is an example of the View Servo Stat menu option.



The display prompts with 4 important servo parameters as discussed below.

Current: The current is displayed in percentage of the drives capacity. The motor and drive is capable of 100% current for short periods of time. Continuous current should be kept below 75% to keep the servo from overheating and loosing torque. The higher the current the higher the drive temperature and the lower the maximum reserve motor torque. If the motor can't supply enough torque the drive will automatically shut down the motor. To restore the power to the driver you must cycle the power on the entire system or reset the servo driver error using the System menu "Reset Servo Err." menu option.

Temp: The temperature is a measured at the servo drives heat sink. The higher the temperature the lower the maximum drive capability. As the drives temperature climbs 40 °C above ambient, the motor torque linearly degrades so that 50 °C the servo driver is 2/3 the capacity when the drive is at 40 °C. If the temperature is consistently high be sure the motor isn't over stressed with continuously high loads and verify that the drive fan is not blocked. If the load frames main bearing is damaged, causing an increased load to the motor, it can also cause the drive temperature to increase. Monitoring the heat sink temperature is a good indication of the condition of the bearing.

Status: The status line displays the general status of the servo drive.
Enabled: The drive is operating and the motor is under power.
Disabled: The drive is disabled and the motor is not under power. The drive can become disabled if the front panel switch is not engaged (pressed in) or if the servo controller cable is unplugged. Even if the drive is disabled the software keeps track of the actuator position.
Fault: A Fault value is displayed if the servo drive recognizes a serious fault. See Copley User Manual for more information. The system error may clear if the servo driver error is reset using the System menu "Reset Servo Err." menu option. Contact Interactive Instruments if the problem persists.
Unconfigured: The Servo drive configuration has been unintentionally reset and is inoperable. The servo drive must be reprogrammed to operate properly. See Interactive Instruments for further details on programming the servo drive parameters.

Load: Load reflects the load measured from the load cell which is the same value shown on the feedback display. The load value doesn't come from the servo driver but it is a useful parameter to monitor the servos torque while watching the servo status.

To exit the View Servo Stat. menu press the (menu) Key.

Note: If the display prompts with nan for any of the values, it means the communication link between the servo drive and the controller is broken. Check to see that the DB9 cable is in place and secured at both ends.

Setup

The Setup menu selection is used to review and modify the channel and system configuration parameters.

View Setup

View the various system and channel configuration settings. Select between viewing the waveform, channel configuration, channel limits, maximum loop error, system configuration settings, date and time (if on a network with access to a time server), and the digital IO (option).

Setup Channels

Modify the desired channel parameters. The menu prompts with a list of channel configurations. The list includes Limit Selection, Max Loop Error, Digital Filter, Display Units, Channel Scale and Channel Offset.

Limit Selection:

Change the desired channels maximum limit, minimum limit and action. The channel limits can be used to prevent the actuator from extending beyond a programmed limit whether the channel is the current control channel or not. When a limit is tripped, an action command can be programmed to perform an operation when a limit is reached or exceeded. Each feedback channel can have different set of programmed limits and limit actions.

For example, if the controller is in load control and a stroke limit is reached, the stroke action is performed and the controller is placed in the stroke limit mode until reset. In the same example if a load limit is tripped while in load control, the load limit action is performed.

When the servo controller is powered up and before the actuator is sent to home, all limit actions will be automatically set to "Ignore". Be sure to reprogram the actions back to the desired action before continuing.

Note: Max/Min Limits and a loop limits are monitored separately and each feedback channel can have separate actions although each control channels min and max limit, share the same action. A limit is considered enabled when an action other than "ignore" is selected. Once a limit is tripped, the limit condition is latched and the display will reflect the error until reset. Reset the limit state by selecting the "Reset Limit" menu item in the "Limit Selection" menu (or remotely, with the "V" command).

Note: Modifying a Max or Min limit with a limit action already enabled will be ignored if the limit will cause an immediate trip. Enabling a limit action that would cause an immediate limit trip will also be ignored.

The list of limit action items are as follows.

Ignore: Any error for the specified channel will be ignored and no action will be taken.
Note: This does not exclude an over range of the load or stroke channel. If the load A/D value exceeds 100.8% of the programmed range, the controller automatically suppresses control in that direction. If the stroke exceeds the limit of the machine, control is also suppressed in that direction.

Reset Waveform: Any feedback values beyond the max or min limits will automatically reset the waveform generator. See Waveform Reset for more information.

Unload: Any feedback values beyond the max or min limits and the controller is placed into load control and the control point is set to a programmed value. The

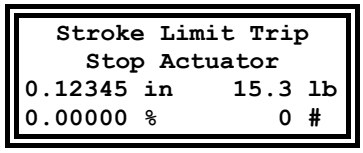
programmed unload value can be set to any load value (within the limits of the controller).

Xfer and Hold: Any feedback values beyond the max or min limits and the controller will transfer to the offending channel and begin controlling to the + or - limit to remove the error condition.

Stop: Any feedback values beyond the max or min limits place the controller in stroke control and halts the actuator at the current stroke feedback and the waveform generator output resets to zero. The feedback display prompt changes from "Run:" to "Stop:". At this time the servo controller is halted until restarted, any change in setpoint will not alter the actuator. To resume control, press and hold the '.' key to restart the controller.

Actuator Off: The controller will send a command to the servo drive to disable the actuator (servo) power The servo motor will be disabled from any motion until re-enabled. To re-enable actuator, toggle control modes.

Note: When a limit action is activated the LCD prompts as shown below for example.



The first line of the display identifies the limit that was tripped in this case the stroke limit and the second line displays the action taken. The action takes place immediately and the programmed action for the offending channel is automatically reset to the "Ignore" action. This allows the controller to perform the action without potentially loop cycling between multiple limits. The error message will continue to display on the top two limes until the limit is acknowledged by resetting the message.

Reset Limit Trip Condition

To reset the action, select the menu item "Limit Selection" from the main menu "Setup", "Setup Channels", menu. The software will automatically recognizes a limit was tripped and prompt with the message "Reset all Limits?". Confirming the reset with a "1" will clear both max and min limit trip conditions for all channels. Canceling the request will not reset the limit trip condition so the limits can be reset individually or reset at a later time.

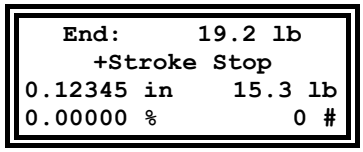
Note: Be sure any tripped limits actions are reactivated prior to restarting a test. Once a limit is tripped the action is reset to ignore.

Control Stops:

Control stops can be set to prevent further actuator motion from encroaching beyond the programmed control stop settings. Each feedback channel has a set of control stops that are programmed by default to the maximum range of each feedback channel. Tighter stops can be set by decreasing the control stops to restrict control and/or feedback from exceeding its programmed stop. The current control channel will be restricted to values between the maximum and minimum stop. Feedback channels that reach one or more of the programmed stops will restrict motion of the control channel as well although control can be issued to move away from the control stop.

Control stops behave differently than limits. A stop will always restrict actuator motion when a stop is reached or exceeded but limits will execute a programmed action to resolve the limit, limits can be ignored entirely if an action isn't set. Control stops don't have associated actions, they are always active and never require a reset. The only way a control stop can be ignored is to move them to the range limits of the feedback channel.

Once a control stop is exceeded, the display will flash an error on the second line of the feedback display until the appropriate feedback is between the max and min stops. For example, the display below (over the load feedback bar graph) identifies a stroke stop while in load control. Notice the message also identifies the maximum stop limit with the '+' sign.



Max Loop Limit:

Change the maximum allowed control loop error and action for a desired channel. When a channel is in control, an error is calculated (desired command – measured feedback) and the maximum error (or loop error) can be tested to be sure the feedback is in an acceptable range. Detecting an excessive loop error is useful to help determine if the current control loop is controllable. Excessive loop errors are typically due to a measurable change in the compliance of the specimen. As a specimen yields or breaks it may be helpful to stop or reset the waveform generator to halt the test and possibly prepare for another specimen.
Each channel maintains its own maximum loop limit value and associated action but the channel in control is the only channel monitored. Since each channel can have a different loop limit and action, the control channel can change from stroke to load and auxiliary without needing to reprogram the loop limit.

When the current loop limit exceeds the programmed maximum loop limit, an action can takes place as shown below. After the action is selected the action is forced to Ignore. Be sure to re-enable an action after an action trips.

When the servo controller is powered up and before the actuator is sent to home, all loop error actions will be automatically set to "Ignore". Be sure to reprogram the actions back to the desired action before continuing.

Ignore: Any error for the specified channel will be ignored and no action will be taken.

Hold Waveform: The waveform is held at the current value. Select "Waveform start" to continue. See Waveform Hold for more information.

Finish Waveform: The waveform will proceed until finished and then end. See "Waveform Finish" for more information.

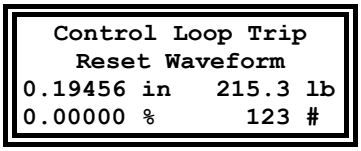
Reset Waveform: The waveform will be reset. See "Waveform Reset" for more information.

Unload: The controller is placed in load control and the control point is set to a programmed value. The programmed unload value can be set to any load value (within the limits of the controller).

Stop: Transfers the controller to stroke control and halts the actuator at the current stroke feedback and the waveform generator output resets to zero. The feedback display prompt changes from "**Run:**" to "**Stop:**". At this time the servo controller is halted until restarted, any change in setpoint will not alter the actuator. To resume control, press and hold the '.' key to restart the controller.

Actuator Off: The controller will send a command to the servo drive to disable the actuator power The servo motor will be disabled from any motion until re-enabled. To re-enable actuator, toggle control modes.

Note: When a loop limit action has tripped, the LCD prompts as shown below



The first line of the display identifies the control loop has exceeded its limit and the second line displays the action taken. The action takes place immediately and the programmed action for the offending channel is automatically reset to the "Ignore" action.
The display will continue to indicate the loop trip until the limit is reset. The reset command is located in the Loop Limit Selection menu.

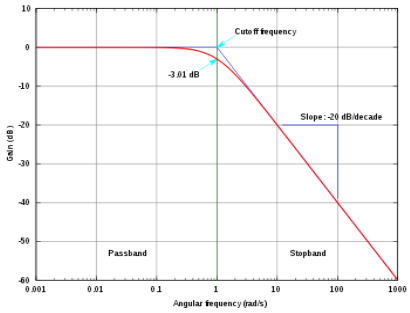
Reset Control Loop Trip Condition
To reset the loop trip action, select the menu item “Max Loop Limit” from the main menu “Setup”, “Setup Channels”, menu. The software will automatically recognizes the control loop was tripped and prompt with the message “Reset all Limits?”. Confirming the reset with a “1” will clear the loop trip conditions for all channels. Canceling the request will not reset the control loop trip condition so the loop trip can be reset individually or reset at a later time.

Note: Be sure any control loop actions are reactivated prior to restarting a test.

Digital Filter:

A low pass digital filter can also be programmed to filter out analog noise. Setting a high filter value (80 Hz) allows the controller to report fast changes to the feedback channels but the digital feedback reflects more analog noise. High level of electrical noise can impact the peak detectors and possibly record and trip a false peak at times. Lowering the filter value (5 Hz or lower) reduces the noise and increase the feedback resolution but the feedback can be slow to the control response. The controller uses the filtered feedback values for display purposes and for recording peak values. The servo controller uses pre-filtered feedback values for control purposes so the digital filter will not impact control characteristics. This allows the use of maximum filtering without having to worry about inducing control oscillation.

Note: The digital filter is a simulated single pole filter so the filter frequency is attenuated by 3db at the selected frequency. For example setting the filter to 1 Hz will reduce a 1 Hz feedback waveform by 3 decibels or reduce the amplitude by a factor of SQRT(2)/2 or about 70% which is actually half the energy. Higher frequencies will be attenuated at 20db per frequency decade (power of 10). For example if the filter is set to 1Hz, the incoming feedback will attenuate the signal 3db at 1Hz and 20db at 10Hz, 40db at 100Hz etc.



Display Units:

The load, stroke or auxiliary units should represent the current range and calibration of the specific channel. Selecting different display units will **NOT** automatically scale the calibration of the load or auxiliary channel. See "Channel Scale" below to scale the load cell range to match the load units.
Stroke is a unique channel. It does not rely on analog signal conditioning and is a fixed range therefore selecting between inches and centimeters will automatically scale the value to match the units.

Available display units for each channel

Load Units: lb, kp, N, kN, kg
Stroke Units: in, cm
Auxiliary Units: %, V, in, cm, lb, kp, N, kN

Channel Scale:

Load: The load cell range arrives from the factory calibrated for 7500 lbs. (or 10,000 lbs for 10K load frames) but other load cell ranges can be configured as well. If the load cell calibration of 7500 is maintained then the load cell range can be set to 3402.0 (kg/7500 lbs.) and the kg units can be used. Another way to calibrate the load cell with metric units. For example the load cell can be calibrated for 3500 kg (or 7716.0 lbs.) and use 3500 as the new load range. **Be careful calibrating the loads in excess of the attached load cell. The motor is capable of loads beyond the load cell, but not continuously.** Once a range is entered, the LCD will prompt if you would like to reset the limits and control stops to match the new range. Select Yes by pressing 1 to match the limits to the new range. You can select No by pressing 0 to maintain the original limits and control stops. With the limits set to the channel range, you don't have to remember to reprogram the limits to avoid unnecessary limit actions.

Note: The load channel scale is a "digital scaling factor" and does not alter the analog calibration. Modifying the channel scale without adjusting the analog calibration will effectively change the displayed values not the actual calibration of the machine. For example assume the load frame is calibrated for the frames load cell 7500 lbs. with the load channel scale also set for 7500 lbs. Changing the load scale to 3750 lbs. without adjusting the analog calibration and the unit will apply twice the commanded load. This is because the calibrated 7500 lbs. now is digitally scaled to represent 3750 lbs. so each load display unit is actually 2 lbs.

Stroke: The stroke scale is fixed internally and can't be increased or decreased. The stroke channel is the only channel that scales the value when the units are modified. This is because the stroke range is fixed and can't be modified. If a higher stroke resolution is needed (< 0.00001"), you can use an LVDT or linear potentiometer attached to the auxiliary channel.

Aux (or strain): The auxiliary range can be scaled to match the sensor attached to the unit. Attaching an extensometer to the Aux channel will allow the controller to monitor strain as feedback and also control strain. If a 20 percent extensometer is used change the auxiliary channel scale to 20.00 and the auxiliary (strain) will be displayed in percent. The auxiliary can also represent in volts (V), load (lb, kp, N, kN) or stroke units (in, cm) as well if the appropriate sensor is properly installed and calibrated in the Aux analog port.

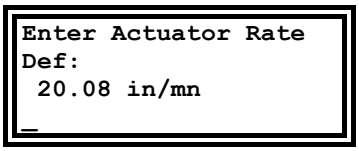
Channel Offset:

Offsets can be added to the channel output to adjust the true output feedback value to a given load, position or auxiliary feedback. This value is digitally added to the channels feedback and remote output and does not impact the analog offset or the analog output signal. Since the offset is added to the feedback, the offset can be negative to removed or positive to add to the feedback signal. The only way the analog offset can be adjusted is using the trim pots built into each port connector. See Analog Output for more information.

Note: If the offset is modified on the current control channel, the actuator will be disabled to prevent the actuator from repositioning to the old setpoint. Reprogram the setpoint and restart the actuator by pressing and holding the '.' key.

Actuator Rate

Select **Actuator Rate** from the Setup menu to display the information as shown below.



The current actuator rate is displayed as the default entry. To select a new rate key in the desired rate and press the ↵(enter) button. To accept the default rate, press ↵ without re-entering the rate. This is the maximum rate that the actuator controller will use in all modes. The controller calculates how fast the actuator can move to minimize control error. If the calculated rate is faster than the maximum rate, the rate is clamped to the maximum rate. The maximum actuator rate is stored in memory so the selected rate will be preserved until changed at a later time. The rate can be programmed for slower actuator speeds to improve the accuracy and stability of the controller. The rate can also be programmed faster to reduce control error faster. The lowest actuator rate possible is 0.00001 in/min. Values less than that will be clamped to 0.00001 in/min.

Note: Faster actuator rates may be slightly faster than the programmed value due to the limited internal 100 ns timer resolution. Slower actuator rates will match the requested rates more accurately while faster rates will be programmed to the next highest value.

Zero Channel

Selecting this menu item will update the load, stroke or auxiliary channel's offset so the current channel digital feedback (display and remote) value is zero, independent of the previous offset value. The LCD will prompt with the new offset programmed for the selected channel. This menu item does not affect the analog output.

Note: If the offset is modified on the current control channel, the actuator will be disabled to prevent the actuator from repositioning to the old setpoint. Reprogram the setpoint and restart the actuator by pressing the '.' key.

PID Parameters

The PID parameters are used to control the motion of the actuator. The three parameters can be modified for the load, stroke and auxiliary channels to improve the response time and minimize control error for each control mode. The default PID parameters were originally selected to work over a wide range of conditions. Sometimes it becomes necessary to modify these parameters to improve the controller's response characteristics for a specific test.

Each of the PID parameters are used to scale the results of control calculations and affect the control behavior. Selecting this menu option prompts the operator for the appropriate control channel that is to be modified. Each channel has a separate array of scale factors so the control channel can be changed without having to re-enter the PID parameters. Once the channel is selected then the display prompts for the Proportional, Integral and Differential scaling factors sequentially. Be careful in modifying these terms because they can quickly cause the actuator control to become unstable. Once all variables are entered they all become programmed at the same time after accepting the parameters by pressing '1' to confirm the change. Pressing the (menu) key cancels the variable update.

The values are stored in memory so they don't require reprogramming after power up. If the control mode is changed, the proper PID parameters are automatically loaded.

Each of the PID parameters can be programmed from 0 (off) to 9999999 (high gain). To disable a parameter set the gain to 0. The Proportional factor cannot be removed entirely so its lowest value is 1. When adjusting, start with small factor and increase them slowly until the proper control is obtained. Be sure both steady state control and waveform control is stable with minimal error. Each channel behaves differently so PID parameters will be different as well.

The best method for tuning a PID controller is to start with a low proportional gain with no integral and no differential gain. Apply a square wave to the control channel and monitor the channel's analog output with an oscilloscope.
Slowly increase the proportional gain until the control overshoots slightly. Then increase the differential gain to minimize the overshoot. Once the waveform is clean and sharp try to increase the integral to improve the accuracy of a stable setpoint. Too much gain will cause an unstable oscillation.

The parameter definitions are as follows.

Proportional

The Proportional value scales the proportional error. This error is calculated by taking the difference between the current and desired setpoint. The proportional value is responsible for most of the error correction. Many controls require only the proportional term

Integral

The integral value scales the accumulated or integral error. This error is calculated by accumulating the proportional errors over time. The purpose of this term is to be more aggressive in the control output the longer the error persists.

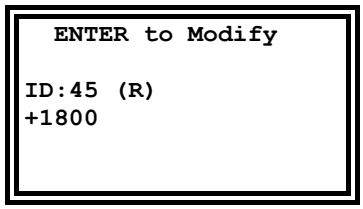
Differential

The differential value scales the rate of change of or the differential error. This error is calculated by measuring how fast the error is changing and to slow the control down if the change in error is too rapid. This term is useful in minimizing setpoint overshoot and allowing a larger proportional value.

Servo Parameters

The Servo Parameter menu option enables the viewing and modification of the Copley servo drive parameters. Please refer to the Copley XPL-230 servo drive manual for details about the parameters and their effects. Be careful when modifying servo tuning parameters because they can cause uncontrollable actuator activity. The parameter modifications are only temporary and are restored back to the original settings when powered down.

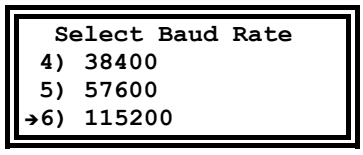
To scroll through the list of parameters alphabetically use the up and down arrows or type the parameter number on the keypad and press ↵(ENTER). The parameter name is displayed on the second line. The parameter ID is used for accessing the parameter remotely. The (R) or the (R/W) message identifies the parameter as read only or capable of read and write.



To modify a parameter press the ↵ key while displaying the proper parameter and the display will prompt for the modified value. For example to modify parameter 34 (Max Current), type 34 followed by the ↵ key or use the up arrow until parameter 34 is displayed. Then press the ↵ key to modify the parameter. The servo drive will only modify parameters that are valid modifiable variables since not all parameters can be written. For example the velocity feedback can be read but not modified.

Select Baud Rate

Select a BAUD rate that better matches the rate for the attached computer. The factory default is 115200 which is fast enough for most applications and computers. If your computer is not capable of operating at the faster rates, select a slower BAUD rate. Slower rates will significantly slow the data transfer rate into and out of the system.



Note: All RS-232 communications are performed with no parity, 1 stop bit, and 8 data bits.

Home Actuator

This performs the Home Actuator procedure similar to power up. After selecting this menu item, the software will request 1 to confirm operation.

Reset Sys Stroke

If the actuator position becomes out of sync with the display values, this feature will enable the operator to program the controller's stroke position to match the actuator. The preferred method is to re-initialize the actuator by disconnecting the specimen cycling the controller's power. Sometimes it isn't possible to re-initialize the system due to test setup so we included an option to manually configure the actuators position relative to the frame. Care should be taken when programming the position because the actuator has no way of properly verifying its position unless it locates the home switch upon power-up. Programming the position with an incorrect value may cause the actuator to run out of room on one end and possibly overdrive the actuator at the other end. Neither cases will harm the actuator, the only problem may be that system will lose power and release the load. The actuators position is programmed by measuring the distance between the top of the actuator and the highest possible actuator position and entering this value. For example, if the actuator is about 3/4" from the upper position, then program 0.75" into the system stroke and the actuator will now know it is 3/4" from the upper end (not including for the stroke offset). Select Reset Sys Stroke from the setup menu displays the following.

```
Enter Position
Def: +2.5000
_
```

The Def: value is the current actuator position relative to the upper position. Note this number does not include the stroke offset it is the absolute distance from the highest actuator position.
If the system actuator position is reset while in stroke mode, the actuator will be disabled to prevent the actuator from repositioning to the old stroke setpoint. Reprogram the setpoint and restart the actuator by pressing the '.' key.

Setpoint Slew

The setpoint can be programmed to slowly slew to the desired setpoint over a programmable period of time. Entering a time value in this menu prompt will slew setpoint adjustments from the current setpoint to the desired setpoint in the time entered. For example, if the Setpoint Slew timer is set to 5 seconds and the setpoint is currently at 1000 lbs., setting the setpoint to 2000 lbs. will slew the setpoint from 1000 to 2000 lbs. at 200 lbs. per second reaching 2000 lbs. in 5 seconds. Selecting a 3000 lb. setpoint would ramp the load at 100 lbs. per second to reach the load in 5 seconds.

If the waveform is running at the time, the entire waveform will slew referencing the ramping setpoint until the desired setpoint is reached.
The setpoint slew timer can be programmed from 0.001 sec to 100.000 sec. All channels are programmed to use the same setpoint slew timer.

Network Config.

View and configure the local network configuration. When selected, displays the menu below.

```
      Network
1) View Config
2) Type
3) IP
```

View Config

Selecting menu item 1 will display the current network parameters which include the Host Name, Network type (DHCP or Static IP), current IP, Subnet Mask and the gateway. Use the Down arrow to display the gateway address.

Type

Menu item 2 allows you to modify the network type between DHCP and Static IP. DHCP is the preferred type if your network supports it. A DHCP network will program the appropriate network parameters automatically. If the local network doesn't support DHCP, the parameters can be entered manually. The default factory setting has DHCP selected so most users only have to plug the network cable into the Ethernet jack to establish connection. You can use the View Config menu item to see what the assigned IP address is if DHCP is available.

IP, Subnet Mask, Gateway

Menu items 3 through 5 are available to modify the static IP address, subnet mask and gateway address if DHCP is not available or a static IP address is required.

Consult with your network administrator for information on network configuration.

The only parameter that can't be modified using the keypad is the host name because it requires a full keyboard to enter. The host name can be modified using the supplied Windows application along with the other network related parameters.

About

Displays the current software version number along with the copyright notice.

System Menu

Various system level commands can be accessed to update the firmware via USB memory or reboot the firmware.

USB Update

This menu item will allow you to update the system firmware without the use of the network. It is much easier to update firmware using the network connection but sometimes it isn't practical in all situations.

Be sure the memory stick is properly formatted for Windows FAT32 or the servo controllers firmware will not recognize the firmware file. Insert the memory stick in one of the two USB device ports on the bottom of the servo controller and select the "USB Update" menu option. Scroll through the memory stick directory entries until the proper file is located and press Enter to select. When the firmware is automatically read and loaded, the controller software will then restart with the new firmware. Verify the new firmware version number after restart using the "About" menu selection.
If you are updating both the servo driver (servo_xxx.bin) and the controller firmware (control_xxx.bin) it is best to update the driver firmware first and before powering down the controller or rebooting, update the controller firmware next. When done updating both the servo driver and controller, it is then safe to cycle power on the controller to complete the update process.

Note: The firmware versions work for a wide range of servo controllers from the older Pac-Sci drivers to the latest 5K, 10K and 15K Copley drivers including our digital A/D controllers. The firmware reads the internal hardware installation settings and adjusts accordingly.

Note: Not all flash memory sticks can be read by the servo controller. If you have trouble locating a device that works, we can repartition and format your memory device for you so it will work in both Windows and on the servo controller.

Lock Keypad

Selecting this option will lock the keypad from accidental key entries. Once the keypad is locked, the display will return to the feedback display and ignore keys. To unlock the keypad, either power down the controller or press any key for about 3 seconds. The keypad will remain unlocked until it is locked again using the same menu option. This option is restored to unlock on power-up.

Config. Menu.

Make changes to the system configuration. You can recall/store a configuration from/to flash memory, reset the configuration to factory settings, modify/view the linear actuator configuration (linear actuator servo type only). See Config Menu below.

Reset Servo Err.

If the servo drive enters an error condition (fault), it will disable power from the drive to prevent further motion of the actuator. You can view the error condition that caused the fault by using the "**View Servo Stat.**" menu option. To restore power and control to the servo drive, you can issue a software reset to the servo drive with this menu option. Care must be taken to address the original error condition because after the drive is reset, it will resume previous operation.

Restart Control

This menu item will restart the firmware without having to reboot the controller. Restarting the firmware is always much faster than rebooting. At times it may be necessary to restart the controller firmware to perform diagnostics. The controller will stop the actuator during the control restart and transition to stroke control after the restart.
Note: It is not recommended to have a specimen in the actuator during restart, unpredictable results may occur.

Reboot

The controller computer can be rebooted to resolve unforeseen controller or computer problems. This process may take 10 to 20 seconds to complete.
Note: It is not recommended to have a specimen in the actuator during reboot, unpredictable results may occur.

View Status

The servo controller preserves several long term system status variables which can be useful to determine how long (and active) a particular load frame has been operating. This information can be useful for preventative maintenance and as general system usage information. The controller maintains the total (non-resettable) system stroke, total cycles and total time in operation even after powering down since the machine was manufactured. A user resettable set of parameters is also available which maintains the same parameters but may be reset any time by the operator. These variables are also preserved after powerdown.

The stroke value is stored as inches of actuator travel reflecting how far the actuator has moved up and down over time. The cycles value is a total count of the waveform generator output which reflects approximately the number of cycles on the main bearing over time. The time interval reflects the approximate number of hours the servo motor in operation, while moving or stationary.
Note: Non cyclic waveform cycles are not recorded in the cycle counts.

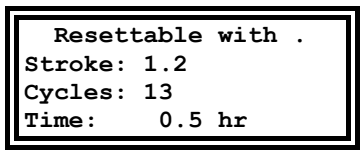
Each parameter is useful and reflects the general usage activity of the frame. The total actuator displacement is useful to determine the activity of the actuator screw while the cycles is useful to determine the relative activity of the main bearing. Time is a good indicator how long the servo motor has been powered up.

Since this information is periodically saved to file (10 minutes while under motion to 1 hr. stopped), some information may be lost if the system is powered off without going through a reboot cycle, but the data loss should be minimal.

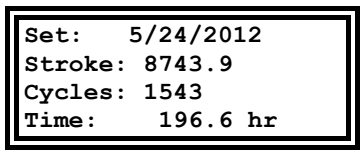
New units will have the Reset date set when the unit was purchased and should be maintained for the life of the controller. If the firmware is updated with this feature for the first time, the Reset date will have to be entered by the operator for the first and only time as noted below.

When the control software is run for the first time, the “Set” value is initially set to “****” until the set date is programmed by the operator. When the operator views the status parameters for the first time the software prompts for the current month, day and year so this information can be used as a reminder when the total status was initially set.

Selecting the View Status menu will display the resettable parameters as sown below. These values can be reset to 0 by pressing the period key.



To view the non-resettable values, press the down arrow and to return to the resettable values, press the up arrow. Note the display also prompts with the Set value which should represent the day the total parameters were zeroed for the first time.



Press the Menu key to return to the run time display.

Lock Remote Key

Selecting this option will lock all remote keypad entries preventing remote applications from controlling the servo controller. Remote applications can still monitor the status of the controllers display in real time but any key commands are ignored. To reactivate the remote keypad access, reselect Lock Remote Key option and remote keys are accepted. **Note:** This option is restored to unlock on power-up.

Config Menu

Recall Config.

Recall from storage a previously stored configuration file. Configuration files contain all of the parameters preserved in storage that are restored after power up such as the actuator rate, PID parameters, feedback channel range, offsets, waveform settings etc. except the actuator position. The current actuator position is preserved and is not restored. The current control channel is not changed as well because the control channel is not preserved in the configuration file since the controller always restores to stroke control from power up. Each file is stored to a file name "configN.txt" where N can be any number so you can theoretically store thousands of unique configurations. This is useful to store various configurations for fast, slow test scenarios, special waveform configurations, limit setups etc.

Store Config.

Selecting this option will store the current controller configurations into a file named "configN.txt" where N is any number. The parameter file can be recalled another time to restore PID parameters, channel limits, waveform settings etc. The actuator position is not restored even though it is saved in the configuration file.

Reset Config.

Reset the current configuration to the factory defaults. It would be a good idea to home the actuator to make sure the stored home position is accurate. Once the factory configuration is restored, the controller software will restart to properly restore the parameters. If the servo controller is configured to use the Copley driver, the firmware will ask if the load frame is 5K, 10K, 15K or Lin Act (Linear Actuator). Select the appropriate load frame actuator attached to the servo driver. The Copley driver is only compatible with the AKM72K (5K) and AKM74L (10K) servo motors with digital (BiSS) feedback. The Copley driver is not compatible with the AKM72K (5K) motor with analog (resolver) feedback unless the Copley Servo resolver driver is provided. Linear actuators are available in a wide range of configurations. The specific parameters of the linear actuator can be selected in the Modify Lin Act menu options below

Modify Lin Act

The linear actuator options can be adjusted to reflect the wide range of servo actuators. Refer to the linear servo actuator specification for details. Parameters such as stroke range, maximum actuator rate, maximum servo current, home current, rotations per inch, steps per rotation and encoders per rotation can be configured to adapt a range of linear actuators. The linear actuator parameters are saved in the flash memory so they are restored after power is restored. These parameters are not necessary for Interactive Instruments standard load frames (5K, 10K or 15K) they are only necessary when nonstandard linear servo actuators are used. Once parameters are modified it is helpful to cycle power and home the actuator to properly initialize the actuator position and servo driver. Care must be taken when adjusting these parameters so the actuator isn't damaged. These parameters will also directly impact the accuracy of the stroke feedback and speed of the actuator.

Stroke Range: The stroke range is adjustable from 1.00000 inch to 9.00000 inches. Refer to your linear actuator documentation for exact length. Making an actuator shorter than the limits is acceptable but programming the actuator longer may damage the actuator. Changing the stroke range will not impact the accuracy of the stroke feedback.
Max Current: The Max actuator current controls the maximum allowed continuous power is applied to the servo motor. Care must be taken to prevent overheating the servo motor. The max allows current is 20 amps continuous which is the limit of the Cpopley servo driver.
Home Current: The home current is adjustable, this is the amount of current applied during the home cycle. The current is reduced to safely locate the home position end stop. If the home cycle fails to locate home properly, try increasing the current. Use the least amount of current necessary.
Rot. per Inch: Rotations per inch tells the controller how many servo rotation are needed to move the actuator one inch. The controller can be programed from 1.0000 servo rotation per inch (coarse) of travel to 10,000 rotations per inch (fine) of travel. Refer to the linear actuator documentation for details. Fractional values are accepted to handle metric values (eg. 6.35 = 4mm pitch).
Step per Rot.: How many steps are needed to rotate the servo motor one complete rotation. The Copley servo driver typically requires 131072 (2^{17}) steps per rotation. This value is a positive integer. This value is used to determine how fast the servo controller moves by also using the rotation per inch parameter
Enc. per Rot.: How encoder pulses are received from the servo driver per rotation. The Copley servo driver typically outputs 131072 (2^{17}) encoder edges per rotation. This value is used to determine the actuator position feedback by counting the pulses and using the programmed rotation per inch parameter.

View Lin Act

This menu option allows the operator to view the Max Stroke, Max Rate, Max (continuous) Current, Home Current, Load Range, Rotations per Inch, Encoders per rotation, Steps per Rotation. The menu option can only display 4 parameters at a time so two pages are available. Toggle between the two pages by pressing the up/down key to toggle between the two pages.

Feedback Display

The feedback display contains the typical information an operator would like to view while the controller is in operation. It provides the current setpoint value and units, actuator and waveform generator status, waveform output sign, feedback output values for load, stroke and auxiliary, along with the current cycle count. The display also graphically displays the load cell feedback in the form of a bar graph for a quick visual feedback of the load frame loading condition.

First Display Line: The first character of the first line is a symbol that identifies the sign of the waveform generator output if active. The symbol switches from '+' to '-' to a blank indicating the output of the waveform generator. This is useful to see if the waveform generator is applying an output to the controller. The label after the first character represents the current state of the actuator. The table below identifies the label with the actuator status.

Actuator Status Indicator

Run: Waveform Generator is running.
Stop: Actuator is stopped and held at the current position and the controller is disabled (setpoint changes ignored). Press the '.' key to resume control.
Hold: Waveform output is held at the current value but the controller is enabled Or the trapezoid is in the hold mode.
Pause: Waveform output is currently paused by keypad Enter key. Press Enter again to resume waveform updates.
End: Waveform generator has completed its operation.
Off: Actuator servo motor is powered off (due to a limit action).

The number after the actuator status indicator is the current control point and units. The control point is made up of the setpoint added to the waveform generator output. As the waveform generator runs, the control output updates in real time to reflect the new control point. As the mode control changes from load to stroke or auxiliary, the control units reflect the control channel.

Second Display Line: The second line is entirely taken up with a 100 element bar graph that represents the absolute value of the load feedback signal. The bar graph is automatically scaled to represent the current load feedback from 0 to the maximum load range. The default represents load from 0 to 7500 lbs. max.

Third Display Line: Displays the feedback values of the stroke and load feedback channels. The display units are also shown as well for each channel.

The load feedback represents the current load measured by the load cell. The display values are filtered with the digital filter. See **Setup Channels** for more information on configuring the load range, offset, filter and units.

The stroke feedback reflects the current actuator position relative to the stroke offset. Since the stroke is calculated digitally based on the applied actuator position the resolution and accuracy is much better than using an analog displacement transducer. See **Setup Channels** for more information on configuring the stroke units and offset.

Fourth display Line: This line displays the optional auxiliary feedback value along with the waveform cycle counter.

The auxiliary channel is used to optionally display and record the results of an extensometer, a second load cell, LVDT or temperature sensor so the results can be read along with the load and stroke data. If a signal is not attached to this port the range should be programmed to 0 to disable the port channel.

The cycle counter is a 32 bit counter that is incremented after each waveform cycle is completed. The cycle counter is capable of displaying up to 9999999 cycles. After exceeding 9999999, it will divide the count by 1000 and place a K in the last location. Exceeding 999999999 counts and the counter stops counting.

Feedback Display Keypad

Display the Main Menu

Pressing the (menu) key while the feedback display is shown will continue to update the waveform, monitor limits etc. while navigating the menu. This is to allow parameter changes such as actuator rate, limit, PID modifications etc., during a test. While in the menu, pressing a second time will return back to display the feedback display.

Modifying the setpoint

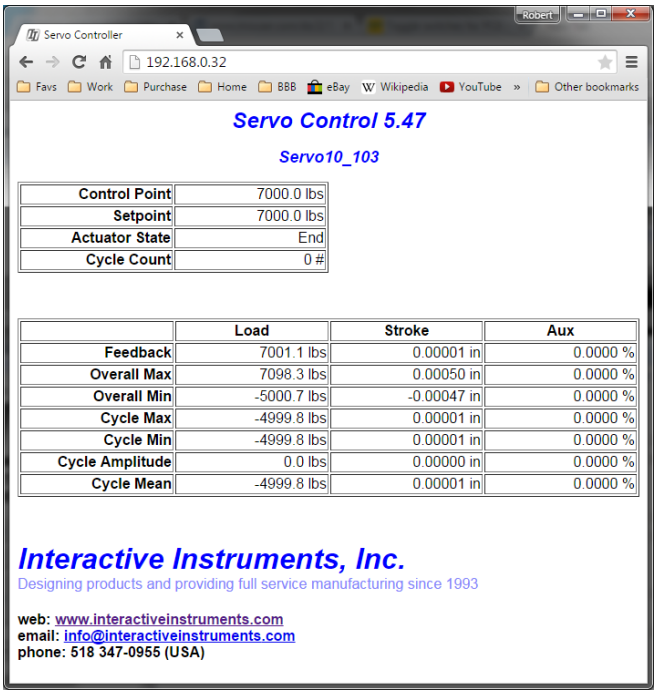
Press the Up or Down arrows while displaying the feedback data will jog the setpoint up or down. Holding the up/down arrows will slew the setpoint. Pressing a number on the keypad will display a prompt allowing the setpoint value to be reprogrammed.

Note: The setpoint can't be changed if the actuator is stopped. Restart the actuator then set the new setpoint.

Network Interface

WEB Server

The servo controller has a built in computer with a network interface. The computer contains a WEB server for the purpose remote monitoring of the current control and feedback parameters. To access the WEB page, identify the IP address of the servo controller using the "View Config" menu option under the "Network Config" menu. Enter the IP address in the WEB browser URL address bar and press enter. And the WEB page should display something similar to the following.



The current default WEB page automatically refreshes every 5 seconds so the data is somewhat current. To refresh more often, press the WEB page refresh key (F5 on most browsers).

The WEB page can be easily customized or enhanced to suit personal requirements. The WEB page layout and parameters can be customized using a simple HTML editor then saved in the controller's nonvolatile memory for future access. Multiple WEB page can be stored and linked together for unlimited flexibility. The default WEB page is named index.html, over writing it can replace the default WEB page with another. You can store different HTML file names in the controller for various WEB pages. For example an updated HTML document named "test.html" can be accessed by trailing the IP address in the WEB browser with "/test.html".

The various system parameters are updated to reflect the latest value every time the WEB page is refreshed. Standard HTML documents can embed various system parameters any place in the document as needed as shown above in the default page. The WEB server searches for special tags with the format ~[NNN] and replaces the string with the appropriate system or channel value (including appropriate units) by the number NNN. Using the {} braces instead of [] will replace the string with the same value without units. The system variables (0 to 999) can be found in the remote command 'j' list (*see Read System or Channel Value*) below. For example to display the current cycle count, in an HTML document, the text string ~[3] will be replaced automatically by the current cycle count value. Download the default HTML document from the controller to get an example how the various HTML documents are tagged.

To access the controllers default WEB page, use any FTP client program and connect using the controllers IP address. Log into the controllers FTP server using "root" as the username, no password is needed. Browse to the "/root/www" directory to find the default index.html document. Download it to a local computer and view the document in an HTML editor to see the various tags.

Any HTML document placed in the www directory can be accessed with a WEB browser even if it doesn't contain system variable tags. Try to keep custom WEB pages as small as possible, with minimal graphics so the WEB updates don't impact the servo controllers update speed. The WEB server is shared by the servo controller so high cyclic updates will be impacted by the large WEB updates.

Examples:

Some examples of WEB pages are already installed in the controllers WWW directory. Download or access the diag1.html and diag2.html for examples on how to view a wide range of controller and driver parameters at once. The web pages can be viewed by entering the browser URL xxx.xxx.xxx.xxx/diag1.html where xxx.xxxx.xxxx.xxxx is your controllers IP address.

Note: Be careful when accessing data using FTP, data files can easily be overwritten or deleted causing the controller to fail. Corrupted controllers may need to be sent to the factory for repairs.

Network Access

The controller can be controlled and monitored over the network as well. The controller monitors TCP/IP network port 50000 to allow the remote commands to be sent to the controller and the results returned as well remotely. More than one computer can access the port at the same time. See the list of remote commands below for more information.

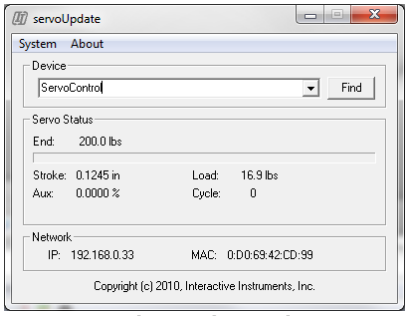
ServoUpdate Windows Application

The servo controller comes with a Windows application that makes it easy to identify various servo controllers on a local network, update the network configurations remotely and even update the controller firmware over a network. The servoUpdate application can automatically locate all controllers on a local network subnet and communicate with controllers on a different subnet as well. If the controller is addressable over the Internet, it is also possible to monitor a servo controller from anywhere.

Identifying Servo Controllers

When the Windows application is started, it send a command over the local subnet to find any controller and identify itself to the Windows application. Multiple controllers can respond and the device drop down list will identify them individually. Controllers beyond the local subnet can be accessed as well one at a time by manually entering the controllers IP address in the Device text box and pressing enter. As each device is linked, the servo controller status and network information will appear below. The servo status is updated regularly and should reflect the same information as the feedback display.

Note: Be sure the servo controller is powered up and activated before attempting to communicate over the network. After the servo controller is powered up, it displays a message to initialize the actuator or stay put. Select one of these options to activate the controller. If the servo controller is not active, it will ignore all network commands. This is a safety feature to restrict remote access until the operator has confirmed the system is ready.



servoUpdate Windows application

Network Configuration

Select the menu item “Network” from the “System” menu and the controller’s network configuration will be displayed. Feel free to change the servo devices name to something more appropriate, avoid using spaces in the name. You can use an underscore for a separator instead. Select DHCP if your local server supports it, the IP address will be automatically selected for you along with the subnet mask and default gateway. You can also select a static IP address if necessary for force the controller to a specific fixed address. Consult with your network administrator to see which would be more appropriate for you.

Firmware Update

The Firmware menu item under the System menu will prompt for a properly formatted firmware file supplied by Interactive Instruments. This file has an extension .BIN and can contain various data files such as driver and controller firmware, WEB pages, system files etc. The .BIN file also contains information where the file should be placed in the controller’s computer. Once the proper .BIN file is selected by the file dialog, it will be sent over the network to the controller, verified and then placed in the appropriate location. The control firmware will then automatically restart with the new firmware. The firmware will automatically configure itself to use the Copley servo driver or the Pac Sci servo driver depending on the hardware configuration of the controller.

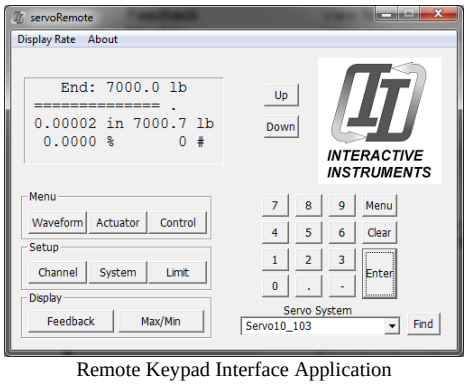
ServoRemote Windows Application

The servo controller also has a remote Windows Application that will allow an operator to remotely operate the controller over the network as though they are in front of the system. Any keypad function can be remotely operated just as it is done on the keypad panel. As the keys are pressed on the Windows app, commands are sent to the controller and the LCD responds with the results. Both the remote keypad and the panels keypad can be manipulated at the same time, pressing a key on the control panel will update both the LCD and any remote panel monitoring the servo system on the network. One application can monitor multiple systems just like the servoUpdate Windows app. Pressing the Find button will attempt to identify any and all systems on the local networks subnet. If the system is not on the local subnet, enter the IP address manually and press Find to connect. Use the standard IP address format with decimal point separators (eg. 192.168.0.100). Communicating over a slow network connection, it may be necessary to slow the display update rate to 2 updates/sec. Select the "Slow" rate from the menu "Display Rate" at the top of the application. Faster display rate is also available for local networks for 10 updates per second. The medium display rate is about 4 updates per second.

With the Windows app as the primary application, you can use your computer keyboard to enter the keypad commands remotely as long as the Windows app keyboard is not focused on the devices hostname text field. If it is, press the Tab key to move to another area of the app.

The 0 to 9 keys and the decimal point, minus, Up, Down and Enter can be entered directly. The other keys are mapped as shown below.

Computer Keyboard	Windows App	Operation
Home	Menu	Display controller menu
Backspace	Clear	Remove entered characters
F2	Waveform	Access the waveform menu
F3	Actuator	Access the actuator menu
F4	Control	Toggle between load and stroke control
F5	Channels	Setup channel menu
F6	System	System menu
F7	Limits	Limit menu
F8	Feedback	View feedback display
F9	Max/Min	View current control channel Max/Min



Remote Keypad Interface Application

Note: Be careful when operating the servo load frame remotely, if an operator is making changes locally, they can be seriously hurt if the controller behaves unexpectedly.

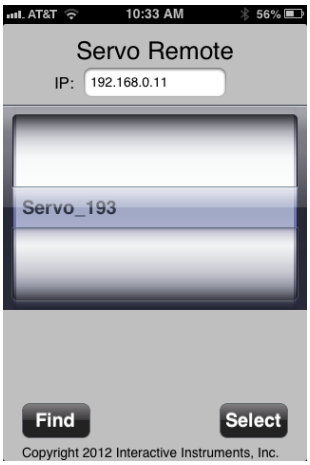
Note: You can dedicate an icon to the Windows desktop to one specific servo controller. This can be done by changing the properties of the Windows application or shortcut icon. Right click on the icon and select properties. Next to the application target "ServoRemote.exe" enter the IP address of the servo controller. For example "C:\AppPath\ServoRemote.exe 192.168.123.200". If the servo controller is available, it will be the default controller for the app on startup. Press Find to find the other controllers on the same subnet.

iPhone® Application

A free application is also available through Apple® iTunes store which will allow you to remote operate the servo controller from your iPhone®, iPad or iPod Touch®. For the application to work properly, the servo controller must be connected and configured properly for your local network. The iPhone/iPod must also have access to the same network as well either with a VPN network connection or Wi-Fi using a local Wi-Fi access point. It is helpful if both the servo controller and the iPhone are on the same subnet but it isn't necessary.

Download the application from iTunes application library by searching for "Servo Remote" and install it on your iPhone or iPod. Run the application and the display will prompt with a list of accessible servo controller on your local subnet. Spin the selector to the appropriate servo controller if more than one are identified and press Select. To access a computer on a different subnet, enter the controllers IP address in the IP: text box and press Select. The application will begin to communicate with the servo controller over the network and the controllers display information will be updated in real-time. Pressing keys on the keypad will send the commands to the controller and return the update LCD information similar to the Windows application.

Note: The servo controller can be programmed to disable the remote keyboard if needed to restrict access. While the remote keypad is disabled, the LCD information can still be viewed but remote key entries are ignored. To disable the remote keypad, enter the "System Menu" and select "Lock Remote Key". Once disabled, the only way to re-enable remote access is from the keypad on the servo controller.

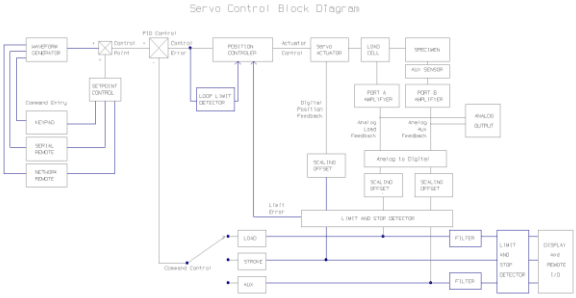


Block Diagram

The following is a block diagram of the basic internal structure of the Servo controller. The control input selector selects the desired input to the system. If the keypad is selected as the control then a keypad menu commands will control the unit. Selecting

Waveform allows the internal waveform generator to manipulate the control point. Placing the unit in Remote Mode allows a computer to control the desired control point.

The feedback switch selects which parameter is controlled. Selecting load as the feedback will place the unit in Load Control and adjust the motor to reduce the load error to zero.



Servo Control Block Diagram

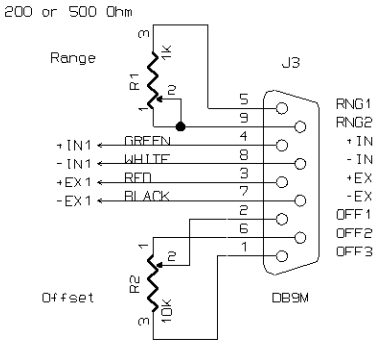
Load Cell Connection

The servo controller supports two type of load cell amplifiers, analog and digital (TEDS: Transducer Electronic Data Sheet). If your unit has a digital load cell amplifier (male DB9 pins) refer to the digital load cell amplifier option below. Analog load cell amplifiers use a female DB9 connector so the two types of load cell cables can't be exchanged accidentally.

Analog Port Connection

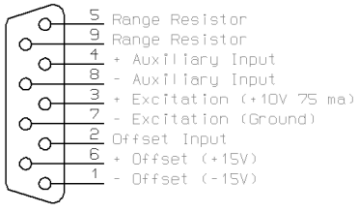
Two analog port connections are available on the bottom of the servo control panel to attach external sensors such as load or strain transducers. Once attached the output of the transducer is amplified for monitoring feedback or possibly as a control channel. The port A connector is typically used to interface with a load cell. The controller reads port A to measure and scale the system load. The port B connector is typically used to measure the specimen strain but can be used to measure almost any type of differential voltage or bridge sensor. Virtually any type of sensor can be attached with the use of an external signal conditioning amplifier.

The pins are arranged so common 3/8" (25 turn) trim pots can be easily attached to the DB9 port using solder or crimp connectors minimizing discrete wiring as shown below. Note Select a value of R1 that gives an acceptable range of gain for the particular sensor. For a typical 2 to 3 mv/volt bridge you can use a 200 ohm trim pot.



Analog Port A and B Calibration and Sensor Interface

Note: Port A and B are electrically identical. Port A is used primarily for the load cell while port B can be used for strain feedback or strain control.



Analog Port A and B Pinout

The input to the port is made between pin 8 (-) and pin 4 (+). The default amplifier gain is +/- 10.0 volts full scale. The gain of the amplifier depends on the value of the resistor between pin 5 and 9. To increase the amplifier gain, add resistance between pin 5 and 9. See the table below to select the appropriate gain.

Voltage Range	Range Resistor	Voltage Range	Range Resistor
+/- 10.0 V	Open	+/- 0.10 V	505 Ω
+/- 5.0 V	50.0K	+/- 0.05 V	251 Ω
+/- 2.0 V	12.5K	+/- 0.02 V	100 Ω
+/- 1.0 V	5.55K	+/- 0.01 V	50.0 Ω
+/- 0.5 V	2.638K		
+/- 0.2 V	1020 Ω		

Other ranges can be selected using the equation below.

$$Range\,\mathrm{Re}\,sistor = \frac{50000}{(10.0 / RangeVoltage) - 1}$$

The ports analog offset (zero control) can be adjusting by setting the voltage on the offset input (pin 2). Two pins are available that can be used to help set the offset voltage. Pin 1 and 6 output +15V and –15V and can be used to trim the offset voltage using a trim pot. With each end of the trim pot attached between +15V and –15V and the wiper attached to the offset pin, the offset can be trimmed to suit most needs. Large offsets may not be possible if the offset is significantly out of range.

Note: The excitation voltage is available to power a full bridge sensor such as a load cell. The excitation voltage is fixed at +10 volts and is able to deliver up to 75 ma. If the excitation is not needed then this pin can be ignored.

Digital Load Cell Amplifier option.

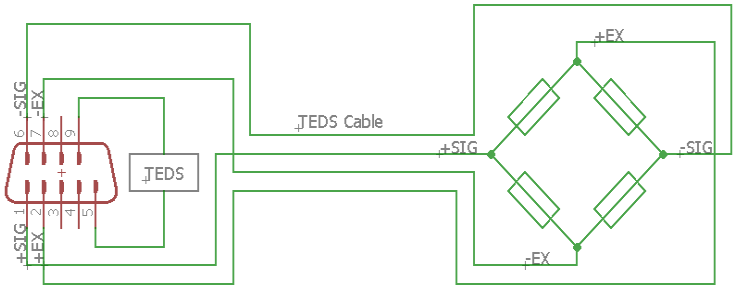
The digital load cell option replaces the standard two port analog interface and performs load cell measurements with a minimal amount of analog components, adjustments and amplifiers. The digital amplifier board uses a multichannel differential input 24 bit A/D converter ADS1256. The output of the load cell (and Aux channel sensor) is fed directly into the A/D differential inputs without analog amplification. The computer communicates with the A/D over a high speed SPI bus so the controller can program and monitor the A/D quickly. The A/D has an integrated programmable amplifier that is set to a gain of 16 so it can measure +/- 5.0 volts/16 or +/-0.3125 volts full scale. The A/D is capable of sampling +/- 23 bits (8388608 counts) or about 0.037 micro volts per bit. Given a typical load cell sensitivity is approximately 3.0 mv/v or about 15 mv full scale, the A/D has an approximate sampling resolution of +/-400,000 counts or roughly +/- 19 bits which is more than adequate for a 4.5 digit feedback resolution. The only analog adjustments on the digital amplifier board are the precision voltage reference for the A/D converter and two load cell excitation adjustments. Once the load cell voltage is sampled digitally, there is little chance the signal can be disturbed so the reading becomes less sensitive to load cell interference.

TEDS Hardware

TEDS, which stands for Transducer Electronic Data Sheet is a standard IEEE interface that provides a range of information about the type of sensor and calibration details. The information is stored in a 2 wire EEPROM in a standard format so a wide range of TEDS bridge sensors (load, pressure, displacement etc) can be exchanged with virtually any TEDS compatible equipment.

The TEDS sensor plugs into one of two DB9 connectors on the servo controllers load and aux channel, providing excitation (+5.0 volt) to the resistive bridge and a differential signal input back into the servo controller. Optionally the TEDS connector can include a calibration chip that provides details about the sensor such as type, range, sensitivity type and serial number. The TEDS information can be used to calibrate the sensor to the servo controller (described below) making calibrations simple without separate calibration load cells. If the TEDS calibration chip is not attached, the sensor can also be calibrated manually as described below.

A typical TEDS sensor is wired to a resistive bridge as shown below with a shielded cable,



Commented [RS1]:

Commented [RS2R1]:

Shunt Cal

A shunt cal button is available to perform a quick verification of the load cell calibration attached to port A.

Establishing the shunt cal value.

1) Calibrate the load cell. See the Calibration procedure for more information.
2) With the load cell on Port A properly calibrated and balanced at 0, insert a paper clip into the hole located below the port A connector. This will closes a switch placing a precision 59k resistor between the +excitation voltage and the +input. The resistor will unbalance the load cell bridge simulating a load.
3) Record the simulated load value displayed on the controller for future reference along with the digital load range and the load cell serial number. Once the shunt cal load value is known the load cell can be checked for proper operation and calibration.

Verifying the load cell calibration.

1) Power up the Servo controller and wait (~15 minutes) for the electronics and load cell temperature to stabilize.
2) Verify the load is removed from the load cell and the digital offset is set to zero. If the load cell does not read close to zero then adjust the load offset to balance the amplifier. Also check the load range is programmed to the same value used to establish the shunt cal. value.
3) Press the shunt cal. button with a paper clip and read the digital load on the controllers LCD. If this value is the same as the value recorded earlier then the load cell calibration is verified.

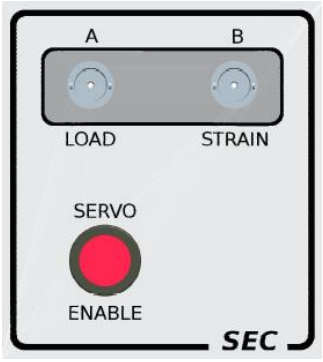
Minor load cell calibration adjustments can be made using the shunt cal. method by adjusting the load cell scale calibration in the connector. Large discrepancies should be accommodated by performing a complete calibration procedure.

The shunt cal. verify method is not a replacement for a proper periodic calibration procedure but is useful for verifying between scheduled calibrations

Note: Do not press the shunt cal. button while in load control or the controller will be fooled into thinking the load cell is loaded and the actuator will attempt to compensate.

Analog Output

Each of the two amplifiers have analog outputs that can be monitored with external instruments such as oscilloscopes, volt meters or analog acquiring systems. The port A amplifier which is typically used for the load cell can be monitored with the BNC connector on the front of the servo control panel. The Port B amplifier which is typically used for an extensometer can also be monitored with the BNC connector on the right.



The analog outputs for port A and B represent the signal that the controller sees. Each signal is a +/- 10 volt magnitude representing the full analog range of the sensor. If a 7500 lb. load cell is attached to one of the ports then the scale factor of the voltage out would be 7500 lb./10 volts or 750 lb. per volt. A 10K load frame would output 1000 lbs per volt.

Note: The two analog output ports for load and auxiliary can be calibrated for better accuracy if necessary. Both ports are currently calibrated so maximum load and maximum AUX output represents +/-10 volts out on the BNC connectors. The potentiometers on the left side of the control panel can be used to adjust the span and offset for each port.

Note: The digital load cell amplifier has a different output range than analog amplifier. The digital analog output range is 0 to 5 volts where 5 volts represents full tension load, 0 volts represents full compression load so zero force represents 2.5 volts.

Servo Enable

The red switch below the analog output ports enables the servo drive. When the switch is pressed in the drive applies power to the servo motor and the actuator position can be controlled by the servo controller. When the drive is disabled, the servo motor current is removed so actuator can't move. If a load is applied to the servo actuator when the drive is disabled, the motor may backspin, removing some or all of the load. Even though the servo motor is disabled, the servo controller still maintains the position of the actuator.

If the controller detects the servo drive is disabled or reports a fault, the controller will prompt with a message after a few seconds similar to the message below.

```
Servo Disabled
Press 1 to Ignore
  or 0 to Retry
```

If the servo drive is re-enabled, the message will automatically be removed and actuator control will resume. If the message doesn't clear when the drive is re-enabled, pressing 0 will attempt to enable the servo drive and resume actuator control. Pressing 1 will ignore the servo status error until the controller recognizes the servo becomes re-enabled.

If the DB9 servo communication cable becomes disconnected from the drive, it will prompt the message below after a few seconds.

```
Servo Disconnected
Press 1 to Ignore
  or 0 to Retry
```

Even though the cable is disconnected, actuator motion can continue as normal. Reconnect the DB9 cable and the message will automatically be removed. If the message doesn't clear when the drive is re-enabled, pressing 0 will re-attempt communications. Pressing 1 will ignore the servo status error until the controller recognizes the servo becomes enabled.

Note: *When you are working on the system and your hands are near the actuator, it is highly recommended to turn off the system power to prevent the actuator from moving. If the controllers power must be left on then you must disable the actuator by pressing in on the enable switch to toggle the driver off, preventing unexpected actuator motion. Verify the servo is disabled by observing the blinking green light on the rear of the servo drive.*

Calibration Procedures

Analog Amp Load cell calibration

Load calibration is accomplished by adjusting the load range and offset trim pots on the load cell connector plugged into the side of the load frame. Before calibrating the load cell a second load cell and external amplifier is needed as a reference. One of two methods can be used to perform the calibration.

1) With the Servo system properly warmed up (~15 minutes) Remove the load cell from the Servo and install it in another load controlling system that is considered a calibration standard. The load cell must still be attached to the servos internal load cell amplifier.
2) Add a calibration standard load cell and load cell in series with the servos load cell and use the servos load frame to apply the load.

Once a calibration system is set up to control the load with a calibration load cell in series, perform the following steps.

1) Adjust the load filter as low as possible and slow the maximum actuator rate to maintain an accurate load control.
2) Be sure the load cell is plugged securely into Port A connector on the servo controller and is screwed in place to make a good connection.
3) Check that the servos load range is configured properly in the load configuration menu and the offset is set to zero.
4) Allow time for the electronics and load cell to warm up and stabilize for approx. 15 minutes.
5) Set the load to zero (using the calibration standard, or disconnecting the load bar) and adjust the servos offset (zero) trim pot (O adjustment) on the load cell connector for as close to zero as possible.
6) Apply the maximum calibration load (in tension) using the calibration standard as the reference.
7) Adjust the span trim pot (S adjustment) on the load cell connector so the LCD feedback matches the calibration standard load.
8) Repeat with step 3 until the two load cells are close as possible. Once you can verify that both ends of the scale agree with the calibration standard, the system is properly calibrated.

Auxiliary Calibration

The Auxiliary data port can be calibrated the same as shown in the load cell calibration with the exception it is plugged into Port B connector and the reference depends on the type of sensor used.

Digital Amp Load Cell Calibration Procedure.

The load cell amplifier also contains a digital channel that can read the original load cell calibration information from the load cell cable. The load cell cable provided with the load cell contains a nonvolatile EEPROM that can be accessed by the controller.
Each cable is programmed by the load cell manufacturer in the standard TEDS data format with the load cell manufacturer, sensor range, serial number, sensitivity, sensor units and a number of other parameters. Given the load cell sensitivity (mv/v), the servo controller can use this value to extrapolate the expected sensors voltage for the load range. Once the TEDS information is read from the cable, it is stored in the controller so it can access it on power up. TEDS supports a wide range of sensor types such as linear displacement, pressure, temperature etc. Any of these sensors can be plugged into one of the two servo controller ports for monitoring and even control if applicable.

A/D TEDS Calibration

Digital Load Cell Range Calibration

Automatic calibration can be performed without the need for an external load reference. The procedure involves reading the load cell range and sensitivity values from the load cell cables EEPROM. If the load cell cable doesn't contain an EEPROM, calibration can be performed manually, see A/D Manual Cal procedure below. TEDS calibration is a good starting point for calibration, it isn't a replacement for a certified laboratory calibration procedure but it can be performed quickly and easily without an external calibration reference.

To perform the automatic calibration follow the steps below.

1) Be sure the load cell and matching cable (check serial numbers to be sure) are installed and plugged into the load port on the servo controller.

2) Select from the controllers menu "7) Setup", 2) Setup Channels" then 8) A/D TEDS Cal" from the menu.

3) The controller will request the channel to calibrate (Load or Aux channel only). Select Load Channel.

4) The controller will confirm that you want to re-program the load channel. Select 1 to confirm.

5) The controller will ask which load feedback units you would like to use. The controller will automatically convert the sensors units to the requested units. Since the controller knows the load cell range and units, the units conversion is automatic.

6) The controller will prompt with the EEPROMS load range before displaying the raw A/D span, offset and feedback voltages and load.

Digital Load Cell Zero

The load cell feedback can be zeroed while displaying the load cell feedback results by pressing "0" on the keypad. Be sure there isn't anything disturbing the load cell that may impact the load cell reading. The controller will sample the current load cell voltage and subtract the zero value from subsequent measurements. Zeroing the load cell does not impact the range calibration setting so zeroing can be performed at any time.

A/D Manual Calibration

You can perform a manual calibration with an external load calibration reference. This type of calibration doesn't require a matching TEDS load cell cable or even a cable with a TEDS EEPROM. The procedure requires a load cell calibration reference which may be a certified proving ring or a calibrate load cell with a matching amplifier and display.

1) Install the calibration standard reference in line with the actuators load cell so load can be applied to both at the same time.

2) Verify sure the actuator is roughly calibrated before switching to load control. The calibration procedure requires controlling the actuator using actuators load cell for feedback so the load cell should react properly and proportionally to applied forces. As long as the load cell sensitivity isn't very different than the previous calibration, the feedback should be close enough to control.

3) Switch the actuator to load control.

4) Check that the controller is in load control and be sure the actuator load cell is ready to zero so little or no load is applied to the load cell.

5) Select from the menu "7) Setup", 2) Setup Channels", "9) A/D Manual Cal".

6) Select the Load channel to calibrate the load feedback channel. The initial load cell sensitivity will be displayed as a reference, if it is about 15 mv it should be in an acceptable range for a 3mv/v load cell similar to the load cell supplied with the load frame. Press Enter to accept.

7) The controller requests the maximum desired load cell scale, the default is the previous load cell range. Enter a new value or press Enter to accept the default.

8) The controller will prompt with "Calibrate Zero?. Press "1" to accept and the controller will sample the load cell voltage and save it to be subtracted from future readings. After another prompt to verify the load cell is unloaded press 1 to continue.

9) The controller will prompt with the sampled load cell voltage, press Enter to accept or use the keypad to enter a different voltage. Pressing Menu will continue with the previous offset voltage.

10) The Controller will then prompt with a request to calibrate the load cell span, press "1" to confirm.

11) The controller will request a setpoint value (enter a value close to your maximum load calibration range. Because the load cell isn't calibrated yet, be sure your setpoint isn't too high by using your calibration feedback reading as a check. The two load cells will likely not match, this will be adjusted once the actuator load cell is properly calibrated. Press Enter to select the setpoint value.

12) The controller will prompt with a request for the actual calibration feedback from your calibration standard display. Enter the calibration standard feedback into the controller and the controller will calculate a load cell sensitivity reading that matches the calibration feedback value.

13) The controller prompts with the calculated load cell sensitivity and allows the operator to accept the default or modify it. Pressing Enter stores the sensitivity in the controller. Pressing Menu will continue with the previous scale voltage.

14) The display prompts with the load cells feedback span and offset information and updates it in real time. You can re-zero the reading by pressing “0” on the keypad. Once the span and offset are calibrated it is good to verify the controller load cell to the calibration standard. If adjustments need to be made, repeat the steps above starting at step 5.

Remote Commands

Remote commands (serial or network) can be sent to the unit to control the basic operation of the unit and collect data in real time. Using a basic set of commands, the servo controller can be programmed with the use of a computer to perform various operations. The default serial configuration for the Controller is 115200 baud, 8 data bits, 1 stop bit, and no parity.

Note: Commands are case sensitive, they behave differently if they are upper or lower case.

Below is a list of the remote commands along with a brief description of the command.

AC(RATE)	Set acquisition rate (samples/second)
Ac[RATE]	Read acquisition rate
AS	Disable data acquisition
AA	Make one sample
Ar[SAMPLES]	Read acquired data (samples to read, 0 for all)
AR	Clear acquisition memory
AM	Start automatic acquisition
AN	Reset acquire index to 0
An	Read current acquire index
AD(CHAN1,CHAN2,CHAN3)	Set 3 channel numbers to acquire
Ad[CHAN1,CHAN2,CHAN3]	Read the 3 acquire channels
+S	Set Servo Parameter
+s	Read Servo Parameter
+D	Set LCD Value Types
+d	Read LCD Value Types
+P	Download Programmable Waveform
+p	Read Programmable Waveform
.	Read servo status
a [LOAD,STROKE,AUXILIARY,TIME]	Read load, stroke, auxiliary, waveform time
B(CHAN,MAX)	Set max loop error
b (CHAN) [MAX]	Read max loop error
C(ON)	Set/Reset Remote control mode
C[ON]	Read Remote control mode
D(AMP)	Set waveform output
d [AMP]	Read waveform output
E(CHAN,U)	Set Units
e(CHAN) [U]	Read Units
F(SET)	Set Setpoint
f [SET]	Read Setpoint
G(CHAN,RNG)	Set Channel Range
g(CHAN) [RNG]	Read Channel Range
H	Reset Total peaks
h(CHAN) [TMX,TMN,CMX,CMN]	Read Total and Cycle peaks
I(CHAN,P,I,D]	Set PID parameters
i(CHAN) [P,I,D]	Read PID parameters
j(N)	Read system or channel value n
J(N)	Set waveform value n
K(CHAN,MAX)	Set Max Limit
k(CHAN) [MAX]	Read Max limit
L(CHAN,MIN)	Set Min Limit
l(CHAN) [MIN]	Read Min limit
M(KEY)	Send a keypad value to the controller
m	Read the 4 LCD lines
N(CHAN,FLT)	Set Channel Filter
n(CHAN) [FLT]	Read Channel Filter
O(CHAN)	Set Control Channel

o [CHAN]	Read Control Channel
P(CHAN,W,P1,P2,P3,P4,P5)	Set Waveform/Parameters
p(CHAN) [W,P1,P2,P3,P4,P5]	Read Waveform/Parameters
Q(STATE)	Set Waveform State
q [STATE]	Read Actuator State
R(TYPE,CHAN,ACT)[load]	Set Limit or Loop Action
r(TYPE,CHAN,ACT)[load]	Read Limit or Loop Action
s [RATE}	Read actuator rate
S(RATE)	Set actuator Rate
T	Reset waveform time to 0
t [TIME]	Read waveform time
u [BITS]	Read status bits in HEX format
v [VER]	Read software version
V(type)	Reset limit or loop limit tripped status flags
W(HOLD)	Set Waveform Hold state
w [HOLD]	Read Waveform Hold state
y [CYCL]	Read cycle counter
Z(CHAN,OFFSET)	Set Offset
z(CHAN) [OFFSET]	Read Offset
*IDN?	Display Manufacturer, Model, Serial, Firmware
?	Display brief Help

Note: Parameters in (parentheses) are input parameters and parameters in [square brackets] are returned parameters

When the servo controller is first powered up, it is in manual control. To place the unit in remote (serial or network) control mode, the command 'C1' followed by a return (CR) can be sent to the controller to lock out the keypad. The LCD prompts with an Asterisk '*' in the upper left corner identifying the remote mode is now enabled. To return back to manual control either press the (menu) command on the keypad, send the command 'C0(CR)', or cycle the power switch on the servo controller. When the controller is in remote mode, the keypad commands are ignored.

Commands can be sent to program the controller in various modes without having to select them from the control panel menu. For example to set the setpoint to 500 lbs, send the command O0 followed by a carriage return (CR) to select load control, if not already in load control. The response from the controller should be a CR to acknowledge the command. Invalid commands are ignored by the controller. A ZERO is often returned from bad parameters. Then send F500.0(CR) to program the setpoint to 500 lbs. To move the specimen actuator to a desired stroke of -.250 inches, send the command O1(CR) to select stroke control followed by F-0.250(CR) and the motor will move to this position within the limits of the unit.

Note: No <cr> is needed after commands that don't need a subsequent parameter, e.g.: a, d, f, H, m, o, q, s, t, T, u, v, w, y. The <CR> is only needed to terminate numerical entries.

Sending Commands

All commands begin immediately unless a number or a list of numbers are needed for the command. For example to read the three feedback channels and the waveform time, send the ASCII 'a' command without a CR terminator. All commands are case sensitive and can perform completely different operations depending on the case. If a command requires a parameter, the number is terminated with a carriage return (0D hex) to terminate numbers. If a return is not sent, the unit will wait until a non-number is received.

It is important to send the commands and numbers as quickly as possible because some controller operations are suspended until the data is completely received. While the controller is waiting for the complete command, background operations such as display updates are temporarily suspended. Once the command is completed normal operation resumes. This is typically only a problem while manually entering commands with a terminal interface. Using a computer to send and receive commands virtually eliminates the problem because commands can be entered instantaneously. Information transmitted from the controller will not hold up the background updates because the serial transmitter is performed in the background.

To send a list of parameters, each parameter is separated by a comma. For example to program the load PID parameters the following command can be sent 'I0,100,1,200' followed by a return to terminate the last number. This will program the load PID controller parameters with P = 100, I = 1, D = 200.

Set Servo Parameter (+S#,#)

Send servo parameter to Copley servo drive. The first value is the integer register number (from Copley documentation) and the second value is the value to be written to the register. See the Copley documentation for more information.

Read Servo Parameter (+s#)

Read the servo drive parameter from the Copley servo drive. See the Copley documentation for more information.

Set the programmable waveform (+P#,#)

Send programmable waveform values to the controller. The first line is an optional waveform name terminated by a carriage return. Following lines are of the form X,Y where X is the waveform amplitude (+/-1.0) and Y is the ramp duration in seconds. You can set 1 to 1000 entries (one per line) and the final entry is terminated with a blank line. Similar to USB waveforms, the time value isn't required if all the segments are of the same length of time.

Read the programmable waveform (+p)

Read the programmable waveform generator name and values.

Set Acquisition Rate (AC#)

Set the data acquisition rate. The rate can be programmed from 1000 samples per second to 1e-300 samples per second.

Read Acquisition Rate (Ac)

Read the current data acquisition rate. The returned rate is the number of samples per second.

Sample one data sample set (AA)

Sample one data sample set. This command is useful to sample data asynchronously so data is collected based on an event instead of time.

Read Acquired Data (Ar#)

Read acquired data in the form of CHAN1,CHAN2,CHAN3,TIME where CHAN1 to 3 are the desired sample channels and TIME is the sample time stamp. The default channels are LOAD, STROKE, AUX. You can read N number of samples from 1 to all 10,000. If you use 0 for the sample count, all sampled data values are read back. If the storage buffer isn't full, it will read back only the stored values. TIME is the floating point time in seconds with 0 referencing the start of the acquisition.

Note: Each line of data sets is separated by a CR. The last line in the data set is terminated with a CR, LF.

Stop Data Acquisition (AS)

Suspend data acquisition. Sampling can be restarted at any time using the AM command.

Clear Acquisition Memory (AR)

Clear Data acquisition memory and return the index to 0.

Start Data Acquisition Timer (AM)

Start timed data acquisition at the programmed data sample rate. Keep sampling until stopped or buffer fills. Up to 10,000 samples can be stored in memory.

Reset acquire index to 0 (AN)

Resets the data acquisition storage index to 0.

Read acquire index (An)

Reads current acquire index. Returns a number between 0 and 9999 to show the current number of data samples acquired.

Set the 3 acquired channel numbers (AD#,#,#)

Programs the 3 data channels which will be stored for each sample. The channel numbers are the same as used by the 'j' command. Avoid using 'j' commands that access the servo drive due to the time needed to access the data over the serial port .

Read the 3 acquired channel numbers (Ad)

Reads back the 3 acquire channel numbers. The values are same as used by the 'j' command. The default acquired channels are load, stroke and AUX feedback which are represented by channels 100, 200 and 300.

Read Servo Status (.)

Read servo motor status and return "0" if the servo is enabled and operating (no faults) If a problem has been detected with the servo motor or drive the status will return "1" if the servo is disabled, "2" if the servo drive has detected a fault and shut down, "3" if the servo drive has an internal problem and 4 if the servo drive is undetected (unplugged or powered down).

Read data (a)

Read the load, stroke, auxiliary feedback and the waveform time in seconds (since the waveform started). The data is collected together as closely as possible so the data is not skewed.

Read Maximum Loop Control Error (b#)
Set Maximum Loop Control Error (B#,#)

Reads and writes the maximum loop control error for a specific control channel. Reading or setting a max error first requires the channel number (0 - load, 1 - stroke, 2 - auxiliary) followed by the max parameter. Reading the command returns the Max error for the selected channel.

Be sure to set the appropriate loop error action to enable the limit. See set limit action 'R' for more information.
The max loop limit protects only the current control. Each channel has its own programmed loop limit and each is saved in nonvolatile storage but the current control channel is only channel that is monitored.

Enter Remote Control (C#)

Once the servo controller has been powered up the unit can then be placed in remote control by sending it the 'C1(CR)' command. The LCD will display an asterisk in the upper left corner in place of the waveform sign status to show the unit is being controlled remotely. Once in the remote command mode, the commands come directly from the serial port or the network, not from the keypad. To exit the remote command mode either press the Menu button on the control panel, send a C0(CR) command or powering down the control panel. If the controller is not placed in remote mode, the keypad can modify system parameters at the same time.

Read waveform output value (d)
Set waveform output value (D#)

Read or set the current internal waveform generator output value. This value is typically updated by the waveform generator when the generator is operating. This value is added to the setpoint internally to create the control point. If the waveform is stopped the waveform output can be modified otherwise the output value is maintained by the waveform generator.

Read Units (e#)
Set Units (E#,#)

Read or set the channels units. To read a channel units send the command "e" followed by the channel number (0: load, 1: stroke, 2: auxiliary). The number returned represents the display units as shown in the table below. To set the display units send the "E" command followed by the channel number then an index from the table below. For example, "E0,2" will set the load channel units to kN.

Index	Load	Stroke	Auxiliary
0	lb	in	%
1	kp	cm	V
2	N		in
3	kN		cm
4	kg		lb
5			kp
6			N
7			kN

Note: Changing the load or auxiliary display units will not automatically scale the data range to match the new units. Be sure to modify the load or auxiliary range to reflect the proper unit scale.

Read Setpoint (f)
Set Setpoint (F#)

Read or set the setpoint value. The setpoint value is used as a base reference for the waveform generator. The signal that comes from the waveform generator is added to the setpoint to derive the control point.

Read Channel Ranges (g#)
Set Channel Ranges (G#,#)

Reads and writes the range or the positive full scale value of a channel. Reading or setting a range first requires the channel number (0-load, 1-stroke, 2-auxiliary). Reading the channel range returns the maximum value allowed by the channel. Writing the

channels range will program the data channels maximum value. Adjusting the channel ranges does not affect the analog voltage output only the digital scaling factor.
Note: Since the stroke channel is fixed digitally, stroke range is not adjustable.

Reset Total Max/Min's (H)
Read Max/Min's (h#)

Reset the total peak readings to the current feedback value or read the total and cycle peak readings for the specified channel.
The controller continuously monitors the filtered load, stroke and filtered auxiliary feedback values 1000 times a second. Any time a value exceeds the currently stored value the new value is recorded in its place. Cycle peaks are maintained on a cycle by cycle bases. Once a cycle completes (determined by the waveform generator), the current cycle peak results are saved and the current peak detector is reset to the current feedback values. This method requires two sets of registers. The first set used to establish the current cycle peaks and the second is used to display the previous cycle peak results once the cycle is complete.
To read the current peaks send the command "hn" where n is the desired feedback channel. The controller responds with 4 numbers. The first two are the overall max and min values since the waveform was started or the "H" command was sent. The second two are the peaks for the previous waveform cycle. The peak monitor is useful to verify that controller performed as expected.

Read PID Parameters (i#)
Set PID Parameters (I#,#,#,#)

Read or set the PID parameters for a specific channel. To read the PID parameters send the command 'i' followed by the channel number (0: load, 1: stroke, 2: auxiliary) and a carriage return. The controller will return with the Proportional, Integral and Differential parameters.
To set the PID parameters send the command 'I' followed by the channel number and the proportional, differential and integral terms. If the PID parameters are for the current control channel then they will be used immediately. See the "PID Parameters" under "Setup" above for more information on adjusting the parameters.

Read system or channel value (j#)

Reads an internal value or servo drive parameter. The table below represents the values that can be read using this command.
Note: Multiple parameters can be accessed with a single command line by separating a list of parameters with commas terminating the last parameter with a carriage return. For example to read parameter 1, 2 and 3 (control point, amplitude, setpoint) enter the command "j1,2,3<CR>" and the controller will return with the 3 values separated by tabs.

System Variables

Index	System Variable
0	Control Point (Waveform output + setpoint)
1	Waveform output
2	Setpoint
3	Cycle Count
4	PID Proportional Term
5	PID Integral Term
6	PID Differential Term
7	Control Channel
8	Current Waveform Type
9	Actuator/Waveform State (0:Stop,1:Run1,2:Hold1,3:End,4:Off,5:Run2,6:Hold2)
10	Maximum Actuator rate

11	Waveform Time (seconds)
12	System status Bits
13	Waveform Paused State
14	PID output value
15	Control error (Feedback error in control units)
16	Current Actuator Rate (stroke units/minute)
17	Limit Tripped Status (None: -1, Load: 0, Stroke: 1, Aux: 2, Control Loop: 3)
18	Limit Tripped Action (None: 0, Reset: 1, Unload: 2, Transfer and hold: 3, Stop: 4, Off: 5)
19	Limit Tripped Time (relative to waveform time)
20	Network Type (0: DHCP, 1: Static)
21	Load Bar (0 to 100%)
22	Run Time (seconds since controller started)
23	Setpoint Slew Time (seconds)
24	Total System Stroke
25	Total System Time
26	Total System Cycles
27	Resettable Stroke
28	Resettable Time
29	Resettable Cycles
30	Waveform State (0:Stop, 1:Run, 2:Hold, 3:Finishing, 4:End)
31	Actuator State (0:Stop, 1:Active, 2:Off, 3:Fault)
32	Constant Amplitude Control (0: Disable, 1: Enable)
33	Waveform in-cycle time (seconds)
34	CA Setpoint Adjustment
35	CA Amplitude Adjustment
36	Servo Driver Current
37	Servo was homed since power-up

Channel Variables (x = 1 for load, 2 for stroke or 3 for auxiliary channel)

Index	**Channel Variable**
x 00	Channel Feedback (filtered)
x 01	Channel Range
x 02	Channel Offset
x 03	Filter factor
x 04	Units
x 05	Overall Maximum
x 06	Overall Minimum
x 07	Cycle Maximum
x 08	Cycle Minimum
x 09	Cycle Amplitude
x 10	Cycle Mean value
x 11	Max Limit
x 12	Min Limit
x 13	Limit error Action
x 14	Current loop error
x 15	Loop error Action
x 16	Limit error unload value
x 17	Loop error unload value
x 18	PID proportional gain constant
x 19	PID Integral constant
x 20	PID Differential constant
x 21	Waveform Amplitude
x 22	Waveform Frequency
x 23	Waveform Ramp Endpoint #1

x 24	Waveform Ramp Endpoint #2
x 25	Waveform Ramp Rate #1
x 26	Waveform Ramp Rate #2
x 27	Waveform Trapezoid Hold time #1
x 28	Waveform Trapezoid Hold time #2
x 29	Waveform Type
x 30	Waveform Envelope Start Time (seconds)
x 31	Waveform Envelope Reset Time (seconds)
x 32	Currently at Max Limit
x 33	Currently at Min Limit
x 34	Currently at loop Limit
x 35	Max Limit Tripped
x 36	Min Limit Tripped
x 37	Loop Error Tripped
x 38	Control Stop Max
x 39	Control Stop Min
x 40	Channel Setpoint
x 41	Cycle Count Limit
x 42	TEDS Manufacturer
x 43	TEDS Serial Number
x 44	TEDS Units
x 45	TEDS Max value (value at max TEDS voltage)
x 46	TEDS Max voltage output (sensitivity, mV)
x 47	TEDS voltage offset (mV)
x 48	TEDS output voltage (mV)
x 49	Peak Detector Time Interval (ms)

For example to read the load feedback send the command j100. The controller will return with the current load feedback value.
Note: Some variables can be read using direct commands but variables such as cycle amplitude and mean can only be read using this command.

System strings can also be accessed as well. Strings are variables that don't fit into a numerical value such as the products name, IP address etc. A list of variables can be accessed using the list of variables below.

Index	**String Variable**
400	Product Name and firmware Version
401	Setpoint (with units)
402	Load (with units)
403	Stroke (with units)
404	Aux (with units)
405	Load Units
406	Stroke Units
407	Aux Units
408	Control Channel
409	Network IP Address
410	Network MAC address
411	Network Subnet Mask
412	Network Gateway Address
413	Network host name
414	Last Limit Trip
415	Last Limit Action
416	Actuator State
417	Setpoint

Other internal system driver variables can be accessed as well for diagnostics (500 – 899).

The Copley Servo drive parameters can be read using this command. Servo parameters can be accessed at any time. Refer to the Copley XPL-230 manual for a list of these parameters and the units associated with them. To isolate the servo drive parameters from the system and channel parameters, the servo drive parameters are numbered 1000 and up. For example to access the temperature parameter (XPL-230 drive parameter 32), issue the command j1032<CR> and the servos heat sink temperature (in degrees C) will be returned. These commands will require serial communication with the servo drive so they may be slow to respond to numerous commands.
Note: If a parameter can't be accessed because it is an invalid ID or the servo drive serial cable is disconnected, the software will return "nan" for not a number.

Write system and channel value (J#)

Writes to a selected system or channel internal values and servo drive parameter. The table below represents the values that can be written using this command.

System Variables

Index	Variable
1	Waveform Generator Output
2	Setpoint
3	Cycle Counter
4	Current PID Proportional Value
5	Current PID Integral Value
6	Current PID Differential Value
7	Control Channel
8	Current waveform type
9	Actuator State
10	Actuator Rate
13	Waveform Pause
23	Setpoint Slew Time (seconds)
32	Constant Amplitude Control (0: Disable, 1: Enable)
38	Peak Servo Current (Copley Only)
39	Max Servo Current (Copley Only)

Channel Variables (x=1 for load, 2 for stroke or 3 for auxiliary channel)

Index	Variable
x 01	Range
x 02	Offset
x 03	Filter
x 04	Units
x 11	Max limit
x 12	Min limit
x 13	Limit action
x 14	Max Loop limit
x 15	Loop limit action
x 16	Limit unload value
x 17	Loop error unload value
x 18	Channel PID Proportional
x 19	Channel PID Integral
x 20	Channel PID Differential
x 38	Control Stop Maximum
x 39	Control Stop Minimum
x 45	TEDS Max Value (value at max TEDS voltage)
x 46	TEDS Max Output Voltage (sensitivity, mV)
x 47	TEDS Max Offset Voltage (offset, mV)

Waveform Channel Variables (x=1 for load, 2 for stroke or 3 for auxiliary channel)

Index	Variable
x 21	Waveform Amplitude
x 22	Waveform Frequency
x 23	Waveform Ramp Endpoint #1
x 24	Waveform Ramp Endpoint #2
x 25	Waveform Ramp Rate #1
x 26	Waveform Ramp Rate #2
x 27	Waveform Trapezoid Hold time #1
x 28	Waveform Trapezoid Hold time #2
x 29	Waveform Type
x 30	Waveform Envelope Start Time (seconds)
x 31	Waveform Envelope Reset Time (seconds)

For example to modify the stroke waveform frequency to 0.012 Hz send the command "J222,0.012". The waveform controller will immediately adjust to the new frequency.
Note: It is possible to modify the waveform parameters without disabling the generator be careful switching between cyclic and ramp type waveforms. It is recommended the waveform generator is disabled before switching in and out of ramping functions or using the P command to properly initialize the entire waveform.

The Servo drive parameters can be modified at any time. Refer to the Copley XPL-230 manual for a list of these parameters and the units associated with them. To isolate the servo drive parameters from the system and channel parameters (1 - 1000), the servo drive parameters are numbered 1000 and up. For example to modify the "continuous current loop" servo drive parameter to 10.00 amps, send the command J1034,1000<cr>.
The parameter modifications are only temporary. Parameters are restored to the original value when the servo drive is powered down. Not all servo drive parameters can be written too. Refer to the XPL-230 manual for more information.
Note: *Be very careful when modifying some of the parameters because they can have a significant impact on control stability.*

Read Max limit (k#)
Set Max limit (K#,#)
Read Min limit (l#)
Set Min limit (L#,#)

Reads and writes the maximum or minimum channel limit. Reading or setting a limit first requires the channel number (0 - load, 1 - stroke, 2 - auxiliary) followed by the max or min parameter. Reading the command returns the Max or Min limit for the selected channel.

Be sure to set the appropriate limit action to enable the limit. See set limit action 'R' for more information.

The limits protect not only the current control channel limits but the indirect channels as well. The limits are saved in nonvolatile storage so be sure to reset them back to the default after modifying them.

Read LCD data (m)

Reads the 4 lines of the LCD with a carriage return terminating each line for a total of 84 characters (21 per line).

Send Keypad character (M#)

Send a single keypad character to the controller simulating a key being pressed on the keypad. Valid ASCII characters are 0 to 9, decimal point and dash. Letters are used for the other keys so “A” is used for enter, “B” for menu , “C” for up arrow and “D” for down arrow. This command in conjunction with the **Read LCD data** command allows remote access to the controller over a network link.

Read port filter factors (n#)
Set port filter factors (N#,#)

Reads and writes the filter value of a channel. Reading or setting a filter value first requires the channel number (0-load, 2-Auxiliary). Reading the channel range returns a number representing the current filter value. Writing the channels filter will program a digital filter for the desired channel. At times it is useful to filter the data from a channel to remove noise. Be careful about over filtering the data because it can also remove useful information from the data. Adjusting the channel filters do not affect the analog voltage output only the digital values.

Filter Values with associated filter frequency

0 – None	5 – 5 Hz.
1 – 80 Hz.	6 – 2.5 Hz
2 – 40 Hz	7 – 1.25 Hz
3 – 20 Hz	8 – 0.625 Hz
4 – 10 Hz	

Note: Since the stroke channel is created digitally this channel should not require filtering.

Read Control Channel (o)
Set Control Channel (O#)

Read or set the current control channel. (0 = Load, 1 = Stroke, 2 = Auxiliary). When a transfer takes place the new control feedback value is used as the new setpoint for minimal movement of the actuator.

Set Waveform Parameters (P#,#,#,#,#,#,#)
Read Waveform Parameters (p#)

Set and read the waveform parameters. The number of parameters depends on the type of waveform. Cyclic waveforms require 4 parameters. The first parameter is the channel number (0-load, 1-stroke, 2-auxiliary) since each channel maintains its own waveform generator parameters. The second parameter contains the type of waveform 0 to 5 for the 6 cyclic waveform types. See the table below for the types of waveforms. The third and fourth parameters contain the amplitude (in control channel units) and frequency (in Hz.) of the waveform. Ramps require the same channel number and wave type (6) and the end amplitude (in control channel units) and ramp rate (in control channel units/sec). The dual ramp requires the same as the single ramp but the type is 7 and the second ramp parameters (end amplitude and rate) follow after the first ramp parameters. The trapezoid contains 7 parameters. It requires the channel, waveform type (8), the amplitude, ramp rate and hold time (in seconds) followed by the second ramp rate and hold time.
The table below identifies the parameters for each type of waveform.

Waveform	Type Par #2	Par #3	Par #4	Par #5	Par #6	Par #7
Sine	0	Amplitude	Freq.			
Square	1	Amplitude	Freq.			
Triangle	2	Amplitude	Freq.			
Haver Sine	3	Amplitude	Freq.			
Haver Square	4	Amplitude	Freq.			
Haver Triangle	5	Amplitude	Freq.			
Single Ramp	6	End Amplitude	Rate			
Dual Ramp	7	End Amp #1	Rate #1	End Amp #2	Ramp #2	
Trapezoid	8	Amplitude	Rate #1	Hold #1	Rate #2	Hold #2
External	9	Amplitude	Offset			
Programmable	10	Amplitude	Freq.			

Once the waveform parameters are programmed the waveform needs to be started with the waveform state control (Q).

If the parameters (waveform type, frequency amplitude etc.) are reprogrammed while the waveform is running, the new parameters take place immediately without resetting the waveform generator. This is useful to modify the test frequency or ramp rate on the fly.

Use the j or J command to read or modify the Start/Reset Envelope time for each channel. For example to set the load waveform start time to 5.234 seconds, enter the command J130,5.234<CR>. Each control channel maintains a separate start and reset time as well.

Note: See the Important Servo Maintenance Requirement section above for cyclic testing

Set Waveform State (Q#)
Read Actuator State (q)

Set the waveform generator state or read the actuator state. The table below identifies the actuator state with the state numbers. The waveform state becomes negative when LED status indicator flashes. (eg. if the actuator is running while the status LED blinks, the state becomes -1).

Actuator states (read only)

0 - STOP	Actuator Control stopped
1 - RUN1	Waveform or ramp is running
2 - HOLD1	First trapezoid hold state
3 - END	Waveform or ramp finished
4 - OFF	Actuator is powered off
5 - RUN2	Second trapezoid (or dual ramp) ramp running state
6 - HOLD2	Second trapezoid hold state

Waveform states (write only)

0 - START	Start programmed waveform (if on hold then release hold)
1 - HOLD	Hold waveform timer (restart using START state)
2 - FINISH	If Cyclic or Trap: Complete waveform and stop If Single or Dual Ramp: Program setpoint to the current control point
3 - RESET	Reset waveform output to 0 and quickly returns to setpoint
4 - STOP	Stop waveform generator timer and transfer to stroke control.

Set Limit Action (R#,#,#,#)
Read Limit Action (r#,#)

Set and read the limit or loop limit action for each channel. Reading or setting the action value requires the action type (0=limit, 1=loop), channel number (0-load, 1-stroke, 2-auxiliary). Reading the action returns the value shown below. To set the action, send the corresponding value after the action value and channel number. The actions are stored in nonvolatile memory. To set the unload action add the unload value as an added parameter. Reading an unload action returns the unload value as the final parameter.

Action Type	Description
0 - Limit	The following action is used if the channels limit is exceeded
1 - Loop Error	The following action is used if the loop error is exceeded

Once an action is tripped, the action is automatically reset to ignore.

Limit Action	Description
0 - Ignore	Ignore Limit
1 - Reset Waveform	Reset Waveform Generator
2 - Unload	Switch to load control and control to a programmed load
3 - Xfer and Hold	Switch to the limited channel program the setpoint to the limit
4 - Stop	Switch to stroke control and hold current position
5 - Actuator Off	Servo Drive is powered off

Loop Error Action	Description
0 - Ignore	Ignore Loop Error
1 - Hold Waveform	Hold Waveform Generator
2 - Finish Waveform	Finish Waveform Generator
3 - Reset Waveform	Reset Waveform Generator
4 - Unload	Switch to load control and control to a programmed load
5 - Stop	Switch to stroke control and hold current position
6 - Actuator Off	Servo Drive is powered off

Note: The unload action requires an extra parameter which is the load setpoint value. When setting this action remember to add the load value as the last parameter. Reading the unload action returns the load as a second parameter.

Read actuator rate (s)
Set actuator rate (S#)

Read and set the maximum allowed actuator rate in inches per minute or centimeters per minute. The new rate will be stored in nonvolatile storage. To set the actuator rate to 15.2 in/min. send the command "**S15.2**" followed by a carriage return. Rates that exceed the limits of the unit will be limited to the valid range. The fastest recommended rate is 75.0 in/minute and the slowest is 0.00001 in/minute. Note the actual rate may be slightly faster due to rounding with the internal 100 ns timer resolution.

Reset Waveform timer (T)
Read Waveform timer (t)

Read or reset the waveform and ramp timer to see how long the waveform has been running. When the waveform is started the waveform time is automatically set to 0. Pausing the waveform will temporarily stop the waveform timer as well. Resetting the waveform timer will also reset the waveform cycles to zero.

Read Controller status (u)

Read the state of the controller. The returned status is a single number (in HEX format) representing which controller status bits are set and reset.

The table below identifies the status bit to the internal control mode.

Bit	Status
0	Limit Tripped (Set if any max/min limit or any loop error is tripped)
1	Currently at Max Load (automatically reset when condition is resolved)
2	Currently at Min Load (automatically reset when condition is resolved)
3	Currently at Max Stroke (automatically reset when condition is resolved)
4	Currently at Min Stroke (automatically reset when condition is resolved)
5	Currently at Max Auxiliary (automatically reset when condition is resolved)
6	Currently at Min Auxiliary (automatically reset when condition is resolved)
7	Waveform Finishing
8	Keyboard Locked (via key switch)
9	Waveform pause Mode
10	Remote Control mode
16	Max load limit tripped
17	Min load limit tripped
18	Max stroke limit tripped
19	Min stroke limit tripped
20	Max auxiliary limit tripped
21	Min auxiliary limit tripped
22	Max load loop control error tripped
23	Max stroke loop control error tripped
24	Max auxiliary loop control error tripped
25	Max Loop Limit Tripped
26	Max Load Control Stop
27	Min Load Control Stop
28	Max Stroke Control Stop
29	Min Stroke Control Stop
30	Max Aux Control Stop
31	Min Aux Control Stop

Reset all action alarm flags (V#)

The controller maintains the limit and loop error alarm status even after the error has been removed. To reset all max/min limit latches enter the command V0 followed by a CR. To reset all loop limit latches enter the command V1 followed by a return.

Firmware Version (v)

Access the unit's firmware name and version number. For example version 5.01 is returned as "`Servo 5.01`" followed by the build time and date.

Read waveform pause status (w)
Set waveform pause status (W#)

Read or set the waveform pause status. Setting the pause status to 1 will suspend the waveform timer placing the waveform on hold. Setting the status to 0 will release the pause and continue running the waveform generator. While in pause, the motor controller will be active so any change in the control feedback will result in motion form the actuator.

Note: this pause is not the same as the trapezoid hold status. The trapezoid hold must continue to run the waveform timer to determine when to begin ramping. Waveform pause can be used with the trapezoid temporarily suspending the trapezoids hold timer.

Restart Firmware (X#)

X0 to restart firmware (warm boot), X1 to reboot controller (cold boot).

Read cycle count (y)

Read the cycle count. The cycle counter is a 32 bit counter counting up to 4,294,967,295 cycles before overflowing back to 0. To reset the counter, you must reset the waveform timer to 0.

Read Channel Offsets (z#)
Set Channel Offsets (Z#,#)

Reads and writes the offset of a channel. Reading or setting the offset first requires the channel number (0-load, 1-stroke, 2-auxiliary). Reading the channel offset returns the value that is currently added to the scaled channel data. It is sometimes necessary to change the channels offset to better represent the actual measured results. For example the load offset can be modified to remove the weight of a test grip or the stroke offset can be programmed to reposition the zero position. The load and aux default zero offset is zero but stroke default is –1.6250" for the Model 5k/10k (-1.7500" for Model 15K) so position 0 is mid stroke.

Help (?)

Displays a brief list of available commands.

Identify (*IDN?)

Displays the standard product information in SCPI format. Displays the manufacturer, model, serial number and firmware versions. Helpful to identify servo controller type and functionality.

Error Conditions

While returning the actuator to home, if the controller detects a servo error, the display will prompt with the error and the LED will blink rapidly. The following descriptions explain each error condition:

"Servo Disabled"

If the servo drive is disabled. Verify the servo is enabled (front panel) and the servo is properly cabled.

"Servo Fault"

The servo driver has detected a fault condition. Check the servo driver manual (Pacific Scientific PC834 or Copley XPL-230-40) for more information on resolving the fault condition.

"Servo Unconfigured"

The servo driver is not configured properly, see Interactive Instruments for help.

"Servo Disconnected"

The servo controller isn't able to communicate with the servo driver (Pacific Scientific (DB9) or Coley (RJ11)). Verify the proper attachment of the servo driver cable.

Servo Specification

5K Load Frame:
Maximum peak actuator load 7500 tension (2000 lbs. compression)
Maximum continuous actuator load is 5500 lbs. tension
Maximum actuator stroke range is 3.25 inches
Maximum actuator rate is 75.0 inches per minute
High performance brushless servo motor for rugged long term reliability
Can be mounted in virtually any position
Power requirements 110 Volts 5 amps peak, 1.5 amps Nominal
Load frame weight 152 lbs, controller and drive weight 18 lbs
Load frame height is only 28 inches
Load resolution: 0.22 lbs.
Stroke feedback resolution: 1.9074e-6 inch (Pac-Sci 1.525e-5 inch)
Stroke control resolution: 1.9074e-6 inch (Pac Sci 3.8147e-6 inch)

10K Load Frame:
Max peak actuator load 10,000 tension (2000 lbs. compression)
Maximum continuous actuator load is 10,000 lbs. tension
Maximum actuator stroke range is 3.25 inches
Maximum actuator rate is 75.0 inches per minute
High performance brushless servo motor for rugged long term reliability
Can be mounted in virtually any position
Power requirements 110 Volts 5 amps peak, 3 amps Nominal
Load frame weight 182 lbs, controller and drive weight 18 lbs
Load frame height is only 32 inches
Load resolution: 0.31 lbs.
Stroke feedback resolution: 1.9074e-6 inch (Pac-Sci 1.525e-5 inch)

15K Load Frame:
Max peak actuator load 20,000 tension (2,000 lbs. compression)
Maximum continuous actuator load is 15,000 lbs. tension
Maximum actuator stroke range is 3.50 inches
Maximum actuator rate is 30.0 inches per minute
High performance brushless servo motor for rugged long term reliability
Must be mounted vertically with the motor up or down, not horizontally
Power requirements 110 Volts 7 amps peak, 5 amps nominal
Load frame weight 235 lbs, controller and drive weight 18 lbs
Load frame height is only 30.1 inches
Load resolution: 0.1 lbs., Stroke resolution: 1.2014e-6 inch

Instrumentation:
Load is measured via mounted pancake load cell or external S-beam load cell
Rack mountable servo drive and servo controller
2 adjustable internal amplifiers with external ports for remote data logging
Shunt calibration button is available for quick load cell verification
Analog load and auxiliary is measured using a 16 bit analog to digital converter
Programmable digital filter ranges from 0.625 Hz to 80 Hz
Results are displayed in Metric or English or custom units
Remote operation and data monitoring using integrated RS-232 serial port
Ethernet control and WEB port monitoring

Controls:
Waveform generator supports sine, square, triangle and havercycle functions
Cyclic rates from 10^{-300} Hz to 30 Hz (conditions permitting).
Ramp generator supports single, dual and trapezoid functions
Ramp rates from 10^{-300} in/min or 10^{-300} lbs/min or faster
LCD panel constantly displays load, stroke auxiliary data in real time
Load control accuracy < 0.05% full scale
Stroke control accuracy < 0.004% full scale
Adjustable digital PID control algorithm precisely maintains control point
Maximum actuator response rate is adjustable from 0.00001 to 30 or 75 in/min
System parameters are stored in flash memory
Programmable max/min limits, loop limits and control stops

Software:
Analog data channels are scaled and offset to match any display units.
Fully programmable waveform and ramp controller
Control loop error can be monitored for excessive values
Programmable high and low limits with programmable actions
Programmable Control Stops to restrict feedback conditions
Overall and cycle peak monitors for each channel
Graphical application interface (LabVIEW, Visual Basic etc.) via serial or network

Electronics:
200 MHz, ARM9 Controller with TS-Linux 2.4.26 Operating System
32M RAM, 32M of Flash storage
1 10/100 Ethernet Port
2 USB 2.0 (12 Mbit/s max) ports
16 key keypad for function selection and parameter entry
Audio Beeper and LED to signal operation status
2 channel high speed 16 bit Analog to Digital converter
Optional high resolution (19 bit) A/D converter
Optional TEDS sensor interface for both load and AUX channels
RS-232 serial interface adjustable to 115200 baud
4 line by 20 character LCD panel
Copley Xenus Plus XPL-230-40 Servo driver for smooth reliable control
Digital servo feedback for accurate and reliable control

Troubleshooting

LCD does not display information

- Check to see that the main power switch on the servo drive panel is on.
- Verify the power cord from the servo drive is plugged into the servo controller and the servo drive is plugged into an outlet.
- Verify that wall socket is getting power. Avoid ground fault interrupt (GFI) protected outlets or electrical noise from the servo drive may falsely trip the breaker.
- Controller may take up to 20 seconds to boot up from power-up.

System Error is displayed

- See that the controller cable is securely plugged into the control panel and the load frame.
- Check that the load cell is properly connected
- Be sure the load, stroke or auxiliary channels are not limited

Actuator will not move

- Check that the controller cable is plugged securely into the control panel and the servo drive
- Be sure the 2 cables from the servo drive are plugged securely into the servo motor
- Make sure that the load, stroke or auxiliary is not out of range
- Be sure the controller is not paused or stopped.
- Check to see if the servo motor is disabled. If so press the Enable button on the control panel

Has trouble controlling load

- Slow the maximum actuator rate so it does not move for any little control error
- Adjust the load filter to minimize noise
- Retune the PID control parameters to stabilize the controller.
- Be sure the specimen is properly anchored
- Check to see that the load cell cable is properly inserted at both ends.

Stroke Limit reached before the end of test

- Reset the actuator to a higher position before starting a test.
- Make sure the control stops aren't set too close restricting stroke
- Verify the servo actuator was homed properly after power-up

Actuator will not initialize

- Check to see if the servo motor is disabled. If so press the Enable button on the control panel
- See that the controller DB9 and DB26 cables are securely attached to both the controller and servo drive.

Keypad is not accepting keys

- The remote mode may be programmed to prevent keypad modifications. See the remote 'C' command for more information.
- Check to see if the Keypad is locked. Press and hold any key for 3 seconds to unlock.

Limited Warranty

Interactive Instruments, Inc. warrants the **Servo Controller and Load Frame** against defects in material and workmanship for a period of *one* year from receipt by the end user. If Interactive Instruments, Inc. receives notice of such defects during the warranty period, Interactive Instruments will either, at its option, repair or replace products which prove to be defective.

Should Interactive Instruments be unable to repair or replace the product within a reasonable amount of time, customer's alternative exclusive remedy shall be a refund of the purchased price upon return of the product.

If this product was purchased as part of a system in a coordinated shipment or as a system add-on, it is warranted against defects in material and workmanship during the same period as the system.

It is the customers responsibility to package the system properly using the original (or better) containers and make arrangements to ship the product to our location in Scotia NY for evaluation or repairs. Interactive Instruments can provide replacement crates for $200 + shipping.

Exclusions

The above warranty shall not apply to defects resulting from:
Improper or inadequate maintenance by customer; customer-supplied software or interfacing; unauthorized modification or misuse; operation outside of the environmental specifications for the product; or improper site preparation and maintenance.

NOTE: The main thrust bearing is NOT covered under the limited warranty agreement.