



MPMS Application Note 1014-825

Using the New MPMS Multivu Multiple Measure Sequence Command

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

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

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

Accessing and Using the Multiple-Measure Command

The **Multiple-Measure** command is a sequence command. Hence, it is located in the **Measure Commands** section of the **Sequence Command** bar, which is shown in Figure 1. The following section explains how to access and use the **Multiple Measure** command.

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

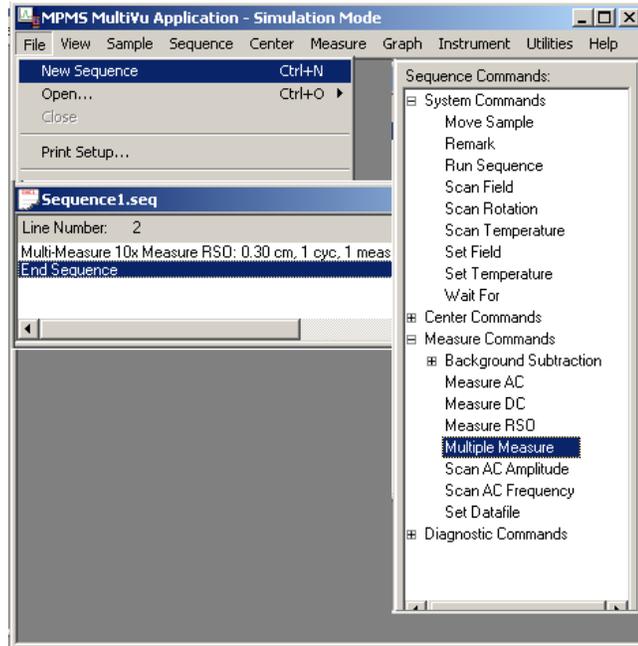


Figure 1. MPMS MultiVu Window, Sequence Commands panel, and new sequence file

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

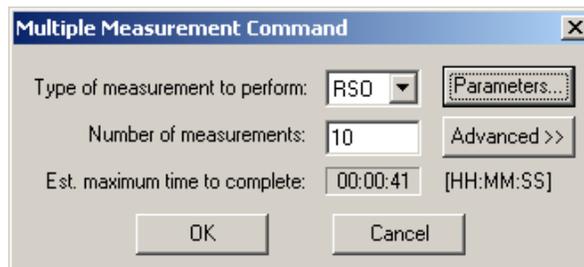


Figure 2. Multiple Measurement dialog box set up to perform RSO measurements.

In Figure 2, the dialog box is set to perform 10 RSO measurements. Additional specifications can be made by using the **Parameters** and **Advanced** buttons on the right side of the dialog box.

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

For example, because the **Multiple Measurement Command** dialog box in Figure 2 is set up for RSO measurements, clicking on the **Parameters** button produces the **Measure RSO** dialog box, as shown in Figure 3. In this example, a typical RSO measurement will consist of a 4 cm center scan at 1 Hz with 5 cycles per scan and 3 scans per measurement. For every measurement, the usual information will be recorded in the .dat, .raw, and .diag files.

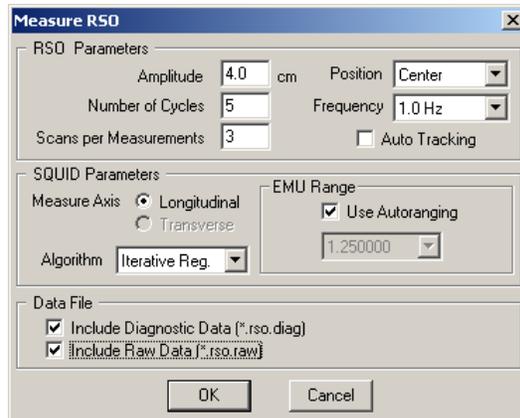


Figure 3. Measure RSO dialog box for setting measurement parameters

The **Advanced** button acts differently. If you click on the **Advanced** button, the **Multiple Measurement Command** dialog box (Figure 2) expands to show a **Measurement Rejection Criteria** panel (see Figure 4). In this panel you can specify the criteria that will be used to reject individual measurements from the data that is collected. You can set two rejection criteria:

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

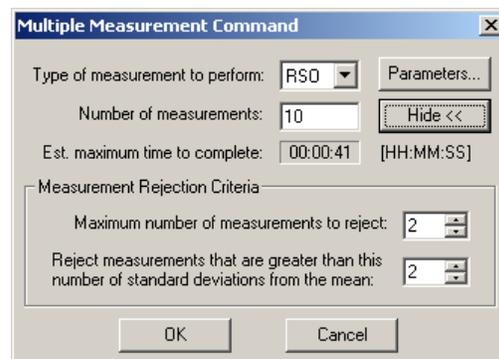


Figure 4. Multiple Measurement Command dialog box after the Advanced button has been selected. Note the Measurement Rejection Criteria panel in the lower half of the window.

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

As depicted in Figure 4, the **Multiple Measurement Command** is set to perform 10 RSO type measurements. The **Multiple Measurement Command** also is set to reject a maximum of two deviant measurements and to reject measurement values that are more than two standard deviations from the mean.

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

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

For the data collected with the settings in Figure 4, a maximum of two measurements could be removed, and a measurement would have to be more than two standard deviations larger or smaller than the mean value before it would be rejected.

Checking the Status of a Multiple-Measure Command

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

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

As illustrated in Figure 5, the **Sample** is Unnamed, and the name of the **Selected Sequence**, Sequence1.seq, is that of the open sequence file.

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

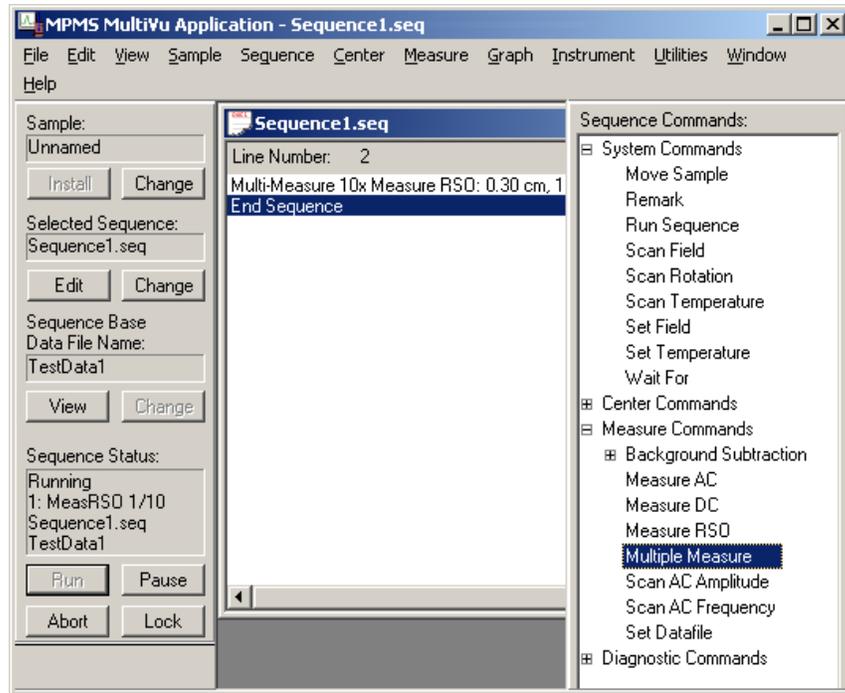


Figure 5. MPMS MultiVu window showing Control Center panel (left side), Sequence Commands, and sequence file

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

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

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

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

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

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

Reading the Statistical Data (.ndat) File

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

One data line (or record) is written to the .ndat file for each completed **Multiple Measure** command. To see the statistical data for the measurements, open the .ndat file and select **View >> Record**. Figure 6 illustrates a data record and its layout. The data fields are defined as follows:

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

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

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

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

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

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

Figure 6. Contents of the statistical data file for record #10 of quartzVR1.rso. Note the .ndat ending for the filename

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

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

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

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

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

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

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

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

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

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

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

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

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