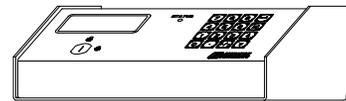
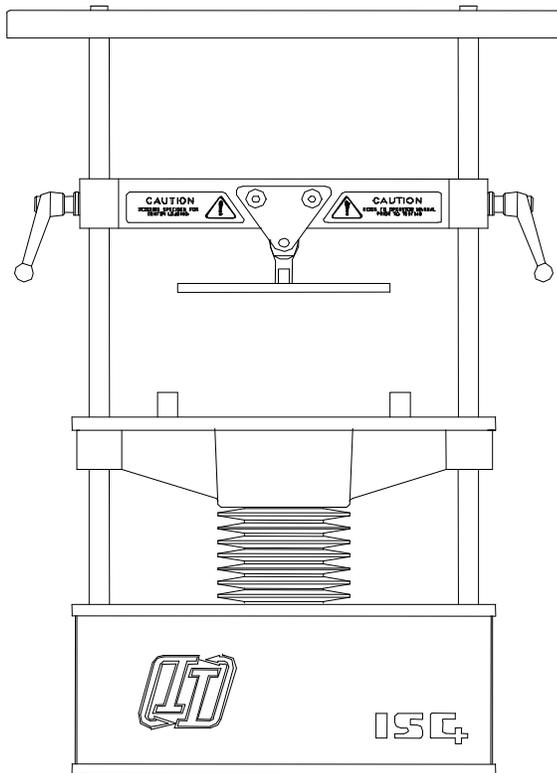


*INTERACTIVE  
INSTRUMENTS*



# Interactive Strength Challenger Plus <sup>TM</sup>

## Instruction Manual

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## Safety Guide

- **Follow the instructions** and be sure to follow all warnings on the equipment and in the manual for trouble free service.
- **Be sure that a supervisor is present** whenever the Interactive Strength Challenger Plus™ (the Challenger) is in operation. It is the responsibility of the supervisor to read and understand this manual before operating the equipment.
- **This product is supplied with a grounded power cord.** Be sure that you use a wall socket that conforms to this cord. Bypassing the ground for any reason may cause personal injury. When using an extension cord, be sure the cord is capable of handling the power requirements of the CHALLENGER. The cord should not be any longer than required.
- **A security key has been supplied** that prevents the CHALLENGER from operating when the key is turned off. The supervisor should have possession of the key to prevent unauthorized use of the product.
- **It is the supervisor's responsibility to inspect the CHALLENGER** to insure it is in proper working order and that none of the built-in safety features are bypassed before and during operation.
- **Unplug the CHALLENGER from the wall** to avoid damage due to lightning or when left unattended for long periods of time.
- **Do not attempt to service, repair or disassemble this product yourself** as removing covers may expose you to *dangerous* voltage or other hazards. *No* user serviceable parts are inside. Refer all servicing to Interactive Instruments, Inc.
- **Do not expose this unit to rain or moisture.** The CHALLENGER must be used in a protected building to prevent shock hazards.
- **This product is intended for instructional use only.** It should not be used for the development of designs that could potentially injure humans.
- **Affix unit to the table top for stability.** Bolt length should be the table top thickness plus 1/2 inch and should not penetrate the unit more than 1 inch or damage to the unit may result.

## Installation and Setup

**Unpack the Interactive Strength Challenger Plus™ (CHALLENGER) from the shipping container. Retain the packing material provided in case the unit must be returned to the factory at a later date. Do not ship the unit in anything other than this container or damage to the CHALLENGER will result.**

After unpacking everything, you should find the main unit, control panel, 15 pin data cable, power cord, and manual. If you are missing any of these parts, please contact Interactive Instruments immediately.

Inspect the Challenger for shipping damage. If any damage occurred in shipping, report the damage to Interactive Instruments immediately. Operating a damaged unit may result in additional damage or personal injury.

Place the CHALLENGER on a sturdy and level workbench. It is best to bolt the CHALLENGER to the workbench to prevent the unit from falling and damaging the unit or causing personal injury. Two mounting holes (3/8" holes 13" on center) are supplied on the bottom of the unit to securely mount the CHALLENGER to the workbench. Affix unit to the table top for stability. Bolt length should be the table top thickness plus .5" and should not penetrate the unit more than 1" or damage to the unit may result.

Plug the 15 pin data cable into the rear of the CHALLENGER Load Frame and also into the rear of the control panel. Secure both ends.

Gently plug the power cord into the rear of the Load Frame, but do not plug the power cord into the wall socket yet.

If you have the optional printer or computer cable, be sure it is plugged in and secured.

Verify that the main power is off before plugging the control panel into a 110 volt, 60 Hz grounded wall outlet. Do not bypass the ground pin on the power cord, this is needed for your safety.

## Turning the Challenger On

Enable the unit by turning the Security key on the control panel counterclockwise.

To test the unit, power the unit by toggling the power switch located on the back of the Load Frame. As the control panel is powering up, it should display the following messages on the LCD panel:

### **Testing System**

If the display prompts

**\*\*\* SYSTEM ERROR \*\*\***

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.

While the test platform is in motion, the LED on the control panel will blink to indicate activity. The same LED will indicate error conditions by flashing at a faster rate and will be on steady if a test is temporarily paused.

If everything is OK, the test platform should move to the home position. The motor, under normal operation, will make a noise while in motion and may also make noise while stopped. If there are any loud or abnormal noises coming from the unit, turn off the control panel and call Interactive Instruments for further instructions.

Please review the remainder of this manual for useful information and testing details.

## Overview

The Interactive Strength Challenger Plus™ (CHALLENGER) is a materials and structure tester, designed to study basic force and deflection principles of various materials and structures. The CHALLENGER design is optimized to instruct students in junior high, middle school, high school and university level classes with a focus on ease of use. Since the CHALLENGER is designed as a general instrument, the uses are limitless. From materials testing to structure analysis, the learning value goes a long way.

## Easy to Operate

The CHALLENGER has an easy to use control panel. Starting the unit is as easy as pressing the  (Enter) key. A 20 character by 4 line display is continuously updated to accurately reflect the system's force, contact displacement and system information. A high torque stepper motor and drive system is powerful enough to produce 1250 lbs. of tension or compression on a specimen. This is usually strong enough to exercise most materials and structures within a classroom. Instrumentation located in the unit constantly monitors the forces exerted on the test specimen so forces can be displayed in *real time* on the display panel. Precision strain gages mounted in the unit accurately measure the forces on the model without having to attach them directly to the model. This allows for easy mounting and removal of the test model.

## Quality Design

The CHALLENGER is a high quality instrument that can *precisely* measure and control the force and displacement exerted on the specimen to better than three percent over the test range. The force is constantly monitored hundreds of times a second to maintain a steady pressure on the specimen. Using precision strain gages, the specimen force is electronically monitored and controlled. This provides a *constant* force independent of the material or structure of the sample. The actual system force is displayed on the control panel which allows studies to be conducted over a wide range of conditions.

## Versatile

An easy to access 10"h x 12"w x 6"d test area allows various models to be quickly mounted for testing. The safety shield is easily removed from the unit for unrestricted access when changing test mounts or test specimens. Three built in test modes allow a wide range of tests. The **Automatic** test mode will test the specimen up to the maximum system force, until the CHALLENGER detects a peak force or the test is paused or halted by the operator. **Incremental** mode allows a more controlled force to be applied to the specimen by increasing the force in small increments. **Interactive** mode is a unique mode that allows direct control of the system force by simply using the key pad to select desired force setting. With the test force controllable in either tension and compression, up to six different tests can be performed which makes the CHALLENGER a very versatile classroom instrument.

## Self Contained

The CHALLENGER performs an automatic self test every time the unit is powered up. If an error is detected within the unit, the display informs the operator of the error condition and disables further operation. The test also detects functional problems before allowing the unit to operate. The built-in force gages are *automatically* zeroed before each test to keep the display in calibration. Therefore the unit should *never* require re calibration.

## Safety

The Interactive Strength Challenger is designed with safety in mind. The CHALLENGER is capable of automatically shutting down if it detects a problem. A security lock is also added to disable the unit when a supervisor is not present to prevent unsupervised operation of the unit.

**Overall, the Interactive Strength Challenger is an invaluable tool to visually demonstrate basic to advanced *strength of material or structure analysis* principles to students.**

## Using the Interactive Strength Challenger

### Loading a test sample:

To load a test model, be sure the test platform is stopped before attempting to change the test sample. Follow the steps below to load a sample.

**Note:** Be sure *not* to power down the unit because the test platform will move to find the home position upon power up. This may cause excessive compression or tension forces on the test specimen while the platform is in motion.

### Removing the safety shield

Lift the safety shield using the handle on the front of the shield. Be sure to clear the shield pins that hold the shield to the CHALLENGER before pulling the shield away from the unit. Place the shield to the side.

### Installing an optional test adapter

Different test adapters can be attached to the test platform and adjustable upper beam for various tests. To connect the adapter to the above upper beam, remove the adapter pin by pushing the button in the center of the pin and removing the pin. Any system force must be removed before the pin can be pulled out of the upper beam. To insert the pin, push the center button on the pin while inserting back into the upper beam.

### Adjusting the upper beam

Adjust the upper beam above the test platform to the desired position to restrain the specimen while under test. To adjust the upper beam, turn each upper beam handle (on each side of the beam) counterclockwise to loosen. The handle is capable of being positioned to various angles by pulling the handle out and turning it to a new angle for better leverage. With both handles loose, position the upper beam to the desired height and tighten each handle securely by turning them clockwise.

**Note:** If you are testing with high forces, be sure that each handle is *very* tight so one or both sides don't slip while under test. If the upper beam does begin to slip, stop the test and release the force by returning the platform to home. Then carefully loosen both upper beam handles to remove any uneven forces on the upper beam. Retighten and resume testing.

### Adjusting the test platform blocks

The platform blocks can be adjusted by aligning the pins in the block with the pins in the test platform. Then secure the block by turning the fastener in the center of the block 1/4 turn clockwise until it clicks. This will secure the block to prevent it from moving.

**Note:** The platform blocks should always be equal distance from the center of the test platform to prevent uneven loading on the test platform and improve the accuracy of the test results.

### Replacing the safety shield

Carefully reinstall the safety shield by lifting the shield by the lower handle and aligning the shield pins with the pin holes in the CHALLENGER. Once the pins are aligned, drop the shield in place. The CHALLENGER will not be able to start without the shield in proper position.

**Before starting a test:**

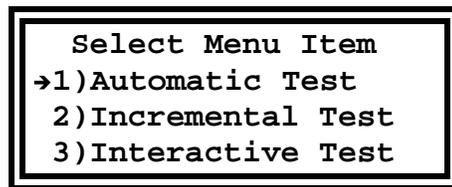
- Verify that the CHALLENGER is properly setup (*see Installation and Setup procedure*)
- Insert the Security key and turn to the unlocked position

**Starting a test:**

It would be best to let the unit warm up for a few minutes before pressing the  (enter) key. This would allow the sensitive electronics to warm up and give more accurate results. If the unit is very cold (below 60 degrees F), be sure to let it warm up for at least 15 minutes (with the unit powered up but stopped) before starting a test. This will allow time for the electronic measurement equipment to reach calibration temperature. Since the CHALLENGER is calibrated in room temperature between 70 to 80 degrees F, more accurate results will be obtained if operation is limited to this room temperature range. Operation outside of this range may give inaccurate force measurements.

**Changing the System configuration:**

Press the  (menu) key on the control panel to display the main menu items as shown below.



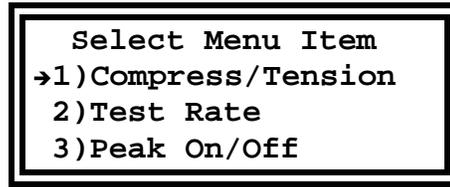
Press the 1, 2 or 3 key on the key pad to select the desired menu item. The  (up) and  (down) arrows on the key pad can also be used to scroll the entire menu. If the menu arrow is pointing to the desired item, press the  (enter) key to select. Once you become more familiar with the menu numbers, it is faster and easier to select options by using the numbers.

The main menu list includes:

- |                           |                                      |
|---------------------------|--------------------------------------|
| <b>1)Automatic Test</b>   | (Selects Automatic Test mode)        |
| <b>2)Incremental Test</b> | (Selects Incremental test mode)      |
| <b>3)Interactive Test</b> | (Selects Interactive test mode)      |
| <b>4)Configuration</b>    | (Configure the CHALLENGER's options) |

The first three items select the test mode and the last item is used to change the system configuration. Select **4)Configuration** from the menu to display the system configuration menu as shown below. This is done by pressing 4 on the key pad or pressing the down arrow until the arrow points to menu item 4 and press  (Enter)

Select **Configuration** from the main menu list to display the menu as shown below.



Use the ▲ (UP) and ▼ (Down) arrows on the key pad to move the menu pointer through the list of options. The list includes:

- |                    |   |
|--------------------|---|
| 1)Compress/Tension | (Selects between Compression and Tension force) |
| 2)Test Rate        | (Sets the platform test rate)                   |
| 3)Peak On/Off      | (Enables or Disables the peak force detector)   |
| 4)Printer On/Off   | (Enables or disables the printer port)          |
| 5)Maximum Force    | (Enter the maximum allowed test force)          |
| 6)English/Metric   | (Selects between English and Metric units)      |

Once the configuration menu is displayed, select the configuration menu options by pressing the menu item number on the key pad or scroll using the ▲ and ▼ keys and press the ← key. For example, to select tension mode press the 1 key on the key pad. This will display a menu to select compression or tension. Press 2 to enable tension testing. Options that require a number to be entered such as setting the **Maximum Force** or **Test Rate** can be selected by entering the number with the key pad. To erase an invalid number, press the [Menu] (menu) key and re-enter the correct number. Press Enter once the proper number is entered. To cancel entry completely, press the [Menu] key until the menu is re-displayed.

## Configuration Options

The following defines the ISC configuration options.

### 1) Compression/Tension

This option selects between Compression and Tension force direction. Compression forces move the platform up to compress the specimen on the test platform against the upper beam. Compression displacement range is from 0 to 2 inches. Tension mode will move the platform down away from the upper beam. If the optional tensile adapter is installed, the Challenger will pull the specimen with up to 1250 lbs. of force. Tension displacement range is from 0 to -0.5 inch. The default force configuration is compression.

### 2) Test Rate

Test rate controls the platform rate in inches per minute. Normal test rate is 2.5 inches per minute which takes less than a minute to travel the full 2" of platform compression range. Slower test rates of 0.00001 inch per minute can be selected requiring over 138 days to travel the 2" platform range. Valid range is from 0.00001 in/min to 3.50 in/min (8.9 cm/min). Default test rate is 2.5 in/min (6.4 cm/min).

**Note:** When testing materials that are very rigid, be sure to use a slow test rate. Fast test rates will not be able to accurately show the force and deflection of the test specimen and may overshoot the desired force.

### Peak On/Off

The peak detector is activated by default but can be disabled if peak force and displacement are not desired. This option can be very helpful when testing materials with several stress points. The peak detector by default is enabled.

### Printer On/Off

An optional printer can be attached to the CHALLENGER to graphically plot the system force vs. contact displacement with any of the test configurations. Call your Dealer to order the optional printer interface kit for your unit.

**Maximum Force**

The Max configuration option is the maximum system force allowed in a test. This is very useful in testing a specimen up to a desired force. For example to exert 700 lbs. of force on a structure, change the system configuration Max force to 700 lbs. and test to the maximum force using the Automatic test. Valid range is from 50 lbs. to 1250 lbs. (or 567 kg). Default maximum test force is 1250 lbs. (567 kg).

**English/Metric**

Metric (kg. and cm.) or English units (lbs. and in.) can be selected to suit the display units of your choice. Default configuration is English units. With the units in metric mode, the display (and printer) will use kg and cm units.

To return to the main menu press the  key. Then select desired test mode as shown below and press .

## Selecting a test mode:

Press the  key on the key pad to display the main menu. Press the menu item number that corresponds to desired test. The list includes **1)Automatic Test**, **2)Incremental Test** and **3)Interactive Test**. See the details for each test mode below.

Pressing the  key on the control panel will begin the current test. The top line of the display will show in which test mode the CHALLENGER is currently configured. The LED will continue to blink while the test platform is in motion.

## Automatic Test:

Selecting the automatic test mode will display a prompt on the control panel as shown below.

```

Auto Compress
Push  or 
Force:    +   0.0 lbs
Disp:    +0.0000 in.

```

After pressing the  key, the CHALLENGER will slowly increase the force to 1250 lbs or the maximum allowed force (compression or tension). The platform will move at the current test rate until it detects a peak force (if enabled) or the test is interrupted by pressing the  or  key. While the test is underway, the display will reflect the maximum test force on the first line as shown below. The second line displays a bar graph to show the current force relative to the maximum force. The last two lines show the current force and contact displacement of the test sample.

```

Set:+1250.0 lbs.
|||||||
Force:    + 523.0 lbs
Disp:    +0.1422 in.

```

Pressing the  key while under test will pause the test platform and pressing  again will resume testing. The peak force is monitored by measuring a maximum force over a 0.075 inch (0.19 cm) displacement. If another force is not found greater than the previous peak force within 0.075", the unit stops and displays the peak force and displacement on the control panel (if enabled).

```

Push  to Home
Peak Force
Force:    + 629.2 lbs
Disp:    +0.1523 in.

```

## Incremental Test:

Selecting the incremental test mode will display a prompt on the control panel as shown below.

```
Incremental Compress
  Push ← or ↵
Force:   +   0.0 lbs
Disp:   +0.0000 in.
```

Push the ← key to start the test and the CHALLENGER will request the desired incremental force as shown below. The default incremental load is 25 lbs. Larger or smaller incremental loads can be selected at this time by keying in a new value. Once the desired increment is entered, press the ↵ key and the platform will move at the current test rate until the desired incremental force (compression or tension) is reached.

```
Enter Force Inc.
Push ← to Continue
Force:   +   25.0_lbs
```

Pressing the ← key again will multiply the incremental force by 2, 3, 4 and so on until a peak force is detected (if enabled). The peak force is monitored by measuring a maximum force over a 0.075 inch (0.19 cm) displacement. If another force is not found greater than the previous peak force within 0.075", the unit stops and displays the peak force and displacement on the control panel (if enabled).

## Interactive Test:

Selecting the interactive test mode will display a prompt on the control panel as shown below.

```
Interactive Compress
Push ← or ↵
Force:    + 0.0 lbs
Disp:    +0.0000 in.
```

Selecting the Interactive test mode will first load the specimen to 20 lbs. to make contact with the structure. Once contact has been made, the operator can key on a force using the key pad to set the test force between 0 lbs. and the maximum force while under test. As the load changes to reach the new setting, the **Set:** prompt at the top of the display will reflect the new test force. Forces can quickly be increased or decreased in tension or compression mode by entering new values on the key pad. Going to 0 force will return the platform to home, not to the contact force of 0 lbs. This is to aid in the removal of a specimen.

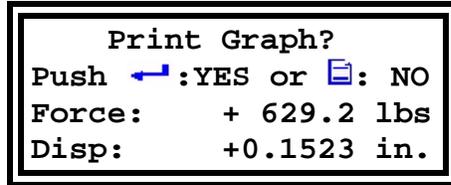
```
Set: + 453.7 lbs.
||||
Force:    + 289.6 lbs
Disp:    +0.1025 in.
```

The peak force is monitored by measuring a maximum force over a 0.075 inch (0.19 cm) displacement. If another force is not found greater than the previous peak force within 0.075", the unit stops and displays the peak force and displacement on the control panel (if enabled). To prevent false peak detection, be sure to disable the peak detector if you plan on ramping the force up and down over a 0.075" displacement.

**Note:** Turning off the CHALLENGER will reset the test modes and parameters back to the default state as shown above.

### Printing the results:

The CHALLENGER collects all of the load vs. displacement data before printing the results. If the printer option is enabled and the test terminates, the display will prompt as shown below. To print the force vs. displacement curve make sure the printer cable is attached, the printer is power up and on line. Press the  key when instructed to begin printing. Press the  key at any time to cancel the printing. The plot may take over 2 minutes to complete depending on the printer. Once the printout is complete, the platform will return to the home position. The printout display will display an auto scaled force vs. displacement graph along with the peak results (if peak detect is enabled).



Print Graph?  
Push :YES or : NO  
Force: + 629.2 lbs  
Disp: +0.1523 in.

### Returning the Test Platform:

Pressing the  key at any time will halt a test in progress. Pressing the  key a second time will return the platform to the home position. Always return the platform home before removing and or re-installing a new test specimen.

## Error Conditions:

If during a test the CHALLENGER detects an error condition, the platform will automatically stop, the display will prompt with an error message and the LED will blink rapidly. The following table explains each error condition:

### "System Locked"

If the security key is locked, the Interactive Strength Challenger is disabled until unlocked. If this occurs, turn the security key to the unlocked position (counter clockwise) before operating the unit.

### \*\*\*\* SYSTEM ERROR \*\*\*\*

When the microprocessor detects a problem during power up, this message is displayed. If this problem occurs, power down and back up to see if the problem re-occurs. If the problem persists, call your Dealer for further instructions.

### "Disp. Out of Range"

If the platform extends to the limit of the test range (2.0" for compression, 0.5" for tension). The CHALLENGER halts and this message is displayed. Press  key to return the platform to the home position.

### "Force Out of Range"

If the platform reaches the maximum force limit of the unit (default 1250.0 lbs) without detecting a peak, the CHALLENGER halts and displays this message. Press  key to return the platform to the home position if in Automatic or Incremental test mode or enter another load if in Interactive mode.

### "Can not return home!"

If the CHALLENGER can't detect the home switch on power up, the CHALLENGER stops and displays this message. The CHALLENGER can not operate if the home switch can not be located. Call Interactive Instruments if this problem occurs.

### "Safety Shield Open"

If the Safety shield is removed, the CHALLENGER halts operation and displays this message. Press START once the shield is replaced to resume operation.

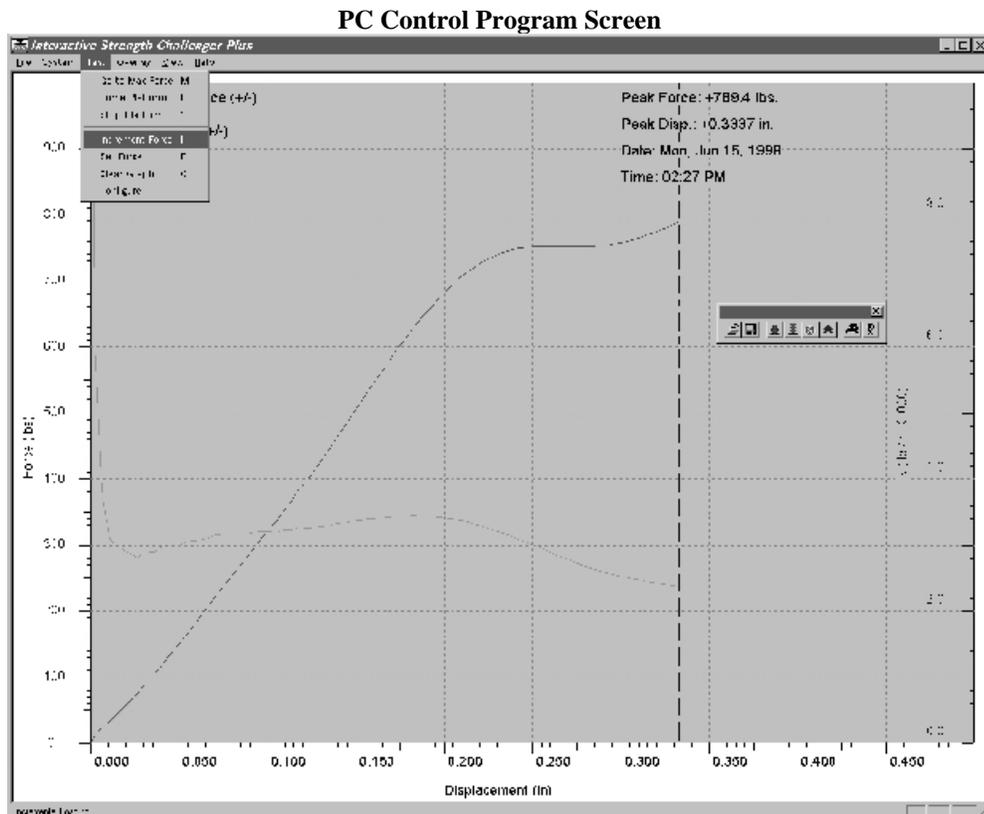
### "Printer is Busy!"

If the printer is busy or off line, the prompt will be displayed. Press  key to cancel printing or put the printer on line to resume printing.

## Available Options

### CHALLENGER PC Control Program

An optional 32 bit Windows™ graphical computer interface is also available which allows full functional control of the Interactive Strength Challenger. The software is an easy to use menu interface with built-in help that will allow you to quickly master the features of the CHALLENGER (see **Figure #1** below). The system force and spring constant (K) will be displayed graphically in real time with respect to the contact displacement. Compression and tension forces can be displayed graphically to compare material or structure strengths for various materials. The graphical and tabular data can then be printed or stored to disk for further comparison.



## Interactive Strength Challenger Plus Specification

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<b>CHALLENGER:</b>	Solid aluminum construction with particle coat paint for rugged use Total dimensions 31" - h, 21" - w, 8" - d Total weight 60 lbs. Computer generated and tested design See through safety shield
<b>Test Platform:</b>	Test area measures 10" - h, 12" - w, 6" - d Measures both compression and tension to 1250.0 lbs. (0.1 lbs. resolution) Measures contact tension to 0.5" and compression to 2.0". (.0001" resolution) Variable platform rate from 0.00001 in/min to 3.50 in/min Optional material adapters for various tests
<b>Motor:</b>	200 step high torque stepper motor with a 7.2 to 1 gear box Microprocessor controlled for precise positioning and force control Stepper controller configured for over 34000 micro steps per revolution
<b>Instrumentation:</b>	Force measured via 2 precision strain gages Data is collected by a microprocessor with a 12 bit A/D converter Displays test results in Metric or English units Support for an optional printer or computer built in
<b>Controls:</b>	Easy to use software menu control to select various tests Automatic, Incremental and Interactive tests supported Compression or tension force control available in any test mode Control panel plugs into the CHALLENGER for manual control LCD panel constantly displays contact force and displacement in real time Security key limits the CHALLENGER to supervised access
<b>Electronics:</b>	24 MHz, 80C320 Microcontroller with 64k of ROM, 32K RAM 11 channel, 12 bit A/D converter RS 232 serial interface @ 9600 baud for optional computer control 4 line by 20 character LCD panel with a 16 key keypad Strain gages and amplifiers to measure the structure force 34722 micro step per revolution stepper motor controller Optional printer port for graphing force vs displacement plots
<b>Optional Software:</b>	Easy to use Windows™ graphical interface with built-in help Graphically displays force (+/-) and spring constant with respect to displacement Overlay graphical test results for quick comparison Displays graphical results in Metric or English units Data can be imported to most spreadsheets for further analysis
<b>Tensile Adapter:</b>	Quickly bolts onto unit for easy installation and removal Accepts threaded tensile specimens

## **Technical Information**

The Interactive Strength Challenger generates the force through the use of a high torque hybrid stepper motor located in the lower compartment of the CHALLENGER. The rotation of the motor turns a shaft that is connected to a heavy duty recirculating ball nut. This rotation drives the ball nut up and down the shaft which in turn moves the test platform. A ball nut is similar to a standard nut and bolt but instead of metal to metal contact, many ball bearings are used allowing the system to support very high dynamic loads. Together this allows the CHALLENGER to precisely position the test platform to apply the desired force at a controlled rate of speed. Also, within the lower compartment are two precision strain gages that continuously detect how much force is placed on the test specimen. The output from these sensors is sent to the control electronics for display.

### **Stepper motor**

A stepper motor is essentially a DC motor without any brushes to make it run by itself. The name Stepper motor comes from its ability to step (in either direction) to a precise angular position. Using a stepper motor has many benefits over standard motors such as precise computer control, long life, positional accuracy and compact designs. To rotate the stepper motor requires a solid state stepper motor controller to control the motor. With the use of a microprocessor and a stepper motor controller chip, the motor can be rotated in any direction at almost any speed. This makes stepper motors ideal for use in printers, robots and electronic typewriters.

Since the computer can directly control the motor, its speed can easily vary from 0 RPM to the limits of the motor. Unlike a DC motor, a stepper motor can maintain its position when stopped. With a DC motor, once the motor is stopped a force applied to the motor shaft will change the position of the shaft. With a stepper motor, a hold current is maintained in the motor windings to hold the motor precisely in the same position. Since the CHALLENGER can stop with a load force, this feature becomes an important design requirement. DC motors must rely on system friction to maintain the load or require that no load be applied when stopped, thus making the system less efficient or practical.

Since the CHALLENGER's stepper motor never becomes de-energized unless the unit is turned off, the motor makes noises even while stationary. The noise comes from the stepper motor controller maintaining a constant current in the motor windings. Since stepper motors require high currents to run, the motor current is actually switched on and off to accurately control the amount of current in the motor. This switching is performed at about 20,000 times a second which is just outside the human hearing range. As the unit is warming up, the frequency may dip below 20,000 Hz and become audible. This is normal and should last only a few minutes.

Since the CHALLENGER uses a Micro-step stepper motor driver/controller, the low speed noise that typically comes from a high torque low speed stepper motor is significantly reduced. Using a micro step controller makes the job of controlling the motor much more difficult. It requires a faster microprocessor and digital to analog converters to properly control the motor. The benefits of such a motor controller are increased motor and bearing life and much smoother motions for quieter operation. With each rotation of the motor shaft (0.034" of platform motion) the controller must micro step over 34,000 times. Using a standard stepper controller, the same rotation would step 400 times. Now that the motor steps are 85 times finer, the motor control is much smoother and quieter.

As with a DC motor, the torque output of a stepper motor is inversely proportional to the speed of the motor. As the motor runs faster and faster, the motor is not able to deliver the same force as with lower speeds. To compensate for this condition, the CHALLENGER constantly monitors the force and will automatically reduce the speed of the motor as the system force increases. This is to prevent the system force from overpowering the stepper motor. If the system force was not monitored, the maximum platform rate would have to be much lower.

## Control Electronics

A microcontroller is used to control, monitor, and display the information on the LCD panel. The microcontroller is a Dallas 80C320 design which is an 8 bit processing unit with built-in RAM, UART, timers, I/O ports and interrupt controller. Attached to the 80C320 is a 64k ROM and 32K RAM which is used for both the control program and look up tables. A 12 bit, 11 channel Analog to Digital converter (A/D) is connected to the 80C320 via serial link. The A/D converter is capable of sampling the data and transmitting the data in as little as 30 microseconds. This would allow sampling rates as high as 33,000 samples per second for a single channel. Since the CHALLENGER currently samples the force every 5 ms, the sampling rate is 200 samples per second. With the speed of a CHALLENGER test taking from 1 to 16 minutes, the CHALLENGER will gather from 12,000 to over 190,000 data samples per test. If a person was to gather the same data and write it down, it would take over 16 days non stop to perform the same test manually. The LCD panel is a 4 line by 20 character which is also connected directly to the 80C320 microcontroller and is responsible for displaying the real time data and peak information.

## Force Sensors

The electronic sensor is used to measure the system force by using precision strain gages and high gain amplifiers to measure the forces exerted on the specimen. The force changes the resistance of the strain gages, and the voltage measured across the resistance is measured with a high gain amplifier. Since the change in resistance is very slight, amplifiers are needed to measure the changes before the analog to digital (A/D) converter can measure the force. Since the voltage output is directly proportional to the force, the voltage is in direct relation to the test model's force. Since the CHALLENGER can exert and measure compression (+) and tension (-) forces, the sensor is mounted so it can measure forces in both directions. Without this, we would only be able to measure force one direction.

## **Troubleshooting**

### **LCD does not display information**

- Check to see that the control panel is properly plugged into the CHALLENGER load frame. The control panel derives power from the load frame through the 15 pin connector
- Check to be sure the CHALLENGER Load frame is properly plugged in and turned on.
- Verify that wall socket is getting power.

### **Test rate appears to change**

- The actual platform rate may change depending on the test specimen. Rigid materials may not run at high platform rates to prevent overdriving the stepper motor.

### **Test Platform will not move**

- Check that the 15 pin data cable is plugged into the control panel and CHALLENGER and secured.
- Be sure the power cord to the CHALLENGER is plugged firmly.
- Check to see that the Safety Shield and Safety Key are in proper position.
- Make sure that the force or displacement is not out of range.

### **Upper beam moves while under test**

- The upper beam handles must be very tight to prevent the upper beam from slipping. Tighten each handle securely before testing with high forces.

### **CHALLENGER makes noises at low test rates**

- The CHALLENGER will make noises at slow test rates and this is normal. The noise comes from the stepper motor running at very low speeds without a load. Once a load is applied, the noise should be reduced.

## **Limited Warranty**

Interactive Instruments, Inc. warrants the **Interactive Strength Challenger** against defects in material and workmanship for a period of *one* year from receipt by the end user (*proof of purchase required*). 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.

## **Glossary**

 <b>key</b>	Enter key on the control panel that selects key entries or operations
 <b>key</b>	Key on the control panel key pad that selects the system menu or cancels entries
 <b>key</b>	Key on the control panel key pad used to select menu items or increment/decrement numbers
<b>Adapter pin</b>	Pin used to connect a test adapter to the adjustable upper beam
<b>Control panel</b>	The main control panel that is used to control the operation of the CHALLENGER
<b>Data cable</b>	15 pin cable that connects the CHALLENGER Load frame to the control panel
<b>Error condition</b>	Prompts are displayed on the LCD panel when the controller recognizes an error condition
<b>Force sensor</b>	Electrical sensors that are used to measure the system force exerted on the specimen
<b>CHALLENGER LCD</b>	Interactive Strength Challenger Liquid Crystal Display which is used to display the test results and error conditions on the control panel
<b>Load Frame</b>	The main CHALLENGER structure is called a load frame
<b>Microprocessor</b>	The digital controller that monitors the system force, control panel functions, updates the LCD panel, and performs the required calculations for operation
<b>Peak force</b>	A force that registers the highest over 0.075 inches (.19 cm)
<b>Peak displacement</b>	The deflection displacement that is registered at the peak force.
<b>Platform blocks</b>	Blocks mounted to test platform used to support compression samples on the test platform
<b>Power cord</b>	110v power cord which powers the CHALLENGER load frame
<b>Safety shield</b>	Shield that blocks the test area to restrict flying material and prevents placing hands near the moving parts while in motion
<b>Security key</b>	A key that is located on the control panel that disables the operation of the CHALLENGER when locked
<b>Stepper motor</b>	Computer controlled motor that is used to precisely control the test platform position.
<b>Strain gage</b>	<i>See Force Sensor</i>
<b>Test adapter</b>	A hardware clamp that is used to grip a test specimen for compression or tension
<b>Test platform</b>	The movable horizontal plate that is used to mount test specimens for tension or compression testing
<b>Test rate</b>	Rate at which the platform moves (in/min or cm/min) during test
<b>Upper beam handle</b>	Two handles on each side of the upper beam that secure the bar for various test heights
<b>Upper beam</b>	Adjustable bar above the test platform which is used to restrain the test specimen

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