Metrics Technical Reference Manual

KI90

Metrics ICS

Version 4.5

Table of Contents

KI Model 90/24x0/6430 Instrument Driver

Getting Started: Setting Up the Hardware

The Keithley Model 90 I-V Test System includes up to six source measurement units (SMUs) and a quad voltage source (VS) coordinated by a trigger control unit (TCU). 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. Additionally, Model 24X0 Source Meters can be substituted for the KI23x SMU in the system with ICS compatibility retained. The Model 90 I-V Test System can be used with the Model 8006 Component Test Fixture.

THIS DRIVER CAN ALSO CONTROL A SINGLE 24X0 OR 6430 SOURCEMETER WITHOUT THE 2361 TRIGGER CONTROL UNIT.

System Block Diagram

An overall block diagram of a Model 90 I-V Test System is shown in Figure 1. This configuration includes two source measure units, a quad voltage source, and a switching matrix and shows all the elements of a typical semiconductor test system. Keithley's modular approach allows many possible configurations, depending on the needs of a particular application. The various system components perform the following functions:

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 2400/2410/2420/2430/6430 Source Meter Units: Each source measure unit can source voltage and simultaneously measure current, or source current and simultaneously measure voltage. Up to six Source Meters can be used in one test system.

Model 2361 Trigger Controller: A Model 2361 Trigger Controller is required when running ICS with the KI2361 Driver. The Model 2361 Trigger Controller simplifies system trigger connections and coordinates the trigger sequences and timing needed for all tests. (The KI23X Driver runs a single source measure unit along with the quad voltage source. The Model 2361 Trigger Controller is not required when running ICS with the KI23X Driver.)

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.

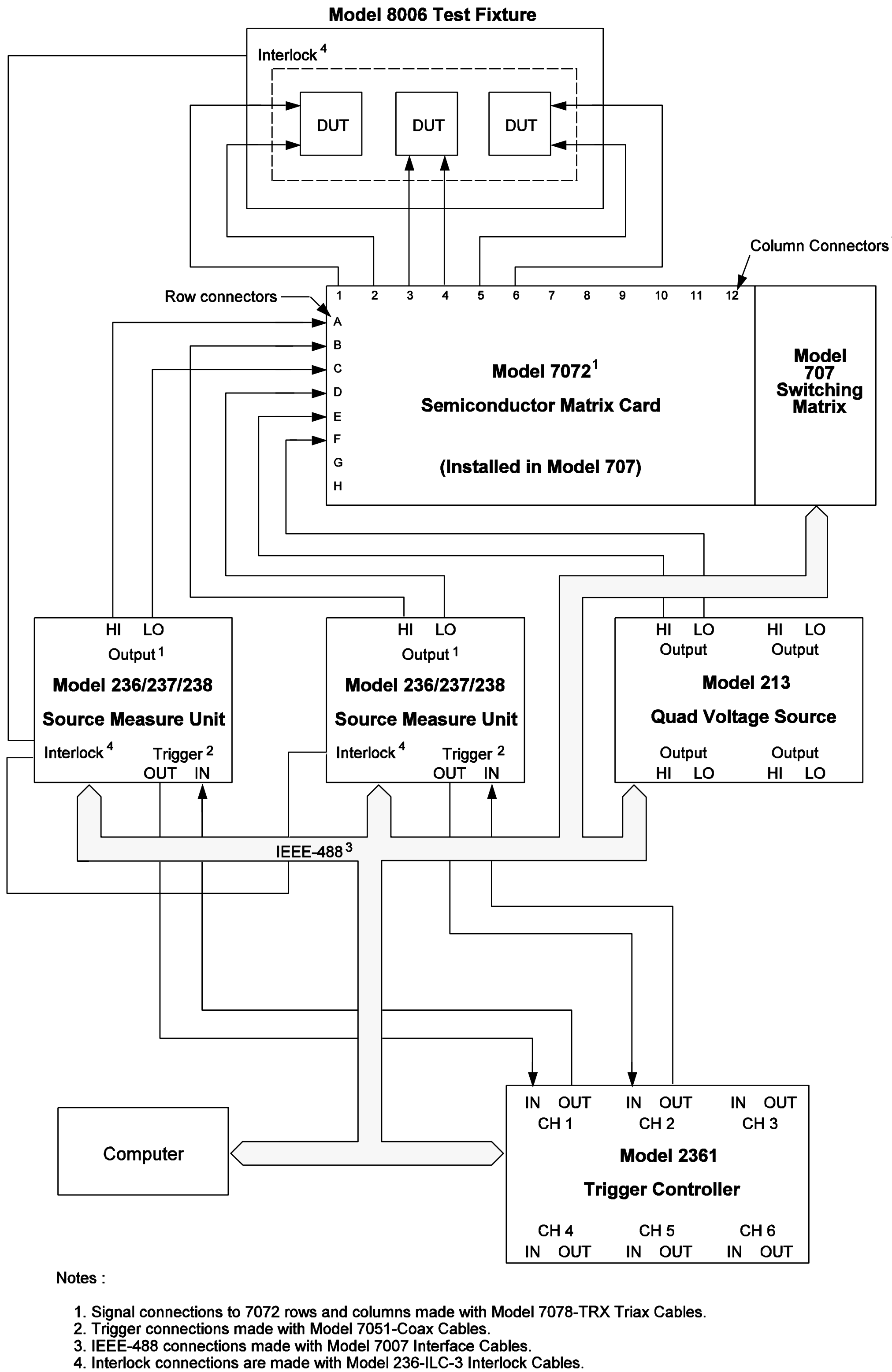


Figure 1: A Block Diagram of a Model 90 I-V Test System

System Connections

The list below summarizes the necessary cables for a test system with Model 236/237/238 Source Measure Units, Model 2400/10/20 Source Meter Units, a Model 2361 Trigger Controller, a Model 707 Switching Mainframe with a Model 7174 Semiconductor Matrix Card, and a Model 8006 Test Fixture.

Model	Description	Application
8503	Trigger Cable	Trigger connections between 2400/10/20 and 2361.
Pomona 1269	Dual Banana to BNC (f) Connector	Signal connection between 2400/10/20 and 7051-5.
7051-5	BNC cable (RG-58C).	Signal connection between Pomona 1269 (output of 2400/10/20) and 7078-TRX-BNC.
7078-TRX-BNC	TRX (m) to BNC (f) connector	Signal connection from 7051-5 to 7174.
7078-TRX-x	Low noise triax cable. Available in 0.9m, 3m, or 6m.	Signal connections between 236/237/238, 7174 and 8006.
7051-x	BNC cable (RG-58C). Available in 0.6m, 1.5m, or 3m.	Trigger connections between 236/237/238 and 2361; unguarded signal connections.
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.

Connect the equipment together as shown in Figures 2 through 4. For test systems using a Model 213 Quad Voltage Source, see Figure 5. The typical method for connecting Model 7072 or 7174 matrix cards to a Keithley source measure unit is shown in Figure 6.

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.

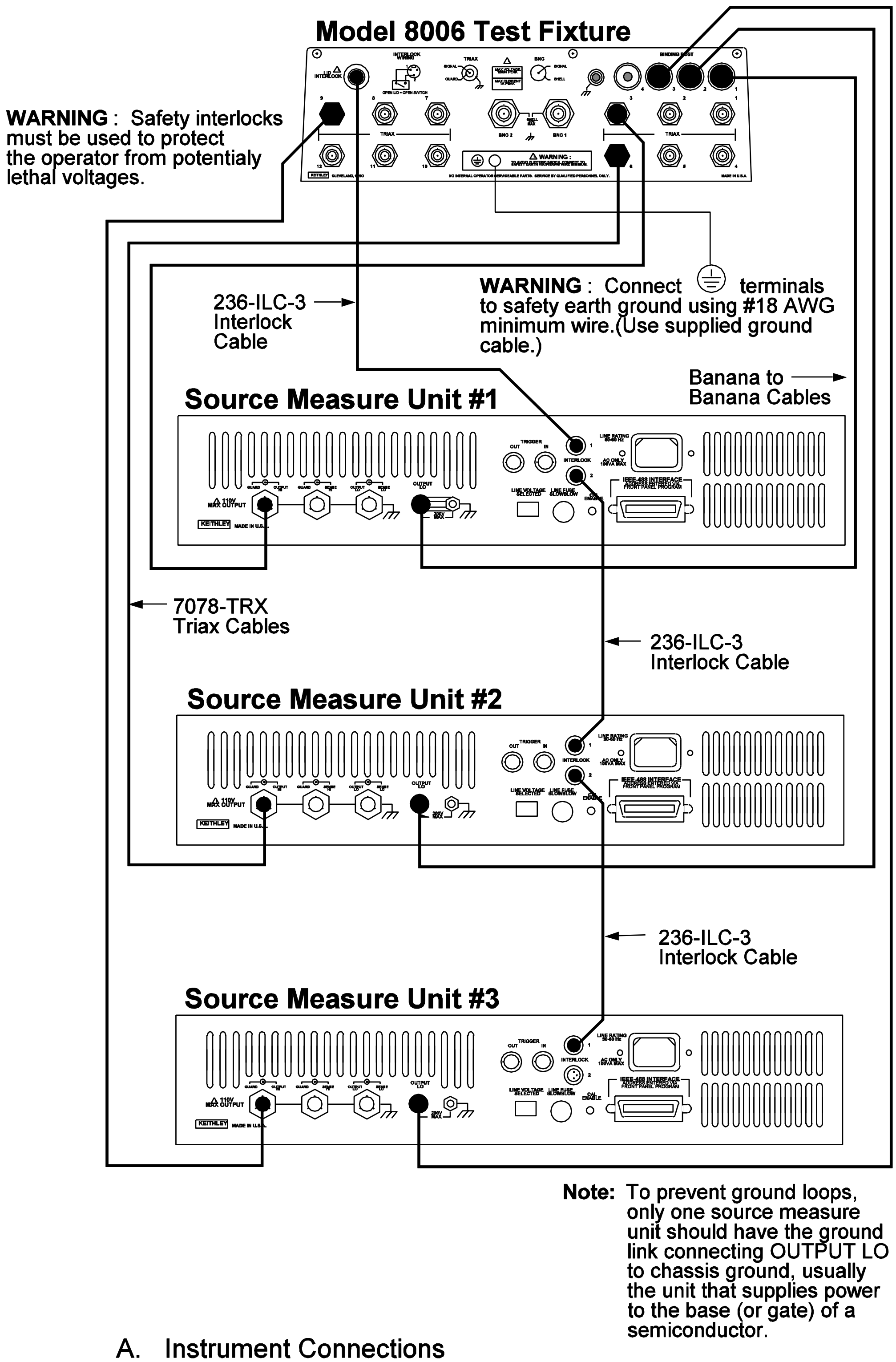
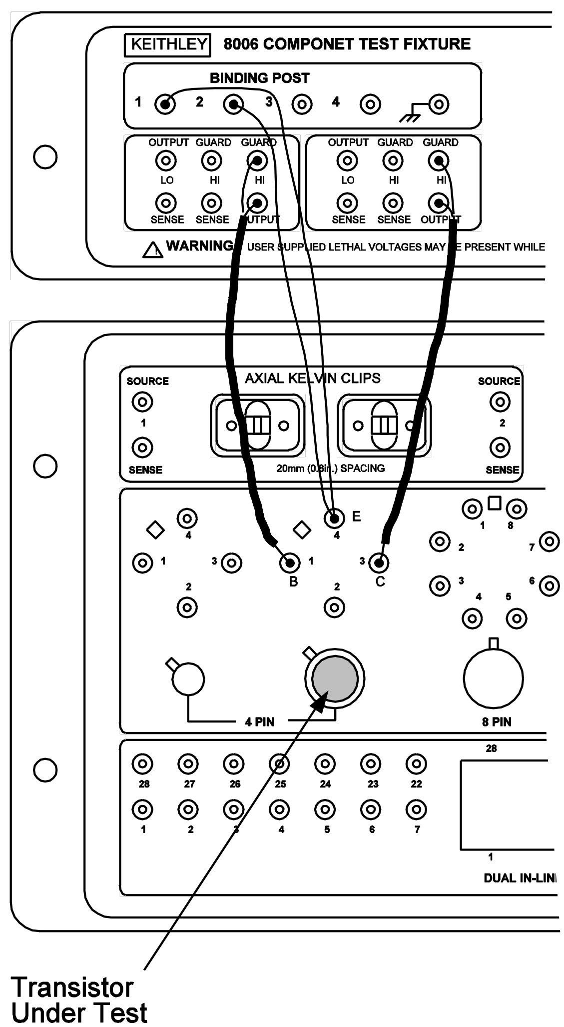


Figure 2A: Multiple Source Measure Unit Signal and Interlock Connections Configured for Local Sensing (Instrument Connections).

Note : Jumpers are shown for common-emitter curves using local sense. This test requires two SMUs.

——— Standard Jumpers

▬▬ Guarded Jumpers



Socket Pinouts : 1 = Base (Unit 1)
3 = Collector (Unit 2)
4 = Emitter

B. 8006 Jumper Connections

Figure 2B: Multiple Source Measure Unit Signal and Interlock Connections Configured for Local Sensing (8006 Jumper Connections).

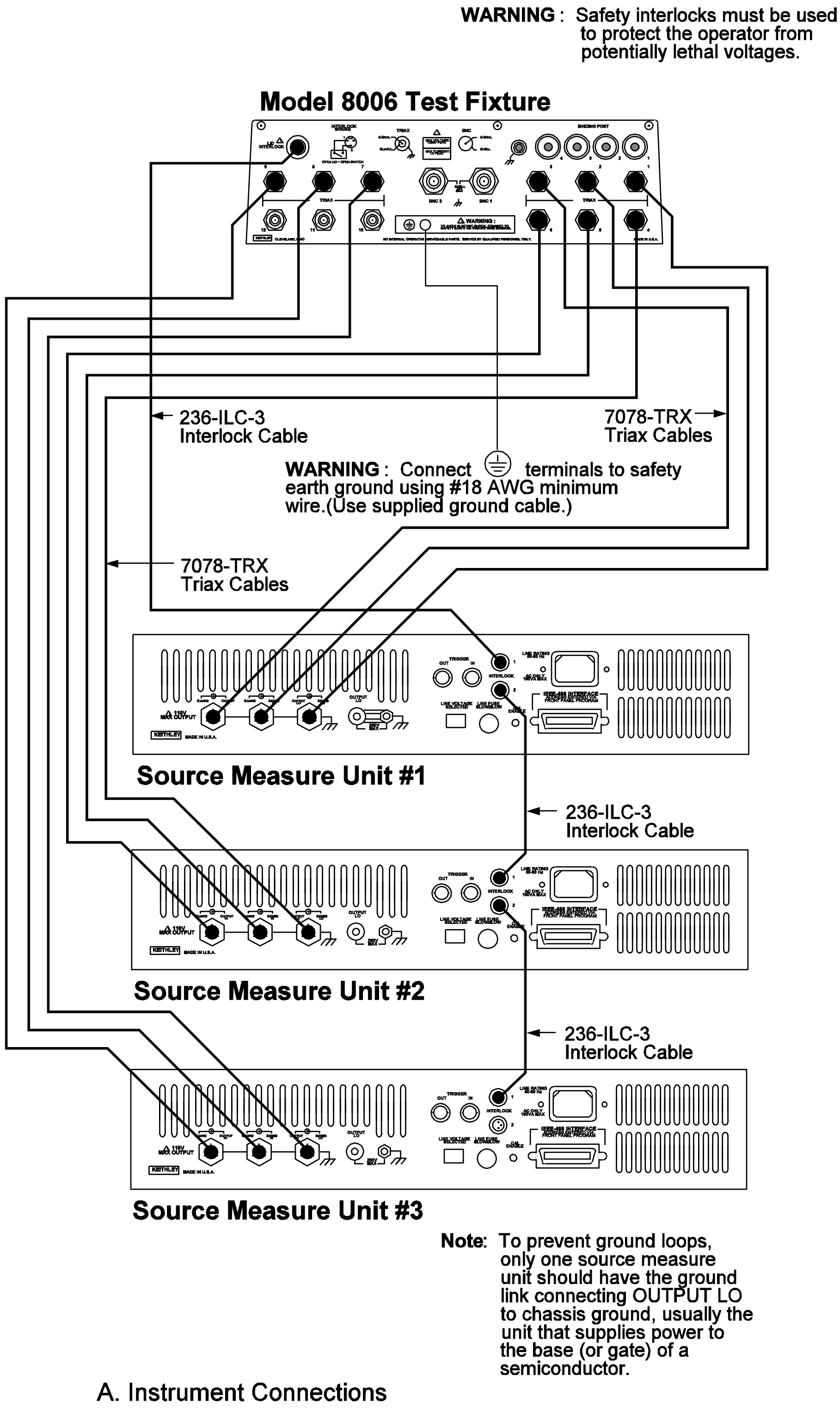
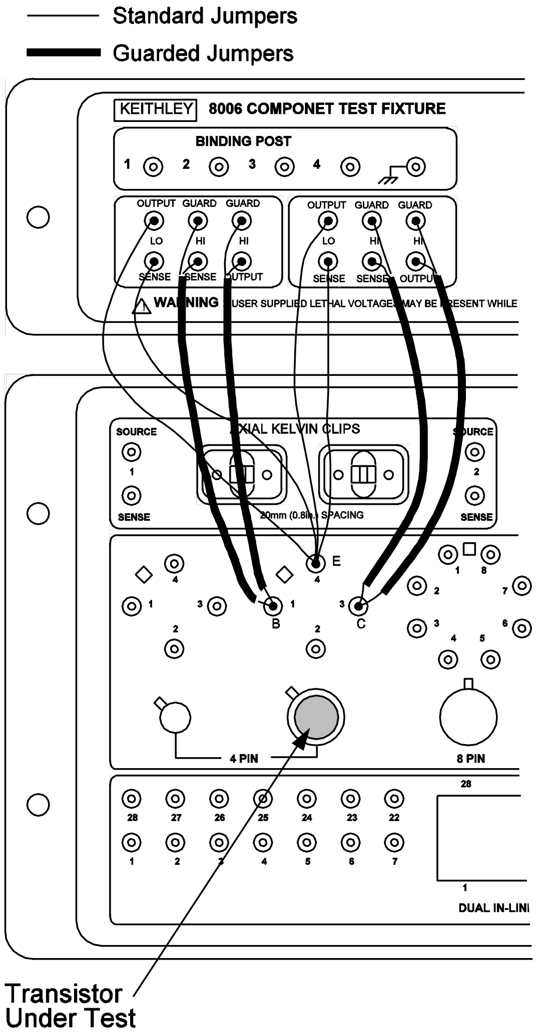


Figure 3A: Multiple Source Measure Unit Signal and Interlock Connections Configured for Remote Sensing (Instrument Connections).

Note : Jumpers are shown for common-emitter curves using remote sense. This test requires two SMUs.



Socket Pinouts : 1 = Base (Unit 1)
3 = Collector (Unit 2)
4 = Emitter

B. 8006 Jumper Connections

Figure 3B: Multiple Source Measure Unit Signal and Interlock Connections Configured for Remote Sensing (8006 Jumper Connections).

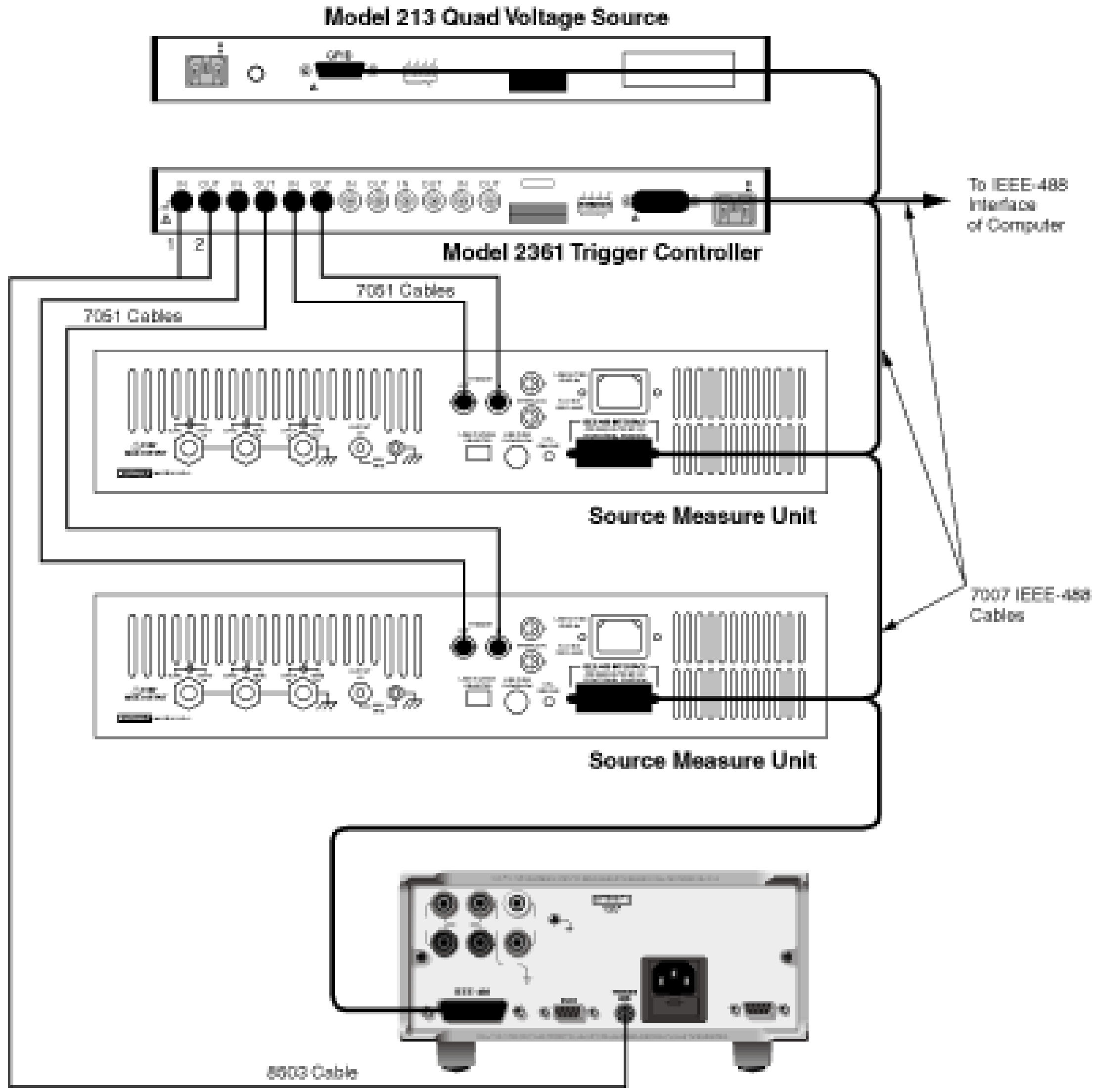


Figure 4: Multiple Unit Trigger and Bus Connections

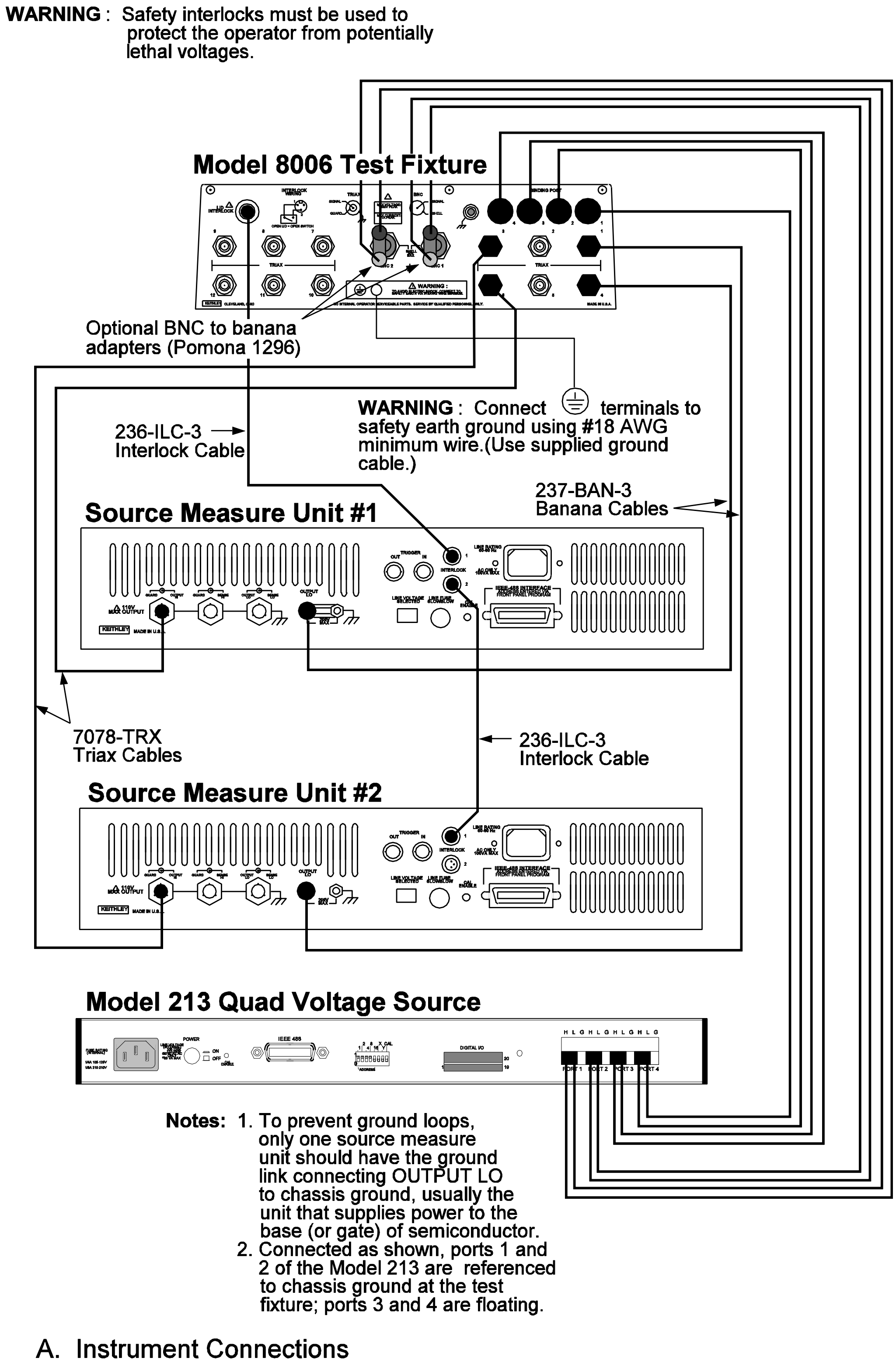


Figure 5A: Example Signal Connections with Model 213 (Instrument Connections).

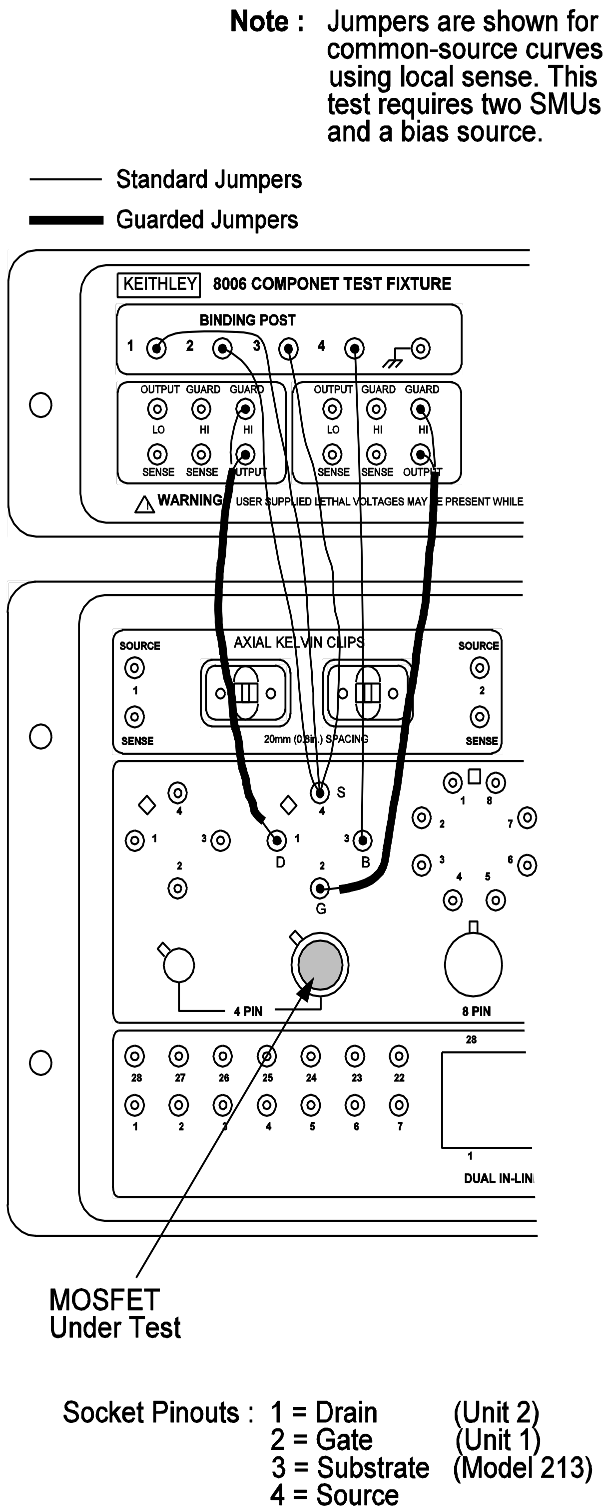


Figure 5B: Example Signal Connections with Model 213 (8006 Jumper Connections).

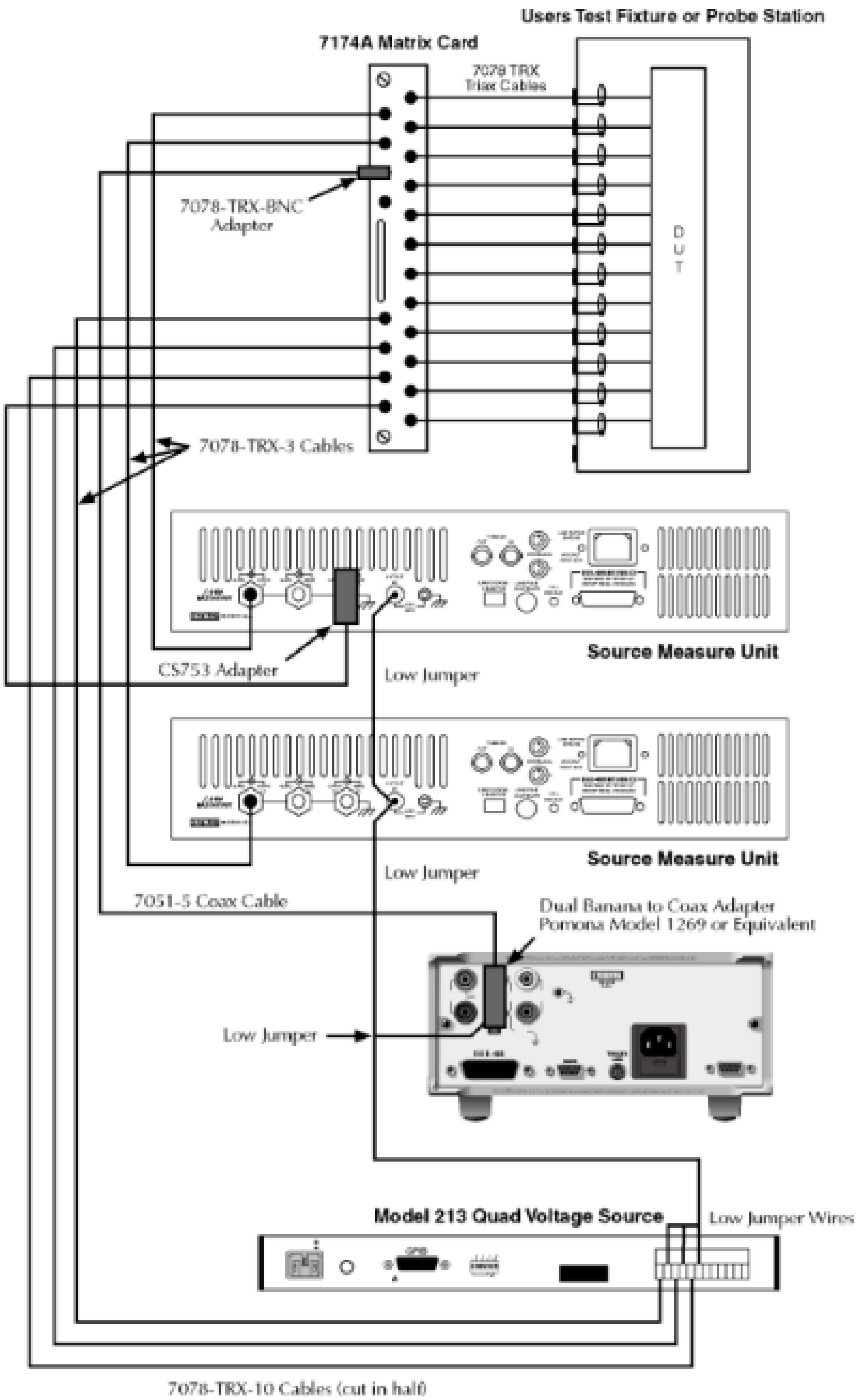


Figure 6: Example Signal Connections with Model 7172 Matrix Card.

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.

Both the Model 2361 Trigger Controller and Model 213 Quad Voltage Source operate 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.

WARNING	As a safety precaution, it is recommended that all instruments in a rack be connected to a single power outlet strip. The strip should be wired to a panel-mounted emergency stop switch within easy access of the user. A red push-pull mushroom switch should be mounted to the top front of the instrument rack. The switch must be UL recognized and have sufficient break current capacity for the load. To specify the break current of the switch, add up the total VA of the rack instruments and divide by the line voltage. Multiply the total by 125% to yield the minimum break current specification for an inductive load.

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 Model 90 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 2361 and Model 213 to the desired IEEE-488 bus addresses. The factory default setting of the Model 2361 is 15. The default setting of the Model 213 is 9, as shown in Figure 7.
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.

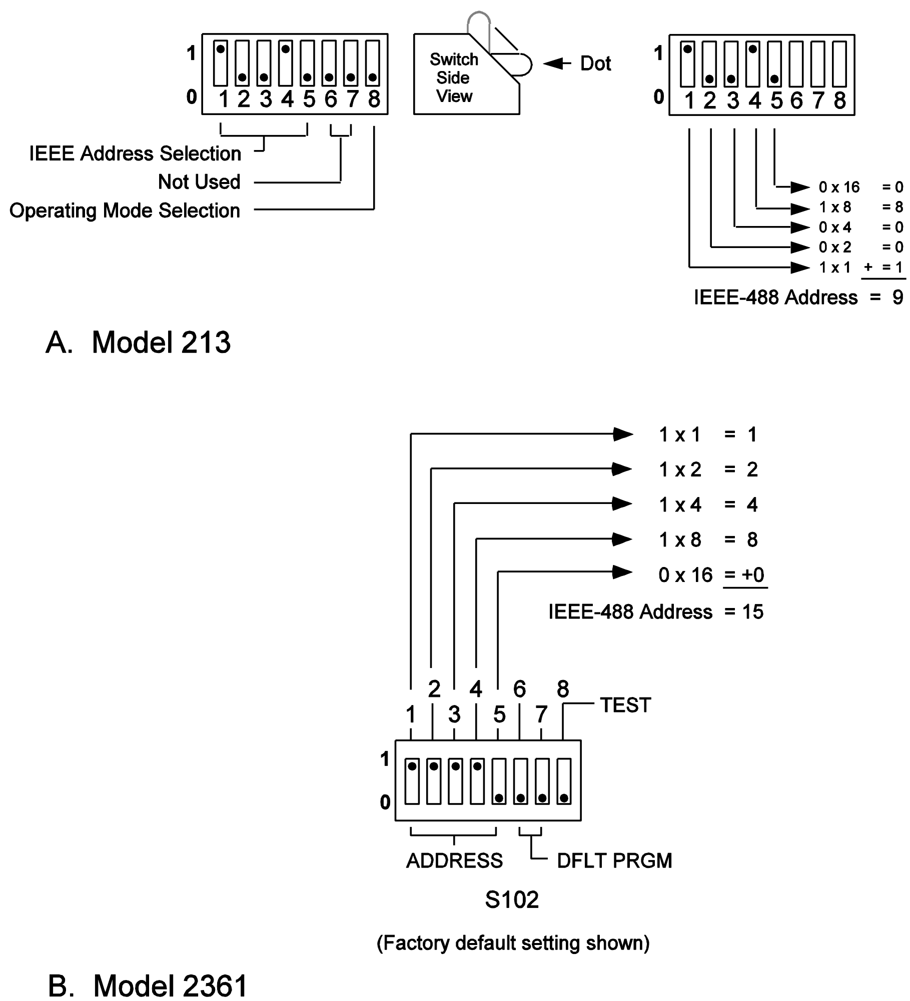


Figure 7: Model 213 and Model 2361 DIP Switch Factory Defaults

Model 2361 Power-Up

The instrument first turns on all LEDs. If the self-test diagnostic passes, all LEDs but the one for POWER will turn off, and the unit is ready for normal operation. If the self-test diagnostic fails, the LEDs will indicate the problem as explained in the Model 2361 Trigger Controller Instruction Manual.

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.

Normal Operation

Once the system has been assembled and configured, use of a master system power switch is recommended. This simplifies operation and maintains integrity of the interlock circuitry.

WARNING	In a multiple source measure unit test system, make sure all the Model 236/237/238s remain powered up during any test. Turning off one or more Model 236/237/238s may result in erratic interlock operation. For example, if any unit is turned off, an operational Model 236/237/238 may not go into standby when the lid of the system test fixture is opened. This condition exposes the operator to potentially lethal voltages that could result in injury or death.

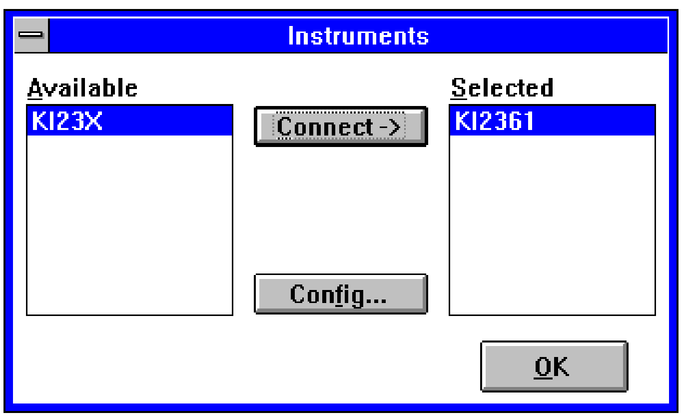
Getting Started: Setting Up a Measurement

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 Model 90 I-V Test System. This is simple measurement, but it will provide you with a general understanding of how ICS and the Model 90 I-V Test System are used to measure device characteristics.

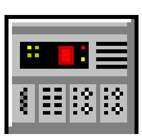
Step 1: Cable the Hardware Connections

Cable all the necessary connections between the Model 90 I-V Test System and the Model 8006 Test Fixture as shown in Figure 2 on page 9. 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.

Step 2: Connect the KI2361 Instrument Driver



Connect the KI2361 Driver in the Connect Instruments dialog box. The Connect Instruments dialog box is displayed by clicking the corresponding toolbar button



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

How to Connect the KI2361 Driver:

1. Open the Connect Instruments dialog box by clicking the CONNECT INSTRUMENTS toolbar button. The Connect Instruments dialog box can also be opened by selecting INSTRUMENTS/SELECT INSTRUMENT from the measurement mode menu bar.
2. Highlight the KI2361 Driver in the AVAILABLE field. Click the CONNECT button.
3. The connected driver will be displayed in the SELECTED field.
4. Clicking the OK button will close the Connect Instruments dialog box and restore control to the ICS desktop. Keep the Connect Instruments dialog 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

THIS DRIVER CAN ALSO CONTROL A SINGLE 24X0 OR 6430 SOURCEMETER WITHOUT THE 2361 TRIGGER CONTROL UNIT.

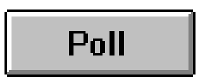
The Model 90 must be connected to your computer with the use of a standard IEEE-488 GPIB (General Purpose Interface Bus). Please refer to Section 2.5 of the Model 236/237/238 Operator's Manual to review GPIB connection procedures and hardware limitations specified by Keithley.

After connecting the KI2361 Driver, the user must designate the Model 90 source unit identities and GPIB addresses in the TCU Setup dialog box. The TCU Setup dialog box identifies the model number of each Source Measure Unit (SMU) connected to the Trigger Control Unit (TCU). The TCU Setup dialog box also identifies the GPIB address assigned to the TCU, each SMU, and the Quad Voltage Source (VS) if present.

This section presents a brief overview that explains how to designate the Model 90 hardware connections and corresponding GPIB addresses using the TCU Setup POLL button. For more information about the TCU Setup Dialog box, refer to *The TCU Setup Dialog Box* later in this chapter.

How to Automatically Designate the Model 90 Source Unit Identities and GPIB Addresses:

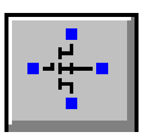
1. If the Connect Instruments dialog box is no longer displayed from Step 2, click the toolbar CONNECT INSTRUMENTS toolbar button or select INSTRUMENT/SELECT INSTRUMENTS from the measurement mode menu bar.
2. Open the KI2361 TCU Setup dialog box by clicking the CONFIG button at the bottom of the Connect Instruments dialog box.
3. Click the POLL button at the bottom of the dialog box. The POLL function will interrogate the Model 90 and automatically configure the SMU fields as well as each applicable GPIB field, including the TCU and VS fields.
4. Click OK to close the TCU Setup dialog box and restore control to the Connect Instruments dialog box. Click the Connect Instruments OK button to restore control to the desktop.



Use the TCU Setup POLL button to automatically configure the TCU Setup dialog 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 dialog box.
2. At the prompt, specify a test setup name. For this example, type "DiodeOn".
3. Click OK. This will close the New Setup dialog 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 dialog 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 dialog 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 dialog 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 dialog box.
2. The Source Units dialog box will display a list of available source unit model numbers.
3. Click on the SMU designation corresponding to the Model 236 Source Measure Unit.
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 dialog 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 dialog box by double-clicking the Close button.

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

Every available source has its own Source Unit Setup dialog box. This Source Unit Setup dialog 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 dialog 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). SMU2 (connected to the cathode) will source a constant voltage of 0.0V 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 dialog box corresponding to the connected SMU.
2. Configure the SMU1 controls as shown in Figure 8. Configure the SMU2 controls as shown in Figure 9. Use the mouse or TAB key to move between the different switches and fields in each Source Unit Setup dialog box.
3. Click OK to close a Source Unit Setup dialog box. Only one Source Unit Setup dialog box can be opened at a time.
4. After the setup configuration of each SMU is specified, close any Source Unit Setup dialog 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.

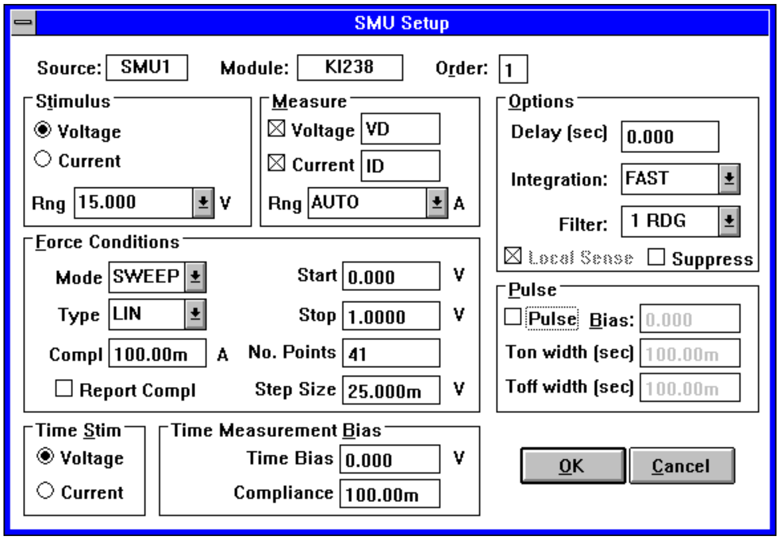


Figure 8: SMU1 Source/Measure Configuration for the DiodeOn Test Setup

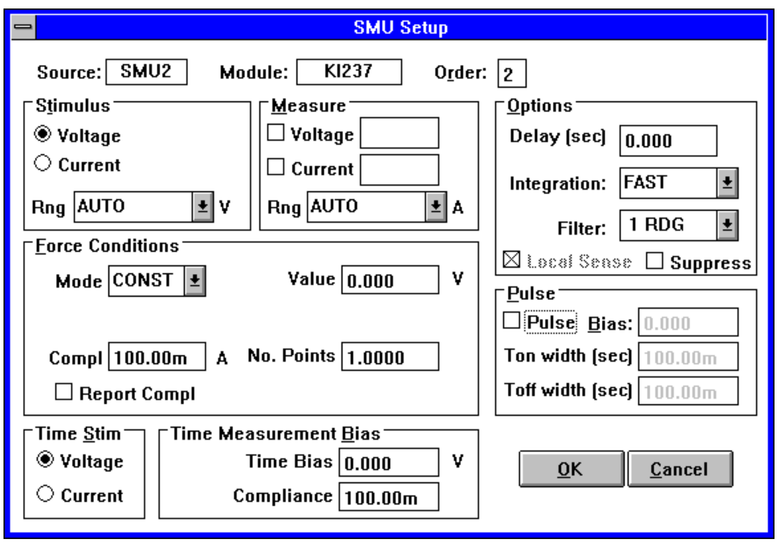


Figure 9: SMU2 Source/Measure Configuration for the DiodeOn Test Setup

For a thorough discussion of the Source Unit Setup dialog box, refer to *The Source Unit Setup Dialog 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 toolbar 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. Ignore this and go to Step #4.
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 dialog 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 dialog 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 dialog 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 dialog box APPLY button. This will create the plot but will not close the Plot Data dialog box. You should notice that at about 0.6V the diode turned on.
9. Click the CLOSE button to close the Plot Data dialog 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. Enter a filename.
3. Click OK, or hit the keyboard ENTER key. You just created your first project file.

The TCU Setup Dialog Box

The TCU Setup dialog box identifies the model number of each Source/Measure Unit (SMU) connected to the Trigger Control Unit (TCU). The TCU Setup dialog box also identifies the GPIB address assigned to the TCU, each SMU, and the Quad Voltage Source (VS) if present.

The KI2361 Driver must be connected to ICS before the TCU Setup dialog box can be opened. The KI2361 Driver is connected from the Connect Instruments dialog box. After connecting the KI2361 Driver, open the TCU Setup dialog box from the Connect Instruments dialog box.

Open the Connect Instruments dialog box by clicking the corresponding toolbar button. Open the TCU Setup dialog box from the Connect Instruments dialog box by clicking the Connect Instruments CONFIG button.

THIS DRIVER CAN ALSO CONTROL A **SINGLE** 24X0 OR 6430 SOURCEMETER WITHOUT THE 2361 TRIGGER CONTROL UNIT. Simply select the SMU1 Identity to be the 24x0 or 6430 and poll the instrument. You will receive an error message stating that the 2361 is not present. This can be ignored.

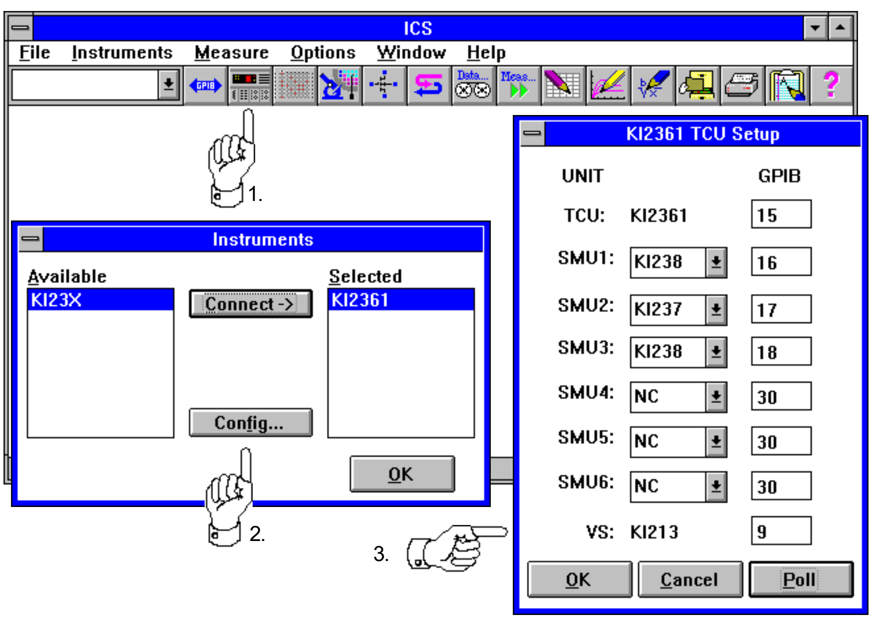


Figure 10: The TCU Setup Dialog Box is Opened from the Connect Instruments Dialog Box.

SMU Fields

The TCU Setup dialog box includes six "SMU" fields used to identify the SMU hardware connected to the TCU. When a user designates source units later in the application, each Source/Measure Unit will be identified by the corresponding "SMU" label designated in the TCU Setup dialog 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 Model 90 I-V Test System.

Configuring the TCU Setup Dialog Box

The SMU identity of each Source/Measure Unit is not arbitrary. The SMU identity of each Source/Measure Unit corresponds to the channel identity that the SMU is connected to on the rear-panel of the TCU. When configuring the TCU Setup dialog box, the user must be certain that the designated configuration agrees with the physical connection of the hardware. For example, if the Model 90 includes a KI236 cabled to the TCU at Channel 1, the "KI236" designation must be configured in the "SMU1" field.

The TCU Setup dialog box is most easily configured using the POLL button at the bottom of the dialog box. The POLL function interrogates the Model 90 and automatically designates each SMU field along with each applicable GPIB field, including the TCU and VS fields. Alternatively, the user may choose to manually designate the TCU Setup dialog box. The TCU Setup dialog 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 KI2361 Driver includes a poll function that will automatically configure the TCU Setup dialog box. The poll function is activated by selecting the POLL button at the bottom of the dialog box. The poll function interrogates the Model 90 and automatically selects the model numbers corresponding to each SMU field. The poll function also designates the correct address at each GPIB field.

Configuring the TCU Setup dialog box with the POLL button is faster than configuring the box manually. Using the POLL button also eliminates any configuration errors that may result from interpreting the rear panel instrument connections incorrectly. In order for ICS to poll as fast as possible, configure each instrument at consecutive GPIB addresses that are as low as possible. Configure the TCU at the lowest address, the VS at the next lowest address, followed by each SMU at incrementally higher addresses. For example, ICS will poll the Model 90 shown in Figure 11 in the shortest time possible.

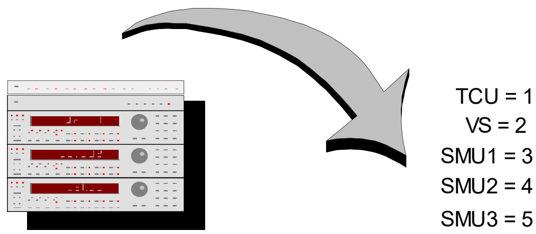


Figure 11: Use Consecutively Low GPIB Addresses to Enhance Polling Speed.

Detailed instructions outlining how to automatically configure the TCU Setup dialog box using the poll function are presented in *Step 3: Specify the Model 90 Source Unit Identities and GPIB Addresses* earlier in this chapter.

Polling Errors and Warnings

ICS will display an error message when the poll function cannot locate the TCU. The poll function cannot locate the TCU if the TCU is OFF or if the TCU is not connected to the GPIB.

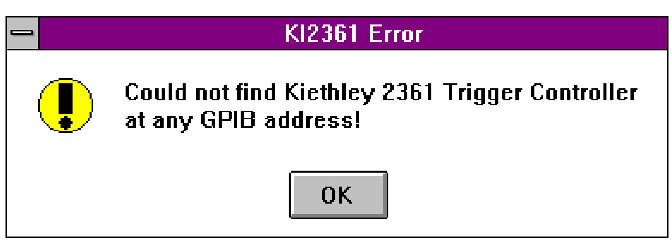


Figure 12: The Poll Function will Display an Error Message When it cannot Locate the TCU.

ICS will display a warning message if one or more SMUs are connected to the GPIB but not the TCU. The warning message will identify the GPIB address of each SMU that is not connected to the TCU. After the warning message is acknowledged by clicking the OK button, the poll function will complete the automatic configuration of the TCU Setup dialog box without the unconnected SMU. An example of this situation is pictured in Figure 13.

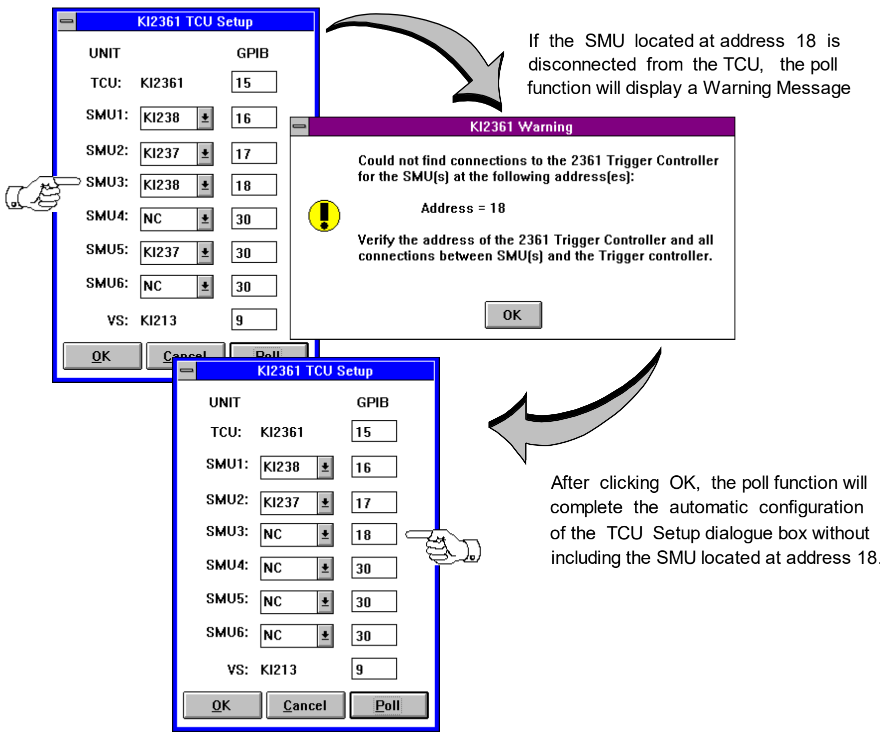


Figure 13: The TCU Setup Poll Function will Identify SMUs that are Connected to the GPIB but not to the TCU.

Manual Configuration

It is not necessary to configure the TCU Setup dialog box using the poll function. The user has the option of configuring the TCU Setup dialog box by manually designating each SMU field and each applicable GPIB field. The TCU Setup dialog 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 an 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 that is cabled to the respective channel on the rear-panel of the TCU. To manually designate the GPIB addresses, highlight the current designation in the KI2361 GPIB field. Specify the correct address. Use the TAB key to advance to each consecutive GPIB field.

How to Manually Designate the Model 90 Source Unit Identities and GPIB Addresses:

1. Open the KI2361 TCU Setup dialog box by clicking the CONFIG button at the bottom of the Connect Instruments dialog box. If necessary, click the toolbar CONNECT INSTRUMENTS button or select INSTRUMENT\SELECT INSTRUMENTS to open the Connect Instruments dialog box.
2. The TCU Setup dialog box includes six "SMU" fields. Each "SMU" field corresponds to the respective TCU channel. Specify the SMU model number corresponding to each TCU channel connection in the corresponding "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 TCU GPIB address in the TCU GPIB field. The KI2361 TCU leaves the factory with the GPIB address set to 17.
5. Enter the appropriate GPIB address in each "SMU" field. Use the keyboard TAB key to advance from one GPIB field to the next. The GPIB address corresponding to each inactive "SMU" field should be set to "30".
6. Designate the GPIB address of the Quad Voltage Source.
7. Click the OK button to close the KI2361 TCU Setup dialog box. Click the OK button in the Connect Instruments dialog box to restore control to the ICS desktop.

When to Configure the TCU Setup Dialog Box

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

1. The KI2361 Driver is connected to ICS for the first time.

2. The Model 90 TCU setup configuration is changed.

The configuration of the TCU Setup dialog box is stored in memory when the user manually specifies the box contents or after the user polls the instrument. The TCU setup is written to the ICS35.INI file as soon as the TCU Setup CLOSE button is selected. The KI2361 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 KI2361 Driver and configure the TCU Setup according to the designations recorded in the ICS35.INI file. This eliminates the need to repeatedly connect the KI2361 Driver or configure the TCU Setup each time a KI2361 project file is opened. After initially configuring the TCU Setup, there is no need for the user to review the TCU Setup dialog box unless the SMU connections to the TCU have changed.

SMU Availability

The Source Units dialog box displays a list of available SMUs and VS units that can be used to build a test setup. The contents of this dialog box match the designations of the active SMU and VS fields defined in the TCU Setup dialog box. In addition to the designated SMUs and VS units, the Source Units dialog box also includes a source unit entitled "KI2361.GND". "KI2361.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 TCU Setup configuration that does not match the TCU 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 TCU Setup dialog box when the test setup was created. Test setups are stored in project files, thus the TCU 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 Model 90 TCU setup. The user may change one or more GPIB addresses, add or remove an SMU, or change the SMU model connected to a TCU channel. Any one or more of these situations will alter the TCU setup configuration. IF the user changes the TCU setup configuration of the hardware, the user must update the TCU Setup dialog 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 TCU Setup dialog box either manually or with the use of the POLL button. As soon as the TCU Setup dialog box is updated, the new TCU setup configuration is stored in memory. The new TCU setup is written to the ICS35.INI file as soon as the CLOSE button is selected in the TCU Setup dialog 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 TCU 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 TCU inconsistencies that were detected when the project file was opened. If there were none, ICS will then interrogate the Model 90 and insure that the SMU model numbers, channel connections, and GPIB addresses of the hardware agree with the TCU setup configuration stored in memory. This verification detects inconsistencies that result when the user changes the TCU setup configuration of the hardware but fails to update the TCU Setup dialog 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.

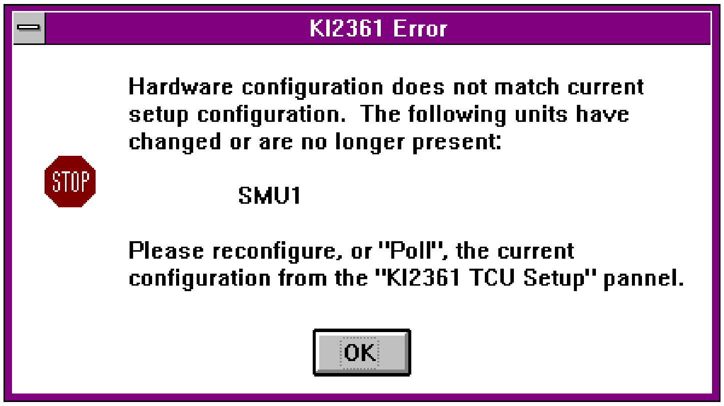


Figure 14: ICS will Identify Hardware Mismatches When the User Attempts to Execute a Test Setup that no Longer Corresponds to the Active TCU Setup Configuration.

In the example shown in Figure 14, ICS detected an inconsistency with SMU1. The designation "SMU1" refers to the SMU connected to Channel 1 of the TCU. There are three situations that could have generated the inconsistency detected in Figure 14:

1. The model number of the SMU connected to Channel 1 is still the same, but the GPIB address changed.
2. There is currently no SMU connected to Channel 1, or the SMU is OFF.
3. The SMU model connected to Channel 1 is not the same SMU model that was originally connected. If this situation occurs it is likely that the GPIB address is different as well.

If a mismatch error is caused only by a changed GPIB address, the test setup can be executed if the TCU setup configuration is updated in memory. Open the TCU Setup dialog box after acknowledging the error message. Update the GPIB fields by selecting the POLL button at the bottom of the dialog box. The test setup will now measure properly after the TCU Setup dialog box is closed.

If the hardware mismatch is the result of an inconsistency between an SMU designation and the model number of the SMU, or if the corresponding TCU channel is currently empty, the user has three options:

1. Delete the test setup and create a new test setup using the active TCU setup configuration.
2. Rewire the rear-panel of the TCU so that each SMU is cabled to the channel specified by the original TCU setup configuration. The SMU designation reported by the error message corresponds to the TCU channel identity. In other words, the designation "SMU1" identifies the SMU connected to Channel 1. Therefore, the original model number of the SMU causing the error can be ascertained by viewing the "Module" field in the respective Source Unit Setup dialog box. To do this, click the error message OK button to close the message box. Open the Setup Editor by clicking the appropriate toolbar button. In the Setup Editor, click on the instrument icon corresponding to the SMU designation that is in error. This will open the SMU's Source Unit Setup dialog box. The "Module" field is at the top of the dialog box. This option is not possible if the original SMU model is no longer available.
3. Undesignate the obsolete SMU connection in the Setup Editor and re-designate the connection. If the same SMU designation is attached to the setup, the Source Unit Setup dialog box will correspond to the new SMU model number. Regardless of whether or not the same SMU designation is re-attached to the device schematic, the user must reconfigure the source/measure configuration of the source unit. If a different SMU connection is designated in the Setup Editor, re-cable the necessary connections between the SMU hardware and the test fixture so that the physical connections match the connections designated in the Setup Editor.

The Source Unit Setup Dialog Box

A Source Unit Setup dialog box is used to specify the sourcing and measuring conditions of the corresponding source. The setup specifications configured within each Source Unit Setup dialog 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.

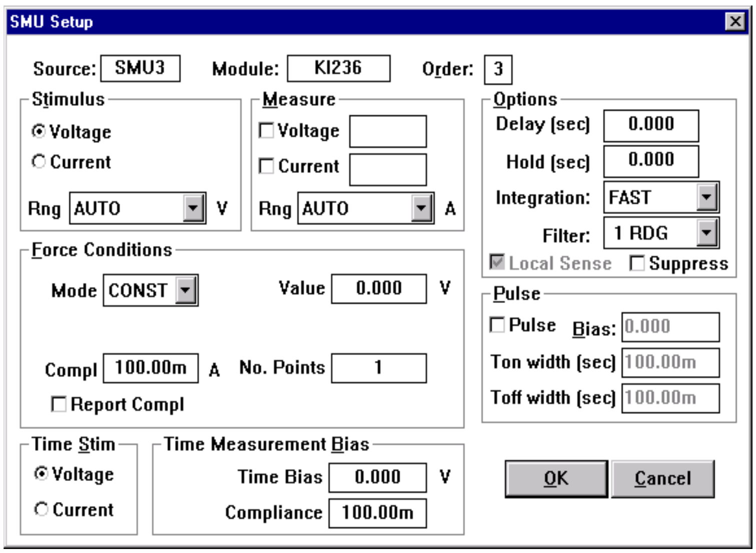


Figure 15: A Source Unit Setup Dialog Box.

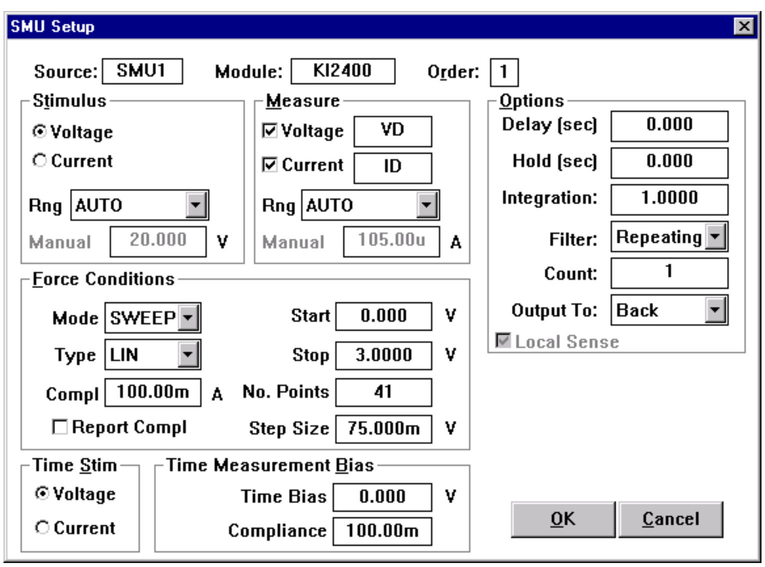


Figure 16: A Source Meter Setup Dialog Box.

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

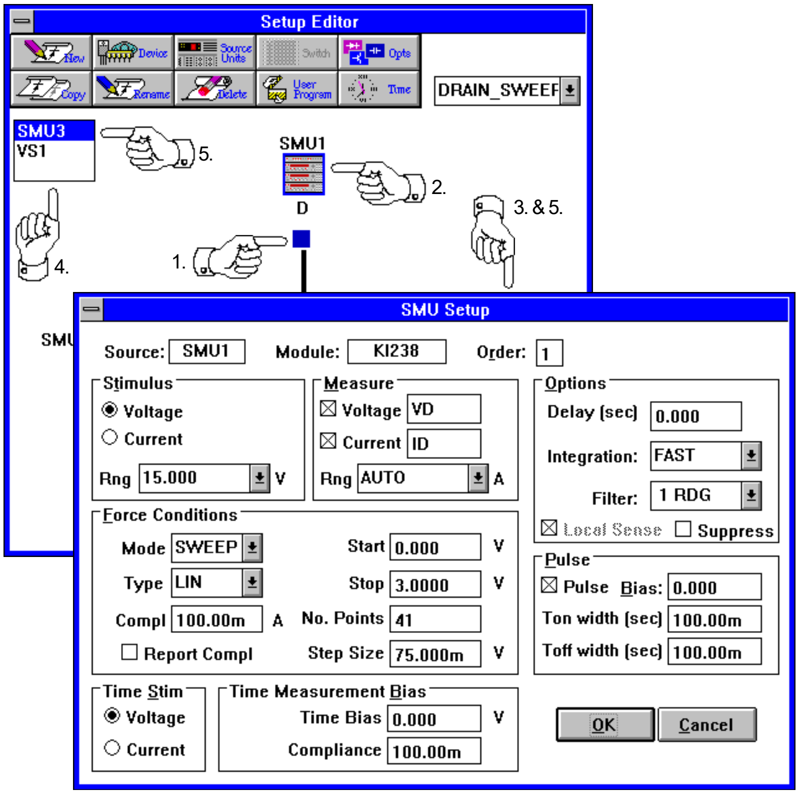


Figure 17: How to Display a Source Unit Setup Dialog Box

The layout of a Source Unit Setup dialog box corresponding to a source measure unit is pictured above. The layout of a Source Unit Setup dialog box corresponding to a KI238 source measure unit is pictured in figure 18.

How to Display a Source Unit Setup Dialog Box:

1. To open a Source Unit Setup dialog 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 dialog 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 dialog box.

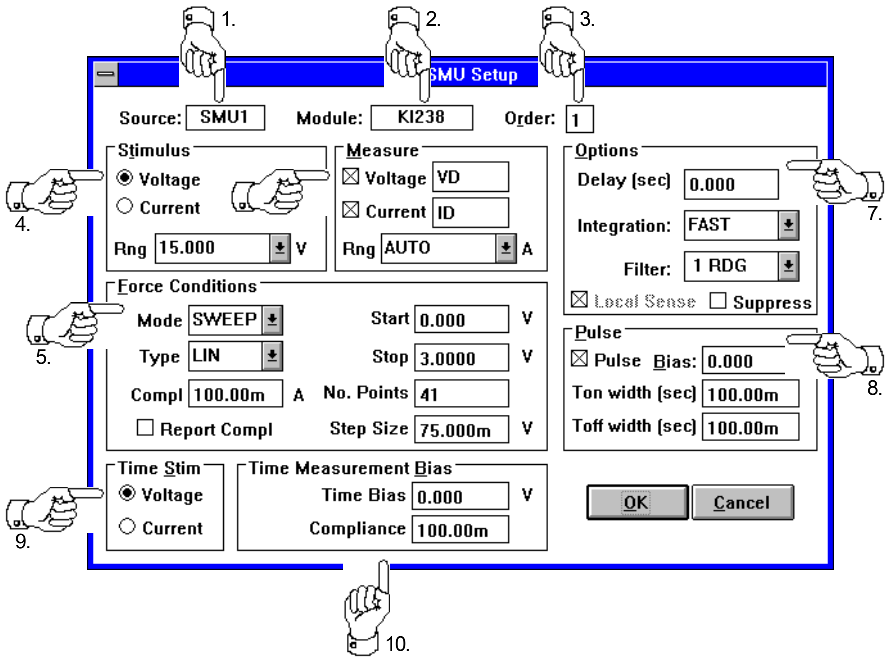


Figure 18: Layout of a Source Unit Setup Dialog Box Corresponding to a Source/Measure Unit.

1. Source Unit Identity Field: This field is a static display that lists the ICS designation for the corresponding source. The numerical value of the SMU designation corresponds to the channel number at which the SMU is connected to the Trigger Control Unit (TCU). For more information, refer to *Configuring the TCU Setup Dialog Box* earlier in this chapter.

2. Module Identity Field: This field is a static display that lists the source unit model number. The model number of each source unit connected to the Trigger Control Unit (TCU) is designated in the KI2361 TCU-Setup dialog box. For more information, refer to *Configuring the TCU Setup Dialog 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. In addition the Hold, Count, and Output to features are controlled for the 24x0 or 6430 SourceMeter.

8. Pulse Function Controls: This group includes the switch and fields used to configure the source unit in pulse mode. Not applicable for the 24x0 or 6430 SourceMeter.

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.

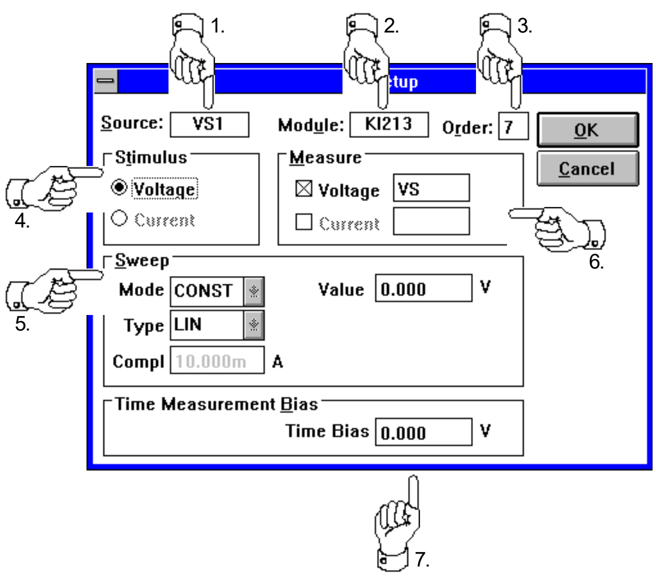


Figure 19: Layout of a Source Unit Setup Dialog Box Corresponding to a Voltage Source Unit.

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 dialog 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 dialog boxes.

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

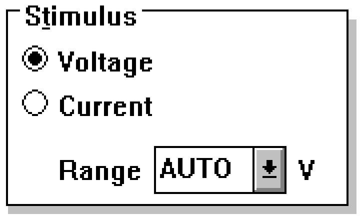
Power-Up Order

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 dialog 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 source unit cabled to Channel #1 of the Trigger Control Unit (TCU) will be assigned a power-up order of "1". The source unit cabled to Channel #2 will be assigned an order of "2". This pattern continues through the six available TCU channels. For example, if source units are connected to all six TCU channels, SMU1 will be triggered first, SMU2 will be triggered second, etc. (Remember that the source unit cabled to Channel #1 is automatically identified as "SMU1", the source unit cabled to Channel #2 is "SMU2", etc. If necessary, review the section entitled *Configuring the TCU Setup Dialog Box*.) Similarly, the four channels of the KI213 Quad Voltage Source (if present) will be assigned orders "7" through ""10". For example, VS1 will be assigned a power-up order of "7". 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, SMU2, and SMU3 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 can not be configured to sweep a current; as a result, the Current switch will be unavailable in the KI213 Source Unit Setup dialog boxes. The Range field is also unavailable in the KI213 Source Unit Setup dialog 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 Model 90 I-V Test System.

NOTE: The Model 90 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 dialog 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 dialog 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 dialog 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.

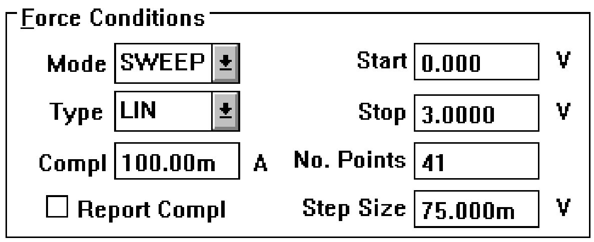
Force Conditions Controls

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 dialog 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.

When creating a test setup that includes a second, synchronized sweep signal, the sweep application described in this section is the primary sweep.

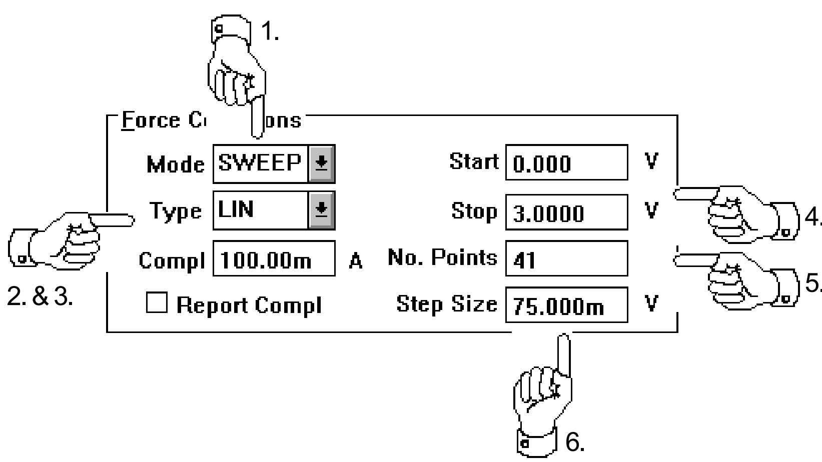
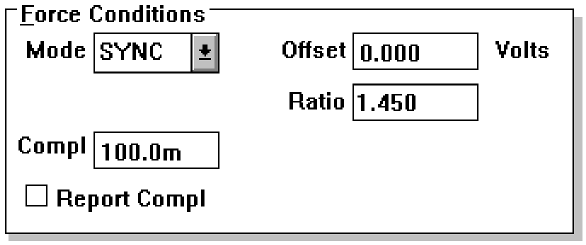


Figure 20: How to Force a Sweep Signal

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.

Synchronized Sweep



A synchronized sweep is a staircase sweep signal that is synchronized in time with a primary sweep signal applied by another SMU.

An SMU can force a synchronized output only when the output of another SMU in the test setup is configured in linear sweep mode. If a synchronized sweep mode is designated in a test setup that does not include a primary linear sweep signal, ICS will display an error message when the user attempts to execute the test setup.

ICS will automatically configure the stimulus of the synchronized sweep to match the stimulus of the primary sweep. In other words, if the primary sweep is a voltage output, the synchronized sweep will be a voltage output also.

While the *timing* of the primary and secondary sweep signals are synchronized, the magnitudes can differ. The magnitude of the synchronized sweep signal is specified relative to the primary sweep by designating a constant ratio and/or a constant offset. The meaning of "ratio" and "offset" is explained with the illustration below.

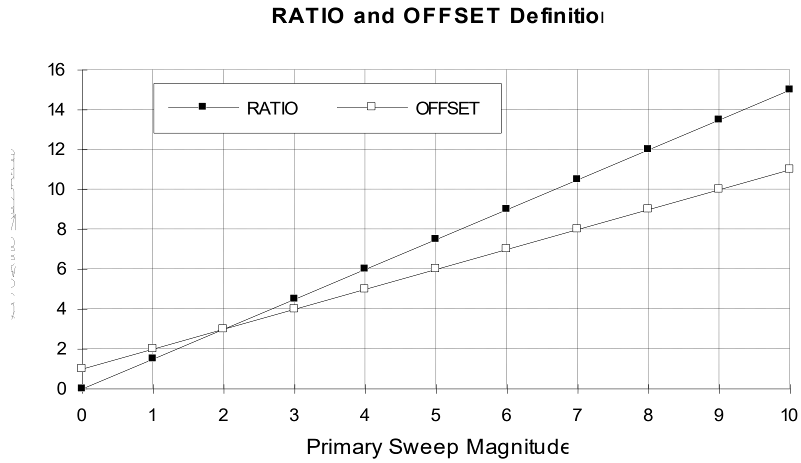


Figure 21: "Ratio" and "Offset" Definitions. In this Illustration, the Ratio was set to a Value of "1.5" and the Offset was set to a Value of "0.5".

When a RATIO is specified:

Sync Sweep Mag = Primary Mag x (Ratio)

When an OFFSET is specified:

Sync Sweep Mag = Primary Mag + (Offset).

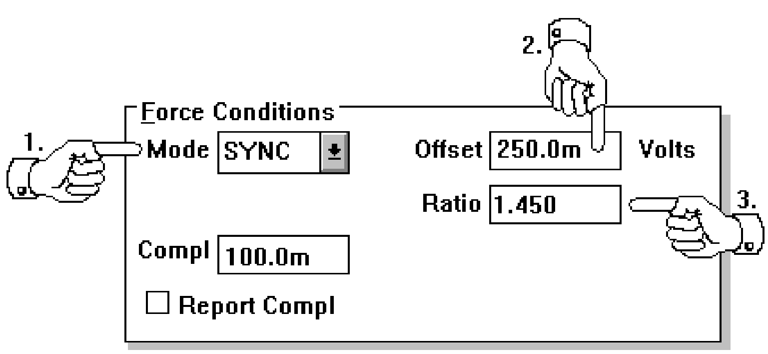


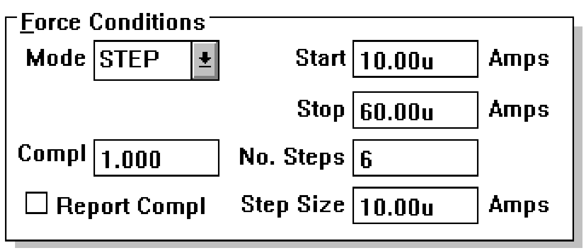
Figure 22: How to Force a Synchronized Sweep.

How to Force a Synchronized Sweep Signal:

A synchronized sweep signal is functional only when a linear sweep signal is sourced by another SMU.

1. Select the "SYNC" designation from the available options listed in the MODE field.
2. If desired, specify a value in the OFFSET field. When an offset value is specified, the offset component of the synchronized sweep magnitude is the sum of the primary sweep magnitude and the OFFSET value.
3. If desired, specify a value in the RATIO field. When a ratio value is specified, the ratio component of the synchronized sweep magnitude is the product of the primary sweep magnitude and the RATIO value. A synchronized ratio can be specified in combination with a synchronized offset.

Step



The step mode forces a constant output while another SMU in the test setup forces a sweep signal. The step mode is functional only in test setups that include an SMU configured in sweep mode.

The step mode generates a constant output signal while a second source unit generates a staircase sweep signal. After the staircase sweep signal reaches the specified STOP value, the magnitude of the step output is incremented by the STEP value and the staircase sweep signal is triggered again. This process continues until the STOP value of the step signal is reached.

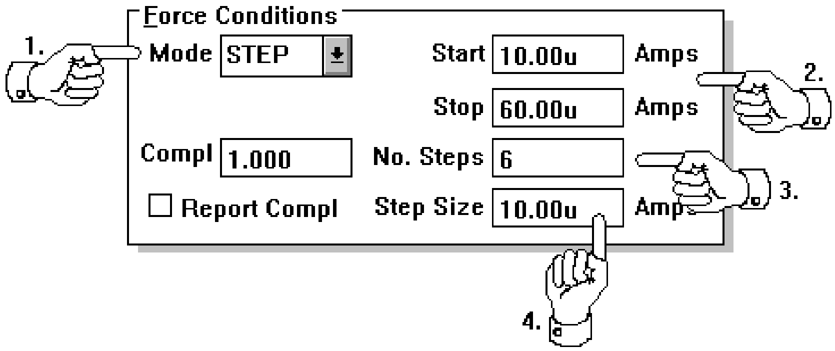
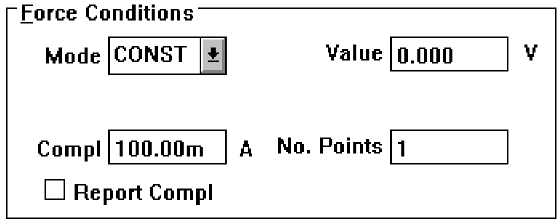


Figure 23: How to Force a Step Signal

How to Force a Step Signal:

1. Select the "STEP" designation from the available options listed in the MODE field. The step mode output signal can only be linearly incremented. When an SMU is configured in step mode, the TYPE field is unavailable.
2. Specify the range of the step signal in the START and STOP fields.
3. Specify the increment quantity in the NO. STEPS field.
4. The increment size will be displayed in the STEP SIZE field. After a value is entered in the NO. STEPS field and the cursor is moved to another location (or OK is selected), the STEP SIZE field will be calculated automatically. 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 updated automatically to accommodate the change.

Constant



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

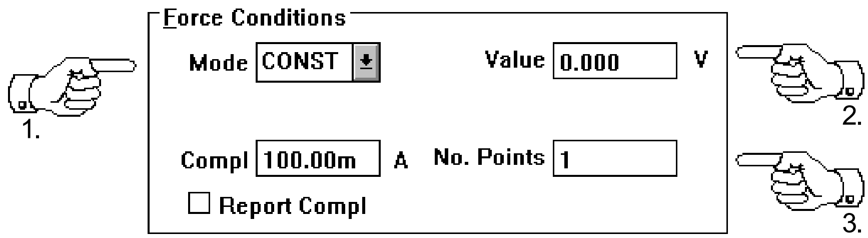


Figure 24: How to Force a Constant Signal

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.

Report Compliance

Each Source Unit Setup dialog 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.

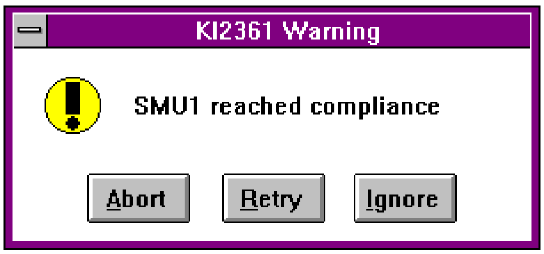
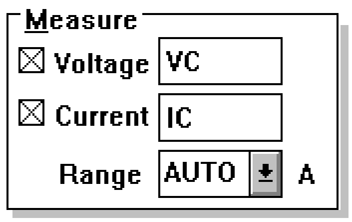


Figure 25: ICS Detects Compliance Limits if the Report Compliance Switch is Selected in the Respective Source Unit Setup Dialog Box.

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. REPORT COMPLIANCE WILL CAUSE AUTO-STEPPING OF THE PROBE STATION TO STOP UNTIL THE USER INTERACTS WITH THE WARNING MESSAGE.

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 dialog 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.

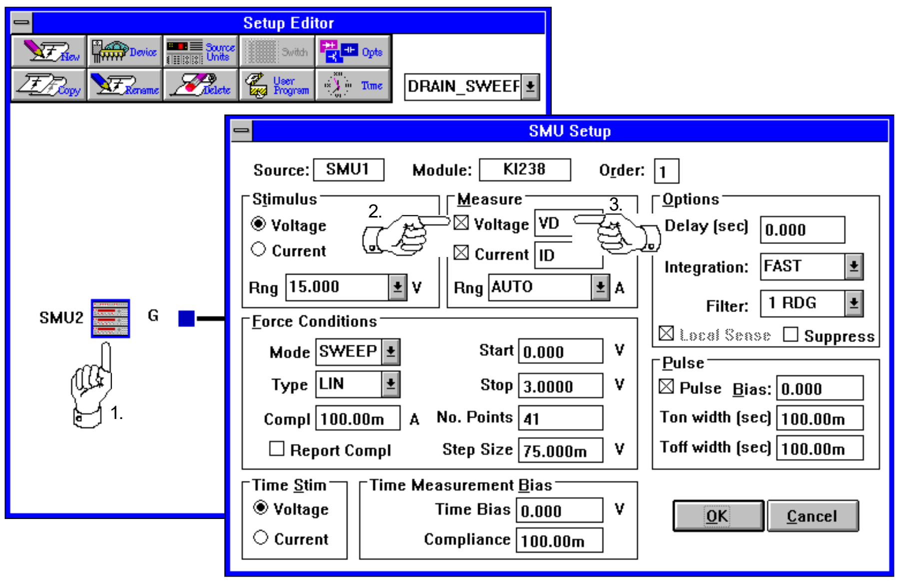


Figure 26: How to Specify Returned Data

How to Specify Returned Data:

1. Open the Source Unit Setup dialog 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 dialog 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 30 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.

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.

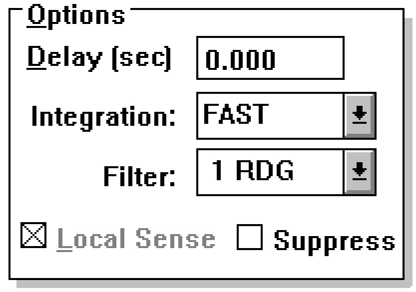
When a measured current is decreasing, the instrument will autorange to the next lower scale when the signal level decreases to 9% of full scale. For example, if a Model 236 is measuring a current of +01.000mA on a ±10mA scale, the instrument will autorange to the ±1mA scale when the reading decreases 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 dialog 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 Model 90 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.

Hold

The Hold field provides the user with the capability to specify a hold time prior to starting a sweep. A hold time ranging from 0.000 to 9.999k sec can be applied.

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.

Count

The Count option is used with the Filter option for the 24X0 SourceMeter to specify the number of readings per measurement to be used for averaging. Refer to the Keithley 2400/2410/2420 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 dialog box must be turned OFF before the Local Sense switch in the Source Unit Setup dialog box can be accessed by the user. As a default, the Local Sense Lockout switch in the KI2361 Mainframe Controls dialog box will be turned ON. When the Local Sense Lockout switch is ON, the Local Sense switch in the Source Unit Setup dialog box can not 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

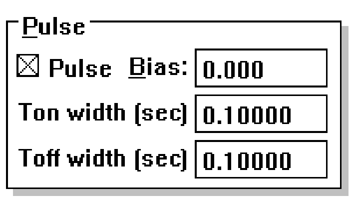
The Suppression function allows a stored offset value to be subtracted from subsequent measurement readings. When the Suppress function is enabled, the next measured value will be internally stored by the instrument as a baseline. All subsequent measurements returned by the instrument will be the difference 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.

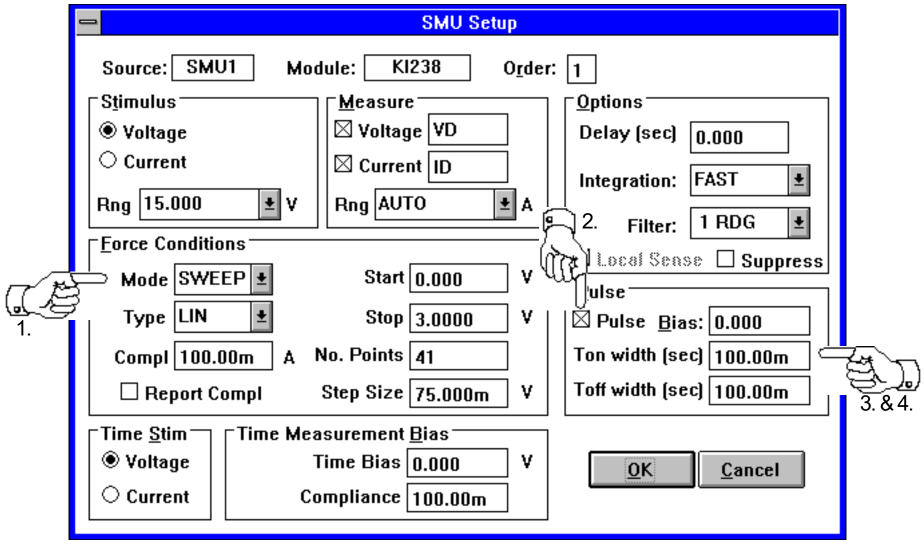


Figure 27: How to Configure a Pulsed Source.

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 Dialog Box

Clicking the OPTIONS button in the Setup Editor will open the KI2361 Global Setup dialog box. The KI2361 Global Setup dialog 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 Model 90 system. The switches are used to enable or disable the Local Sense Lockout and Time Stamp Data functions.

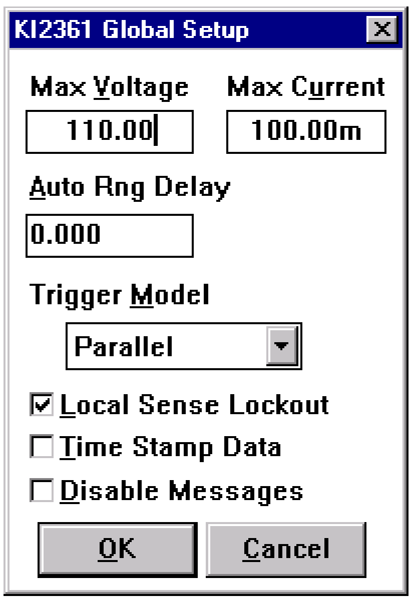
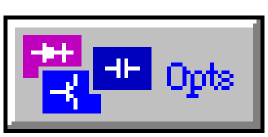


Figure 28: The KI2361 Global Setup Dialog Box

The configuration of the KI2361 Global Setup dialog box is applicable to every source unit in the test setup. The KI2361 Global options are only applied to the test setup in which they were specified. Once a new test setup is defined, the KI2361 Global options can be re-specified without changing the configuration of the global setup options in a previously defined test setup.



The KI2361 Global Setup dialog box is displayed by clicking the Setup Editor OPTIONS button after first designating at least one Source Unit/DUT connection.

Global Output Limitations

The KI2361 Global Setup dialog 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 dialog 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 dialog 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 Model 90 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 KI2361 Global Setup dialog 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.

Trigger Model

The trigger model value is the trigger model used by the 2361 TCU. For fastest throughput choose parallel mode. When using a source that will autorange choose serial mode. Please refer to the Applications Booklet- Semiconductor Measurements available from Keithley Instruments for further information regarding trigger models.

Local Sense Lockout

If the Local Sense Lockout switch is selected in the KI2361 Global Setup dialog box, the Local Sense switch in each Source Unit Setup dialog 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 dialog 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 KI2361 Global Setup dialog 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 dialog box is configured in the ON position. The Local Sense Lockout switch in the KI2361 Global Setup dialog box must be turned OFF before the Local Sense switch in each Source Unit Setup dialog box can be toggled by the user. As a default, the Local Sense Lockout switch in the KI2361 Global Setup dialog 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 dialog box can not be altered.

The function of the Local Sense Lockout switch is pictured in Figure 29 on the following page. For more information about the Model 90 Local and Remote Sense modes, refer to an earlier section of this chapter entitled *Source Unit Options/Local Sense*.

Disable Messages

The Disable Messages option prevents ICS from displaying error messages during run-time.

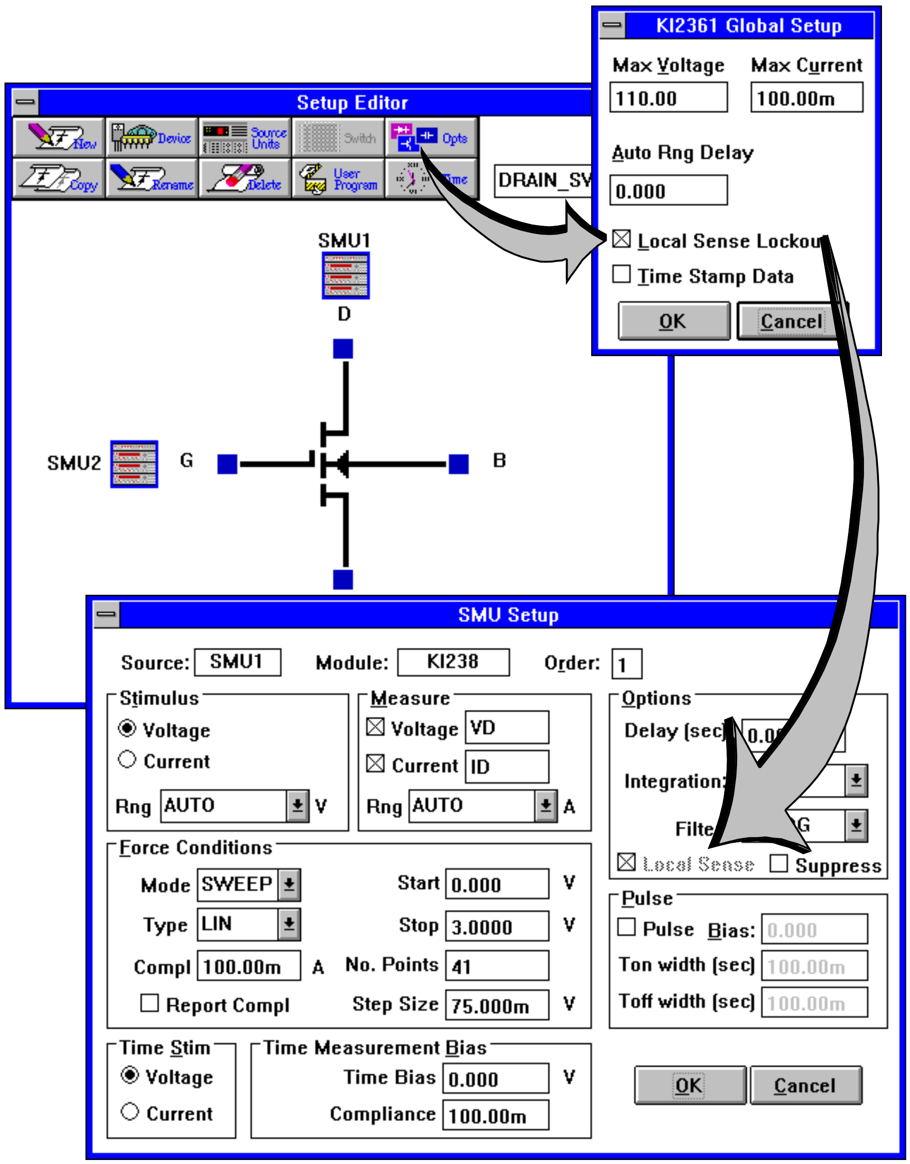


Figure 29: If the Local Sense Lockout Switch in the KI2361 Global Setup Dialog Box is ON, the Configuration of the Source Unit Setup Remote Sense Switch Cannot be Altered.

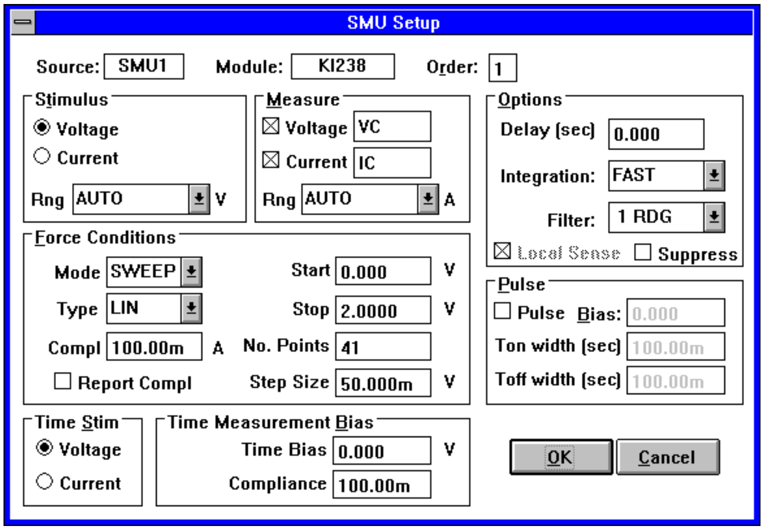
Time Stamp Data

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 KI2361 Global Setup dialog box.

Because the Time Stamp Data switch is located in the Global Setup dialog 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 KI2361 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 labeled "Time" and will be positioned at the first column position of the spreadsheet.

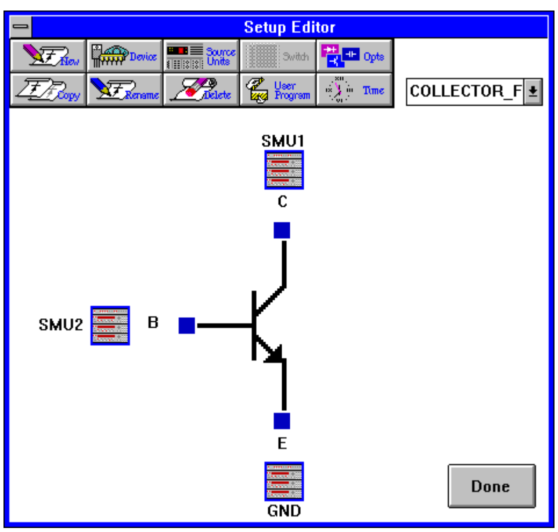
Setup Example



Collector Family

This setup measured the DC collector characteristics of a 2N3700 bipolar transistor. A voltage sweep was applied to the collector for a series of stepped base currents. A family of curves was generated by measuring and plotting the collector current with respect to the collector voltage sweep for each base current step. The following source units and setup conditions were used:

Collector Family Setup Conditions

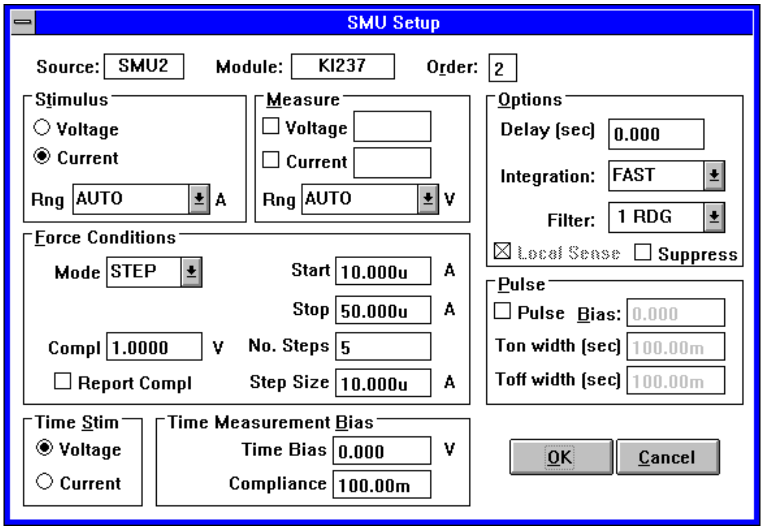


Collector: SMU1

Mode: Voltage Sweep

Output: 0V-2V

Return: VC, IC



Base: SMU2	**Emitter: GNDU**
Mode: Current Step	Mode: Ground
Start: 10u	Output: 0V
Step Size: 50u	Return: None
Step Qty: 5	
Return: None	

Results