INSTRUCTION MANUAL

Models 308C, 312C, 312C-I, 315C, 315C-I, 322C and 322C-I

High-Speed Length Controllers

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1.0 Introduction

The 308C, 312C, 312C-I, 315C, 315C-I, 322C and 322C-I high-speed length controllers were designed to enable physiology researchers to study the transient mechanical characteristics of muscle tissue. These systems are capable of generating forces of 50 mN for the 308C/312C/312C-I/315C/315C-I and 100 mN for the 322C/322C-I.

The 312C and 315C systems are the fastest versions of our length controllers. The 312C has a step response time of 200 microseconds while the 315C has a step response time of 250 microseconds. The 308C uses an older motor design and has a step response time of 250 microseconds. To achieve the fastest possible step response times the control electronics uses a proportional/derivative (PD) servo control loop. The disadvantage of the PD controller is that there is no correction for small, steady state errors. This means that there is a small amount of arm movement with load (typically less than 10 μm movement at full load).

The 312C-I, 315C-I and 322C-I models include an integrator in the control loop that turns them into proportional/integral/derivative (PID) controllers. The addition of the integrator results in an exceptionally flat response and also ensures virtually no movement of the arm regardless of the force applied (less than 1 μm movement at full load). The disadvantage of the PID controller is that it increases the system response time to 400 microseconds for the 312C-I, to 500 microseconds for the 315C-I and to 700 microseconds for the 322C-I.

All models in this series are length controllers only. For measuring very small forces, an external force transducer is required. Please contact Aurora Scientific Inc. for information about our 400A series of force transducers that were designed for muscle physiology research.

The heart of our high-speed length controllers is a very high performance moving magnet rotary motor. The rotor of these motors is a magnet suspended on precision ball bearings. A high performance optical position detector at the rear of the motor senses length changes at the end of the lever arm. A three-meter cable connects the motor to the control electronics. The motor is protected against various overload conditions by the electronics. In addition there are mechanical stops inside the motor to prevent gross over travel.

Note: The motors are high performance devices that require some special handling. Never let them impact a hard surface especially on the shaft. Do not pull or push with anything other than light finger pressure on the shaft or damage to the bearings can occur. Do not expose the motor to extremes of temperature. Do not let any foreign material, e.g. dust, dirt, solvents, water, oil, biological fluids, etc. come in contact with the front bearing. The bearing is located just behind the front of the motor where the shaft exits. Foreign material inside the bearing will reduce bearing life.

2.0 Specifications Models: 308C, 312C, 312C-I, 315C, 315C-I, 322C and 322C-I

Length Excursion:	308C:	4 millimeters
	312C, 312C-I:	3 millimeters
	315C, 315C-I:	3 millimeters
	322C, 322C-I:	6 millimeters
Arm Length:	308C:	13 millimeters
	312C, 312C-I:	9 millimeters
	315C, 315C-I:	11 millimeters
	322C, 322C-I:	20 millimeters
Length Signal Resolution:	308C:	1.0 micron
	312C/I, 315C/I, 322C/I:	0.5 micron
Length Signal Linearity:	308C:	98% minimum
	312C/I, 315C/I, 322C/I:	99.5% minimum
Length Scale Factor:	308C:	0.20 millimeter per volt +/-10%
	312C, 312C-I:	0.15 millimeter per volt +/-10%
	315C, 315C-I:	0.15 millimeter per volt +/-10%
	322C, 322C-I:	0.30 millimeter per volt +/-10%
Length Step Response Time:	308C:	250 microseconds (200 μm step)
(1% to 99% critically damped.)	312C:	200 microseconds (150 μm step)
	312C-I:	400 microseconds (150 μm step)
	315C:	250 microseconds (150 μm step)
	315C-I:	500 microseconds (150 μm step)
	322C:	350 microseconds (300 μm step)
	322C-I:	700 microseconds (300 μm step)
Length Sinusoidal Response:	308C:	DC to 2.4 kHz, -3db
	312C:	DC to 3.0 kHz, -3db
	312C-I:	DC to 1.5 kHz, -3db
	315C:	DC to 2.5 kHz, -3db
	312C-I:	DC to 1.2 kHz, -3db
	322C:	DC to 1.8 kHz, -3db
	322C-I:	DC to 0.9 kHz, -3db
Maximum Isometric Force:	308C, 312C, 312C-I, 315C, 315C-I:	50 milliNewton
	322C, 322C-I:	100 milliNewton

Isometric Compliance:	308C:	0.4 micron per mN
	312C:	0.2 micron per mN
	315C:	0.1 micron per mN
	322C:	0.15 micron per mN
	312C-I, 315C-I, 322C-I:	<0.01 micron per mN
Warm Up Time:	All models:	1 minute to rated accuracy
Power Requirements:	All models:	120VAC ±10%, 50/60Hz, 0.5A max. 100, 220 and 240VAC optional
Dimensions:	Electronics:	3.5 in. (9 cm) high, 8.4 in. (21 cm) wide (1/2 rack), 10 in. (25 cm) deep
	Motor:	See Head Assembly Drawings
Weight:	Electronics:	6 lbs (2.7 kg)
	308C Motor:	50 grams
	312C Motor:	17 grams
	315C Motor:	26 grams
	322C Motor:	42 grams

3.0 First Time Operation

The following procedure is recommended to verify that the system is operating properly.

1. Attach the male end of the 3-meter cable the rear panel of the electronics box and the other end to the motor. Use the screws supplied on the electronics end of the cable to firmly secure the cable to the electronics
2. With the power switch, located on the front of the electronics box, in the OFF (down) position, plug the instrument into an appropriate AC source using the detachable line cord.
3. Turn the front-panel LENGTH OFFSET control so that the turns counting dial reads 5.0 (the center of the range).
4. Attach the lever arm to the motor shaft (for the 308C, 312C, 312C-I, 315C and 315C-I the arm is attached at the factory). Gently, push the lever arm back and forth. It should move freely until the mechanical stops are reached. Be careful when placing the motor on a surface that the arm does not hit anything during operation.
5. Switch the Inhibit switch to the Stop position (down). Turn the power switch ON. The POWER LED should illuminate.
6. Switch the Inhibit switch to the Run position (up). Turn the LENGTH OFFSET control back and forth a turn or so. The arm should move in proportion to the turning of the control and the voltage shown on the front panel meter should change as well.
7. Input a signal into the LENGTH IN BNC connector. The arm should move in response to the input. Positive signals should cause clockwise (CW) rotation and vice versa for negative signals. Refer to the specifications at the front of the manual for the scale factor.
8. View the LENGTH OUT signal with an oscilloscope. The waveform should follow the input signal with ~300 microseconds of time lag.

This concludes the initial instrument checkout procedure.

3.1 Mounting Scheme

The customer must provide an adequate path for conducting heat generated by the motor away from the motor body. The maximum temperature that the motor body should be allowed to attain is 50°C. This is below the temperature at which a person feels pain, thus the motor should **never** get too hot to touch!

Drawings of suggested motor mounts for each model are located at the end of this manual.

4.0 General Operating Procedure

The high-speed length controller will drive the arm position to match the length input signal. The actual arm position is provided at the LENGTH OUT connector. The front panel voltmeter provides an indication of the actual arm position. (Note: since the voltmeter only updates two times per second the output of the meter is an average and it will not accurately indicate high-speed movements.)

4.1 Controlling and Measuring Length

LENGTH IN controls the position of the tip of the lever arm such that a positive signal rotates the arm in a clockwise direction, and conversely, a negative signal counter-clockwise. The maximum length input signal is ±10V.

LENGTH OUT is a bipolar signal that swings symmetrically about zero volts. The center of the mechanical range is when LENGTH OUT is at zero volts. Try to make use of the center portion of the range rather than just one side of the mechanical center. A clockwise rotation of the shaft causes LENGTH OUT to become more positive, and conversely a counter-clockwise rotation more negative. A length change can be accomplished by either turning the LENGTH OFFSET knob located on the front panel or by inputting a signal to the LENGTH IN connector. Both LENGTH IN and LENGTH OUT have the same scale factor which is shown in the specifications section.

4.2 Controlling Force

High-speed length controllers cannot control force by themselves. Aurora Scientific Inc. has a digital controller available that interfaces with a high-speed length controller and a force transducer and allows the user to control force. Our model 600A Digital Controller can generate critically damped force clamps in as little as 1.5 msec.

The 600A Digital Controller includes a PC computer, data acquisition card, signal interface, all necessary cables and custom software. The software runs under the real-time Linux operating system and includes all of the standard muscle physiology test protocols. Custom protocols can be generated using the on-screen test editor. In addition to controlling the high-speed length controller the software also collects data from the length controller and a force transducer and also provides digital I/O to control other instruments such as stimulators. For more information please contact ASI.

4.3 Controlling the System with External Electronics

Most experiments will require that LENGTH IN be driven with an external electronic device. The cost of computers and data acquisition circuit boards have dropped to such a level that they are the best way to control a high-speed length controller. One analog input and one analog output are all that are required to control the instrument. Analog-to-digital resolution of 12 bits (1 part in 4096) is adequate however a resolution of 16 bits is preferred. An ASI model 600A Digital Controller provides a complete data acquisition and control capability as a turn-key system.

4.4 Inhibit Shutdown

All models include an inhibit circuit that interrupts the current drive to the motor and lights the FAULT LED. When the instrument is inhibited all external control inputs (Length In and Length Offset) are disconnected internally and power is cut to the motor. This leaves the lever arm free to move.

The inhibit function is quite useful when attaching a muscle preparation since the arm can be pulled and pushed on without causing any unwanted oscillations of the arm. If the system is not inhibited when the muscle is being attached to the lever arm the instrument can sometimes oscillate in reaction to non-compliant loading of the arm. An example of non-compliant loading is touching the lever arm with metal tweezers.

Moving the Inhibit switch to the Stop position will inhibit the instrument. To re-activate the system simply move the switch to the Run position. When re-activating the system the motor will initially be driven to the centre of its range of motion, 2 seconds later the motor will move to the currently commanded position (the sum of the signal attached to Length In plus the signal due to the position of the Length Offset knob). The FAULT LED may remain lit for about 2 seconds while the system attempts to restart see section 4.5 below. The position detector works all the time regardless of whether the Inhibit switch is in the Run or the Stop position. This feature can be useful when attaching a muscle to the length controller. Use the following procedure.

1) Switch Inhibit to the Stop position
2) Turn the system power on.
3) Attach the muscle tissue to the arm and to the external force transducer.
4) Before moving the Inhibit switch to the Run position, check the Length Out signal (use the front-panel voltmeter). Move the arm so that the reading on the meter is close to 0.000 volts.
5) Set the Offset knob to 5 on the dial and ensure that the signal connected to Length In is at 0.000 volts.
6) Switch to the Run position. The arm will move from the current position to the 0.000-volt position and remain there.

4.5 Overload Shutdown

All models contain protection circuitry to protect the motor and electronics from various types of overloads. If an overload is detected, current drive to the motor is interrupted and the FAULT LED lights. After about 2 seconds the system will attempt to restart but will quickly go back into overload mode if the condition that caused the overload remains.

When the power switch is first turned on the overload circuitry is activated. This ensures that power-on transients are eliminated. If the motor is driven to a position much outside its legal range of ±10 volts an overload will also be triggered. The length-input command must be reduced before the system will restart. If the force at the tip of the arm exceeds maximum force an overload will be triggered. If the motor is not connected to the electronics an overload will be triggered.

The overload circuitry is also triggered when the power switch is flipped off. Since current to the motor is interrupted quickly, there is little or no turn-off transient in the motor when power to the instrument is removed.

5.0 Calibration

The calibration procedure involves measuring the output scale factor of the LENGTH OUT signal.

5.1 Calibrating Length Out

In order to calculate the output scale factor of LENGTH OUT the user must cause the arm to move a known amount and compare this value with the voltage measured at LENGTH OUT. One method of achieving this is the following.

1) Apply a 10-volt peak-to-peak square wave to LENGTH IN at the frequency shown in chart #1.

Chart #1	System	Frequency
	All models	75Hz

2) Using a finely divided ruler, measure the deflection at the tip of the lever arm as it moves back and forth. The amount of movement should be close to that shown in chart #2 below. Record the actual movement.

Chart #2	System	Peak-to-peak motion
	308C	2.0 mm
	312C, 312C-I, 315C, 315C-I	1.5 mm
	322C, 322C-I	3.0 mm

3) Using an oscilloscope measure the peak-to-peak voltage at LENGTH OUT.

4) Calculate the length scale factor as follows.

   Length Scale Factor = actual movement measured / LENGTH OUT voltage

   Example: For a model 312C system the actual movement is measured as 1.4 mm and LENGTH OUT is measured as 9.92 volts. Therefore the Length Scale Factor will be 1.40 mm/9.92 volts = 0.141 mm/volt.

Ensure that a non-contact method of measuring the length is used. Touching a micrometer or other non-compliant instrument to the lever arm will often cause the arm to oscillate.

Alternate methods of measuring the movement include using an optical reticule or a traveling stage microscope. Another method of calibrating the length would be to simply use the LENGTH OFFSET control on the front panel of the instrument. In this case the user would set the offset control near one end of the range of motion, use a voltmeter to measure the voltage at LENGTH OUT and mark the position of the lever arm tip. Then set the offset control to a point near the other end of the range of motion and once again record the LENGTH OUT voltage. Mark the final position of the lever arm and then measure the distance between the marks. Use this information to calculate the scale factor. By mounting a finely divided ruler behind the lever arm the LENGTH OFFSET control can be adjusted such that the lever tip lines up with a division on the ruler. Then move the offset control until the tip lines up with another division. This saves having to mark the positions and then measuring them.

6.0 Instrument Tuning

There are two tuning procedures presented in this chapter. The first is for an instrument with a PD (proportional/derivative) controller. This is a controller that does not have an integrator and the model number will read 308C, 312C, 315C or 322C. The second procedure is for a PID (proportional/integral/derivative) controller. This is a controller with an integrator and the model number will read 308C-I, 312C-I, 315C-I or 322C-I. Ensure you use the correct tuning procedure for your controller.

***** CAUTION: Lethal voltages are exposed during this procedure. *****
Use caution whenever the top cover of the electronics box is removed.

Your high-speed length controller was tuned at the factory before shipment. It should not need re-tuning over the life of the instrument. This procedure is written to help those customers that want to readjust their length controller. Some reasons for readjusting are:

a) Change in the load inertia, i.e., a mass has been added or removed from the lever arm.
b) The adjustment pots on the circuit board have inadvertently been altered.
c) The researcher wants the system step response slightly faster or slower.

Please read the entire procedure before attempting any changes. It is possible to damage the motor if the procedure is not understood completely. If there are any questions, please contact Aurora Scientific Inc.

The following materials are needed:

a. Dual-trace oscilloscope
b. 3-1/2 digit DVM
c. Function generator
d. Phillips screwdriver
e. Flat-tip screwdriver (small)
f. Several BNC cables

6.1 Tuning Instruments without an Integrator, 308C, 312C, 315C and 322C

1. Ensure the power switch located on the front panel of the electronics box is turned **OFF**. Attach the power cable to the back of the box and to the appropriate power.
2. Firmly attach the cable between the electronics box and motor using the captured screws on the cable. Place the arm on the motor such that it swings about the same distance to either side of the motor centerline. Tighten the arm's clamp. For models 308, 312 and 315C the arm is factory installed.

***** CAUTION: Lethal voltages are exposed during this procedure. *****
Use caution whenever the top cover of the electronics box is removed.

3. Remove the Phillips-head screw located on the back panel along the top edge of the electronics box. Slide the top cover back and remove it from the box. Connect scope CH1 to LENGTH OUT and connect scope CH2 to CR9 (non band end). Connect the function generator to LENGTH IN.

**** Note: If only a slight adjustment to the dynamic tuning of the system is required then skip down to step (10) below. ****

4. Locate potentiometers R25, R28 and R59 and then turn them counter clockwise (CCW) 25 turns or until a click is heard.
5. Turn the front panel LENGTH OFFSET to the center of its range (5 turns from either stop).
6. Disable servo by moving the Inhibit switch to the STOP position. Turn on the power switch.
7. Observe LENGTH OUT while moving the arm back and forth. LENGTH OUT should change positively for clockwise (CW) rotation.
8. Turn R25 and R59 2 turns CW.
9. While holding the motor and arm such that the arm is prevented from moving an excessive amount, move the Inhibit switch to the RUN position. The FAULT lamp may light up for a few seconds and then turn off. When it does the arm should now want to sit close to the center of the range.
10. Apply a 1-volt peak-to-peak square wave to LENGTH IN at the frequency shown in Table 6.1. While carefully monitoring LENGTH OUT with the oscilloscope synced to the function generator, slowly turn R28 CW until the motor begins to respond to the signal input. Continue to turn R28 CW until the waveform looks under damped. Monitoring both the LENGTH OUT signal and the motor current signal during the tuning procedure makes it easier to tune the system because small oscillations tend to be amplified on the current trace.

Table 6.1 Tuning Frequency

System	Frequency
308C, 312C, 315C, 322C	75Hz

11. The three potentiometers R28, R25, and R59 should now be alternately turned in a generally CW direction until a critically damped square wave with a step response time as shown in Table 6.2 is achieved. (This requires practice and an intuitive feel for what these three controls do). In general the three pots have the following effect:
    a. R25 is the position differentiator potentiometer. This provides low frequency damping to the system. Turning this CW will increase damping during the beginning of the tuning process, but soon runs out of bandwidth. At that point R59 should be turned up in conjunction with R25.
    b. R28 is the error amplifier potentiometer. It controls servo gain for the system. During calibration, this pot acts to increase the speed and overshoot of the system.
    c. R59 is the current integrator potentiometer. It provides high frequency damping to the system. Use this pot in conjunction with R25 to dampen an under damped waveform after R25 alone loses its effectiveness.

    The tuning procedure normally involves increasing R28, then increasing the damping, R25, and R59 to remove the "bump" that is seen in the response.

Table 6.2 Step Response Time

System	Step Response Time (ms)
308C	0.25
312C	0.20
315C	0.25
322C	0.35

12. When the servo is properly tuned, the following points should be checked:
    a. The output response should look critically damped with no overshoot or undershoot.
    b. There should be no ringing on the position signal or on the current signal. If there is then R28 is probably turned up too high.
    c. It is always best to use the least amount of R28 possible to get the job done.
    d. There should be no audible ringing heard from the motor. If there is then R28 is probably turned up too high. There might be a small amount of hissing heard. That is a normal condition and should be ignored. The hissing will go up as R28 is increased.

Adjusting the Fieldsize

13. Apply a 10-volt peak-to-peak square wave to LENGTH IN at the frequency shown in Table 6.1. Adjust R13 such that the tip of the lever arm moves the amount shown in Table 6.3 below. If any adjustments were made to R13, go back and check the step response again. Ensure that the system is still critically damped (step 11).

Table 6.3 Deflection

System	**Peak-to-Peak Motion (mm)**
308C	2.0
312C, 315C	1.5
322C	3.0

14. Measure the voltage at U9, pin 14. It should be between +5.0VDC and +11.5VDC. If the voltage is outside of this range there is probably a motor problem. Contact Aurora Scientific Inc.

6.2 Tuning Instruments with an Integrator, 308C-I, 312C-I, 315C-I and 322C-I

1. Ensure the power switch located on the front panel of the electronics box is turned **OFF**. Attach the power cable to the back of the box and to the appropriate power.
2. Firmly attach the cable between the electronics box and motor using the captured screws on the cable. Place the arm on the motor such that it swings about the same distance to either side of the motor centerline. Tighten the arm's clamp. For models 308 and 312 the arm is factory installed.

***** CAUTION: Lethal voltages are exposed during this procedure. *****
Use caution whenever the top cover of the electronics box is removed.

3. Remove the Phillips-head screw located on the back panel along the top edge of the electronics box. Slide the top cover back and remove it from the box. Connect scope CH1 to LENGTH OUT and connect scope CH2 to CR9 (band end). Connect the function generator to LENGTH IN.

**** Note: If only a slight adjustment to the dynamic tuning of the system is required then skip down to step (10) below. ****

4. Locate potentiometers R25, R28, R31 and R59 and then turn them counter clockwise (CCW) 25 turns or until a click is heard.
5. Turn the front panel LENGTH OFFSET to the center of its range (5 turns from either stop).
6. Disable servo by moving the Inhibit switch to the STOP position. Turn on the power switch.
7. Observe LENGTH OUT while moving the arm back and forth. LENGTH OUT should change positively for clockwise (CW) rotation.
8. Turn R25, R28 and R59 2 turns CW.
9. While holding the motor and arm such that the arm is prevented from moving an excessive amount, move the Inhibit switch to the RUN position. The FAULT lamp may light up for a few seconds and then turn off. When it does the arm should now want to sit close to the center of the range (R28 brings arm to center - leave a small offset initially).
10. Apply a 1-volt peak-to-peak square wave to LENGTH IN at the frequency shown in Table 6.4. While carefully monitoring LENGTH OUT with the oscilloscope synced to the function generator, slowly turn R31 CW until the motor begins to respond to the signal input. Continue to turn R31 CW until the waveform looks under damped (see figure 1). In the figure the larger amplitude signal is Length Out and the signal centered at the mid-point of the screen is the current measured at CR9. Monitoring both the LENGTH OUT signal and the motor current signal during the tuning procedure makes it easier to tune the system because small oscillations tend to be amplified on the current trace.

Table 6.4 Tuning Frequency

System	Frequency
308C-I, 312C-I, 315C-I, 322C-I	75Hz

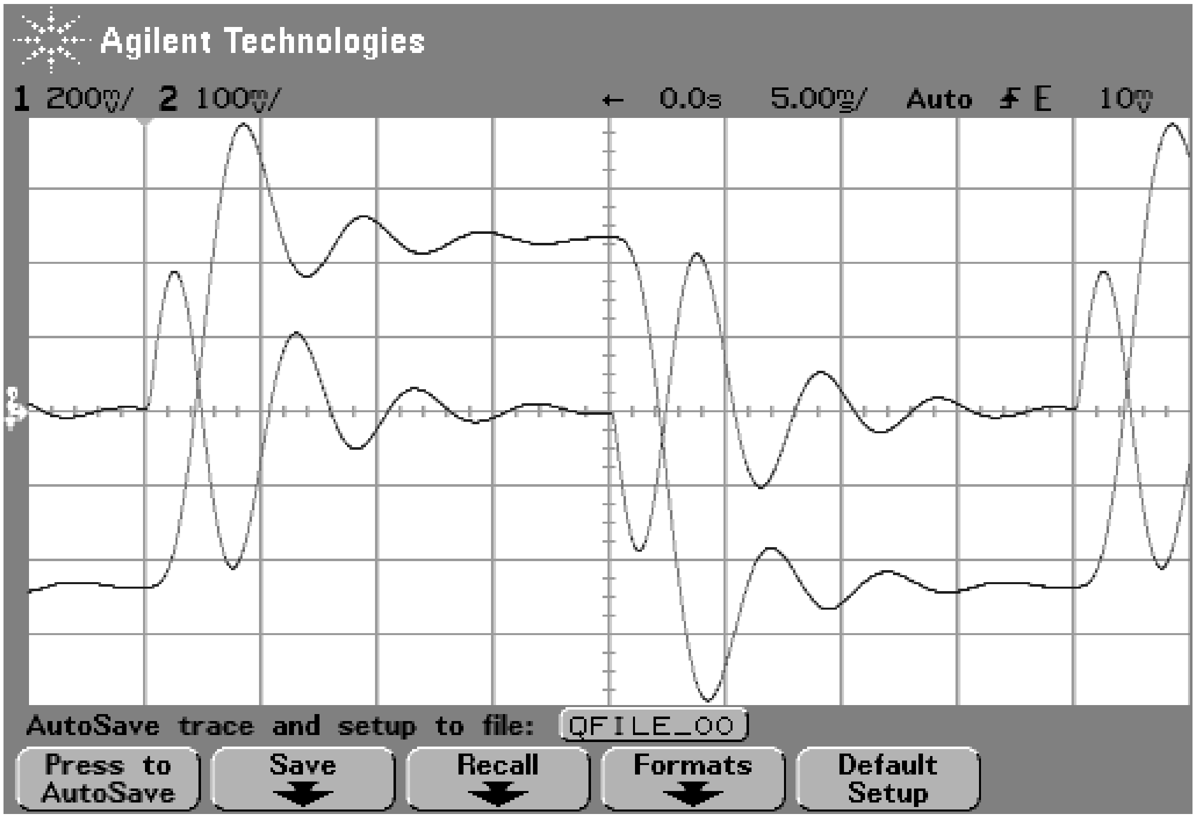

Figure 1 Under Damped Response

11. The four stability pots R31, R28, R25, and R59 should now be alternately turned in a generally CW direction until a critically damped square wave with a step response time as shown in table 6.5 is achieved. (This requires practice and an intuitive feel for what these four controls do). In general the four pots have the following effect:

    a. R31 is the error integrator potentiometer. It controls the servo gain or the speed of the system. As this pot is turned up, the system will respond more quickly to a step input. During tune-up, this pot causes the step response time to decrease, or in other words it causes the speed of the system to increase.
    b. R28 is the error amplifier potentiometer. It produces an electrical spring that acts like a restoring force on the motor. This restoring force always acts in the direction of the final commanded position. During tune-up, this pot acts to limit the overshoot of the system.
    c. R25 is the position differentiator potentiometer. This provides low frequency damping to the system. Turning this CW will increase damping during the

beginning of the tuning process, but soon runs out of bandwidth. At that point R59 should be turned up in conjunction with R25.

d. R59 is the current integrator potentiometer. It provides high frequency damping to the system. Use this pot in conjunction with R25 to dampen an under damped waveform after R25 alone loses its effectiveness.

The tuning procedure normally involves increasing the gain, R31 (figure 1), then increasing the damping R28 to eliminate the initial over shoot (figure 2), then increasing R59 to remove the first oscillation after the overshoot (2nd order “bump”) (figure 3), then increasing R25 to remove the 3rd order "bump" (figure 4). After these adjustments there will be an overshoot so R28 will need to be adjusted again (figure 5). Now the system should look close to critically damped but the speed (rise time) will not meet the specification of table 6.5, so now increase R31 again (figure 6) and then repeat all the previous adjustments to retune the system to a critically damped condition. The finished state should look like Figure 7 with a rise time equal or better than that specified in Table 6.5. It is normal to go through the tuning process several times before reaching the fully tuned condition. Don’t try to save time by initially adding a lot of gain (R31) as the system will go unstable and the arm will start to oscillate. When severe oscillation occurs the motor can be damaged. It is best to tune the motor to the optimum condition in smaller steps.

Table 6.5 Step Response Time

System	**Step Response Time (ms)**
308C-I	0.5
312C-I	0.4
315C-I	0.5
322C-I	0.7

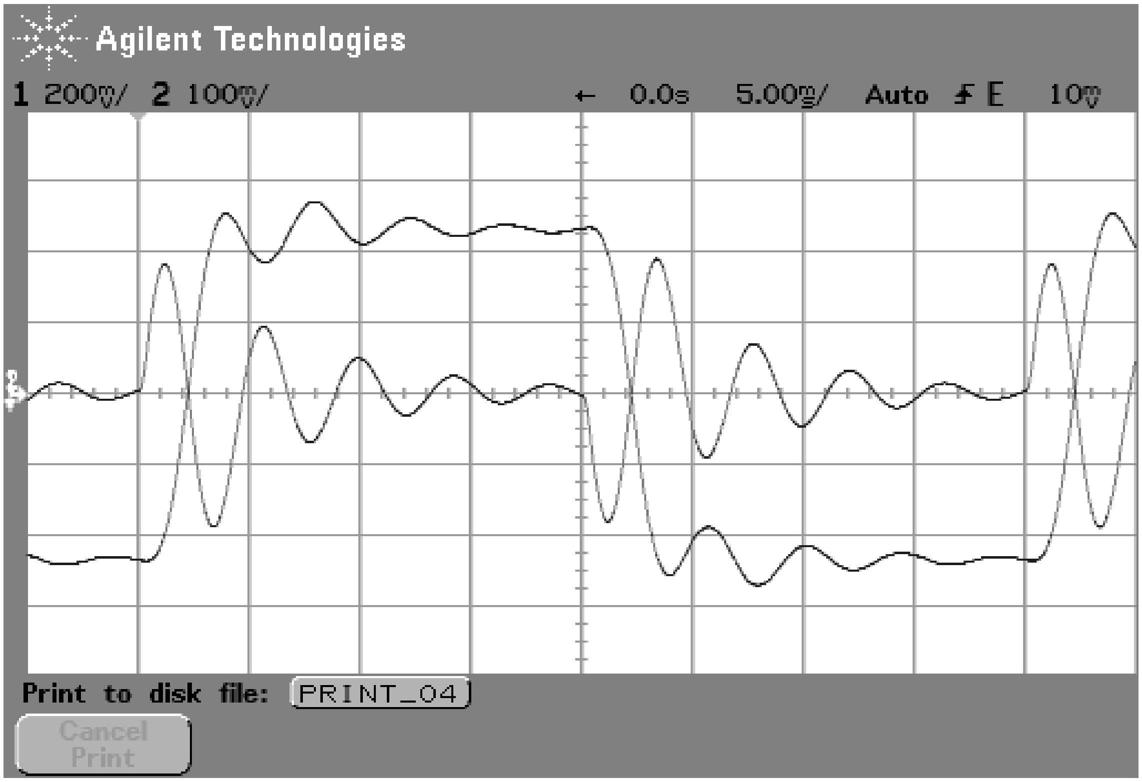

Figure 2 R28 Adjusted to Remove Over Shoot

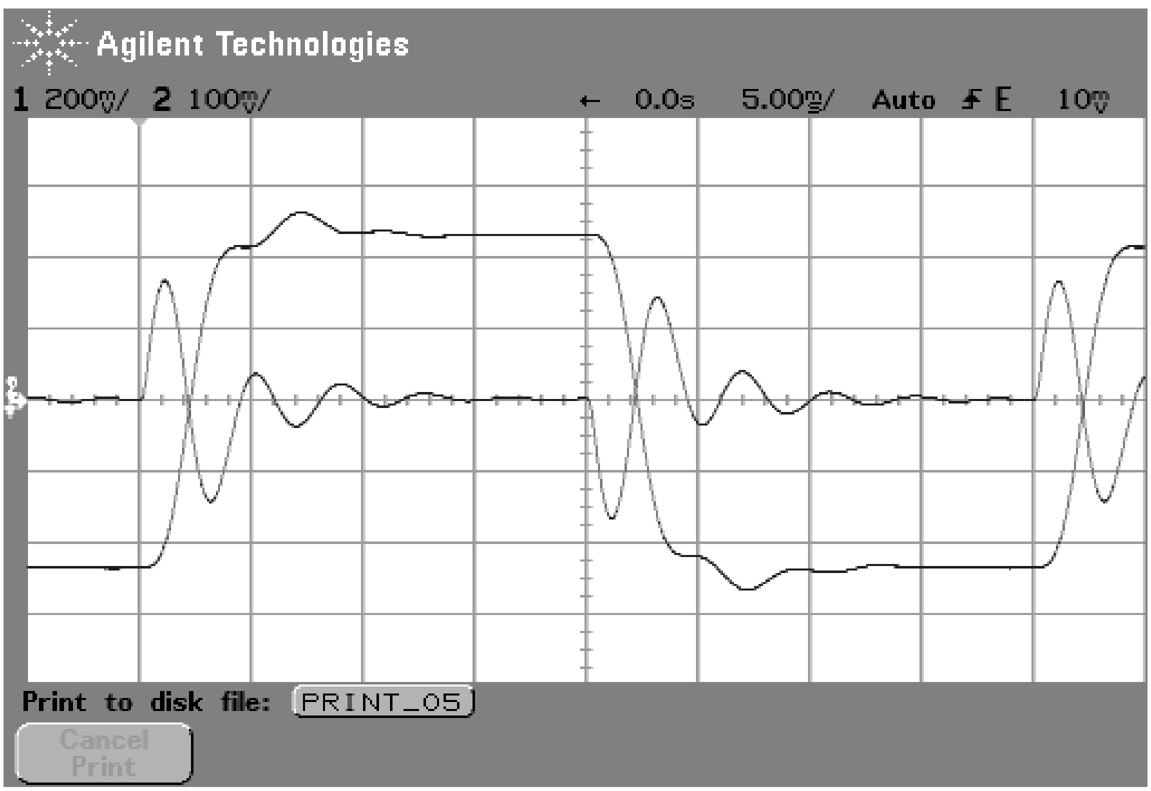

Figure 3 R25 Adjusted to Remove Low Frequency Oscillations

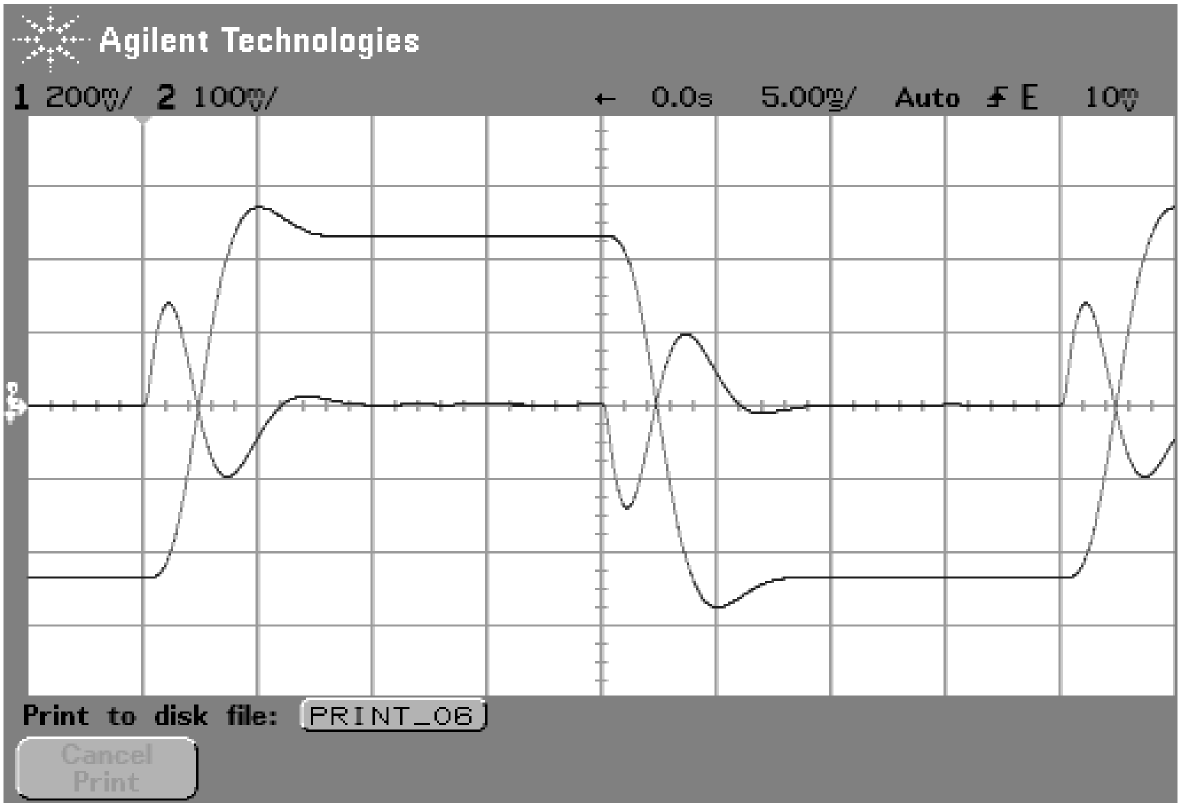

Figure 4 R59 Adjusted to Remove High Frequency Oscillations

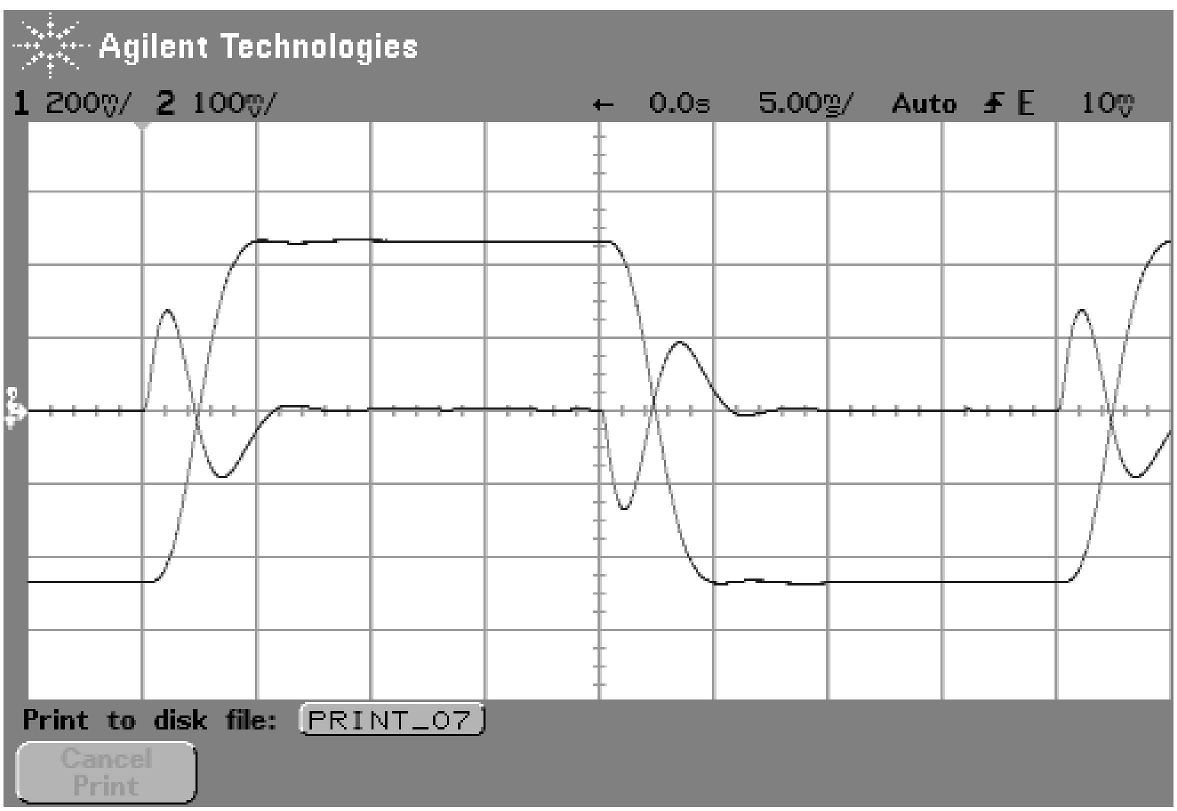

Figure 5 R28 Adjusted to Remove Over Shoot

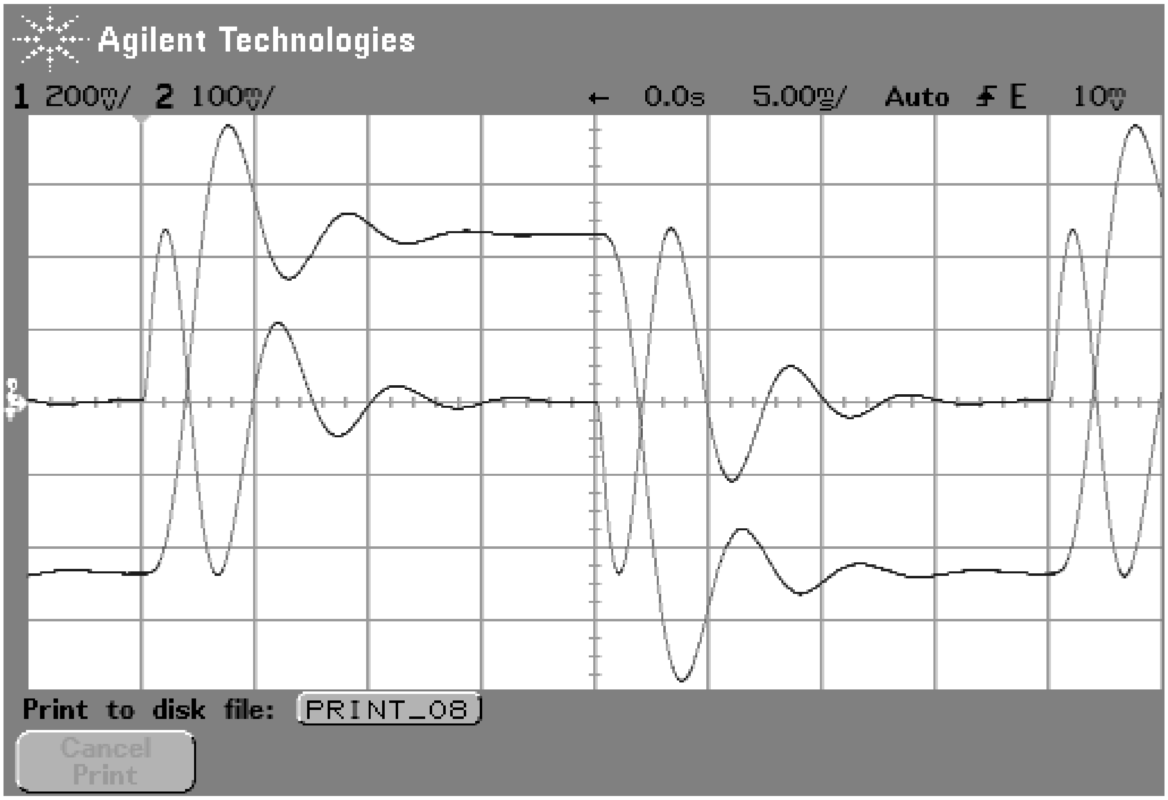

Figure 6 R31 Adjusted to Increase System Speed

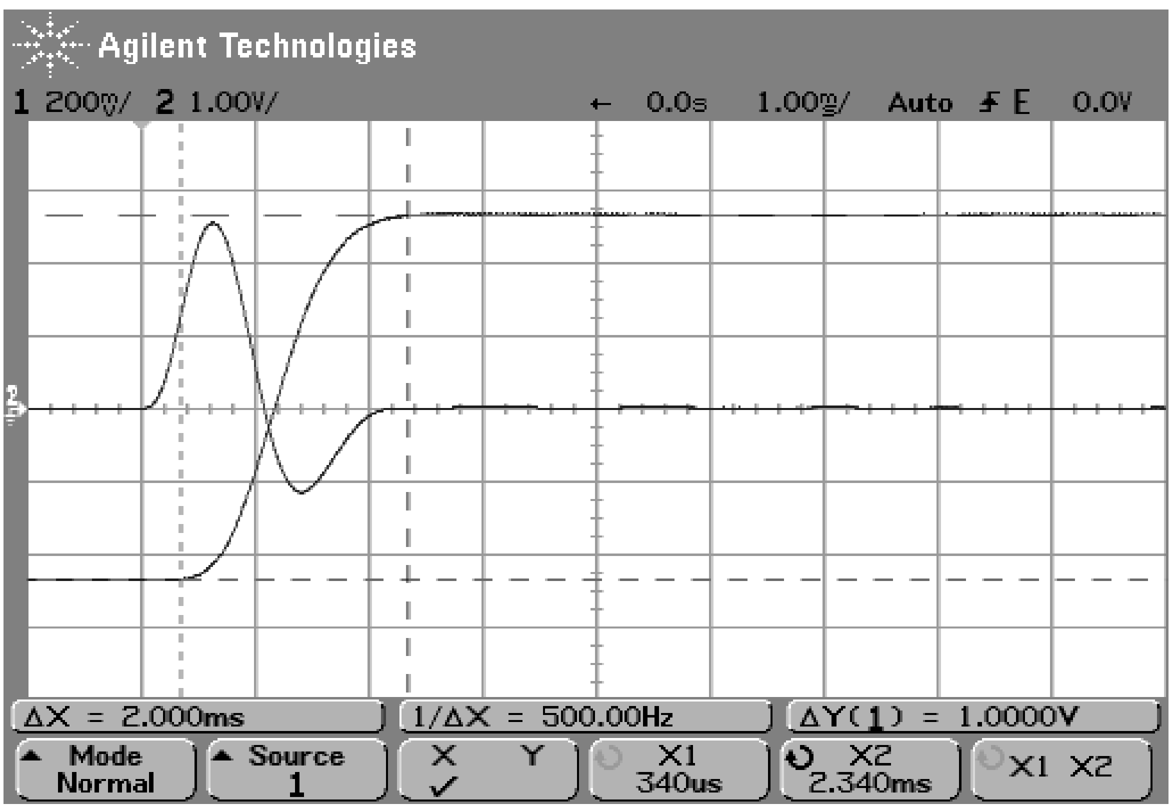

Figure 7 Tuning Finished - Critically Damped Response

12. When the servo is properly tuned, the following points should be checked:
    a. The output response should look critically damped with no overshoot or undershoot.
    b. There should be no ringing on the position signal or on the current signal. If there is, the loop gain is probably turned up too high.
    c. It is always best to use the least amount of loop gain possible to get the job done.
    d. There should be no audible ringing heard from the motor. If there is, the loop gain is probably turned up too high. There might be a small amount of hissing heard. That is a normal condition and should be ignored. It also will go up as the loop gain is increased.

Adjusting the Fieldsize

13. Apply a 10-volt peak-to-peak square wave to LENGTH IN at the frequency shown in table 6.6. Adjust R13 such that the tip of the lever arm moves the amount shown in table 6.6. If any adjustments were made to R13, go back and check the step response again. Ensure that the system is still critically damped (step 11).

Table 6.6 Deflection

System	Peak-to-Peak Motion (mm)
308C-I	2.0
312C-I	1.5
315C-I	1.5
322C-I	3.0

14. Measure the voltage at U9, pin 14. It should be between +5.0VDC and +11.5VDC. If the voltage is outside of this range there is probably a scanner problem. Contact Aurora Scientific Inc.

7.0 Warranty

The 308C, 312C, 312C-I, 315C, 315C-I, 322C and 322C-I high-speed length controller systems are warranted to be free of defects in materials and workmanship for three years from the date of shipment. Aurora Scientific Inc. will repair or replace, at our option, any part of the system that upon our examination is found to be defective while under warranty. Obligations under this warranty are limited to repair or replacement of the instrument. Aurora Scientific Inc. shall not be liable for any other damages of any kind, including consequential damages, personal injury, or the like. Opening the motor assembly itself will void this warranty. Damage to the system through misuse will void this warranty. Aurora Scientific Inc. pursues a policy of continual product development and improvement therefore we reserve the right to change published specifications without prior notice.

Drawings

This section consists of the following drawings:

1. 308C Head Assembly Drawing D02394
2. 312C Head Assembly Drawing D04091
3. 315C Head Assembly Drawing D05893
4. 322C Head Assembly Drawing D06220
5. Preferred Mount for Model 308C A02469
6. Preferred Mount for Model 312C D03771
7. Preferred Mount for Model 322C A03772