



SI-MT/SI-MKB

Signal Conditioning Amplifier System for Muscle Testers

www.wpiinc.com

INSTRUCTION MANUAL

Serial No. _____

032312

World Precision Instruments

SI-H Muscle Testers



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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 (Left) SI-MT is a convenient platform for all standard mechanical experiments on intact muscle preparations.

Fig. 2 (Right) The SI-MKB platform also uses the electronic components that are discussed in this manual.

SI-H Muscle Testers



Fig. 3 The Signal Conditioning Amplifier System is a flexible chassis that is specifically configured for an SI-MT or SI-MKB system (Muscle Testers).

INTRODUCTION

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 optional modules as you need.

When the system is ordered with an **SI-MT** or **SI-MKB** (Muscle Tester) system, the Signal Conditioning Amplifier System (chassis) is configured with an **SI-BAM21-LCB**. Optional modules include an **SI-TCM2B** Temperature Control Module, an **SI-MOTTEST** Linear Motor Controller, an **SI-AOSUB** Anti Oscillation Unit, the **SI-SARCAM** Sarcomere Spacing Module and the **SI-COLU** Constant Load Unit. The Temperature Control Module, Linear Motor Controller and Sarcomere Spacing Module require two slots each 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 an **SI-MT** or **SI-MKB** system.



Features

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

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

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 an **SI-BAM21-LCB**

(1) Power cord

(1) Instruction Manual

OPTIONAL COMPONENTS:

(1) **SI-TCM2B** Temperature Control module

(1) **SI-MOTTEST** Linear Motor Control module

(1) **SI-AOSUB** Anti-Oscillation module

(1) **SI-SARCAM** Sarcomere Spacing module (For use with the Muscle Tester only.)

(1) **SI-COLU** Constant Load Unit

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.

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INSTRUMENT DESCRIPTION

Signal Conditioning Amplifier for the SI-MT/SI-MKB

Front Panel



Fig. 4 The front panel of a Signal Conditioning Amplifier System configured for a Muscle Tester shows the SI-BAM21-LCB, the SI-AOSUB, The SI-SARCAM, the SI-MOTTEST and the SI-TCMB2.

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.

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. An **SI-AOSUB** is necessary when a linear motor is used.

Sarcomere Spacing Module—Sarcomere spacing measurement requires a system with an optical cuvette (cuvette with a window). A laser passes through the muscle, and the diffracted light is captured with a CCD camera. By monitoring the diffraction pattern, the length of the sarcomeres can be calculated.

Linear Motor Control Module—When a linear motor is required, this module powers the motor and provides an output indicating the actual motor position. It connects to an analog to digital converter output of the data acquisition system (like LabTrax 8/16) to control the waveform and timing for the motor control. The output connects with an analog input of the data acquisition system to monitor the sensor feedback from the motor.



Temperature Control Module—When temperature control is required, the **SI-TCM2** 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 can be user defined.

Constant Load Module—(Not pictured in the unit here.) It is often important to maintain a constant sarcomere length rather than keep the total length of the preparation constant during an isometric contraction. For example, if the muscle is fixed with its tendons, the muscle contraction elongates these tendons. Even though the distance between the ends of the muscle is kept constant, the muscle contraction effects an internal shortening of the sarcomeres of the muscle. In order to get a true isometric muscle contraction, the sarcomere length must be kept constant during the contraction. For this purpose the output signal of the camera (**SI-SARCAM**) can be fed into the feedback controlling the linear motor position using the **SI-COLU**. The feedback system controls the linear motor so that the sarcomere length is held constant.

Expansion Slots—Empty slots (not shown) on the back plane are filled with expansion slots which can be replaced at a later time when other modules are added to the system.

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

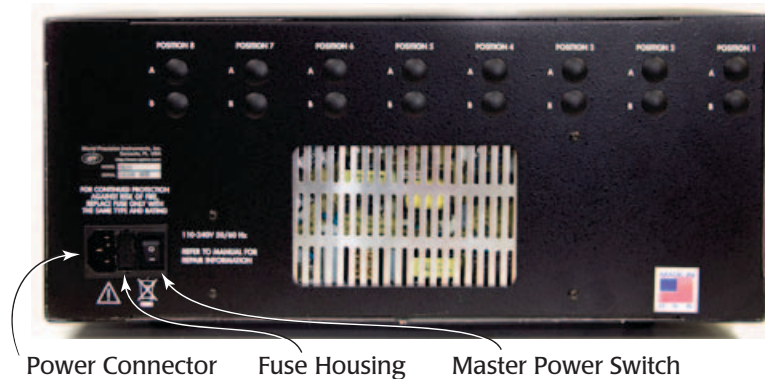


Fig. 5 The back panel of the Signal Conditioning Amplifier System has a master power switch that is usually left on.

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

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

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

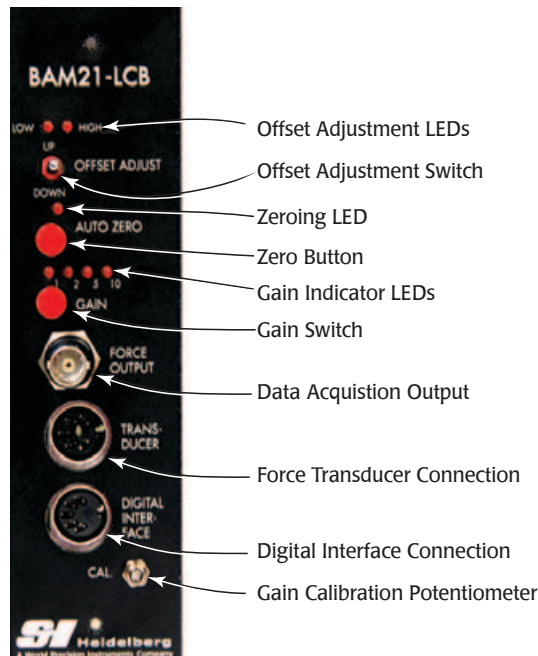


Fig. 6 SI-BAM21-LCB KG Optical Force Transducer Amplifier

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 than 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 20.

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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-KG** 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-MT** or **SI-MKB** electronics are configured at the factory for the muscle 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-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

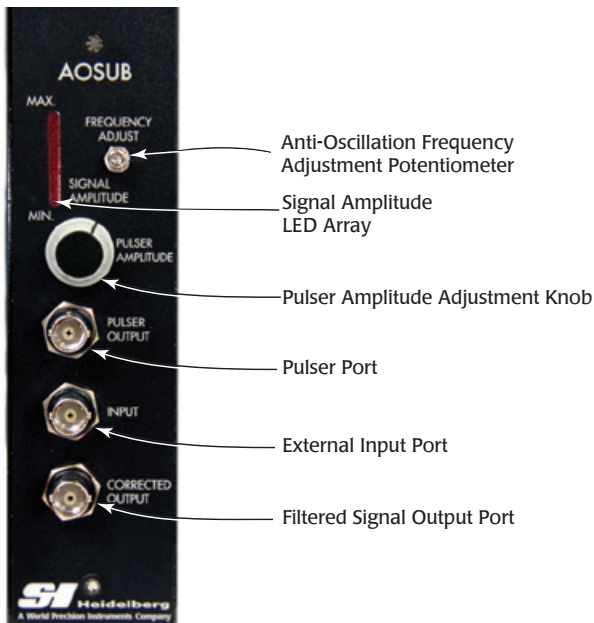


Fig. 7 SI-AOSUB Anti-Oscillation Module



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 electro-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.

SI-SARCAM

Skeletal and heart muscles are composed of basic contractile units called sarcomeres. Sarcomeres give these muscles their characteristic striated appearance.

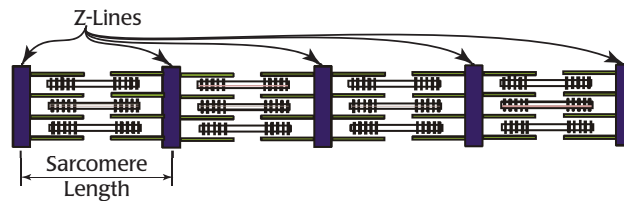


Fig. 8 Sarcomere units are arranged one after another within a muscle as shown schematically here.

When a laser light is shined through the muscle fibers, the light is diffracted in a pattern, which is determined by the spacing between the muscle fibers (sarcomeres). Because of the sarcomere structure, the refraction pattern looks similar to placing a grating in front of the light source. In other words, the monochromatic light (from the laser) falling perpendicular on a muscle preparation is diffracted corresponding to the distance of the grating, also called the grating constant. (Fig. 9)

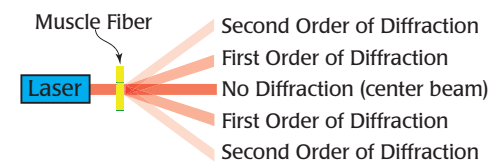


Fig. 9 As the light shines through the muscle fiber, the sarcomeres diffract the light in a pattern.

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A red laser diode ($\lambda=650\text{nm}$) is used. A one-dimensional (linear) CCD camera with a time resolution of 1ms scans the light intensity of the diffraction pattern beginning 6.8mm from the center beam. The camera scans only half the diffraction pattern, assuming that the pattern is symmetrical with respect to the center beam. When the scan arrives at the part of the CCD chip which is hit by the first order of diffraction, the output voltage increases to a peak level, and the first order of diffraction is captured (Fig. 10). Then, the intensity signal decreases again. The sarcomere length is calculated from the first order diffraction distance.

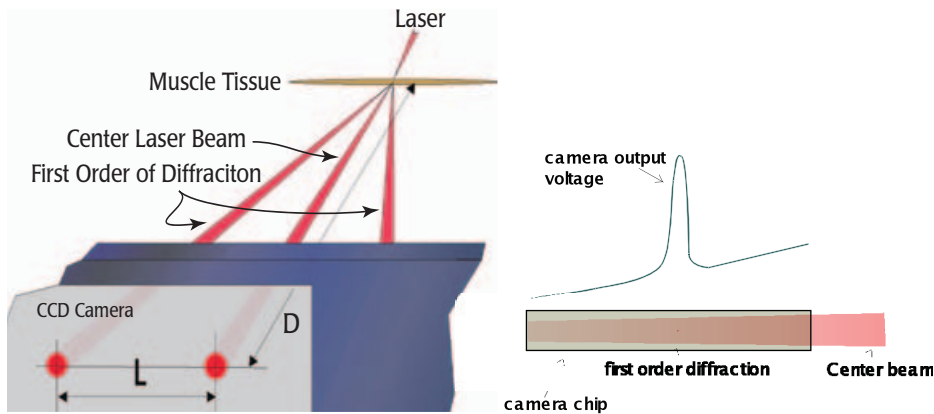


Fig. 10 (Left) The distance between the center laser beam and the first order diffraction is captured with a one-dimensional CCD camera. Then, the sarcomere spacing is calculated.

Fig. 11 (Right) The output voltage of the camera peaks as it scans over the spot where the first order diffraction hits the CCD screen.

The sarcomere spacing can be specifically calculated using geometry: $s = \lambda \times \sqrt{(D^2/L^2 + 1)}$.

λ = wavelength of the laser (650nm)

s = grating constant (The grating constant is the sarcomere length.)

D =distance from the muscle to the camera

L =measured distance from the center beam of the laser to the first order of diffraction

The results of this calculation are shown on the LCD display of the **SI-SARCAM** module.

For a quick approximation, the sarcomere length can be calculated using the formula:

$s = \lambda \times (D/L)$. The sarcomere lengths reported by the analog outputs are approximations using this formula.

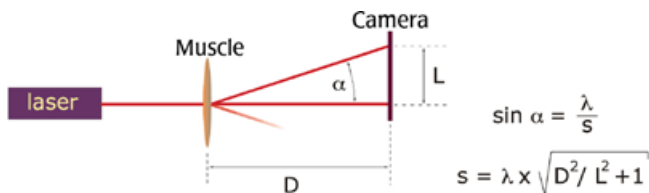


Fig. 12 The geometry of the system is shown above.

NOTE: If the sarcomeres all have the same length, the laser diffraction line is very narrow. When the sarcomere order is more random, wider diffraction lines result as the lines of

the shorter sarcomeres superimpose with the lines of the longer sarcomeres. This provides a qualitative method for judging how much the sarcomeres get disordered during a contraction. Broadening of the sarcomere distribution indicates increased sarcomere disarray. Often this is not reversible and indicates loss of sarcomere integrity and reduced viability of the muscle preparation. Reduction in peak force and simultaneous increased resting tension can then be further indication of a dying muscle; the preparation needs to be replaced.

NOTE: Often it is important to keep the sarcomere length constant, as opposed to the total length of the preparation, during an isometric contraction. If, for instance, the muscle is fixed with its tendons, the muscle contraction elongates the tendons. Even though the distance between the ends of the muscle is kept constant, the muscle contraction effects an internal shortening of the sarcomeres of the muscle. In order to get isometric contractions of the muscle, the sarcomere length must be kept constant during the contraction. In this case, the output signal of the camera is used with additional feedback system electronics to control the linear motor position. The feedback system controls the linear motor such that the sarcomere length is held constant. This is referred to as sarcomere clamping and is implemented in the **SI-COLU** constant load unit. With this unit, clamping can be around force, overall muscle length and sarcomere length in tonically contracting striated muscle.

Front Panel



WARNING: DO NOT EXPOSE YOUR EYES TO LASER LIGHT. EVEN REFLECTED LASER LIGHT MAY BE HARMFUL. ALWAYS WEAR PROTECTIVE LENSES WHEN WORKING WITH LASERS.



Fig. 13 SI-SARCAM Sarcomere Spacing Module

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LCD Display—Upon startup, this display shows the version of the software the **SI-SARCAM** is running. During normal operations, this display can show the calculated (actual) sarcomere spacing, the first order diffraction distance or the signal amplitude. During configuration, this display shows parameters and confirmation messages.

Laser Intensity—Rotate this dial to change the intensity of the laser's power output.

Sync Output—This digital output is used for synchronizing the video with a timing reference. Connect this BNC port to an oscilloscope channel used as a synchronization source (trigger).

Video Output—Connect this BNC port to an oscilloscope to monitor the output of the linear camera.

USB Port—This port is reserved for future development.

Analog Outputs—The Sarcomere and Distance analog outputs can be connected to a data acquisition system to monitor the sarcomere spacing and measured distance:

- Approximate sarcomere spacing length can be accessed from the **Sarcomere** analog output. 1.0V corresponds to 500nm sarcomere length. This output uses the equation described on the preceding page: $s = \lambda \times (D/L)$. The actual sarcomere length is calculated and displayed on the digital display. Press the **Display** button until "Sarcomere Space" appears.
- The measured distance between the center beam and the first order diffraction can be read from the **Distance** analog output BNC connection. 10.0V corresponds with a first order diffraction distance of 40mm from the center beam. The sarcomere length can be calculated from this value using the equation: $s = \lambda \times \sqrt{(D^2/L^2 + 1)}$. The measured distance is shown on the digital display. Press the **Display** button until "First Order Dist" appears.

Configuration Buttons—The Display button is used to toggle the display between the first order of diffraction distance and the signal amplitude. The Setup button rotates through the array of configurable parameters. The Up and Down buttons are used to adjust the parameters.

Laser Connection—The cord from the laser plugs into this connection to power the laser.

Camera Connection—The cord from the linear, CCD camera plugs into this connection to power the camera.

SI-MOTTEST

The SI-H Linear Motor Controller is designed for use with the SI-H line of muscle physiology research platforms. For systems that require a linear motor, this unit provides the precision control of the motor. A linear motor is required for measuring mechanical muscle properties such as slack-test, isotonic release, constant velocity release, stretch release, vibration studies, after-loaded contractions and eccentric contractions (intact muscle).



Fig. 14 The Linear Motor is an optional part for the SI-MT or SI-MKB systems.

The position of the linear motor is determined by a combination of the data from the controller indicating the current position and the DC value applied to the front panel at the Position In port. The applied Position In signal can be provided by a data acquisition system. The data acquisition analog output signal is set to define the waveform and timing pattern of force to be applied to the sample.

The Linear Motor Controller has been designed with an automatic shutoff feature. That means that the voltage driving the motor automatically shuts off if the motor draws too much current. After less than a second, the motor cycles back on again. If the setup still draws too much current, it repeats the power down cycle. This could happen if too much force is being applied to the sample. The system continues to cycle the motor off and on until the force on the motor is reduced. If this happens, the motor hums as if it is trying to work, but the motor produces no force output. If an auto-shutdown occurs, adjust the experiment and force tension on the motor.

NOTE: Use of a linear motor with a muscle testing platform creates vibration which excites the sensor's resonant frequency and requires an anti-oscillation unit (**SI-AOSUB**) for best results.

This linear motor control unit is only available as a module for the Signal Conditioning Amplifier System backplane.

Features

The **SI-MOTTEST** Linear Motor Controller has the following features:

- Powers the motor and provides an output indicating the actual motor position
- Connects to Analog to Digital Converter output of the computer or data acquisition system (like LabTrax 8/16) to allow the programming to control the waveform and timing of the motor control
- Input range of $\pm 10\text{VDC}$
- Over current protection that automatically shuts down when the supply voltage dips below the reference value
- Linear motor position is determined by a DC value applied from the Position In port

SI-H Muscle Testers

Front Panel

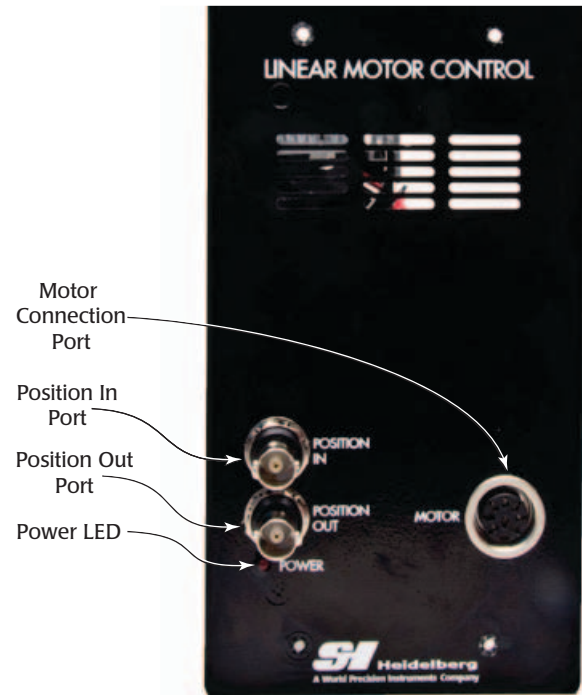


Fig. 15 The Linear Motor Controller

Motor Connector—Use this port to connect the linear motor used with the SI-MT or SI-MKB muscle testers. The motor is setup and calibrated to the Linear Motor Controller that is shipped with it. The motor and controller have a maximum range of motion of $\pm 3.5\text{mm}$ from the center of travel.

Position In—This BNC interface provides for an external position command input. The input range is $\pm 10\text{VDC}$. The signal presented at the input will affect the length of motor travel. The motor/controller combination are calibrated for travel of $1.0\text{mm}/2.0\text{VDC}$. For example, $+7\text{VDC}$ translates to $+3.5\text{mm}$ of travel from the center, and -7VDC equals -3.5mm of travel from the center.

Position Out—This BNC output provides a signal proportional to the sensor feedback from the motor. Connect this port to a data acquisition system to track the motor position over time.

Power—This LED Indicates that the controller has power from the Signal Conditioning Amplifier System.



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 45°C. 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

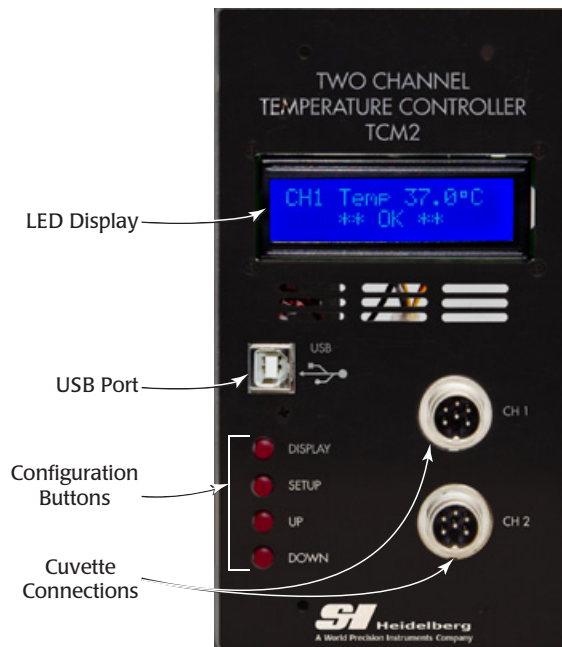


Fig. 16 The SI-TCM2B temperature controller can control two cuvettes simultaneously.

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).

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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.

SI-COLU

The Constant Load Module lets you maintain a constant force, muscle length or sarcomere length rather than keep the total length of the preparation constant during an isometric contraction. In order to get a true isometric muscle contraction, the sarcomere length must be kept constant during the contraction. For this purpose the output signal of the camera (**SI-SARCAM**) can be fed into the feedback controlling the linear motor position using the **SI-COLU**. The feedback system controls the linear motor so that the sarcomere length is held constant.

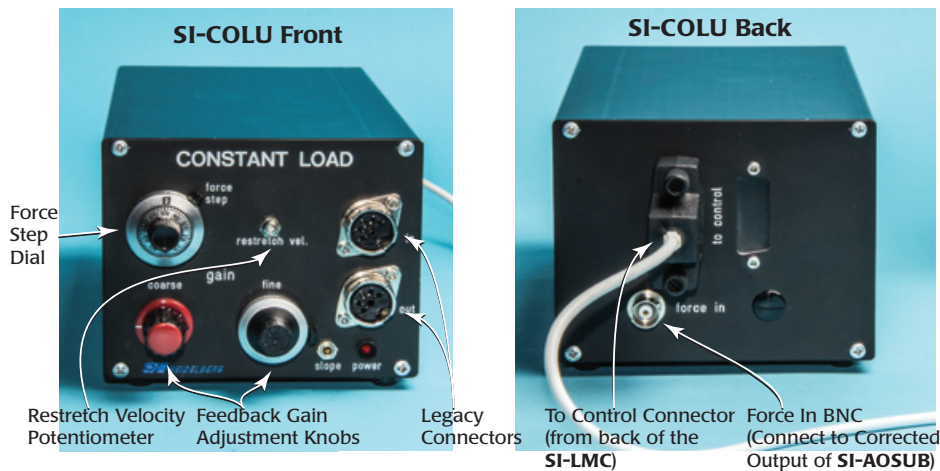


Fig. 17 The SI-COLU Constant Load Module can be used to switch from an isometric to an isotonic contraction by engaging a feedback around a reduced constant measured force.

Force Step Dial—During a tonic contraction, activation of the **SI-COLU** unit causes the force to drop to the level, which is set using with the **Force Step** dial. The numbers on the dial correspond to the percentage of the force (F_0) gained by the muscle at the moment when the load is placed on the muscle. The number 10 corresponds with 100% of the force. For example, adjusting the potentiometer to 5 means that the applied force drops to 50% of the original force F_0 .

Feedback Gain Adjustment Knobs—The feedback gain can be adjusted with the **Coarse** and **Fine** knobs. In order to avoid oscillations of the system, start with a low gain. Once the gain is adjusted for a muscle type and the force transducer, the gain normally needs only slight modifications to optimize it from one experiment to the next.

CAUTION: When using the system with a tetanically contracting muscle, it is important to make the time interval of the motor action so short that the isotonic shortening is completed before the activation of the muscle stops. Otherwise, the instrument keeps the force at the adjusted level, when the muscle is already relaxed. This could over-stretch the muscle.

Restretch Velocity Potentiometer—Use a small screwdriver or POT tweaker to adjust the speed at which the muscle returns to the original force after a constant load force has been applied.

IMPORTANT NOTE: THE **SI-COLU** unit can only be used on tonically contracting muscle tissue (for example, during a tetanic contraction). For equivalent experiments in cardiac muscle and twitch type contractions, the **AFTERLOAD** unit is needed. Contact WPI for further information.

Connecting the Signal Conditioning Amplifier System



Fig. 18 Connect the system as shown above.

1. Connect the 5-pin connector on the force transducer to the port labeled **Transducer** on the front panel of the **SI-BAM21-LCB** transducer amplifier. For information on using the amplifier, see "Using the SI-BAM21-LCB" on page 20.
2. (Optional) Make the linear motor connections, if a motor is used.
 - Connect the linear motor to the port labeled **Motor Connector** on the **SI-MOTTEST**.
 - Using a standard BNC cable, connect the analog output of the data acquisition system (like **LabTrax8/16**) that controls the linear motor input to the **Position In** port on the **SI-MOTTEST**.
 - Using a standard BNC cable, connect the **Position Out** port on the **SI-MOTTEST** to a second analog input of the data acquisition system that monitors the motor feedback.

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3. (Optional) If a motor is used, an anti-oscillation unit is necessary to minimize vibration. When the **SI-MT** or **SI-MKB** electronics are configured at the factory with an **SI-AOSUB**, 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.
 - If a motor is used, then use a BNC cable to 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.

For information on using the **SI-AOSUB**, see "Using the Anti-Oscillation Unit" on page 23.
5. (Optional) If a Sarcomere Length Unit is included, connect the **SI-SARCAM** as follows:
 - Connect the cord from the laser to the **Laser** connection port.
 - Connect the cord from the camera to the **CCD** connection port.
 - (Optional) Connect the **Video** BNC port to an oscilloscope to display the laser diffraction pattern.
 - To monitor the approximate sarcomere length over time, connect the **Sarcomere** BNC connector to an analog input on your data acquisition system.
 - To track the distance from the center laser beam to the first order of diffraction, connect the **Distance** BNC connector to an analog input on your data acquisition system.

For information on using the **SI-SARCAM**, see "Using the Sarcomere Length Unit" on page 25.
6. (Optional) If cuvette temperature control is required, connect the **SI-TCM2B** as follows:
 - Line up the 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 cuvette may be connected to the other port, if necessary.
 - 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 31.
7. (Optional) If a Constant Load Module is used, the Signal Conditioning Amplifier System has two BNC connectors on the back (Fig. 19). The following connections must be made:



- Connect the cable from the back of the Linear Motor Controller to the back of the **SI-COLU** unit.
- Use a coaxial cable to connect the **Force In** BNC on the back of the **SI-COLU** unit to the **Corrected Output** of the **SI-AOSUB**.
- Use a coaxial cable to connect the **Position** BNC on the back of the chassis to the digital input of the data acquisition system that is used to trigger the constant load mode.
- Use a coaxial cable to connect the **Gate** BNC on the back of the chassis to the **Position In** BNC on the front of the **SI-MOTTEST** Linear Motor Control module.

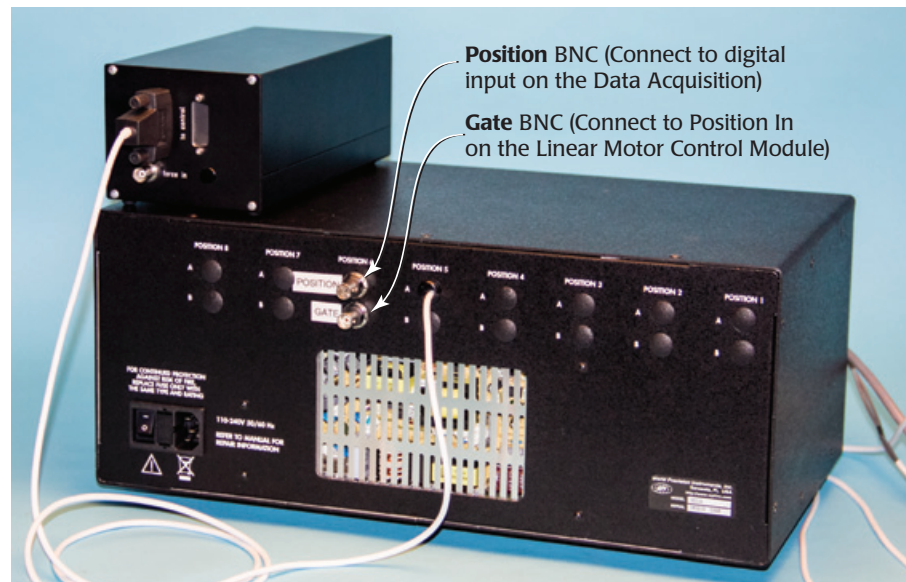


Fig. 19 Connect the Linear Motor Controller cable to the Constant Load Module.

8. 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.

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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-KG** force transducers respond linearly within its measurement range. Consequently, The **SI-BAM21-LCB** can be calibrated using only two reference points.

Methodology

The basic procedure for calibrating the **SI-BAM21-LCB** involves:

1. Setting a zero reference point with the force transducer unloaded.
2. Applying a load to the transducer with a known mass.
3. Use the **Gain Calibration Potentiometer** to adjust the amplifier's output range. Choose a value that EITHER (choose one):
 - Maximizes the resolution for the intended measurement range.
 - Numerically correlates the force with a voltage output.

This allows you to choose the calibration method that best serves your application.

- For the greatest precision, maximize the resolution of the **SI-BAM21-LCB** by calibrating so that the 10.0V output is set a little above the maximum expected force (~5%). For example, if your maximum expected value is 4.75g, set the **SI-BAM21-LCB** so that a 5g mass yields a 10.0V output. The maximum expected output would then be 9.5V, with a 4.75g applied load.
- On the other hand, for quick visualization, you might choose to establish a numerical correlation by calibrating the **SI-BAM21-LCB** so that a force like 1.0g generates a 1.0V output.

Although each of the **SI-KG** force transducers has a fixed load range, the design of the **SI-BAM21-LCB** offers four levels of amplification using the **Gain** switch (X1, X2, X5 and X10). You can choose to use the full-load range of the transducer (X1) or, if higher resolution is desired, one of the other multipliers (X2, X5, X10). For example, using X10

uses 1/10th of the full-load range of the transducer. Under ideal conditions, the **Gain** switch is set to an amplification factor of X1 using an SI-KG force transducer with a force range that is no more than 120% of the maximum force anticipated. In general, it is best to choose a gain factor that will not need to be changed during an experiment. This is because each gain factor can have slight variances in offset. However, if it is necessary to switch between gain ranges during an experiment, check the offsets in each of the ranges to be used. Then, use the Offset Adjustment switch to set the minimum average offset between the ranges.

Procedure

The following calibration procedure may be used with any **SI-KG** force transducer. For illustration purposes a **SI-KG4** force transducer is used in the example. Note that a 0.5g mass is about 10% of the total range of the **SI-KG4** force transducer, and a 5g mass is the maximum force the SI-KG4 can measure. If we intend to use the X10 mode, 0.5g is the largest mass we can use with this force transducer.

1. Attach the desired force transducer to the **Transducer** port on the front panel of the **SI-BAM21-LCB**. For this example, use a **SI-KG4** force transducer.
2. Mount the force transducer on the calibration stand of the Muscle Tester. The calibration stand holds the force transducer at the same angle that is used when measurements are taken. This angle is critical in establishing a proper calibration ratio.

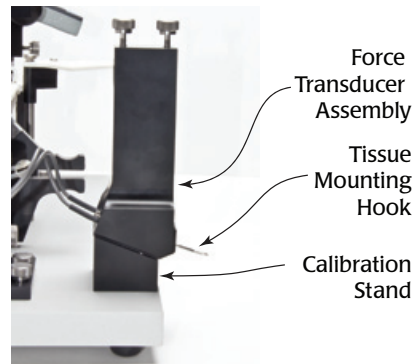


Fig. 20 When the force transducer is properly mounted in the calibration stand on the muscle tester, the force transducer is held at the same angle used when making measurements.

3. Connect a data acquisition system or a digital multi-meter to the **Output** (BNC connection) on the front panel of the **SI-BAM21-LCB**. The analog BNC output on the front panel can be connected to a multi-meter for DC voltage measurements between -10.0 and +10V DC. Alternatively, a data acquisition system with analog data tracking, recording and analysis can be connected to a PC to provide a record of the analog output (WPI #**LAB-TRAX-816**).
4. Set the **Gain** switch to the amplification factor you intend to use.
5. With no weight suspended from the transducer, press and release the **Zero** button and monitor the output. You should see a reading of 0.0V DC \pm 50mV. Keep in mind

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that for higher gain settings the zeroing error is larger and requires the use of the Offset Adjustment switch 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.

6. 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 than 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.

7. From the transducer, suspend a known mass that is close to the maximum range for the amplification factor and force transducer. For the **SI-KG4** force transducer, use a less than 5.0g for X1 or less than 0.5g for X10.

NOTE: Mass in grams is not equal to force in newtons. Since force equals mass times acceleration ($F = ma$), a 0.5g weight is equal to 4.9mN. ($0.0005\text{kg} * 9.8\text{m/s}^2 = 0.0049\text{N}$) The mass you choose must exert a force that falls within the operating range of the force transducer and amplification factor you select.

8. After the suspended mass becomes motionless, monitor the output while adjusting the **Gain Calibration Potentiometer**. The output voltage may be set to almost any arbitrary value up to 10.0V. Use a potentiometer adjustment tool (WPI #13661) to adjust the **Gain Calibration Potentiometer** for the desired output voltage.
9. If you intend to use multiple amplification factors, cross-check your calibration. Set the **Gain** switch to X1 and verify that the output is one tenth of the value recorded in the X10 gain setting. If a 0.5g mass is used and the **SI-BAM21-LCB** is calibrated as close as possible 10.0V in X10, then in X1, the monitor should display very close to 1.0V.

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 you 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 Muscle 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).

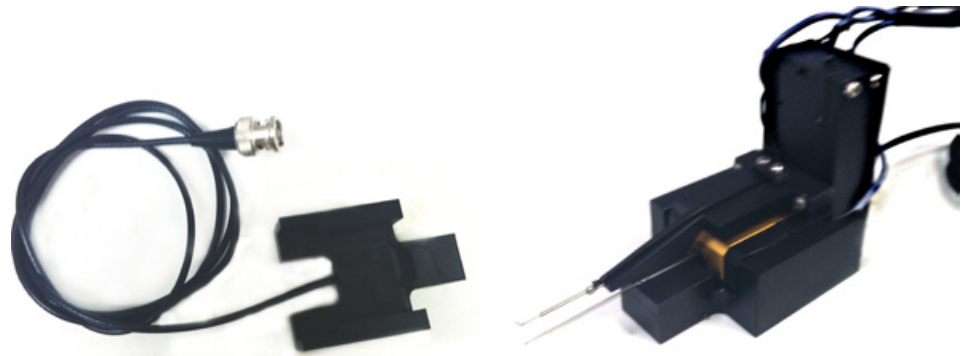


Fig. 21 (Left) This pulser assembly has no force transducer mounted in it.

*Fig. 22 (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.

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- 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. 22.
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 Muscle 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.

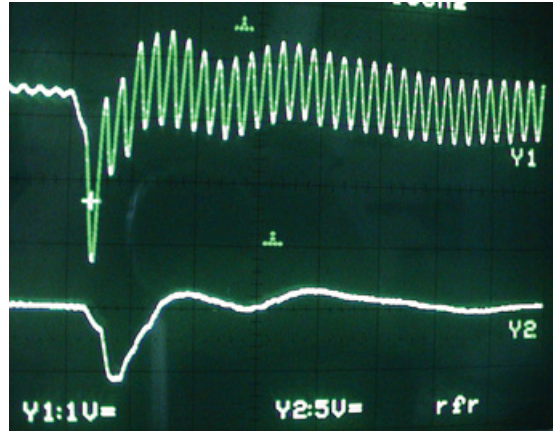


Fig. 23 The upper trace is a force transient obtained directly from the bridge amplifier output, and the lower trace shows the signal after it passes through the “anti oscillation” unit.

Using the Sarcomere Length Unit

Setup

1. Turn on the system. See "Turning the System On" on page 20.
2. Line up the laser connector with the port labeled **Laser** on the **SI-SARCAM** module and press it into place.
3. Line up the camera connector with the port labeled **CCD** on the **SI-SARCAM** module and press it into place.
4. Press the **Setup** button to toggle through the setup parameters.
5. 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.

NOTE: For safety reasons, the laser is always disabled at startup.

Choosing a Display Mode

The default display is two lines and shows the calculated (exact) sarcomere spacing, first order diffraction distance that is used to calculate the sarcomere spacing and the signal amplitude, which is used when you are aligning the camera. To toggle through the display modes, press the **Display** button. Press one time to see the first order diffraction distance. Press it again to view the signal amplitude. Press it a third time to return to the sarcomere spacing display.

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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. 24.

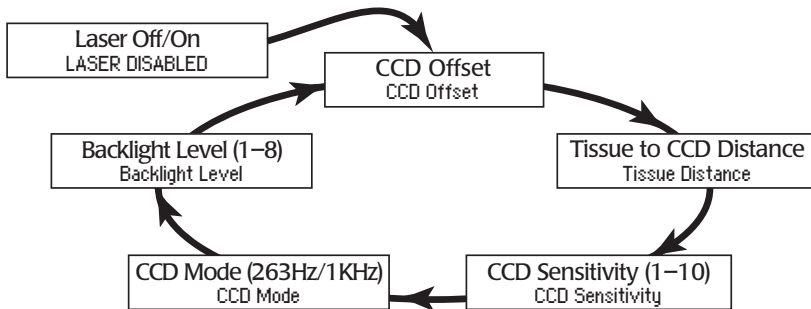


Fig. 24 The Setup button lets you toggle through the list of parameters.

Turning On/Off the Laser

For safety reasons, the laser is always disabled at startup.

1. Press the **Setup** button. The state of the laser displays (LASER DISABLED or LASER ENABLED).

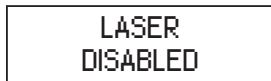


Fig. 25 Press the Up or Down button to change the laser state.

2. Press the **Up** or **Down** button to change the laser state.
3. Press the **Display** button to save the configuration and return to the normal display.

Adjusting the CCD Offset

CAUTION: The CCD offset should not be modified from the factory default of 6.8mm unless you have a reason to place the zero order laser spot at a different location other than the cross hair mark on the cuvette.

1. Press the **Setup** button until "CCD Offset" appears. This is the distance between the crosshair marking on the cuvette and the first pixel of the CCD camera.

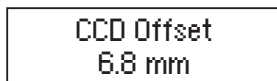


Fig. 26 Press the Up or Down button to adjust the offset.

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

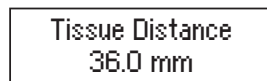


Setting the Tissue Distance



CAUTION: The default value for the tissue distance is 36.0mm. This value should not be modified.

1. Press the **Setup** button until "Tissue Distance" displays. This is the distance between the muscle tissue sample and the CCD camera (D).



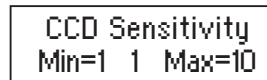
```
Tissue Distance
36.0 mm
```

Fig. 27 Press the Up or Down button to set the tissue distance.

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

Adjusting the CCD Sensitivity

1. Press the **Setup** button until "CCD Sensitivity" displays. The camera's sensitivity can range from 1 (minimum) to 10 (maximum). By default the sensitivity is set to the minimum (1). To modify the sensitivity, press the **Setup** button.



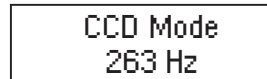
```
CCD Sensitivity
Min=1 1 Max=10
```

Fig. 28 Press the Up or Down button to adjust the camera sensitivity.

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

Setting the Camera (CCD) Mode

1. Press the **Setup** button until "CCD Mode" displays. Two options are available:
 - If you set the system to 263Hz (default), the full display of the CCD is used and the camera operates at 263Hz.
 - For faster operations (1KHz), set the system to 1KHz. At the faster speed, only the first quarter of the CCD camera display is used for making measurements.



```
CCD Mode
263 Hz
```

Fig. 29 Press the Up or Down button to change the CCD mode.

NOTE: The update rate is only supported on the analog outputs. The LCD display update rate is much slower.

2. Press the **Up** or **Down** button to change the CCD mode.
3. Press the **Display** button to save the configuration and return to the normal display.

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Aligning the Laser and the Camera



WARNING: DO NOT EXPOSE YOUR EYES TO LASER LIGHT. EVEN REFLECTED LASER LIGHT MAY BE HARMFUL. ALWAYS WEAR PROTECTIVE LENSES WHEN WORKING WITH LASERS.

1. Turn on the system. See "Turning the System On" on page 20.
2. Enable the laser. By default, the laser is always disabled on startup. See "Turning On/Off the Laser" on page 26. When the laser is enabled, a red dot (the laser beam) appears near the cross hair mark on the front of the camera.
3. The laser beam (center beam) must hit the cross hair mark on the CCD camera front plate.

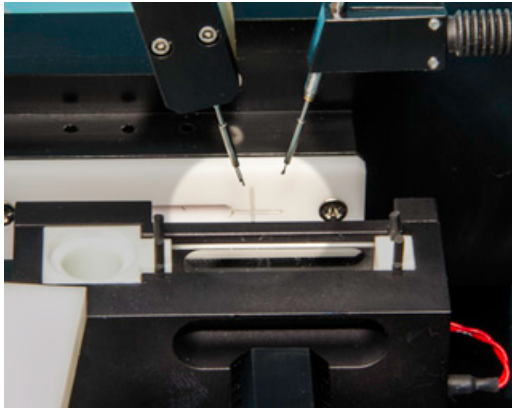


Fig. 30 The cross hair mark is etched on the front of the camera, which is mounted just behind the optical cuvette.

SI-SARCAM Front

SI-SARCAM Back

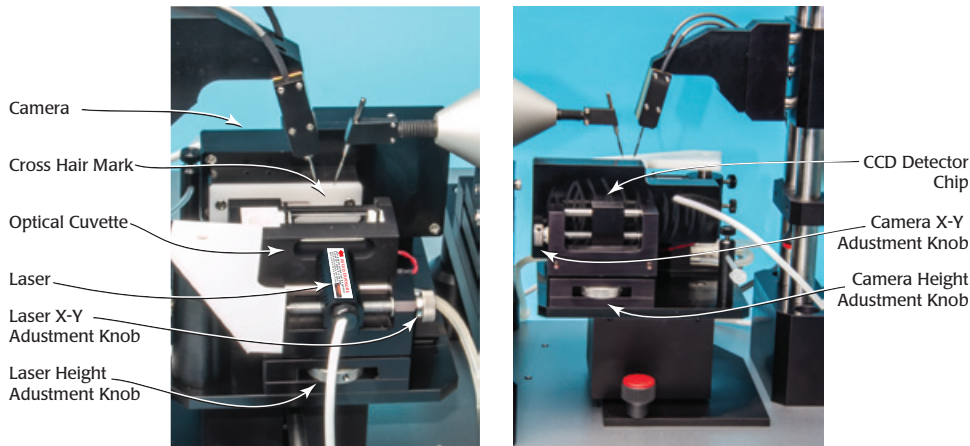


Fig. 31 The front and back of an SI-SARCAM system is shown mounted on an SI-MKB platform.

To adjust the laser:

- Use the **Camera X-Y Adjustment Knob** and the **Camera Height Adjustment Knob** for coarse alignment of the position of the camera.
- Verify that the camera's front plate is perpendicular to the main laser beam.
- Use the **Laser X-Y Adjustment Knob** and the **Laser Height Adjustment Knob** for the fine alignment of the horizontal and the vertical position of the laser.
- When the camera is properly aligned the light of the first order diffraction hits the sensitive area of the CCD detector chip. It may be necessary to adjust the vertical position (not the horizontal position) of the camera for a maximum signal. To do this, press the **Display** button on the controller to view the signal amplitude. This shows the detected first order diffraction of the laser pattern. This amplitude is maximal if the focused light hits the sensitive area of the detector chip. To keep the signal from saturating the CCD and giving erroneous signals, adjust the amplitude so that it is as close to 3.0V as possible. Using the **Laser Power** knob on the controller and the **Camera X-Y Adjustment Knob**, you can precisely position the CCD camera and control the laser power so that a desirable signal is achieved.

Calibrating the Camera

Your Sarcomere Length Unit comes with several calibration gratings. These are clear plastic films with an embedded grid (Fig. 32). When exposed to the laser, the grating acts in place of the muscle to create a consistent diffraction pattern that is used to calibrate the camera.



Fig. 32 (Left) The sarcomere grating fits into the cuvette and provides a foolproof calibration method.

Fig. 33 (Right) The grating is position in the optical cuvette to calibrate the camera.

1. Turn on the system. See "Turning the System On" on page 20.
2. Enable the Laser. For safety reasons, the laser is always disabled on startup. See "Turning On/Off the Laser" on page 26. When the laser is enabled, a red dot (the

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laser beam) appears near the cross hair mark on the front of the camera.

3. Position a calibration grating inside the optical cuvette so that the laser beam shines through the grating and casts a diffraction pattern on the camera lens (Fig. 33).
4. Adjust the zero order laser spot (the center beam) so that it hits the cross hair mark on the camera. See "Aligning the Laser and the Camera" on page 28.
5. Using the **Camera Height Adjustment Knob** and the **Laser Power Knob** on the controller to display the ideal signal for the first order signal.
6. Read the sarcomere length on the LCD display.
7. Use the **Camera X-Y Adjustment Knob** to adjust the horizontal position control on the camera until the sarcomere is displayed at $2.0\mu\text{m}$.

Display Laser Diffraction Pattern on an Oscilloscope

1. In order to display the laser diffraction pattern on an oscilloscope connect the **Sync** BNC connector with the external trigger input of an oscilloscope. The trigger signal is 5.0V. It jumps high when the scan begins.



Fig. 34 The top trace shows the timing reference to the video. The camera signal is shown in the bottom trace.

2. Adjust the trigger level on the oscilloscope.
3. Connect the **Video** BNC connector to the analog input of the oscilloscope.
4. Set the time scale of the oscilloscope to display the desired portion of the video signal. The scan of the photodiodes lasts 1ms in 1KHz mode or 3.8ms in 263Hz mode.

NOTE: If the scanned signal is less than 1.0V, the sarcomere length may be incorrectly calculated.

NOTE: If no oscilloscope is available, view the signal amplitude by pressing the **Display** button. Adjust the amplitude by adjusting the **Laser Power** knob.

If the laser pattern becomes weak compared to the background (peak height less than twice the maximum background), then check the quality of the laser pattern with an oscilloscope as described above.



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.

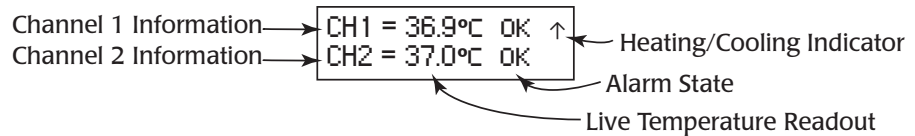


Fig. 35 Two Channel display mode provides live data on both channels.



Fig. 36 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 62.9°C. 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.

SI-H Muscle Testers

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. 37.

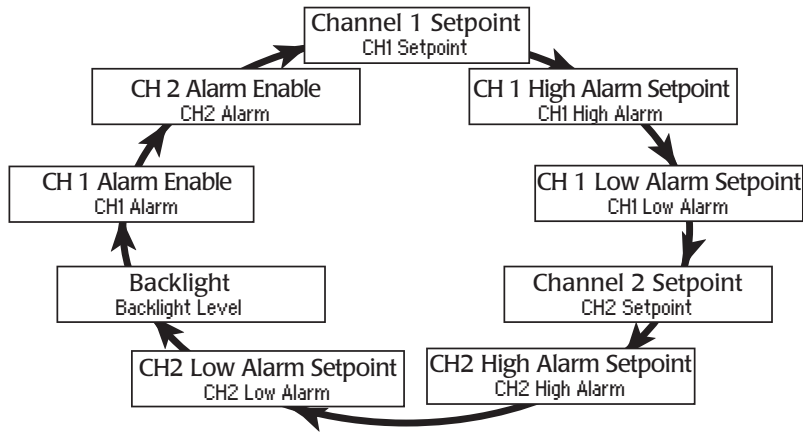


Fig. 37 The Setup button lets you toggle through the list of parameters.

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.

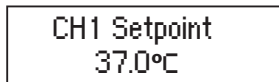


Fig. 38 Press the Up and Down buttons to adjust the Channel 1 Setpoint.

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. 39 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. 40 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. 41 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.

SI-H Muscle Testers

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.



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 |
| LABTRAX-8/16 | 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-FS | Electrode for field stimulation |

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 |

SI-MOTTEST Accessories

| Part Number | Description |
|---------------|-----------------------------------|
| 2851 | BNC Cable |
| 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-H Muscle Testers

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. |
| 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 23. 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

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

SI-SARCAM Specifications

Input Configuration Current to voltage converter
Laser Red laser diode
Laser Wavelength 650nm
Camera Linear CCD Camera
Power Requirements 12V DC provided by the chassis

SI-TCM2B Specifications

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

SI-MOTTEST Specifications

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

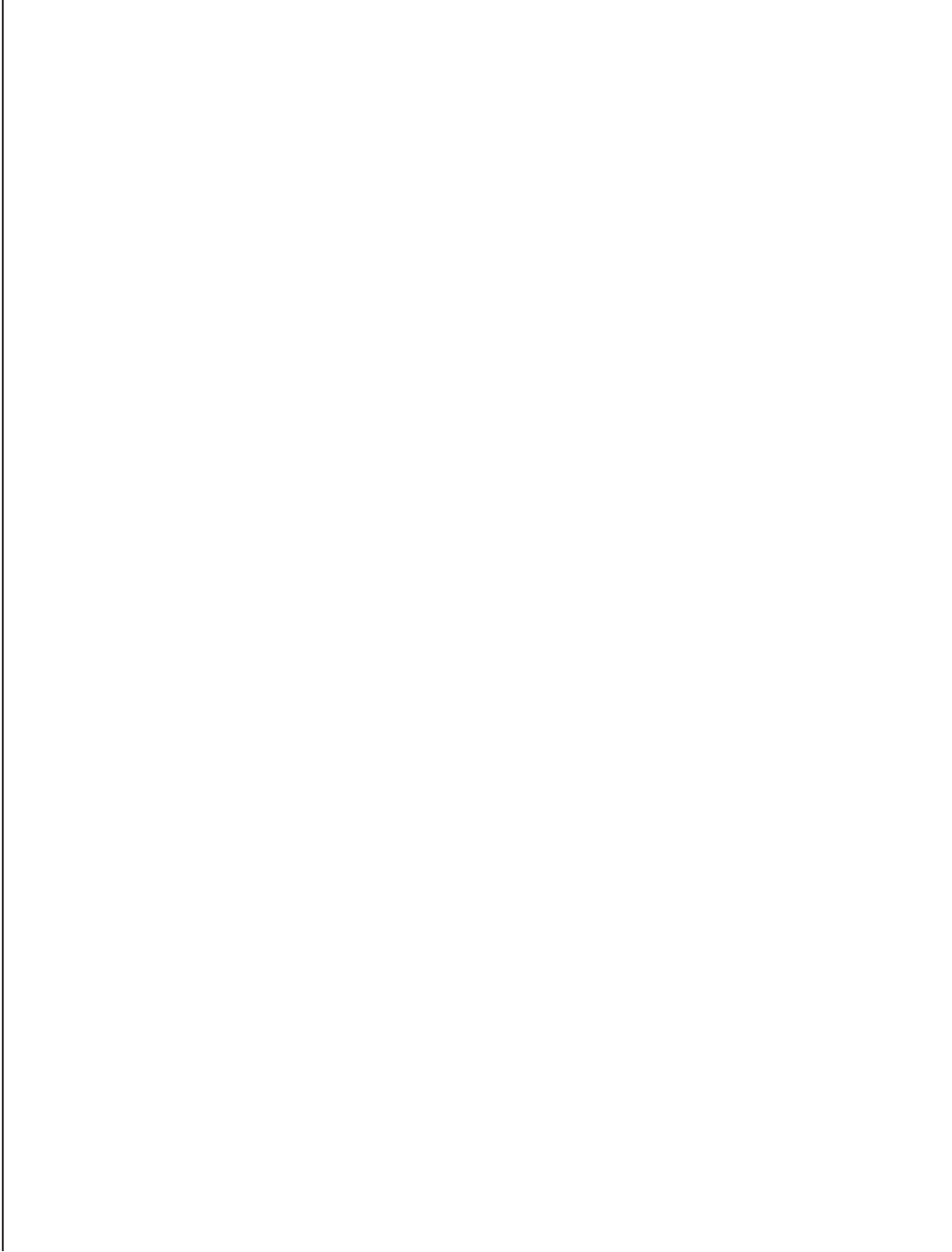
SI-AOSUB Specifications

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

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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SI-H Muscle Testers

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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