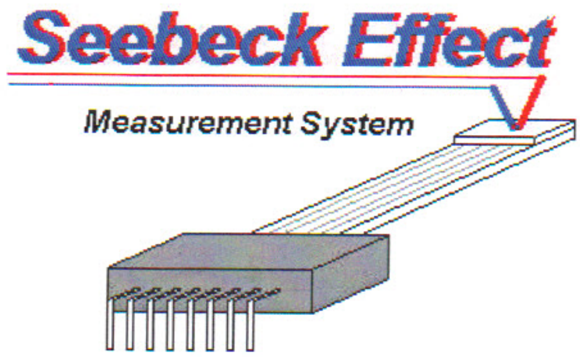
Seebeck Effect Measurement System
Windows® Version



MMR Seebeck Measurement System Program.
Version 5.10 Copyright © 1993-2005
For assistance call (650) 962-9620. FAX (650) 962-9647.

USER'S MANUAL

MMR Technologies, Inc.
1400 North Shoreline Blvd., Suite A5
Mountain View, CA 94043
(650) 962-9620
www.mmr-tech.com

Seebeck Effect Measurement System
Windows® Version

USER'S MANUAL

MMR Technologies, Inc.
1400 North Shoreline Blvd., Suite A5
Mountain View, CA 94043
(650) 962-9620
www.mmr-tech.com

SEEBECK MEASUREMENT SYSTEM

MMR TECHNOLOGIES, INC.
MOUNTAIN VIEW, CA

USER'S MANUAL

TABLE OF CONTENTS

SECTION I: THEORY OF OPERATION

The system described below measures the Thermo- voltage (Seebeck Voltage) of metals and semiconductors. It also provides the user with the opportunity to study the temperature dependence of the Seebeck Voltage for different materials. Fig 1 shows a picture of the Seebeck Stage which is attached to the cold stage of the MMR refrigerator.

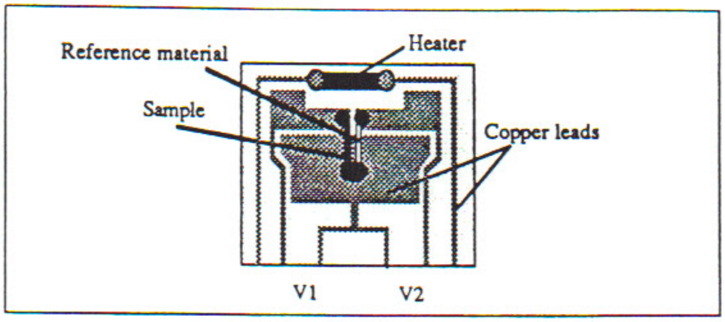


Fig.1 MMR Seebeck Stage

A. Theory of Operation

The Seebeck Stage has two pairs of thermocouples: one of copper and a metal with known properties, and the other pair of copper and a metal with properties to be determined. One of the junctions in each pair is considered a reference junction, and the other the working or temperature modulated junction. The Stage also has a computer controlled heater, located close to the working junctions of each pair, and remote from the reference junctions. This heater is controlled by the MMR Programmable Seebeck Controller SB100. The Seebeck stage is attached to the cold stage of an MMR refrigerator, which provides a given stable temperature for the measurement. The MMR Cold stage is controlled by the MMR K20A Programmable Temperature Controller. The Seebeck Stage has two outputs: V1 and V2, which are monitored by a computer through the SB100.

The principle of operation is the following. Assume, that all four thermocouples are at the same temperature. Then V1 and V2 will be zero because each member of each pair of thermocouples compensate the voltage of the othe. If power is applied to the heater, then a temperature difference will be created between the working and the reference junctions because they are located at different distances from the heater. As a result, thermo-voltages will be generated in each pair giving non zero output voltages V1 and V2. These are given by:

$$V1 = \varepsilon_1 \Delta T(P) \quad (1)$$

and,

$$V2 = \varepsilon_2 \Delta T(P) \quad (2),$$

where ε_1 and ε_2 are the specific thermo-voltages of the sample and known thermocouples respectively and $\Delta T(P)$ is the temperature difference between the working and the reference junctions created by applying power P to the computer controlled heater. We expect, that the temperature difference $\Delta T(P)$ will be the same for both pairs, because the stage has a symmetrical shape. The value of the specific thermo-voltage of the unknown junction is then:

$$\varepsilon_1 = \varepsilon_2 \, V1/V2 \quad (3).$$

However, one should use a small temperature deviation ΔT in order to obtain representative data in the temperature domain. Therefore, the values of V1 and V2 also will be small. Because of this a direct measurement will not give high accuracy, because of instrumental errors and any undesired thermo-voltage effects from wires, connectors, etc. These effects can create substantial offset voltages which, in addition to the temperature drifts and offsets of the input amplifiers, can contribute a major source of measurement error. These can be eliminated, however, by taking mesuarements at two different temperature offsets, using two different power settings, and then using the difference signal. We show this as follows. The real values of V1 and V2 acquired by the SB100 are given by:

$$V1(P_1) = \varepsilon_1 \Delta T(P_1) + \Delta V_1 \quad (4)$$

$$V2(P_1) = \varepsilon_2 \Delta T(P_1) + \Delta V_2 \quad (5),$$

where ΔV_1 and ΔV_2 are the instrument and extraneous thermal offset voltages, discussed above, and P_1 is the power applied to the heater at the first measurement point. Now, if the heater power is changed to a new value P_2, we obtain a second pair of values for V1 and V2:

$$V1(P_2)= \varepsilon_1 \Delta T(P_2)+\Delta V_1 \quad (6)$$

and,

$$V2(P_2)= \varepsilon_2 \Delta T(P_2)+\Delta V_2 \quad (7).$$

The offset voltages ΔV_1 and ΔV_2 can be assumed to be independent of power P, because only the temperature in the immediate neighbourhood of the reference and sample junctions change, not those where these other offset voltages originate.

Subtracting equations (6) and (7) from (4) and (5), respectively, we obtain the true value of ε_1 from the following:

$$\varepsilon_1 = \varepsilon_2 \{V1(P_1) - V1(P_2)\}/\{V2(P_1) - V2(P_2)\} \quad (8).$$

Now (8) does not include ΔV_1 and ΔV_2. The offsets have been removed.

Certain hardware and software precautions have also been implemented to eliminate any possible electrical coupling between the heater and measurement circuits as well.

The process is illustrated in Fig 2.

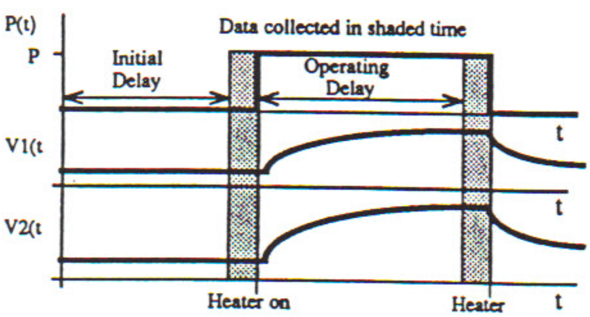


Figure 2. Graphs P(t), V1(t), V2(t)

The power of the heater (P(t)) is changed from zero to level P. V1 and V2 are plotted schematically to show the corresponding changes of the thermo-voltages, as the temperature of the working junctions change. The gray areas show the time intervals during which readings are taken. The average values of V1 and V2 for power levels 0 and P are used at the end of every period to calculate the specific thermo-voltage of the sample. The initial and operating time delays provide time for the system to stabilize thermally before taking the data.

The MMR Seebeck System allows the temperature of the MMR Cold Stage and attached Seebeck Stage to be controled over a wide temperature range. One can thus study the temperature dependence of the specific thermo-voltage of the samples by repeating the measurements at a series of temperatures. The Seebeck System allows this to be done automatically.

B. Definitions.

In the following the various terms used in this Manual and in the operation of the System are defined.

1 **Measurement point.** The set temperature for the Seebeck stage provided by the MMR Cold Stage. Different measurement points are used in order to study the temperature dependence of the specific thermo-voltage.

2. **Experiment.** The process that includes: a sequence of settings of the *measurement points*, starting from the *Initial Temperature* and finishing with the *Final Temperature*; data acquisition at every *measurement point*; and calculation and presentation of the results.

3. **Initial and Final Temperatures.** These temperatures set the range of the data acquisition process. If the *Initial Temperature* is less than the *Final Temperature* then the sample will be heated during data collection. If the *Final Temperature* is lower, then the sample will be cooled. The *Initial* and *Final Temperatures* are always displayed on the Command bar. The permitted range of the settings for these temperatures depends on the type of Thermal Stage used. Refer to the corresponding data sheets.

4. **Stand-by Temperature.** The temperature to which the Seebeck stage is to be set after the *experiment* is completed.

5. **Current Temperature.** The actual, present temperature of the Cold Stage.

6. **Target Temperature** The temperature at which the present activity of the system is targeted. It can be the *Initial Temperature*, the *Measurement point* Temperature, or the *Standby Temperature*. The temperature setting process is complete when the *Current Temperature* is equal to the *Target Temperature*.

7. **Current Power.** The power being applied presently, to the MMR Cold Stage by the K20 MMR Temperature Controller.

8. **Temperature Step.** The difference between two successive *measurement points.*

9. **Sweep speed.** The rate at which the temperature is changed from one *measurement point* to the next.

10. **Modulation Power.** The value of the power applied to the Seebeck Stage heater to produce a temperature gradient across the samples.

11. **Initial Time Delay.** The waiting period from the time the Cold Stage reaches the measurement temperature until the system takes the first set of readings. (See Fig. 2) This delay is needed to allow the Seebeck Stage to reach equilibrium with the Cold Stage.

12. **Operating Time Delay.** The waiting period from the time the Seebeck Stage heater is turned on until the second set of readings are taken.(See Fig. 2). This allows a steady state to be reached across the Seebeck Stage.

13. **Reference Thermo-Voltage.** The specific thermo-voltage (Seebeck Coefficient) of the known junction, used in the Seebeck Stage as a reference. Since this parameter changes with temperature, the data acquisition software includes a file with a look-up table to provide the value which corresponds to that for the set temperature. The Standard MMR Seebeck System is supplied with a look-up table for Constantan as the reference material (relative to Copper).

14. **Averaging Parameter.** The parameter that defines the number of acquired data readings made during the measurement time interval which are subsequently averaged at one *measurement point.* The parameter can vary from 0 to 7. The actual number of data readings is calculated as a corresponding power of 2, so a parameter 0 means 2^0 or one reading, while a parameter 7 means 2^7 or 128 readings.

15. **PID Time Constant.** A numerical parameter that controls the response time of the Temperature Controller to the temperature changes. The PID (Proportional-Integral-Derivative) regulating cycle has more than one time parameter, but only one, the derivative parameter has been made accessible to the user in order to simplify the setting procedure. Increasing the parameter speeds the controller response, but can result in a significant overshoot in the temperature.

16. **Monitor.** The system mode where only the current values of the acquired data are displayed. No data is collected, nor does the system generate a plot.

C. System package.

Computer: 386 or better;
Communication board (if computer is not supplied with the system);
K20A Temperature Controller;
SB100 Seebeck Controller;
Vacuum Chamber with build-in pre-amplifier and MMR refrigerator;
Set of disposable Seebeck Stages;
System Cables;
Seebeck System data acquisition and control software;
System Manuals.

See Fig. 3

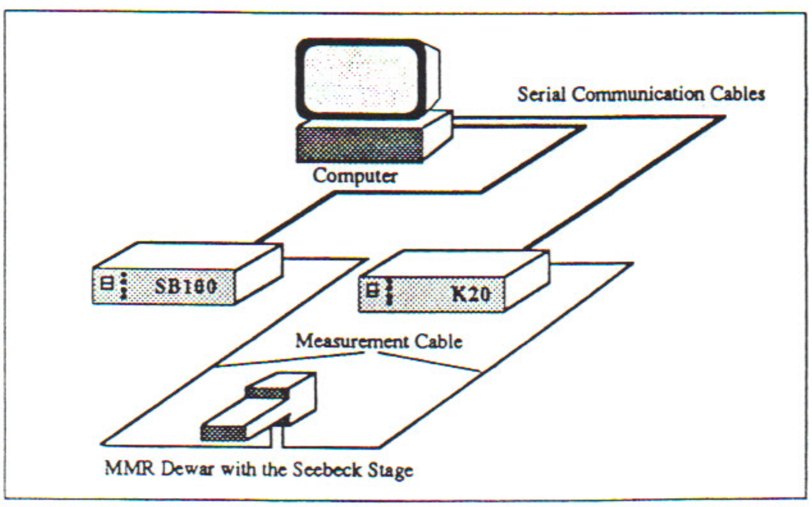


Figure 3. Seebeck Measurement System

SECTION II: SYSTEM SETUP AND TEST

In this section the set-up of the computer, communication board and Seebeck Stage is described. Instructions are then given on how to test the integrity of the system.

1. **Set up the computer.** If, however, the system was supplied with a computer, skip section 1.1.

1.1. Installation of the communication board. The MMR Seebeck Measurement System can operate with the K20A and the SB100 using either the RS-232 or the IEEE-488 interfaces. For the latter, a Capital Equipment Corp. IEEE-488 board is needed, and which can be supplied by special order from MMR. If the RS-232 is to be used, then two free RS-232 ports are needed for the system. The standard PC AT compatible computer is supplied with two serial ports (RS-232) - COM1 and COM2, but usually these are used for the mouse, modem, etc. To avoid this conflict the Seebeck System is supplied with an additional communication board with two additional serial ports - COM3 and COM4. If your system was purchased with a computer, then all the necessary setting have been made, and you can skip the rest of section 1.1

1.1.1. Take off the cover of your computer.

1.1.2. If you are going to use the additional communication board with ports COM3 and COM4, then check first that your computer BIOS supports these ports. If not, call MMR for assistance.

1.1.3 Check that the hardware jumpers on the additional communication board are configured to be COM3 and COM4. If not, configure them so.

1.1.4 Check the hardware jumpers that set the IRQ request numbers. **Do not use the same IRQ numbers that are set for COM1 and COM2.** If any additional boards are used in your computer then use different numbers to those used by these boards.

We recommend the following configuration:

- Serial ports are configured as COM3 and COM4, with IRQs 5 and 9, respectively;
- Parallel port is configured as LPT2, IRQ7. (The system does not use LTP2 port, but this configuration is necessary to avoid a hardware conflict.)

1.1.5 Connect the flat cables provided with the communication board to the board. These are terminated by the outer computer connectors.

COM3 should go to the 25 pin serial connector (DB25 male);

COM4 should go to the 9 pin serial connector (DB9 male).

1.1.6. Insert the Communication board in any mother board connector slot of the computer. Screw in the fixing bolt.

1.1.7. Install the hardware piece with the serial connectors provided with the board in any free slot on the rear panel of the computer. Screw in the fixing bolt.

1.1.8. Re-install the computer cover.

1.1.9. Turn on the computer and start Windows. From the Main Program group select *Control Panel*. From the Control Panel select *Ports*. Select the COM port number to be configured. Select *Advanced option*. Set the IRQ which corresponds to the harware jumper configuration. After all settings have been made, close the Ports, and restart Windows. Turn off the computer.

2. **Connect all computer power cables,** the Monitor, Keyboard, and Mouse.

3. **Using the K20A communication cable** (DB25 male /DB25 female) connect the K20A to the outer connector COM3 of the installed communication board. Do not confuse it with the regular serial connectors for COM1 and COM2.

4. **Using the SB100 communication cable** (DB25 male /DB9 female) connect the SB100 to the outer connector COM4 of the installed communication board. Do not confuse it with the regular serial connectors for COM1 and COM2.

Notice: COM3 and COM4 connectors are clearly marked on the rear of the computer. The Communication Cables have K20A and SB100 marked on the terminating connectors.

5. **IEEE Installation.** If your computer has the IEEE board, then connect the special IEEE-488 cables to the computer, the K20A, and the SB-100. For IEEE-488 installation procedure refer to the chapter, "Initial Setup and Test".

6. **Connect the power cables to the K20A and SB100.**

7. **Install the MMR refrigerator in the vacuum chamber.** Refer to the refrigerator and vacuum chamber Manuals for installation procedures.

8. **Install the Seebeck Stage in the vacuum Chamber.** Refer to Fig. 4. Proceed as follows:

8.1. Get a Seebeck Stage from the package

8.2. On the under side of it, put a thin layer of thermal grease on the thick Copper plate.

8.3. Unlock the ZIF (Zero Insertion Force) connector on the pre-amplifier board in the vacuum chamber. Using thumbs on each side of ZIF connector, push the two tabs in simultaneously, and push the moving frame toward the refrigerator cold end by 3-4 millimeters. Do not remove this frame completely.

8.4. Holding the Seebeck Stage with spring fasteners facing down, insert its edge with contact traces into the ZIF connector as deeply as possible. Do not apply force!

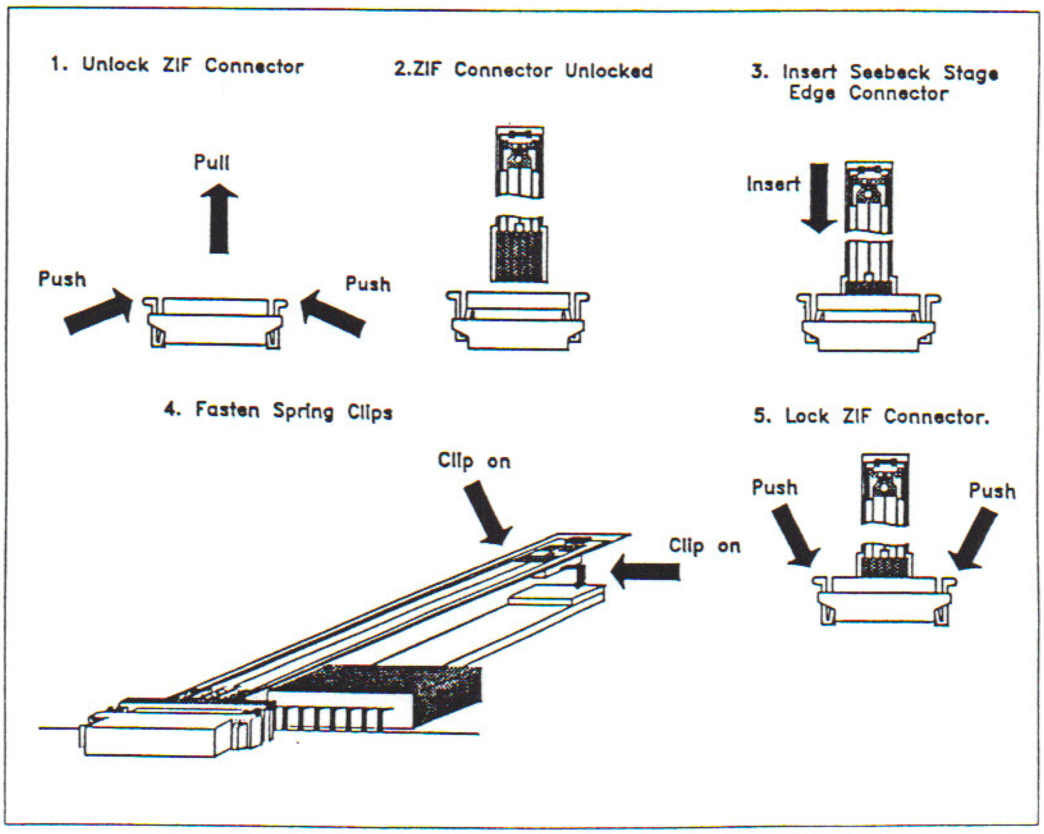
8.5. Affix the Seebeck Stage to The Cold Stage by the spring fasteners. Be extremely careful! Do not apply any downward force on the refrigerator. This can break the refrigerator! Use the tweezers for adjusting the fasteners during installation. You can move the Seebeck Stage backwards and forwards by a couple of millimeters to get the best location.

8.6. Lock the ZIF connector. Push the tabs simultaneously toward the direction opposite to the refrigerator cold end. This will return the moving frame to the locked position.

8.7. Install the cover on the vacuum chamber.

9. **Install the system measurement cable.** Insert the connector labeled "K20" into Refrigerator port on the K20A rear panel. Insert the connector labeled "SB100" into Seebeck Stage port on the SB100 rear panel. Insert the connector labeled "Dewar" to the vacuum chamber.

10. **If you are going to use the system at temperatures below ambient**, you should also install all system components required for cooling according to the MMR Refrigerator Manual.



SECTION III: SAMPLE PREPARATION

In the following section the manner in which the sample should be prepared and installed are described.

The MMR Seebeck System can be used for measurement of the Seebeck coefficient of a wide range of different conductive substances, metals, organic conductors and semiconductors. Samples should be in the form of a thin strip or wire to be installed on the Seebeck Stage. The actual dimensions and the shape of samples are not critical, but should be considerably smaller than the Seebeck stage itself. We recommend that the width of the samples not exceed 1mm (10 mils), and the length 5 mm (200 mils).

For proper installation of the samples, good electrical and thermal contacts must be provided at both ends of the sample to the Seebeck Stage areas shown in Fig. 1. **The unknown sample should be installed to the left of the Seebeck Stage center, the reference sample to the right.** Do not switch these locations, otherwise you will get completely incorrect results! For attaching the samples to the copper surfaces, one can use either regular soldering alloys, or electrically/thermally conductive cement or epoxy. The bonding substance should be able to withstand the temperature range of the proposed measurements. Materials of high specific resistivity and low thermal conductivity should not be used. The resistance of the sample plus the bonding material to the Seebeck Stage should be less than 100KΩ.

To begin, install the unknown sample first, using the bonding material of your choice. See Fig. 5. The working junction (see Section I: A) should be located as close as possible to the slot that separates the two copper surfaces of the unknown and reference samples. The location of the other end of the sample is much less critical. If the sample can not be formed or folded, attach it at any convenient point on the copper plate which is common to the unknown and reference samples, and as close to the center as possible. Install the reference sample in a similar manner. Cut approximately 5 millimeters (0.2") of the reference material wire supplied with the System. For the standard Seebeck System version this is a wire of Constantan. Attach one end of the wire piece to the copper plate which is common to both samples. Use the same point as for the unknown sample. The unknown and reference samples should have direct thermal contact at this point. Attach the other end of the reference sample taking into account the same considerations, as for tested sample (See above). The working junctions of both samples should have symmetrical locations relatively to the stage heater.

To complete the installation, follow the steps, as described in Section II, paragraph 8.

Finally, using an appropriate fluid, clean the Seebeck Stage of possible surface contamination. We recommend the use of Freons and/or methyl or ethyl alcohol. Any cleaning materials used must be non-conductive.

Notice: Be very careful while mounting the samples. Bad electrical or thermal contacts, asymmetrical location of the working junctions, and surface contamination can cause serious measurement errors.

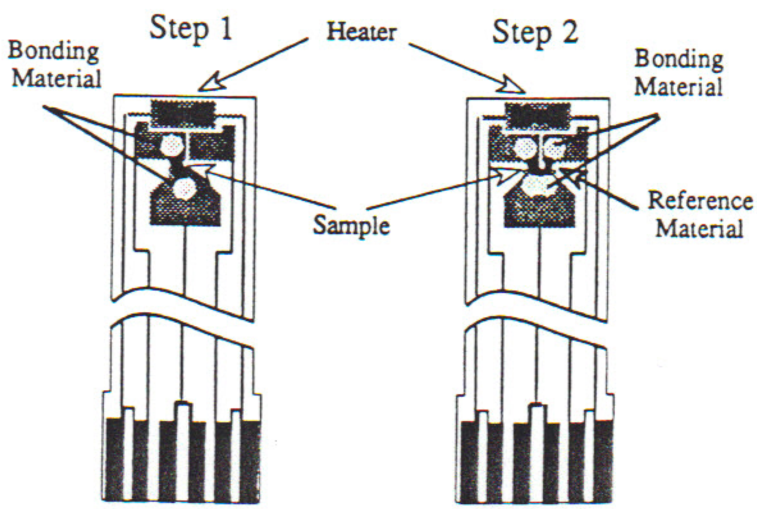


Figure 5. Sample Installation

SECTION IV: SEEBECK SYSTEM SOFTWARE

Below we describe the software used in the operation of the Seebeck System

If your System has been purchased with a computer, skip paragraphs 1.0 and 2.0.

1. System Requirements.

The Seebeck Measurement Software can be installed on any PC AT compatible computer (386 or better) operating in the Windows 3.1 environment. The use of a mouse, a color monitor and a math co-processor is recommended.

2. Installation.

2.1. Insert the diskette provided in drive B: (A:).
2.2. Start Windows 3.1
2.3. In the Program Manager choose *Run* from the File menu.
2.4. Type B:\Setup and press Enter.
2.5. Follow the instructions of the Setup program.
2.6. To Start the system, double click the mouse on the Seebeck Measurement System icon in the MMR Seebeck System program group.

3. Initial Setup and Test.

3.1. When you start the Seebeck Software for the first time, you will need to make several system settings. You will not have to repeat this operation, as the system saves these settings and will retrieve them when you start the software the next time.

3.2. Start the Seebeck System Software. After the introductory window appears on the screen, click the mouse on the OK button. You will get the Main System window on the screen.

3.3. From the command bar, select the *Setup* command. To do this, click the mouse on the command name, or push ALT S.

3.4. After the pull-down menu appears, select *Communication*. The Communication Setup window will be displayed.

3.5. Select the appropriate *Interface Type* , depending on the interface you are going to use. Click the mouse on the desired option button.

3.6. If you selected *RS-232* you have to specify the computer COM ports' numbers which will be used to control the K20 and the SB-100, and the communication speed. MMR controllers use 4800 Baud as a default speed.

3.7. If you are going to use the IEEE-488 interface, you should specify the IEEE addresses of the K20 and the SB-100. To do this you can either enter the address in the range from 00 to 30 using the keyboard, or set this number by pressing and holding the left mouse key on the arrows of the spin buttons, which are located to the left of the address boxes.

3.8. After all settings are done click the *OK* button.

3.9. The next step is to test if system operates properly. To do this select *Test Command* from the command bar or push ALT T on the keyboard. The test window will appear on the screen.

3.10. Select the command you want to send to the controllers. (A detailed description of the commands can be found in the K-20 and the SB-100 Manuals). To select the command click the mouse on the corresponding command button. The command will appear in the command text box. Some commands require numeric parameters, which can be entered using the keyboard. You can also use the keyboard to edit and enter any command sequences. To send the command to a particular controller, click the mouse on the "*Send Command*" control button in the command group dedicated to this controller.

3.11. Send the *TS* (Type of Sensor) command to the K-20. Observe the controller's response in the response text box. The received message should include the type of temperature sensor of the MMR Cold Stage and the corresponding temperature range.

3.12. Send the *TC* (Test Communication) command to the SB-100. The response should be "OK".

3.13. If any errors occur, the corresponding error messages will be displayed. The message "Communication Error" means a hardware or configuration problem exists. Check, that power is on for the K-20 and the SB-100 is turned on; check that the communication cable is connected; check that the communication cable is connected to the selected COM port; check that the selected Baud rate matches the Baud rate setting of the controller (refer to the corresponding Manuals). If you are using the IEEE-488, check the address settings for the K-20 and SB-100.

3.14. If you get an error message that a certain COM port is unavailable, this indicates that there is hardware conflict in the computer, i.e. another system device has been configured to use this COM port. This could be the mouse, a modem, etc. To resolve this conflict, use a different COM port for the system. Usually, this message will be accompanied by the corresponding Windows' error message. Do not be alarmed, however, as this kind of error does not cause damage to other applications that are currently running.

3.15. If the communication test is OK, then you can test the functioning of the MMR Cold Stage and Seebeck Stage. Before doing this, complete all the steps in Section II: System Setup and Test. Then send the command *TE* (Temperature) to the K-20. The K-20 will return with the value of the current temperature of the Cold Stage. Since no temperature settings have been made, the temperature returned should be room temperature.

3.16. Send the command *SM* (Start Measurement) to the SB-100. If you click the control button *SM*, the command SM will appear in the command textbox with the present setting of the averaging parameter. If you want to change this setting, use the keyboard to edit it. This is described in Section V: Experimental Setup. After you receive "OK", send the commands *GV1* and *GV2*. The responses will return the absolute voltages across the reference and sample. These values should be in the range ±0100.00 mV, which indicates the system is functioning normally.

Note 1: If either GV1 or GV2 returns the message, "ADC overflow", or the values of the voltages are greater than 1000, turn off the SB-100, disconnect the vacuum chamber, and check the electrical connections.

Note 2 : Never connect the vacuum chamber to the SB-100 if samples are not installed on the Seebeck stage. Doing so could damage the pre-amplifier.

3.17. The error messages beginning with capital E and a number, for example E5, indicate that there are problems with the K-20 or the SB-100. The error messages will be accompanied by the name of the command that caused the error. To resolve these errors refer to the corresponding Manuals.

3.18. After system testing is complete, click the mouse on the *Exit* command button. The system is now ready to run.

SECTION V: EXPERIMENTAL SETUP

In this section the software commands used to setup the different parameters for the Seebeck System are described in detail.

We describe below the way in which the various parameters used by the Seebeck System are set up or changed.

1. Temperature range. To setup the temperature range for your measurements, select the *Setup* Command from the Command Bar. Then, after the pull-down menu appears, select *Temperature Range*. The corresponding window will be displayed.

Set the desired initial and final temperatures. You may do so in several ways:

You can use the scroll bars. Move the mouse cursor to the control buttons located at the ends of the scroll bars. Press and hold the left mouse key. The temperature values displayed in the text boxes will be incremented (decremented) by 1 degree steps depending on the button pressed. If you click the mouse on the scroll bar area, then the temperature value will be incremented (decremented) by 20 degrees for each click, depending on which side of the scroll box you click.

You can also drag the scroll box to any point along the scroll bar. The temperature value will change accordingly.

Finally, you can click the mouse inside the textbox and enter the temperature value using the keyboard.

If you want the sample to be heated up during the experiment, select an initial temperature less than the final temperature. If you want to cool the sample, set the final temperature to a lower value. If you want to keep the same temperature range but change from heating to cooling or vice versa, press the command button "Reverse". The initial and final temperatures will exchange their values.

After you complete all settings, click the *OK* button.

2. Temperature Step. To setup the Temperature Step, select the *Setup* Command from the Command Bar. Then, after the pull-down menu appears, select *Temperature Step*. The corresponding window will be displayed.

Set the desired Temperature Step value using the same technique as for the temperature settings.

Click the *OK* button.

3. Slope. To setup the slope, select the *Setup* Command from the Command Bar. Then, after the pull-down menu appears, select *Slope*. The corresponding window will be displayed.

Set the desired slope value using the same technique as for the temperature settings.

Click the *OK* button.

4. PID Time Constant. To setup the PID Time Constant, select the *Setup* Command from the Command Bar. Then, after the pull-down menu appears, select *PID Time Constant*. The corresponding window will be displayed.

Set the desired PID Time Constant value using the same technique, as for the temperature settings.

Click the *OK* button.

Note. The default value of the time constant is 100. Usually the K-20 works well with this constant with a wide variety of samples. Unless you experience trouble with the temperature stability we do not recommend changing this value.

5. Modulation Power. To setup the Modulation Power, select the *Setup* Command from the Command Bar. Then, after the pull-down menu appears, select *Power*. The corresponding window will be displayed.

Set the desired Modulation Power value using the same technique, as for temperature settings.

Click the OK button.

Note. The value of the modulation power depends on the thermal mass of the sample and the Seebeck Coefficient of the studied sample. We recommend using a power setting in the range of 20-50 mW. The smaller the power, the smaller will be the temperature difference across the sample and thus the data will reflect more precisely the value of the Seebeck Voltage at the mean temperature of the stage. On the other hand, the smaller the temperature difference the smaller the output signal, so the system resolution may be insufficient for a precise measurement. We recommend making several trials to determine the optimal Power value. You can read the temperature difference and the Seebeck voltage across the sample in the corresponding data boxes on the screen. See Section VI: Screen Structure.

6. Standby Temperature. To setup the Standby Temperature, select the *Setup* Command from the Command Bar. Then, after the pull-down menu appears, select *Standby Temperature*. The corresponding window will be displayed.

Set the desired Standby Temperature value using the same technique, as for temperature settings.

You can select the option with the standby temperature set to the value of the initial temperature. If you select this option, any future adjustment of the initial temperature will result in the same change of the standby temperature. This selection also disables the scroll bar in the standby temperature window.

There are two ways to proceed to set the standby status. If you select the option "Auto Go to Standby", the software will automatically orders the SB-100 to go to the Standby temperature upon completion of data collection. If the "Auto Go" option is disabled, the system will ask the user to confirm that the system should go to standby status at the end of the experiment.

After completing all selections, click the OK button.

7. Averaging Parameter. To setup the Averaging Parameter, you should select the *Setup* Command from the Command Bar. Then, after the pull-down menu appears, select *Averaging Parameter*. The corresponding window will be displayed.

Set the desired Averaging Parameter value from 0 to 7 using the keyboard, or set this number by pressing the left mouse key on the arrows of the spin buttons. The left data box will display the Averaging Parameter, the right will display the corresponding number of points to be averaged.

Click the OK button.

8. Y-scale. To setup the Y- scale, select the *Setup* Command from the Command Bar. Then, after the pull-down menu appears, select *Y-scale*. The corresponding window will be displayed.

Set the desired Y- scale value using the same technique, as for temperature settings. In general, you will not know the range of values of the data to be acquired, so your plot may lie out of the Y-scale range. Do not worry about this as the collected data will not be lost. The Y-scale can be adjusted during the experiment or later. If you do not observe any plot during the experiment, you can determine the current value of a measurement from the data display boxes at the bottom of the screen, and then make the necessary Y-scale adjustments.

After the experimental data has been acquired you can use the "Best Fit" button for automated, optimal Y-scaling. If no data is plotted this button will be disabled.

After you complete these settings, click the OK button.

9. Reference Material. To setup the Reference Material, you should select the *Setup* Command from the Command Bar. Then, after the pull-down menu appears, select *Reference Material*. The corresponding window will be displayed.

Set the desired Reference Material by checking the option buttons.

Click the OK button.

Note: Some software versions may have only one selection - Constantan.

10. Communication. The Communication setup is explained in Section IV. 3 "Initial Setup and Test"

11. "Save Settings on Exit" Command. When you quit the program you may want to keep the system settings. To do so you should enable the "Save Settings on Exit" option. Select the *Setup* Command from the Command Bar. Then, after the pull-down menu appears, you can select or deselect the option by clicking the mouse on the *"Save Settings on Exit"* command. If the "Check" sign is present, then the command is enabled.

If this option is enabled, then the program creates the configuration file, SB.CFG when you quit the program. This file saves all current system settings, including temperatures, slope, time constant, temperature step, averaging parameter and communication parameters, etc. When you start your program the next time all these settings will be automatically retrieved. The SB.CFG is created in, and must exist in the working directory. If the program does not find SB.CFG when starting, the system parameters will take their default values.

SECTION VI: SYSTEM COMMANDS AND FUNCTIONS

In this Section the system software commands and functions used in the Seebeck System are described.

We present here details of the commands for viewing, saving, and printing files and other system commands for use with the Seebeck System.

The File Commands. The File commands allows the user to save collected data on disk and to view the contents of previously saved data files.

1. View MMR data file. If you want to study the contents of the Seebeck data file, you should select the *File Command* from the Command Bar. Then, after the pull-down menu appears, select *View Seebeck Data File*. The File list window will appear on the screen. If you want to change the active drive or directory, you should double click the mouse on the appropriate item. File selection can be done by clicking on the file name. You can also click the mouse on the file name text box, and then enter the full file name using the keyboard.

Note: You can only view files saved in the special MMR format. (See Save File section below.).

After you have selected the file, click the OK button. The Seebeck data file will be loaded. The current system parameter values will be overwritten by the respective values of the loaded file, and the temperature scale will be adjusted automatically to the new values. The File Info (ID) string will appear on the top of the graph. The new data curve should appear on the screen. However, it may not if this new curve is out of the Y-scale range. A reset of the scale will then be neccessary. Use the *Setup-Y-Scale -Best Fit* commands to view the graph.

To study a loaded file you can change the temperature and Y-scales, print the file and save it in a modified form.

To get the system parameters of the loaded file use "Info" command (See below).

2. Save File. If you want to save a data file, you should select the *File Command* from the Command Bar. Then, after the pull-down menu appears, select *Save File*. The File Save window will appear on the screen.

Select the *File Format*. First option is CSV - Comma Separated Values format. This format is compatible with the popular spreadsheet software packages, such as Excel. If you save a file in this format, you can use the powerful data presentation tools of the spread sheets, but you would not be able to study this file later using the Seebeck System. If you do select this option, you can input the data file information string, which will be saved in the file and presented in the first cell of the data set. To enter the file title you should click the mouse on the file title textbox, and then type the string using the keyboard.

If you select the option "*Seebeck datafile*" format, the file will be saved in a special format, that is readable by the Seebeck system software. This makes it possible to load and study this file using this software. When you save the file in the "Seebeck data file" format, you can also enter the file Info string (up to 40 Characters). This ID data will be retrieved when you re- load the file. All system parameters are saved automatically when you select this file format.

Note: You can save the same file in both formats. The "Seebeck data file" can be loaded by the Seebeck software and then saved in a CSV format.

Enter the name of file to be saved. Click the mouse on the file name text box and then enter the full file name using the keyboard. If you want to change the active drive or directory, you have to double click the mouse on the selected item in the directory/drive lists.

Click the OK button. You will get the message "File is saved". Click OK.

8. Info Command. Selection of the "Info" command displays the list of the system parameters on the screen. To remove the list, click "OK" or click the mouse at any place on the screen outside the list window.

4. Print Command. The Print command is used to produce hard copy of the plot presented on the screen.

Select the *Print Command*. The "Input Chart Title" window will appear on the screen. Enter the Chart title using the keyboard (up to 40 Characters). This title will be printed at the top of your printout. If you check the boxes "Print Date" or/and "Print Time", the date/time information will be printed at the left top corner.

Note: Printout reproduces only the part of the plot that is presented on the screen, not the total plot.

Click OK to start printing.

10. Test Command. The Test command is used to test the communication with the controllers and their functions. The use of the Test command is described in the Section IV. 3: "Initial System Setup and Test". For more information on the SB-100 and K-20 commands refer to the corresponding Manuals.

11. Quit Command. To quit the program, use the Quit command. If you selected *Quit* and any unsaved collected data is present in the system memory, the Seebeck System will issue the corresponding warning message.

SCREEN STRUCTURE

The Command bar is located at the top of the screen. The Command bar includes the system commands and it is also used to display the two most important system parameters: the temperature range and temperature step.

The Plot area is located under the command bar and occupies most of the screen. If you use the program other than in a maximized window mode, the plot area, including the scales and graph, will be resized in proportion to the window.

Below the plot area lie a number of Data boxes, divided into functional groups. The first group presents data relating to the point at which data is being acquired:

-The Temperature of the Data Point;
-The Calculated Seebeck Coefficient;
-The Voltages across the Reference and Sample;
-The Ratio of these Voltages;
-The Calculated temperature across the sample.

The second group represents parameter relating to the manner in which the experiment is being conducted:

-The type of the process (Cooling or Heating).
-Experiment Run Time;
-The Target Temperature;
-The Current Temperature;
-The Current Power (delivered by the K-20 to maintain the temperature of the stage).

This second group of data boxes is activated when the experiment is in progress. (The Current Power and the Current Temperature are also enabled in the Monitoring regime).

The first group will display their values after the acquisition of the data for the point has been completed. The small push-button to the left of the "Run Time" box is used to reset the time counter.

If some parameters to be presented on the screen, are not needed, click the mouse on the box with the parameter name. The boxes with this parameter name and value will become transparent. To restore the data presentation click the mouse on the parameter name one more time. This feature is possible only for parameters contained in the light green boxes.

The system Status box is located to the right of the data acquisition group. The System status box always displays information about the current system condition.
If any error occurs during an experiment or in the monitoring regime, the error box with the corresponding error message will be displayed under the status box. In the monitoring regime, an error event produces a Beep, But if an error is encountered during an experimental run, a Siren will sound.

The system Control group is located in the right hand, bottom corner of the screen. This group includes three push-buttons. At start-up, the push-buttons have captions "Monitor", "Start", and "Pause", but depending on the system status, these captions can change.

Clicking the push-button, "Monitor" switches the system to the monitoring regime, and the caption of this push-button changes to "Stop Monitor". A second click will take the system out of the monitoring mode.

The push-button, "Start" initiates an experimental run, and the caption changes to "Stop".

The "Pause" command can change its caption to "Continue".