SI-CTS200

Signal Conditioning Amplifier System for the Cell Tester

INSTRUCTION MANUAL

Serial No.____________________

072712

World Precision Instruments

CONTENTS

ABOUT THIS MANUAL

The following symbols are used in this guide:

This symbol indicates a **CAUTION**. Cautions warn against actions that can cause damage to equipment. Please read these carefully.

This symbol indicates a **WARNING**. Warnings alert you to actions that can cause personal injury or pose a physical threat. Please read these carefully.

NOTES and **TIPS** contain helpful information.

Fig. 1—SI-CTS200 allows you to work with a single, living cell or fiber without damaging it.

Fig. 2–The Signal Conditioning Amplifier System is a flexible chassis that is specifically configured for the SI-CTS200 (Cell Tester).

INTRODUCTION

Platform

All living systems can be studied from several perspectives. We can examine the entire organism or a specific organ system. We can characterize a single organ in a system or a type of tissue in an organ or the cells that make up that tissue. To completely understand any system, all of these perspectives must be considered. Often, entirely different systems are needed in a parallel experimental paradigm. The **Cell Tester** accomplishes this on one platform.

*The **Cell Tester** can, without adaptation, be used for one single living cell, for a small multi-cellular preparation and for single or larger skinned muscle strip preparations.* Translational experiments from the single living cells to the intact multi-cellular level can be accomplished. For example, using the **Cell Tester**, the influence of the connective tissue on muscle function can be distinguished from the clean muscle work for the first time. Conversely, skinning allows a direct comparison between the living cell response and a cell, whereby the subcellular contractile proteins are studied with full experimental access to cell signalling and cellular biochemistry.

The **Cell Tester** gives you the comprehensive ability to investigate and characterize the physiological, bio-mechanical and bio-physical properties of single isolated living cells and extend these findings to the sub- and multi-cellular level. Features of this system include:

- Integrated microtweezers facilitate cellular attachment
- Two integrated piezo micromanipulators are standard
- Bio-compatible adhesive included
- Unique rotational stage allows for easy cellular alignment, improved experimental throughput
- Ultra-quiet force transducer included

- Linear displacement motor stretches or compresses cells with 25nm precision
- Fits ANY inverted microscope
- Use native cuvette or ANY 35mm glass bottom dish

Electronics

The Signal Conditioning Amplifier System provides a flexible electronic platform intended to process the transduction of mechanical signals, the filtering of transducer outputs and the control of motor positions.

The system consists of an 8-channel, rack-mountable frame that includes an ultra quiet, shielded power supply. Outputs are routed internally to the inputs of other modules. If you prefer, the module outputs may be routed to external outputs on the front panels. The system has a small footprint and may be stacked to provide as many channels as you need.

When the system is ordered with an **SI-CTS200** (Cell Tester) system, the Signal Conditioning Amplifier System (chassis) is configured with an **SI-BAM21-LCB** (Optical Transducer Amplifier), an **SI-CISB** (Cell Tester Position Controller), an **SI-AOSUB** (Anti Oscillation Unit), an **SI-TCM2B** Temperature Controller and two expansion slots. The Position Controller and the Temperature Controller each requires two slots on the chassis backplane.

NOTE: The system is flexible and configurable. A variety of modules are available for the Signal Conditioning Amplifier System, and you can mix and match the modules to suit your requirements. For this manual, we will only discuss the modules used with the **SI-CTS200** system.

This Signal Conditioning Amplifier System offers eight expansion slots, configured at the factory to meet your requirements.

NOTE: The system for the **SI-CTS200** is configured at the factory. If you need to add additional modules, contact Technical Support at 941.371.1003 or TechnicalSupport@wpiinc.com.

Three **Cell Tester** systems are sold:

- **SI-CTS200A** includes an **SI-NAMO** Nanomotor with microtweezer, **SI-KG7TWE** Force transducer with microtweezer, Signal Conditioning Amplifier System with **SI-BAM21-LCB** Optical Transducer Amplifier, **SI-AOSUB** Anti-Oscillation Unit, **SI-TCM2** 2-Channel Temperature Controller, **SI-CISB** Nanomotor Position Controller (piezo motor driver), glass fiber tissue mounts, **MyoTak**™ biocomaptible adhesive and **LABTRAX 8/16** data acquisition system.
- **SI-CTS200B** includes the **SI-CTS200A** components plus the base unit with rotating cuvette.
- **SI-CTS200** includes: **SI-CTS200B** components plus two 3-axis motorized micromanipulators with a controller.

Cautions and Warnings

⚠ **WARNING: TURN OFF THE SIGNAL CONDITIONING AMPLIFIER SYSTEM AND UNPLUG IT FROM THE POWER OUTLET BEFORE REMOVING OR INSTALLING ANY MODULE IN THE UNIT.**

Parts List

After unpacking, verify that there is no visible damage to the instrument. Verify that all items are included:

(1) **Signal Conditioning Amplifier System** with the **SI-BAM21-LCB**, **SI-AOSUB**, **SI-CISB** and **SI-TCM2B** modules

(1) Power cord

(1) Base plate with rotating cuvette (**SI-CTS200** and **SI-CTS200B** only)

(2) Micromanipulators with controller (**SI-CTS200** only)

(1) 0.9mm hex wrench for fine adjustment of the force transducer and nanomotor

(1) 3mm hex wrench

(1) **13661** Potentiometer Adjustment Tool

(1) Force Transducer Assembly with microtweezer

(1) Nanomotor Assembly with microtweezer

(1) **97204** Pulser assembly for **SI-AOSUB** calibration

(5) 20µL vials of **MyoTak™** biocompatible adhesive (ships separately)*

(1) 100µL vials of Pre-Coat for **MyoTak**

(1) Instruction Manual

***The **MyoTak** included with your order consists of 5 vials of 20µL aliquots each. With daily testing, this supply will last five weeks. Additional aliquots of **MyoTak** may be ordered, as needed. **MyoTak** must be express shipped on dry ice and MUST be stored in a freezer immediately upon receipt. If the gel is exposed to temperatures above 4ºC, it polymerizes and quickly sets, making it unsuitable for its intended use. Contact WPI to schedule delivery of the **MyoTak** included with your system. Use the purchase order number of your system when requesting your first shipment of **MyoTak**.

Unpacking

Upon receipt of this instrument, make a thorough inspection of the contents and check for possible damage. Missing cartons or obvious damage to cartons should be noted on the delivery receipt before signing. Concealed damage should be reported at once to the carrier and an inspection requested. Please read the section entitled “Claims and Returns” on page 40 of this manual. Please contact WPI Customer Service if any parts are missing at 941.371.1003 or customerservice@wpiinc.com.

Returns: Do not return any goods to WPI without obtaining prior approval (RMA # required) and instructions from WPI’s Returns Department. Goods returned (unauthorized) by collect freight may be refused. If a return shipment is necessary, use the original container, if possible. If the original container is not available, use a suitable substitute that is rigid and of adequate size. Wrap the instrument in paper or plastic surrounded with at least 100mm (four inches) of shock absorbing material. For further details, please read the section entitled “Claims and Returns” on page 40 of this manual.

INSTRUMENT DESCRIPTION

Signal Conditioning Amplifier for the SI-CTS200

Front Panel

Fig. 3—The front panel of a Signal Conditioning Amplifier System configured for a Cell Tester shows the SI-BAM21-LCB, the Position Controller and the SI-AOSUB.

Optical Transducer Amplifier—The **SI-BAM21-LCB** powers the force transducer and converts the output of the transducer to an amplified analog voltage that is proportional to the force applied to the transducer. The output signal can be multiplied by a factor of 1, 2, 5 or 10 to provide better resolution for a minimal change in applied force.

Position Controller—The Cell Tester nanomotor and force transducer are extremely sensitive. The **SI-CISB** position controller is used to open and close the microtweezers on both devices, and to control the movement of the nanomotor used to stretch or release the cell or fiber held by the microtweezers.

Anti-Oscillation Unit (**SI-AOSUB**)—Each force transducer has a resonance frequency at which it vibrates. The **SI-AOSUB**, when properly tuned to that resonance frequency, removes the resonance noise from the output signal of **SI-BAM21-LCB** transducer amplifier.

Temperature Control Module—When temperature control is required, the **SI-TCM2B** is used. It can control two cuvettes simultaneously, using digital control to maintain a constant temperature. It has both high and low alarm warnings which are user defined.

Expansion Slots–These empty slots allow room for four other Signal Conditioning Amplifier System modules to be added in the future.

Power Switch–This system has two power switches, one on the back panel and one on the front. Both switches must be on to power the system.

Back Panel

Fig. 4–The back panel of the Signal Conditioning Amplifier System has a master power switch that is usually left on.

Power Connector–Insert the power cord into the power connector, and plug the cord into a standard wall AC outlet.

Fuse Housing–This housing contains the fuse for the chassis system.

Master Power Switch–The signal conditioning chassis distributes sub-regulated DC power (12V) to the individual modules through a backplane of the chassis. For convenience, the unit has two power switches, and both must be on to power the system. All the modules power on/off simultaneously. When your system is set up, just leave this power switch in the on (**I**) position

NOTE: The 16 plugs marked with A or B are for future development. They are not used at this time.

SI-KG7TWE Force Transducer

The **SI-KG7TWE** is a specialized transducer, which is capable of measuring the force of a single muscle cell. It is equipped with a pair of electronically controlled microtweezers, which hold onto the cell during force determinations and perturbations of the cell with load and length changes.

A skinned skeletal muscle cell can be held directly by uncoated microtweezers, and an intact skeletal muscle cell needs to be held by microtweezers that are coated with a special biocompatible adhesive (**MyoTak™**). However, heart cells cannot be held directly by coated or uncoated microtweezers. For the **SI-KG7TWE** transducer to hold a heart cell, the ends of the cell are attached to glass rods coated with **MyoTak**. The microtweezers are used to grasp the coated glass rod to which the heart muscle cell is glued (Fig. 5). In heart cell studies, the microtweezer/transducer assembly, as well as the microtweezer/nanomoter assembly that holds the glass rod on the other end of the cell, are rotated 90º.

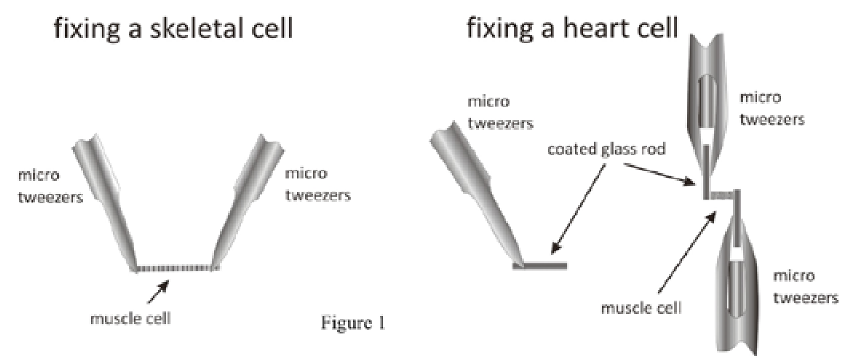


Fig. 5—The microtweezers hold a muscle cell, but a cardiac myocyte must be fixed to a coated glass rod.

The microtweezers are opened or closed by rotating the **Force Transducer Tweezer Control** potentiometer on the front panel of the Position Control module. The use of this potentiometer to gradually open and close the microtweezers controls the pressure exerted on the end of the cell according to the experimental needs. Remote electronic control of the microtweezers prevents the vibration that could damage the cell.

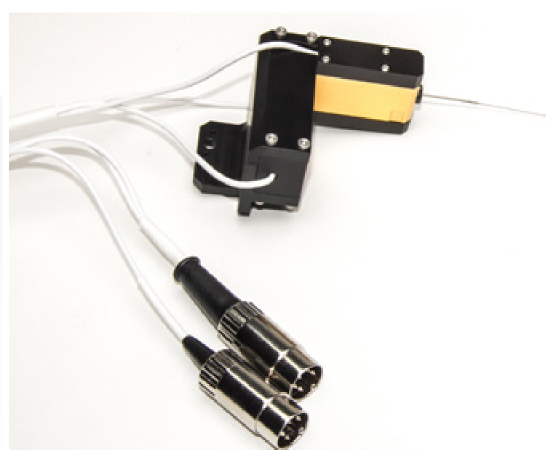


Fig. 6—(Left) The force transducer (sensor assembly) is packaged in a sturdy box to protect the sensitive assembly, and it should always be stored in the case to protect the delicate tip.
Fig. 7—(Right) The force transducer has a colored band on one cable to indicate which connector plugs into the Transducer Tweezer port on the Position Control module.

SI-NAMO Nanomotor

Like the **SI-KG7TWE** force transducer, the **SI-NAMO** nanomotor is equipped with microtweezers for grasping the end of the cell that is opposite the transducer. The microtweezers are operated in the same manner as the ones on the transducer. Through feedback circuitry in the Position Control module, the position of the nanomotor is controlled accurately so that cell attached to the nanomotor can be stretched, relaxed or loaded according to the experimental protocol.

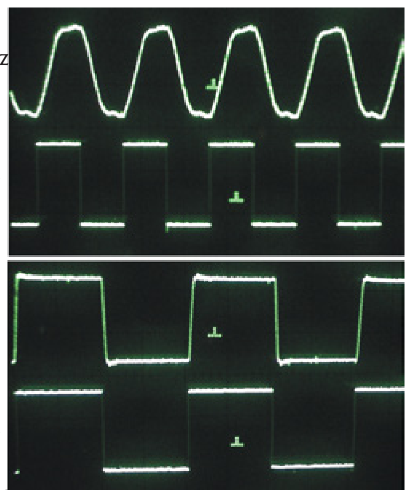


Fig. 8—Length response to a rectangular input signals.

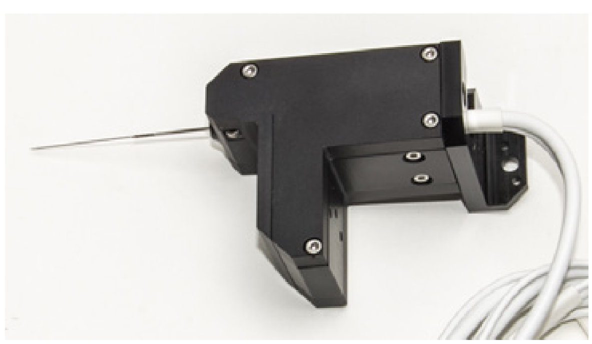


Fig. 9—(Left) The nanomotor assembly is shipped in a sturdy box.
Fig. 10—(Right)The nanomotor, like the force transducer, has a tiny microtweezer that is highly sensitive.

Rotating Cuvette

The complete system utilizes a unique rotating bath to dramatically improve experimental throughput. The rotating bath is designed to orient cells in the XY plane so that no physical manipulation of the position of the cell itself is required prior to capture by the grabbing devices attached to the force sensor and linear actuator.

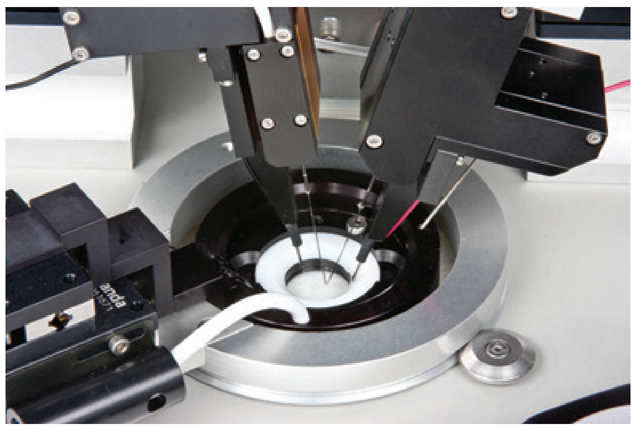


Fig. 11—The cuvette rotates to allow for precise positioning of the cells to be mounted

This bath has two interchangeable inserts. The first holds any 35mm glass bottom dish (WPI #**FD35-100**). When coating tweezers or glass rods with MyoTak biocomaptible adhesive, insert a Fluorodish into the holder and place it in the rotating cuvette. When finished, remove the insert and dispose of the Fluorodish. Then, insert the native cuvette insert containing the live cells.

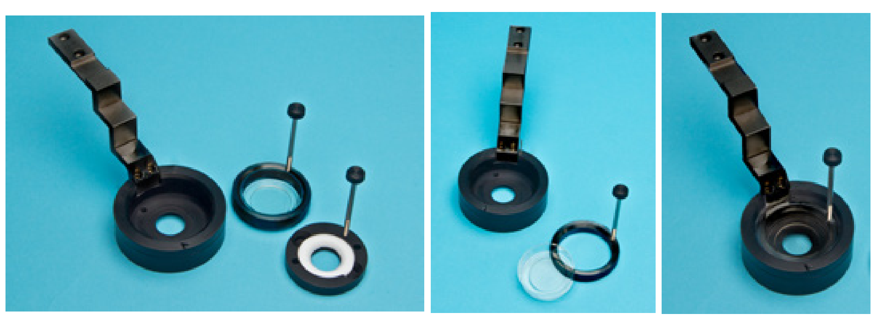


Fig. 12—(Left) The two inserts fit into the rotating stage holder. (Center) The 35mm glass bottom dish fits into the first insert. (Right) The insert and dish are placed in the rotating cuvette.

SI-BAM21-LCB

The **SI-BAM21-LCB** KG Optical Force Transducer Amplifier is used in conjunction with the SI-H tissue bath and muscle physiology systems. The **SI-BAM21-LCB** powers the force transducer and converts the output of the transducer to an amplified analog voltage that is proportional to the force applied to the force transducer. The output signal can be multiplied by a factor of 1, 2, 5 or 10 to provide better resolution for a minimal change in applied force.

NOTE: An optional factory setting increases the multiplier by a factor of 10, allowing the signal to be multiplied by 10, 20, 50 and 100.

NOTE: The **SI-BAM21-LC** is the standalone version of this optical force transducer amplifier.

Features

The **SI-BAM21-LCB** amplifier works with KG optical force transducers to:

- Generate an analog output (-10VDC to +10VDC) that is proportional to the force applied to the tissue sample.
- Supply a DC voltage that powers the KG force transducer to which it is connected.

How the Amplifier Works

In a typical setup, a muscle is held by a force transducer. The force transducer is connected to the **SI-BAM21-LCB**. As the muscle contracts or releases, the force transducer converts the force into an electrical current signal which is proportional to the force applied to the force transducer. The **SI-BAM21-LCB** converts the current signal into a voltage signal that can be displayed on the screen of the recording device.

Before initiating an experiment, the **SI-BAM21-LCB** must first be zeroed. This sets the baseline for measurements to follow.

The output signal is buffered and multiplied by 1, 2, 5 or 10, depending on the Gain switch setting on the front panel of the amplifier module. The X10 setting is useful when output signals are extremely small. Finally, the force proportional signal is sent through the output amplifier circuit.

The analog output has a range of –10V to +10V that drives a data acquisition system, multimeter or oscilloscope.

Notes and Warnings

NOTE: The **SI-BAM21-LCB** is only designed for use with KG optical force transducers. Use with any other type of transducer may cause damage to either the transducer or the amplifier or both.

Front Panel

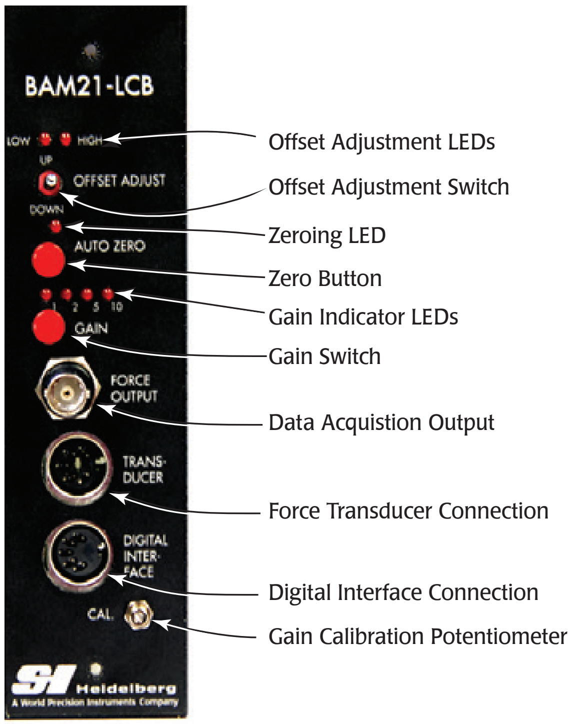


Fig. 13—SI-BAM21-LCB KG Optical Force Transducer Amplifier

Zero Button—When pressed, the **SI-BAM21-LCB** output comes close to zero and the **Zeroing LED** illuminates. Before any measurements are taken, the **SI-BAM21-LCB** should be zeroed to establish a baseline value for the force transducer.

Offset Adjustment Switch—This toggle switch permits the position of the baseline to be adjusted after the baseline is zeroed. Press and hold the toggle switch to the left if you want to raise the baseline. Or, press and hold the toggle switch to the right to lower the baseline. If the baseline is more that 0.3V above zero, the **High** LED illuminates, and if it is less than –0.3V, the **Low** LED illuminates. When the baseline is within 0.3V of zero, the LEDs are off.

Gain Switch—Under normal conditions, the **Gain** switch is set to X1. The output of the force transducer can be amplified by a factor of 2, 5 or 10. Press the **Gain** switch to toggle between the gain settings. A **Gain Indicator LED** illuminates to show which gain factor is applied. Larger gains are essential when working with extremely small forces.

Gain Calibration Potentiometer— This potentiometer can be used to maximize the output of the amplifier for the anticipated range of forces to be measured. Use the provided potentiometer adjustment tool (WPI#**13661**) to calibrate the output of the amplifier to the range of forces that will be measured by the transducer. See "Calibrating the SI-BAM21-LCB" on page 24.

Data Acquisition Output–Connect a data acquisition system like WPI's **Lab-Trax-8/16** to this BNC connector to record the raw **SI-BAM21-LCB** voltage output. For test purposes, a multi-meter or oscilloscope may be connected using a standard BNC cable (WPI **#2851**).

Force Transducer Connection–An **SI-KG7TWE** force transducer is plugged into this DIN connector. Align the pins, and insert the connector until it is fully seated.

Digital Interface–This connection is a legacy interface for classic SI-H equipment.

NOTE: When the **SI-CTS200** electronics are configured at the factory for the Cell Tester systems, the signal is routed internally from the **SI-BAM21-LCB** module to the **SI-AOSUB** module. The **Force Output** connection on the front of the **SI-BAM21-LCB** module also shows the raw unfiltered signal from the transducer, but it does NOT need to be connected externally.

SI-CISB

The **Position Controller** is used exclusively with the **SI-CTS200** Cell Tester systems. It allows for:

- Fine control of opening and closing the microtweezers on the nanomotor and the force transducer
- Position control of the nanomotor
- Stimulation
- Direct light source control

The Cell Tester Position control module is only sold in a Signal Conditioning Amplifier System enclosure with an **SI-AOSUB** Anti-Oscillation Unit and an **SI-BAM21-LCB** Optical Force Transducer Amplifier.

Notes and Warnings

NOTE: This system is designed for use exclusively with the SI-H line of KG force transducers.

CAUTION: Use care when handling the nanomotor and the force transducer. The tweezers are extremely delicate and easily damaged.

Front Panel

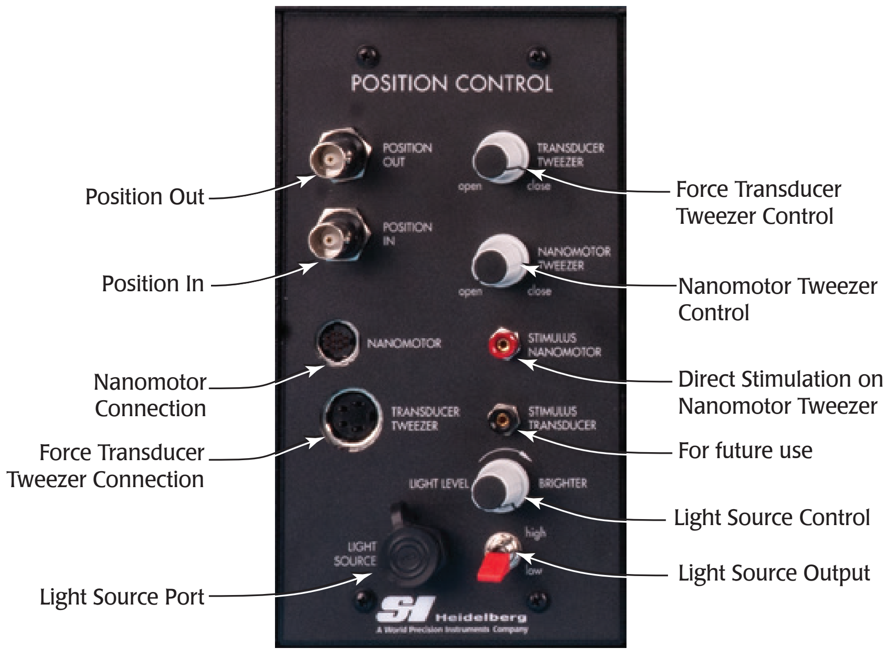


Fig. 14—SI-H Position Controller for use with the CTS200 Cell Tester Systems

Position In– Connect an analog output of the data acquisition unit to this BNC port. A protocol that controls the movement of the nanomotor can be programmed using the software of the data acquisition system and delivered through its analog output. Every 1V of output creates 10µm of nanomotor movement.

The same data acquisition system used to record the output of the force transducer can be used to generate the protocol that controls the position of the nanomotor (**Position In**) and records the position of the nanomotor (**Position Out**). A second analog output of the same system can provide the stimulus that causes the cell to contract or trigger an external stimulator that causes cell contraction.

Position Out– Connect this BNC port to an analog input of the data acquisition system. Every 10µm of nanomotor movement creates 1V analog signal that is used to verify the range of movement.

Nanomotor Connection–Plug the 10-pin connector from the nanomotor into this port.

Force Transducer Tweezer Connection–Plug the 4-pin connector from the force transducer into this port. (This connector has a red or green identifier on the cable.)

Light Source Port–Plug in the cable for the LED light source into this port.

Force Transducer Tweezer Control–Use this dial to open and close the microtweezer on the force transducer.

Nanomotor Tweezer Control—Use this dial to open and close the microtweezer on the nanomotor.

Stimulus Nanomotor—The microtweezer on the nanomotor can be used as an electrode to stimulate the muscle cell directly. If direct stimulation is required, connect the positive output of the stimulator to this jack. Any stimulator that can generate a ±10VDC square wave may be used. It could be one that is built into a data acquisition system or an external stimulator that is triggered by a data acquisition system.

NOTE: The separate stimulation port on the force transducer is for future development. At this time, the force transducer tweezers are permanently grounded.

Light Source Control—Use this dial to increase or decrease the light intensity.

Light Source Output—Choose **High** or **Low** with this toggle switch to set the maximum light output scale.

SI-AOSUB

Every force transducer has a resonance frequency at which it vibrates. The **SI-AOSUB** allows you to locate that frequency and filter the signal to mitigate the noise of the resonance frequency. Since each force transducer is unique, the anti-oscillation unit must be calibrated for each force transducer. Likewise, the tissue mounting hardware affects the resonance frequency. Therefore, the system must be calibrated with the mounting hardware attached to the force transducer.

Front Panel

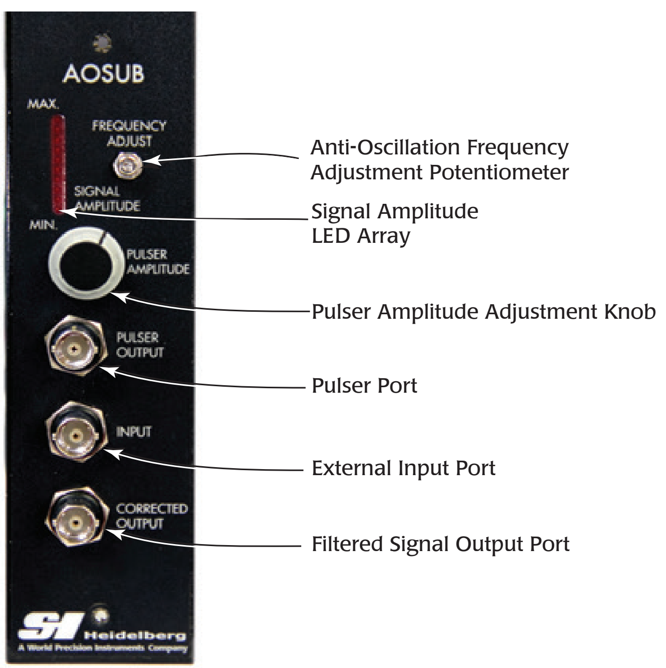


Fig. 15—SI-AOSUB Anti-Oscillation Module

Pulser Port–Connect the Pulser cable to this port when you need to calibrate the system for a force transducer. The force transducer fits inside the Pulser, and the Pulser uses a strong magnet to exert small square-wave forces on the force transducer.

Pulser Amplitude Adjustment Knob–When calibrating a force transducer, this knob adjusts the amplitude of the pulser waveform so the display registers on the **Signal Amplitude Array**.

Signal Amplitude Array–The 10-position LED array indicates the amplitude of the transducer's response to the pulser's excitations. The LED array indicates when the frequency of the square wave is equal to the resonance frequency of the force transducer.

Anti-oscillation Frequency Adjustment potentiometer– Use the included potentiometer adjustment tool (WPI #**13661**) to rotate the potentiometer until the force transducer resonates. During this procedure, the number of segments in the **Signal Amplitude LED** array that light up increases as the resonance frequency approaches that of the force transducer.

External Input Port–The output signal from the transducer amplifier comes into the **SI-AOSUB** through this port. If the signal is not routed along the backplane, connect the **SI-BAM21-LCB Force Output** to this port.

NOTE: When the **SI-CTS200** electronics are configured at the factory for the Cell Tester systems, the signal is routed internally from the **SI-BAM21-LCB** module to the **SI-AOSUB** module. The **Force Output** connection on the front of the **SI-BAM21-LCB** module also shows the raw unfiltered signal from the transducer, but it does NOT need to be connected externally.

Filtered Signal Output Port– Connect a data acquisition system like WPI's **Lab-Trax-8/16** to this BNC connector to record the filtered voltage output signal voltage. For test purposes, a multi-meter or oscilloscope may be connected using a standard BNC cable (WPI #**2851**).

SI-TCM2B

The SI-H Temperature Control Unit is designed for use with the SI-H line of muscle physiology research platforms. It maintains the temperature of an SI-H cuvette up to 45ºC. This unit is available in a standalone model and as a module for the Signal Conditioning Amplifier System backplane.

Features

The **SI-TCM2B** temperature controller:

- Controls two cuvettes simultaneously
- Uses digital control to maintain a constant temperature
- Has both high and low alarm warnings which can be user defined

Front Panel

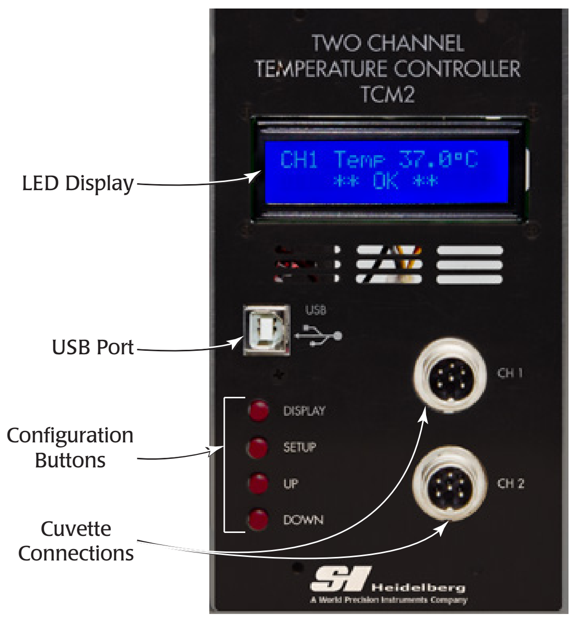


Fig. 16—The SI-TCM2B temperature controller can control two cuvettes simultaneously.

LED Display—Upon startup, this display shows the version of the software the **SI-TCM2** is running. During normal operations, this display shows the temperature of the cuvette attached to the channel 1 port, channel 2 port or both. During configuration, this display shows parameters and confirmation messages.

USB Port—This port can be used to connect to a computer to log the temperature history. In order to communicate with the computer, a terminal emulation program is required. Several third party options are available, including: Hyperterminal, Real Term (realterm. sourceforge.net) or Cool Term (freeware.the-meiers.org).

Configuration Buttons—The Display button is used to toggle the display between Channel 1 temperature, Channel 2 temperature and both. The Setup button rotates through the array of configurable parameters. The Up and Down buttons are used to adjust the parameters.

Cuvette Connections—Use these ports to connect SI-H cuvettes used with the SI-MT and SI-MKB platforms.

System Setup

Assembling the Platform

NOTE: The rotating cuvette is installed in the base platform before shipping. If you need to remove it, place your thumbs together in the front center of the cuvette (where the "Rotating Cuvette" arrow in the diagram is pointing) and push backwards, lifting slightly, and then release slowly. It will slide out. A spring-loaded catch secures the cuvette in place.

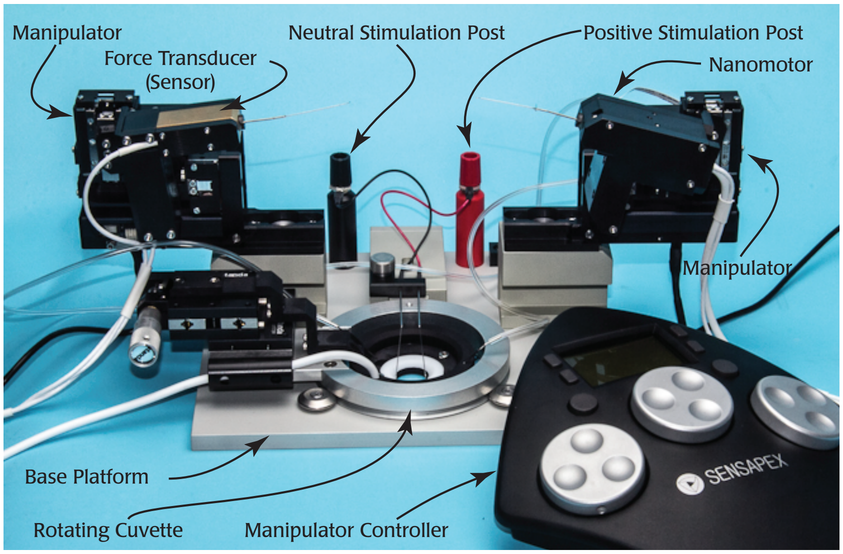


Fig. 17–The force transducer and the nanomotor are mounted on the micromanipulators on the back of the base platform of the SI-CTS200.

CAUTION: Use great care when handling the force transducer and the nanomotor assemblies. The microtweezers tips are extremely delicate and easily damaged.

1. To assembly your **SI-CTS200**, position the base platform on a solid surface.
2. Install the manipulators.
   A. Remove the manipulators from their packaging.
   B. The manipulators are built on a hinged platform. Open the hinged platform to reveal the screw holes (Fig. 19).

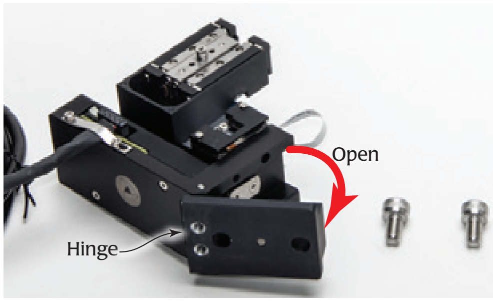
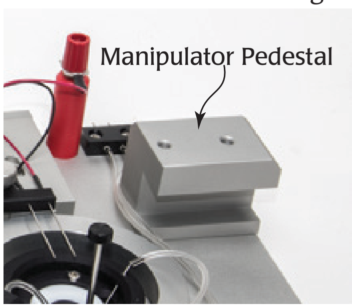
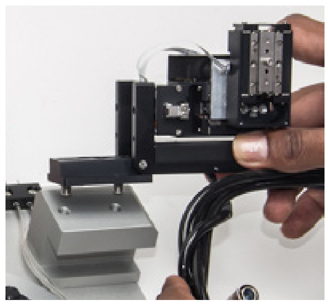


Fig. 18–(Left) The SI-CTS200 comes in a sturdy carrying case.
Fig. 19–(Right) Open the hinged platform on the bottom of the manipulator.

C. Place two M6 screws into the holes on the base of the manipulator and line up the screws with the holes on the base platform manipulator pedestals (Fig. 21). Use a hex wrench and tighten the screws (Fig. 22).





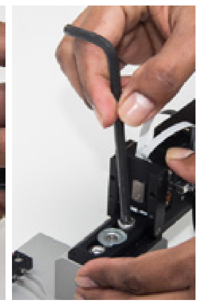


Fig. 20—(Left) The base platform has two manipulator pedestals on the back side.
Fig. 21—(Center) Line up the screws with the holes in the pedestals.
Fig. 22—(Right) Tighten the screws.

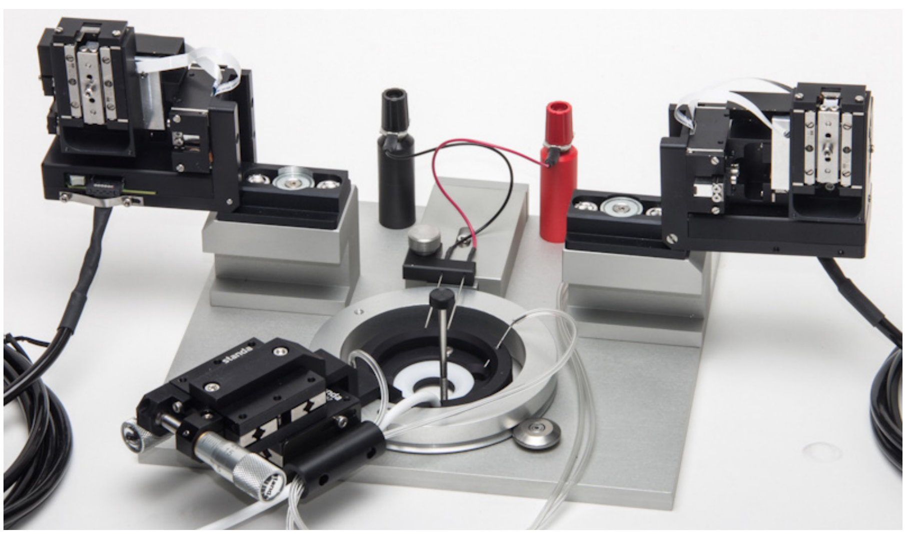


Fig. 23—Both manipulators are mounted and tilted back as far as they can go.

3. Mount the nanomotor to the micromaniplator on the right side of the base platform.

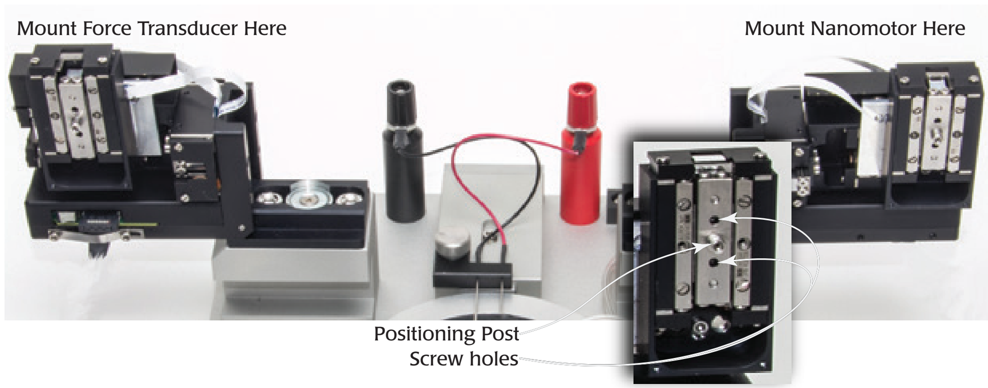


Fig. 24—The force transducer must be mounted on the left and the nanomotor on the right side.

CAUTION: To avoid damaging the microtweezers, flip the two micromanipulators all the way back before installing the nanomotor and sensor (Fig. 23).

A. Place the two screws into the screw holes on the nanomotor (Fig. 25).
B. There is a small post on the micromanipulator to help position the nanomotor. Slide the nanomotor over the post and line up the screws with the holes on the micromanipulator.
C. Use a small hex wrench to tighten both screws securely.

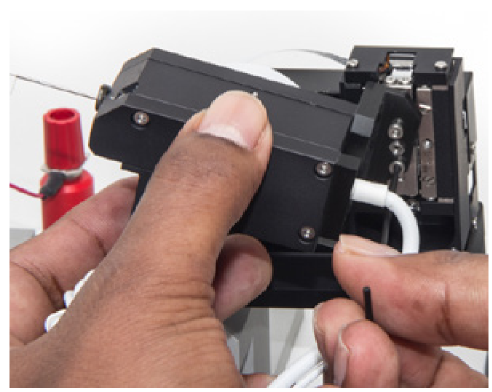


Fig. 25—(Left) The screw holes are labeled.
Fig. 26—(Right) Secure the nanomotor to the micromanipulator on the right side of the base platform

4. Mount the force transducer to the micromanipulator on the left side of the base platform in the same way that you mounted the nanomotor to the right side micro-manipulator.

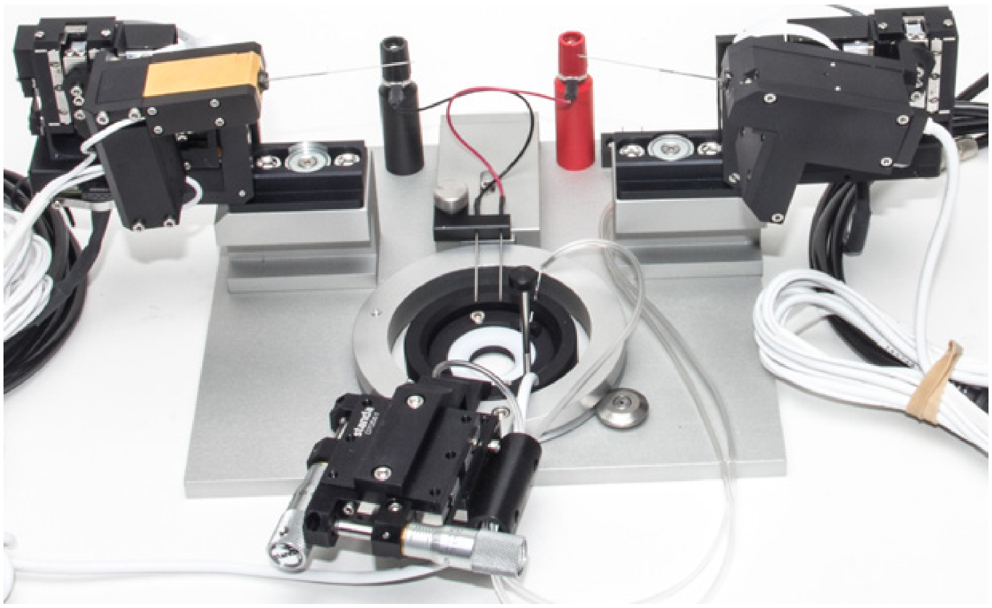


Fig. 27–The force transducer is mounted on the left side and the nanomotor on the right side.

5. OPTIONAL: if you are using field stimulation, install the platinum electrodes (Fig. 29).

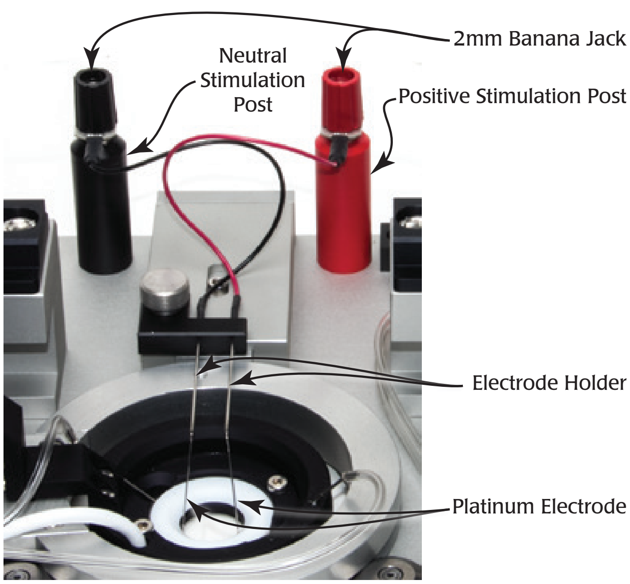
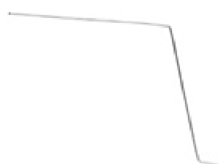


Fig. 28–When using field stimulation, the platinum electrodes are submerged in the cuvette bath, and the posts are connected with a stimulator.

A. The electrode holders are connected by wires to the red stimulation post and the black neutral post. Be careful not to bend the electrode. Gently slide it into the electrode holder (Fig. 30).
B. Rotate the electrode in order to position the tip of it in the cuvette bath.
C. Connect the positive output of your stimulator to the knob on the red positive stimulation post using a banana cable. In a similar manner, connect the negative output of your stimulator to the knob on the black neutral stimulation post using a banana cable.



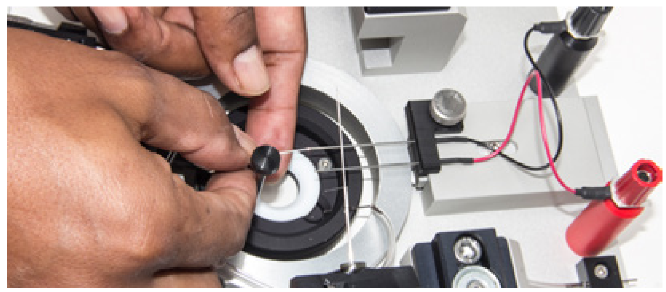


Fig. 29—(Left) The stimulation electrodes are platinum.
Fig. 30—(Right) The platinum electrode slides into the electrode holder and reaches into the cuvette.

Fig. 31—The assembled system is ready to be positione on the microscope stage.

6. Place the assembled **SI-CTS200** on your inverted microscope.

Connecting the Signal Conditioning Amplifier System

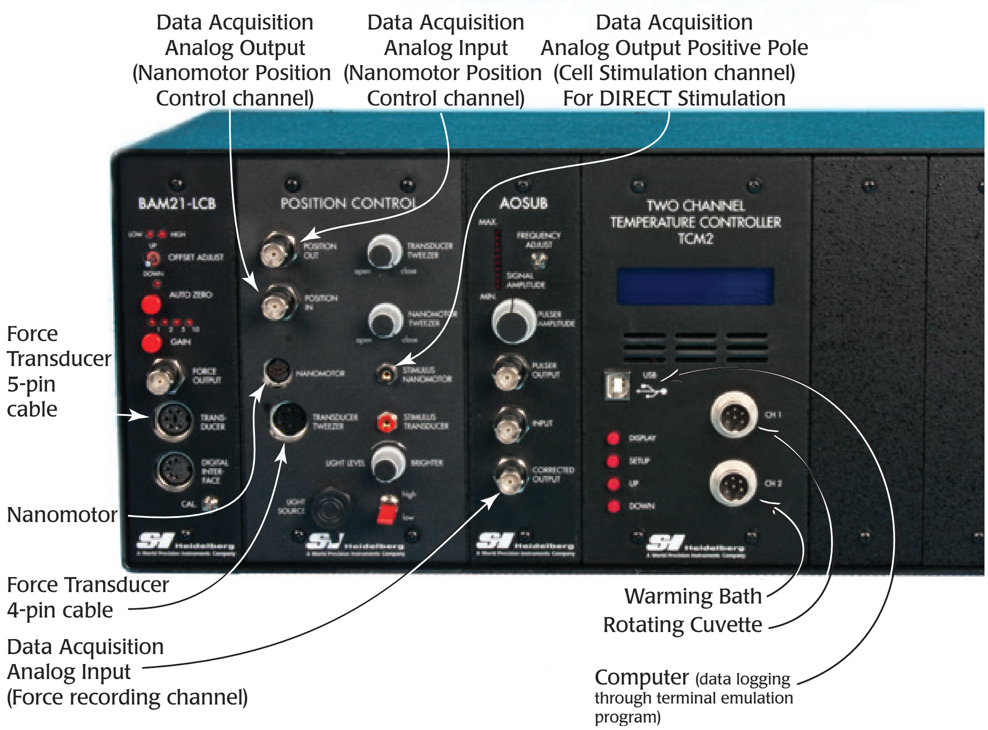


Fig. 32—Connect the system as shown above.

1. Connect the **SI-KG7TWE** force transducer to the appropriate modules in the Signal Conditioning Amplifier System as follows:
   - Plug the 5-pin connector (black cable) into the port labeled **Transducer** on the front panel of the **SI-BAM21-LCB** transducer amplifier.
   - Plug the 4-pin connector (red or green band around the cable) into the port labeled **Transducer Tweezer** on the front panel of the Position Control module.
2. Connect the **SI-NAMO** nanomotor to the **SI-CISB** Postion Control module in the Signal Conditioning Amplifier System. Plug its 10-pin connector into the port labeled **Nanomotor**.
3. When the **SI-CTS200** electronics are configured at the factory, the signal is routed internally from the **SI-BAM21-LCB** module to the **SI-AOSUB** module. The **Force Output** connection on the front of the **SI-BAM21-LCB** module shows the raw unfiltered signal from the transducer, but it does NOT need to be connected externally.

   IF the **SI-BAM21-LCB** transducer amplifier module and the **SI-AOSUB** anti-oscillation module are not connected to each other through the backplane of the Signal

Conditioning Amplifier System, these two modules must be connected through ports on the front panels of the modules. Use a BNC-BNC cable to connect the **Force Output** port on the front panel of the **SI-BAM21-LCB** module to the **Input** port on the front panel of the **SI-AOSUB** module.

4. Using a BNC cable, connect the **Corrected Output** port of the **SI-AOSUB** module to the analog input of the data acquisition system, which is designated as the force recording channel. The **Corrected Output** is the signal from the transducer amplifier that exists after the resonance frequency of the transducer was removed from the raw transducer signal by the anti-oscillation filter.
5. Using a BNC cable, connect the analog output of the data acquisition system, which is designated as the nanomotor position controller channel, to the **Position In** port on the front panel of the **SI-CISB** Position Control module.
6. Connect the **Position Out** port on the **SI-CISB** module to a second analog input of the data acquisition system, which is designated as the nanomotor position channel.
7. Contraction of the cell in the tester can be triggered by either of two methods of stimulation:
    - DIRECT stimulation is through the microtweezers holding the ends of the cell being tested. Using the appropriate cable, connect the positive pole of the analog output of the data acquisition system, which is designated as the cell stimulator channel, to the jack that is labeled **Stimulus Nanomotor**.
    - FIELD stimulation is through the stimulus electrodes attached to the nanomotor and transducer assemblies. The tips of these electrodes are placed in the perfusion buffer near the cell being tested. Using the appropriate cable, connect the positive pole of the analog output of the data acquisition system, which is designated as the cell stimulator channel, to the knob on top of the red Positive Stimulation Post on the Cell Tester platform. In a similar manner connect the negative pole of the same analog output to the knob on top of the black Neutral Stimulation Post on the Cell Tester platform.
8. If cuvette temperature control is required, connect the **SI-TCM2B** as follows:
    - Line up the rotating cuvette connector with the CH1 or CH2 port on the **SI-TCM2B**, press it into place and screw the outer ring of the connector to secure the connector. A second SIH cuvette may be connected to the other port for a warming bath, if desired.
    - To monitor the temperature over time, use a USB cable to connect a computer's terminal emulation program using the USB port on the **SI-TCM2B.**

    For information on using the **SI-TCM2B**, see "Using the Temperature Control Module" on page 29.
9. Verify that the **Power** switches on the back panel and on the front panel of the Signal Conditioning Amplifier System are in the on (**I**) position.

OPERATING INSTRUCTIONS

Turning the System On

For convenience, the Signal Conditioning Amplifier System has two power switches, and both must be on to power the system. One is located on the back panel, and one is on the front. Both switches must be on to power the system. Verify that the power cord is properly installed and plugged into an AC power outlet. All the modules power on/off simultaneously. When the system is setup, just leave the back power switch in the on (I) position.

Using the SI-BAM21-LCB

Calibrating the SI-BAM21-LCB

Before taking measurements, the **SI-BAM21-LCB** must be calibrated. The **SI-KG7TWE** force transducer responds linearly within its measurement range. Consequently,The **SI-BAM21-LCB** can be calibrated using only two reference points.

NOTE: The following procedure is specifically designed for calibrating the **SI-BAM21-LCB** transducer amplifier module with an **SI-KG7TWE** force transducer.

1. Connect the force transducer, the modules in the amplification system and the data acquisition system. See "System Setup" on page 17.
2. Set the **Gain** switch on the front panel of the **SI-BAM21-LCB** to **X1**.
3. With no weight suspended from the transducer, press and release the **Zero** button on the **SI-BAM21-LCB**. Use the data acquisition system to monitor the transducer signal from the **Corrected Output** on the **SI-AOSUB** module. You should see a reading of 0.0VDC ±50mV. Remember that the zeroing error is larger with higher gains. The **Offset Adjustment** switch needs to be used if a smaller error is desired.

   NOTE: When the **Zero** button is pressed, the zeroing LED illuminates to indicate that the zeroing function is processing.
4. Use the **Offset Adjustment** switch to adjust the baseline to zero. Press and hold the toggle switch to the left if you want to raise the baseline. Or, press and hold the toggle switch to the right to lower the baseline. If the baseline is more that 0.3V above zero, the **High** LED illuminates, and if it is less than –0.3V, the **Low** LED illuminates. When the baseline is within 0.3V of zero, the LEDs are off.

   NOTE: Once the baseline is zeroed to the desired position, do not touch the **Offset Adjustment** switch until the calibration procedure is completed.
5. Suspend an 80mg weight on the tip of the transducer rod (Fig. 33).

NOTE: Mass in grams in not equal to force in newtons. Force equals mass times acceleration (F = ma). So, an 80mg weight is equal to 784uN (0.000080kg * 9.8m/s^2 = 0.000784N). Make sure that the mass used to calibrate the transducer amplifier creates a force that falls within the operating range of the force transducer and amplification factor you selected.

Fig. 33—Suspend a 80mg weight from the end of the force transducer.

6. After the suspended mass becomes motionless, use the data acquisition system to monitor the **Corrected Output** from the **SI-AOSUB** module while adjusting the **Gain Calibration** potentiometer on the **SI-BAM21-LCB**. Use a potentiometer adjustment tool (WPI #**13661**) to adjust the **Gain Calibration** potentiometer to a value of 8.0V, so that each 10mg deflection is equal to 1.0V.

   NOTE: This procedure is adequate if the force acts perpendicular on the transducer pin. If the angle is not 90°, the output signal has to be adjusted correspondingly.

Realigning the Nanomotor Mechanical Zero Position

Like other components in the Cell Tester system, the **SI-NAMO** nanomotor is calibrated at the factory. This includes setting the mechanical zero (center) position of the actuator. After extensive use, the zero position of the actuator may shift slightly. The shift is identified when the travel of the actuator is restricted more in one direction than the other. You can reset the mechanical zero position of the nanomotor as follows:

1. Connect the **SI-NAMO** nanomotor to the Cell Tester Signal Amplification system by plugging the 10-pin connector of the nanomotor into **Nanomotor** port on the front panel of the Position Control module. Turn the amplifier system on.
2. Connect the analog output of the data acquisition system, which is designated for controlling motor movement, to the **Position In** port of the Position Control module.
3. Connect the analog input of the data acquisition system, which is designated for recording motor position, to the **Position Out** port of the Position Control module.
4. Program the data acquisition system so that the signal that controls the position of the nanomotor is 0.0V and constant. Normally, the actuator of the nanomotor is centered at this voltage. Program the channel, which is used to record the nanomotor position, to a range of +10V.
5. Start the data recording software to:
   - Send the 0.0V positioning signal to the nanomotor through the **Position In** port
   - Record the nanomotor position signal from the **Position Out** port.

6. If the voltage being recorded on the nanomotor position (**Position Out**) channel is not 0.0V, use the small hex wrench to turn the recessed adjustment screw on the back of nanomotor (Fig. 34) until the voltage on that channel is zero. When the voltage on the **Position Out** channel is zero, the actuator of the nanomotor is centered and the device is ready to use.

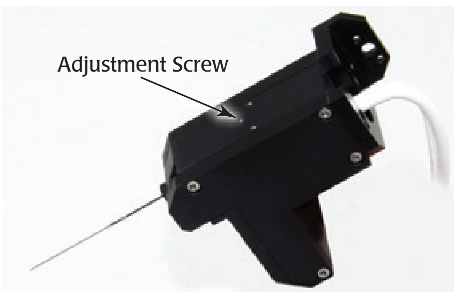


Fig. 34—The adjustment screw is on the back of the nanomotor.

Making Measurements

After the **SI-BAM21-LCB** has been calibrated, measurements may be taken.

1. Turn the Signal Conditioning Amplifier System **Power** switch on (I). The system needs to be powered on for 30 minutes before calibration. Leave it on while your prepare to take measurements.
2. Turn on the data acquisition system.
3. Press the **Zero** button to set the baseline value for the measurements.

   NOTE: When the **Zero** button is pressed, the zeroing LED illuminates to indicate that it is functioning properly.
4. Measurements may be taken.

Setting System Gain Factor

The **SI-BAM21-LCB** gain multiplier setting is selected with an internal jumper that is configured at the factory for use with either an **SI-MT** muscle tester system or an **SI-MB** tissue bath system. The **SI-MT** setting allows for 1X, 2X, 5X and 10X gains. The **SI-MB** setting allows for 10X, 20X, 50X and 100X gains.

1. Turn off the Signal Conditioning Amplifier System and unplug it from the power outlet.
2. Remove the two screws on the face of the **SI-BAM21-LCB** module.
3. Gently slide the module out of the Signal Conditioning Amplifier System frame.
4. Locate the 3-pin jumper J16.
5. Jumper pins 1 and 2 to use the **SI-BAM21-LCB** with the **SI-MT** system, or jumper pins 2 and 3 for use with the **SI-MB** systems.
6. Reinstall the module into the frame and secure it with the screws.

Using the Anti-Oscillation Unit

Adjusting the Anti-Oscillation Filter

The anti-oscillation filter is adjusted at the factory using the transducer that is supplied with the Cell Tester system. Normally, the filter does not need to be reset, unless a different force transducer is connected to the unit. To adjust the anti-oscillation filter properly, the transducer is excited at its resonance frequency using a magnetic driver or pulser (WPI #**97204**).

Fig. 35—(Left) This pulser assembly has no force transducer mounted in it.
Fig. 36—(Right) A force transducer is mounted in the **SI-AOSUB** *pulser assembly.*

Keep in mind that:

- The closer the anti-oscillation frequency matches the resonance frequency of the force transducer, the more the ringing phenomenon is removed from the force signal.
- The resonance frequency of the transducer can also be evoked at an anti-oscillation frequency that is set at half the resonance frequency. The filter works fine when the anti-oscillation frequency is set to half of the resonance frequency, but the amplitude of the force measurement at that frequency will be halved. Therefore, use the highest anti-oscillation frequency that will evoke resonance oscillation.

1. Slide the force transducer forward into the pulser (magnetic driver assembly) until it rests against the stop at the front of the pulser. See Fig. 36.
2. Attach the cable of the pulser to BNC connector of the **Pulser Output** on the front of the Anti-Oscillation module (**SI-AOSUB**).

To set the anti-oscillation frequency properly, complete the following steps:

1. Using the potentiometer adjustment tool (WPI #**13661**) provided with the Cell Tester system, rotate the calibration screw of the **Anti-oscillation Frequency Adjustment** potentiometer completely to the right (clockwise). The anti-oscillation frequency is now set to the highest possible level.

2. Turn the **Pulser Amplitude Adjustment** knob completely to the right (clockwise). The amplitude of the anti-oscillation frequency is now set to the highest possible level.

3. Using the potentiometer adjustment tool, slowly turn the calibration screw of the **Anti-oscillation Frequency Adjustment** potentiometer to the left (counterclockwise) while observing the **Signal Amplitude LED** array. As the calibration screw is turned to the left, the anti-oscillation frequency gets closer to the resonance frequency of the transducer, and the transducer begins to oscillate as indicated by bars on the LED array beginning to illuminate.

4. Continue to rotate the calibration screw of the **Anti-oscillation Frequency Adjustment** potentiometer to the left (counterclockwise) until the greatest number of bars on the **Signal Amplitude LED** array are illuminated.

   If the **Signal Amplitude LED** array becomes fully illuminated, decrease the pulse amplitude by turning its control knob to the left (counterclockwise). Turn the knob to the left until some of the bars at the top of the **Signal Amplitude LED** array are no longer illuminated.

5. Repeat Step 4 until the greatest number of bars on the **Signal Amplitude LED** array are illuminated without the signal amplitude being saturated. When this occurs, the anti-oscillation frequency has been set equal to the resonance frequency of the transducer.

   NOTE: If the **Signal Amplitude LED** array is saturated at any time during the frequency calibration, reduce the amplitude by rotating amplitude control knob to the left until some of the bars at the top of the array are no longer illuminated.

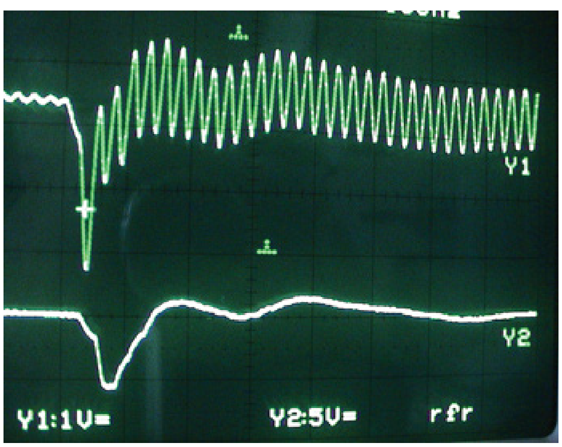


Fig. 37—The upper trace is a force transient obtained directly from the bridge amplifier output, and the lower trace shows the signal after it passes through the "anti oscillation" unit.

Using the Temperature Control Module

Understanding the Display

The default display is two lines and shows the temperature of both channels. If you prefer, you may display information from a single channel, either Channel 1 or Channel 2.

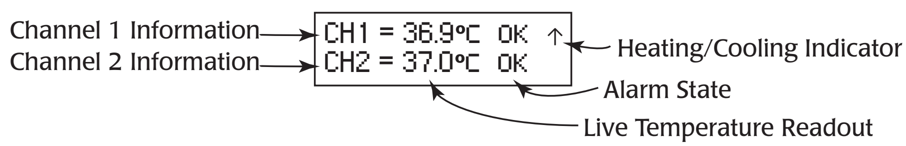


Fig. 38—Two Channel display mode provides live data on both channels.

Fig. 39—One channel display mode provides live data on a single channel.

Live Temperature Readout—The temperature of the cuvette connected to Channel 1 displays in the first line, and the Channel 2 cuvette temperature appears in the second line.

NOTE: The maximum temperature the sensor can monitor is 62.9ºC. If a channel has no cuvette plugged in, the display will default to the maximum temperature display.

Alarm State—If the temperature of the cuvette is within the defined range, OK displays on the screen. If the temperature falls below the defined range, a low alarm sounds and LO appears on the display. HI appears on the display and a high alarm sounds if the temperature exceeds the defined range. If the alarm is not enabled, no audible alarm is heard.

Heating Indicator—A flashing arrow pointing up (↑) indicates that the cuvette is heating.

Setup

1. Turn on the system.
2. Line up the cuvette connector with the port on the **SI-TCM2**, press it into place and screw the outer ring of the connector to secure the connector.
3. Press the **Setup** button to toggle through the setup parameters.
4. Press the **Display** button to save the configuration and return to the normal display.

   NOTE: The unit remembers the state of all the parameters, even after it is powered off. To reset the factory defaults, turn the unit off, press both the **Up** and **Down** buttons simultaneously while you turn the system back on.

Choosing a Display Mode

To toggle through the display modes, press the **Display** button. Press one time to see the Channel 1 Only display. Press it again to see the Channel 2 Only display. Press it a third time to return to the Two Channel display.

Setup Menu

Press the Setup button to toggle through the Setup menu and cycle through the list of available parameters. Parameters are shown in Fig. 40.

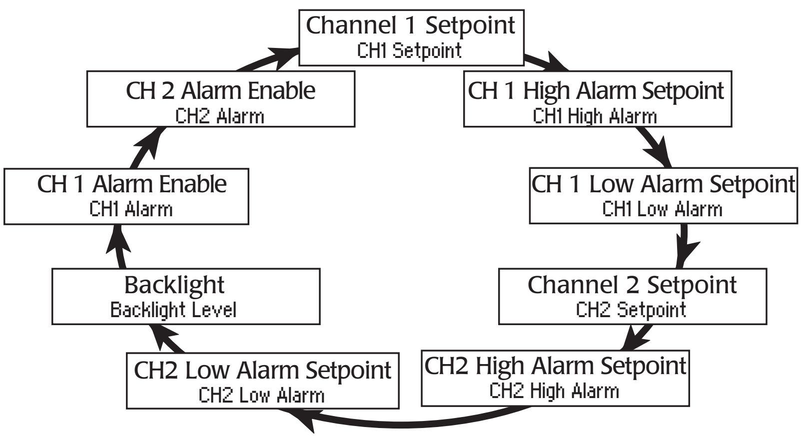


Fig. 40—The Setup button lets you toggle through the list of parameters.

Adjusting the Setpoint

1. Press the **Setup** button. The Channel 1 setpoint displays. To modify the Channel 2 setpoint, press the **Setup** button until "CH2 Setpoint" displays.

Fig. 41—Press the Up and Down buttons to adjust the Channel 1 Setpoint.

2. Press the **Up** or **Down** button to adjust the setpoint. The maximum setpoint allowed is 45°C.
3. Press the **Display** button to save the configuration and return to the normal display.

Setting Alarms

Both Channel 1 and Channel 2 have high and low alarm values. By default, the low alarms are set at 36°F, the high alarms are set at 38°F and the alarms are disabled.

1. Press the **Setup** button:
   - Twice to display the Channel 1 High Alarm
   - Three times to display the Channel 1 Low Alarm
   - Five times to display the Channel 2 High Alarm
   - Six times to display the Channel 2 Low Alarm

   The alarm setting displays.

```
CH1 High Alarm
    38.0°C
```

Fig. 42—Press the Up and Down buttons to adjust the alarm setting.

2. Press the **Up** or **Down** button to adjust the alarm setting.
3. Press the **Display** button to save the configuration and return to the normal display.

Changing the Backlight Level for the Display

By default the backlight level is set at 4. To make the display brighter, increase the level up to a maximum of 8. To dim the display, choose a lower level.

1. Press the **Setup** button until "Backlight Level" appears on the screen.

```
Backlight Level
Min=1 4 Max=8
```

Fig. 43—Press the Up or Down buttons to adjust the backlight level.

2. Press the **Up** or **Down** button to adjust the backlight level.
3. Press the **Display** button to save the configuration and return to the normal display.

Enabling/Disabling the Alarms

By default the alarms are disabled. When enabled, the unit will emit a beep when an alarm state occurs.

1. Press the **Setup** button until "CH1 Alarm" or "CH2 Alarm" appears on the screen.

```
CH1 Alarm
DISABLED
```

Fig. 44—By default the alarms are disabled.

2. Press the **Up** or **Down** button to enable or disable the alarm.
3. Press the **Display** button to save the configuration and return to the normal display.

Using the USB Port Output

The USB port can be used to connect to a computer to log the temperature history. In order to communicate with the computer, a terminal emulation program is required. Several third party options are available, including: Hyperterminal, Real Term (realterm.sourceforge.net) or Cool Term (freeware.the-meiers.org).

1. When you use a standard USB cable to connect the **SI-TCM2** to your computer, the computer will automatically install the necessary drivers.
2. Set up your terminal emulation program using the following parameters:
    - Baud rate: 38400 Bd
    - Data: 8 bits, (1 start, 1 stop)
    - Parity: None
3. The comma delimited, output file logs the temperature 10 times a second.

Holding Cells with Microtweezers

NOTE: Additional information about **MyoTak™** biocoampatible cellular adhesive and its usage is available in the **MyoTak** manual available at www.wpiinc.com.

CAUTION: Even though microtweezers are used to manipulate and hold single cells, the cells are not held by the clamping pressure of the tweezers. Cells are held to the tips of the tweezers by bonding with the **MyoTak** coating on the tweezers. If excessive pressure is exerted on the cell's membrane, the cell will burst.

1. Before placing buffer and cells in the cuvette used during the experiment, coat the bottom of the cuvette with a thin layer of a 100µM BSA (Bovine Serum Albumin) solution.
    - Apply the coating by placing a large drop of the BSA solution on the bottom of the cuvette and spreading it with the edge of a microscope slide or cover slip.
    - Tilt the cuvette dish or its bottom to allow excess BSA solution to drip off. Allow the BSA coating to dry before using the cuvette.
    - The BSA layer prevents the cells from sticking to the bottom of the cuvette and improves the flow of buffer in the cuvette.
2. Place the buffer containing the isolated cells in the cuvette, and place the cuvette on the stage of microscope.
3. Immerse the coated microtweezers in the buffer contained in the cuvette as soon as possible to prevent the dehydration of the **MyoTak** glue.

    NOTE: For directions on coating the microtweezers with **MyoTak**, see the **MyoTak** manual available at www.wpiinc.com.
4. While viewing the cell suspension with a 10X objective, locate a cell and move the stage to position the cell in the center of the field of view. Position a set of tweezers near each end of the cell.
5. While viewing a cell with a 40X objective, position one of the pairs of open tweezers

around the end of the cell. Bring the surface of the **MyoTak** layer that is between the tweezers into focus. Gently close the tips of the tweezers until the **MyoTak** layer depresses the cell membrane only a fraction of a micron. After being gently pressed into the cell membrane, the **MyoTak** glue should bind to the cell, and the tweezers can be opened until the cell membrane is not depressed anymore.

6. Repeat Step 5 on the other end of the cell.
7. Use the manipulator controls to lift the cell off the bottom of the cuvette without stretching it.
8. Once the cell is off the bottom of the cuvette, test the binding of the cell to the tweezers. Either stretch the cell a few microns or stimulate the cell to make it contract:

CAUTION: When the cell is stimulated using field stimulating electrodes and a stimulus isolator, the first contraction is usually greater than the subsequent contractions. After the first contraction, the cell enters a steady activation state and responds with lower force in each subsequent contraction.

- If the cell remains attached to the same section of **MyoTak**, the bond between the cell and the glue is strong enough to continue the experiment.
- If the cell slides across the **MyoTak** layer, close the tweezers another fraction of a micron around the end of the cell in an attempt to secure a tighter bond.
- If the cell still slides across the **MyoTak** layer, the **MyoTak** coating was either too thick or not completely dried. The Myotak must be removed from the tweezers, and the tweezers need to be re-coated.
- If the cell falls off the **MyoTak** layer after being pressed into the glue, the **MyoTak** layer was dried too long and did not rehydrate properly. The **MyoTak** must be removed from the tweezers, and the tweezers need to be re-coated.
- After re-coating, test the binding of the cell and **MyoTak** again before beginning the experiment.

Attaching Cells to Glass Microrods

1. Before placing buffer and cells in the cuvette used during the experiment, coat the bottom of the cuvette with a thin layer of a 100µM BSA (Bovine Serum Albumin) solution.
   - Apply the coating by placing a large drop of the BSA solution on the bottom of the cuvette and spreading it with the edge of a microscope slide or cover slip.
   - Tilt the cuvette dish or its bottom to allow excess BSA solution to drip off. Allow the BSA coating to dry before using the cuvette.
   - The BSA layer prevents the cells from sticking to the bottom of the cuvette and improves the flow of buffer in the cuvette.
2. Place the buffer containing the isolated cells in the cuvette, and place the cuvette on the stage of microscope.
3. Immerse the coated microrods in the buffer contained in the cuvette as soon as possible to prevent the dehydration of the **MyoTak** glue.

4. While viewing the cell suspension with a 10X objective, locate a cell and move the stage to position the cell in the center of the field of view. Position one of the microrods over each end of the cell. The rods should be perpendicular to the long axis of the cell, which means that the rods are also across the axis of the force and stretch of the cell.
5. Lower one of the glass microrods onto the surface of the cell near its end. Lower the rod until the surface of the cell conforms to the shape of the microrod.
6. Repeat Step 5 on the other end of the cell.
7. Use the manipulator controls to lift the cell off the bottom of the cuvette without stretching it.
8. Once the cell is off the bottom of the cuvette, test the binding of the cell to the microrods. Either stretch the cell a few microns or stimulate the cell to make it contract:

CAUTION: When the cell is stimulated using field stimulating electrodes and a stimulus isolator, the first contraction is usually greater than the subsequent contractions. After the first contraction, the cell enters a steady activation state and responds with lower force in each subsequent contraction.

- If the cell remains attached to the same section of **MyoTak**, the bond between the cell and the glue is strong enough to continue the experiment.
- If the cell slides across the **MyoTak** layer, lower the cell to the bottom of the cell and push the rods onto the surface of the cell again.
- If the cell still slides across the surface of the **MyoTak**, the layer of **MyoTak** was either too thick or not completely dried. The glass microrod must be removed from its support and replaced with a new microrod that needs to be re-coated.
- If the cell falls off the **MyoTak** layer after being pressed into the glue, the **MyoTak** layer was dried too long and did not rehydrate properly. The glass microrod must be removed from its support and replaced with a new microrod that needs to be recoated.
- After recoating, test the binding of the cell and **MyoTak** again before beginning the experiment.

MAINTENANCE

The Signal Conditioning Amplifier System is maintenance free. However, to protect **it**, follow these guidelines:

- Place the Signal Conditioning Amplifier System in a clean, dry location.
- Keep liquids away from the Signal Conditioning Amplifier System connections.

ACCESSORIES

SI-BAM21-LCB Accessories

Part Number	Description
13661	Potentiometer Adjustment Tool (Tweaker)
2851	BNC Cable
SI-DAS	SI-H Data Acquisition/Analysis System
SI-KG2	0-2N Force Transducer
SI-KG2B	0-0.5N Force Transducer
SI-KG4	0-50mN Force Transducer
SI-KG4A	0-20mN Force Transducer
SI-KG7	0-5mN Force Transducer
SI-KG7A	0-5mN Force Transducer
SI-KG7B	0-10mN Force Transducer
LAB-TRAX-8/16	8-Channel Data Acquisition System
SI-MT-L	Muscle Tester with long cuvette
SI-MT-S	Muscle Tester with short cuvette
SI-MT-O	Muscle Tester with optical cuvette
SI-FS	Electrode for field stimulation

Position Controller Accessories

Part Number	Description
2851	BNC Cable
SI-DAS	SI-H Data Acquisition/Analysis System
LAB-TRAX-8/16	8-Channel Data Acquisition System

SI-AOSUB Accessories

Part Number	Description
13661	Potentiometer Adjustment Tool (Tweaker)
2851	BNC Cable
97204	Pulser – SI-AOSUB Calibration Unit
LAB-TRAX-8/16	8-Channel Data Acquisition System

SI-TCM2B Accessories

Part Number	Description
801513	Universal Input Power Supply AC Adapter (12V DC at 3.75A 50/60Hz, 2.5mm ID/5.5mm OD with positive center DC barrel (Standalone SI-TCM2 only)
801514	Power Cord for AC Adapter, US plug
LAB-TRAX-8/16	8-Channel Data Acquisition System

TROUBLESHOOTING

Issue	Possible Cause	Solution
Chassis has no power	One of the two power switches is off.	Verify that the power switch one the back of the chassis and the power switch on the front panel are both in the on (I) position.
	The power cord is loose or not connected properly to the AC wall outlet	Unplug the power cord from the wall and the chassis and re-install it.
SI-BAM21-LCB has no output signal (0.0V DC)	Poor force transducer connection	Verify that the cables are securely connected to the **SI-BAM21-LCB**.
	BNC cable is bad	Try substituting a different BNC cable to troubleshoot the cause.
	Transducer failed	Try substituting a different force transducer to troubleshoot the cause.
Tweezers do not open or close	The nanomotor or the transducer assemblies are not connected to the Position Controller	Check the connections of the transducer and nanomotor assemblies to the position controller
	The modules are not getting power	Make sure the Signal Conditioning Amplifier System is turned on and the modules are installed properly. There is one main power switch on the back of the chassis and another power switch on the front face.
Resonance noise still exists on the transducer output signal	Anti-oscillation frequency is not set properly	Repeat the adjustment of the anti-oscillation filter. See "Adjusting the Anti-Oscillation Filter" on page 27. Verify that the pulser amplitude is reduced below maximum before trying another anti-oscillation frequency.

NOTE: If you have a problem/issue with that falls outside the definitions of this troubleshooting section, contact the WPI Technical Support team at 941.371.1003 or technicalsupport@wpiinc.com.

SPECIFICATIONS

This instrument conforms to the following specifications:

Chassis

Maximum Power Consumption	1.3A at 115V 50/60Hz, 1.8A at 230V 50/60Hz

SI-BAM21-LCB Specifications

Input Configuration	Current to voltage converter
Gain	1X, 2X, 5X, 10X - Switch slectable
Output Impedance	470Ω
Power Requirements	12V DC provided by the chassis
Output Range	±10V DC

Position Controller Specifications

Power Requirements	12V DC provided by the chassis
Position In Range	±10V, IV = 104µ
Position Out Range	±10V, IV = 104µ

SI-AOSUB Specifications

Power	12V DC provided by the chassis
Input	±10V DC

SI-TCM2B Specifications

Input Configuration	Current to voltage converter
Operating Temperature Range	Room temperature
Display Precision	0.1ºC
Controller Resolution	0.1ºC
Cuvette Temperature Sensor	1000Ω RTD (1000Ω at 0ºC)
Power Requirements	12V DC provided by the chassis

SI-KG7TWE Force Transducer

Range	0–5mN (0–0.5g)
Noise	20nN at 10X gain
Compliance	10µm/mN
Force Resolution	0.3µN
Resonance Frequency	250Hz
Time Resolution	7ms

Resolutions were determined while using the **SI-AOSUB** anti-oscillation filter.

NAMO Nanomotor Specifications

Total Travel	±90µm
Resolution	20nm
Smallest Step	60nm
Input	±10V (calibrated at 10µm/V)

97204 Pulser Specifications

Pulser Output	0–10V DC adjustable
	85Hz–1.0KHz
Damping Frequency Range	85Hz–1.0KHz
Output Range	±10V

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DECLARATION OF CONFORMITY

WORLD PRECISION INSTRUMENTS, INC.
175 Sarasota Center Boulevard
Sarasota, FL 34240-9258 USA
Telephone: (941) 371-1003 Fax.: (941) 377-5428
e-mail: wpi@wpiinc.com

DECLARATION OF CONFORMITY

We: World Precision Instruments, Inc.
175 Sarasota Center Boulevard
Sarasota, FL 34240-9258 USA

As the manufacture of the apparatus listed, declare under sole responsibility that the product(s):
SI-MB4 Signal Conditioning Amplifier System
SI-CTS100A Cell Tester
SI-CTS100B Cell Tester

To which this declaration relates is/are in conformity with the following standards or other normative documents:

Safety: EN 61010-1:2010
Emc: EN 61326-2-3:2006
EN 61326:1997+A1:1998+A2:2001+A3:2003

And therefore conform(s) with the protection requirements of Council Directive 2004/108/EC relating to electromagnetic compatibility and Council Directive 2006/95/EC relating to safety requirements:

Issued on: June 15th, 2011

Cliff Bredenberg
President
World Precision Instruments, Inc.
175 Sarasota Center Boulevard
Sarasota, FL 34240-9258 USA

Glen Carlquist
Vice President of Production
World Precision Instruments, Inc.
175 Sarasota Center Boulevard
Sarasota, FL 34240-9258 USA

WARRANTY

WPI (World Precision Instruments, Inc.) warrants to the original purchaser that this equipment, including its components and parts, shall be free from defects in material and workmanship for a period of one year* from the date of receipt. WPI's obligation under this warranty shall be limited to repair or replacement, at WPI's option, of the equipment or defective components or parts upon receipt thereof f.o.b. WPI, Sarasota, Florida U.S.A. Return of a repaired instrument shall be f.o.b. Sarasota.

The above warranty is contingent upon normal usage and does not cover products which have been modified without WPI's approval or which have been subjected to unusual physical or electrical stress or on which the original identification marks have been removed or altered. The above warranty will not apply if adjustment, repair or parts replacement is required because of accident, neglect, misuse, failure of electric power, air conditioning, humidity control, or causes other than normal and ordinary usage.

To the extent that any of its equipment is furnished by a manufacturer other than WPI, the foregoing warranty shall be applicable only to the extent of the warranty furnished by such other manufacturer. This warranty will not apply to appearance terms, such as knobs, handles, dials or the like.

WPI makes no warranty of any kind, express or implied or statutory, including without limitation any warranties of merchantability and/or fitness for a particular purpose. WPI shall not be liable for any damages, whether direct, indirect, special or consequential arising from a failure of this product to operate in the manner desired by the user. WPI shall not be liable for any damage to data or property that may be caused directly or indirectly by use of this product.

Claims and Returns

• Inspect all shipments upon receipt. Missing cartons or obvious damage to cartons should be noted on the delivery receipt before signing. Concealed loss or damage should be reported at once to the carrier and an inspection requested. All claims for shortage or damage must be made within 10 days after receipt of shipment. Claims for lost shipments must be made within 30 days of invoice or other notification of shipment. Please save damaged or pilfered cartons until claim settles. In some instances, photographic documentation may be required. Some items are time sensitive; WPI assumes no extended warranty or any liability for use beyond the date specified on the container.

• WPI cannot be held responsible for items damaged in shipment en route to us. Please enclose merchandise in its original shipping container to avoid damage from handling. We recommend that you insure merchandise when shipping. The customer is responsible for paying shipping expenses including adequate insurance on all items returned.

• Do not return any goods to WPI without obtaining prior approval and instructions (RMA#) from our returns department. Goods returned unauthorized or by collect freight may be refused. The RMA# must be clearly displayed on the outside of the box, or the package will not be accepted. Please contact the RMA department for a request form.

• Goods returned for repair must be reasonably clean and free of hazardous materials.

• A handling fee is charged for goods returned for exchange or credit. This fee may add up to 25% of the sale price depending on the condition of the item. Goods ordered in error are also subject to the handling fee.

• Equipment which was built as a special order cannot be returned.

• Always refer to the RMA# when contacting WPI to obtain a status of your returned item.

• For any other issues regarding a claim or return, please contact the RMA department

Warning: This equipment is not designed or intended for use on humans.

* Electrodes, batteries and other consumable parts are warranted for 30 days only from the date on which the customer receives these items.

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