Metrics ICS Driver Manual

KI23X

Metrics ICS

Version 4.5

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KI Model 236/237/238/213/2400 Instrument Driver

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The KI23X Driver

The KI23X Driver provides control of a single source measure unit (SMU) and the Model 213 Quad Voltage Source. The KI23X Driver is available for users who wish to implement the capability of a Keithley SMU but do not require the complexity of a KI23X I-V Test System. The combination of a single SMU and the quad voltage source allows the user to perform spot measurements or single-sweep device tests.

There are three SMU models available: the KI236 SMU, the KI237 High Voltage SMU, and the KI238 High Current SMU. Each SMU can source either a voltage or current, and return voltage, current, or both. Each SMU Model can be used with the Model 8006 Component Test Fixture.

Model 236/237/238 Source Measure Units: Each source measure unit can source voltage and simultaneously measure current, or source current and simultaneously measure voltage. One unit is necessary to run two-terminal device tests, while two units are required to run bipolar transistor and FET tests. If a substrate bias is required, a third source measure unit, a quad voltage source, or a current or voltage source will be necessary. Up to six SMUs can be used in one test system.

Model 213 Quad Voltage Source: The Model 213 provides four isolated bias sources. Each bias source can force an output at ranges of ±1V, ±5V, or ±10V at up to 10mA.

Model 8006 Component Test Fixture: The test fixture is the interface between the DUT (device under test) and the instruments. The Model 8006 includes sockets for axial-component, TO packages, and 24-pin DIP package devices. A Model 8007 Semiconductor Test Fixture or a user-supplied test fixture could also be connected through suitable adapter cables.

System Connections

Table 1 summarizes the necessary cables for a test system with Model 236/237/238 Source Measure Units and a Model 8006 Test Fixture.

Model	Description	Application
7078-TRX-x	Low noise triax cable. Available in 0.9m, 3m, or 6m.	Signal connections between 236/237/238, 7072 and 8006.
236-ILC-3	3m shielded cable	Interlock connections between 236/237/238 and 8006.
7007	Shielded IEEE-488 cable. Available in 1m or 2m.	IEEE-488 instrument bus.

Table 1: Signal and Interlock Cables

Connect the equipment together as described in section 2.3 "Basic Test Connections" of the Model 236/237/238 Operators' Manual. For test systems using a Mode 213 Quad Voltage Source, refer to the Model 213 Quad Voltage Source Instruction Manual.

WARNING All equipment should be turned off when making connections.

WARNING Safety interlocks must be used to protect the operator from potentially lethal voltages that could result in injury or death. Keithley source measure units are designed to be used with test fixtures that incorporate a safety interlock switch, such as the Keithley Model 8006 Test Fixture. By using the interlock, the source measure unit cannot source current or voltage when the lid of the test fixture is open. Refer to paragraph 2.3 in the Model 236/237/238 Operator's Manual for more information on interlock usage for the Model 8006 and custom test fixtures.

WARNING The test fixtures must be connected to safety earth ground using #18 AWG or larger wire.

To simplify test connections, most examples in this manual use local sensing for the source measure units. Local sensing requires connecting only two signal cables between the source measure unit and the test fixture (OUTPUT HI and OUTPUT LO). Also, the appropriate jumpers between the test fixture signal panel and the component test module must be installed. See Section 2 of the Model 236/237/238 Operator's Manual for complete details on test connections.

To optimize accuracy at higher currents (above 1mA), remote sensing is recommended. To use remote sensing, connect SENSE HI and SENSE LO to the test fixture, and add the necessary jumpers to the DUT.

WARNING With remote sensing enabled, an open sense lead will result in lethal voltages appearing at OUTPUT HI and GUARD. This voltage can cause injury or death, and damage external circuitry. Always make sure that the sense leads are properly connected before enabling remote sense. NEVER change connections with power applied. Be sure to always discharge and/or disconnect external power sources.

System Power-Up

Instrument Power Requirements

The Model 236/237/238 Source Measure Units are designed to operate from 105-125V or 210-250V line power ranges. A special transformer may be installed (at the factory) for 90-110V and 195-235V ranges. A slide switch on the rear panel indicates the present operating voltage. If the line voltage needs to be changed, refer to the Model 236/237/238 Operator's Manual.

The Model 213 Quad Voltage Source operates from 90-125V or 180-250V line power ranges. The present operating voltage is indicated on the rear panel. If the line voltage needs to be changed, a slide switch is located inside the unit (refer to the appropriate instruction manual).

WARNING Do not attempt to operate an instrument on a supply voltage outside the allowed range, or instrument damage may occur.

Power Connections

Each instrument should be connected to a grounded AC outlet using the supplied AC power cord or the equivalent.

WARNING Each instrument must be connected to a grounded outlet to ensure protection from electric shock. Failure to use a grounded outlet and a 3-wire power cord may result in personal injury or death because of electric shock.

Environmental Conditions

For maximum accuracy, all measuring instruments and the test fixture must be operated at an ambient temperature between 18° and 28°C at a relative humidity less than 70%. (See specifications in Model 236/237/238 Operator’s Manual.)

Warm-up Period

The system can be used immediately when all instruments are first turned on, however, to achieve rated system accuracy, all instruments should be turned on and allowed to warm up for at least one hour before use.

Power-up Procedure

Follow the general procedure below to power up a KI23X I-V Test System for the first time:

1. Connect the instruments together as outlined in *System Connections*.
2. Set the rear panel DIP switches on the Model 213 to the desired IEEE-488 bus addresses. The factory default setting of the Model 213 is 9.
3. Turn on each instrument by pressing in its power switch. Verify that each instrument goes through its normal power-up routine, as described below, and that each instrument is set to a unique bus address.

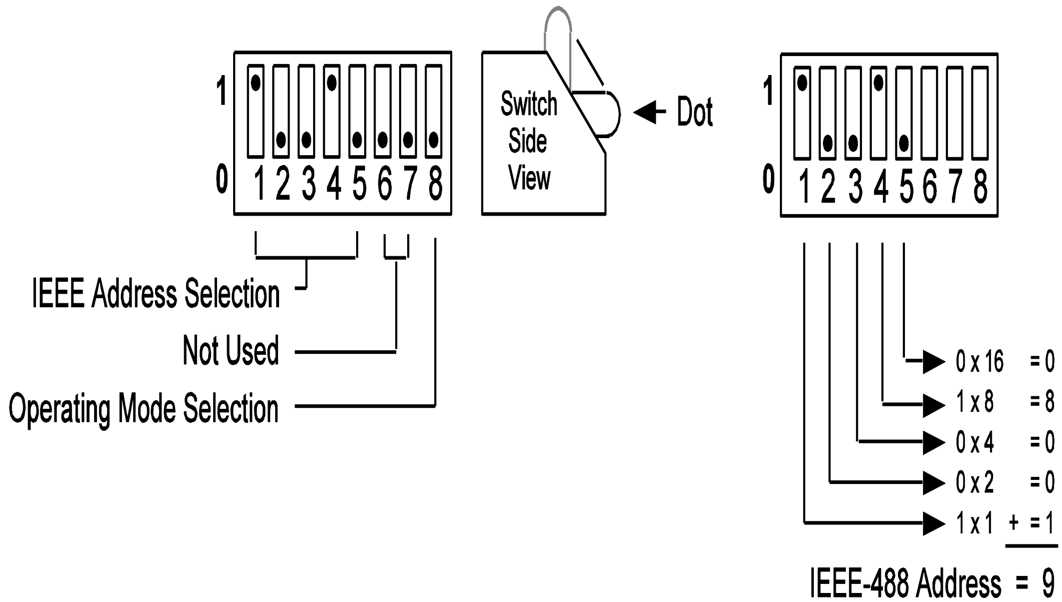


Figure 1: Model 213 DIP Switch Factory Defaults

Model 236/237/238 Power-Up

The source measure units perform a self-test at power-up, then display a model number, software revision, and IEEE-488 address.

The MANUAL TRIGGER LED on the front panel should be blinking when the source measure unit completes its self-test. If it is not, cycle power on the instrument. (Complete details on the power-up sequence are in the Model 236/237/238 Operator's Manual.)

> The instrument will operate at a line frequency of 50 or 60Hz. To check the line frequency setting, press the MENU button and rotate the knob until the line frequency is displayed. The alternate line frequency can be selected by displaying it with the SELECT buttons and then pressing ENTER. To exit from the menu, press the MENU button.

> To change the IEEE-488 bus address, press the MENU button and rotate the knob until the bus address is displayed. Key in the desired address and press ENTER. To exit from the MENU, press the MENU button.

Model 213 Power-Up

All the front panel LEDs should light for approximately one second while the unit performs an internal ROM and RAM self-test. At the end of this self-test, all indicators should turn off except POWER. Flashing LEDs or the ERROR LED indicate failure of the self-test. Refer to the Model 213 Instruction Manual for details.

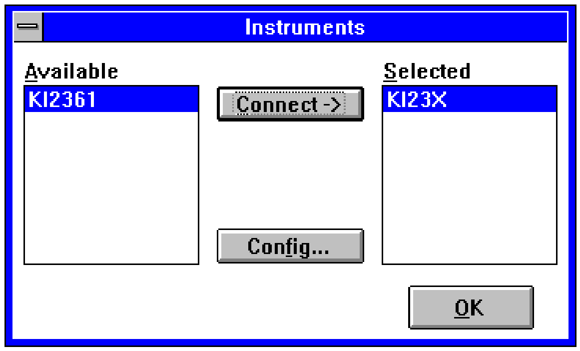
Getting Started: Setting Up a Measurement

This section will walk you through the steps required to create and execute a ICS test setup that measures diode turn-on voltage using the KI23X I-V Test System.   This is simple measurement, but it will provide you with a general understanding of how ICS and the KI23X I-V Test System are used to measure device characteristics.

Step 1: Cable the Hardware Connections

Cable all the necessary connections between the source units and the Model 8006 Test Fixture. Connect the required jumpers on the test fixture connection panel from the desired source units to the test fixture sockets corresponding to the diode cathode and anode. The source unit connections cabled to the cathode and anode will be designated later in ICS' graphic workspace.

<u>Step 2: Connect the KI23X Instrument Driver</u>



Connect the KI23X Driver in the Connect Instruments dialogue box. The Connect Instruments dialogue box is displayed by clicking the corresponding toolbar button or by selecting INSTRUMENTS/SELECT INSTRUMENT from the measurement mode menu bar.

The Connect Instruments dialogue box is displayed by clicking the corresponding toolbar button.

How to Connect the KI23X Driver:

1. Open the Connect Instruments dialogue box by clicking the CONNECT INSTRUMENTS toolbar button. The Connect Instruments dialogue box can also be opened by selecting INSTRUMENTS/SELECT INSTRUMENT from the measurement mode menu bar.
2. Highlight the KI23X Driver in the AVAILABLE field.
3. Click the CONNECT button.
4. The connected driver will be displayed in the SELECTED field.
5. Clicking the OK button will close the Connect Instruments dialogue box and restore control to the ICS desktop. Keep the Connect Instruments dialogue box displayed for now, because the next step requires you to click the Connect Instruments CONFIG button.

Step 3: Specify Source Unit Identities and GPIB Addresses

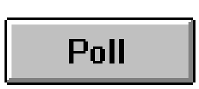
The source units must be connected to your computer with the use of a standard IEEE-488 GPIB (General Purpose Interface Bus). Please refer to Section 2.5 of the Model 236/237/238 Operator's Manual to review GPIB connection procedures and hardware limitations specified by Keithley.

After connecting the KI23X Driver, the user must designate the source unit identities and GPIB addresses in the KI23X Setup dialogue box. The KI23X Setup dialogue box identifies the model number of the Source Measure Unit (SMU) connected. The KI23X Setup dialogue box also identifies the GPIB address assigned to the SMU and the Quad Voltage Source (VS) if present.

This section presents a brief overview that explains how to designate the source unit hardware connections and corresponding GPIB addresses using the KI23X Setup POLL button. For more information about the KI23X Setup Dialogue box, refer to *The KI23X Setup Setup Dialogue Box* later in this chapter.

How to Automatically Designate the Source Unit Identities and GPIB Addresses:

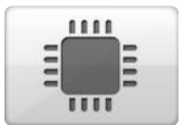
1. If the Connect Instruments dialogue box is no longer displayed from Step 2, click the toolbar CONNECT INSTRUMENTS toolbar button or select INSTRUMENT/SELECT INSTRUMENTS from the measurement mode menu bar.
2. Open the KI23X Setup dialogue box by clicking the CONFIG button at the bottom of the Connect Instruments dialogue box.
3. Click the POLL button at the bottom of the dialogue box. The POLL function will interrogate the source units and automatically configure the SMU fields as well as each applicable GPIB field including the VS fields.
4. Click OK to close the KI23X Setup dialogue box and restore control to the Connect Instruments dialogue box. Click the Connect Instruments OK button to restore control to the desktop.



Use the KI23X Setup POLL button to automatically configure the KI23X Setup dialogue box.

Step 4: Create the Test Setup

Test setups are created in the Setup Editor. Open the Setup Editor by selecting the SETUP EDITOR toolbar button. In this example, we will create a test setup that measures the forward current of an NP diode with respect to a forward voltage sweep.



Click the corresponding toolbar button to display the Setup Editor.

Step 4A: Specify the Test Setup Name

When creating a new test setup, a test setup name must be specified before any other selections or conditions are designated.

How to Specify the Test Setup Name

1. Click the Setup Editor NEW button. This will open the New Setup dialogue box.
2. At the prompt, specify a test setup name. For this example, type "DiodeOn".
3. Click OK. This will close the New Setup dialogue box.
4. The test setup name will appear in the Setup Editor SETUP window.

Step 4B: Select a Device Schematic Corresponding to the DUT

A device schematic is located at the center of the Setup Editor. The device schematic is designed to provide a graphic image of the test fixture socket.

A MOSFET schematic will appear at the center of the Setup Editor when the Setup Editor is first opened. In this step the MOSFET schematic will be replaced with a diode schematic. The MOSFET device is the default Setup Editor schematic.

How to Select a Device Schematic:

1. Click the Setup Editor DEVICE button. This will open the Device dialogue box.
2. The Device Type window will display a list of available device schematics. Select DIODE. Notice the selected schematic is previewed in the small window to the right of the Device Type window.
3. Some device schematics will display a set of polarity switches when selected. Select the "NP" designation for this example.
4. Click OK. This will close the Device dialogue box and display the diode schematic at the center of the Setup Editor.

Step 4C: Designate the SMU/DUT Connections

SMU/DUT connections are designated in the Setup Editor. The Setup Editor workspace is provided as a tool to document the SMU/DUT connections required for the corresponding device measurement. The SMU/DUT connections designated in the Setup Editor are a graphic representation of the physical connections between the SMUs and the test fixture. The connections designated in the Setup Editor should correspond to the reality of your hardware arrangement.

The Setup Editor displays a device schematic representing the DUT. Connections are designated by first clicking one of the SMU or VS designations listed in the Source Units dialogue box. After the source unit is selected, click the blue pad next to one of the device schematic pins. Select the blue pad corresponding to the DUT pin that the source unit will be physically connected to. An instrument icon, along with the name of the connected source unit, will appear above the device schematic pin as a means of indicating the connection.

This example will show how to designate the connection of a Model 236 SMU to the anode of an NP diode and a Model 237 SMU to the diode cathode.

How to Designate the SMU/DUT Connections:

1. Select the Setup Editor SOURCES button. This will open the Source Units dialogue box.
2. The Source Units dialogue box will display a list of available source unit model numbers. These are the same sources designated in the KI23X Setup dialogue box. If necessary, refer to *Step 3: Specify the GPIB Address and Source Unit Identities*.
3. Click on the SMU designation corresponding to the Model 236 Source Measure Unit. The source unit used to create this example included only one Model 236. The Model 236 corresponded to the "SMU1" designation.
4. Designate the connection between the source unit and the device by clicking the blue pad next to the appropriate device schematic location. To designate the connection between the Model 236 SMU and the diode anode described in this example, click the blue pad next the diode anode.
5. Repeat this process for each source connected to the DUT. To designate the second and last connection in this example, select the Model 237 SMU from the Source Units dialogue box and click the blue pad next to the diode cathode.
6. After all of the SMU/DUT connections are designated, close the Source Units dialogue box by double-clicking the close button of the dialogue box.

Step 4D: Specify the Source/Measure Configuration of Each Source

Every available source has its own Source Unit Setup dialogue box. This Source Unit Setup dialogue box is used to specify the source/measure configuration of the respective source. Once an SMU/DUT connection is designated, the corresponding Source Unit Setup dialogue box is opened by clicking on the instrument icon displayed above the respective device schematic location.

In this example, SMU1 (connected to the anode) will source a linear voltage sweep. The sweep will start at 0.0V and stop at 1.0V and consist of 51 data points. SMU1 will measure voltage (V) and current (I). GNDU (connected to the cathode) will be a ground and will not measure anything.

How to Specify the Source/Measure Configuration of Each Source:

1. Click once on one of the displayed instrument icons to open the Source Unit Setup dialogue box corresponding to the connected SMU.
2. Configure the SMU1 controls as shown in Figure 2. Use the mouse or TAB key to move between the different switches and fields in each Source Unit Setup dialogue box.
3. Click OK to close a Source Unit Setup dialogue box. Only one Source Unit Setup dialogue box can be opened at a time.
4. After the setup configuration of each SMU is specified, close any Source Unit Setup dialogue box that is still displayed. Click the Setup Editor CLOSE button. This will close the Setup Editor and restore control to the desktop. Notice that there is a white icon at the bottom of the desktop titled "DiodeOn". This icon represents the data window spreadsheet that will store the numerical results once the test setup is executed. At this time, however, the spreadsheet is empty.

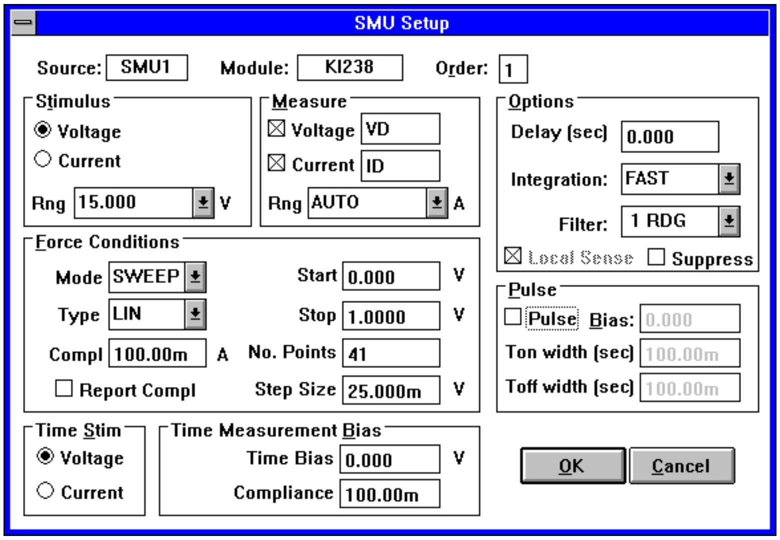


Figure 2: SMU1 Source/Measure Configuration for the DiodeOn Test Setup

For a thorough discussion of the Source Unit Setup dialogue box, refer to *The Source Unit Setup Dialogue Box* later in this chapter.

Step 5: Insert the DUT Into the Test Fixture

Insert the DUT into the test fixture according to the SMU/DUT connections designated in the Setup Editor.

Step 6: Execute the Measurement

Execute the DiodeOn test setup by clicking the remote control MEASURE button. Shortly after the measurement is in process, a message will appear on your screen telling you that the test setup is being executed.

Step 7: View the Results

Data is automatically generated in the corresponding data window spreadsheet each time the measurement is executed. To display the numerical data, double-click on the white spreadsheet icon labeled "DiodeOn" at the bottom of the ICS desktop.

Data window spreadsheets are dynamically linked to the test setup. Each time the corresponding test setup is executed, the spreadsheet data is replaced with the most recently measured data. For this reason the data window spreadsheet is automatically titled with the same as the test setup.

Step 8: Create a Plot of the Results

A plot window is dynamically linked to a corresponding data window spreadsheet. This means that the plot is regenerated any time there is a change to the corresponding spreadsheet data. If the test setup is executed more than once, the plot window is regenerated after each measurement. If the data window spreadsheet is edited, the plot window is updated by clicking the REDRAW button at the top of the spreadsheet. Up to ten plots can be created from a single data window spreadsheet, and each plot can be independently formatted.

The steps below will show you how to create a plot of diode current with respect to the forward voltage sweep. This plot will correspond to the DiodeOn data.

How to Create a Plot

1. If you created the "DiodeOn" test setup without first creating any other test setups or importing a project file, the "DiodeOn" test setup will be the only test setup on the desktop. If you defined more than one test setup or imported a project file, you must first designate which test setup data you will use to create the plot window. You can do this in one of two ways:
2. Click once on the appropriate data window spreadsheet icon (the data window can be either displayed or minimized). Clicking once on a data window spreadsheet icon will also pop-up a system menu.
3. Click the toolbar setup window arrow and select the desired test setup from the displayed list.
4. Click the NEW PLOT toolbar button. This will open an empty plot window and the Plot Data dialogue box.
5. Designate the independent variable of the plot by double-clicking on the appropriate data vector listed in the Data window. Only two quantities were measured in the DiodeOn test setup, voltage and current. There should be two data vectors in the dialogue box Data window: "V" and "I". This example will create a plot of current with respect to voltage. Since voltage will be the independent variable, double-click on "V". Notice that the X-button is now labeled with a "V".
6. Designate the first dependent variable of the plot (in our case the only dependent variable) by double-clicking the appropriate data vector in the dialogue box Data window. For this example, double-click on the "I". Notice that the Y1-button is now labeled with an "I".
7. You could plot up to nine more data vectors with respect to the independent variable if more data vectors were measured. You can measure more than ten data vectors, but only ten data vectors can be plotted in a single plot window.
8. Click the dialogue box APPLY button. This will create the plot but will not close the Plot Data dialogue box. You should notice that at about 0.6V the diode turned on.
9. Click the CLOSE button to close the Plot Data dialogue box.

Step 9: Save the Results into a Project File

A project file includes all of the information necessary to execute a test setup or group of test setups. The information in a project file is classified into three categories:

1. A project file stores the associated test setup(s).

2. A project file stores any of the measured data and plots corresponding to the test setups.

3. A project file stores the Instrument Driver information required to execute the test setup(s).

How to Save Your Work as a Project File

1. Click the SAVE AS toolbar button or select FILE/SAVE AS from the menu bar. This will open the File Manager.
2. Select the directory and filename.
3. Click OK, or hit the keyboard ENTER key.

The KI23X Setup Dialogue Box

The KI23X Setup dialogue box identifies the model number of the Source/Measure Unit (SMU) connected. The KI23X Setup dialogue box also identifies the GPIB address assigned to the SMU and the Quad Voltage Source (VS) if present.

The KI23X Driver must be connected to ICS before the KI23X Setup dialogue box can be opened. The KI23X Driver is connected from the Connect Instruments dialogue box. If necessary, refer to *Step #3, Connecting the KI23X Driver*. After connecting the KI23X Driver, open the KI23X Setup dialogue box from the Connect Instruments dialogue box.

Open the Connect Instruments dialogue box by clicking the corresponding toolbar button. Open the KI23X Setup dialogue box from the Connect Instruments dialogue box by clicking the Connect Instruments CONFIG button.

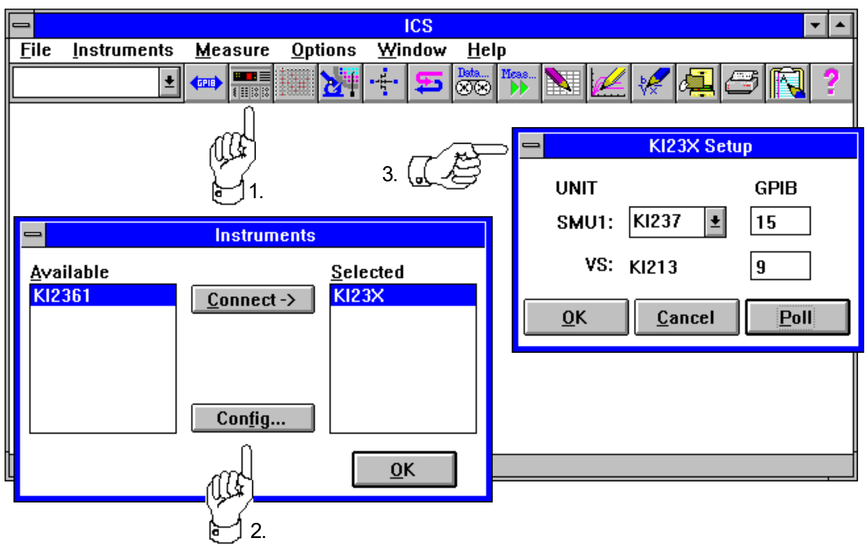


Figure 3: The KI23X Setup Dialogue Box is Opened from the Connect Instruments Dialogue Box.

<u>*SMU Fields*</u>

The KI23X Setup dialogue box includes a single "SMU" field used to identify the SMU hardware connected. When a user designates source units later in the application, the Source/Measure Unit will be identified by the corresponding "SMU" label designated in the KI23X Setup dialogue box. Source/Measure Units are identified by "SMU" labels instead of model numbers in order to eliminate confusion when two or more identical instruments are included in the Test System.

Configuring the KI23X Setup Dialogue Box

The KI23X Setup dialogue box is most easily configured using the POLL button at the bottom of the dialogue box. The POLL function interrogates the source units and automatically designates each SMU field along with each applicable GPIB field, including the SMU and VS fields. Alternatively, the user may choose to manually designate the KI23X Setup dialogue box. The KI23X Setup dialogue box must be manually designated if there are no instruments connected to the other end of the GPIB cable. This situation occurs when test setups are created on a copy of ICS different than the copy that will be used to execute the testing.

Automatic Configuration

The KI23X Driver includes a poll function that will automatically configure the KI23X Setup dialogue box. The poll function is activated by selecting the POLL button at the bottom of the dialogue box. The poll function interrogates the source units and automatically selects the model numbers corresponding to each SMU field. The poll function also designates the correct address at each GPIB field.

Manual Configuration

It is not necessary to configure the KI23X Setup dialogue box using the poll function. The user has the option of configuring the KI23X Setup dialogue box by manually designating each SMU field and each applicable GPIB field. The KI23X Setup dialogue box must be manually designated if there are no instruments connected to the other end of the GPIB cable. This situation occurs when test setups are created on a copy of ICS other than the copy that will be used to execute the testing.

To manually designate the SMU field, click on the scroll arrow at the end of the field to display a list of possible model number designations. Click once on the desired option. The selected model number must correspond to the SMU. To manually designate the GPIB addresses, highlight the current designation in the KI23X GPIB field. Specify the correct address. Use the TAB key to advance to each consecutive GPIB field.

How to Manually Designate the KI23X Source Unit Identities and GPIB Addresses:

1. Open the KI23X Setup dialogue box by clicking the CONFIG button at the bottom of the Connect Instruments dialogue box. If necessary, click the toolbar CONNECT INSTRUMENTS button or select INSTRUMENT\SELECT INSTRUMENTS to open the Connect Instruments dialogue box.
2. Specify the SMU model number in the "SMU" field. Click the scroll arrow to display a list of available model numbers. Click on the desired designation.
3. Designate each "SMU" field that does not correspond to an SMU connection with the "NC" selection. "NC" stands for "Not Connected".
4. Enter the GPIB address in the SMU GPIB field.
5. Designate the GPIB address of the Quad Voltage Source.
6. Click the OK button to close the KI23X Setup dialogue box. Click the OK button in the Connect Instruments dialogue box to restore control to the ICS desktop.

When to Configure the KI23X Setup Dialogue Box:

It is only necessary to configure or update the KI23X Setup dialogue box in either of two situations:

1. The KI23X Driver is connected to ICS for the first time.
2. The source unit configuration is changed.

The configuration of the KI23X Setup dialogue box is stored in memory when the user manually specifies the box contents or after the user polls the instrument. The KI23X setup is written to the ICS35.INI file as soon as the KI23X Setup CLOSE button is selected. The KI23X Driver connection is documented in the corresponding project file when FILE/SAVE or FILE/SAVE AS is selected. When the project file is opened, ICS will automatically connect the KI23X Driver and configure the KI23X Setup according to the designations recorded in the ICS35.INI file. This eliminates the need to repeatedly connect the KI23X Driver or configure the KI23X Setup each time a KI23X project file is opened. After initially configuring the KI23X Setup, there is no need for the user to review the KI23X Setup dialogue box unless the source unit connections have changed.

SMU Availability

The Source Units dialogue box displays a list of available SMUs and VS units that can be used to build a test setup. The contents of this dialogue box match the designations of the active SMU and VS fields defined in the KI23X Setup dialogue box. In addition to the designated SMU and VS units, the Source Units dialogue box also includes a source unit entitled "KI23X.GND". "KI23X.GND" is the designation for a hard ground. A hard ground is a grounding condition that is established by a hardwire connection from the test fixture to the grounding plug of an SMU.

It is possible to open a project file that was created with a KI23X Setup configuration that does not match the KI23X Setup configuration of the instrument presently available. This is called a hardware mismatch. A hardware mismatch is more precisely defined in the paragraphs that follow.

When a test setup is created, the association between the SMU model number and the SMU designation is stored as part of the test setup. This association is the same association defined in the KI23X Setup dialogue box when the test setup was created. Test setups are stored in project files, thus the KI23X setup configuration associated with each test setup is recorded in the corresponding project file. After creating the above project file, the user may alter the source unit setup. The user may change one or more GPIB addresses, add or remove an SMU, or change the SMU model. Any one or more of these situations will alter the KI23X setup configuration. If the user changes the KI23X setup configuration of the hardware, the user must update the KI23X Setup dialogue box. Failing to do so will generate a hardware mismatch error when the user attempts to execute a test setup. The user can update the KI23X Setup dialogue box either manually or with the use of the POLL button. As soon as the KI23X Setup dialogue box is updated, the new KI23X setup configuration is stored in memory. The new KI23X setup is written to the ICS.INI file as soon as the CLOSE button is selected in the KI23X Setup dialogue box.

When a user opens a project file, ICS will verify that the correspondence between the test setup SMU designations and the SMU model numbers agree with the KI23X setup configuration stored in memory. If there is disagreement, ICS will identify the inconsistency but will not display a hardware mismatch error until the respective test setup is executed.

When the user selects a test setup and clicks the toolbar MEASURE button, ICS will do two things. First, ICS will display an error message reporting any KI23X inconsistencies that were detected when the project file was opened. If there were none, ICS will then interrogate the source units and insure that the SMU model numbers, channel connections, and GPIB addresses of the hardware agree with the

KI23X setup configuration stored in memory. This verification detects inconsistencies that result when the user changes the KI23X setup configuration of the hardware but fails to update the KI23X Setup dialogue box. If this comparison agrees, ICS will execute the test setup. If it does not, ICS will display a hardware mismatch error.

When the user attempts to execute a test setup that includes a hardware mismatch, ICS will display a message box informing the user of the problem. The message box will identify the SMU designation that includes the inconsistency.

The Source Unit Setup Dialogue Box

A Source Unit Setup dialogue box is used to specify the sourcing and measuring conditions of the corresponding source. The setup specifications configured within each Source Unit Setup dialogue box are unique to each test setup. In other words, SMU1 may be configured with a particular set of specifications during the first test setup while configured differently for an alternative test setup.

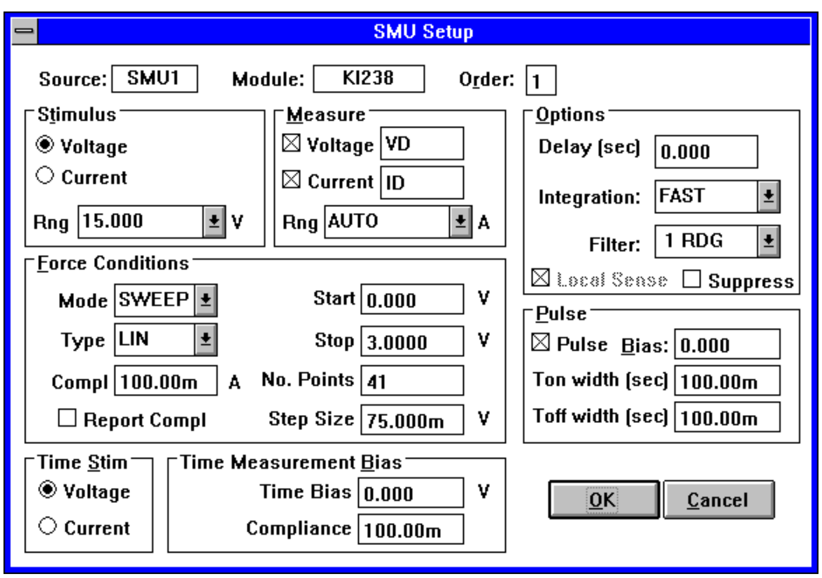


Figure 4: A Source Unit Setup Dialogue Box.

There is a Source Unit Setup dialogue box that corresponds to each SMU or VS unit. Each Source Unit Setup dialogue box is accessed from the Setup Editor.

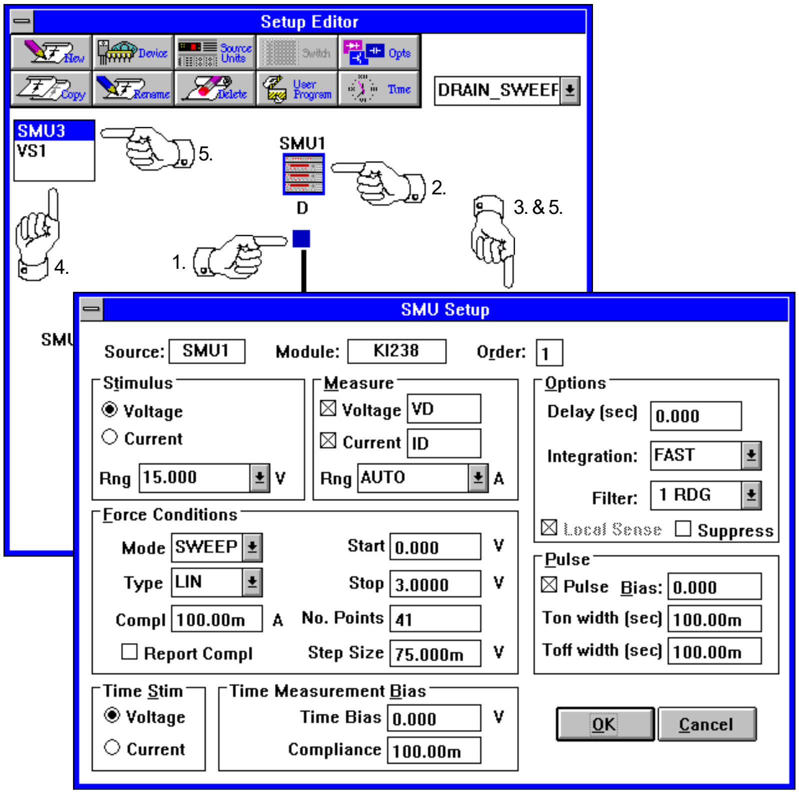


Figure 5: How to Display a Source Unit Setup Dialogue Box

The layout of a Source Unit Setup dialogue box corresponding to a source measure unit is pictured above. The layout of a Source Unit Setup dialogue box corresponding to a KI213 voltage source unit is pictured in Figure 5.

How to Display a Source Unit Setup Dialogue Box:

1. To open a Source Unit Setup dialogue box, the corresponding source must be connected to a DUT location in the Setup Editor device schematic. If the source unit is not connected, connect the source unit to a DUT location as described in *Step 4C: Designate the Source Unit/DUT Connections*.
2. Click once on the instrument icon corresponding to the designated Source Unit/DUT connection.
3. If only one source unit is connected to the DUT location, clicking on the instrument icon will open the corresponding Source Unit Setup dialogue box
4. If more than one source unit is connected to the DUT location, clicking on the instrument icon will open a list box of connected sources.
5. Click once to select the desired source. Double click on the selected source to open the corresponding Source Unit Setup dialogue box.

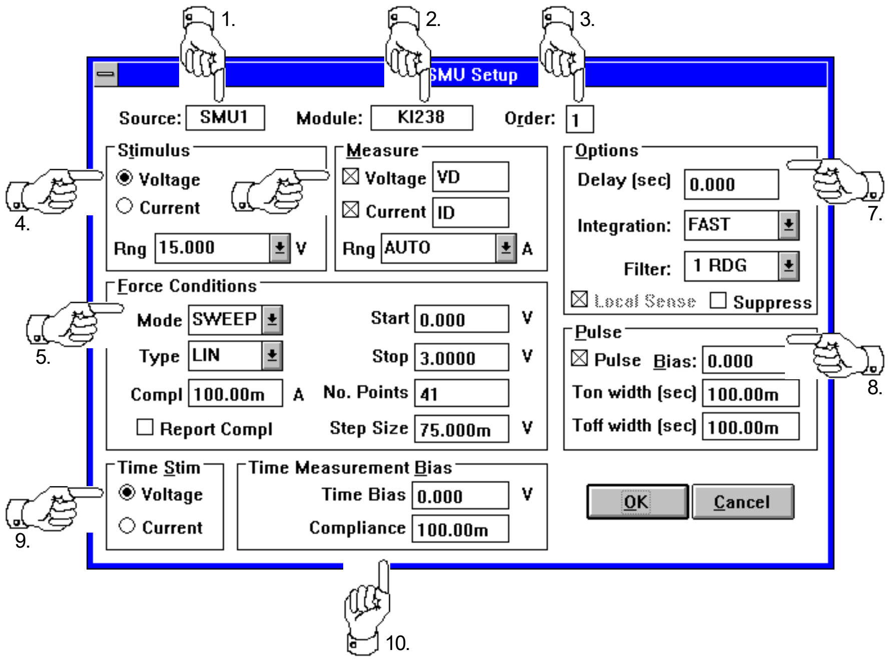


Figure 6: Layout of a Source Unit Setup Dialogue Box Corresponding to a Source/Measure Unit.

1. Source Unit Identity Field: This field is a static display that lists the ICS designation for the corresponding source.

2. Module Identity Field: This field is a static display that lists the source unit model number. The model number of the source unit connected is designated in the KI23X Setup dialogue box. For more information, refer to *Configuring the KI23X Setup Dialogue Box* earlier in this chapter.

3. Power-Up Order Field: This field is used to designate the order in which the source unit output will be applied to the DUT.

4. Stimulus Controls: This group includes a pair of switches and a list box. The switches are used to identify whether the source unit output signal is a voltage or a current. The list box is used to designate the source range of the output signal.

5. Force Conditions and Compliance Controls: The fields included in this group are used to designate the source unit output. The compliance controls are also included in this group.

6. Measure Controls: This group includes a pair of switches and text fields along with a single list box. The switch pair is used to identify the data that will be recorded in the test setup's data window spreadsheet. Both voltage and current can be returned at the same time. When the stimulus signal is selected as a measured quantity, the data written to the data window spreadsheet is calculated by ICS. The text fields are used to label the returned data. The list box is used to designate the measurement range of the source unit.

7. Options Controls: This group includes a set of fields used to control the Delay, Integration, and Filter capabilities of the source unit. The Local Sense and Suppress features are also controlled from this group.

8. Pulse Function Controls: This group includes the switch and fields used to configure the source unit in pulse mode.

9. Time Stimulus Controls: This group includes a pair of switches. The switches are used to identify whether the source unit output signal is a voltage or a current during time measurements.

10. Time Measurement Bias Condition Controls: The fields included in this group are used to designate the source unit output during time measurements. The time measurement compliance controls are also included in this group.

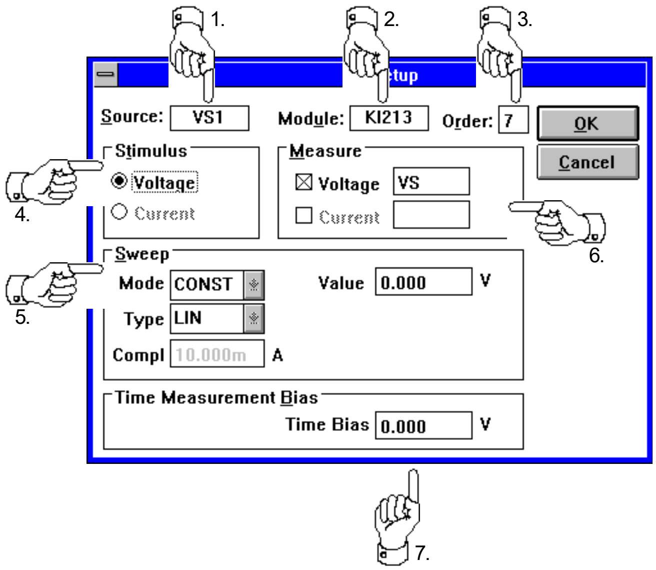


Figure 7: Layout of a Source Unit Setup Dialogue Box Corresponding to a Voltage Source Unit.

1. Source Unit Identity Field: This field is a static display that identifies the corresponding voltage source. This field will display a designation ranging from "VS1" through "VS4".

2. Module Identity Field: This field is a static display that lists the model number of the quad voltage source.

3. Power-Up Order Field: This field is used to designate the order in which the source unit output will be applied to the DUT. As a default, the SMU will power-up first, and the four voltage sources will power-up sequentially based upon the numerical identity of the voltage source designations. In other words, VS1 through VS4 are configured with default power-up orders of "2" through "5" respectively.

4. Stimulus Controls: The Stimulus controls include switches for voltage and current; however, the stimulus controls are locked in the voltage position since the Model 213 cannot source a current. The unavailability of the current switch is indicated by its gray color. Both switches are displayed in order to maintain a standard appearance among the Source Unit Setup dialogue boxes.

5. Force Conditions and Compliance Controls: The fields included in this group are used to configure the output waveform of the source unit. The output of the four voltage source units are limited to a constant signal between ±10V. The compliance of each voltage source is fixed at 100mA.

6. Measure Controls: This group includes a pair of switches and text fields. The switches are used to identify the data that will be recorded in the test setup's data window spreadsheet. Both voltage and current switches are displayed, but only the voltage switch is accessible to the user since current measurements are outside the capability of the Model 213. The unavailability of the current switch is indicated by its gray color. The text fields to the right of the measure switches are used to label the returned data. Again, the text field corresponding to the current switch is not accessible to the user. Both switches are displayed in order to maintain a standard appearance among the Source Unit Setup dialogue boxes.

7. Time Measurement Bias Condition Control: The field included in this group is used to designate the source unit output during time measurements.

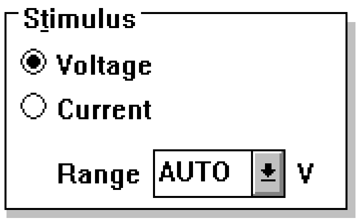
Power-Up Order

The order in which each source unit output signal is applied to the DUT is controlled from the Power-Up Order field. By designating the appropriate values in the Order field of each Source Unit Setup dialogue box, the user can control the power-up sequence of the source units connected to the DUT. The output of the source unit with the lowest value designated in the Order field will be the first output applied to the DUT. The output of the source unit with the next higher value will be the second output applied to the DUT. Finally, the output of source unit with the highest value designated in the Order field will be applied last.

As a default, the SMU will be assigned a power-up order of "1". Similarly, the four channels of the KI213 Quad Voltage Source (if present) will be assigned orders "2" through "5". For example, VS1 will be assigned a power-up order of "2". If two or more source units are configured at the same power-up order, ICS will display an error message when the user attempts to execute the test setup.

NOTE: The numerical values designated in the Order fields of each source unit do not have to be consecutive values. To achieve the desired power-up sequence, it is only important to maintain a "greater than" or "less than" relationship between each designated source unit order. For example, a test setup consisting of SMU1, VSU1, and VSU2 designated in an order of "1", "2", and "3" (respectively) will power up no differently than the same source units designated in an order of "2", "3", and "5".

Stimulus Controls



The stimulus controls consist of two switches and a list box. The VOLTAGE and CURRENT switches are used to specify the characteristic of the sweep signal. The list box is used to designate the source range of the instrument.

The KI213 Quad Voltage Source cannot be configured to sweep a current; as a result, the Current switch will be unavailable in the KI213 Source Unit Setup dialogue boxes. The Range field is also unavailable in the KI213 Source Unit Setup dialogue boxes since ICS automatically autostores the output of the KI213 sources.

Designating the Source Range of the Instrument

The instrument source range is designated by selecting the desired option in the Stimulus group Range field. As a default, the Range field will be configured in Autorange mode. When configured in Autorange mode, the instrument will select a source range automatically in response to the output level of the instrument. In some cases the user may wish to operate the instrument in "Best Fixed" mode or designate a fixed source range. To designate an alternative source range, click on the scroll arrow at the right end of the Range field. This will display a list of available options. Click on the desired selection.

The available ranges are a function of the source unit and selected source mode: VOLTAGE or CURRENT. Table 2 on page 50 lists the source range options available with the source units implemented in the KI23X I-V Test System.

NOTE: The KI23X implementation of the KI213 Quad Voltage Source is designed to provide four additional channels of constant voltage bias. The Quad Voltage Source forces an output at one of three ranges: 1V, 5V, or 10V. No Source Range field is provided in the Source Unit Setup dialogue boxes corresponding to the four VS units. The Quad Voltage channels are automatically configured in an Autorange mode. For more information about the output characteristics of the Quad Voltage Source, refer to the specification page at the beginning of the KI213 Quad Voltage Source Instruction Manual.

Autorange

As default, the source range of each instrument will be configured in Autorange mode as indicated by the "Auto" designation in the Stimulus Range field. When operating in Autorange, the instrument will select the source range scale that optimizes the resolution of the output signal. The instrument's selection will be based upon the actual signal output of the instrument, not the forcing conditions designated in the Source Unit Setup dialogue box.

When Autorange is selected, the instrument will not necessarily operate at the same source range throughout the entire measurement. At the beginning of the measurement, the instrument will select a source range scale based upon its initial output level. The instrument will continually monitor its output and select a new source range as necessary throughout the duration of the measurement. At each point in the output signal, the instrument will select the source range scale that provides the greatest output accuracy. For example, if a Model 236 is configured to force a voltage sweep from 100.0mV to 10.000V, Autorange will select the ±1.1V scale for the portion of the sweep output from 100.0mV to 1.1000V, and the ±11V scale for the potion of the sweep from 1.1000V to 10.000V.

Best Fixed

When Best Fixed is selected, ICS will select a fixed range based upon the instrument forcing conditions designated in the Force Conditions group of the Source Unit Setup dialogue box.

The Best Fixed source range is distinct from the instrument's Autorange mode in two important ways. Best Fixed mode selects a single fixed range that will apply to the entire measurement. Autorange mode changes source ranges as necessary throughout the measurement duration. Best Fixed mode selects a fixed range based upon the instrument forcing conditions designated in ICS. The source range selection in Autorange mode is based upon the actual output level of the instrument.

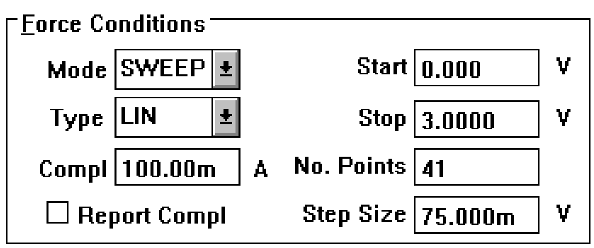
Force Conditions Controls

The Force Conditions controls are used to control the shape and magnitude of the source unit output as well as the output signal compliance limit.

Mode

The output signal shape of each source unit is controlled from the MODE field of the respective Source Unit Setup dialogue box. A source unit output signal may be characterized as a sweep, synchronized sweep, step, or constant supply. To select the desired sweep mode, click the scroll arrow at the right of the MODE field. This will display a list of available sweep mode selections. Click on the desired mode.

Sweep



The sweep mode generates either a linear or logarithmic staircase sweep signal between two specified boundary values.

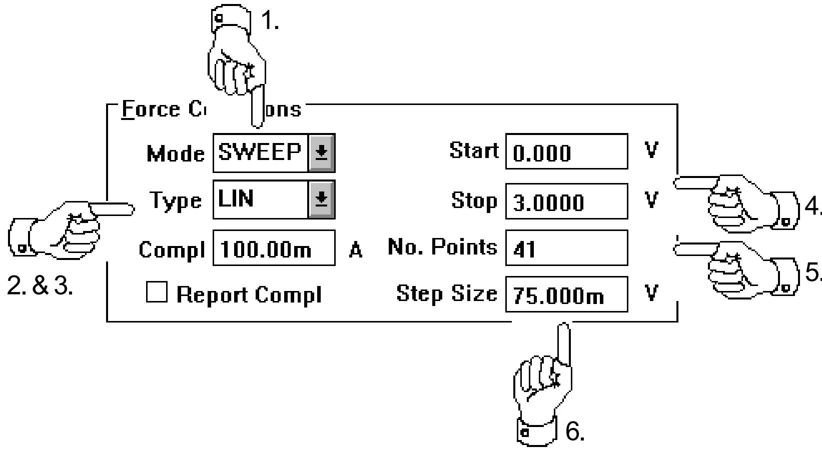
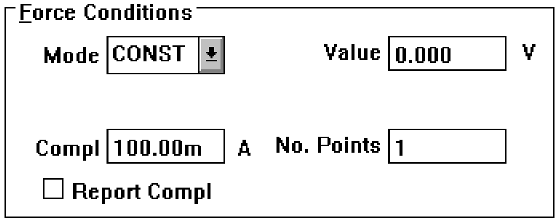


Figure 8: How to Force a Sweep Signal

How to Force a Sweep Signal:

1. Select the "SWEEP" designation from the available options listed in the MODE field.
2. The data point distribution of the sweep signal can be either linearly or logarithmically calculated between the START and STOP values that will be specified in Step #4. Select between a linear or logarithmic distribution by selecting the appropriate designation in the TYPE field.
3. Logarithmic distributions are designated by the number of data points per decade: LOG5, LOG10, LOG25, and LOG50. These designations represent 5, 10, 25, and 50 data points per decade.
4. Specify the sweep signal boundary values in the START and STOP fields.
5. Hitting the tab key from the STOP field will move the cursor to the NO. POINTS field. Enter the number of data points that will comprise the sweep signal. When a logarithmic sweep is selected, the NO. POINTS field is converted to a static field entitled "PTS/DEC" and automatically displays the data point quantity per decade selected in Step #3.
6. If a linear sweep type was selected, the Sweep controls will include a STEP SIZE field. The STEP SIZE field will be calculated automatically after a value is entered in the NO. POINTS field and the cursor is moved to another location (or OK is selected). If desired, the calculated STEP SIZE can be updated by the user. If a new value is entered in the STEP SIZE field, the STOP field will be updated to accommodate the new STEP SIZE value. If any of the other fields are edited, the STEP SIZE field will be automatically updated to accommodate the change.

Constant



The constant mode generates an output signal at constant magnitude throughout the duration of the test setup.

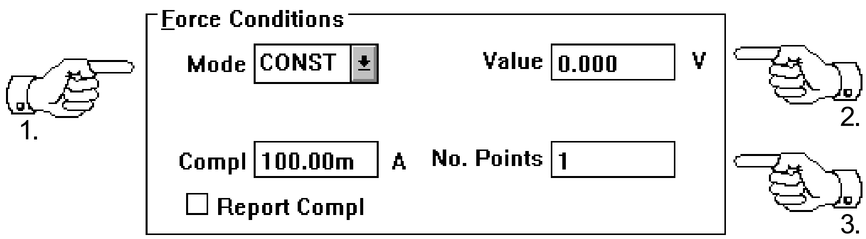


Figure 9: How to Force a Constant Signal

How to Force a Constant Signal:

1. Select the "CONST" designation from the available options listed in the MODE field.
2. Specify the magnitude of the constant signal in the VALUE field.
3. If a fixed sweep is being performed specify the number of points in the fixed sweep. Otherwise after measurement completion the point value will match the Sweep source's number of points.

Type

The TYPE field is used to designate the data point distribution of a sweep output. This field is displayed when a sweep designation is selected in the MODE field.

Start

The START field is used to specify the starting value of the sourcing signal. This field is displayed when a sweep or step designation is selected in the MODE field.

Stop

The STOP field is used to specify the stopping value of the sourcing signal. This field is displayed when a sweep or step designation is selected in the MODE field.

No. Points

The NO. POINTS field is used to specify the data point quantity in a linear or fixed sweep signal. This field is displayed when a sweep or constant signal is selected in the MODE field, and a linear characteristic is selected in the TYPE field.

Pnts/Dec

The PNTS/DEC field is a static field that displays the data point quantity per decade corresponding to a logarithmic sweep source. This field is displayed when a sweep signal is selected in the MODE field, and a logarithmic characteristic is selected in the TYPE field.

No. Steps

The NO. STEPS field is used to specify the increment quantity of a step signal. This field is displayed when a step signal is selected in the MODE field.

Step Size

The STEP SIZE field designates the sweep or step signal increment size. The value of this field is automatically calculated after the user specifies either the NO. POINTS in a linear sweep or the NO. STEPS in a step output. If the value of this field is changed by the user, the value of the STOP field will be updated to accommodate the change. This field is displayed when either a sweep or step signal is selected in the MODE field, and a linear characteristic is selected in the TYPE field.

Value

The VALUE field is used to specify the magnitude of a constant signal. This field is displayed when a constant source is selected in the MODE field.

Compliance

The COMPLIANCE field is used to specify the limiting magnitude of a measured signal. When an SMU is sourcing voltage and measuring current, a current compliance must be specified. Similarly, if an SMU is sourcing current and measuring voltage, a voltage compliance must be specified.

The default value of the COMPLIANCE field is determined by the stimulus mode of the source unit. When sourcing a voltage, the default value of the COMPLIANCE field is 100mA. When sourcing a current, the default value of the COMPLIANCE field is 1V.

The compliance limit allows the user to execute a test setup that is within an acceptable power range of the device by limiting the operating range of the SMU. The maximum compliance limit that ICS will allow is determined by the operating boundaries of the instrument. If necessary, refer to Table 2 on page 50 to review the capability of each source unit model.

Report Compliance

Each Source Unit Setup dialogue box includes a switch that provides the user with the option of configuring ICS to display a message when a compliance limit is detected. If the Report Compliance switch is selected, ICS will interrupt the measurement and display a message box if the respective source unit reaches compliance. The message box will present the options of retrying the test setup, aborting the test setup, or ignoring the message. After selecting an option, ICS will close the message box and proceed as instructed.

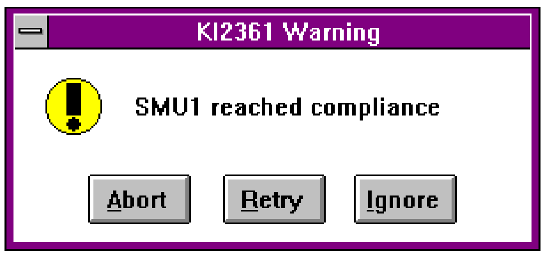
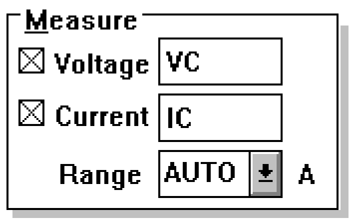


Figure 10: ICS Detects Compliance Limits if the Report Compliance Switch is Selected in the Respective Source Unit Setup Dialogue Box.

If the user does not want to interrupt device measurements when a compliance limit is detected, ensure that the Report Compliance switch is not selected. This is desirable when you wish to execute a sequence of measurements while away from the machine. As a default, the Report Compliance switch is OFF.

Measure Controls



The Measure controls consist of two switches and a list box. The VOLTAGE and CURRENT switches are used to designate the data that will be written to the corresponding data window spreadsheet. The list box is used to designate the measurement range of the instrument.

In addition to the two measure switches and list box, a text field is located to the right of each switch. The text fields are used to label the data that will be returned when the test setup is executed.

The KI213 Quad Voltage Source is not capable of performing a measurement. For this reason, the Current switch and Range field are unavailable in the KI213 Source Unit Setup dialogue boxes. When the Voltage switch is selected, the voltage data written to the data window spreadsheet is calculated by ICS.

Specifying Returned Data

A source unit's measurement configuration is designated by turning ON or OFF the Voltage and Current switches located in the Measure controls. Depending upon the particular source, one of the two switches may be unavailable.

Both voltage and current values can be returned simultaneously to the data window spreadsheet; however, only the signal type that is opposite to the stimulus type will be obtained from the instrument. When the stimulus signal is selected as a returned quantity, the corresponding data written to the data window spreadsheet is calculated by ICS.

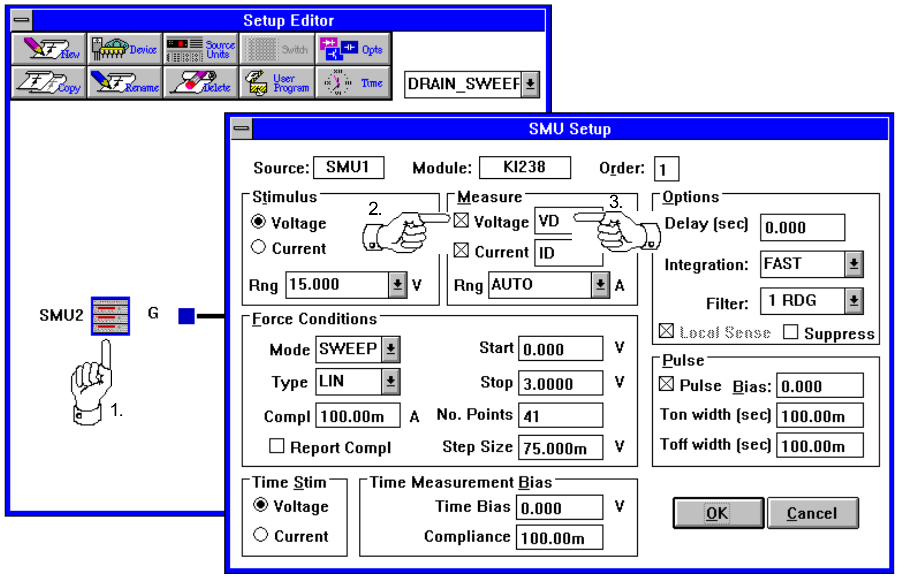


Figure 11: How to Specify Returned Data

How to Specify Returned Data:

1. Open the Source Unit Setup dialogue box corresponding to the source that will return data.
2. Click on one or both of the data return switches. Depending upon the capability of the corresponding source, one of the two switches may be unavailable.
3. When either of the two data return switches is selected, a default data vector label will be displayed in the corresponding text field. The data vector label identifies the returned data. If desired, specify a different data vector label.

Labeling Measured Data

All of the data that corresponds to a single curve is collectively referred to as a "data vector". Each data vector is identified by a "data vector label" that must be defined in the text field to the right of the VOLTAGE or CURRENT switch. A data vector label can be any alphanumeric string up to three characters in length.

When either of the measure switches is selected, a default data vector label will be displayed in the appropriate text field. The default data vector label is determined by the device schematic displayed in the Setup Editor and the pin at which the source unit connection is designated. For example, if the test setup implements the MOSFET schematic, data returned by selecting the Measure Voltage switch in the Source Unit Setup dialogue box corresponding to the gate will be identified as "VG". The default data vector labels can be overwritten by the user with any alphanumeric string up to three characters in length.

The presence of only two data vector fields does not mean that only two data vectors can be specified in a test setup. In fact, by using a combination of step and sweep source units, up to 42 data vectors can be defined per test setup.

Test setups that use a combination of stepped sources and swept sources can return both sequential and non-sequential data vectors. Test setups that use a combination of constant sources and swept sources only return non-sequential data vectors.

Sequential Data Vectors

A sequential data vector is a device characteristic that is described by a family of unique curves. Each curve is measured in response to a stepped bias condition. Sequential data vectors are the result of test setups that include stepped sources and repeated sweeps.

For example, consider the DC collector characteristics of a bipolar transistor. The DC collector characteristics are obtained by generating a family of I_{CE} vs. V_{CE} curves. This setup was created by applying a stepped current supply to the base and a swept voltage supply to the collector. The source unit connected to the collector returned both collector voltage (V_{CE}) and collector current (I_{CE}). Each time the base current was stepped to a new value, a unique I_{CE} curve was obtained in response to the collector voltage sweep. The result of this test setup was a family of unique I_{CE} curves. I_{CE} is a sequential data vector because collector current is described by a family of unique curves measured in response to stepped base current.

Non-Sequential Data Vectors

A non-sequential data vector is a device characteristic that is described by a single curve.

For example, consider the example presented in the previous section, *Sequential Data Vectors*. The DC collector characteristics of a bipolar transistor were obtained by generating a family of I_{CE} vs. V_{CE} curves. This test setup was created by applying a stepped current supply to the base and a swept voltage supply to the collector. The source unit connected to the collector returned both collector voltage (V_{CE}) and collector current (I_{CE}). Because the base current was stepped, this test setup returned a family of I_{CE} curves. The voltage sweep applied to the collector during each base current step was the same. Therefore, V_{CE} is a non-sequential data vector, because V_{CE} can be described by a single curve.

Designating the Measurement Range of the Instrument

The instrument measurement range is designated by selecting the desired option in the Measure group Range field. As a default, the Range field will be configured in Autorange mode. When configured in Autorange mode, the instrument will automatically downrange to the lowest range possible in order to optimize the sensitivity of the measurement. In some cases the user may wish to designate a "Best Fixed" or fixed range in order to precisely control the measurement resolution of the source unit. To designate an alternative measurement range, click on the scroll arrow at the right end of the Range field. This will display a list of available options. Click on the desired selection.

When both Measure switches are selected, only the signal type that is opposite to the stimulus type will be obtained from the instrument. The data corresponding to the stimulus signal will be calculated by ICS. For this reason, the options available in the Measurement Range field are opposite in type to the options available in the Source Range field.

The available ranges are a function of the source unit and selected source type: VOLTAGE or CURRENT. Table 3 on page 65 lists the measurement range options available with the source units implemented in the KI23X I-V Test System.

Autorange

As a default, the measurement range of each instrument will be configured in Autorange mode as indicated by the "Auto" designation in the Measure Range field. When operating in Autorange, the instrument applies the highest scale possible within its measurement capability and then downranges to the scale that optimizes the measurement resolution.

When Autorange is selected, the instrument will not necessarily operate at the same measurement range throughout the entire measurement. The instrument will continually monitor its input and change the measurement range as necessary throughout the duration of the measurement. At each point in the input signal, the instrument will select the measurement range scale that provides the greatest input resolution. For example, if a Model 236 is measuring a current signal that varies from +05.000nA to +075.00nA, Autorange will select the ±10nA scale for the portion of the input signal from +05.000nA to +10.000nA, and the ±100nA scale for the potion of the input signal from +010.01nA to +075.00nA.

When a measured reading is increasing, the instrument will autorange to the next highest range when full scale is surpassed. For example, if a Model 237 is measuring a current of +0.8971mA on a ±1mA scale, the instrument will autorange to the ±10mA scale when the reading surpasses +1.0000mA.

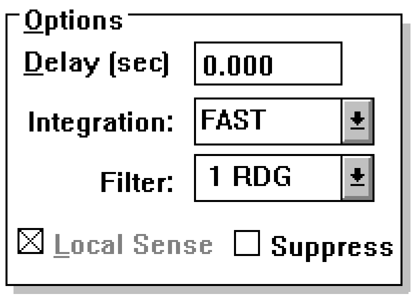
When a measured current is decreasing, the instrument will autorange to the next lower scale when the signal level decreases to 9% of full scale. For example, if a Model 236 is measuring a current of +01.000mA on a ±10mA scale, the instrument will autorange to the ±1mA scale when the reading decreases past +00.900mA. When the instrument is measuring a voltage signal, the instrument will downrange when the signal level decreases to 8.1% of full scale. An exception to specification occurs with the 1.5V and 15V ranges of the Model 238. When operating at these scales, the instrument will downrange at 9% of full scale.

Best Fixed

When Best Fixed is selected, ICS will select a fixed range based upon the instrument compliance limit designated in the Force Conditions group of the Source Unit Setup dialogue box.

The Best Fixed measurement range is distinct from the instrument's Autorange mode in two important ways. Best Fixed mode selects a single fixed range that will apply to the entire measurement. Autorange mode changes measurement ranges as necessary throughout the measurement duration. Best Fixed mode selects a fixed range based upon the instrument compliance limit designated in ICS. The measurement range applied in Autorange mode is based upon the actual signal level measured by the instrument.

Source Unit Options



The Options controls provide access to higher level KI23X features that don't necessarily require configuration each time a test setup is created. The default configuration of the Options group should be sufficient for most applications.

The Options controls are used to configure a Delay time, Integration time, and Filter selection. The Options controls also provide the capability to turn ON or OFF the Local Sense and Suppress functions.

Delay

The Delay field provides the user with the capability to specify a delay time prior to obtaining a measurement. A delay time ranging from 0.000 to 65.000sec can be applied to any of the non-pulsed sweep modes.

For more information about the sweep delay, refer to Section 2.19 of the Keithley 236/237/238 Operator's Manual.

Integration

The Integration time specifies the rate at which the instrument will obtain consecutive measurement points. Select from among a fast, medium, or 60Hz line cycle integration. Integration time alone does not account for the total span of time between consecutive measurements. The specified sweep may also add to the length of time between measurements.

Click on scroll arrow to display a drop-down list of the available options. Click on the desired choice.

The Integration time provides the user with the capability to balance speed, resolution, and noise rejection. For a detailed overview of each Integration selection, refer to Section 2.15 of the Keithley 236/237/238 Operator's Manual.

Filter

The Filter option is used to minimize the effects of noisy measurements by averaging a number of readings. Select among 1, 2, 4, 8, 16, or 32 readings per measurement. Click on the scroll arrow to display a drop-down list of the available options. Click on the desired choice.

Higher readings per measurement will reduce noise affects but will increase the measurement time. Refer to Section 2.16 of the Keithley 236/237/238 Operator's Manual for a detailed overview of the filtering capability.

Local Sense

When an SMU is configured to source either a voltage or a current, the SMU will monitor a feedback signal to determine if the source unit output matches the programmed value. If the Local Sense switch is left in the default OFF position, the source unit will measure the feedback signal at the load. This is referred to as "Remote Sensing". If the Local Sense switch is turned ON, the source unit will measure the feedback signal at the source unit.

WARNING You must connect the sense leads between the test fixture and the SMU before initiating a remote sensing measurement. Failure to do so causes a safety hazard with potentially lethal voltages at OUTPUT HI and its GUARD, and the GUARD surrounding SENSE HI.

To make it more difficult for a user to configure a test setup for remote sensing while unaware of the additional hardware requirements, the Local Sense Lockout switch in the KI21361 Mainframe Controls dialogue box must be turned OFF before the Local Sense switch in the Source Unit Setup dialogue box can be accessed by the user. As a default, the Local Sense Lockout switch in the KI23X Mainframe Controls dialogue box will be turned ON. When the Local Sense Lockout switch is ON, the Local Sense switch in the Source Unit Setup dialogue box cannot be switched from the default ON position to OFF.

When sourcing voltage and measuring current with remote sensing, the sense leads provide a feedback voltage. If the feedback voltage is less than the programmed voltage, the internal voltage source is increased until the voltages are equal. Remote sensing compensates for test lead I/R drops, ensuring that the programmed voltage level is delivered to the load.

When sourcing current and measuring voltage with remote sensing, the voltage reading is the actual voltage drop across the load. Test lead I/R drops are not included in the reading.

Suppress

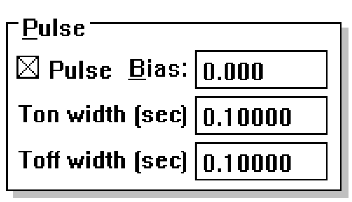
The Suppression function allows a stored offset value to be subtracted from subsequent measurement readings. When the Suppress function is enabled, the next measured value will be internally stored by the instrument as a baseline. All subsequent measurements returned by the instrument will be the difference between the suppressed value and the actual signal level. The suppressed readings can be as small as the measurement resolution of the instrument or as large as full range.

The baseline value maintains its value regardless of range. For example, if a 0.5V measurement is suppressed on a Model 236 1.1V range, the suppressed value will remain at 0.5V on both the 11V and 110V ranges.

A suppressed value is not saved for both the voltage source and the current source. The respective baselines will be lost when the Stimulus controls are toggled between VOLTAGE and CURRENT.

For a detailed overview of the Suppression function, refer to Section 2.17 of the Keithley Model 236/237/238 Operator's Manual.

Configuring a Pulsed Source



The sweep, step, and constant sourcing modes can be used in conjunction with the pulse function to source a pulsed signal. Pulse mode can be used with either a linear or logarithmic source type selected.

To configure the selected sweep, step, or constant signal in pulse mode, select the Pulse switch in the Pulse Mode controls box. When the Pulse switch is selected, the bias and timing fields are accessible. Pulse mode is not available for time measurements.

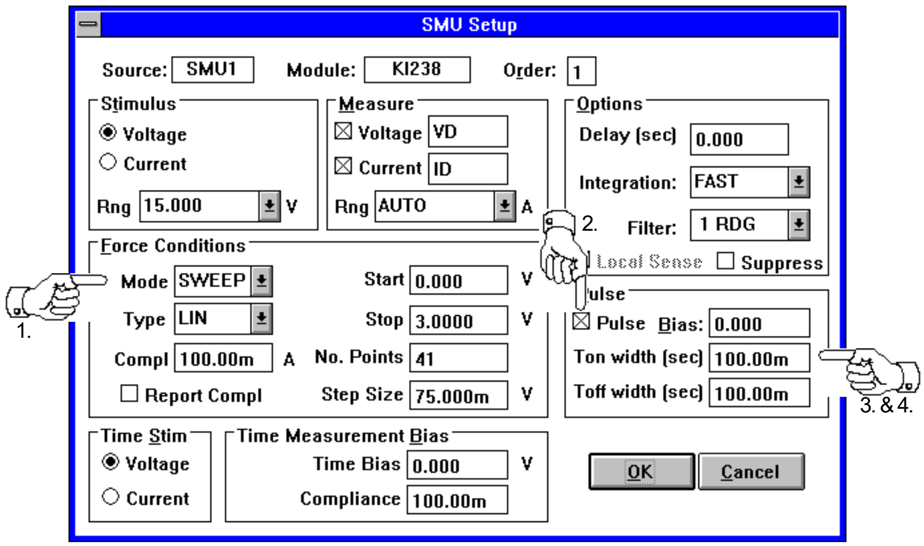


Figure 12: How to Configure a Pulsed Source.

How to Configure a Pulsed Source:

1. Select the desired linear or logarithmic sweep mode in the Sweep controls.
2. Select the Pulse switch.
3. Specify a pulse bias in the Bias field. The pulse bias is the signal magnitude the SMU will source between pulse levels.
4. Specify a T_{on} Width. T_{on} Width is the time duration (in seconds) at each pulse level. T_{on} can be designated between 0.001sec and 65.000sec.
5. Specify a T_{off} Width. T_{off} Width is the time duration (in seconds) at the bias level. T_{off} can be designated between 0.001sec and 65.000sec.

The Global Setup Dialogue Box

Clicking the OPTIONS button in the Setup Editor will open the KI23X Global Setup dialogue box. The KI23X Global Setup dialogue box includes two fields along with two switches. The MAX VOLTAGE and MAX CURRENT fields are used to limit the operating range of every source unit in the KI23X system. The switches are used to enable or disable the Local Sense Lockout and Time Stamp Data functions.

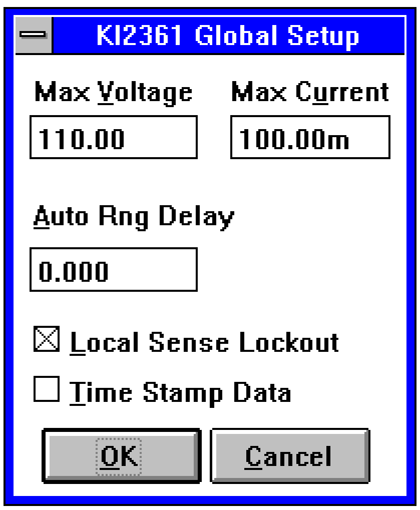
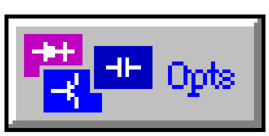


Figure 13: The KI23X Global Setup Dialogue Box

The configuration of the KI23X Global Setup dialogue box is applicable to every source unit in the test setup. The KI23X Global options are only applied to the test setup in which they were specified. Once a new test setup is defined, the KI23X Global options can be re-specified without changing the configuration of the global setup options in a previously defined test setup.



The KI23X Global Setup dialogue box is displayed by clicking the Setup Editor OPTIONS button after first designating at least one Source Unit/DUT connection.

Global Output Limitations

The KI23X Global Setup dialogue box include two fields: MAX VOLTAGE and MAX CURRENT. The values designated in these fields impose a limit on the voltage and current output levels that can be configured from each of the Source Unit Setup dialogue boxes relevant to the test setup. For example, if the MAX VOLTAGE and MAX CURRENT fields are set to 500mV and 100mA, then none of the test setup source units can be configured to force an output signal that exceeds these limits regardless of the instrument's source range or output capability. If the user attempts to force a voltage output past 500mV, ICS will generate a warning message when the user tries to close the respective Source Unit Setup dialogue box. The message box will display the acceptable range of the output signal in violation of the global output limit.

The global output limitations are designed to protect the DUT from test configurations that may potentially damage the device. For example, a KI23X may include a Model 237 High Voltage Source Measure Unit. In many cases, forcing 1100V on a DUT may destroy the device. The user can set the MAX VOLTAGE field to 110V in order to lessen the probability that the DUT would be inadvertently exposed to damaging input conditions.

As a default, the MAX VOLTAGE and MAX CURRENT fields will be set to 110V and 100mA. The default Global Output Limits represent a capability that is common to the Model 236, 237, and 238 Source Measure Units. Designating a Global Output Limit in excess of a particular instrument's capability will not generate an error message. If a Global Output Limit exceeds the capability of the instrument, the Global Output Limit will be ignored and the instrument will be configurable across the full range of its output capability.

The Global Output Limits do not impose a restriction on measured signal levels. The Global Output Limits are applicable only to the magnitude of the source unit output levels.

The values designated in the MAX VOLTAGE and MAX CURRENT fields are distinct from the compliance limit specified in the Force Conditions group of each source unit. The compliance value limits the source unit output by sensing the magnitude of the measured signal. In other words, the compliance value imparts a power limitation to the DUT. The Global Output Limits designated in the KI23X Global Setup dialogue box limit the output range of each source unit in the test setup. The Global Output Limits impart a limiting magnitude on the source unit output signal independent of the return signal's magnitude. In other words, the Global Output Limits control the magnitude of the source unit output signals, not the power drawn by the DUT. Further, the compliance specification is not global to every source unit in the test setup. Each source unit can be configured with a unique compliance limit. On the other hand, the Global Output Limits are applicable to every source unit relevant to the test setup.

Auto Range Delay

The Auto Range Delay value is the delay time, from 0.0s to 65s, between the end of the previous measurement point and the start of the next measurement point.

Local Sense Lockout

If the Local Sense Lockout switch is selected in the KI23X Global Setup dialogue box, the Local Sense switch in each Source Unit Setup dialogue box will be inaccessible to the user. The inaccessibility of the Source Unit Setup Local Sense switch will be evident by the grayed-out appearance of the control.

If the Local Sense switch is selected in a Source Unit Setup dialogue box, the source unit output level will be monitored at the source unit. If the switch is turned OFF, the source unit output level will be monitored at the load. This is referred to as "Remote Sensing". A test setup configured for remote sensing requires special cabling from the source unit to the test fixture.

Failure to use the proper cabling will eliminate the remote sensing feedback path. If no feedback is provided to the source unit during remote sensing, the source unit will continue to increase the output signal magnitude until the output limit of the instrument is reached. This situation is potentially hazardous to the device as well as to the operator.

The implementation of the Local Sense Lockout switch in the KI23X Global Setup dialogue box is an attempt to prevent the casual selection of remote sense mode without connecting the appropriate cables between the instrument and test fixture. As a default, the Local Sense switch in each Source Unit Setup dialogue box is configured in the ON position. The Local Sense Lockout switch in the KI23X Global Setup dialogue box must be turned OFF before the Local Sense switch in each Source Unit Setup dialogue box can be toggled by the user. As a default, the Local Sense

Lockout switch in the KI23X Global Setup dialogue box will be turned ON. When the Local Sense Lockout switch is ON, the configuration of the Local Sense switch in each Source Unit Setup dialogue box can not be altered.

The function of the Local Sense Lockout switch is pictured in Figure 14. For more information about the KI23X Local and Remote Sense modes, refer to an earlier section of this chapter entitled *Source Unit Options/Local Sense*.

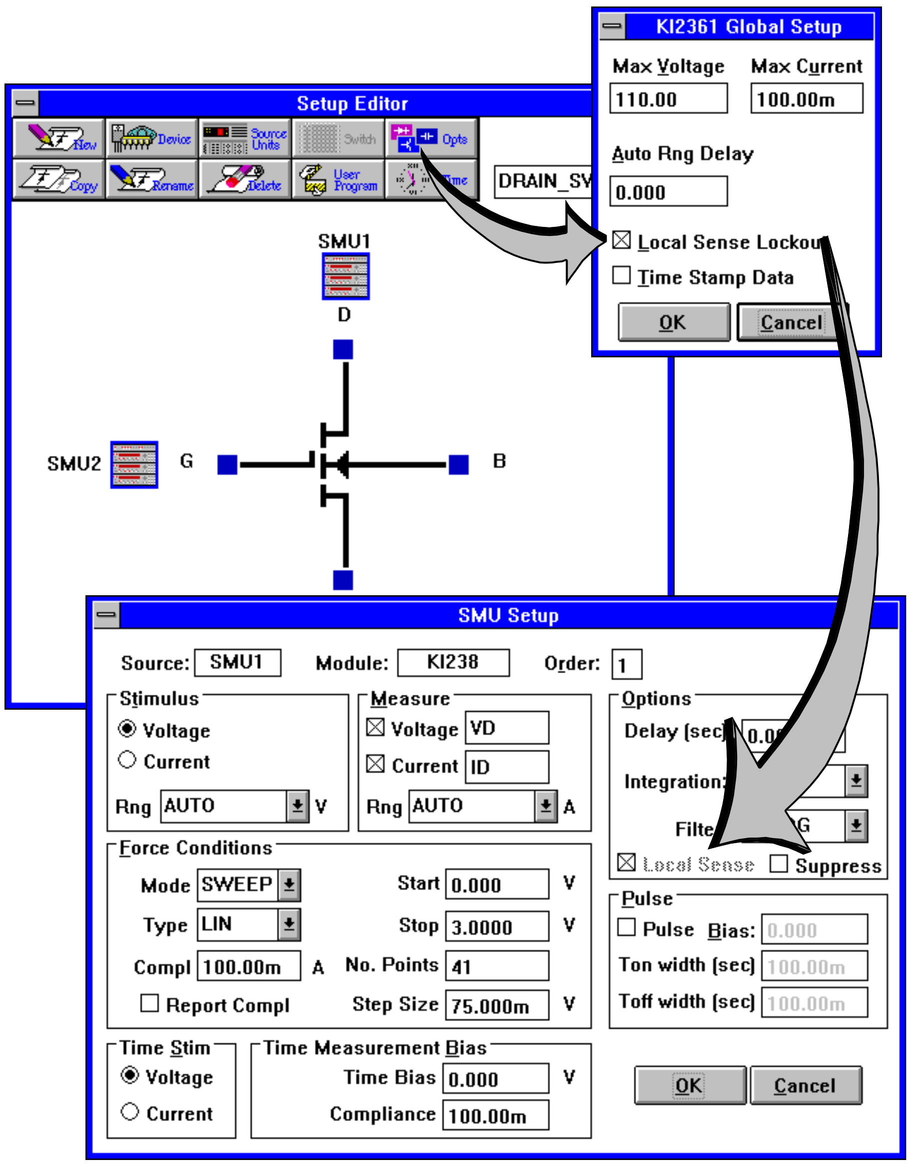


Figure 14: If the Local Sense Lockout Switch in the KI23X Global Setup Dialogue Box is ON, the Configuration of the Source Unit Setup Remote Sense Switch Cannot be Altered.

Time Stamp Data

Each data point that is measured during the execution of a test setup is "time stamped". This means that in addition to storing the value of the measured signal, each source unit will also record the elapsed time between the beginning of the source unit output signal and the end of the measured data point. The time stamp is useful for data logging, recording I or V versus time, and measuring transient response time and other time-dependent effects.

As a default, the time stamp data will not be returned to the corresponding data window spreadsheet. (The sourced and/or measured signals are returned by selecting the appropriate switch(es) in the Source Unit Setup Measure controls.) However, the time stamp data can be returned to the data window spreadsheet by selecting the Time Stamp Data switch in the KI23X Global Setup dialogue box.

Because the Time Stamp Data switch is located in the Global Setup dialogue box, time stamp data recorded in the data window spreadsheet will apply to the timing of every source unit in the setup. This is possible since the output signals of multiple source units are synchronized by the KI23X Trigger Control Unit. If data is returned by more than one source unit, the same time stamp data will correspond to each measured signal. For this reason, when the Time Stamp Data switch is ON, only one column of time measurements will be recorded in the data window spreadsheet. This column will be labeled "Time" and will be positioned at the first column position of the spreadsheet.