Quantum Design

Physical Property Measurement System

VSM Ultra-Low Field Option User's Manual

Part Number 1096-500

Quantum Design
6325 Lusk Boulevard
San Diego, CA 92121
USA
Technical support (858) 481-4400
(800) 289-6996
Fax (858) 481-7410

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Trademarks

U.S. Patents
4,791,788 Method for Obtaining Improved Temperature Regulation When Using Liquid Helium Cooling
4,848,093 Apparatus and Method for Regulating Temperature in a Cryogenic Test Chamber
5,311,125 Magnetic Property Characterization System Employing a Single Sensing Coil Arrangement to Measure AC Susceptibility and DC Moment of a Sample (patent licensed from Lakeshore)
5,647,228 Apparatus and Method for Regulating Temperature in Cryogenic Test Chamber
5,798,641 Torque Magnetometer Utilizing Integrated Piezoresistive Levers

Foreign Patents
U.K. 9713380.5 Apparatus and Method for Regulating Temperature in Cryogenic Test Chamber

CE

Safety Instructions

No operator-serviceable parts are inside. Refer servicing to qualified personnel.

For continued protection against fire hazard, replace fuses only with same type and rating of fuses for selected line voltage.

Observe the following safety guidelines when you use your system:

- To avoid damaging the system, verify that the system power requirements match the alternating current (AC) power available at your location. If the system has not been configured for the correct power available at your location, contact your local service representative before you proceed with the system installation.
- To prevent electrical shock, verify that the equipment is properly grounded with three-wire grounded plugs.
- To prevent electrical shock, unplug the system before you install it, adjust it, or service it.
- Do not spill food or liquids on the system or its cables.
- Refer to the section titled “Safety Precautions” before you install or operate this system. Direct contact with cryogenic liquids, materials recently removed from cryogenic liquids, or exposure to the boil-off gas, can freeze skin or eyes almost instantly, causing serious injuries similar to frostbite or burns.
- Wear protective gear, including clothing, insulated gloves, and safety eye protection, when you handle cryogenic liquids.
- Transfer liquid helium only in areas that have adequate ventilation and a supply of fresh air. Helium gas can displace the air in a confined space or room, resulting in asphyxiation, dizziness, unconsciousness, or death.
- Keep this system away from radiators and heat sources. Provide adequate ventilation to allow for cooling around the cabinet and computer equipment.
- Refer to the manuals for the supplied computer and monitor for additional safety warnings and notices before you operate the system.

Regulatory Information

- This apparatus has been tested to the requirements of the EMC Directive 89/336/EEC.
- This apparatus is defined as ISM Group 1, Class A and B equipment per EN 50011:1991 (industrial and light industrial environment limits of radio frequency emission).
- This apparatus has been tested to the requirement of the Low Voltage Directive 73/23/EEC.
- See the EU Declaration of Conformity for additional regulatory information regarding your PPMS.

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Contents and Conventions

P.1 Introduction

This preface contains the following information:

- Section P.2 discusses the overall scope of the manual.
- Section P.3 briefly summarizes the contents of the manual.
- Section P.4 illustrates and describes conventions that appear in the manual.

P.2 Scope of the Manual

This manual contains background information about the PPMS VSM Ultra-Low Field (ULF) option and instructions for installing the option, using the software and hardware, and performing field-zeroing and profiling operations with it.

P.3 Contents of the Manual

- Chapter 1 provides an overview of the VSM ULF option, its notable features, our safety recommendations, and information for contacting Quantum Design.
- Chapter 2 provides instructions for the initial installation of the VSM ULF option as well as for connecting and removing it from the PPMS and VSM.
- Chapter 3 explains VSM ultra-low-field operations.
- Chapter 4 describes the VSM Ultra-Low Field hardware.

P.4 Conventions in the Manual

File menu	Bold text identifies the names of menus, dialogs, options, buttons, and panels used in the PPMS MultiVu and VSM software.
File >> Open	The >> symbol indicates that you select multiple, nested software options.
`.dat`	The Courier font indicates file and directory names and computer code.
Important	Text is set off in this manner to signal essential information that is directly related to the completion of a task.
Note	Text is set off in this manner to signal supplementary information about the current task; the information may primarily apply in special circumstances.

C A U T I O N !

Text is set off in this manner to signal conditions that could result in loss of information or damage to equipment.

W A R N I N G !

Text is set off in this manner to signal conditions that could result in bodily harm or loss of life.

W A R N I N G !

Text is set off in this manner to signal electrical hazards that could result in bodily harm or loss of life.

C H A P T E R 1

Introduction to the VSM Ultra-Low Field Option

1.1 Introduction

This chapter contains the following information:

- Section 1.2 presents an overview of the PPMS VSM Ultra-Low Field (ULF) option.
- Section 1.3 describes notable features of the VSM ULF option.
- Section 1.4 outlines safety considerations for working with the VSM ULF option.
- Section 1.5 provides information on Quantum Design service centers and how to contact your customer service representative.

1.2 Overview

The PPMS VSM Ultra-Low Field (ULF) option performs two functions: it profiles the magnetic field that is in the sample chamber and it nulls, or *zeroes*, the residual magnetic field at a specific position in the sample chamber. The VSM ULF option is offered with systems that have standard and EverCool dewars and 7- and 9-tesla magnets, and is designed to operate at room temperature (295–315 K). The VSM ULF option measures the magnetic field using a fluxgate magnetometer that has its movement controlled by the VSM linear motor transport. The VSM option, the AC Measurement System (ACMS) board, the low-field magnet coil, and the magnet reset heater option are required in order to operate the VSM ULF.

The ULF option adjusts the magnetic field at a given position based on readings from the fluxgate sensor, embedded at 1.1 cm from the bottom of the fluxgate probe. Zeroing of the field (field nulling) consists of iteratively using the magnet reset option to quench the magnet while simultaneously using the ACMS board to apply a compensation current to the low-field magnet coil.

1.3 Notable Features of the VSM ULF Option

The Model CM-A motor module plugs into the Model 1000 Modular Control System, which communicates with the PC via the CAN network cable. The Model CM-A motor module controls the VSM Linear Motor Transport that moves the Fluxgate Magnetometer. The PC also communicates with the ACMS board installed in the Model 6000 controller (or the Model 6500 controller if the PPMS is an EverCool system).[1]

The ACMS board in the Model 6000 (or Model 6500)[2] controller provides the drive current that runs the low-field magnet coil, which is a superconducting coil wound directly on a coil form that fits between the outer vacuum jacket and the main PPMS superconducting magnet. The low-field magnet coil applies a compensation field that is used to adjust the flux trapped in the superconducting magnet. Fields of less than 0.1 G can be achieved at a user-specified location in the sample chamber.

Inside the dewar are installed the VSM coilset, the VSM sample tube, the low-field magnet coil, and the magnet reset heater.

Figure 1-1 illustrates the hardware and functional connections for the VSM ULF option.

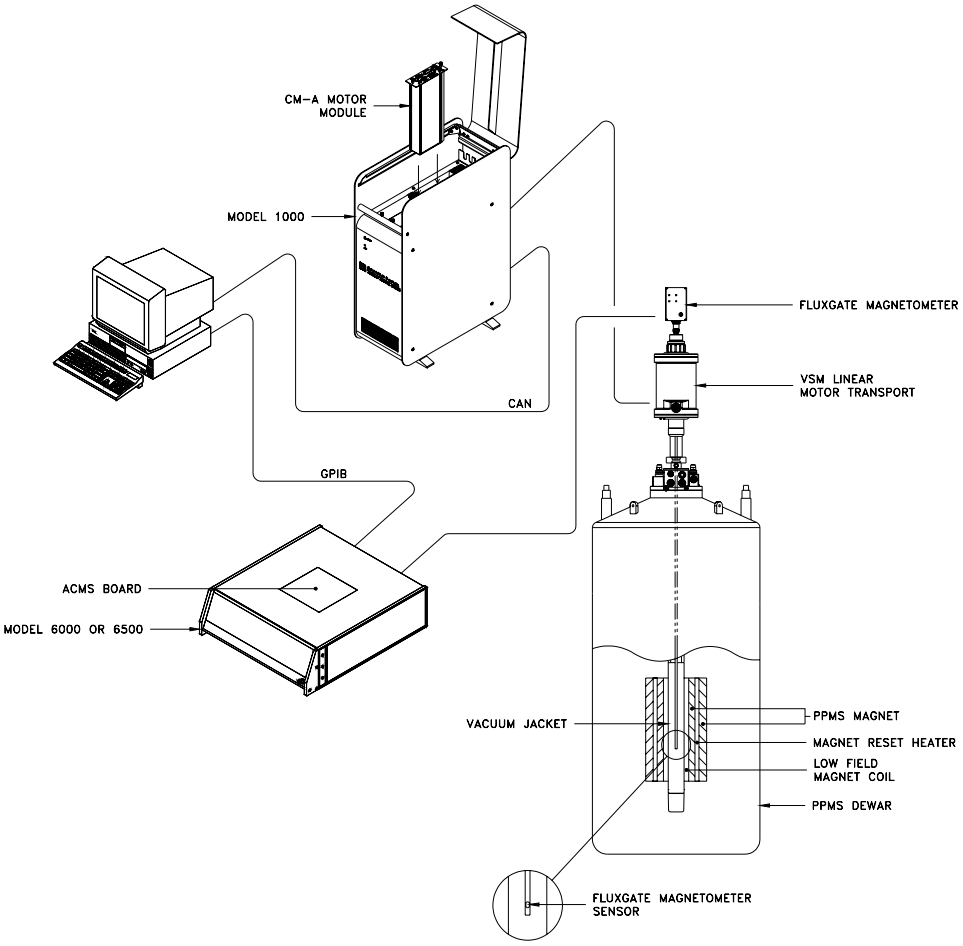


Figure 1-1. Operating principle for the VSM ULF option.

[1] EverCool systems use the Model 6000 controller and the Model 6500 controller.
[2] The Model 6000 and Model 6500 controllers are often referred to simply as the Model 6000 or Model 6500.

1.4 Safety Precautions

W A R N I N G !

The VSM and ULF options are used in conjunction with the Physical Property Measurement System (PPMS), so you should be aware of the safety considerations for all the equipment. PPMS-related safety precautions include those for the use of superconducting magnets and for the use of cryogenic liquids, as is reviewed below and in the *Physical Property Measurement System: Hardware Manual*.

Above all, Quantum Design and its staff ask that you use standard safe laboratory procedures.

- Use common sense.
- Pay attention to the state of the system and to your surroundings.
- If the system appears to be behaving abnormally, investigate to see if there is a malfunction. If necessary, take the appropriate action (e.g., troubleshoot, shut down the system, contact Quantum Design).
- Supervise inexperienced users and train them in general electrical safety procedures.

The VSM and PPMS have safety features to prevent accidents from causing injury or serious equipment damage. *If you use the equipment in a manner that is not specified by Quantum Design, the protection afforded by the equipment may be impaired.*

1.4.1 Magnets

W A R N I N G !

Any person who wears a pacemaker, electrical medical device, or metallic implant must stay at least 5 m (16.5 ft.)[3] from the PPMS dewar. In addition, personnel should keep all ferromagnetic objects at least 5 m (16.5 ft.) from the PPMS dewar. Verify that all magnetic fields are at zero (0) before you handle the VSM linear motor transport in any way.

The following precautions should be followed to ensure the safety of personnel who work with or around a PPMS with a superconducting magnet. This material is covered in more depth in Chapter 1 of the *Physical Property Measurement System: Hardware Manual.*

[3] At the current time (January 2005), 5 m should be a large enough distance to protect wearers of metallic implants or medical devices from most magnetic fields produced by Quantum Design magnets. However, the safe distance from newer magnets (in development) could be greater. Hence, personnel who work with and around the superconducting magnets should review thoroughly documentation for new equipment.

- Verify that any person who has a metallic implant or is wearing a pacemaker or electrical or mechanical medical device stays at least 5 m (16.5 ft.) from the PPMS dewar. Large magnetic fields are dangerous to anyone who has a metallic implant or is wearing a pacemaker or other electrical or mechanical medical device.

  Important: The automated control system can turn on the magnet while the system is unattended. Furthermore, the three-dimensional magnetic field of the PPMS will penetrate nearby walls, the ceiling, and the floor. Therefore, your safety considerations should include such adjacent spaces.

- Keep all iron, nickel, and other ferromagnetic objects at least 5 m (16.5 ft.) from the PPMS dewar. Large magnets, such as the PPMS superconducting magnets, can attract iron and other ferromagnetic materials with great force. The observable effects of magnetic fields are listed in Chapter 1 of the *Physical Property Measurement System: Hardware Manual*.

- Never attempt to install, remove, or handle the VSM linear motor transport (4096-400) when there is a field set in the PPMS or in any other nearby equipment. In addition, the VSM linear motor transport must be secured when it is stored within 5 m (16.5 ft.) of the PPMS or any other large field source. The VSM linear motor transport contains nearly 9 kg of iron, which presents a considerable hazard in a large magnetic field such as that produced by the PPMS or other laboratory equipment such as an NMR magnet.

1.4.2 Cryogens

W A R N I N G !

Always wear protective clothing and ensure that the room has good ventilation when you work with cryogenic materials such as liquid helium and liquid nitrogen. These precautions will protect you against cryogenic material hazards: (1) they can expand explosively when exposed to room temperature; (2) they can cause serious burns.

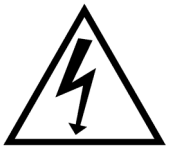
- Always wear protective clothing, including thermal gloves, eye protection, and covered shoes, when you work with liquid helium, liquid nitrogen, or other cryogens.

- Avoid loose clothing or loose fitting gloves that could collect cryogenic liquids next to the skin. The extreme cold of liquid and gaseous cryogens can cause serious burns and has the potential to cause loss of limbs.

- Use cryogens only in well-ventilated areas. In the event a helium container ruptures or there is a helium spill, vent the room immediately and evacuate all personnel. In a poorly ventilated area, helium can displace the air, leading to asphyxiation. Because helium rises, well-vented rooms with high ceilings generally provide the safest setting for working with it.

1.4.3 Electricity

W A R N I N G !



The VSM and the PPMS are powered by nominal voltages between 100 V to 240 V AC. These voltages are potentially lethal, so you should exercise appropriate care before opening any of the electronics units, including turning off the equipment and disconnecting it from its power source.

- Turn off and unplug all electronic equipment before removing any equipment covers.
- Keep electrical cords in good working condition and replace frayed and damaged cords.
- Keep liquids away from the workstations.

1.4.4 Lifting and Handling

The VSM linear motor transport (4096-400) should be handled with care, as it is very heavy (about 10 kg or 22 lb) and could cause crushing injuries.

1.5 Contacting Quantum Design

If you have questions or problems related to your Quantum Design equipment, contact your local Quantum Design service representative at one of the offices listed below. When you call, please be able to give the representative a full description of the problem, including the circumstances involved and the recent history of your system.

United States

Quantum Design World Headquarters
6325 Lusk Boulevard
San Diego, CA 92121

Tel: 1-858-481-4400
1-800-289-6996
Fax: 1-858-481-7410

Email: service@qdusa.com
Web: http://www.qdusa.com

Service for Canada, Mexico, the United States, and other countries not listed below

Europe

L.O.T.—Gmbh & Co KG
Im Tiefen See 58
D-64293 Darmstadt, Germany

Tel: 49-6151-880631
Fax: 49-6151-896667

Email: qd.euroservice@lot-oriel.de
Web: http://www.lot-oriel.com

Service for Austria, Belgium, Crete, Croatia, Czech Republic, Denmark, England, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, and Yugoslavia

Japan

Quantum Design Japan
Sanpo Ikebukuro Building Annex
4-32-8 Ikebukuro
Toshima-ku, Tokyo
171-0014, Japan

Tel: 81-3-5954-8570
Fax: 81-3-5954-6570

Email: qdjapan@tkb.att.ne.jp
Web: http://www.qd-japan.com

Service for Japan

Korea

Quantum Design Korea
Kyungbin Building, Fourth Floor
517-18 Dogok-dong, Kangnam-gu
Seoul, 135-270, Korea

Tel: 82-2-2057-2710
Fax: 82-2-2057-2712

Web: http://www.qdkorea.com

Service for Korea

People's Republic of China

Quantum Design Instrumentation (Bejing) Co., Ltd
Room 502-04, Tower B, COFCO Plaza
No.8 Jianguomennei Avenue
Dong Cheng District,
Beijing 100005
P.R. China

Tel: 8610-8512-0277/80
Fax: 8610-8512-0276

Email: quantum-design@163.com

Service for People's Republic of China

Taiwan

Omega Scientific Taiwan Ltd.
13F-3, No. 415, Sec. 4
Hsin Yi Road
Taipei City 110, Taiwan R.O.C.

Tel: 886-2-8780-5228
Fax: 886-2-8780-5225

Email: lonson.lin@omega-cana.com.tw

Service for Taiwan, Hong Kong, Singapore

C H A P T E R 2

Installing and Removing the VSM ULF Option

2.1 Introduction

This chapter contains the following information:

- Section 2.2 includes definitions and a list of the VSM ULF components.
- Section 2.3 describes the procedures for the initial installation of the VSM ULF option and its software.
- Section 2.4 describes how to connect the fluxgate magnetometer to the PPMS.
- Section 2.5 explains how to remove the VSM ULF option so that the PPMS can be used to perform a zero-field measurement.
- Section 2.6 describes how to reconfigure the PPMS for the VSM ULF option.

2.2 Overview of VSM ULF Option Installation

This chapter describes the procedures you will use to install the hardware and software for the VSM Ultra-Low Field (ULF) option. Note that the procedures for the *initial* installation of the ULF option are different from those for subsequent installations (i.e., when you re-install the ULF after having used a non-VSM option). The initial installation procedures vary according to the options with which the PPMS is equipped. However, if you purchased the VSM ULF option as part of a complete Quantum Design system, many of the installation procedures will have been performed before you receive the equipment.

2.2.1 Terminology

The following usages and definitions will help distinguish among the various activities that are involved in installing and operating the VSM ULF option:

Activate option refers to the **Utilities >> Activate Option** command in PPMS MultiVu. When an option is activated, the program incorporates option-specific commands into MultiVu.

Install hardware refers to activities involved in setting up equipment, such as installing the VSM linear motor transport, the VSM sample tube or the VSM coilset, connecting cables, and so on.

Install the fluxgate magnetometer refers to the procedures for inserting the VSM fluxgate probe into the PPMS. You will perform these operations by using the **VSM ULF Operations** dialog, which is available after you have activated the VSM ULF option within MultiVu.

Load position refers to the position of the slider tube in the VSM linear motor transport when the indicator pin is at the top of the window. Use the load position to install the fluxgate magnetometer.

Oscillating the field refers to using the oscillating mode to charge and discharge the superconducting magnet.

PPMS VSM User's Manual refers to the *Physical Property Measurement System: Vibrating Sample Magnetometer (VSM) Option User's Manual.*

Quenching the magnet refers to the act of expelling trapped magnetic flux by using the magnet reset heater to warm the superconducting magnet.

Remnant field **(**also ***Residual field*****)** refers to the residual magnetic field in the superconducting magnet after the magnetic field has been zeroed.

Touchdown operation refers to the act of slowly lowering the motor position until there is no more levitation force, indicating that the bottom of the fluxgate probe is resting on the puck surface.

Touchdown position refers to the position (motor-encoder value) where there is zero levitation force as measured by the touchdown operation.

2.2.2 VSM ULF Option Components

To operate the VSM ULF option on a PPMS with a 7- or 9-tesla magnet and a standard dewar, the system must be equipped with the ACMS board, low-field magnet coil, magnet-reset heater, Model 1000 modular control system, standard VSM option, Model 6000 Firmware ROM (version 1.912 or later), and the VSM–MultiVu application software (rev 1.3.2 or later). If the ULF option will be installed on an existing PPMS that does not have one or more of the necessary components, those items will be shipped with the VSM ULF option.[1] Table 2-1 lists the basic components of the Quantum Design VSM ULF option.

Table 2-1. Components of the PPMS VSM ULF option

COMPONENT	PART NUMBER	ILLUSTRATION
VSM ULF option interface cable (also called the low-field option interface cable)	3077-203	Pages 2-10, 4-4
Fluxgate cable assembly	3077-202	Pages 2-10, 4-5
VSM fluxgate magnetometer (5 gauss)	4096-521	Pages 2-9, 4-1
Fluxgate wall bracket	4049-025	Pages 2-9, 4-4
VSM fluxgate adapter assembly	4096-530	Page 4-2
VSM ULF User's Kit	4096-510	
VSM ULF option software (shipping disk)	4096-544	
VSM ULF Option User's Manual	1096-500	

[1] You will need to ship your probe to Quantum Design for installation of the low-field magnet coil and the magnet reset heater.

Before you begin the installation, we recommend that you use your order form to verify that you have received every item necessary for a complete installation of the VSM ULF.

2.3 Initial Installation of the VSM ULF Option

Important: The instructions in this section only apply to the *initial* installation of the VSM ULF option. If you subsequently reconfigure the PPMS to use a non-VSM option, you must reconfigure the PPMS for the standard VSM before you can begin using any of the VSM options. For complete instructions on reconfiguring the PPMS for the standard VSM, see the *PPMS VSM User's Manual*. After the PPMS has been reconfigured for the VSM, you only will need to activate the VSM ULF option and install the hardware to start using it again.

The procedures for the initial installation of the VSM ULF option will depend on whether it was purchased as part of a complete Quantum Design (QD) system (e.g., PPMS with VSM options) or as an upgrade to an operating PPMS.

If you purchased the VSM ULF option along with a new PPMS, you can go to Step 3 of Section 2.3.3, "Install the VSM ULF Software." If you purchased the VSM ULF option as an upgrade, please review the support materials and the procedures below as a guide to installation.

VSM ULF Requirements

Operation of the VSM ULF option requires a PPMS with a 7- or 9-tesla magnet and the standard VSM option, the Model 1000 modular control tower, a Quantum Design AC Measurement System (ACMS) board, the low-field magnet coil, and the magnet-reset heater. To insert the fluxgate magnetometer into the sample chamber, a vertical clearance of 10 feet is required between the floor and ceiling of the room in which the VSM ULF option is used.[2]

If your PPMS does not have the low-field magnet coil and the magnet reset heater, you must send the probe to Quantum Design so that these components can be installed.

Altogether, the procedures for installing the VSM ULF option in an operational PPMS will depend on the pre-existing equipment. Below are the procedures that will be required if you are missing all or part of the requirements at the time that you purchase the VSM ULF option:

1. Install the ACMS board in the Model 6000 (systems with standard dewars) or Model 6500 (systems with EverCool dewars).
2. Install and verify the operation of any components required for the VSM ULF: the Model 1000 modular control tower and CAN network adapter, the Model CM-A and CM-B[3] modules (required for the standard VSM), and the standard VSM option, including the necessary software.
3. Install the VSM ULF software.

Some or most of these procedures might have been performed at the factory. Please review the instructions before you begin, and call Customer Service at Quantum Design if you have any questions.

[2] This is the standard recommendation for the PPMS.

[3] The Model CM-B module is not part of the VSM ULF option or required for it, but it is needed for the standard VSM option.

2.3.1 Install the ACMS Board

You will use the instructions in this section only if the ACMS board has not been installed on the PPMS. First, you will place the PPMS in **Shutdown** (standby) mode to stabilize it and conserve helium (see Section 2.3.1.1).

Important: The magnet must be in **Persistent** mode and the **Field** must be at zero (0) Oe *before* you place the system in **Shutdown** mode.

The next steps for installing the ACMS board will vary for standard systems (Section 2.3.1.2) and EverCool systems (Section 2.3.1.3).

2.3.1.1 PPMS SHUTDOWN PROCEDURES

Use the instructions below to put the PPMS in **Shutdown** mode. For more information about **Shutdown** mode, see Chapter 4 of the *PPMS Hardware Manual*.

1. If the magnetic field is not in **Persistent** mode *and* at zero (0) Oe, reset it by using the **Field** dialog box.
   a. Select **Instrument** >> **Field** from the dropdown menus at the top of the MultiVu window.
   b. When the **Field** dialog box opens (Figure 2-1), set the **Mode** to **Persistent** and the **Set Point** to zero (0) Oe.
   c. Click on the **Set** button.
   d. Leave the dialog box open so that you can monitor the field until it is within 1000 Oe of zero (do not continue until the field is within 1000 Oe of zero).
   e. In the **Field** dialog box, click on the **Close** button.

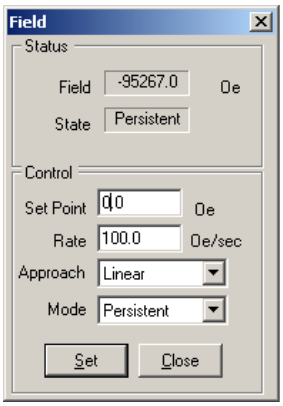


Figure 2-1. Field dialog box

2. Start **Shutdown** mode.
   - To use the Model 6000, select **CTRL** >> **Interactive Control** >> **8. Shutdown Mode**.
   - To use MultiVu, select **Instrument** >> **Shutdown** from the dropdown menus at the top of the MultiVu window.

2.3.1.2 INSTALLATION ON A PPMS THAT HAS A STANDARD DEWAR

If you have a PPMS with a standard type of dewar, you will install the ACMS board into the Model 6000 controller. Use Figure 2-2 as a guide for the installation procedures.

1. Verify that the PPMS is in **Shutdown** (standby) mode (see Section 2.3.1.1).
2. At the front of the cabinet, turn off the power switch to the Model 6000.
3. Open the PPMS cabinet by removing the top wooden cover and the metal cover.
4. Looking at the Model 6000 from the front of the cabinet, find the panel at the back of the second slot from the left, corresponding to port P3. Remove the screws and panel and install the ACMS board in this slot.
5. Connect the daughter ribbon cable from the J15 connector on the Model 6000 mother board to the J3 connector on the ACMS board.

6. Connect the power cable (black and red wires from the Model 6000) to the J4 connector on the ACMS board.
7. Slide the metal cover back onto the top of the Model 6000.
8. Replace the wooden cover on the top of the PPMS cabinet.
9. Turn on the power switch to the Model 6000.

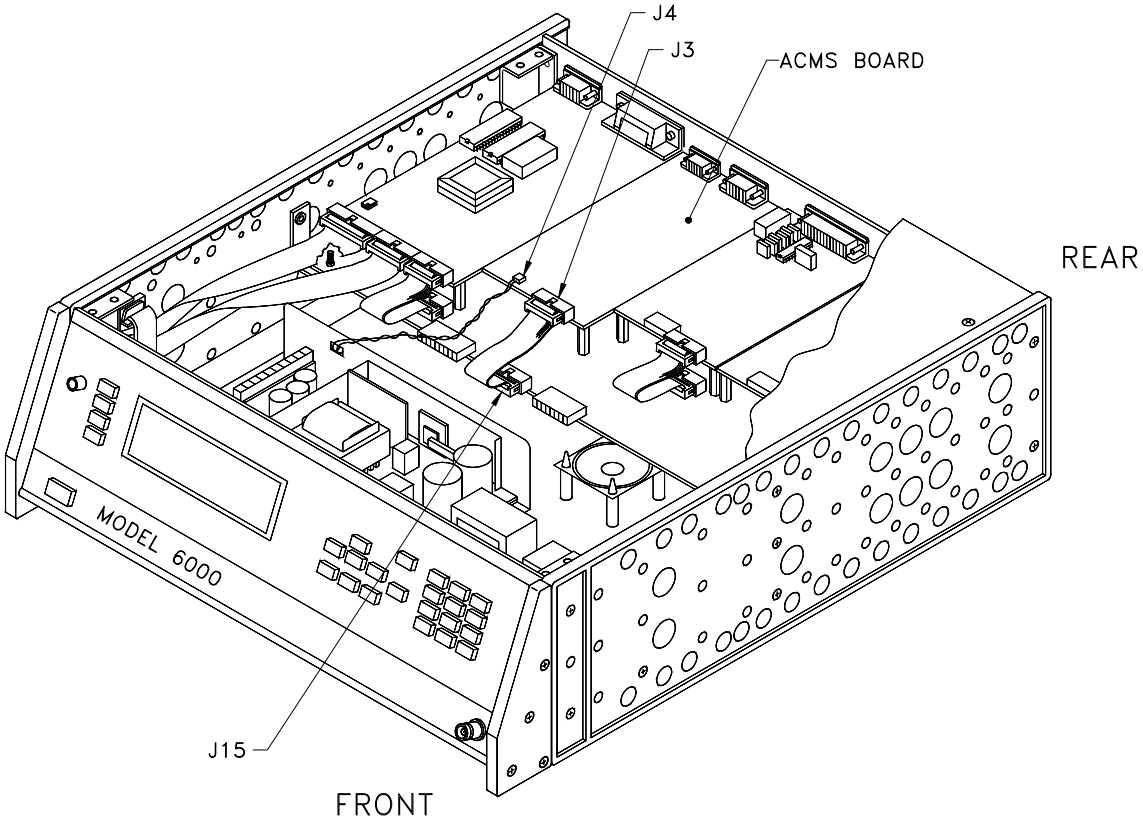


Figure 2-2. Illustration of Model 6000 controller (from the front), with the ACMS board inserted and J3 and J4 connectors in place

2.3.1.3 INSTALLATION ON A PPMS THAT HAS AN EVERCOOL DEWAR

If you have an EverCool system, you will install the ACMS board into the Model 6500 controller. Use Figure 2-3 as a guide for the installation procedures.

1. Verify that the PPMS is in **Shutdown** (standby) mode (see Section 2.3.1.1).
2. Turn off the power switch to the Model 6500 at the front of the cabinet.
3. Unplug the cables from the back of the Model 6500 so that you can slide it out of the cabinet.
4. Remove the Model 6500 from the rack by sliding it out from the front of the cabinet. Place the Model 6500 on a flat surface at a comfortable working height.
5. Looking at the Model 6500 from the front (cabinet end), locate the panel that covers the second slot from the right. The slot is labeled P2-Option2. Remove the screws and panel.
6. Install the ACMS board.

7. Connect the end of the ribbon cable supplied with the Model 6500 (labeled P2 (J3) Option2 daughter board) to the J3 connector of the ACMS board. Connect the other end of the ribbon cable to the Option2 connector on the daughter board.
8. Connect the black and red wires from the power supply to the J4 connector on the ACMS board.
9. Slide the Model 6500 back into the cabinet rack.
10. Reconnect the cables at the back of the Model 6500.
11. Turn on the power to the Model 6500.

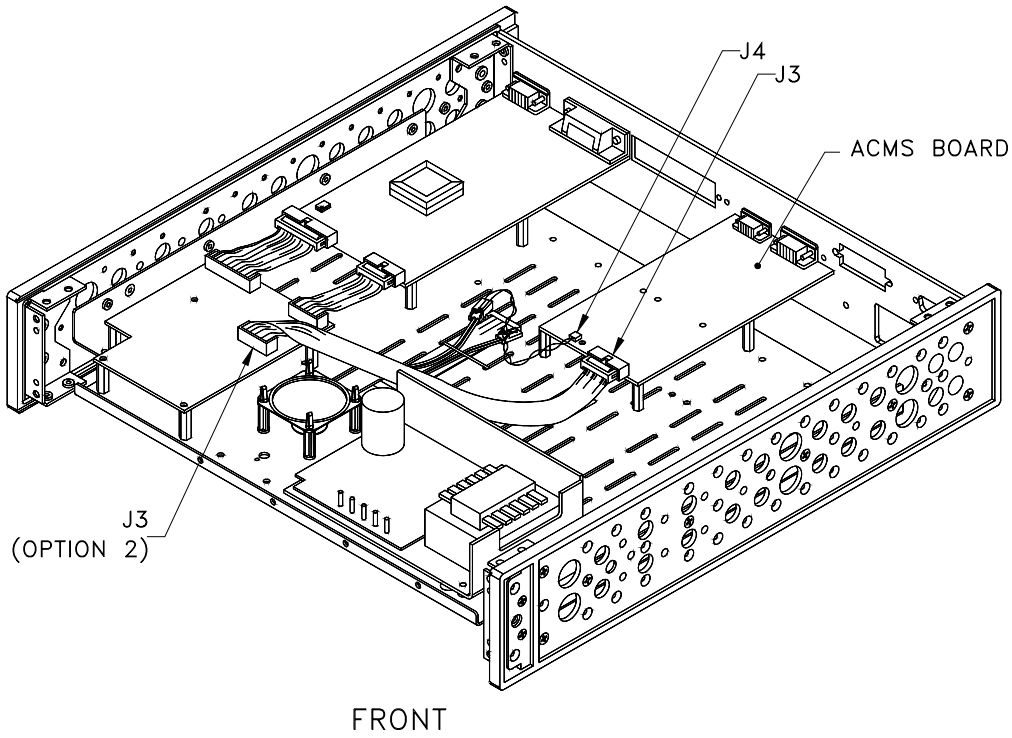


Figure 2-3. Illustration of Model 6500 controller in electronics cabinet, with ACMS board inserted and J3 and J4 connectors in place

2.3.2 Install the Model 1000, Standard VSM Option, and Application Software

You will use the instructions in this section only if you have an operational PPMS (and computer) without the Model 1000 modular control tower and standard VSM option. If the Model 1000 and standard VSM option have been installed already, go to Section 2.3.3.

1. Install the Model 1000, CAN Network Adapter, and CAN Manager driver software, using the instructions in the *Model 1000 Modular Control System User's Manual*. Remember to verify the software installation and the hardware connections.
2. Install the CM-A and CM-B control modules and the standard VSM option, including the VSM linear motor transport, sample tube, and coilset puck, using the instructions in Chapter 2 of the *PPMS VSM User's Manual*.

3. Using Figure 2-4 for guidance, verify that you have attached all the connectors and the connections are firm.

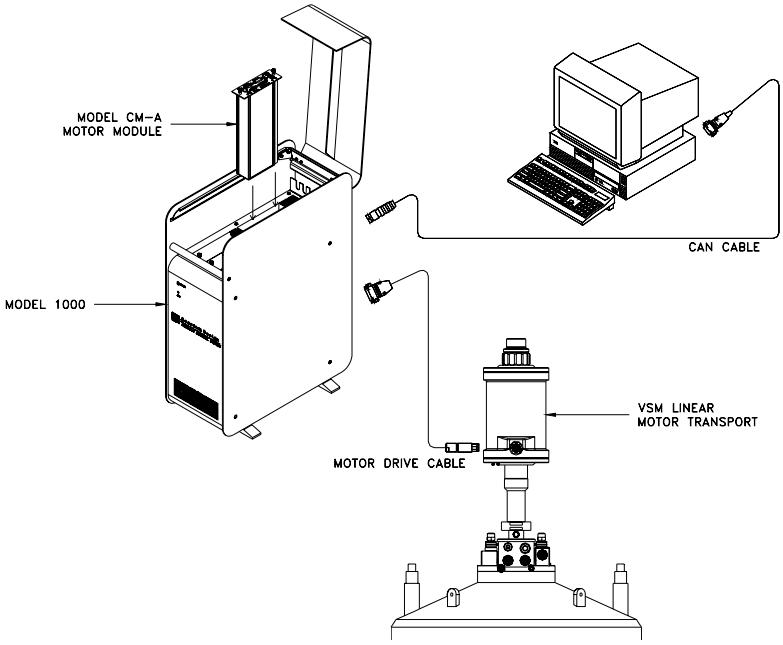


Figure 2-4. PPMS—VSM option components and interconnections

4. Install or update the software (MultiVu, VSM), as necessary. Any required software will be included with the ULF option shipment, along with detailed instructions for installation. Remember to verify that the software is operating properly.

2.3.3 Install the VSM ULF Software

The following instructions presume that you have already installed PPMS MultiVu (Version 1.3.2. or later) and the standard VSM software (refer to Section 2.3.2 for further information).

If you purchased your VSM ULF option as part of a new PPMS, go to Step 3 below—you only need to verify that the software is operating properly.

1. Insert into the computer the media (CD or floppy diskette) that contains the software.
2. On the media, open the DISK1 folder and double-click on the file named `Setup.exe`. A wizard (an automated program) will start and guide you through the installation process. Continue through the `Setup` program until it indicates that it has finished.
3. Verify that the program is properly installed by activating it from within MultiVu.
   a. Start PPMS MultiVu.
   b. Open the **Option Manager** by selecting **Utilities** >> **Activate Option** from the dropdown menus at the top of the MultiVu window.
   c. When the **Option Manager** dialog box (Figure 2-5) appears with a list of the **Available Options**, click on **VSM Ultra Low Field** under the **Available Options** heading.

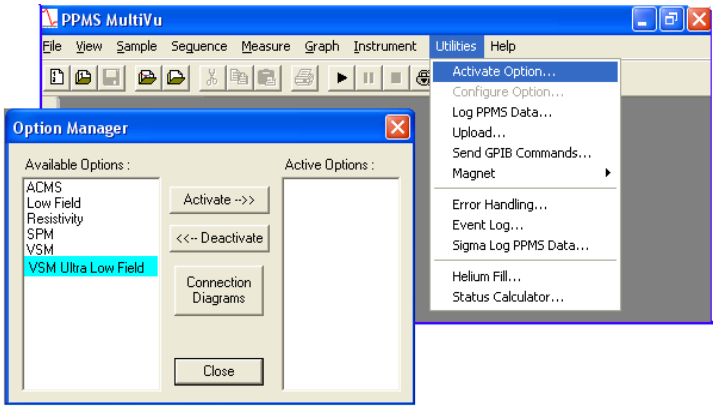


Figure 2-5. Using MultiVu to activate the VSM Ultra Low Field option

d. Click on the **Activate** button.

e. **VSM Ultra Low Field** will move to the **Active Options** area of the **Option Manager**.

f. A control dialog, a log window, and an information popup will open (Figure 2-6a–2-6c) when you activate the VSM ULF option. If these items appear, it indicates that the software is operating properly. If one or more of these software components does not appear, contact Customer Service at Quantum Design.

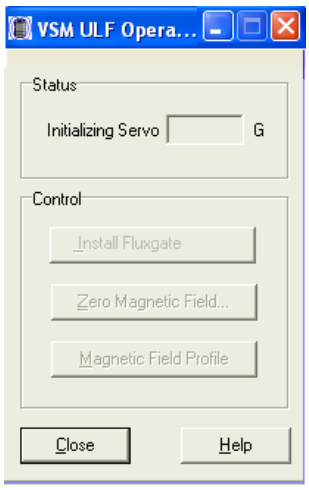


Figure 2-6a. VSM ULF Operations dialog at activation

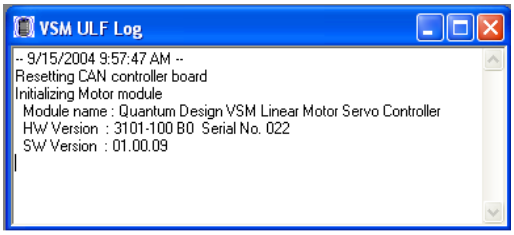


Figure 2-6b. VSM ULF Log dialog

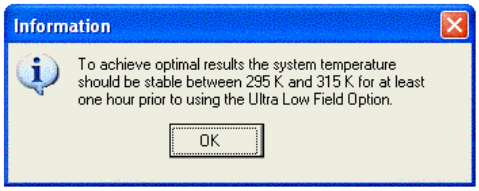


Figure 2-6c. VSM ULF Information popup with PPMS temperature instructions

2.3.4 Attach the Fluxgate Storage Bracket

The final part of the initial installation process is to attach the magnetometer storage bracket to the wall and place the fluxgate magnetometer in it.

1. Select a location for the fluxgate storage (wall) bracket that is relatively close to the PPMS dewar.
2. Hold the storage bracket so that the permalloy fluxgate shield is at the bottom and the bracket just rests on the floor. Figure 2-7 shows the bracket after it has been attached to the wall and the fluxgate magnetometer has been placed in it.

3. Attach the bracket to the wall with the four bronze screws and screwdriver that are included in the VSM ULF Option User's Kit.

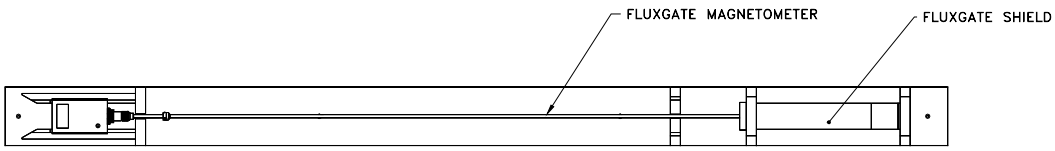


Figure 2-7. VSM ULF storage (wall) bracket and fluxgate magnetometer

4. Verify that the same serial number is used on the electronics control box and the fluxgate probe. If the two components do not have the same serial number, contact Customer Service at Quantum Design.
5. The initial installation is now complete.
6. Place the fluxgate magnetometer in the wall bracket until later in the installation procedures, when you will install it into the VSM linear motor transport.

You will probably never perform the *initial* installation of the ULF option again. However, several additional (but brief) steps are required before you can use the VSM ULF option for zeroing and field profiling, such as connecting the fluxgate magnetometer cables, preparing the sample chamber, and inserting the probe. These steps will be necessary each time you use the VSM ULF option, so they have been separated from the initial installation procedures. Begin the final steps by connecting the fluxgate magnetometer cables (Section 2.4).

2.4 Connecting the Fluxgate Magnetometer Cables

The VSM ULF option uses specific connections to the PPMS, as explained below. After you have connected the cables, you will use the instructions in Sections 3.4–3.5 to stabilize the system, insert the fluxgate, and perform the field-nulling and field-profiling operations.

Figures 2-8 and 2-9 show the VSM ULF cables, and Figures 2-10 and 2-11 show the connection diagrams for the VSM ULF option on systems with standard or EverCool dewars. Use the screwdrivers provided in the VSM ULF User's Kit to connect the cables.

1. Disconnect the dewar cable from the “P6–Dewar” port on the back of the Model 6000. Do *not* disconnect the other end of the cable, which is plugged into the blue Lemo port on the PPMS probe head.
2. Plug the J1 connector on the VSM ULF option interface cable assembly into the “P6–Dewar” port. Let the low-field coil connector on the option interface cable remain unattached. As is shown in Figure 2-8, the low-field coil connector is at the end of the cable that is attached to the silver-colored box.

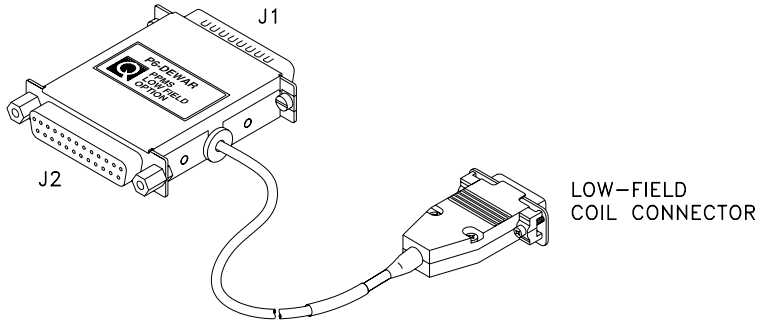


Figure 2-8. VSM ULF option interface cable assembly

3. Plug the free end of the dewar cable into the J2 connector on the option interface cable assembly.
4. Plug in the low-field coil connector on the option interface cable assembly as follows:
   - PPMS system with standard dewar: Attach the low-field coil connector to the 15-pin P3–Option port on the back of the Model 6000.
   - PPMS system with EverCool dewar: Attach the low-field coil connector to the P2–Option2 port on the back of the Model 6500.
5. Plug the fluxgate cable DB-25 connector into the "P8–Auxiliary" port on the back of the Model 6000. As is shown in Figure 2-9, the section of the cable near the DB-25 connector is labeled "P8–Aux." Let the right-angle Lemo connector remain unattached for the moment.[4]

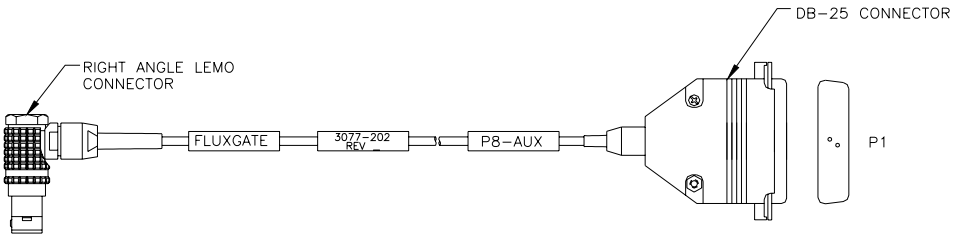


Figure 2-9. Fluxgate cable assembly

6. Chapter 3 has the instructions for completing the ULF–PPMS connections and for using the VSM ULF software to insert the fluxgate magnetometer and zero and profile the field. Because ultra-low field measurements should be performed immediately following the field-nulling operation(s), we recommend that you review the instructions for removing the fluxgate magnetometer (Section 2.5) before you start Chapter 3.

[4] When you complete the connections, you will plug the right-angle Lemo connector on the fluxgate cable into the electronics control box of the magnetometer.

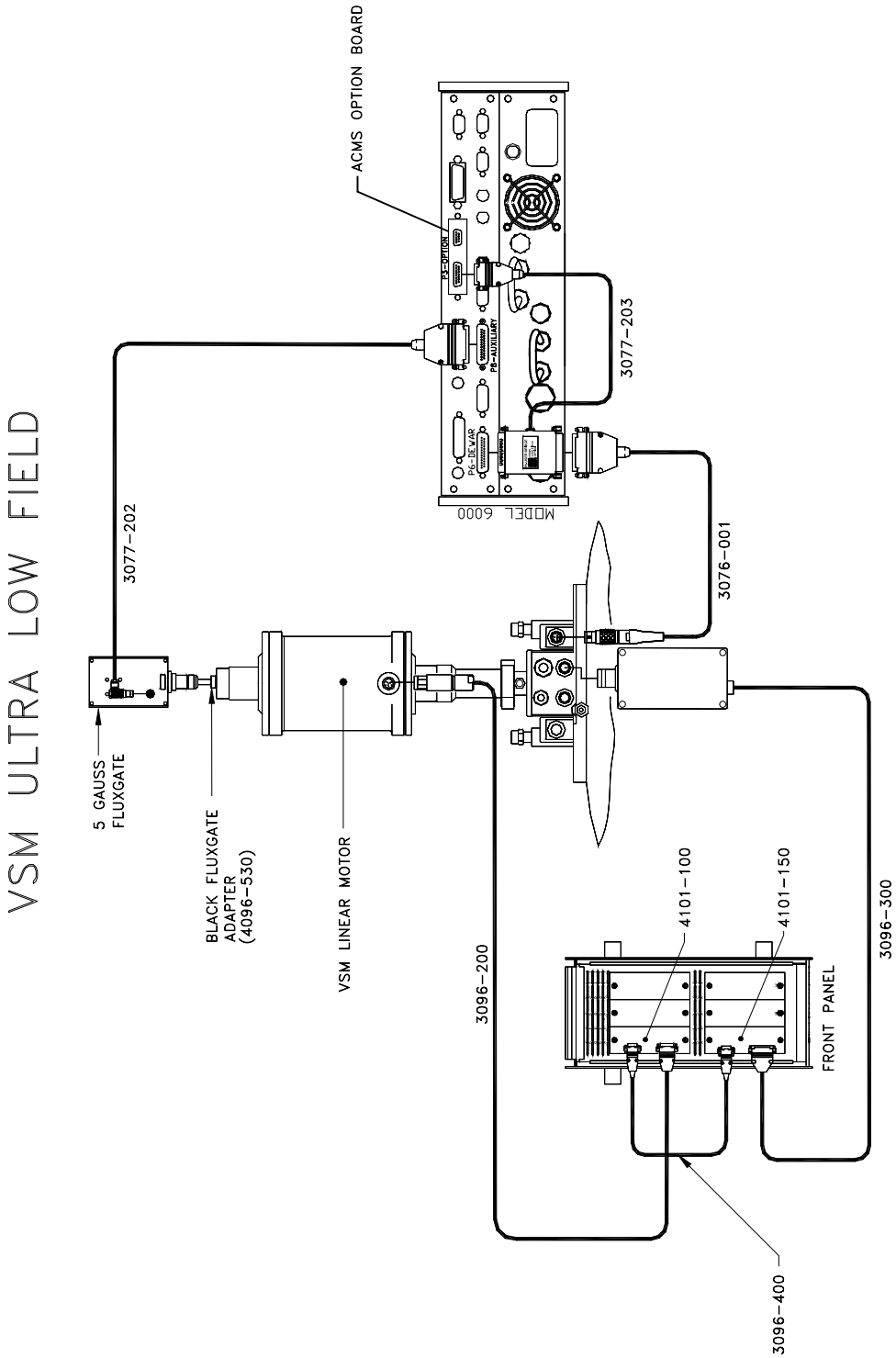


Figure 2-10. Connections for the VSM ULF option on a PPMS VSM system that uses a standard dewar

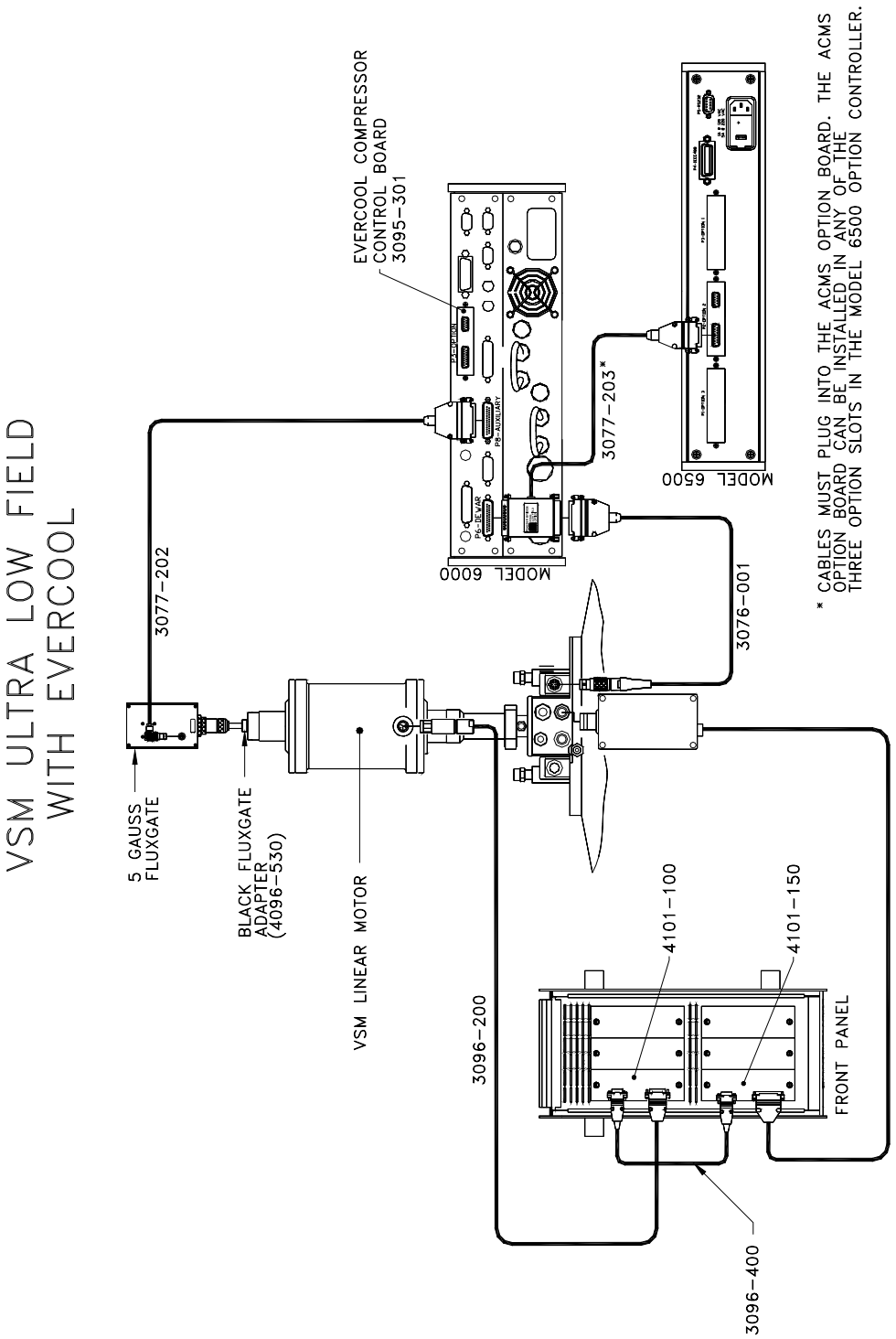


Figure 2-11. Connections for the VSM ULF option on a PPMS VSM system that uses an EverCool dewar

2.5 Preparing for Zero-Field Measurements

After you complete the field-nulling and profiling operation(s), you must remove the VSM ULF fluxgate magnetometer,[5] deactivate the VSM ULF option, and install the option that you intend to use for zero-field measurements. For the best results, perform ultra-low field measurements immediately after you finish performing the field-nulling and profiling, because relaxation effects in the magnet could result in small field changes over hours or days. This section describes the procedures for removing the VSM ULF hardware in preparation for an ultra-low field measurement. Please review all the removal instructions before you begin the procedure, as the dialog boxes only summarize the steps.

2.5.1 Remove the VSM ULF Hardware

1. Turn off the fluxgate by pressing the "Power" button on the electronics control box.
2. If necessary, open the **VSM ULF Operations** dialog box (Figure 2-12) by selecting **Utilities >> VSM Ultra Low Field** from the MultiVu dropdown menus**.**
3. In the **VSM ULF Operations** dialog, click on the **Remove Fluxgate** button. This button starts the **Removing Fluxgate** wizard and its dialog box (Figure 2-13).

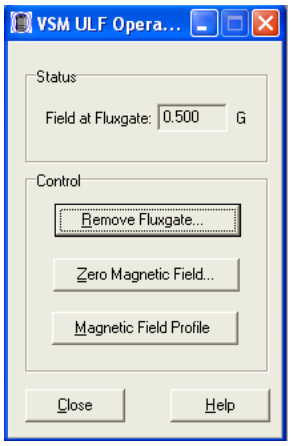


Figure 2-12. VSM ULF Operations dialog box

4. Remove the electronics control box from the fluxgate probe by loosening the fluxgate coupling and pulling the box off the probe.
5. In the **Removing Fluxgate** dialog box, click on the **Remove** button to move the transport into the load position. The **Controls** area will report on the process (Figure 2-14).

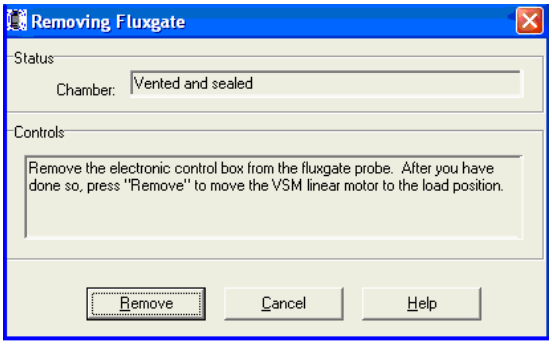


Figure 2-13. Removing Fluxgate dialog: Ready to move linear motor to load position

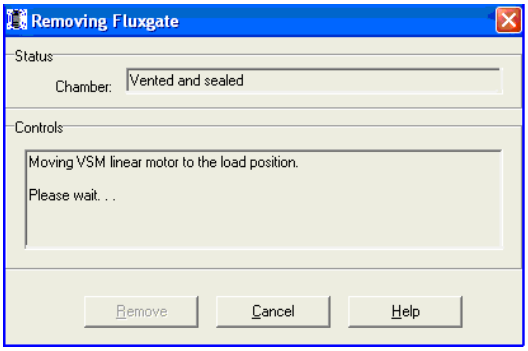


Figure 2-14. Removing Fluxgate dialog: Moving the linear motor transport into the load position

6. When the instructions indicate that the VSM linear motor is in the load position (Figure 2-15), remove the fluxgate probe from the sample chamber.

[5] You might also remove the standard VSM hardware.

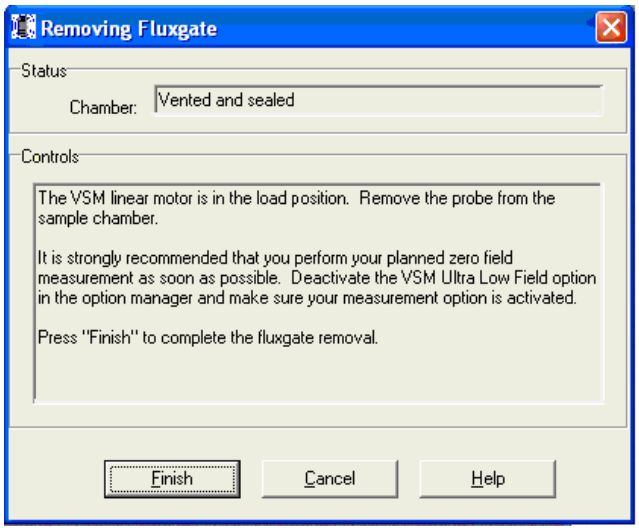


Figure 2-15. Removing Fluxgate dialog: Ready to remove fluxgate probe

7. Disconnect the right-angle Lemo connector on the fluxgate cable (Figure 2-9) from the electronics control box.
8. Re-attach the electronics box to the probe and place the fluxgate magnetometer in the storage (wall) bracket.
9. Disconnect the J1 connector on the VSM ULF option interface cable assembly (Figure 2-8) from the P6–Dewar port.
10. Disconnect the low-field coil connector from the P3–Option port on the back of the Model 6000 (systems with a standard dewar) or from the P2–Option2 port on the back of the Model 6500 (systems with an EverCool dewar).
11. Disconnect the DB-25 connector on the fluxgate cable from the P8–Auxiliary port on the back of the Model 6000.
12. Click on the **Finish** button at the bottom of the **Removing Fluxgate** dialog box to complete the removal process.
13. The **Removing Fluxgate** wizard will close its dialogs and you will be returned to the **VSM ULF Operations** dialog.
14. Next, you will deactivate the VSM ULF option.

2.5.2 Deactivate the VSM ULF Option

Using the **Option Manager** dialog box (Figure 2-16), deactivate the VSM ULF option:

1. Open the **Option Manager** dialog box by selecting **Utilities >> Activate Option** from the main MultiVu dropdown menus.
2. Click on **VSM Ultra Low Field** in the **Active Options** panel.
3. Click on the **Deactivate** button. **VSM Ultra Low Field** will move from the **Active Options** panel to the **Available Options** panel.

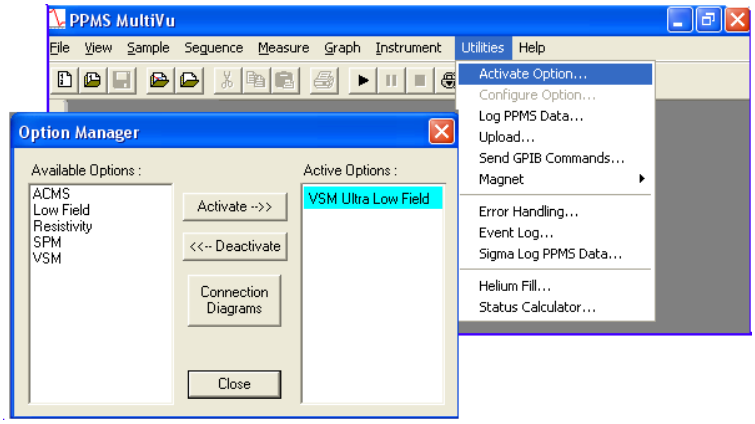


Figure 2-16. Using MultiVu to deactivate the VSM Ultra Low Field option

4. If you will be using the standard VSM option to perform zero-field measurements, you now can activate it and begin the usual procedures for taking these types of measurements. If you will be using a non-VSM option to perform zero-field measurements, you will remove the standard VSM option (see Section 2.5.3).

2.5.3 Remove the Standard VSM Hardware

If you will not be using the VSM for the zero-field measurements, use the instructions in this section to remove the VSM linear motor transport, sample tube, and coilset puck.

C A U T I O N !

Quantum Design recommends that you have another person help you remove the VSM linear motor transport, which is fragile, bulky, and moderately heavy (about 10 kg or 22 lb).

2.5.3.1 REMOVE THE VSM LINEAR MOTOR TRANSPORT

1. Unplug the electrical connector from the back of the VSM linear motor transport (see Figures 2-10, 2-11, and 2-17). You can leave the other end of the cable connected to the Model 1000 modular control system.

   Important: Never attempt to move the linear motor transport when it has a cable connected to it.

2. Remove the flange clamp from the top flange of the PPMS (see Figure 2-17).
3. Slowly lift the linear motor transport until it has cleared the stabilizer post, as is illustrated in Figure 2-17.
4. Place the linear motor transport back in the storage case.

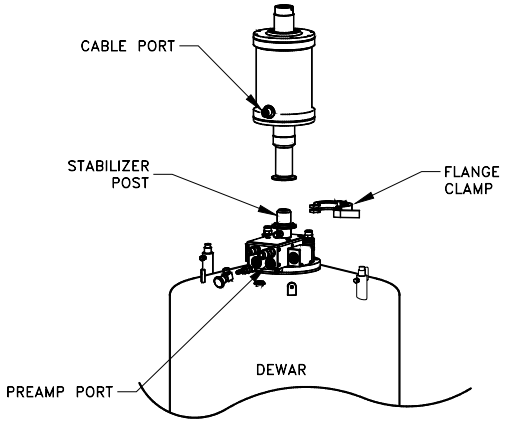


Figure 2-17. Removing the VSM linear motor transport

W A R N I N G !

Store the VSM linear motor transport in a secure location to prevent it from being attracted to magnetic fields in the laboratory, including those produced by the PPMS, as explained in Section 1.4.1.

2.5.3.2 REMOVE THE VSM SAMPLE TUBE AND COILSET PUCK

1. Remove the VSM sample tube from the PPMS sample chamber.
2. Remove the VSM coilset puck from the sample chamber by using the puck insertion/extraction (or sample insertion) tool. Refer to the *Physical Property Measurement System: Hardware Manual* for a detailed description of puck insertion and extraction.
3. Unplug the VSM preamp from the probe head and set it aside. You do not need to disconnect the other end of the cable from the Model 1000.
4. Return the blank flange to the top of the probe head or install another of the Quantum Design measurement options.
5. Once the sample chamber has been closed, you can purge and seal it by using the **Chamber** dialog box.
   - Select **Instrument >> Chamber** from the dropdown menus at the top of the MultiVu window.
   - In the **Chamber** dialog box, click on the **Purge/Seal** button.
6. The base measurement system is now ready for you to install a different option.

2.5.4 Install the Option for Performing Zero-Field Measurements

Install the hardware for the option that you intend to use for zero-field measurements. Remember, for optimal data, perform the zero-field measurements immediately after you have removed and deactivated the ULF hardware.

2.6 Reconfiguring the PPMS for the VSM ULF Option

If you reconfigure the PPMS in order to install and use a non-VSM option, you will not be able to use any of the VSM options until you have reconfigured the PPMS for the standard VSM option. For complete instructions on reconfiguring the PPMS for the standard VSM, see the *PPMS VSM Option User's Manual*. After the PPMS has been reconfigured for the VSM, you can use the VSM ULF option again by activating it and installing the fluxgate magnetometer with its connections.

C H A P T E R 3

VSM ULF Operations

3.1 Introduction

This chapter contains the following information:

- Section 3.2 summarizes VSM ULF option operations.
- Section 3.3 describes how to prepare the system for installation of the VSM ULF option.
- Section 3.4 describes how to activate the VSM ULF option and install the option hardware.
- Section 3.5 describes how to perform zeroing and field-profiling operations with the VSM ULF option.

3.2 Overview of VSM ULF Operations

VSM ULF operations involve zeroing the magnetic field at a fixed position and profiling the field. These operations are organized through the **VSM ULF Operations** dialog (Figure 3-1), which has automated procedures (wizards) for installing the fluxgate and setting up the system to perform the zeroing and field-profiling operations.

The overall process of using the VSM ULF includes activating the VSM ULF option and installing the fluxgate magnetometer in the sample chamber. The next steps include locating the sensor, quenching the magnet, and compensating for the residual field as well as monitoring the field profile. The following sections explain these steps.

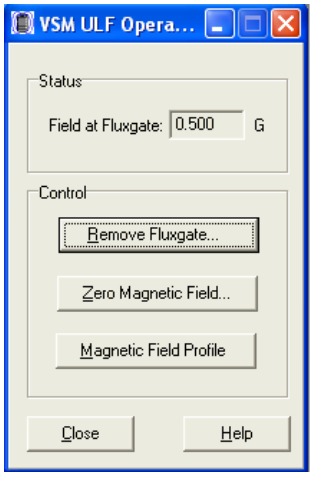


Figure 3-1. The VSM ULF Operations dialog

3.3 Verify System Readiness

We recommend the following preliminary steps before you start to install the fluxgate magnetometer. Subsequent to the initial installation and use of the fluxgate, Step 1 will be unnecessary, but Steps 2–5 will serve as a reminder of the installation procedures.

1. *(First use only)* Verify that any initial installation procedures that are required (see Section 2.3) have been completed. Such procedures might include installing the ACMS board, the VSM option, the appropriate application software, and the fluxgate storage bracket.
2. Verify that the ULF option interface and fluxgate cables are connected properly and firmly (see Section 2.4 and Figures 2-8–2-11):
   a. ULF option interface cable (Figures 2-8, 2-10, 2-11):
      - Standard, non-EverCool systems: Attach the low-field coil connector to the P3–Option port on the back of the Model 6000 controller; attach the J1 connector to the P6-Dewar port on the back of the Model 6000; and attach the dewar cable to the J2 connector.
      - EverCool systems: Attach the low-field coil connector to the P2–Option2 port on the back of the Model 6500 controller. Connections to-and-from the J1 and J2 connectors are the same as for non-EverCool systems.

   b. Fluxgate cable (Figures 2-9–2-11): Attach the DB-25 connector to the P8–Auxiliary port in the back of the Model 6000 controller. Let the right-angle Lemo connector remain free until later.
3. Verify that the magnet is in the **Persistent** mode and the **Field** is at zero (0) Oe.
4. Bring the system to a temperature between 295 K and 315 K and let it sit for at least 20 minutes before beginning the fluxgate installation.
5. Review the fluxgate magnetometer removal instructions (Section 2.5) before you perform the field-nulling and field-profiling operations.
6. Verify that the fluxgate adapter assembly (Figure 4-2) is located 48.8–49.2 inches from the bottom of the fluxgate probe (see Section 4.2.2.3).

3.4 Installing the Fluxgate Magnetometer

The final procedures for installing the fluxgate magnetometer include activating the VSM ULF option, preparing the PPMS sample chamber for VSM ULF operations, inserting the fluxgate magnetometer, and completing the system connections.

First, the VSM ULF option must be activated to start the VSM ULF software and open the **VSM ULF Operations** dialog box.

3.4.1 Activate the VSM ULF Option

1. If necessary, start the MultiVu software program.
2. Select **Utilities >> Activate Option** from the dropdown menus at the top of the MultiVu window. The **Option Manager** dialog box will open (Figure 3-2).
3. If another option is active, select it and click on the **Deactivate** button.

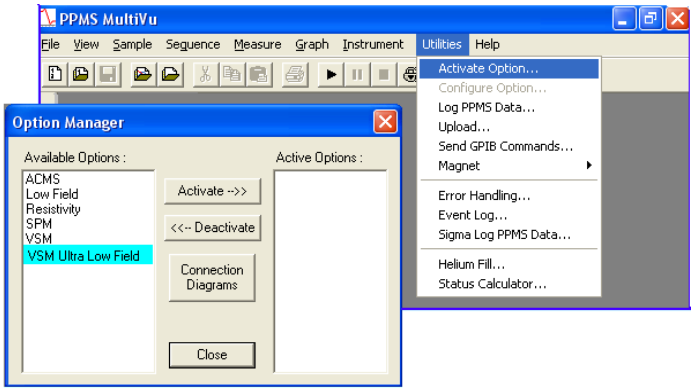


Figure 3-2. Using MultiVu to activate the VSM option

4. Select "VSM Ultra Low Field" and click on the **Activate** button. The **VSM ULF Operations** dialog box, the **VSM ULF Log** dialog, and the **Information** dialog will appear as soon as you activate the VSM ULF option (Figures 3-3a–3-3c). The **VSM ULF Operations** dialog box coordinates operations with the VSM ULF option, the **VSM ULF Log** dialog records system activities during the current session, and the **Information** popup explains that optimal VSM ULF results are obtained when the system temperature has been stable and at 295–315 K for at least one hour before you use the ULF. Note that 20 minutes is an adequate wait time.

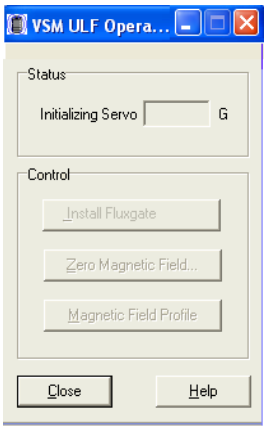


Figure 3-3a. Initial appearance of the VSM ULF Operations dialog box

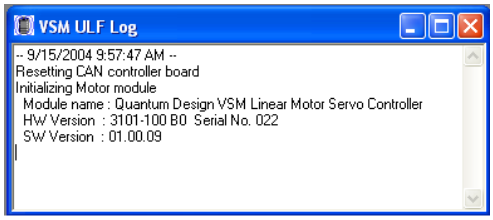


Figure 3-3b. VSM ULF Log dialog

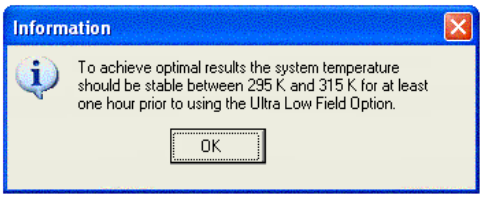


Figure 3-3c. Information popup

5. When the **VSM ULF Operations** dialog box opens, the **Control** buttons will be inactive (e.g., Figure 3-3a). To activate them so that you can proceed with the installation, click on the **OK** button in the **Information** popup. When the **Information** popup closes, the **Install Fluxgate** button will be available for use (Figure 3-4).

   Note that there will be fluctuations in the **Field at Fluxgate** reading until you have installed the fluxgate.

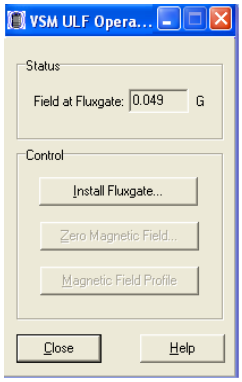


Figure 3-4. VSM ULF Operations dialog: Install Fluxgate button active

3.4.2 Prepare the PPMS for the Fluxgate

During this phase of the installation, you will use the **Installing Fluxgate** dialog box to quench the magnet and prepare the sample chamber.

1. Click on the **Install Fluxgate** button in the **VSM ULF Operations** dialog box (Figure 3-4).
2. The **Installing Fluxgate** dialog box will open (Figure 3-5) at Page 1. This dialog has a **Status** area and a **Controls** area, as well as **Quench**, **Skip Quench**, **Cancel**, and **Help** buttons for starting and stopping the processes.

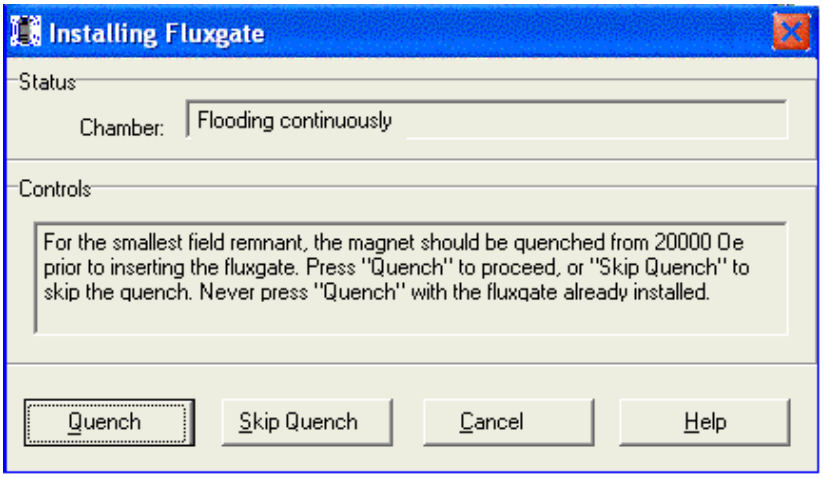


Figure 3-5. Page 1 of the Installing Fluxgate wizard

- The **Status** area will display the status of the sample chamber. For example, in Figure 3-5 the **Chamber** status is "Flooding continuously" because the chamber is continuously flooding.
- The **Controls** area will instruct you to quench the magnet from 20000 Oe, which is the recommended starting field value when you are performing a quench to expel the remnant field from the magnet. Note that you would ***never*** perform a quench when the fluxgate has been installed in the VSM.

C A U T I O N !

Never attempt to quench the magnet when the VSM ULF fluxgate magnetometer is installed in the VSM.

3. Click on the **Quench** button at the bottom left of the dialog box. Page 2 of the **Installing Fluxgate** wizard will open, where the **Controls** area will indicate that the field is being set to 20000 Oe (Figure 3-6a) and then that the magnet is being quenched (Figure 3-6b). (If you click on the **Skip the Quench** button, the wizard will open the dialog shown in Figure 3-7.)

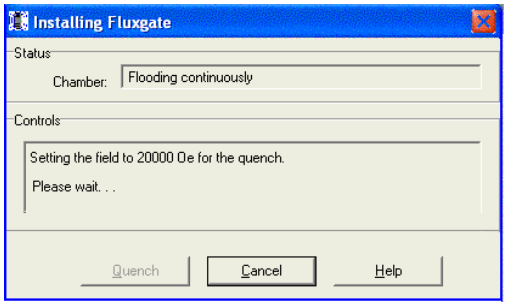


Figure 3-6a. Installing Fluxgate dialog: Setting the field to 20000 Oe

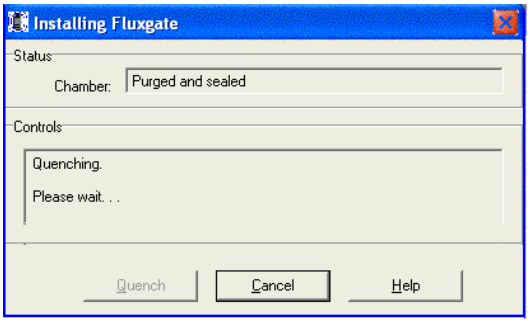


Figure 3-6b. Installing Fluxgate dialog: Quenching the magnet

4. When the magnet has been quenched, Page 3 of the **Installing Fluxgate** wizard will appear (Figure 3-7), indicating the status of the sample chamber (in this case it is purged and sealed).
5. Click on the **Vent** button to prepare the sample chamber for installing the fluxgate probe.
6. The **Status** area of the **Installing Fluxgate** dialog will indicate that the chamber is being vented and sealed, and the **Controls** area of the dialog will display the process (Figures 3-8a and 3-8b).

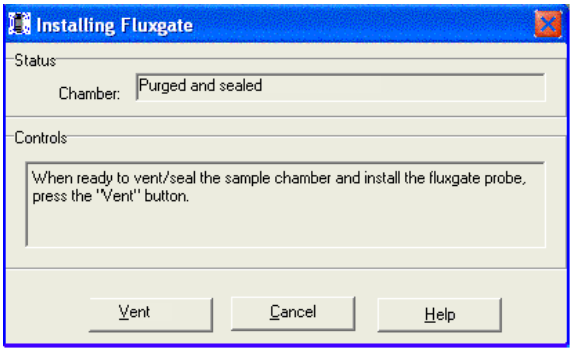


Figure 3-7. Installing Fluxgate dialog: Ready to vent/seal

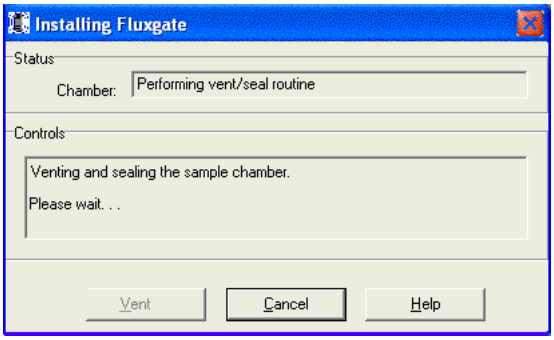


Figure 3-8a. Installing Fluxgate dialog: Venting and sealing the sample chamber

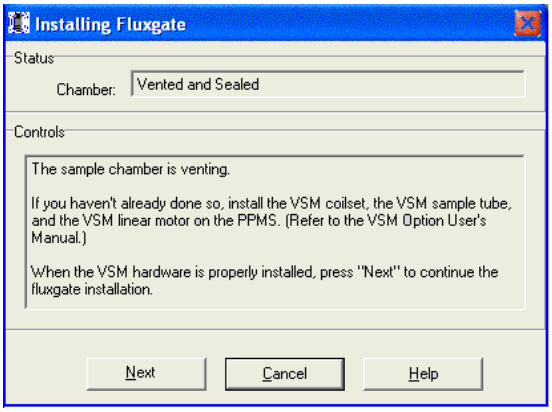


Figure 3-8b. Installing Fluxgate dialog: Reminder to install standard VSM

7. If you have not already done so, install the components of the standard VSM—the VSM coilset, the VSM sample tube, and the VSM linear motor—on the PPMS, as noted in the **Controls** area of the dialog (Figure 3-8b).

8. When the chamber has been vented and you have installed any necessary VSM components, click on the **Next** button at the bottom left of the dialog.
9. Page 4 of the **Installing Fluxgate** dialog (Figure 3-9) will open to start the final instructions for installing the VSM ULF fluxgate magnetometer into the sample chamber.
10. Please read the instructions in Section 3.4.3 before you start the installation, as the dialog boxes only provide a summary of the next steps.

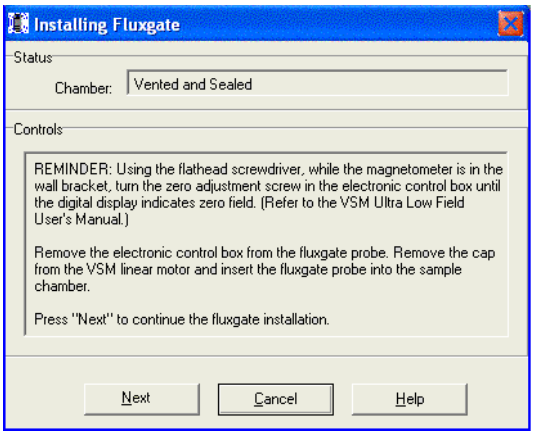


Figure 3-9. Installing Fluxgate dialog: Starting the final installation instructions

3.4.3 Prepare and Install the Fluxgate

1. Verify that the digital display on the fluxgate magnetometer reads zero (0) Oe while it is in the wall bracket:
   - Press the power button on the fluxgate magnetometer.
   - If the reading is more than zero (0) Oe, use the flat head screwdriver provided in the ULF Option User's Kit to reset it, turning the zero-adjustment screw in the electronics control box until the reading is at zero (0) Oe.
2. Remove the cap from the VSM linear motor transport so that you can insert the fluxgate probe.
3. Remove the fluxgate magnetometer from the wall bracket by lifting it upward until it clears the fluxgate shield and then pulling it out of the bracket.
4. Lay the fluxgate magnetometer on a flat surface and detach the electronics control box by loosening the fluxgate coupling until you can pull the box off the probe. Figure 3-10 illustrates the location of the fluxgate coupling.

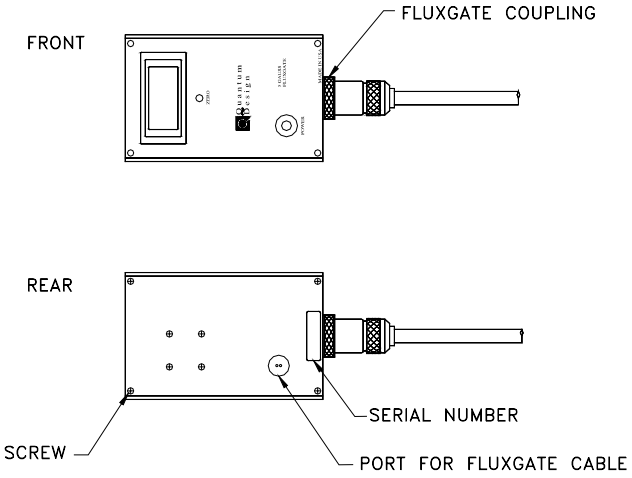


Figure 3-10. Electronics control box for the magnetometer

5. Insert the probe into the sample-access port until the magnetic lock at the base of the fluxgate adapter assembly engages the magnetic lock ring in the linear motor transport. Tug on the probe to verify that the magnetic lock has engaged the magnetic lock ring.

6. Plug the right-angle Lemo connector on the fluxgate cable (Figure 3-11) into the port on the rear panel of the electronics control box of the magnetometer (Figure 3-10). The top of the connector is marked by a red dot.

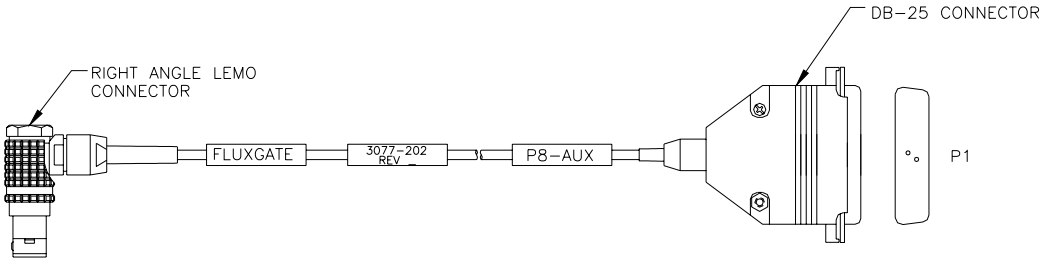


Figure 3-11. Fluxgate cable

7. Verify the cable connections: The option interface cable and the fluxgate cable attach to the back of the Model 6000 (and Model 6500 for EverCool systems), as explained in Sections 2.4 and 3.3.
8. Click on the **Next** button at the bottom of the **Installing Fluxgate** dialog (Figure 3-9) to continue the installation process. Page 5 of the **Installing Fluxgate** dialog (Figure 3-12) will open, with the final instructions for installing the VSM ULF fluxgate magnetometer.
9. Using minimal force, attach the electronics control box to the fluxgate probe in the sample chamber. Work with care so that you do not damage the armature of the VSM linear motor transport.

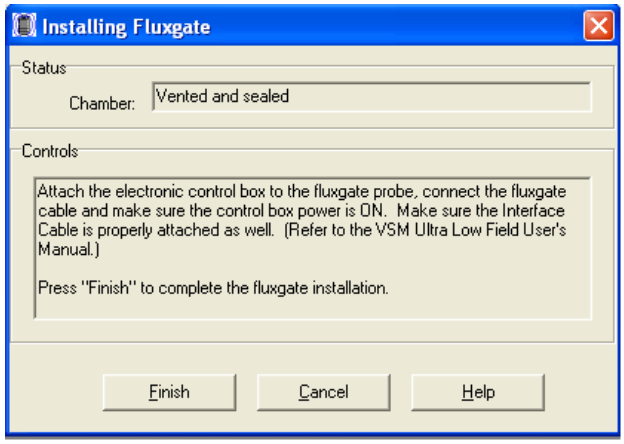


Figure 3-12. Installing Fluxgate dialog: Completing the fluxgate installation

C A U T I O N !

Avoid applying excessive force when you attach the electronics box to the fluxgate probe. Otherwise, you could damage the armature of the VSM linear motor transport.

10. Verify that the electronics control box power is turned on (it automatically turns off after 15 minutes). If it is not, press the power button.
11. Click on the **Finish** button at the bottom of the dialog box to complete the fluxgate installation. The system will now perform a **Homing** operation and the process will be shown in the **Installing Fluxgate** dialog (Figure 3-13).

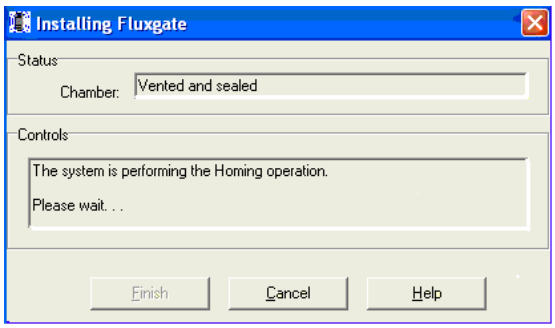


Figure 3-13. Installing Fluxgate dialog: Performing a Homing operation

During the **Homing** operation the software finds the minimum and maximum positions for the magnetic field sensor, which is embedded 1.1 cm from the bottom of the G-10 portion of the fluxgate probe. These two values define the range of positions at which the remnant field can be zeroed during the next phase. The range depends on where the adapter assembly is clamped and is the basis for the recommendation to clamp it 48.8–49.2 inches from the bottom of the probe (see Section 4.2.2.3).

12. When the **Homing** operation finishes you will have completed the fluxgate installation.
13. The **Installing Fluxgate** dialog will close and the **VSM ULF Operations** dialog will have three active **Control** buttons, indicating that you can now perform any of the three operations: remove the fluxgate, zero the magnetic field, or perform a magnetic field profile (Figure 3-14).

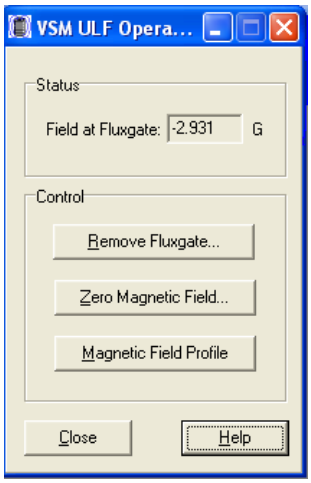


Figure 3-14. VSM ULF Operations dialog with active Control buttons

The next section (Section 3.5) explains how to perform zeroing and field-profiling operations with the VSM ULF fluxgate magnetometer.

Important: Before you begin zeroing or field-profiling operations, verify that the **Field at Fluxgate** value in the **VSM ULF Operations** dialog box is the same as the value that is displayed in the electronics control box. If these two displays do not show the same value, please contact Customer Service at Quantum Design.

3.5 Using the VSM ULF Option

Zeroing procedures are organized by the **VSM ULF Zero Magnetic Field** dialog box (Figure 3-15), which has two options for the fluxgate position. After introducing the dialog box (Section 3.5.1), we explain how to use the **Center of the VSM Coil (4.1 cm)** option (Sections 3.5.2 and 3.5.3). The second, "off-center" option is explained in Section 3.5.4.

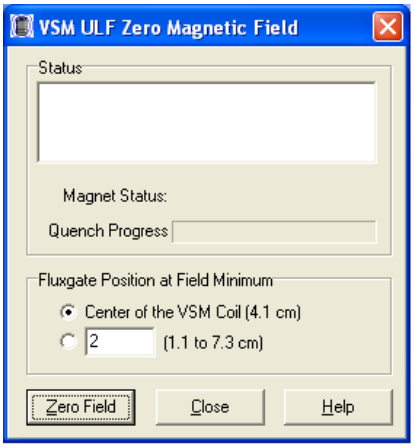


Figure 3-15. VSM ULF Zero Magnetic Field dialog (Zero Field dialog)

3.5.1 VSM ULF Zero Magnetic Field Dialog

1. To open the **VSM ULF Zero Magnetic Field** dialog box (**Zero Field** dialog for short), click on the **Zero Magnetic Field** button in the **VSM ULF Operations** dialog box (Figure 3-14).
2. When the **Zero Field** dialog box opens (Figure 3-15), you will see **Status** and **Fluxgate Position ...** sections and **Zero Field**, **Close**, and **Help** buttons.
   - The **Status** area will display the status of the magnet and any magnet quench in progress.
   - Options in the **Fluxgate Position at Field Minimum** allow you to zero the field at the **Center of the VSM Coil (4.1 cm)** or at an "off-center" location, which is any other location between the two limits that were found during the **Homing** operation (see Section 3.4.3, Step 11). Note that the off-center limits will vary according to the distance between the magnetic lock and the bottom of the probe (see Section 4.2.2).
   - The **Zero Field** button is used to start the zeroing process. After you have started it, the label of this button changes to **Abort** (see Figure 3-16). You can stop the zeroing operation at any time by clicking on this button.
   - The **Close** button closes the **Zero Field** dialog.

3.5.2 Example: Zeroing the Field at 4.1 Centimeters

1. If necessary, open the **Zero Field** dialog box (Figure 3-15) by clicking on the **Zero Magnetic Field** button in the **VSM ULF Operations** dialog box (Figure 3-14).
2. In the **Zero Field** dialog box, click in the check box next to **Center of the VSM Coil (4.1 cm)**.
3. Click on the **Zero Field** button at the bottom of that dialog box.
4. The program will automatically perform an initial quench to expel the remnant field (Figure 3-16).

   Note that the button at the lower left of the **Zero Field** dialog box is now labeled **Abort**.

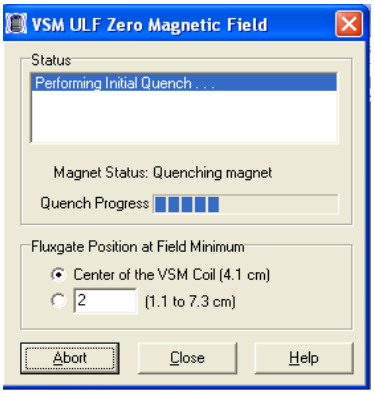


Figure 3-16. Zero Field dialog: Zeroing the field at 4.1 cm

5. The program will move the fluxgate magnetometer to 4.1 cm and measure the field. These procedures will be reported in the **Zero Field** dialog box (Figure 3-17) and in the **VSM ULF Log** (Figure 3-18), which will report that the system is performing a touchdown.

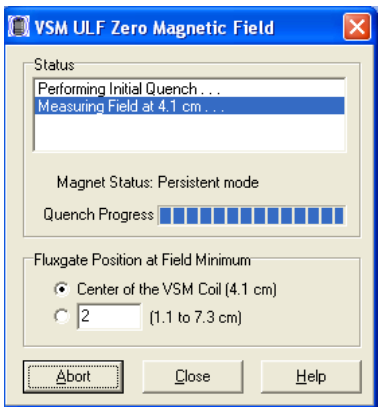


Figure 3-17. Zero Field dialog: Measuring the field at 4.1 cm

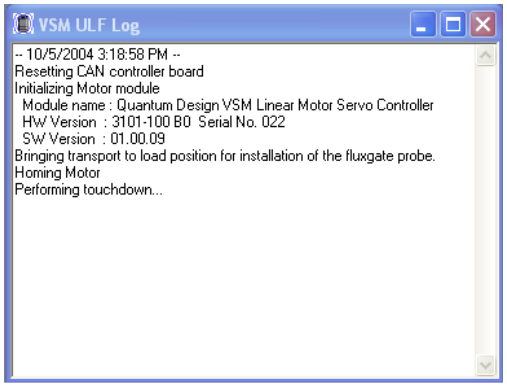


Figure 3-18. VSM ULF Log: Logging the zero-field operation

7. Next, the program will automatically apply a compensation field and quench the magnet to reduce the measured remnant (Figure 3-19), and the **VLM ULF Log** will show that the magnetic sensor was moved to 4.1 cm (Figure 3-20). After the remnant field measurement, the transport will move the fluxgate magnetometer to the bottom of the travel range that was determined during the **Homing** operation. This repositioning prevents the CAN module from being overheated.

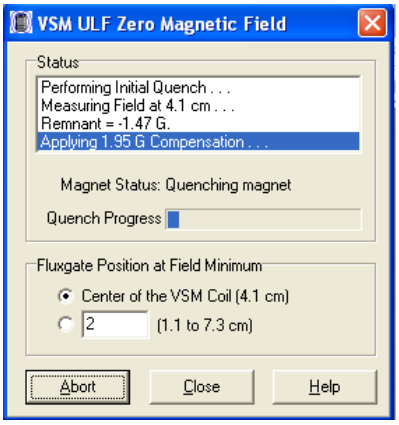


Figure 3-19. Zero Field dialog: Compensating for the remnant field

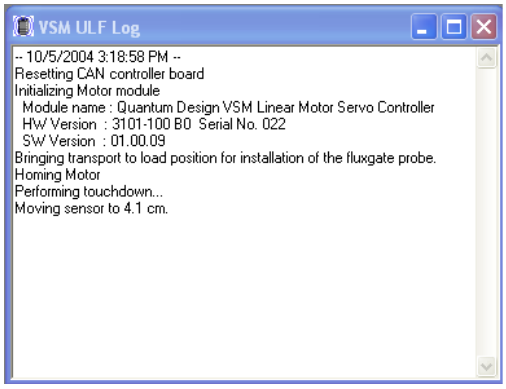


Figure 3-20. VSM ULF Log: Logging the sensor movement

Important: If the adapter assembly was installed less than 48.8 inches from the bottom of the probe, the system will not be able to perform a touchdown and a **Warning** message will be issued (Figure 3-21).

You will not be able to proceed further until you have repositioned the adapter assembly by using the sequence given below.

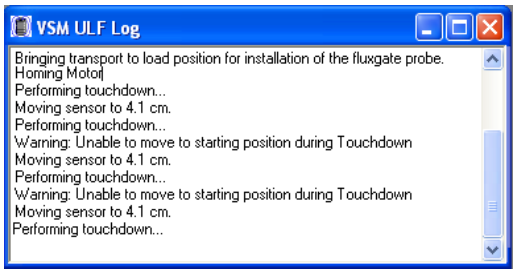


Figure 3-21. VSM ULF Log: Warning message

a. Stop the current procedure by clicking on the **Abort** button at the bottom left of the **Zero Field** dialog box (Figure 3-19).

b. Bring the fluxgate probe to the load position as explained in Section 2.5.1, Steps 1–5.

c. When the **Removing Fluxgate** dialog indicates that the VSM linear motor is in the load position, loosen the knurled nut on the fluxgate adapter assembly and reposition it (see Section 4.2.2).

d. Click on the **Cancel** button at the bottom left of the **Removing Fluxgate** dialog (see Figure 2-15). Now you will be returned to the **VSM ULF Operations** dialog box (e.g., Figure 3-24).

e. Re-attach the electronic control box to the fluxgate probe.

f. In the **VSM ULF Operations** dialog box, click on the **Zero Field** button to open the **Zero Field** dialog box and return to zeroing the magnetic field (e.g., at Step 1 of Section 3.5.2).

8. As shown in Figures 3-22 and 3-23, the system will automatically continue to reduce the field and perform magnet quenches until the field remnant is under 0.1 G.

9. When the remnant has been reduced to 0.1 G, the status area of the **Zero Field** dialog box will display "Done" (Figure 3-23). Note that the button that was labeled **Abort** has changed back to **Zero Field**.

10. Click on the **Close** button.

11. Now you will be returned to the **VSM ULF Operations** dialog box (Figure 3-24). Note that the value in the **Field at Fluxgate** text box now reads 0.098 G, by comparison with the value of –2.931 G at the start of the field-zeroing operation (Figure 3-14).

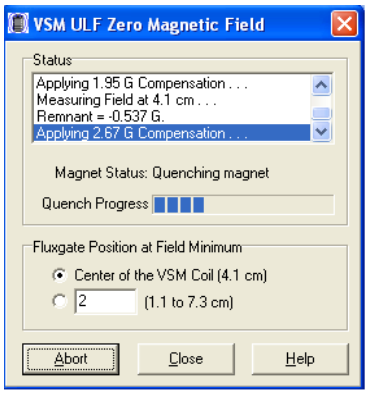


Figure 3-22. Zero Field dialog: Reducing the field remnant

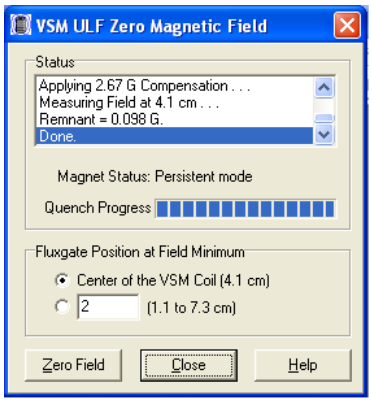


Figure 3-23. Zero Field dialog: Field remnant under 0.1 G

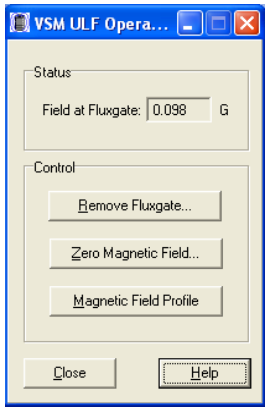


Figure 3-24. VSM ULF Operations dialog box after field zeroing

3.5.3 Profiling the Magnetic Field

1. Click on the **Magnetic Field Profile** button in the **VSM ULF Operations** dialog box.

2. The **VSM ULF Log Data** dialog box (Figure 3-25) will open so that you can save the profile data to a file.

   "`VSMUlfProfile.dat`" is the default name for the field profile data file, but you can choose another name by clicking on the **Browse** button and designating another file name and/or directory, as is shown in Figure 3-26.

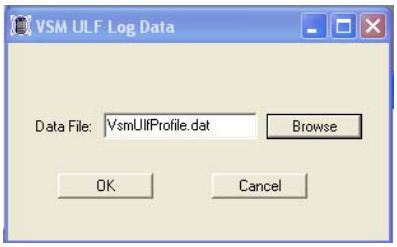


Figure 3-25. VSM ULF Log Data dialog box for saving field profile data

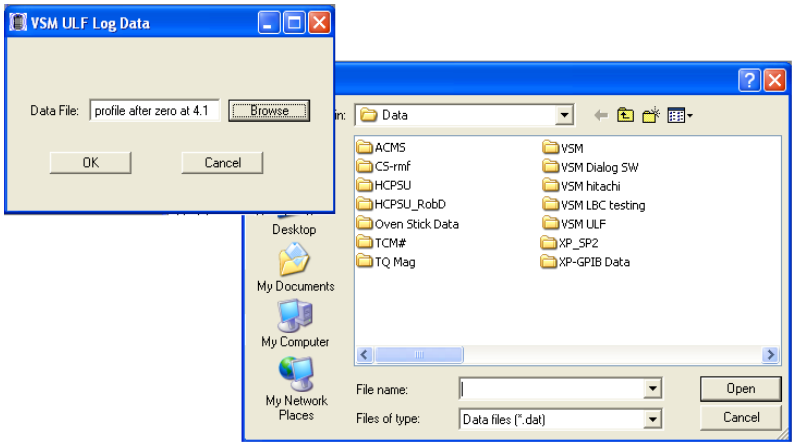


Figure 3-26. Changing the name of the field profile data file

3. After designating a name for your profile data file, click on the **OK** button at the bottom of the **VSM ULF Log Data** dialog box. The program will begin the field profile, and the only active button in the **VSM ULF Operations** dialog box will be one that allows you to **Abort** the field-profiling operation (Figure 3-27).
4. During the field profile, the program will move the fluxgate magnetometer to the top of the travel range determined during the **Homing** operation, then it will slowly lower it down. At the same time, it will log the data (Figure 3-28). In the **VSM ULF Operations** dialog box, the **Field at Fluxgate** reading (in the **Status** section) will change during the movement, reflecting the field that remains in the magnet, and the only active control button will be labeled **Abort**.

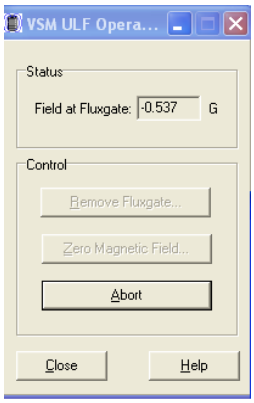


Figure 3-27. VSM ULF Operations dialog box during field profiling

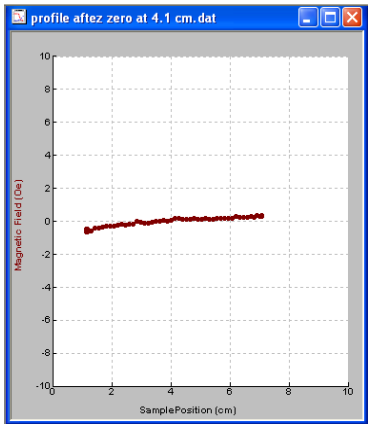


Figure 3-28. Plotting the field profile data

3.5.4 Example: Zeroing the Field at 5 Centimeters

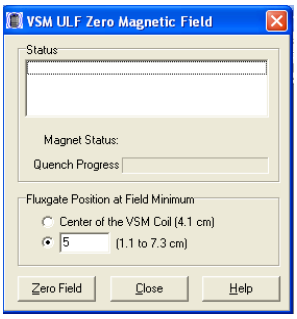


Figure 3-29. Zero Field dialog: Zeroing the field at 5 cm

As is explained in Section 3.5.1, you can zero the field at a fluxgate position other than the center of the VSM coilset. Use this "off-center" option as follows:

1. If necessary, open the **Zero Field** dialog box (Figure 3-29) by clicking on the **Zero Magnetic Field** button in the **VSM ULF Operations** dialog box (e.g., Figure 3-24).
2. In the **Zero Field** dialog, select the second option, which is shown in Figure 3-29 as **(1.1 to 7.3 cm)**, and enter your value in the option text box. For example, in Figure 3-29 we used 5 cm.

   Important: Remember that the limits for the off-center option depend on where you placed the adapter assembly, as is explained in Section 4.2.2.
3. Click on the **Zero Field** button at the bottom of the **Zero Field** dialog box.
4. The remainder of the process will proceed the same as when you use the center of the VSM coil to zero the field (see Section 3.5.2).

   Important: If the adapter assembly was installed less than 48.8 inches from the bottom of the probe, the **VSM ULF Log** will not be able to perform a touchdown at the position you designated, and a **Warning** message will be issued (Figure 3-30).

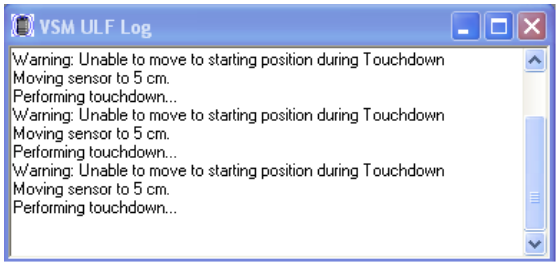


Figure 3-30. VSM ULF Log: Warning message

If this type of warning message appears, you will not be able to proceed further until you have repositioned the adapter assembly by using the sequence given below.

a. Stop the current procedure by clicking on the **Abort** button at the bottom left of the **Zero Field** dialog box (e.g., Figure 3-22).
b. Bring the fluxgate probe to the load position as explained in Section 2.5.1, Steps 1–5.
c. When the **Removing Fluxgate** dialog indicates that the VSM linear motor is in the load position, loosen the knurled nut on the fluxgate adapter assembly and reposition it (see Section 4.2.2).
d. Click on the **Cancel** button at the bottom left of the **Removing Fluxgate** dialog (see Figure 2-15). Now you will be returned to the **VSM ULF Operations** dialog box (e.g., see Figure 3-24).
e. Re-attach the electronic control box to the fluxgate probe.
f. In the **VSM ULF Operations** dialog box, click on the **Zero Magnetic Field** button to open the **VSM ULF Zero Magnetic Field** dialog box and return to zeroing the magnetic field (e.g., at Step 1 of Section 3.5.4).

C H A P T E R 4

VSM ULF Hardware

4.1 Introduction

This chapter contains the following information:

- Section 4.2 describes hardware components of the VSM ULF option.
- Section 4.3 describes maintenance and use of the fluxgate magnetometer.

4.2 VSM ULF Hardware Components

The hardware components of the VSM Ultra-Low Field (ULF) option include a fluxgate magnetometer, a magnetometer storage (wall) bracket, a fluxgate cable, and an interface cable.

4.2.1 Fluxgate Magnetometer

The fluxgate magnetometer is used to measure the magnetic field in the sample chamber. As is shown in Figure 4-1, the fluxgate magnetometer consists of an electronic control box and a probe. The fluxgate probe includes a coupling, a fluxgate adapter assembly, a stainless-steel tube, a fiberglass tube, and the field sensor.

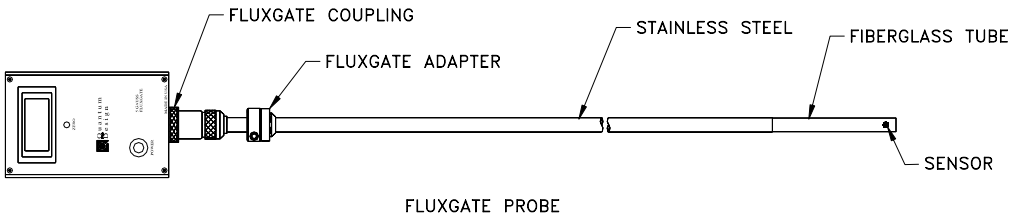


Figure 4-1. VSM fluxgate magnetometer assembly

The fluxgate magnetometer is a precision instrument that must be handled with care. When you are working with it, hold it by the stainless steel section of the probe to avoid damaging the fiberglass tube and sensor.

C A U T I O N !

Handle the fluxgate magnetometer carefully to avoid damaging the fiberglass tube and the fluxgate sensor that are located at the bottom of the fluxgate probe. Only hold the fluxgate probe by the stainless-steel portion, ***never*** by the fiberglass tube.

The fluxgate magnetometer is a vector instrument that reads the magnetic field parallel to the longitudinal axis of the fluxgate probe. The VSM ULF option requires the fluxgate magnetometer in order to zero the magnetic field at a specific position or plot the field profile. This fluxgate magnetometer is specifically designed to fit inside the VSM linear motor transport, sample tube, and VSM coilset. Its movement is controlled by the VSM linear motor transport.

The fluxgate sensor in the fluxgate magnetometer measures the magnetic field inside the sample chamber. The sensor, which is 1.1 cm above the bottom of the fluxgate probe, is embedded in the G-10 fiberglass tube, which is the lower part of the fluxgate probe. The fiberglass housing prevents the fluxgate sensor from contacting anything magnetic. The VSM linear motor transport moves the fluxgate probe up and down within the sample chamber so that the fluxgate sensor can measure the field at any number of locations. PPMS MultiVu reads the field measurements and can plot them or instruct the system to apply a compensation field that nulls the measured remnant field.

Important: The performance of the fluxgate sensor has not been characterized at cryogenic temperatures. Thermal cycling can cause serous damage to the magnetometer.

C A U T I O N !

Always wait to use the magnetometer until the temperature of the system has been stable for at least 20 minutes. This is to prevent thermal shocking, which can seriously damage the magnetometer.

4.2.2 Fluxgate Adapter Assembly

The fluxgate adapter assembly (Figure 4-2) holds the fluxgate probe in place in the VSM linear motor transport. The adapter is constructed of anodized aluminum and has two components: an adjustable clamp and a magnetic lock. The adjustable clamp allows you to move the adapter up and down on the fluxgate probe to change the zeroing and profiling range, and the magnetic lock sticks to the magnetic lock ring, which is a thin steel ring at the top of the VSM sample access port.

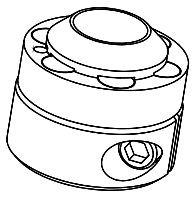


Figure 4-2. Fluxgate adapter assembly (upside down)

4.2.2.1 ADJUSTABLE CLAMP

The adjustable clamp is closed around the fluxgate probe by tightening the horizontal screw. Two vertical screws hold the clamp in place on top of the magnetic lock. If you need to loosen or tighten the adjustable clamp, you can use the Allen wrench provided in the VSM ULF Option User's Kit to turn the horizontal screw.

4.2.2.2 MAGNETIC LOCK.

The magnetic lock contains six small, very strong magnets that attach the fluxgate probe to the armature of the linear motor transport during zeroing and field-profiling operations. Keep the magnets clean and prevent them from contacting any magnetic object.

Important: Keep the magnet surfaces clean, as the strength of the lock depends on the magnets being flush in contact with the mating part in the linear motor transport. Also, avoid bringing the magnets into contact with magnetic objects. Although small, the magnets are extremely strong.

4.2.2.3 POSITIONING THE FLUXGATE ADAPTER ASSEMBLY

The VSM ULF option is shipped with an assembled fluxgate magnetometer (Figure 4-1). Note that the fluxgate adapter assembly (Figure 4-2) is located 48.8 inches from the bottom of the probe. If you adjust the fluxgate adapter assembly, attach it 48.8–49.2 inches from the bottom of the fluxgate probe. A distance of 48.8 inches is the minimum that will allow the bottom of the fluxgate probe to touch the surface of the puck at the VSM coilset. This contact is necessary for touchdown operations. A distance of 49.2 inches will allow the magnetometer to profile the magnetic field over 2 cm around the center of the VSM coilset. Distances greater than 49.2 inches reduce the profiling capability below 2 cm.

Important: Verify that there is 48.8–49.2 inches between the fluxgate adapter assembly and probe bottom. At this location, the magnets of the adapter assembly will engage the armature of the linear motor transport. If there is less than 48.8 inches between the adapter assembly and the bottom of the fluxgate probe, the system will not be able to perform touchdowns or valid field-nulling operations.

The adapter assembly is secured in place on the probe by a horizontal screw (see Figure 4-2). Use the Allen wrench in the VSM ULF Option User's Kit to loosen and tighten the screw if you reposition the adapter assembly.

4.2.3 Electronics Control Box

Figure 4-3 shows the electronics control box, which mounts on top of the fluxgate probe and contains the electronics that operate the fluxgate sensor. The digital display on the front panel of the electronics control box shows the field, in gauss, as measured by the fluxgate sensor. The power to the fluxgate is turned on-and-off by pressing the “Power” button. The zero-adjustment screw adjusts the zero offset of the fluxgate.

When the magnetometer is installed in the PPMS, the electronics box is connected to the Model 6000 by the fluxgate cable, which plugs into the port on the rear panel of the electronics control box (Figure 4-4).

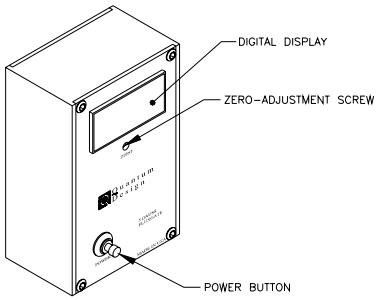


Figure 4-3. Front of electronics control box

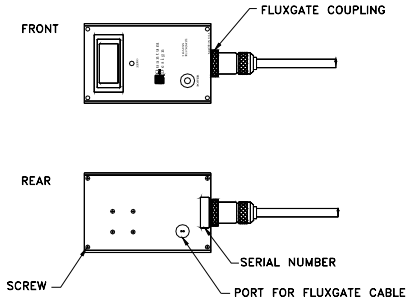


Figure 4-4. Front and back views of electronics control box

The electronics control box can be detached from the fluxgate probe by loosening the fluxgate coupling, which is at the top of the fluxgate probe, and then pulling the box off the probe. Figure 4-4 shows the fluxgate coupling in relation to the fluxgate magnetometer.

Important: Verify that the same serial number is used on the electronics control box and the fluxgate probe. Quantum Design assigns the same serial number to sets of these components to help ensure that the correct ones are used together. If the serial number is not the same, contact Customer Service at Quantum Design.

4.2.4 Wall Storage Bracket

The wall storage bracket (Figure 4-5) holds and protects the fluxgate magnetometer when it is not in the sample chamber. You can vertically mount the storage bracket on any wall, but you should locate it relatively near the PPMS to facilitate installing and removing the fluxgate magnetometer. For instructions on attaching the storage bracket to the wall, see Section 2.3.4.

Near the base of the storage bracket is a two-layer permalloy fluxgate shield that protects the fiberglass tube and fluxgate sensor, which are at the bottom of the fluxgate probe. The fluxgate shield is also a magnetic shield that attenuates the magnetic field of the Earth by more than 60 dB. Thus, within the shield, the remnant field is less than 0.5 mG.

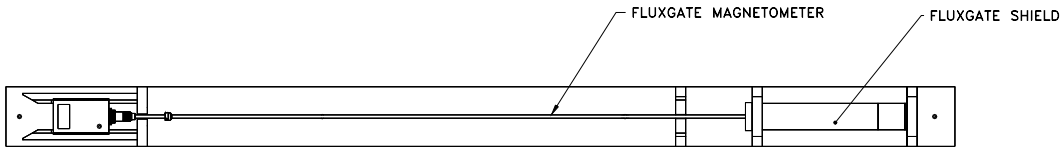


Figure 4-5. Fluxgate magnetometer in wall storage bracket

To further protect the magnetometer, we have designed the wall bracket so that you cannot remove the magnetometer until the probe section has cleared the fluxgate shield.

Important: Place the magnetometer in the bracket as soon as you remove it from the sample chamber. This reduces the risk that it will be damaged as you move around the laboratory.

4.2.5 Interface Cable Assembly

The interface cable assembly for the VSM ULF option (Figure 4-6) reroutes the signal from the ACMS board to the low-field magnet coil in the magnet. (In systems with standard dewars, the ACMS board is in the Model 6000 controller; in PPMS–EverCool systems, the ACMS board is in the Model 6500 controller.)

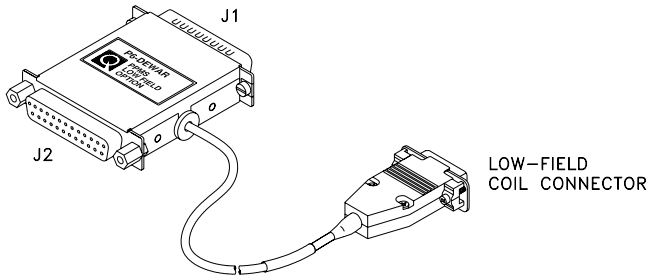


Figure 4-6. Interface cable assembly for the VSM ULF option

The ULF option interface cable assembly has three connectors. The J1 and J2 connectors are on opposite ends of the large, silver-colored box that is labeled "P6–Dewar PPMS Low Field Option." The low-field coil connector is at the end of the cable that is attached to the silver-colored box.

4.2.6 Fluxgate Cable Assembly

Figure 4-7 shows the fluxgate cable, which is the electrical connection between the fluxgate magnetometer and P8–Auxiliary port on the Model 6000 PPMS controller. The Lemo connector on the cable plugs into the port on the rear panel of the fluxgate electronics control box (Figure 4-4), and the DB-25 connector plugs into the Model 6000. This cable feeds a voltage proportional to the field to an analog input on the Model 6000 that is ultimately read by the ULF software.

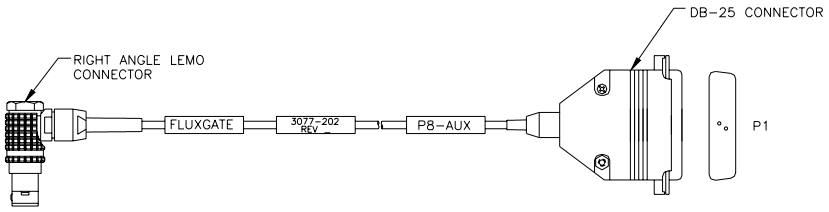


Figure 4-7. Fluxgate cable assembly

4.3 Maintenance and Use of the Fluxgate Magnetometer

Periodically, the VSM ULF fluxgate magnetometer will require a new battery (see Section 4.3.4). Aside from that, it does not need regular maintenance. Instructions for verifying fluxgate magnetometer operations and adjusting the zero offset are given below.

4.3.1 Power Requirements

One standard 9 V transistor battery will continuously operate the fluxgate magnetometer for 8 to 10 hours.

The control unit of the fluxgate magnetometer has an automatic shut-off feature that turns off the power to the magnetometer after it has been on for approximately 15 minutes, which prevents the battery from being discharged if the unit is left on. Those 15 minutes should be enough time to run a field-nulling operation and plot the residual field. However, if the fluxgate magnetometer turns off while you are using it, just press the "Power" button to turn it on again (see Figure 4-3).

When it is time to replace the battery, a small icon of a battery will appear in the upper left corner of the display on the electronics control box. This icon is the low-battery indicator. Section 4.3.4 has instructions for replacing the battery.

4.3.2 Verifying Proper Operation

1. Remove the fluxgate magnetometer from the wall bracket as follows: Lift the fluxgate magnetometer upward until it clears the fluxgate shield, and then pull the fluxgate magnetometer out of the wall bracket.
2. Activate the fluxgate magnetometer by pressing the "Power" button on the electronics control box. The digital display should immediately begin showing the ambient field.
3. Test the fluxgate magnetometer by altering its orientation with respect to the ambient field of the earth, and watch the fluxgate to see if the output changes.
4. If the output does not change, contact Customer Service at Quantum Design.

4.3.3 Adjusting the Zero Offset

1. If necessary, place the fluxgate magnetometer in the wall bracket. The two-layer permalloy fluxgate shield in the wall bracket is a magnetic shield that establishes a true zero field around the sensor.
2. Activate the fluxgate magnetometer by pressing the "Power" button on the electronics control box. The digital display should indicate that the field is zero (0).
3. If the field is not zero, adjust the zero offset of the magnetometer. Use the flathead screwdriver included with the VSM ULF Option User's Kit to turn the zero-adjustment screw until the digital display indicates the field is zero (0).

4.3.4 Replacing the Battery

You must replace the battery in the electronics control box whenever the display shows a small icon of a battery. The icon is the low-battery indicator.

Complete the following steps to replace the battery:

1. If the fluxgate magnetometer is in the sample chamber, remove it (refer to Section 2.5.1).
2. Lay the fluxgate magnetometer on a flat surface and detach the electronics control box from the fluxgate probe.
   - Loosen the fluxgate coupling (see Figures 4-1 and 4-4).
   - Pull the box off the probe.
3. Use the screwdriver included with the VSM ULF Option User's Kit to remove the screws at the corners of the rear panel of the electronics control box (see Figure 4-4).
4. Remove the rear panel from the electronics control box.
5. Remove the battery from its holder. Work carefully to avoid pulling out the wires that connect the battery and rear panel receptacle to the electronics inside the control box.
6. Place a new 9 V transistor battery into the battery holder.
7. Reattach the rear panel to the electronics control box.
8. Please follow the local regulations when you dispose of the used battery.

References

Quantum Design. *Model 1000 Modular Control System User's Manual*, 2003.

———————. *Physical Property Measurement System: Hardware Manual, B-0*, 2004.

———————. *Physical Property Measurement System: Vibrating Sample Magnetometer (VSM) Option User's Manual, A-2*, 2004.