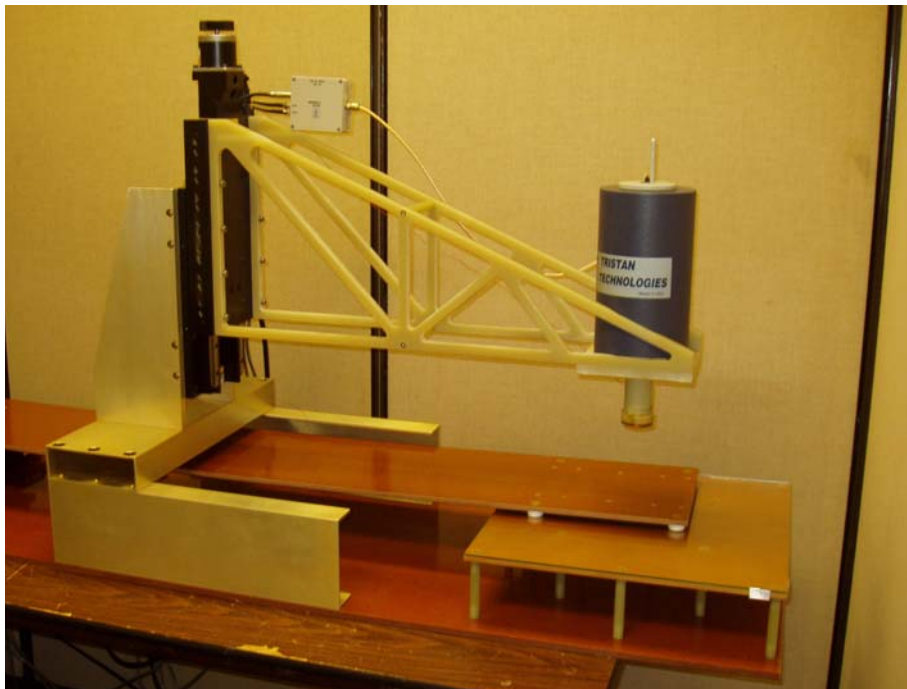


User's Manual
for

Model SMM-701G HTS NDE System



By



Tristan Technologies, Inc.
San Diego, California
USA

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Tristan Part Number 3000-120

<i>Revision Record</i>		
Date	Revision	Description
September 07, 2003	version 1.0	Initial Release
September 27, 2004	version 1.0A	Modified for 701G

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1. WARRANTY

Tristan Technologies, Inc. warrants its products to be free from defects in material and workmanship. Obligations under this warranty shall be limited to replacing, repairing, or giving credit for the purchase price, at Tristan's option, of any instrument returned, shipment prepaid, to its factory for that purpose within one year of delivery to the original purchaser, provided prior authorization for such return has been given by an authorized Tristan representative.

This warranty shall not apply to any instrument which Tristan's inspection discloses to have become defective or unworkable due to abuse, mishandling, misuse, accident, alteration, negligence, improper installation, or other causes. This warranty shall not apply to any instrument or component not manufactured by Tristan. When products manufactured by others are included in Tristan's equipment, the original manufacturer's warranty, if any, is extended to purchaser to the extent permitted by that manufacturer.

Tristan reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

There are no warranties which extend beyond the description herein. This warranty is in lieu of, and excludes any and all other warranties or representations, expressed, implied or statutory, including merchantability and fitness for purpose as well as any and all other obligations or liabilities of seller, including, but not limited to, special or consequential damages. No person, firm or corporation is authorized to assume for Tristan any additional obligation or liability not expressly provided for herein.

2. GENERAL INFORMATION

2.1 INTRODUCTION

This instruction manual contains installation, operation and maintenance instructions for the model SMM-701G HTS SQUID gradiometer measurement system supplied by Tristan Technologies, Inc.

The model SMM-701G HTS NDE System (block-diagram is presented in Figure 1) has been designed and built by Tristan Technologies, Inc. The system includes the following basic components:

- Liquid Nitrogen Dewar System
- HTS SQUID Gradiometer Probe
- iMAG[®] SQUID Electronics
- AC Magnet System
- Sample Motion Control System
- Data Acquisition System

2.2 SYSTEM COMPONENTS

Please check the enclosed packing list carefully when unpacking the equipment to verify that everything is present and undamaged. We recommend that you save the shipping crates for possible future use in case the system has been damaged and needs to be repaired.

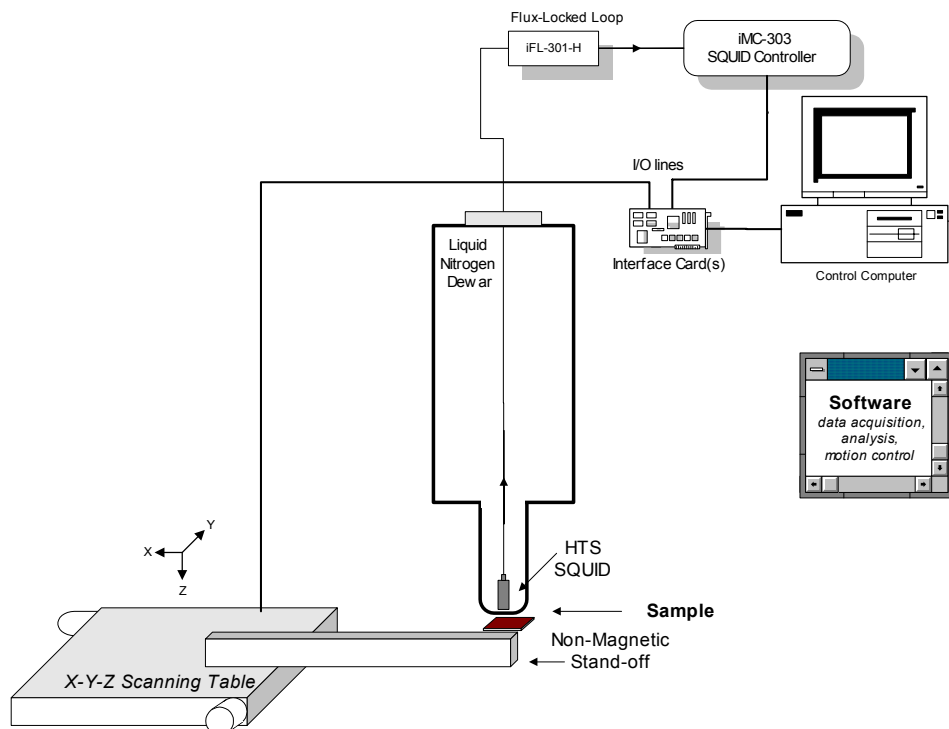


Figure 1 Model SMM-701G components

2.2.1 List of system components

- Model iMC-303 iMAG[®] SQUID Control Electronics
- Model iFL-301-H iMAG[®] Flux Locked Loops
- Model NLD-530/T liquid nitrogen dewar
- LN₂ filling funnel
- Model NL-51G 1-channel SQUID probe
- Model HTG-10N planar SQUID gradiometer (dB_z/dx)
- Model CC-6 six meter composite cables
- HTS iMAG[®] User's Manual and Applications Disk
- X-Y-Z Motion System
- BNC-2090 Junction Box
- SH-68 to SH-68 Digital I/O Cable
- MID-7604 Stepper Motor Drive
- Motion Control Cable
- (2) 6" Motion Table
- 8" Motion Table
- QTY 3 ZETA-57 Stepper Motor (Attached to Motion Tables)
- Dell 19" Monitor M992
- Dell CD-ROMs and Manual
- Power Cords
- Dell Precision 360 Workstation
- Windows XP Operating System
- National Instruments 4-Axis Stepper Controller
- National Instruments Multifunction Digital I/O
- Dell Keyboard
- Dell Mouse
- Power Cord
- Dell CD-ROMs and Manuals
- National Instruments CD-ROMs and Manuals
- RS-232 Cable
- Parker Motion Control Manuals
- Model SMM-701G Manual

The country of origin for all components is the United States, with the exception of the HTG-10N SQUID sensor whose country of origin is Germany.

2.3 MEASURED PARAMETERS AND FACTORY TEST DATA

The following parameters were measured at Tristan prior to shipment. Dimensions and weights are approximate and are given for reference only. Performance data is the result of testing done at Tristan. Boil-off tests values were taken after thermal equilibrium was established. Under ideal conditions, you should expect to achieve similar performance in your laboratory, but some differences are to be expected.

2.3.1 SQUID sensor

The HTG-10N is a flip-chip design* with a detection coil mounted directly above that of the Josephson loop. Figure 2 shows the shape of the detection coil. The center-to-center distance is 10 mm. The effective baseline may be slightly larger because of the width of the patterned lines. The black regions indicate where the YBCO superconductor is placed.

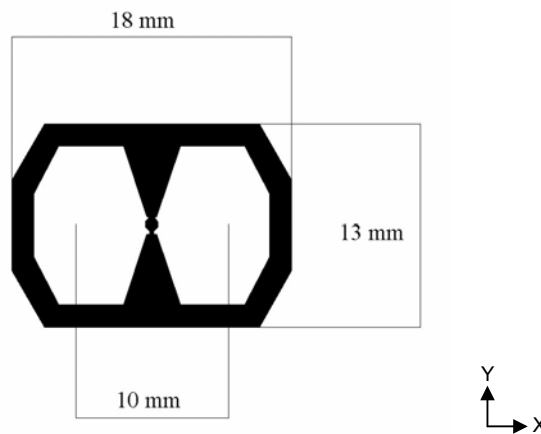


Figure 2 Mask of HTG-10N planar gradiometer input coil shown at ~2x actual size.

The plane of the SQUID chip is located ~4 mm from the bottom of the HTG-10N SQUID sensor. In the dB_z/dx or dB_z/dy (“horizontal”) orientations, the bottom of the sensor is recessed ~ 1 mm above the bottom of the probe. These distances must be added to the tail gap to determine the sensor-to-sample distance. Normally, the coil-to-room temperature distance is ~10 mm when the dewar is cold.

The SQUID sensor was initially tested in a HTS superconducting shield to eliminate all external environmental noise contributions. Testing was done using Tristan iMAG[®] 300 SQUID electronics. The flux transfer function ($nT/cm\Phi_0$) and noise ($fT/cm\sqrt{Hz}$) was determined. The test results of the supplied SQUID sensor is shown in Figure 3 as a function of frequency. The white noise (guaranteed < 70 $fT/cm\sqrt{Hz}$) was measured at 100 Hz and is listed along with sensitivity at 1 Hz (not a guaranteed value, but shown for informational purposes).

*Faley, M.I., Poppe, U., Urban, K., Paulson, D.N., Starr, T. and Fagaly, R.L., “HTS dc-SQUID with a gradiometric flux transformer”, *Proceedings of the 4th European Conference on Applied Superconductivity (EUCAS'99)* Barcelona, Published in: *Inst. Phys. Conf. Ser.*, No.167, p.509-512 (2000)

G40810 (6" cable length)

1.7 nT/cm Φ_0
Bias = 42 %
Mod = 6 % (6 peaks)
Skew = 37 %
 $V_{pp} = 2.4$ V

First cooling time: 15 min
Time to heat above T_c : 10 sec
Cooling after heating: 15 min

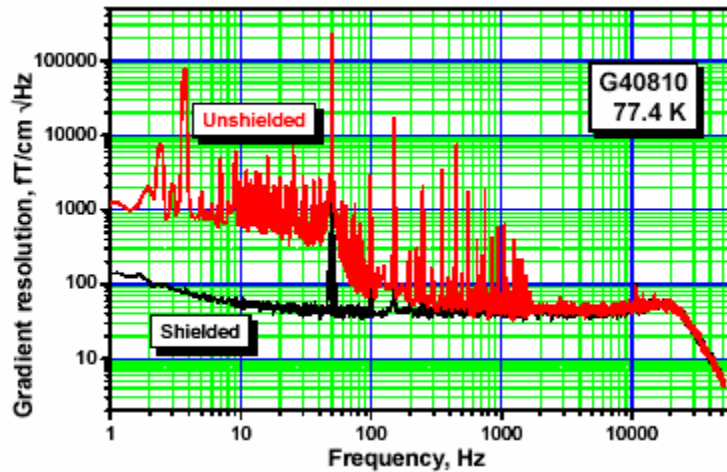


Figure 3 G40810 White Noise (measured at 100 Hz): 40 fT/cm $\sqrt{\text{Hz}}$; noise at 1 Hz \sim 140 fT/cm $\sqrt{\text{Hz}}$

2.3.1.1 Measurements in a non-superconducting shield

Additional measurements were made at Tristan in a non-superconducting mu-metal shield. These tests determine the bandwidth and voltage transfer function for each device. Operation at various gains and ranges are verified using the customer's electronics. Testing is done using Hewlett-Packard (34401 A DMM, 35665A dynamic signal analyzer) and other appropriate test equipment. Typically, multiple average FFT's are taken using a Hanning window to give the spectra shown below.

Because of the local environmental noise (even inside a mu-metal shield), these measurements show different noise levels than the results shown in Figure 3 (77 vs. 40 fT/cm $\sqrt{\text{Hz}}$ in a superconducting shield). It should be noted that HTS SQUID sensors typically show a 10 - 30% variation from device to device.

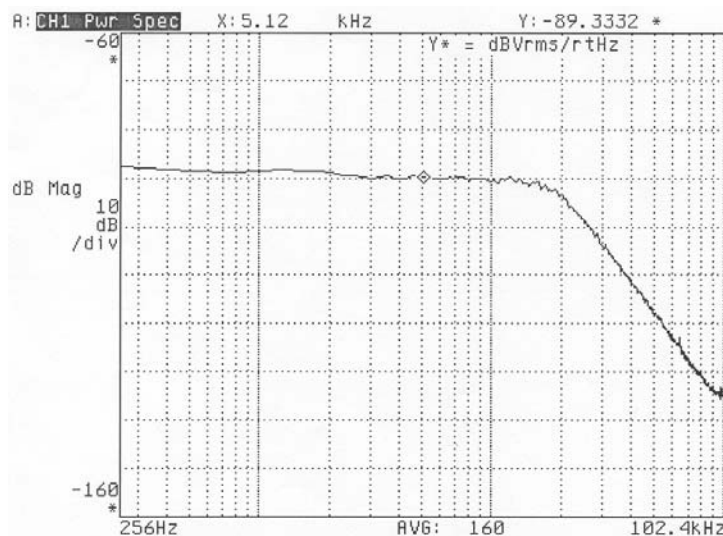


Figure 4 G40810 bandwidth measured at Tristan

These tests were not to demonstrate ultimate performance in a remote environment, but to verify proper operation of the SQUID electronics; higher noise is typical of unshielded

operation. Reducing external noise contributions can be very difficult. In gradiometers—especially in a laboratory environment—significant noise can be introduced if the dewar is positioned near a metal fixture. Section 4.3, discusses ways to reduce the influence of environmental noise sources.

2.3.2 Test configuration

SQUID Controller used	iMC-303	S/N: 1098
Flux-locked Loop used	iFL-301-H	S/N: 2071
SQUID sensor used	HTG-10N	S/N: G40810
System Channel #	1	

Test Setup

Gain: x100 Slew: Normal

Heater Test

Heat Time: 20 sec Cool Time:> 20 min

Autotune

Triangle Amplitude: 2.4 V_{peak-to-peak}

<u>Tune Parameters</u>	in mu-metal shield	unshielded (9/22/04)
Bias +	28%	30%
Bias -	28%	30%
Mod	33%	25%
Skew	52%	18%

Note that tune parameters can vary and can be dependant on environmental noise.

Gain Slew	X100 Normal	X100 Slow	X50 Normal	units
	0.681	N/A	N/A	V/ Φ_0
	2.50	N/A	N/A	nT/cm V
Noise @ 1 kHz	77	N/A	N/A	fT/cm \sqrt Hz
Bandwidth	20	N/A	N/A	kHz
Loop Locked	yes	yes	yes	N/A

Balance

> 400:1 with respect to 60 Hz measured in the dB_z/dy orientation.

2.3.2.1 Unshielded Operation

For planar gradiometers, testing is also done in an unshielded environment. Completely unshielded operation was achieved (*c.f.*, Figure 39).

	Channel 1
Loop Locked	Yes

2.3.3 Dewar Parameters

The dewar construction (Figure 5) is: outer case is fiberglass with vacuum space, superinsulated, nitrogen reservoir, and neck

Volume	1.19 Liters
Boil off (no probe)	¼ L/Day
Hold Time (no probe)	~4 Days
Dewar Tail Gap	warm 4.1 mm cold ~5.2 mm

Table 1 Dewar Test Report Results

The dewar gap is defined as the distance between the inner (cold) tail and the bottom of the outer (room temperature) tail. Because of the ~0.3% thermal contraction of G-10 from room temperature to 77 K, the inner tail length will shrink and increase the tail gap.

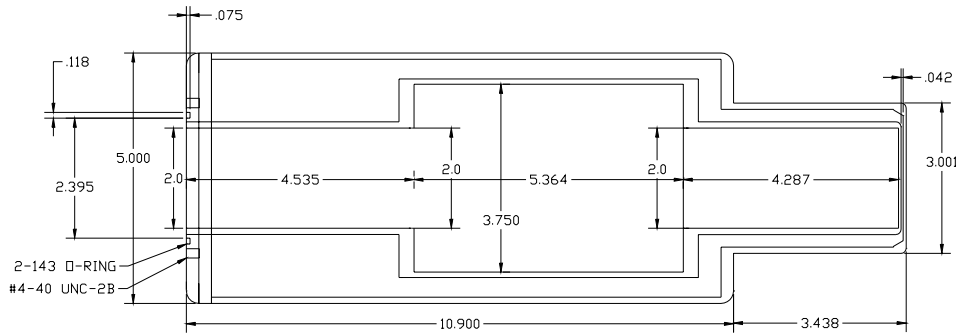


Figure 5 model NLD-530 dewar dimensions (in inches)

2.3.4 Insert and sensor orientation



Figure 6 NLI-53G Probe

The probe is designed to allow the sensor to be oriented in either the dB_z/dx or dB_x/dz direction. Normally the system is delivered with the sensor in the “horizontal” (dB_z/dx or dB_z/dy) orientation (Figure 7).



Figure 7 SMM-701G probe in the “horizontal” orientation

To change orientation (horizontal ↔ vertical), if the probe/dewar is cold, follow the warm-up instructions in section 4.2. When the probe is warm, if there is any rf shielding (e.g., aluminumized Mylar[®] superinsulation), carefully remove it (assuming you plan to reuse it). The HTG-10N SQUID sensor is held on to a semi-circular G-10 block by two (2) #2-56 x .5 round head G-10 screws (the removable block is fastened to the probe cylinder by another two screws). Remove them (and the semi-circular block) and re-orient the HTG-10N SQUID sensor. Be careful not to break the multi-colored cabling. The HTG-10N SQUID sensor should be mounted so that the cabling is arranged as shown in Figure 8.



Figure 8 SMM-701G probe in the “vertical” orientation

As mentioned, in the “vertical” (dB_x/dz or dB_y/dz) orientation, the G-10 mounting block is not needed. When in the desired orientation, carefully tighten the G-10 screws and replace any (superinsulation) rf shielding. Follow the normal cooldown procedure (section 3.2.3) when finished. To return to the dB_z/dx orientation, reverse the procedure, making sure that the G-10 mounting block is attached to the probe cylinder before mounting the HTG-10N SQUID sensor.

2.3.5 Electronics and software

See the User's Manual for iMAG HTS[®] Multi-Channel dc SQUID System for information on the use of the electronics and software.

3. INSTALLATION

3.1 INITIAL INSPECTION

All Tristan instruments and equipment are carefully inspected and packaged at Tristan prior to shipment. However, if a unit is received mechanically damaged, notify the carrier and the nearest Tristan representative, or the factory in San Diego, California. Keep the shipping container and packing material for the carrier and insurance inspections.

If the unit does not appear to be damaged but does not operate to specifications, contact the nearest Tristan representative or the Tristan factory and describe the problem in detail. Please be prepared to discuss all surrounding circumstances, including installation and connection detail. After obtaining authorization from the Tristan

representative, return the unit for repair along with a tag to it identifying yourself as the owner. Please enclose a letter describing the problem in as much detail as possible.

3.1.1 REPACKING FOR RETURN SHIPMENT

If it is necessary to return the system, you should repack the unit in its original container (if available). For this reason, it is advisable to save the original crate sent by Tristan; however, if this is not possible, use the following instructions for repacking.

1. Wrap the unit in either bubble wrap or foam rubber.
2. Cover the bottom of a sturdy container with at least 3 inches of Styrofoam pellets or shredded paper.
3. Set the unit down onto the packing material and fill the rest of the container with Styrofoam or shredded paper. The unit must be completely protected by at least 3 inches of packing material on all sides.

3.1.2 RETURN FROM CUSTOMERS OUTSIDE THE USA

To avoid delays in Customs clearance of equipment being returned, contact the Tristan representative in your area, or the Tristan factory in San Diego, California, for complete shipping information and necessary customs requirements. Failure to do so can result in significant delays.

3.2 NORMAL INSTALLATION

The SMM-701G scanning stage (including liquid nitrogen and SQUID probe) requires an area of 75 cm x 150 cm (3' x 6'). The computer, SQUID electronics and data acquisition hardware requires an area of 50 cm x 100 cm (2' x 4').

If the scanning stage is mounted on a table or desk, be sure that the platform is rigid. Movement of the SQUID sensor relative to the Earth's magnetic field can cause vibrationally induced noise. Do not put the scanning stage on a metal table or desk. Placing the SQUID sensor near metal (especially steel) will couple magnetic field gradients into the SQUID sensor and significantly increase sensitivity to environmental noise. The SQUID may not be able to hold lock in the presence of large gradients. Likewise, placing the system directly on a concrete floor that has rebar in it may couple gradients into the SQUID sensor. To minimize the pick up of 60 Hz, the SMM-701G should be placed as far from powerlines and distribution boxes as possible. To reduce the influence of the scanning platform, it may be worthwhile to mount the sample on a nonmagnetic platform.

3.2.1 SQUID Sensor Orientation

The NLD-530 dewar is glued (GE 7031 varnish) to a rectangular mounting plate (that mounts on the z-stage extension arm). This is to ensure proper orientation of the dewar and probe. The probe has indicating marks to indicate the **x** direction. The scanning stage motors are labeled to indicate **x**, **y**, and **x** directions. The NLI-51G probe has four mounting holes on the top plate that allow it to be rotated in 90° increments. This allows the user to set the SQUID sensor to be in the dB_z/dx or dB_z/dy orientations (Figure 7).

3.2.2 Connecting LEMO connectors.

If the SQUID sensor is not attached to the cryogenic insert, remove any shunting cap that is attached.

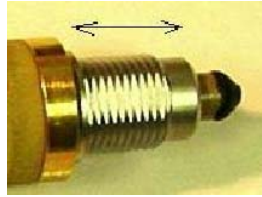


Figure 9 LEMO shunting connector

Do *not* twist the cap when removing (or attaching) it. Otherwise, the LEMO connector pins can be sheared off. When inserting the shunting cap or connectors, be sure that the red spot on the female connector is lined up in the center of the slot or its corresponding red spot on the male connector.

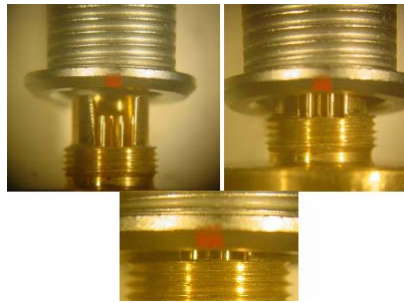


Figure 10 correct connector alignment

Do not twist or attempt to force the connector as that can cause the pins to break (Figure 11).

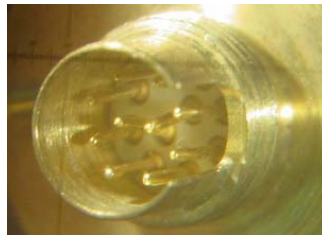


Figure 11 bent pins from twisting connector during improper attachment

3.2.3 Cooling the system from room temperature

Install the funnel in the neck of the dewar. Fill the dewar by slowly adding LN₂ until full. Remove the funnel and slowly lower the probe into the dewar. *Avoid freezing the o-ring and pump-out fitting.* When fully lowered, secure the probe to the dewar with the proper hardware.

Remove the fill tube plug and install the funnel into the fill tube. Slowly pour LN₂ into the funnel until LN₂ vents from the vent port. Wait a moment and then add more LN₂ until it again vents from the vent port. Repeat this sequence until adding LN₂ causes immediate venting. The dewar is now filled. Remove the funnel and replace it with the fill tube plug. **Leave the vent port open.**

CAUTION:

O-rings located on the probe will not be flexible if cold and may easily be cracked.
Spare o-rings are provided.

CAUTION:

To avoid contamination of the vacuum space, do not freeze the pump-out valve on the top of the probe or the gasket on the top of the probe during transfer.

4. NORMAL OPERATION

4.1 REFILLING THE DEWAR WITH LIQUID NITROGEN

After the initial nitrogen transfer, subsequent transfers will be required on a regular basis. The boil-off time recorded in Table 1 for the dewar will be reduced when a probe is installed and operating. The dewar is designed to operate in the vertical position and boil-off will increase when the dewar is tilted from vertical. The boil-off of the dewar with probe should be measured—this will determine the minimum time between refills of the dewar. The dewar should be refilled periodically and should not be allowed to warm unintentionally via boil-off.



Figure 12 Adding Liquid Nitrogen to a Cold Dewar

To refill a cold dewar, remove the fill tube plug and install the provided funnel into the fill tube. Slowly pour LN₂ into the funnel until LN₂ vents from the vent port. Wait a moment and then add more LN₂ until it again vents from the vent port. Repeat this sequence until adding liquid causes immediate venting. The dewar is now filled. Remove the funnel and replace it with the fill tube plug. **Leave the vent port open.**

4.1.1 HTS Sensor Cool Down and Usage

- Do not touch the pins or connector of the SQUID. Observe ESD precautions when connecting the SQUID's cables.
- Do not measure SQUID cable resistances when cold.
- Initial cool down of the SQUID is with the Tristan iFL-301-H flux-locked loop electronics connected to the LEMO connectors at the top of the cryostat. **However**, do not yet connect the CC-6 composite cable(s) to the iFL-303-H Flux Lock Loop(s).
- Connect the CC-6 composite cable(s) to the Tristan model iMC-303 SQUID Control Electronics first. Turn on the Tristan electronics with the SQUID not connected. Go to SETUP; MANUAL TUNING; ENTER and then reduce Bias, Mod, and Skew to 0%.
- Allow the SQUID electronics to stabilize for 10 minutes.
- Connect the CC-6 composite cable(s) at the Flux Lock Loop first, then connect 10-pin LEMO connector, and then connect the 5-pin LEMO connector last.
- If the SQUID is in a vacuum, verify that the correct heater current limits are in place. This is not normally applicable to the 703G system, but is relevant if you are performing other tests.
- Run the TUNE Utility.
- Heat for about 3 seconds, then pause for 2 minutes. If the SQUID does not go "normal" (as seen by observing the triangles—as described in the User's Manual for iMAG HTS[®] Multi-Channel dc SQUID System), you may increase the heat time (in small increments) until the SQUID goes normal. If the heat time becomes excessively long, contact Tristan or your local distributor for advice before proceeding.
- Run the TUNE Utility.
- When turning off the system, set Bias and Mod and Skew to 0%, disconnect the CC-6 composite cable(s) and then turn off AC power.
- When disconnecting all cables, disconnect the 5-pin LEMO connector first, then the 10-pin LEMO connector.

4.2 DEWAR WARM-UP PROCEDURE

If the SQUID magnetometer probe is not in the dewar, then pouring out the liquid nitrogen or, letting the liquid nitrogen evaporate is acceptable, However, since HTS SQUID sensors will be damaged by exposure to moisture (section 7.2), special

precautions must be taken when warming up dewars that are being used to cool HTS SQUIDs. To prevent exposure to moisture, immediately remove the probe and place the probe inside a tight-fitting plastic bag to prevent excessive condensation of moisture. Be sure that a desiccant is inside the bag. When the probe and sensor has warmed up to room temperature, place the probe in a moisture-free container (e.g., a dry box).

The sensor can be removed from the probe or the stored attached to the probe. If the probe and SQUID sensor are kept together, the dry box dimensions must be greater than 10 cm (4") diameter x 46 cm (18") to be able to accommodate the probe.

After removing the probe, turn the dewar upside down to pour out the remaining nitrogen. Be sure not to pour the liquid nitrogen on anything that could be damaged. Then let the dewar warm up to room temperature (leave the neck tube open). Turning the dewar upside down will minimize the amount of moisture that may condense inside the dewar. If this procedure is used, it will be necessary to make sure that any water which condenses in the dewar is removed prior to using the system again. This can be done by wiping it out using a rag on the end of a rod or by blowing *room-temperature* air into the tail of the dewar.

WARNING:

DO NOT BLOW HOT AIR INTO THE DEWAR AS THIS MAY CAUSE FAILURE OF THE EPOXIED JOINTS.

4.3 SAFETY PRECAUTIONS FOR HANDLING CRYOGENIC LIQUIDS

The potential hazards of handling liquid helium stem mainly from the following properties:

WARNING

- 1. LIQUID NITROGEN IS EXTREMELY COLD.**
- 2. THE LOW TEMPERATURE OF LIQUID NITROGEN AND CONDENSE AND SOLIDIFY AIR.**
- 3. DO NOT LET LIQUID NITROGEN BE CONFINED IN A CLOSED SPACE—*VERY SMALL AMOUNTS OF LIQUID NITROGEN ARE CONVERTED INTO LARGE VOLUMES OF GAS.***
- 4. NITROGEN IS *NOT* LIFE SUPPORTING.**

4.3.1 Extreme Cold—Cover Eyes and Exposed Skin

Accidental contact of liquid nitrogen or the cold gas that results from its rapid evaporation may cause a freezing injury similar to a burn. Protect your eyes and cover the skin where the possibility of contact exists. Eye protection should always be worn when transferring liquid helium.

4.3.2 KEEP AIR AND OTHER GASES AWAY FROM LIQUID HELIUM

The low temperature of liquid nitrogen can solidify another gas. Solidified gasses and liquid, particularly solidified air, can plug pressure-relief passages and foul relief valves. Plugged passages are hazardous because of the continual need to vent the nitrogen

gas which evolves as the liquid continuously evaporates. Therefore, always store and handle liquid nitrogen under positive pressure and in closed systems to prevent the infiltration and solidification of air or other gases. Do not permit condensed air on transfer tubes to run down into the container opening.

4.3.3 KEEP EXTERIOR SURFACES CLEAN TO PREVENT COMBUSTION

Atmospheric air will condense on exposed nitrogen-cooled piping. Nitrogen, having a lower boiling point than oxygen, will evaporate first from condensed air, leaving an oxygen-enriched liquid that may drip or flow to nearby surfaces. Areas and surfaces upon which oxygen-enriched liquid can form, or come in contact with, must be cleaned to oxygen-clean standards to prevent possible ignition of grease, oil, or other combustible substances. Leak-testing solutions should be selected carefully to avoid mixtures that can leave a residue that is combustible. When combustible type foam insulations are used, they should be carefully applied to reduce the possibility of exposure to oxygen-enriched liquid which could, upon impact, cause explosive burning of the foam.

4.3.4 PRESSURE-RELIEF DEVICES MUST BE ADEQUATELY SIZED

Even minor deterioration of the vacuum in the nitrogen container can result in significant evaporation. Pressure relief devices for liquid nitrogen equipment must, therefore, be of adequate capacity to release nitrogen vapor resulting from such heat inputs, and thus, prevent hazard due to excessive pressure. This system has been designed to safely vent the evolving nitrogen gas in the event of any reasonable failure mode.

WARNING

DO NOT MAKE ANY MODIFICATIONS TO THIS SYSTEM WHICH MIGHT AFFECT ITS ABILITY TO VENT NITROGEN GAS IN THE EVENT OF AN EMERGENCY SUCH AS LOSS OF VACUUM IN THE DEWAR VACUUM SPACE.

4.3.5 KEEP EQUIPMENT AREA WELL VENTILATED

Although nitrogen is nontoxic, it can cause asphyxiation in a confined area without adequate ventilation. Any atmosphere which does not contain enough oxygen for breathing can cause dizziness, unconsciousness, or even death. Nitrogen, being colorless, odorless, and tasteless cannot be detected by the human senses and will be inhaled normally as if it were air. Without adequate ventilation, the expanding nitrogen can displace air and result in an atmosphere that is not life-supporting. The issuing nitrogen gas is invisible. Liquid containers should be stored in large, well ventilated areas.

If a person becomes groggy or loses consciousness when working around nitrogen, get them to a well ventilated area immediately. If breathing has stopped, apply artificial respiration. If a person loses consciousness, summon a physician immediately.

5. DATA ACQUISITION AND SCANNING SOFTWARE

5.1 Block Diagram

Figure 13 shows the main components of the data acquisition system. The software is described in section 5.2.

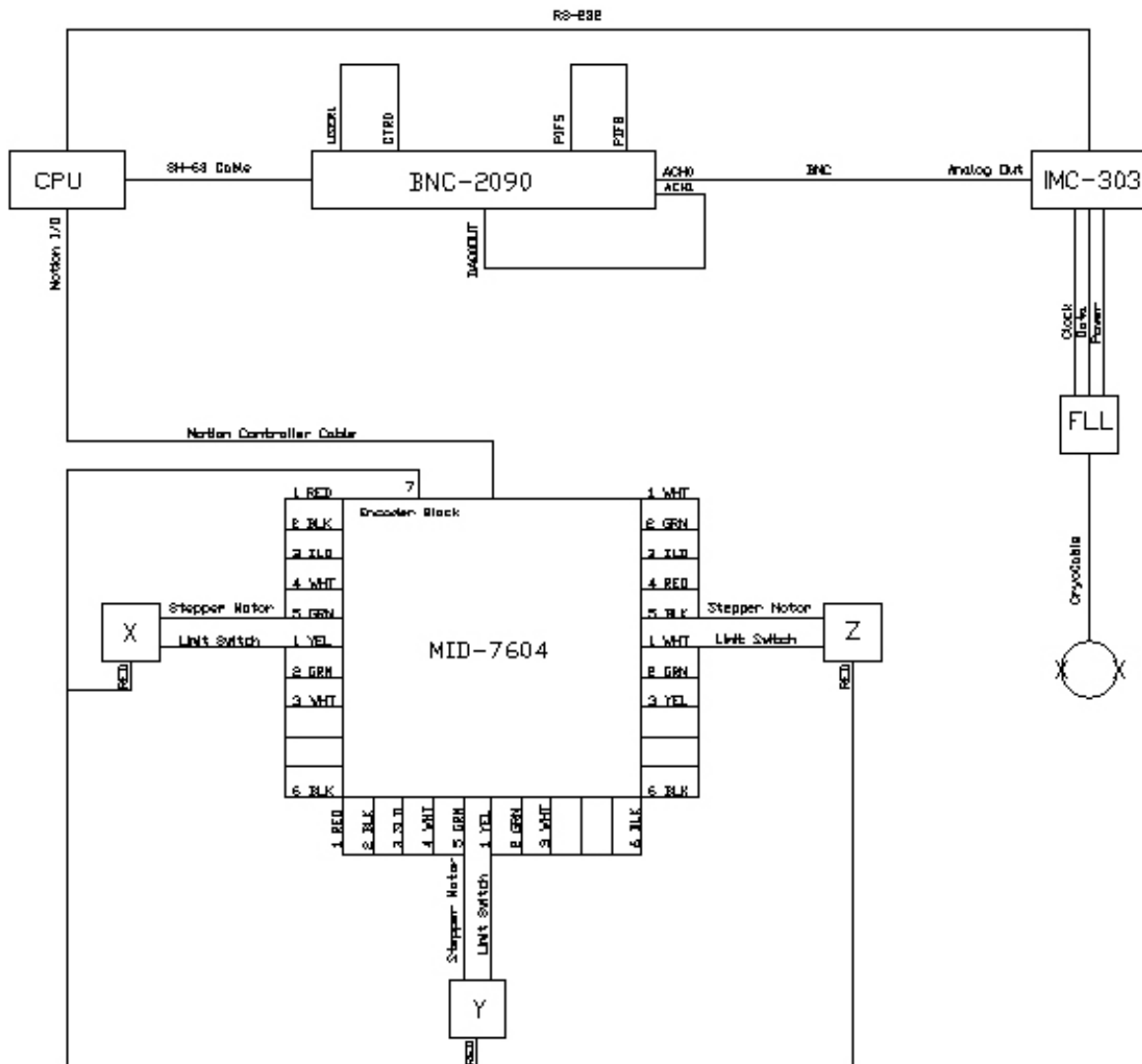


Figure 13 Data Acquisition Block Diagram

5.2 Software Start

To begin using the Tristan Technologies SMM-701G Magnetic Field Imaging System software, double-click on the **MagScan.exe** shortcut on the desktop or from its location in the **C:\MagScan** folder. After the software opens the **Initialization File Window** (see Figure 1411) will open and prompt the user for a selection. The **Default.ini** selection will set all software parameters to the factory settings while the **Current.ini** selection will set

all software parameters to the previous parameter settings from the last time the software was run.

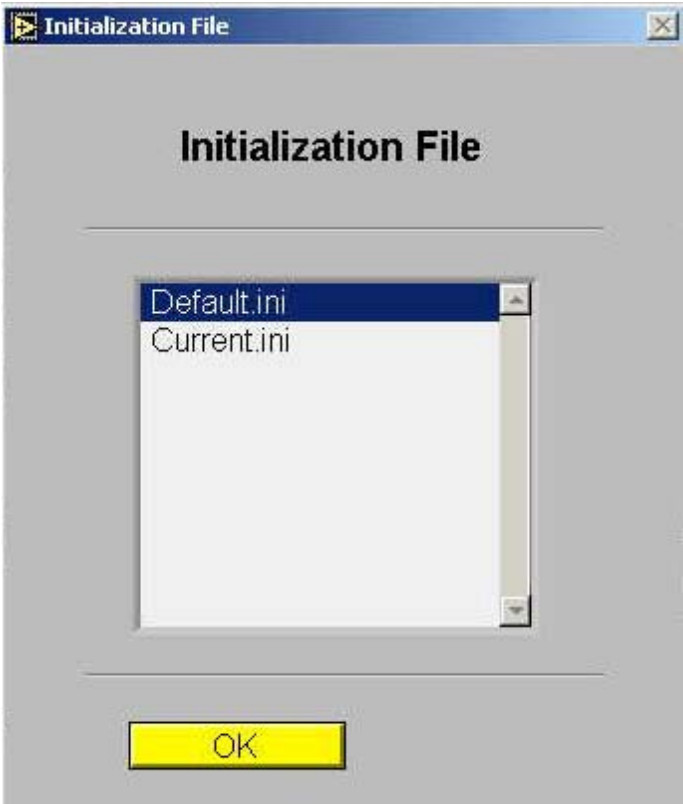


Figure 14 Initialization File Window

After the initialization file is loaded, the software will prompt for **Motor Position Initialization** (see Figure 1512). Be sure that the sample stage is free from obstructions before clicking **OK** button.



Figure 15 Motor Position Initialization Prompt

WARNING

CLICKING THE OK BUTTON IN THE MOTOR POSITION INITIALIZATION PROMPT WILL ALLOW THE SAMPLE STAGE ASSEMBLIES TO MOVE IN ALL THREE RECTANGULAR COORDINATE AXIS SIMULTANEOUSLY. OBSTRUCTIONS TO THIS MOTION COULD CAUSE DAMAGE TO THE OBSTRUCTIONS AND/OR TO THE SMM-701G SYSTEM WHICH ARE NOT COVERED BY THE TRISTAN TECHNOLOGIES LIMITED WARRANTY. SHOULD THE MOTION NEED TO BE STOPPED AT ANY TIME FOR AN EMERGENCY, TURN OFF EITHER THE AC POWER OR ENABLE SWITCHES ON THE FRONT OF THE NATIONAL INSTRUMENTS MID-7604 MOTION CONTROLLER.

When the motor positioning sequence concludes, the **Motor Position Initialization Complete** prompt appears (see Figure 163). Once the **OK** button is clicked, the software is ready for use.



Figure 16 Motor Position Initialization Complete

5.2.1 Default.ini file

```
[Motion]
MotorEnable=TRUE
MotorConv(steps/mm)="-3200.0,-3200.0,-1250"
MotorSet(steps/rev)="3200,3200,3200"
MotorVelocity=50.0
MotorAccel=20.0
ResetPos(mm)="-9.5125,-8.2812,-75.5000"
InitPos(mm)="0.0,0.0,-75.0"
PosLimit(mm)="75,75,38"
NegLimit(mm)="-75,-75,-75"
Center(mm)="0,0,38"
Step(mm)="1,1,1"
N="25,25,1"
[DAQ]
NumChans=2
CoilCalibration(fT/V)="2.5e+8,1"
ExcitationCalibration(fT/V)=8.47e+7
MeasureTime(ms)=998
SettleTime(ms)=100
InputRange(V)="10,10"
HighPassFilter=0
LowPassFilter=0
Gain=1
Offset=0
Slew=0
ExcitationFreq(Hz)=0.00
ExcitationAmplitude(fT)=1e+9
Decimation=FALSE
[Misc]
```

```
FLLComPort="COM1"  
DataDirectory=/C/MagScan/Experiment_Data  
TemporaryDirectory=/C/MagScan/Temporary
```

5.2.2 Current.ini file

```
[Motion]  
MotorEnabled=TRUE  
MotorConv(steps/mm)=-3200.000000,-3200.000000,-1250.000000  
MotorSet(steps/rev)=3200,3200,3200  
MotorVelocity=50.000000  
MotorAccel=20.000000  
ResetPos(mm)=-9.5125,-8.2812,-75.5000  
InitPos(mm)=0.00,0.00,-75.00  
PosLimit(mm)=75.000000,75.000000,38.000000  
NegLimit(mm)=-75.000000,-75.000000,-75.000000  
Center(mm)=0.00,0.00,38.00  
N=25,25,1  
Step(mm)=1.00,1.00,1.00  
MotorEnable=TRUE  
[DAQ]  
NumChans=2  
CoilCalibration(fT/V)=2.50E+8,1.00E+0  
ExcitationCalibration(fT/V)=8.47E+7  
MeasureTime(ms)=998  
SettleTime(ms)=100  
InputRange(V)=10.0,10.0  
HighPassFilter=0  
LowPassFilter=0  
Gain=1  
Offset=0  
Slew=0  
ExcitationFreq(Hz)=0.000000  
Amplitude(fT)=1.00E+9  
Decimation=FALSE  
ExcitationAmplitude(fT)=1.00E+9  
[Misc]  
FLL resource name=COM1  
DataRootPath=/C/MagScan/Experiment_Data  
TemporaryRootPath=/C/MagScan/Temporary
```

5.3 Speed Adjustment

The speed can be adjusted. Go to C:\MagScan\Configuration*.ini. Current.ini is the most recent settings, and Default.ini is the factory default. Change the row for "MotorVelocity". There is no absolute position feedback, so if you make it too high, it will miss steps and have an inaccurate position. We do not recommend speed settings above 100.

5.4 The Main Window

At the end of the software initialization process the **Main** window remains (see Figure 174). The Main window is broken down into five different sections, namely the **User Log**, **Parameter Input**, **Time Display**, **Status Display** and **3D Scan Display**.

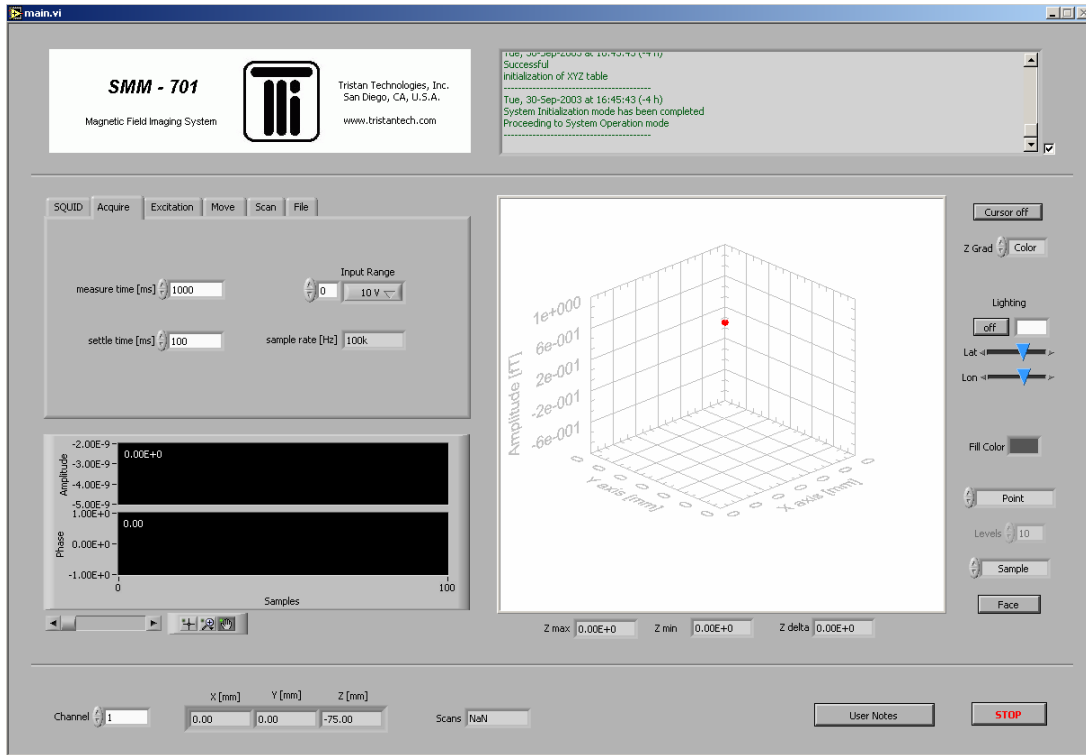


Figure 17 The Main Window

5.4.1 User Log

The **User Log** is a tool which displays and logs software commands for use in documenting scanning experiments (see Figure 185). The logs are automatically saved in the C:\MagScan\System_Log directory in separate folders for the month and year of the log. A separate log is kept in the folders for every time the software is run and is automatically named by the date and time of the software start. When the box to the right of the user log display is checked, the display auto-scrolls to the bottom of the log to display the most recent commands. To view previous commands from the current log, uncheck the box and use the scroll bar at the right of the display. To view logs of previous runs, access the .txt format files in the directory.

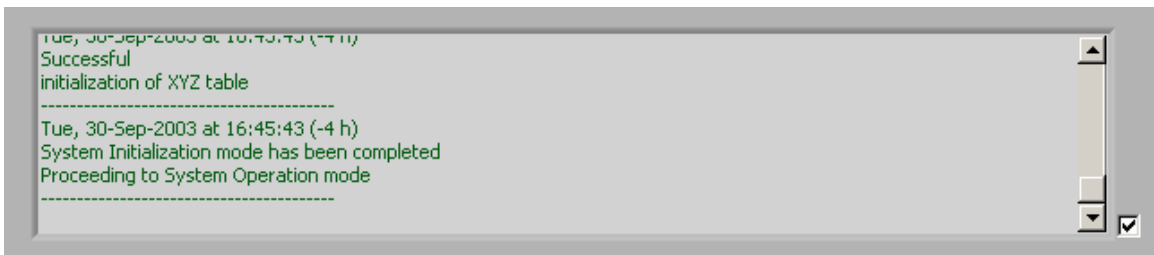


Figure 18 User Log Section of Main Window

5.4.2 Parameter Input

The **Parameter Input** section of the main window provides the controls for setting up, initiating and saving data. The section is made up of six tabs, each of which controls a different aspect of the measurement process.

The **SQUID** tab (see Figure 196) has controls that perform functions available from the front panel of iMAG SQUID controller. These functions are described in the iMAG SQUID Controller Manual. These controls are disabled during a scan, but may be used between scans, or when a scan is paused.

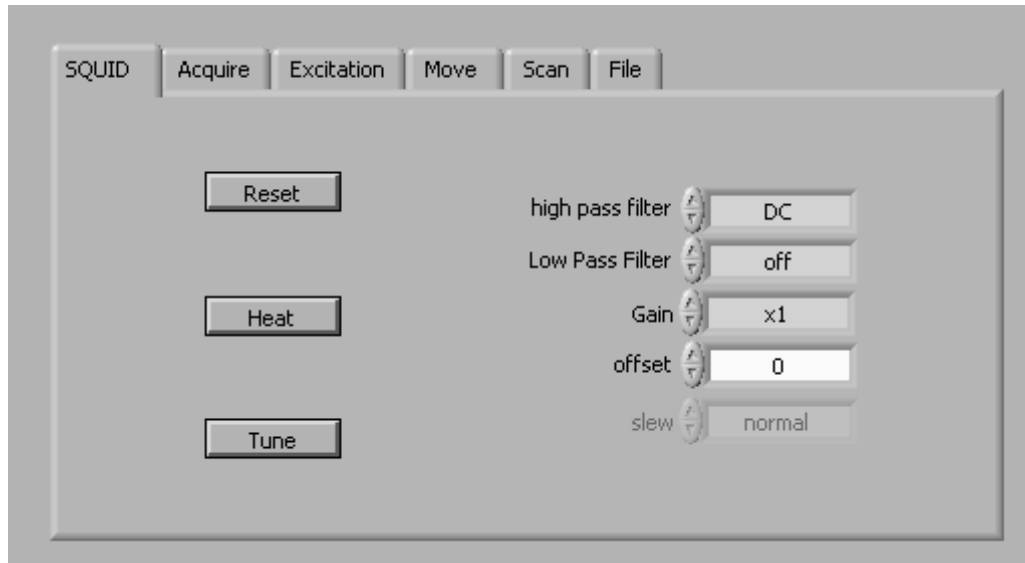


Figure 19 SQUID Parameter Input of Main Window

The **Acquire** tab (see Figure 207) has controls for the acquisition of data. **Measure time** sets the duration of the acquisition used for the measurement of each point in a scan. **Settle time** sets the duration of acquisition after a move that is discarded. It may be necessary to set this non-zero to allow for mechanical and SQUID settling. **Input ranges**, controls the maximum range of the acquisition hardware for each channel. The channel is selected by the numeric control and range by the menu. The range is plus or minus the indicated value. This controls the pre-amplifier gain of the acquisition hardware. **Sample Rate** is fixed at 100 kHz.

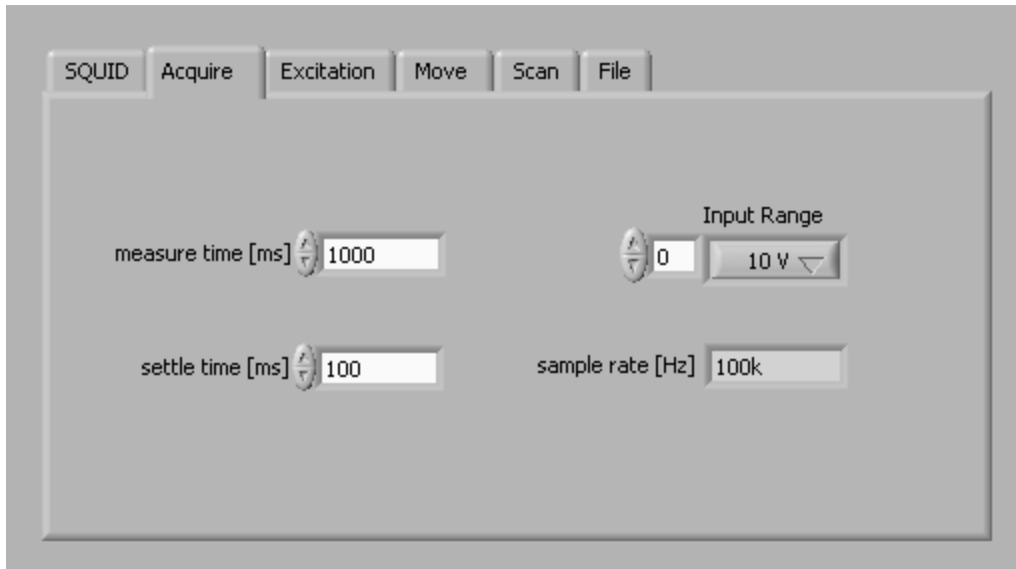


Figure 20 Acquire Parameter Input of Main Window

The **Excitation** tab (see Figure 21) controls the output of the AC magnet. **Frequency** sets the cycles per second of the signal and **Amplitude** sets the magnetic flux density at the bottom of the dewar tail. When frequency is set to zero and amplitude is set to a non-zero value, the magnet output is DC. When Amplitude is set to zero there is no magnet output. *This tab has been removed for the Wright-Patterson installation as there is no AC magnet currently included with the system.*

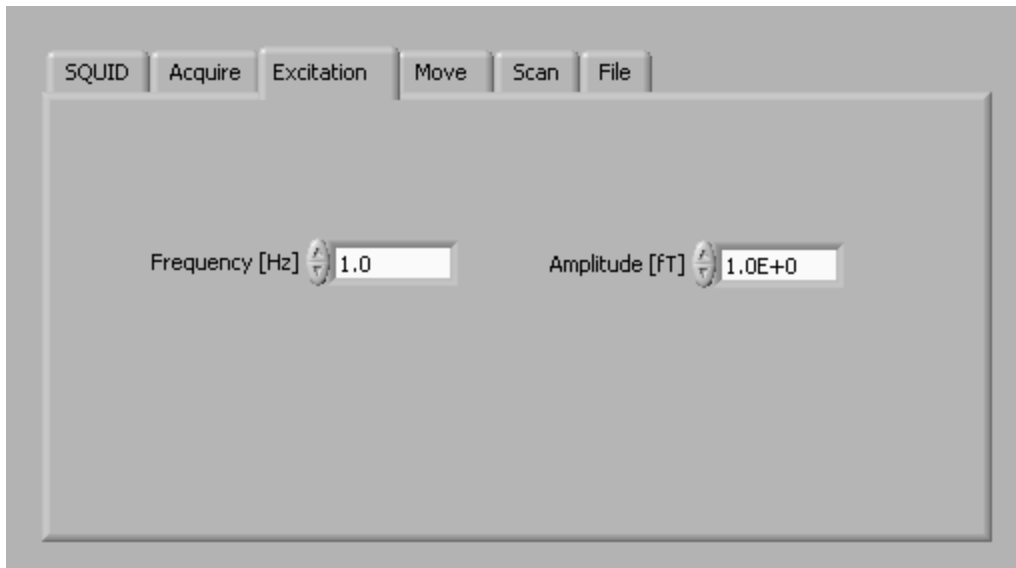


Figure 21 Excitation Parameter Input of Main Window

The **Move** tab (see Figure 229) controls both stage position and stage position limits. To move an axis, change the value for that axis for **Position**. To redefine stage position limits, change the value of the position to the desired limit and then click on the corresponding numerical value for either the **+** or **- Limit**.

WARNING

MOVING STAGES INTO OBSTRUCTIONS COULD CAUSE DAMAGE TO THE OBSTRUCTIONS AND/OR TO THE SMM-701G SYSTEM WHICH ARE NOT COVERED BY THE TRISTAN TECHNOLOGIES LIMITED WARRANTY. BE AWARE OF THE CONSEQUENCES OF MOVING OR CHANGING THE LIMITS OF THE MOTION BEFORE EXECUTING COMMANDS. SHOULD THE MOTION NEED TO BE STOPPED AT ANY TIME FOR AN EMERGENCY, TURN OFF EITHER THE AC POWER OR ENABLE SWITCHES ON THE FRONT OF THE NATIONAL INSTRUMENTS MID-7604 MOTION CONTROLLER.

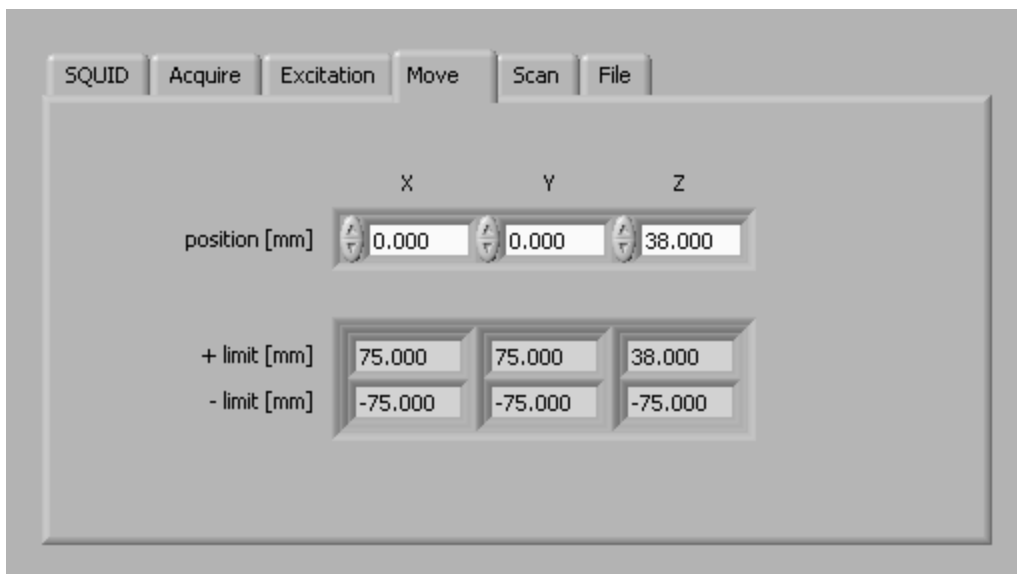


Figure 22 Move Parameter Input of Main Window

The **Scan** tab (see Figure 2320) controls the motion of the scanning stage during a measurement. For each axis the **Center** value selects the position of the center of the area to be measured. The **Step** value controls the distance the sample stage moves per step in each axis. The **N** value controls the number of steps taken per axis. The motion is carried out in the following order: all positions of X are scanned for a given Y, then the Y value changes and all positions of X for the new Y value are measured. When all positions have been measured for a X-Y plane are measured at a given Z, then the Z value changes and all positions in the X-Y plane for the new Z value are measured. The yellow Scan button starts and pauses scans. The numerical value to the right of the yellow scan button selects the number of times each position in X-Y-Z is scanned. If the number of scans selected is greater than one, the measured values from each scan are averaged for each position measured. The Clear button removes existing data which is being displayed.

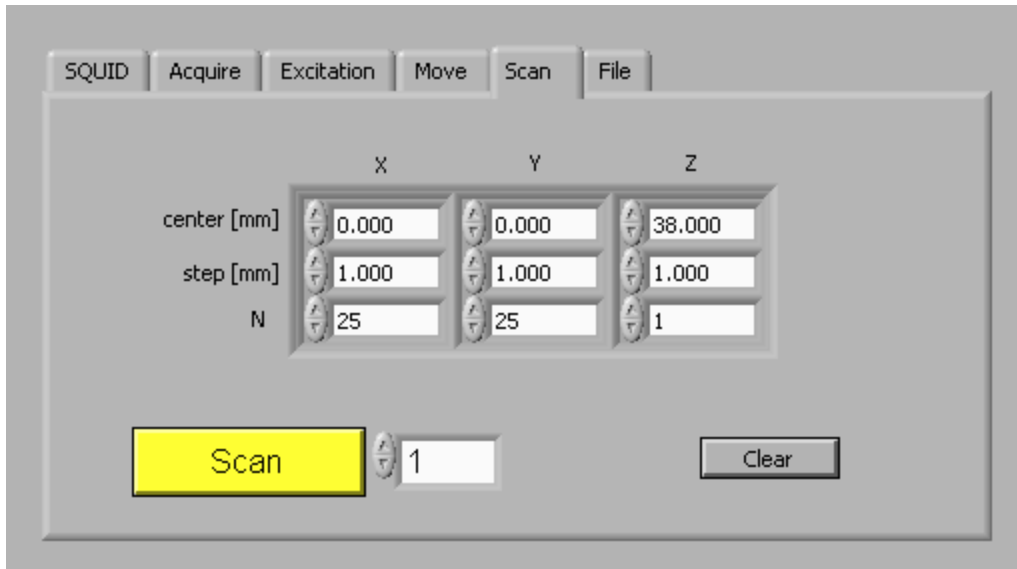


Figure 23 Scan Parameter Input of Main Window

The **File** tab (see Figure 24) controls the handling of acquired data. The yellow **Save Data** button allows acquired data to be saved. The **Save Image** button allows the current 3D scan display to be saved as a jpeg image. The **Load Sample** button allows previously acquired data to be displayed on the 3D scan display for analysis. The **Load Reference** button allows previously acquired data to be loaded as reference data for sample comparison and noise reduction purposes. The **Delete** button allows for previously acquired data to be selected and removed from the computer.

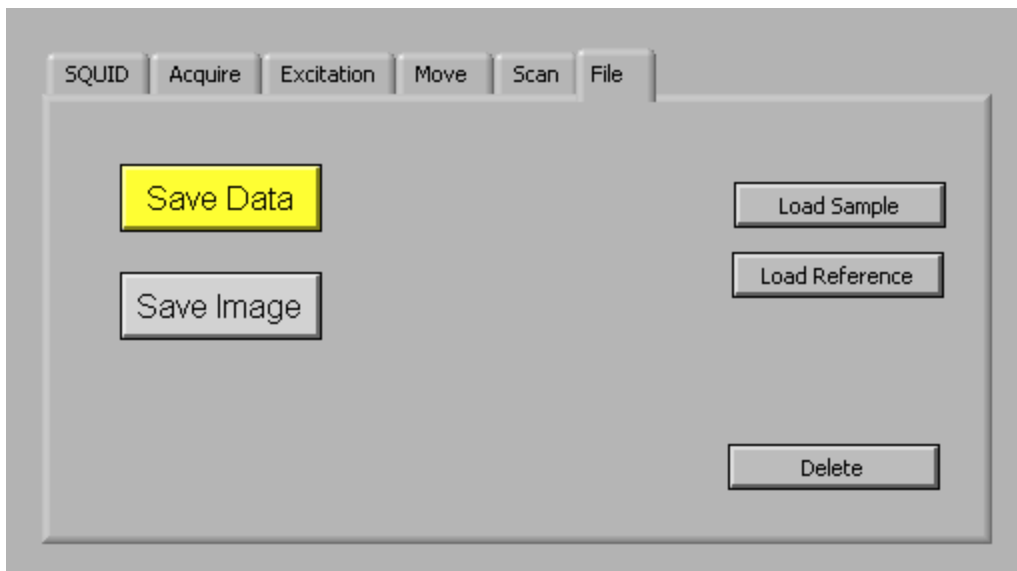


Figure 24 File Parameter Input of Main Window

5.4.3 Time Display

During a measurement, the **Time Display** (see Figure 25) gives a real-time 1D picture of the Amplitude and Phase (relative to the magnet output) of the data being acquired. The controls below the graphs allow for pan and zoom functions within the display.

Right-clicking the mouse while pointing the cursor over the graph opens more graph controls.

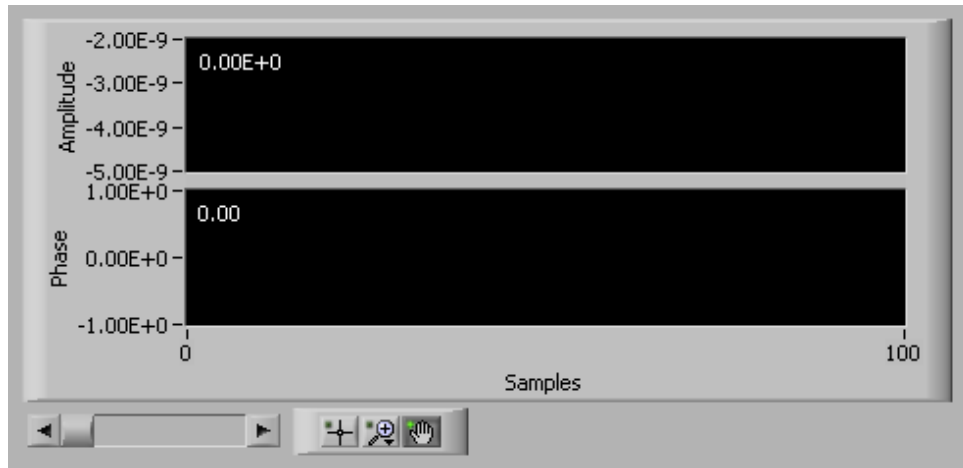


Figure 25 Time Display in Main Window

5.4.4 Status Display

The **Status Display** (see Figure 263) gives information regarding the current status of the system. The **Channel** is always set to a value of “1” because the system contains a single channel of data acquisition. The **X-Y-Z** values display the current position of each axis of the motion control stages. The **Scans** value is an indicator of the progress of the system as it is running a scanning measurement. If one scan is selected and is measuring 100 different positions, then the scan value will increase by 0.01 each time a measurement is taken. At the end of a measurement, the scan value is equal to the number of scans selected. To add experiment information to the user log for purposes of documentation, select the **User Notes** button. This feature allows the user log to be used as a limited laboratory notebook.

WARNING:

if you want to stop the scan process, do not press the **STOP** button, press the **Scanning** button

When the **Stop** button is pressed, the software will shut itself down. After it has done so, it is safe to close the main window.



Figure 26 Status Display in Main Window

5.4.5 3D Scan Display

The **3D Scan Display** (see Figure 274) is an analysis tool which can be used in real-time, with current data or with previously acquired data. Amplitude is displayed in fT (femtoTesla). Strictly speaking (because the SQUID sensor is a gradiometer), the units should be fT/cm. The fT notation is used for software compatibility with other Tristan SMM scanning SQUID systems.

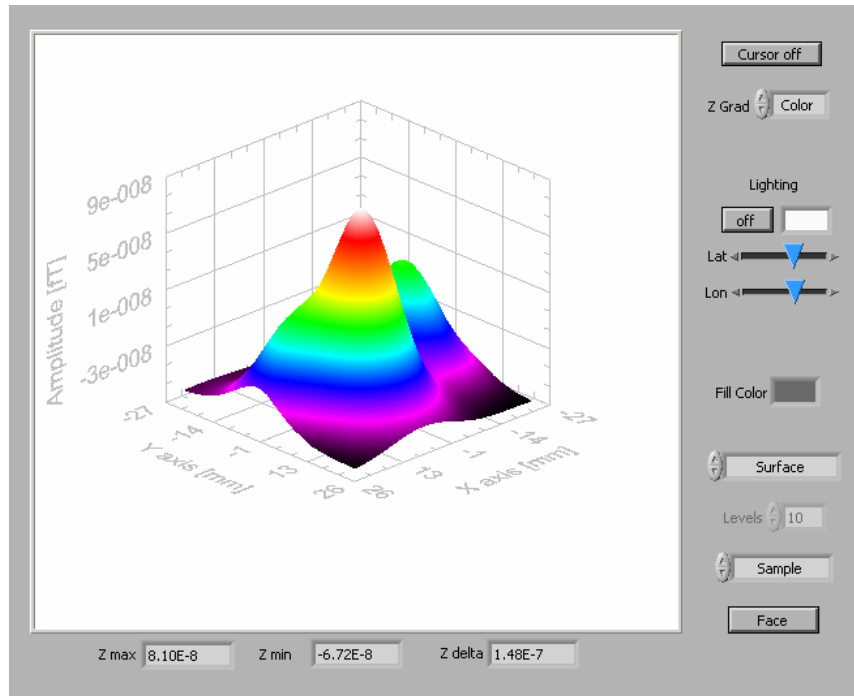


Figure 27 3D Scan Display in Main Window

The display may be rotated in any direction (see Figure 285) by using the computer mouse to place the cursor on the display, press and hold the left mouse button and move the mouse.

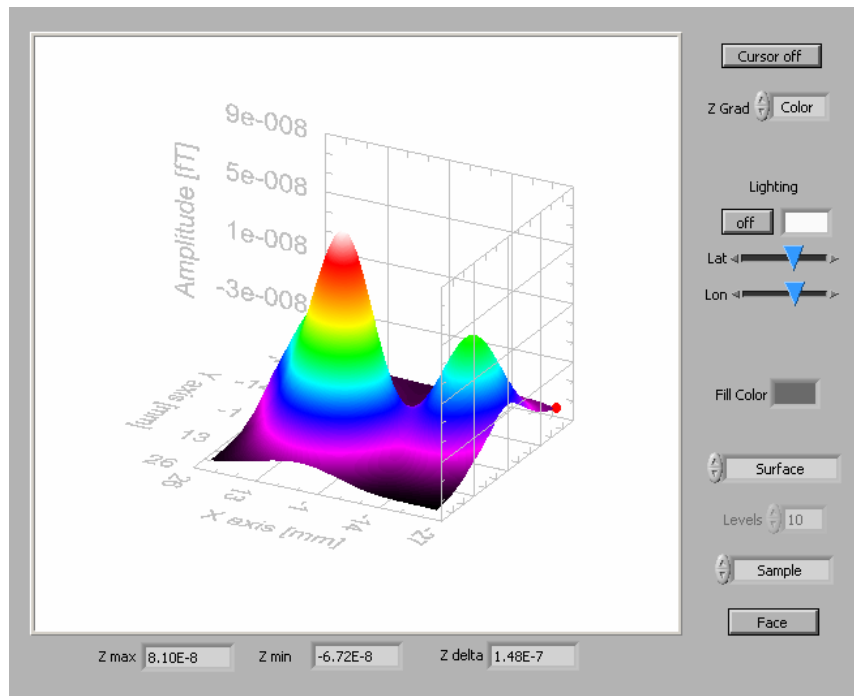


Figure 28 3D Rotation of 3D Scan Display

Holding down the ALT key of the computer keyboard, pressing and holding the left mouse button and moving the mouse allows for zooming in and out of the display (see Figure 296 and Figure 307).

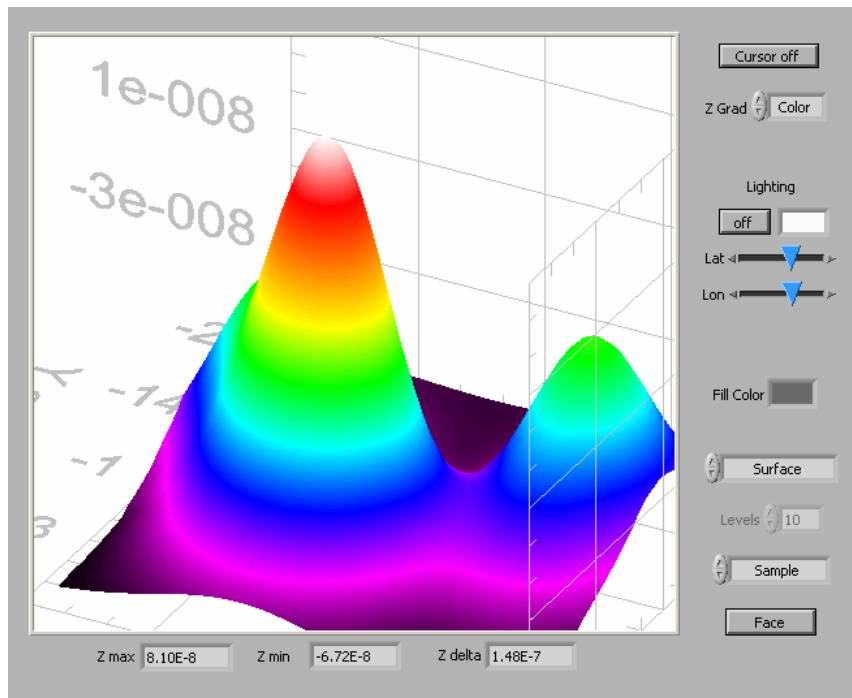


Figure 29 Zoom In of 3D Scan Display

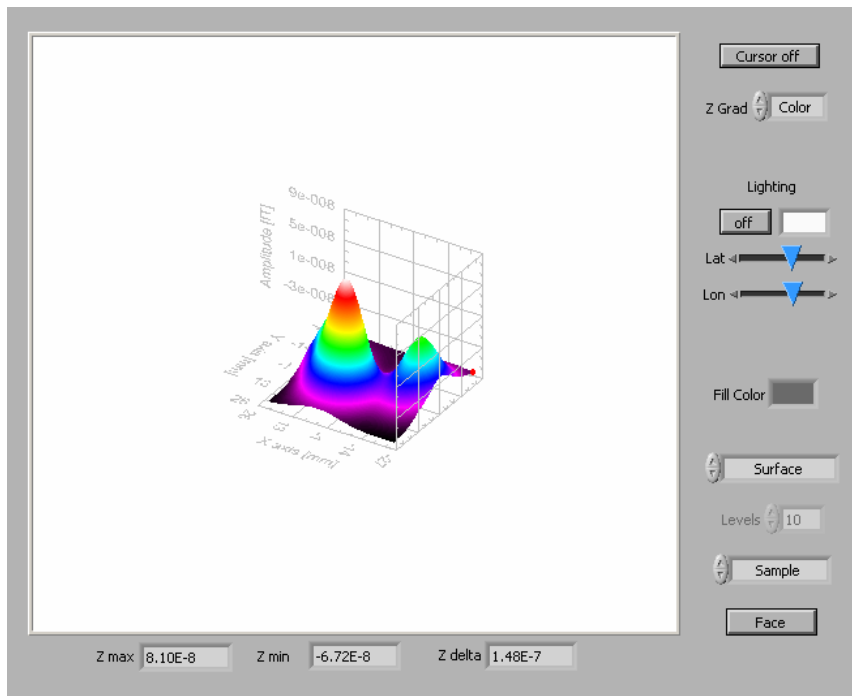


Figure 30 Zoom Out of 3D Scan Display

Holding down the SHIFT key of the computer keyboard, pressing and holding the left mouse button and moving the mouse allows for panning of the display (see Figure 318).

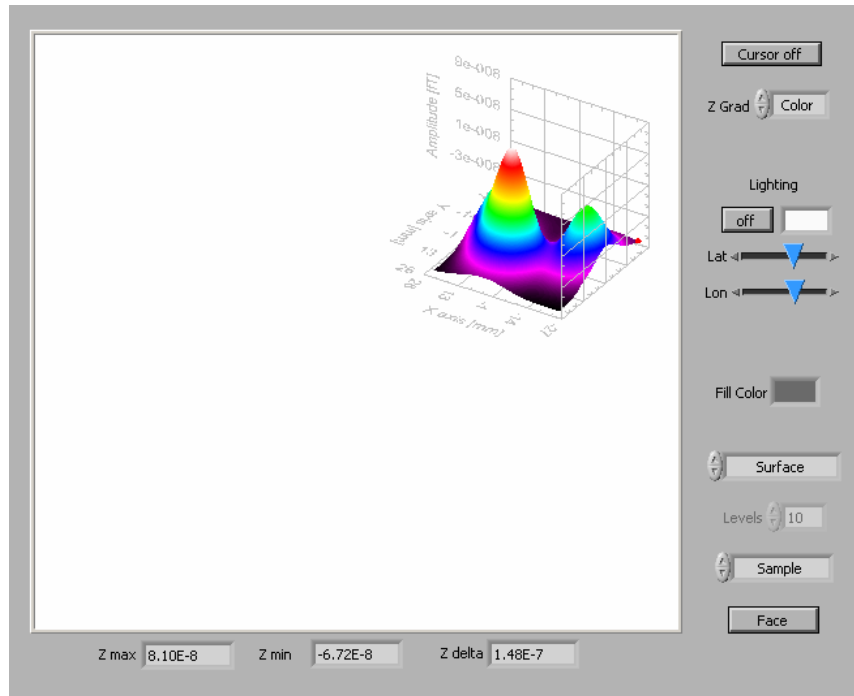


Figure 31 Panning of 3D Scan Display

The **Cursor** button turns on a cursor (see Figure 329) which may be moved about the graph using the left mouse button to find amplitude at data point positions.

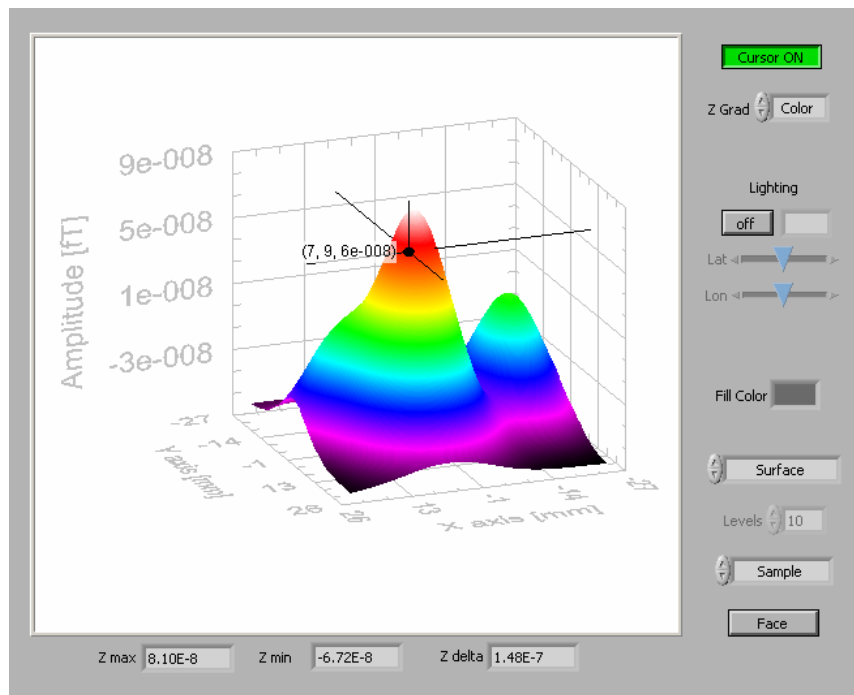


Figure 32 Cursor On in 3D Scan Display

The **Lighting** feature (see Figure 33) allows a virtual light to be powered and moved in latitude and longitude for better perception of the 3D surface.

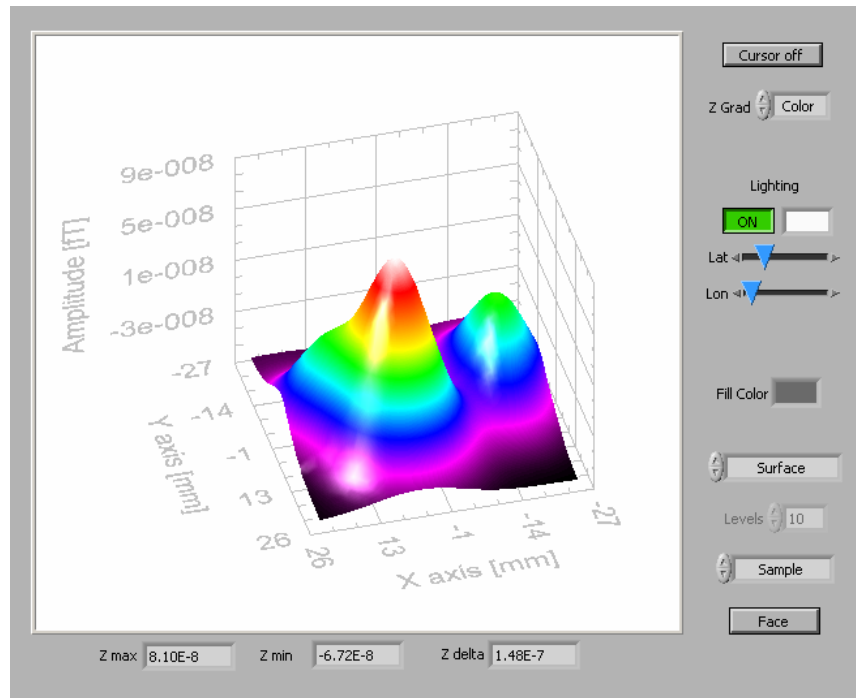


Figure 33 Lighting Effects in 3D Scan Display

Selecting **Point** removes the surface smoothing from the display and shows the point of data that were acquired (see Figure 34).

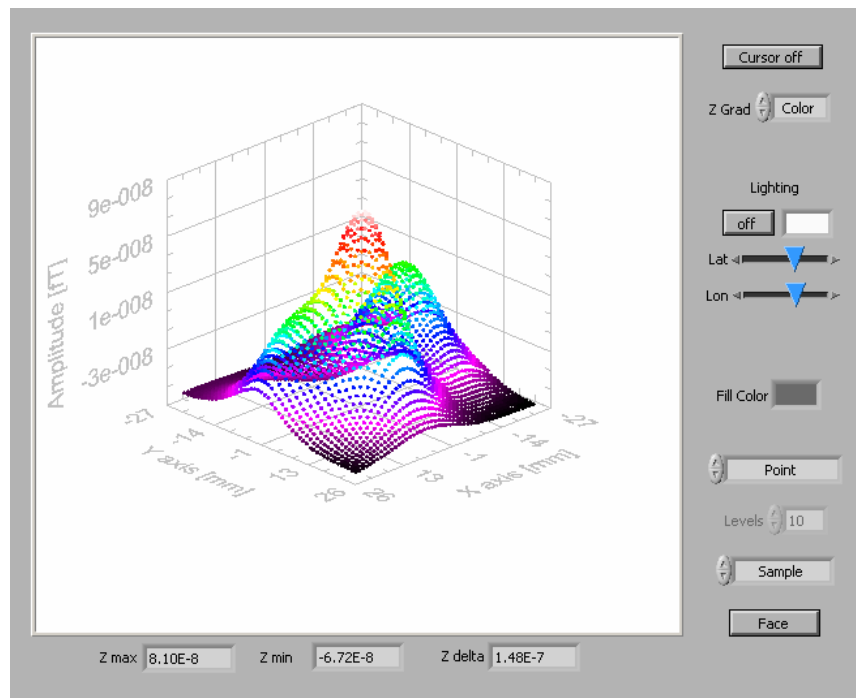


Figure 34 Points in 3D Scan Display

Surface Contours may be added to a surface for better perception of the 3D surface (see Figure 3532). The number of contour levels on the graph is selectable by changing the **Level** value.

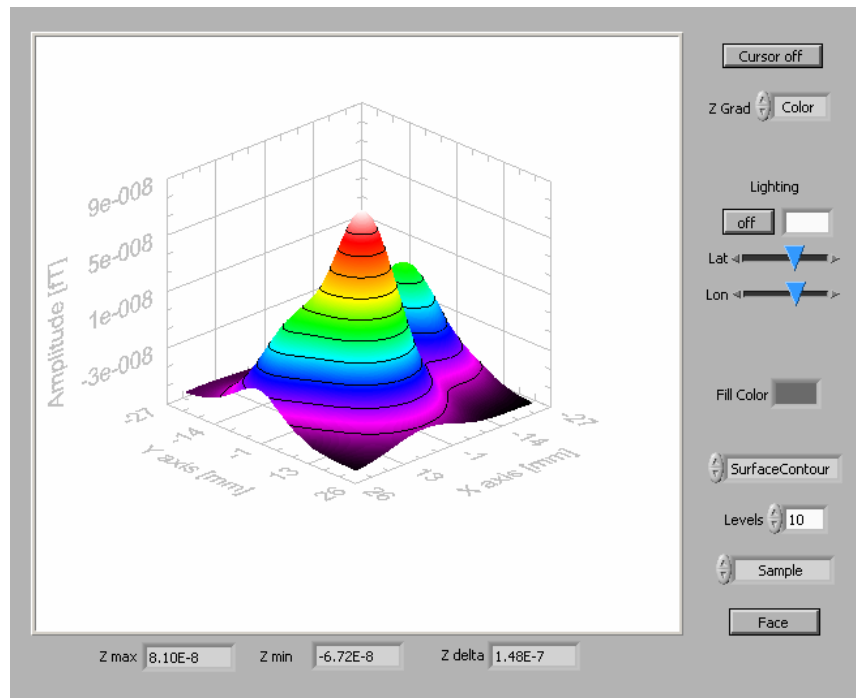


Figure 35 Surface Contours in 3D Scan Display

Surface Normals may be displayed as well (see Figure 363).

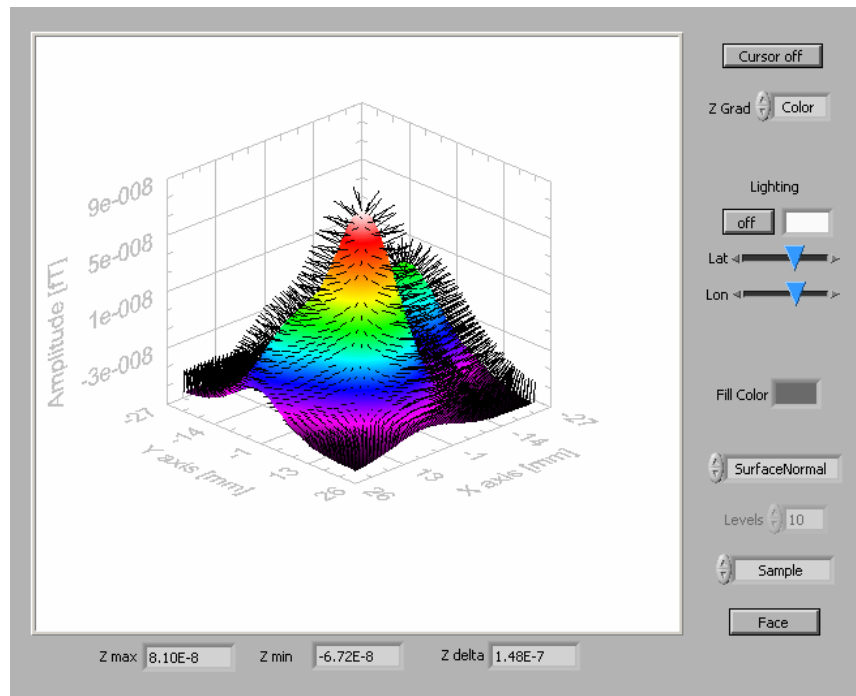


Figure 36 Surface Normals in 3D Scan Display

When data different data sets are loaded as sample and reference, the two can be toggled between the **Sample** and **Reference** for purpose of comparison (see Figure 374). Additionally, the **Sample vs. Reference** setting subtracts the reference amplitude from the sample amplitude for each measured value of X and Y to display the differences between two data sets. For use in noise reduction, a series of data sets should be collected without a sample on the scanning stage to be used as the reference. Then a series of data sets can be taken with samples. In the sample vs. reference mode, the average background and environmental noise will be significantly reduced.

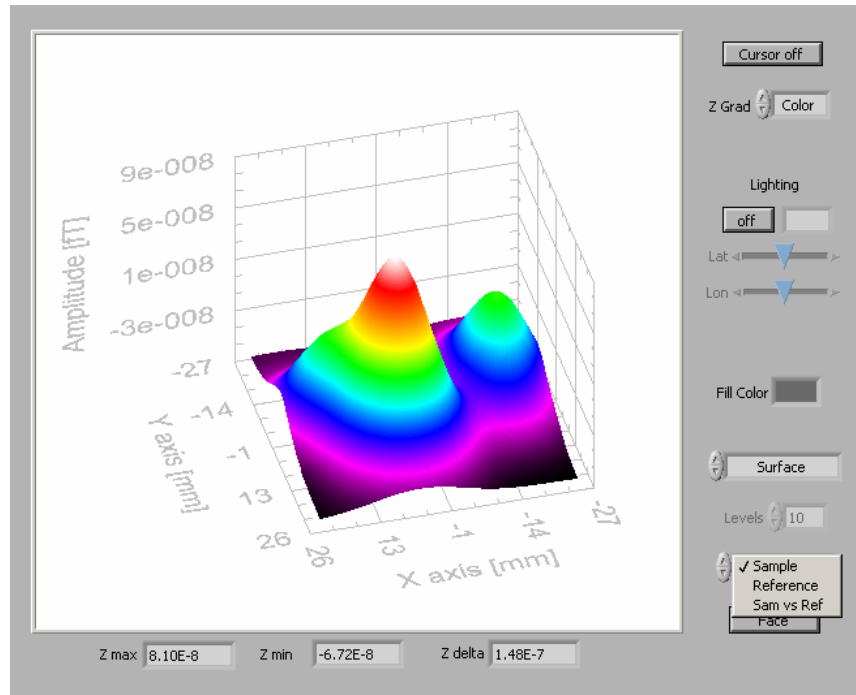


Figure 37 Sample vs. Reference in 3D Scan Display

To quickly view the graph from directly above the X-Y plane, click on the **Face** button (see Figure 385).

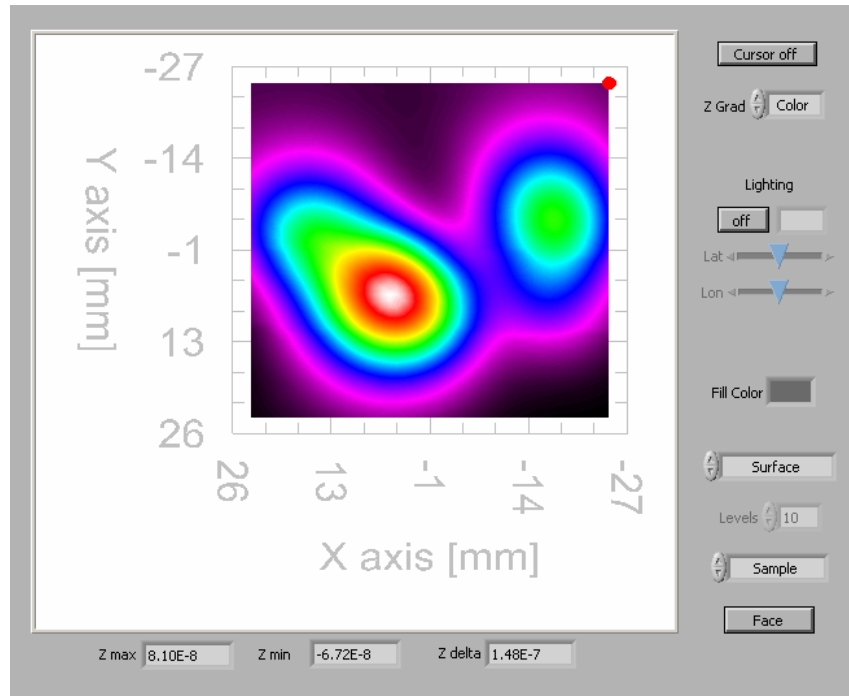


Figure 38 Face X-Y Plane in 3D Scan Display

5.5 Software Help

A brief description of software features may be accessed at any time by pressing CTRL+H and moving the mouse cursor over the main window. To close the help either press CTRL+H again or close the help dialog window.

5.6 Sample scan

It is recommended that the user begin with a simple object and to familiarize him/herself with the capabilities of the SMM-701G. This will allow the user to vary the scan parameters and compare their effects on a known output.

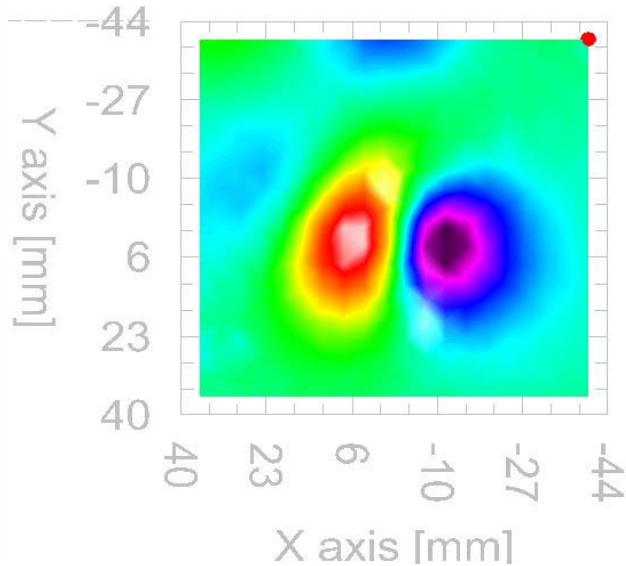


Figure 39 dB_z/dx scan of magnetic dipole

Figure 39 shows a scan of a small magnetic dipole with the SQUID gradiometer in the horizontal (dB_z/dx) orientation (tuning parameters given in section 0.). The sample was made by cutting off a small (~1 mm) section of a paperclip. Another sample could be a straight wire with a current flowing through it (Figure 40). Section 6.1 discusses the difficulties associated with current sources.

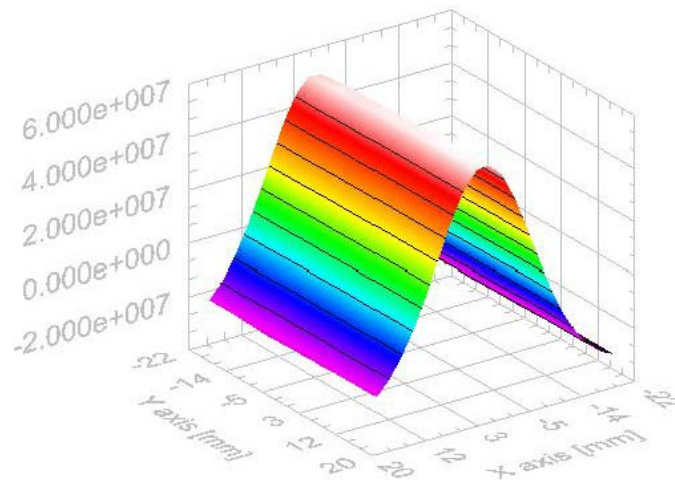


Figure 40 Magnetic field gradient (dB_z/dx) generated by a 1 mA current wire oriented in the y direction.

5.7 File Format

5.7.1 Data file:

```
<start description>
scan of paperclip...25x25 steps @ 1.0mm and z=30
<end description>

<start miscvar>
File Format Version      1.0
Scan Start Time          Tue, 21-Sep-2004 at 14:38:20 (-7 h)
Scan Stop Time           Tue, 21-Sep-2004 at 15:14:25 (-7 h)
Total Scans              1.00
Total Samples            400
Total Channels           2
Center XYZ               0.00,0.00,30.00
```

```

Step XYZ 4.00,4.00,1.00
n XYZ 20,20,1
<end miscvar>

<start header>
X position [mm] Y position [mm] Z position [mm] Ch1_Amplitude [fT] Ch1_Phase [deg] Ch2_Amplitude [fT] Ch2_Phase
[deg]
<end header>

<start databody>
-40.000 -40.000 30.000 -3.20792E+7 0.00000E+0 -8.10658E-2 0.00000E+0
-36.000 -40.000 30.000 -3.06972E+7 0.00000E+0 -8.07005E-2 0.00000E+0
-32.000 -40.000 30.000 -3.04671E+7 0.00000E+0 -8.00491E-2 0.00000E+0

-32.000 36.000 30.000 -3.12402E+7 0.00000E+0 -8.44737E-2 0.00000E+0
-36.000 36.000 30.000 -3.13715E+7 0.00000E+0 -8.41468E-2 0.00000E+0
-40.000 36.000 30.000 -3.11499E+7 0.00000E+0 -8.35829E-2 0.00000E+0
<end databody>

```

5.7.2 Acquisition parameters file (current.ini):

```

[Motion]
MotorEnabled=TRUE
MotorConv(steps/mm)=-3200.000000,-3200.000000,-1250.000000
MotorSet(steps/rev)=3200,3200,3200
MotorVelocity=50.000000
MotorAccel=20.000000
ResetPos(mm)=-9.5125,-8.2812,-75.5000
InitPos(mm)=0.00,0.00,-75.000
PosLimit(mm)=75.000000,75.000000,38.000000
NegLimit(mm)=-75.000000,-75.000000,-75.000000
Center(mm)=0.00,0.00,38.00
N=25,25,1
Step(mm)=1.00,1.00,1.00
MotorEnable=TRUE
[DAQ]
NumChans=2
CoilCalibration(fT/V)=2.00E+9,1.00E+0
ExcitationCalibration(fT/V)=8.47E+7
MeasureTime(ms)=998
SettleTime(ms)=100
InputRange(V)=10.0,10.0
HighPassFilter=0
LowPassFilter=0
Gain=1
Offset=0
Slew=0
ExcitationFreq(Hz)=0.000000
Amplitude(fT)=1.00E+9
Decimation=FALSE
ExcitationAmplitude(fT)=1.00E+9
[Misc]
FLL_resource_name=COM1
DataRootPath=/C:/MagScan/Experiment_Data
TemporaryRootPath=/C:/MagScan/Temporary

```

6. TROUBLE SHOOTING

The greatest obstacle to SQUID measurements is external noise sources. Metallic shielding can minimize external noise (e.g., act as a low pass eddy current shield). In the case of HTS SQUID sensors, the use of high permeability mu-metal shields (such as the Tristan MS-830) can significantly attenuate external field variations. This assumes that any electrical inputs to the experimental region have been appropriately filtered. Powerline or microprocessor clock frequencies can severely degrade performance. Unfortunately, if external objects are to be measured, external shields are not appropriate. However, external shields are helpful in verifying proper operation of the SQUID system and electronics.

When measuring external fields, the SQUID magnetometer must operate in an environment — the magnetic field of the earth — that can be 10 orders of magnitude greater than its sensitivity. The magnetic field at the surface of the earth is generated by a number of sources. There exists a background field of ~50 μT with a daily variation of $\pm 0.1 \mu\text{T}$. In addition, there is a contribution (below 1 Hz) from the interaction of the solar wind with the magnetosphere. The remaining contributions to external magnetic fields

are primarily man-made. These can be caused by structural steel and other localized magnetic materials such as furniture and instruments that distort the earth's field and result in field gradients, moving vehicles that generate transient fields, electric motors, elevators, radio, television, and microwave transmitters, and the ever present powerline electromagnetic field and its harmonics.

It is highly advisable to perform initial tests in a magnetically shielded environment. If you do not have a shielded room, measurements made after midnight or on the weekend can be compared to measurements during the day to see if there are environmental effects. In areas where rfi is extreme, it is advisable operate the system in an rf screened (eddy current) room. If this is not possible, wrapping the dewar in household aluminum foil may improve the situation. This acts as an eddy current shield. While it may reduce the system's bandwidth (depending on the amount of aluminum foil used) and perhaps increase the system's white noise, it can be very effective in attenuating rfi.

As mentioned above, significant gradient noise can be introduced if the dewar is positioned near a metal fixture (such as a steel filing cabinet) or a power distribution box. If a planar gradiometer is being tested, rotating the gradiometer (anywhere from 30°~90°) can often make a significant change in the measured gradient noise.

During the initial testing, be sure that the system is on a sturdy platform. A flimsy table may cause motion induced noise. Also be sure that the platform (or whatever mounting is being used) is free of any ferromagnetic contaminants. Avoid using conductive metal tables as they can couple in gradient noise.

6.1 dc current supplies

When generating dc currents, avoid the use of any power supply driven by 60 cycle ac current. Many current sources have a large amount of high-frequency noise in their output. This is frequently large enough to prevent reliable operation of the system. This will show up as rapid jumps in the output voltage or, in the extreme case, a steady full-scale drift in the output which indicates that the feedback loop is completely inoperative. In this situation, you will observe that the SQUID's periodic transfer function ("triangles") will be severely degraded or completely unobservable.

The Tristan model CCS Constant Current Source has a relatively noise-free stable current supply. The article "Constant-current supply of 3 ppm stability and resettability; application for a SQUID" by Levy and Greenfield, *Review of Scientific Instruments*, volume 50 (May) 1979 pp. 655 – 658 describe how to build a suitable current source.

Even if the current source is quiet, rf pick up on the leads connected to the current source can introduce substantial rf interference. If you suspect that rf interference from the current source, or the leads connected to it, is a problem, you should observe the periodic transfer function using the Analog Output on the iMC-303 Controller rear panel. This is described in Section 3.9.6 of the iMAG SQUID System manual. First, tune the channel by pressing the TUNE Key. Then switch to the MANUAL TUNE display and observe the sinusoidal transfer function via the Analog Output BNC. The transfer function should look like a clean, steady, approximately sinusoidal signal with the current source disconnected from the probe. If it is severely degraded when the current

source is connected to the probe, you can be sure that it is causing a problem. You will need to replace the current source or improve the shielding of the leads. Alternatively, you can install additional rf filtering in the output lines from the current source.

7. MAINTENANCE

7.1 DEWAR VACUUM

Prior to cooling down (especially if the dewar has been at room temperature for a long period of time), the dewar vacuum should be checked to verify that the vacuum space is evacuated.

There is a small amount of nitrogen diffusion that occurs during normal operation through the warm, upper portion of the neck tube. Large quantities of air, water, and other gasses are also outgassed from the warm, interior surfaces of the dewar vacuum space. However, there is a getter in the vacuum space which absorbs large amounts of gas when the dewar is cold.

Eventually, the vacuum space of the dewar will need to be re-evacuated. This will become obvious in one of two ways:

- The nitrogen evaporation rate will increase during normal operation. If the evaporation rate has increased by more than 30%, you should consider re-pumping the vacuum space.
- You will be unable to transfer liquid nitrogen. All of the nitrogen transferred into the dewar will immediately evaporate. If the vacuum is extremely poor, the outside of the dewar may get cold and even condense water, especially along the tail.

If you suspect a poor vacuum, use the following procedure to check and pump on the vacuum:

WARNING:

EXTREME caution must be used when examining the vacuum. There are many fine layers of superinsulation in the vacuum space. Rapid changes in pressure may cause rupturing of the superinsulation. Therefore, NEVER abruptly open the dewar vacuum space to atmospheric pressure; the dewar vacuum should be slowly vented over a period of about 15 minutes. The nitrogen reservoir must always be at room temperature when gas is admitted to the vacuum space or when it is being pumped.

The dewar is equipped with a vacuum space evacuation valve mounted on the dewar top. Before opening this valve, a leak-tight connection should be made to it and the pumping line to the valve should be evacuated using a leak detector or a pumping station equipped with a diffusion pump and cold trap (or other pumping system with equivalent capability). The cold trap is necessary to prevent back-streaming of pump oil into the vacuum space after it has reached a low, static pressure.

WARNING:

OPEN THE VALVE VERY SLOWLY AND OBSERVE THE PRESSURE IN THE DEWAR. DO NOT BEGIN PUMPING UNTIL YOU OBSERVE THE PRESSURE.

If you observe a high pressure (more than a few torr), you should pump the vacuum space very slowly by opening the valve as little as possible.

A satisfactory vacuum is about 100-200 millitorr *when the whole dewar is at room temperature*. Depending on the pressure, it may take up to 24 hours to obtain a satisfactory pressure.

WARNING:

DO NOT LEAVE THE DEWAR PUMPING UNATTENDED.

Since most of the time required is for outgassing of the surfaces in the dewar, it is better to pump the dewar for 15 minutes every few hours. There is little advantage to leave the pump connected continuously.

If your leak detector indicates any helium gas, it may be advantageous to flush the vacuum space once with nitrogen gas. Slowly fill the vacuum space with 10 torr of nitrogen gas (this should not be done at a rate faster than 1 torr per minute). It should then be re-evacuated as described above. This procedure may be repeated several times until the helium level is low.

WARNING:

THE PRESSURE IN THE VACUUM SPACE MUST NEVER BE ALLOWED TO CHANGE QUICKLY. RAPID PRESSURE CHANGES WILL CAUSE PERMANENT DAMAGE TO THE THERMAL SHIELD AND SUPERINSULATION.

If the dewar does not perform well after pumping the vacuum, or if it requires pumping at intervals more frequent than once a year, there may be a leak in the dewar. If you suspect this problem, contact your Tristan representative for assistance.

7.2 HIGH TEMPERATURE SQUID SENSOR ADVISORY

In order to insure optimum performance for your Tristan High Temperature SQUID system, the following handling precautions should be followed. Carefully adhering to these procedures will allow your instrument to function accurately for the duration of the warranty period and beyond. Please feel free to contact Tristan with any questions.

7.2.1 Handling for Shipping and/or Storing at Room Temperature

- SQUIDS are electro-static discharge (ESD) sensitive devices. Always store them in appropriate ESD safe packaging.

- Use appropriate static sensitive handling equipment such as ESD mats and wrist straps when handling and connecting High Temperature SQUIDs.
- Connect the shunting plug at the top connector when the SQUID is not in use for extended periods and always for shipment. See Figure 41.

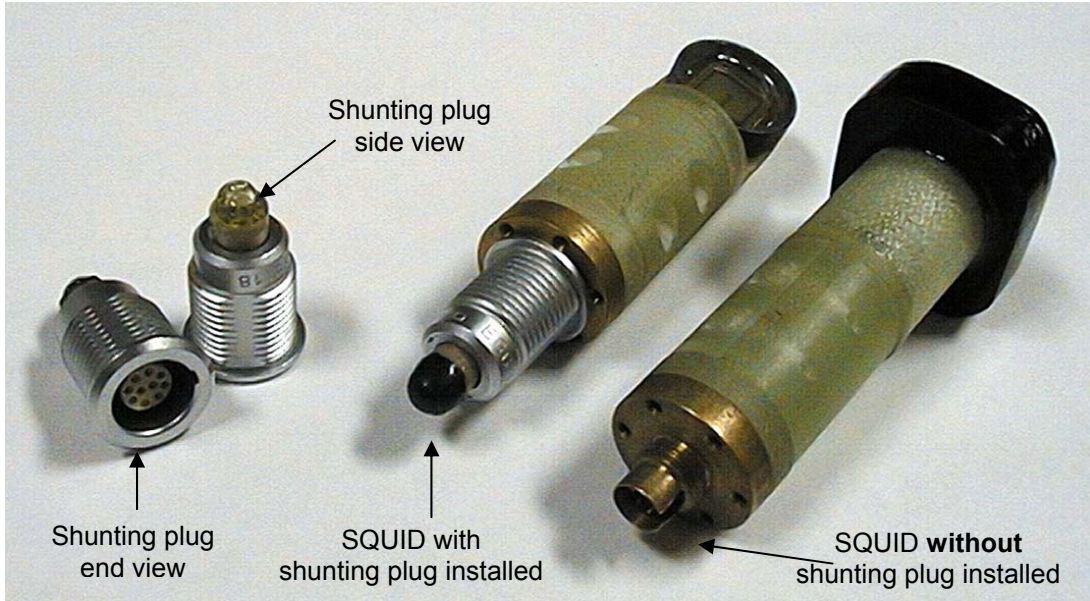


Figure 41 Shunting Plugs

Be sure to install shunting plugs on the connector of the SQUID when it is not in use for extended periods or during shipping.

- Store the SQUID sensor in a moisture free environment by using desiccant in conjunction with a closed container. ***This is especially important in humid or damp environments.*** Typically desiccant (Silica Gel) appears **blue** when active and **red** or **pink** when saturated with moisture. See Figure 42.



Figure 42 Silica Gel Indicator Colors

A **Blue color** indicates that the desiccant is still active. A **Red color** indicates that the desiccant should be replaced.

- When warming the SQUID sensor, immediately place the SQUID sensor in a plastic bag when it is removed from the cryogen to minimize the condensation of water vapor on the cold surfaces. After the SQUID sensor reaches room temperature, dry the body of the SQUID sensor / Probe (observing ESD precautions) and then store with desiccant.
- When testing the SQUID cables at room temperature limit the current by using a manual range on a low current digital multi-meter. Do not use the auto-range function of the digital multi-meter. Select the “KΩ range”.
- Do not heat the SQUID (using HEAT button on the Tristan model iMC-303 SQUID Control Electronics or equivalent heating circuit) at when the SQUID sensor is at room temperature.
- Ship the SQUID sensor with the shunting plug attached and in a closed container with desiccant inside.
- **NEVER** allow the SQUID to sit in a sealed dewar with water condensed on the bottom.

WARNING:

MOISTURE DAMAGE DUE TO FAILURE TO FOLLOW THESE INSTRUCTIONS *WILL* VOID THE WARRANTY.