Quantum Design

Magnetic Property Measurement System

MPMS MultiVu Application User's Manual

Part Number 1014-110C

Quantum Design

6325 Lusk Blvd.
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
5,053,834	High Symmetry DC Squid System
5,110, 034	Superconducting Bonds for Thin Film Devices
5,139,192	Superconducting Bonds for Thin Film Devices
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)
5,319,307	Geometrically and Electrically Balanced DC Squid System Having a Pair of Intersecting Slits
5,647,228	Apparatus and Method for Regulating Temperature in Cryogenic Test Chamber

Foreign Patents

U.K.	9713380.5	Apparatus and Method for Regulating Temperature in Cryogenic Test Chamber
Canada	2,089,181	High Symmetry DC Squid System
Japan	2,533,428	High Symmetry DC Squid System
Japan	2,533,428	High Symmetry DC Squid System

C O N T E N T S

Table of Contents

CHAPTER 3

CHAPTER 4

CHAPTER 6

Figures

Tables

P R E F A C E

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 discusses the MPMS MultiVu application, which is the software running the Magnetic Property Measurement System (MPMS) and the MPMS options. This manual describes how you install and how you use MPMS MultiVu.

The MPMS MultiVu application must run on Windows 95. This manual assumes you are familiar with Windows 95.

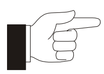
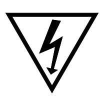
For information about the MPMS hardware, refer to the *MPMS Hardware Reference Manual*. For specific information about any of the MPMS options, refer to the appropriate option manual.

P.3 Contents of the Manual

- Chapter 1 introduces the MPMS MultiVu application.
- Chapter 2 discusses the MPMS MultiVu interface.
- Chapter 3 explains how to use MPMS MultiVu to take a sample measurement.
- Chapter 4 discusses MPMS MultiVu data files.
- Chapter 5 discusses MPMS MultiVu sequence files and sequence operation.
- Chapter 6 discusses MPMS MultiVu sequence commands.

- Chapter 7 explains how to use MPMS MultiVu to perform basic system operations.
- Chapter 8 explains how to use MPMS MultiVu to perform diagnostic functions.
- Appendix A explains how to install MPMS MultiVu.
- Appendix B explains the format of MPMS MultiVu data files.

P.4 Conventions in the Manual

File menu	Bold text distinguishes the names of menus, options, buttons, and panels appearing on the PC monitor.
File➤Open	The ➤ symbol indicates that you select multiple, nested software options.
`.dat`	The Courier font distinguishes code and the names of files and directories.
<Enter>	Angle brackets distinguish the names of keys located on the PC keyboard.
<Alt+Enter>	A plus sign connecting the names of two or more keys distinguishes keys you press simultaneously.
	A pointing hand introduces a supplementary note.
	An exclamation point inside an inverted triangle introduces a cautionary note.
	A lightning bolt inside an inverted triangle introduces a warning.

C H A P T E R 1

Introduction to MPMS MultiVu

1.1 Introduction

This chapter contains the following information:

- Section 1.2 presents an overview of the MPMS MultiVu application.
- Section 1.3 explains how to start up MPMS MultiVu.

1.2 Overview of the MPMS MultiVu Application

MPMS MultiVu is a 32-bit, Windows 95–based application that controls and monitors the operation of the MPMS hardware and the operation of installed MPMS options. MPMS MultiVu integrates all system operations into one versatile and easy-to-use Windows 95 interface (see figure 2-1). System operation is simplified; multiple commands that open files, run measurements, or set parameters are always enabled. The control center and status bar in the MPMS MultiVu interface always display status information.

MPMS MultiVu functions like any Windows 95 application and uses all Windows 95 conventions. Windows 95 utilities may be used to control and manage MPMS MultiVu file folders without exiting MPMS MultiVu. MPMS MultiVu may run simultaneously with other applications.

NOTE

This manual generally describes one method of performing a specific task in MPMS MultiVu. However, different MPMS MultiVu commands can often be used to perform the identical task. As you work with MPMS MultiVu, you will discover multiple ways of performing identical tasks.

1.2.1 Immediate Mode and Sequence Mode Operation

MPMS MultiVu supports manual, or immediate, tasks and automated, or sequence, tasks. Menu options and control center commands execute immediately. Sequence commands execute only when the sequence file in which the commands are included runs, but while the sequence runs, the commands are executed automatically. If you select a measurement command in the MPMS MultiVu

Measure menu, you are taking a measurement in immediate mode. If you add a measurement sequence command to a sequence file and then run the sequence, you are taking a measurement in sequence mode.

1.2.2 Data Viewing

MPMS MultiVu offers tremendous flexibility in data-viewing options. When you open a data file, you see a plot of the actual data stored in the file. You can modify the appearance of the graph view of the file and select which types of data are plotted in the graph. You can also use tables or a text editor to examine the data, and you can import the data file into another graphics application. MPMS MultiVu automatically saves all system-generated data to data files.

1.2.3 Comparison with the MPMSR2 DOS Software

MPMS MultiVu simplifies many of the tasks performed in the MPMSR2 DOS software and includes new features that make it easier to work with the MPMS.

Table 1-1. New Features in MPMS MultiVu

TASK	WHAT MPMS MULTIVU DOES	MANUAL REFERENCE
Storing Data	Stores data in data files and prevents data files from being overwritten. Allows data files to be opened at any time.	Section 4.2 Section 4.3
Viewing Data	Allows graph of data file to be modified and data to be examined in different viewing formats.	Section 4.5 Section 4.6
Automating Operation	Edits, executes, and controls sequence files.	Section 5.2 Section 5.4
Recording Events	Includes event log that records error, information, and sequence events.	Section 7.8.6
Recording System Data	Includes environment log file that can store system data indefinitely.	Section 4.3.3
Tuning SQUID	Allows SQUID coils to be tuned automatically.	Section 7.5
Running Control Loop	Includes scan sequence commands that create execution loops.	Section 6.3
Performing Diagnostics	Includes Diagnostics dialogs that list all diagnostic parameters and allow parameters to be modified.	Chapter 8

MPMS MultiVu allows you to convert MPMSR2 DOS sequence files and data files to the MPMS MultiVu format.

- Select the **Utilities➤Convert Sequence** menu option to convert an MPMSR2 DOS sequence.
- Select the **Utilities➤Convert Data File** menu option to convert an MPMSR2 DOS data file.

1.3 Starting Up MPMS MultiVu

1. Do one of the following: (*a*) select the **MPMS MultiVu** icon that is on the desktop or (*b*) open the Windows 95 **Start** menu and then locate and select the **MPMS MultiVu** option. The **MPMS MultiVu** option may be located in the **Programs➤Quantum Design** folder.
2. Wait for MPMS MultiVu to start up. The MPMS MultiVu interface opens, and in the center of the interface, the **System Startup** dialog box appears. The **System Startup** dialog box identifies each task the system performs as part of start-up. The dialog box disappears as soon as start-up is complete.

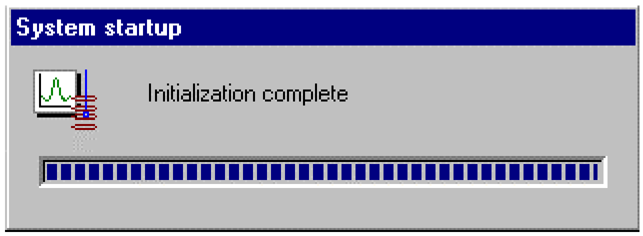


Figure 1-1. **System Startup** Dialog Box

C H A P T E R 2

MPMS MultiVu Interface

2.1 Introduction

This chapter contains the following information:

- Section 2.2 summarizes the function of the MPMS MultiVu interface.
- Section 2.3 discusses the main features of the MPMS MultiVu interface.

2.2 Function of the MPMS MultiVu Interface

Menu options and command buttons in the MPMS MultiVu interface perform all manual and automated MPMS tasks. Immediate instrument status feedback information displayed in the interface indicates the current system status. The interface allows immediate control of the MPMS for performing a wide variety of standard tasks, such as changing the temperature or magnetic field, running measurements, or logging system data. The interface also allows most functions of the MPMS and the MPMS options to be automated by using a series of simple commands, called a sequence. MPMS MultiVu provides the sequence editor and the commands that initiate and control the running sequence.

The MPMS MultiVu interface simplifies data collection and data viewing. Data can be viewed in a graphic, tabular, or raw data format. Data can be viewed in real time during automated operation, or it can be viewed after it has been collected.

2.2.1 MDI Application Interface

MPMS MultiVu is a multiple document interface (MDI) Windows application. In MPMS MultiVu, multiple documents may be open for viewing and editing at any one time, and a single document can be viewed in multiple ways. For example, a data file can be viewed in a graph, table, record, or raw data window. Each different view presents the same information in a unique manner. The name of the active document appears in the title bar of the main **MPMS MultiVu** window. To activate a document, you simply click anywhere within its window.

2.3 Features of the MPMS MultiVu Interface

The MPMS MultiVu menu options and command buttons provide multiple ways of performing many basic tasks, such as opening files and running sequences. The menu options and command buttons that are available depend on the active file and the task being performed and also on the installed hardware options. Figure 2-1 illustrates the basic elements of the MPMS MultiVu interface. Other windows may be visible, depending on the task being performed.

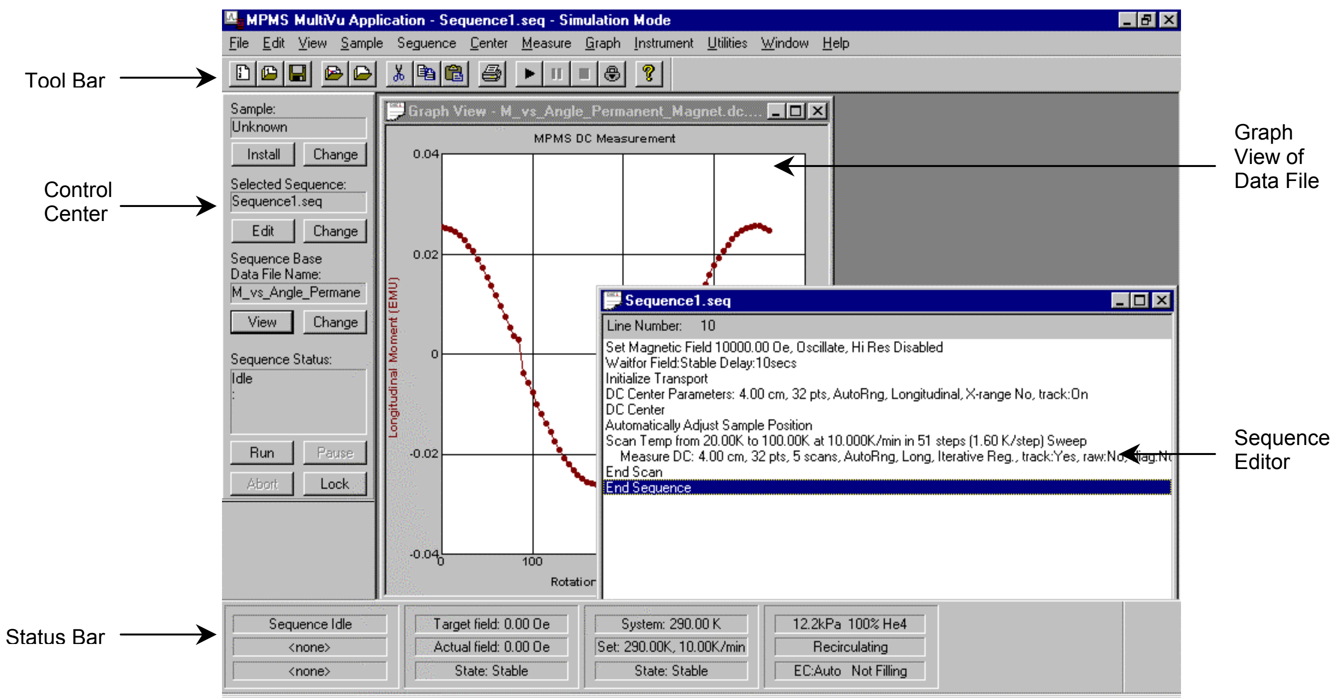


Figure 2-1. MPMS MultiVu Interface

2.3.1 Menu Bar

All MPMS MultiVu functions are accessible through the menus in the menu bar. The available menus and menu options vary, based on the current task, active file, and installed MPMS options. Some options add items to the menus.

Table 2-1. MPMS MultiVu Menus

MENU	FUNCTION
File	Contains standard Windows commands that create, open, or close files.
Edit	Contains standard Windows editing commands that edit sequence files. Menu is available only when sequence file is active.
View	Options show or hide parts of interface or select data-viewing formats.
Sample	Options summarize sample parameter and sample installation data.
Sequence	Options control sequence operation.
Center	Options control centering operation.
Measure	Options control measurement operation.
Graph	Options open and modify graph configuration files and create and apply graph template files.
Instrument	Options control basic operation of MPMS hardware.
Utilities	Options are tools that help operate MPMS or are diagnostics that directly control MPMS hardware.
Window	Contains standard Windows organization commands that arrange icons or windows. Menu is available only when sequence or data file is active.
Help	Standard Windows Help menu.

2.3.2 Pop-up Menus

In addition to the menus in the menu bar, MPMS MultiVu includes a **Graph** pop-up menu and an **Edit** pop-up menu, which provide shortcuts to data-viewing commands and editing commands, respectively. The **Graph** pop-up menu is available only when the graph view of a data file is active. The **Edit** pop-up menu is available only when a sequence file is active.

You open the **Graph** pop-up menu by right-clicking the mouse inside a graph window. If you right-click anywhere inside the graph window except immediately above or below the graph, then all menu options, including **X Axis Auto Scale** and **Y Axis Auto Scale**, are available.

Graph pop-up menu options and **Graph** menu options are nearly identical. Options in both menus modify graph configuration files and create and apply graph template files. However, **Graph** pop-up menu options emphasize modifying the graph format and selecting data-viewing formats. **Graph** menu options emphasize opening and saving files.

You open the **Edit** pop-up menu by right-clicking the mouse inside a sequence editor window. **Edit** pop-up menu options and **Edit** menu options are identical. Both menus contain standard Windows editing commands that you apply to sequence files.

2.3.3 Tool Bar

The tool bar buttons provide shortcuts that let you initiate many of the more frequently performed MPMS MultiVu functions without having to select multiple, nested menu options. The buttons are grouped according to function. The active file and the current state of sequence operation determine which buttons are enabled.

You may move, resize, dock, hide, or display the tool bar. The **View➤Tool Bar** toggle option hides or displays the tool bar.

If the mouse pointer pauses over a tool bar button, a ToolTip pops up to display the name of the button.

Table 2-2. MPMS MultiVu Tool Bar Buttons

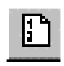
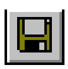
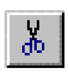
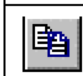
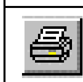
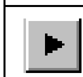
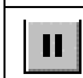
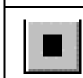
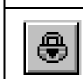
BUTTON		FUNCTION
	New Sequence File	Creates and opens new sequence file by opening sequence editor window for file.
	Open Sequence File	Opens sequence file by opening sequence editor window for file.
	Save Sequence File	Saves active sequence file. Button is enabled only when sequence file is active.
	Open Graph File	Opens data file whose graph format is defined by selected graph configuration file.
	Open Data File	Opens data file.
	Cut	Removes command or commands selected in sequence file. Button is enabled only when sequence file is active.
	Copy	Copies command or commands selected in sequence file. Button is enabled only when sequence file is active.
	Paste	Pastes last cut or copied command or commands into sequence file. Button is enabled only when sequence file is active.
	Print	Prints active sequence file or graph view of active data file.
	About	Identifies which version of MPMS MultiVu is running.
	Run Sequence	Runs selected sequence. Button is enabled only when sequence status is unlocked and no sequence is running.
	Pause Sequence Resume Sequence	Pauses or resumes unlocked sequence run. Button is enabled only when unlocked sequence runs.
	Abort Sequence	Aborts unlocked sequence run. Button is enabled only when unlocked sequence runs.
	Lock\Unlock Sequence	Locks or unlocks current sequence status.

Table 2-3. Equivalent Tool Bar Button and Menu Commands

TOOL BAR BUTTON	EQUIVALENT MENU COMMAND
New Sequence File	File➤New Sequence
Open Sequence File	File➤Open➤Sequence
Save Sequence File	File➤Save
Open Graph File	File➤Open➤Graph
Open Data File	File➤Open➤DataFile
Cut	Edit➤Cut
Copy	Edit➤Copy
Paste	Edit➤Paste
Print	File➤Print
About	Help➤About
Run Sequence	Sequence➤Control➤Run
Pause Sequence	Sequence➤Control➤Pause
Resume Sequence	Sequence➤Control➤Resume
Abort Sequence	Sequence➤Control➤Abort
Lock Sequence	Sequence➤Control➤Options➤Lock
Unlock Sequence	Sequence➤Control➤Options➤Unlock

2.3.4 Control Center

The control center summarizes sequence status information and allows you to control sequence operation without having to select menu options. The status panels and command buttons in the control center are grouped according to function and are arranged, from top to bottom, in the order you normally review or select them.

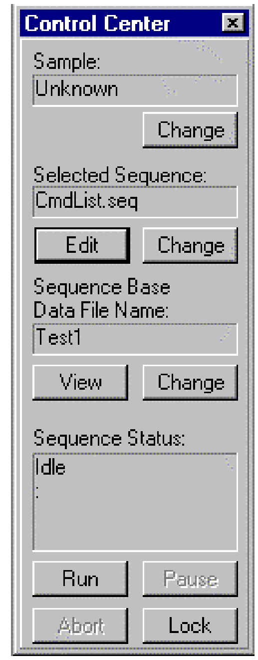


Figure 2-2. Control Center

The **Sample** panel at the top of the control center displays the name of the sample. You select the **Sample Change** button to review or redefine the sample parameters.

The **Selected Sequence** panel displays the name of the selected sequence, which is the sequence file that runs the next time an MPMS MultiVu **Run** command is issued. The **Edit** button opens the selected sequence, and the **Selected Sequence Change** button lets you choose another sequence to run.

The **Sequence Base Data File Name** panel displays the base name of the data files that will store the sequence measurement data. The **View** button opens the graph view of one of these files. The **Sequence Base Data File Name Change** button lets you select another data file to store the measurement data.

The **Sequence Status** panel indicates the status of the selected sequence—Idle, Running, or Paused—and when the sequence runs, displays (1) the command line number, as indicated in the sequence editor, and name of the sequence command being executed; (2) the name of the running sequence; and (3) the base name of the active data files. Clicking once in the **Sequence Status** panel opens the **Sequence Status** dialog box.

Run and **Abort** buttons as well as **Pause** or **Resume** and **Lock** or **Unlock** toggle buttons are at the bottom of the control center.

The **View➤Control Center** toggle option hides or displays the control center. Clicking once on any sequence status panel in the MPMS MultiVu status bar (see section 2.3.5.1) also displays the control center. You may move or dock the control center.

2.3.5 Status Bar

The status bar displays the sequence status and the status of the magnetic field, system temperature, and MPMS sample chamber. Panels displaying the same type of information are grouped together.

You may minimize, maximize, hide, display, or move the status bar. By default, the status bar is maximized to show the maximum amount of status information. The **View➤Status Bar➤Minimum** option minimizes the status bar so that it shows a minimal amount of information. **View➤Status Bar➤None** hides the status bar. **View➤Status Bar➤Maximum** displays the entire status bar.

Each field, temperature, and chamber status panel in the status bar is also a command button that opens the **Magnetic Field**, **Temperature Parameters**, or **Chamber** dialog box, respectively. These dialog boxes display status information and let you change the system state.

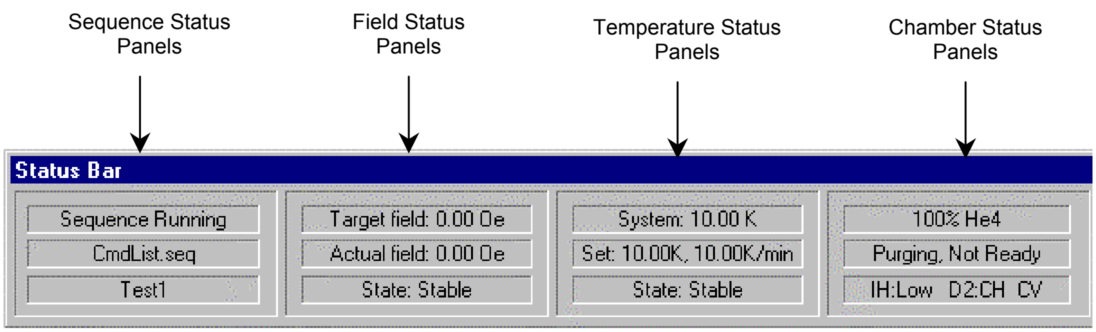


Figure 2-3. Status Bar Maximized

2.3.5.1 SEQUENCE STATUS PANELS

The sequence status panels indicate whether a sequence is running. The top or first panel always indicates the sequence status: Idle, Running, or Paused. During the run, the sequence status panels display the name of the running sequence and the base name of the active data files. If another sequence is selected for editing while a sequence is running, the sequence status panels continue to show the name of the running sequence and the base name of the data files storing the measurement data from the current sequence run.

Clicking once on any sequence status panel displays the control center.

Table 2-4. Data in Sequence Status Panels

	DISPLAYED DATA	
PANEL	**STATUS BAR MAXIMIZED**	**STATUS BAR MINIMIZED**
Top or Left	• Sequence status: “Idle,” “Running,” or “Paused”	• Sequence name and status during sequence run • “none” and “Idle” if sequence is idle
Middle or Right	• Sequence name during sequence run • “none” if sequence is idle	• Data file name if sequence is running • “none” if sequence is idle
Bottom	• Data file name if sequence is running • “none” if sequence is idle	

2.3.5.2 FIELD STATUS PANELS

The field status panels display the current magnetic field and indicate the state of field control.

Clicking once on any field status panel opens the **Magnetic Field** dialog box.

Table 2-5. Data in Field Status Panels

PANEL	DISPLAYED DATA	
	STATUS BAR MAXIMIZED	**STATUS BAR MINIMIZED**
Top	Field set point	Current field and state of field control
Middle	Current field	
Bottom	State of field control	

2.3.5.3 TEMPERATURE STATUS PANELS

The temperature status panels display the current system temperature and indicate the state of temperature control.

Clicking once on any temperature status panel opens the **Temperature Parameters** dialog box.

Table 2-6. Data in Temperature Status Panels

PANEL	DISPLAYED DATA	
	STATUS BAR MAXIMIZED	**STATUS BAR MINIMIZED**
Top	Current system temperature	Current system temperature and state of temperature control
Middle	Temperature set point and sweep rate	
Bottom	State of temperature control	

2.3.5.4 CHAMBER STATUS PANELS

The chamber status panels display the state of the sample chamber status and indicate the level of helium in the dewar.

Clicking once on any chamber status panel opens the **Chamber** dialog box.

Table 2-7. Data in Chamber Status Panels

PANEL	DISPLAYED DATA	
	STATUS BAR MAXIMIZED	STATUS BAR MINIMIZED
Top	Helium level in dewar	Helium level in dewar
Middle	State of sample chamber	
Bottom	Status of impedance heater, driver, and cooling valve	

When the EverCool option is active, the MPMS MultiVu status bar can display EverCool system status data instead of sample chamber status data. Refer to the *Magnetic Property Measurement System: EverCool Dewar Option User's Manual*.

2.3.6 Data File Windows

MPMS MultiVu documents include data files. You may examine data files in graph, table, record, or raw data windows. You may move, minimize, and maximize these windows. Any number of these windows may be open at one time.

Chapter 4 discusses data files and data-viewing formats in detail.

2.3.7 Sequence Windows

MPMS MultiVu documents include sequence files. A sequence editor window displays the sequence commands and command parameters comprising one sequence file. The sequence command bar displays all available sequence commands. Any number of sequence editor windows may be open at one time. You may move, minimize, or maximize the sequence editor window. You may edit a sequence within the sequence editor window. You may move, dock, hide, or display the sequence command bar.

Chapter 5 discusses sequence files and sequence operation in detail.

C H A P T E R 3

Sample Measurement

3.1 Introduction

This chapter contains the following information:

- Section 3.2 presents an overview of the sample measurement process.
- Section 3.3 explains how to take a DC sample measurement in immediate mode.
- Section 3.4 describes the measurement algorithms.
- Section 3.5 discusses factors to consider when performing a measurement.

3.2 Overview of Sample Measurements

MPMS MultiVu measures the magnetic moment of a sample by reading the output of the SQUID detector while the sample moves upward, from the initialization position, through the SQUID pickup coils. This upward movement through the SQUID pickup coils completes one vertical scan. Voltage readings that are taken as a function of the sample's position in the coils comprise the raw measurement data. At each position in the coils, MPMS MultiVu typically reads the SQUID output voltage several times, and MPMS MultiVu can average together multiple scans in order to improve the measurement resolution. MPMS MultiVu saves the raw measurement data to the active raw data, or `.raw`, file. After collecting the raw voltages, MPMS MultiVu computes the magnetic moment of the sample and saves the magnetic moment to the active measurement data, or `.dat`, file.

The magnetic moment calibration for the MPMS is determined by measuring a palladium standard over a range of magnetic fields and by then adjusting the system calibration factors to obtain the correct moment for the standard. The standard is a right circular cylinder approximately 3 mm in diameter × 3 mm in height. Due to the geometry of the SQUID pickup coils, samples of this size or smaller are effectively point sources to an accuracy of approximately 0.1%.

3.3 Measuring the Sample

The procedures in this section explain how you use the standard sample transport to perform a manual, or immediate, DC sample measurement. Section 5.4 explains how you automate DC measurements by running a sequence. The *Magnetic Property Measurement System: AC Option User's Manual* explains how you perform an AC sample measurement. The *Magnetic Property Measurement System: Reciprocating Sample Option User's Manual* explains how you perform an RSO sample measurement and how you use the RSO sample transport.

3.3.1 Attach the Sample

The type, size, and geometry of a sample determine the method you use to attach it to the sample rod. This section explains how you use a clear plastic drinking straw to attach a sample. The straw has minimal magnetic susceptibility and is thus a useful means of attaching a sample. The *MPMS Hardware Reference Manual* describes other techniques you can use to attach samples.

Complete the following steps to attach the sample to the sample rod:

1. Cut off a small section of a clear plastic drinking straw. The section must be small enough to fit lengthwise inside the straw.
2. Weigh and measure the sample. After you insert the sample into the sample chamber, you can use the **Sample➤Description** option to define the sample's mass, in milligrams, and its diameter and length, in millimeters.
3. Use phenolic tweezers to place the sample inside the small straw segment.
4. Hold the straw segment so that its two open ends are vertical.
5. Place the straw segment inside the drinking straw, and move the segment until it is in approximately the middle of the length of the straw. Verify that the walls of the straw obstruct the open ends of the segment. Refer to figure 3-1.
6. Wrap a sufficient amount of tape around the brass-colored end of the sample rod so that the drinking straw will fit snugly over the rod. Quantum Design recommends using Kapton tape.

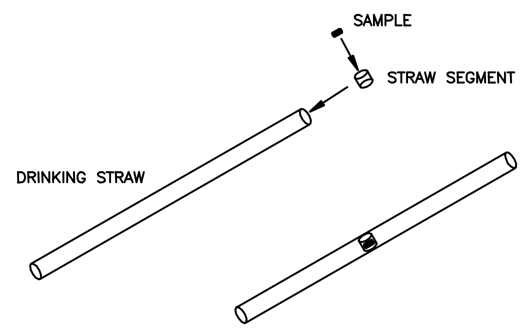


Figure 3-1. Correctly Positioned Sample

7. Place the end of the drinking straw over the tape on the sample rod, and then use additional tape to securely attach the straw to the rod.
8. Place a small piece of tape over the exposed end of the drinking straw. This extra piece of tape prevents a loose sample from falling into the sample chamber.
9. Move the slide seal plug up and down part of the sample rod to verify that the rod is well lubricated. If the plug does not move easily, apply a small amount of Apiezon H Grease to the rod. Run your fingers along the length of the rod to ensure a light, even coating of grease.

3.3.2 Insert the Sample

1. Turn the airlock lever on the electronic control assembly counterclockwise so that it is horizontal and in the “Closed” position (see figure 3-2). The MPMS vents the airlock space, which is the portion of the sample chamber located above the airlock valve.

   When the airlock lever is closed, it closes the airlock value that is near the top of the sample chamber, thus protecting the lower portion of the chamber from air flowing into the top of the chamber.

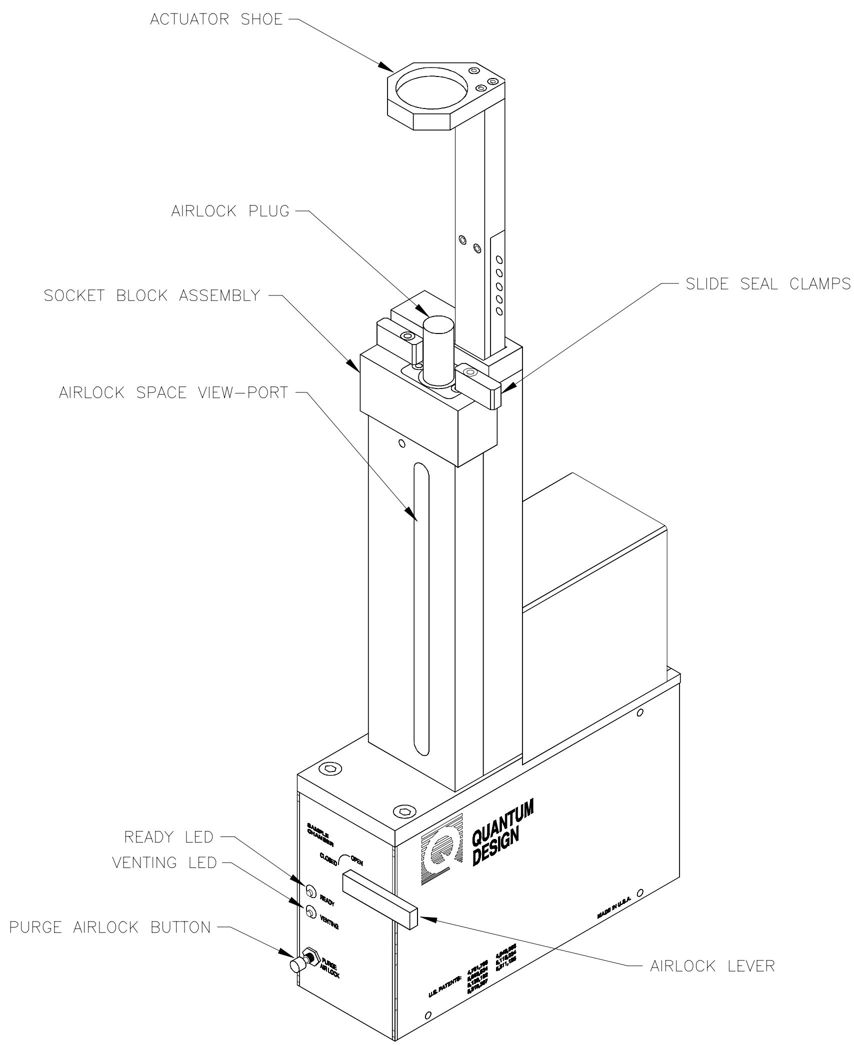


Figure 3-2. Sample Transport and Electronic Control Assembly

2. Wait for the MPMS to vent the airlock space. The yellow “Venting” LED (figure 3-2) flashes on and off while the system vents the space and remains off when the space is vented. The green “Ready” LED does *not* turn on.
3. Push the two slide seal clamps on the socket block assembly (see figures 3-2 and 3-3) so that the handles of the clamps face the front of the MPMS. When the clamp handles face the front of the MPMS, the airlock plug is unlocked and may be removed from the opening of the airlock space.
4. Remove the airlock plug, which has an anodized, blue coating. Store the plug in a safe place.

5. Verify that three O-rings are on top of the socket block assembly (see figure 3-3). If necessary, stand on a stool or small ladder so that you can examine the top of the socket block. Reinsert any missing O-rings.

   The large O-ring at the mouth of the airlock space occasionally sticks to the sample rod when the rod is removed from the sample chamber.

WARNING

Never insert the sample rod into the sample chamber if the O-rings on the top of the socket block assembly are missing. The O-rings prevent air from pumping into the chamber. Air pumped into the chamber can damage the vacuum pump and freeze the sample.

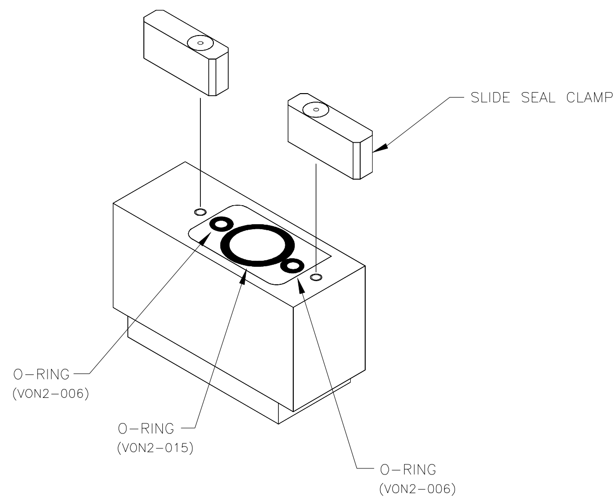


Figure 3-3. O-Rings on Socket Block Assembly

6. Move the slide seal plug down the sample rod until the plug rests just above the sample holder.
7. Lower the sample rod into the airlock space.
8. Move the slide seal plug down the sample rod until the plug rests on top of the socket block assembly. If necessary, adjust the position of the slide seal clamps to correctly seat the plug.
9. Turn the slide seal plug until the white dot on the plug faces the front of the MPMS. When the white dot faces the front of the MPMS, the proper amount of gas flows through the slide seal.
10. Push the two slide seal clamps completely outward or inward. When the handles of the clamps do not face the front of the MPMS, the clamps lock the slide seal plug in position by forcing it downward against the three O-rings.
11. Press the "Purge Airlock" button on the electronic control assembly (see figure 3-2). The MPMS purges the airlock space and cycles through the purge sequence four times. The yellow "Venting" LED turns on during the purge.
12. Wait for the MPMS to purge the airlock space. The green "Ready" LED turns on when the purge sequence is complete.

    If the "Ready" LED does not turn on, the airlock space may have a leak. Missing or improperly seated O-rings may cause the leak. Perform the following steps to check for a leak: (*a*) Select **Instrument➤Chamber➤Vent Sample Space** to vent the sample chamber; (*b*) remove the sample rod when the "Venting" LED turns off; and (*c*) verify that the O-rings are properly seated and lubricated. If necessary, correctly seat and lubricate the O-rings.

13. Turn the airlock lever clockwise so that it is vertical and in the “Open” position. When the lever is in the “Open” position, it opens the airlock value.
14. Lower the sample rod gently and slowly until the black slide clamp on the rod engages the actuator shoe on top of the sample transport. Figure 3-2 illustrates the actuator shoe. When the slide clamp engages the actuator shoe, the rod is fully inserted into the sample chamber.

    The knurled nut must be near the top of the sample rod or you will be unable to fully insert the rod into the sample chamber. If necessary, loosen the nut, and then move it until it is 1 to 2 inches from the top of the rod.
15. Loosen the two clip screws on top of the actuator shoe until the screw threads are visible. Do not remove the screws.
16. Rotate the slide clamp so that its two curved slots hook around the clip screws. If necessary, continue to loosen the clip screws until the slide clamp is properly seated.
17. Tighten the clip screws. The clip screws secure the sample rod to the actuator shoe, so the sample transport can move the rod vertically.

3.3.3 Define the Sample Parameters

Defining the sample parameters is optional; MPMS MultiVu does not read the parameters during the measurement. However, if you want to save the parameters to a measurement data file, you must define them before specifying the base name of the data file and before running the measurement. MPMS MultiVu saves sample parameter data to a data file header only while creating the data file.

Table 3-1. Sample Parameters

PARAMETER	ACCEPTED VALUES	DEFAULT VALUE
Mass	0–10,000 mg	1 mg
Diameter	0–9 mm	1mm
Length	0–100 mm	1 mm

Complete the following steps to define the sample parameters:

1. Select **Sample➤Description**. The **Sample Description** dialog box opens.

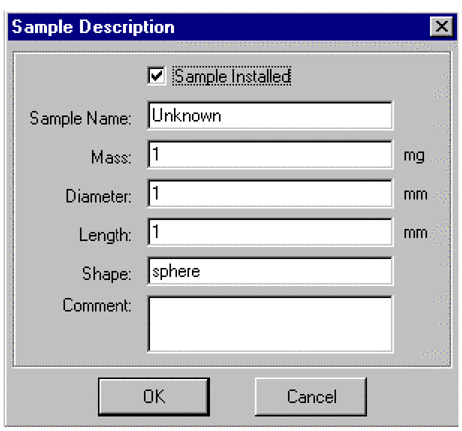


Figure 3-4. **Sample Description** Dialog Box

2. Verify that the **Sample Installed** check box is selected. If necessary, click once on the check box.
3. Enter a descriptive name for the sample. **Unknown** is the default name until a name is specified. The name you enter is the name under which MPMS MultiVu stores all information about the sample and the measurement.
4. Enter the mass, in milligrams, of the sample.
5. Enter the diameter, in millimeters, of the sample.
6. Enter the length, in millimeters, of the sample.
7. Define the shape of the sample.
8. Enter a comment if you want to include a comment in the data file header. A comment may have up to 63 characters.
9. Select **OK**.

3.3.4 Center the Sample

The sample must be centered in the SQUID pickup coils to ensure that all four coils sense the magnetic moment of the sample. If the sample is not centered, the coils read only part of the magnetic moment.

The MPMS can run a full DC centering measurement or a partial DC centering measurement. System operation during a full centering measurement is factory defined; the MPMS scans the entire length of the sample transport's vertical travel path, and MPMS MultiVu reads the maximum number of data points. System operation during a partial centering measurement is defined by the values you set for the scan and SQUID parameters. During a partial centering measurement, the MPMS scans only the distance you specify, and MPMS MultiVu reads only the number of data points you specify.

The parameter values set for a partial centering measurement are set for any subsequent sample measurements. A partial centering measurement therefore indicates whether the sample will be centered during the sample measurement. Before you measure the sample, you should run a partial centering measurement.

Table 3-2. Scan Parameters

	ACCEPTED VALUES		
PARAMETER	**CENTERING SCAN**	**FULL SCAN**	**DEFINITION**
Scan Length	0.1–12 cm	12 cm	Length of sample transport's vertical travel path that is scanned. Sample is centered when it is in middle of scan length.
Data Points	2–64	64	Individual voltage readings plotting response curve in centering scan data file.
Autotracking	Enabled Disabled	Enabled Disabled	Automatic tracking and adjustment of sample position to keep sample centered in SQUID coils. Autotracking compensates for thermal expansion and contraction in sample rod.

Table 3-3. SQUID Parameters

	ACCEPTED VALUES		
PARAMETER	**CENTERING SCAN**	**FULL SCAN**	**DEFINITION**
Measurement Axis	Longitudinal Transverse	Longitudinal	SQUID axis from which measurements are taken.
EMU Range	Autoranging Normal Extended	Autoranging Normal Extended	Autoranging allows EMU range to be changed as necessary so that it is appropriate for SQUID output. EMU range is sensitivity value indicating maximum magnetic moment MPMS can measure without saturating SQUID detector.

Sections 3.3.4.1 through 3.3.4.4 explain how you center the sample.

3.3.4.1 INITIALIZE THE SAMPLE TRANSPORT

1. Select **Center➤DC**. The **DC Centering** dialog box opens. The **Status** panel at the top of the dialog box indicates the status of an on-going centering measurement and the result of the last centering measurement. The **Control** panel contains the centering command buttons. The function of each button is summarized to the right of the button.

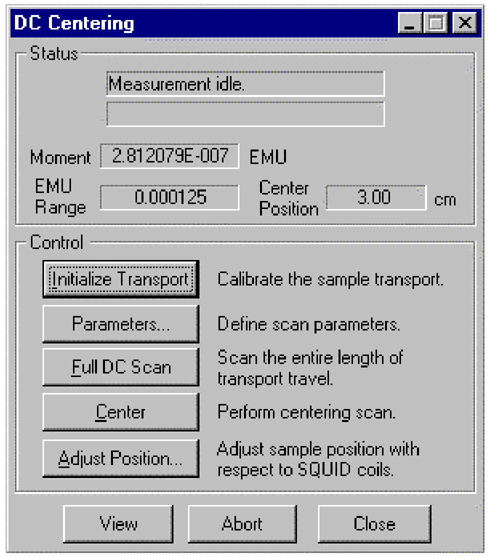


Figure 3-5. **DC Centering** Dialog Box

2. Select **Initialize Transport**. The MPMS initializes, or calibrates, the sample transport by first lowering it to the lower-travel-limit switch, which is defined as zero, and then raising it until it is in a known position that is just above the lower-travel-limit switch. When the transport is in this known position, it is correctly located to begin centering the sample. The initialization position places the sample far enough below the pickup coils that the SQUID does not detect the sample moment.

   If autotracking is enabled when you initialize the transport, the MPMS initializes the transport by moving it to a position far enough above the lower-travel-limit switch in order to allow adjustments for any shrinkage that occurs in the sample rod. This position corresponds to a 0.5-cm offset when the sample chamber is at room temperature. To enable autotracking, select **Center➤DC➤Parameters➤Autotracking**. Refer to section 3.3.4.2 below.

3.3.4.2 DEFINE THE PARAMETERS

1. Select **Parameters** in the **DC Centering** dialog box. The **DC Center Parameters** dialog box opens and displays the value of each scan and SQUID parameter MPMS MultiVu uses during a partial centering measurement.

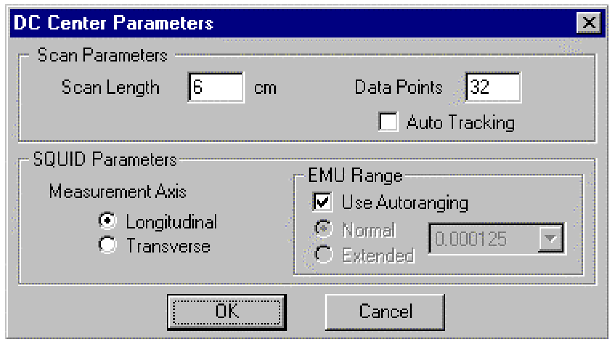


Figure 3-6. **DC Center Parameters** Dialog Box

2. Enter the length, in centimeters, of the scan. The default length of a partial centering measurement is 6 cm. During a full centering measurement, the MPMS scans the complete travel path, which is 12 cm.
3. Enter the number of data points that MPMS MultiVu reads during the scan. The default number of data points read during a partial centering measurement is 32. During a full centering measurement, MPMS MultiVu reads the maximum number of data points, which is 64.
4. Verify that autotracking is enabled. If necessary, click once on the **Autotracking** check box.

NOTE

Disable autotracking only if you are working with a sample that is very sensitive to centering or if you are using a custom-built sample rod. Quantum Design used a normal sample rod and a quartz sample holder to develop the sample-tracking algorithms. Sample holders and rods that respond to temperature differently than brass, steel, or quartz exhibit greater variations in the position of the sample.

5. Select the SQUID axis from which MPMS MultiVu takes measurements. The **Transverse** axis option is enabled only if the Transverse SQUID is installed. During a full centering measurement, MPMS MultiVu uses the longitudinal SQUID axis.
6. Verify that autoranging is enabled. If necessary, click once on the **Use Autoranging** check box.

NOTE

Disable autoranging only if you know the sample's approximate EMU value and you want to define the normal or extended EMU range most closely matching that value. The **Extended** EMU range option is enabled only if the Extended Range (EDR) option is installed.

7. Select **OK**. The **DC Center Parameters** dialog box closes, and the **DC Centering** dialog box appears again.

3.3.4.3 RUN THE CENTERING MEASUREMENT

1. Select **Full DC Scan** or **Center** in the **DC Centering** dialog box.

    - **Full DC Scan** runs a full centering measurement, which covers the complete length of the sample transport's travel path. A full centering measurement always locates the sample.
    - **Center** runs a partial centering measurement. A partial centering measurement locates the sample only if the sample is within the section of the travel path that is scanned.

    As soon as you initiate the centering measurement, the sample transport moves upward, carrying the sample through the pickup coils. While the sample moves through the coils, MPMS MultiVu measures the SQUID's response to the magnetic moment of the sample and saves all data from the centering measurement to the centering scan data, or `center.dc.lastscan`, file. Status messages appearing at the top of the **DC Centering** dialog box identify the specific task MPMS MultiVu is performing. Figure 3-7 on the following page illustrates the progress of a centering measurement.

    During a partial centering measurement, MPMS MultiVu uses the iterative regression algorithm to calculate the magnetic moment of the sample. During a full centering measurement, MPMS MultiVu uses the full scan algorithm. If the iterative regression algorithm cannot center the signal, MPMS MultiVu substitutes the linear regression algorithm. The centering measurement continues uninterrupted. Section 3.4 discusses the measurement algorithms in detail.

    When the centering measurement is complete, the **Moment** box in the **DC Centering** dialog box displays the new sample moment, and the **Center Position** box indicates the sample's new position. The `center.dc.lastscan` file opens as a graph that plots the SQUID's voltage response and the regression fit to that response against the length of the scan.

2. Examine the plot of the `center.dc.lastscan` file to determine whether the sample is centered in the SQUID pickup coils. Refer to figure 3-7. The sample is centered when the peak of the large, middle curve is within 0.05 cm of the half-way point of the scan length. In a 6-cm scan, for example, the sample is centered when the peak of the middle curve is within 0.05 cm of the 3-cm point.

    The shape of the plot is a function of the geometry of the pickup coils. The coils are wound in a second-derivative configuration in which the single-turn, positively charged upper and lower coils are counterwound with respect to the two-turn, negatively charged center coil. In the plot, the large, middle curve is the reading from the two center coils. The smaller first and third curves are the readings from the first and fourth coils, respectively.

    The second-derivative configuration strongly rejects interference from nearby magnetic sources and lets the MPMS function without a superconducting shield around the pickup coils.

3. Select **Full DC Scan** if the MPMS just ran a partial centering measurement but did not locate the sample. After the full centering measurement runs, examine the plot of the `center.dc .lastscan` file. Refer to step 2.

4. Select **Center** if the MPMS just ran a full centering measurement or has not yet run a partial centering measurement. After the partial centering measurement runs, examine the plot of the `center.dc.lastscan` file. Refer to step 2.

You may abort a centering measurement at any time. Simply select the **Abort** button located at the bottom of the **DC Centering** dialog box. After the measurement aborts, **Measurement aborted** appears in the **Status** panel at the top of the dialog box.

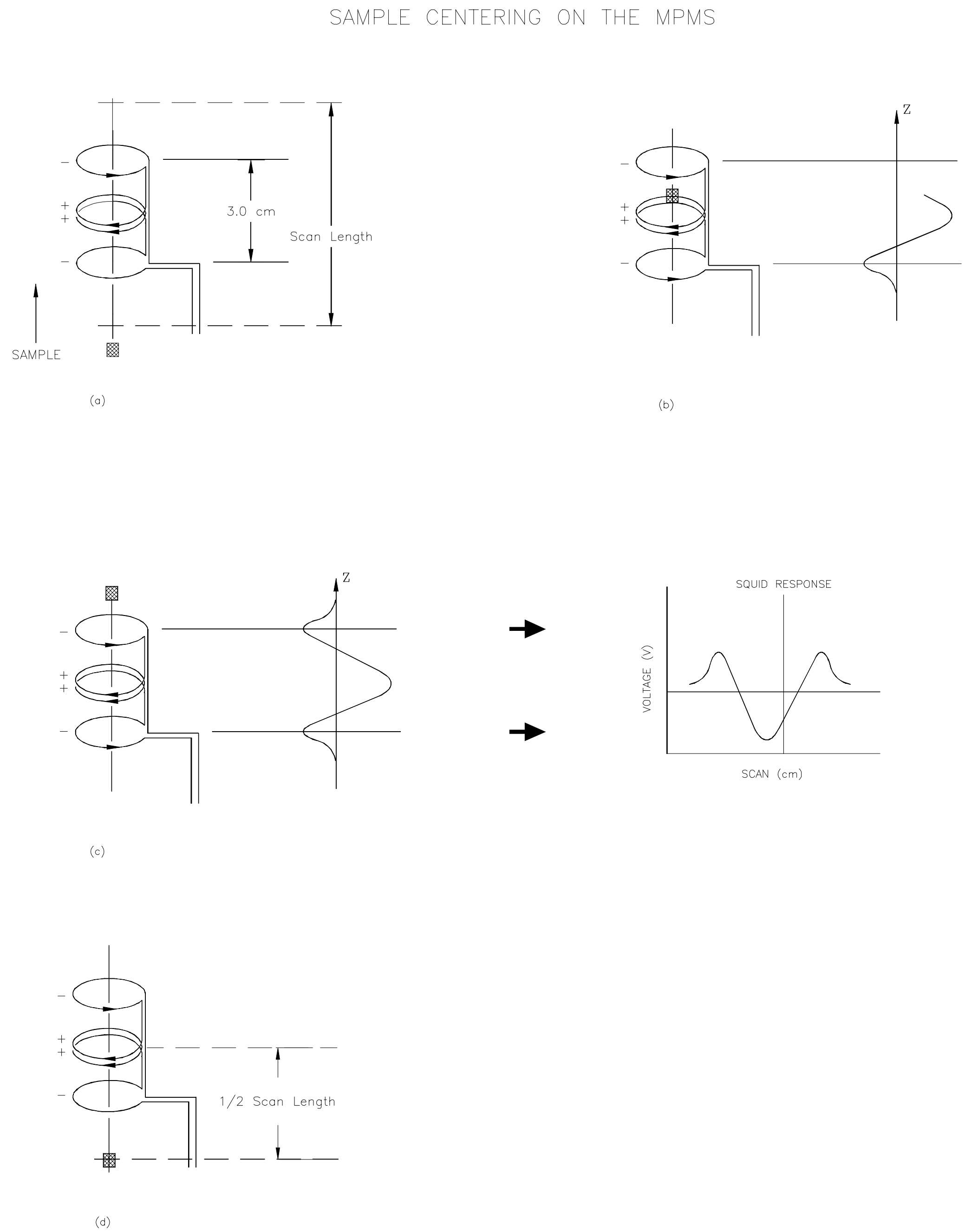


Figure 3-7. DC Centering Measurement and Measured SQUID Voltage Response

Figure 3-7a illustrates the sample moving upward through the SQUID pickup coils. Figure 3-7b illustrates MPMS MultiVu measuring the SQUID response while the sample moves through the coils. Figure 3-7c plots the SQUID response against the scan length; the output in figure 3-7c indicates that the sample is too high and must be lowered. Figure 3-7d illustrates a centered sample. In figure 3-7d, the scan begins one-half scan length below the center coils.

3.3.4.4 ADJUST THE SAMPLE POSITION

1. Select **Adjust Position** in the **DC Centering** dialog box if the sample is not centered in the SQUID pickup coils. **Adjust Position** opens the **Adjust Sample Position** dialog box.

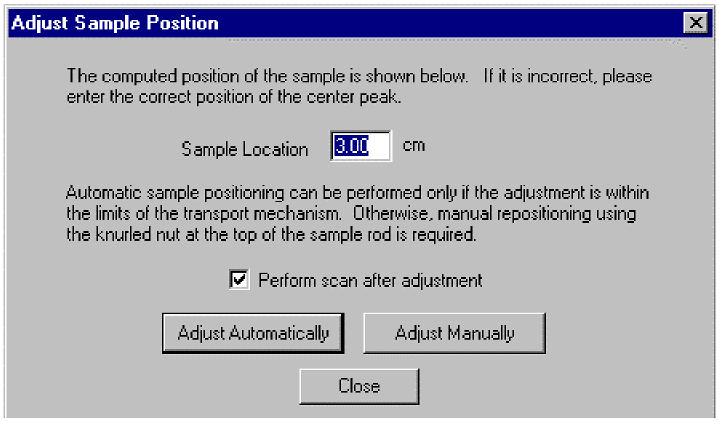


Figure 3-8. **Adjust Sample Position** Dialog Box

2. Enter, in centimeters, the correct position of the sample if the computed position displayed in the **Sample Location** text box is incorrect.
3. Verify that the **Perform scan after adjustment** check box is selected. If necessary, click once on the check box.
4. Select **Adjust Automatically**. The MPMS adjusts the position of the sample so that the center peak of the SQUID's voltage response is within 0.1 cm of half the length of the scan. The MPMS then runs a partial centering measurement. A plot of the `center.dc.lastscan` file opens when the centering measurement is complete.

   If automatic adjustment is outside the limits of the transport mechanism *and* the RSO option is not installed, a pop-up message tells you to adjust the position manually. Select **Adjust Manually** in the **Adjust Sample Position** dialog box and then follow the on-screen instructions.

   - Lower the sample if the peak of the large, middle curve in the `center.dc.lastscan` file is to the left of the half-way point of the scan length.
   - Raise the sample if the peak is to the right of the half-way point of the scan length.
5. Select **Close**, and then select **Close** again to close the **DC Centering** dialog box.

3.3.5 Measure the Sample

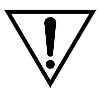
When you initiate an immediate-mode measurement, MPMS MultiVu measures the sample at the current system conditions without waiting for any conditions to stabilize. If you want to ensure that system conditions are stable when the measurement begins, run the measurement in a sequence and use appropriate sequence commands to stabilize system conditions. Refer to section 5.4.

Sections 3.3.5.1 through 3.3.5.3 explain how you run a measurement in immediate mode. Before running a measurement, you may want to refer to section 3.5, “Measurement Considerations.”

3.3.5.1 DEFINE THE PARAMETERS

1. Select **Measure➤DC**. The **Measure DC** dialog box opens. The **Status** panel at the top of the dialog box indicates the status of an on-going measurement and the result of the last measurement. The **Control** panel lists the scan and SQUID parameters MPMS MultiVu uses during a measurement and identifies which data files will store the measurement data.

   Table 3-2 defines the scan parameters. Table 3-3 defines the SQUID parameters.



CAUTION

Avoid radically modifying the scan and SQUID parameters before you run the sample measurement. By using identical parameter values for the partial centering measurement and the sample measurement, you help ensure that the sample remains centered and that the partial centering measurement accurately reflects the conditions of the sample measurement.

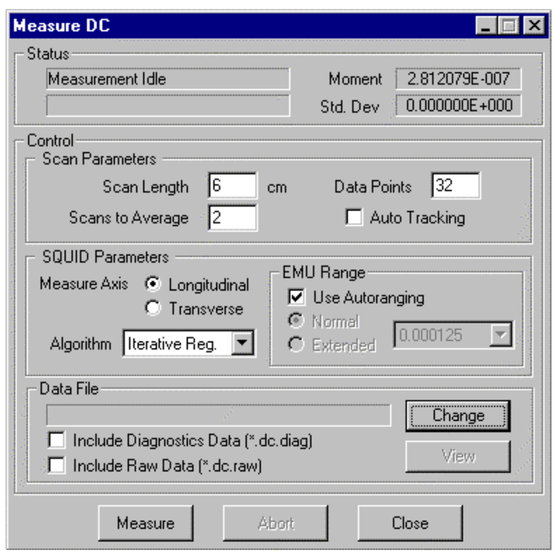


Figure 3-9. **Measure DC** Dialog Box

2. Enter the length, in centimeters, of the scan if the specified scan length is inappropriate for the measurement.
3. Enter the number of scans that MPMS MultiVu runs and averages together. The MPMS can run from 1 to 50 scans. Specify a large number if the sample is data sensitive or has an extremely small signal. Specify a small number if the sample or experiment is time sensitive. A large number of scans, by including changes that occur in the data, produces more reliable data.

   When two or more scans run as part of one measurement, MPMS MultiVu computes the average sample moment and standard deviation of each scan and then averages the values of the scans.

4. Enter the number of data points that MPMS MultiVu reads during the scan if the specified number is inappropriate for the measurement. The data points plot the response curve appearing in the active measurement data, or `.dat`, file.
5. Verify that autotracking is enabled. If necessary, click once on the **Autotracking** check box.

NOTE

Disable autotracking only if you are working with a sample that is very sensitive to centering or if you are using a custom-built sample rod. Quantum Design used a normal sample rod and a quartz sample holder to develop the sample-tracking algorithms. Sample holders and rods that respond to temperature differently than brass, steel, or quartz exhibit greater variations in the position of the sample.

6. Select the SQUID axis from which MPMS MultiVu takes measurements. The **Transverse** axis option is enabled only if the Transverse SQUID option is installed.
7. Select the measurement algorithm MPMS MultiVu uses to calculate the magnetic moment of the sample. Section 3.4 discusses the measurement algorithms in detail.
8. Verify that autoranging is enabled. If necessary, click once on the **Use Autoranging** check box.

NOTE

Disable autoranging only if you know the sample's approximate EMU value and you want to define the normal or extended EMU range most closely matching that value. The **Extended** EMU range option is enabled only if the Extended Range (EDR) option is installed.

3.3.5.2 SELECT THE DATA FILES

1. Select **Change** if you want to save measurement data to a file other than the measurement data, or `.dat`, file currently selected to store immediate-mode measurement data. The name of the selected `.dat` file appears in the **Data File** panel, which is to the left of the **Change** button.

   Change opens the **Select or Enter a New DC Data File** dialog box. The dialog box lists the names of all `.dat` files. You can select a file and then select **Open**, *or* you can enter the base name of a file in the **File name** text box, and then select **Open**. The full name of the `.dat` file you select or create appears in the **Data File** panel.

   You must create a new `.dat` file if you want to save the sample parameter data you entered in section 3.3.3 to a `.dat` file. MPMS MultiVu saves sample parameter data to a data file header only while creating the `.dat` file. Consequently, there may not be an existing data file containing sample parameter data identifying your sample. If you want to append data to an existing `.dat` file, try to select a file whose header information identifies your sample.
2. Verify that the **Include Diagnostics Data** check box is selected if you want to save diagnostic measurement data to a diagnostic data, or `.diag`, file. If necessary, click once on the check box.
3. Verify that the **Include Raw Data** check box is selected if you want to save raw measurement data to a raw data, or `.raw`, file. If necessary, click once on the check box.

3.3.5.3 RUN THE MEASUREMENT

To run a measurement, select **Measure** in the **Measure DC** dialog box. The measurement begins. The sample transport moves upward, carrying the sample through the pickup coils. While the sample moves through the coils, MPMS MultiVu measures the SQUID's response to the magnetic moment of the sample. If autoranging is disabled, the MPMS repeats each measurement until it locates the EMU range that accommodates the SQUID's sensitivity. MPMS MultiVu saves all data from the measurement to the active data files. Status messages appearing at the top of the **Measure DC** dialog box identify the specific task MPMS MultiVu is performing.

If the iterative regression algorithm is selected but iterative regression cannot center the signal, MPMS MultiVu substitutes the linear regression algorithm. The measurement continues uninterrupted.

When the measurement is complete, the **Moment** box in the **Measure DC** dialog box displays the new sample moment, and the **Standard Deviation** box displays the new standard deviation.

You may abort a measurement at any time. Simply select the **Abort** button located at the bottom of the **Measure DC** dialog box. The measurement aborts as quickly as possible, although it does not abort in the middle of a scan, but waits until the scan is complete. MPMS MultiVu collects all available data from the aborted measurement and stores the data in the active data files. After the measurement aborts, **Measurement aborted** appears in the **Status** panel at the top of the **Measure DC** dialog box.

3.3.5.4 VIEW THE DATA FILES

Selecting the **View** button in the **Measure DC** dialog box can open any data file that is selected to store the immediate-mode measurement data. **View** opens the **Select a Data File** dialog box. By default, the dialog box lists the names of only the files that are either actively storing measurement data or that will store data the next time a measurement runs. The files share the identical base name. When you select a data file, and then select the **Open** button, the graph view of the data file opens.

You may open a new data file you have selected to store immediate-mode measurement data even before you run a measurement. If you specify a new base file name and then select the **View** button, MPMS MultiVu creates the `.dat` file and the file's associated `.lastscan` file. MPMS MultiVu also creates the `.diag` and `.raw` files if you have selected the **Include Diagnostics Data** and **Include Raw Data** options. All the new files are blank; they contain only the header information, which defines the default graph format. Once you open a new file, you can modify the default graph format. New files remain blank until you run a measurement.

3.4 Measurement Algorithms

After MPMS MultiVu collects the raw measurement data, it uses a measurement algorithm to compute the sample's magnetic moment. Three measurement algorithms are available: iterative regression, linear regression, and full scan. The algorithms should work effectively if MPMS MultiVu collects 24 data points during the scan, although MPMS MultiVu can collect up to 64 data points.

Table 3-4 summarizes the operation of the measurement algorithms and indicates when you should use each algorithm. The following sections discuss the algorithms in more detail.

Table 3-4. Summary of Functions of Measurement Algorithms

ALGORITHM	DEFINITION	WHEN TO USE
Iterative Regression	Calculates magnetic moment by mathematically fitting analytical curve to measurement response data. Default measurement algorithm during partial centering measurement.	• To perform short, high-precision scans with few data points. • To perform fast measurements that are relatively insensitive to noise and drift. • To measure very small, noisy, or off-center signals.
Linear Regression	Calculates magnetic moment by mathematically fitting analytical curve to measurement response data and by assuming sample is properly centered. Used during partial centering measurement if iterative regression cannot center signal.	• To perform short, high-precision scans with few data points. • To measure very small, noisy, or off-center signals.
Full Scan	Calculates magnetic moment by building response curve as sample moves through full length of pickup coils and by then computing weighted summation of all points in scan. Default measurement algorithm during full centering measurement.	• To perform full centering measurement. • To locate sample within pickup coils.

3.4.1 Iterative Regression Algorithm

The iterative regression algorithm calculates the magnetic moment of the sample by mathematically fitting an analytical curve to the measurement response data. By fitting the curve to the data, the iterative regression algorithm can accommodate variations in the sample's position that are caused by the thermal expansion of the sample rod. The use of an analytical curve also allows short, high-precision scans that have relatively few data points. The iterative regression algorithm thus permits fast measurements that are less sensitive to noise and drift than measurements performed with the full scan algorithm.

The iterative regression algorithm is the default measurement algorithm during a partial centering measurement. MPMS MultiVu substitutes the linear regression algorithm only if the iterative regression algorithm cannot center the signal. Iterative regression cannot locate the signal if the signal is beyond a certain tolerance.

During a measurement, you select the iterative regression algorithm if you require short, high-precision scans with few data points, or if you require fast measurements that are relatively insensitive to noise and drift. You also select the iterative regression algorithm if you are measuring very small, noisy, or off-center signals. You should avoid selecting the iterative regression algorithm if the scan length includes most of the sample transport's travel path. Iterative regression—because it tries to fit data to an ideal curve—has difficulty calculating the sample moment when the scan length is large.

3.4.2 Linear Regression Algorithm

The linear regression algorithm calculates the magnetic moment of the sample by mathematically fitting an analytical curve to the measurement response data and by assuming the sample is properly centered. The use of an analytical curve allows short, high-precision scans that have relatively few data points. Regression calculations eliminate noise effectively. The linear regression algorithm thus permits fast measurements that are less sensitive to noise and drift than measurements performed with the full scan algorithm. MPMS MultiVu substitutes the linear regression algorithm if the iterative regression algorithm cannot center the signal.

During a measurement, you select the linear regression algorithm if you require short, high-precision scans with few data points, or if you are measuring very small, noisy, or off-center signals.

3.4.3 Full Scan Algorithm

The full scan algorithm calculates the magnetic moment of the sample by building a response curve as the sample moves through the full length of the SQUID pickup coils and by then computing a weighted summation of all points in the scan. The sample moment is computed as the square root of the sum of the squares, normalized for the number of data points and the system calibration factors. This analysis works well when the signal is larger than the noise in the system. However, when the response of the sample is comparable to the system noise, the full scan algorithm, because of its squaring process, effectively sums the system noise as well as the sample response instead of trying to average the noise to zero.

The full scan algorithm is the default measurement algorithm during a full centering measurement. The MPMS always locates the sample during a full scan, so MPMS MultiVu never substitutes another algorithm while a full scan is in progress.

During a measurement, you select the full scan algorithm if the MPMS will perform a full scan of the sample transport's travel path, or if the MPMS has not located the sample within the pickup coils. You select the iterative regression algorithm or linear regression algorithm instead of the full scan algorithm if you are measuring very small, noisy, or off-center signals. The full scan algorithm does not analyze very small signals as effectively as the iterative regression and linear regression algorithms.

3.5 Measurement Considerations

If a single scan takes too long, low-frequency drifts, which degrade the data, occur in the SQUID detector. Consequently, you should average together several short scans rather than try to collect a large number of data points during a single, lengthy scan. Quantum Design recommends that you average at least 10 to 12 readings at each point. You want to take as much data as possible during a single scan without unduly extending the time required to complete the scan. An individual reading of the SQUID output takes approximately 5 milliseconds, and it takes approximately 1 second to move the sample and allow the filter in the SQUID electronics to settle. The time required to move the sample can be reduced somewhat, but this reduction does not decrease the filter settling time for the SQUID electronics. The scan length and the number of data points collected determine the spacing between each pair of data points.

Collecting a number of data points that is an integral power of 2 may be advantageous if you anticipate that more unusual data processing may be performed on the raw data at a later date. Using an integral power of 2 for the number of data points may be required when you use Fast Fourier Transform routines. Otherwise, the MPMS has no specific requirement on the number of data points collected.

The values defining the measurement parameters significantly affect the accuracy of a measurement when you measure samples producing signals that are either slightly larger or slightly smaller than the instrument noise. The values defining the measurement parameters affect the accuracy of a measurement less significantly when you measure samples producing large signals.

3.6 Multiple Measure Sequence Command

A new feature—the **Multiple Measure** sequence command—has been implemented in revision 1.52 of the MPMS MultiVu software. The **Multiple Measure** sequence command performs a user-specified number of measurements (of type DC or RSO) and reports the average moment, standard error, and other statistical figures for the population of those measurements. With this command, the user can collect time-dependent statistical measurement data from the MPMS instrument. In addition, the user can set the command to reject measurements that deviate from the average of the overall data set. Thus, the feature allows the user to reject spurious measurements (noise or artifacts) from the data population. Such problem measurements may arise from magnet-flux jumps, external vibrations, and so on, which are most commonly observed when running magnetization versus field loops (see *MPMS Application Note #1014-820*) while detecting low-moment samples (see *MPMS Application Note #1014-822*).

3.6.1 Compatibility

The **Multiple Measure** command does not alter the way that the MPMS system performs the actual measurement. It only coordinates the running and collection of the measurement data and the calculation of the statistics for that collection. The statistical data is recorded in a file that is separate from the measurement file. The new data file has the same base name as the measurement data file but the file extension is `.ndat` (e.g., `mydata.dc.ndat`). One line item is written to the `.ndat` file for every **Multiple Measure** command that is completed.

The **Multiple Measure** command is compatible with the **Automated Background Subtraction** feature of the MPMS system. However, there are difficulties in using the **In Order** search method when applying a background data file, because the **Multiple Measure** command can reject a deviant measurement and collect another as a substitute. Such substitute measurements may not track with the correct data in the background data file. Therefore, it is recommended that the **In Order** search method not be used with the **Multiple Measure** command. All other search methods will work properly.

3.6.2 Accessing and Using Multiple Measure Command

The **Multiple Measure** command is a sequence command. Hence, it is located in the **Measure Commands** section of the **Sequence Command** bar, which is shown in Figure 3-10. The following section explains how to access and use the **Multiple Measure** command.

1. In the main MultiVu window, select **File >> New Sequence** (or **Sequence >> New**).
2. When the **Sequence Command** panel opens, click on the plus (+) sign next to the **Measure Commands** section.
3. When the list of commands appears, double click on the **Multiple Measure** command. The **Multiple Measurement Command** dialog box will open (see Figure 3-11).

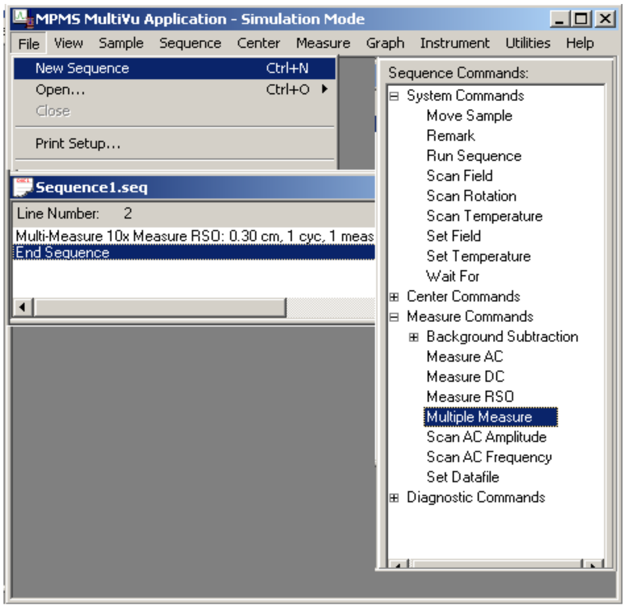


Figure 3-10. MPMS MultiVu Window, Sequence Commands panel, and new sequence file

The **Multiple Measurement Command** dialog box is used to specify the **Type of measurement** to perform and the **Number of measurements** to be collected.

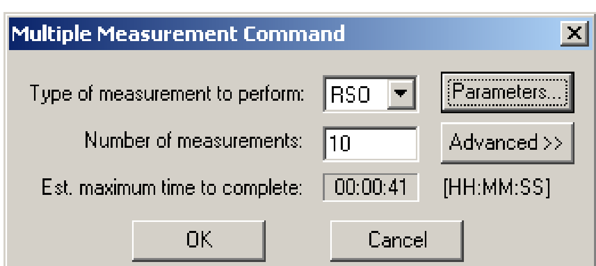


Figure 3-11. Multiple Measuremeant dialog box set up to perform RSO measurements.

In Figure 3-11, the dialog box is set to perform 10 RSO measurements. Additional specifications can be made by using the **Parameters** and **Advanced** buttons on the right side of the dialog box.

Clicking on the **Parameters** button opens the standard dialog box for the type of measurement you chose. Here you can specify details about the measurements that you want taken.

For example, because the **Multiple Measurement Command** dialog box in Figure 3-11 is set up for RSO measurements, clicking on the **Parameters** button produces the **Measure RSO** dialog box, as shown in Figure 3-12. In this example, a typical RSO measurement will consist of a 4 cm center scan at 1 Hz with 5 cycles per scan and 3 scans per measurement. For every measurement, the usual information will be recorded in the `.dat`, `.raw`, and `.diag` files.

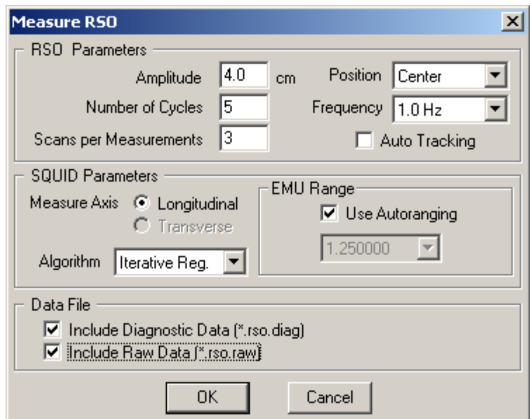


Figure 3-12. Measure RSO dialog box for setting measurement parameters

The **Advanced** button acts differently. If you click on the **Advanced** button, the **Multiple Measurement Command** dialog box (Figure 3-11) expands to show a **Measurement Rejection Criteria** panel (see Figure 3-13). In this panel you can specify the criteria that will be used to reject individual measurements from the data that is collected. You can set two rejection criteria:

- the maximum number of measurements that are to be rejected
- the number of standard deviations that is permitted before a measurement moment is a candidate for rejection

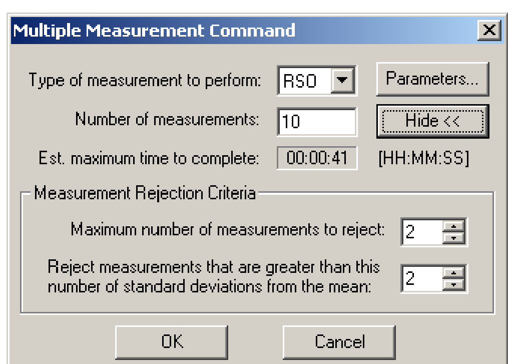


Figure 3-13. Multiple Measurement Command dialog box after the Advanced button has been selected. Note the Measurement Rejection Criteria panel in the lower half of the window.

For your reference, the **Multiple Measurement Command** dialog box also shows an estimate (**Est. maximum time to complete**) of the time that it will take to perform the number of measurements you specified. This estimate includes the time that will be needed to take any necessary extra measurements.

As depicted in Figure 3-13, the **Multiple Measurement Command** is set to perform 10 RSO type measurements. The **Multiple Measurement Command** also is set to reject a maximum of two deviant measurements and to reject measurement values that are more than two standard deviations from the mean.

After the measurements have been completed, the program computes the average (M_{bar}) and standard deviation (SD_M) from the collection of moment values. Next, the program determines the moment value that deviates most from the average. If the value deviates by more than the maximum limit that the user set, that moment value is removed from the array of data. Then the program initiates another RSO measurement, which is added to the collection, and M_{bar} and SD_M are recomputed.

As long as the user-specified number of rejections has not been reached, the program will again determine the most deviant moment value. If the deviant value exceeds the average by more than the specified number of standard deviations, it is rejected, another measurement is made, and M_{bar} and SD_M are recomputed. If necessary, this process continues until the maximum number of data rejections has been reached. The final M_{bar} and SD_M are recorded in the `.ndat` file.

For the data collected with the settings in Figure 3-13, a maximum of two measurements could be removed, and a measurement would have to be more than two standard deviations larger or smaller than the mean value before it would be rejected.

3.6.3 Checking the Status of a Multiple-Measure Command

When a **Multiple Measure** sequence command is executed, the command continues until the specified number of measurements has been completed.

To see the status of the current sequence command, open the **Control Center** (**View >> Control Center**), which appears at the left of the MultiVu window. The **Control Center** shows whether a command is running or complete; the type of measurement being taken; the sequential number of that measurement; and if extra measurements were taken.

As illustrated in Figure 3-14, the **Sample** is Unnamed, and the name of the **Selected Sequence**, Sequence1.seq, is that of the open sequence file.

The **Sequence Base Data File Name** is TestData1. As each of the 10+ measurements is completed, it is stored in a standard data file named `TestData1.rso.dat.`

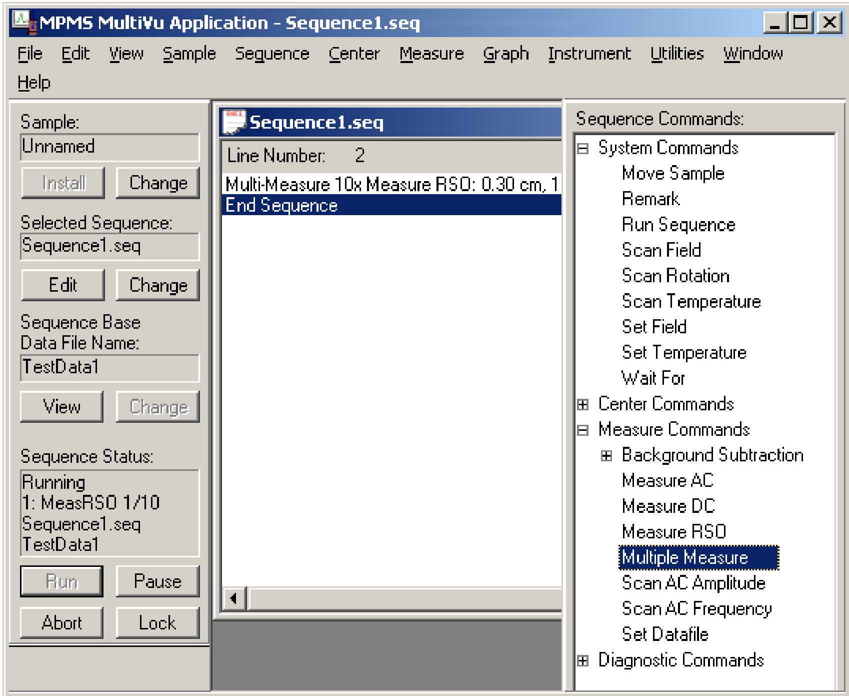


Figure 3-14. MPMS MultiVu window showing Control Center panel (left side), Sequence Commands, and sequence file

When the **Multiple Measurement Command** has performed the specified number of measurements and ended, the statistical data will be stored in a data file named `TestData1.rso.ndat.`

The **Sequence Status** section of the **Control Center** shows that the command is "Running"; that RSO measurements are being made; and that the measurement is number 1 of 10 (e.g., MeasRSO 1/10). If one extra (substitute) measurement had been taken, the MeasRSO status reading would be 11/10 (i.e., MeasRSO 11/10).

If a measurement meets the rejection criteria and is removed from the array of data that was used to compute M_{bar} and SD_M, an entry is made in the **Event Log**:

```
00:45:13 06/08/01 INFO    Rejectable measurement found at position: 1,
timestamp: 991986148.703000
```

```
00:45:13 06/08/01 INFO    Measurement rejected.
```

The position of the rejected measurement is relative to its order in the data. The timestamp corresponds to the time that is recorded in the measurement .dat file for that measurement.

3.6.4 Reading the Statistical Data (`.ndat)` File

Recall that the **Multiple Measure** command records the results of a statistical analysis of the population of measurement results into a file that has the base name of the individual measurement data file `(.dat)`, but the statistical data file ends with the `.ndat` extension.

One data line (or record) is written to the `.ndat` file for each completed **Multiple Measure** command. To see the statistical data for the measurements, open the `.ndat` file and select **View** >> **Record**. Figure 3-15 illustrates a data record and its layout. The data fields are defined as follows:

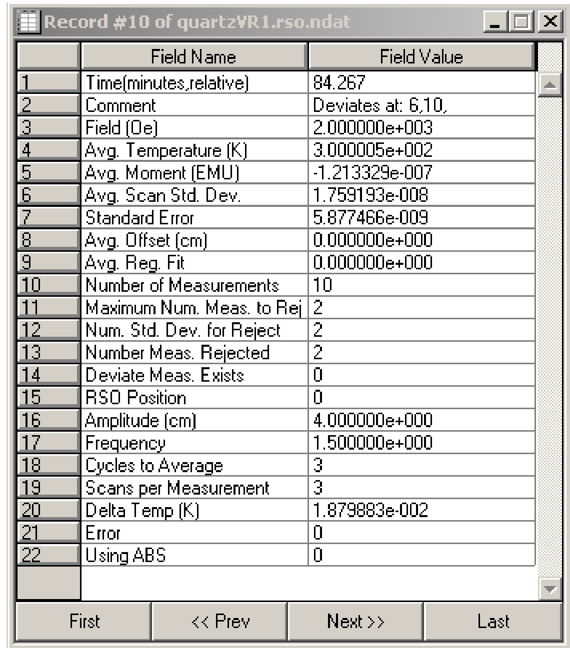
Time: The time stamp corresponding to the completion of the first measurement in the collection

Comment: The measurements, if any, that were deviant and rejected. In the example, the 6th value was rejected, then the 10th value was rejected.

Field: The magnetic field present when the **Multiple Measure** command started.

Avg. Temperature: The average of all the temperatures for the individual measurements in the collection.

Avg. Moment: The average of all the moment values for the individual measurements in the collection.



Record #10 of quartzVR1.rso.ndat

	Field Name	Field Value
1	Time(minutes,relative)	84.267
2	Comment	Deviates at: 6,10,
3	Field (Oe)	2.000000e+003
4	Avg. Temperature (K)	3.000005e+002
5	Avg. Moment (EMU)	-1.213329e-007
6	Avg. Scan Std. Dev.	1.759193e-008
7	Standard Error	5.877466e-009
8	Avg. Offset (cm)	0.000000e+000
9	Avg. Reg. Fit	0.000000e+000
10	Number of Measurements	10
11	Maximum Num. Meas. to Rej	2
12	Num. Std. Dev. for Reject	2
13	Number Meas. Rejected	2
14	Deviate Meas. Exists	0
15	RSO Position	0
16	Amplitude (cm)	4.000000e+000
17	Frequency	1.500000e+000
18	Cycles to Average	3
19	Scans per Measurement	3
20	Delta Temp (K)	1.879883e-002
21	Error	0
22	Using ABS	0

Figure 3-15. Contents of the statistical data file for record #10 of quartzVR1.rso. Note the `.ndat` ending for the file name

Avg. Scan Std. Dev.: The average of all the scan standard deviation values for the individual measurements in the collection

Standard Error: The standard deviation of the individual measurements in the collection from the mean of the population moment (***m***) values, computed using the following equation:

`S.E. = $$\sqrt{\frac{1}{n-1}[\sum_{i=1}^{n} m_i^2 - \frac{1}{n}(\sum_{i=1}^{n} m_i)^2]}$$

Note: This value is not to be confused with the average of the scan standard deviations.

Number of Measurements: The number of measurements (as specified in the Multiple Measurement Command dialog box)

Maximum Num. Meas. to Reject: The maximum number of measurements that could be rejected (as specified in the Multiple Measurement Command dialog box)

Num. Std. Dev. for Reject: The rejection criterion (the allowable number of standard deviations before a measurement is rejected, as specified in the Multiple Measurement Command dialog box). If an individual moment value deviates from the average moment of the collection by more than this value, it will be removed from the collection if the *Maximum Num. Meas. to Reject* value has not already been reached.

Number Meas. Rejected: The number of individual moment values that were rejected and removed from the collection, causing additional measurements to be taken. This number cannot exceed *Maximum Num. Meas. to Reject.*

Deviate Meas. Exists: The presence of at least one moment value within the collection that still meets the rejection criterion (exceeds the specified maximum number of standard deviations from the average moment) after the maximum number of moment values has been rejected. Note, the position of this deviant measurement will be listed last in the Comment filed.

RSO Position (Data field 15)—*Scans per Measurement* (Data field 19): Measurement-specific (DC or RSO) parameters

Delta Temp (K): The difference between the largest and smallest temperatures reported for all the measurements in the collection

Error: The presence of a measurement error for at least one measurement in the collection. If an error is reported for a measurement in the collection, the measurement will be rejected (just as a deviant measurement moment value would be) and the program will perform an additional measurement, unless the *Maximum Num. Meas. to Reject* has been reached. Errant measurements are rejected from the list before deviant measurement values.

Using ABS: The use of Automated Background Subtraction for the population of measurements.

C H A P T E R 4

Data Files

4.1 Introduction

This chapter contains the following information:

- Section 4.2 presents an overview of data files.
- Section 4.3 discusses the various types of data files.
- Section 4.4 discusses data file management.
- Section 4.5 discusses the data-viewing formats.
- Section 4.6 discusses how to change graph formats.

4.2 Overview of Data Files

Multiple types of data files store all measurable data generated by sample measurements, system parameters, and helium fills. Each type of data file stores a specific type of data. Stored data may be examined in several different data-viewing formats, and the plot of the data may be modified. Every data file opens as a graph. A template automatically saves the graph view of a data file.

Data generated by the measurement options is stored in up to four different data files. This multiple-file storage system is in direct contrast to the single-file storage system used in the MPMSR2 DOS software. By separating the measurement data into several files, MPMS MultiVu allows you to easily import the files into other graphics applications.

Data files storing measurement data cannot be overwritten, and no data file can be deleted from within MPMS MultiVu. To delete a data file, you must open the Windows directory that stores the file, and then delete the file from within that directory.

4.2.1 File Format

Every data file consists of two main sections: the header and the data section. The data file header defines the type of data file and the type of data stored in the file as well as the file's default graph format. Data file headers contain the identical type of information. The data section lists the actual data stored in the file. Data sections list data that is specific to the measurement option that generated the data and to the type of data the file stores.

The format of the data files is designed such that the files may be easily imported by other graphic applications, such as Microsoft Excel. The data file format is comma delimited. Appendix B discusses the data file format in more detail.

4.2.2 Naming Conventions

You specify the base name of any data file you want to create. When MPMS MultiVu creates the file, it adds file extensions to the base name. One file extension always identifies which type of data the file stores. When appropriate, a second file extension identifies which type of measurement option generated the data. The generic format of a data file name is thus

`BaseName.DataType` *or*
`BaseName.MeasurementType.DataType`.

The addition of the file extensions means that multiple data files may share a base name. When you specify a base name for a new measurement data, or `.dat`, file, MPMS MultiVu uses that name to create the base names of the other data files that also store data while the new `.dat` file is active. If the base name of a new `.dat` file is `testdata`, MPMS MultiVu saves DC sample measurement data to the `testdata.dc.dat` file and DC centering scan data to the `testdata.dc.lastscan` file. The file extensions identify and organize the related files. The file extensions also protect the function of each data file, ensuring that the file stores only the appropriate type of data.

Table 4-1. Components of Data File Names

COMPONENT	SIGNIFICANCE
Base Name	Defines base data file name and can be shared by multiple data files storing different types of data. Base name is user specified and can be any valid Windows 95 file name.
Measurement Type	Indicates type of measurement option generating data. Measurement type is system specified.
Data Type	Indicates type of data stored in file. Data type is system specified.

Table 4-2. File Extensions

FILE EXTENSION	VALID ENTRIES	WHAT ENTRY INDICATES

Measurement Type	`.dc`
	`.rso`
	`.ac`
	`.pfl`
		DC measurement
		RSO measurement
		AC measurement
		Field-profiling measurement

Data Type	`.dat`
	`.lastscan`
	`.diag`
	`.raw`
	`.env`
		Measurement data
		Last scan data
		Summary data from scans
		Raw SQUID voltages from scans
		System parameter data

4.2.2.1 EXAMPLE: NAMING DATA FILES THAT SAVE SEQUENCE MEASUREMENT DATA

If you specify a new base data file name called `PbtoAu_Test1` and then run a sequence that includes DC measurement commands but no other type of measurement command, MPMS MultiVu creates the following two data files when it finishes taking the first measurement in the sequence run:

```
PbtoAu_Test1.dc.dat
PbtoAu_Test1.dc.lastscan
```

MPMS MultiVu adds the file extensions to the base file name. By default, the data files reside in the `C:\QdMpms\Data` directory.

If you specify a new base data file name called `PbtoAu_Test2`, then modify the DC measurement commands in the selected sequence so that MPMS MultiVu saves diagnostic and raw data, and then run the sequence, MPMS MultiVu creates the following four data files when it finishes taking the first measurement in the sequence run:

```
PbtoAu_Test2.dc.dat
PbtoAu_Test2.dc.diag
PbtoAu_Test2.dc.raw
PbtoAu_Test2.dc.lastscan
```

If you specify a new base data file name called `PbtoAu_Test3`, then modify the selected sequence so that it includes RSO measurement commands, and then run the sequence, MPMS MultiVu creates the following six data files when it finishes taking the first measurement in the sequence run:

```
PbtoAu_Test3.dc.dat
PbtoAu_Test3.dc.diag
PbtoAu_Test3.dc.raw
PbtoAu_Test3.dc.lastscan
PbtoAu_Test3.rso.dat
PbtoAu_Test3.rso.lastscan
```

4.2.2.2 EXAMPLE: NAMING DATA FILES THAT SAVE IMMEDIATE MEASUREMENT DATA

If you specify, in the **Measure DC** dialog box, a new base data file name called `CuMagProperties` and then run an immediate DC sample measurement, MPMS MultiVu creates the following two data files when it finishes taking the measurement:

```
CuMagProperties.dc.dat
CuMagProperties.dc.lastscan
```

When you specify the base file name, MPMS MultiVu adds the file extensions to the name immediately because it knows which type of measurement option will generate the data.

By default, the data files reside in the `C:\QdMpms\Data` directory.

4.2.3 Active Data Files

The active data files are the files actively storing the measurement data as the data is generated. A data file that is selected to store measurement data does not become "active" until a sequence or immediate measurement begins to run. An active file remains active until the sequence or immediate measurement is aborted or completes or until MPMS MultiVu reads a **Set Datafile** sequence command.

MPMS MultiVu identifies the data files that either are active or that will be active. The sequence status panels in the status bar and the **Sequence Status** panel in the control center display the base name of the files storing sequence measurement data. The **Sequence Base Data File Name** panel in the control center displays the base name of the files storing sequence measurement data or that will store data the next time a sequence runs. The **Data File** panel in the **Measure** dialog box displays the full name of the `.dat` file storing immediate-mode measurement data or that will store data the next time a measurement runs. Figure 5-4 illustrates the control center. Figure 3-9 illustrates the **Measure DC** dialog box.

The **Set Datafile** sequence command instructs MPMS MultiVu to make new data files the active data files. The base name of the new files appears in the **Sequence Status** panel and the sequence status panels, but does not appear in the **Sequence Base Data File Name** panel.

4.2.4 Template Files

Two types of template files save the defined graph format of data files. A graph configuration, or `.gph`, file is the template saving the most recently defined graph format of a data file. A graph template, or `.tpl`, file is a template you create to save the defined graph format of a data file. The graph format is the physical appearance of the graph; that is, the data parameters the graph plots and the gridlines and data indicators the graph uses to plot the data points.

A `.gph` file is associated with each data file you have opened and then closed. MPMS MultiVu creates the `.gph` file the first time you close the file. MPMS MultiVu uses the base name of the data file to create the base name of the `.gph` file. The first time you close the `testdata.dc.dat` file, MPMS MultiVu creates the `testdata.dc.dat.gph` file. Every time you reopen and close a data file, MPMS MultiVu updates the associated `.gph` file. The `.gph` file ensures that any changes you make to the graph format are saved and reappear when you reopen the data file.

You create `.tpl` files. You can create a `.tpl` file of the defined graph format of any data file and then apply that `.tpl` file to any data file, including the file from which you created the `.tpl` file. If you apply a `.tpl` file created from a data file storing one type of measurement data to a file storing a different type of measurement data, MPMS MultiVu may not copy the full format of the template to the other file, because the other file may be unable to use all format items defined in the template. Section 4.4.4 explains how you create `.tpl` files. Section 4.4.5 explains how you apply `.tpl` files.

4.3 Types of Data Files

Each type of MPMS MultiVu data file performs a unique function by storing a specific type of measurement data. A file extension, which MPMS MultiVu adds to the base file name at the time the file is created, identifies the type of data file and protects the function of the file, ensuring that it saves only the type of measurement data it was created to save.

Table 4-3. Name and Function of Data File Types

DATA FILE	FILE EXTENSION	FUNCTION
Measurement Data	`.dat`	Stores pertinent data from measurement.
Scan Data	`.lastscan`	Stores raw SQUID voltages from data points read during last scan.
Raw Data	`.raw`	Stores raw SQUID voltages from data points read during any number of scans.
Diagnostic Data	`.diag`	Stores summary data from any number of scans.
Helium Data[1]	`.dat`	Records level of helium in dewar.
Environment Log	`.env`	Stores specified system parameters.
Field Profile Scan[2]	`.pfl.dat`	Stores pertinent data from field profile scan.
EDC Data	`.edc`	Generated by EDC program.

[1] MPMS MultiVu has one helium data file. The base name of the file is `heliumgr`.

[2] The field profile scan data file is available only if the Low Field Profiling option or Ultra Low Field option is installed.

4.3.1 Sample Measurement Data Files

For any sample measurement, MPMS MultiVu may save measurement data in up to four different data files, called the sample measurement data files. The measurement data, scan data, raw data, and diagnostic data files are the sample measurement data files. MPMS MultiVu automatically saves sample measurement data to a measurement data file and data from the last scan to a scan data file. MPMS MultiVu creates the raw data and diagnostic data files and then saves data to those files only if you instruct it to do so.

Each sample measurement data file saves data from only one type of measurement. The name of the file indicates which measurement option generated the data stored in the file. The abbreviation of the measurement option—`dc`, `rso`, or `ac`—appears immediately after the base name of the file. For example, the `testdata.dc.dat` file stores data from a DC sample measurement. The `testdata.rso.dat` file stores data from an RSO sample measurement. MPMS MultiVu adds file extensions to the base name of the file when it creates the file.

4.3.1.1 MEASUREMENT DATA FILES

A measurement data, or .dat, file stores all pertinent data generated by any number of sample measurements taken by one type of measurement option. The first type of measurement option to save data to a .dat file determines the type of measurement option data the file stores.

A .dat file stores measurement data only when it is active, and only one .dat file is active at a time. MPMS MultiVu uses the base name of the active .dat file to create the base names of the other files that are active while the .dat file is active. The **Sequence Base Data File Name** panel in the control center displays the base name of the .dat file that is active during a sequence run or that will be active when a sequence runs. The **Data File** panel in the **Measure** dialog box displays the full name of the .dat file that is active during an immediate measurement or that will be active when an immediate measurement runs.

A .dat file contains one line of data for every identical type of measurement taken while the .dat file is active. If a sequence run includes five DC measurement commands, the active .dat file has five new lines of data. MPMS MultiVu appends data to a .dat file and never overwrites a .dat file.

MPMS MultiVu includes a default .dat file, called data0000. You may create any number of additional .dat files. Section 4.4.1 explains how you create .dat files.

4.3.1.2 SCAN DATA FILES

A scan data, or .lastscan, file stores the raw SQUID voltages from the individual data points read during only the last scan taken as part of a measurement. When the same measurement option runs another measurement, MPMS MultiVu updates the .lastscan file, overwriting the file with the data from the last scan.

One .lastscan file is associated with each .dat file, and the files share the identical base name. MPMS MultiVu creates the .lastscan file the first time a measurement runs while the .dat file is active. MPMS MultiVu overwrites the .lastscan file whenever another measurement runs while the same .dat file is active.

One centering scan data, or center.lastscan, file is associated with each measurement option. MPMS MultiVu creates and names the center.lastscan file the first time the measurement option runs a centering measurement. MPMS MultiVu overwrites the center.lastscan file whenever the same option runs another centering measurement.

A .lastscan file contains one line of data for every data point read during the last scan taken as part of a measurement. The lines summarizing data include the average voltage and the average detrended and demeaned voltage as well as the average regression, detrended, and demeaned fit of all data points in the file. If a .lastscan file includes data from a scan that has 32 data points, the file has 32 lines of data.

The .lastscan file performs the same function as the SQUID response graph that was generated by the MPMSR2 DOS software.

4.3.1.3 RAW DATA FILES

The raw data, or `.raw`, file stores the raw SQUID voltages from the individual data points read during any number of scans taken by one type of measurement option. MPMS MultiVu creates a `.raw` file only if you instruct it to do so. Each `.raw` file you create is associated with one `.dat` file, and the files share the identical base name. MPMS MultiVu saves data to the `.raw` file only while the file's associated `.dat` file is active.

A `.raw` file contains one line of data for every data point read during every scan run while the file is active. The lines summarizing data from the last scan that was run include the average voltage and fit of all data points in the `.raw` file. If a `.raw` file includes data from two scans and each scan has 10 data points, the file has 20 lines of data, and lines 11 through 20 include the average voltage and the average detrended and demeaned voltage as well as the average regression, detrended, and demeaned fit of all data points in the file. MPMS MultiVu always appends data to a `.raw` file and never overwrites a `.raw` file.

4.3.1.4 DIAGNOSTIC DATA FILES

The diagnostic data, or `.diag`, file stores summary data from any number of scans taken by one type of measurement option. MPMS MultiVu creates a `.diag` file only if you instruct it to do so. Each `.diag` file you create is associated with one `.dat` file, and the files share the identical base name. MPMS MultiVu saves data to the `.diag` file only while the file's associated `.dat` file is active.

The `.diag` file contains one line of data for every scan performed while the file is active. If a `.diag` file includes data from 10 scans, the file has 10 lines of data. MPMS MultiVu always appends data to a `.diag` file and never overwrites a `.diag` file.

4.3.2 Helium Data File

The helium data, or `heliumgr.dat`, file stores the helium-level data from the last helium fill. The file plots the level of helium in the dewar against the length of time of the helium-filling operation. The **Utilities➤Helium Fill** option opens the graph view of the `heliumgr.dat` file. MPMS MultiVu has one `heliumgr.dat` file that it overwrites whenever you run another helium fill.

The `heliumgr.dat` file has one line of data for every helium level recorded during the last helium fill. Each line has two data entries: the timestamp and the helium level. The MPMS system defines the time interval at which the `heliumgr.dat` file stores data.

4.3.3 Environment Log Files

The environment log, or `.env`, file stores time-based system data parameters. Once a `.env` file begins to store data, it stores data until it is instructed to stop.

You create all `.env` files (see section 4.4.2). You specify which system data parameters MPMS MultiVu saves to the `.env` file, and you specify the time interval at which MPMS MultiVu saves the data. Only one `.env` file stores data at a time.

The `.env` file has one line of data for each data reading. The number of data readings is determined by the specified time interval. The content of each line of data is determined by the specified data parameters. By default, MPMS MultiVu appends data to a `.env` file. You can instruct MPMS MultiVu to overwrite a `.env` file.

The `.env` file is also referred to as the log MPMS file.

4.3.4 Field Profile Scan Files

The field profile scan, or `.pfl`, file stores all pertinent data from a field profile scan. MPMS MultiVu creates a `.pfl` file during a field profile scan. The `.pfl` files are available only if the Low Field Profiling option or the Ultra Low Field option is installed.

The `.pfl` file contains one line of data for every field recorded during the field profile scan. By default, MPMS MultiVu appends data to a `.pfl` file. You can instruct MPMS MultiVu to overwrite the file.

4.3.5 EDC Data Files

Data files created in an EDC program by using the EDC data file commands use the same format and naming conventions as all other MPMS MultiVu measurement data files, but add the `.edc` extension to the data file name. The *Magnetic Property Measurement System: External Device Control Language User's Manual* discusses the EDC data files in detail.

4.4 Data File Management

4.4.1 Creating a Measurement Data File

If you specify the base name of a new `.dat` file before you run a measurement, you can save data from that measurement to the new file.

The following procedures explain how you create a `.dat` file to store DC measurement data. The procedures you use to create a `.dat` file to store RSO measurement data or AC measurement data are nearly identical.

4.4.1.1 CREATING A MEASUREMENT DATA FILE TO SAVE IMMEDIATE MEASUREMENT DATA

1. Select **Measure➤DC**. The **Measure DC** dialog box opens (see figure 3-9).
2. Select **Change**. The **Select or Enter a New DC Data File** dialog box opens. By default, the dialog box lists all `.dat` files.
3. Select the directory in which the data files will reside, if necessary. The default directory is `C:\QdMpms\Data`. If you select a directory, all new data files will reside in that directory.
4. Enter only the base name of the new `.dat` file, and then select **Open**. The **Select or Enter a New DC Data File** dialog box closes, and the **Measure DC** dialog box appears again. The full name of the `.dat` file, including the file extensions, appears in the **Data File** panel in the **Measure DC** dialog box.
5. Select the **Include Diagnostics Data** and **Include Raw Data** check boxes if you want MPMS MultiVu to create the `.diag` and `.raw` files.
6. Do the following if you want to modify the default graph format of any data file that will store the immediate measurement data: (*a*) select **View**, (*b*) select the file, (*c*) select **Open**, and then (*d*) modify the graph format as necessary. Refer to section 4.6.

   Selecting **View** prompts MPMS MultiVu to create the `.dat` and `.lastscan` files and—if the **Include Diagnostics Data** and **Include Raw Data** check boxes are selected—the `.diag` and `.raw` files. The new files contain only header information, which defines the default graph format.
7. Select **Measure** to run the measurement. If you did not select **View**, MPMS MultiVu creates the data files when it completes the first measurement. If you run multiple measurements while the same data files are active, MPMS MultiVu appends data to the files.

4.4.1.2 CREATING A MEASUREMENT DATA FILE TO SAVE SEQUENCE MEASUREMENT DATA

1. Select the **Sequence Base Data File Name Change** button in the control center. The **Select a Data File** dialog box opens. By default, the dialog box lists all `.dat` files.
2. Select the directory in which the data files will reside, if necessary. If you select a directory, all new data files will reside in that directory.
3. Enter only the base name of the new `.dat` file, and then select **Open**. The **Select a Data File** dialog box closes. The base name of the `.dat` file appears in the **Sequence Base Data File Name** panel in the control center. MPMS MultiVu has deleted any file extensions you added to the base file name.
4. Open the selected sequence file if you want to modify the DC measurement commands. In the command dialog box, select the **Include Diagnostic Data** and **Include Raw Data** check boxes if you want MPMS MultiVu to create the `.diag` and `.raw` files. Section 5.3.2 explains how you edit a sequence.
5. Save the selected sequence file if you have edited it.
6. Select the **Run** button in the control center in order to run the sequence.

MPMS MultiVu creates the `.dat` and `.lastscan` files when it completes the first measurement in the sequence. MPMS MultiVu also creates the `.diag` and `.raw` files if you instructed it to do so. MPMS MultiVu creates the files and adds the file extensions to the base file names when it knows which type of measurement data the files will store.

Once a measurement is complete, you may open any of the active data files. Do the following: (*a*) select the **Sequence Base Data File Name View** button in the control center, (*b*) select a data file in the **Select a Data File** dialog box, and then (*c*) select **Open**.

If you run multiple sequences while the same data files are active, MPMS MultiVu appends data to those files.

4.4.1.3 CREATING A MEASUREMENT DATA FILE WITHIN A SEQUENCE

1. Select the **Selected Sequence Edit** button in the control center. A sequence editor opens and lists all commands in the selected sequence. The sequence command bar also opens unless it is hidden or already open.
2. Double-click on the **Set Datafile** command, which is in the **Measure** command group in the sequence command bar. **Set Datafile** opens a dialog box that lists all `.dat` files.
3. Select the directory in which the data files will reside, if necessary. If you select a directory, all new data files will reside in that directory.
4. Enter only the base name of the new `.dat` file, and then select **Open**. The **Select a Data File** dialog box closes. The base name and file location of the `.dat` file appear on a single command line in the sequence editor. MPMS MultiVu has deleted any file extensions you added to the base file name.
5. Edit the sequence file in order to correctly position **Set Datafile**, if necessary. **Set Datafile** must precede a measurement command if you want to save the data generated by that command to the new files. Section 5.3.2 explains how you edit a sequence.
6. Modify the DC measurement commands, if necessary. In the command dialog box, select the **Include Diagnostic Data** and **Include Raw Data** check boxes if you want MPMS MultiVu to create the `.diag` and `.raw` files.
7. Save the sequence.

8. Select the **Run** button in the control center in order to run the sequence.

   MPMS MultiVu creates the `.dat` and `.lastscan` files when it completes the first measurement after it reads **Set Datafile**. MPMS MultiVu also creates the `.diag` and `.raw` files if you instructed it to do so. The files created with **Set Datafile** remain active throughout the sequence run unless MPMS MultiVu reads another **Set Datafile** command.

   During the sequence run, the base name of the data files created with **Set Datafile** appears in the **Sequence Status** panel and the sequence status panels, but does not appear in the **Sequence Base Data File Name** panel.

4.4.2 Creating an Environment Log File

1. Select **Utilities➤Log MPMS Data**. The **Log Data** dialog box opens.
2. Select the **General** tab. You use the **General** tab to select an environment log file and to specify how frequently MPMS MultiVu logs data to the file.

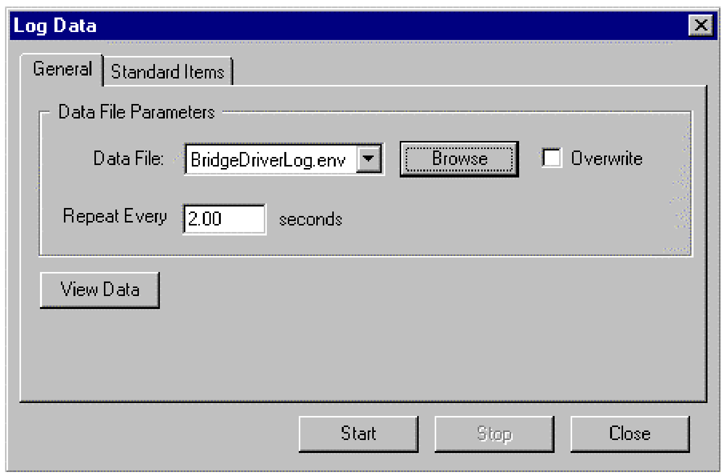


Figure 4-1. **General** Tab in **Log Data** Dialog Box

3. Select **Browse**. The **Select an Environment Data File** dialog opens and lists all `.env` files.
4. Select the directory in which the `.env` file will reside, if necessary. If you select a directory, all new data files will reside in that directory.
5. Enter only the base name of the new `.env` file, then select **Open**. The full name of the `.env` file appears at the top of the **Data File** pull-down menu in the **General** tab. MPMS MultiVu has added the file extension to the base file name because it knows which type of data the file will store.

   Notice that you select the **Overwrite** check box if you want to overwrite an existing `.env` file. By default, MPMS MultiVu appends data to `.env` files.
6. Enter the time interval, in seconds, defining how frequently MPMS MultiVu logs data to the `.env` file. The time interval may be any length from 0.25 seconds to 99,999 seconds.

7. Select the **Standard Items** tab. You use the **Standard Items** tab to select the system data parameters that MPMS MultiVu logs to the `.env` file.

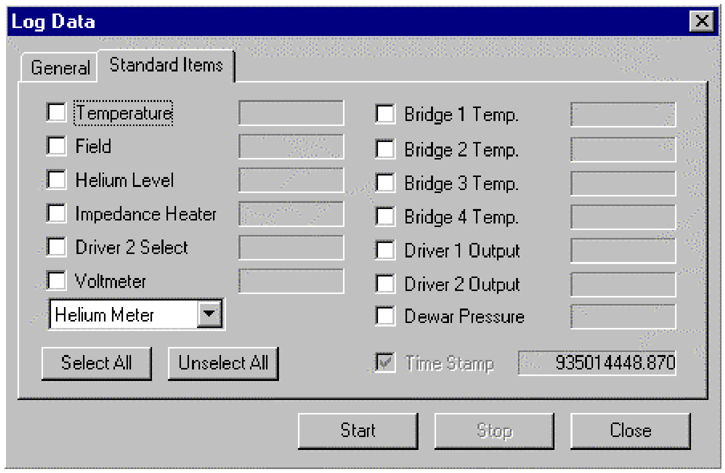


Figure 4-2. **Standard Items** Tab in **Log Data** Dialog Box

8. Select system parameters. Click on **Select All** to save all parameters. Click on **Unselect All** to deselect all parameters. When you select a parameter, its value appears in the **Standard Items** tab. If you select a large number of parameters, data logging occurs more slowly.
9. Select **Start** to begin logging the specified parameters. MPMS MultiVu creates the `.env` file when it begins logging data.

   At any time, you can specify different parameters for MPMS MultiVu to log. However, while MPMS MultiVu logs the data, you cannot redefine the time interval at which the data is logged. You cannot run multiple `.env` files.
10. Select **View Data** in the **General** tab in order to open the `.env` file.
11. Select **Stop** to stop logging data. MPMS MultiVu logs data until you instruct it to stop.

4.4.3 Changing the Sequence Base Data File Name

1. Select the **Sequence Base Data File Name Change** button in the control center. The **Select a Data File** dialog box opens. By default, the dialog box lists all `.dat` files.
2. Select a `.dat` file, then select **Open**. The base name of the `.dat` file appears in the **Sequence Base Data File Name** panel in the control center. The file does *not* open.

4.4.4 Creating a Graph Template File

1. Select an open data file, and verify that the graph view is active.
2. Modify the graph format, if necessary. Refer to section 4.6.
3. Select **Graph➤Save Template As**. The **Save as a Graph Template File** dialog box opens and lists all `.tpl` files. The full name of the data file you are using to create the template is displayed. However, MPMS MultiVu has replaced the original file extension with the `.tpl` extension.
4. Select **Open** or specify a different file name and then select **Open**. MPMS MultiVu creates the `.tpl` file.

4.4.5 Applying a Graph Template File

1. Select an open data file, and verify that the graph view is active.
2. Select **Graph➤Apply Template**. The **Apply a Template to the Current Graph** dialog box opens and lists all `.tpl` files.
3. Select a `.tpl` file, then select **Open**. MPMS MultiVu applies the `.tpl` file to the graph format of the data file, modifying the graph format so that it is defined by the template.

If you apply a `.tpl` file created from a data file storing one type of measurement data to a file storing a different type of measurement data, MPMS MultiVu does not necessarily copy the full format of the template to the data file; the data file may not be able to use all format items defined in the `.tpl` file.

4.4.6 Printing a Graph

*Before you print any graph view or sequence file, you can use the **File➤Print Preview** option to see what the graph or sequence file will look like when it is printed. The view window also includes a **Print** button.*

1. Select an open data file, and verify that the graph view is active.
2. Select **File➤Print**. The **Print Parameters** dialog box opens. The dialog box defines the appearance of the printed graph.
3. Specify what labels, such as the name and path of the data file, you want to print on the graph. Also specify the printing options.
4. Select **OK**. The **Print** dialog box opens.
5. Select a printer and define the printer properties, specify the number of copies, and so on.
6. Select **OK**. The graph is printed.

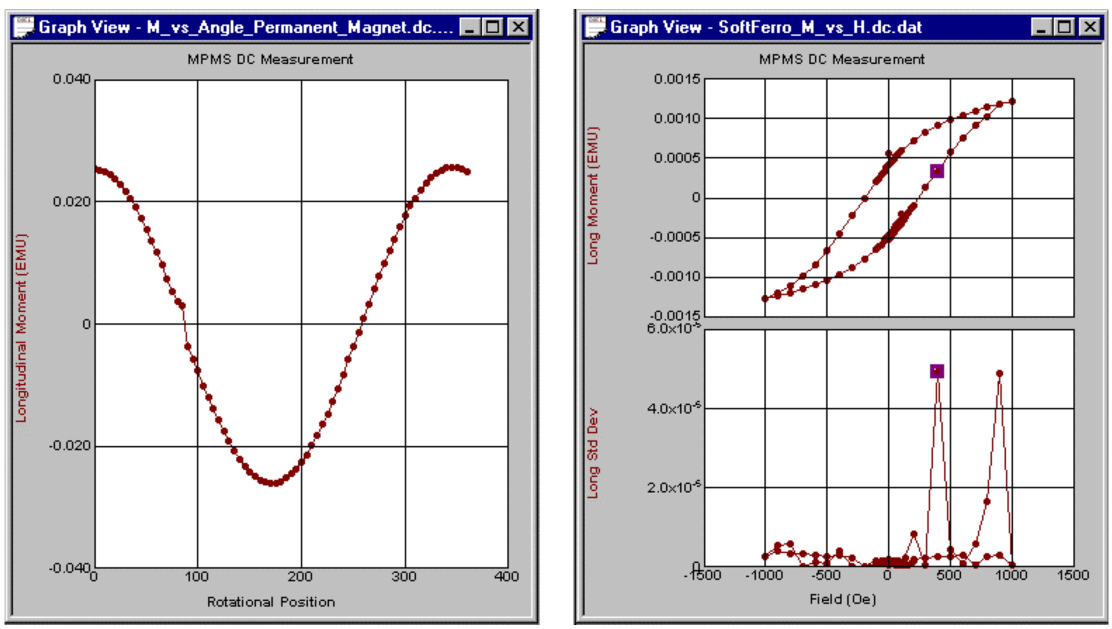
4.5 Data-Viewing Formats

MPMS MultiVu includes four data-viewing formats—the graph view, record view, table view, and raw data view—that give you four different ways of examining the information stored in a data file. The graph view is the default viewing format. Every data file opens in the graph view. Once a data file is open, you can select any of the other three viewing formats. Multiple views of a data file or of several files may be open at one time.

Commands in the **View** menu and **Graph** pop-up menu open and select viewing formats. You open the **Graph** pop-up menu by right-clicking the mouse inside any graph window.

4.5.1 Graph View

The graph view is a plot of data points that MPMS MultiVu has saved to a data file. The graph plots only the specified data points and may not plot all data points saved to the file. MPMS MultiVu uses the current graph configuration, or `.gph`, file to plot the points.



One Plot in Graph View

Two Plots in Graph View

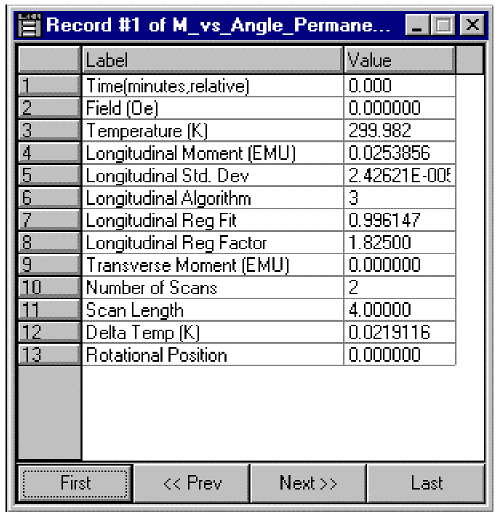
Figure 4-3. Graph View

In the graph view, one data point is highlighted, or selected. If you double-click close to the selected data point, the record view opens and lists the values of all parameters for that data point. If you double-click a part of the graph area that is not near the selected data point, the table view opens and lists all parameters for all data points in the data file. To select a different data point, click on that data point.

The graph view automatically opens when you open a data file. If a data file is open and selected, but the graph view is not selected, you can open the graph view by selecting the **View➤Graph** option.

4.5.2 Record View

The record view is a table listing the value of all parameters for one data point that MPMS MultiVu has saved to a data file. Each row in the table displays the name and value of one parameter. The number in the left-hand column of every row helps separate the rows and identifies which column in the table-view table displays the same parameter data. The number of rows in the record-view table is determined by the number of parameters associated with the data point.



	Label	Value
1	Time(minutes,relative)	0.000
2	Field (Oe)	0.000000
3	Temperature (K)	299.982
4	Longitudinal Moment (EMU)	0.0253856
5	Longitudinal Std. Dev	2.42621E-005
6	Longitudinal Algorithm	3
7	Longitudinal Reg Fit	0.996147
8	Longitudinal Reg Factor	1.82500
9	Transverse Moment (EMU)	0.000000
10	Number of Scans	2
11	Scan Length	4.00000
12	Delta Temp (K)	0.0219116
13	Rotational Position	0.000000

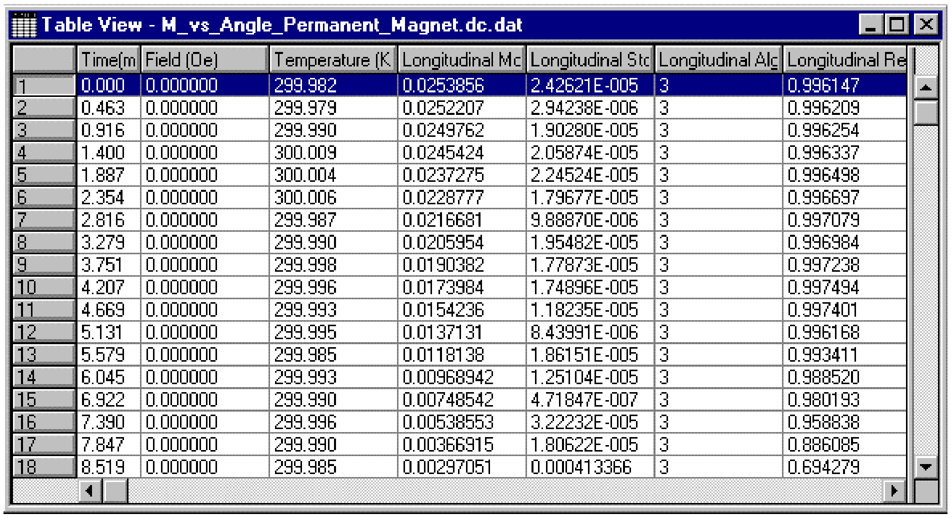
Figure 4-4. Record View

The header in the record window indicates which data point you are examining. The data point is always the last data point selected in the graph view or table view. To select a different data point, use the **First**, **Prev**, **Next**, and **Last** buttons that are at the bottom of the record window, or click on a data point in the graph view or on a row in the table view.

You can open the record view whenever a data file is open and selected, but the record view is not selected. To open the record view, you can select the **View➤Record** option. You can also open the record view by double-clicking on any point in the graph view or by double-clicking on any row in the table view.

4.5.3 Table View

The table view is a table listing the value of all parameters for all data points that MPMS MultiVu has saved to a data file. Each row in the table displays all parameter data for one data point. The number in the left-hand column of a row identifies the order in which the data point was read in the sequence of data points comprising the data file. The number of data points read determines the number of rows in the table.



	Time(m	Field (Oe)	Temperature (K	Longitudinal Mc	Longitudinal Stc	Longitudinal Alg	Longitudinal Re
1	0.000	0.000000	299.982	0.0253856	2.42621E-005	3	0.996147
2	0.463	0.000000	299.979	0.0252207	2.94238E-006	3	0.996209
3	0.916	0.000000	299.990	0.0249762	1.90280E-005	3	0.996254
4	1.400	0.000000	300.009	0.0245424	2.05874E-005	3	0.996337
5	1.887	0.000000	300.004	0.0237275	2.24524E-005	3	0.996498
6	2.354	0.000000	300.006	0.0228777	1.79677E-005	3	0.996697
7	2.816	0.000000	299.987	0.0216681	9.88870E-006	3	0.997079
8	3.279	0.000000	299.990	0.0205954	1.95482E-005	3	0.996984
9	3.751	0.000000	299.998	0.0190382	1.77873E-005	3	0.997238
10	4.207	0.000000	299.996	0.0173984	1.74896E-005	3	0.997494
11	4.669	0.000000	299.993	0.0154236	1.18235E-005	3	0.997401
12	5.131	0.000000	299.995	0.0137131	8.43991E-006	3	0.996168
13	5.579	0.000000	299.985	0.0118138	1.86151E-005	3	0.993411
14	6.045	0.000000	299.993	0.00968942	1.25104E-005	3	0.988520
15	6.922	0.000000	299.990	0.00748542	4.71847E-007	3	0.980193
16	7.390	0.000000	299.996	0.00538553	3.22232E-005	3	0.958838
17	7.847	0.000000	299.990	0.00366915	1.80622E-005	3	0.886085
18	8.519	0.000000	299.985	0.00297051	0.000413366	3	0.694279

Figure 4-5. Table View

The highlighted, or selected, row in the table view identifies the last data point selected in the graph view or record view. If you double-click on the selected row, the record listing the value of all parameters for that data point opens. To select a different data point, click on another row in the table view.

You can open the table view whenever a data file is open and selected, but the table view is not selected. To open the table view, you can select the **View➤Table** option.

4.5.4 Raw Data View

The raw data view is a text editor view of a data file. You can open the raw data view whenever a data file is open and selected, but the raw data view is not selected. To open the raw data view, you can select the **View➤Raw Data** option.

4.6 Graph Formats

The graph format is the physical appearance and layout of the graph view of a data file. A graph's appearance refers to the gridlines and data indicators the graph uses to plot different types of data stored in the file. The header section of a data file defines the default graph format of the file. You cannot change the default graph format. However, when the graph view is active, you can modify its appearance in multiple ways.

Commands in the **Graph** menu and **Graph** pop-up menu change the graph format. **Graph** menu and **Graph** pop-up menu options are nearly identical. However, **Graph** menu options emphasize opening and saving files; **Graph** pop-up menu options emphasize viewing data. The **Graph** pop-up menu is available only when the graph view is active. You open the **Graph** pop-up menu by right-clicking the mouse inside any graph window.

4.6.1 Selecting Gridlines and Data Indicators

1. Select an open data file, and verify that the graph view is active.
2. Select **Graph➤Appearance**. The **Appearance** submenu opens. The submenu can contain up to four numbered **Plot** options. One option is enabled for each plot in the graph view.
3. Select a **Plot** option. A pop-up dialog box opens and identifies which gridline and data indicator options define the format of the selected plot.
4. Select options in the **Plot Appearance** pop-up dialog box. If the active graph view has multiple plots, you can select **Apply to All Plots** to apply the format of the selected plot to all plots in the graph view.
5. Select **Apply** to apply the changes and keep the pop-up dialog box open *or* select **OK** to apply the changes and close the dialog box.

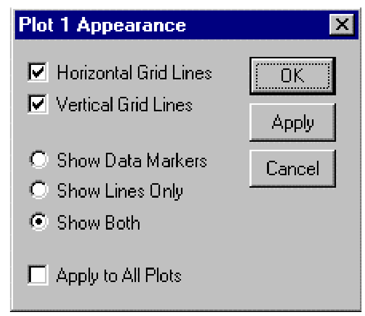


Figure 4-6. **Plot Appearance** Dialog Box

The **Graph➤Auto Scale All Plots** option or the **Graph** pop-up menu**➤Auto Scale All Plots** option adjusts the axis limits so that the plotted data points are comfortably spaced and you can see all of your data.

The **Graph** pop-up menu**➤X Axis Auto Scale** toggle option or **Y Axis Auto Scale** toggle option adjusts the x-axis gridlines or y-axis gridlines, respectively, so that the plotted data points are comfortably spaced.

4.6.2 Plotting Parameters

1. Select an open data file, and verify that the graph view is active.
2. Select **Graph➤Data Selection**. The **Data Selection** dialog box opens and lists all available axes and parameters that may appear in the graph.

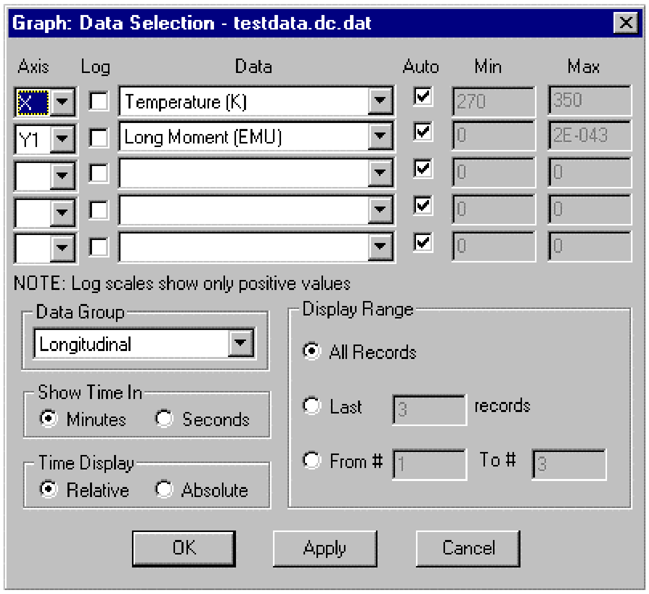


Figure 4-7. **Data Selection** Dialog Box

3. Use the **Axis** pull-down menus to select the axes on which MPMS MultiVu plots data in the graph. Each graph must have one x-axis and one y-axis. A graph may have up to four y-axes. To remove an extra y-axis, select **off** in the corresponding pull-down menu.
4. Select the **Log** check box associated with each axis if you want to logarithmically scale the parameter data on that axis. If **Log** is not selected, MPMS MultiVu scales the data linearly.
5. Use the **Data** pull-down menu associated with each axis to select the type of parameter data plotted on the axis. If the graph includes multiple y-axes, you can select a different type of parameter data for each y-axis. When multiple y-axes plot different types of data, MPMS MultiVu creates a separate plot of each x-axis–and–y-axis combination within the graph window.

   An asterisk appearing to the left of any parameter name in a **Data** pull-down menu indicates that MPMS MultiVu has not found data for that parameter.

   The **Data** pull-down menus list only the types of parameter data that are in the specified data group. You use the **Data Group** pull-down menu to specify the data group. Refer to step 7.
6. Select the **Auto** check box associated with each axis in order to automatically scale the axis. If **Auto** is not selected, you can specify the minimum and maximum values for the axis. Enter the minimum and maximum values in the **Min** and **Max** text boxes, respectively. The default values appearing in the **Min** and **Max** text boxes represent the axis limits presently defined by the autoscale function.
7. Use the **Data Group** pull-down menu to specify the data group. The data group is a subgroup of similar data parameter types. Select **Longitudinal** to plot only parameters used by the longitudinal SQUID. Select **Transverse** to plot only parameters used by the transverse SQUID. Select **All** to plot all available parameters. MPMS MultiVu can plot only the data parameters in the specified data group.
8. Select the time interval the x-axis uses to represent time.

9. Select the method of displaying time in the graph. Select **Relative** to start the time scale at zero. Select **Absolute** to use the absolute timestamp value that is stored in the data file.
10. Select the graph's display range. Select **All Records** to plot all data points. Select **Last** or **From** to display only specified data points.
11. Select **Apply** to apply the changes and keep the **Data Selection** dialog box open *or* select **OK** to apply the changes and close the dialog box.

4.6.3 Magnifying a Graph

1. Select an open data file, and verify that the graph view is active.
2. Click anywhere on the graph, drag the mouse through the graph so that you select the part of the graph you want to magnify, and then release the mouse. The selected part of the graph is magnified. You may repeat this procedure any number of times.
3. Select **Graph➤Zoom Previous** to return a magnified graph to its previous magnification. You can select **Zoom Previous** any number of times until the graph returns to its original size.

4.6.4 Restoring the Current Graph Configuration File

Select **Graph➤Restore Graph** to return the graph format of a data file to the format defined by the current graph configuration, or `.gph`, file. The current `.gph` file is the file created the last time the data file was closed. You may select **Restore Graph** at any time.

4.6.5 Restoring the Default Graph Format

Select **Graph➤Default Graph** to return the graph format of a data file to the default graph format defined in the data file header. You may select **Default Graph** at any time.