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STACIS® 2100

Piezoelectric Active Vibration Isolation System

INSTALLATION & OPERATION MANUAL



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Symbols Used in this Manual

Symbol	Purpose		Symbol	Purpose
	Warning / Caution			Important Information or Notes
	Reminder			

Warning:

No user-serviceable parts inside isolators or controller.
If the system fails to perform as specified, please contact TMC for repair or service.

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1 Principle of Operation

STACIS® is a high-bandwidth, high-gain active vibration isolation system. It provides very high vibration isolation performance without introducing a low-stiffness isolation system (such as traditional air isolators). The high-stiffness "hard mount" feature of STACIS® provides excellent position stability and low susceptibility to external noise forces, giving facility engineers and researchers flexibility in locating equipment in the manufacturing and laboratory area.

The STACIS® system is based on a central controller with three or more individual isolators. Each isolator contains three axes of active isolation (X, Y, and Z). When three or more isolators are combined, the result is full six degree-of-freedom vibration isolation for the supported payload. Although at first glance the system seems over-constrained, the patented topology of STACIS® allows the isolators to act independently of each other without conflict. Installation generally requires no special tuning, and once installed the system is maintenance-free.

Each STACIS® isolator contains a small "intermediate mass" supported in three axes by a set of five piezoelectric (PZT) actuators. Three seismic sensors measure the translational motions of this mass. This signal is filtered and fed back to the PZTs by a high voltage amplifier (HVA). A ~20Hz, highly damped rubber isolator (also internal to the isolator) couples the intermediate mass to the supported payload. The active feedback loop provides isolation between 0.6 and 150Hz, with a peak in isolation around 10Hz. As the active isolation starts to reduce above 10Hz, the passive isolator takes over. An example of the resulting vibration isolation performance is shown below[1]:

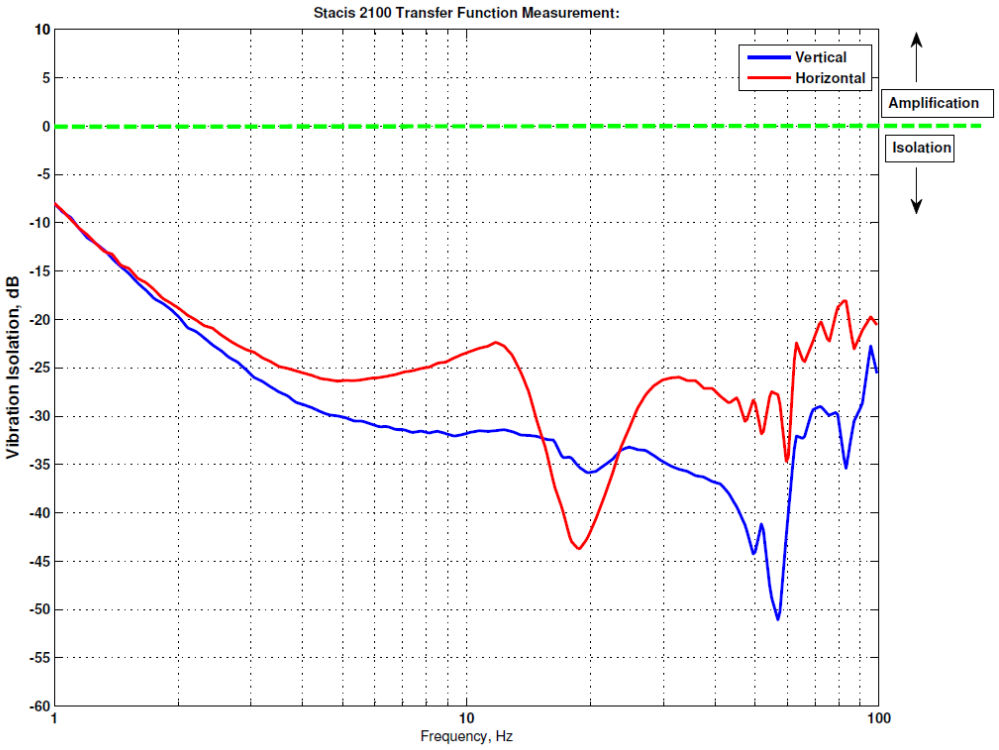


Figure 1: Vertical and Horizontal Transmissibility for STACIS® 2100

TMC's DC-2000 Digital Controller is used to implement sophisticated non-linear feedback algorithms. These ensure the isolation system performs well in extreme circumstances such as deep saturation and

[1] The horizontal and vertical transmissibility was measured on a special shaker table with micron-level input. The isolated mass was granite. Actual performance will vary depending on the nature of the floor and payload.

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marginally suitable installations. The result is a truly 'plug-and-play' system. The digital controller also allows for monitoring the system over a standard RS-232 interface.

2 General Information

2.1 Introduction

STACIS® 2100 typically consists of three, four, six or eight floor-mounted Isolators systems. The isolators are made primarily of aluminum, weighing approximately 34 kg (75 lbs.) each. Each Isolator contains electronics, vibration detection and correction devices, along with a passive isolator and an adjustable wedgemount for load distribution. A digital Controller calculates vibration compensation signals for each individual axis in each Isolator and provides communications and diagnostics.

2.2 Product Selection

TMC can provide on-site surveys to determine the suitability of STACIS® for a particular installation. The survey includes:

- Vibration measurements to determine if the proposed site's floor noise is within the dynamic capability of STACIS® .
- Evaluation of the potential benefits derived from the installation of a STACIS® system.
- The suitability of the floor for installation of STACIS® (see following sections for details).
- The proper selection of the number and capacity of STACIS® isolators.
- Whether the subject payload can be mounted directly on STACIS® Isolators or if 'risers', bridge plates, or other fixtures will be required.

The selection of the appropriate STACIS® System is based largely on the load that each Isolator will be required to support. When calculating this load, all supported weight (tool plus platform, etc.) must be considered.

STACIS® 2100 isolators are available in three load ranges, designated by a "dash number" after the primary part number (-01, -02, or –03). The (-01) load range is 400-1100 lbs., the (-02) is 900-2100 lbs., and the (-03) is 1900-4500 lbs. The table below provides a quick reference to total payload weights using multiple isolators:

Table 1: STACIS® Standard Configurations

Reference	Load Range per Isolator (operating)	Min./Max Total Load (operating)
3x Isolator -01	400-1100 lbs. (182-500 kg)	1200-3300 lbs. (546-1500 kg)
3x Isolator -02	900-2100 lbs. (410-955 kg)	2700-6300 lbs. (1230-2865 kg)
3x Isolator -03	1900-4500 lbs. (864-2045 kg)	5700-13500 lbs. (2592-6135 kg)
4x Isolator -01	400-1100 lbs. (182-500 kg)	1600-4400 lbs. (728-2000 kg)
4x Isolator -02	900-2100 lbs. (410-955 kg)	3600-8400 lbs. (1640-3820 kg)
4x Isolator -03	1900-4500 lbs. (864-2045 kg)	7600-18000 lbs. (3456-8180 kg)
6x Isolator -03	1900-4500 lbs. (864-2045 kg)	11400-27000 lbs. (5184-12270 kg)
8x Isolator -03	1900-4500 lbs. (864-2045 kg)	15200-36000 lbs. (6912-16360 kg.)



Care must be used in selecting the system so that the maximum and minimum load for each isolator is not exceeded. STACIS® 2100 Systems with mixed isolator capacities are also available. Contact your sales engineer or TMC for further information.

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2.3 General Specifications

2.3.1 Performance

Active Degrees of Freedom (system of 3+ isolators) 6
Active Bandwidth ..... 0.6 to 150 Hz
Transmissibility at Resonance ..... <1.1
Isolation above 2Hz ..... >90%
Settling Time[2] (10 lb. Step input) ..... <300 ms
Dynamic Range ..... 60 dB Max.
Static Load Capacity/Isolator ..... 182-2045 kg (400-4500 lbs.)
Number of Isolators / system ..... 3 or more
Maximum Displacement ..... 15 µm peak-peak below 10 Hz
Maximum Static Load (non-operating) ..... 2727 kg (6000 lbs.)

2.3.2 Physical Dimensions

DC-2000 Controller ..... 482.6mm(19")W x 368.3mm(14.5")D x 44.5mm(1.75")H
..... (1 Standard RETMA unit w/rack mounting holes)
Isolator Size ..... 300mm(11.75")W x 320mm(12.5")D x 277mm(10.9")H (unloaded)

2.3.3 System Requirements

2.3.4 Environmental

(refer to EN 61010-1: 1993, EN 61010-1/A2: 1995):
For indoor use only, up to an elevation of 2,000m (6560ft.)
Maximum allowable operating temperature range: ..... 10°C to 32°C (50 to 90°F)
Maximum allowable storage temperature range: ..... -40°C to 55°C (-40 to 130°F)
Maximum allowable humidity ..... 53% up to 40°C, (20°C dew point)
Tolerance in mains supply voltage ..... +/-10% of nominal voltage
Over voltage category 2
Pollution degree (IEC 664) 2
Controller ventilation requirements ..... 25mm clearance on sides, 0mm top and bottom

2.3.5 Floor Requirements

Flatness ..... +/- 1.5 mm from perfect plane at isolators
Stiffness (low load isolators) ..... 4.4×10^7 N/m (250,000 lb./in)
Stiffness (medium load isolators) ..... 6.2×10^7 N/m (350,000 lb./in)
Stiffness (high load isolators) ..... 8×10^7 N/m (450,000 lb./in)

2.3.6 Utility Requirements

Mains Power Supply ..... 90 – 230VAC, 50 or 60 Hz, less than 400VA
Computer (optional) ..... PC compatible w/ a 1:1, M-F, DB-9 serial cable

[2] Settling time is defined as the time required for the oscillation amplitude to decrease by 90% from the initial peak amplitude

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2.3.7 Terminology Defined

Terms specific to the STACIS® isolation system and its operation are listed below for your convenience.

Table 2: Terminology Used in the Manual

Term:	Meaning:
STACIS®	From the word stasis meaning a stable state
Isolator	A single load-bearing mount providing three axes of active vibration isolation, connected to a central controller. Three or more isolators are required for a complete isolation system.
Iso	Interchangeable abbreviation for the Isolator
Controller	The central control and power supply unit with a menu-driven interface
Actuator	A piezoelectric ceramic device used as the actuator in STACIS® isolators
Fault	A system condition which compromises the vibration isolation performance of one or more STACIS® isolators. Depending on the condition, the Controller will generate a message on the LCD. The LED on the controller will turn amber, a message may be sent over the serial port interface, and the axis where the error was detected may be switched off.
Active Bandwidth	Range of frequencies covered by the active vibration isolation. A passive isolator built into STACIS® provides isolation above the active bandwidth.
Flash Memory	Nonvolatile memory in the controller. It contains the STACIS® software and user-set parameters, such as gains and other preferences.
Compensation	An action by each Isolator to isolate/dampen vibrations that affect the payload supported by STACIS®
Resonant Frequency	The frequency at which a system will oscillate at when given an impulse (such as a jump on the floor). This may be electronic (from the servo), or a passive structural resonance.
Geophone	The vibration sensor used for active isolation in STACIS®
POST	Power On Self Test. A self test conducted every time the power to the controller is turned on.
Wedgemount	A machined low profile adjustable mount inside each isolator used to adjust the load distribution between isolators in a system with at least 4 isolators. Wedgemounts have limited travel and are not intended to be used to level the platform and/or payload.

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3 Installation

3.1 Introduction

STACIS® 2100 systems are shipped FOB from Peabody, MA, in wooden crates measuring 1220 x 838 x 584mm (48" x 33" x 23"). The crates weigh 175kg (385 lbs.) for a 3-Isolator system, or 209kg (460 lb.) for a 4-Isolator system. Six and eight isolator systems are shipped in two crates of the same size. The crates have indicators to show if the crate was subjected to excessive shock, tilt or vibration during shipment. Check the sensors, and inspect the crate for gross damage (punctures, etc.). DO NOT remove the contents from the crate if the damage indicator is broken or if the crate or contents are damaged. The carrier and TMC should be notified immediately, and a claim should be filed with the carrier. The carrier is responsible for all shipping damages and all claims for damages must be made against the carrier. Typical crate contents are:

Table 3: Typical Shipping Crate Contents

Quantity 3-Isolators	Quantity 4-Isolators	Description
1	1	Controller
3	4	Isolator
1	2	Main Double Cable
1	-	Main Single Cable
3	4	Base Pad (Mylar sandwich)
1	1	AC Power Cord
1	1	STACIS Load Adjustment Tool
1	1	Software and User's Manual (this document) on CD

3.2 Unpacking System

Remove the Isolators, Controller, and cables from the packing crate **(see lifting note in figure 2 below)**. Move all components to the installation site prior to performing the following steps.

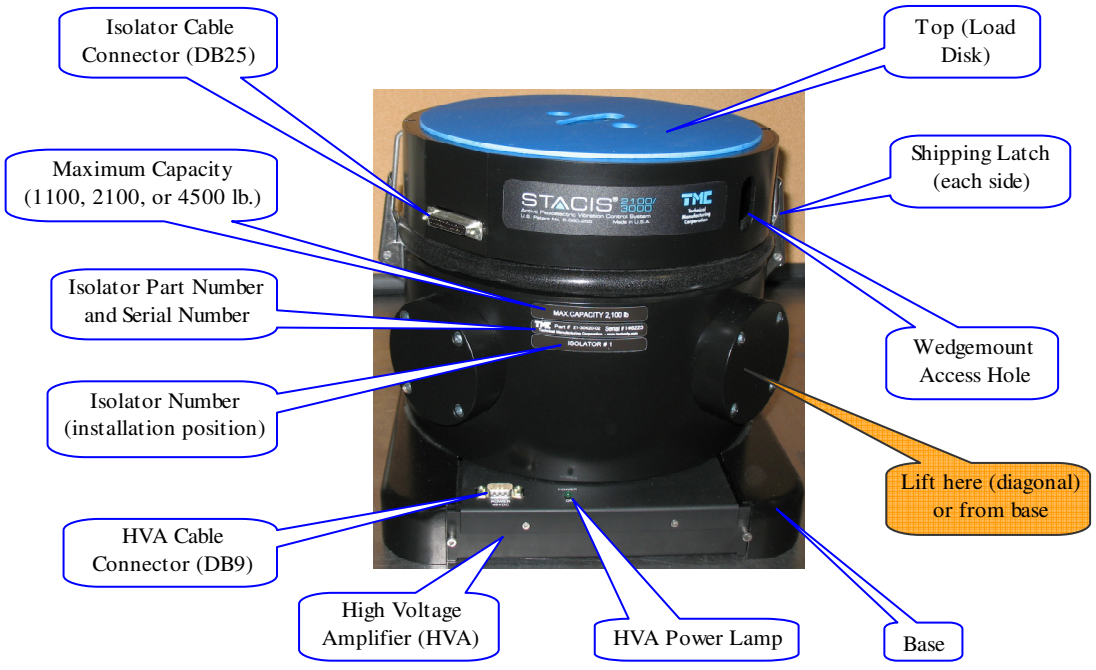
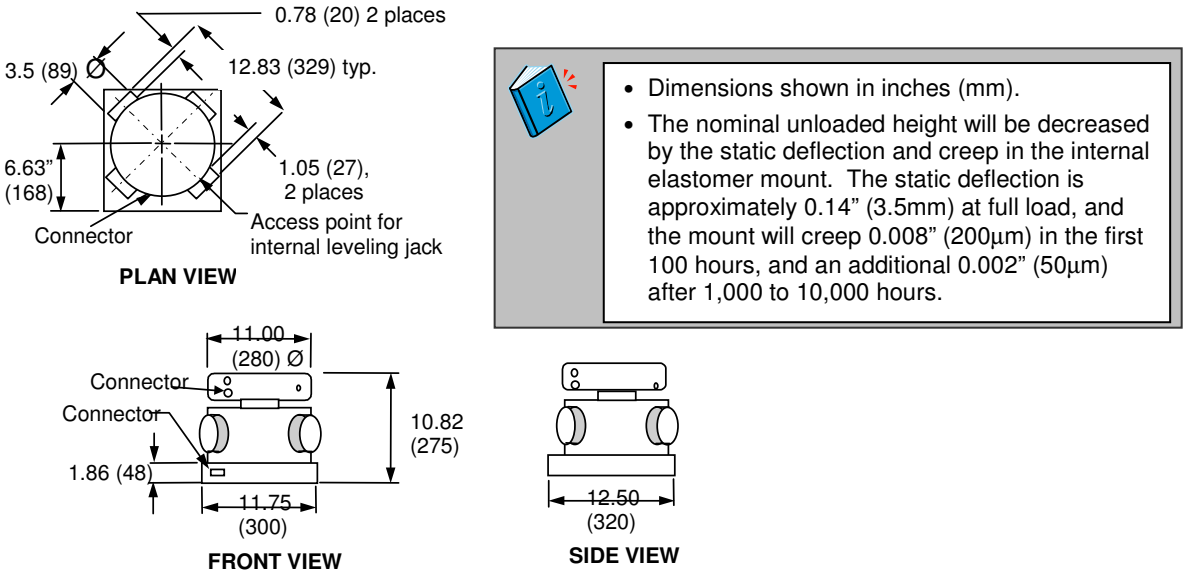


Figure 2: STACIS Isolator

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- **Isolators weigh 75 lbs. (34 kg) each and require two persons to lift safely.**
- **Lift only by the four caps on the sides or the base.**
- **Isolators must never be lifted by the load disk.**
- **Failure to adhere to the cautions above will result in potentially permanent damage to internal components.**



- Dimensions shown in inches (mm).
- The nominal unloaded height will be decreased by the static deflection and creep in the internal elastomer mount. The static deflection is approximately 0.14" (3.5mm) at full load, and the mount will creep 0.008" (200µm) in the first 100 hours, and an additional 0.002" (50µm) after 1,000 to 10,000 hours.

Figure 3: STACIS 2100 Isolator Dimensions

3.3 Floor Surface Requirements

- Please also refer to "Pre-Installation Manual" for detail of floor requirements and riser installation.
- Contact TMC for set-up training specific to your application.

1) STACIS 2100 should be installed on a concrete floor and not on a raised computer floor. If the concrete floor is flat within .02" (.5 mm) over the area of the isolator and level so that each isolator location is at the same height within .12" (3 mm), the isolators can be installed directly on the floor. The isolator base contacting the floor has an area of 64 in² (.04 m²). If the floor is not flat and level, and at the same height within .12" (3 mm), steel plates 13" x 13" x 0.5" thick (330 x 330 x 12 mm thick) should be grouted to the concrete floor level within 0.010"/ft. (.8 mm/m) and the same elevation within .06" (1.5 mm). See *Appendix A in Pre-Installation Manual* for detailed information on measuring the floor flatness, grouting, waffle floors, and vibration measurements. If isolators will be installed on risers for increased elevation, see also *appendix B in Pre-Installation Manual* as the floor flatness and level requirements are nullified in this case. Remove any burrs or high points on the surfaces where the STACIS isolators will be placed.

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2) STACIS should only be installed on floors having a minimum stiffness (in all axes) as specified here. Risers and stands can be used under STACIS isolators, providing the stand-to-isolator interface also meets the same stiffness requirement.

Isolator Load	**Minimum Interface Stiffness**
Low load (-01)	250,000 lbs/in. (44 x 10^6 N/m)
Medium load (-02)	350,000 lbs/in (62 x 10^6 N/m)
High load (-03)	450,000 lbs/in (80 x 10^6 N/m)

3) STACIS has a maximum displacement of 480 µ" (12 µm) peak-peak or ± 240 µ" (6 µm) at frequencies below 10 Hz. At frequencies above 10 Hz, the maximum displacement decreases as the frequency increases.

4) The maximum peak-peak broadband displacement of the floor in each axis under all conditions (vibration plus displacements due to walking, etc.) must be less than 480 µ" (12 µm). If the floor exceeds 480 µ" (12 µm) of displacement, one or more channels of the STACIS isolators may overload and isolation may be briefly lost. If it is known, or suspected, that the floor exceeds the maximum displacement, consult with TMC.

A maximum floor displacement of 400 µ" (10 µm) is recommended to provide a safety factor due to the fact that walking frequently produces non symmetrical displacements which can exceed the displacement in only the + or - direction even though the peak to peak displacement may be within the limit.

3.4 Installation Spacer

If steel plates as noted above will be used, fabricate a temporary wooden spacer for each Isolator with dimensions of 150x150x290mm (4"x4"x 12.25"). If base plates will not be used, or if risers will be used to increase the operating height of STACIS, calculate the correct height for the spacer blocks. These blocks will support the payload (or platform) and provide a 0.25" clearance above the isolators to avoid shocking the isolator and to also while minimize excessive wedge loading; both of which can lead to overloading and damage of the isolator (see installation steps in section 3.8).

Mechanical jacks with an adequate load capacity can be used in place of the spacers, providing the jacks do not leak or drift downward under load. Professional rigging is required in most cases.

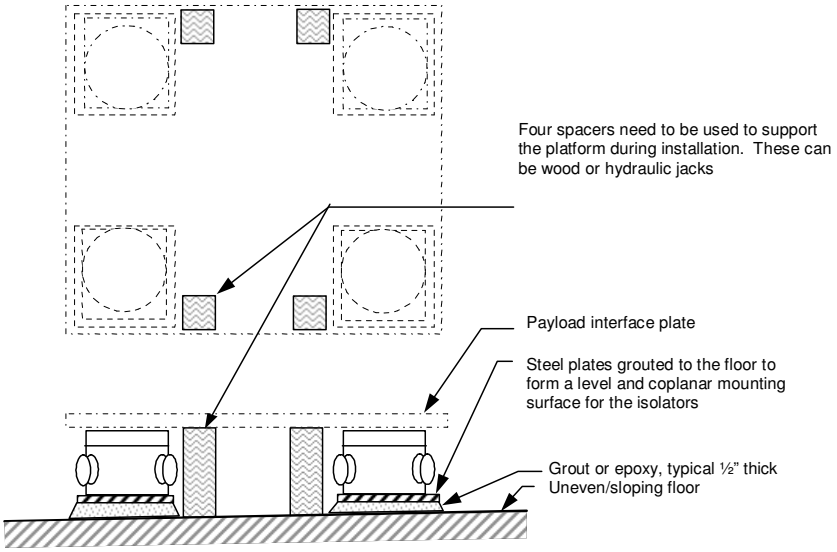


Figure 4: Installation of STACIS® on Uneven or Sloping Floor.

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- If using non-adjustable spacers, a bottle jack or jack stand is needed to slightly off-load and remove the spacers.
- Professional rigging is recommended

3.5 Payload/STACIS® Interface

In some instances, the payload can be installed directly on the top surface of the Isolators. This is determined during the vibration survey and engineering analysis discussed in 2.2, or through information supplied to TMC. If the payload has more than four points of support, or if the support points do not completely cover the top surface of each Isolator, an interface plate will be needed. Some suggested configurations are shown in Figure 5.

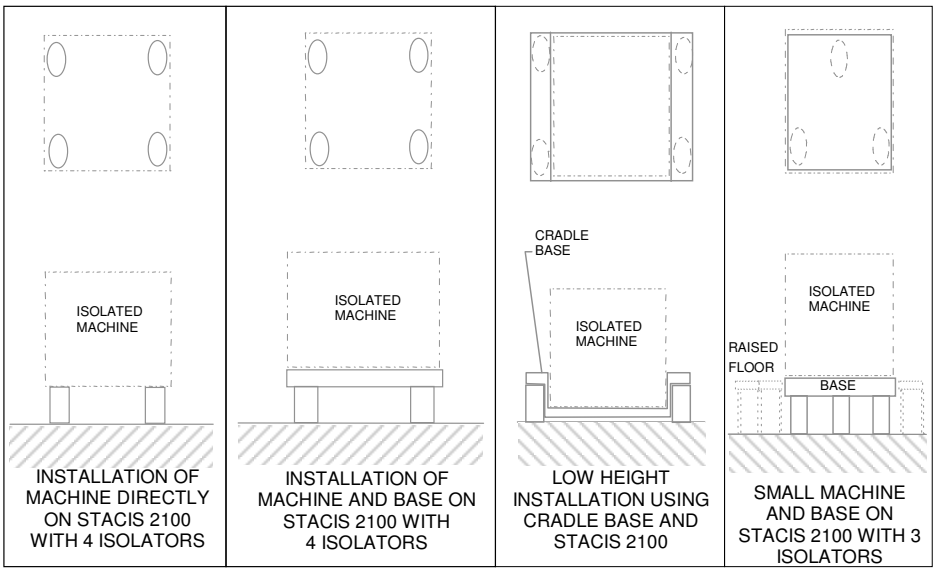


Figure 5: Payload/STACIS® Interface Configurations

3.6 Earthquake Restraints

In certain areas of the world that are prone to earthquakes, the STACIS® system can be provided with the necessary restraints to minimize or prevent damage to the system and its payload. Contact TMC for details.

3.7 Isolator Orientation and Cable Connections

STACIS® 2100 can also be used as a platform for producing controlled vibration (a shaking platform). For this function to work properly, the isolators need to be installed in a specific orientation with respect to each other. This is shown for three and four isolator systems below:

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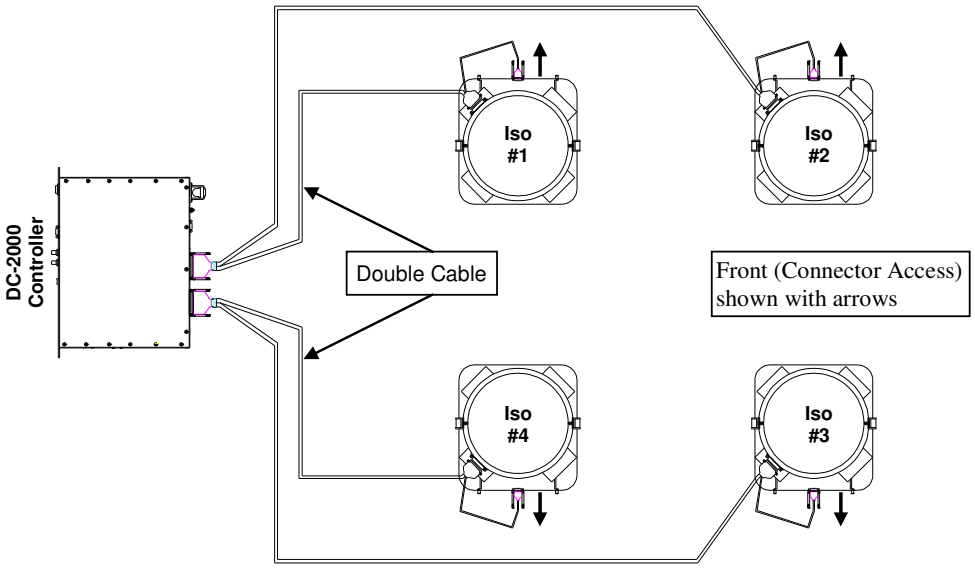


Figure 6: Four Isolator System with Cables

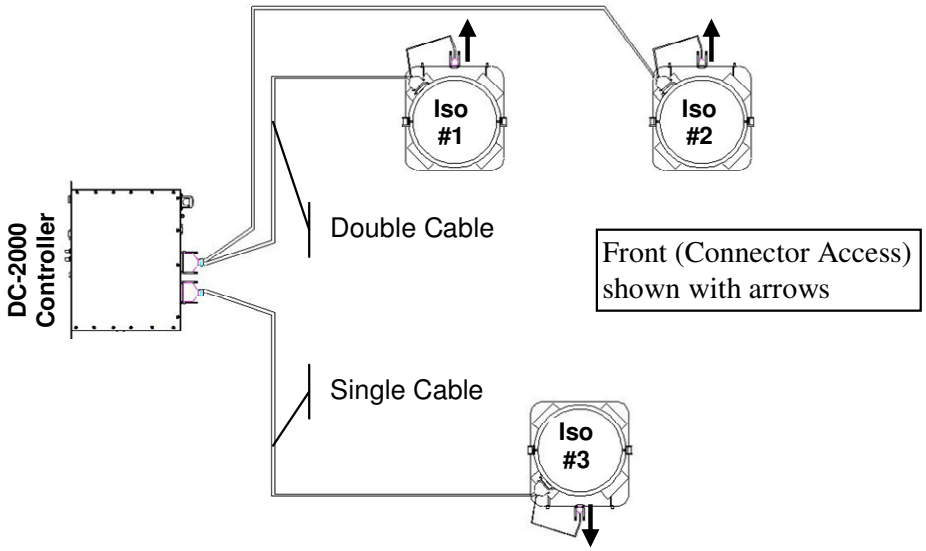


Figure 7: Three Isolator System with Cables

- In STACIS systems built prior to December 2005, the combination of a "Y" cable and two (2) "single" cables are used instead of a "double" cable. For a 3-isolator system, the "Y" cable for isolators #1 & #2 connects into the controller's Analog Input/Output Channels 0-7 connector.
- If the system will not be used as a shaker, the isolators may be placed in any location and orientation that provides the best loading. Contact TMC for a setup drawing specific to your application.

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3.8 Detailed Mechanical Installation Steps (Pre-Power Up)

- If risers or baseplates will be used, they must be installed with grout a minimum of 12 hours prior to operating the STACIS system. See "Pre-Installation Manual and Checklist".
- Prior to starting the mechanical installation, the installer must confirm the load that each isolator will be required to support. This can be calculated using the weight of the payload, its center of gravity (CG), the weight of the platform and the number of isolators.
- The installer must ensure that the isolator capacities are properly matched with their installation locations.

1) Position the STACIS base pads (see figure below) on the riser, baseplate, or floor where the isolators will be located. Place the isolators on the base pads according to the orientation shown in the figures above.



Figure 8: STACIS Base Pad

The base pads consist of a soft compound sandwiched between two sheets of Mylar. They conform to the gap between the bottom of the isolator and the riser, baseplate, or the floor and thus provide a very solid mechanical point of contact. The base pads are an important component in the successful installation of the system.

2) Release the Shipping Latches (see Figure 2). **This is very important!!!** Do not use excessive force to release latches. If latches are very tight they can be released after isolator is loaded.

3) Place a wooden spacer or jack on the floor next to each isolator to support the payload prior to lowering it directly onto the isolators (see Section 3.4).

Ensure the pickup point of the wooden spacer or jack is 5mm higher than the top surface of the nearest isolator.

4) Verify that the entire top surface of each Isolator will be in contact with the payload when it is lowered onto the isolators. Adjust the position of the isolators as necessary.

5) Use the jacks to support the payload within 5mm of the top of the isolators, but not contacting. Re-check the alignment to confirm that the payload will fully cover the top surface of each isolator, and then lower the payload the final 5mm.

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If using wooden blocks,

- place a bottle jack between two isolators, centered under one end of the platform,
- raise the platform slightly, just enough to remove the spacer blocks,
- then slowly lower the jack in a very controlled manner until this end of the payload is resting on the nearest isolators.
- Repeat for the other end.

The 5mm gap prevents excessive wedge loads from being applied to the isolators.



- **Use care to avoid shocking and/or overloading the Isolators. The Isolators can be damaged if exposed to a load or force (load plus shock) greater than 6000 lbs (2727 kg).**
- **When moving or replacing an isolator, lifting one corner of the payload will transfer up to 50% of the total weight to the diagonally opposite isolator, potentially damaging its piezo ceramic stacks. Therefore, always locate the jack midway between the Isolators on one side rather than just one corner, especially if the total weight exceeds 10,000 lbs. (4545 kg).**

6) Relieve any side-load on the Isolators by slightly raising the payload/plate over each Isolator with a hydraulic jack thus allowing the Isolator to center itself and then slowly lower the plate on the Isolator.



The high-frequency passive mount in STACIS® will cause the isolator height to creep downward over time. The initial loading will deflect the isolators by up to 0.125" (4 mm). Within the first week, the isolators may creep down an additional 0.04" to 0.12" (1-3 mm) depending on the load. The system can be operated during this time; however, the level of the system may change.



The isolators are equipped with a built-in wedgemount. The wedgemounts provide a mean to redistribute the loading between the isolators. **They are not, however, intended to be used to level the payload**. The stroke of the wedgemounts is very limited.

The wedgemounts may be used on rare occasions for *very small* changes to the payload's level; however, care must be used to keep the isolator loading adequately distributed. Adjustments to the payload's level should be done with shims placed between the isolators and the supported payload. The use of the wedgemounts for load distribution is described below.

7) Confirm that the shipping latches on either side of the isolators (quantity 2 per isolator) have been disengaged.

3.9 Initial Power Up and Load Adjustment

For four (4) STACIS® isolator systems, the loading of the isolators must be adjusted using the internal wedgemounts [after the installation of the payload] to achieve a distribution within the nominal load range for all isolators To aid with the load redistribution, each isolator has an electronic displacement sensor that measures the deflection of the STACIS' internal high-frequency passive mount. The output of the sensor can be displayed on the digital controller's LCD. The sensor readings relate to the load exerted on the isolators according to Table 4 below.

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- The sensor reading is not related to the overall height of the isolator.
- Adjusting the wedgemount in one isolator will affect the displayed value by altering the load on all isolators, as in *redistribution of the load*.
- The reading of the load sensors is not intended for precise measurement. It is simply an effective method for providing information about the relative load distribution between the isolators.

For three (3) isolator STACIS® systems, the wedgemounts cannot be used to adjust loading of the isolators. Follow the steps below to monitor isolator loading. If the isolators are not properly loaded, their installation location must be changed until each isolator is within its proper load range.

8) Connect the Main Cables between the Controller and Isolators as illustrated in Figure 6 and Figure 7.

- The main cable connectors are labeled at both ends to indicate controller and isolators connection points.
- At the isolator end, the cable forks, with one connector going to the top of the isolator (DB25), and a second (DB9) going to the High Voltage Amplifier (HVA).
- **Do not connect the cable to the high voltage amplifier in the base of the isolator at this time.** These cables (which power the active isolation) should only be connected after the load adjustment procedure is complete.
- Any excess length of the cables could be coiled.

9) Connect the Controller's AC Power Cord to an appropriate AC power source (110-230 VAC).

10) Switch the Controller's Main Power ON (rocker switch on the left of the front panel). **Note:** The LCD backlight and System Status LED will light.

11) The system will perform an automatic Power-On Self Test (POST). The LED will turn amber and the following message will display on the LCD:

```
STACIS 2100
Power-Up Self Test
```

This test will last approximately 60 seconds.

At this point of the installation, the POST will find that all axes are "out of range". This is because the HVA cables are not connected. **This is normal**.

Throughout the test, the controller's LCD will show error messages like:

```
1Z axis Not Optimiz
dG=-70.5dB dP=-45º
```

Upon completion of the test, the System Status LED will turn green and the LCD will show a message indicating the "not optimized" condition for the last axis tested.

12) Press the switch **PREVIOUS** on the controller's front panel repeatedly until the following message is seen on the LCD:

```
TMC STACIS 2100
pn 95-28756-01 Rev #
```


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13) Press the "**+**" switch repeatedly until the following message is seen:

```
+/- Selects Function:
Monitor Load Sensors
```

14) Hit the "**SELECT**" switch. The following LCD screen will be shown:

```
Iso1:2.6  Iso2:2.8 mm
Iso3:2.7  Iso4:2.4 mm
```



The controller should have been configured at the factory to the correct number of isolators (2, 3 or 4). If not, (typically when the controller is shipped as a replacement) the display may not show the correct number of readings. If this is the case, refer to the **Menu Driven Functions** in the Section 5 for instructions on how to configure the controller for the correct number of isolators.

The displacement (deflection), in mm, displayed for each isolator is proportional to the load compression of the isolator's internal high-frequency elastomer mount. The table shows the corresponding load range in lbs or kg based on range of deflection.

Table 4: Load Sensor Calibration

	LOW LOAD (-01) ISO.	MED. LOAD (-02) ISO.	HIGH LOAD (-03) ISO.
LOAD lbs. (kg)	**DEFLECTION (mm)**	**DEFLECTION (mm)**	**DEFLECTION (mm)**
400-600 (180-270)	2.2-2.8	*	*
600-900 (270-410)	2.8-3.6	*	*
900-1100 (410-500)	3.6-4.5	2.2-2.5	*
1100-1500 (500-680)		2.5-3.5	*
1500-2100 (680-955)		3.5-4.5	*
1900-2100 (865-955)			2.2-2.5
2100-2500 (955-1135)			2.5-3.0
2500-3200 (1135-1455)			3.0-3.3
3200-3800 (1455-1730)			3.3-3.8
3800-4500 (1730-2045)			3.8-4.5



- Readings less than 2.2 mm may be an indication of an under-loaded isolator, whereas readings greater than 4.5 may be an indication of an over-loaded isolator.
- For proper loading, each isolator should have between 2.2 and 4.5mm deflection. If an isolator is loaded outside of this range, follow the instructions in the following section to re-distribute the load. If all isolators are out of this range, please contact TMC.

15) Isolator Load Re-Distribution Using the Internal Wedgemount



For a 3-isolator system, if the isolators are not properly loaded, their installation location must be changed until each isolator is within the proper load range specified above. The loading of the isolators should not be adjusted using the internal wedgemount.

If proper loading cannot be achieved, a different load capacity isolator may need to be purchased to correct the problem.

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When performing the load adjustment procedure, the cable to the HVA connector (bottom of the Isolator) must be disconnected.

The following procedure applies only to a 4-isolator system.

A tool is provided for adjusting the loading of the isolators using the wedgemounts. The tool is a 7/16 (11.1 mm) hex rod 5.75" (146 mm) long. There is an oval hole on the side of the top cover of the isolator where the tool can be inserted to engage the wedgemount. There are three notches on the rod to indicate the position (height) of the wedgemount. When the tool is fully inserted into the wedgemount, the position of the notches relative to the outer surface of the isolator indicates the height as follows:



Figure 9: Wedgemount Access Hole



Figure 10: Load Adjustment Tool

Tool Notch Location Relative to Isolator Outer Surface	Wedgemount Position
Inner notch is flush	fully down (minimum usable height)
Center notch is flush	mid height position
Outer notch is flush	fully up (maximum usable height)

To adjust the load on the isolators, proceed as follows:

A) Confirm that all of the wedgemounts are at their mid height position.

B) Depending on the displacement reading (refer to the previous section on displaying the reading on the controller LCD), increase the loading of the isolators by turning the tool clockwise (the displacement value increases)) or decrease the loading by turning the tool counterclockwise (the displacement value decreases) until all isolators are loaded within the proper displacement range for the weight of the supported payload

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- Ensure the difference in the displacement readings is kept to a minimum. For example, on a symmetric payload supported by 4 isolators, the isolators along one diagonal should not be loaded more than those on the opposite diagonal.
- Adjusting the wedgemount on one isolator will change the load on all isolators.
- If adequate adjustment cannot be achieved with the wedgemount, aluminum or stainless steel shims, maximum one (1) per isolator, of approximately 10" x 10" (254mm x 254mm) square should be added between the top of the isolator and the interface plate/payload for the isolators with the less than desired loading.
- Similarly, if the platform is not level as desired, shims must be used to change the level. Measure the height of the platform at the corners to calculate the height difference at each isolator. Compensate for the height difference by adding shims on top of each isolator accordingly. This can be accomplished by slightly jacking up one end of the platform to add shims to two isolators at a time. When complete, **allow 20-40 minutes for the internal elastomer mounts to settle** before re-checking the level. Use 10" x 10" (254mm x 254mm) square shims, maximum one per isolator

16) After the loads are correctly set, turn the controller power OFF, and connect the high voltage amplifier (HVA) power connectors to the bottom of the isolators.

Mechanical Installation is complete.

4 System Initialization



Prior to initial power-up, confirm the room environment is within a temperature range of 10 °C to 32 °C (50 °F to 90 °F) and the dew point (humidity) is less than 20 °C (68 °F). Allow the STACIS® System to stabilize in temperature to prevent condensation which could damage the actuators.

4.1 Pre-Operational Self-Testing (POST)

After switching the controller power to ON, the controller will start its boot sequence; the system status LED will light up red momentarily, then flash green for a few seconds. The controller will then perform a number of internal self-tests to confirm system performance. The tests last approximately 60 seconds. This includes a ~25 second warm-up time for stabilizing the analog filters and preamplifiers. Immediately on power up, the following display will be shown:

```
TMC STACIS 2100
Power-Up Self Test
```

The system status LED will then change to steady amber as the unit goes through the POST. The system is not ready for operation until the self-test is successfully completed.

The beginning of the system diagnostics (servo-loop) tests is indicated by the following message:

```
Test in Progress
1Z axis
```


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During the power-up self test, isolation, alarms and some control functions are disabled. A test is run for each axis sequentially. The gain and phase of each channel is measured at a single frequency, to confirm proper actuator and sensor function. The difference between the measured value and a reference value is displayed on the LCD as:

```
@ 5Hz 1Z axis:
dG = 2.5dB  dP = 5º
```

The values for the last axis checked are displayed until the measurement for the next axis is completed. After completion of all tests, the LED will turn green, and the LCD will display either:

`STACIS 2100` `pn 95-28756-01 Rev #`	If the gain and phase of each axis are within the default values. This screen is called the "title screen".
`3Y axis NotOptimiz` `dG = -70.5dB  dP = -45º`	Message similar to the one at left if one or more values are detected to be out of optimal range of the reference value during the gain/phase measurements; only the last axis detected to be out of range will remain on the display. This is called a "not optimized" message.



Not Optimized Message During POST

Possible situations which may cause this malfunction include:

1. Installations with excessive floor noise level - vibration sensors saturate due to the combination of high sensor gains and running of the self-test with servo feedback loop OFF i.e. "open loop".

   To verify if this is the case, connect an oscilloscope to the BNC connector "ANALOG OUTPUT" on the controller's front panel and then monitor vibration sensors' readings during the pre-operational self-test (POST) [restart the POST by switching the Controller OFF and then ON] to determine if the signal is "clipping" at +10 V or -10 . If signal clipping is happening, the pre-operational self-test should be disabled; use menu option **Set Powerup Test** (see *Description of Menu Tree Functions* section).

2. HVAs are not properly connected to the isolators.
3. Cables are not properly connected.
4. System is simply not functioning correctly. If this is the case, contact TMC Service.

Report all "Not Optimized" messages to TMC.

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If the title screen does not appear after completion of the POST and there is no error message displayed on the LCD, or if the status LED remains amber/orange, shut the controller OFF and then turn it back ON after approximately 10 secs to repeat the power up sequence. If system still does not function correctly, contact TMC service.



If at any time during operation the system becomes unstable, proceed to section 6.4 for instructions on control loop gains adjustment using the menu ***Adjust X/Y/Z Gains***

When the title screen appears, the isolation system is fully enabled, including access to all functions. Normal operation will start.

Optional configurations are described in the following sections.

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5 Menu Driven Functions

The primary functions that control the behavior of STACIS® are accessed through the controller's front-panel menu system. These include required parameters (such as the number of isolators), and optional parameters (such as COM port function).

5.1 Menu Tree:

On power up the controller LCD displays a message like "TMC STACIS 2100" "pn 95-28576-01 r #"; pressing **any** one of the menu key leads to the first main menu option; pressing **PREVIOUS** repeatedly from any menu tree level returns to the default display.

The Menu Tree is described below on a graphical map (Figure 13). The DC-2000 controller's primary functions are listed on the left. In general, press **SELECT** to move to the right on the map or press **(+)** to move up the map or **(-)** to move down the map.

Detailed descriptions of the controller's functions follow the graphical map.

5.2 Navigating the Menu Function Tree

As discussed above, navigation through the menu tree is accomplished by using the "Menu Keys" (Figure 11 below). Figure 12 illustrates how to navigate the menu tree. This is an example – the actual messages might differ depending on the revision of the software installed in your system.

The top level (default display upon power-up) shows the product name, and the firmware revision number. Press any key to navigate to the *main options* menu level to access the primary functions. From this level,

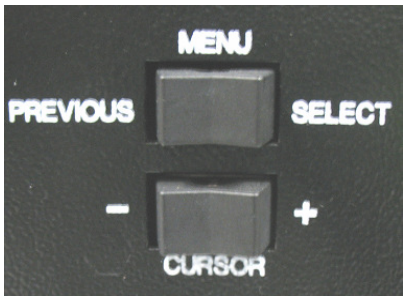


Figure 11: The Menu Keys

- Press ***Select*** *key to* move one level down the tree; thus, selecting the currently displayed option.
- Press ***Previous*** key to move one level up the tree; i.e. return to last menu level visited.
- Use the **(+)** and **(-)** keys to select between the different options at a given menu level, to change a parameter's value (such as adjusting a gain up or down), or to select a different Degree of Freedom or axis.

Moving down the tree always leads to the first option at the next new level. Moving up the tree goes back to the last menu option visited.

Try it out. Rest assured that the controller cannot be damaged simply from navigating the menu tree and/or making changes to operating parameters. Parameter values will not be permanently changed unless saved using the ***Save Parameters*** menu option. Even after saving changes to operating parameters, the controller can be returned to the "factory default" settings through the ***Restore Defaults*** menu option.



After configuring the system to your liking, always *go to the Save Parameters* menu option to permanently store the settings. Settings are not saved automatically.

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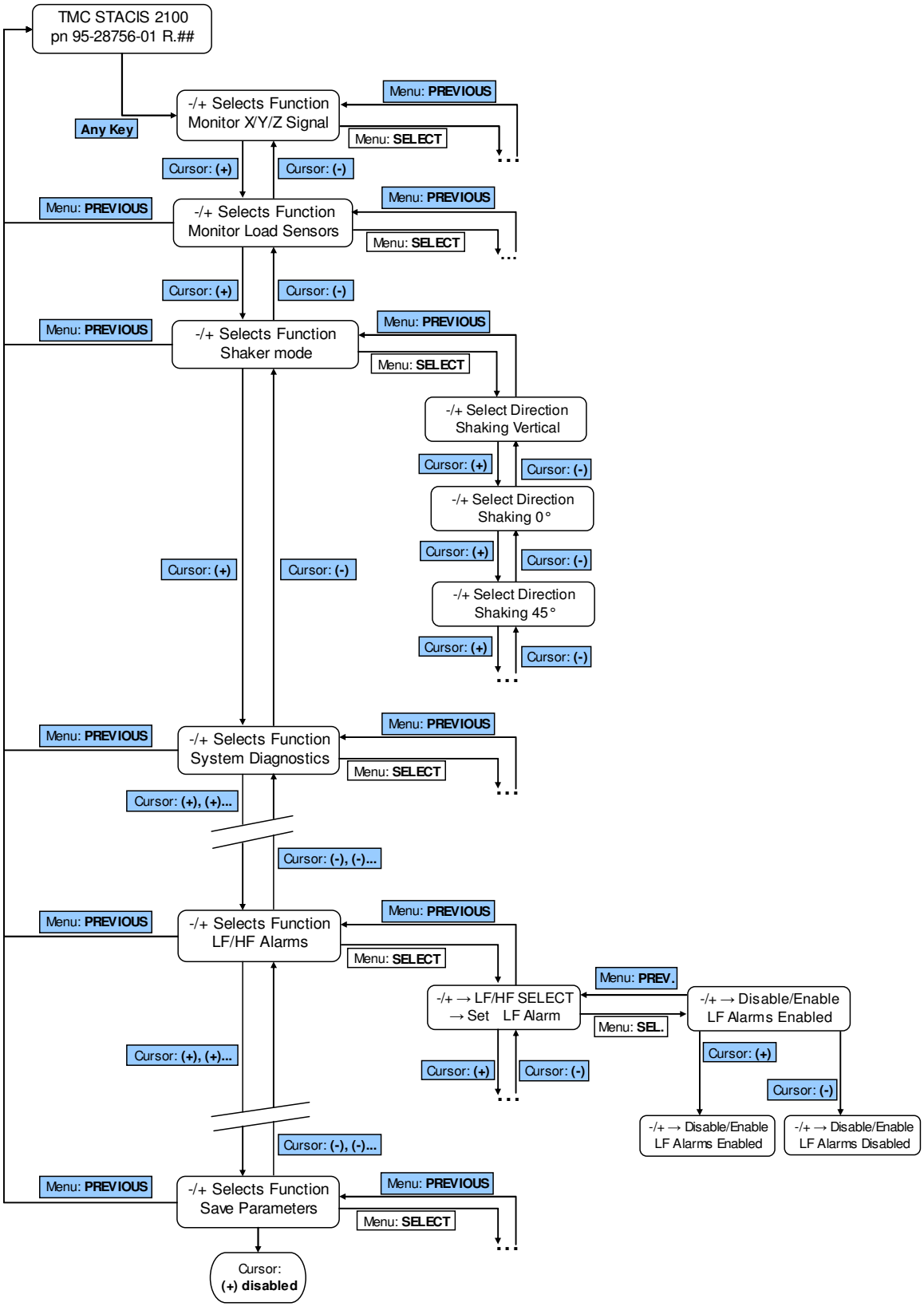


Figure 12: Example of Using the Menu Keys

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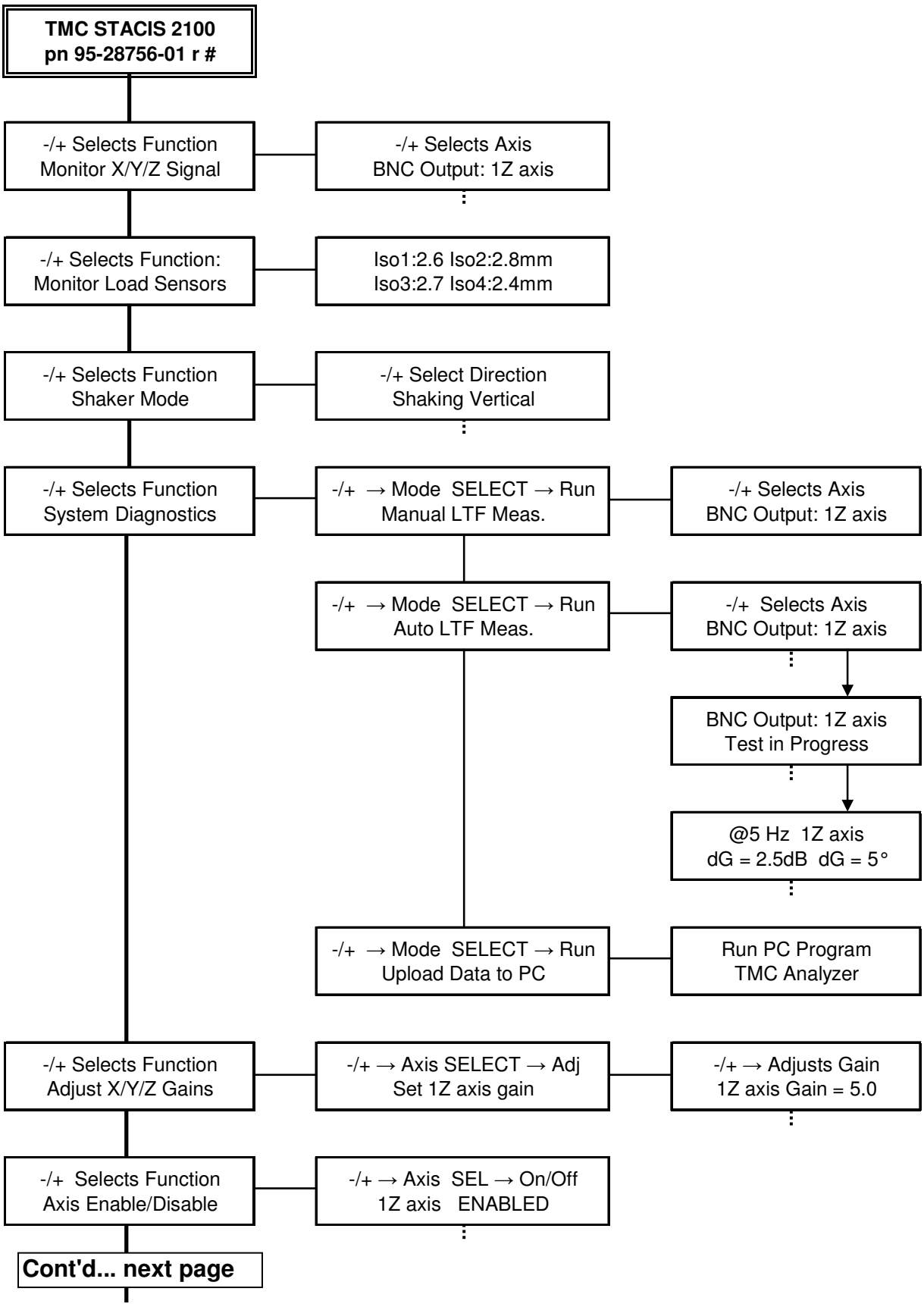


Figure 13: Detailed Menu Structure for STACIS® 2100

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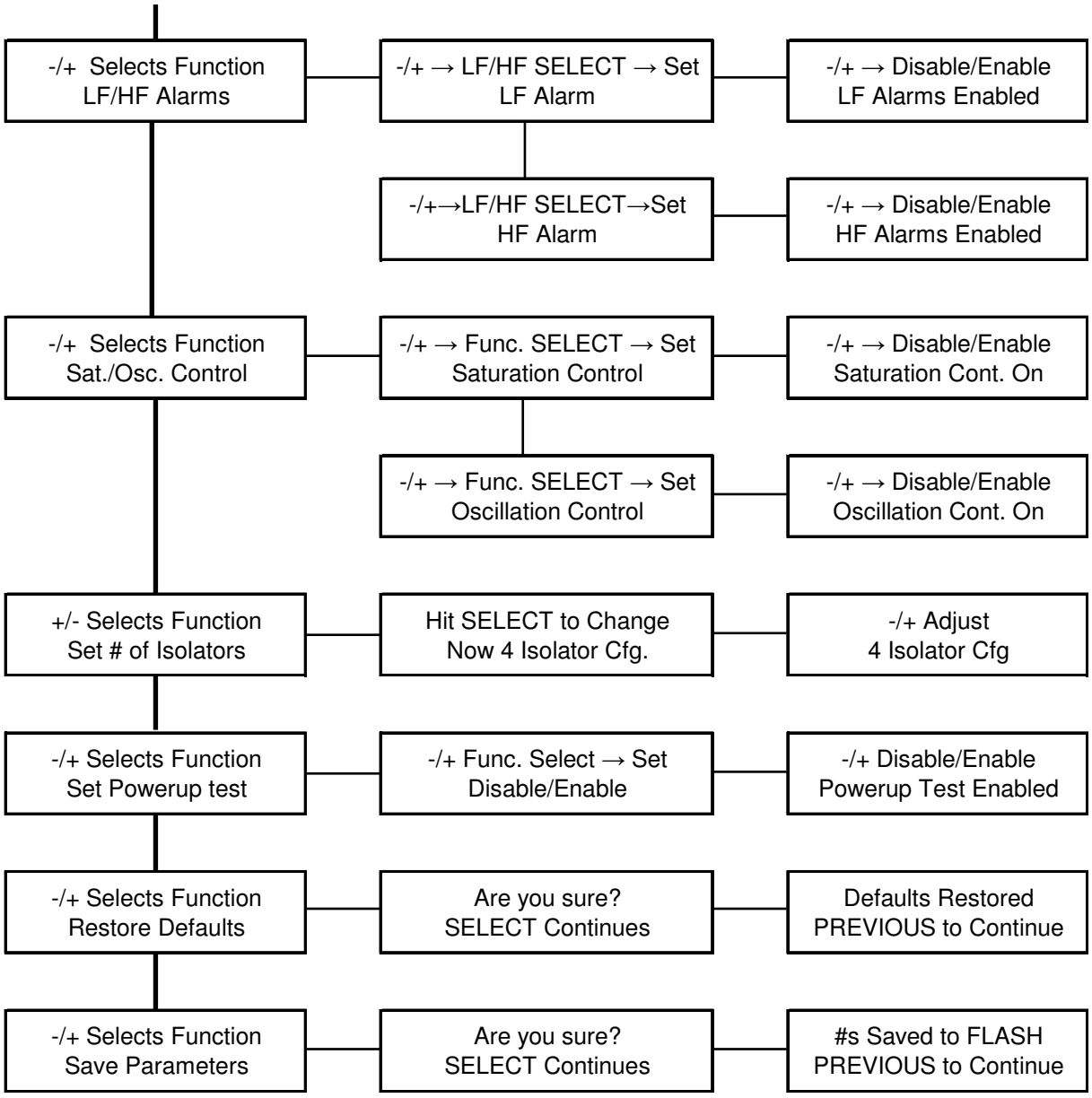


Figure 13: Detailed Menu Continued

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5.3 Description of Menu Tree Functions

The following sections describe the function of the different options shown above.

5.3.1 Monitoring X, Y, or Z Signals

This menu option allows the monitoring of the control signal sent to the HVAs for the three control axes (X, Y and Z) for each of the isolators. The signal can be seen on the BNC Output located on the controller's front panel. The signal is proportional to the vibration motion being cancelled by the system. If little or no signal is present on an axis relative to the other system' axes, this may be an indication of a damaged vibration sensor. If the signal is too large, it may be an indication that an actuator is damaged or the floor displacement is too high and the system gains need to be lowered. The Monitor Sig. on BNC function is used primarily for troubleshooting and monitoring the system's performance. The output is immediate when the user selects the axis to monitor.

5.3.2 Monitoring Isolator Loads

As described in the earlier **Installation** section of the manual, this function is used to monitor the loading of the isolators. It shows the nominal deflection of the internal elastomer mount inside each STACIS® isolator.

5.3.3 Shaker Mode

With this function, STACIS® can be used as a dynamic shaker for vibration testing of equipment. The shaker function operates in "open loop" mode and can be set for the vertical axis, every 45 degree axis in the horizontal plane, X Twist (rotation), Y Twist or Z Twist.

"Open Loop" mode disables the vibration isolation function, and uses a signal applied to the controller's front-panel BNC Input directly to the PZT stacks in the STACIS® isolators. The resulting displacement of the payload is proportional to the input at frequencies below 10Hz, but it rolls off quickly at high frequencies. This mode applies the largest signals to the payload, and

Shaker Mode is ideal for two-channel vibration transfer measurements, etc.



When using the STACIS® system as a shaker, the actuators and/or sensors can saturate depending on the mode, frequency, and amplitude of input signal. If saturation occurs, the resultant payload motion will no longer be proportional to the input. TMC recommends that a reference sensor (such as an accelerometer) is always used to confirm that the payload motion is correct.

5.3.4 System Diagnostics

This function is a test mode, used only for troubleshooting. It allows the user to test and collect data for each of the system's servo loops individually.

In ***Manual Mode***, the user is able to inject a known signal into a particular axis (1X through 4Z) through the controller BNC Input using a signal generator. The controller processes the signal and output a response through the BNC Output. The signal can be monitored with an oscilloscope.

In ***Automatic Mode***, the same checks performed during the power-up sequence are reproduced on the user selected axis. The response signal can be monitored by connecting an oscilloscope to the controller's BNC Output.

The ***Upload Data to PC*** option allows the user to collect, save and recall data representing the structural "signature" of the entire assembly (i.e. customer supporting frame, payload and TMC's isolation

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system) using the TMC PC based application ***TMC Analyzer***. **See Appendix C for detailed instructions on running the analyzer software**.

5.3.5 Adjust X/Y/Z Gains - Gain Adjustment

All control gains of the **STACIS® isolation systems have been set at the factory to provide optimal** performance in all typical installations. However, in some installations (installations on weak floors, for example), it may be necessary to adjust the control gain of one or more axes to improve system stability.



Optimal adjustment of the gains requires training and experience. Though the system cannot be damaged, **always contact TMC prior to adjusting the gains**. The STACIS® isolation system is designed with two advanced features (Oscillation Control and Saturation Control) which virtually eliminate the need for end-user gain adjustment.



Gains must never be increased above the 0 dB level. The system is not designed to handle gains above this level. Too high a gain may result in oscillation and saturation.

The procedure for adjusting the system's control gains is as follows.

a. Plug an oscilloscope to the controller's BNC Output to monitor the system's signal.

b. Select the axis for which the gain needs to be adjusted.

c. Adjust the gain as appropriate, using **(+)** key to increase (but not above 0 dB) or **(-)** key to decrease. **Note: each click of the key alters the gain by 1 dB**



- If the system goes into high-frequency oscillation (making an audible 'chirp' sound), the gain should be reduced until the oscillation is eliminated.
- If the low-frequency drift of the control signal exceeds +/- 0.5 volts under 'normal' circumstances (a quiet room environment, and no storms outside), the gain should also be reduced until this behavior goes away.



To keep the new gains permanently, save them in the controller's non-volatile (FLASH) memory (explained later in this section)

5.3.6 Axis Enable/Disable

This is the menu option for individually activating or deactivating the control servo loop for each active axis. This menu is a powerful diagnostic tool that can be used to identify sources of system's instability. The **BNC output** is automatically set to the axis displayed on the LCD. The standard procedure is to identify unstable axis is the following:

- Disable all axes – set each axis as ***Disabled.***
- Enable them by adding (set to ***Enabled***) one axis at the time. After each axis is enabled, monitor the system stability for approximately 15-30 seconds. In this matter, systematically find the axis, which by ***Enabling or Disabling*** create or eliminate instability.

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- Adjust (reduce) the servo loop gain for the identified axis by three (3) dB, i.e. 3 clicks of the (**-**) menu key, through the ***Adjust X/Y/Z Gains*** menu discussed above, and then re-assess the performance of the system.
- Continue to check one axis at a time to screen for any other underperforming axis by repeating the above procedure until all instability problems are eliminated.



- The setting for an individual axis is preserved once saved in NVRAM. Thus, a disabled axis will remain disabled until the user re-enables it.
- Even with a disabled axis, all testing (data collection, etc.) will be unaffected for the axis.

5.3.7 Sat./Osc. (Saturation/Oscillation) Control

This is the menu option for enabling or disabling saturation and/or oscillation control. The Saturation Control and Oscillation Control features are advanced, non-linear, and adaptive control algorithms. They allow the system to operate trouble-free for extended period of time under adverse conditions (periods of high seismic noise or large payload disturbances).



TMC strongly recommends that these functions remain enabled during system operation. They may be disabled **only for diagnostic purposes** and reset to "*enabled*" once the diagnostic is completed.

Saturation Control monitors when the signal to an HVA is in danger of saturating the actuator. To prevent saturation, the controller automatically reduces the gain in the affected channel. Although this preventive action also reduces the vibration isolation, it prevents a hard saturation in the servo, which can result in unwanted impulses sent to the payload. In our experience, this is much less disruptive for most applications. If Saturation Control reduces the gain by more than 20dB, a warning is sent over the COM port (if enabled). If this occurs, check and remove the source of excessive external disturbance.

Oscillation Control is a very advanced feature which monitors for oscillations in the control loops. If oscillation is detected, this feature modifies the control system filters in an attempt to stabilize the STACIS® system.

An oscillation is a consistent and high-amplitude frequency in the feedback signal. The frequency is identified, and a filter is added to make the system more stable at that frequency. Oscillation Control will continue to increase the aggressiveness of this filter, until the oscillation goes away. If too large a correction was necessary to the control filters, an Alarm is triggered, and the channel is disabled.



- Filtering is limited by the need for isolation. The aggressiveness of the filter is increased through a series of 6 steps. Each increase causes a reduction in low-frequency isolation. Beyond the 6 steps of adjustment, the loss in low-frequency isolation is too great and the system will prompt for user intervention.
- Oscillation control filters are not stored in FLASH memory; if the controller power is turned OFF, the filters will all be reset to zero. If oscillation reoccurs, the filters will re-adjust.

Both Saturation Control and Oscillation Control are applied to a single axis at a time. Gain reduction in one axis usually causes minimal changes in the system's overall isolation performance.

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5.3.8 *LF/HF Alarms*

This is the menu option for enabling or disabling the alarms for Oscillation Control and Saturation Control. These two features monitor the operation of the STACIS® system for oscillation and saturation, respectively (see Oscillation Control and Saturation Control sections above). Whenever oscillation or saturation is detected, the controller automatically attempts to correct the problem. If the automatic adjustment fails, an "Alarm" (if enabled) condition is indicated by:

- a message on the LCD showing the axis and type of alarm. **Note:** To acknowledge the message and to clear it from the LCD, press the **Previous** key;
- the System Status LED turns from green to flashing amber;
- Alarm Relay by triggers (see Table 3).

In addition, the affected axis is disabled to prevent damage to the actuator.

Two types of alarm condition may occur: an "LF" (Low-Frequency) Alarm or an "HF" (High-Frequency) Alarm.

Low-Frequency Alarms happen when the control signal to an actuator exceeds a specified value for an extended period of time. If Saturation Control is enabled **(strongly recommended default)**, the system gains are automatically adjusted to prevent saturation of the actuator from ever developing. Therefore, if Saturation Control is enabled, LF Alarms will never be triggered. If Saturation Control reduces the gain by large amounts, a warning can be sent over the controller's COM port interface (if enabled).

High-frequency Alarms happen when the system detects an oscillation. The system monitors the period and amplitude of the signals to the HVAs. If the system oscillates - signal with a regular period and high amplitude detected - for longer than a specified time period, then an Alarm is triggered, and the channel is disabled.



It is strongly recommended that the Alarms stay enabled. Disabling them could cause permanent damage to the actuators from uncontrolled oscillation. The option to turn the alarms off is mainly a diagnostic tool.

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ERROR	LF ALARM Required stroke of isolation system exceeds the dynamic range of the actuators.	HF ALARM High Frequency Oscillation
INDICATIONS	• The SYSTEM STATUS LED turns to amber. • A message similar to the following is displayed on the LCD: `Alarm: Low Freq Osc Isolator #3 Axis Y` • Alarm Relay is triggered	• The SYSTEM STATUS LED turns to amber. • A message similar to the following is displayed on the LCD: `Alarm: High Freq Osc Isolator #3 Axis Y` • Alarm Relay is triggered
FAULT DETECTED	▪ Repeated low frequency instability. ▪ Actuator dynamic range is exceeded. ▪ Control signal is over a preset threshold (near saturation) for more then 60% of any given 60 second period.	▪ Constant instability at a frequency between 10 Hz and 150 Hz. ▪ Actuators generate a drumming sound. ▪ A channel oscillates for more then 360 consecutive cycles at a constant frequency.
PROBABLE CAUSE	▪ Heavy mechanical disturbances applied to the floor near the STACIS® installation. ▪ Heavy mechanical disturbances applied directly to the payload (moving stage problems, maintenance work, etc.). ▪ Load adjustment for one or more of the isolators is incorrect. ▪ Soft floor causing the isolator to tilt (horizontal channels only) ▪ One or more isolators have failed.	▪ Floor is soft and does not meet the installation requirements. ▪ Load for one or more isolators is incorrect. ▪ Gain for an isolator is too high in one or more axes, making servo loop unstable. ▪ One or more actuators has failed
RECOMMENDATION-TROUBLESHOOTING	▪ Check the operation of the system located on the payload for malfunction. ▪ Verify that the reported isolator rests solidly on the floor/surface without any rocking. Replace the base pad with a new one as necessary. ▪ Check all isolators for proper loading and adjust loading as necessary. ▪ Reduce loop gain by 3dB (3 clicks of (**-**) menu key) for the channel shown in the alarm message. ▪ If none of the above helps, contact TMC for assistance.	

Table 5: Alarm Conditions

5.3.9 Select Number of Isolators.

The DC-2000 controller can be configured to control 2, 3, or 4 isolators. When purchased as part of a STACIS® system, i.e. isolators and controller, the correct number of isolators is pre-configured at TMC before to shipment. This function makes it possible to update the number of isolators in the event of a change in the installation, e.g. an isolator is added or removed due to changes in the weight of the payload, etc. The number of isolators may also need to be re-configured when the “Restore Defaults” option is used, or the controller software is updated.

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5.3.10 Set Powerup Test

Menu option for enabling or disabling the automatic execution of the Power Up Self Test. The self test at power up consists of running "open loop" gain and phase measurements for each axis.



If the power up self test is run in a "noisy" environment, e.g. high level base vibration, the measured signal could be compromised and produce faulty results. To avoid such situations, the power-up [self] test should be disabled.

5.3.11 Restore Defaults

This function makes it possible to restore all parameters to the factory default settings. This includes **ALL** settings which can be changed through the menu system, such as control gains, number of isolators, etc.



The system may not function properly, or may incorrectly indicate an ALARM condition after using this command, especially in cases where there was a significant difference between the installed system configuration and the factory default configuration. One example is the case where the number of isolators defined in the controller's software no longer matches the actual number of installed isolators



- The factory default configuration will not automatically be saved into the controller's non-volatile memory.
- To keep the factory default configuration, save them using the **Save Parameters** function.
- To go back to the last saved system configuration, i.e. to not keep default configuration, simply turn off controller and then reboot.

5.3.12 Save Parameters

This function permanently saves all of the currently active settings in the controller to non-volatile memory. It should be used only confirming that the settings are proper for the system, and functioning correctly. All saved parameters are retained even after the controller is power cycled OFF and ON.

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6 Downloading New Software:

New system operating software can be downloaded by connecting the controller to a computer via the serial ports (COM1 or COM2). The software package shipped with the system includes a program called **SerialLoader.exe** to facilitate the downloading process.

Downloading new software will reset all parameters to the factory defaults.

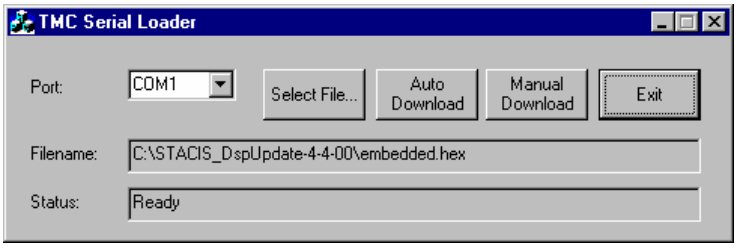
Follow the instructions below to install new software.

1. Connect the controller to a computer using a serial communication cable.

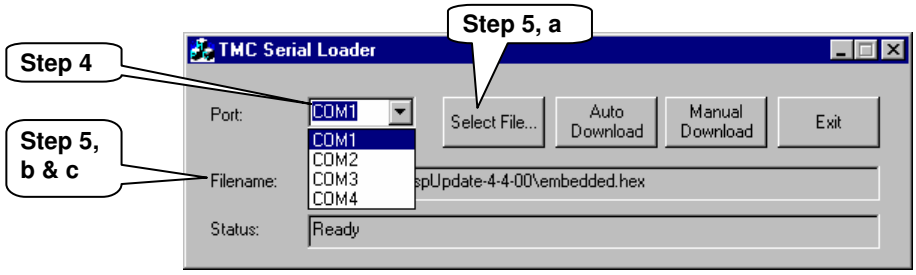
   A DB-9 Male to DB-9 Female "one-to-one" serial cable is needed. For computers with only USB ports, a commercially available USB-to-RS232 (to COM) exchanger is required.

2. Load the provided software package to the computer.
3. Launch the SerialLoader.exe program.

   After the program opens, a dialog box similar to the one below will display.



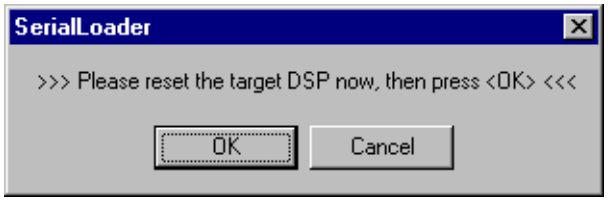
4. From the dialog box, select the PC serial port that is connected to the controller.



5. Click on ***Select File***. A standard Microsoft Windows file dialog box will display.
   a. Locate and select the new system profile ***.hex*** file to load.
   b. The file selected will be displayed in the *Filename* field, and the *Auto Download* and *Manual Download* buttons will turn from gray to solid.
   c. Confirm the file loaded is correct (computer location and name).
6. The new software will be downloaded using the ***Manual Download*** method.

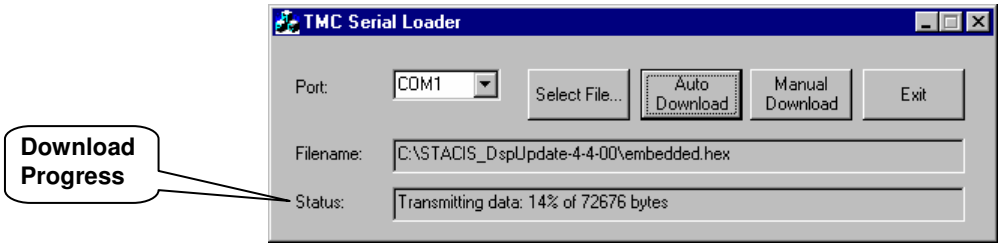
Click the ***Manual Download*** button. The following screen will then display:

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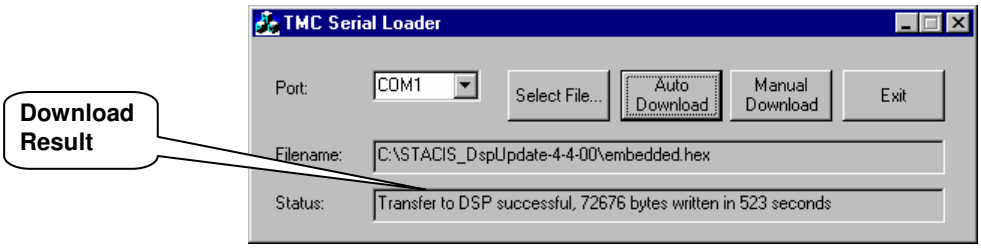


7. Turn the controller power OFF, and then back ON after 10 seconds. The System Status LED on the Controller's front panel will be "***red"***, and then turn "***green"*** and start to blink. Click the **OK** button above or press the **Enter** key on the computer keyboard immediately after the status LED starts blinking ***"green"***.

   The LED on the Controller's front panel will turn "***amber"*** and start blinking rapidly, indicating that the download is in progress. The **Serial Loader** window will now indicate the progress of the download in the *Status* window.



8. After the download is complete, the *Status* box will indicate the total bytes transmitted, and the time required in seconds. 'Successful' means the downloaded .HEX file passes the checksum test, and is written to flash (non-volatile) memory.



After the download is complete, the LED will turn "***green"***, and the controller will automatically reboot, and the new software will start to run.



- New software download resets all system parameters to the factory default settings. Therefore, the system must be re-configured for the specific application/installation. Parameters such as number of isolators, control gains, etc. typically require adjustments; refer to the *Description of Menu Tree Functions* section for instructions.
- After configuring the system, permanently save the parameters in memory using the "Save Parameters" menu option.

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Failed Downloads:

On rare occasions, a software download will fail the checksum and the new software will NOT be written to flash. If download fails,

- Manually shut the power OFF and then back ON to reboot the old version of the application software.
- Repeat the downloading process described above.

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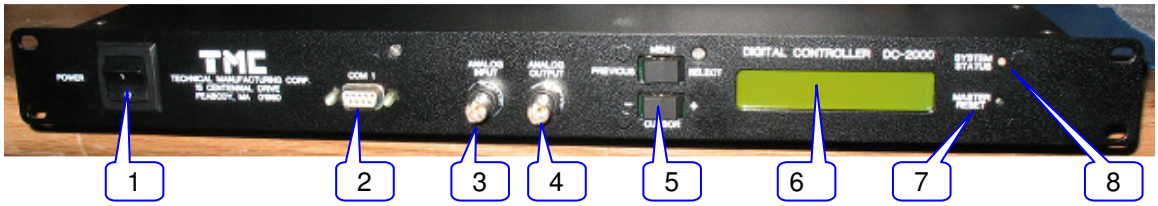
7 Appendix A: DC-2000 Controller Overview

7.1 Controller Performance Specifications

Analog Inputs ..... 16 x16 bit / 96dB Dynamic Range, ±10V full scale
Analog Input Protection ..... ±15 Volts
Analog Outputs ..... 16 x 14 bit / 84dB Dynamic Range, ±10V full scale
Analog Output Protection ..... indefinite short circuit protection
Digital Input Current Rating ..... 2mA min / 30mA max.
Digital Output Current Rating ..... 30mA max.
Digital I/O Protection ..... full optical isolation (see *The DI/O Interface*)
DI/O Isolated Supply ..... 5VDC, 300mA max. (1.5 Watt)
COM Ports ..... 9600 Baud, 8 data, 1 stop, no parity, no flow control
DSP Engine ..... TMC320C32 / 60MHz
Sampling Rate ..... 5KHz (Max. Transport Delay 0.6ms)
Power Consumption 200W

7.2 Controller Front Panel

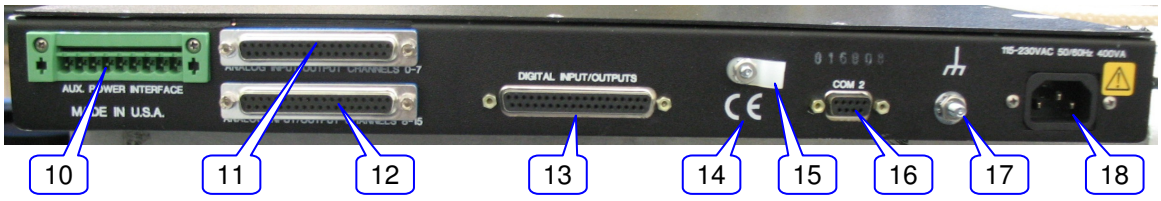
Figure 14: DC-2000 Digital Controller – Front Panel



Ref. #	Name	Description
1	Main Power	AC Power ON/OFF rocker switch.
2	COM 1	Serial RS232 interface port; used to establish a communication channel to a personal computer; pinout information follows.
3	Analog Input	BNC connector for injecting external analog signals (analyzer, etc) into selected isolator axes.
4	Analog Output	BNC connector for monitoring the control signal from a selected axis.
5	Menu Control	Four switches: SELECT, PREVIOUS, +,and -.
6	LCD	Main display used for navigating the menu system and communicating information and instructions to the user.
7	Master Reset	Used to force a hardware reset; same as power cycling.
8	System Status	Tricolor system status LED (green - normal, red - alarm, amber - warning).

7.3 Controller Back Panel

Figure 15: DC-2000 Digital Controller – Rear Panel



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Ref. #	Name	Description
10	Alarm Relay, AUX Power Interface	”Dry contact” alarm relay, Auxiliary power source; used in special applications; pinout information follows.
11	Main Analog I/O Connector, Channels 0-7	Cable connection point to isolation system using channels 0-7 as designated.
12	Main Analog I/O Connector, Channels 8-15	Cable connection point to isolation system using channels 8-15 as designated.
13	Digital Input/Output	Optional digital I/O connector; pinout information follows.
14	CE Label	Marking to indicate compliance to CE requirement.
15	Cable Restraint	Loop power cord through the restraint to provide strain relief
16	COM 2	Second RS232 interface port
17	Ground	External grounding lug.
18	AC Power Entry Module	Standard IEC power cord connection point.

7.4 System Status LED and Alarm Relay

Possible system status LED indications:

- Green LED - indicates normal operation. Alarm relay (see Table 10 above) is enabled, indicating that Alarm is OFF – normal operation condition.
- Yellow/Amber LED - indicates system is or has moved outside of the normal operation Go/No-Go window as a result of external disturbance, system’s instability, etc. In this case, the Alarm relay is disabled, indicating an Alarm condition.
- Immediately after power up, the LED will turn red, then flash green for a 5 seconds. The period, when the LED flashes green, is when new software can be downloaded using the ‘manual’ download option. Alarm relay is disabled, indicating Power-up condition.

The function of the LED and Alarm Relay can be customized for application-specific requirements.

7.5 The DI/O Interface

This connector located on the rear the controller provides access to 16 digital inputs and 16 digital outputs. Both inputs and outputs are isolated with optical couplers.

Figure 16 below shows a schematic diagram of the controller internal wiring. Connections available to the user are shown on the right (Rear Panel Access).

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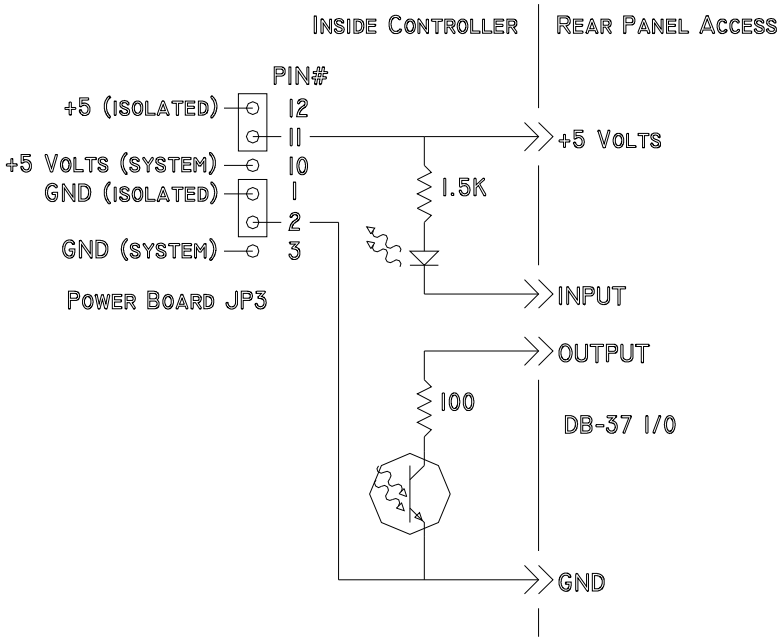


Figure 16: Digital Inputs and Outputs Schematic

- The (+5Volts) and (GND) on the DB-37 connector are configured with jumpers and *are connected to an isolated power supply (300mA, 1.5W),* internal to the controller.
- The jumpers are set as shown above by default, but can be changed before shipping upon request. ***The jumpers are internal to the controller and must be changed at the factory, or by authorized TMC personnel only***
- All of the LED (+) terminals are connected to a common +5 volt bus through 1.5 KOhm resistors.
- All of the open collector emitters are connected to a common ground bus.
- Current-limiting 100 Ohm resistors are used to protect the output transistors.
- Both +5V and GND are available on the DB-37 connector.

7.6 Connector Pinouts

The following tables show the pinouts for each of the connectors on the back of the DC-2000:

Digital Input/Output Connector

Table 6: Digital Input/Output DB-37 Connector Pinout:

Pin #	Function	Pin #	Function	Pin #	Function	Pin #	Function
1	D in 0	11	+5 VDC	21	D in 9	31	D out 1
2	D in 1	12	D out 8	22	D in 10	32	D out 2
3	D in 2	13	D out 9	23	D in 11	33	D out 3
4	D in 3	14	D out 10	24	D in 12	34	D out 4
5	D in 4	15	D out 11	25	D in 13	35	D out 5
6	D in 5	16	D out 12	26	D in 14	36	D out 6
7	D in 6	17	D out 13	27	D in 15	37	D out 7

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Pin #	Function	Pin #	Function	Pin #	Function	Pin #	Function
8	D in 7	18	D out 14	28	GND	-	-
9	N. C.	19	D out 15	29	+5 VDC	-	-
10	GND.	20	D in 8	30	D out 0	-	-



- *'N.C.' means 'no connection'.*
- *The +5 VDC and GND connections shown in this table are configured as shown in the previous section. They are connected to an isolated power supply (300mA, 1.5W).*

Analog Input/Output Connectors



- *For both Analog I/O connectors, the GND and power connections are non-isolated.*
- *The '**+V Aux**' pins are connected to a dedicated power supply for powering systems external to the digital controller.*

Table 7: Analog Input/Output Channels 0-7 DB-37 Connector Pinout:

Pin #	Function	Pin #	Function	Pin #	Function	Pin #	Function
1	A Out 0	11	A In 6	21	A Out 3	31	GND
2	A Out 2	12	GND	22	GND	32	+15 VDC
3	GND	13	GND	23	A Out 5	33	-15 VDC
4	A Out 4	14	GND	24	A Out 7	34	GND
5	A Out 6	15	GND	25	GND	35	GND
6	GND	16	+48V	26	A In 1	36	GND
7	A In 0	17	+48V	27	A In 3	37	GND
8	A In 2	18	+48V	28	GND	-	-
9	GND	19	+48V	29	A In 5	-	-
10	A In 4	20	A Out 1	30	A in 7	-	-

Table 8: Analog Input/Output Channels 8-15 DB-37 Connector Pinout:

Pin #	Function	Pin #	Function	Pin #	Function	Pin #	Function
1	A Out 8	11	A In 14	21	A Out 11	31	GND
2	A Out 10	12	GND	22	GND	32	+15 VDC
3	GND	13	GND	23	A Out 13	33	-15 VDC
4	A Out 12	14	GND	24	A Out 15	34	GND
5	A Out 14	15	GND	25	GND	35	GND
6	GND	16	+V Aux	26	A In 9	36	GND
7	A In 8	17	+V Aux	27	A In 11	37	GND
8	A In 10	18	+V Aux	28	GND	-	-
9	GND	19	+V Aux	29	A In 13	-	-
10	A In 12	20	A Out 9	30	A in 15	-	-



- *Analog input 15 is connected to the controller's front-panel BNC input.*
- *Analog output 15 is connected to the controller's front-panel BNC output.*

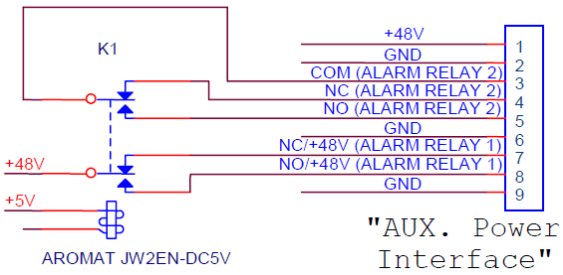
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AUX. Power Interface

This connector located in the rear of the controller can be utilized as an auxiliary power source or a “dry contact” alarm relay.

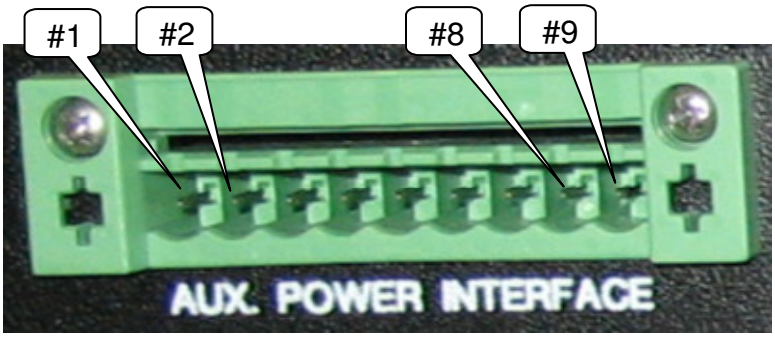
Table 9: AUX. Power Interface Connector Pinout:

Pin #	Function
1	+ 48V
2	GND
3	COM (Alarm Relay 2)
4	NC (Alarm Relay 2)
5	NO (Alarm Relay 2)
6	GND
7	NC/+48V (Alarm Relay 1)
8	NO/+48V (Alarm Relay 1)
9	GND



*** N.C. means no connection ***

Figure 17: AUX Power Connector – Pin Identification



Serial Ports (COM1 and COM2)

The serial ports provide a communication interface between the DC-2000 controller and a host computer or other machines. The controller and computer must be connected using a DB9 serial cable or a commercially available USB-to-RS232 (to COM) exchanger for computer with USB ports only.

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The serial port follows the RS-232 standard and has the following properties:

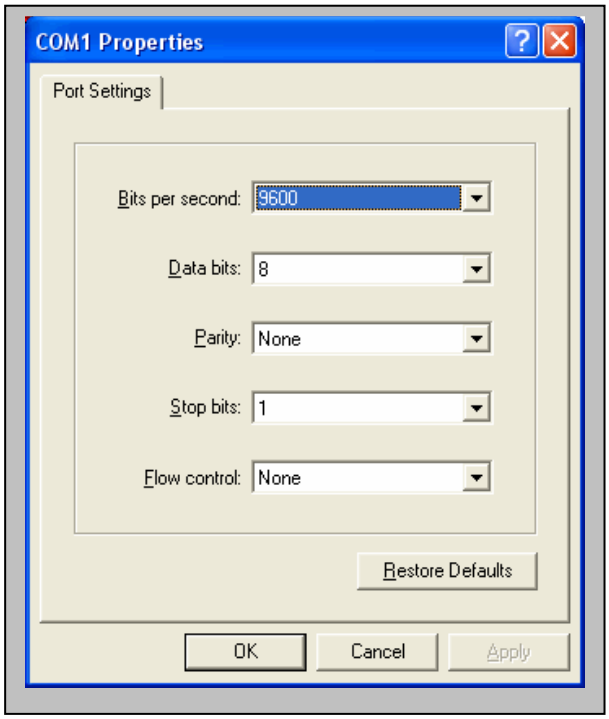


Table 10: COM1& COM2 Pinouts

PIN Number	Function	Pin Number	Function
1	N.C.	6	N.C.
2	TXD2	7	CTS2
3	RXD2	8	RTS2
4	N.C.	9	N.C.
5	GND		

*** N.C. means no connection ***

Serial Port Commands & Status Byte

The commands structure for communication is a single character terminated with a carriage return. When a command is issued, the system echoes back its current status in the form of a status byte, terminated by a **<CR>, e.g.** x00<CR>… xFF<CR>, or echoes back a string, also called ***Status Byte***, like "**Part Number: p <CR>**", indicating the command typed. The status byte is reported over the serial port as a combined 8 bit value of two ASCII format bytes, followed by the a carriage return (**<CR>)**. If an unknown command is issued, the system echoes back "Unknown Command". The table below lists typical serial port commands. Contact TMC for more information.

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Table 11: Summary of Serial Port Commands

s <CR>	'Read Status" - Returns status byte, this is a null command; it does not affect any changes to system operating parameters.
p <CR>	"Part Number" - sends the TMC system software part number and revision to the front panel LCD. It also echoes the P/N to the serial port if the port is used.
w <CR>	"Print System Status" - sends to PC the string of current status of all of alarms, warnings, feedback settings, etc.
u <CR>	"System Self-test result" - sends to PC the string of measured value, compared with default value for each active servo loop.
r <CR>	**"**Reset**"** - System Reset; restores parameters to values saved in flash memory (NVRAM), and then initiates startup sequence. Returns status byte showing current mode.

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8 Appendix B: Using TMC Analyzer to Collect and Upload Data

If not already installed on your computer, install the *TMC Analyzer* application by running the Setup.exe file from the "TMC_Analyzer 1.xx install" folder. Contact TMC Service for a copy of the application, if necessary.

Follow the procedure below:

A. Connect a DB9 serial cable between the computer and the COM 1 port located on the controller's front panel.

B. Set the controller LCD menu to *System Diagnostics → Upload Data to PC → Run PC Program TMC Analyzer* (see illustration below).

Press the **PREVIOUS** switch on the controller's front panel repeatedly until the following message is seen on the LCD:

```
T M C  S T A C IS  2 1 0 0
p n  9 5 - 2 8 7 5 6 - 0 1  R e v  #
```

Press the "**+**" switch repeatedly until the LCD shows:

```
+ / -  S e l e c t s  F u n c t i o n :
S y s t e m  D i a g n o s t i c s
```

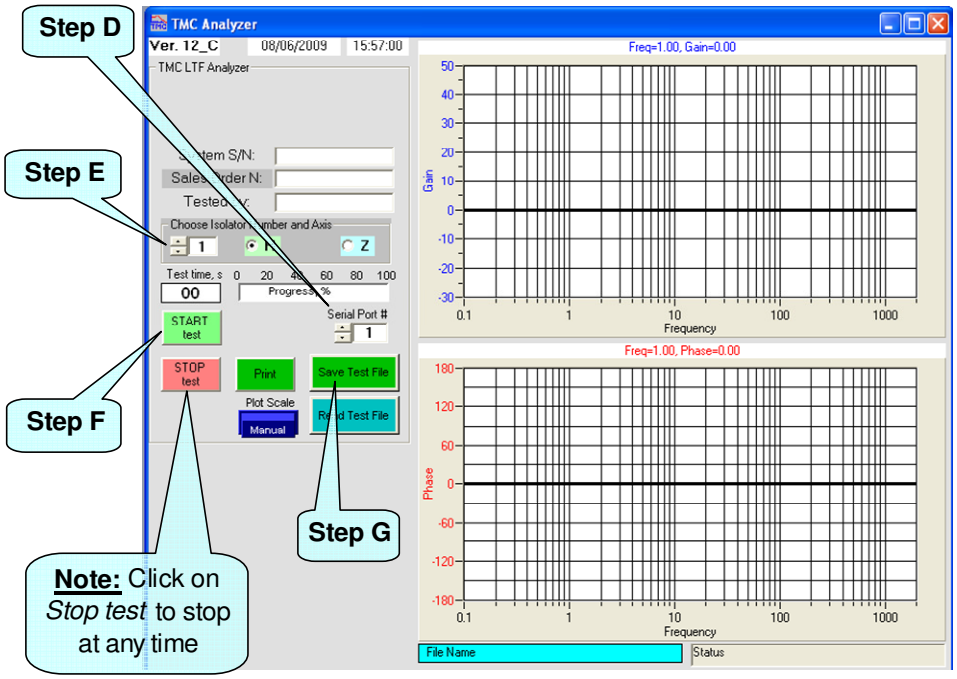
Press the "**SELECT**" switch, and then press the "**+**" switch repeatedly until the LCD shows:

```
-/+ → M o d e  S E L E C T → R u n
U p l o a d  D a t a  t o  P C
```

Press the "**SELECT**" switch. The LCD will now show:

```
R u n  P C  P r o g r a m
T M C  A n a l y z e r
```

C. Launch the TMC analyzer application Analyzer.exe. A screen similar to the one below will display.



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D. Select communication port for RS232 interface (same port as in step A above).

E. Select axis (1, 2, 3, and 4 in H (horizontal) or Z (vertical)). Numbers (1,2, etc.) correspond to the isolator position.

F. Click on *Start test*.



- The controller LCD will display *"## axis / Test in Progress*".
- The gain-phase profile will plot on a log graph starting with the higher frequencies.
- The complete test takes approximately 3 minutes.
- Click on *Stop test* to stop at any time.

G. Click on *Save Test File* and then save test data for each axis as a *CSV* file.

H. After collecting the transfer function for all axes, exit from ***Upload Data to PC*** controller LCD menu and close TMC Analyzer program.

I. E-mail test data files to TMC for review.

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