



# **Physical Property Measurement System**

## **AC Measurement System (ACMS II) Option User's Manual**

**Part Number 1084-800, Rev. A2**

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## **U.S. Patents**

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

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# Contents and Conventions

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## 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.
- Section P.5 describes the safety guidelines and regulatory information in the manual.
- Section P.6 contains disposal information.
- Section P.7 contains information on how to contact your Quantum Design service representative.

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## P.2 Scope of the Manual

This manual discusses the Quantum Design AC Measurement System (ACMS II) for the Physical Property Measurement System (PPMS), the PPMS VersaLab™ and DynaCool™ platforms. It contains information about basic functionality, describes the system hardware, and the control software.

The ACMS II measurement option includes a DC Magnetometer measurement mode that can be performed in conjunction with AC susceptibility measurements. This measurement mode is performed with different hardware and software than the stand alone PPMS VSM option. Be sure to read separate VSM measurement option user manuals when making measurements with that option.

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## P.3 Contents of the Manual

- Chapter 1 provides an overview and theory of the operation of the ACMS II.
- Chapter 2 provides an overview of the ACMS II option installation.
- Chapter 3 describes sample preparation and mounting
- Chapter 4 describes ACMS II measurements types and how to perform them.
- Chapter 5 describes details of the ACMS II hardware.
- Chapter 6 describes details of the ACMS II software.
- Chapter 7 describes common troubleshooting of the ACMS II.
- Appendix A provides a description of the CM-A Motor Module Electronics.
- Appendix B provides a description of the CM-M ACMS II Module Electronics.

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## P.4 Conventions in the Manual

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

**CAUTION!**

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

	<p style="text-align: center;"><b>WARNING!</b></p> <p>This symbol signals specific caution or conditions that could result in system damage, bodily harm, or loss of life.</p>
	<p style="text-align: center;"><b>ELECTRIC SHOCK!</b></p> <p>This symbol signals electrical hazards that could result in bodily harm, or loss of life. Used at all accessible 200-230 V and 380-408 V power outlets.</p>
	<p style="text-align: center;"><b>WARNING!</b></p> <p>This symbol signals <b>cryogenic hazards</b> that could result in bodily harm and loss of life. Used wherever accessible parts could reach temperatures below 0°C (32°F).</p>
	<p style="text-align: center;"><b>PROTECTIVE CONDUCTOR TERMINAL</b></p> <p>The protective conductor terminal symbol in the left figure identifies the location of the bonding terminal, which is bonded to conductive accessible parts of the enclosure for safety purposes.</p>
	<p style="text-align: center;"><b>EUROPEAN UNION CE MARK</b></p> <p>The presence of the CE Mark on the equipment signifies that it has been designed, tested and certified as complying with all applicable European Union (CE) regulations and recommendations.</p>
	<p style="text-align: center;"><b>ALTERNATING VOLTAGE SYMBOL</b></p> <p>This international symbol indicates an alternating voltage or current.</p>
	<p style="text-align: center;"><b>STANDBY SYMBOL</b></p> <p>The power standby symbol indicates a sleep mode or low power state. The switch does not fully disconnect the device from its power supply, depressing the button switches between on and standby.</p>



**WASTE ELECTRICAL AND ELECTRONIC  
EQUIPMENT (WEEE)!**

This symbol on the product or on its packaging indicates that this product must not be disposed of with regular waste. Instead, it is the users' responsibility to dispose of waste equipment according to local laws. The separate collection and recycling of the waste equipment at the time of disposal will help to conserve natural resources and ensure that it is recycled in a manner that protects human health and the environment. For information about where the user can drop off the waste equipment for recycling, please contact your local representative. Contact Quantum Design for instructions on how to disassemble the equipment for recycling purposes.



This symbol signals information on **fusing**.

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## P.5 Safety Guidelines and Regulatory Information

Before using this product, please read the entire content of this User's Manual and observe all instructions, warnings and cautions. These are provided to help you understand how to safely and properly use the ACMS II and reach its best performance.

Quantum Design Inc. disclaims any liability for damage to the system or injury resulting from misuse or improper operation of the system.

**WARNING!**



If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.  
Do not position the equipment so that it is difficult to operate or disconnect the device.

### P.5.1 Inspection for Damage

The ACMS II measurement option is carefully packaged at the factory to minimize the possibility of damage during shipping. Inspect the box for external signs of damage or mishandling. Inspect the contents for damage. If there is visible damage to the instrument upon receipt, inform the shipping company and Quantum Design immediately.

	<b>W A R N I N G !</b>
<p>Do not attempt to operate this equipment if there is evidence of shipping damage or you suspect the unit is damaged. Damaged equipment may present additional hazards. Contact Quantum Design technical support for advice before attempting to power on and operate damaged equipment.</p>	

## P.5.2 Electricity

- In case of emergency, switch off the breaker on the back of the pump cabinet labeled “MAIN PWR” and the breaker on the compressor if your system is a cryocooled instrument switch off the main breaker on the compressor.

Observe the following safety guidelines when you use your system:

- To prevent electrical shock, unplug the system before you install it, adjust it, or service it. Permit only qualified electricians or Quantum Design personnel to open electrical enclosures, and perform electrical servicing and checks. In cryocooled instruments, to prevent electrical shock, disconnect the compressor from the power before you install it, adjust it, or service it.
- Keep electrical cords in good working conditions, and replace frayed and damaged cords.
- For continued protection against fire hazard, electric shock and irreversible system damage, replace fuses only with same type and rating of fuses for selected line voltage.
- In general, keep liquids away from the PPMS and ACMS II equipment.
- Keep the PPMS and ACMS II away from radiators and heat sources. Be sure to follow circuit breaker specifications outlined in the PPMS manual.

## P.5.3 Magnet Safety

Observe the following precautions for magnet safety. Also make certain you review the material in chapter 1 in the *Physical Property Measurement System: Hardware Manual*.

	<b>W A R N I N G !</b>
<p>Large magnetic fields are dangerous to anyone wearing a pacemaker or other electrical medical device. Make certain any person wearing a pacemaker or similar device stays at least 3.0–4.5 m (10–15 ft.) from the PPMS dewar whenever the PPMS superconducting magnet is charged.</p>	

**WARNING!**

Large magnets, such as the PPMS superconducting magnets, can attract iron and other ferromagnetic materials with great force. Keep all iron, nickel, and other ferromagnetic objects at least 5.0 m (16.5 ft.) from the PPMS dewar.

The observable effects of magnetic fields are listed in chapter 1 in the *Physical Property Measurement System: Hardware Manual*.

**P.5.4 Cryogenic Safety**

When you work with cryogenic materials such as liquid helium and liquid nitrogen, keep in mind that (1) they can expand when subjected to room temperature and (2) they can burn.

**WARNING!**

The extreme cold of liquid and gaseous cryogenics can cause serious burns. Always wear protective clothing, including thermal gloves, eye protection, and covered shoes, when you work with liquid helium, liquid nitrogen, or any other cryogen.

**WARNING!**

In a poorly ventilated room, helium can displace air and lead to asphyxiation. Always perform cryogen transfers in a well-ventilated room. In the event of a rupture or spill, vent the room immediately and evacuate all personnel.

Cryogenics stored in confined spaces are subject to extremely high pressure buildup, resulting in dangerous explosions. Pressure relief valves are installed on the PPMS dewar and cooling annulus, and rupture disks are installed on the vacuum sleeve and dewar to eliminate the possibility of explosion. *Do not remove, disable, or otherwise tamper with these safety devices.*

## P.6 Disposal Information

The ACMS II is excluded from the requirements of:

- DIRECTIVE 2011/65/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS 2)

The ACMS II complies with the requirements of:

- DIRECTIVE 2012/19/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 4 July 2012 on waste electrical and electronic equipment (WEEE)

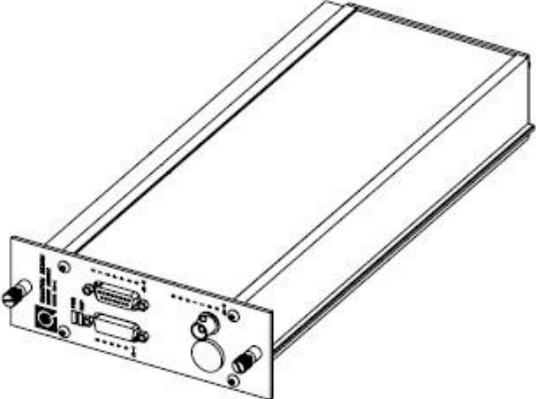
### P.6.1 RoHS Statement

The ACMS II is explicitly excluded from the Recast RoHS Directive in Article 2(4)(f) which covers: “*equipment specifically designed solely for the purpose of research and development only made available on a business-to-business basis*”.

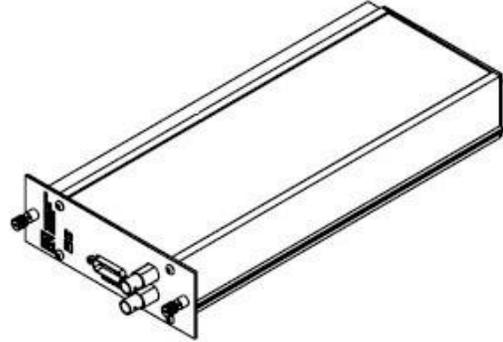
### P.6.2 WEEE Statement

WEEE Statement: ACMS II is WEEE compliant as Quantum Design uses recyclable materials in the fabrication of the equipment. Several components require special handling and processing and these components must be removed at time of decommissioning for proper handling before recycling/disposal. Contact Quantum Design for updated procedure/recommendations before disposal.

Table P-1. List of Components to be Removed before Recycling or Disposal.

<i>Component Description / Location</i>	<i>Identifying Photograph/Diagram</i>
Motor Module (QD P/N.: 4101-100)	

ACMS II Module (QD P/N.: 4101-430)



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## P.7 Contacting Quantum Design

If you have trouble with your ACMS II or your system, please contact your local Quantum Design service representative for assistance. See [www.qd-international.com](http://www.qd-international.com) for the information about your local representative. You will be asked to describe the problem, the circumstances involved, and the recent history of your system.



## Introduction

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### 1.1 Introduction

This chapter contains the following information:

- Section 1.2 presents an overview of the AC measurement system (ACMS II) option.
- Section 1.3 presents the theory of operation.

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### 1.2 Overview of the ACMS II Option

The Quantum Design AC Measurement System (ACMS II) option for the Physical Property Measurement System (PPMS) is a versatile susceptometer. In addition to a mutual-inductance-based determination of the AC magnetic susceptibility for frequencies between 10 and 10,000 Hz, the coil set permits measurements of the DC magnetization as well, using the DC magnetization (DCM) option, without any change in hardware, sample or sample mount. The state-of-the-art technology of the ACMS II offers extensive susceptibility and magnetization capabilities while retaining a user-friendly interface. By being interfaced with the automated temperature and field control systems of the PPMS, the ACMS II provides a highly powerful, fully automated workstation for the study of magnetic materials.

The ACMS II coil set houses the drive, detection and calibration coils, thermometer, and electrical connections for the ACMS II system. The coil set is used in conjunction with the sample rod guide tube and it fits directly in the PPMS sample chamber. The sample is attached to the end of a rigid sample rod, and it is positioned at the center of the coil set during the measurements. The longitudinal (vertical) motion of the sample is controlled by the sample transport assembly. The linear motor provides rapid and very smooth longitudinal sample motion. The ACMS II sample transport assembly mounts on top of the PPMS probe.

## 1.3 Theory of Operation

In AC magnetic measurements, a small AC drive magnetic field is superimposed on the external DC field, causing a time-varying magnetization in the sample. The change in flux due to the time-dependent moment induces an emf in the pickup coil, which is proportional to the magnetization, allowing measurements without sample motion. The detection circuitry is configured to detect only in a narrow frequency band, normally at the fundamental frequency (that of the AC drive field), which in the ACMS II is in the range from 10 to 10,000 Hz. On the other hand, the DC magnetization is determined using the DCM option; while the sample is magnetized by the external magnetic field of the PPMS's superconducting magnet, it is made to oscillate around the center of the two detection coils of the coil set. The coil set picks up a signal that is proportional to the magnetization, amplitude and frequency of the vibration.

In order to understand what is measured in AC magnetometry, it is useful to first consider very low frequencies (e.g., 1 Hz), where the measurement is most similar to DC magnetometry. In this case, the magnetic moment of the sample follows the  $M(H)$  curve that would be measured in a DC experiment. As long as the AC field is small, the induced AC moment is  $M_{AC} = (\partial M / \partial H) \cdot H_{AC} \sin(\omega t)$  where  $H_{AC}$  is the amplitude of the driving field,  $\omega$  is the driving frequency, and  $\chi = \partial M / \partial H$  is the slope of the  $M(H)$  curve, called the susceptibility. The susceptibility is the quantity of interest in AC magnetometry.

As the applied DC magnetic field is changed, different parts of the  $M(H)$  curve are accessed, giving a different susceptibility. One advantage of the AC measurement is already evident: the measurement is very sensitive to small changes in  $M(H)$ . Since the AC measurement is sensitive to the slope of  $M(H)$  and not to the absolute value, small magnetic shifts can be detected even when the absolute moment is large.

At higher frequencies, the AC moment of the sample may not necessarily match the DC magnetization curve, due to dynamic effects in the sample. For this reason, the AC susceptibility is often known as the dynamic susceptibility. In this higher frequency case, the magnetization of the sample may lag behind the drive field, an effect that is detected by the magnetometer circuitry. Thus, the AC magnetic susceptibility measurement yields two quantities: the magnitude of the susceptibility,  $\chi$ , and the phase shift,  $\varphi$  (relative to the drive signal). Alternately, one can think of the susceptibility as having an in-phase (or real) component  $\chi'$  and an out-of-phase (or imaginary) component  $\chi''$ . The two representations are related by

$$\chi' = \chi \cos \varphi, \quad \chi'' = \chi \sin \varphi \quad (1)$$

$$\chi = (\chi'^2 + \chi''^2)^{1/2}, \quad \varphi = \text{atan2}(\chi'', \chi') \quad (2)$$

where  $\text{atan2}()$  is the two-argument  $\arctan()$  function.<sup>1</sup>

In the limit of low frequency where AC measurement is most similar to a DC measurement, the real component  $\chi'$  is just the slope of the  $M(H)$  curve discussed above. The imaginary component,  $\chi''$ , indicates dissipative processes in the sample. In conductive samples, the dissipation is due to eddy currents. Relaxation and irreversibility in spin-glasses give rise to a nonzero  $\chi''$ . In ferromagnets, a nonzero imaginary susceptibility can indicate irreversible domain wall movement or absorption due to a permanent moment. Also, both  $\chi'$  and  $\chi''$  are very sensitive to thermodynamic phase changes, and are often used to measure transition temperatures. AC magnetometry allows one to probe all of these interesting phenomena. Typical measurements to access this information are  $\chi$  vs. temperature,  $\chi$  vs. driving frequency,  $\chi$  vs. DC field bias, and  $\chi$  vs. AC field amplitude

<sup>1</sup>  $\text{atan2}(y, x) = \arctan(y/x)$  for  $x > 0$ ;  $\text{atan2}(y, x) = \arctan(y/x) + 180^\circ$  for  $x < 0$

### 1.3.1 AC Susceptibility Measurement Process

AC susceptibility measurements do not directly measure a sample's magnetic moment. Rather they measure the derivatives  $dM/dH$ . Therefore, samples with very different magnetic moments can still have the same response to a changing magnetic field if their AC susceptibilities are the same in the measurement regimes of interest. The AC susceptibility option in the ACMS II superimposes a small alternating field to the applied external field from the PPMS superconducting magnet, in order to determine the sample's AC magnetic moment response. Both the amplitude and phase of this response are reported. Alternatively, the ACMS II can report the in-phase and quadrature components of the sample's response. Note that the reported amplitude is the amplitude of the *change* in magnetic moment  $dM$  and is not an absolute magnetic moment or a susceptibility. To obtain the AC susceptibility, you must divide the amplitude of the change in moment by the amplitude of the alternating field  $dH$ . This gives

$$\chi_{ac} = dM/dH. \quad (3)$$

It is important to keep in mind that this is only the local slope of the sample's magnetization curve  $M(H)$  and not the "true" susceptibility

$$\chi = M/H. \quad (4)$$

It is important to note the difference between AC susceptibility and "true" susceptibility when dealing with samples that have non-linear magnetization curves.

During an AC susceptibility measurement, an alternating magnetic field generated by the primary of the coil set is superimposed to the DC field of the PPMS superconducting magnet. This alternating field is synthesized by the AC stimulus response (ACSR) high speed electronics' board and sent to a digital-to-analog converter. The analog signal is amplified and used to control the precise AC excitation currents sent to the drive and compensation coils.

By default, the sample undergoes a three-point measurement process that utilizes the calibration coils in order to increase measurement accuracy. The first reading is made with the sample positioned at the center of the bottom detection coil. The sample is then repositioned to the center of the top detection coil and a second reading is taken. A third reading is made with the sample back at the center of the bottom coil. During all three readings, the signals are measured with a lock-in amplifier, conditioned with a low-pass filter, and digitized with an analog-to-digital converter (A/D). The three-point measurement permits comparing the sum of the two bottom coil signals with the top coil signal multiplied by two, such that a correction for drifts of the sample moment and background over the course of the measurement can be made.

When the bottom-top-bottom coil readings are complete, the sample is placed at the bottom of the detection coil. Two more readings are taken with the calibration coil switched into the detection circuit with opposing polarities.

Higher harmonics of the AC susceptibility have been used to probe a number of properties in condensed matter physics, including the strength of the pinning forces in superconducting materials, the peak effect, the distinction between intra- and intergranular superconductivity, the emergence of the pseudo-gap in cuprate superconductors, and spin glass behavior. In its current version (March 2014), the ACMS II is optimized to provide accurate and reliable values for the first harmonic only.

### 1.3.2 DC Magnetization Measurement Process

The basic principle of operation for the DC magnetization measurement process is that a changing magnetic flux, due to the vibration of the sample concentrically within the coil set, induces a voltage in the pickup coils. This is akin to the operation of a vibrating sample magnetometer. The pickup coil set,

which is shared with the ACMS II, consists of two counterwound coils connected in series and located just above and below the sample, in a first-order gradiometer configuration. The time-dependent induced voltage is given by:

$$V_{coil} = \frac{d\Phi}{dt} = \left(\frac{d\Phi}{dz}\right)\left(\frac{dz}{dt}\right) \quad (5)$$

In equation (5),  $\Phi$  is the magnetic flux permeating by the pickup coils,  $z$  is the vertical position of the sample with respect to the coil, and  $t$  is time. For a sinusoidally oscillating sample position, the voltage is based on the following equation:

$$V_{coil} = 2\pi f C m A \sin(2\pi f t) \quad (6)$$

In equation (6),  $C$  is a coupling constant,  $m$  is the DC magnetic moment of the sample,  $A$  and  $f$  are the amplitude and frequency of oscillation, respectively.

The acquisition of magnetic moment measurements involves measuring the coefficient of the sinusoidal voltage response from the detection coil. Figure 1-1 illustrates how this is done with the DCM option.

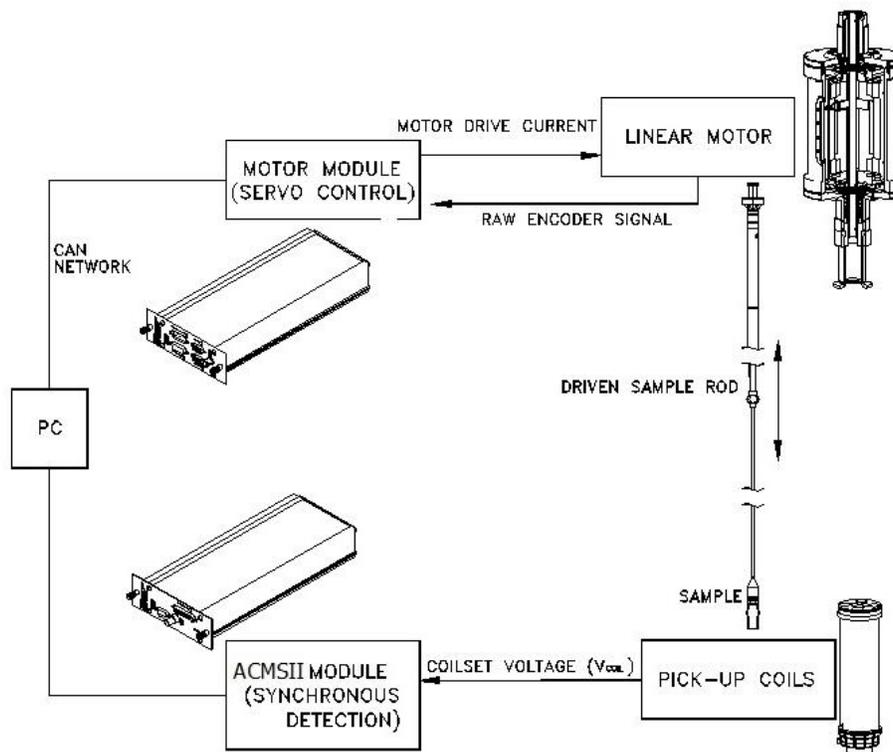


Figure 1-1. Operating Principle for the ACMS II Option.

The sample is attached to the end of a sample rod that is driven sinusoidally. The center of oscillation is positioned at the vertical center of the pickup coil set, which is arranged in a first-order gradiometer configuration. The precise position and amplitude of oscillation is controlled from the DCM motor module using an optical linear encoder signal readback from the DCM linear motor transport. The voltage induced in the pickup coil is amplified and lock-in detected in the DCM detection module. The DCM detection module uses the position encoder signal as a reference for the synchronous detection. This encoder signal is obtained from the DCM motor module, which interprets the raw encoder signals from the DCM linear motor transport. The DCM detection module detects the in-phase and quadrature-phase signals from the encoder and from the amplified voltage from the pickup coil. These signals are averaged and sent over the CAN bus to the MultiVu application running on the PC.

Chapter 5 describes the hardware components of the Quantum Design DCM option in more detail.

### **1.3.3 Notable Features of the ACMS II System**

The Quantum Design ACMS II features a uniquely designed linear motor to move or vibrate the sample. Unlike other vibrating sample magnetometers that use a short-throw resonant voice-coil design, you will find that the DCM linear motor is designed to operate at 40 Hz, with rapid slewing possible over about 6.5 cm of travel.

The sensitivity of the pickup coil is not significantly affected by large magnetic fields, so the DCM can perform sensitive measurements up to the maximum field available from your magnet.

The DCM/ACMS II detection coil is inserted in the sample chamber by using the standard insertion tool assembly. This procedure will make it easy to reconfigure the DCM option with alternate pickup coil designs in the future. You will find that you can change the pickup coil configuration as easily as you can change a puck.

The DCM option is fairly easy to activate or deactivate, just like the other PPMS options. The modularity of the design enables you to perform successive types of measurement with little additional effort. For example, you could follow state-of-the-art DCM measurements with heat-capacity measurements by inserting a different puck or probe.

### **1.3.4 The ACMS II Coil Set**

The ACMS II coil set serves a dual-purpose, to support the measurement of AC susceptibility, using the ACMS II option, as well as the measurement of the DC magnetization, using the DCM option. The detection coils are shared by both options. Refer to figure 1-2.

In support of the AC susceptibility measurements, the coil set contains an AC-drive coil that provides an alternating excitation field, and a detection coil set that inductively responds to the combined sample moment and excitation field. The copper windings for the drive, calibration and detection coils are concentric with each other and with the superconducting DC magnet of the PPMS.

The drive coil is wound longitudinally around the detection coil set. The field amplitude that can be applied depends on the frequency of the alternating field and the temperature within the PPMS probe, but, at any temperature, the drive coil can generate alternating fields of up to 17 Oe in a frequency range from 10 Hz to 10 kHz. As the frequency increases and the temperature decreases, larger amplitude fields can be applied, limited though by self-heating concerns. At temperatures below 25 K, large amplitude fields at sufficiently high frequencies can warm the PPMS sample chamber and ACMS II coil set. See section 4.4.1.2 for more information.

The detection coils are arranged in a first-order gradiometer configuration both to help isolate the sample's signal from uniform background sources, and to provide a reliable centering algorithm for the DC measurements with the DCM. The gradiometer response is optimized for a flat response around the center position, in order to make the magnetic moment insensitive to small variations in the starting position. This configuration utilizes a set of two counterwound copper coils connected in series and separated by about 2 cm. For the DCM measurements, a constant field is applied to the measurement region and the sample is vibrates longitudinally around its position in the center of the gradiometer, inducing a signal according to Faraday's Law. During AC measurements, an alternating field is applied to the measurement region in superposition to the DC field of the magnet, and the sample is positioned in the center of each detection coil. The signal from the detection coils reflects the change in mutual inductance due to changes in the magnetization of the sample.

A compensation coil is situated outside the AC drive coil. The drive coil and compensation coil are counter wound and connected in series so that they receive the same excitation signal. A net field remains within the measurement region, but outside the measurement region the fields from the two coils cancel. It effectively confines the excitation fields to the volume of the coil set, thereby reducing instrument interaction with conductive materials outside the measurement region—that is, the sample chamber walls, the magnet core, and so on—by three orders of magnitude. Each ACMS II system is individually calibrated so that the drive and compensation coils produce the appropriate net excitation signal at the location of the sample.

Each detection coil also contains a low-inductance calibration coil. These two single-turn calibration coils are connected in series and are situated at the center of each detection coil, where the sample measurements occur. During AC measurements, the accuracy of the phase and amplitude calibration is increased by placing the sample between the two detection coils and switching the calibration coils into the detection coil circuit with both possible polarities. The calibration coil is a feature found only on the Quantum Design ACMS II.

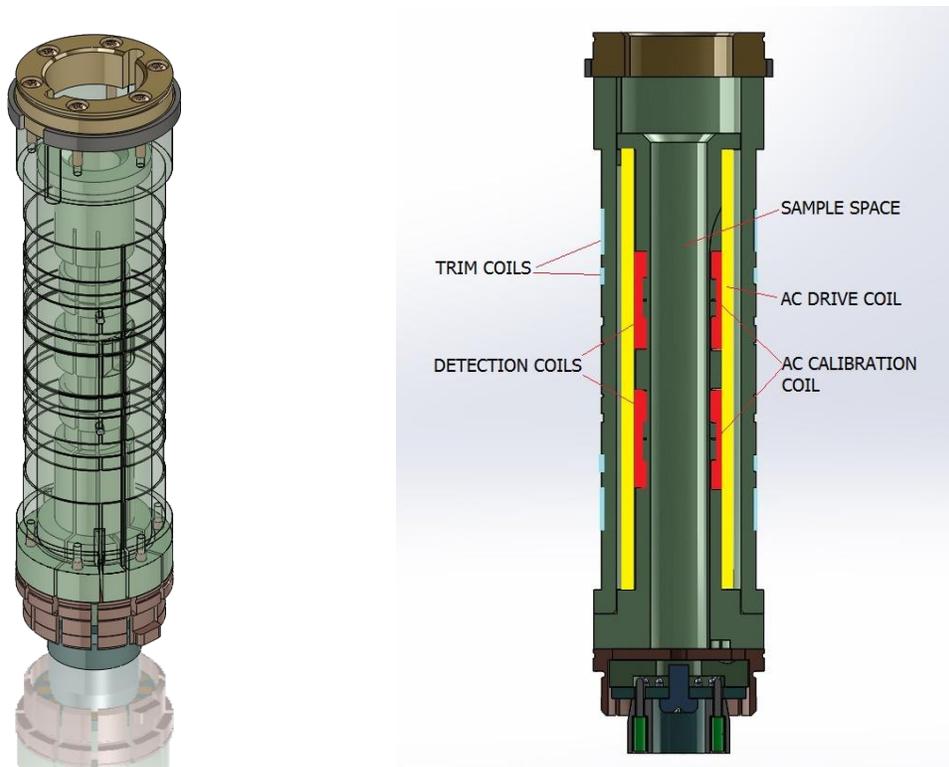


Figure 1-2. DCM and ACMS II Insert and Coil Set

In addition to the alternating field supplied by the ACMS II drive coil, the host PPMS platform can apply a constant field during both AC and DC measurements. The magnitude of the constant field can be up to 16 T, depending on the type of superconducting magnet in the PPMS. The magnetic fields generated by the PPMS superconducting magnets have high homogeneity, of about 0.01% within the measuring region.

One of the most notable features of the Quantum Design ACMS II is its ability to accurately separate real and imaginary components of AC moment response. In light of the resistive and inductive character of the coils, all AC instruments have phase shifts between the drive and the measured signals. These phase shifts are dependent upon parameters such as temperature and AC drive frequency, and therefore susceptible to changes with various measurement parameters. It is important to be able to separate the sample phase shift from this instrumental phase shift. The ACMS II corrects for instrument-dependent phase shift by actually performing measurements in the absence of the sample for each measurement point, using the calibration coils to simulate a sample with an entirely real response as described in section 4.2.

### 1.3.5 Probe Thermometry

The ACMS II insert is thermally anchored to the base of the PPMS sample chamber, such that the automated temperature control capabilities of the PPMS can be used to control the temperature of the ACMS II sample chamber.

In addition to the PPMS thermometers, the ACMS II has a thermometer mounted directly on its coil form. This thermometer helps reduce errors from thermal lags that may exist, particularly at higher temperatures. The sample maintains close thermal contact with the ACMS II thermometer by virtue of

the thermal conductivity provided by the low-pressure helium vapor in the PPMS sample chamber. This design gives fast thermal response times. The fast thermal response, precise temperature control hardware, and automation software provide accurate, time-efficient, user-friendly thermometry.

### **1.3.6 ACMS II Control Area Network (CAN) Module Electronics**

The ACMS II coils are connected to the PPMS electronics through the 12-pin connector located at the base of the PPMS sample chamber. This configuration uses the existing electronic wiring that is built into the PPMS hardware, thus eliminating the need for additional wiring and connectors.

The ACMS II option includes an ACMS II CAN Module, which is installed in the model 1000 Modular Control System. The ACMS II module provides the electronics that produce the desired excitation current in the drive coils, and it also effectively measures and separates the real and imaginary components of the sample's magnetic response. The heart of the AC board is a high-speed AC stimulus response (ACSR) card that synthesizes the excitation signal and processes the detection coils' response signal.

The ACMS II also uses the DCM Motor module. The Motor module contains the electronics that control the DCM sample transport linear motor.

# Installing and Removing the ACMS II Option

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## 2.1 Introduction

This chapter contains the following information:

- Section 2.2 lists the components of the ACMS II option and describes the procedures you will use for the initial installation on the system.
- Section 2.3 describes the procedures you will use to deactivate and remove the ACMS II option so that you can use a different measurement option.

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## 2.2 Initial Installation of the Hardware and Software

This section describes the procedures you will use for the initial installation of the Quantum Design AC Measurement System (ACMS II). These procedures apply *only* to the first time you set up and use the ACMS II option. To re-install the ACMS II option after it has been deactivated and a different measurement option (e.g., the Heat Capacity option) has been used, you will use the procedures in Section 2.2.7, "Activate the ACMS II Option Software."

**Important:** Parts of the initial installation may have been performed at the factory if the ACMS II option was purchased as part of a new system.

Table 2-1 lists the components of the Quantum Design ACMS II option. Verify that you have received all the components before you start the installation process.

Table 2-1. ACMS II system components

COMPONENT	PART NUMBER	ILLUSTRATION
Linear Motor Transport	4096-400	Figures 2-1, 2-6, 2-7, 2-8, 5-1, 5-2,
Extender tube flange (sometimes referred to as the "Bottom Weldment Flange") and O-rings	4096-418 or 4096-450 and VON2-030	Figures 2-1, 2-6, 2-7, 2-8, 5-1
Storage Case	4096-150	Figure 5-2
ACMS II Coilset Assembly*	4084-850	Figures 2-1, 2-2, 2-3, 4-4, 5-3, 5-4
Sample Guide Tube	4096-301 or 4096-350	Figures 2-1, 2-4, 2-5, 5-5
Sample Rods	4096-352 or 4096-275	Figures 2-1, 5-6
Sample Holders (paddle-shaped)	4096-392	p. 3-4
Sample Straws	4096-391	p. 3-5
Signal Cable Assembly	3084-801-01 or 3084-801-02 or 3084-801-03	Figures 2-1, 2-8, 5-9
Motor Drive Cable	3096-200 or 3096-201	Figures 2-1, 2-8, 5-10
Model CM-A Motor Module**	4101-100	Figures 2-1, 2-8, 5-11
Model CM-M ACMS II Module	4101-430	Figures 2-1, 2-8, 5-12
ACMS II Option User's Kit	4084-810	Figure 5-7

\*This item is shipped in the ACMS II Option User's Kit.

\*\*This item might be pre-installed in the system.

### Installation Process

In the event that you are performing a complete initial installation (i.e., no components were installed at the factory), the process includes the following phases:

- installing and verifying the modular control system, CAN network adapter, and CAN driver software (if no other CAN-based measurement options have been previously installed on your system)
- inserting the control modules
- warming the sample chamber, setting the magnetic field to zero, and venting the sample chamber
- installing the ACMS II coilset puck
- inserting the sample rod guide tube
- mounting the linear motor transport
- completing the electrical connections
- installing the MultiVu software application and the ACMS II software
- activating the ACMS II option
- configuring the ACMS II coilset

The complete initial installation of the ACMS II option should take no longer than 30 minutes.

In the event that you are performing a partial installation only, check the instructions for each phase to be sure that you understand critical aspects of the process.

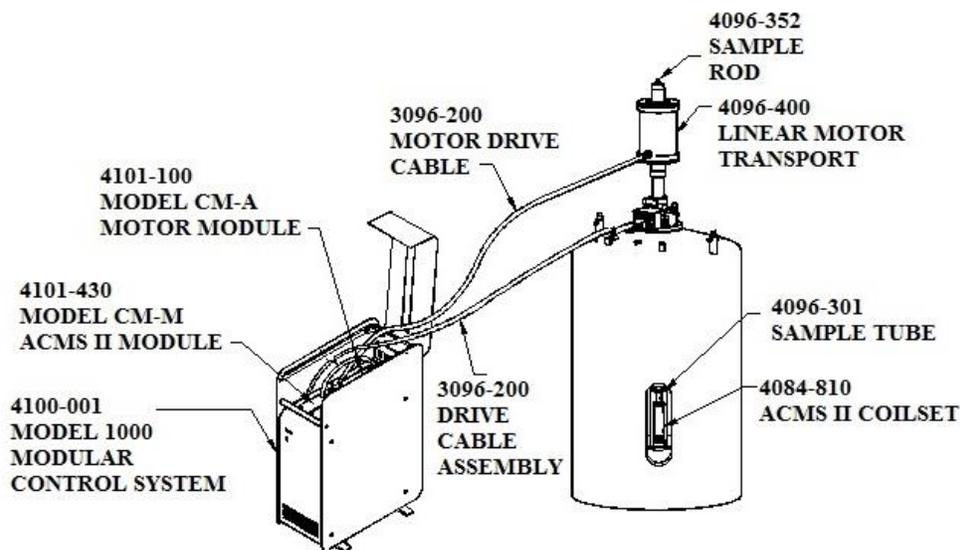


Figure 2-1. System components for the PPMS ACMS II option.

**Note:** The general setup of the ACMS II option will vary between system platforms.

## 2.2.1 Install the Modular Control System and CAN Network Adapter (PPMS ONLY)

You will use the instructions in this section only if a Model 1000 modular control system and the driver software have not yet been installed on your PPMS and PC. If your system already has been configured to use Quantum Design modules, you can go to Section 2.2.2.

To install the Model 1000, CAN network adapter, and CAN Manager driver software, refer to the *Model 1000 Modular Control System User's Manual*.

### System Verification

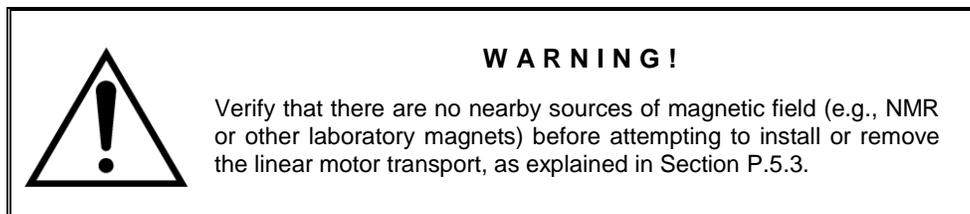
After you have completed installation of the Model 1000 and other components, perform a verification of the system:

1. Verify that the power cable has been connected to the Model 1000 and it has been turned on.
2. Verify that the power LED on the front of the Model 1000 is lit green.
3. Verify that the Model 1000 is connected to the CAN adapter on the PC via the CAN network cable

## 2.2.2 Prepare the System for Option Installation

To prepare the System for installation of the ACMS II option, you will use the MultiVu application to warm the sample chamber to 300K, set the magnetic field to zero (0) Oe, and vent the sample chamber. Then, you will remove any sample puck or option that is currently installed in the chamber. When you do this, be sure to remove the standard centering ring from the chamber opening (the ACMS II has a custom-designed centering ring).

1. Set the system temperature to 300 K.
2. Set the field to zero (0) Oe.



3. Vent the sample chamber.
4. Remove any sample puck or option that is installed in the sample chamber.
5. Remove the standard centering ring (or any other hardware that is present) from the top flange of the system.

## 2.2.3 Install the ACMS II Coilset

The coilset puck contains the ACMS II drive and detection coils, and a thermometer for monitoring the sample temperature. You will insert the coilset puck into the sample chamber by using the standard puck-insertion tool<sup>1</sup> and the same procedures that are used to insert other types of pucks (see the system User Manual for more information). **Install the puck before you insert the sample tube.**

1. On the system, verify that all items have been removed from the sample-chamber opening, including the standard centering ring.
2. Locate the serial number of the detection coilset puck (4084-850), as shown in Figure 2-2. This serial number will be used to identify the calibration data for the coilset in a later step.
3. Insert the coilset into the sample chamber by using the puck-insertion tool, as illustrated in Figure 2-3.

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<sup>1</sup> The puck-insertion tool is also referred to as the puck-extraction tool, the sample-holder tool, and the sample-insertion (sample-extraction) tool, depending on context.

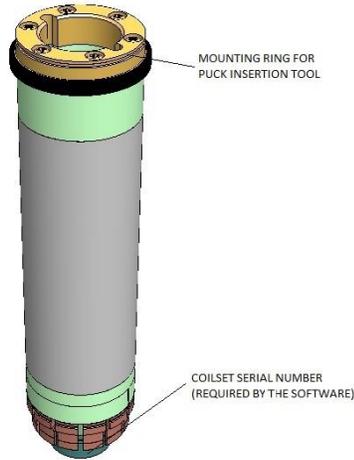


Figure 2-2. Coilset puck (4084-850), with arrows to coilset serial number and to mounting ring for attaching the puck-insertion tool

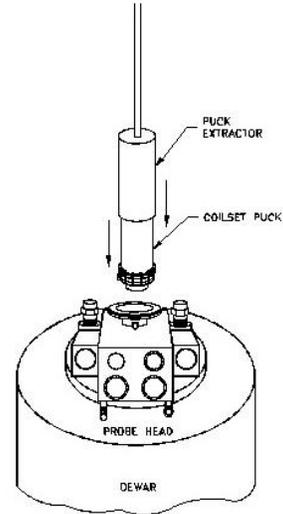


Figure 2-3. Installing the ACMS II coilset puck with the puck-insertion tool.

## 2.2.4 Insert the Sample Tube

The sample tube contains low-friction bearing sleeves to center the sample rod in the bore of the coilset. Figure 2-4 shows the sample-tube assembly, where you can see that the top of the sample tube assembly includes an integrated centering ring and a stabilizer post. When the sample tube has been inserted into the sample chamber, the stabilizer post will extend into both the sample chamber and the extender tube flange on the sample linear motor transport, as is shown in Figure 2-5. The primary functions of the post are to act as a guide when the transport is installed and to keep the transport on the system. See Chapter 5 for more information on the sample tube.

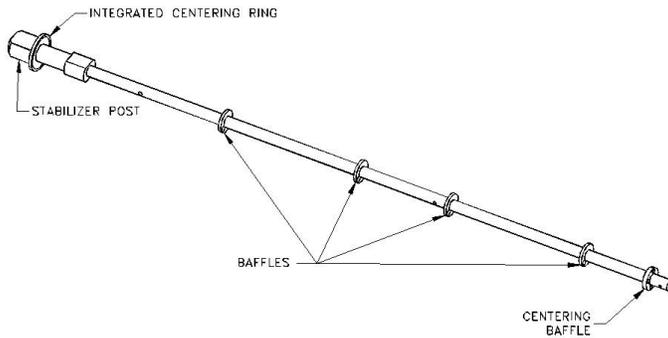


Figure 2-4. Sample rod guide tube assembly (4096-301 is shown for example).

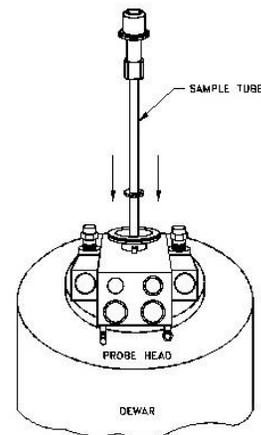


Figure 2-5. Inserting the sample rod guide tube into the sample chamber.

Use the steps below to install the sample-tube assembly.

1. Verify that the standard centering ring has been removed from the top of the system. (An ACMS II-specific centering-ring assembly has been integrated into the sample rod guide-tube assembly.)

**Important:** You cannot use a standard centering ring between the sample linear motor transport and the sample chamber. As a safety mechanism, the ACMS II system cannot be installed on the system without the ACMS II-specific components, such as the ACMS II sample rod guide tube assembly with its integrated centering-ring and stabilizer post.

2. Examine the O-ring on the sample-tube centering ring for dust or dirt. If it is dirty, clean it and lightly grease it with silicone vacuum grease.
3. Using Figure 2-5 as a guide, carefully lower the sample tube assembly into the sample chamber until the ACMS II centering ring seats onto the top flange.

## 2.2.5 Mount the Sample Linear Motor Transport



**WARNING !**

Verify that there are no nearby sources of magnetic field (e.g., NMR or other laboratory magnets) before attempting to install or remove the linear motor transport, as explained in Section P.5.3.

The sample linear motor transport (Figure 2-6) moves the sample. You will mount the linear motor transport directly on top of the sample-chamber opening after you have inserted the sample tube into the sample chamber. Before you install the linear motor transport, you must remove the shipping plug and install the extender-tube-flange assembly. See Chapter 5 for more information on the linear motor transport and its operations.

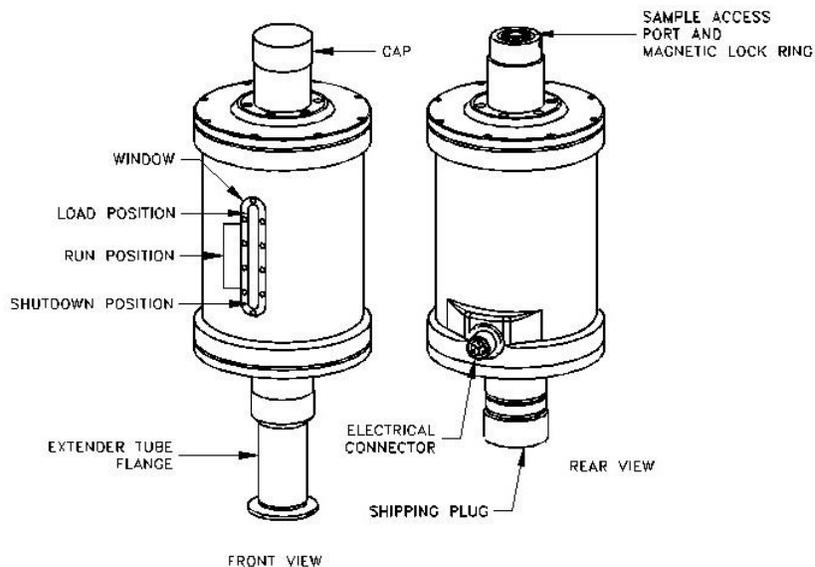


Figure 2-6. Front and rear views of the sample linear motor transport (4096-400). The rear view (right) shows the transport with the shipping plug installed; in the front view (left), the shipping plug has been replaced by the extender tube flange.

### CAUTION!

- ◆ Use care when installing the DC linear motor transport—it is fragile, bulky, and moderately heavy (about 10 kg or 22 lb).
- ◆ Always use the ACMS II-specific parts (e.g., the centering rings) to ensure that the equipment operates safely and properly.
- ◆ Always use the flange clamp (Figure 2-7) to hold the linear motor transport onto the stabilizer post.

1. Prepare the extender tube flange:
  - Locate the extender tube flange and the flange O-ring (part number VON2-030).
  - Wipe the neck of the flange with a lint-free cloth (e.g., Kimwipe) to remove any dust or dirt.
  - Place the O-ring into the neck of the extender tube flange. Firmly press on the O-ring to assure it is completely seated.
  - Wipe the O-ring and lightly grease it with silicon vacuum grease.
  - Place the extender tube flange on a clean piece of paper or lint-free cloth until it can be installed.
2. Remove the sample linear motor transport and its stand from the storage case and place them on a stable work surface, keeping the motor in a vertical position.
3. Remove the shipping plug from the bottom of the motor (see Figure 2-6).
4. Verify that the O-ring of the extender tube flange is still in place and its exposed surface is clean. If it is dusty or dirty, clean it and lightly grease it with silicon vacuum grease.
5. Screw the extender tube flange onto the bottom of the motor until it is tightly attached, using Figure 2-6 for an example. Hand-tighten the tube **only**.
6. Remove the sample linear motor transport from the stand, keeping it upright. For example, you can support the weight of the linear motor transport by gripping it with one hand on the top tube and the other hand on the extender tube flange.
7. Place the sample linear motor transport onto the top flange of the system by orienting the electrical connector to the rear of the cryostat. The linear motor transport should slide over the stabilizer post at the top of the sample rod guide-tube assembly. Figure 2-7 shows where the stabilizer post emerges from the sample chamber, the correct orientation of the linear motor transport, and other relevant parts of the equipment.
8. Verify that the integrated centering ring is sandwiched snugly between the top flange and the linear motor transport.
9. Attach the flange clamp to the flange. **Always use the flange clamp to hold the linear motor transport onto the stabilizer post.**

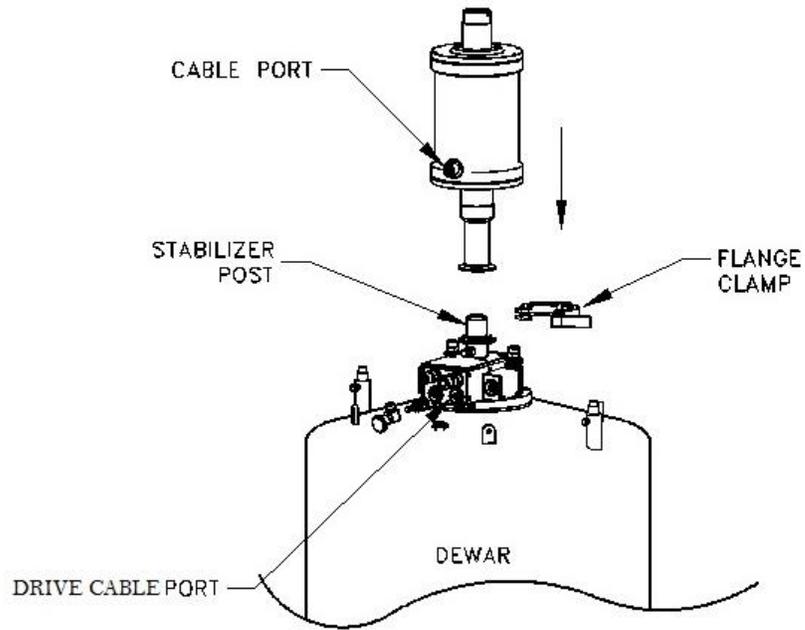


Figure 2-7. Installing the sample linear motor transport on the top flange.

## 2.2.6 Complete the System Connections

Using Figure 2-8 for guidance, complete the electrical connections for the ACMS II option. After you have attached the connectors, verify that the connections are firm.

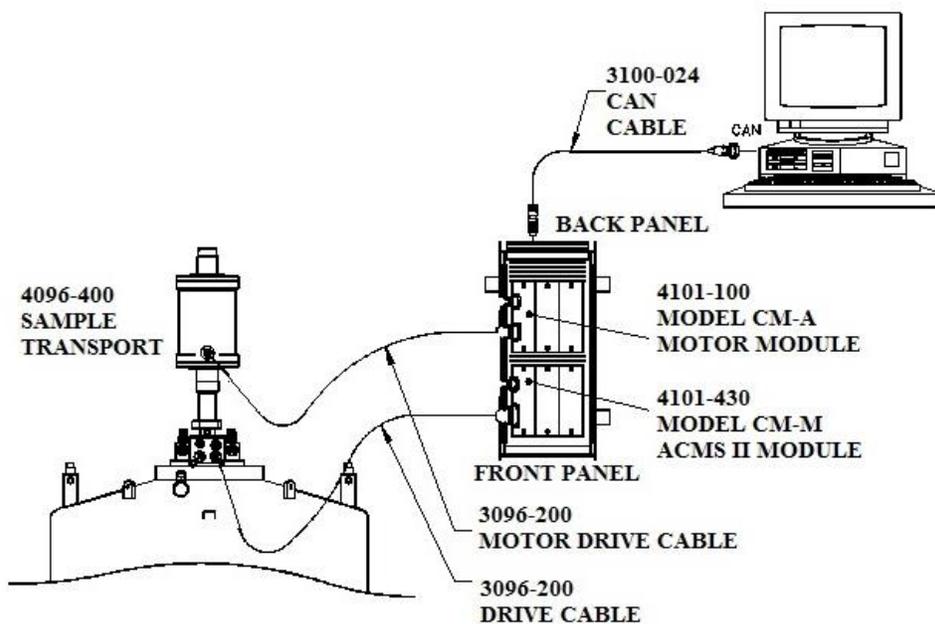


Figure 2-8. ACMS II option connections on the PPMS.

## 2.2.7 Activate the ACMS II Option Software

Use the following instructions to install the MultiVu and ACMS II software applications on your PC. If you purchased the ACMS II option as part of a new system, you can go to Step 3 below, "Verify that the ACMS II software is properly installed . . ." See Chapter 6 for more information on the ACMS II application.

1. Install the most recent version of the MultiVu software if it is not already installed.
2. Install the ACMS II software by starting the ACMS II software setup wizard and following the instructions.
3. Verify that the ACMS II software is properly installed by activating it from within MultiVu:
  - a. Start the MultiVu application program.
  - b. Go to the **Utilities** menu on the main MultiVu menu bar (at the top of the application window).
  - c. Select **Utilities >> Activate Option**.
  - d. The Option Manager will open. Click on the ACMS II and then on the "Activate" button (Figure 2-9).

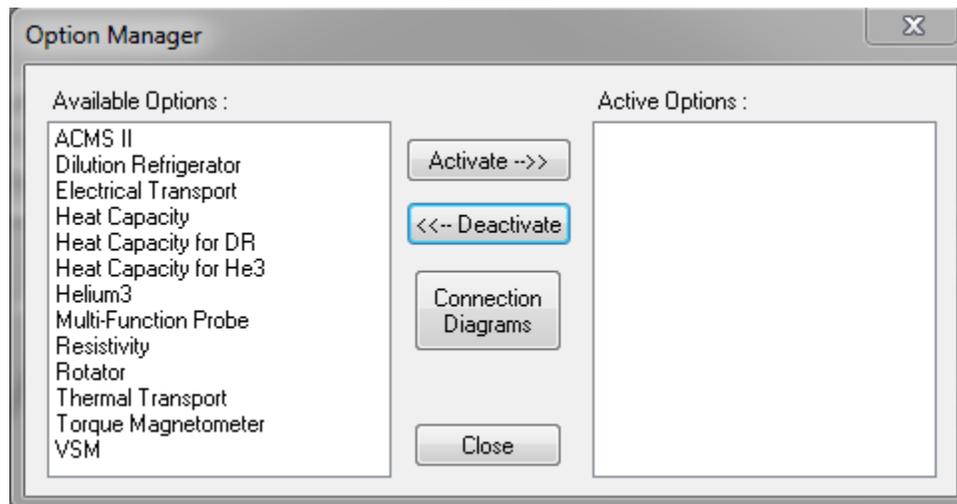


Figure 2-9. Option Manager Window.

4. Three events will occur as soon as you have activated the ACMS II option.
  - The **ACMS II Log** window and the **ACMS II Control Center** will open (see Figure 2-10). In the control center you will see four panels or "tabs": **Install**, **Data File**, **Sample**, and **Advanced**. The **Install** tab is usually at the front when the control center opens. (When running in simulation mode, the **ACMS II Control Center** is titled **ACMS II Simulation**.)

Note the **Configure ACMS II System** button under the **Chamber Status** area of the **Install** panel; you will use this button to verify and test the coilset calibration in the next phase.
  - The sample linear motor transport will perform a **Home** (or homing) operation. During a homing operation the system finds the full range of travel for the transport by going through a full travel cycle. The cycle ends at the top in the sample-load position.
  - The **View**, **Sample**, and **Measure** menus on the MultiVu menu bar will show ACMS II -specific features. For example, the **Status** bar at the bottom of the **ACMS II Control Center** (Figure 2-10) reads "ACMS II Ready," and ACMS II-specific commands are accessible on the **Measure** dropdown menu (Figure 2-11). See Chapter 6 for a full description of the ACMS II software.

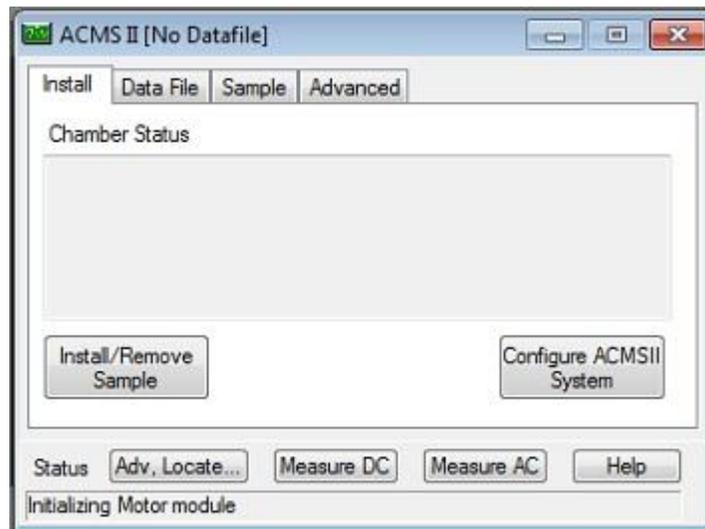
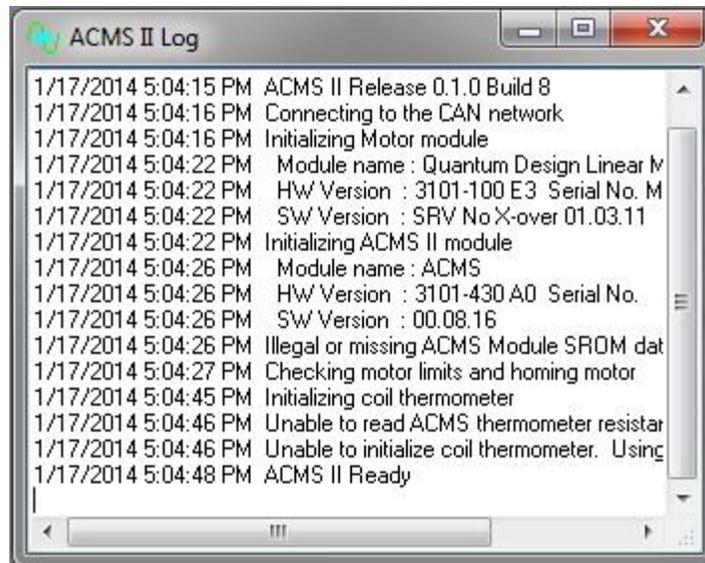


Figure 2-10. ACMS II Log (top) and Control Center (bottom).

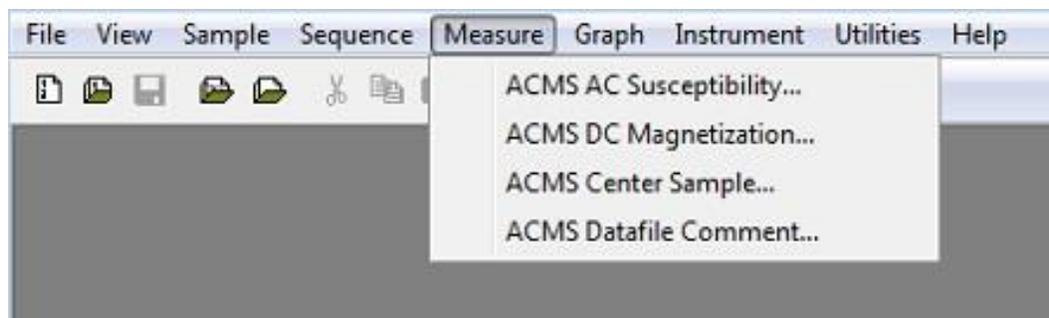


Figure 2-11. MultiVu menu bar and Measure dropdown menu for ACMS II option.



5. Next, you will verify the serial number on the detection coilset puck and test the coilset thermometer and system calibration.

## 2.2.8 Configure the ACMS II System

The serial number of the detection coilset puck identifies the calibration file that is used to calibrate the coilset. You must verify that the serial number on the puck, which you obtained in Section 2.2.3, matches the standard calibration file referenced in the software. You will use the **Configure ACMS II System** dialogs to specify the puck serial number and test the hardware.

1. Locate the puck serial number that you obtained in Section 2.2.3.
2. Click on the **Configure ACMS II System** button, which is located on the right-hand side of the **Install** tab (Figure 2-10).
3. Page 1 of the **Configure ACMS II System** dialog will open (Figure 2-12). Note the text box where you will enter the serial number of the calibration file.

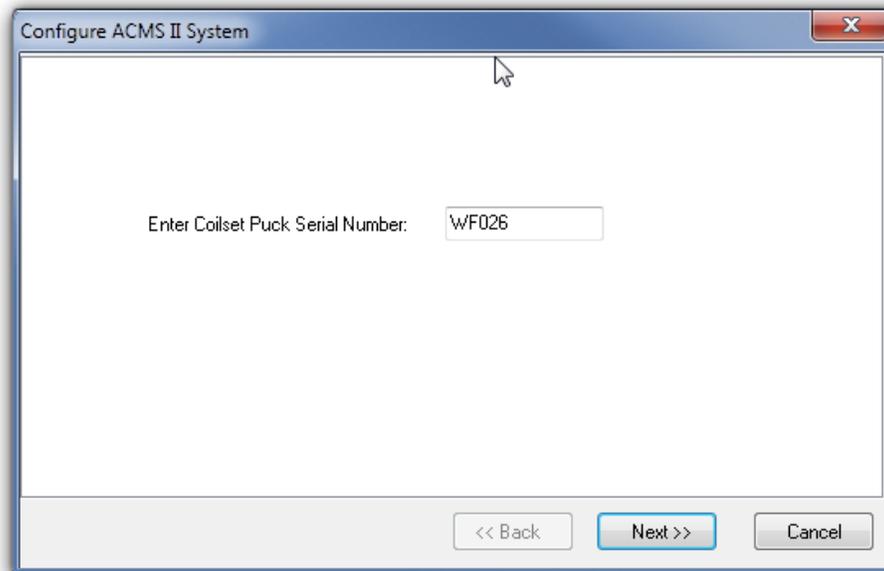


Figure 2-12. Configure ACMS II System dialog, page 1.

4. Verify that the number in the text box matches the serial number of your detection coilset puck. If no number is displayed, enter the serial number of your detection coilset puck in the text box.
5. Click on the **Next >>** button at the bottom of the dialog box. Page 2 of the **Configure ACMS II System** dialog (Figure 2-13) will open, showing the results of system tests to verify system operations.

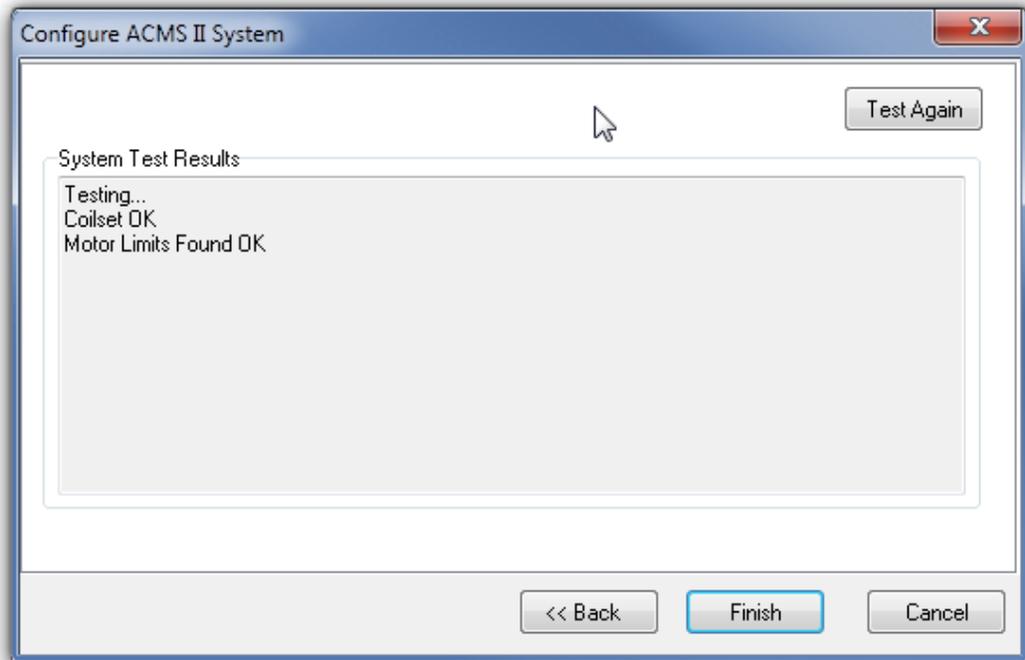


Figure 2-13. Configure ACMS II System dialog, page 2: Testing calibration file.

5. When the report in the **ACMS II System Test Results** area is complete and no errors are reported, click on the **Finish** button. The **Configure ACMS II System** dialog will close and you will be back at the **ACMS II Control Center** and the **Install** tab.
6. If you have completely followed the ACMS II hardware and software setup steps, the system is now ready for you to mount a sample, install it in the cryostat, and perform AC susceptibility and DC measurements, as is explained in Chapters 3 and 4. First, please review Section P.5, "Safety Guidelines and Regulatory Information" for important information.

## 2.3 Removing the ACMS II Option



### WARNING!

Verify that there are no nearby sources of magnetic field (e.g., NMR or other laboratory magnets) before attempting to install or remove the linear motor transport, as explained in Section P.5.3.

You do not need to remove the sample linear motor transport and its associated hardware from the system while it is idle. However, if you intend to use it for other types of measurements (e.g., Heat Capacity, Thermal Transport), you must first remove the ACMS II option.

As summarized below, you will use the **ACMS II Install/Remove Sample Wizard** to prepare the system so that you can remove the sample linear motor transport, sample tube, and coilset puck. These procedures are essentially the reverse of the installation procedure.

### Summary of ACMS II Removal Procedures

1. Prepare for removal of the sample linear motor transport and hardware:
  - a. Set the field to zero.
  - b. Use the **ACMS II Install/Remove Sample Wizard** to warm the sample chamber to 300 K, vent the chamber, and move the transport to the load position.
  - c. Remove the sample rod.
  - d. Shut down the sample linear motor transport.
2. Deactivate the ACMS II software application.
3. Remove the sample linear motor transport and place it in the storage case.
4. Remove the sample tube and the coilset puck.

### 2.3.1 Prepare for Removal

1. If necessary, activate the ACMS II software from MultiVu (select **Utilities >> Activate Option >> ACMS II**) as explained in Section 2.2.7.
  - If the field is not zero, set it to
  - Use the **ACMS II Install/Remove Sample Wizard** to remove the sample rod.

### CAUTION!

Verify that you have removed the sample rod before continuing.

2. To continue with the ACMS II removal process, end the **ACMS II Install/Remove Sample Wizard** by clicking on the **Cancel** button. This button will close the install dialog and return you to the **ACMS II Control Center** and the **Install** tab. Before you can remove the sample linear motor transport, you must deactivate the ACMS II option, as is explained in Section 2.3.2.

### 2.3.2 Deactivate the ACMS II Option

1. Select **Utilities >> Activate Option** from the dropdown menu of the MultiVu window (Figure 2-9).
2. When the **Option Manager** dialog opens, select **ACMS II** and click on the **Deactivate** button. This will move the ACMS II option from the **Active Options** section of the dialog to the **Available Options** section. The **ACMS II Control Center** and the **ACMS II Log** window will close, but the MultiVu software application will remain open.
3. Continue with the ACMS II removal procedures below.

### 2.3.3 Remove the Sample Linear Motor Transport

1. Unplug the electrical connector from the back of the sample linear motor transport. (You can leave the other end of the cable connected to the Motor Module.)  
**Important:** Never attempt to move the sample linear motor transport when it has a cable connected to it.
2. Remove the flange clamp from the top flange of the sample chamber (see Figure 2-7).

	<b>WARNING !</b>
<p>Be careful when lifting the linear motor transport. Do not drop the motor, because doing so could cause damage. Do not attempt to lift the motor by yourself, because doing so could cause injury. Take care not to damage the bottom and top "o" ring sealing surfaces.</p>	

3. Slowly lift the sample linear motor transport until it has cleared the stabilizer post (see Figure 2-7).
4. Place the sample linear motor transport back in the storage case (4096-150).

	<b>WARNING !</b>
<p>Store the sample linear motor transport in a secure location to prevent it from being attracted to magnetic fields in the laboratory, including those produced by the superconducting magnet, as explained in Section P.5.3.</p>	

### 2.3.4 Remove the Sample Rod Guide Tube and ACMS II Coilset Puck

1. Remove the sample rod guide tube from the sample chamber.

2. Remove the ACMS II coilset puck from the sample chamber by using the puck-extraction tool.<sup>2</sup>
3. Unplug the ACMS II drive cable from the probe head and set it aside. You do not need to disconnect the other end of the cable from the ACMS II Module.
4. Return the blank flange to the top of the probe head or install another of the Quantum Design measurement options.
5. When the sample chamber has been closed, you can purge and seal it by using the **Chamber** dialog box.
  - Select **Instrument >> Chamber**.
  - In the **Chamber** dialog box, click on the **Purge/Seal** button.
6. The base measurement system is now ready for you to install a different option.

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<sup>2</sup> See Footnote 1.

## Sample Preparation and Mounting

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### 3.1 Introduction

This chapter contains the following information:

- Section 3.2 discusses constraints on the samples that can be measured with the ACMS II option.
- Section 3.3 explains how to mount samples for measurement with the ACMS II option.

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### 3.2 Sample Properties

The quality of your AC and DC measurement results will be affected by the dimensions and shape of the sample and the size of its magnetic moment.

#### 3.2.1 Size and Shape

The geometry of the detection coils in the ACMS II constrains the dimensions of samples that can be measured. Figure 5-4 gives the dimensions of the ACMS-II coilset puck. In order for the sample and sample holder to fit into the detection coils without a high risk of rubbing against the coil set bore, their diameter should be less than 6 mm. Frictional heating (especially at low temperatures) and noise in the measurements at high fields are common symptoms of friction between the sample holder and coil set. In AC measurements, the sample is vertically centered within one of the detection coils, so an accurate reading of the AC magnetic properties requires samples that are less than ~6mm high, i.e., that have a small vertical size compared to the 14 mm height of one of the detection coils. For DC measurements, in which the sample is vibrated halfway between the lower and upper detection coils, the reported DC magnetic moment is more sensitive to the sample size and shape than AC measurements. The DC response is calibrated against the included Pd standard, so accuracy of the reported DC moment will be ideal for a sample of these same dimensions. Since this measurement is identical to that used by the VSM option and these coils are larger than the VSM detection coils, the reported moment for DC measurements in ACMS-II will be less dependent on sample size and shape than in the VSM option (see Figure 3-1 in *VSM Option User's Manual 1096-100*).

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## 3.3 Mounting Samples

### 3.3.1 Accurate Sample Location

The ACMS-II system uses a touchdown technique for automatic centering of the sample in the detection coils. This technique is described in detail in Chapter 4. To optimize the touchdown, take special care with two steps in your preparations:

- Verify that the sample is mounted on the sample holder near 25 mm from the bottom of the sample holder. Quantum Design has provided you with a special sample mounting fixture (see Figures 4-1 and 5-8) for locating the sample.
- Verify that the end of the sample holder has a very well defined contact surface for performing the touchdown operation.
- The total length of the sample holders should be 96mm: If using a straw, cut the straw to 83mm to give correct total length when assembled with the straw adapter (4084-815)

Quantum Design recommends that you locate the sample at an offset of 25 mm. The height above the puck surface of the bottom detection of the coilset is about 30 mm, so the offset of 25 mm leaves 5 mm of a safety gap. Note that for DC measurements there will be an “end effect” signal from the bottom of the sample holder to account for. This will appear as a diamagnetic (negative slope in  $M(H)$ ) contribution for sample holder materials that are paramagnetic (e.g., straws).

### 3.3.2 ACMS Sample Mounting Techniques

1. The **sample holders supplied by Quantum Design** are designed to fit on the mounting station. The total length of the holder and exact location of the sample are better defined by using the mounting station. While the fragile quartz paddle is designed for the lowest moment samples, a more robust straw provides versatility.
  - A. The **quartz paddle** is redrawn from a 4 mm diameter rod. Elimination of surface microcracks improves mechanical strength of the quartz paddle. A nitric acid dip removes surface impurities. Smooth surface can make cleaning easy but reduces adhesion of glue. The adapter is made of glass-filled polycarbonate, which should never be exposed to organic solvents, especially acetone. The outer gluing surfaces of the quartz pieces are sanded to help bind with the epoxy. A complimentary shaped shim is added to the paddle and put inside the adapter containing epoxy resin. The epoxy is specially chosen to withstand both high temperatures (400 K) and cryogenic conditions. The assembly is cured straight in a custom fixture.



- a) For mounting **thin films parallel to field** (see figure 3-1 to the left), do not exceed the width of the paddle. Wider samples can be mechanically secured and better protected using the brass trough or aluminum frame techniques. Place the quartz holder in mounting station. Using a sharp wooden stick or other tool, place a small drop of glue on the paddle, set film on top and press to secure bond. Let it dry completely at ambient conditions. If the sample can handle the heat, increase temperature to 340 K and purge sample chamber. Return to 300 K, purge and seal, or lower temperature and follow centering routine. To remove sample, hold length of quartz paddle with no pressure on adapter junction. A thin wooden flat can transport solvent under the chip. Wait for solvent to penetrate. Free the sample with appropriate leverage.
- b) For **single crystal** samples and low temperature analysis, put GE 7031 on crystal then secure to quartz. A small amount of **fine powder** can be mixed into a drop of varnish, although it is difficult to get a quantitative mass with this technique. If taken to 340 K to cure before completely dry, a large field like 5 Tesla should result in the alignment along a preferred crystallographic axis which is frozen in place by going cold. Kapton tape is also effective way to secure small amounts of material, but keep sample as point source and tape symmetrical along the axis of motion. Concern with tape is the random contamination from dust in a lab environment.
- c) To **clean the quartz paddle** use a solvent specific to the glue. Cotton swabs help keep all solvents away from the polycarbonate adapter, especially acetone. Do not use sonicator, which could introduce cracks at the junction points. The common break point is at the adapter junction and caused by lateral force on the sample rod. Frequently, breakage occurs during the sample mounting and cleaning process.

Figure 3-1. Quartz Paddle.

### B. Clear plastic Straw and adapter

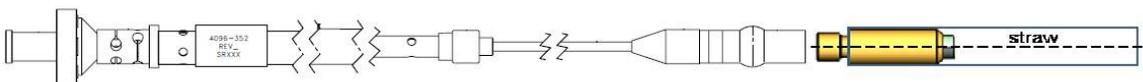


Figure 3-2. The ACMS II Sample Rod (4096-352) and Straw Adapter (4084-815).

Quantum Design provides a specific type of clear drinking straws (QD part # AGC2-BOX) that are held securely using a straw adapter (p/n 4084-815). The 2 part adapter works by pushing the straw over the barb of the main body (much like in older straw barb adapters from QD) and then screwing the collar down to retain the straw. Use straws for the following samples:

- a) Films perpendicular to field: diagonal size = 5.8mm (e.g., 4.1 x 4.1mm square film); this is best done by placing the film near the recommended 25mm offset and using two clean applicators from each end of straw to turn it sideways and jam it into the straw material so that it does not move.
- b) Films parallel to the field: width = 6mm; this width will ensure that the film does not slip, but note that if precise vertical alignment of the film is required, the quartz paddle may be preferred

For bulk samples or films that are slightly too small, consider the technique of slitting a ~80mm section of straw lengthwise so that it can be inserted in another straw, providing a smaller inner diameter for sample mounting. To immobilize the inner straw after it is inserted in the main

straw, poke several holes with a pin near the bottom of the assembly so that the holes pass through both the outer and inner straws.

The **palladium standard** is mounted with GE-7031 varnish to help withstand thermal cycles during installation tests. It is mounted in the brass sample holder used for VSM option. The brass holder is not used for ACMS-II due to the AC susceptibility of the brass, but since the Pd is strictly a DC standard this is not an issue. The sample offset of the Pd sample is also 35mm in order to minimize the sample holder end effect. The only function is DC calibration of magnetometer at 1 Tesla and 298 K. To get the expected moment, simply multiply the mass of palladium, the applied field and the susceptibility, which is  $5.25 \times 10^{-2}$  emu/gram-Tesla at 298 K. The expected moment at 1 Tesla for a 0.25 gram cylindrical shape is 0.013 emu. Since the magnetization versus temperature for palladium has characteristic features, it is not a suitable thermal reference standard. Consider temperature independent diamagnetic Quantalloy or the Curie-Weiss paramagnet dysprosium oxide pellet. Even at the lowest temperatures, the contribution from impurities in the varnish is below 0.1% of the large Pd moment.

### C. Sample cleaning supplies

Specific cotton swab for brass trough iso-propanol (IPA), acetone, toluene, nitro-methane



Figure 3-3. Sample cleaning supplies.

D. Just a few of the **methods and materials for securing the sample** to the holder are presented. The primary goal is to keep the sample a point source dipole during the measurement. Since any glue or tape will introduce point source dipole contributions to the total magnetic moment, the material should be applied sparingly and symmetrically.

1. The term **glue** is loosely applied to any material that will secure a sample to a support material. Generally the materials will harden over time, with the process aided by increasing temperature and keeping under vacuum. Pockets of trapped oxygen or adsorption to very high surface area materials will produce a magnetic signature around 50 K. Each material has a specific range of conditions for optimal usage; with varnish best at the lowest temperatures and Duco cement the most easily removed. Since the contents of each glue are not normally disclosed by manufacturers, it is hard to know magnetic properties. A general rule is that colorless materials are less magnetic than colored

ones because dyes used in the materials tend to have magnetic signature. However, it is best for users to verify the magnetic properties of the glue.

- a) The legendary **GE7031 varnish** is a vinyl phenolic adhesive (safety labeling H=1; F=4; R=3; PE=3). As the bulk material in container ages, it will become thicker. Adding iso-propanol (IPA) and/or toluene will thin solution. Cleaning is best aided with toluene. The aging and/or oxidation process will lead to a darker coloring of the solution. This tends to correlate with increased magnetic signature. The ideal solution is a light tan honey colored solution, freely flowing without addition of extra solvents.
  - b) Easily obtained **Duco cement** is useful at room temperature and for securing materials of similar thermal properties, like quartz on quartz. Differing materials will force cracking in the brittle Duco cement upon cooling below 150 K. Duco may go on thick but it will dry or cure to a thin residue. A key reason for regular use is Duco solubility in acetone. Powders secured with Duco can be easily recovered by soaking in acetone.
  - c) Easily obtained **Superglue** (cyanoacrylate) is a fast drying, very secure bonding method for room temperature measurements. The very thin nature allows low mass, low magnetic signature application. At the colder temperatures, it may not hold materials with different thermal properties. The solvent of choice is nitro-methane. Still readily available as a stock car fuel, it should be handled carefully. A cotton swab of nitro-methane with a thin stick to wedge the sample off the holder should work effectively. Please see MSDS for proper ventilation requirements when using these solvents.
2. Tape is a simple and effective method for securing to the quartz paddle. It will prevent the sample from being lost during the measurement. The background can be reasonably small if the mass is symmetrical about the sample. Keeping the tape clean from magnetic dust around the lab is the primary concern.
- a) **Kapton tape** is commonly used at low temperatures and is available from Quantum Design. It retains properties over entire range of 1.8 K to 400 K. As a point source may show  $10^{-6}$  emu ferro-magnetic signature at room temperature. Like with a straw, if the tape is evenly distributed in the background, there will be no contribution to the reported moment of the sample. To replace common drinking straws, Kapton tubing is available through the medical community and may provide flexibility in diameter selection with lowest level of impurities. Organic solvents like toluene or maybe iso-propanol (IPA) can help dissolve the glue remaining on the holder after tape is removed.
  - b) Thin Teflon tape can be wrapped around the quartz holder to secure the sample location without use of glue. However, the technique tends to produce a significant paramagnetic oxygen peak around 50 K. As a precaution, add a heat and purge step to the sequence. The Teflon tape can cover the full temperature range of the instrument, but 350 K is usually sufficient for this purpose. When Teflon becomes a point source dipole like when wrapping the sample, a more significant ferro-magnetic contribution is measured. Each batch should be tested for impurities.
  - c) The standard Parafilm roll and various wax materials can be used to secure the sample. Watch maximum exposure temperatures of the wax. These types of materials are typically low moment background and useful with air-sensitive samples or when recoverability is desired.



# Immediate Mode Measurements

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## 4.1 Introduction

This chapter contains the following information:

- Section 4.2 describes the AC and DC measurement processes and compares these two measurement types.
- Section 4.3 explains how to install and center the sample.
- Section 4.4 explains how to perform AC and DC measurements.

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## 4.2 Overview of ACMS II Measurements

The ACMS II is both an AC susceptometer and a DC magnetometer. The distinction between the two types of measurements is important. DC magnetization measurements measure a sample's magnetic moment in an applied magnetic field at a specific temperature. AC susceptibility measurements do not directly measure a sample's magnetic moment but are far more sensitive.

Once the ACMS II is electronically connected to the system, it is fully configured to perform both AC susceptibility and DC magnetization measurements. No hardware or software reconfiguration is necessary to switch from AC susceptibility to DC magnetization. In fact, you can actually perform both measurements on a sample within a single sequence. To save time, both AC susceptibility and DC magnetization can be measured at each measurement step. If the magnetization criteria are different from the susceptibility criteria, the sequence can be configured to perform each measurement individually, yet within a single sequence.



Before a sample is measured for the first time, it should be centered relative to the detection coils that are in the ACMS II insert. Section 4.3 discusses centering methods.

## 4.2.1 Choosing a Measurement Method

In the ACMS II option, AC measurements are nearly three orders of magnitude more sensitive than DC measurements. Conductive samples usually yield much larger signals during AC measurements. However, in some situations, DC measurements produce better results than AC measurements. For example, weakly paramagnetic samples with magnetic moments near the noise floor of the ACMS II's AC measurement capability ( $\sim 1 \times 10^{-8}$  emu) can often be detected more easily in the large DC fields applied by the PPMS superconducting magnet, because the larger DC field raises the sample's moment well above the noise floor for DC measurements ( $\sim 5 \times 10^{-6}$  emu). In such cases a DC center (section 4.3.3) is appropriate. Most PPMS platforms contain at least 7-T DC magnets, while the ACMS II can only apply alternating fields of up to  $\pm 10$  Oe consistently (1 T = 10,000 Oe). In addition, large or asymmetric sample holders generally require DC methods to properly account for background sources. Other symmetry and field uniformity concerns — such as small applied fields — usually demand DC methods as well.

There are many other points to consider when determining whether to use AC or DC centering and measurement methods. It is your responsibility to choose centering and measurement techniques that are appropriate for the type of information being sought and the type of sample being examined. Important sample characteristics to consider include type of magnetic behavior, magnetic moment, conductivity, shape, and size. Applied field and temperature can also be important. Finally, the nature of the information that the experiment examines should be considered. AC susceptibility measurements are fundamentally different than DC measurements in that they report a *change* in a sample's magnetic moment with a relatively small change in field, rather than a sample's absolute moment in a relatively large constant field. Contact a Quantum Design representative if you would like to discuss considerations specific to your application.

## 4.2.2 Operating Modes

ACMS II measurements and sample centering may run in immediate mode or sequence mode. ACMS II control center commands and PPMS MultiVu **Measure** menu commands execute operations immediately, but each control center or menu command must be selected manually. ACMS II measurement sequence commands included in a PPMS MultiVu sequence file are executed automatically when they are read while the sequence runs. Any number and combination of measurement sequence commands may be included in a sequence file.

Data from immediate-mode measurements or sample centering is saved only if an ACMS II measurement data file is selected to store the data. Measurement and selected system data read during sequence mode measurements and sample centering is automatically saved to the specified data file.

The immediate-mode measurement dialog boxes show the results from the last measurement of that same type (see figure 4-5, for example). The sequence mode measurement dialog boxes do not show measurement results, but you can use them to select which system data items you want to save to the specified ACMS II measurement data file.



You are encouraged to use the ACMS II control center to perform all normal system operations. The automated routines in the control center help ensure that you complete the necessary procedures when you install new samples and create data files. This chapter illustrates use of the control center.

The *Physical Property Measurement System: PPMS MultiVu Application User's Manual* discusses sequence files, sequence operation, and all standard PPMS sequence commands in detail.

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## 4.3 Installing a Sample

### 4.3.1 Attach a Sample and Measure the Sample Offset

1. Attach the sample to the sample holder using the techniques discussed in Chapter 3.
2. Use the sample-mounting station to measure the distance from the center of the sample to the bottom of the sample holder, reading the position from the scale as demonstrated in Figure 4-1. This distance is called the sample offset. Measure the sample position to an accuracy of 0.5 mm. The ACMS II hardware can safely accommodate a sample offset between zero (i.e., sample is at the bottom end of the sample holder) and 25mm. However, a sample offset less than ~20mm can result in a significant signal from the magnetic “end effect” of the sample holder. A sample offset larger than 25mm presents the risk of the sample holder rattling against the puck surface when measuring.

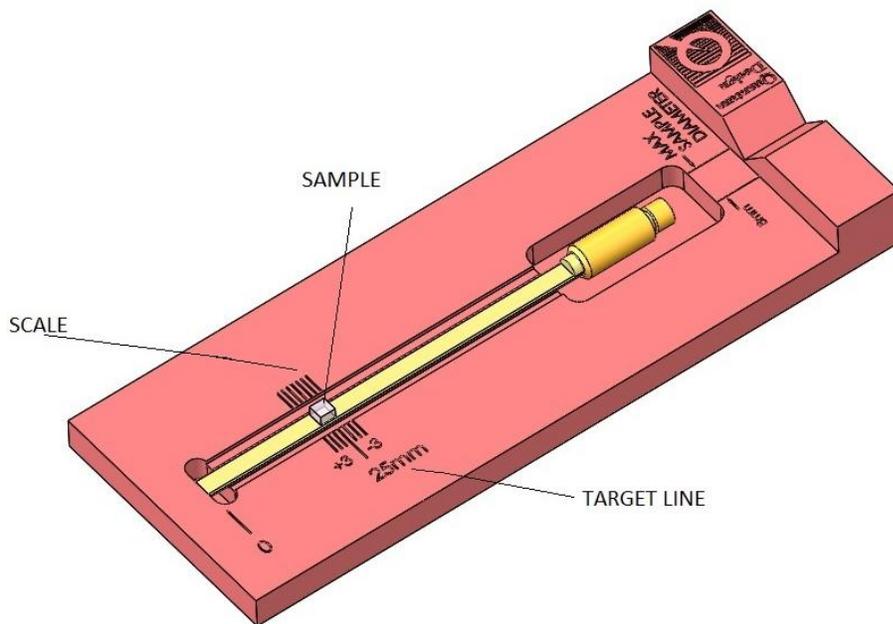


Figure 4-1. Reading the position of the sample from the sample-mounting station

3. Remove the sample holder (with the mounted sample) from the mounting station and screw it firmly onto the end of the sample rod.
4. Inspect the sample rod and sample holder to ensure they are straight. Deviations can result in rubbing of the sample or sample holder in the coil set which causes heating at low temperatures and noise in the measured moment when a magnetic field is applied.

### 4.3.2 Activate the ACMS II Option and Control Center

1. To start the ACMS II application and open the **ACMS II Control Center**, select **Utilities >> Activate Option** in the MultiVu window.
2. At this time, the system also will perform a **Home** operation to determine the full range of travel for the sample transport by touching down and then going to the load (top) position.

### 4.3.3 Install the Sample

1. In the **Install** tab of the **ACMS II Control Center**, click on the **Install/Remove Sample** button.
2. Click on the **Open Chamber** button (below the **Instructions** area). The wizard will bring the sample chamber to room temperature, vent the chamber, and move the transport to the load position, and the **Instructions** area will show the status of these processes.
3. When the **Instructions** area indicates that the chamber has been flooded and the transport is in the load position use the sequence outlined below to install the sample rod and sample.
  - If you have not already measured your sample offset position, use the sample-mounting station to obtain the sample offset from the end of the sample holder (see Section 4.3.1).
  - Attach the sample holder to the sample rod.
  - Remove the cap from the top of the sample linear motor transport.
  - Insert the sample rod with the attached sample holder into the sample access port until the magnetic lock at the top of the sample rod engages the magnetic lock ring in the linear motor transport. Verify that the magnetic lock has engaged the magnetic lock ring.  
**Important:** The sample will be subject to vertical magnetic fields of up to approximately 200 gauss when it passes through the head. If this is unacceptable for your samples, please contact your local Quantum Design service representative.
4. Click on the **Next >>** button at the bottom of the **ACMS II Install** wizard.
5. Enter the sample properties in the provided fields at the top and then open a new or existing output data file. Note that all parameters entered here are for informational purposes only and are not used in calculating the reported sample moment.
6. Click on the **Next >>** button at the bottom of the dialog. Here you can **Scan For Sample Offset** or **Enter Offset Manually** if you used the sample mounting station to visually locate the sample.
  - Select between AC and DC centering scan from the popup menu.
  - A sample signal larger than  $\sim 10^{-5}$  emu is required in order to be detected using a DC centering scan. This may require the application of magnetic field in order to magnetize your sample.
  - Magnetic contamination and sample holder end effects can obscure the sample signal, so it is recommended to verify the scan results with the known approximate sample offset of the sample.
  - The **Advanced Centering** mode will locate the motor at a fixed height and will not permit touchdown centering. Thus, it is not generally recommended.

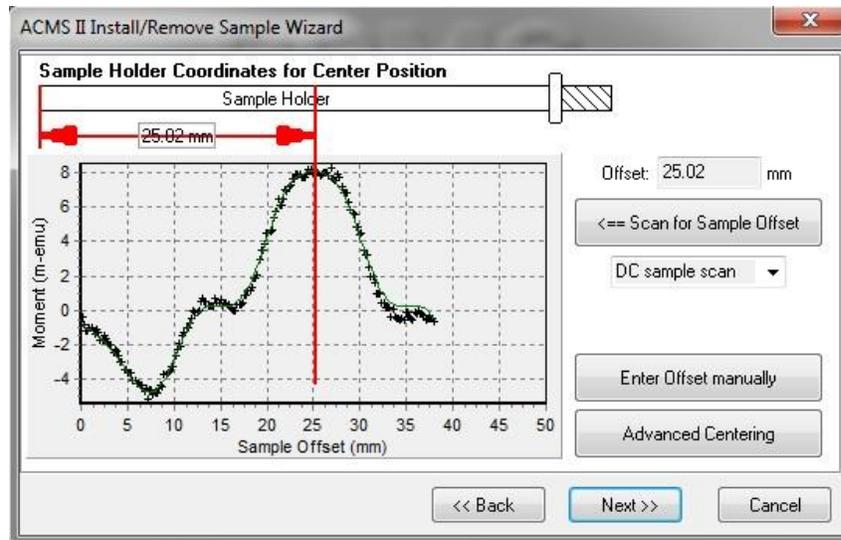


Figure 4-2. Example of a DC centering scan for a sample with a large positive magnetic moment.

7. Click on the **Next >>** button at the bottom of the dialog (Figure 4-2). This button opens the last page of the **ACMS II Install** wizard (Figure 4-3), which reports the sample-offset position and related instructions.

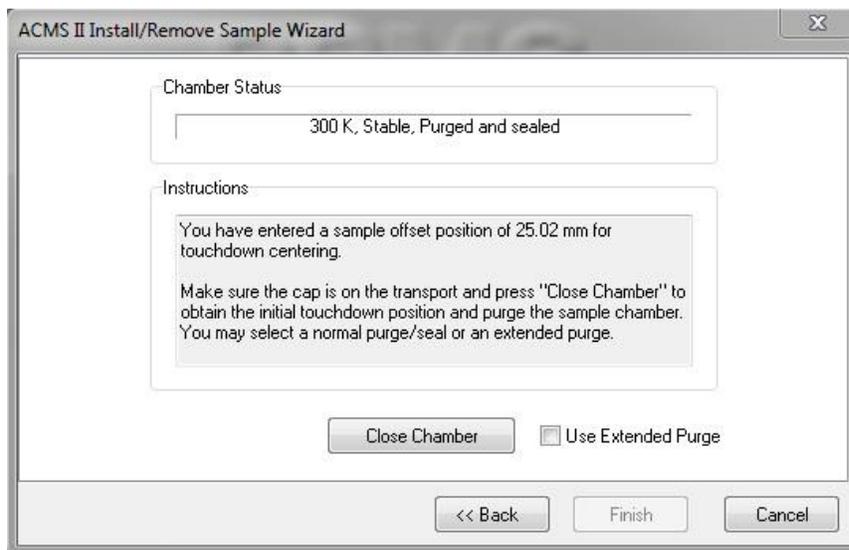


Figure 4-3. The ACMS II Install wizard, final page

Select **Use Extended Purge** any time you plan to use low temperatures ( $T < 270$  K). Note that this ~10 minute extended purge must complete before measurements of temperature variations are started.

1. Place the cap on the linear motor transport and click on the **Close Chamber** button.  
**IMPORTANT:** do not perform any CPU-intensive tasks on the computer while the touchdown operation completes.
2. You can now set up the system to perform sample measurements

#### 4.3.3.1 THE TOUCHDOWN OPERATION

Automatic sample centering is accomplished with the touchdown operation. To perform a touchdown operation, the linear motor transport lowers the sample rod until the end of the sample holder touches the puck surface (see Figure 4-4). At this point, the software knows the precise offset between the coilset and the sample, based on the dimensions of the coilset and the location of the sample on the sample holder. The linear motor transport then moves the center of the sample to the center of the coilset to continue measuring according to the following relation:

$$\text{Measure location} = (\text{touchdown location}) + (\text{coilset height}) - (\text{sample offset}),$$

where coilset height ("H" in Figure 5-4) is a calibrated constant for a given puck and is near 40.1 mm.

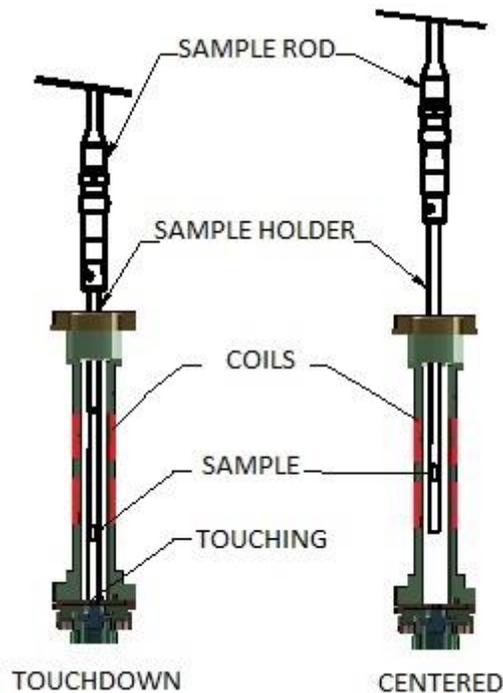


Figure 4-4. The touchdown centering operation

#### 4.3.3.2 SCHEDULING TOUCHDOWN OPERATIONS

The software usually performs touchdown operations automatically at prescribed intervals of temperature (typically 10 K) or time (typically 10 minutes). Touchdowns can also be performed explicitly in a sequence (**DC >> Center Sample**) in immediate measurement mode (**Measure >> DC Center Sample** in the MultiVu dropdown menu)

### CAUTION!

Failure to perform frequent enough centering operations will lower the accuracy of measurements.

Automatic centering is a key quality-control mechanism in the software. When automatic centering has been disabled, the software cannot know how far the sample has drifted from the center of the pickup coils unless a touchdown is performed.

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## 4.4 Taking ACMS II Measurements



ACMS II measurements can be taken only if the ACMS II hardware is installed and the ACMS II option is activated in the PPMS MultiVu software. Refer to chapter 2 to install and activate the ACMS II option.



A sample should be centered relative to the detection coils in the ACMS II insert before it is measured for the first time. A sample should be re-centered following any large temperature change, and it is advisable to re-center the sample prior to re-measuring it with a different measurement method. Refer to section 4.3.2 to center the sample.

Before you take measurements, you may want to refer to section 4.2.1, “Choosing a Measurement Method,” and section 4.2.2, “Operating Modes.”

### 4.4.1 Taking AC Susceptibility Measurements

#### 4.4.1.1 TAKING A MEASUREMENT IN IMMEDIATE MODE

To summarize, you take a measurement in immediate mode by first installing the sample and then defining and running the measurement. Complete the following steps:

1. Select the **Datafile** tab in the ACMS II control center if you want to select a different data file or create a new file (see section 6.4.1.2). The **Sample** tab in the control center displays the sample property information stored in the header of the selected data file. Please note that the information displayed in the “Sample Tab” is read-only. Sample information can be entered during the sample installation process or when creating a new data file. If you run the measurement when no data file is selected, the data is discarded.
2. Mount the sample on a suitable sample holder. Refer to section 3.2.
3. Select the **Sample** tab in the ACMS II control center. Then select the **Change** button and insert the sample into the sample chamber. Section 3.3 describes this procedure.

4. Select the **Measure AC** button in the ACMS II control center *or* select the **Measure>ACMS II AC Susceptibility** menu option. The **ACMS II AC Susceptibility** dialog box opens (see Figure 4-5).

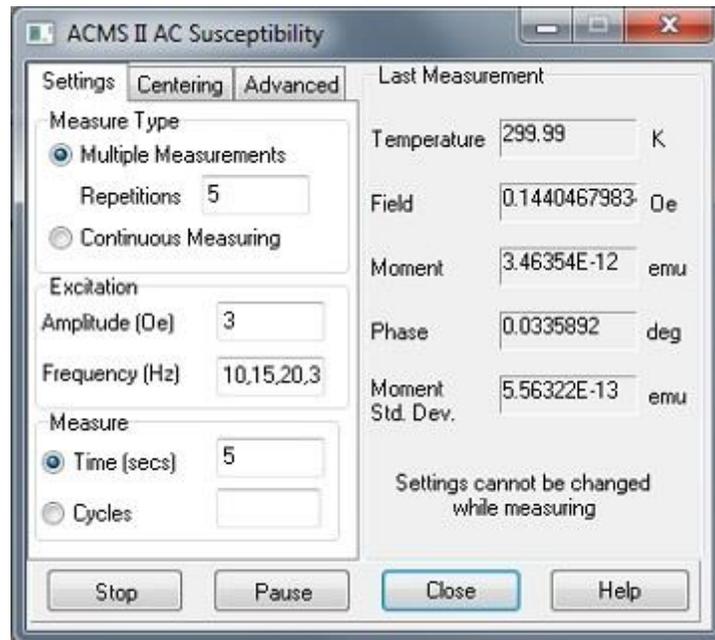


Figure 4-5. **AC Susceptibility** dialog box. Items on the left side of the dialog box designate measurement conditions that should be set prior to initiating the measurement. Items on the right side of the dialog box display the results of the last immediate-mode AC measurement.

5. Define the AC measurement as follows.
  - a. In the **Advanced** Tab, select the **AC Measurement Type** that defines the number and location of the individual measurements that are taken and averaged to obtain a single, final measurement value. Three measure modes are available for immediate-mode AC measurements. The default measure mode is the three-point measurement. The fastest and least comprehensive mode is the one-point measurement. Refer to table 4-1.
  - b. In the **Settings** Tab, define the peak **Amplitude** of the sine wave excitation that is applied to the sample. Not all amplitude values can be achieved in all frequency and temperature ranges. Amplitudes up to 10 Oe are producible at all frequencies and temperatures.
  - c. In the **Settings** Tab, define the **Frequency** of the sample excitation signal.
  - d. Also in the **Settings** Tab, define either the measurement's **Time (secs)** or **Cycles**. **Time (secs)** specifies the boxcar average duration for each measurement and will be an integer number of period of sine wave excitation. **Cycles** on the other hand, specifies the number of excitation periods that elapses between recorded measurements.

Table 4-1. Measure Modes for AC Susceptibility Measurements (*Please refer to Appendix C for details on the data analysis for the different modes.*)

MEASUREMENT MODE	WHERE MEASUREMENTS ARE TAKEN	SUGGESTED USE
Five Point	(1) Center of coil array (2) Bottom detection coil (3) Top detection coil (4) Bottom Detection Coil Bottom Detection Coil (reversed Cal coil polarity) (5) Center of coil array	This provides a calibrated measurement with temperature drift compensation. The center measure before and after the bottom-top-bottom measures cancels the effect of a linear temperature drift.
Three Point	(1) Bottom detection coil (2) Top detection coil (3) Bottom detection coil Bottom Detection Coil (reversed Cal coil polarity)	This provides faster calibrated measurements without temperature correction. This is the default and should be good for most measurements.
One Point	(1) Bottom detection coil	Use for fastest, but least accurate, measurements.  One-point measurement uses calibration from previous four- or five-point measurement.

e. Select the **Measure** button in the **AC Magnetization** dialog box. The measurement begins.

#### 4.4.1.2 LIMITATION OF THE APPLIED AC FIELD DUE TO EDDY CURRENT HEATING

At low temperatures, the AC field created by the ACMS II can cause the PPMS sample and the ACMS II insert to warm. The AC field induces eddy currents in the copper portion of the sample chamber, which results in joule heating. In order to prevent such warming, the user should limit the applied AC field at temperatures below 25 K. Table 4-2 shows the maximum applied fields as a function of temperature, frequency, and measurement time that should be used to ensure a temperature rise of less than approximately 0.25%. Larger fields may be applied if more temperature rise is tolerable. Note that 17 Oe is approximately the maximum field amplitude the ACMS II can generate.

Table 4-2. Maximum AC Field Amplitude (Oe) to Avoid Warming

Temperature (K)	Frequency (Hz)				Excitation Field (Oe)
	10	100	1000	10000	
10	17	17	17	11	
4	17	17	17	7.7	
2	11.9	9.4	6.8	1.7	
1.9	9.4	6.8	5.1	0.85	
1.8	5.1	5.1	4.3	0.85	

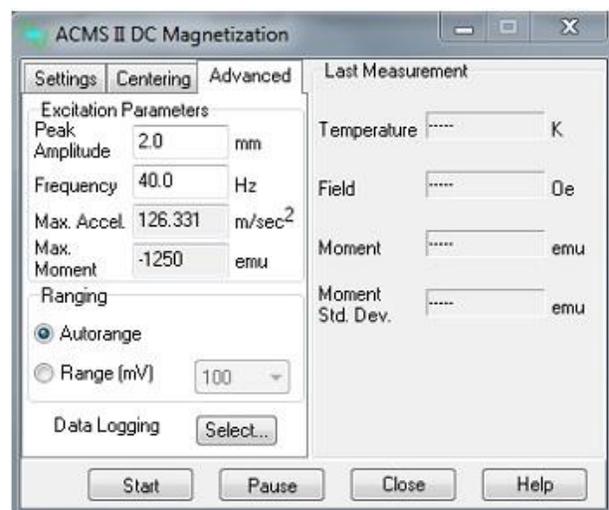
## 4.4.2 Taking DC Magnetization Measurements

### 4.4.2.1 TAKING A MEASUREMENT IN IMMEDIATE MODE

To summarize, you take a measurement in immediate mode by first installing the sample and then defining and running the measurement. Complete the following steps:

1. Select the **Datafile** tab in the ACMS II control center if you want to select a different data file or create a new file (see section 6.4.1). The **Sample** tab in the control center displays the sample property information stored in the header of the selected data file. If you run the measurement when no data file is selected, the data is discarded.
2. Mount the sample on a suitable sample holder. Refer to section 3.2.
3. Select the **Install** tab in the ACMS II control center. Then select the **Install/Remove Sample** button and insert the sample into the sample chamber. Section 3.3 describes this procedure.
4. Select the **DC Measure** button in the ACMS II control center *or* select the **Measure** ► **ACMS DC Magnetization** menu option. The **DC Magnetization** dialog box opens.

Figure 4-6. **DC Magnetization** dialog box. Items on the left side of the dialog box designate measurement conditions that should be set prior to initiating the measurement. Items on the right side of the dialog box display the results of the last immediate-mode DC measurement.



5. Define the DC measurement as follows.
  - a. Define the peak amplitude and averaging time to obtain a measurement value.





## ACMS II Hardware

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### 5.1 Introduction

This chapter contains the following information:

- Section 5.2 describes each of the basic hardware components that make up the ACMS II option.
- Section 5.3 describes the contents of the ACMS II User's Kit.
- Section 5.4 describes the sample-mounting station and its use.
- Section 5.5 describes the electrical components of the ACMS II option.

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### 5.2 ACMS II Hardware Components

This section describes each of the basic hardware components that make up the ACMS II system. For instructions about installing the various components, please refer to Chapter 2.

#### 5.2.1 Sample Transport

The sample linear transport (4096-400) is the motor that moves the sample. The linear motor transport and many of its component parts are illustrated in Figure 5-1. You will mount the linear motor transport directly on top of the PPMS, DynaCool, or VersaLab sample-chamber opening after you have inserted the sample tube into the sample chamber.

The sample rod is inserted into the sample chamber through an access port on top of the sample linear motor transport. The sample chamber is sealed (for storage and during operations) by a cap and an O-ring seal. An electrical connector at the rear of the linear motor transport provides the Model CM-A with electrical access to the drive coil and position encoder via the motor drive cable (3096-200 or 3096-201).

The sample rod is held in place in the sample linear motor transport by a magnetic-locking mechanism consisting of small magnets in the top of the rod; the magnets stick to a thin steel ring at the top of the armature.

A spring-suspension mechanism inside the linear motor transport isolates the vertical motion of the motor from the housing during vibration. The resonant frequency of the spring-suspension mechanism is about 5 Hz. You can verify whether the suspension mechanism is functioning

correctly by gently tapping the top of the sample rod at the sample access port during sample loading. A mechanism that is working correctly will oscillate for at least 5 seconds.

The transport is shipped from the factory with the shipping plug installed to prevent oscillation of the motor suspension mechanism. Before using the equipment, you must remove the shipping plug and install the extender tube flange.

A window in the front side of the linear motor transport (opposite the electrical connector) displays the location of the armature (the moving section of the motor transport). When you are installing or removing samples, you will be able to see an indicator pin at the top of the window: The indicator pin will be at the *top* of the window when the system is in the "load" position. The indicator pin will be at the *bottom* of the window, which is the "shutdown" position, *only* when the sample rod has been removed and the linear motor transport has been shut down. During AC measurements the indicator pin will move to pre-determined positions and stand still for a few seconds while for DC operations, the indicator pin will vibrate rapidly (1–4 mm peak-to-peak amplitude at 40 Hz) between the load and shutdown positions.

**Important:** The sample will be subject to vertical magnetic fields of up to approximately 200 gauss when it passes through the head. If this is unacceptable for your samples, please contact Quantum Design.

### CAUTION!

- ◆ The indicator pin should be at the bottom of the window when the linear motor transport has been shut down. If it is NOT, it indicates that the sample rod has been inadvertently left in the sample chamber.
- ◆ Never attempt to remove the linear motor transport from the system while the sample rod is installed.

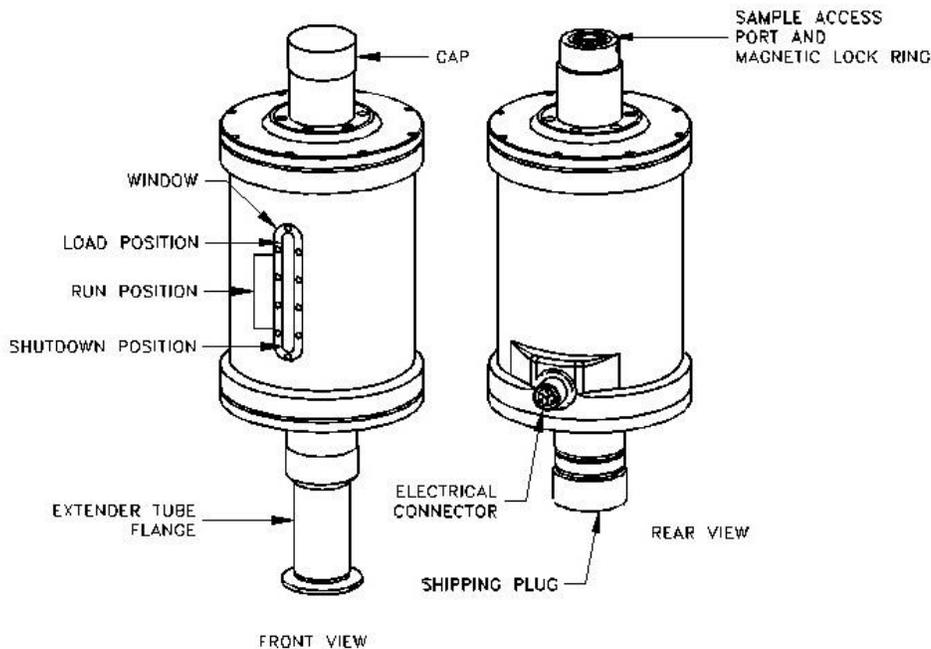


Figure 5-1. Sample linear motor transport (4096-400)

## 5.2.2 Storage Case for Linear Motor Transport

Because the linear motor transport is both heavy and delicate, Quantum Design has furnished you with a specially designed storage case to protect it during transport and storage. When the linear motor transport is not being used, it should be stored in this case. You can keep the case on a shelf or in a cabinet, so long as it is on a stable base and is stored upright as shown in Figure 5-2.

**CAUTION!**

Because the storage case has a high center of gravity, it is critical that you place it on a very stable base such as the floor.

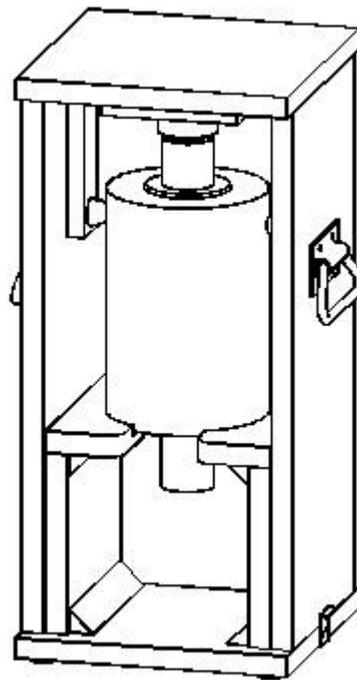


Figure 5-2. Storage case (4096-150) for the linear motor transport.

## 5.2.3 ACMS II Coilset Puck

The coilset puck contains the ACMS II detection coils and a thermometer for monitoring the sample temperature. You will insert the coilset puck into the sample chamber by using the PPMS sample insertion tool (also called the puck insertion/extraction tool) and the same procedures used to insert other types of pucks (see the *Physical Property Measurement System: Hardware Manual* for information on puck insertion and extraction). You must install the puck **before** you insert the sample tube.

The electrical connector at the bottom of the coilset puck has a serial number (see Figure 5-3). As explained in Sections 2.2.3, you will use this serial number to verify the numbers contained in the application software. The system uses the serial number to identify the puck calibration information.

The dimensions of the coilset puck are shown schematically in Figure 5-4. The center of the gradiometer pick-up coils is located 40.1 mm (1.58 in) above the location corresponding to the puck surface. This position corresponds to the center position of the magnet.

After repeated insertions of the ACMS II puck, the contact fingers at the base of the coilset (above the serial number in Figure 5-3) might bend inwards, which would loosen the fit of the coilset in the bottom of the sample chamber. When this happens, you should make the coilset fit snugly again by using the puck adjustment tool, as described in the *Physical Property Measurement System: Hardware Manual*.

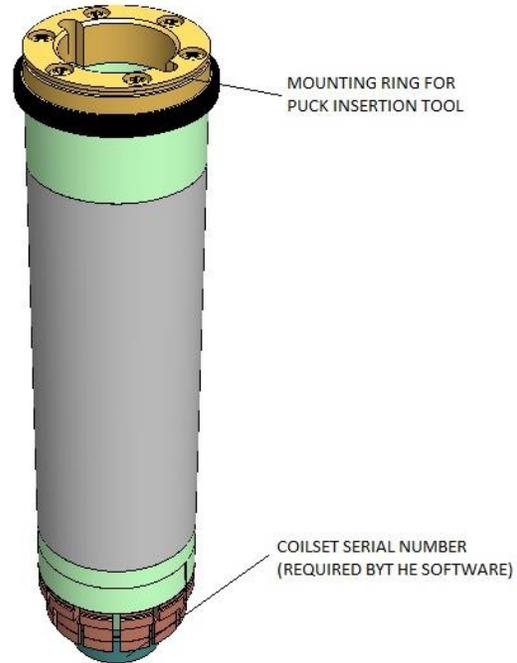


Figure 5-3. ACMS II Coilset puck (4084-850)

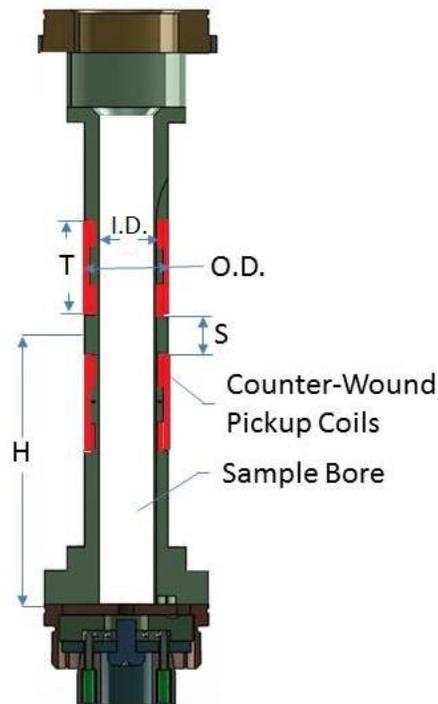
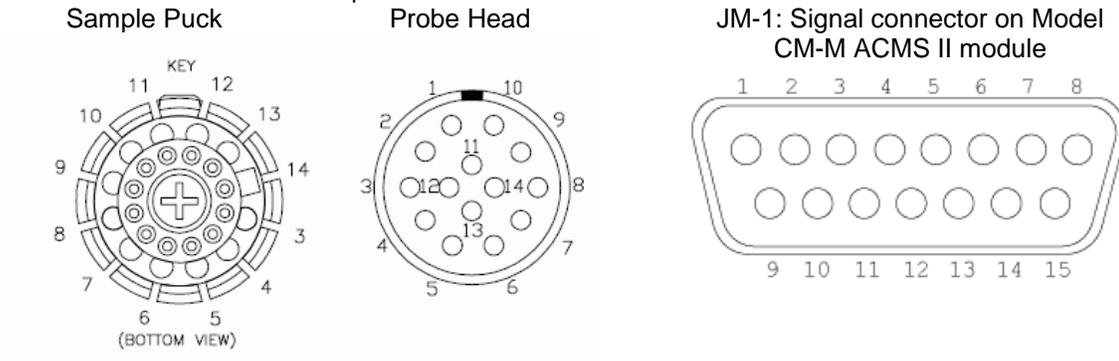


Figure 5-4. The internal dimensions of a standard coil set puck are as follows: Bore Inner Diameter (I.D.) = 8.1 mm; coil thickness (T) = 14.0 mm; coil spacing (S) = 5.9 mm; coil outer diameter (OD) = 12.4 mm; height above puck surface (H) = 40.1 mm.

Table 5-1. Sample Connection with ACMS II Detection Cable Connected.



SAMPLE PUCK	GRAY LEMO CONNECTOR AT PROBE HEAD	JM-1 SIGNAL ON CM-M ACMS II MODULE	FUNCTION
3	3	14	Thermometer Current +
4	4	7	Thermometer Current -
5	5	15	Thermometer Voltage +
6	6	8	Thermometer Voltage -
7	7	1	Trim Coil +
8	8	9	Trim Coil -
9	9	4	Calibration Coil -
10	10	12	Calibration Coil +
11	11	5	Detection Coil +
12	12	13	Detection Coil -
13	13	3	Drive Coil +
14	14	10	Drive Coil -

### 5.2.4 Sample Rod Guide Tube

You will insert the sample tube (Figure 5-5) into the sample chamber after you have installed the coilset puck. The sample tube provides low-friction guide sleeves for the sample rod. The top of the sample tube consists of an integrated O-ring attached to a stabilizer post. The stabilizer post provides a rigid, bayonet-style mount that prevents the linear motor transport from tipping over. Part of the post extends into the sample chamber and part extends into the extender tube flange on the bottom of the linear motor transport, as shown in Figure 2-7.

**CAUTION!**

You should always use the flange clamp to hold the linear motor transport onto the post, even though the stabilizer post helps prevent the linear motor transport from tipping over.

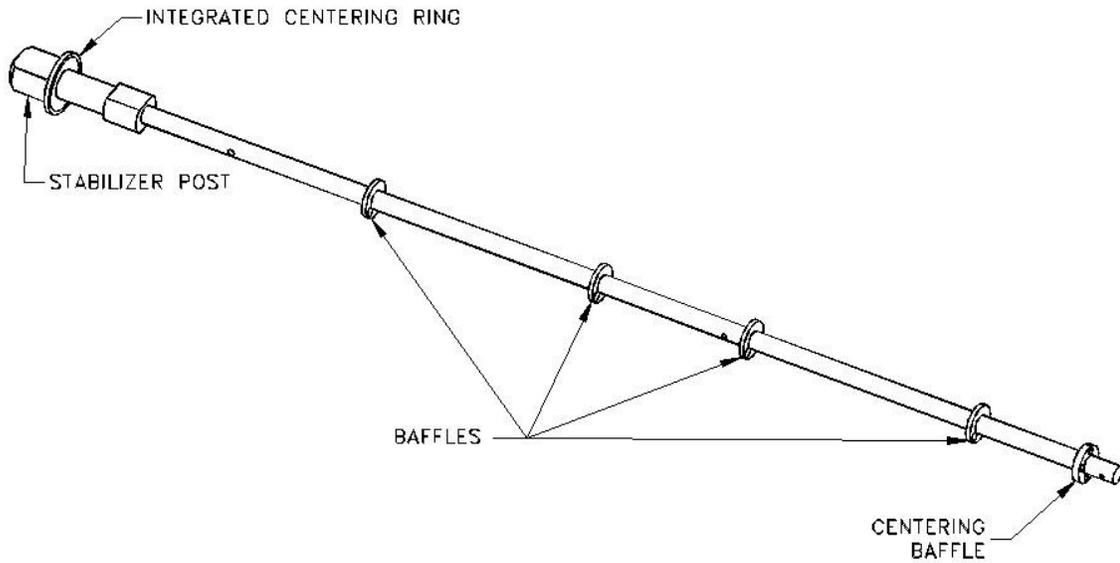


Figure 5-5. Sample rod guide tube (4096-301 shown for example)

### 5.2.5 Sample Rod

Many of the design features of the sample rod were introduced to reduce the background signal from mechanical vibrations at the DC oscillation frequency. Such features control the rattling or friction between the rod and the system and they eliminate resonant flexure of the shaft.

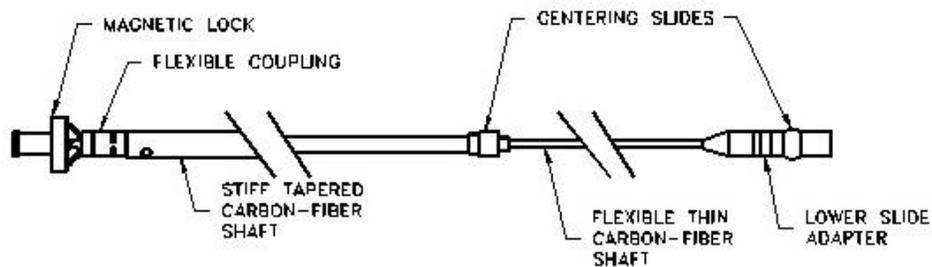


Figure 5-6. ACMS II sample rod (4096-352 shown for example)

Figure 5-6 shows the sample rod in a horizontal position (during use, the magnetic lock would be at the top of the rod).

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

## 5.3 ACMS II Option User's Kit

The ACMS II Option User's Kit contains miscellaneous hardware and supplies that you will use to mount samples and to verify the operation of the option. The convenient portable toolbox (see Figure 5-7) helps organize the items.

The kit includes the following contents:

- **Sample-Mounting Station**  
The sample-mounting station is used to mount samples at the correct location in the sample holder. For more information about mounting samples, see Figure 5-8 and Section 3.3.
- **Sample Holders**  
Sample holders are used to hold samples (see Figure 5-8); the holders screw onto the bottom of the sample rod. Quantum Design has provided five paddle-shaped sample holders.
- **Calibration Sample**  
A palladium and Er:YAG calibration sample is used to calibrate the ACMS II option and to verify its accuracy.
- **Coilset Assembly**  
The ACMS II coilset assembly is shipped as part of the ACMS II Option User's Kit.

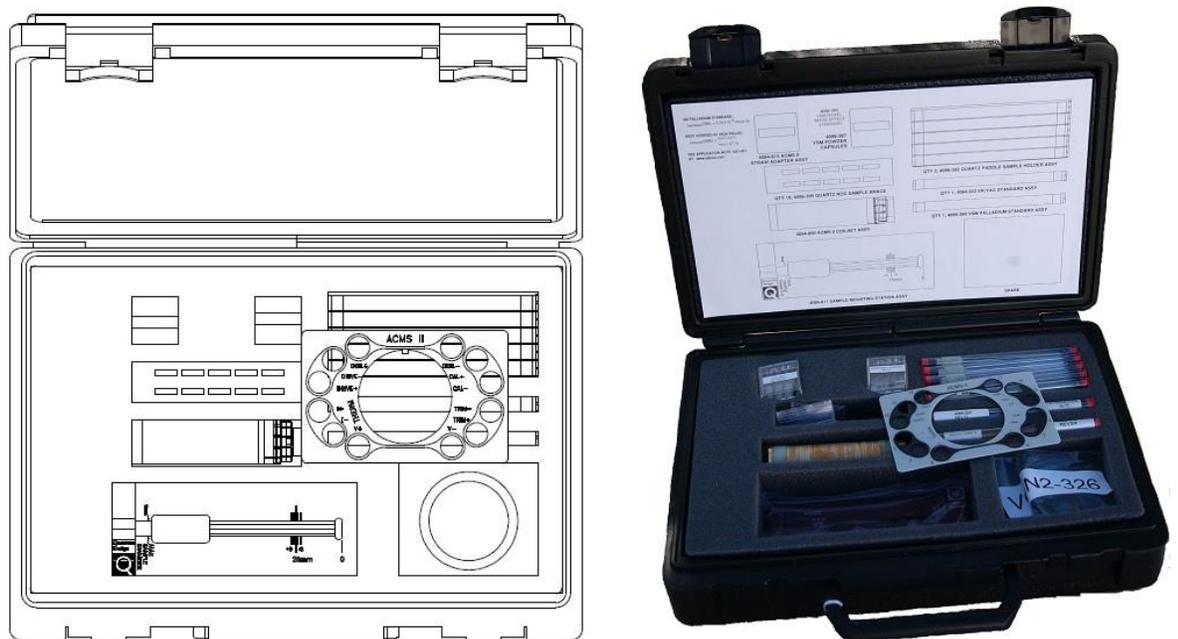


Figure 5-7. ACMS II Option User's Kit (4084-810)

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## 5.4 Sample-Mounting Station

The sample-mounting station (4084-811) is used to precisely locate and measure (within 0.5 mm) the sample offset, which is the distance between the sample and the bottom of the sample holder (see Figure 5-8).

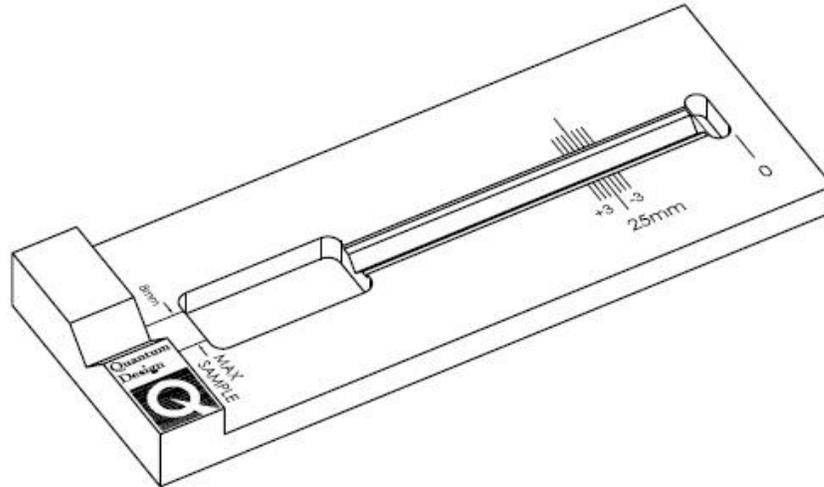


Figure 5-8. Sample-mounting station (4084-811)

Both AC and DC measurement algorithms requires an accurate measurement of this distance so that it can perform touchdown operations (See Chapter 4 for more details about touchdown operations).

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## 5.5 ACMS II Electronics

### 5.5.1 Signal Cable Assembly

Figure 5-9 shows the preamp cable assembly (3084-801), which is the electrical connection between the coilset puck and the “SIGNAL” port (JM-1) on the Model CM-M ACMS II module. The “Grey Lemo” end of the cable is plugged into the gray connector at the PPMS probe head.

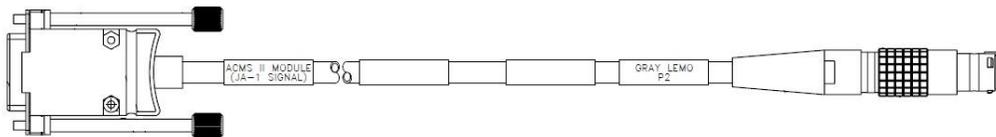


Figure 5-9. ACMS II signal/drive cable assembly (3084-801)

### 5.5.2 Motor Drive Cable

Figure 5-10 shows the DC motor drive cable (3096-200), which connects the back of the linear motor transport to the “SERVO” port (JA-1) on the Model CM-A (motor module). The drive cable provides drive-coil power to the linear motor transport, position-encoder read-back to the module, and serial communication between the linear motor transport and the module for diagnostic and configuration purposes.

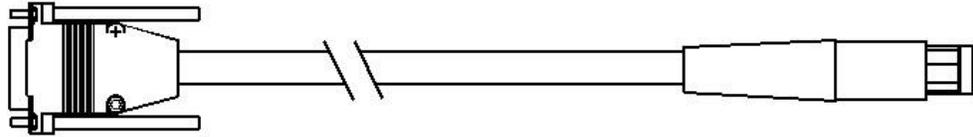


Figure 5-10. Motor drive cable (3096-200)

### 5.5.3 Model CM-A (Motor Module)

Figure 5-11 shows the Model CM-A motor module (4101-100), which provides all the power and logic that are necessary to drive the sample linear motor transport. All configuration and control of this module is through the ACMS II application software on the computer (PC) via the CAN-bus connector on the back panel of the module.

See Appendix A for a detailed description of the functions of this module.

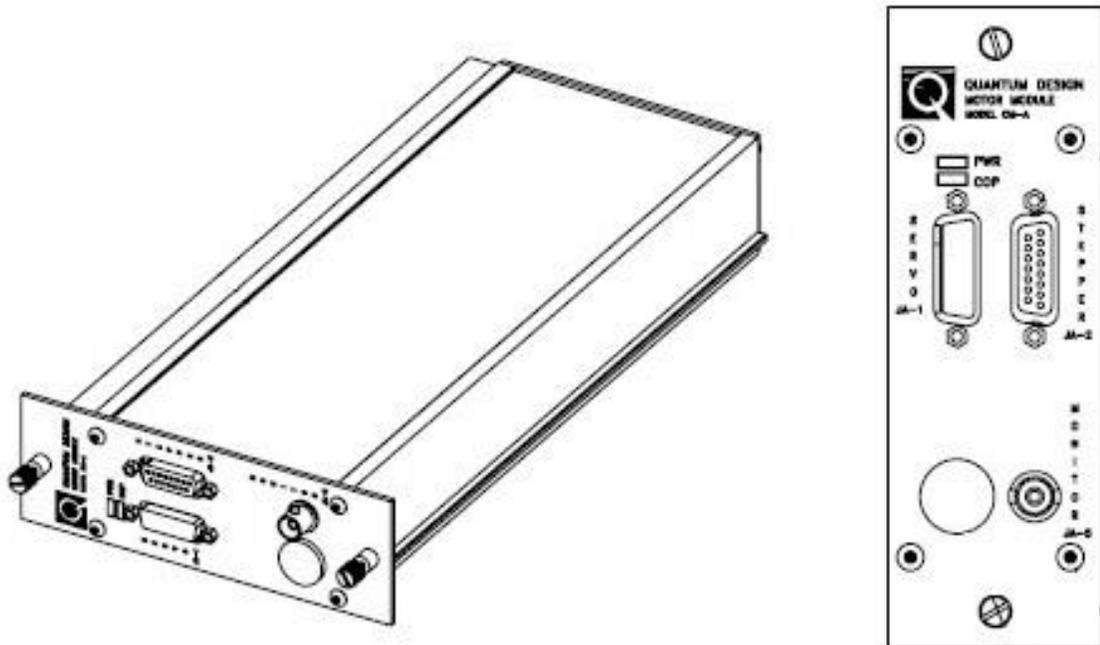


Figure 5-11. Model CM-A motor module (4101-100)

### 5.5.4 Model CM-M (ACMS II Module)

Figure 5-12 shows the Model CM-M (4101-430), which performs the synchronous detection (or “lock-in”) operation for the ACMS II option. The module provides the AC drive current for AC measurements, performs the signal detection for both AC and DC measurements, and measures the temperature of the ACMS II coil set. All configuration and control of this module is handled through the ACMS II application software on the computer (PC) via the CAN-bus connector on the back panel of the module.

See Appendix B for a detailed description of the functions of this module.

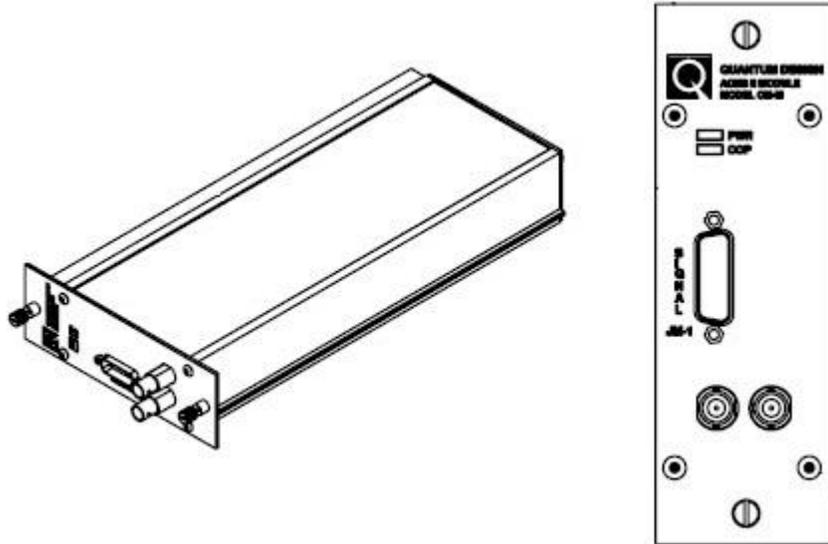


Figure 5-12. Model CM-M ACMS II module (4101-430)

### 5.5.5 Model 1000 (Modular Control System) (PPMS ONLY)

The Model 1000 modular control system (4100-001) is a general-purpose chassis (Figure 5-13) that houses, cools, and provides power to both the Model CM-A DC motor module and the Model CM-M ACMS II detection module. The Model 1000 can accommodate up to four additional modules for other PPMS options. The backplane provides connections for power as well as a CAN-based network connection to the computer (PC).

See the *Model 1000 Modular Control System User's Manual* for more information about the Model 1000 modular control system.

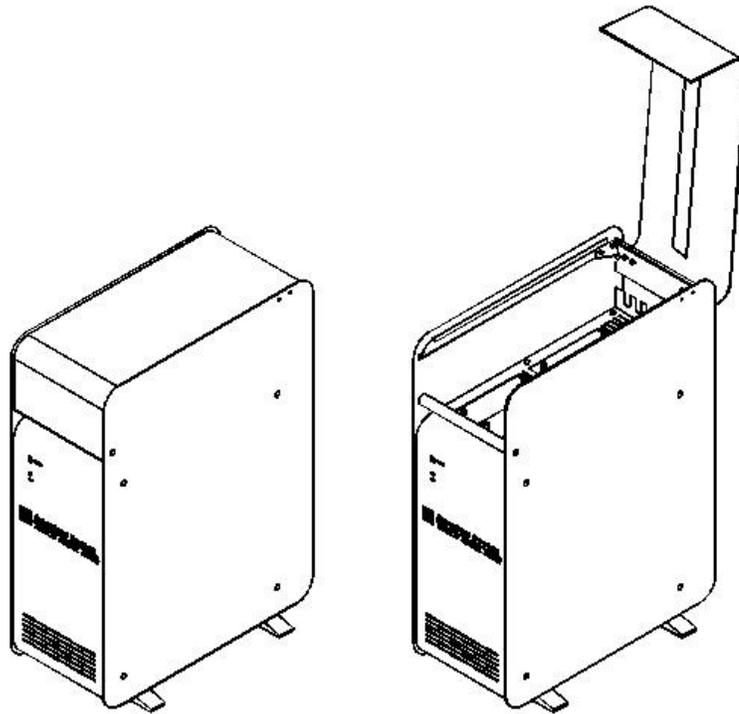


Figure 5-13. Model 1000 modular control system (4100-001)

### 5.5.6 CAN Computer Interface Kit

The CAN computer interface (or network adapter) kit contains the CAN-based network adapter, cable (3100-024), and software that are needed to connect the Model 1000 to the computer (PC).

For measurement platforms such as DynaCool and VersaLab, the CAN Computer Interface is built into the instrument.



# ACMS II Software

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## 6.1 Introduction

This chapter contains the following information:

- Section 6.2 describes option activation and deactivation.
- Section 6.3 describes the ACMS II-specific dialogs and menu items in the MultiVu dropdown menus.
- Section 6.4 describes the **ACMS II Control Center** and its components.
- Section 6.5 briefly describes sequence mode commands.
- Section 6.6 explains use of the ACMS II sequence-mode **Center Sample** command.
- Section 6.7 describes the format of ACMS II data files.

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## 6.2 Activating and Deactivating the ACMS II Option

1. To activate the ACMS II application and open the **ACMS II Control Center**, select **Utilities >> Activate Option** from the dropdown menu of the MultiVu window (Figure 6-1).

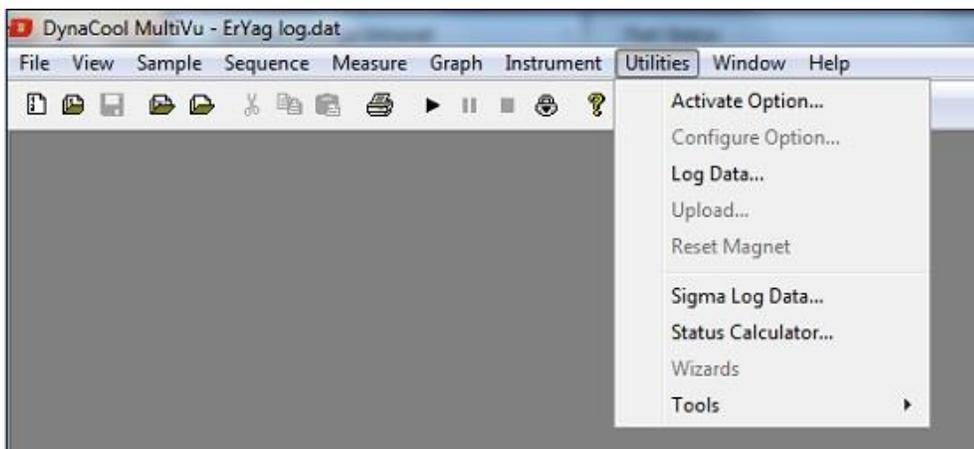


Figure 6-1. Using the MultiVu dropdown Utilities menu and Option Manager to activate the ACMS II Option

2. When the **Option Manager** dialog opens, select **ACMS II** and click on the **Activate** button. This will move the ACMS II option from the **Available Options** section of the dialog to the **Active Options** section. The **ACMS II Control Center** and the **ACMS II Log** window will open concurrently. When running in simulation mode, the **ACMS II Control Center** is titled **ACMS II SIMULATION** (see Figure 6-2). To deactivate the ACMS II option, select it on the right side and click **Deactivate** in this dialog.

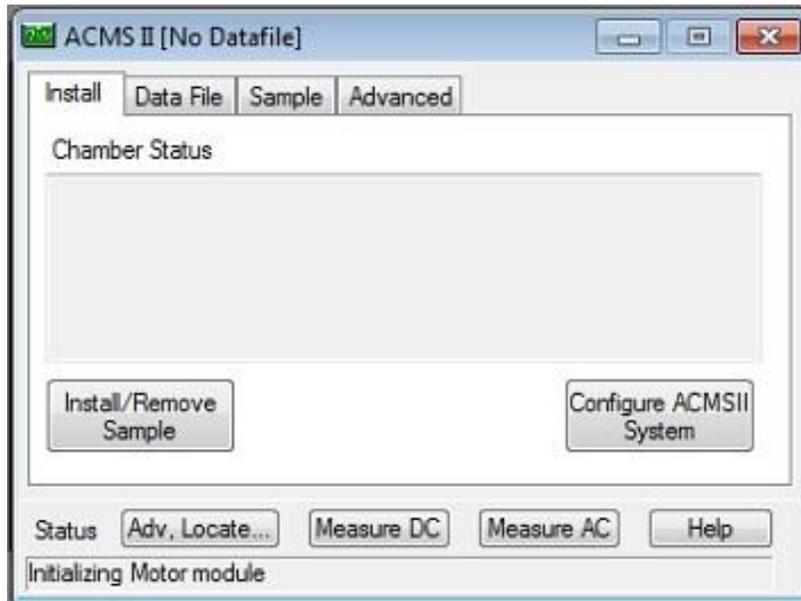


Figure 6-2. The MultiVu window and the ACMS II Control Center, including the Install tab, the ACMS II Status area, and the MultiVu Status bar. Note that the ACMS II Log window has been minimized.

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## 6.3 ACMS II Dropdown Menus

ACMS II-specific actions, dialogs, and commands are incorporated into the **View**, **Sample**, and **Measure** dropdown menus in the MultiVu window after you have activated the option. The other dropdown menus in the MultiVu window contain menu items that are common to all Quantum Design systems.

### 6.3.1 View

You can use the **View** dropdown menu at the top of the MultiVu window (Figure 6-3) to open ACMS II-specific log files as well as to perform general actions, such as opening and closing the MultiVu **Status Bar**, the sequence **Control Center** panel at the side of the window, or the tool bar.

- Select **ACMS II Status Log** to view the events logged during the current ACMS II activation. The file located in \ACMS II\Logfiles\ACMS IIlog.txt contains the entire history of this log and is a useful resource for troubleshooting.
- Select **ACMS II Error Count** to open a dialog showing only errors encountered as well as the total count.

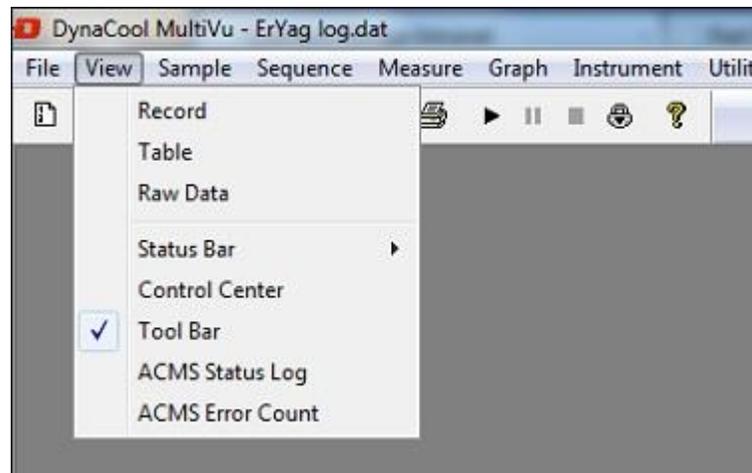


Figure 6-3. The MultiVu window and the View dropdown menu showing ACMS II log file entries

### 6.3.2 Sample

You can use the **Sample** dropdown menu at the top of the MultiVu window (Figure 6-4) to install and remove samples and to center the sample manually.

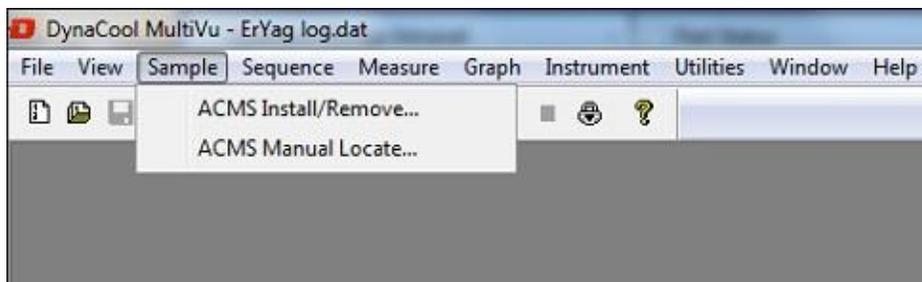


Figure 6-4. The MultiVu window and the Sample dropdown menu showing ACMS II immediate-mode commands

- To install a sample, designate an output data file, and center the sample, select **Sample >> ACMS II Install/Remove**. This selection opens the **ACMS II Install/Remove Sample Wizard** (Figure 6-5).
- To provide the software with the location of the sample, select **Sample >> ACMS Manual Locate**. The **Specify Sample Location** dialog will open so that you can enter the sample offset or perform an automatic scan. This dialog also appears when you use the **ACMS II Install/Remove Sample Wizard** to install a sample (Section 4.3.3).

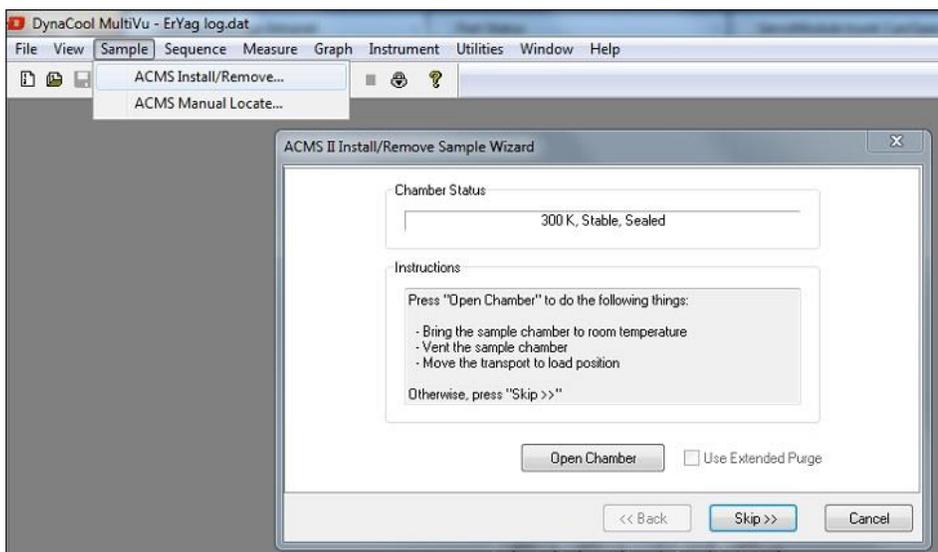


Figure 6-5. The Sample Installation dialog that opens from the dropdown menu when you select Sample >> ACMS Install/Remove...

### 6.3.3 AC Measure

If a sample has been installed in the ACMS II, you can use the **Measure** dropdown menu at the top of the MultiVu window (Figure 6-6) to open immediate-mode ACMS II measurement dialogs (e.g., for setting up and taking measurements, for centering the sample, and for adding a comment to an output data file). In the event you attempt to use commands in the **Measure** dropdown menu but you have not installed a sample, a popup message will open, directing you to first install and center a sample.

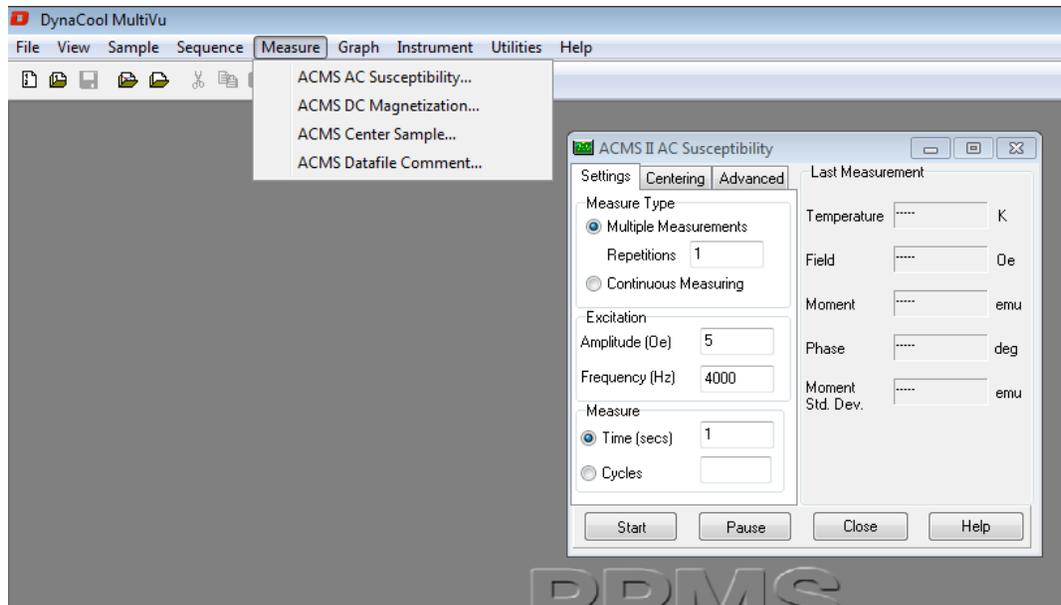


Figure 6-6. ACMS II immediate-mode commands in the context of the MultiVu window and the Measure dropdown menu

- To set up and take measurements, select **Measure** and choose either **AC Susceptibility** or **DC Magnetization** from the drop-down menu. The **ACMS II Measurement** dialog will open (Figure 6-6), with three tabs (or pages) of settings you can use to delineate your measurements. The same dialog appears when you click on the **Measure** button in the **ACMS II Control Center**. For a complete explanation of the **ACMS II Measurement** dialog, see Section 6.4.2.
- To center a sample, select **Measure >> ACMS II Center Sample**. This selection sequence opens the **ACMS II Center Sample** popup (Figure 6-7), which allows you to initiate touchdowns at will. As explained in Chapter 4, centering operations help ensure the accuracy of measurements.
- To add a comment to a ACMS data file, select **Measure >> ACMS II Datafile Comment**. When the **ACMS II Datafile Comment** popup appears (Figure 6-8), enter your comment in the text box. The text will be appended to the currently open ACMS II data file in the Comment column (first column).



Figure 6-7. The immediate-mode AC Center Sample popup



Figure 6-8. The immediate-mode AC Datafile Comment popup

## 6.4 ACMS II Control Center

The **ACMS II Control Center** opens within the MultiVu window as soon as you activate the ACMS II option and application software. Figure 6-9 shows the **ACMS II Control Center** and the commands, dialogs, tabs, buttons, and software prompts that organize measurement-related activities, making it easy for you to perform basic operations (e.g., create data files, install samples, and set up and initiate immediate-mode measurements).

### 6.4.1 ACMS II Control Center: Components

#### 6.4.1.1 INSTALL TAB

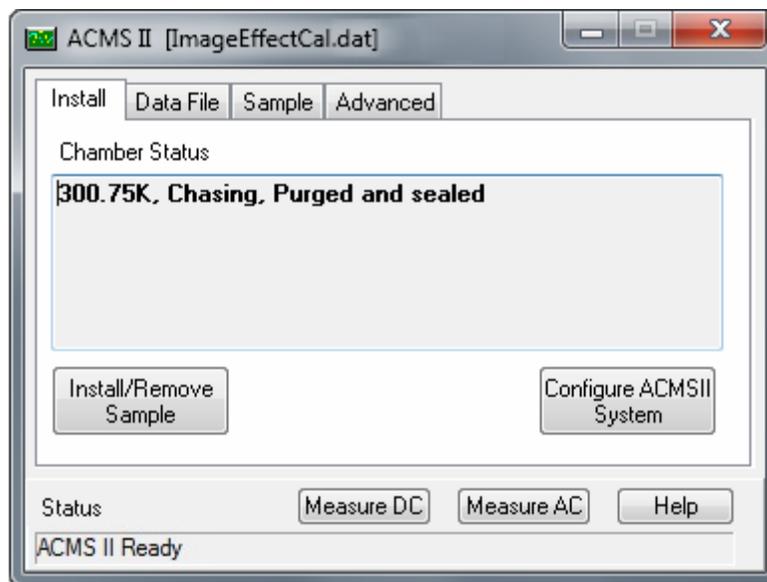


Figure 6-9. Install tab in the ACMS II Control Center

The **Install** tab provides access to two wizards:

- **Install/Remove Sample** guides the user through installation of a sample into the ACMS II measurement space and is outlined in Section 4.3.3.
- **Configure ACMS II System** will allow the user to select a different active ACMS II coilset (see Section 2.2.8). Coilsets are distinguished by serialization on the puck base (see Section 5.2.3) and there is a corresponding calibration file `ACMSCOIL-XXX.cfg` in the `ACMSII\Calibration` folder. One sign that an incorrect coilset is in use is that the temperature between coilset and base system differ by >1% or the ACMS option declares that the option thermometer is not responding.

### 6.4.1.2 DATA FILE TAB

The Data File tab (Figure 6-10) identifies the output data file that will contain the measurement data. If you have not selected an output data file, the File Name and Title panels in the Data File tab will be blank.

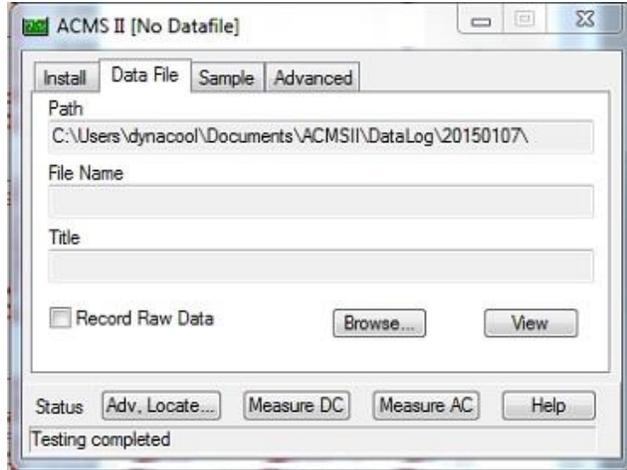


Figure 6-10. Data File tab in the ACMS II Control Center

#### View Button

The **View** button opens the graph view of the active output data file. To use the **View** button, you must have designated an output data file.

#### Browse... Button

The **Browse...** button initiates a series of dialogs that guide you through the process of designating (selecting or creating) a data file (see Fig. 6-11). The file-designation process and the dialogs are similar to the ones in the **Install/Remove Sample Wizard** (see Section 4.3.3).

**Important:** You must designate an output data file (by selecting an old file or by making a new one) if you want the measurement data saved. If no data file is designated, the measurement data will be written to the file `\Data\ACMSII\default.DAT`.

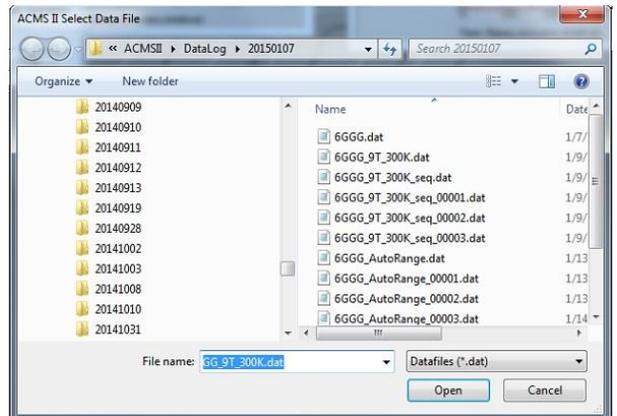


Figure 6-11. Browse button initiates a dialog to select data file

Creating a new data file will prompt the user to enter sample properties as shown in Figure 6-12. This information, recorded in the header of the data file, is for information only and is not used in calculating the reported magnetic moment.

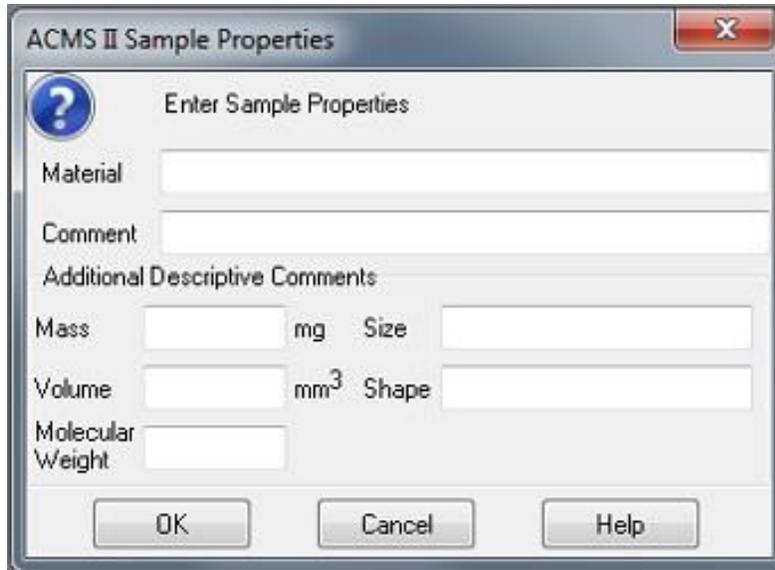


Figure 6-12. Recording sample properties

#### 6.4.1.3 SAMPLE TAB

The **Sample** tab (Figure 6-13) is a read-only status display that shows the sample properties (e.g., material, comments, mass, and volume) for the active output data file. The information in the **Sample** tab originates from your entries in the **ACMS II Sample Properties** dialog, which are stored in the header of the output data file. If you select a pre-existing file to which you want data appended and bring the **Sample** tab forward, the information in the **Sample** dialog will reflect the entries in the header of the pre-existing file.

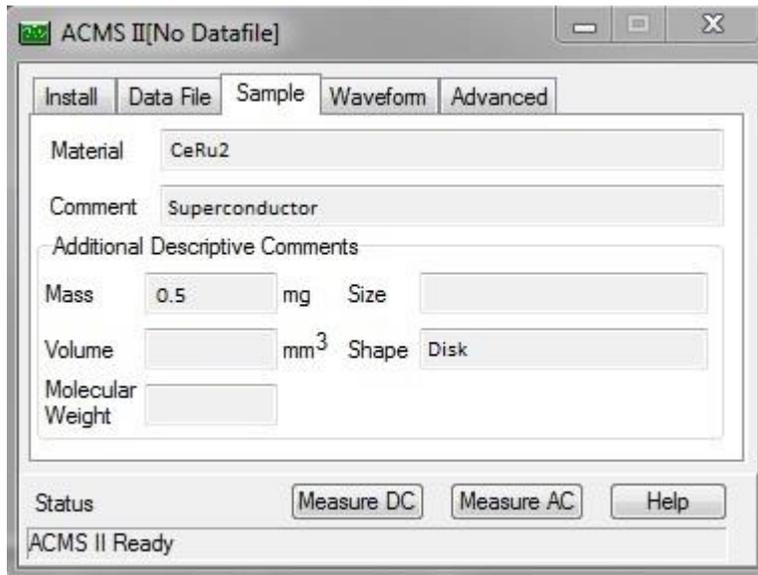


Figure 6-13. Sample tab in the ACMS II Control Center.

#### 6.4.1.4 ADVANCED TAB

The **Advanced** tab (Figure 6-14) organizes support for troubleshooting, for example, checking calibrations and troubleshooting system performance. Hence, you will use the options on the **Advanced** tab only if you are an experienced ACMS II operator.

- The **Motor Friction Scan** button moves the sample linear motor transport through the full range of motion. The system plots the motor force (as current) as a function of position for both lifting the sample and lowering the sample. A difference between these two curves indicates friction due to ice or other obstructions.

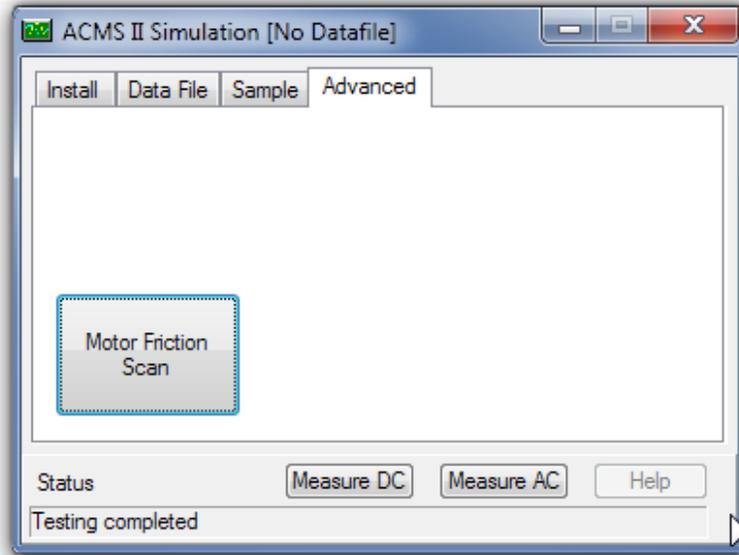


Figure 6-14. Advanced tab in the ACMS II Control Center

### 6.4.2 ACMS II Control Center: "Measure" Buttons

The **Measure DC** or **Measure AC** buttons in the **ACMS II Control Center** opens either the **ACMS II DC Magnetization** or the **ACMS II AC Susceptibility** measure dialog boxes (DC left and AC right of Figure 6-15), which organizes immediate-mode measurement settings and initiates measurements. Each of these dialogs has a section showing the measurements, three tabs (**Settings**, **Centering**, and **Advanced**), and four buttons (**Start (Stop)**, **Pause (Resume)**, **Close**, and **Help**).

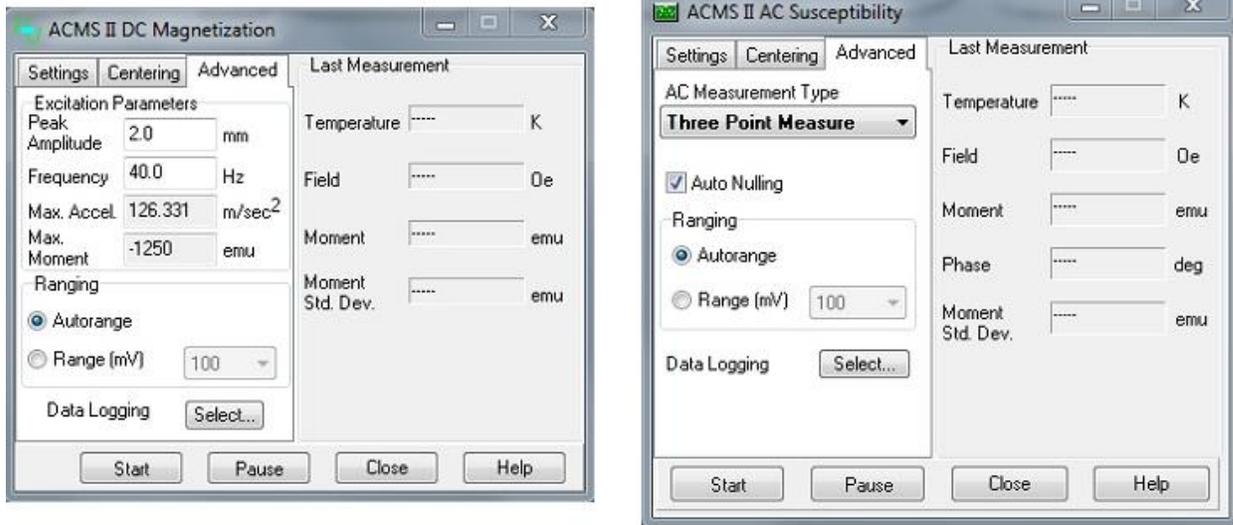


Figure 6-15. DC Magnetization and AC Susceptibility measure windows

#### 6.4.2.1 MEASURE DIALOGS: BUTTONS

- The **Start (Stop)** toggle button starts and stops the measurement process, but it does not close the dialog.
- The **Pause (Resume)** toggle button only stops the system from performing measurements, as the system continues to oscillate the sample and execute any scheduled automatic touchdown operations. To restart the data output after a **Pause**, click on the **Resume (Pause)** toggle button.
- The **Close** button closes the **ACMS II DC Magnetization** or **ACMS II AC Susceptibility** measurement dialogs, but it does not stop the measurement.
- The **Help** button initiates the online Help menu (if available).

### 6.4.2.2 MEASURE DIALOGS: LAST MEASUREMENT

The **ACMS II AC Susceptibility** and **DC Magnetization** measure dialogs are divided into two main areas: On the left side are the tabs with the measurement settings. On the right side is a **Last Measurement** area that displays the most recent **Temperature, Field, Moment, and Moment Std. Error** data, which are written to the currently selected data file.

- **Temperature** represents the average temperature during the measurement, in Kelvin.
- **Field** represents the average field, in oersted.
- **Moment** represents the average of the moment over the averaging time, in emu.
- **Moment Std. Error** represents the error on the mean, that is, the error bar on the reported moment.

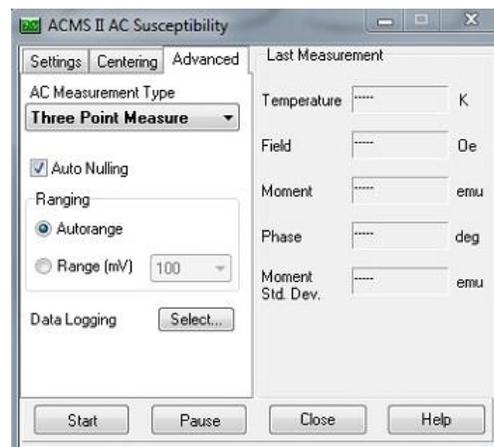


Figure 6-16. ACMS II AC Susceptibility measure dialog.

### 6.4.2.3 MEASURE DIALOGS: ADVANCED TAB

The **Advanced** tab of the **ACMS II DC Magnetization** measurement dialog (Figure 6-15) contains settings for **Excitation Parameters, Ranging, and PPMS Data Logging.**

The **Advanced** tab of the **ACMS II AC Susceptibility** measurement dialog (Figure 6-15, 6-16) contains settings for **AC Measurement, Ranging, and PPMS Data Logging.**

A short description for each of these settings is given below:

#### **Excitation Parameters (DC magnetization dialog only)**

The excitation parameters are explained by the equation:

$$\text{Position}(\text{time}) = [\text{Peak Amplitude}] \times \sin(2\pi * [\text{Frequency}] \times \text{time})$$

- The **Peak Amplitude** is typically set to 2 mm and can be varied from 0.1 to 5 mm with a recommended range of 0.5 to 4 mm. Low amplitudes allow for measuring a larger moment (see **Max Moment** value in this dialog) because the induced coil set signal is proportional to the amplitude. However, low amplitudes (<0.5mm) can result in an inaccurate reported moment. High amplitudes provide more coil set signal but also produce large accelerations (see **Max Accel.** value in this dialog) which can lead to higher noise in measurements.

**Important:** Quantum Design staff recommend that you limit the maximum **Peak Amplitude** to 4 mm, because the motor module could overheat at greater amplitudes. By limiting the maximum **Peak Amplitude** to 4 mm, you also ensure that the sample holder clears the puck surface. For example, taking into account that the detection coils are 40 mm above the puck surface and using a sample offset of 35 mm, the use of a **Peak Amplitude** of 5 mm or greater would cause the sample holder to touch the puck surface, which could dislodge the sample or the sample rod.

- The **Frequency** is typically 40 Hz; it specifies the frequency with which the linear motor oscillates the sample. It can be moved to a different value if there is interference at 40 Hz. See PPMS Service Note 1096-304 at [www.qdusa.com](http://www.qdusa.com) for information about changing the vibration frequency.
- **Max. Accel.** is computed from **Frequency** (40 Hz) and the **Peak Amplitude** entry; it represents the maximum acceleration the sample will experience during a measurement in units of meter per second squared.

**Important:** Do not proceed with a measurement if your sample cannot tolerate accelerations of this magnitude. To reduce the acceleration, reduce the amplitude.

- **Max. Moment** is computed from **Frequency** (40 Hz) and the **Peak Amplitude** entry; it represents the maximum sample moment that can be measured using these settings.

**Important:** Do not proceed with a measurement if the magnetic moment of your sample is larger than the calculated **Max. Moment**, as the system will not be able to complete the measurement. Larger moments can be measured by using relatively small values for amplitude.

### **AC Measurement Type (AC susceptibility dialog only)**

The **AC Measurement Type** pull down menu allows the user to select between: 1) Five point, 2) Three point and 3) One point measurements. See Table 4.1 in Section 4.4.1.1 for detailed descriptions of these measurement modes.

### **Auto Nulling**

Checking the **Auto Nulling** box will initiate a nulling operation every time an AC measurement with a different excitation frequency is performed. In general, nulling will result in quieter and more sensitive measurements.

### **Ranging**

The **Ranging** setting refers to the way the system chooses the gain of the amplifiers in the ACMS II module during a measurement; the optimal setting is typically **Autorange**. The preamplifiers in the ACMS II module can change the gain ranges by factors of 10, depending on the size of the signal that is induced in the pickup coils. In the rare case when you need more control than is offered by **Autorange**, you can change the **Ranging** setting to a fixed value.

- **Autorange:** The system automatically increases the gain by a factor of 10 if the current peak signal drops below 2% of the current range. The system automatically decreases the gain by a factor of 10 if the current peak signal exceed 50% of the current range.
- **Fixed Range:** The system always uses the specified gain range. This can be useful when measuring samples which change signal rapidly (e.g., ferromagnets with a very sharp hysteresis loop) and range-changing is not desired.

### Data Logging

In the **Data Logging** area of the Advanced tab of the **ACMS II AC Susceptibility** or **DC Magnetization** measure dialogs, the **Select ...** button opens the dialog (Figure 6-17), which lists additional system data items that you can choose to add to the current data file. These items are in addition to the ACMS II data items that are typically included, which are summarized in Table 6-1 (Section 6.8.2).

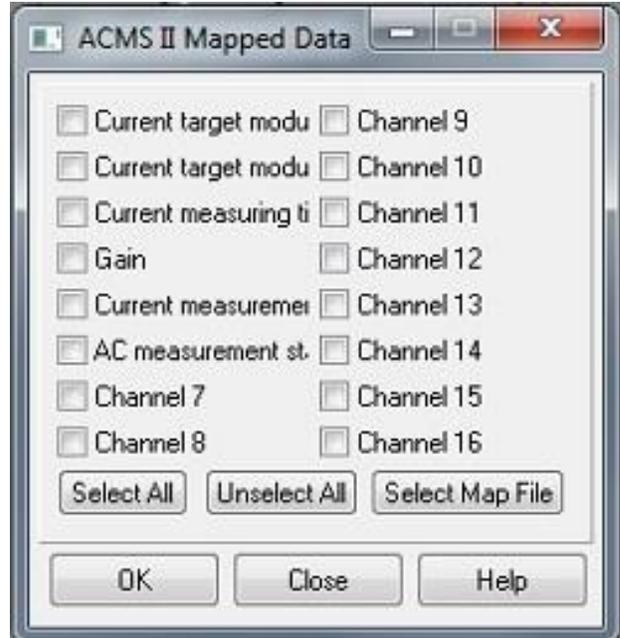


Figure 6-17. Data-logging dialog for selecting additional types of data to be collected

#### 6.4.2.4 MEASURE DIALOGS: SETTINGS TAB

The **Settings** tab of the **ACMS II DC Magnetization** measurement dialog (Figure 6-18, left) contains settings for **Measure Type** and **Measurement Parameters**.

The **Settings** tab of the **ACMS II AC Susceptibility** measurement dialog (Figure 6-18, right) contains settings for **Measure Type**, and **Measurement Parameters**.

A short description for each of these settings is given below:

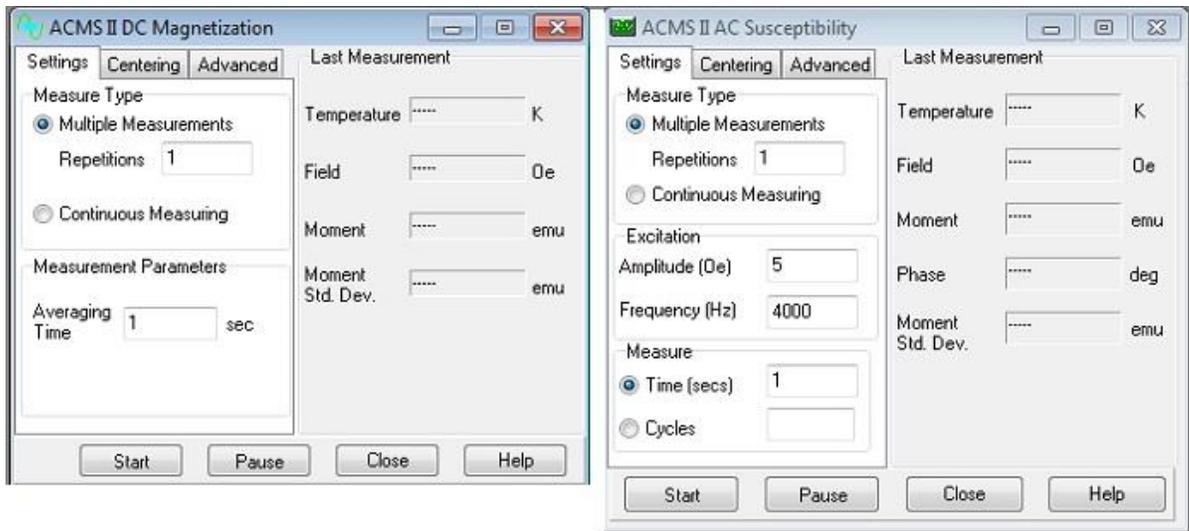


Figure 6-18. Settings tab in the Measure Dialogs.

### Measure Type

The **Multiple Measurements** mode collects the number of data points specified in the “Repetitions” field upon pressing the **Start** button. In addition, measurements can also be taken in **Continuous** mode in which new data is collected and written to the data file until the **Stop** button is pressed.

### Excitation Parameters (AC susceptibility dialog only)

The **Excitation Parameters** are specified by the user to define the Amplitude (Oe) and Frequency (Hz) of the magnetic excitation field during AC Susceptibility measurements.

### Measurement Parameters (DC Magnetization only)

- **Averaging Time (secs)** specifies the boxcar average duration for each measurement and will be an integer number of periods of sample oscillation. A practical minimum for this time interval is 0.5 seconds and a typical value is 1 second.

### Measure (AC Susceptibility only)

- **Time (secs)** specifies the boxcar average duration for each measurement and will be an integer number of periods of sine wave excitation. A practical minimum for this time interval is 0.5 seconds and a typical value is 1 second.
- **Cycles** is the number of sine wave excitation periods that elapses between recorded measurements.

#### 6.4.2.5 MEASURE DIALOGS: CENTERING TAB

The **Centering** tab displays the automatic centering settings that are in effect (see Figure 6-19). Normally, you will not need to adjust these settings.

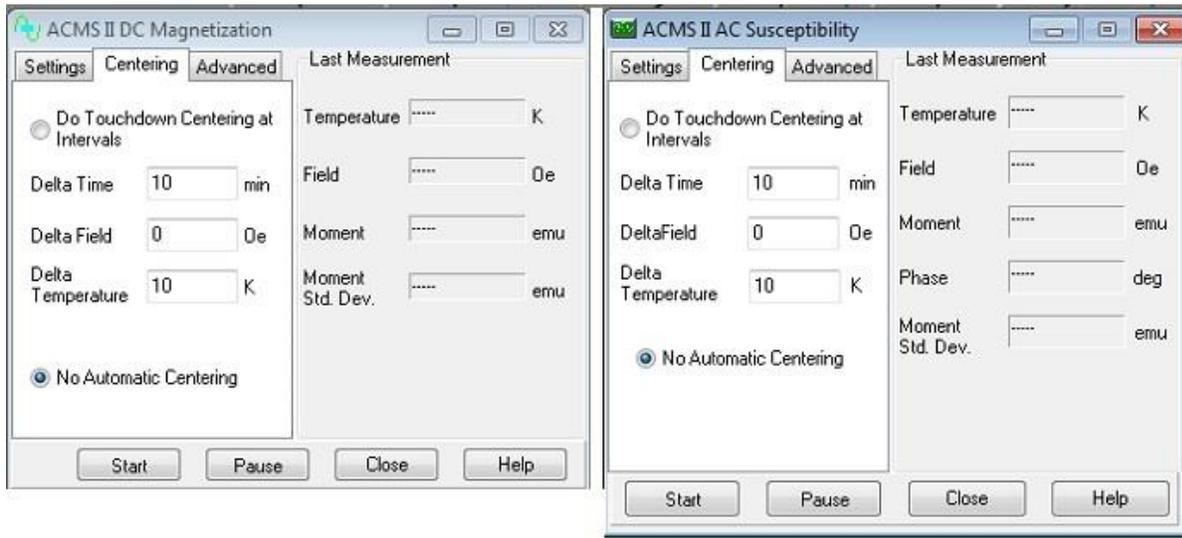


Figure 6-19. Centering tab in the Measure Dialogs

It is recommended to use touchdown centering to ensure the sample remains centered in the coil set.

Touchdown operations will occur when any one of the monitors (time, field or temperature) has been exceeded. The default parameters of Delta Time = 10 minutes and Delta Temperature = 10 K will be sufficient for most cases. Selecting zero (0) for any of the monitors will turn it off. For instance, Delta Field = 0 should be used for all systems except the 16 tesla PPMS (it is provided because the stray field of the main magnet can slightly pull on the motor and change the operating height of the sample).

Touchdowns result in an approximately 20 second interruption in measurements. If this is unacceptable in your measurements then centering can be triggered explicitly by selecting **Measure >> ACMS II Center Sample** or using the **Center Sample** sequence command.

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## 6.5 Overview of Sequence-Mode ACMS II Commands

ACMS II sequence-mode commands are, essentially, encapsulated versions of ACMS II immediate-mode measurement commands. The ACMS II sequence-mode commands have interactive dialogs that help you specify your measurements, and these dialogs are similar to the ones used to set up the immediate-mode measurements.

### 6.5.1 Taking an AC Susceptibility Measurement in Sequence Mode

To take a measurement in sequence mode, you first define the sequence file and include the measurement command in the sequence file. Then after you install the sample, you run the sequence, and the measurement is executed when the measurement command is read in the running sequence. A single sequence file may include any number of measurement sequence commands.

The **AC Susceptibility** measurement sequence command can either take a single AC measurement — just like the immediate-mode AC measurement — or it can function like a scan sequence command and take multiple measurements within a control loop. **AC Susceptibility** functions like a scan command if you define an amplitude or frequency range for the command parameters. Refer to the *Physical Property Measurement System: PPMS MultiVu Application User's Manual* for detailed information about scan commands and control loop operation.

Complete the following steps to take an AC measurement in sequence mode:

1. Select a new or existing sequence file.
2. Select the **AC Susceptibility** command, which is in the **Measurement Commands ACMS II** group in the sequence command bar. Then select the **Excitation** tab in the **ACMS II Measure AC Susceptibility** dialog box. See figure 6-20 (center).

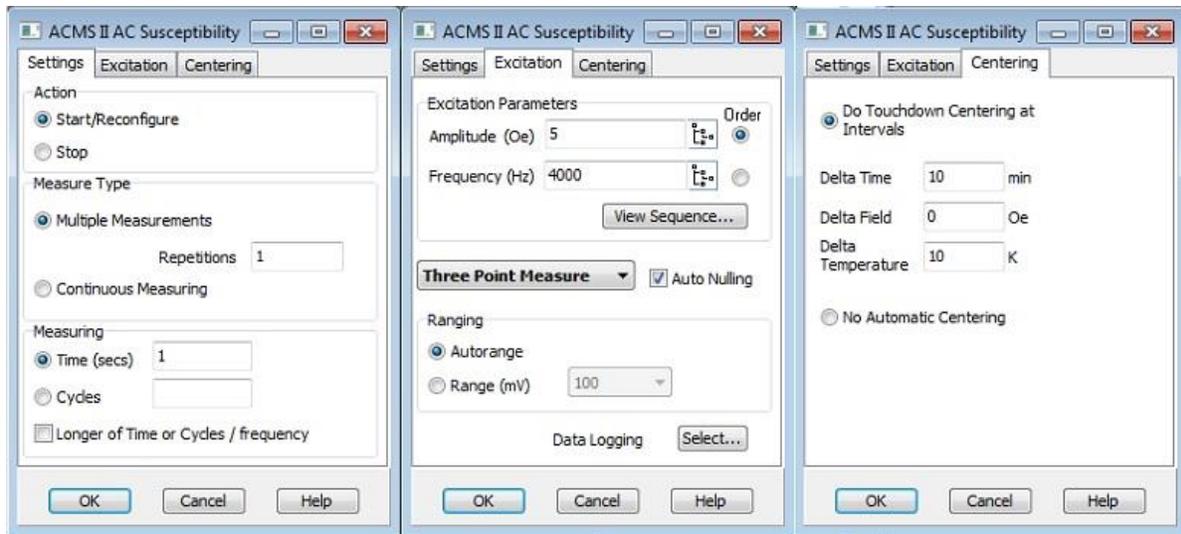


Figure 6-20. Tabs in **ACMS II AC Susceptibility Sequence Command Dialog Box**

- a. Under **Excitation Parameters** check the **Order** button that determines whether the amplitude or frequency is measured first. The measurement order may be important if you are using the **AC Susceptibility** command like a scan command.
- b. Define the **Amplitude** of the sine wave excitation that is applied to the sample. Do one of the following:
  - Enter a single value in the **Amplitude** text box.
  - Select the **Amplitude** button and define an amplitude range in the **Scan AC Field** dialog box. Defining a range prompts the **AC Magnetization** command to function like a scan command. Do the following: specify the initial and final set points, select a spacing mode (see table 6-1), specify the increment between the set points (if applicable), and specify the number of set points.

Table 6-1. Amplitude Spacing Modes

SPACING MODE	DEFINITION
Uniform	Uniform spacing equally spaces the set points. This mode allows you to define the increment separating the set points. Uniform spacing is the default spacing mode.
log(H)	log(H) spacing logarithmically spaces the set points, so defining the increment separating the set points is unnecessary.
H <sup>2</sup>	H <sup>2</sup> spacing equally spaces the set points in the square of the field, so defining the increment separating the set points is unnecessary.

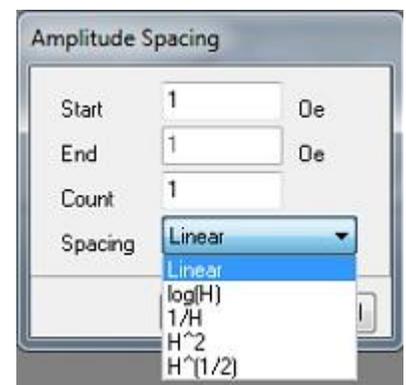


Figure 6-21. **Scan AC Field Dialog Box**



Not all amplitude values can be achieved in all frequency and temperature ranges. Amplitudes up to 10 Oe are producible at all frequencies and temperatures.

- c. Define the **Frequency** of the sample excitation signal. Do one of the following:
  - Enter a single value in the **Frequency** text box.
  - Select the **Frequency** button and define a frequency range in the **Scan Frequency** dialog box. Defining a range prompts the command to function like a scan command. Do the following: specify the initial and final set points, select a spacing mode (see table 6-2), specify the increment between the set points (if applicable), and specify the number of set points.

Table 6-2. Frequency Spacing Modes

SPACING MODE	DEFINITION
Uniform	Uniform spacing equally spaces the set points. This mode allows you to define the increment separating the set points. Uniform spacing is the default spacing mode.
log(f)	log(f) spacing logarithmically spaces the set points, so defining the increment separating the set points is unnecessary.
1/f	1/f spacing uses the inverse frequency to equally space the set points, so defining the increment separating the set points is unnecessary.

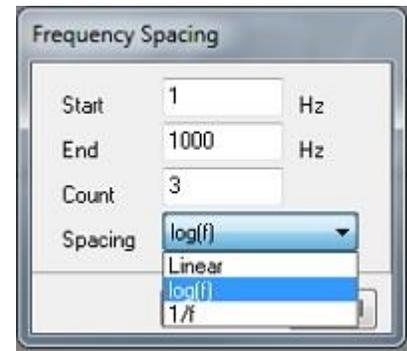


Figure 6-22. Scan Frequency Dialog Box

- d. Select the **View Sequence** button if you want to see a visual representation of the control loop measurement that is defined by the amplitude and frequency ranges. For example, the view tree in figure 6-23 depicts a control loop for a **Moment vs. Amplitude** primary scan mode measurement. Measurements are taken at multiple frequencies while the system holds a single amplitude.
- e. Select the type of measurement from the popup (see Table 4-1).

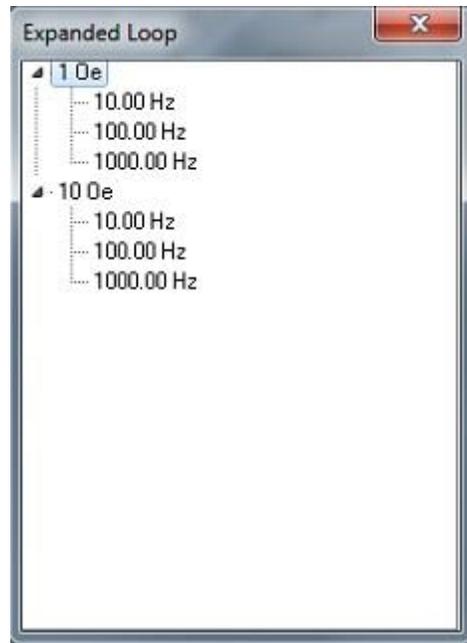


Figure 6-23. ACMS II View Tree

- f. Choose the **Ranging** mode used for voltage detection. **Autorange** changes the gain setting at the beginning of every measurement so that the optimum setting is selected. **Fixed Range** uses only a single user-specified gain setting.
3. Select the **button next to the “Data Logging” entry**, and then select the data items you want to save to the measurement data file. By default, the general system status, system temperature, magnetic field, and the sample temperatures are saved to the file.

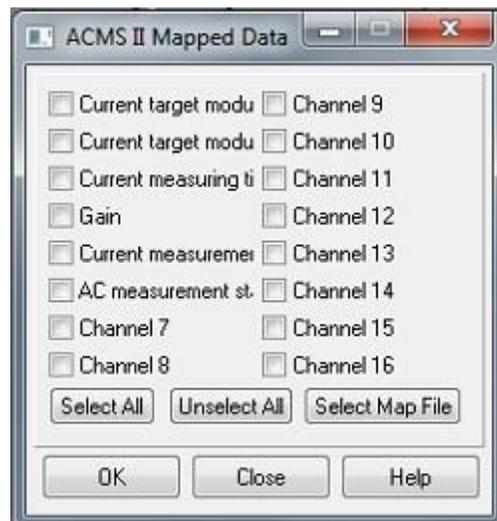


Figure 6-24. **Mapped Data** Tab in **AC Magnetization Sequence Command** Dialog Box

4. Switch to the “Settings” tab and define the averaging time.
5. Select the measurement type and action.
6. Select the **OK** button in the **AC Magnetization** dialog box to add the **AC Magnetization** command to the sequence.

7. Save the sequence.
8. Select a data file and install the sample just as you would for any immediate-mode measurement.

During the sequence run, you may also prompt the ACMS II software to save the sequence measurement data to different data files. Remember to save the sequence again if you make any additional changes to it.

Select any **Run Sequence** command in PPMS MultiVu. Then wait for the sequence run to finish. The commands in the sequence determine the length of time the sequence runs. When the run is complete, all **Run** commands are enabled. The measurement data is automatically saved to the data file you previously selected.

## 6.5.2 Taking a DC Magnetization Measurement in Sequence Mode

To take a measurement in sequence mode, you first define the sequence file and include the measurement command in the sequence file. Then after you install the sample, you run the sequence, and the measurement is executed when the measurement command is read in the running sequence. A single sequence file may include any number of measurement sequence commands.

Complete the following steps to take a DC measurement in sequence mode:

1. Select a new or existing sequence file.
2. Select the **DC Moment** command, which is in the **Measurement Commands ACMS** group in the sequence command bar. Then select the **Measure** tab in the **DC Magnetization** dialog box, and define the DC measurement as follows.
  - a. Define the number of **Scans** that are taken and averaged to obtain a measurement value.
  - b. Select the **Ranging** mode used for voltage detection. **Autorange** changes the gain setting at the beginning of every measurement so that the optimum setting is selected. **Fixed Range** uses only a single user-specified gain setting.

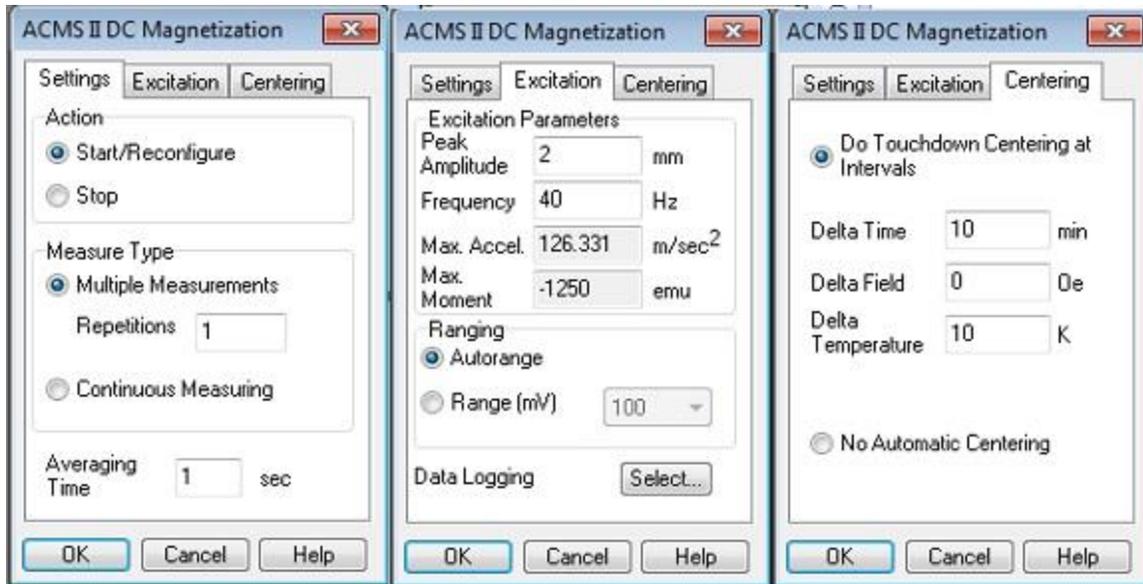


Figure 6-25. Settings Tab in DC Magnetization Sequence Command Dialog Box

3. Select the **button next to the "Data Logging" entry**, and then select the data items you want to save to the measurement data file. By default, the general system status, system temperature, magnetic field, and the sample temperatures are saved to the file.
4. Switch to the "Settings" tab and define the averaging time.
5. Select the measurement type and action.
6. Select the **OK** button in the **DC Magnetization** dialog box to add the **DC Moment** command to the sequence.
7. Save the sequence.
8. Select a data file and install the sample just as you would for any immediate-mode measurement.

During the sequence run, you may also prompt the ACMS II software to save the sequence measurement data to different data files. Refer to section 6.4.3. Remember to save the sequence again if you make any additional changes to it.

9. Select any **Run Sequence** command in PPMS MultiVu. Then wait for the sequence run to finish. The commands in the sequence determine the length of time the sequence runs. When the run is complete, all **Run** commands are enabled. The measurement data is automatically saved to the data file you previously selected.

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## 6.6 Sequence-Mode ACMS II "Center Sample" Command

**Center Sample** sequence commands can be combined with non-ACMS II sequence commands and looping constructs. If you choose not to use automatic centering, you will need to perform centering operations by using the dropdown menu or by inserting centering operations into a

sequence file. As explained in Chapter 4, centering operations help ensure the accuracy of measurements, keeping the centering position stable to within about 0.1 mm at the center of the pickup coils by informing the system about sample position shifts with respect to the coilset.

To insert a centering operation into a sequence file, click on the **Center Sample** sequence command in the **Sequence Commands** bar. This opens the **ACMS II Center Sample Sequence** dialog shown in Figure 6-26.

When the sequence file is run and the program encounters the **Center Sample** sequence command, it temporarily halts the current **ACMS II Measure** command. During the pause, the program performs a centering operation and adjusts the center of oscillation for the measurement. Then it resumes the measure command, continuing from the point where it stopped. This operation takes about 20 seconds.



Figure 6-26. Sequence-mode ACMS II Center Sample command: ACMS II Center Sample Sequence popup

The **Center Sample** sequence command is invaluable when you have disabled automatic centering (by selecting **No Automatic Centering**), but it is also useful when automatic centering has been enabled. In the latter case, you can place the **Center Sample** command in your sequence just before measurements that you would like to have performed without the interruption of a touchdown operation. The measurement is still subject to the other parameters (e.g., **Averaging Time** and **Logging Interval**) that you have set, but by explicitly executing the **Center Sample** command, you reset the beginning of the interval.

---

## 6.7 ACMS II Data Files

Data files have a `.dat` file extension. To save ACMS II measurement data, you must open a measurement data file *before* you start the measurement. You designate data files by creating a new one or selecting a pre-existing one, as is explained in Section 6.4.1.3.

### 6.7.1 Data File Headers

The header of a data file contains information such as the title of the data set and the sample properties. You have the opportunity to include this information when you create the file—this is the only time you can add this information to the data-file header. Instead, after a file has been created, you can append comments.

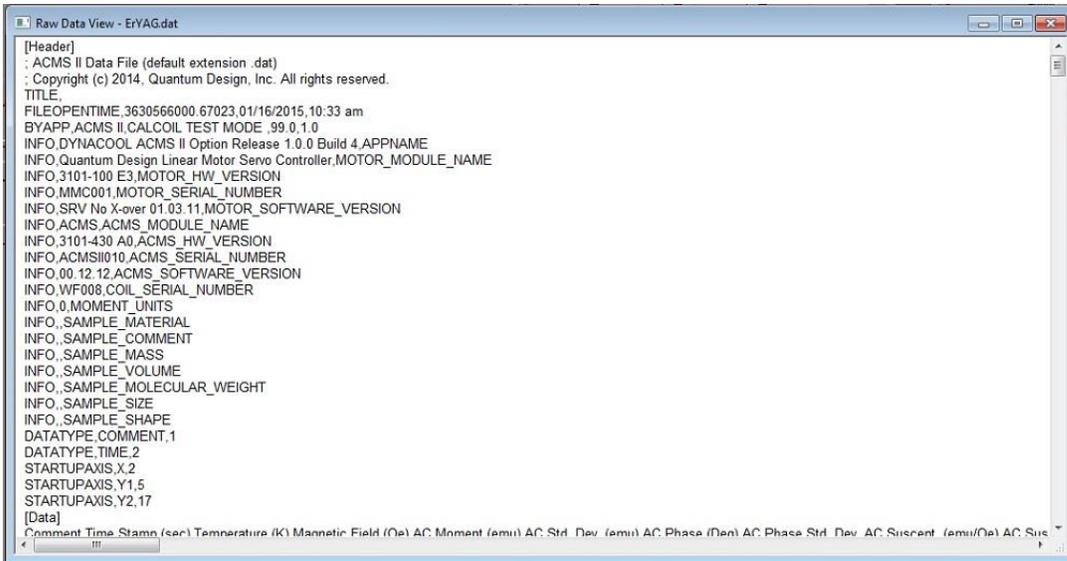


Figure 6-27. A Raw Data view of the ACMS II data file

## 6.7.2 Fields in ACMS II Data Files

Table 6-3 defines the fields in a ACMS II data file, and Section 6.4.1.3 explains how to create ACMS II measurement data files.

Table 6-3. Definitions of column headers for ACMS II data files (\*.dat files), shown in the order they appear.

COLUMN HEADER/TERM	DEFINITION
<b>Comment</b>	user-specified comment; added by using the Datafile Comment command
<b>Time stamp (sec)</b>	time stamp of the measurement
<b>Temperature (K)</b>	average temperature (T) of the sample during measurements. The sample temperature is measured by the coil thermometer.
<b>Magnetic field (Oe)</b>	average magnetic field during measurement
<b>AC Moment (emu)</b>	Average AC magnetic moment of the sample
<b>AC Std. Dev. (emu)</b>	Standard deviation of the AC moment
<b>AC Phase (Deg)</b>	Phase angle of the AC moment in relation to the drive field
<b>AC Phase Std. Dev. (Deg)</b>	Standard deviation of the phase angle
<b>AC Suscept. (emu/Oe)</b>	Magnetic susceptibility of the sample (moment/drive)
<b>AC Suscept. Std. Dev. (emu/Oe)</b>	Standard deviation of the susceptibility
<b>AC X' (emu/Oe)</b>	In-phase component of the sample susceptibility
<b>AC X'' (emu/Oe)</b>	Quadrature component of the sample susceptibility
<b>AC X' Std. Dev. (emu/Oe)</b>	Standard deviation of the in-phase component
<b>AC X'' Std. Dev. (emu/Oe)</b>	Standard deviation of the quadrature component
<b>AC Drive (Oe)</b>	AC drive field applied to the sample
<b>AC Frequency (Hz)</b>	AC frequency of the drive field
<b>DC Moment (emu)</b>	Average DC magnetic moment of the sample (synchronous component)
<b>DC Std. Err. (emu)</b>	Standard error of the DC moment
<b>DC Quad. Moment (emu)</b>	Quadrature component of the DC moment (out of phase component)

COLUMN HEADER/TERM	DEFINITION
Range (mV)	Range 1mV, 10mV, 100mV of the signal amplifier
AC=1 DC=2 Locate=3	Measurement type as indicated by the number
Measure Type	AC measure type: 1=one point 3=three point 5=five point
Measure Count	Number of signal (V) readings used to calculate the moment
Measure Time (sec)	Elapsed time of the measurement
Measure Number	Sequential number for a measurement in a multi-measurement command
AC' Raw (emu/Oe)	In-phase component of the sample susceptibility without corrections
AC'' Raw (emu/Oe)	Quadrature component of the sample susceptibility without corrections
DC' Raw (emu)	Average DC magnetic moment (in-phase) of the sample without corrections
DC'' Raw (emu)	Quadrature component of the DC moment without corrections
Coil InPhase (V)	Average in-phase component of the raw signal voltage readings
Coil Quad. (V)	Average quadrature component of the raw signal voltage readings
Max Signal (V)	Maximum voltage read by the AD converter during the measurement (future)
Motor Frequency (Hz)	Measured vibration frequency of the motor used for the DC measurement
Motor Ampl. (mm)	Measured vibration amplitude of the motor used for the DC measurement
System temp. (K)	block temperature
System field (Oe)	currently the same as the "Magnetic Field (Oe)" column
Min. temperature (K)	minimum temperature reading of the coil thermometer for this measurement
Max. temperature (K)	maximum temperature reading of the coil thermometer for this measurement
Min. field (Oe)	minimum field reading of the coil thermometer for this measurement
Max. field (Oe)	maximum field reading of the coil thermometer for this measurement
Pressure (torr)	pressure in sample chamber
Temp. Status (code)	Status of the temperature of the system (eg. Stable, see system manual)
Field Status (code)	Status of the system magnet (eg. holding, see system manual)
Chamber Status (code)	Status of the chamber of the system (eg. Purged, see system manual)
ACMS II status (code)	status codes unique to the ACMS II module
Motor status (code)	status codes unique to the motor module
Measure status (code)	error condition codes of varying severity. Zero indicates no errors.
Center position (mm)	Average position of the transport for the current data point. Position is reported in motor coordinates and does not reflect the sample offset position that is shown in the locate dialog.
Transport action	1 = measurement 2 = auto-touchdown 3 = manual touchdown
Motor lag (deg)	phase lag between motor drive current and motion
Motor Current (Amps)	Motor current required to maintain position and amplitude
Motor Heatsink Temp. (C)	Temperature of the motor heatsink
Motor Board Temp. (C)	Temperature of the motor board

# Model CM-A Sample Motor Module

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## A.1 Introduction

This appendix contains the following information:

- Section A.2 provides a functional overview of the Model CM-A sample motor module, including a block diagram and electrical specifications.
- Section A.3 describes the front panel and relevant components of the Model CM-A sample motor module.
- Section A.4 describes the back panel and relevant components of the Model CM-A sample motor module.
- Section A.5 describes maintenance of the Model 1000.

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## A.2 Functional Overview

The Model CM-A (4101-100) is a servomotor controller module that was designed with the specific needs of the sample motor in mind. Figure A-1 shows the module and the front panel.

The principle function of this module is to provide closed-loop servo control to a linear motor equipped with a position encoder output. A programmed wave table allows the module to drive the motor sinusoidally at 40 Hz. The servo loop is closed digitally at about 2000 Hz using a 16-bit current source and the read-back from the position encoder. For use with other synchronous detection hardware, including the Model CM-M ACMS II detection module, the real-time encoder position is output digitally, using a high-speed serial port, and as a voltage through a BNC connector. Other features include in-system programmable on-board flash memory for program storage and a serial ROM for calibration and other configuration data.

The module is designed to plug into the Model 1000 modular control system or an equivalent host chassis that can provide power and the required CAN network signals that communicate with the module.

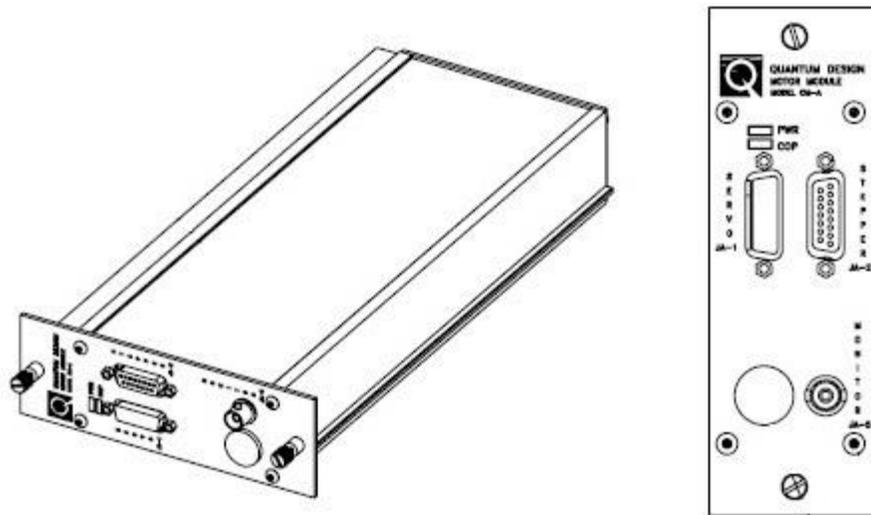


Figure A-1. Model CM-A sample motor module (4101-100)

### A.2.1 Functional Block Diagram

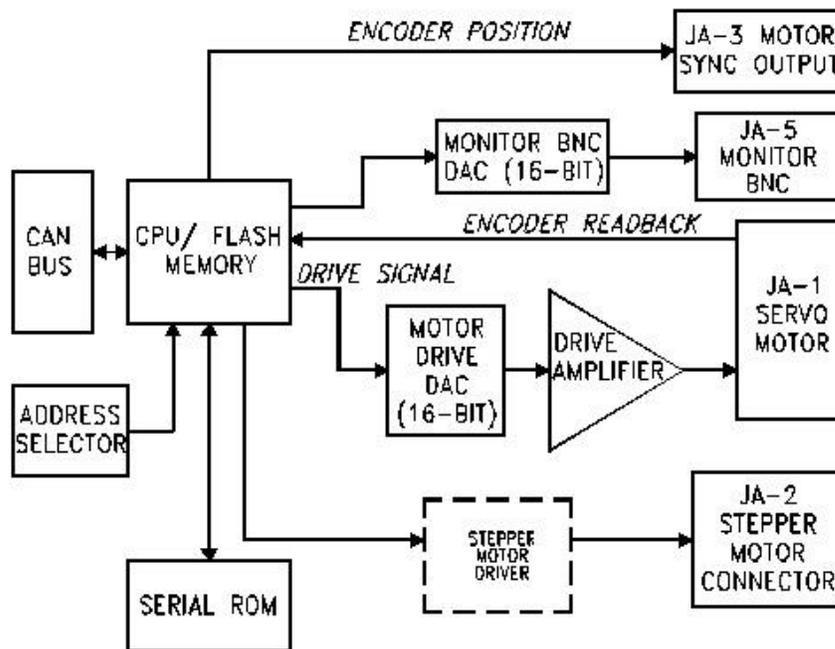


Figure A-2. Abridged functional block diagram of Model CM-A sample motor-module specifications

## A.2.2 Specifications

Table A-1. Electrical specifications for Model CM-A motor module

Drive Current Limit	3 A
Drive Voltage Compliance Limit	20 V peak
Encoder Range	32-bit
Supply Voltage	±24 V DC

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## A.3 Model CM-A Sample Motor Module: Front Panel

### A.3.1 Indicator LEDs

The front panel of the Model CM-A motor module has two LEDs in the top left, as shown in Figure A-1. The PWR LED indicates the power-on status of the module. The COP (CANopen Protocol) LED indicates the status of the CAN network controller. Table A-2 outlines the LED states and provides solutions in the event of a problem.

**Important:** The error information in Table A-2 refers to situations that persist for longer than about 15 seconds. Typically, when the module is powered on, the LEDs may briefly flash red before they turn green. This is a normal part of the startup or reset sequence.

Table A-2. LED guide for Model CM-A VSM motor module

LED	COLOR	STATUS	MEANING AND/OR SOLUTION
PWR	Green	On	The processor is running with no errors (normal).
	Red	Flashing	Errors were encountered during the self-test. The flashing sequence can be used to determine the cause of the failure.
COP	Green	On	CAN status is operational (normal).
		Flashing	CAN status is pre-operational. Verify that cable is connected to PC.
	Red	On or flashing	Error on the CAN bus. Contact Quantum Design for assistance.

If you are unable to achieve operation with both LEDs green, please contact Quantum Design for assistance.

## A.3.2 Connectors and Pinout Tables

### A.3.2.1 JA-1: SERVO CONNECTOR

This connector is used to provide the current drive to the motor and read back the position information from the encoder. This connector also supports serial communication to logic associated with the motor (e.g., serial ROM for storing calibration or configuration information about the motor).

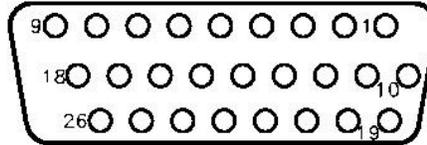


Figure A-3. JA-1: Servo connector for the Model CM-A motor module

Table A-3. JA-1: Servo connector for the Model CM-A motor module

PIN	FUNCTION
1	Motor -
2	+5 V
3	Encoder Input A+
4	Encoder Input B+
5	Unused Encoder Input Z+
6	n.c.
7	n.c.
8	Motor Max Limit Switch
9	Motor Min Limit Switch
10	Motor +
11	Ground
12	Encoder Input A-
13	Encoder Input B-
14	Unused Encoder Input Z-
15	n.c.
16	n.c.
17	Motor Max Limit Switch Rtn
18	Motor Min Limit Switch Rtn
19	Serial Com Data Out
20	Serial Com Data Input
21	Serial Com Clock
22	Serial Com Select 1
23	Serial Com Select 2

**A.3.2.2 JA-2: STEPPER CONNECTOR**

The stepper connector is available for future expansion. You must contact Quantum Design before you attempt to use the connector.

**A.3.2.3 JA-3: MOTOR SYNC CONNECTOR**

This connector outputs the motor encoder position as a high-speed digital serial signal.

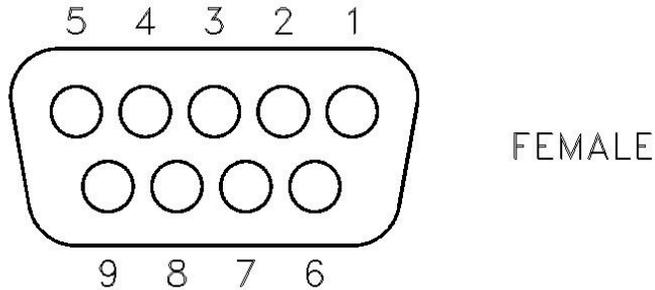


Figure A-4. JA-3: Motor sync connector for the Model CM-A motor module

Table A-4. JA-3: Motor sync connector for the Model CM-A motor module

PIN	FUNCTION
1	Sync +
2	Data +
3	Clock +
4	PSync +
5	Ground
6	Sync –
7	Data –
8	Clock –
9	PSync –

### A.3.2.4 JA-4: AUX CONNECTOR

This connector provides three analog inputs and three digital I/O lines for future options.

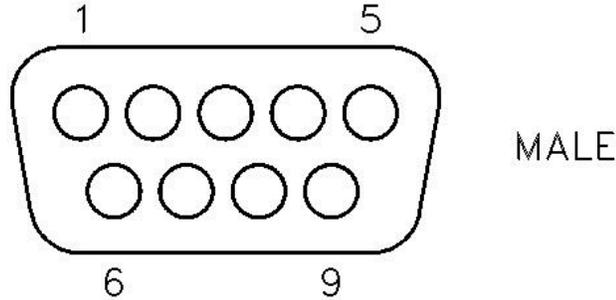


Figure A-5. JA-4: Aux connector for the Model CM-A motor module

Table A-5. JA-4: Aux connector for the Model CM-A motor module

PIN	FUNCTION
1	+5 V
2	Digital I/O P3.10
3	n.c.
4	Analog Input P5.13
5	Ground
6	Digital I/O P3.11
7	Digital I/O P3.8
8	Analog Input P5.12
9	Analog Input P5.14

### A.3.2.5 JA-5: MONITOR BNC

This connector is for use by Quantum Design. It can be configured to output signals for diagnostic purposes. By default, the firmware is configured to output the motor position here.

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## A.4 Model CM-A Sample Motor Module: Rear Panel

The rear panel of the module contains an address selector, a single-guide hole, and the CAN connector through which the module sends and receives network data and receives power.

### A.4.1 Address Selector

Each module on the CAN bus must have a unique 5-bit binary address. The selector on the back panel is used to set the four least significant bits, and an internal jumper sets the most significant bit. If the selector is set to zero (0), the module uses its default address. For a Model CM-A motor module, the default address is 10 (or equivalently, “A” on the selector).

### A.4.2 Single Guide Hole

The single guide hole is used to align the connector with one of the back-row (high-power) receptacles on the Model 1000 modular control system.

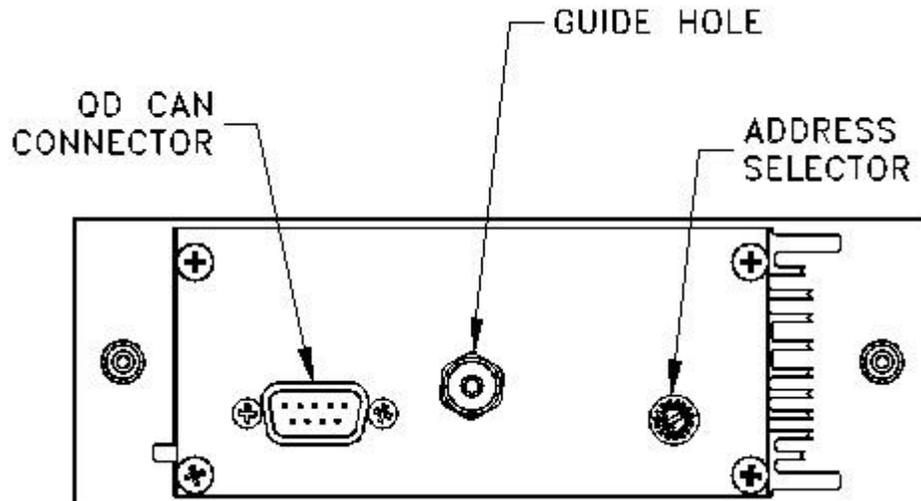


Figure A-6. Rear panel of the Model CM-A motor module

### A.4.3 QD CAN Connector

The QD CAN connector is the main communication connection for controlling the module. The CAN network signals (CAN High, CAN Low) are connected to all other CAN modules on the bus and to the PC. Power ( $\pm 24$  volts), reset, and sync signals are also provided to the module through this connector.

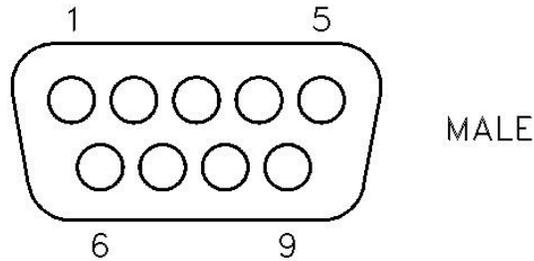


Figure A-7. QD CAN connector on the rear of the Model CM-A motor module

Table A-6. QD CAN connector on the rear of the Model CM-A motor module

PIN	FUNCTION
1	-24 V
2	CAN Low
3	Power Return (24V)
4	Sync Low
5	Line Sync
6	System Ground
7	CAN High
8	Sync High / Reset
9	+24 V DC

---

## A.5 Maintenance

(Service Note 1096-307)

The CAN motor module CM-A (QD part number 4101-100), which is used to drive the linear motor of the ACMS II option, dissipates a significant amount of heat when providing the large currents (sometimes over 1 amp) to the motor drive coil. Therefore, it is critical that adequate air cooling is supplied by the fan on the back of the Model 1000 Modular Control Center. If the motor module overheats, the current output is turned off abruptly until the amplifiers cool sufficiently, at which point the current is turned back on. This causes erratic behavior of the motor and presents a hazard to the user. It might also result in damage to the hardware or your research sample.

To help prevent such overheating effects, please follow these guidelines:



**WARNING!**

As with any CAN module, turn off the power to the Model 1000 before inserting or removing the motor module.

- Regularly—every few months—clean the filter of the air intake fans on the back of the Model 1000. In the case of the upper fan for the module cooling (this is the most critical fan), remove the filter by first pulling off the black plastic guard. The lower fan, for the power supply drawer, can be cleaned by turning off the Model 1000 and vacuuming the outside of the filter.
- Maintain a laboratory temperature below 25 °C.
- Keep the Model 1000 at least 25cm away from walls so that air flow is not impeded.
- Cooling air inside the Model 1000 flows upward past the module and exits at the grate by the front plate of the modules. Make sure these grates are unobstructed.
- Try to minimize the dust level in the lab and keep the floors clean.
- Connect all cables before activating the ACMS II option, and do not unplug the motor drive cable while the option is activated. Reconnecting the cable in this state can lead to motor malfunction.

Quantum Design is continually working to improve the handling of error conditions such as this by enhancing the software, module firmware, and module hardware. Updates to option software (such as the PPMS ACMS II option), new service notes, and application notes are posted on our website [www.qdusa.com](http://www.qdusa.com). Firmware and hardware updates are handled on an individual basis by Quantum Design service.

If you are encountering performance problems with your motor module after observing the above maintenance steps, please contact your local Quantum Design service representative.



# Model CM-M ACMS II Module

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## B.1 Introduction

This appendix contains the following information:

- Section B.2 provides a functional overview of the Model CM-M-ACMS II module, including a block diagram and electrical specifications.
- Section B.3 describes the front panel and relevant components of the Model CM-M ACMS II module.
- Section B.4 describes the back panel and relevant components of the Model CM-M ACMS II module.

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## B.2 Functional Overview

The Model CM-M (4101-430) is a synchronous detection module that performs the real-time signal processing for the ACMS II option. The module and its front panel are shown in Figure B-1.

The principle function of this module is to detect the in-phase and quadrature-phase components of one or two input signals (e.g., pickup coils), as well as a digital reference from, say, a position encoder. The detection is done by multiplying each of the signals by both a sine function and a cosine function. These sine components are computed once per cycle and can be output at this rate, or they can be averaged for multiple cycles with statistics calculated for the ensemble of measurements. Other features include a thermometer bridge circuit for temperature measurements, two programmable gain amplifiers, in-system programmable on-board flash memory for program storage, and a serial ROM for calibration and other configuration data.

The module is designed to plug into the Model 1000 modular control system or an equivalent host chassis that can provide power and the required CAN network signals to communicate with the module.

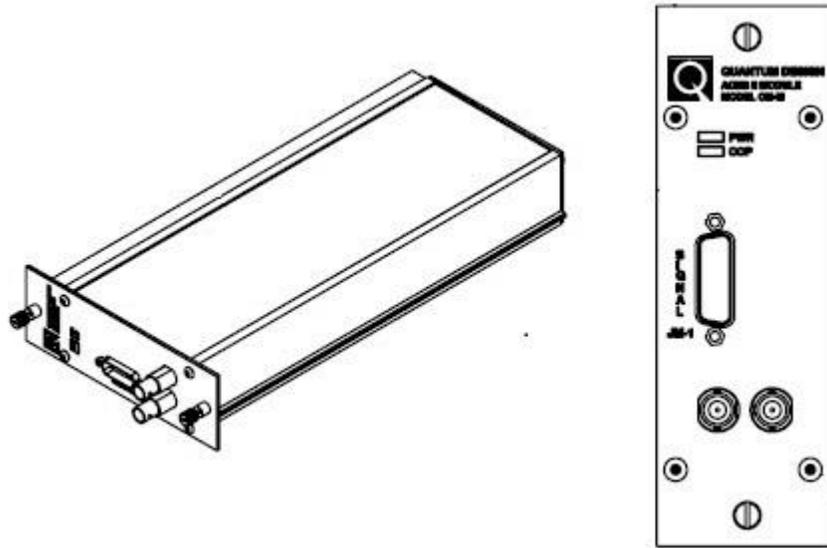


Figure B-1. Model CM-M ACMS II module (4101-430)

### B.2.1 Functional Block Diagram

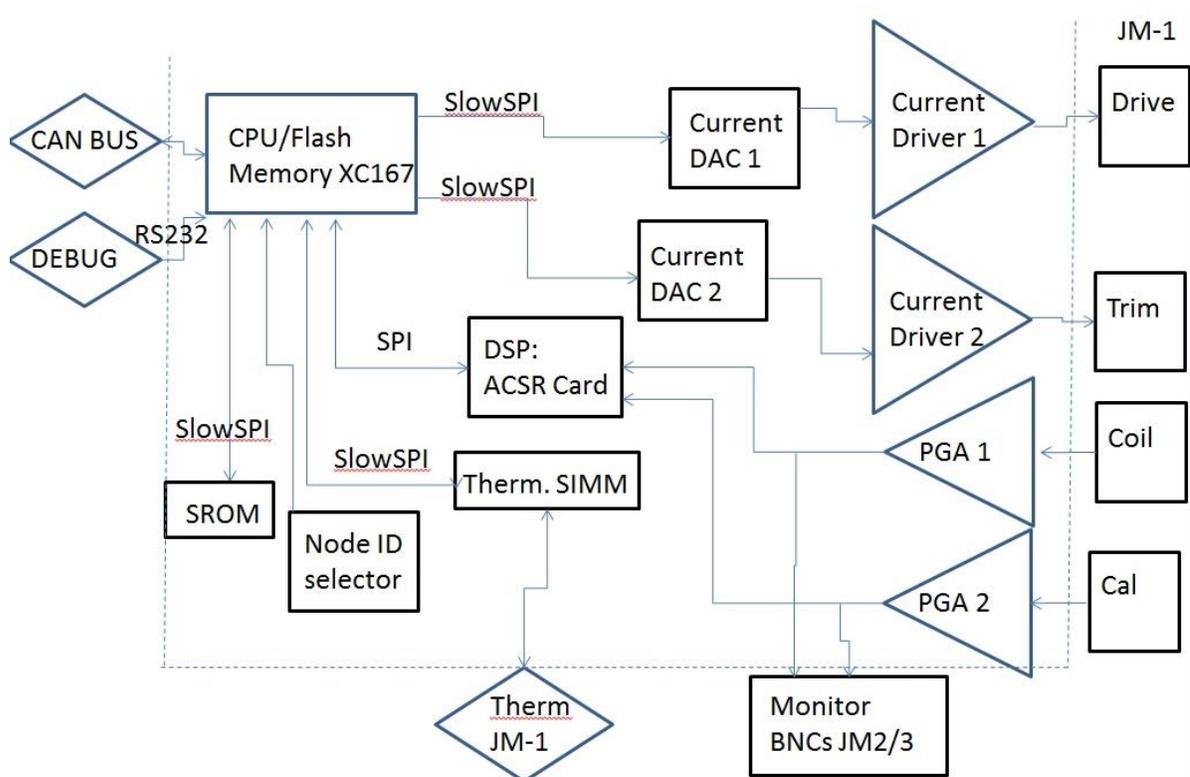


Figure B-2. Abridged functional block diagram of the Model CM-M ACMS II module

## B.2.2 Specifications

Table B-1. Electrical specifications for the Model CM-M ACMS II module

Input Ranges (from preamp)	5 V, 0.5 V, 50 mV, 5 mV
Thermometer Current Ranges	±0.02 mA, ±0.5 mA
Thermometer Voltage Range	±10 mV
Thermometer Sample Rate	14 Hz
Thermometer Resistance Range	20 to 200,000 ohms
Supply Voltage	±24 V DC

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## B.3 Model CM-M ACMS II Module: Front Panel

### B.3.1 Indicator LEDs

The front panel of the Model CM-M ACMS II module has two LEDs in the top left, as shown in Figure B-1. The PWR LED indicates the power-on status of the module. The COP (CANopen Protocol) LED indicates the status of the CAN network controller. Table B-2 outlines the LED states and provides solutions in the event of a problem.

**Important:** The error information in Table B-2 refers to situations that persist for longer than about 15 seconds. Typically, when the module is powered on, the LEDs briefly flash red before they turn green. This is a normal part of the startup or reset sequence.

Table B-2. LED guide for the Model CM-M ACMS II detection module

LED	COLOR	STATUS	MEANING AND/OR SOLUTION
PWR	Green	On	The processor is running with no errors (normal)
	Red	Flashing	Errors were encountered during the self-test. The flashing sequence can be used to determine the cause of the failure.
COP	Green	On	CAN status is operational (normal)
		Flashing	CAN status is pre-operational. Verify that cable is connected to PC.
	Red	On or flashing	Error on the CAN bus. Contact Quantum Design for assistance.

If you are unable to achieve operation with both LEDs green, please contact Quantum Design for assistance.

## B.3.2 Connectors and Pinout Tables

### B.3.2.1 JM-1: SIGNAL CONNECTOR

This connector is the main connection to the coilset puck. It contains two analog inputs for the synchronous detection, current and voltage for a thermometer, and two current outputs for the drive signals when performing AC measurements.

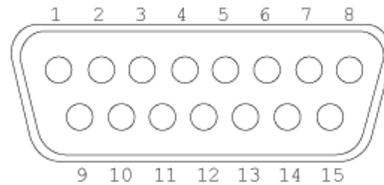


Figure B-3. JM-1: Signal connector for the Model CM-M ACMS II module

Table B-3. JM-1: Signal connector for the Model CM-M ACMS II module

PIN	FUNCTION
1	Trim Coil Current +
2	N/C
3	Drive Coil Current -
4	Cal Coil Signal -
5	Gradiometer Signal -
6	N/C
7	Thermometer Current +
8	Thermometer Voltage +
9	Trim Coil Current +
10	Drive Coil Current +
11	N/C
12	Cal Coil Signal +
13	Gradiometer Signal +
14	Thermometer Current -
15	Thermometer Voltage -

### B.3.2.2 JM-2 & JM-3: MONITOR BNCs

These connectors allow external monitoring of various signals. The default configuration shows the pickup coil signal on JM-2 and (for AC measurements) the excitation signal on JM-3.

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## B.4 Model CM-M ACMS II Module: Rear Panel

The rear panel of the Model CM-M ACMS II module contains an address selector, two guide holes, and the CAN connector through which the module sends and receives network data and receives power.

### B.4.1 Address Selector

Each module on the CAN bus must have a unique 5-bit binary address. The selector on the back panel is used to set the four least significant bits, while an internal jumper sets the most significant bit. If the selector is set to “0,” the module uses its default address. For a Model CM-M ACMS II module, the default address is 22 (selector set to 6).

### B.4.2 Guide Holes

The two guide holes are used to align the connector with either a low-power receptacle or a high-power receptacle on the Model 1000 modular control system.

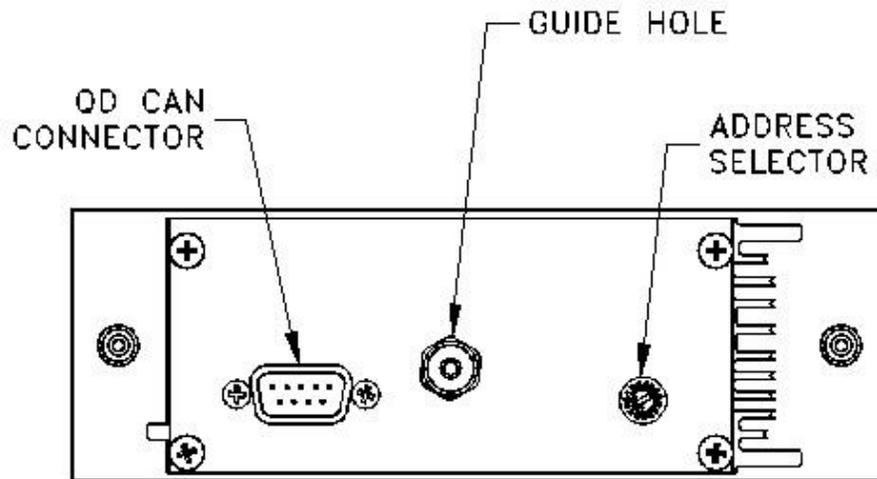


Figure B-4. Rear panel of the Model CM-M ACMS II detection module

### B.4.3 QD CAN Connector

The QD CAN connector is the main communication connection for controlling the Model CM-M ACMS II module. The CAN network signals (CAN High, CAN Low) are connected to all other CAN modules on the bus and to the PC. Power ( $\pm 24$  volts), reset, and sync signals also are sent to the module through this connector.

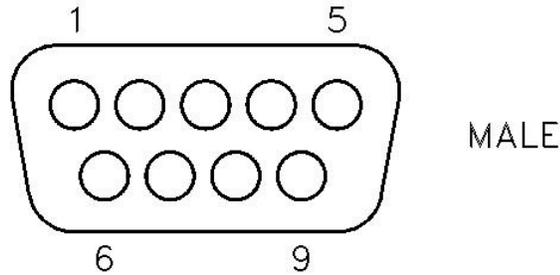


Figure B-5. QD CAN connector on rear of the Model CM-M ACMS II module

Table B-4. QD CAN connector on the rear of the Model CM-M ACMS II module

PIN	FUNCTION
1	-24 V
2	CAN Low
3	Power Return (24V)
4	Sync Low
5	Line Sync
6	System Ground
7	CAN High
8	Sync High / Reset
9	+24 V DC

# ACMS II Moment Calculations

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## C.1 Definitions

$M$ Sample Signal	$BG$ Background Signal
$CC$ CalCoil Signal	$r$ CalCoil ratio (center/max = 0.15)
$k$ CalCoil sensitivity (1/1210)	

## C.2 Measured Values based on Channel and Sample Position

	Ch1 (Sample only)	Ch2+ (Sample + CalCoil)	Ch2- (Sample - CalCoil)
Top (T)	$BG - M$	$BG - (1 - k) \times M + CC$	$BG - (1 + k) \times M - CC$
Center (C)	$BG$	$BG + r \times k \times M + CC$	$BG - r \times k \times M - CC$
Bottom (B)	$BG + M$	$BG + (1 + k) \times M + CC$	$BG + (1 - k) \times M - CC$

## C.3 1-Point Measurement

Measurement Sequence: B

Moment calculation:

1 Sample Signal

$$M_S = \text{Ch1}(B) - BG$$

(using background measured at the Center position before starting the first 1-point measurement with given parameters)

2 CalCoil Signal

$$CC = \text{Ch2}(B) - \text{Ch1}(B) - k \times M_S$$

(CalCoil Signal is calculated for first 1-point measurement with given parameters and then reused for subsequent points)

3 Raw Sample Moment

$$M_{raw} = \frac{M_S}{CC}$$

## C.4 3-Point Measurement:

Measurement Sequence: B<sub>1</sub>TB<sub>2</sub>B<sub>3</sub> (B<sub>3</sub> uses negative CalCoil polarity)

Moment calculation:

1. Sample Signal

$$M_S = \frac{\text{Ch1}(B_1) - 2 \times \text{Ch1}(T) + \text{Ch1}(B_2)}{4}$$

2. CalCoil Signal

$$CC = \frac{\text{Ch2}(B_2) - \text{Ch2}(B_3)}{2} - k \times M_S$$

3. Raw Sample Moment

$$M_{raw} = \frac{M_S}{CC}$$

## C.5 5-Point Measurements

Measurement Sequence: C<sub>1</sub>B<sub>1</sub>TB<sub>2</sub>B<sub>3</sub>C<sub>2</sub> (B<sub>3</sub> uses negative CalCoil polarity)

Moment calculation:

1. Drift

$$\frac{\Delta V_{\text{Ch1}}}{\Delta t_{CC}} = \frac{\text{Ch1}(C_2) - \text{Ch1}(C_1)}{t(C_2) - t(C_1)}; \quad \frac{\Delta V_{\text{Ch2}}}{\Delta t_{BB}} = \frac{\text{Ch2}(B_2) - \text{Ch2}(B_1)}{t(B_2) - t(B_1)}$$

2. Time Difference between  $t(T)$  and temporal midpoint between  $t(B_1)$  and  $t(B_2)$

$$\Delta t_{BTB} = \frac{t(B_1) + t(B_2)}{2} - t(T)$$

3. Drift-corrected value for  $T$  Measurement ( $T^*$ )

$$\text{Ch1}(T^*) = \text{Ch1}(T) + \Delta t_{BTB} \times \frac{\Delta V_{\text{Ch1}}}{\Delta t_{CC}}$$

4. Sample Signal

$$M_S = \frac{\text{Ch1}(B_1) - 2 \times \text{Ch1}(T^*) + \text{Ch1}(B_2)}{4}$$

5. Drift-corrected value for  $B_2$  Measurement ( $B_2^*$ )

$$\text{Ch2}(B_2^*) = \text{Ch2}(B_2) + (t(B_3) - t(B_2)) \times \frac{\Delta V_{\text{Ch2}}}{\Delta t_{BB}}$$

6. CalCoil Signal

$$CC = \frac{\text{Ch2}(B_2^*) - \text{Ch2}(B_3)}{2} - k \times M_S$$

7. Raw Sample Moment

$$M_{\text{raw}} = \frac{M_S}{CC}$$

