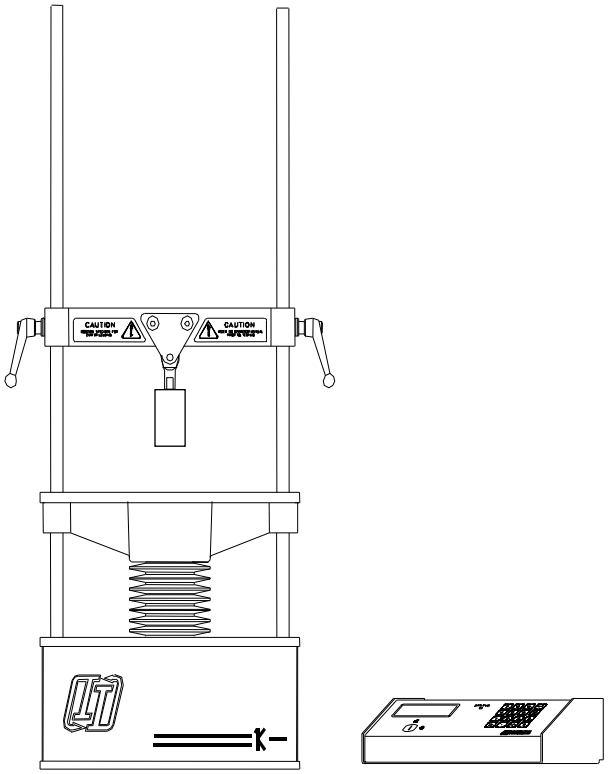
INTERACTIVE INSTRUMENTS



Model 1K-16
Universal Materials Tester
Instruction Manual

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Overview

The Model 1K is a general purpose universal materials tester designed as an affordable alternative to servo hydraulic systems. It is an invaluable tool for business, colleges and universities interested in simple materials analysis and/or product inspection.

The 1K is capable of compression and tension testing within its capacity of 1000 lbs. over the 2.5-inch stroke range. The controller is manually or remotely programmed to maintain the load or stroke setpoint. The built-in function generator can be programmed to hold, ramp or cycle a setpoint for hours, days or even months for unattended testing. Other desktop systems typically support open loop displacement ramps, recording the load with respect to time. The Model 1K contains a closed loop load, stroke and strain controller for real-time control of the setpoint making it a true materials tester.

Best of all the 1K does not require costly maintenance programs, special power requirements, a dedicated location or expensive training like other testers.

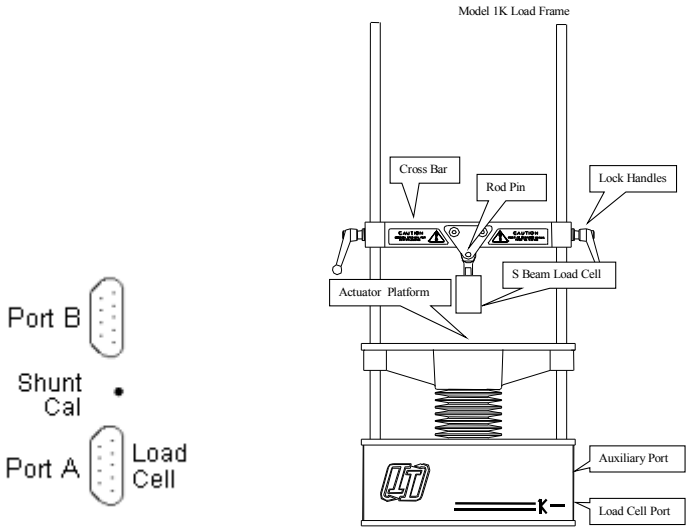
The control panel has a built in RS-232 serial port enabling a computer to have full control of the Model 1K's functionality. Languages such as LabVIEW, Visual Basic etc. can control the units operation while collecting data for long or short term data logging or real-time graphing. Using external programs to access and control the Model 1K makes it a truly flexible unit.

The easy to access 24"h x 13"w x 6"d test area allows various specimens to be quickly mounted for testing. The upper cross bar height is infinitely adjustable without tools for accommodating various specimens. The load cell is attached to the cross bar and various specimen grips or compression plates attach directly to the load cell. A lower tensile mount can be bolted onto the lower actuator platform to accept tensile grips.

Since the 1K is designed as a general purpose instrument, the uses are limitless. From materials analysis, product testing to fatigue analysis, its functionality goes a long way.

Installation and Setup

On the side of the load frame is a panel of connectors as shown below. Follow the steps below to prepare the system before powering up the load frame.



1) Place the load frame on a stable surface. Two 3/8 16 threaded holes are available on the bottom of the load frame so it can be bolted securely to the surface. Be sure the bolts do not extend more than 1/2" into the load frame or damage to the electronics may result.

2) Plug the 15 pin control cable into the rear of the load frame and also into the rear of the control panel and secure both ends with thumb screws. **NOTE: The stepper motor driver can be damaged if the controller cable is disconnected or partially unplugged with power applied to the load frame.**

3) Connect the load cell cable to the lower 9 pin port connector (**port A**) on the load frame. Be sure to secure the cable to the frame using the two screws on the connector shell. The shunt 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.

4) Plug the power cord into the rear of the load frame and into a 110 volt 60 Hz grounded wall outlet.

5) Inspect the load frame and control panel 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.

6) Be sure the controller is enabled by turning the security key on the control panel fully counterclockwise. If the security key is locked the keypad is disabled.

7) Verify the actuator platform and the upper cross bar are free of obstruction before applying power.

8) Power up the unit using the power switch on the rear of the load frame. As the control panel is powered up, the microprocessor performs internal diagnostics to verify the internal components are performing properly. If the display prompts an error for example:

```
System RAM          FAIL
```

This is due to the microcontroller detecting an error in the system. Please refer to the **Error Condition** section of this manual for more information.

If the internal diagnostics pass, the LCD will then prompt:

```
    Power Up OK
Locate Home Switch?
 Press 1 to Locate
    or 0 to Stay
```

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 battery backed RAM the actual position may be different than the stored position if the actuator moves while powered down.

Pressing 1 displays a confirmation prompt below. Pressing 1 a second time and the actuator moves up or down to locate the home switch then sets the actuator position to the home position.

```
  Ready to Locate
Press 1 to Confirm
   Or 0 to Stay
```

Note: It is preferred to locate the home switch 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 are off by more than 1/4" the actuator will bottom out internally. This will not damage the load frame but will affect the true stroke reading.

While the controller is active or in control, the status LED on the control panel will blink to indicate 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.

Guide to the Model 1K Controller

Before starting a test

- Verify that the load frame and controller is properly setup (*see* **Installation and Setup**)
- Insert the security key and turn to the unlocked position (counterclockwise)
- Power up the controller by switching the power switch on the rear of the control panel
- Press the 1 or 0 key to locate the home switch or stay. The LCD will prompt with the run time display.

Resetting the Controller

The controller stores some of the control parameters in battery backed memory. To reset all controls back to the factory default settings, power up the controller with the 0 key held down. 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 real time 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 strain control)
Setpoint	(Set the desired control setpoint)
Waveform	(Configure and control the waveform generator)
Set Stroke	(Quickly position the actuator to a desired position)
View Max/Min	(View the Max and Min feedback values in real time)
View Control	(View the actuator control, feedback and error)
Setup	(Configure the System and Channel parameters)
Remote Display	(View the Remote display)
About	(View the Software Version)

Mode Control is used to select which channel is in control. Select between load, stroke or strain control. Two options are available in transferring control. Option 1 is to set the new setpoint to the new control mode feedback value (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. Once the setpoint is programmed all waveforms will be applied to the setpoint value.

Waveform selects the waveform generator configuration and control options menu. Options include selecting the waveform type such as sine, square, triangle, haversine, haversquare, havertriangle, single ramp, dual ramp and trapezoid along with the required parameters. The waveform controls are also available such as start, hold, finish, reset and stop. Each control channel maintains separate waveform parameters so the parameters don't need reprogramming if the mode control is changed back and forth.

Set Stroke Quickly position the actuator to a desired position. This is useful to rapidly position the actuator when setting up a test

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.

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

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

Remote Display View the remote display. When the remote display is viewed, a remote device can send commands to update the LCD with text. It makes it convenient for a computer to acquire data from the controller and update the LCD with specially formatted results. Up to 2 pages of 4 lines by 20 characters may be viewed.

About Views the software version and copyright notice.

Mode Control

The controller can be programmed to control load, stroke or strain. 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 Strain. The display then prompts with options on how the control change will take place.

Immediate

The first option (Immediate) will quickly transfer control to the new channel and set the current setpoint to the new control channel feedback. 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 after the transfer of control is performed. This is an efficient method of switching control and programming the new setpoint in one operation.

Setpoint

Programs the setpoint to a new value. The setpoint is the mean value 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 without entering a new value re-selects the current setpoint.

The setpoint can be changed at any time even while a waveform is running.

Waveform

Each control channel has a waveform generator with separate parameters providing a command signal to drive the test system when that channel is in control. Only one set of waveform parameters are enabled at a time allowing the load, stroke or strain to be controlled while monitoring the independent feedback channels.

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.

Timer Resolution

The internal waveform cycle timer is maintained as a 32 bit integer. The 32 bit integer maintains a 24 bit second counter with the remaining 8 bits representing fractional seconds in 5 millisecond resolution. Limitations of the generator are the waveform can't exceed 2^{24} seconds or 194 days or 5.96 e^{-8} Hz. Another limitation is all cycle times are rounded to 5 milliseconds time resolution. The cyclic waveform can be repeated indefinitely.

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 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.

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.

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) Strain
```

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 ↵ (enter). Pressing (menu) 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(up)-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 last display show 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 or subtracts the waveform amplitude to the setpoint depending on the sign of the amplitude. Once started the cycle counter, waveform timer and the total max/min values for all channels are reset.
The first line of the run time display prompts with "**Run:**" while the function generator is running. The character in the upper left corner identifies the status of the waveform amplitude. A '+' or '-' identifies the sign of the controlling waveform value. A blank identifies the waveform amplitude as zero.

Hold

Hold the waveform generator at the current control point. The run time display prompt changes from "**Run:**" to "**Hold:**". Select Start from the Waveform menu to restart the waveform without resetting the time, cycle count or total max/min's.

Note: Pressing the ↵ key while displaying the Run Time display will also hold the function generator. Pressing ↵ a second time 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 run time 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 fastest actuator rate (see Actuator Rate command). For a ramp waveform, return back to the setpoint at the fastest actuator rate. The run time display prompt changes from "**Run**" to "**End**".

Stop

Stop transfers to stroke control and holds the actuator at the current stroke position and the waveform generator output resets to zero. The run time display prompt changes from "**Run**" to "**End**".

Set Stroke

The actuator can be quickly positioned independent of the current test rate and type of control. The default stroke value is zero so to return to stroke zero press ↵.

```
Go to? (in.)
Def: 0
:_
```

Key the desired position on the keypad and press ↵ (Enter) and the actuator will quickly position to the desired location.

The LCD displays the run time display to show the real time status of the actuator. Once the actuator is set to the desired position, the actuator rate and control mode is restored and the actuator control is stopped. The display then returns to the Main Menu.

This feature is convenient for positioning the actuator for mounting multiple tensile specimens without having to program a faster test rate and select stroke control.

Note: The zero position is in reference to the programmed stroke offset which can be programmed to any position (see setup of the stroke channel offset). Since the offset is added to the actual actuator position, offsets can only be negative so the logical position is always below the highest stroke position.

View Max/Min

This menu item displays the maximum and minimum channel feedback results in real time. Selecting this option prompts with the Select Channel menu. Once the desired channel is selected the overall (Total) and cycle maximum and minimum values are displayed. The controller continuously updates these values 200 times a second so even if the display is not fast enough to show the peak value, this viewer will.

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

Peak Detector

The controller continuously monitors the load, stroke and strain feedback values 200 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 controllers main responsibility is to minimize the error between the control value and the measured feedback of the selected control channel. 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 1:1 or every horizontal pixel = 1 error bit. Pressing the 0 to 9 keys rescale the bar graph from 1:1 (key 0) to 1:1000 (key 9).

To exit press the 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, filter values and the PID parameters. These three items significantly change how the controller reacts to the control error. No one setting can be used for all test conditions.

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, or system configuration settings.

Setup Channels

Modify the desired channel parameters. The menu prompts with a list of channel configurations. The list includes Limit Selection, 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. The action command can be programmed to perform an operation when a limit is reached.
Note: Limits and a loop error are monitored separately and can have separate actions (the min and max limit share the same action). A limit/error is considered enabled when an action other than "ignore" is selected. Once tripped, the limit/error is latched, and must be cleared (remotely, this is done with the "V" command).

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 2.4% beyond the programmed range, the controller automatically suppresses control in that direction. If the stroke exceeds 2.550", 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 stops the controller.

Actuator Off: Any feedback values beyond the max or min limits remove the motor current and stop the controller. Turning off the motor current will allow the specimen to back drive the motor as though the load frame is powered off. It may require a significant load to back-drive the motor, gearbox and ball screw. This is similar to turning off the pump on a hydraulic system. To reactivate, change the state of the function generator.

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

```
Stroke Limit
Resetting Waveform
Action Set to Ignore
Press 1 to Cont.
```

The first line of the display identifies the limit that was tripped 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.
Note: Be sure any tripped limits are reactivated prior to restarting a test.

Max Loop Error:

Change the maximum allowed control loop error and action for a desired channel. When a channel is in control, an error is calculated (desired - measured) and the maximum error (or loop error) can be tested to be sure the feedback is in an acceptable range. Detecting an excessive amount of 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 prepare for another specimen.
Each channel maintains its own maximum error value and action but the channel in control is the only channel monitored. Since each channel can have a different error and action, the control channel can change from stroke to load and strain without needing to reprogram the loop error.

When the error exceeds the programmed maximum loop error 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.

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: The waveform will be stopped and the controller is set to stroke control.

Actuator Off: The motor current is removed and the controller is stopped. Turning off the motor current will allow the specimen to back drive the motor as though the load frame is powered off. It may require a significant load to back-drive the motor, gearbox and ball screw. This is similar to turning off the pump on a hydraulic system. To reactivate, change the state of the function generator.

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

```
Control Loop Error
Resetting Waveform
Action Set to Ignore
Press 1 to Cont.
```

The first line of the display identifies the control loop error has tripped 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.
Note: Be sure any tripped limits are reactivated prior to restarting a test.

Digital Filter:

A low pass filter can also be programmed to filter out any analog noise. Setting a high filter value (16 Hz) allows the controller to respond quickly to variations but can become susceptible to analog noise. Lowering the filter value (1 Hz or lower) reduces the noise but the system becomes sluggish to change. Over filtering a control channel with a rigid specimen and fast actuator settings can generate an uncontrollable oscillation. If this happens, stop the actuator (using the period '.' key) and increase the filter frequency or reduce the maximum actuator speed.

Note: The stroke channel does not have a filter because stroke is calculated digitally (not a measured feedback) and is not susceptible to noise.

Display Units:

The load, stroke or strain 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 strain 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 an analog signal 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
Strain Units:	%, V, in, cm, lb, kp, N, kN

Channel Scale:

Load: The load cell range comes factory calibrated for 1000 lbs. but other load cell ranges can be configured as well. If the load cell calibration of 1000 lb is maintained then the load cell range can be set to 453.6 (kg/1000 lbs.) and then kg units can be used. Another way is to calibrate the load cell in metric units. For example the load cell can be calibrated for 500 kg (or 1102.2 lbs.) and use 500 as the new load range. **Be careful calibrating the loads in excess of 1400 lbs. (the limit of the load frame).**

Note: The load channel scale is in fact 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 1000 lbs with the channel scale also set for 1000 lbs. Changing the load scale to 500 lbs without adjusting the analog calibration and the unit will apply twice the commanded load. This is because the calibrated 1000 lbs now is digitally scaled to represent 500 lbs.

Stroke: The stroke scale is fixed and can't be changed

Strain: The strain range can be scaled to match the sensor attached to the unit. If a 4 percent extensometer is used change the strain channel scale to 4.000 and the strain will be displayed in percent. The strain can also represent in volts (V), load (lb, kp, N, kN) or stroke units (in, cm) as well.

Channel Offset:

Offsets can be added to the channel output to adjust the true output feedback value to a given load, position or strain feedback. This value is digitally added to the channels display and remote serial output and does not impact the analog offset or the analog output signal. Since the offset is added to the output, the offset can be negative to removed or positive to add to the output 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 the '.' key.

Actuator Rate

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

```
Enter Actuator Rate
Def: 1.5 in/mn
:_
```

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 (except "Set Stroke" command). The controller calculates how fast the actuator should move to reduce the control error. If the calculated rate is faster than the maximum rate then the rate is clamped to the maximum rate. The maximum actuator rate is stored in battery backed RAM 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 of the controller.

Note: Slower rates along with an aggressive filter can produce very stable and accurate control as long as the control point and feedback signal is stable.

Zero Channel

Selecting this menu item will update the load, stroke or strain channel's offset so the current channel digital output (display and remote serial) 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 strain channels to improve the response time and minimize control error for each control mode. Each channels PID parameters were selected to work over a wide range of conditions. Sometimes it becomes necessary to modify these parameters to improve the controllers response characteristics for a specific test.

Each of the PID parameters are used to scale the results of control calculations and effect 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. 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. Pressing the Menu key cancels the variable update.

The values are stored in battery backed RAM 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 65535 (high gain). To disable a parameter set the gain to 0. When adjusting, start with small gain and increase them slowly until the proper control is obtained.

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 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. To 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 to rapid. This term is useful in minimizing setpoint overshoot and allowing a larger proportional value.

Sys. Deflection

The system deflection can be removed from the digital (display and remote serial) stroke feedback value to improve the accuracy of the results. Since the system deflection is somewhat predictable for a specific load the system deflection can be subtracted based on the magnitude of the system load. By programming the total system deflection at maximum range into the controller, the system deflection can be calculated by using the current load. Removing system deflection using the current load is not perfect because the actual system deflection is not 100% linear with respect to the load but it can be better than not removing it at all.

Selecting the Sys. Deflection option from the System menu displays the prompt shown below.

```
   Enter Full Load
  System Deflection
Def:    0 in/FS
:
```

Enter the full scale system deflection (in inches or centimeters) and the controller will automatically subtract or add the deflection depending on the magnitude of the load and the load direction.
Be careful about removing excessive system deflection. If to much deflection is removed the controller can be tricked into thinking the increasing load is over deflecting the system and sending the stroke in the opposite direction. While in stroke control the controller assumes the actuator direction is in phase with the stroke value. If the stroke goes out of phase then the control will become unstable. If this happens, disable the actuator and select a smaller system deflection value.

Note: To remove all system deflection compensations from the stroke feedback set the deflection value to 0.

Select Baud Rate

Select a BAUD rate that better matches the rate for the attached computer. The factory default is 38400 which is fast enough for most applications and computers. If your computer is not capable of operating at the faster rates, slow the rate down. Slower rates will significantly slow the rate of transferring data into and out of the unit. The serial controller also supports software handshake (XON/XOFF) which may be necessary when downloading large volumes of data acquisition data.

```
  Select Baud Rate
 4) 9600
 5) 19200
→6) 38400
```

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

Remote Display

View the remote display. When the remote display is viewed, a remote device can send commands to update the LCD with text. It makes it convenient for a computer to acquire data from the controller and update the LCD with specially formatted results. Up to 2 pages of 4 lines by 20 characters may be viewed.

Selecting this menu item will display information programmed from a remote device on the LCD. If the remote device has not updated the remote display area (using the '+L' command) the display will be blank. The remote display can manage up to 2 pages of text each with 4 lines by 20 characters for a total of 160 characters. Selecting the Remote Display menu selection automatically displays the first of 2 pages of text. Pressing the down arrow displays the second page and the up arrow returns to the first page. If the remote device refreshes the same viewed display area, the new information will display automatically. Press  (menu) to return back to the main menu.

About

Displays the software version number along with the copyright notice.

Run Time Display

The Run Time 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 strain, 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. The character switches from '+' to '-' to a blank indicating the sign 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
Hold: Waveform output is held at the current value but the controller is enabled
Or the trapezoid is in the hold mode
End: Waveform generator has completed its operation
Off: Actuator motor is powered down (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 strain, 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.

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

The load feedback represents the current load measured by the load cell.. 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. The system deflection can be removed from the calculated actuator position for better accuracy. This allows the Model 1K to measure 0" to 2.5" with 0.0001" resolution or 0.0025% resolution. See **Setup Channels** for more information on configuring the stroke units and offset.

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

The strain 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 32 bit counter will represent up to 4,294,967,295 cycles before overflowing back to 0.
Note: The LCD will only display up to 24 bits of resolution (16,777,215) counts before wrapping back to zero

Run Time Keypad

Holding the Waveform Generator
Pressing the ↵ key under test will temporarily hold the waveform generator clock until the ↵ key is pressed a second time.

Display the Main Menu
Pressing the (menu) key while the run time display is shown will continue the test and bring up the main menu. This is to allow parameter changes such as actuator rate or limit modifications during a test. While in the menu, pressing a second time will return back to display the run time display.

Stopping the Controller
Pressing the period '.' key while displaying the real time data or in the menu will stop the controller and hold the waveform generator output. The first line prompts with "Stop:" to indicate the controller is disabled. Pressing the period key a second time will restart the controller but not the waveform generator. To restart the waveform generator go to the waveform menu and select Run.

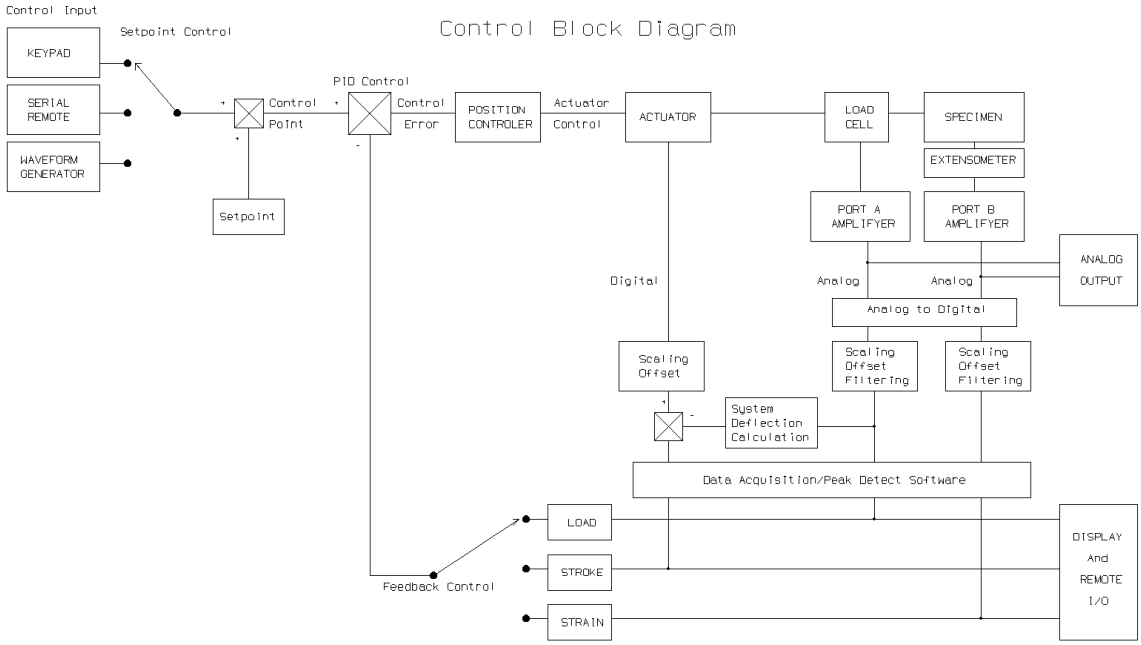
Modifying the setpoint
Press the Up or Down arrows while displaying the real time data will jog the setpoint up or down. Holding the up/down arrows will slew the setpoint. Pressing a number on the keypad will display a prompt allowing the setpoint value to be reprogrammed.

Disabling the Keypad
Turning the key switch on the control panel clockwise will disable the keypad. Any presses of the keypad will be ignored.
Note: The LED will also go dark but the controller will still operate.

Block Diagram

The following is a block diagram of the basic internal structure of the Model 1K 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.

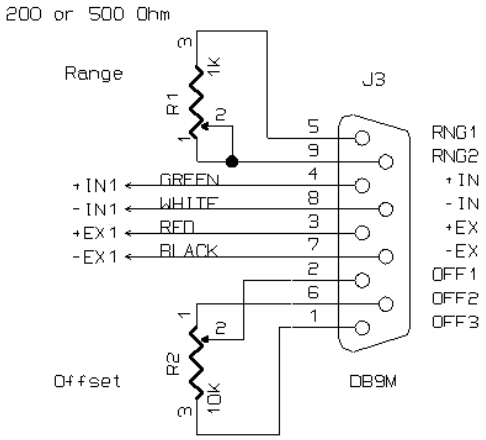


Model 1K System Block Diagram

Port Connection

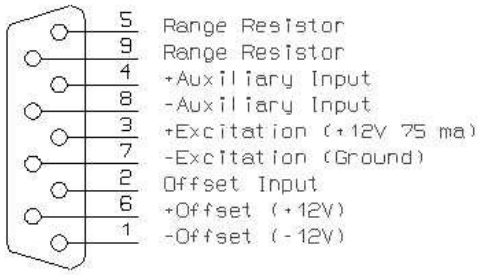
Two port connections are available on the side of the load frame to attach external sensors such as load or strain transducers. Once attached the output of one or both transducer can be monitored or used as a control channel. The upper port A connector is typically used to interface with a load cell. The load channel reads this port to measure the system load. The lower 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.



Note: Electrically both port A and B are identical. Port A is used primarily for the load cell while port B is typically used for strain monitoring/control

.



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	404 Ω
+/- 5.0 V	40.0K	+/- 0.05 V	201 Ω
+/- 2.0 V	10.0K	+/- 0.02 V	80.1 Ω
+/- 1.0 V	4.44K	+/- 0.01 V	40.0 Ω
+/- 0.5 V	2.11K		
+/- 0.2 V	816 Ω		

Other ranges can be selected using the equation below.

$$Range\,\mathrm{Re}sistor = \frac{40000}{(10.0 / RangeVoltage) - 1}$$

The port offset 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 +12V and –12V and can be used to trim the offset voltage using a trim pot. With each end of the trim pot attached between +12V and –12V and the wiper attached to the offset pin, the offset can be trimmed to suit most needs.

Note: The excitation voltage is available to power a full bridge sensor such as a load cell. The excitation voltage is fixed at +12 volts and is able to deliver up to 75 ma. If the excitation is not needed then this pin can be ignored.

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 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 Model 1K 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 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.

Calibration

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 Model 1Ks 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 Model 1K properly warmed up (~15 minutes) Remove the load cell from the Model 1K and install it in another load controlling system that is considered a calibration standard. The Model 1K load cell must be attached to the 1Ks internal load cell amplifier.
2) Add a calibration standard load cell and load cell in series with the Model 1Ks load cell and use the 1Ks 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. Be careful about setting the filter too low causing an uncontrollable system oscillation.
2) Be sure the load cell is plugged securely into the upper DB9 connector on the side of the load frame and is screwed in place to make a good connection.
3) Check that the Model 1Ks load range is configured properly in the load configuration menu and the offset is set to zero.
4) Allow time for the electronics to warm up and stabilize for approx. 15 minutes.
5) Set the load to zero (using the calibration standard) and adjust the 1Ks Zero trim pot (lower pot with letter O) for zero reading on the LCD.
6) Apply the maximum calibration load (in tension) using the calibration standard as the reference.
7) Adjust the Span trim pot (upper pot with letter S) so the LCD matches the calibration standard load.
8) Continue with step 3 until the two load cells are close as possible.

Strain Calibration

The strain data port can be calibrated the same as shown in the load cell calibration with the exception it is plugged into the top DB9 connector and the reference depends on the type of sensor used.

Serial Commands

Serial commands 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 Model 1K Controller can be programmed with the use of a computer to perform various operations. The default serial configuration for the Controller is 38400 baud, 8 data bits, 1 stop bit, no parity. Note that the commands are case sensitive and some commands are different depending on if the command is upper or lower case .

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

a [LOAD,STROKE,STRAIN,TIME]	Read load, stroke, strain, time
AA	Acquire one sample now
Ac [RATE]	Read acquire rate
AC(RATE)	Set acquire rate
Ad [C1,C2,C3,C4]	Read acquire data channels
AD(C1,C2,C3,C4)	Set acquire data channels
AM	Trigger acquire and fill buffer
An [COUNT]	Read acquire sample count
AN	Reset acquire sample count
Ar(N) [C1[0],C2[0],C3[0],C4[0],C1[1]…]	Read N acquired data points
AR	Reset acquired data to 0
AS	Stop acquiring data
B(CHAN,MAX)	Set max loop error
b (CHAN) [MAX]	Read max loop error
C(ON)	Set/Reset Remote control mode
D(AMP)	Set Amplitude
d [AMP]	Read Amplitude
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 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(SD)	Set system deflection
m [SD]	Read System Deflection
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(CHAN,ACT)	Set Limit Action
r(CHAN) [ACT]	Read Limit Action
s [RATE}	Read actuator rate
S(RATE)	Set actuator Rate
T	Reset test time to 0
t [TIME]	Read test time
u [BITS]	Read status bits in HEX format
v [VER]	Read Software Version
V	Reset all limit tripped status flags
W(HOLD)	Set Waveform Hold state
w [HOLD]	Read Waveform Hold state
y [CYCL]	Read cycle counter
Z(CHAN,OFF)	Set Offset
z(CHAN) [OFF]	Read Offset
+L(DISP),[STRING]	Update Remote Display Viewer
?	Display Help

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

When the Model 1K Controller is first powered up, it is in manual control. To place the unit in remote (serial) control mode, the command 'C1' followed by a return (cr) must be sent serially to the control panel so the unit knows to take commands from the serial port instead of the keypad. The LCD prompts with an Asterisk '*' in the upper left corner marking the remote mode is now enabled. To return back to manual control either press the  (menu) key on the keypad, send a serial 'C0(cr)', or cycle the power switch on the load frame.

Once in the remote control mode, commands can be sent to program the unit in various modes without having to select them from the control panel menu. For example to test up to a force of 500 lbs, send the command O0 followed by a carriage return (cr) to select load control if not in load control. The response from the controller should be a CR to acknowledge the command. Any invalid commands are ignored by the controller. 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.:
AA, Ac, AC, Ad, AM, An, AN, AR, AS, H a, d, f, m, o, q, s, t, T, u, v, w, y

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 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 (0Dh) 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 waveform generator (not the waveform time) and display updates are temporarily halted. 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 (using interrupts).

To send a list of numbers, each number 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.

Read data (a)

Read the load, stroke, strain 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.

Data acquisition Commands

Commands beginning with a capital A are data acquisition commands. The data acquisition software can be programmed to read four system or channel values and record them in memory to be read at a later time. Since the acquisition software can record up to 200 samples a second our to 1 sample every 248 days it can be very useful in automating process of collecting test data. The acquisition software can be programmed very easily. The default configuration will record the load, stroke and strain feedback along with the system time. Default sampling time is set to 200 samples per second. The software will record up to 1900 samples before completely filling system memory. Once memory is filled, the acquisition halts. As the data is collected or after the memory is filled, some or all of the data can be downloaded through the serial port in ASCII format.

Acquire one sample (AA)

Sample one value into acquisition memory. The default sample configuration records the load, stroke, strain and time as one sample. See the **AD** command to change the data stored in a sample. This command is useful when a particular test requires asynchronous sampling of data based on a specific event, not time based.

Read acquire rate (Ac)
Set acquire rate (AC#)

Read or Set how fast or slow the data is automatically sampled into the controllers data acquisition memory. Sample rate represents the sample rate in number of samples per second. Since the internal sample resolution is 5 ms, the time between samples rate will be rounded to 5 ms. The valid range of rates is between 200 samples per second to 4.7e-8 sample per second or one sample every 248 days.

Read data channels acquired (Ad)
Set data channels acquired (AD#,#,#,#)

Read or set the current data accession channel configuration. The accession software can be programmed to acquire different sets of data into the controllers memory. Up to 4 accession channels can be programmed to acquire data in the background for up to 1900 data values.

The list below represents the different types of System data along with the value

Index	Description	Format
0	Control Point (setpoint + amplitude)	float (control channel units)
1	Waveform current amplitude	float (control channel units)
2	Setpoint	float (control channel units)
3	Cycle count	float (24 bit mantissa)
4	Data acquisition rate	float (Hz)
5	Data acquisition counter	integer
6	System deflection rate	float (stroke units)
7	Control channel (0: load, 1: stroke, 2: strain)	integer
8	Current waveform type	integer
9	Actuator state	integer
10	Maximum actuator rate	float (stroke units per minute)
11	Waveform time	float (seconds)
12	System status bits	integer
13	System hold	Boolean
14	PID output value	float
15	Control error	float (control channel units)

The list below represent the values for the load, stroke and strain channels. Values in the range from 100 to 199 represent load while values in the range 200 to 299 and 300 to 399 represent stroke and strain values respectfully.

Index	Description	Format
x 00	Feedback	feedback channel units
x 01	Range	feedback channel units
x 02	Offset	feedback channel units
x 03	Filter	integer
x 04	Units	integer
x 05	Overall Maximum	feedback channel units
x 06	Overall Minimum	feedback channel units
x 07	Cycle Maximum	feedback channel units
x 08	Cycle Minimum	feedback channel units
x 09	Cycle Amplitude	feedback channel units
x 10	Cycle Mean value	feedback channel units
x 11	Max Limit	feedback channel units
x 12	Min Limit	feedback channel units
x 13	Limit Action	integer
x 14	Current loop error	feedback channel units
x 15	Loop error Action	integer
x 16	Limit error unload value	load channel units
x 17	Loop error unload value	load channel units
x 18	PID proportional gain constant	integer
x 19	PID Integral constant	integer
x 20	PID Differential constant	integer
x 21	Waveform Amplitude	feedback channel units
x 22	Waveform Frequency	float Hz
x 23	Waveform Ramp Endpoint #1	feedback channel units
x 24	Waveform Ramp Endpoint #2	feedback channel units
x 25	Waveform Ramp Rate #1	feedback channel units/sec
x 26	Waveform Ramp Rate #2	feedback channel units/sec
x 27	Waveform Trapezoid Hold time #1	float seconds
x 28	Waveform Trapezoid Hold time #2	float seconds
x 29	Waveform Type	integer

Note: x = 1 for load, 2 for stroke 3 for strain.

For example stroke range is represented as 200 + 01 or 201 and strain cycle mean is 300 + 10 or 310.

The default configuration stores load feedback , stroke feedback, strain feedback and waveform time. To program the accession software to read Load feedback, Strain feedback, Cycle count and waveform Time send the following command "**AD100,300,3,11**". All 4 channels store data in 32 bit floating point format. When the data is read out of the acquisition memory (Ar command) the data is automatically converted to ASCII floating point format.

Start acquisition and fill buffer (AM)

Trigger the data acquisition and begin collecting at the configuration rate. The data acquisition is done entirely in the background so other serial commands can be sent without having to wait for all samples to be acquired.

Read acquired count (An)
Reset acquired count (AN)

Read or reset the current sample count. The maximum number of samples is 1900. The count can be reset with the reset sample count command but continue to collect data starting at count 0.

Read acquired data (Ar#)
Clear acquired data (AR)

Read or clear the acquired data stored in the units RAM. The command requires a count which defines how many data points are returned. Be sure to select a number less than or equal to the current sample number. Reading n data samples returns the data in the following format (C1[1], C2[1], C3[1], C4[1] (cr) C1[2], C2[2], C3[2], C4[2](cr) .... C1[n], C2[n], C3[n], C4[n](cr)). This data is not battery backed and will be lost if powered down.

Note: All samples do not have to be collected before the first samples are read.

Stop acquiring data (AS)

Stop acquiring data.

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 - strain) 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 error protect only the current control. The limits are saved in battery backed RAM so be sure to reset them back to the default after modifying them.

Enter Remote Control (C#)

Once the Model 1K 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 and not from the control panel. 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.

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 value. To read a channel units send the command "e" followed by the channel number (0: load, 1: stroke, 2: strain). 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.

Index	Load	Stroke	Strain
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 strain display units will not automatically scale the data range to match the new units. Be sure to modify the load or strain 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-strain). 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 do not effect 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 strain feedback values 200 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" there 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: strain) 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. The table below represents the values that can be read using this command. These are the same values used with the data acquisition command.

System Variables

Index	Variable
0	Control Point (amplitude + setpoint)
1	Amplitude
2	Setpoint
3	Cycle Count (if > 1,000,000 cycles rounding may occur due to conversion to float. (Use y command for a more accurate count to)
4	Acquisition rate
5	Acquisition counter
6	System Deflection
7	Control Channel
8	Current Waveform Type
9	Actuator State
10	Maximum Actuator rate
11	Waveform Time
12	System status Bits
13	Hold State
14	PID output value
15	Control error

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

Index	Variable
x 00	Feedback
x 01	Range
x 02	Offset
x 03	Filter
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 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

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 other commands but variables such as cycle amplitude and mean can only be read using this command.

Write waveform channel value (J#)

Writes to a selected waveform internal value. The table below represents the values that can be written using this command.

Channel Variables (x = 1 for load, 2 for stroke or 3 for strain 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

For example to modify the stroke waveform frequency to 0.012 Hz send the command "J222,0.012". The waveform controller will immediately convert 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 waveform.

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 - strain) 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 battery backed RAM so be sure to reset them back to the default after modifying them.

Read System deflection (m)
Set System deflection (M#)

Read or set the system deflection ratio. Most of the system deflection can be removed from the stroke calculation if the deflection ratio is programmed into the controller. This ratio can be measured buy compressing a rigid object up to the maximum range of the load cell. The measured stroke is the full scale system deflection ratio. Entering this number into the controller will remove the deflection from the stroke calculations. Be careful about removing excessive deflection or stroke control can become unstable. Since the calculated system deflection is linear and the true deflection is not, not all error can be removed with this method.

To read the currently programmed deflection ratio enter the command 'k' and the ratio is returned as the number of inches (or cm's) deflected at full load. To program a new value send the command 'K' followed by the number of inches (or cm's) deflected at full load. The deflection ratio is stored in battery backed memory.

Note: To disable the deflection calculation, set the ratio to 0.

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-Strain). 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 as well and may make the control channel unstable. Adjusting the channel filters do not effect the analog voltage output only the digital values.

Filter Values with associated filter frequency

0 – None	5 – 1 Hz.
1 – 16 Hz.	6 – 0.5 Hz
2 – 8 Hz	7 – 0.25 Hz
3 – 4 Hz	8 – 0.125 Hz
4 – 2 Hz	

Note: Since the stroke channel is created digitally this channel can not be filtered.

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

Read or set the current control channel. (0 = Load, 1 = Stroke, 2 = Strain). 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 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 #1	**Par #2**	**Par #3**	**Par #4**	**Par #5**	**Par #6**	**Par #7**
Sine	0	Amplitude	Freq.			
Square	1	Amplitude	Freq.			
Triangle	2	Amplitude	Freq.			
HSine	3	Amplitude	Freq.			
HSquare	4	Amplitude	Freq.			
HTriangle	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

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.

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.

Actuator states (read only)

0 - STOP	Actuator Control stopped
1 - RUN1	Waveform running
2 - HOLD1	First trapezoid hold state
3 - END	Waveform finished and controller is running
4 - OFF	Actuator is powered off
5 - RUN2	Second trapezoid 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 error 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-strain). 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 battery backed memory.

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

If an action is tripped, the action is 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	Disable actuator motor current and allow the actuator to back-drive

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	Disable actuator motor current and allow the actuator to back-drive

Note: The unload action requires an extra parameter which is the load 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 battery backed RAM. To set the actuator rate to 1.25 in/min. send the command "**S1.25**" 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 3.0 in/minute with a resolution of 0.0001 in/minute. ***Note:*** This speed does not take into account the system deflection. If the controller was programmed to run slow (e.g. < 0.001"/min) the actual testing rate can be significantly slower due to the actuator stroke being converted into system deflection.

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 timer is set to 0. Holding the waveform will also hold the timer. Resetting the waveform timer will also reset the waveform cycles as well.

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 Error (true if a max/min limit is exceeded)
1	At Max Load
2	At Min Load
3	At Max Stroke
4	At Min Stroke
5	At Max Strain
6	At Min Strain
8	Keyboard Locked (via key switch)
9	Waveform Hold 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 strain limit tripped
21	Min strain limit tripped
22	Max load loop control error tripped
23	Max stroke loop control error tripped
24	Max strain loop control error tripped
25	At max loop control error

Reset all action alarm flags (V#)

The controller maintains the limit and loop error alarm status even after the error has been removed. This is to notify the remote software an error occurred because actions typically remove the error conditions. To reset all limit error latches enter the command V0 followed by a CR. To reset all loop error latches enter the command V1 followed by a return.

Firmware Version (v)

Access the units firmware name and version number. For example version 2.0 is returned as "`1K 2.0`".

Read hold status (w)
Set hold status (W#)

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

Note: this hold 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. This hold can be used with the trapezoid temporarily halting the trapezoids hold timer.

Read cycle count (y)

Read the cycle count. The cycle counter is a 31 bit counter counting up to 2,147,483,648 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-strain). 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.

Update Remote Display Viewer page (+L#,string)

Writes a string of up to 80 characters into one of two remote display viewer pages. Once the strings are written into the controller, the operator can view the results at any time by selecting the "Remote Display" feature on the main menu. The first parameter '#' should be a 0 or 1 depending on which page is being updated. The second parameter 'string' is a "carriage return" terminated string up to 80 characters in length. The 80 characters are displayed on the LCD in a 4 line by 20 character format. Each of the 2 pages operate independently and can be viewed at any time. The operator can view each page by pressing the up/down arrows on the control panel. This feature is useful if a remote computer must acquire specific information from the controller and report the results in a unique way. Press the  (menu) key to return to the main menu

For example to update the first page send the following string "+L0,"This is a String". The information will be viewed once the operator enables the remote viewer via the control panel.

Help (?)

Displays a list of available serial commands.

Error Conditions

If during a test the Controller detects an error condition, the motor will automatically turn off, the display will prompt with the error and the LED will blink rapidly. The following table explains each error condition:

"Remove Load"

If the controller reads a load over 200 lbs. while returning the actuator to home. If this error occurs, remove the load and try again.

"Can not Initialize"

If the controller can't detect the home switch, the unit stops and displays this message. Try locating home again and see if the condition repeats.

Model 1K Specification

Load Frame:

Maximum actuator load capacity is +/- 1400 lbs.
Maximum actuator stroke range is 2.5 inches
Maximum actuator rate is 3.0 inches per minute
High torque micro-stepped stepping motor for rugged long term reliability
Adjustable cross bar can be positioned to accommodate long or short specimens
Power Requirements 110 Volts < 0.3 amps. Total weight ~65 lbs.

Instrumentation:

Load is measured via mounted pancake load cell or S-beam load cell
Load resolution: 0.1 lbs., Stroke resolution: 0.0001 in
Two adjustable integrated amplifiers accept bridge sensors or direct voltage input
Shunt calibration button is available for quick load cell verification
Analog load and strain is measured using a 16 bit analog to digital converter
Programmable digital filter ranges from 0.125 Hz to 16 Hz
Results are displayed in Metric or English or custom units
Remote operation and data collection using integrated RS-232 serial port

Controls:

Waveform generator supports sine, square, triangle and havercycle functions
Ramp generator supports single, dual and trapezoid functions
LCD panel constantly displays load, stroke strain data in real time
Security key prevents unauthorized parameter changes
Load control accuracy < 0.05% full scale
Stroke control accuracy < 0.0025% full scale
Adjustable digital PID control algorithm precisely maintains control point
Maximum actuator response rate is adjustable from 0.00001 to 3.000 in/min
System parameters are stored in battery backed RAM (10 year life)

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
Overall and cycle peak detectors for each channel
Adjustable acquisition rate of 200 samples/sec to 248 days/sample
Programmable data acquisition of 7600 32 bit readings
Graphical application interface (LabVIEW, Visual Basic etc.) via RS-232 port
Optionally removes system deflection in stroke calculations

Electronics:

24 MHz, Dallas 80C320 Microcontroller
32k RAM, 64k of ROM, Battery backup RAM/Clock timer
16 key keypad for function selection and numerical entry
Audio Beeper and LED to signal operation status
2 channel high speed 16 bit Analog to Digital converter
RS-232 serial interface adjustable from 1200 to 38,400 baud
4 line by 20 character LCD panel
Integrated micro-step stepper motor driver/controller for quite positioning

Troubleshooting

LCD does not display information

- Check to see that the switch on the load frame is on.
- Check to be sure the control panel is properly attached to the load frame with the 15 pin data cable.
- Verify that wall socket is getting power.

System Error is displayed

- See that the 15 pin data 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 strain channels are not limited

Actuator will not move

- Check that the 15 pin data cable is plugged securely into the control panel and load frame
- Be sure the power cord is plugged into the load frame and the unit is powered up
- Check to see that the Security Key is in proper position (counter clockwise)
- Make sure that the load, stroke or strain is not out of range
- Be sure the controller is not paused or disabled. Press Enter to release

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 but not low enough to distort the load feedback
- Retune the PID control parameters to stabilize the controller.
- Be sure the specimen is properly anchored
- Verify the load is centered around the load cell thread and does not contact the frame

Stroke Limit reached before the end of test

- Reset the actuator to a higher (for tension) or lower (for compression) position before starting a test.

Actuator makes noises at times

- The actuator will make noises at some test rates. The motor has a mechanical resonance frequency that will vibrate the frame at some rates. Once a load is applied, the noise should be reduced.
- If the actuator makes excessive noise check that the load frame is not obstructed preventing the actuator from moving freely.

Actuator will not initialize

- Check that the load cell is properly plugged into the side of the load frame and secured
- Be sure a load is not applied to the load cell. Loads over 10% of the load range will stop the actuator from locating home on power up
- See that the 15 pin data cable is securely attached to both the load frame and the control panel.
- Be sure the power cord is plugged into the load frame and the unit is powered up
- Check to see that the Security Key is in proper position (counter clockwise)

Keypad is not accepting keys

- The security key should be in the counter clockwise (unlocked) position to allow the keypad to operate

Limited Warranty

Interactive Instruments, Inc. warrants the **Model 1K Controller** 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.

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.