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Automated Characterization Suite (ACS) Basic Edition

Libraries Reference Manual

ACSBASIC-908-01 Rev. D November 2023

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KEITHLEY
A Tektronix Company

ACS Basic

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Safety precautions

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with nonhazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read and follow all installation, operation, and maintenance information carefully before using the product. Refer to the user documentation for complete product specifications.

If the product is used in a manner not specified, the protection provided by the product warranty may be impaired.

The types of product users are:

Responsible body is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

Operators use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

Maintenance personnel perform routine procedures on the product to keep it operating properly, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the user documentation. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

Service personnel are trained to work on live circuits, perform safe installations, and repair products. Only properly trained service personnel may perform installation and service procedures.

Keithley products are designed for use with electrical signals that are measurement, control, and data I/O connections, with low transient overvoltages, and must not be directly connected to mains voltage or to voltage sources with high transient overvoltages. Measurement Category II (as referenced in IEC 60664) connections require protection for high transient overvoltages often associated with local AC mains connections. Certain Keithley measuring instruments may be connected to mains. These instruments will be marked as category II or higher.

Unless explicitly allowed in the specifications, operating manual, and instrument labels, do not connect any instrument to mains.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30 V RMS, 42.4 V peak, or 60 VDC are present. A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.

Operators of this product must be protected from electric shock at all times. The responsible body must ensure that operators are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product operators in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 V, no conductive part of the circuit may be exposed.

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance-limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, ensure that the line cord is connected to a properly-grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

When installing equipment where access to the main power cord is restricted, such as rack mounting, a separate main input power disconnect device must be provided in close proximity to the equipment and within easy reach of the operator.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

For safety, instruments and accessories must be used in accordance with the operating instructions. If the instruments or accessories are used in a manner not specified in the operating instructions, the protection provided by the equipment may be impaired.

Do not exceed the maximum signal levels of the instruments and accessories. Maximum signal levels are defined in the specifications and operating information and shown on the instrument panels, test fixture panels, and switching cards.

When fuses are used in a product, replace with the same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as protective earth (safety ground) connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If a screw is present, connect it to protective earth (safety ground) using the wire recommended in the user documentation.

The symbol on an instrument means caution, risk of hazard. The user must refer to the operating instructions located in the user documentation in all cases where the symbol is marked on the instrument.

The symbol on an instrument means warning, risk of electric shock. Use standard safety precautions to avoid personal contact with these voltages.

The symbol on an instrument shows that the surface may be hot. Avoid personal contact to prevent burns.

The symbol indicates a connection terminal to the equipment frame.

If this Hg symbol is on a product, it indicates that mercury is present in the display lamp. Please note that the lamp must be properly disposed of according to federal, state, and local laws.

The **WARNING** heading in the user documentation explains hazards that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in the user documentation explains hazards that could damage the instrument. Such damage may invalidate the warranty.

The **CAUTION** heading with the symbol in the user documentation explains hazards that could result in moderate or minor injury or damage the instrument. Always read the associated information very carefully before performing the indicated procedure. Damage to the instrument may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits — including the power transformer, test leads, and input jacks — must be purchased from Keithley. Standard fuses with applicable national safety approvals may be used if the rating and type are the same. The detachable mains power cord provided with the instrument may only be replaced with a similarly rated power cord. Other components that are not safety-related may be purchased from other suppliers as long as they are equivalent to the original component (note that selected parts should be purchased only through Keithley to maintain accuracy and functionality of the product). If you are unsure about the applicability of a replacement component, call a Keithley office for information.

Unless otherwise noted in product-specific literature, Keithley instruments are designed to operate indoors only, in the following environment: Altitude at or below 2,000 m (6,562 ft); temperature 0 °C to 50 °C (32 °F to 122 °F); and pollution degree 1 or 2.

To clean an instrument, use a cloth dampened with deionized water or mild, water-based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., a data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

Safety precaution revision as of June 2018.

Table of contents

Section 1

TSP LPT library commands

In this section:

Series 2600B TSP LPT library

NOTE

When the Series 2600B System SourceMeter® instruments are referenced, it also includes the Series 2600A System SourceMeter instruments.

The Keithley Instruments Linear Parametric Test Library (LPTLib) is a high-speed data acquisition and instrument control software library. It is the ACS Basic programmer's lowest level of command interface to the system instrumentation.

ACS Basic incorporates two LPT libraries. The ACS Basic TSP LPT library contains commands that are compatible with the Keithley Instruments Series 2600B and 2650A System SourceMeters®. Most of the commands in the ACS Basic TSP LPT Library contain the same format as those in the Model 4200A-SCS library.

The ACS Basic TSP LPT library is built with the TSP builder and is programmed with Lua language. TSP builder can be used in STMs. For more information about STMs, refer to "Configuring a Script Test Module (STM)" in the *ACS Basic Reference manual*.

The second library contains commands that are generally used when creating ACS Basic Python Test Modules (PTM) and can be used with the Model 4200A-SCS, Series 2600B and 2650A System SourceMeters, Series 2400 instruments, and Series 23X instruments. In addition, the Python LPT library contains commands that allow you to control other GPIB-based instruments. The following commands are listed in alphabetical order.

addcon

This command adds a terminal-pin connection.

Usage

`addcon(*instMTRX, ter, pin, *more_pin)`

instMTRX	Optional; the matrix name in the hardware configuration
ter	The list of terminals to connect
pin	The list of pins to connect
more_pin	Indicates additional pins to connect

Details

Terminal and pin lists must have the same number of items. Terminals and pins are matched according to the sequence. If the numbers in the terminal and pin lists are not the same, the connections are performed based on the shortest list.

Normally, the `addcon` command supports the `ROW_COLUMN` mode of the matrix. When the matrix is set to `INSTRUMENT_CARD` mode, a row is assigned automatically to connect the terminal and the pin.

Example

```
addcon(MTRX1,SMU1,1)
addcon(SMU1,1)
addcon(SMU1H,1)
addcon(SMU1L,1)
addcon(SMU1,1,2,3)
addcon([SMU1,SMU2], [1,2])
addcon(SMU1, SMU2)
addcon(CVU1H,1)
```

Also see

clrcon (on page 2-13)
conpin (on page 1-6)
delcon (on page 1-10)

addpth

This command adds a terminal-pin connection through a row in a matrix.

Usage

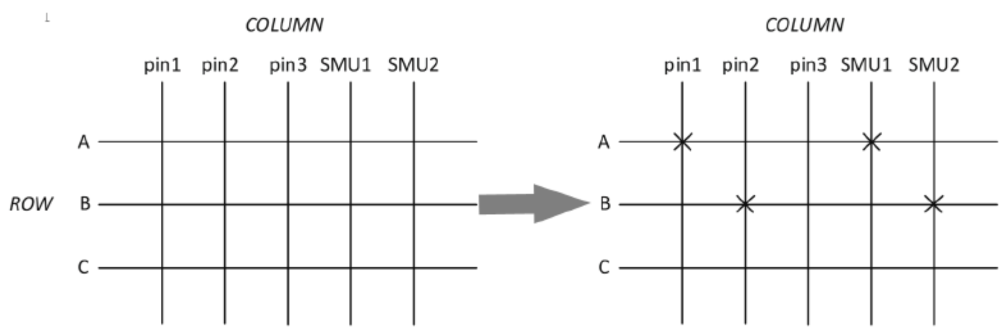
`addpth(*instMTRX, ter, pin, row)`

instMTRX	Optional; the matrix name in the hardware configuration
ter	The list of terminals to be connected
pin	The list of pins to be connected
row	The row used to connect terminals and pins

Details

A terminal and a pin are connected through an assigned row to a matrix. In the following figure, terminal SMU1 and pin 1 are connected through Row A. Terminal SMU2 and pin 2 are connected through Row B. Note that you must use another instance of the `addpth` command to make a connection in another matrix.

Figure 1: addpth and conpth command example



This function can only be applied when the matrix is set to `INSTRUMENT_CARD` mode.

For more information about how to set the `INSTRUMENT_CARD` mode and `ROW_COLUMN` mode, refer to "Hardware configurations" in the *Automated Characterization Suite (ACS) Fundamental Reference Manual* (document number ACS-914-01).

NOTE

This TSP LPT command can only be used with a matrix connected using TSP-Link®.

Example 1

```
addpth(MTRX1,SMU1,1,'A')
addpth(SMU1,1,'A')
addpth(SMU1H,1,'A')
addpth(SMU1L,1,'A')
```

This is an example of using the `addpth` command with a Model 707/708 Switch Matrix.

Example 2

```
addpth(MTRX1,SMU1,1,'1')
addpth(SMU1,1,'1')
addpth(SMU1H,1,'1')
addpth(SMU1L,1,'1')
```

This is an example of using the `addpth` command with a Series 3700 System Switch.

Also see

clrcon (on page 2-13)
conpth
delpth (on page 1-9)

avgi/avgv

This command performs a series of measurements and averages the results.

Usage

```
avgi(SMUX, Itable, step_num, step_time)
avgv(SMUX, Vtable, step_num, step_time)
```

`SMUX`	The instrument identification code of the instrument; for example, `SMU1`
`Itable`	The table you created; the measured current value is saved into `Itable[1]`
`Vtable`	The table you created; the measured voltage value is saved into `Vtable[1]`
`step_num`	The number of steps averaged in the measurement; this number ranges from `1` to `160,000`
`step_time`	The interval in seconds between each measurement; minimum practical time is approximately 0.0001 s (NPLC must be set as 0.001)

Also see

None

clrscn

This command clears the measurement scan tables associated with a sweep.

Usage

```
clrscn()
```

Details

The measurement-scan tables associated with a sweep are internal tables defined by `savgi/savgv`, `sintgi/sintgv`, `smeasi`, or `smeasi/smeasv`, or `rtfary`. The `clrscn` command is called after the sweep and it clears these tables.

Example

`clrscn()`
Clear the measurement scan tables defined by the sweep.

Also see

savgi/savgv (on page 21)
sintgi/sintgv (on page 1-24)
smeasi/smeasv/smeast (on page 1-25)

crtbf

This command applies to only Series 2600B System SourceMeter® instruments. This command creates a buffer in which the specified SMU stores its measurements.

Usage

buff_name = crtbf(*SMUX*, *buff_cap*, *append_flag*, *timestamp_flag*)

buff_name	The name of the buffer
SMUX	The instrument identification code of the instrument; for example, `SMU1`
buff_cap	The capacity of the buffer
append_flag	Enable or disable buffer append mode: ■ To enable: Set to `KI_EBAP` ■ To disable: Set to `KI_DBAP`
timestamp_flag	Enable or disable timestamp collection: ■ To enable: Send `KI_EBTS` ■ To disable: Send `KI_DBTS`

Also see

None

conpin

This command clears existing connections and adds new terminal-pin connections.

Usage

`conpin(*instMTRX, ter, pin, *more_pin)`

instMTRX	Optional; the matrix name in the hardware configuration
ter	The list of terminals to connect
pin	The list of pins to connect
more_pin	Additional pins to connect

Details

Terminal and pin lists must have the same number of items and are arranged (by number) in the same sequence. If the numbers in the terminal and pin lists are not the same, the connections are performed on the shortest list and other entries are ignored.

Normally, the `conpin()` command supports the `ROW_COLUMN` mode of the matrix. When the matrix is set to `INSTRUMENT_CARD` mode, a row is assigned automatically to connect the terminals and the pins.

For more information about how to set the `INSTRUMENT_CARD` mode and `ROW_COLUMN` mode, refer to "Hardware configurations" in the *Automated Characterization Suite (ACS) Fundamental Reference Manual* (document number ACS-914-01).

Example

```
conpin(MTRX1,SMU1,1)
conpin(SMU1,1)
conpin(SMU1H,1)
conpin(SMU1L,1)
conpin(SMU1,1,2,3)
conpin([SMU1,SMU2], [1,2])
conpin(CVU1H,1)
```

This example demonstrates different methods of using `conpin` to connect terminals to pins.

See also

addcon (on page 1-2)
clrcon (on page 2-13)
delcon (on page 1-10)

conpth

This command clears all matrix connections and makes a new terminal-pin connection through a row.

Usage

```
conpth(*instMTRX, ter, pin, row)
```

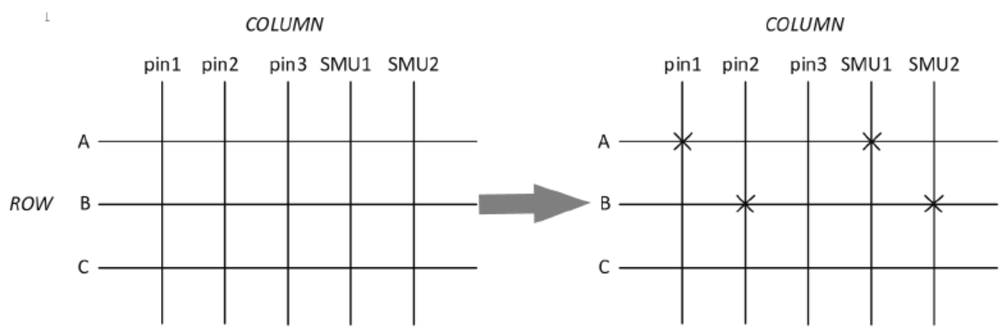
instMTRX	The matrix name in the hardware configuration (the name is optional)
ter	The list of terminals to connect
pin	The list of pins to connect
row	The row used to connect terminals and pins

Details

The terminal and pin are connected through an assigned row in a matrix. In the following figure, terminal SMU1 and pin1 are connected through row A. Terminal SMU2 and pin2 are connected through row B.

You must use one instance of the conpth command for each connection made in a matrix. You cannot use the conpth command to make a connection in multiple matrices (see the following figure).

Figure 2: addpth and conpth command example



You must use one instance of the *conpth* command for each connection made in a matrix. You cannot use the *conpth* command to make a connection in multiple matrices (see the following figure).

This function can only be applied when the matrix is set to `INSTRUMENT_CARD` mode.

Example 1

```
conpth(MTRX1,SMU1,1,'A')
conpth(SMU1,1,'A')
conpth(SMU1H,1,'A')
conpth(SMU1L,1,'A')
```

This is an example of using the `conpth` command with a Model 707B or 708B Switch Matrix.

Example 2

```
conpth(MTRX1,SMU1,1,'1')
conpth(SMU1,1,'1')
conpth(SMU1H,1,'1')
conpth(SMU1L,1,’1’)
```

This is an example of using the `conpth` command with a Series 3700A System Switch.

Also see

addpth (on page 1-3)
clrcon (on page 2-13)
delpth (on page 1-9)

delpth

This command deletes a terminal-pin connection based on a specific row in a matrix.

Usage

```
delpth(*instMTRX, ter, pin, row)
```

instMTRX	Optional; the matrix name in the hardware configuration
ter	The list of terminals to disconnect
pin	The list of pins to be connected
row	The row used to connect terminals and pins

Details

The terminal, pin, and row must be in the same group when connected. Otherwise, the command is not valid.

Example 1

```
delpth(MTRX1,SMU1,1,'A')
delpth(MTRX1,1,'A')
delpth(SMU1H,1,'A')
delpth(SMU1L,1,'A')
```

This is an example of using the `delpth` command with a Model 707B or 708B Switch Matrix.

Example 2

```
delpth(MTRX1,SMU1,1,'1')
delpth(SMU1,1,'1')
delpth(SMU1H,1,'1')
delpth(SMU1L,1,'1')
```

This is an example of using the `delpth` command with a Series 3700A System Switch.

Also see

addpth (on page 1-3)
clrcon (on page 2-13)
conpth (on page 2-13)

delcon

This command deletes a terminal-pin connection.

Usage

`delcon(*instMTRX, ter, pin, *more_pin)`

instMTRX	Optional; the matrix name in the hardware configuration
ter	The list of terminals to connect
pin	The list of pins to connect
more_pin	Indicates additional pins to connect

Details

The terminal and pin must be connected before the command will delete the terminal pin connection, otherwise the connection is invalid.

Example

```
delcon(MTRX1,SMU1,1)
delcon(SMU1,1)
delcon(SMU1H,1)
delcon(SMU1L,1)
delcon(SMU1,1,2,3)
delcon([SMU1,SMU2], [1,2])
```

This example shows valid methods for defining the matrix, terminals, and pins.

Also see

addcon (on page 1-2)
clrcon (on page 2-13)
conpin (on page 1-6)

devclr

This command sets all sources to a zero state.

Usage

`devclr()`

Example

```
devclr()
```

Set all sources to a zero state.

Also see

None

devint

This command resets all instruments and clears the system by opening all relays and disconnecting the pathways.

Usage

```
devint()
```

Details

This command resets all the instruments in the TSP-Link group to their default states. The default states for each instrument are provided in the instrument documentation.

Also see

None

disable

This command stops the timer, sets the time value to zero, and stops the timer reading.

Usage

```
disable(ntimer[Y])
```

Y	Timer number, such as `1`, `2`, `3`

Example

`disable(ntimer[1])`
This example disables a timer named ntimer[1].

Also see

enable (on page 1-12)

enable

This command enables a timer, which can be used with the command `meast()` to measure time.

Usage

`enable(ntimer[Y])`

Y	Timer number, such as `1, 2, 3`

Details

The timer enabled can be used in `imeast()` to measure time and can be disabled using `disable()`.

Example

```
enable(ntimer[1])  --enable timer ntimer[1]
```

This example enables a timer named `ntimer[1]`.

Also see

disable (on page 1-11)
measi/measv/meast (on page 1-15)

forceclr

This command turns the source output off on the specified SMU.

Usage

`forceclr(SMUX)`

SMUX	The instrument identification code of the instrument; for example, `SMU1`

Example

```
forceclr(SMU1) --turns the SMU1 source output off.
```

Turns the source output of SMU1 off.

Also see

None

forcei/forcev

This command programs a sourcing instrument to generate a voltage or current at a specific level.

Usage

```
forcei(SMUX, value)
forcev(SMUX, value)
```

SMUX	The instrument identification code of the instrument; for example, `SMU1`
value	The level of current or voltage forced in amperes or volts

Example

```
forcei(SMU1, 1e-6) --force current 1e-6A on SMU1
forcev(SMU2, 0.02) --force voltage 0.02V on SMU2
```

Sets up SMU1 to source 1 µA and SMU2 to source 0.02 V.

Also see

None

intgi/intgv

This command makes voltage or current measurements averaged over a user-defined period (usually one AC-line cycle).

Usage

```
intgi(SMUX, Itable)
intgv(SMUX, Vtable)
```

SMUX	The instrument identification code of the instrument; for example, `SMU1`
Itable	The table created by you; the measured current value is saved into `Itable[1]`
Vtable	The table created by you; the measured voltage value is saved into `Vtable[1]`

Details

Averaging is done in the hardware by integration of the analog measurement signal over a specified time. The integration is automatically corrected for 50 Hz or 60 Hz power mains.

Example

```
forcei(SMU1, 1e-6) --force current 1e-6A on SMU1
```

Also see

None

ioli/iolv/ioliv

This command applies to only Series 2600B System SourceMeter® instruments.

This command uses overlap mode to measure current, voltage, or current and voltage.

Usage

```
ioli(SMUX, i_buff_name)
iolv(SMUX, v_buff_name)
ioliv(SMUX, i_buff_name, v_buff_name)
```

SMUX	The instrument identification code of the instrument; for example, `SMU1`
i_buff_name	The buffer to store current measurements; see **Details**
v_buff_name	The buffer to store current measurements; see **Details**

Details

The integration time is set by `setmode()` and the measure count is set by `setcount()`. The only difference between this function and `msoli()` is that the integration time `msoli()` uses a fixed 0.001 NPLC.

The buffer must be created by `crtbf()` for the same SMU.

Also see

crtbf (on page 1-5)

limiti/limitv

This command allows you to specify a current or voltage limit.

Usage

```
limiti(SMUX, value)
limitv(SMUX, value)
```

SMUX	The instrument identification code of the instrument; for example, `SMU1`
value	The value of current limit in amperes or the voltage limit voltage

Example

```
--Set the current limit of SMU1 to 0.01 A.
limiti(SMU1, 0.01)
--Set voltage limit of SMU2 to 200 V>.
limitv(SMU2, 200)
```

Set the current limit for SMU1 to 0.01 A and the voltage limit of SMU2 to 200 V.

Also see

None

lorangei/lorangev

This command defines the lowest autorange limit for current or voltage measurements.

Usage

```
lorangei(SMUX, value)
lorangev(SMUX, value)
```

SMUX	The instrument identification code of the instrument; for example, `SMU1`
value	The value of the lowest autorange limit in amperes or volts

Example

```
--Set lowest autorange limit of current on SMU1 to 1E-6A.
lorangei(SMU1, 1E-6)
--Set lowest autorange limit of voltage on SMU2 to 0.2V.
lorangev(SMU2, 0.2)
```

Sets the lowest autorange limit for current on SMU1 to 1 µA.
Sets the lowest autorange limit for voltage on SMU2 to 0.2 V.

Also see

None

measi/measv/meast

This command allows the measurement of voltage, current, or time.

Usage

```
measi(SMUX, Itable_num)
measv(SMUX, Vtable)
meast(ntimer[Y], Ttable)
```

SMUX	The instrument identification code of the instrument; for example, `SMU1`
Itable_num	The table created by you; the measured current value is saved into `Itable[1]`
Vtable	The table created by you; the measured voltage value is saved into `Vtable[1]`
ntimer[Y]	The timer number
Ttable	The table created by you; the measured voltage value is saved into `Ttable[1]`

Also see

None

moli/molv/moliv

This command is only for the Series 2600B System SourceMeter® instruments.

This command measures current, voltage, or current and voltage using overlap mode with a fixed 0.001 NPLC.

Usage

```
msoli(SMUX, i_buff_name)
msolv(SMUX, v_buff_name)
msoliv(i_buff_name, v_buff_name)
```

SMUX	The instrument identification code of the instrument; for example, SMU1
i_buff_name	The buffer to store current measurements; see **Details**
v_buff_name	The buffer to store voltage measurements; see **Details**

Details

The buffer must be created by `crtbf()` for the same SMU.

Also see

None

postscript

This command prints a list of scripts that are presently stored in the parent of the Series 2600B instruments.

Usage

```
postscript(location)
```

location	The location of the script: ■ Volatile memory: `0` ■ Nonvolatile memory (default): `1`

Also see

None

postbuffer

This command prints buffered data to a GPIB output buffer in binary format.

Usage

```
postbuffer("name", start_index, end_index, buff_name, avg_num)
```

name	A string that represents the values in the script, defined by the script writer
start_index	The starting index of values to post and print
end_index	The ending index of values to post and print
buff_name	The name of the buffer to print; it could be a default name or a user-defined name
avg_num	The average number (must be an integer); if this number is equal to 2 or greater, the DATA Engine automatically calculates the average result of each `avg_num` value; if this parameter is not provided, the system assigns a default value of `1` (print every value point)

Details

ACS Basic software can only recognize buffered data printed by the `postbuffer` function.

Also see

None

postbuftime

This command prints timestamps of buffered data in binary format.

Usage

```
postbuftime("name", start_index, end_index, buff_name, avg_num)
```

name	A string that represents the values in the script
start_index	The starting index of values to post and print
end_index	The ending index of values to post and print
buff_name	The name of the buffer to print; it could be a default name or a user-defined name
avg_num	The average number (must be an integer); if this number is equal to 2 or greater, the DATA Engine automatically calculates the average result of each `avg_num` value; if this parameter is not provided, the system assigns a default value of `1`

Details

ACS Basic software only recognizes buffered `timestamp` data printed by the `postbuftime` function.

In the same buffer, always use `avg_num` with `postbuffer()`, or the number of the timestamps will not match the number of the values. If you do not define this parameter, the system uses a default value of 1 (print every value point).

Also see

None

postdata

This command prints a single value.

Usage

```
postdata("name", value)
```

name	A string that represents the values in the script
value	The value to print

Details

The value to print, for example, could be an execution: "`node[2].smua.measure.i()`", or "`measi(SMU1)`".

ACS software only recognizes single values printed by the `postdata` function.

Also see

None

posterror

This command prints all errors in the error queue separately.

Usage

```
posterror()
```

Details

This function was designed for the DATA Class engine of ACS.

Also see

None

postsmuinfo

This command prints information for all SMUs.

Usage

```
postsmuinfo()
```

Also see

None

posttable

This command prints a table data. Each item in the table must be a numeric value.

Usage

`posttable("`*`name`*`", `*`tableName`*`)`

name	A string that represents the values in the script, defined by the script writer
tableName	The name of the table

Also see

None

rangei/rangev

This command selects the current or voltage measurement range and prevents the selected instrument from autoranging.

Usage

```
rangei(SMUX, value)
rangev(SMUX, value)
```

SMUX	The instrument identification code of the instrument; for example, `SMU1`
value	The value of the current or voltage measurement range in amperes or volts.

Details

By selecting a range, the time required for autoranging is eliminated.

Example

```
--Set the current measurement range on SMU1 to 1e-3A.
rangei(SMU1, 1e-3)
--Set the voltage measurement range on SMU2 to 20V.
rangev(SMU2, 20)
```

Set the current measurement range on SMU1 to 1 mA and the voltage measurement range on SMU2 to 20 V.

Also see

None

rdelay

This command provides a user-programmable delay in a test sequence.

Usage

```
rdelay(dDelayTime)
```

dDelayTime	The delay duration in seconds

Details

This command delays the test sequence by a specified number of seconds.

Example

```
--delay 0.001 s
rdelay(0.001)
```

Add a 1 ms delay.

Also see

None

savgi/savgv

This command performs a current or voltage measurement for every point in a sweep and determines the average for every point.

Usage

```
savgi(SMUX, Itable, step_num, step_time)
savgv(SMUX, Vtable, step_num, step_time)
```

X	SMU number, such as `1`, `2`, or `3`
Itable	The table created by you; the measured current value is saved into `Itable[1]`.
Vtable	The table created by you; the measured voltage value is saved into `Vtable[1]`.
step_num	The number of measurements made at each point before the average is computed.
step_time	The time delay in seconds between each measurement within a given ramp step.

Also see

None

scnmeas

This command performs a single measurement on multiple instruments at the same time.

Usage

```
scnmeas()
```

Details

This function behaves like a single point sweep. It performs a single measurement on multiple instruments at the same time. Any forcing or delaying must be done prior to calling `scnmeas`. And `smeasX`, `sintgX`, or `savgX` must be used to set up result arrays which is also done for a sweep call. Each call to `scanmeas` will add one element to the end of each array. Calls to `scnmeas` may be mixed with calls to `sweepX` and all results will be appended to the result arrays the same way multiple `sweepX` calls behave.

Also see

None

setauto

This command sets the SMU measurement autorange.

Usage

`setauto(SMUX)`

SMUX	The instrument identification code of the instrument; for example, `SMU1`

Also see

None

setcount

This command applies to only Series 2600B System SourceMeter® instruments. This command sets the number of measurements performed when a measurement is requested.

Usage

`setcount(SMUX, value)`

SMUX	The instrument identification code of the instrument; for example, `SMU1`
value	Number of measurements

Details

This attribute controls the number of measurements taken any time a measurement is requested. When using a reading buffer with a measure command, the count also controls the number of readings to be stored.

The reset function sets the measure count to 1.

Example

```
--Set the number of measurements on SMU1 to 5.
setcount(SMU1, 5)
```

Set the number of measurements on SMU1 to 5.

Also see

None

setitv

This command applies to only Series 2600B System SourceMeter® instruments. This command sets the interval between multiple measurements in seconds.

Usage

`setitv(SMUX, value)X = SMU number(1,2,3,...)`

SMUX	The instrument identification code of the instrument; for example, `SMU1`
value	The interval between multiple measurements in seconds

Details

This attribute sets the time interval between groups of measurements when `setcount()` is set to a value greater than 1. The SMU will attempt to start the measurement of each group when scheduled.

- If the SMU cannot keep up with the interval setting, measurements are made as fast as possible.
- The reset function sets the measure interval to 0.

Example

```
--Set the interval between multiple measurements on SMU1 to 0.001.
setitv(SMU1, 0.001)0.001 s
```

Set the interval between multiple measurements on SMU1 to 0.001 s.

Also see

None

setmode

This command sets instrument-specific operating mode parameters.

Usage

```
setmode(SMUX)
```

SMUX	The instrument identification code of the instrument; for example, `SMU1`

Details

This will modify the parameters of the instruments' specific operating characteristics (see the following table).

Parameters			Comments
smu[X]	**Modifier**	**Value**	
smu[X]	KI_INTGPLC	<value> (in units of line cycles)	Specifies the integration time the SMU will use for the `intgx` command. The default `devint` value is 1.0. The valid range is 0.001 to 25.0.
	KI_AVGMODE	KI_MEASX	Controls what kind of readings are taken for `avgX` calls. The `devint` default value is KI_MEASX. When KI_INTEGRATE is specified, the time used is that specified by the setmode (KI_INTGPLC) call.
		KI_INTEGRATE	
	KI_OFFMODE	KI_OFF_NORM	Set source output-off mode. KI_OFF_NORM: Outputs 0V when the output is turned off. KI_OFF_ZERO: Zero the output (in either volts or current) when off. KI_OFF_OPEN: Opens the output relay when the output is turned off.
		KI_OFF_ZERO	
		KI_OFF_OPEN	
	KI_SENSE	KI_SENSE_LOCA	Sets the sense mode to remote, local, or calibration. KI_SENSE_LOCA: selects local sense (2-wire). KI_SENSE_REMO: selects remote sense (4-wire). KI_SENSE_CALA: selects calibration sense mode.
		KI_SENSE_REMO	
		KI_SENSE_CALA	

Also see

None

sintgi/sintgv

This command performs an integrated current or voltage measurement for every point in a sweep.

Usage

```
sintgi(SMUX, Itable)
sintgv(SMUX, Vtable)
```

SMUX	The instrument identification code of the instrument; for example, `SMU1`
Itable	The table created by you; the measured current value is saved into `Itable[1]`
Vtable	The table created by you; the measured voltage value is saved into `Vtable[1]`

Also see

None

slorangei/slorangev

This command applies to only Series 2600B System SourceMeter® instruments. This command defines the lowest autorange limit for the current or voltage source.

Usage

```
slorangei(SMUX, value)
slorangev(SMUX, value)
```

SMUX	The instrument identification code of the instrument; for example, `SMU1`
value	The lowest autorange limit for the current or voltage source

Example

```
--Set the lowest autorange limit for the current source on SMU1 as 1e-6 A.
slorangei(SMU1, 1e-6)
--Set the lowest autorange limit for the voltage source on SMU2 as 0.2 V.
slorangev(SMU2, 0.2)
```

Set the lowest autorange limit for the SMU1 current source to 1 µA..
Set the lowest autorange limit for the voltage source on SMU2 to 0.2 V.

Also see

None

smeasi/smeasv/smeast

This command allows several current or voltage/time measurements to be made by a specified instrument during a `sweepX` function.

Usage

```
smeasi(SMUX, Itable_num)
smeasv(SMUX, Vtable)
smeast(ntimer[Y], Ttable)
```

SMUX	The instrument identification code of the instrument; for example, `SMU1`
Itable	The table created by you; the measured current value is saved into `Itable[1]`
Vtable	The table created by you; the measured voltage value is saved into `Vtable[1]`
Ttable	The table created by you; the measured voltage value is saved into `Ttable[1]`

Details

The results of the measurements are stored in the defined array.

Also see

None

srangei/srangev

This command selects the current or voltage source range and prevents the selected instrument from autoranging.

Usage

```
srangei(SMUX, value)
srangev(SMUX, value)
```

SMUX	The instrument identification code of the instrument; for example, `SMU1`
value	The current or voltage source range

Details

By selecting a range, the time required for autoranging is eliminated.

Example

```
--Set the current source range on SMU1 to 1e-3A.
srangei(SMU1, 1e-3)
--Set the voltage source range on SMU2 to 20V.
srangev(SMU2, 20)
```

Also see

None

ssetauto

This command sets the source-measure unit (SMU) source to autorange.

Usage

```
ssetauto(SMUX)
```

SMUX	The instrument identification code of the instrument; for example, `SMU1`

Also see

None

sweepi/sweepv

This command generates a ramp consisting of ascending or descending currents or voltages.

Usage

```
sweepi(SMUX, start, end, step_number, delay_time)
sweepv(SMUX, start, end, step_number, delay_time)
```

SMUX	The instrument identification code of the instrument; for example, `SMU1`
start	The initial voltage or current level output from the sourcing instrument that is applied for the first sweep measurement; this value can be positive or negative
end	The final voltage or current level applied in the last step of the sweep; this value can be positive or negative
step_number	The number of current or voltage changes in the sweep; the actual number of forced data points is one greater than the number of steps specified
delay_time	The delay in seconds between each step and the measurements defined by the active measure list

Details

The sweep consists of a sequence of steps, each with a user-specified duration.

Also see

None

sysinit

This command sets NPLC to 0.001 and measure count to 1.

Usage

```
sysinit()
```

SMUX	The instrument identification code of the instrument; for example, `SMU1`

Details

This command affects every SMU in the system and clears error queues and resets all registers.

Also see

None

sysquery

This command queries every node and every source-measure unit (SMU) in the system and gives every SMU a unique name.

Usage

```
sysquery()
```

Details

When using this command query, SMU*X* indicates the node number and the SMU number on every Series 2600B instruments' screen.

This command sets the integration NPLC to 1 and the average mode to `KI_MEASX` on every SMU in the system.

Also see

None

Examples

The following LPT examples are provided for your reference.

Example 1

```
Function: R_single (sensemode, testmode, RSMU1, RSMU2, forcevalue, myLIMIT, myNPLC,
   testdelay, Rvalue)
local v_value = {}
local i_value = {}
local error = {}
if sensemode ~= 0 and sensemode ~= 1 then
table.insert(error,-10100)
posttable("error",error)
return
end
if testmode ~= 0 and testmode ~= 1 then
table.insert(error,-10100)
posttable("error",error)
return
end
setmode(RSMU1, KI_INTGPLC, myNPLC)          --set RSMU1's NPLC
setmode(RSMU1, KI_SENSE, sensemode)         --set RSMU1 in sensemode
if RSMU2 ~= KI_GND then
setmode(RSMU2, KI_SENSE, sensemode)
limiti(RSMU2, 1)                            --set RSMU2 current limit
end
if testmode == 0 then                       --if
limiti(RSMU1, myLIMIT)                      --set RSMU1 current limit
forcev(RSMU1, forcevalue)                   --force RSMU1 voltage source value
elseif testmode == 1 then
limitv(RSMU1, myLIMIT)                      --set RSMU1 voltage limit
forcei(RSMU1, forcevalue)                   --force RSMU1 current source value
end
if RSMU2 ~= KI_GND then --if
forcev(RSMU2, 0)                            --force RSMU2 voltage source value
end       --if
delay(testdelay)                            --set delay time before measure
intgv(RSMU1, v_value)                       --measure RSMU1 voltage
intgi(RSMU1, i_value)                       --measure RSMU1 current
Rvalue[1] = v_value[1]/i_value[1]
posttable("Rvalue", Rvalue)
table.insert(error, 0)
posttable("error",error)
devint()                                    --reset all instruments after test
end       --function
--CALL--
local sensemode = 0
local testmode = 1
local RSMU1 = SMU1
local RSMU2 = KI_GND
local forcevalue = 1e-3
local myLIMIT = 20
local myNPLC = 1
local testdelay = 0.01
```

```
local Rvalue = {}
R_single(sensemode, testmode, RSMU1, RSMU2, forcevalue, myLIMIT, myNPLC, testdelay,
   Rvalue)
```

Example 2

```
Function: Four_term_MOSFET_idvg (DSMU, GSMU, SSMU, BSMU, Vg_start, Vg_stop,
   Vg_points, Dcompliancei, Gcompliancei, Scompliancei, Bcompliancei, VD, VSS,
   VBULK, myNPLC, holdtime, sweepdelay, error, time, Id, Vg)
local  vg
 local  i
 local  Vg_inc
 local  id_t1={}
 local  dummy={}
 setmode(DSMU, KI_INTGPLC, myNPLC)          --set the NPLC of DSMU
 limiti(GSMU,Gcompliancei)                  --set current compliance to GSMU
 limiti(DSMU,Dcompliancei)                  --set current compliance to DSMU
  setauto(DSMU)                             --set DSMU measure range to auto
  if SSMU~=KI_GND  then
     limiti(SSMU,Scompliancei)              --set current compliance to SSMU
     forcev(SSMU,VSS)                       --apply SSMU voltage source
  end
  if BSMU~=KI_GND  then
     limiti(BSMU,Bcompliancei)              --set current compliance to BSMU
     forcev(BSMU,VBULK)                     --apply BSMU voltage source
  end
  Vg_inc=(Vg_stop-Vg_start)/(Vg_points-1)
  forcev(DSMU,VD)                           --apply DSMU voltage source
  forcev(GSMU,Vg_start)                     --apply GSMU voltage source
  delay(holdtime)                           --set time delay before measure
  intgi(DSMU,dummy)                         --perform current measure on DSMU
  forcev(DSMU,VD)                           --apply DSMU voltage source
  timer.reset()
  for i=1,Vg_points do
     vg=Vg_start+(i-1)*Vg_inc
     forcev(GSMU,vg)                        --apply GSMU voltage source
     table.insert(Vg,vg)
     delay(sweepdelay)                      --set time interval between every point
     intgi(DSMU,id_t1)                      --perform current measure on DSMU
     table.insert(Id,id_t1[1])
     table.insert(time,timer.measure.t())
  end
   --for
  table.insert(error,0)
  posttable("error",error)
  posttable("time",time)
  posttable("Vg",Vg)
  posttable("Id",Id)
  devint()
end
---------------------------------------------------------------------------
--CALL--
local DSMU=SMU2
local GSMU=SMU1
local SSMU=KI_GND
local BSMU=KI_GND
local Vg_start=0
```

```
local Vg_stop=2
local Vg_points=21
local Dcompliancei=0.1
local Gcompliancei=0.1
local Scompliancei=0.1
local Bcompliancei=0.1
local VD=1
local VBULK=0
local VSS=0
local myNPLC=1
local holdtime=0.01
local sweepdelay=0.001
local error={}
local time={}
local Id={}
local Vg={}
Four_term_MOSFET_idvg(DSMU, GSMU, SSMU, BSMU, Vg_start, Vg_stop, Vg_points,
   Dcompliancei, Gcompliancei, Scompliancei, Bcompliancei, VD, VSS, VBULK, myNPLC,
   holdtime, sweepdelay, error, time, Id, Vg)
```

Section 2

Python LPT library commands

In this section:

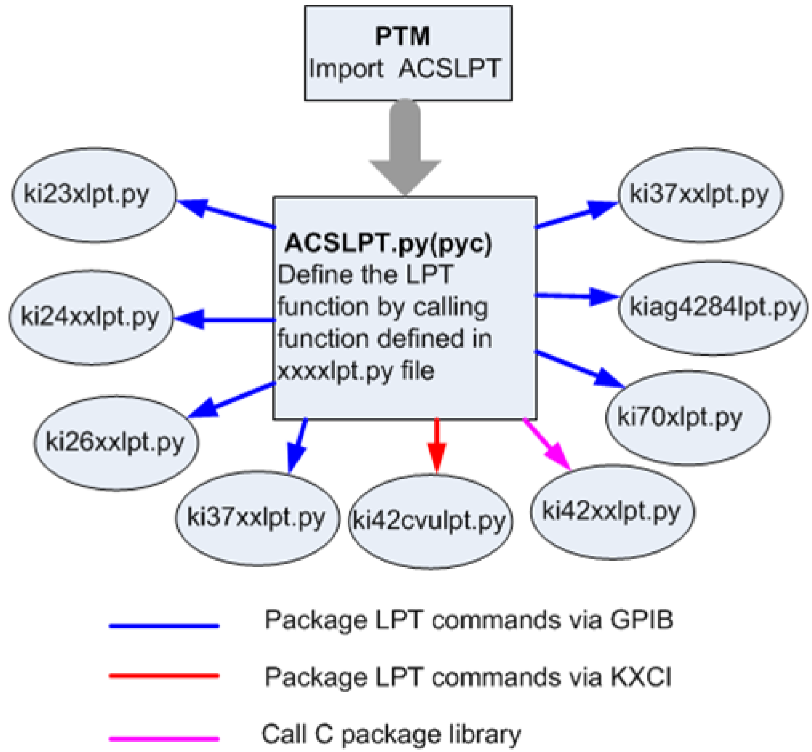
Introduction

For the PTM (Python test module), ACS Basic includes the special LPT library ACSLPT. The ACSLPT library has functions that let you configure one or multiple instruments to perform parametric tests.

The ACSLPT commands can be used to configure some general instruments. To use these commands, you need to import ACSLPT to a PTM.

The ACSLPT commands can control the following instruments: Series 23x, Series 2400 SourceMeter, Series 2600B SourceMeter, Series 3700A System Switch, Model 4200A CVU, Model 4200A/4210 SMU, Switch Matrix 707/707A/707B and 708/708A/708B, and LCR 4284/4980 capacitance meter (see the following figure). For more information about configuring a PTM, refer to Configure a PTM script.

Figure 3: LPT call flow



The following table shows interactions between the CTM modules and the ACS Basic software functions.

ACS Basic software and CTM modules

ACS Basic installed on	Interface	Compatible library
Model 4200A-SCS	Normal (non-KXCI)	CTM functions
	KXCI and ethernet cable	Kicvulpt commands
PC	KXCI and ethernet cable	Kicvulpt commands

LPT Functions

In the following tables, function calls are grouped by different instruments. The details on functions for the source-measure units (SMUs) and general operations are listed alphabetically in ACS Basic Python LPT library commands (on page 2-5).

Models 236, 237, 238 LPT function list

Models 236, 237, 238 LPT functions			
devclr	devint		
forcei	forcev	intgi	intgi
limiti	limitv	lorangei[1]	lorangev[1]
measi	measv	rangi	rangev
setauto	setmode	srangei	srangei
[1]These two functions are similar to autorange, no matter what value the parameter is set to.			

Series 2400 LPT function list

Series 2400 SourceMeter instruments LPT functions (SCPI and TSP mode)			
abort	adelayadelay	asweepi	asweepv
bsweepi	bsweepv	Asweepi	delay
devclr	forcev	intgi	intgv
limiti	limitv		
measi	measv	rangi	rangev
rtfary	savgi	savgv	setauto
setmode	sintgi	sintgv	smeasi
smeasv	srangei	srangev	
sweepi	sweepv	trigig	trigil
trigvg	trigvl		

Series 2600B LPT function list

Series 2600B SourceMeter instruments LPT functions			
abort	adelay	asweepi	asweepv
avgi	avgv	bsweepi	bsweepv
devclr	devint	forcei	forcev
intgi	intgv	limiti	limitv
lorangei	lorangev	measi	measv
rangi	rangev	rtfary	savgi
savgv	setauto	setmode	sintgi
sintgv	smeasi	smeasv	srangei
srangev	sweepi	sweepv	trigig
trigil	trigvg	trigvl	

Series 3700 LPT function list

Series 3700 System Switch LPT functions			
addcon	addconrc	addpth	clrcon
conpin	conpth	conrowcol	delcon
delconrc	delpth	devint	

Model 4200A-SCS LPT function list

Model 4200A-SCS LPT functions			
avgi	avgv	clrscn	clrtrg
delay	devclr	devint	disable
enable	execut	forcei	forcev
getinstatrr	getinstid	getstatus	imeast
intgi	intgv	limiti	limitv
lorangei	lorangev	measi	measv
measz	rangi	rangev	
rdelay	setauto	setfreq	setlevel
setmode	smeasz_sweep v	sweepi	sweepv
tstdsl	tstsel		

Models 707A/707B, 708A/708B LPT function list

Models 707A/707B, 708A/708B LPT functions			
addcon	addconrc	addpth	clrcon
conpin	conpth	conrowcol	delcon
delconrc	delpth	devint	

Model 4200A CVU (KXCI) LPT function list

Model 4200A CVU LPT functions		
devclr	devint	forcev
measz	rangei	setauto
setfreq	setlevel	setmode

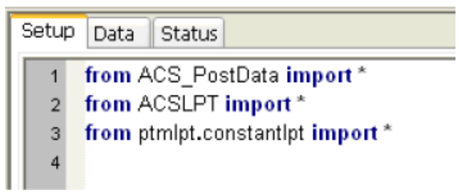
Capacitance Meter LPT function list

Model 4284 LCR Meter LPT functions			
devclr	devint	forcev	getstatus
measz	rangei	setauto	setfreq
setlevel	setmode		

ACS Basic Python LPT library commands

Before using the ACSLPT commands, you need to import ACSLPT and ptmlpt.constantlp to the header lines of a PTM (see the following figure). The ACSLPT commands are listed in alphabetical order.

Figure 4: Import ACSLPT



addcon

This command adds a terminal-pin connection.

Usage

`addcon(*instMTRX, ter, pin, *more_pin)`

instMTRX	Optional; the matrix name in the hardware configuration
ter	The list of terminals to connect
pin	The list of pins to connect
more_pin	Indicates additional pins to connect

Details

Terminal and pin lists must have the same number of items. Terminals and pins are matched according to the sequence. If the numbers in the terminal and pin lists are not the same, the connections are performed based on the shortest list.

Normally, the `addcon` command supports the `ROW_COLUMN` mode of the matrix. When the matrix is set to `INSTRUMENT_CARD` mode, a row is assigned automatically to connect the terminal and the pin.

Example

```
addcon(MTRX1,SMU1,1)
addcon(SMU1,1)
addcon(SMU1H,1)
addcon(SMU1L,1)
addcon(SMU1,1,2,3)
addcon([SMU1,SMU2], [1,2])
addcon(SMU1, SMU2)
addcon(CVU1H,1)
```

Also see

clrcon (on page 2-13)
conpin (on page 1-6)
delcon (on page 1-10)

addpth

This command adds a terminal-pin connection through a row in a matrix.

Usage

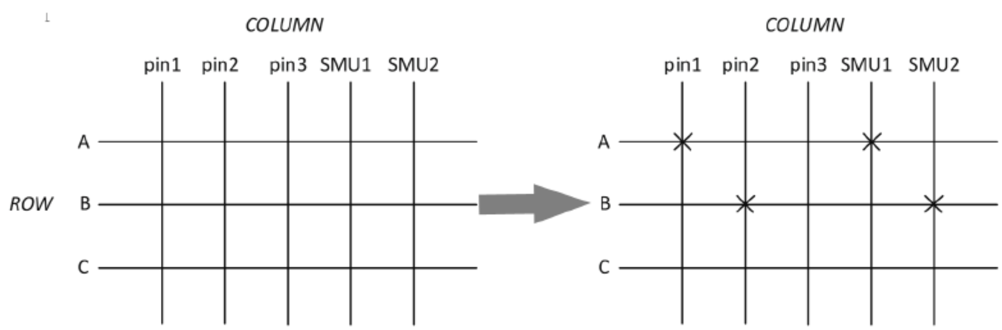
`addpth(*instMTRX, ter, pin, row)`

instMTRX	Optional; the matrix name in the hardware configuration
ter	The list of terminals to be connected
pin	The list of pins to be connected
row	The row used to connect terminals and pins

Details

A terminal and a pin are connected through an assigned row to a matrix. In the following figure, terminal SMU1 and pin 1 are connected through Row A. Terminal SMU2 and pin 2 are connected through Row B. Note that you must use another instance of the `addpth` command to make a connection in another matrix.

Figure 5: addpth and conpth command example



This function can only be applied when the matrix is set to `INSTRUMENT_CARD` mode.

For more information about how to set the `INSTRUMENT_CARD` mode and `ROW_COLUMN` mode, refer to "Hardware configurations" in the *Automated Characterization Suite (ACS) Fundamental Reference Manual* (document number ACS-914-01).

NOTE

This TSP LPT command can only be used with a matrix connected using TSP-Link®.

Example 1

```
addpth(MTRX1,SMU1,1,'A')
addpth(SMU1,1,'A')
addpth(SMU1H,1,'A')
addpth(SMU1L,1,'A')
```

This is an example of using the `addpth` command with a Model 707/708 Switch Matrix.

Example 2

```
addpth(MTRX1,SMU1,1,'1')
addpth(SMU1,1,'1')
addpth(SMU1H,1,'1')
addpth(SMU1L,1,'1')
```

This is an example of using the `addpth` command with a Series 3700 System Switch.

Also see

clrcon (on page 2-13)
conpth (on page 18)
delpth (on page 1-9)

adelay

This command sets the source delay list for sweep functions using the commands `asweepi` or `asweepv`.

Usage

`adelay (`*`delayPoints`*`, `*`delayArray`*`)`

delayPoints	Number of delay points
delayArray	Delay array in seconds

Details

Use the `adelay` command to set the delay list for sweep functions with the force list `asweepi` or `asweepv` command. Each delay in the list is added to the step delay specified in `asweepi`/`asweepv` .

The `adelay` command must be called before the `asweepi` or `asweepv` command.

Example

```
forceList = [0, 1, 1.5, 3, 3.2]

   #Set source delay list for a 5-point sweep.
adelay(5, [1e-4, 2e-4, 3e-4, 4e-4, 5e-4])
#Sweep measure current on SMU1.
smeasi(SMU1)
#Sweep source voltage according to the forceList with 5 steps and with 1e-3(s)
stepdelay; based on the source delay list set by adelay, the actual delay list
for the 5 steps is [1.1e-3, 1.2e-3, 1.3e-3, 1.4e-3, 1.5e-3](s).
swpData = asweepv(SMU1, 5, 1e-3, forceList)
devint()
#Post measured current data.
ACSPostArrayDouble("Imeas", swpData["smeasi_SMU1"], 5)
#Post forced voltage value.
ACSPostArrayDouble("Vsource", swpData["rtfary"], 5)
```

Also see

None

asweepi/asweepv

This command performs a current or voltage sweep that forces a list of values and returns the measured data based on the measurement setup.

Usage

```
asweepi(instName, stepNo, stepDelay, forceList)
asweepv(instName, stepNo, stepDelay, forceList)
```

instName	Instrument name for forcing
stepNo	Step number of sweep
stepDelay	Delay before every sweep step
forceList	List of force values
return	*{"savgi_SMUX":[data_1, data_2,…, data_StepNo]}* *{"savgv_SMUX":[data_1, data_2,…, data_StepNo]}* *{"smeasi_SMUX":[data_1, data_2,…, data_StepNo]}* *{"smeasv_SMUX":[data_1, data_2,…, data_StepNo]}* *{"singti_SMUX":[data_1, data_2,…, data_StepNo]}* *{"singtv_SMUX":[data_1, data_2,…, data_StepNo]}* *{"rtfary":[value_1, value_2,…, value_StepNo]}*

Details

Use the `asweepi` command to sweep current or the `asweepv` command to sweep voltage using a list of forced values. This returns measured data based on the measurement setup for `savgi/savgv` or `sintgi`/`sintgv` or `smeasi`/`smeasv`. If the `rtfary` command is called, the return value includes programmed forced values of the sweep.

NOTE

The measurement setup function `savgi/savgv` or `sintgi`/`sintgv` or `smeasi`/`smeasv` must be called before `asweepi`/`asweepv`. The forced values return function `rtfary` must be called before `asweepi`/`asweepv`.

Example

```
forceList =  [0, 1, 1.5, 3, 3.2]

   #Sweep measure current on SMU1.
smeasi(SMU1)
#Return force value of sweep.
rtfary()
   #Sweep source voltage based on the forceList with 5 steps and with 0.001s delay
   swpData = asweepv(SMU1, 5, 0.001, forceList).
devint()

   #Post measured current data.
ACSPostArrayDouble("Imeas", swpData["smeasi_SMU1"], 5)
#Post forced voltage value.
ACSPostArrayDouble("Vsource", swpData["rtfary"], 5)
```

Also see

savgi/savgv (on page 2-43)
sintgi/sintgv (on page 2-56)
rtfary (on page 2-42)
smeasi/smeasv (on page 2-57)

avgi/avgv

This command performs a series of measurements and averages the results.

Usage

```
avgi(unitname, iStepNo, dStepTime)
avgv(unitname, iStepNo, dStepTime)
```

unitname	The instrument identification code of the instrument; for example, `SMU1`
iStepNo	The number of steps averaged in the measurement; `1` to `160,000` (for 4200A it is `32767`)
dStepTime	The interval in seconds between each measurement; minimum practical time is approximately 0.0001 s (NPLC must be set at 0.001, for Model 4200A set at 2.5 µs)

Example

`I1= avgi(SMU1, 100, 0.001)`
Averages the results of 100 measurements from SMU1. Measurements are made at 1 ms intervals.

Also see

None

bsweepi/bsweepv

This command performs a current or voltage force sweep.

Usage

`bsweepi/bsweepv (`*`instName`*`, `*`startVal`*`, `*`endVal`*`, `*`stepNo`*`, `*`stepDelay`*`, `*`BIresult/BVresult`*`)`

instName	Instrument name used to force sweep
startVal	Start value of the force sweep
endVal	End value of the force sweep
stepNo	Step number of the sweep
stepDelay	Delay before every sweep step
BIresult/BVresult	Empty list to store the force break value

return	`{"savgi_SMUX":[data_1, data_2,…, data_StepNo]}`
	`{"savgv_SMUX":[data_1, data_2,…, data_StepNo]}`
	`{"smeasi_SMUX":[data_1, data_2,…, data_StepNo]}`
	`{"smeasv_SMUX":[data_1, data_2,…, data_StepNo]}`
	`{"singti_SMUX":[data_1, data_2,…, data_StepNo]}`
	`{"singtv_SMUX":[data_1, data_2,…, data_StepNo]}`
	`{"rtfary":[value_1, value_2,…, value_StepNo]}`

Details

Use the `bsweepi` or `bsweepv` command to sweep the current or voltage using a defined start value, end value, step number, and step delay. The sweep breaks when the tested data exceeds the level set by the trigger functions `trigil`, `trigvl`, `trigig`, and `trigvg`. This returns measured data based on the measurement setup commands `savgi/savgv`, `sintgi/sintgv`, `smeasi`, or `smeasi/smeasv`, and the force value. If `rtfary` is called, the return value includes programmed force values of the sweep.

Note that the measurement setup function `savgi/savgv` or `sintgi/sintgv` or `smeasi/smeasv` must be called before `bsweepi/bsweepv`. The trigger functions `trigil/trigvl/trigig/trigvg` must be called before `bsweepi/bsweepv`. The force values return function `rtfary` must be called before `bsweepi/bsweepv`.

Example

```
#list to store force break value
BVresult = []
#set trigger of current low level
trigil(SMU1, 1e-11)
#measure current on SMU1
smeasi(SMU1)
#return force value of sweep
rtfary()
#sweep source voltage from 0~5V by 5 steps, with 0.001s delay,
#breaks according to the trigger level setting
swpData = bsweepv(SMU1, 0, 5, 5, 0.01, BVresult)
devint()
#post force break value
ACSPostArrayDouble("BV", BVresult[0])
#post measured current data
ACSPostArrayDouble("Imeas", swpData["smeasi_SMU1"], 5)
#post forced voltage value
ACSPostArrayDouble("Vsource", swpData["rtfary"], 5)
```

Also see

rtfary (on page 2-42)
savgi/savgv (on page 2-43)
sintgi/sintgv (on page 2-56)
smeasi/smeasv (on page 2-57)
trigil/trigvl/trigig/trigvg (on page 2-60)

clrattrset

This command clears the present instrument setting in memory.

Usage

`clrattrset(*instName)`

**instName*	Optional; list of instruments in the system to clear the memory

Details

Example

```
clrattrset () #clear the setting in memory for all the instruments in the system
clrattrset(SMU1, SMU2) #clear the setting in memory for SMU1 and SMU2
```

Also see

None

clrcon

This command clears all the connections of all the matrices or specified matrices.

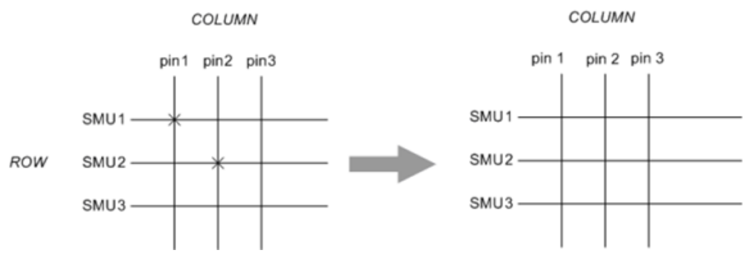
Usage

`clrcon(unitname)`

unitname	The instrument name in the directory `\\ACS\KATS\CONFIG\ACS_hdcon_Online.kcf`, such as `MTRX1`

Details

Figure 6: clrcon (clear all) connections example



Example

```
clrcon()
clrcon(MTRX1)
```

Clear all matrix connections in the hardware configuration.
Clear only matrix1 connections.

Also see

None

clrscn

This command is only for the Model 4200A-SCS instrument.

This command clears the measurement scan tables associated with a sweep.

Usage

`clrscn(*instName)`

`*instName`	List of instrument names of the sweep (optional)

Details

The measurement-scan tables associated with a sweep are internal tables defined by `savgi/savgv`, `sintgi/sintgv`, `smeasi`, or `smeasi/smeasv`, or `rtfary`. The `clrscn` command is called after the sweep and it clears these tables.

Example

```
#Measure forward
smeasi(SMU1)
#Output 0 to 0.5 V in 10 steps, each 5 ms duration.
forcur=sweepv(SMU1, 0.0, 0.5, 10, 5.0e-3)
#Clear the measurement scan tables associated with a sweep for all instruments in
the system.
clrscn()
#Clear the measurement scan tables associated with a sweep for SMU1, SMU2.
clrscn(SMU1,SMU2)
```

Also see

None

clrtrg

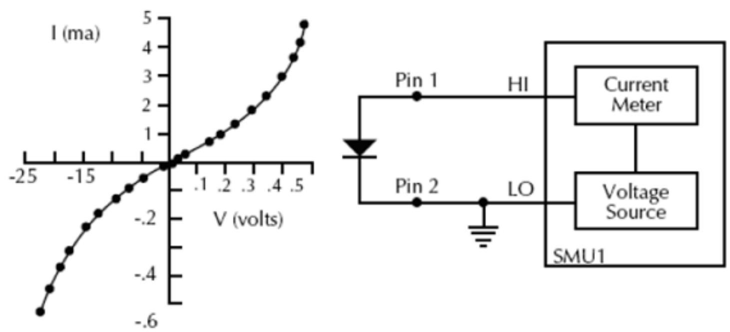
This command clears previously defined sweep trigger settings.

Usage

`clrtrg(*instName)`

`*instName`	Optional; list of instruments that have trigger settings cleared

Figure 7: clrtrg library command



Details

This command permits the use of `trigXl` or `trigXg` more than once at various levels within a single test sequence.

Example

```
#increase ramp to I = 5 mA
trigil(SMU1, 5.0e-3)
#measure forward
smeasi(SMU1)
#output 0 to 0.5V in 10 steps, each 5 ms duration
forcur=sweepv(SMU1, 0.0, 0.5, 10, 5.0e-3)
clrtrg() #clear trigger settings for all instruments in the system
#clear trigger settings only for SMU1
clrtrg(SMU1)
```

Also see

trigil/trigvl/trigig/trigvg (on page 2-60)

conpin

This command clears existing connections and adds new terminal-pin connections.

Usage

`conpin(*instMTRX, ter, pin, *more_pin)`

instMTRX	Optional; the matrix name in the hardware configuration
ter	The list of terminals to connect
pin	The list of pins to connect
more_pin	Additional pins to connect

Details

Terminal and pin lists must have the same number of items and are arranged (by number) in the same sequence. If the numbers in the terminal and pin lists are not the same, the connections are performed on the shortest list and other entries are ignored.

Normally, the `conpin()` command supports the `ROW_COLUMN` mode of the matrix. When the matrix is set to `INSTRUMENT_CARD` mode, a row is assigned automatically to connect the terminals and the pins.

For more information about how to set the `INSTRUMENT_CARD` mode and `ROW_COLUMN` mode, refer to "Hardware configurations" in the *Automated Characterization Suite (ACS) Fundamental Reference Manual* (document number ACS-914-01).

Example

```
conpin(MTRX1,SMU1,1)
conpin(SMU1,1)
conpin(SMU1H,1)
conpin(SMU1L,1)
conpin(SMU1,1,2,3)
conpin([SMU1,SMU2], [1,2])
conpin(CVU1H,1)
```

This example demonstrates different methods of using `conpin` to connect terminals to pins.

Also see

addcon (on page 1-2)
clrcon
delcon (on page 1-10)

conpth

This command clears all matrix connections and makes a new terminal-pin connection through a row.

Usage

```
conpth(*instMTRX, ter, pin, row)
```

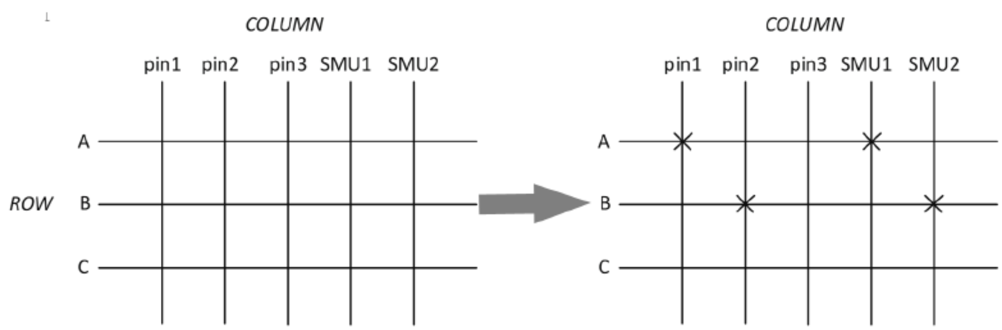
instMTRX	The matrix name in the hardware configuration (the name is optional)
ter	The list of terminals to connect
pin	The list of pins to connect
row	The row used to connect terminals and pins

Details

The terminal and pin are connected through an assigned row in a matrix. In the following figure, terminal SMU1 and pin1 are connected through row A. Terminal SMU2 and pin2 are connected through row B.

You must use one instance of the conpth command for each connection made in a matrix. You cannot use the conpth command to make a connection in multiple matrices (see the following figure).

Figure 8: addpth and conpth command example



You must use one instance of the *conpth* command for each connection made in a matrix. You cannot use the *conpth* command to make a connection in multiple matrices (see the following figure).

This function can only be applied when the matrix is set to `INSTRUMENT_CARD` mode.

Example 1

```
conpth(MTRX1,SMU1,1,'A')
conpth(SMU1,1,'A')
conpth(SMU1H,1,'A')
conpth(SMU1L,1,'A')
```

This is an example of using the `conpth` command with a Model 707B or 708B Switch Matrix.

Example 2

```
conpth(MTRX1,SMU1,1,'1')
conpth(SMU1,1,'1')
conpth(SMU1H,1,'1')
conpth(SMU1L,1,’1’)
```

This is an example of using the `conpth` command with a Series 3700A System Switch.

Also see

addpth (on page 1-3)
clrcon (on page 2-13)
delpth (on page 1-9)

delay

This command provides a user-programmable delay within a test sequence.

Usage

`delay(iDelayTime)`

iDelayTime	The time to delay in milliseconds

Example

```
#delay 0.001s
delay(0.001)
```

Also see

None

delcon

This command deletes a terminal-pin connection.

Usage

`delcon(*instMTRX, ter, pin, *more_pin)`

instMTRX	Optional; the matrix name in the hardware configuration
ter	The list of terminals to connect
pin	The list of pins to connect
more_pin	Indicates additional pins to connect

Details

The terminal and pin must be connected before the command will delete the terminal pin connection, otherwise the connection is invalid.

Example

```
delcon(MTRX1,SMU1,1)
delcon(SMU1,1)
delcon(SMU1H,1)
delcon(SMU1L,1)
delcon(SMU1,1,2,3)
delcon([SMU1,SMU2], [1,2])
```

This example shows valid methods for defining the matrix, terminals, and pins.

Also see

addcon (on page 1-2)
clrcon (on page 2-13)
conpin (on page 1-6)

delpth

This command deletes a terminal-pin connection based on a specific row in a matrix.

Usage

`delpth(*instMTRX, ter, pin, row)`

instMTRX	Optional; the matrix name in the hardware configuration
ter	The list of terminals to disconnect
pin	The list of pins to be connected
row	The row used to connect terminals and pins

Details

The terminal, pin, and row must be in the same group when connected. Otherwise, the command is not valid.

Example 1

```
delpth(MTRX1,SMU1,1,'A')
delpth(MTRX1,1,'A')
delpth(SMU1H,1,'A')
delpth(SMU1L,1,'A')
```

This is an example of using the `delpth` command with a Model 707B or 708B Switch Matrix.

Example 2

```
delpth(MTRX1,SMU1,1,'1')
delpth(SMU1,1,'1')
delpth(SMU1H,1,'1')
delpth(SMU1L,1,'1')
```

This is an example of using the `delpth` command with a Series 3700A System Switch.

Also see

addpth (on page 1-3)
clrcon (on page 2-13)
conpth

devclr

This command sets all sources to a zero state.

Usage

`devclr(*instName)`

`*instName`	Optional; list of instruments and sources to set to a zero state

Details

This function sends output off commands or calls the Model 4200A `devclr` function. It does not work on a matrix.

If the system is configured using KCon, the Model 4200A `devclr` function executes. This function clears all sources sequentially.

Before clearing all Keithley Instruments supported instruments, GPIB-based instruments are cleared by sending all strings defined with `kibdefclr`. `Devclr` is implicitly called by `clrcon`, `devint`, `execut`, and `tstdsl`.

Example

```
#set all sources for all instruments in the system to zero state
devclr()
#set SMU1 to a zero state
devclr(SMU1)
#set all SMU1 and CVU1 sources to a zero state
devclr(SMU1, CVU1)
```

Also see

None

devint

This command resets the instruments and clears the system by opening all relays and disconnecting the pathways..

Usage

`devint(*instName)`

`*instName`	Optional; list of the instrument names to be reset and cleared

Details

This function will reset all instruments in the TSP-link group to their default states.

The default states for different instruments can be referred to in their manuals.

The following table indicates the default settings for the Series 2600B and 2400 instruments after using the devint LPT command.

<table>
<tr><th colspan="3">Default settings</th></tr>
<tr><td colspan="3">Series 2400B SourceMeter® instruments setting after <code>devint</code></td></tr>
<tr><td colspan="2">Output</td><td>turn source off</td></tr>
<tr><td colspan="2">Reset</td><td>Resets all bits of the following registers to 0:
■ Standard event register
■ Operation event register
■ Measurement event register
■ Questionable event register</td></tr>
<tr><td colspan="2">Long-form and short-form versions</td><td>Command word is sent in short-form version</td></tr>
<tr><td rowspan="3">ACS hardware configuration setting window</td><td>If interlock enabled</td><td>Enable interlock</td></tr>
<tr><td>If rear panel enabled</td><td>Enable rear panel</td></tr>
<tr><td>If beeper disabled</td><td>Disable beeper</td></tr>
</table>

<table>
<tr><th colspan="2">Default settings</th></tr>
<tr><th colspan="2">Series 2600B SourceMeter® instrument settings after <code>devint</code> is applied</th></tr>
<tr><td>Current range</td><td>0.1 A (all SMUs)</td></tr>
<tr><td>Output</td><td>Clear</td></tr>
<tr><td>Error queue</td><td>Clear</td></tr>
<tr><td>Status model</td><td>Reset all bits</td></tr>
<tr><td>Error display</td><td>Disable</td></tr>
</table>

Default settings	
PLC	0.001
	1 (for intgx)
Measure count	1
DTNS	Clear sweep table, clear trigger, clear garbage, then set all 26xx in DTNS group 0
Sense mode	Depends on ACS software preference setting
Reset	The default factory setting for each instrument

This command also performs the following actions before resetting the instruments:

- Clears all sources by calling `devclr`
- Clears the matrix cross-points by calling `clrcon`
- Clears the sweep tables by calling `clrscn`
- Clears the trigger tables by calling `clrtrg`.
- Resets GPIB instruments by sending the string defined with `kibdefint`.
- Stops the pulse generator card, and check the standard pulse mode and its default settings (for example, `*RST`).

`devint` is implicitly called by `execut` and `tstdsl`.

Example

```
#Reset and clear the instruments in the system.
devint()
#Reset and clear SMU1.
devint(SMU1)
#Reset and clear SMU1 and MTRX1.
devint(SMU1, MTRX1)
```

This example demonstrates how to reset and clear all instruments in the system, a single SMU1, and a SMU1 and a MTRX1.

Also see

None

disable

This command stops the timer, sets the time value to zero, and stops the timer reading.

Usage

`disable(`*`timerName`*`)`

timerName	Timer name defined by the `enable()` command

Example

`disable('TIMER1')`
Stops TIMER1 and sets the time to zero.

Also see

enable (on page 2-24)
imeast (on page 2-35)

enable

This command enables a timer, which can be used with the command `imeast()` to measure time.

Usage

`enable('`*`timerName`*`')`

timerName	The name of the timer to be enabled

Example

```
enable('TIMER1')
```

Also see

disable (on page 2-24)
imeast (on page 2-35)

execut

This command invokes the system to wait for the preceding test sequence to be executed.

Usage

```
execut(instaName)
```

`*instname`	List of instrument names to be executed (optional).

Details

For the Model 4200A-SCS or Series 2600B SourceMeter instruments, this function waits for all previous LPT commands to finish testing and then issues a `devint`.

Example

```
execut()    #execute all the instruments in the system.
execut(SMU1)    #execute SMU1)
```

Also see

None

forcei/forcev

This command programs a sourcing instrument to generate a voltage or current at a specific level.

Usage

```
forcei(unitname, dValue)
forcev(unitname, dValue)
```

`unitname`	The instrument name in the directory `\\ACS\KATS\CONFIG\ACS_hdcon_Online.kcf`
`dValue`	The level of the voltage or current forced in volts or amperes.

Example

```
#Force current 1e-6A on SMU1.
forcei(SMU1, 1e-6)
#Force voltage 0.02V on SMU2.
forcev(SMU2, 0.02)
```

Also see

None

getcommon

This command gets common attributes from the global dictionary.

Usage

```
getcommon()
```

Details

Return key list:

- **UNITLIST**: List of instrument IDs in the system
- **PLC**: Power line cycle
- **Pin**: Information about the pin

Example

```
print getcommon()
{'PLC': '60HZ', 'UNITLIST': ['GNDU', 'PRBR1', 'SMU1', 'TIMER1']}
```

Also see

None

getinstattr

This command gets the instrument attribute from the instrument name string.

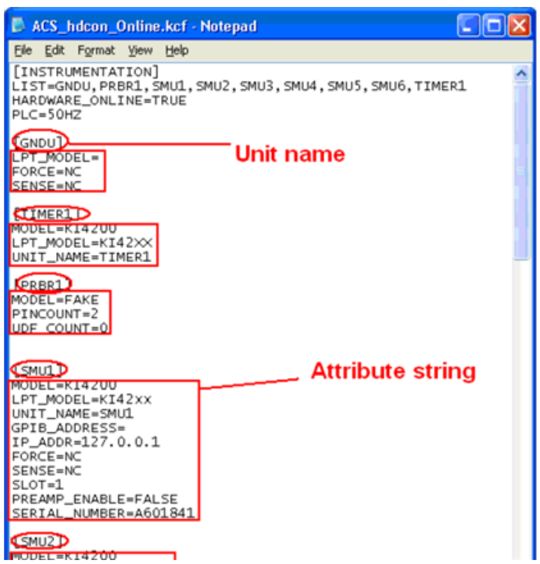
Usage

`getinstattr(`*`unitname`*`, `*`attr_str`*`)`

unitname	The instrument name in the directory `\\ACS\KATS\CONFIG\ACS_hdcon_Online.kcf`
attr_str	The attribute string list is in the directory `\\ACS\KATS\CONFIG\ACS_hdcon_Online.kcf`

Details

Figure 9: Unit name and Attribute string .kcf file



Return value: `INVAL_INST_ID`

`-1` ---- This function does not apply to this unit.

Example

`getinstattr(SMU1, "GPIB_ADDRESS")` `print getinstattr(SMU1, "MODEL")`
An example return from this example is: `KI4200A`

Also see

None

getinstid

This command applies to only the Model 4200A-SCS instrument.

This command gets the instrument identifier (ID) from the instrument name string.

Usage

```
getinstid(unitname)
```

`unitname`	The instrument name in the directory `\\ACS\KATS\CONFIG\ACS_hdcon_Online.kcf`

Details

The return value is: `instrument identifier (ID)`

Example

```
print getinstid(SMU1)
4100
```

Also see

None

getstatus

This command applies to only the Model 4200A-SCS instrument.

This command returns the operating state of the specified instrument.

Usage

```
getstatus(unitname, iCode)
```

`unitname_str`	The instrument name (string type) in the folder `\\ACS\KATS\CONFIG\ACS_hdcon_Online.kcf`
`iCode`	The parameter of the query

Details

The data returned from the instrument. `getstatus` returns one item.

The `UT_INVLDPRM` invalid parameter error is returned from `getstatus`. The status item parameter is illegal for this device. The requested status code is invalid for selected device.

A list of supported `getstatus` query parameters for a SMU are provided in the next table.

Getstatus parameters		
iCode	**Comment**	
KI_IPVALUE	The presently programmed output value	Current value (I output value)
KI_VPVALUE		Voltage value (V output value)
KI_IPRANGE	The presently programmed range	Current range (full-scale range value, or 0.0 for autorange)
KI_VPRANGE		Voltage range (full-scale range value, or 0.0 for autorange)
KI_IARANGE	The presently active range	Current range (full-scale range value)
KI_VARANGE		Voltage range (full-scale range value)
KI_IMRANGE	The range used when the last measurement was performed	For autorange, the range at which the previous I measurement was performed.
KI_VMRANGE		For autorange, the range at which the previous V measurement was performed.
KI_COMPLNC	Active compliance status	Bitmapped values: 2 = LIMIT (at the compliance limit set by limitX). 4 = RANGE (at the top of the range set by rangeX)
KI_RANGE_COMPLIANCE	Active compliance status for fixed range	In range compliance if 1
KI_COMPLNC_EVER	Compliance history	Reset by reading compliance history and by *devint*

Getstatus parameters	
iCode	**Comment**
KI_VPRANGE	The presently programmed voltage range
KI_VARANGE	The presently active voltage range
KI_VMRANGE	The range used when the last measurement was performed. For autorange, the range at which the previous V measurement was performed

Example

```
gstatus=getstatus(SMU1, KI_COMPLNC)
```

Also see

None

gpibenter

This command is used to read a device-dependent string from an instrument connected to a GPIB, LAN, or USB interface.

Usage

`gpibenter(unitname, max_size)`

unitname	The instrument name in the directory `\\ACS\KATS\CONFIG\ACS_hdcon_Online.kcf`
max_size	A value specifying the maximum number of characters you want to receive; maximum length can be a number from `0` to `32767` (hex `FFFF`)

Details

The return value is (tupple type) (receive str, length, status).

If the string is read back successfully:

Output data display	Data/reason
receive str	The received string.
length	The length of the received string.
status	0

If the reading times out:

Output data display	Data/reason
receive str	String of TIMEOUT.
length	The length of TIMEOUT string.
status	8

Example

```
rvalue = gpibenter(SMU2, 100)
```

Also see

None

gpibsend

This command sends a device-dependent command to an instrument connected to GPIB, LAN, or USB.

Usage

```
gpibsend(unitname, cmd_str)
```

unitname	The instrument name in the directory `\\ACS\KATS\CONFIG\ACS_hdcon_Online.kcf`
cmd_string	A command string sent to the device. Note that terminating characters are automatically added to the end of this string when it is sent. The default terminator is a line feed character.

Details

Return value: A variable which indicates the success or failure of the data transfer.

Example

```
gpibsend(SMU1, 'devint()')
gpibsend(GPI1, "L2X")
```

Also see

None

gpibspl

This command conducts a serial poll that reads the status of an instrument connected to the GPIB interface.

Usage

```
gpibspl(unitname)
```

unitname	The instrument name in the directory `\\ACS\KATS\CONFIG\ACS_hdcon_Online.kcf`

Details

The following indicates the name of the output data string displayed in the data panel .

Return value: (tuple type) − (receive number, status) or error code

If the serial poll is read back successfully:

Output data display	Data/reason
Receive number	Serial poll number received
Status	0

If the reading times out:

Output data display	Data/reason
Receive number	Predefined string indicating TIMEOUT
Status	8

Example

```
poll1 = gpibspl(SMU1)
```

Also see

None

insbind

This command binds the high-voltage (HV) SMU and high-voltage ground (HVGND) to the CVU HI, LO, and ground (CVU_HI/LO/GRD) to the bias tee through pins 09, 10, and 11 (PIN09/10/11).

Usage

`insbind(ter1, ter2)`

ter1	CVU terminal to be connected
ter2	SMU terminal to be connected

Details

The pin number is defined in the `ACS_setting.ini` file. Only the terminals related to HV SMU, HVGND, and HV CVU are supported as inputs.

Example

```
insbind(CVU1H, SMU1)
insbind(CVU1G, HVGND)
```

Also see

None

imeast

This command forces a read of the timer and returns the result.

Usage

```
imeast(unitname)
```

`unitname`	The instrument name in the directory `\\ACS\KATS\CONFIG\ACS_hdcon_Online.kcf` For example, TIMER1 or TIMER2.

Details

This command applies to all timers. You must call the enabled timer (for example, TIMER1) first. This will indicate the elapsed time.

Example

```
t1= imeast(TIMER1)
```

Also see

enable (on page 2-24)
disable (on page 2-24)

intgi/intgv

This command performs voltage or current measurements averaged over a user-defined period.

Usage

```
intgi(unitname)
intgv(unitname)
```

unitname	The instrument name in the directory `\\ACS\KATS\CONFIG\ACS_hdcon_Online.kcf`

Details

This averaging is done in the hardware through the integration of the analog measurement signal over a period of specified time (usually this is completed during one AC-line cycle). The integration is automatically corrected for 50 Hz or 60 Hz power mains.

Example

```
i1= intgi(SMU1)
```

Also see

None

limiti/limitv/limitp

This command allows the programmer to specify a current, voltage, or power limit other than the instrument's default limit.

Usage

```
limiti(unitname,dValue)
limitv(unitname,dValue)
limitp(unitname,dValue)
```

`unitname`	The instrument name in the directory `\\ACS\KATS\CONFIG\ACS_hdcon_Online.kcf`
`dValue`	The maximum level of current, voltage, or power. The value is bidirectional. For example, a `limitv` ("SMU1", 10.0) limits the voltage of the current source of SMU1 to ± 10.0V. A `limiti` ("SMU1", 1.5E-3) limits the current of the voltage source of SMU1 to ± 1.5mA. And `limitp` ("SMU1", 20) limits the power of the source of SMU1 to ± 20W

Details

Use `limiti` to limit the current of a voltage source. Use `limitv` to limit the voltage of a current source. Use `limitp` to limit the power of the SMU source.

Example

```
#Set the current limit of SMU1 to ± 0.01A.
limiti(SMU1, 0.01)
#Set the voltage limit of SMu2 to ± 200V.
limitv(SMU2, 200)
```

Also see

None

lorangei/lorangev

This command defines the lowest autorange limit.

Usage

```
lorangei(unitname,dValue)
lorangev(unitname,dValue)
```

`unitname`	The instrument name in the directory `\\ACS\KATS\CONFIG\ACS_hdcon_Online.kcf`
`dValue`	The maximum level of current, voltage, or power. The value is bidirectional. For example, a `limitv` ("SMU1", 10.0) limits the voltage of the current source of SMU1 to ± 10.0V. A `limiti` ("SMU1", 1.5E-3) limits the current of the voltage source of SMU1 to ± 1.5mA. And `limitp` ("SMU1", 20) limits the power of the source of SMU1 to ± 20W

Details

Use `lorangei` with autoranging to limit the number of range changes, which saves test time.

For the Model 4200A-SCS, if the instrument was on a range lower than the one specified by `lorange`, the range is changed. Model 4200A-SCS automatically provides any range change settling delay that may be necessary due to this potential range change. Once defined, `lorange` is in effect until a `devclr`, `devint`, `execut`, or another `lorangeX` executes.

For the Model 23x instruments, this function works as autorange. The second `dValue` will be ignored.

It cannot be used for the Series 2400 SourceMeter instruments.

Example

```
lorangei(SMU1, 1E-6)  #Set lowest autorange limit of current on SMU1 to 1E-6A.
lorangev(SMU2, 0.2)   #Set lowest autorange limit of voltage on SMU2 to 0.2V.
```

Also see

None

measi/measv

This command allows the measurement of current or voltage.

Usage

```
measi(unitname)
measv(unitname)
```

unitname	The instrument name in the directory `\\ACS\KATS\CONFIG\ACS_hdcon_Online.kcf`

Details

For this measurement, the signal is sampled for a specific period. This sampling time for the measurement is called the integration time.

For the `measX` function, the integration time is fixed at 0.01 PLC. For 60 Hz line power, 0.01 PLC = 166.67 µs (0.01 PLC/60 Hz).

For 50 Hz line power, 0.01 PLC = 200 µs (0.01 PLC/50 Hz).

Example

`i1= measi(SMU1)`
This is a variable name presenting measure current

Also see

None

measz

This command performs an impedance measurement on a CVU or other capacitance measuring instrument.

Usage

```
measz(unitname, iModel, iSpeed)
```

`unitname`	The instrument name in the directory `\\ACS\KATS\CONFIG\ACS_hdcon_Online.kcf`
`iModel`	The measurement model; see **Details**
`iSpeed`	The measurement speed: ■ `KI_CVU_SPEED_FAST` ■ `KI_CVU_SPEED_NORMAL` ■ `KI_CVU_SPEED_QUIET`

Details

The first result data of the selected measure model is `result1`.

The second result data of the selected measure model is `result2`.

The measurement speed setting `KI_CVU_SPEED_FAST` performs the fastest measurements, but has the highest noise.

Measurement settings			
unitname (Model name)	**iModel (Measurement Model)**		**Parameter values**
CVU1	ZTH	Impedance (Z) and phase (in radians)	KI_CVU_TYPE_ZTH or 0
	RjX	Resistance and reactance	KI_CVU_TYPE_RJX or 1
	CpGp	Parallel capacitance and conductance	KI_CVU_TYPE_CPGP or 2
	CsRs	Series capacitance and resistance	KI_CVU_TYPE_CSRS or 3
	CpD	Parallel capacitance and dissipation factor	KI_CVU_TYPE_CPD or 4
	CsD	Series capacitance and dissipation factor	KI_CVU_TYPE_CSD or 5
	RAW	Raw data from measure	KI_CVU_TYPE_RAW or 6
CMTR1	Z-thr	Impedance (Z) and phase (in radians)	KI_AGCV_TYPE_CPD or 0
	R-X	Resistance and reactance	KI_AGCV_TYPE_RX or 1
	Cp-G	Parallel capacitance and equivalent parallel conductance	KI_AGCV_TYPE_CPG
	Cs-Rs	Series capacitance and resistance	KI_AGCV_TYPE_CSRS
	Cp-D	Parallel capacitance and dissipation factor	KI_AGCV_TYPE_CPD
	Cs-D	Series capacitance and dissipation factor	KI_AGCV_TYPE_CSD
	Cp-Q	Parallel capacitance and quality factor (inverse of D)	KI_AGCV_TYPE_CPQ
	Cs-Q	Series capacitance and quality factor (inverse of D)	KI_AGCV_TYPE_CSQ

Measurement settings			
unitname (Model name)	**iModel (Measurement Model)**		**Parameter values**
	Lp-D	Inductance value measured with parallel-equivalent circuit model and dissipation factor	KI_AGCV_TYPE_LPD
	Lp-Q	Inductance value measured with parallel-equivalent circuit model and quality factor (inverse of D)	KI_AGCV_TYPE_LPQ
	Lp-G	Parallel inductance value and equivalent parallel conductance	KI_AGCV_TYPE_LPG
	Lp-Rp	Parallel inductance value and equivalent parallel resistance	KI_AGCV_TYPE_LPRP
	Ls-D	Series inductance value and dissipation factor	KI_AGCV_TYPE_LSD
	Ls-Q	Series inductance value and quality factor (inverse of D)	KI_AGCV_TYPE_LSQ
	Ls-Rs	Series inductance value and equivalent resistance	KI_AGCV_TYPE_LSRS
	Z-thd	Impedance (Z) and phase (in degrees)	KI_AGCV_TYPE_ZTD
	Cp-Rp	Parallel capacitance and equivalent resistance	KI_AGCV_TYPE_CPRP
	G-B	Equivalent parallel conductance and susceptance	KI_AGCV_TYPE_GB
	Y-thd	Admittance and phase (in degrees)	KI_AGCV_TYPE_YTD
	Y-thr	Admittance and phase (in radians)	KI_AGCV_TYPE_YTR
	Vdc-Idc	Direct-current voltage and direct-current electricity	KI_AGCV_TYPE_VDID

Example

```
measData = measz(CVU1, KI_CVU_TYPE_CSRS, KI_CVU_SPEED_NORMAL)
```

Also see

None

rangei/rangev

This command selects the measurement range and prevents the selected instrument from autoranging. By selecting a range, the time required for autoranging is eliminated.

Usage

```
rangei(unitname_str,dValue)
rangev(unitname_str,dValue)
```

unitname	The instrument name in the directory `\\ACS\KATS\CONFIG\ACS_hdcon_Online.kcf`
dValue	The value of the highest measurement made. The most appropriate range for this measurement will be selected. If range is set to 0, the instrument will autorange. However, autorange will not occur on the Series 2600B SourceMeter instruments

Details

By selecting a range, the time required for autoranging is eliminated.

Example

```
rangei(SMU1, 2.0E-3)  #Select current range of 2mA
rangev(SMU2, 20)  #Select voltage range of 20V
```

Also see

None

rdelay

This command provides a user-programmable delay in a test sequence.

Usage

```
rdelay(dDelayTime)
```

dDelayTime	The delay duration in seconds

Details

This command delays the test sequence by a specified number of seconds.

Example

```
--delay 0.001 s
rdelay(0.001)
```

Add a 1 ms delay.

Also see

None

rtfary

This command returns the programmed force values of the sweep.

Usage

```
rtfary()
```

Details

If `rtfary` is called before the sweep functions `sweepi`, `sweepv`, `asweepi`, `asweepv`, `bsweepi`, or `bsweepv`, the return value includes the programmed force values of the sweep in the following format:

```
{"rtfary":[value_1, value_2,…, value_StepNo], …}
```

The number of values returned by the `rtfary` command is determined by the number of force points generated by the sweep.

Example

```
#sweep measure current on SMU1
smeasi(SMU1)
#return force value of sweep
rtfary()
#sweep source voltage from 0 V to 5 V by 5 steps with a 0.001 s delay
swpData = sweepv(SMU1, 0, 5, 5, 0.001) devint()
#post measured current data
ACSPostArrayDouble("Imeas", swpData["smeasi_SMU1"], 5)
#post forced voltage value
ACSPostArrayDouble("Vsource", swpData["rtfary"], 5)
```

Also see

asweepi/asweepv (on page 2-58)
bsweepi/bsweepv (on page 2-11)
sweepi/sweepv (on page 2-58)

savgi/savgv

This command determines the measurement method to average the measurement for the current or voltage sweep.

Usage

```
savgi(instName, avgNum, delayTime)
savgv(instName, avgNum, delayTime)
```

instName	Instrument name for the measurement
avgNum	Average number
delayTime	Delay time

Details

Use the `savgi` or `savgv` command to set the measurement method of the current or voltage sweep. Note that the measurement setup function `savgi`/`savgv` must be called before the sweep functions `sweepi`/`sweepv`, `asweepi`/`asweepv`, or `bsweepi`/`bsweepv`.

Example

```
#sweep measure current on SMU1
savgi(SMU1)
#sweep source voltage from 0~5V by 5 steps and with 0.001s delay
swpData = sweepv(SMU1, 0, 5, 5,0.001)

devint()
#post measured current data
ACSPostArrayDouble("Imeas", swpData["savgi_SMU1"], 5)
```

Also see

asweepi/asweepv (on page 2-9)
bsweepi/bsweepv (on page 2-11)
sweepi/sweepv (on page 2-58)

setauto

This command enables autoranging and cancels any previous `rangeX` command for the specified instrument.

Usage

```
setauto(unitname)
```

`unitname`	The instrument name in the directory `\\ACS\KATS\CONFIG\ACS_hdcon_Online.kcf`

Details

When an instrument is returned to the autorange mode, it remains in its present range for measurement purposes. The source range changes immediately.

The SMU has dual mode operation (voltage and current), so `setauto` sets both voltage and current ranges to autorange.

Example

```
setauto(SMU1)
# enable autorange mode
```

Also see

None

setfreq

This command sets the frequency for the AC drive.

Usage

```
setauto(unitname)
```

`unitname`	The instrument name in the directory `\\ACS\KATS\CONFIG\ACS_hdcon_Online.kcf`
`frequency`	Frequency of the ac drive in hertz.

Details

This is a CVUn and CMTRn test command. Frequency of the AC drive is in hertz.

Example

```
status = setfreq(CVU1,10000) # Set the frequency to 1e4Hz.
```

Also see

None

setlevel

This is a CV test command that sets the voltage level of the AC drive.

Usage

```
setlevel(unitname,dSignalLevel)
```

`unitname`	The instrument name in the directory `\\ACS\KATS\CONFIG\ACS_hdcon_Online.kcf`
`dSignalLevel`	Voltage level of the ac drive (10 mV to 100 mV RMS) in volts

Details

This is a CVUn and CMTRn test command. There are different voltage level ranges for the CVU and CMTR which can be referred to in the datasheet of 4200A CVU and CMTR.

Example

```
status = setlevel(CVU1,0.05)
```

Also see

None

setmode

This command sets the instrument-specific operating mode parameters.

Usage

`setmode(`*`unitname`*`, `*`iModifier`*`, `*`dValue`*`)`

unitname	The instrument identification code of the instrument; for example, `SMU1`
iModifier	The `setmode` modifier; select the links below for specific parameters based on the model
dValue	The value of the `setmode` modifier

Details

The `setmode` command allows control over certain instrument-specific operating characteristics. Refer to the documentation for your instruments to determine what each instrument supports.

The following topics, as indicated in *Also see* below, contain the `setmode` modifiers arranged by the instrument model number.

Example

```
status = setmode("CVU1", KI_CVU_OPEN_COMPENSATE, isCmpstOpen=0)
```

This example disables compensation constants for open load and short on CVU1.

Also see

Model 23x setmode modifiers (on page 2-47)
Series 2400 setmode modifiers (on page 2-49)
Series 2600B setmode modifiers (on page 2-49)
Model 4200A setmode modifiers (on page 2-50)
Model 4200A CVU setmode modifiers (on page 2-53)
Model 4284 setmode modifiers (on page 2-54)

Model 23x setmode modifiers

Model 23x LPT parameters			
Unit name	**iModifier**	**dValue**	**Comments**
SMU1	KI_INTGPLC	<value> (in units of line cycles)	Specifies the integration time the SMU uses for the intgx command. The default devint value is 1.0 PLC. The valid range is 0.001 PLC to 25.0 PLC.
	KI_SENSE	KI_SENSE_LOCA (or 0)	Sets local sense mode (2-wire).
		KI_SENSE_REMO (or 1)	Sets remote sense mode (4-wire).
	KI_TRIG_IN	KI_TRIG_IN_CONT = 0	Input triggers control when source, delay, and measure operations occur. This setting continuously processes all source-delay-measure (SDM) cycles.
		KI_TRIG_IN_SRC = 1	Each trigger processes an SDM cycle.
		KI_TRIG_IN_DLY = 2	Initial trigger sets the source. Each subsequent trigger initiates a delay and measure, then sets the source of the next SDM cycle.
		KI_TRIG_IN_SRCDLY = 3	Two-trigger process for each SDM cycle. First trigger sets the source. Second trigger initiates a delay and then measures.
		KI_TRIG_IN_MSR = 4	Initial trigger sets the source and initiates a delay. Second trigger initiates a measurement, then sets the source and initiates a delay for the next SDM cycle.
		KI_TRIG_IN_SRCMSR = 5	Two triggers process each SDM cycle. First trigger sets the source and initiates a delay. Second trigger initiates a measurement.
		KI_TRIG_IN_DLYMSR = 6	Initial trigger sets the source. Two triggers process each SDM cycle. First trigger initiates a delay. Second trigger initiates a measurement and sets the source of next SDM cycle.
		KI_TRIG_IN_SRCDLYMSR = 7	Three triggers process each SDM cycle. First trigger sets the source. Second trigger initiates a delay. Third trigger initiates a measurement.

Model 23x LPT parameters			Comments
Unit name	iModifier	dValue	
		KI_TRIG_IN_PULSE = 8	Pulse-sweep trigger. Each trigger processes the on time and off time of each pulse in the sweep. Two measurements are made on each pulse.
	KI_TRIG_SOURCE	KI_TRIG_X = 0	Input trigger origin. The input trigger stimulus may be provided by the front-panel manual trigger function, an external device that applies a TTL-level pulse to the TRIGGER connector on the rear panel, or an appropriate IEEE-488 operation. IEEE X origin; X sent over IEEE-488 bus.
		KI_TRIG_GET = 1	Group execute trigger.
		KI_TRIG_TALK = 2	Unit addressed to talk over IEEE-488 bus.
		KI_TRIG_EXTERNAL = 3	Negative-going TTL-level pulse applied to TRIGGER connector.
		KI_TRIG_INTERNAL = 4	Front-panel MANUAL trigger function or HO command over IEEE-488 bus.
	KI_TRIG_OUT	KI_TRIG_OUT_NONE = 0	Output trigger generation: No output triggers.
		KI_TRIG_OUT_SRC = 1	Outputs a trigger pulse after every source phase.
		KI_TRIG_OUT_DLY = 2	Outputs a trigger pulse after every delay phase.
		KI_TRIG_OUT_SRCDLY = 3	Outputs a trigger pulse after every source phase and delay phase.
		KI_TRIG_OUT_MSR = 4	Outputs a trigger pulse after every source phase and measure phase.
		KI_TRIG_OUT_SRCMSR = 5	Outputs a trigger pulse after every source phase and measure phase.
		KI_TRIG_OUT_DLYMSR = 6	Outputs a trigger pulse after every delay phase and measure phase.
		KI_TRIG_OUT_SRCDLYMSR = 7	Outputs a trigger pulse after every source phase, delay phase, and measure phase.
		KI_TRIG_OUT_PULSE = 8	For pulse sweeps; outputs a trigger pulse after the end of each off-time measure.
	KI_SWEEPEND_TRIGOUT	KI_SWEEPEND_TRIGOUT_EN = 1 KI_SWEEPEND_TRIGOUT_DIS = 0	When enabled, an output trigger pulse occurs at the end of the sweep.
	KI_AVGNUMBER	0, 2, 4, 8, 16, 32	Number of readings to use to make an average; 0 means disable average filter.

Series 2400 setmode modifiers

Series 2400 instruments LPT parameters			Comments
Unit name	**Modifier**	**Value**	
SMU1	KI_INTGPLC	<value> (in units of line cycles)	Specifies the integration time the SMU uses for the intgx command. The default devint value is 1.0 PLC. The valid range is 0.01 PLC to ~10 PLC (DC) and 0.004 PLC to ~0.1 PLC (2430 pulse mode).
SMU1 (only 2430 SMU)	KI_TRIG_IN_CONT	<value>	Sets the output pulse count.
SMU1	PULSE_MODE_PULSE	VOLT: Voltage source CURR: Current source	Selects the pulse mode and pulse source function.
	PULSE_MODE_WID	<value>	Selects the pulse mode and sets the pulse width.
	PULSE_MODE_DELAY	<value>	Selects the pulse mode and sets pulse delay.

Series 2600B setmode modifiers

Series 2600B instruments LPT parameters			Comments
Unit name	**Modifier**	**Value**	
SMU1	KI_INTGPLC	<value> (in units of line cycles)	Specifies the integration time the SMU uses for the intgx command. The default devint value is 1.0 PLC. The valid range is 0.001 PLC to 25.0 PLC.
	KI_AVGMODE	KI_MEASX	Controls what kind of readings are taken for avg*X* calls; KI_MEASX is the devint default value.
		KI_INTEGRATE	Uses the time specified by the setmode command.
	KI_OFFMODE	KI_OFF_NORM	Sets source output-off mode to output 0 V when the output is turned off.
		KI_OFF_ZERO	Resets the output to 0 (either voltage or current) when output is off.
		KI_OFF_OPEN	Opens the output relay when the output is turned off.
	KI_SENSE	KI_SENSE_LOCA	Sets local sense mode (2-wire).
		KI_SENSE_REMO	Sets remote sense mode (4-wire).
		KI_SENSE_CALA	Sets calibration sense mode.

Model 4200A setmode modifiers

Support	LPT Parameters			Comments
	Instrument ID	Modifier	Value	
Supported	KI_SYSTEM	KI_TRIGMODE	KI_MEASX KI_INTEGRATE KI_AVERAGE KI_ABSOLUTE KI_NORMAL	Redefines all existing triggers to use a new method of measurement.
		KI_AVGNUMBER	*value*	Sets the number of readings to make when KI_TRIGMODE is set to KI_AVERAGE.
		KI_AVGTIME	*value* (in seconds)	Sets the time between readings when KI_TRIGMODE is set to KI_AVERAGE.
No operations performed*	KI_SYSTEM	KI_MX_DEFMODE	KI_HIGH KI_LOW	Sets the default mode to high-current mode or low-current mode. This setting remains in effect until the end of the present session and is not reset by the devint command.
		KI_HICURRENT	KI_ON	Forces the matrix into high-current mode. The mode reverts to the default at the next devint call unless the configuration file sets this parameter to reset on a clrcon call.
		KI_CC_AUTO	KI_ON KI_OFF	Turns automatic compliance clear processing on or off; the devint command resets this value to KI_ON.
		KI_CC_SRC_DLY	*value*	The minimum time after a source value change before a compliance clear scan may start. This represents the time that it takes the circuit under test to settle after a source value change and prevents false compliance detection due to transients.
		KI_CC_COMP_DLY	*value*>	The time between compliance scans while processing the compclr command. This also represents the time that it takes the circuit under test to settle after a source value change and prevents false compliance detection due to transients. However, the source value changes are only due to removing the instrument from an artificial compliance state.
		KI_CC_MEAS_DLY	*value*	The minimum time after the last source value change before a measurement can be made. This represents the time it takes the circuit under test to settle to the requested level for the subsequent measurements.

Supported	SMU*n*	KI_INTGPLC	*value* (in numbers of line cycles)	Specifies the integration time the SMU uses for the intgx and sintgx commands. The default devint value is 1.0 PLC. The valid range is 0.01 PLC to 10.0 PLC.
		KI_AVGMODE	KI_MEASX KI_INTEGRATE	Controls the type of readings that are made for avg*X* calls. The devint default value is KI_MEASX. When KI_INTEGRATE is specified, the integration time specified by the KI_INTGPLC setmode call is used.
No operations performed*	SMU*n*	KI_IMTR		Sets up the SMU as a current meter. The ranges used are representative of the type of instrument being simulated. **NOTE** This setmode turns the source on.
			KI_S400	Sets the SMU to use ranges equivalent to the Model S400.
			KI_DMM	Sets the SMU to use ranges equivalent to a DMM (lowest range is 100 µa). Provides a lower resolution, fast measurement. Used for high-current applications.
			KI_ELECTROMETER	Sets the SMU to use ranges equivalent to an electrometer. Provides best measurement resolution, but has a slower measurement time. Used for low-current measurements.
		KI_LIM_INDCTR	Any	Controls that measured value that is returned if the SMU is at its programmed limit. The devint default is SOURCE_LIMIT (7.0e22). **NOTE** The SMU always returns INST_OVERRANGE (1.0e22) if it is on a fixed range that is too low for the measured signal.
		KI_LIM_MODE	KI_INDICATOR KI_VALUE	Controls whether the SMU will return an indicator value when in limit or overrange, or if the actual value is measured. The default mode after a devint is to return an indicator value.
		KI_RANGE_DELAY	<value> (in seconds) ranges from -2147493.647 seconds to +2147483.647 seconds	Specifies an additional delay time for the SMU driver to add to the range settle delay time whenever it is changing a preamplifier range. Value may be negative to shorten the overall range change delay. In no event is the overall delay time less than the preamplifier circuit hardware switching time. The devint default value is 0.0.

		`KI_RANGE_SETTLE`	`0.01`
			`0.1`
			`1.0`
			`2.5`
			`5.0`
			`10.0`
				Controls how long the SMU driver delays when changing a preamplifier range. Value is specified in percent settling accuracy (using the listed valid percent values). The actual delay time depends on which range the preamp is switched from and the range it is switched to. The `devint` fault value is `1.00`.

		`KI_VMTR`		Sets up the SMU as a voltmeter. The ranges used are representative of the type of instrument being simulated. **NOTE** This `setmode` turns the source on.
			`KI_S400`	Sets the SMU to use ranges equivalent to the Model S400.
			`KI_DMM`	Sets the SMU to use range equivalent to a DMM. Provides a low impedance, fast measurement. Used for low-voltage applications.
			`KI_ELECTROMETER`	Sets the SMU to use ranges equivalent to an electrometer. Provides a high input impedance, but has a slower measurement time. Used for high-resistance measurements.

* These modifiers do not perform any operations in the Model 4200A-SCS. They are included for compatibility reference for existing
S600 programs that use the `setmode` function. S600 programs can be ported to the Model 4200A-SCS.

Model 4200A CVU setmode modifiers

Model 4200A CVU LPT parameters			Comments
Unit name	**Modifier**	**Value**	
CVU1	KI_CVU_CABLE_CORRECT	0, 1.5 or 3 (meters)	Cable length setting can be set to any floating-point number between 0 m and 3.0 m, but will be coerced to 0, 1.5, or 3 m.
	KI_CVU_OPEN_COMPENSATE KI_CVU_SHORT_COMPENSATE KI_CVU_LOAD_COMPENSATE	0 = OFF 1 = ON	Enables or disables compensation constants for open, short, and load.
	KI_CVU_FILTER_FACTOR	0 to 100	Sets the custom speed filter factor.
	KI_CVU_MEASURE_SPEED	KI_CVU_SPEED_FAST = 0 KI_CVU_SPEED_NORMAL = 1 KI_CVU_SPEED_QUIET = 2 KI_CVU_SPEED_CUSTOM = 3	Sets CVU speed.
	KI_CVU_MEASURE_MODEL	KI_CVU_TYPE_ZTH = 0 KI_CVU_TYPE_RJX = 1 KI_CVU_TYPE_CPGP = 2 KI_CVU_TYPE_CSRS = 3 KI_CVU_TYPE_CPD = 4 KI_CVU_TYPE_CSD = 5 KI_CVU_TYPE_RAW = 6	For more information about the CVU mode see measz (on page 2-39).
	KI_CVU_MODE	0 = User mode 1 = System mode	Sets the CVU mode to user mode or system mode

Model 4284 setmode modifiers

Model 4284 LPT parameters			Comments
Unit name	Modifier	Value	
CMTR1	KI_CVU_CABLE_CORRECT	0, 1.5, or 3	Cable length setting can be set to any floating-point number between 0 m and 3.0 m, but will be coerced to 0, 1.5, or 3 m.
	KI_CVU_OPEN_COMPENSATE KI_CVU_SHORT_COMPENSATE KI_CVU_LOAD_COMPENSATE	0 = OFF 1 = ON	Enables or disables compensation constants for open, short, and load.
	KI_CVU_FILTER_FACTOR	0 to 100	Sets the custom speed filter factor.
	KI_CVU_MEASURE_SPEED	KI_CVU_SPEED_FAST = 0 KI_CVU_SPEED_NORMAL = 1 KI_CVU_SPEED_QUIET = 2 KI_CVU_SPEED_CUSTOM = 3	Sets CVU speed.
	KI_CVU_MEASURE_MODEL	KI_CVU_TYPE_ZTH = 0 KI_CVU_TYPE_RJX = 1 KI_CVU_TYPE_CPGP = 2 KI_CVU_TYPE_CSRS = 3 KI_CVU_TYPE_CPD = 4 KI_CVU_TYPE_CSD = 5 KI_CVU_TYPE_RAW = 6	For more information about the CVU mode see measz (on page 2-39).
	KI_CVU_MODE	0 or 1	0: Sets CVU to user mode. 1: Sets CVU to system mode.
	KI_AGCV_CORRECT_METHOD		Selects the correction mode (single or multi). Scanner I/F should be installed for multi-mode.
		KI_AGCV_CORRECT_METHOD_ MULT = 0	Sets the correction mode to MULTI.
		KI_AGCV_CORRECT_METHOD_ SING = 1	Sets the correction mode to SINGLE.
	KI_AGCV_TRIG_SOURCE		Selects the trigger mode.
		KI_AGCV_TRIG_INTERNAL = 0	Sets trigger source to internal.
		KI_AGCV_TRIG_HOLD = 1	Sets trigger source to manual.
		KI_AGCV_TRIG_EXTERNAL = 2	Sets trigger source to external connector on the rear panel.
		KI_AGCV_TRIG_BUS = 3	Sets trigger source to GPIB/LAN/USB.
	KI_AGCV_INIT_CONTINUE	0 = OFF (default value; disables automatic trigger state change) 1 = ON (enables automatic trigger state change)	Enables the automatic trigger to change state from the idle state to the wait for trigger state.
	KI_AGCV_DISPLAY_PAGE		Selects the page to be displayed.
		KI_AGCV_DISPLAY_MEAS = 0	Sets displayed page to <MEAS DISPLAY>.
		KI_AGCV_DISPLAY_BNUMBER = 1	Sets displayed page to <BIN No. DISPLAY>.
		KI_AGCV_DISPLAY_BCOUNT = 2	Sets displayed page to <BIN COUNT DISPLAY>.

Model 4284 LPT parameters			Comments
Unit name	**Modifier**	**Value**	
		KI_AGCV_DISPLAY_LIST = 3	Sets displayed page to <LIST SWEEP DISPLAY>.
		KI_AGCV_DISPLAY_MSETUP = 4	Sets displayed page to <MEAS SETUP>.
		KI_AGCV_DISPLAY_CSETUP = 5	Sets displayed page to <CORRECTION>.
		KI_AGCV_DISPLAY_LTABLE = 6	Sets displayed page to <LIMIT TABLE SETUP>.
		KI_AGCV_DISPLAY_LSETUP = 7	Sets displayed page to <LIST SWEEP SETUP>.
		KI_AGCV_DISPLAY_CATALOG = 8	Sets displayed page to <CATALOG>.
		KI_AGCV_DISPLAY_SYSTEM = 9	Sets displayed page to <SYSTEM INFO>.
		KI_AGCV_DISPLAY_SELF = 10	Sets display page to <SELF TEST>.
		KI_AGCV_DISPLAY_MLARGE = 11	Sets page to display measurement results in large characters.
		KI_AGCV_DISPLAY_SCONFIG = 12	Sets displayed page to <SYSTEM CONFIG>.
		KI_AGCV_DISPLAY_SERVICE = 13	Sets displayed page to <SERVICE>.

sintgi/sintgv

This command performs voltage or current measurement sweeps averaged over a user-defined period (usually, one AC line cycle).

Usage

`sintgi/sintgv(instName)`

instName	Instrument name for measurement

Details

Use the `sintgi` or `sintgv` command to set the measurement method for the integrated measurement of current/voltage sweep.

Note that the measurement setup function `sintgi/sintgv` must be called before the sweep functions `sweepi/sweepv` or `asweepi/asweepv` or `bsweepi/bsweepv`.

Example

```
#sweep measure current on SMU1
sintgi(SMU1)
#sweep source voltage from 0~5V by 5 steps and with 0.001s delay
swpData = sweepv(SMU1, 0, 5, 5,0.001)

devint()
#post measured current data
ACSPostArrayDouble("Imeas", swpData["savgi_SMU1"], 5)
```

Also see

asweepi/asweepv (on page 2-9)
bsweepi/bsweepv (on page 2-11)
sweepi/sweepv (on page 2-58)

smeasi/smeasv

This command sets the measurement of current or voltage during a sweep..

Usage

```
smeasi/smeasv (instName)
```

`instName`	Instrument name for the measurement

Details

Use the `smeasi` or `smeasv` command to set the measurement for the current or sweep. These commands must be called before the sweep functions `sweepi`, `sweepv`, `asweepi`, `asweepv`, `bsweepi`, or `bsweepv`.

Example

```
#sweep measure current on SMU1
smeasi(SMU1)
#sweep source voltage from 0 to 5 V by 5 steps with a 0.001 s delay.
swpData = sweepv(SMU1, 0, 5, 5,0.001)

devint()
#post measured current data
ACSPostArrayDouble("Imeas", swpData["savgi_SMU1"], 5)
```

Also see

asweepi/asweepv (on page 2-9)
bsweepi/bsweepv (on page 2-11)
sweepi/sweepv (on page 2-58)

sweepi/sweepv

This command performs current and voltage sweeps and returns the measured data based on the measurement setup.

Usage

```
sweepi(instName, startVal, endVal, stepNo, stepDelay)
sweepv(instName, startVal, endVal, stepNo, stepDelay)
```

instName	Instrument name for forcing
startVal	Start value of sweep force
endVal	End value of sweep force
stepNo	Step number of sweep
stepDelay	Delay before every sweep step

return	`{"savgi_SMUX":[data_1, data_2,…, data_StepNo]}`
	`{"savgv_SMUX":[data_1, data_2,…, data_StepNo]}`
	`{"smeasi_SMUX":[data_1, data_2,…, data_StepNo]}`
	`{"smeasv_SMUX":[data_1, data_2,…, data_StepNo]}`
	`{"singti_SMUX":[data_1, data_2,…, data_StepNo]}`
	`{"singtv_SMUX":[data_1, data_2,…, data_StepNo]}`
	`{"rtfary":[value_1, value_2,…, value_StepNo]}`

Details

Use the `sweepi` or `sweepv` command to perform current or voltage sweep forcing with a defined start value, end value, step number, and step delay. This returns the measured data according to the measurement setup `savgi`, `savgv`, `sintgi`, `sintgv`, `smeasi`, or `smeasv`. If `rtfary` is called, the return value includes the programmed force values of the sweep.

NOTE

The measurement setup function for `savgi`, `savgv`, `sintgi`, `sintgv`, `smeasi`, or `smeasv` must be called before `sweepi` or `sweepv`. The force values return function, `rtfary`, must be called before `asweepi` or `asweepv`.

Example

```
#sweep measure current on SMU1
smeasi(SMU1)
#return force value of sweep
rtfary()
#sweep source voltage from 0~5V by 5 steps and with 0.001s delay
swpData = sweepv(SMU1, 0, 5, 5,0.001)

devint()
#post measured current data
ACSPostArrayDouble("Imeas", swpData["smeasi_SMU1"], 5)
#post forced voltage value
ACSPostArrayDouble("Vsource", swpData["rtfary], 5)
```

Also see

savgi/savgv
sintgi/sintgv (on page 2-56)
smeasi/smeasv (on page 2-57)
rtfary (on page 2-42)

srangei/srangev

This command selects the current or voltage source range and prevents the selected instrument from autoranging.

Usage

```
srangei(SMUX, value)
srangev(SMUX, value)
```

SMUX	The instrument identification code of the instrument; for example, `SMU1`
value	The current or voltage source range

Details

Using the `srangei` or `srangev` command to select the range eliminates the time required for autoranging.

Example

```
#set the current source range on SMU1 to 1e-3A
srangei(SMU1, 1e-3)
#set the voltage source range on SMU2 to 20V
srangev(SMU2, 20)
```

Also see

None

trigil/trigvl/trigig/trigvg

This command sets the level for a break used in the sweep functions `bsweepi` and `bsweepv`.

Usage

```
trigil(instName, level)
trigvl(instName, level)
trigig(instName, level)
trigvg(instName, level)
```

instName	Instrument name for forcing
level	Level of the tested data to break the sweep

Details

When the level is exceeded by the tested data, the sweep breaks as follows:

- `trigil`: When the tested current is lower than the level.
- `trigvl`: When the tested voltage is lower than the level.
- `trigig`: When the tested current is greater than the level.
- `trigvg`: When the tested voltage is greater than the level.

These trigger functions must be called before `bsweepi`/`bsweepv`.

Example

```
#List to store force break value.
BVresult = []
#Set trigger of current low level.
trigil(SMU1, 1e-11)
#Measure current on SMU1.
smeasi(SMU1)
#Return force value of sweep.
rtfary()
#Sweep source voltage from 0~5V by 5 steps, with 0.001s delay, breaks according to the
trigger level setting.
swpData = bsweepv(SMU1, 0, 5, 5, 0.01, BVresult)
devint()
#Post force break value.
ACSPostArrayDouble("BV", BVresult[0])
#Post measured current data.
ACSPostArrayDouble("Imeas", swpData["smeasi_SMU1"], 5)
#Post forced voltage value.
ACSPostArrayDouble("Vsource", swpData["rtfary"], 5)
```

Also see

bsweepi/bsweepv (on page 2-11)

tstsel

This command is only for the Model 4200A-SCS instrument.

This command enables or disables the test station.

Usage

`tstsel(iStatus)`

iStatus	State of the test station; `1` = enabled, `0` = disabled

Details

The `tstsel(1)` command is normally called at the beginning of a test program to gain control of the test station before running any test control functions..

The `tstsel(0)` can be called at any position of a test program. To relinquish control of the test station, the `tstsel(0)` command is called.

To regain control of the test station, the `tstsel(1)` command is called. This must be done before any subsequent test control functions are performed.

Example

```
#enable control of the test station
tstsel(1)
forcev(SMU1, 1)
Id = measi(SMU1)
#disable control of the test station
tstsel(0)
```

Also see

None

ACS post data and log commands

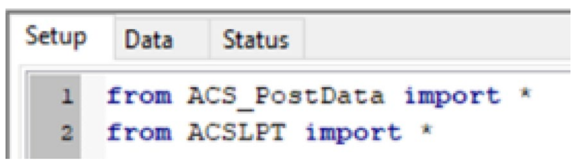
NOTE

Before using the ACS post data and log commands, you need to import `ACS_PostData` to the header of a Python test module (PTM). For more information about importing a header, refer to Creating PTM or STM test libraries and modules.

NOTE

When you create a new PTM in the test tree, headers are created (`ACS_PostData` and `ACS LPT`), as seen in the following figure. Additionally, you have the option to import a header after the PTM is created.

Figure 10: Import ACSLPT



NOTE

The ACS LPT commands and post data and log commands are listed in alphabetical order.

ACSPostArrayDouble

This command posts an array to the data panel as a double data type.

Usage

`ACSPostArrayDouble (name, array, size)`

name	The name of the output data string displayed in the data panel
array	The array posted in double data type
size	The size of array posts as a double data type

Details

Example

```
Imeas = [1.31e-6, 1.32e-6, 1.33e-6]
ACSPostArrayDouble ("Imeas",Imeas, 3)
```

Also see

None

ACSPostArrayFloat

This command is used to post an array to the data panel in float data type.

Usage

`ACSPostArrayFloat(name, array, size)`

name	The name of the output data string displayed in the data panel
array	The array posted in float data type
size	The size of the array posted in float data type

Details

Example

```
Vmeas = [2.1, 2.2, 2.3]
ACSPostArrayFloat ("Vmeas", Vmeas, 3)
```

Also see

None

ACSPostArrayInt

This command is used to post an array to the data panel as an integer data type.

Usage

`ACSPostArrayInt(`*`name`*`, `*`array`*`, `*`size`*`)`

name	The name of the output data string displayed in the data panel
data	The array posted in an integer data type
size	The size of the array posted in float data type

Details

Example

```
Num_meas = [1, 2, 3, 4, 5]
ACSPostArraryInt ("Num_meas", Num_meas, 5)
```

Also see

None

ACSPostDataDouble

This command is used to post data to the data panel as a double data type.

Usage

`ACSPostDataDouble(`*`name`*`, `*`data`*`)`

name	The name of the output data string displayed in the data panel
data	The data posted as a double data type

Details

Example

```
ACSPostDataDouble ("Imeas", 1.34e-6)
```

Also see

None

ACSPostDataFloat

This command is used to post an array to the data panel as a float data type.

Usage

`ACSPostDataFloat(name, data)`

name	The name of the output data string displayed in the data panel
data	The array posted in float data type

Details

Example

```
ACSPostDataFloat ("Vmeas", 2.2)
```

Also see

None

ACSPostDataInt

This command is used to post an array to the data panel as an integer data type.

Usage

`ACSPostDataInt(name, data)`

name	The name of the output data string displayed in the data panel
data	The data posted in an integer data type

Example

```
ACSPostDataInt ("Num_meas", 3)
```

Also see

None

ACSPostGdata

This command is used to define global data that is accessed in the UAP PTM.

Usage

`ACSPostGdata (name, value)`

name	The name of the global output data string that is displayed in the UAP PTM
value	The value of the global data

Example

```
ACSPostGdata ("global_Vsource", 3.5)
```

Also see

None

logCritical

This command posts critical messages in the log window.

Usage

`logCritical (msg, color=useColor, title='messageTitle')`

msg	The message string displayed in the log window
useColor	Enable or disable critical message color: ■ Enable color: `true` ■ Disable color: `false`
messageTitle	The title of the critical message

Example

```
msg = "The SMU%d is not found in the system." %smuNum
logCritical (msg, color=True, title='CRITICAL')
```

Displays a critical message using color.

Also see

None

logError

This command is used to post the error message in the log window.

Usage

`logError (msg, color=useColor)`

msg	The message string displayed in the log window
useColor	Enable or disable error code color: ■ Enable color: `true` ■ Disable color: `false`

Example

```
msg = "The value for Vforce %g is out of limits."%Vforce [1]
logError (msg, color=True)
```

Display the message with color applied.

Also see

None

logInfo

This command posts an information message in the log window.

Usage

`logInfo (msg)`

msg	The message string to be displayed in the log window

Example

```
msg = "The diagnostic of SMU%d is passed"%smuNum
logInfo (msg)
```

Also see

None

PTM Examples

The following ACSLPT examples are provided for your reference.

ACSLPT example: vgsid1

```
##outputlist=GateV,DrainI,Time##
from ACS_PostData import *
from ACSLPT import *
from ptmlpt.constantlpt import *
from math import *
Get4200HWCtrl()
def vgsid1(DrainSMU, DrainPin, GateSMU, GatePin, SourceSMU, SourcePin, BulkSMU,
   BulkPin, GateVStart,GateVStop, numberofpoint, SweepDelay, DrainV,
   SourceV,BulkV,RangeDrainI, ComplianceDrainI,StoponCompliance,NPLC):
    GateV=[]
    DrainI=[]
    Time_meas=[]
    tstsel(1)
    #Some input checking is needed
    if  GateVStart < -200 or GateVStart > 200:
        return INVAL_PARAM
    if  GateVStop < -200 or GateVStop > 200:
        return INVAL_PARAM
    if  numberofpoint < 1 or numberofpoint > 4096:
        return INVAL_PARAM
    if  SweepDelay < 0 or SweepDelay > 100:
        return INVAL_PARAM
    if  DrainV < -200 or DrainV > 200:
        return INVAL_PARAM
    if  SourceV < -200 or SourceV > 200:
        return INVAL_PARAM
    if  BulkV < -200 or BulkV > 200:
        return INVAL_PARAM
    if RangeDrainI < 1 or RangeDrainI > 12:
        return INVAL_PARAM
    if ComplianceDrainI < -0.1 or ComplianceDrainI > 0.1:
        return INVAL_PARAM
        # Switch Matrix connection
    '''
    clrcon()
    if  GatePin > 0:
        conpin(GateSMU,GatePin)
    if DrainPin > 0:
        conpin(DrainSMU,DrainPin)
    if  SourcePin > 0:
        conpin(SourceSMU,SourcePin)
    if  BulkPin > 0:
        conpin(BulkSMU,BulkPin)
    '''
    #Set the SMUs range
    rangei(GateSMU,0.1)
    rangei(BulkSMU,0.1)
    rangei(SourceSMU,0.1)
    setauto(DrainSMU)
```

```
    limiti(DrainSMU, ComplianceDrainI)
    # best fix for voltage range
    if fabs(SourceV) < 0.2:
        rangev(SourceSMU, 0.2)
    elif fabs(SourceV) < 2:
        rangev(SourceSMU, 2)
    elif fabs(SourceV) < 20:
        rangev(SourceSMU, 20)
    else:
        rangev(SourceSMU, 200)
    if fabs(BulkV) < 0.2:
        rangev(BulkSMU, 0.2)
    elif fabs(BulkV) < 2:
        rangev(BulkSMU, 2)
    elif fabs(BulkV) < 20:
        rangev(BulkSMU, 20)
    else:
        rangev(BulkSMU, 200)
    if fabs(DrainV) < 0.2:
        rangev(DrainSMU, 0.2)
    elif fabs(DrainV) < 2:
        rangev(DrainSMU, 2)
    elif fabs(DrainV) < 20:
        rangev(DrainSMU, 20)
    else:
        rangev(DrainSMU, 200)
    if fabs(GateVStart) > fabs(GateVStop):
        temp = fabs(GateVStart)
    else:
        temp = fabs(GateVStop)
    if temp < 0.2:
        rangev(GateSMU, 0.2)
    elif temp < 2:
        rangev(GateSMU, 2)
    elif temp < 20:
        rangev(GateSMU, 20)
    else:
        rangev(GateSMU, 200)
    if RangeDrainI == 1:               # autorange
        setauto(DrainSMU)
    elif RangeDrainI == 2:              # limited auto 10pA
        lorangei(DrainSMU, 1e-11)
    elif RangeDrainI == 3:              #limited auto 100pA
        lorangei(DrainSMU, 1e-10)
    elif RangeDrainI == 4:                   #limited auto 1nA
        lorangei(DrainSMU, 1e-9)
    elif RangeDrainI == 5:                   #limited auto 10nA
        lorangei(DrainSMU, 1e-8)
    elif RangeDrainI == 6:                   #limited auto 100nA
        lorangei(DrainSMU, 1e-7)
    elif RangeDrainI == 7:                   #limited auto 1uA
        lorangei(DrainSMU, 1e-6)
    elif RangeDrainI == 8:                   # limited auto 10uA
        lorangei(DrainSMU, 1e-5)
    elif RangeDrainI == 9:                   # limited auto 100uA
        lorangei(DrainSMU, 1e-4)
    elif RangeDrainI == 10:                  # limited auto 1mA
```

```
        lorangei(DrainSMU, 1e-3)
    elif RangeDrainI == 11:                  # limited  auto 10mA
        lorangei(DrainSMU, 1e-2)
    elif RangeDrainI == 12:                 # limited auto 100mA
        lorangei(DrainSMU, 0.1)
    else:                                  #limited auto 10mA
        lorangei(DrainSMU, 1e-2)
    # set integration time
    setmode(GateSMU, KI_INTGPLC, NPLC)
    #Activate the range
    if  SourceSMU!=GNDU:
        forcev(SourceSMU, SourceV)
    if  BulkSMU!=GNDU:
        forcev(BulkSMU,BulkV)
    forcev(GateSMU,GateVStart)
    forcev(DrainSMU,DrainV)
    idummy = measi(DrainSMU)
    enable(TIMER1)
    # sweep setup
    if  numberofpoint>1:
        for index1 in range(numberofpoint):
            GateV_tmp = GateVStart+(GateVStop-GateVStart)*index1/(numberofpoint-1)
            print   GateV_tmp
            GateV.append(GateV_tmp)
            forcev(GateSMU,GateV_tmp)
            delay(int(SweepDelay*1000))
            DrainI_tmp = intgi(DrainSMU)
            if DrainI_tmp > ComplianceDrainI:
                break
            DrainI.append(DrainI_tmp)
            Time_meas.append(imeast(TIMER1))
    else:
        forcev(GateSMU, GateVStart)
        GateV.append(GateVStart)
        delay(int(SweepDelay*1000))
        DrainI.append(intgi(DrainSMU))
        Time_meas.append(imeast(TIMER1))
    # check compliance
    Dstatus = getstatus(DrainSMU, KI_COMPLNC)
    if  Dstatus == 2:
        return  KI_RANGE_COMPLIANCE
    if  Dstatus == 4:
        return  KI_COMPLIANCE
    devint( )
    #clrcon(MTRX1)
    # test finished
    for index2 in range(numberofpoint):
        ACSPostDataDouble("GateV",GateV[index2])
        ACSPostDataDouble("DrainI",DrainI[index2])
        ACSPostDataDouble("Time",Time_meas[index2])
return GateV,DrainI,Time_meas
##################CALL######################
DrainSMU=SMU1
DrainPin=1
GateSMU=SMU2
GatePin=2
SourceSMU=GNDU
```

```
SourcePin=3
BulkSMU=GNDU
BulkPin=4
GateVStart=0.0
GateVStop=3.0
numberofpoint=21
SweepDelay=0.001
DrainV=0.1
SourceV=0
BulkV=0
RangeDrainI=1
ComplianceDrainI=0.1
StoponCompliance=0
NPLC=1
vgsid1(DrainSMU, DrainPin, GateSMU, GatePin, SourceSMU, SourcePin, BulkSMU,
   BulkPin, GateVStart,GateVStop, numberofpoint, SweepDelay, DrainV, SourceV,
   BulkV, RangeDrainI, ComplianceDrainI,StoponCompliance,NPLC)
```

Section 3

ACS Basic device library

In this section:

Introduction

ACS Basic has a large device test library that includes the following libraries:

- Parametric
- WLR
- CommonLib_CV
- CommonLib_other
- CommonLib_SMU
- Mixed_SMU_Mode

The tables below indicate all of the test modules in these libraries.

You can also import and use a library using ACS Basic.

General notes

NOTE

When the Series 2600B System SourceMeter® instruments are referenced, it also includes the Series 2600A System SourceMeter instruments.

To create a new library, you can use any of the following:

- Test Script Processor (TSP) and Lua on the Keithley Instruments Series 2600B System SourceMeter
- Test Script Processor (TSP) and Lua on the Linear Parametric Test Library (LPT Library)
- The Python language in ACS Basic
- The Script Editor in ACS Basic

TSP script must use the ACS Basic functions postdata, postbuffer, or posttable to retrieve data from the Series 2600B. For examples, refer to the folder: C:\ACS_BASIC\library\26Library

The 26library is used with a Series 2600B to create test script files, based on the Series 2600B LPT library. The 42library is used with a Model 4200 using the Keithley User Library Tool (KULT) files, based on the Model 4200 LPT library.

The parametric library is used to test the normal parameters of the device.

The WLR_script library is for wafer reliability tests. They are STM with a GUI.

To create a test library with a graphical user interface (GUI), The first line must be the name of the .xrc GUI file, and the .xrc GUI file must be saved to the following folder:\ACS_BASIC\Library\26Library\xrc

ACS Basic then loads the GUI file automatically when importing the script file ----<<xrc=HCI.xrc>>----.

The types of input variables must be:

- instid (SMU input)
- string
- double
- integer
- table

You can set a default value for every input variable. You can also set the input range for double and integer-type input variables, as shown in the following table.

instid smu_S=SMU3	SMU1, SMU2, SMU3,..., SMU64, KI_GND
double vg_stress=-2.0 in [-40,40]	gate stress voltage; -40 ≤ vg_stress ≤40
double V_rd=0 in ['',0]	reverse voltage, Vrd <= 0
double meas_delay=0 in [0,]	measure delay after stress is off, meas_delay >= 0

`integer navg=1 in [1,20]`	points for average, average = 1, 2, 3,…19, 20
`table t_array={1,2,5,10,20,50,100}`	stress time array

The input variables must be defined in the first section of the test script, after the `.xrc` line, listed between `--INPUT--` and `--END of INPUT--`:

INPUT	
`instid CSMU=SMU3`	SMU1, SMU2, SMU3, … , SMU64
`double Vb_stop=1.2`	stop voltage (Units:V)
`double Vb_points=100`	sweep points
`integer resetflag=1 in [0,1]`	`1` resets instruments after test, `0` does not
END OF INPUT	

The Call function must start with a `--CALL--` line, then assign a value for every input variable and a call test function.

NOTE

For examples, refer to the directory `C:\ACS_BASIC\library\26Library\WLR`.

npnBJT parametric library		
BVCBO	BVCEI	BVCEO
BVCEV	BVEBO	BVECO
Ccb	Cce	Ceb
Cibo	Cobo	HFE_SW
IBCO	IBEO	IbIcVbe
IbVbe	ICBO	ICEO
ICEV	IcVcb	IcVce_BiasIb
IcVce_BiasVb	IcVce_StepIb	IcVce_StepVb
IEBO	IECO	IeVeb
VBCO	VCE	

npnPowerBJT parametric library		
BVCBO	BVCEO	BVEBO
Ccb	Cce	Ceb
Cibo	Cobo	HFE
ICBO	ICEO	ICES
ICEV	IcVce_StepIb	IcVce_StepIb_MIX
IcVce_StepVbe	IcVce_StepVbe_MIX	IEBO
VbeON	VbeSAT	VceSAT
VceSAT_MIX	VCESUS	

pnpBJT device parametric library		
BVCBO	BVCEI	BVCEO
BVCEV	BVEBO	BVECO
Ccb	Cce	Ceb
Cibo	Cobo	HFE_SW
IBCO	IBEO	IbIcVbe
IbVbe	ICBO	ICEO
ICEV	IcVcb	IcVce_BiasIb
IcVce_BiasVb	IcVce_StepIb	IcVce_StepVb
IEBO	IECO	IeVeb
VBCO	VCE	

pnpPowerBJT parametric library		
BVCBO	BVCEO	BVEBO
Ccb	Cce	Ceb
Cibo	Cobo	HFE
ICBO	ICEO	ICES
ICEV	IcVce_StepIb	IcVce_StepIb_MIX
IcVce_StepVbe	IcVce_StepVbe_MIX	IEBO
VbeON	VbeSAT	VceSAT
VceSAT_MIX	VCESUS	

nMOSFET parametric library		
BVDSS	BVDSV	BVGSO
BVGDS	BVGDO	Cds
Cgd	Cgs	Ciss
Coss	Crss	IDL
IDS_ISD	IdVd_BiasVg	IdVd_StepVg
IdVg_BiasVd	IdVg_StepVd	IdVg_StepVsub
IGL	IgVg	ISL
Vtci	Vtext	Vtext_llsq

nMOSFET WLR_script library
HCI

nPowerMOSFET parametric library		
BVDSS	IGSSF	Cds
Cgd	Cgs	Ciss
Coss	Crss	GFS
IdON	IdON_MIX	IDSS
IdVd_StepVg	IdVd_StepVg_MIX	IdVg_StepVd
IGSSF	IGSSR	RdsON
RdsON_MIX	VdsON	VgsON
VgsON_MIX	VGSTH	VSD

pMOSFET parametric library		
BVDSS	BVDSV	BVGDO
BVGDS	BVGSO	Cds
Cgd	Cgs	Ciss
Coss	Crss	IDL
IDS	idvd_biasVG	idvd_stepVG
idvg_biasVD	idvg_stepVD	IGL
igvg	ISL	IsubVg
Vtci	Vtext	Vtext_llsq

pMOSFET WLR_script library	
HCI	NBTI
NBTI_meas	NBTI_on_the_fly

pPowerMOSFET parametric library		
BVDSS	Cds	Cgd
Cgs	Ciss	Coss
Crss	GFS	IdON
IdON_MIX	IDSS	IdVd_StepVg
IdVd_StepVg_MIX	IdVg_StepVd	IGSSF
IGSSR	RdsON	RdsON_MIX
VdsON	VgsON	VgsON_MIX
VGSTH	VSD	

Diode parametric library		
DynamicZ	Spot_IfdVfd	Spot_IrdVrd
Spot_VbrIrd	Spot_VfdIfd	Spot_VrdIrd
Sweep_IfdVfd	Sweep_IrdVrd	

IGBT parametric library		
BVCES	Cce	Cgc
Cge	Cies	Coes
Cres	ICES	IcON
IcVce_StepVge	IcVce_StepVge_MIX	IcVge
IcVge_MIX	IGESF	IGESR
VceSAT	VceSAT_MIX	VF
VgeON	VGETH	

Two-terminal resistor parametric library	
Spot_IV_2SMU	Spot_VI_2SMU
Sweep_IV_2SMU	Sweep_VI_2SMU

TRIAC parametric library	
IDRM	ILpos
IGT	IRRM
IHneg	VGT
IHpos	VTneg
ILneg	VTpos

Zener parametric library		
BVZ	IR	VF

Capacitor_MOS WLR_script library	
qbd_rmpj	qbd_rmpv
TDDB_CCS	TDDB_per_pin

CommonLib_CV		
Cv4282	Generic_HVCV_Test	KI42xxCVU

CommonLib_other		
KI37XX_DMM_Switch	power_supply	switchctrl_6cards_3706
switchctrl_6cards_70x	TEKSCOPE_ReadWave	

Mixed_SMU_Mode library		
BiasIMeasV_Pluse_2430	BiasVMeasI_Pulse_2430	BiasVolt_SampleCurr_23x
BVcei_any_SMU	BVcev_any_SMU	BVdsv_any_SMU
combined_mixed_SMU	hFE_BJT_any_SMU	IcVce_StepIb_any_SMU
IcVce_StepVbe_any_SMU	IcVce_StepVge_any_SMU	IcVge_any_SMU
IdON_any_SMU	Idvd_24xx	IdVd_BiasVg_any_SMU
IdVd_Pulse_24xx	IdVd_StepVg_any_SMU	IdVg_24xx
IdVg_BiasVd_any_SMU	IdVg_Pulse_24xx	RdsOn_any_SMU
SweepCurr_23x	SweepI_MeasV_24xx	SweepV_MeasI_24xx
SweepVolt_23x	Vcesat_bjt_any_SMU	Vcesat_IGBT_any_SMU
vdsId_237	VgsON_any_SMU	

Common library	
FourWireResistor_3706	Gpibresistor_3706

npnBJT parametric library

The BJT parametric library components are in the following folder:

```
C:\ACS_BASIC\library\devLibrary\npnBJT\Parametric
```

This npnBJT parametric library is used to test parameters of a npn-type power BJT, including leakage, breakdown, gain, on-state, capacitance, and characteristic curves.

BVCBO

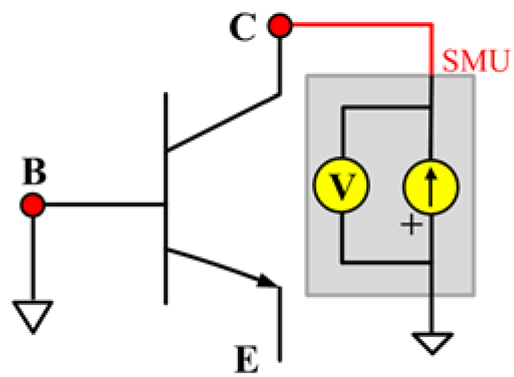
Module name: BVCBO

DUT: Three-terminal BJT

Function: Measures the collector-base breakdown voltage of the BJT, with the emitter open.

Pin connections: Use one SMU to force a reverse current to the collector. Open the circuit to the emitter or use a SMU to supply a zero-current bias. Connect the base to GND or use a SMU to supply a zero-voltage bias.

Figure 11: Three-terminal npnBJT BVCBO pin connections



BVCBO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

Figure 12: Three terminal npnBJT BVCBO 2600B ITM setting

Device Num	SMU	Pad	Function	Force Range	Source	Measure	Compliance	Meas Range	Limits Auto
1	SMU2	Collector	Bias I	auto	1.5e-009	I+V	20.0	auto	
	SMU3	Emitter	Open						
	SMU1	Base	Bias V	auto	0.0	None	0.1		

Figure 13: Three terminal npnBJT BVCBO 4200 ITM setting

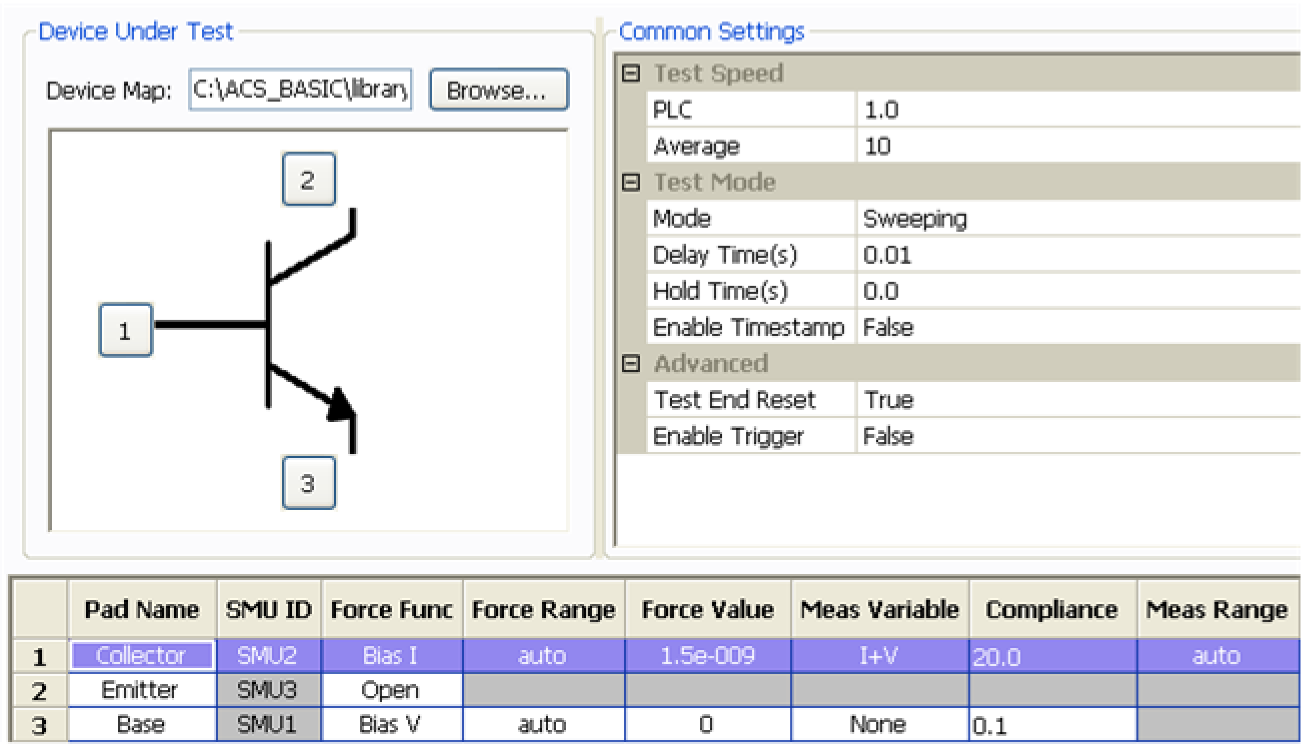
Device Num	SMU	Pad	Function	Force Range	Source	Measure	Compliance	Meas Range	Limits Auto
1	SMU2	Collector	Bias I	auto	0.001	I+V	40.0	auto	
	SMU3	Emitter	Bias I	100nA	0.0	None	20.0		
	SMU1	Base	Bias V	auto	0	None	0.1		

BVCBO General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Figure 14: Three terminal npnBJT BVCBO general PTM setting



	Pad Name	SMU ID	Force Func	Force Range	Force Value	Meas Variable	Compliance	Meas Range
1	Collector	SMU2	Bias I	auto	1.5e-009	I+V	20.0	auto
2	Emitter	SMU3	Open					
3	Base	SMU1	Bias V	auto	0	None	0.1	

BVCEI

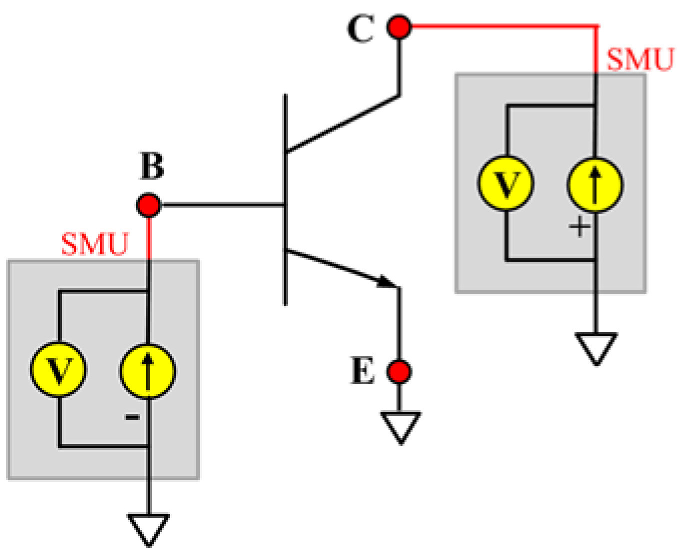
Module name: BVCEI

DUT: Three-terminal npnBJT

Function: Measures the collector-emitter breakdown voltage of the npnBJT with a bias base-forced current.

Pin connections: Use a SMU to force current to the collector. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 15: Three-terminal npnBJT BVCEI pin connections



BVCEI ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

Figure 16: Three terminal npnBJT BVCEI 2600B ITM Setting

Device Num	SMU	Pad	Function	Force Range	Source	Measure	Compliance	Meas Range	Limits Auto
1	SMU2	Collector	Bias I	auto	1.5e-009	I+V	20.0	auto	
	SMU3	Emitter	Bias V	auto	0	None	0.1		
	SMU1	Base	Bias I	auto	-5e-008	None	20.0		

Figure 17: Three terminal npnBJT BVCEI 4200 ITM Setting

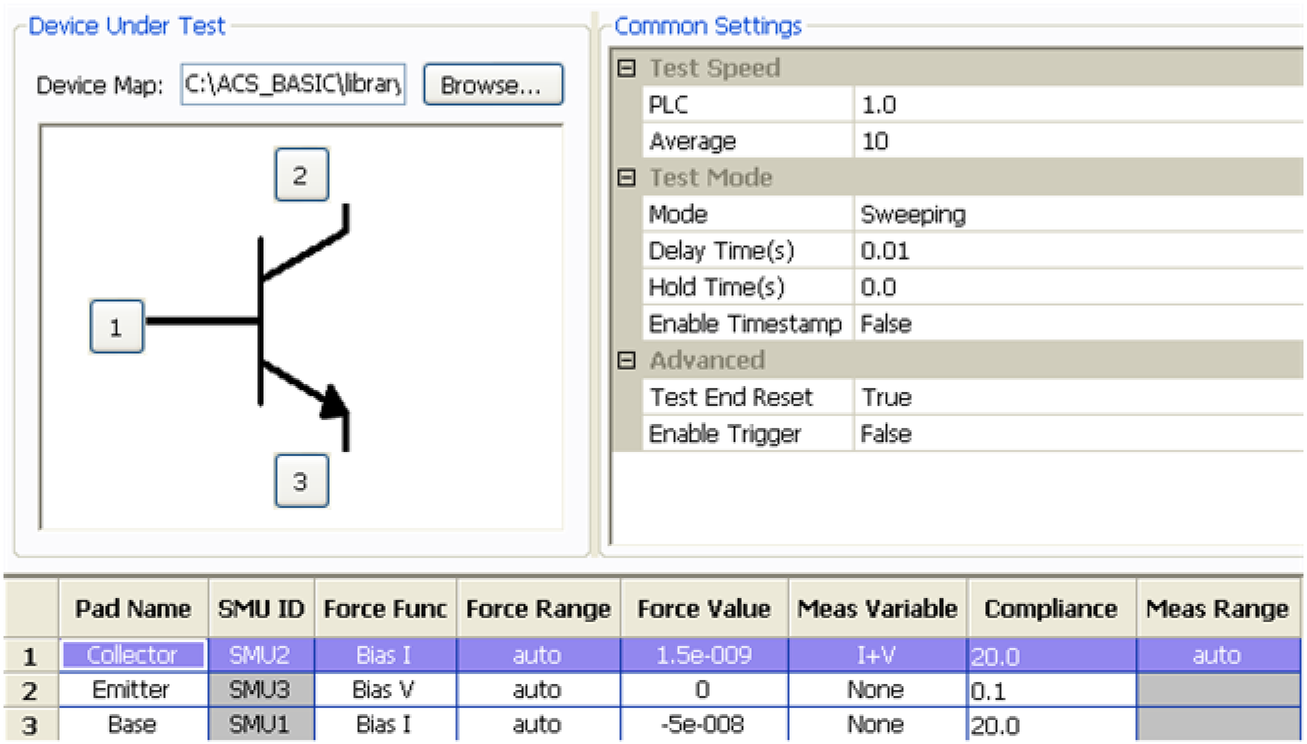
Device Num	SMU	Pad	Function	Force Range	Source	Measure	Compliance	Meas Range	Limits Auto
1	SMU2	Collector	Bias I	auto	0.001	I+V	40.0	auto	
	SMU3	Emitter	Bias V	auto	0	None	0.1		
	SMU1	Base	Bias I	auto	5e-008	None	20.0		

BVCEI General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Figure 18: Three terminal npnBJT BVCEI General PTM Setting



BVCEO

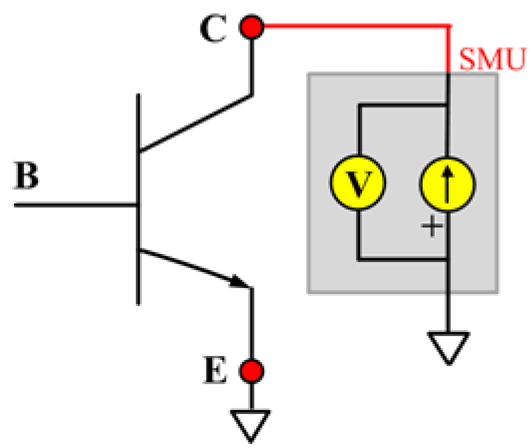
Module name: BVCEO

DUT: Three-terminal npnBJT

Function: Measures the collector-emitter breakdown voltage, with the base opened.

Pin connections: Use a SMU to force current to the collector. Open the circuit to the base or use a SMU to supply a zero-current bias to the base. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 19: Three-terminal npnBJT BVCEO pin connections



BVCEO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

BVCEO General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVCEV

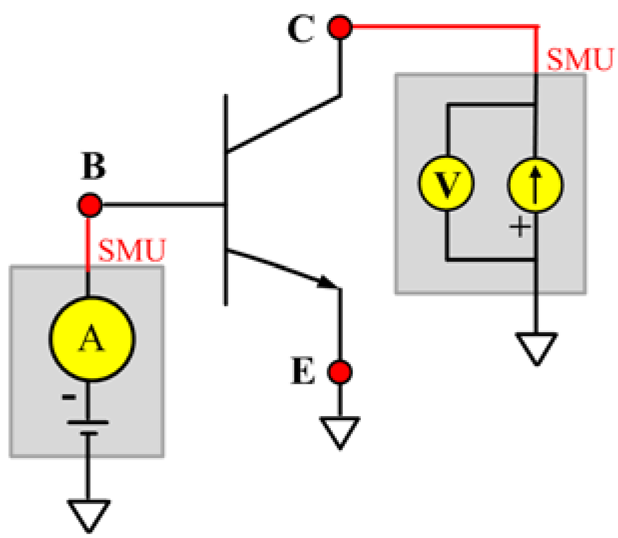
Module name: BVCEV

DUT: Three-terminal npnBJT

Function: Measures the collector-emitter breakdown voltage with a biased base.

Pin connections: Use a SMU to force voltage to the base. Use a SMU to force current to the collector. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 20: Three-terminal npnBJT BVCEV pin connections



BVCEV ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

BVCEV General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVEBO

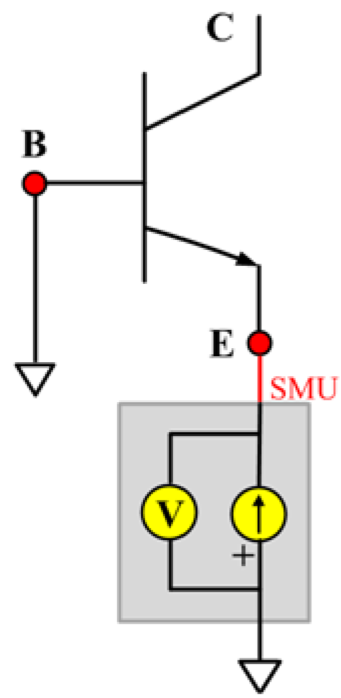
Module name: BVEBO

DUT: Three-terminal npnBJT

Function: Measures the emitter-base breakdown voltage of the npnBJT with the collector opened.

Pin connections: Use a SMU to force current to the emitter. Connect the base to GND or use a SMU to supply a zero-voltage bias. Open the circuit to the collector or use a SMU to supply a zero-current bias.

Figure 21: Three-terminal npnBJT BVEBO pin connections



BVEBO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

BVECO

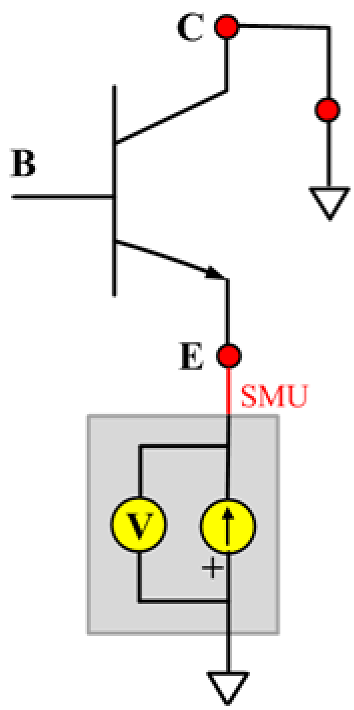
Module name: BVECO

DUT: Three-terminal npnBJT

Function: Measures the emitter-collector breakdown voltage of the npnBJT with the base opened.

Pin connections: Use a SMU to force current to the emitter. Connect the collector to GND or use a SMU to supply a zero-voltage bias. Open the circuit to the base or use a SMU to supply a zero-current bias.

Figure 22: Three-terminal npnBJT BVECO pin connections



BVECO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

Ccb

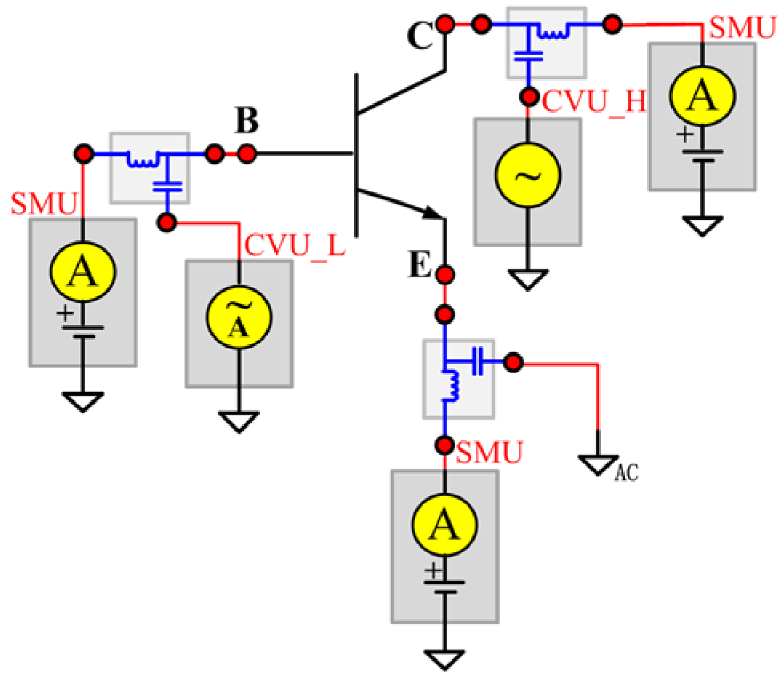
Module Name: Ccb

DUT: Three-terminal npnBJT

Function: Measures the capacitance between the Collector and Base terminals with the Emitter terminal connected to the guard terminal of a three-terminal bridge.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the collector. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the base. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the guard terminal of a three-terminal bridge through one remote bias tee to the emitter. Use the Series 2600B to supply zero voltage bias.

Figure 23: Three_term_npnBJT_Ccb pin connection



Ccb PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Cce

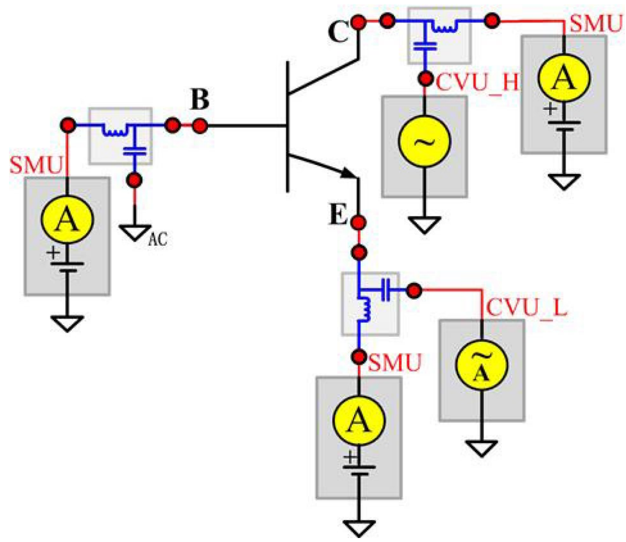
Module Name: Cce

DUT: Three-terminal npnBJT

Function: Measures the capacitance between the collector and emitter terminals with the base terminal connected to the guard terminal of a three-terminal bridge.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the collector. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the emitter. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the guard terminal of a three-terminal bridge through one remote bias tee to the base. Use the Series 2600B to supply zero voltage bias.

Figure 24: Three-terminal npnBJT Cce pin connections



Cce PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Ceb

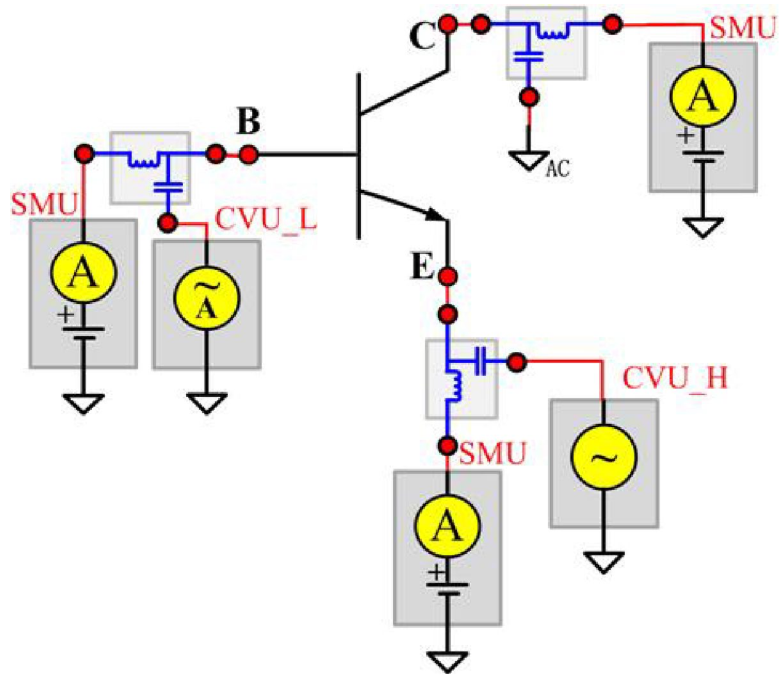
Module Name: Ceb

DUT: Three-terminal npnBJT

Function: Measures the capacitance between the emitter and base terminals with the collector terminal connected to the guard terminal of a three-terminal bridge.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the emitter. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the base. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the guard terminal of a three-terminal bridge through one remote bias tee to the collector. Use the Series 2600B to supply zero voltage bias.

Figure 25: Three-terminal npnBJT Ceb pin connections



Ceb PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Cibo

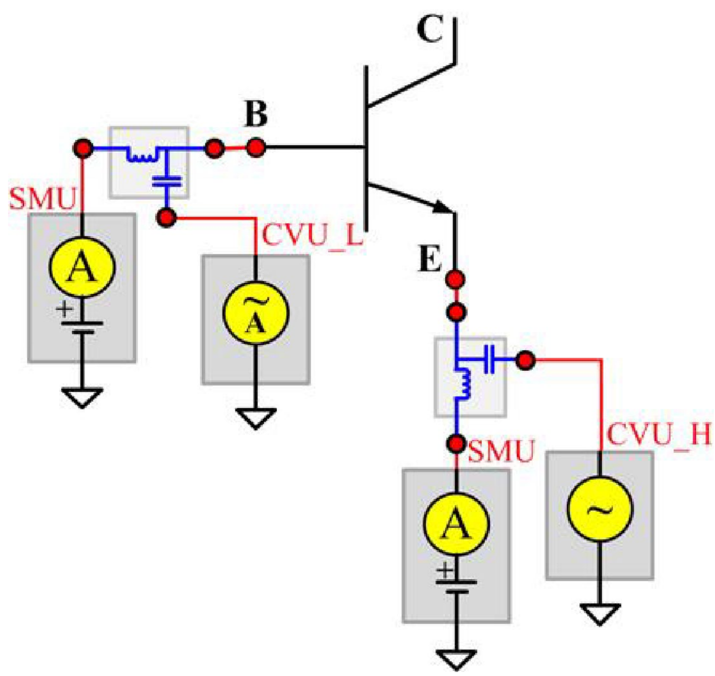
Module Name: Cibo

DUT: Three-terminal npnBJT

Function: Measures the capacitance between the input terminals (base and emitter) with the collector terminal open.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the emitter. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the base. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the guard terminal of a three-terminal bridge through one remote bias tee to the collector. Use the Series 2600B to supply zero voltage bias.

Figure 26: Three-terminal npnBJT Cibo pin connections



Cibo PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Cobo

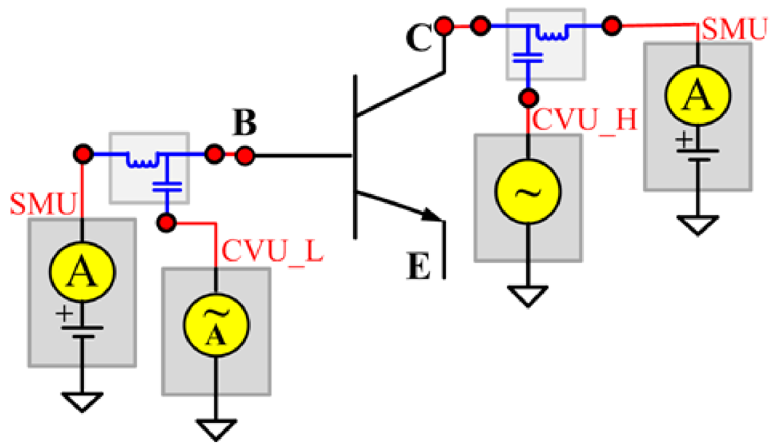
Module Name: Cobo

DUT: Three-terminal npnBJT

Function: Measures the capacitance between the output terminals (base and collector) with the emitter terminal open.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the collector. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the base. Use the Series 2600B to supply zero voltage bias. Open the circuit to the emitter.

Figure 27: Three-terminal npnBJT Cobo pin connections



Cobo PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

HFE_SW

Module name: HFE_SW

DUT: Three-terminal npnBJT

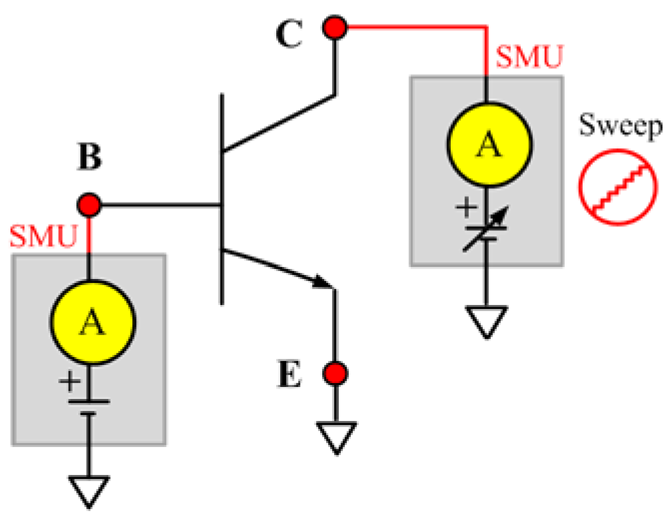
Function: Measures the collector current, base current, and dc current gain based on the collector sweep voltage.

Pin connections: Use a SMU to apply a sweep voltage to the collector. Use a SMU to bias the base.

HFE= Ic/Ib:

- Force CollectorV sweep
- Measure Ib and Ic
- Check for measurement problems
- Calculate HFE(= Ic/Ib)

Figure 28: Three-terminal npnBJT HFE SW pin connections



HFE_SW ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

HFE_SW General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IBCO

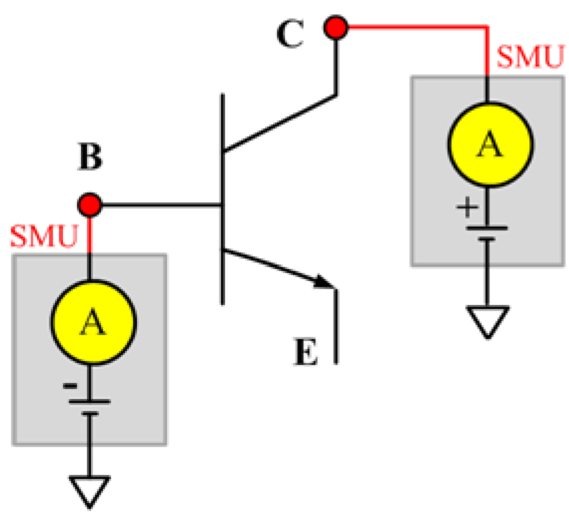
Module name: IBCO

DUT: Three-terminal npnBJT

Function: Measures the base-collector current with the emitter opened.

Pin connections: Use a SMU to force voltage to the base. Connect the collector to GND or use a SMU to supply a zero-voltage bias. Open the circuit to the emitter or use a SMU to supply a zero-current bias.

Figure 29: Three-terminal npnBJT IBCO pin connections



IBCO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IBCO General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IBEO

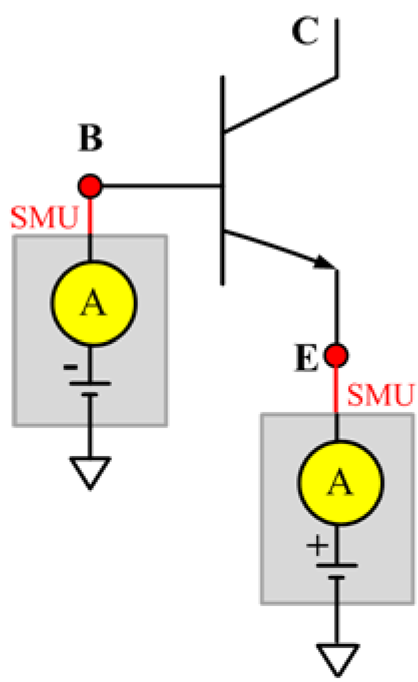
Module name: IBEO

DUT: Four-terminal npnBJT

Function: Measures the base-emitter current with the collector opened.

Pin connections: Use a SMU to force voltage to the base. Connect the collector to GND or use a SMU to supply a zero-voltage bias. Open the circuit to the emitter or use a SMU to supply a zero-current bias.

Figure 30: Three-terminal npnBJT IBEO pin connections



IBEO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IBEO General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IbIcVbe

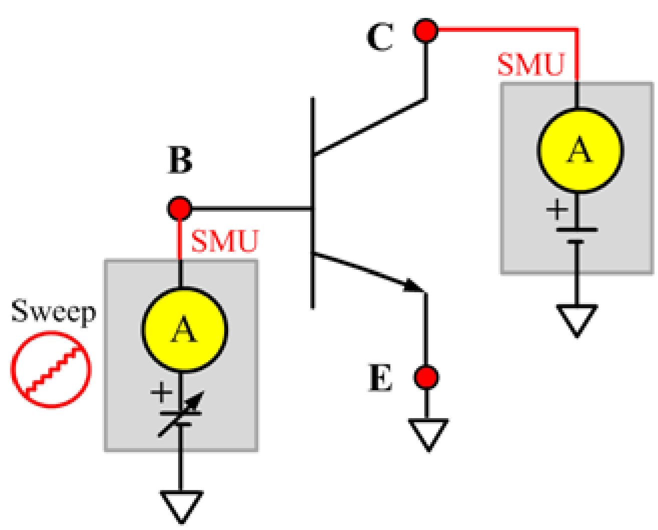
Module name: IbIcVbe

DUT: Three-terminal npnBJT

Function: Measures the base current and collector current of the npnBJT by sweeping a specified base voltage and measures the Ib-Vbe and IcVbe curves and the Gummel plot if the axis properties of result have changed (logarithm instead of right-angle coordinate).

Pin connections: Use a SMU to apply a voltage sweep to the base. Use a SMU to bias the collector. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 31: Three-terminal npnBJT IbIcVbe pin connections



IbIcVbe ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IbIcVbe General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IbVbe

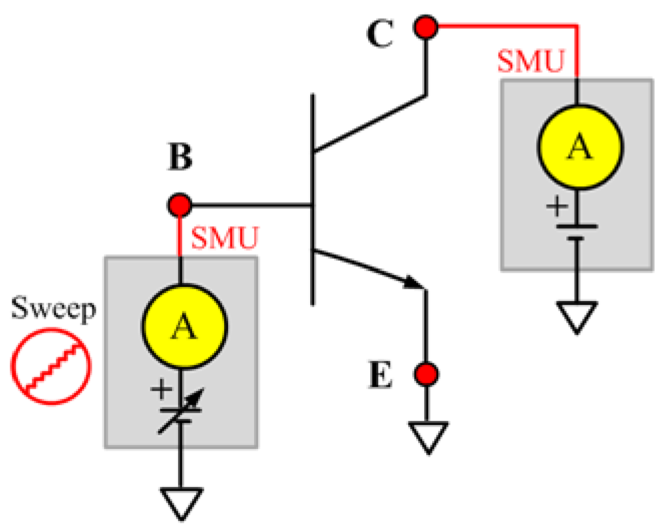
Module name: IbVbe

DUT: Three-terminal npnBJT

Function: Measures the base current of the npnBJT by sweeping a specified base voltage and measures the Ib-Vbe curve.

Pin connections: Use a SMU to apply a voltage sweep to the base. Use a SMU to bias the collector. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 32: Three-terminal npnBJT IbVbe pin connections



IbVbe ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IbVbe General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

ICBO

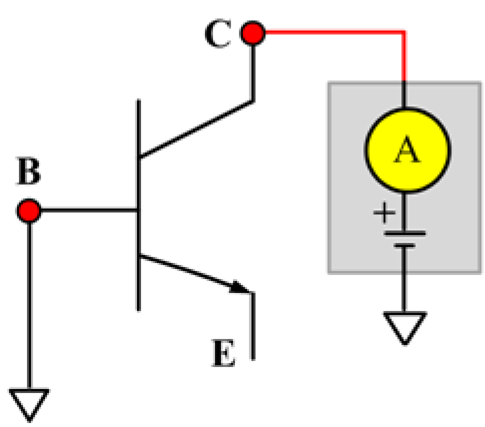
Module name: ICBO

DUT: Three-terminal npnBJT

Function: Measures the collector-base cut off current with the emitter opened.

Pin connections: Use a SMU to force voltage to the collector. Connect the base to GND or use a SMU to supply a zero-voltage bias. Open the circuit to the emitter or use a SMU to supply a zero-current bias.

Figure 33: Three-terminal npnBJT ICBO pin connections



ICBO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

ICBO General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

ICEO

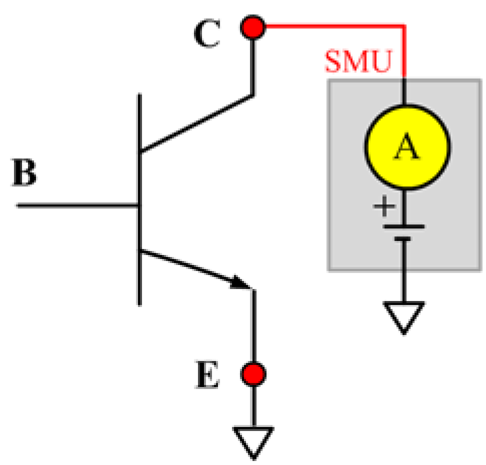
Module name: ICEO

DUT: Three-terminal npnBJT

Function: Measures the collector-emitter cut off current with the base opened.

Pin connections: Use a SMU to force voltage to the collector. Connect the emitter to GND or use a SMU to supply a zero-voltage bias. Open the circuit to the base or use a SMU to supply a zero-current bias.

Figure 34: Three-terminal npnBJT ICEO pin connections



ICEO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

ICEO General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

ICEV

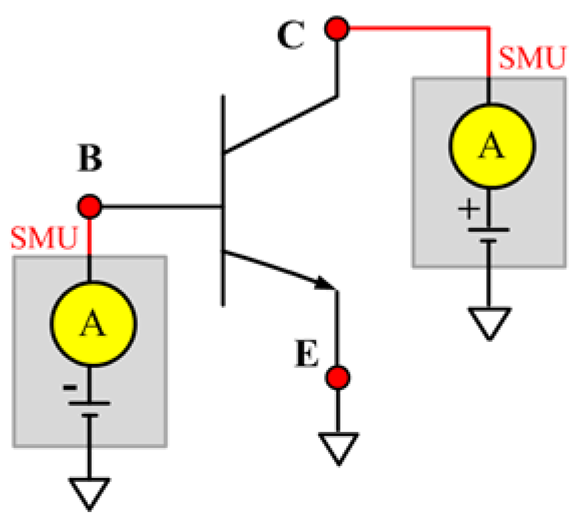
Module name: ICEV

DUT: Three-terminal npnBJT

Function: Measures the collector-emitter cut off current with a bias base voltage.

Pin connections: Use a SMU to force voltage to the base and the collector. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 35: Three-terminal npnBJT ICEV pin connections



ICEV ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

ICEV General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IcVcb

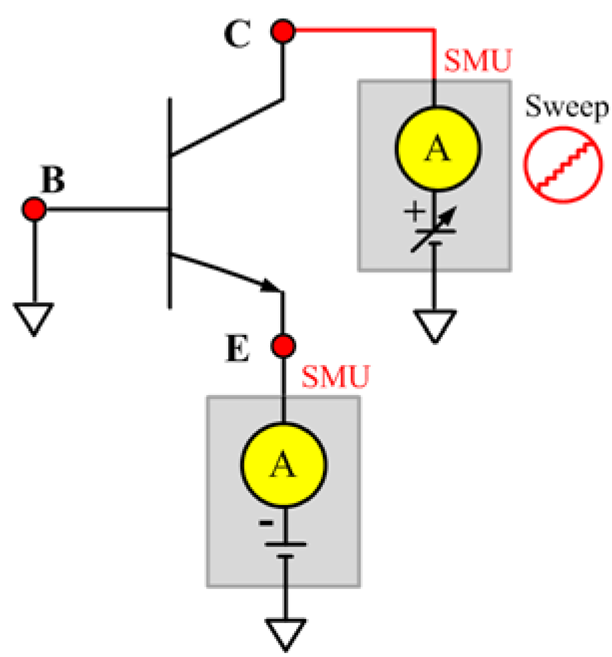
Module name: IcVcb

DUT: Three-terminal npnBJT

Function: Measures the collector current of the npnBJT by sweeping a specified collector voltage.

Pin connections: Use a SMU to apply a sweep voltage to the collector. Use a SMU to bias the emitter. Connect the base to GND or use a SMU to supply a zero-voltage bias.

Figure 36: Three-terminal npnBJT IcVcb pin connections



IcVcb ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IcVcb General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IcVce_BiasIb

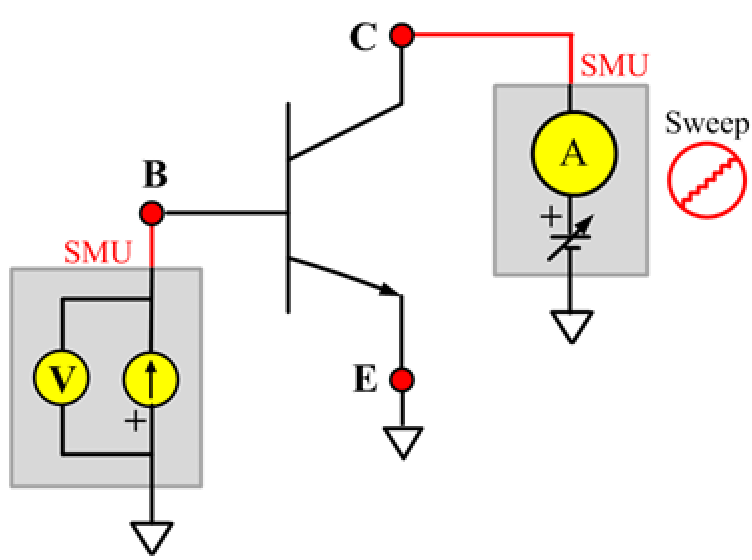
Module name: IcVce_BiasIb

DUT: Three-terminal npnBJT

Function: Measures the collector current based on a base step current and a collector sweep voltage, and a series of IcVce curves with a base current step.

Pin connections: Use a SMU to apply a sweep voltage to the collector. Use a SMU to bias the current to the base. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 37: Three-terminal npnBJT IcVce_BiasIb pin connections



IcVce_BiasIb ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IcVce_BiasIb General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IcVce_BiasVb

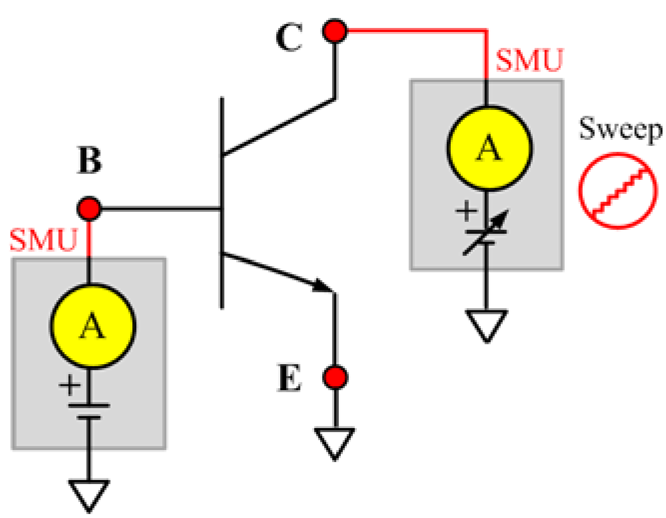
Module name: IcVce_BiasVb

DUT: Three-terminal npnBJT

Function: Measures the collector current based on the collector sweep voltage and a fixed based voltage and measures a series of IcVce curves with a fixed base voltage.

Pin connections: Use a SMU to apply a sweep voltage to the collector. Use a SMU to supply a zero-voltage bias to the base. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 38: Three-terminal npnBJT IcVce_BiasVb pin connections



IcVce_BiasVb ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IcVce_BiasVb General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IcVce_StepIb

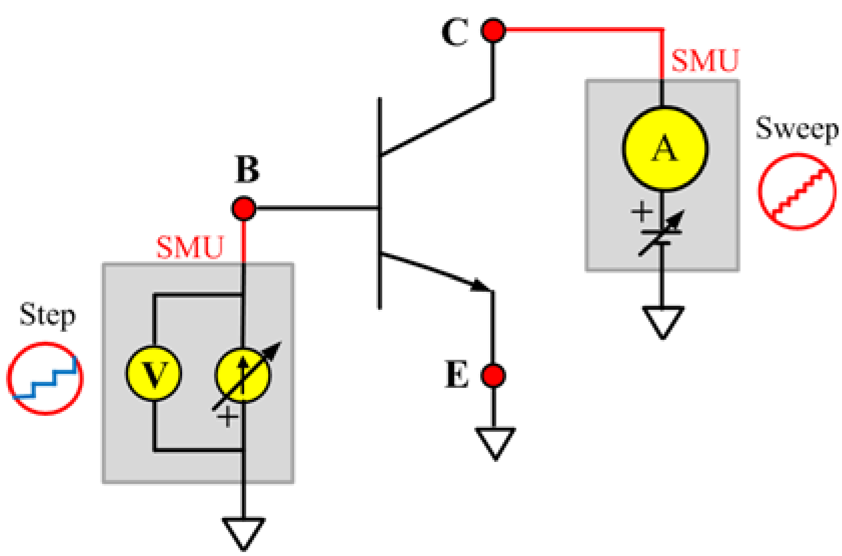
Module name: IcVce_StepIb

DUT: Three-terminal npnBJT

Function: Measures the collector current based on the base step current and the collector sweep voltage and measures a series of IcVce curves with a base current step.

Pin connections: Use a SMU to apply a sweep voltage to the collector. Use a SMU to apply a step current to the base. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 39: Three-terminal npnBJT IcVce_StepIb pin connections



IcVce_StepIb ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IcVce_StepIb General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IcVce_StepVb

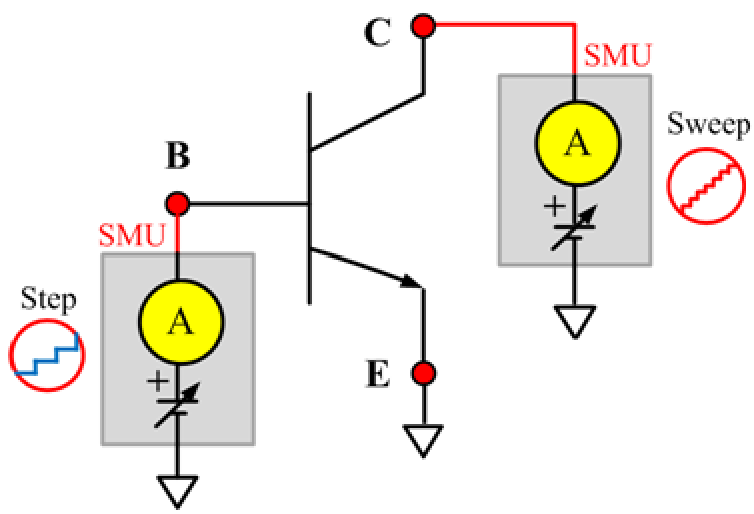
Module name: IcVce_StepVb

DUT: Three-terminal npnBJT

Function: Measures the collector current based on the base step and the collector sweep voltage and measures a series of IcVce curves with a base voltage step.

Pin connections: Use a SMU to apply a sweep voltage to the collector. Use a SMU to apply a step voltage to the base. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 40: Three-terminal npnBJT IcVce_StepVb pin connections



IcVce_StepVb ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IcVce_StepVb General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IEBO

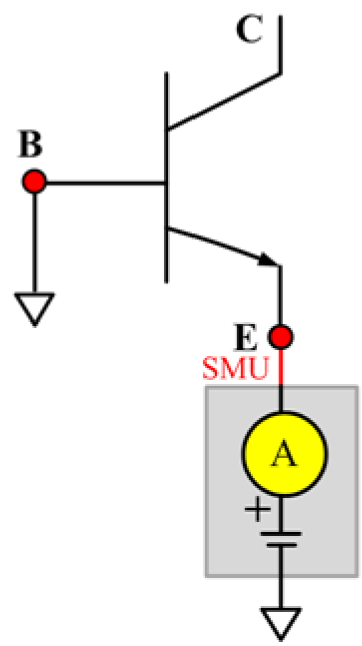
Module name: IEBO

DUT: Three-terminal npnBJT

Function: Measures the emitter-base cut off current with the collector opened.

Pin connections: Use a SMU to force voltage to the emitter. Connect the base to GND or use a SMU to supply a zero-voltage bias. Open the circuit to the collector or use a SMU to supply a zero-current bias.

Figure 41: Three-terminal npnBJT IEBO pin connections



IEBO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IECO

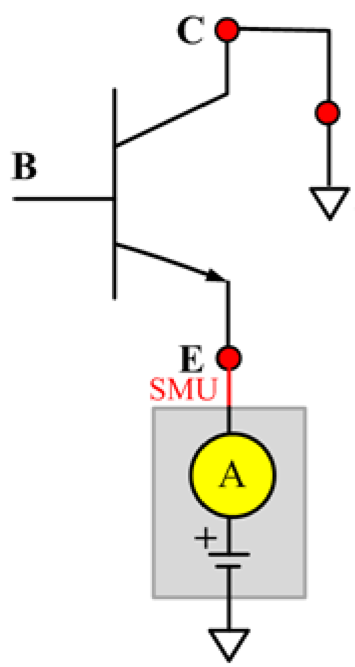
Module name: IECO

DUT: Three-terminal npnBJT

Function: Measures the emitter-collector current with the base opened.

Pin connections: Use a SMU to force voltage to the emitter. Open the circuit to the collector or use a SMU to supply a zero-voltage bias. Open the circuit to the base or use a SMU to supply a zero-current bias.

Figure 42: Three-terminal npnBJT IECO pin connections



IECO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IeVeb

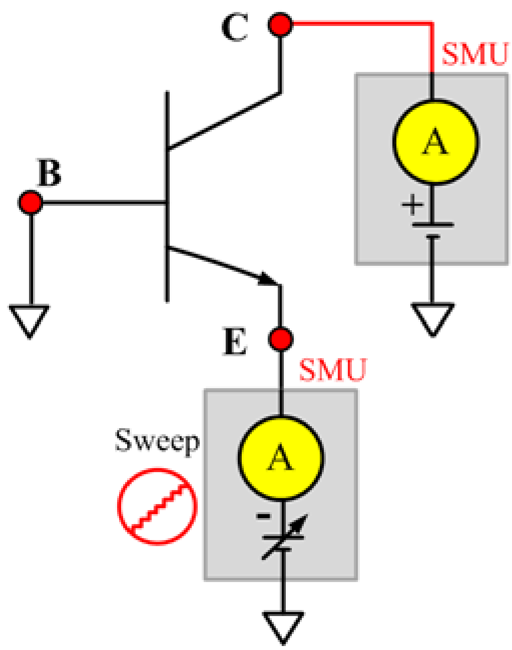
Module name: IeVeb

DUT: Three-terminal npnBJT

Function: Measures the emitter current of the npnBJT with a specified sweeping emitter voltage and measures the IeVeb curves.

Pin connections: Use a SMU to apply a sweep voltage to the emitter. Use a SMU to apply biased voltage to the collector. Connect the base to GND or use a SMU to supply a zero-voltage bias.

Figure 43: Three-terminal npnBJT IeVeb pin connections



IeVeb ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

VBCO

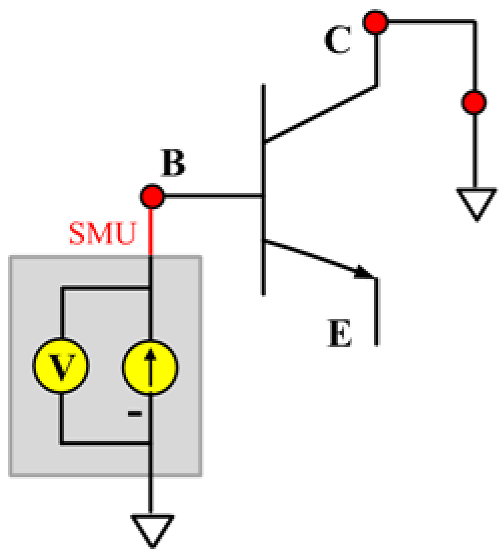
Module name: VBCO

DUT: Three-terminal npnBJT

Function: Measures the base-collector voltage of the npnBJT with the emitter opened.

Pin connections: Use a SMU to apply a biased current to the base. Connect the collector to GND or use a SMU to supply a zero-voltage bias. Open the circuit to the emitter or use a SMU to supply a zero-current bias.

Figure 44: Three-terminal npnBJT VBCO pin connections



VBCO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

VBCO General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

VCE

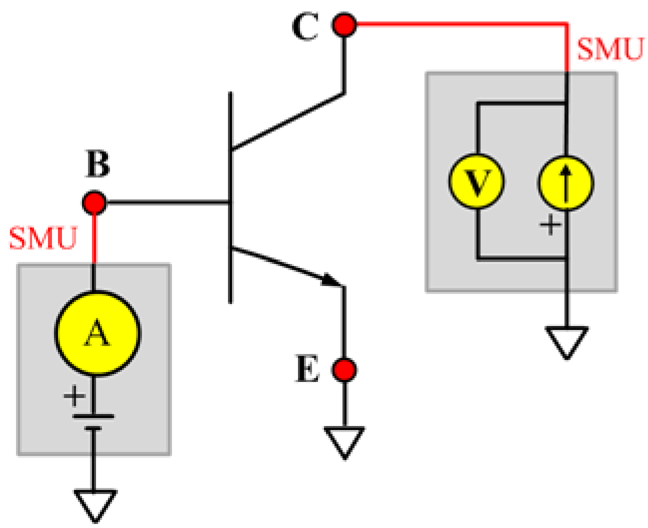
Module name: VCE

DUT: Three-terminal npnBJT

Function: Measures the collector-emitter voltage of the npnBJT device.

Pin connections: Use a SMU to apply a biased current to the collector. Use a SMU to apply a biased voltage to the base. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 45: Three-terminal npnBJT VCE pin connections



VCE ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

VCE General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

npnPowerBJT library

The npnPowerBJT library components are in the following directory:

```
C:\ACS_BASIC\library\devLibrary\npnPowerBJT
```

You can use this npnPowerBJT parametric library to test parameters of a npn-type power BJT, including leakage, breakdown, gain, on-state, capacitance, and characteristic curves.

BVCBO

Module name: BVCBO

Module type: ITM

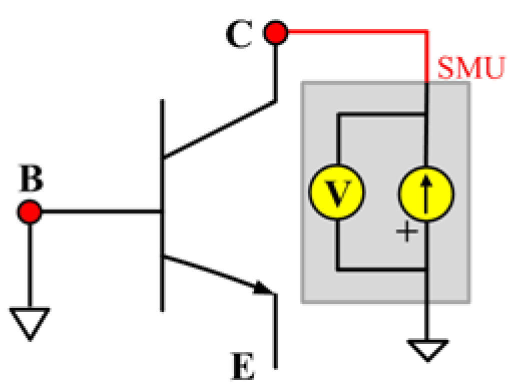
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal npnPowerBJT

Function: Measures the collector-base breakdown voltage with the emitter opened. The voltage is measured with a specific collector current that is given in the datasheet.

Pin connections: Use a SMU to force current and make a voltage measurement from the collector to the base. Connect the base to GND or use a SMU to supply a zero-voltage bias. Open the circuit to the emitter or use a SMU to supply a zero-current bias.

Figure 46: npnPowerBJT BVCBO pin connections



BVCEO

Module name: BVCEO

Test type: ITM

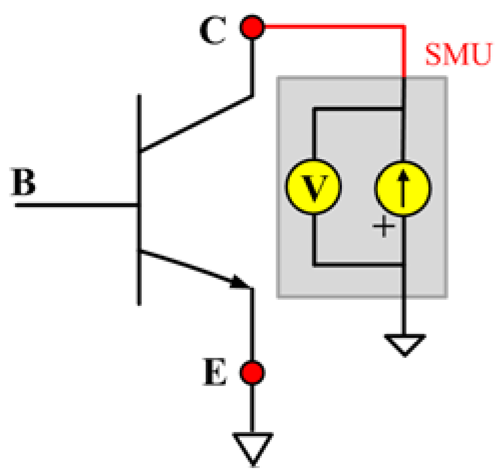
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal npnPowerBJT

Function: Measures the collector-emitter breakdown voltage with the base opened. The voltage is measured with a specific collector current that is given in the data sheet.

Pin connections: Use a SMU to force current and make a voltage measurement from the collector to emitter. Connect the emitter to GND or use a SMU to supply a zero-current bias. Open the circuit to the base or use a SMU to supply a zero-current bias.

Figure 47: npnPowerBJT BVCEO pin connections



BVEBO

Module name: BVEBO

Test type: ITM

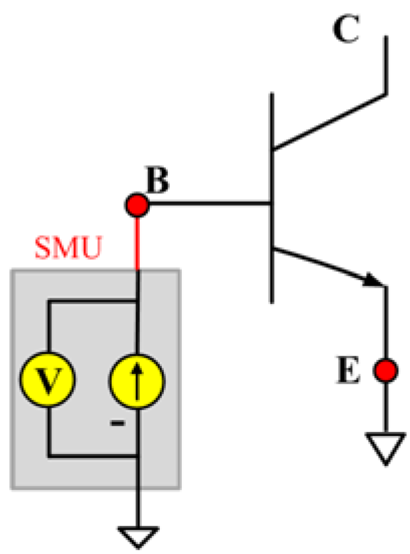
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal npnPowerBJT

Function: Measures the emitter-base breakdown voltage with the collector opened. The voltage is measured with a specific base current or emitter current in reverse direction that is given in the data sheet.

Pin connections: Use a SMU to force current and make a voltage measurement from the base to the emitter. Connect the emitter to GND or use a SMU to supply a zero-voltage bias. Open the circuit to the collector or use a SMU to supply a zero-current bias.

Figure 48: npnPowerBJT BVEBO pin connections



Ccb

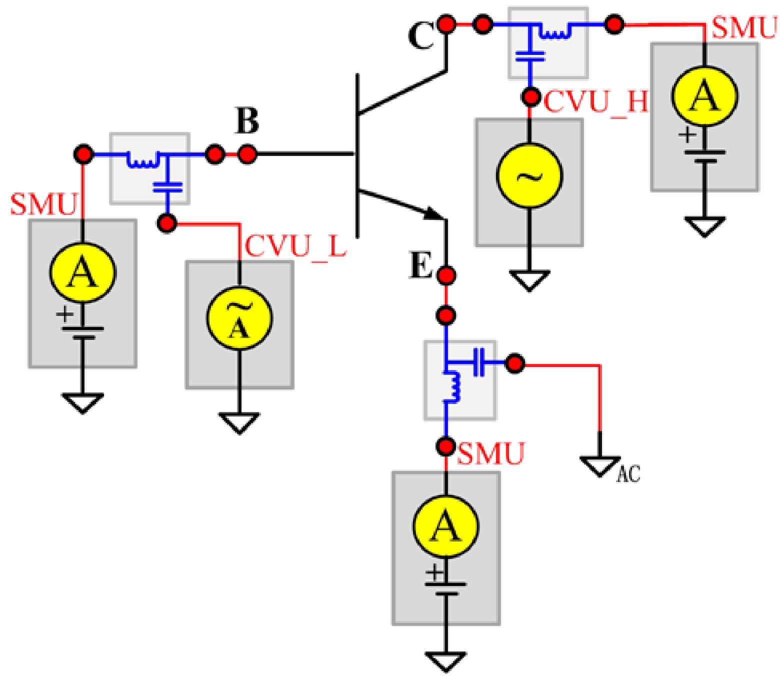
Module Name: Ccb

DUT: Three-terminal npnPowerBJT

Function: Measures the capacitance between the Collector and Base terminals with the Emitter terminal connected to the guard terminal of a three-terminal bridge.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the collector. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the base. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the guard terminal of a three-terminal bridge through one remote bias tee to the emitter. Use the Series 2600B to supply zero voltage bias.

Figure 49: Three-terminal npnPowerBJT Ccb pin connections



Ccb PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Cce

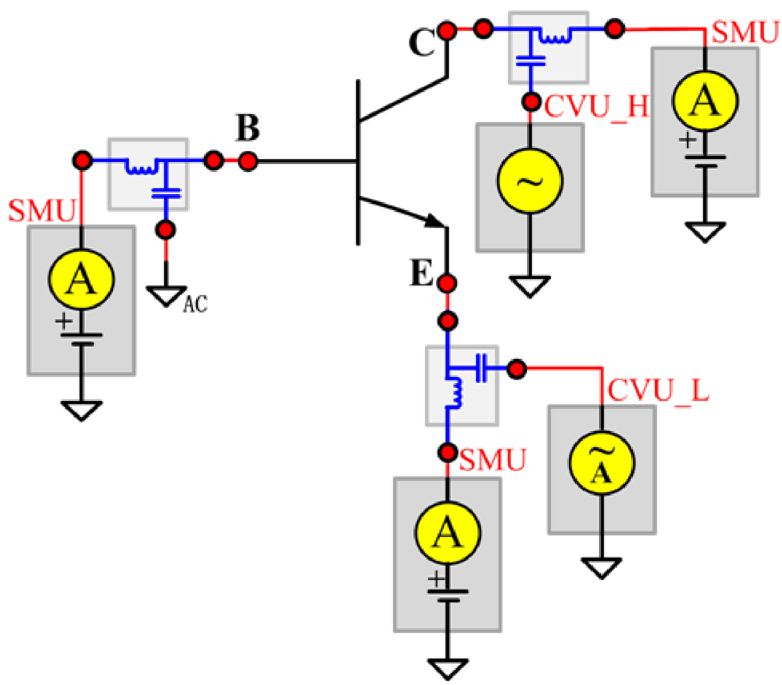
Module Name: Cce

DUT: Three-terminal npnPowerBJT

Function: Measures the capacitance between the collector and emitter terminals with the base terminal connected to the guard terminal of a three-terminal bridge.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the collector. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the emitter. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the guard terminal of a three-terminal bridge through one remote bias tee to the base. Use the Series 2600B to supply zero voltage bias.

Figure 50: Three-terminal npnPowerBJT Cce pin connections



Cce PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Ceb

Description:

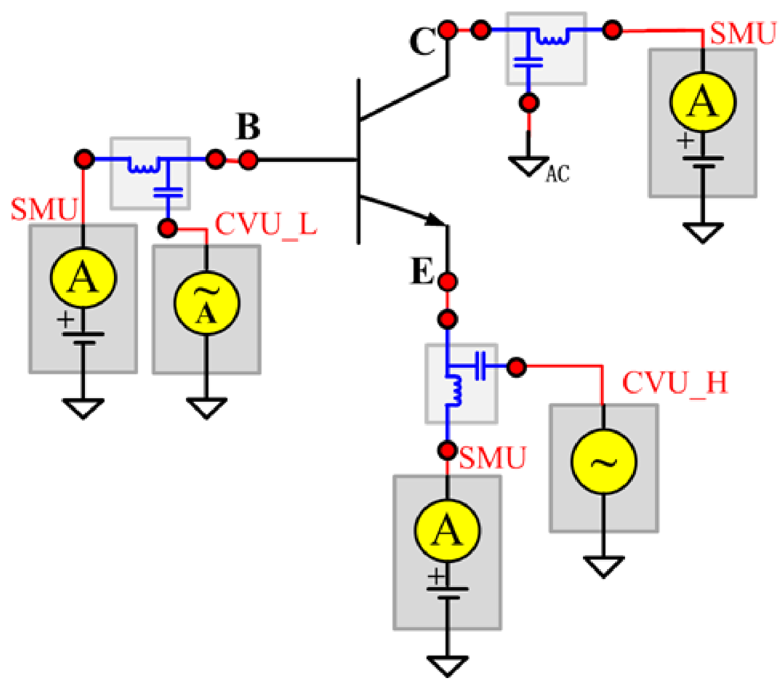
Module Name: Ceb

DUT: Three-terminal npnPowerBJT

Function: Measures the capacitance between the emitter and base terminals with the collector terminal connected to the guard terminal of a three-terminal bridge.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the emitter. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the base. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the guard terminal of a three-terminal bridge through one remote bias tee to the collector. Use the Series 2600B to supply zero voltage bias.

Figure 51: Three-terminal npnPowerBJT Ceb pin connections



Ceb PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Cibo

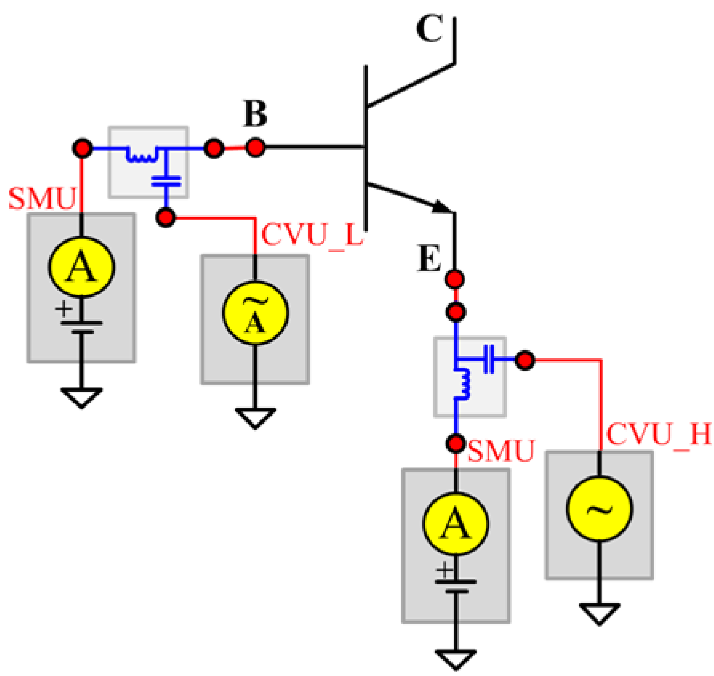
Module Name: Cibo

DUT: Three-terminal npnPowerBJT

Function: Measures the capacitance between the input terminals (base and emitter) with the collector terminal open.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the emitter. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the base. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the guard terminal of a three-terminal bridge through one remote bias tee to the collector. Use the Series 2600B to supply zero voltage bias.

Figure 52: Three-terminal npnPowerBJT Cibo pin connections



Cibo PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Cobo

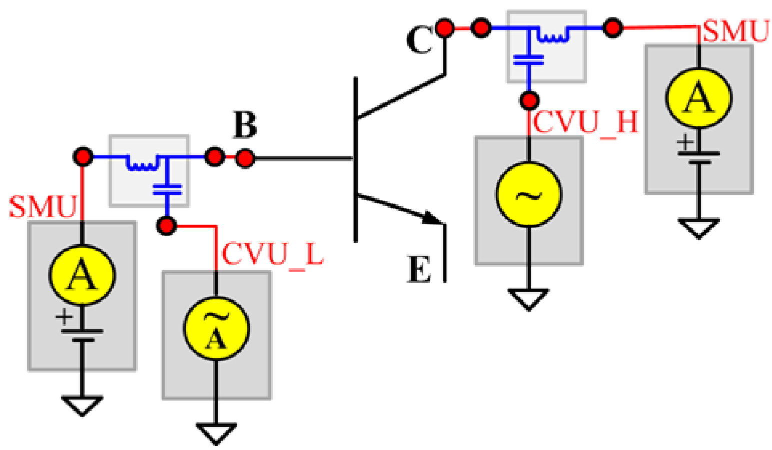
Module Name: Cobo

DUT: Three-terminal npnPowerBJT

Function: Measures the capacitance between the output terminals (base and collector) with the emitter terminal open.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the collector. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the base. Use the Series 2600B to supply zero voltage bias. Open the circuit to the emitter.

Figure 53: Three-terminal npnPowerBJT Cobo pin connections



Cobo PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

HFE

Module name: HFE

Test type: ITM

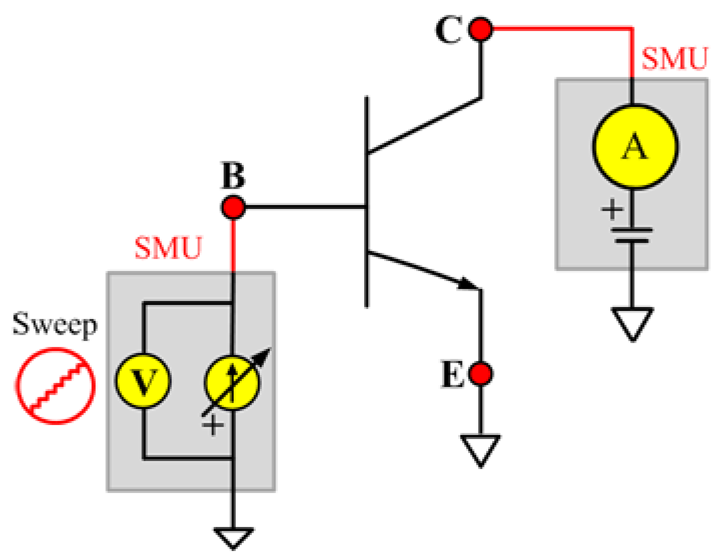
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal npnPowerBJT

Function: Measures the collector-emitter static forward current transfer ratio with the output voltage (Vce) held constant (HFE = Ic/Ib).

Pin connections: Use one SMU to apply voltage bias and make a current measurement from the collector to the emitter. Connect the emitter to GND or use a SMU to supply a zero-voltage bias. Use a SMU to apply a sweep current to the base.

Figure 54: npnPowerBJT HFE pin connections



ICBO

Module name: ICBO

Test type: ITM

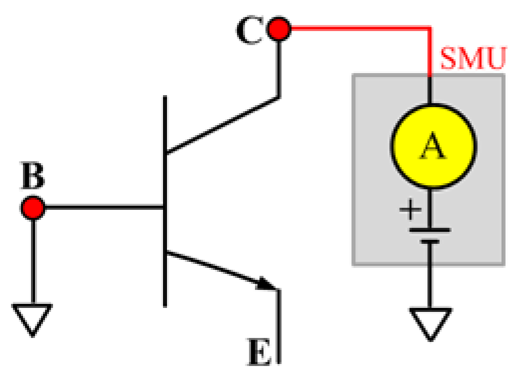
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal npnPowerBJT

Function: Measures the collector-base cut-off current. Measures the current on the collector with a reverse bias on the collector-base and with the emitter opened.

Pin connections: Use a SMU to force voltage and make a current measurement from the collector to base. Connect the base to GND or use a SMU to supply a zero-voltage bias. Open the circuit to the emitter or use a SMU to supply a zero-current bias.

Figure 55: npnPowerBJT ICBO pin connections



ICEO

Module name: ICEO

Module type: ITM

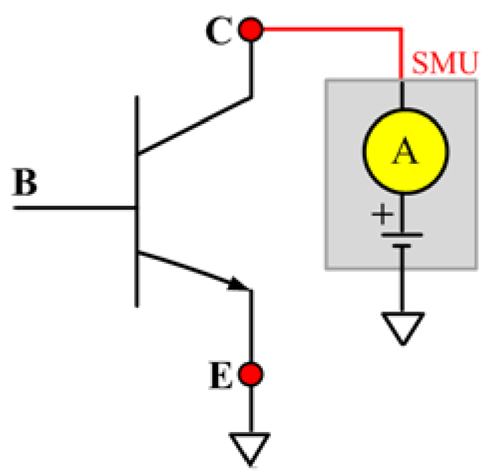
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal npnPowerBJT

Function: Measures the collector-emitter cut-off current with the base opened.

Pin connections: Use a SMU to force voltage and make a current measurement from the collector to the emitter. Connect the emitter to GND or use a SMU to supply a zero-voltage bias. Open the circuit to the base or use a SMU to supply a zero-current bias.

Figure 56: npnPowerBJT ICEO pin connections



ICES

Module name: ICES

Test type: ITM

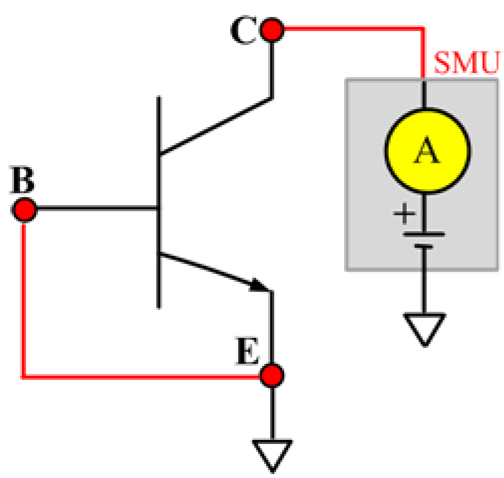
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal npnPowerBJT

Function: Measures the collector-emitter cut-off current with the base short-circuited to the emitter.

Pin connections: Use a SMU to force voltage and make a current measurement from the collector to the emitter. Short the base to the emitter or use a SMU to supply a zero-voltage bias.

Figure 57: npnPowerBJT ICES pin connections



ICEV

Module name: ICEV

Test type: ITM

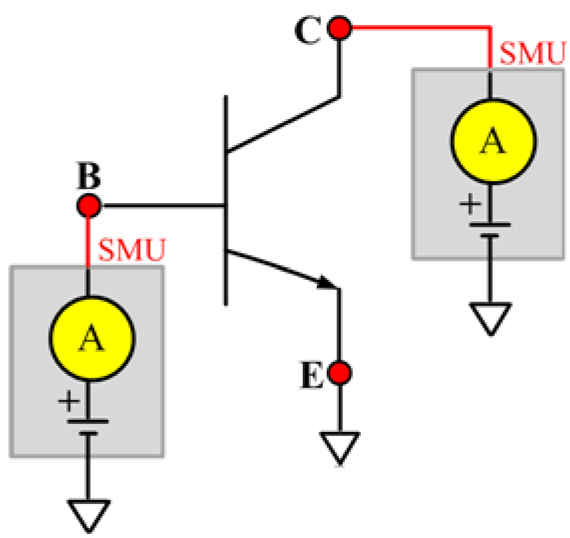
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal npnPowerBJT

Function: Measures the collector-emitter cut-off current with a reverse bias on the emitter-base.

Pin connections: Use a SMU to force voltage and make a current measurement from the collector to the emitter. Connect the emitter to GND or use a SMU to supply a zero-voltage bias. Use another SMU to bias the base with a specified voltage.

Figure 58: npnPowerBJT ICEV pin connections



IcVce_StepIb

Module name: IcVce_StepIb

Module type: ITM

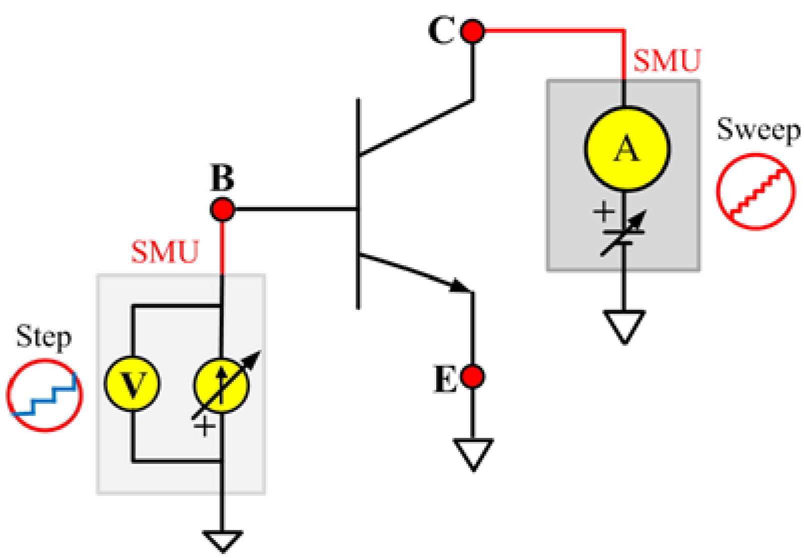
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal npnPowerBJT

Function: Measures the collector-emitter output characteristic curve with a current step at the base.

Pin connections: Use one SMU to apply a voltage sweep and make a current measurement from collector to emitter. Connect the emitter to GND or use a SMU to supply a zero-voltage bias. Use a SMU to apply a current step to the base.

Figure 59: npnPowerBJT IcVce_StepIb pin connections



IcVce_StepIb_MIX

Module name: IcVce_StepIb_MIX

Test type: PTM

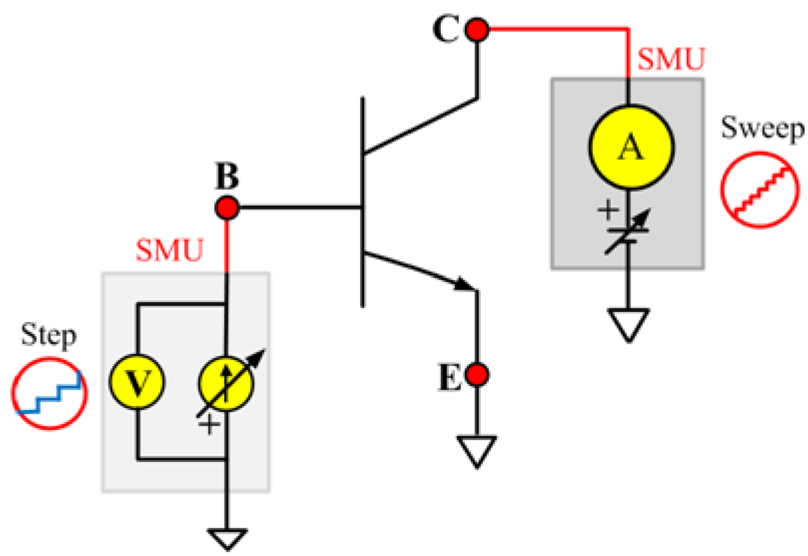
Instrument: Keithley Instruments Model 2657A, and Series 2600B, Series 2400, Model 4200A-SMU

DUT: Three-terminal npnPowerBJT

Function: Measures the collector-emitter output characteristic curve with a current step at the base.

Pin connections: Use a SMU to apply a voltage sweep and make a current measurement from the collector to the emitter. Connect the emitter to GND or use a SMU to supply a zero-voltage bias. Use a SMU to apply current step to base.

Figure 60: npnPowerBJT IcVce_StepIb_MIX pin connections



IcVce_StepVbe

Module name: IcVce_StepVbe

Test type: ITM

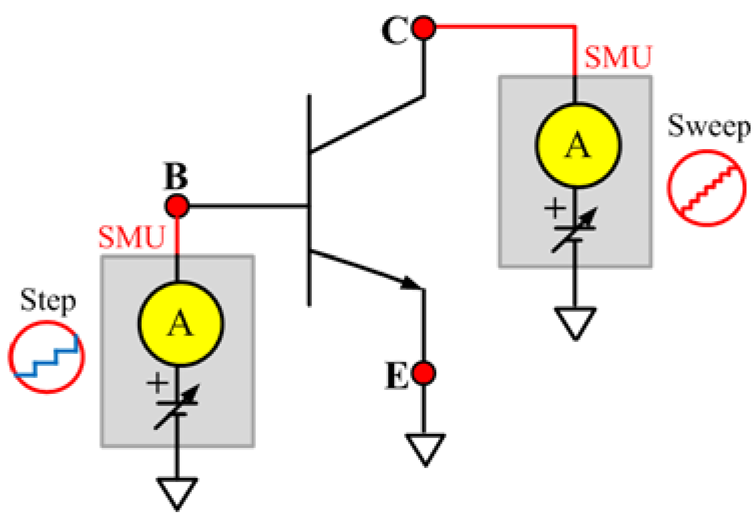
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal npnPowerBJT

Function: Measures the collector-emitter output characteristic curve with a voltage step at the base.

Pin connections: Use a SMU to apply a voltage sweep and make a current measurement from collector to emitter. Connect the emitter to GND or use a SMU to supply a zero-voltage bias. Use a SMU to apply a voltage step to the base-emitter junction.

Figure 61: npnPowerBJT IcVce_StepVbe pin connections



IcVce_StepVbe_MIX

Module name: IcVce_StepVbe

Module type: PTM

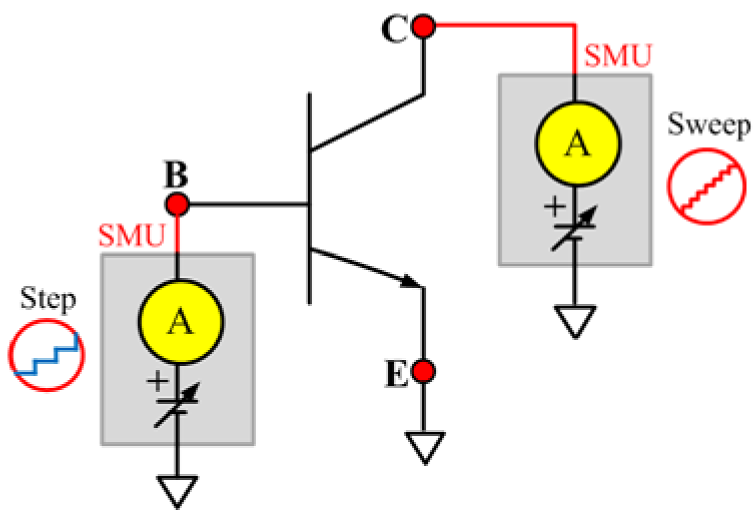
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200A-SMU

DUT: Three-terminal npnPowerBJT

Function: Measures the collector-emitter output characteristic curve with a voltage step on the emitter-base junction.

Pin connections: Use a SMU to apply a voltage sweep and make a current measurement from the collector to the emitter. Connect the emitter to GND or use a SMU to supply a zero-voltage bias. Use a SMU to apply a voltage step to the base-emitter junction.

Figure 62: npnPowerBJT IcVce_StepVbe_MIX pin connections



IEBO

Module name: IEBO

Test type: ITM

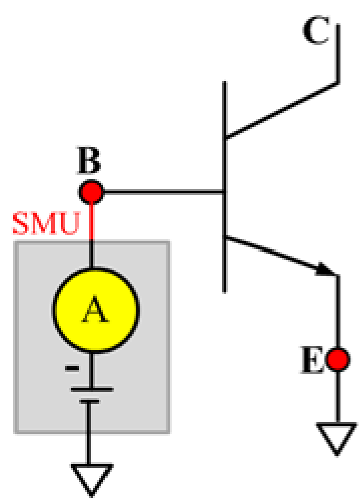
Instrument: Keithley Instruments Series 2600B

DUT: Three-terminal npnPowerBJT

Function: Measures the emitter-base cut-off current. Measures the current on the emitter with reverse bias on the emitter-base and with the collector opened.

Pin connections: Use a SMU to force voltage and make a current measurement from the base to the emitter. Connect the emitter to GND or use a SMU to supply a zero-voltage bias. Open the circuit to the collector or use a SMU to supply a zero-current bias.

Figure 63: npnPowerBJT IEBO pin connections



VbeON

Module name: VbeON

Test type: ITM

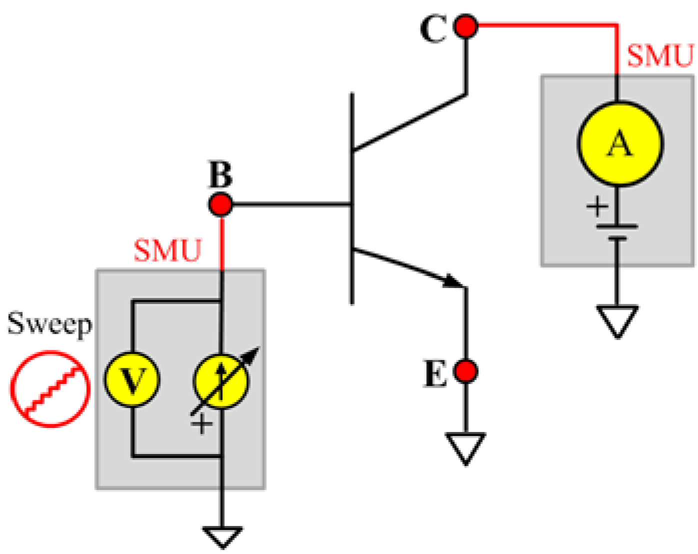
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal npnPowerBJT

Function: Measures the on voltage of the base-emitter when the BJT is in the active region. The voltage is measured with the base-emitter forward biased and the collector-emitter voltage higher than the VceSAT.

Pin connections: Use a SMU to apply a current sweep and make a voltage measurement from the base to the emitter. Connect the emitter to GND or use a SMU to supply a zero-voltage bias. Use a SMU to apply voltage bias to the collector.

Figure 64: npnPowerBJT VbeON pin connections



VbeSAT

Module name: VbeSAT

Test type: ITM

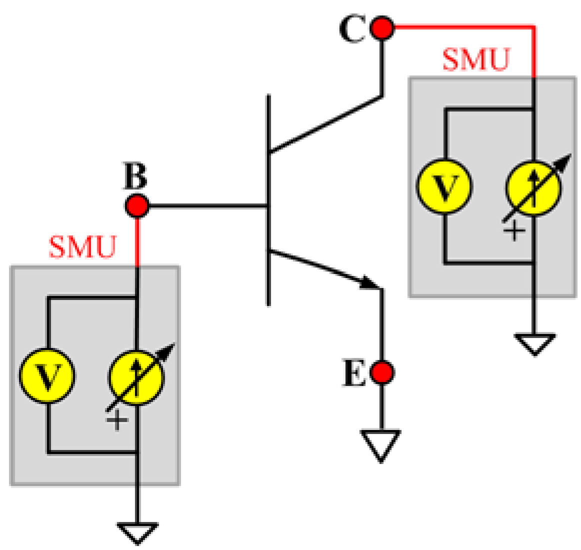
Instrument: Keithley Instruments Models 2651A, Series 2600B

DUT: Three-terminal npnPowerBJT

Function: Measures the base-emitter saturation voltage. The voltage is measured at a specific base current and a collector current that is given in the data sheet to ensure that both the emitter-base and collector-base junctions are forward biased.

Pin connection: Use a SMU to force current and make a voltage measurement from the base to the emitter. Connect the emitter to GND or use a SMU to supply a zero-voltage bias. Use one SMU to apply current bias to the collector.

Figure 65: npnPowerBJT VbeSAT pin connections



VceSAT

Module name: VceSAT

Test type: ITM

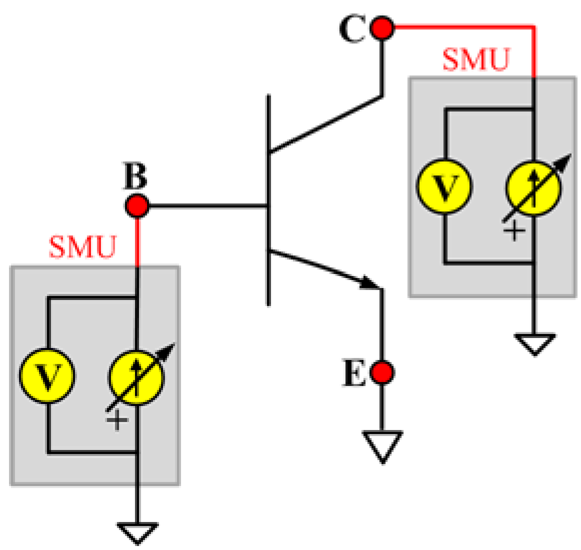
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal npnPowerBJT

Function: Measures the collector-emitter saturation voltage. The voltage is measured at a specific base current and collector current that is given in the data sheet to ensure that both the emitter-base and collector-base junctions are forward biased.

Pin connections: Use a SMU to force current and make a voltage measurement from the collector to the emitter. Connect the emitter to GND or use a SMU to supply a zero-voltage bias. Use a SMU to apply a current bias to the base.

Figure 66: npnPowerBJT VceSAT pin connections



VceSAT_MIX

Module name: VceSAT_MIX

Module type: PTM

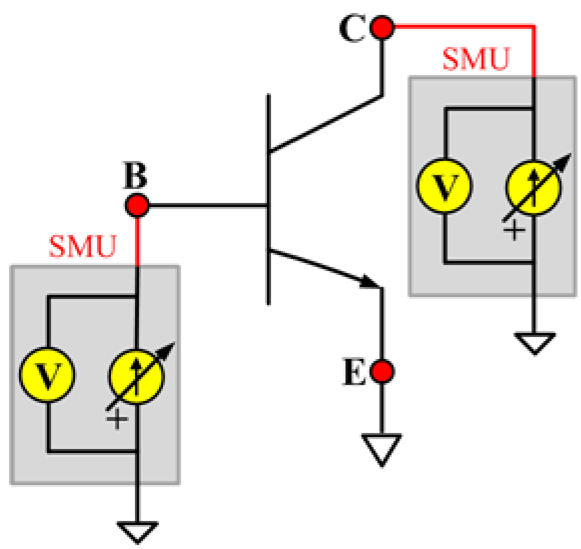
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200A-SMU

DUT: Three-terminal npnPowerBJT

Function: Measures the collector-emitter saturation voltage. The voltage is measured at a specific base current and collector current that is given in the data sheet to ensure that both the emitter-base and collector-base junctions are forward biased.

Pin connections: Use a SMU to force current and make a voltage measurement from the collector to the emitter. Connect the emitter to GND or use a SMU to supply a zero-voltage bias. Use a SMU to apply current bias to the base.

Figure 67: npnPowerBJT VceSAT_MIX pin connections



VCESUS

Module name: VCESUS

Test type: ITM

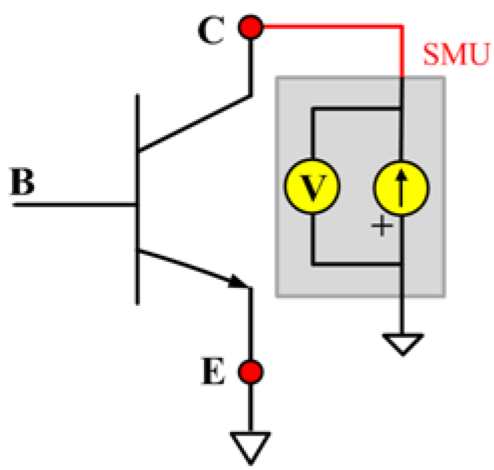
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal npnPowerBJT

Function: Measures the collector-emitter sustaining voltage with the base opened. The voltage is measured at a specific collector current that is given in the data sheet.

Pin connections: Use a SMU to force current and make a voltage measurement from the collector to the emitter. Connect the emitter to GND or use a SMU to supply a zero-voltage bias. Open the circuit to the base or use a SMU to supply a zero-current bias.

Figure 68: npnPowerBJT VCESUS pin connections



pnpBJT library

pnpBJT parametric library overview

The pnpBJT device library components are in the following directory:

```
C:\ACS_BASIC\library\devLibrary\pnpBJT
```

You can use the tests in the pnpBJT device parametric library to test parameters of a pnp-type BJT, including leakage, breakdown, gain, on-state, capacitance, and characteristic curves.

BVCBO

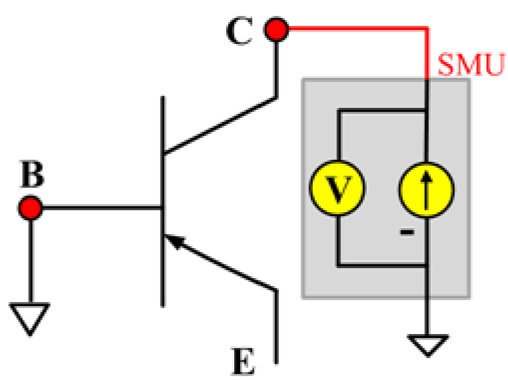
Module name: BVCBO

DUT: Three-terminal BJT

Function: Measures the collector-base breakdown voltage of the BJT with the emitter open.

Pin connections: Use one SMU to force a reverse current to the collector. Open the circuit to the emitter or use a SMU to supply a zero-current bias. Connect the base to GND or use a SMU to supply a zero-voltage bias.

Figure 69: pnpBJT and pnpPowerBJT BVCBO pin connections



BVCBO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

BVCBO General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVCEI

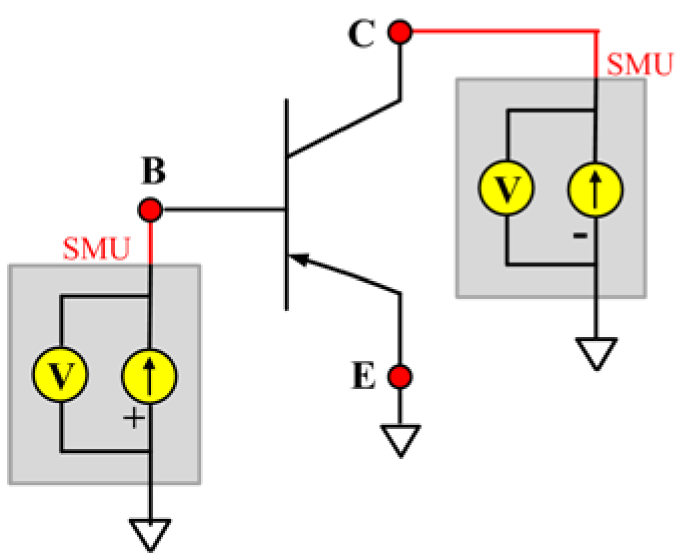
Module name: BVCEI

DUT: Three-terminal pnpBJT

Function: Measures the collector-emitter breakdown voltage of the pnpBJT device with a bias base-forced current.

Pin connections: Use two SMUs to force current to the base and collector. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 70: Three-terminal pnpBJT BVCEI pin connections



BVCEI ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

BVCEI General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVCEO

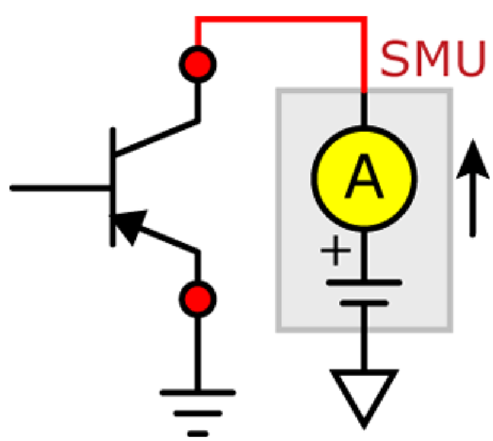
Module name: BVCEO

DUT: Three-terminal pnpBJT

Function: Measures the collector-emitter breakdown voltage with the base opened.

Pin connections: Use a SMU to force current to the collector. Connect the emitter to GND or use a SMU to supply a zero-voltage bias. Open the circuit to the base or use a SMU to supply a zero-current bias.

Figure 71: Three-terminal pnpBJT BVCEO pin connections



BVCEO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

Figure 72: Three-terminal pnpBJT BVCEO 2600B ITM setting

Device Num	SMU	Pad	Function	Force Range	Source	Measure	Compliance	Meas Range	Limits Auto
1	SMU2	Collector	Bias I	auto	-1.5e-009	I+V	20.0	auto	
	SMU3	Emitter	Bias V	auto	0	None	0.1		
	SMU1	Base	Open						

Figure 73: Three-terminal pnpBJT BVCEO 4200 ITM setting

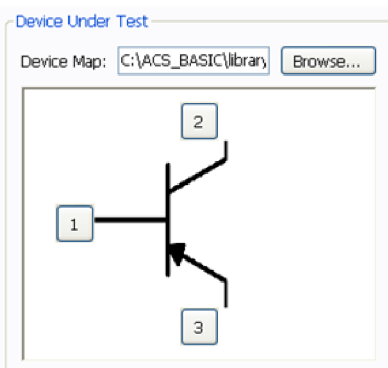
Device Num	SMU	Pad	Function	Force Range	Source	Measure	Compliance	Meas Range	Limits Auto
1	SMU2	Collector	Bias I	auto	-0.001	I+V	40.0	auto	
	SMU3	Emitter	Bias V	auto	0	None	0.1		
	SMU1	Base	Bias I	100nA	0.0	None	20.0		

BVCEO General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Figure 74: Three-terminal pnpBJT BVCEO General PTM setting



Common Settings

Test Speed	
PLC	1.0
Average	0
Test Mode	
Mode	Sweeping
Delay Time(s)	0.0
Hold Time(s)	0.0
Enable Timestamp	False
Advanced	
Test End Reset	True
Enable Trigger	False

	Pad Name	SMU ID	Force Func	Force Range	Force Value	Meas Variable	Compliance	Meas Range
1	Collector	SMU2	Bias I	auto	-1.5e-009	I+V	20.0	auto
2	Emitter	SMU3	Bias V	auto	0	None	0.1	
3	Base	SMU1	Open					

BVCEV

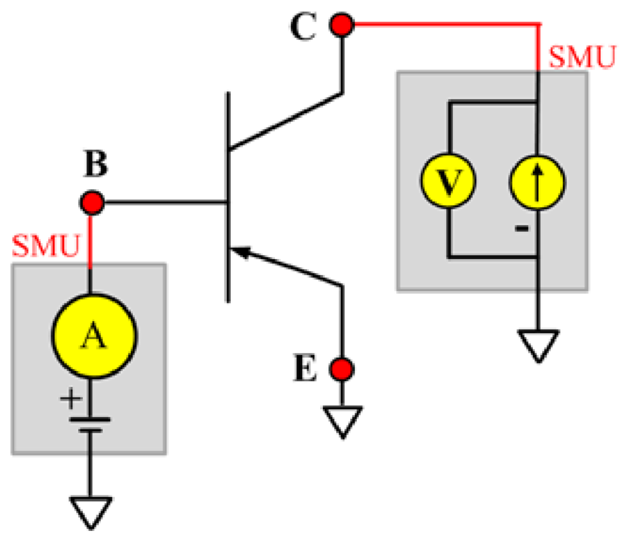
Module name: BVCEV

DUT: Three-terminal pnpBJT

Function: Measures the collector-emitter breakdown voltage with the base forced with a voltage bias.

Pin connections: Use two SMUs to force voltage to the base and collector. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 75: Three-terminal pnpBJT BVCEV pin connections



BVCEV ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

BVCEV General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVEBO

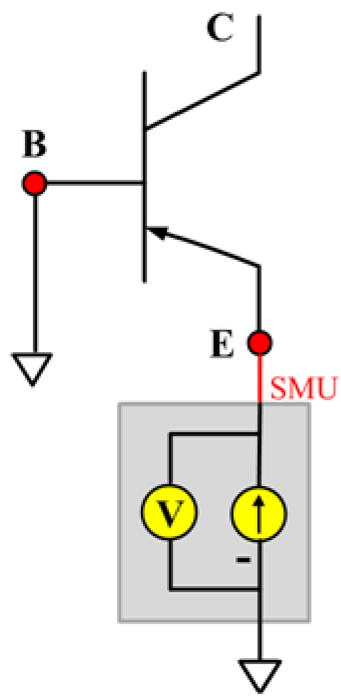
Module name: BVEBO

DUT: Three-terminal pnpBJT

Function: Measures the emitter-base breakdown voltage of the pnpBJT device with the collector opened.

Pin connections: Use a SMU to force current to the emitter. Connect the emitter to GND or use a SMU to supply a zero-voltage bias. Open the circuit to the collector or use a SMU to supply a zero-current bias.

Figure 76: Three-terminal pnpBJT BVEBO pin connections



BVEBO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

BVEBO General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVECO

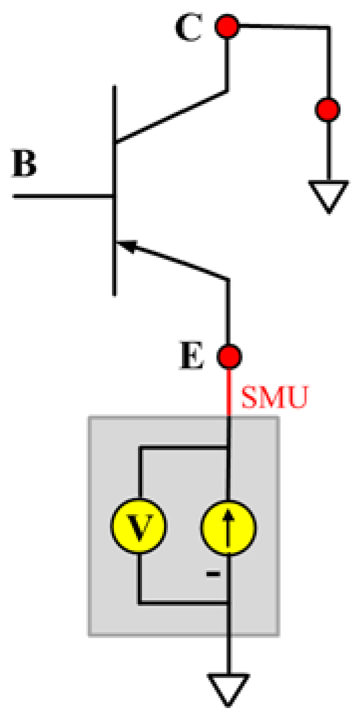
Module name: BVECO

DUT: Three-terminal pnpBJT

Function: Measures the emitter-collector breakdown voltage of the pnpBJT device with the base opened.

Pin connections: Use a SMU to force current to the emitter. Open the circuit to the base or use a SMU to supply a zero-current bias. Connect the collector to GND or use a SMU to supply a zero-voltage bias.

Figure 77: Three-terminal pnpBJT BVECO pin connections



BVECO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

BVECO General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Ccb

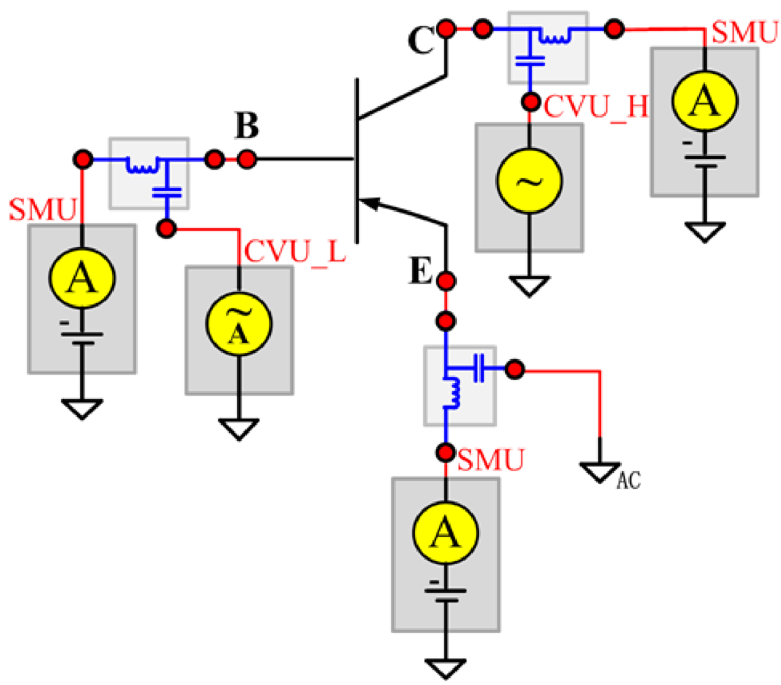
Module Name: Ccb

DUT: Three-terminal pnpBJT

Function: Measures the capacitance between the Collector and Base terminals with the Emitter terminal connected to the guard terminal of a three-terminal bridge.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the collector. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the base. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the guard terminal of a three-terminal bridge through one remote bias tee to the emitter. Use the Series 2600B to supply zero voltage bias.

Figure 78: Three-terminal pnpBJT Ccb pin connections



Ccb PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Cce

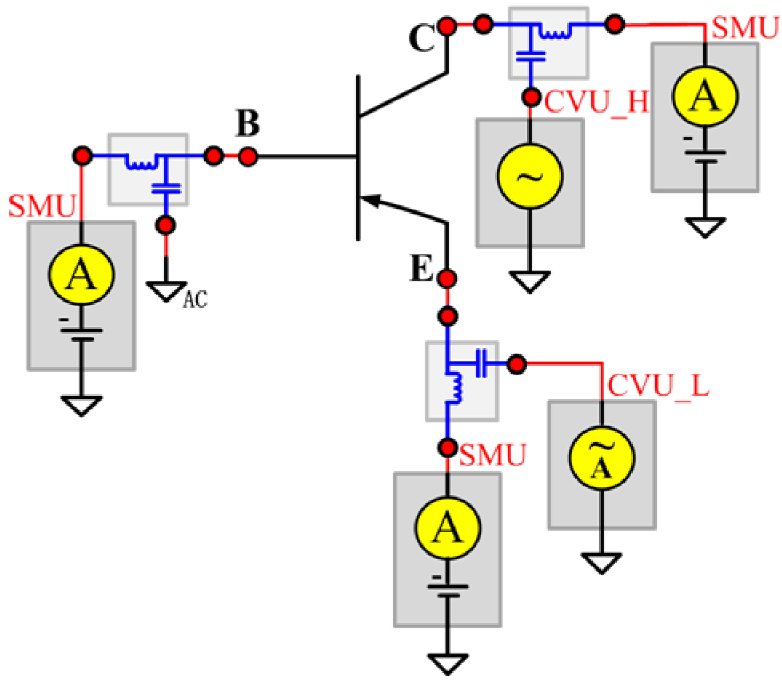
Module Name: Cce

DUT: Three-terminal pnpBJT

Function: Measures the capacitance between the collector and emitter terminals with the base terminal connected to the guard terminal of a three-terminal bridge.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the collector. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the emitter. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the guard terminal of a three-terminal bridge through one remote bias tee to the base. Use the Series 2600B to supply zero voltage bias.

Figure 79: Three-terminal pnpBJT Cce pin connections



Cce PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Ceb

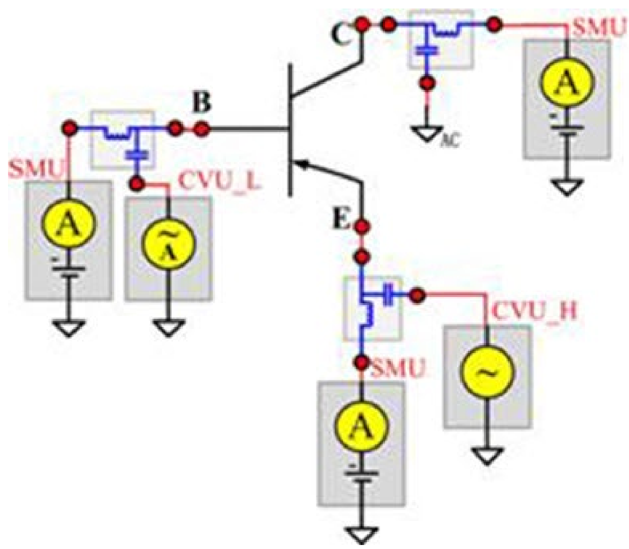
Module Name: Ceb

DUT: Three-terminal pnpBJT

Function: Measures the capacitance between the emitter and base terminals with the collector terminal connected to the guard terminal of a three-terminal bridge.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the emitter. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the base. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the guard terminal of a three-terminal bridge through one remote bias tee to the collector. Use the Series 2600B to supply zero voltage bias.

Figure 80: Three-terminal pnpBJT Ceb pin connections



Ceb PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Cibo

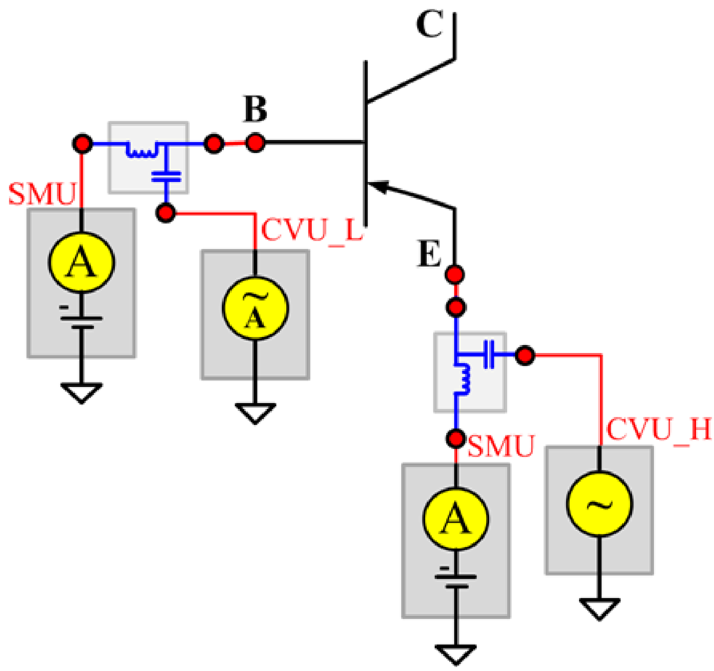
Module Name: Cibo

DUT: Three-terminal pnpBJT

Function: Measures the capacitance between the input terminals (base and emitter) with the collector terminal open.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the emitter. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the base. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the guard terminal of a three-terminal bridge through one remote bias tee to the collector. Use the Series 2600B to supply zero voltage bias.

Figure 81: Three-terminal pnpBJT Cibo pin connections



Cibo PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Cobo

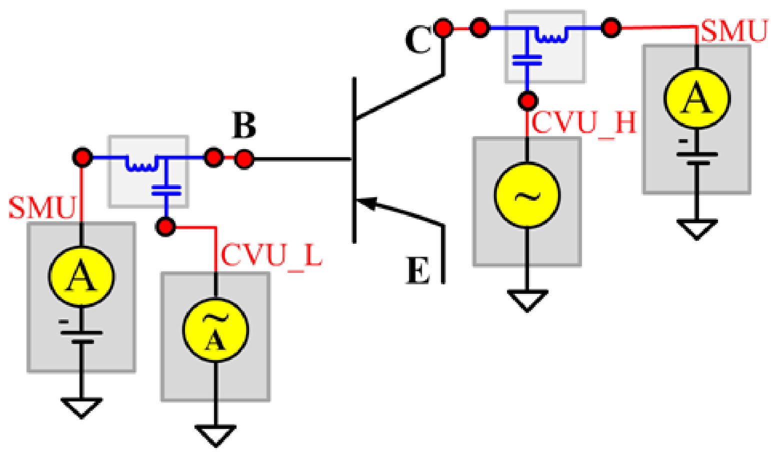
Module Name: Cobo

DUT: Three-terminal pnpBJT

Function: Measures the capacitance between the output terminals (base and collector) with the emitter terminal open.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the collector. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the base. Use the Series 2600B to supply zero voltage bias. Open the circuit to the emitter.

Figure 82: Three-terminal pnpBJT Cobo pin connections



Cobo PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

HFE

Module name: HFE

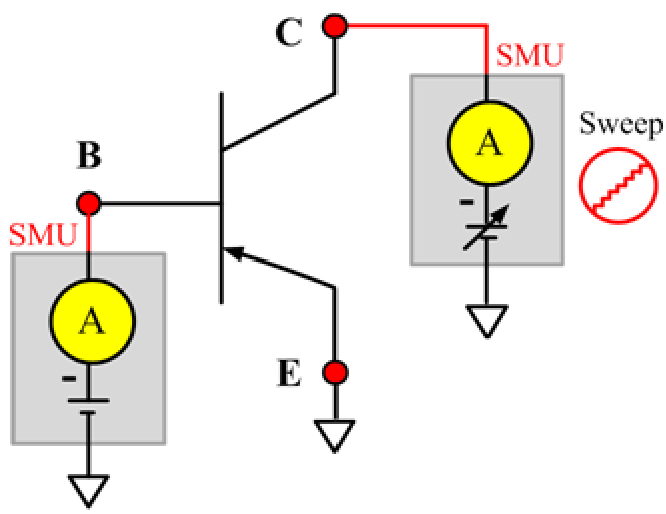
DUT: Three-terminal pnpBJT

Function: Measures the collector current, base current, and dc current gain based on the collector sweep voltage.

Pin connections: Use a SMU to apply a sweep voltage to the collector. Use a SMU to bias the base. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

- Force CollectorV sweep
- Measure Ib and Ic
- Check for measurement problems
- Calculate HFE= Ic/Ib

Figure 83: Three-terminal pnpBJT HFE sweep pin connections



HFE_sw ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

HFE_sw General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IBCO

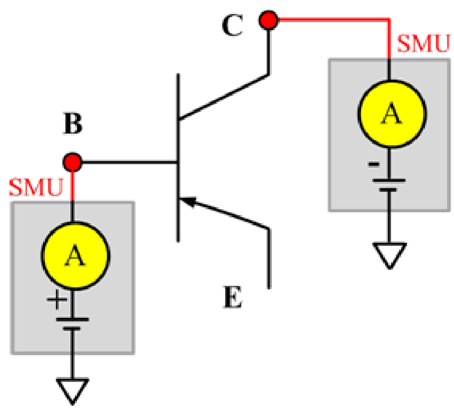
Module name: IBCO

DUT: Three-terminal pnpBJT

Function: Measures the base-collector current with the emitter opened.

Pin connections: Use a SMU to force voltage to the base. Connect the collector to GND or use a SMU to supply a zero-voltage bias. Open the circuit to the emitter or use a SMU to supply a zero-current bias.

Figure 84: Three-terminal pnpBJT IBCO pin connections



IBCO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IBCO General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IBEO

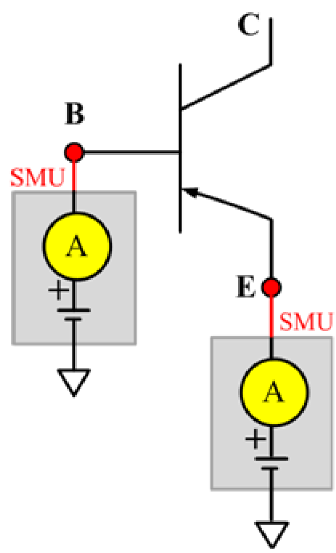
Module name: IBEO

DUT: Three-terminal pnpBJT

Function: Measures the base-emitter current with the collector opened.

Pin connections: Use a SMU to force voltage to the base. Connect the emitter to GND or use a SMU to supply a zero-voltage bias. Open the circuit to the collector or use a SMU to supply a zero-current bias.

Figure 85: Three-terminal pnpBJT IBEO pin connections



IBEO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IBEO General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IbIcVbe

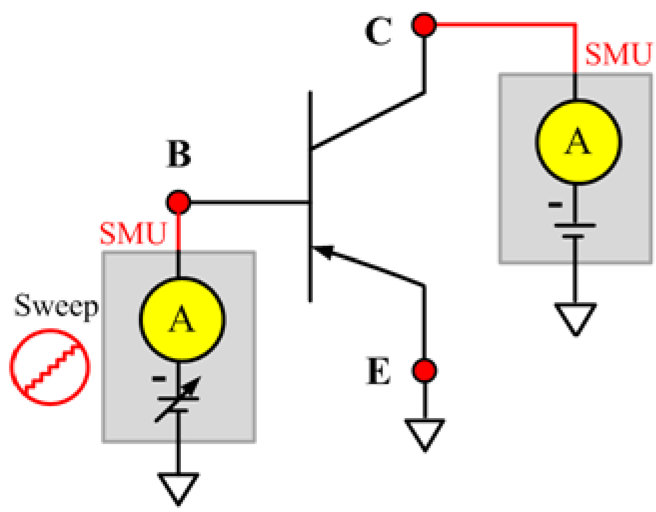
Module name: IbIcVbe

DUT: Three-terminal pnpBJT

Function: Measures the base current and collector current of the pnpBJT device with a specified base voltage sweep, measures the IbVbe and IcVbe curves, and measures the Gummel plot if the axis properties of the data plot have changed (the logarithm instead of right-angle coordinate.

Pin connections: Use a SMU to apply a sweep voltage to the base. Use a SMU to bias the collector. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 86: Three-terminal pnpBJT IbIcVbe pin connections



IbIcVbe ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IbIcVbe General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IbVbe

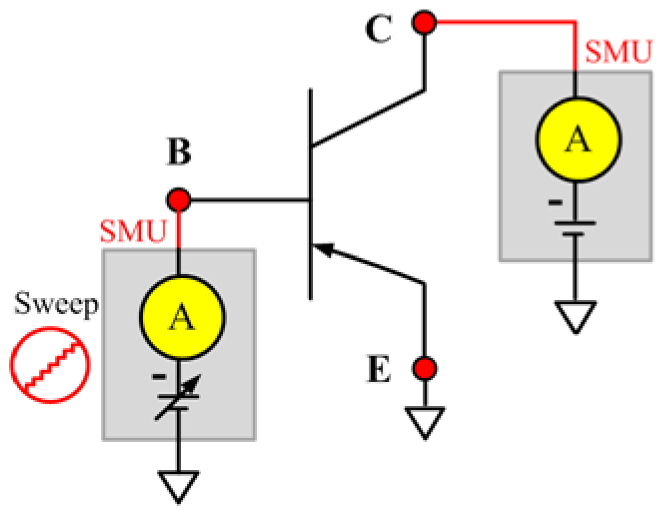
Module name: IbVbe

DUT: Three-terminal pnpBJT

Function: Measures the base current of the pnpBJT device with a specified base voltage sweep and measures the IbVbe curve.

Pin connections: Use a SMU to apply a sweep voltage to the base. Use a SMU to bias the collector. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 87: Three-terminal pnpBJT IbVbe pin connections



IbVbe ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IbVbe General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

ICBO

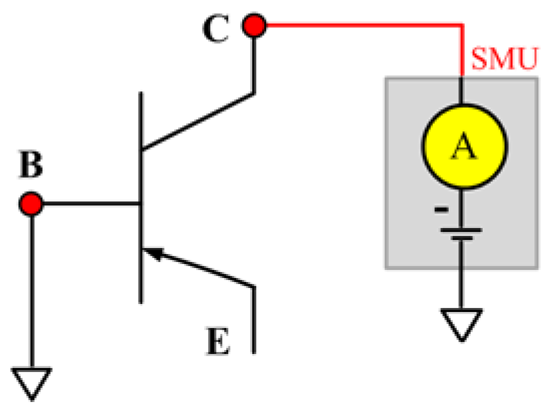
Module name: ICBO

DUT: Three-terminal pnpBJT

Function: Measures the collector-base cut-off current with the emitter opened.

Pin connections: Use a SMU to force voltage to the collector. Connect the base to GND or use a SMU to supply a zero-voltage bias. Open the circuit to the emitter or use a SMU to supply a zero-current bias.

Figure 88: Three-terminal pnpBJT ICBO pin connections



ICBO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

ICBO General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

ICEO

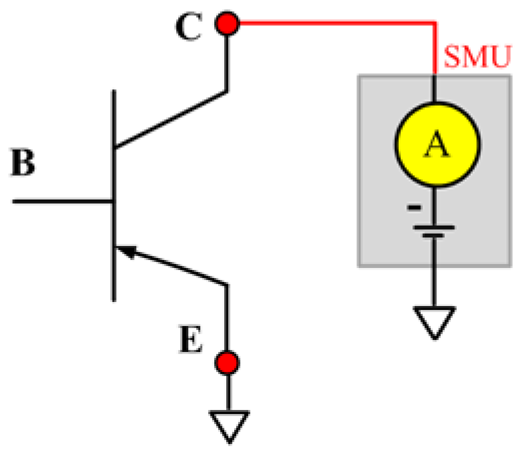
Module name: ICEO

DUT: Three-terminal pnpBJT

Function: Measures the collector-emitter cut-off current with the base opened.

Pin connections: Use a SMU to force voltage to the collector. Open the circuit to the base or use a SMU to supply a zero-current bias. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 89: Three-terminal pnpBJT ICEO pin connections



ICEO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

ICEO General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

ICEV

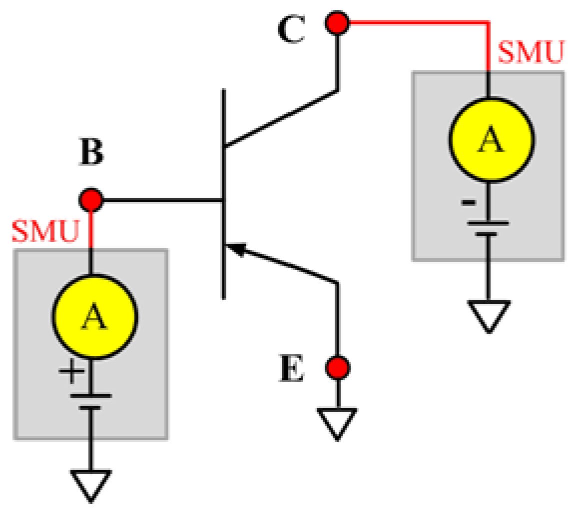
Module name: ICEV

DUT: Three-terminal pnpBJT

Function: Measures the collector-emitter cut off current with the base voltage biased.

Pin connections: Use two SMUs to force voltage to the base and collector. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 90: Three-terminal pnpBJT ICEV pin connections



ICEV ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

ICEV General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IcVcb

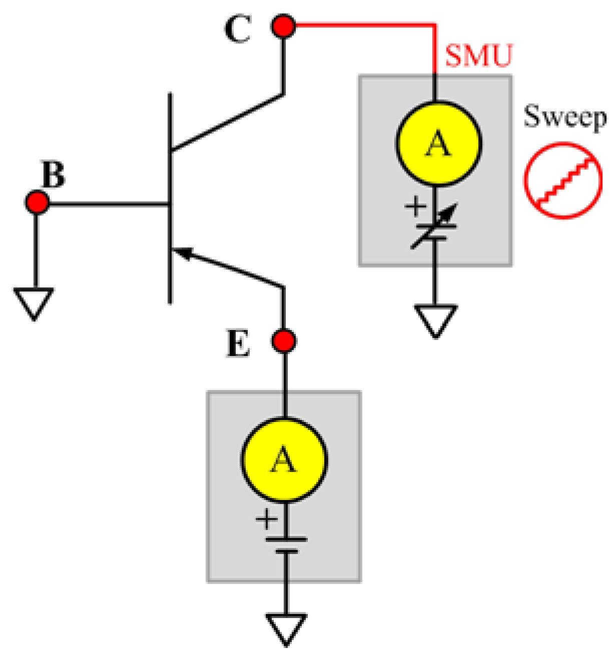
Module name: IcVcb

DUT: Three-terminal pnpBJT

Function: Measures the collector current of the pnpBJT device with a specified collector voltage sweep.

Pin connections: Use a SMU to apply a sweep voltage to the collector. Use a SMU to bias the emitter. Connect the base to GND or use a SMU to supply a zero-voltage bias.

Figure 91: Three-terminal pnpBJT IcVcb pin connections



IcVcb ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IcVcb General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IcVce_BiasIb

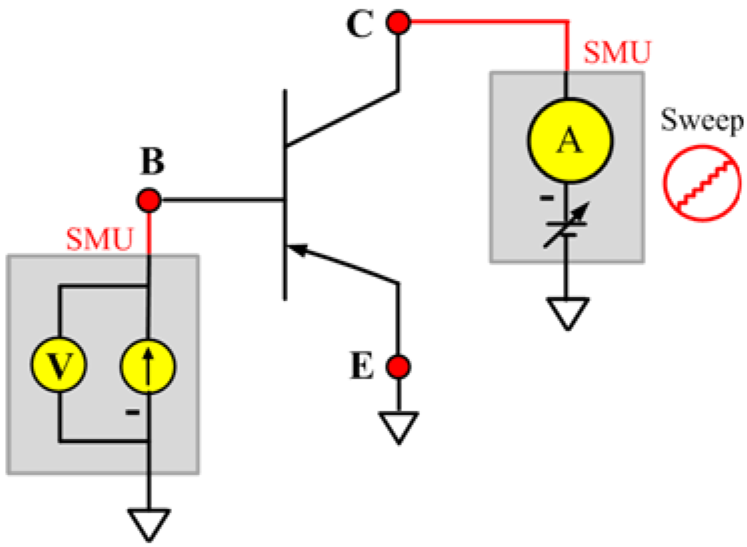
Module name: IcVce_BiasIb

DUT: Three-terminal pnpBJT

Function: Measures the collector current based on the base bias current and collector sweep voltage and measure the IcVce curve.

Pin connections: Use a SMU to apply a sweep voltage to the collector. Use a SMU to bias current to the base. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 92: Three-terminal pnpBJT IcVce_BiasIb pin connections



IcVce_BiasIb ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IcVce_BiasIb General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IcVce_BiasVb

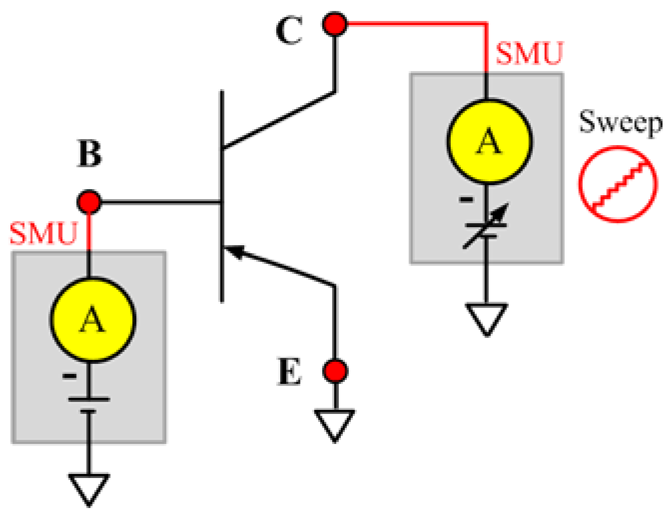
Module name: IcVce_BiasVb

DUT: Three-terminal pnpBJT

Function: Measures the collector current based on the base bias voltage and the collector sweep voltage and measures the IcVce curve.

Pin connections: Use a SMU to apply a sweep voltage to the collector. Use a SMU to bias voltage to the base. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 93: Three-terminal pnpBJT IcVce BiasVb pin connections



IcVce_BiasVb ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IcVce_BiasVb General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IcVce_StepIb

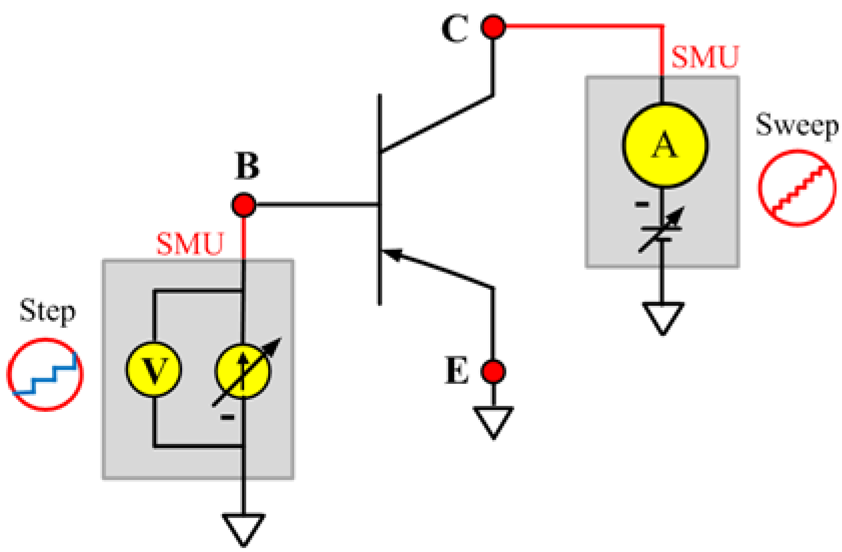
Module name: IcVce_StepIb

DUT: Three-terminal pnpBJT

Function: Measures the collector current based on the base step current and the collector sweep voltage and measures the series of IcVce curves with a base current step.

Pin connections: Use a SMU to apply a sweep voltage to the collector. Use a SMU to step current to the base. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 94: Three-terminal pnpBJT IcVce StepIb pin connections



IcVce_StepIb ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IcVce_StepIb General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IcVce_StepVb

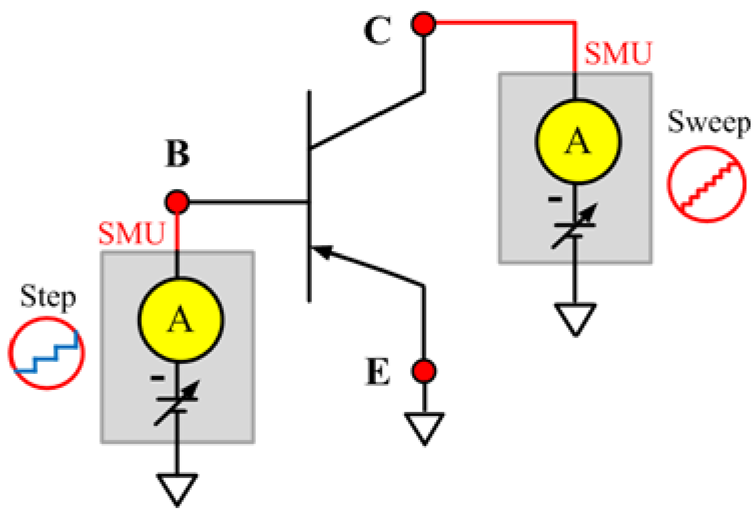
Module name: IcVce_StepVb

DUT: Three-terminal pnpBJT

Function: Measures the collector current based on base step and the collector sweep voltage and measures the series of IcVce curves with at base voltage step.

Pin connections: Use a SMU to apply a sweep voltage to the collector. Use a SMU to apply a step voltage to the base. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 95: Three-terminal pnpBJT IcVce_StepVb pin connections



IcVce_StepVb ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IcVce_StepVb General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IEBO

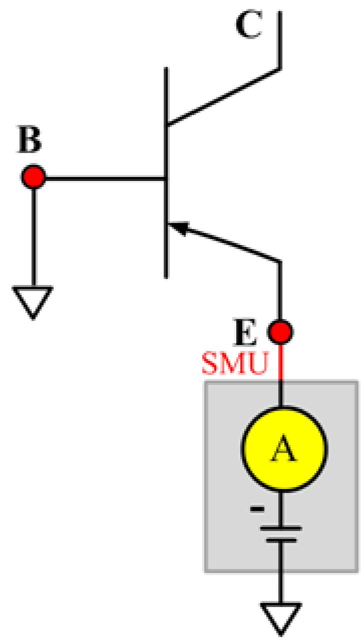
Module name: IEBO

DUT: Three-terminal pnpBJT

Function: Measures the emitter-base cut off current with the collector opened.

Pin connections: Use a SMU to force voltage to the emitter. Connect the base to GND or use a SMU to supply a zero-voltage bias. Open the circuit to the collector or use a SMU to supply a zero-current bias.

Figure 96: Three-terminal pnpBJT IEBO pin connections



IEBO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IEBO General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IECO

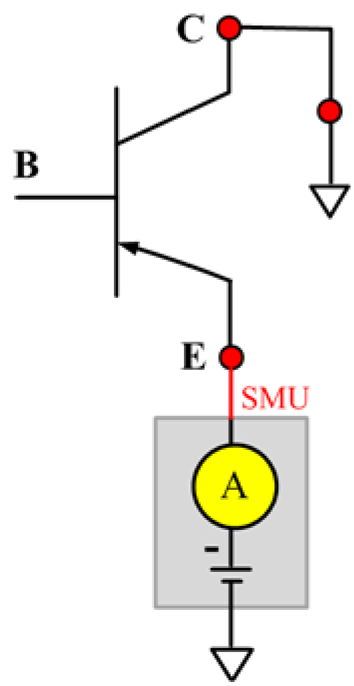
Module name: IECO

DUT: Three-terminal pnpBJT

Function: Measures the emitter-collector current with the base opened.

Pin connections: Use a SMU to force voltage to the emitter. Open the circuit to the base or use a SMU to supply a zero-current bias. Connect the collector to GND or use a SMU to supply a zero-voltage bias.

Figure 97: Three-terminal pnpBJT IECO pin connections



IECO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IECO General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IeVeb

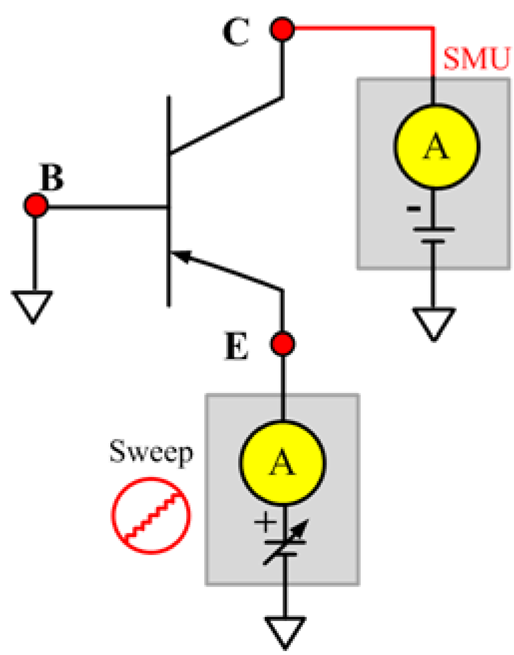
Module name: IeVeb

DUT: Three-terminal pnpBJT

Function: Measures the emitter current based on the emitter voltage sweep and measures the IeVeb curves.

Pin connections: Use a SMU to force voltage to the emitter. Open the circuit to the base or use a SMU to supply a zero-current bias. Connect the collector to GND or use a SMU to supply a zero-voltage bias.

Figure 98: Three-terminal pnpBJT IeVeb pin connections



IeVeb ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IeVeb General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

VBCO

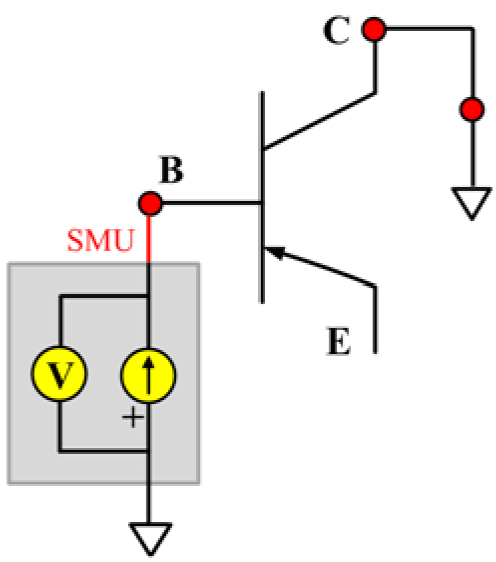
Module name: VBCO

DUT: Three-terminal pnpBJT

Function: Measures the base-collector voltage of the pnpBJT device with the emitter opened.

Pin connections: Use a SMU to apply a bias current to the base. Open the circuit to the emitter or use a SMU to supply a zero-current bias. Connect the collector to GND or use a SMU to supply a zero-voltage bias.

Figure 99: Three-terminal pnpBJT VBCO pin connections



VBCO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

VBCO General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

VCE

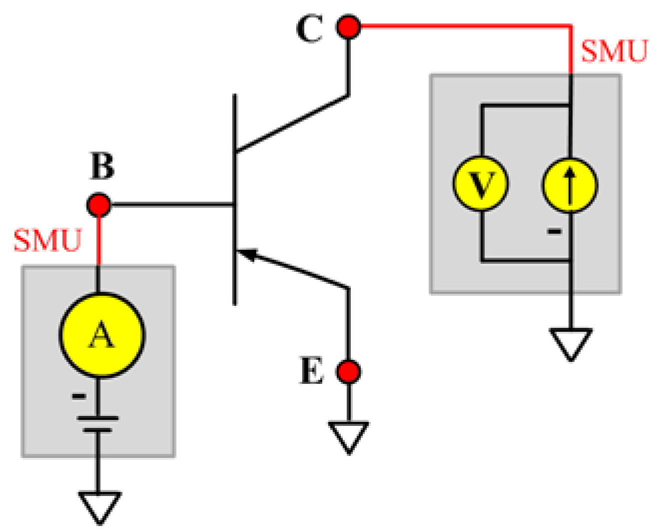
Module name: VCE

DUT: Three-terminal pnpBJT

Function: Measures the collector-emitter voltage of the pnpBJT device.

Pin connections: Use a SMU to apply bias current to the collector. Use a SMU to apply bias voltage to the base. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 100: Three-terminal pnpBJT VCE pin connections



VCE ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

VCE General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

pnpPowerBJT library

pnpPowerBJT library overview

The pnpPowerBJT library components are in the following directory:

```
C:\ACS_BASIC\library\devLibrary\pnpPowerBJT
```

The pnpPowerBJT parametric library is used to test parameters of a pnp-type power BJT, including leakage, breakdown, gain, on-state, capacitance, and characteristic curves.

BVCBO

Module name: BVCBO

Test type: ITM

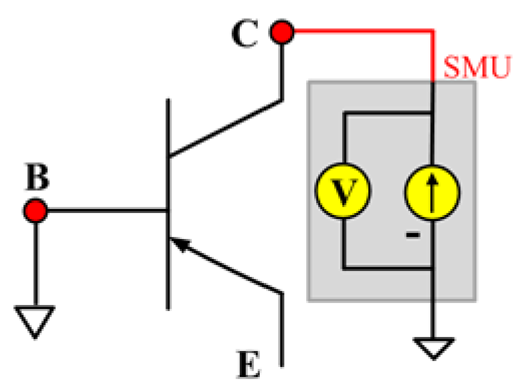
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal pnpPowerBJT

Function: Measures the collector base breakdown voltage with the emitter opened. The voltage is measured with a specific collector current that is given in the data sheet.

Pin connections: Use a SMU to force current and make a voltage measurement from the collector to base. Open the circuit to the emitter or use a SMU to supply a zero-current bias. Connect the base to GND or use a SMU to supply a zero-voltage bias.

Figure 101: pnpBJT and pnpPowerBJT BVCBO pin connections



BVCEO

Module name: BVCEO

Test type: ITM

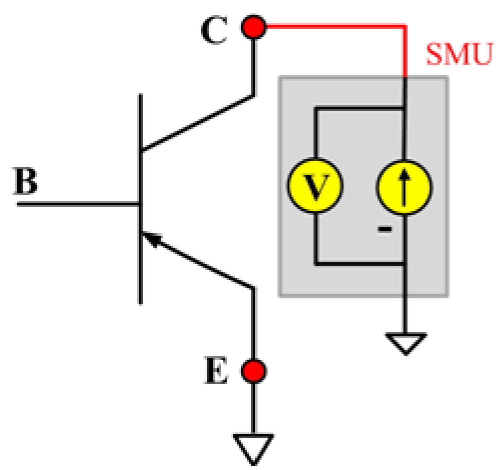
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal pnpPowerBJT

Function: Measures the collector-emitter breakdown voltage with the base opened. The voltage is measured with a specific collector current that is given in the data sheet.

Pin connections: Use a SMU to force current and make a voltage measurement from the collector to emitter. Open the circuit to the base or use a SMU to supply a zero-current bias. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 102: pnpPowerBJT BVCEO pin connections



BVEBO

Module name: BVEBO

Test type: ITM

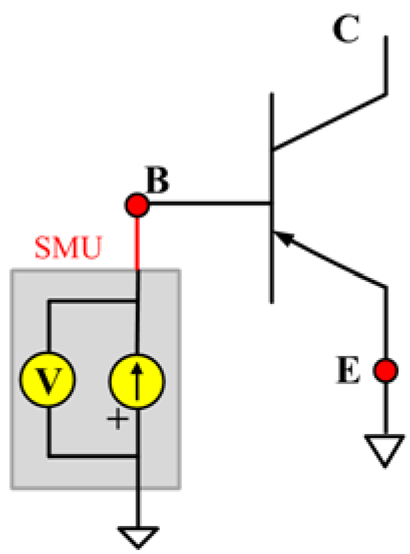
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal pnpPowerBJT

Function: Measures the emitter-base breakdown voltage with the collector opened. The voltage is measured with a specific base current or emitter current in a reverse direction that is given in the data sheet.

Pin connections: Use a SMU to force current and make a voltage measurement from the base to the emitter. Open the circuit to the collector or use a SMU to supply a zero-current bias. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 103: pnpPowerBJT BVEBO pin connections



Ccb

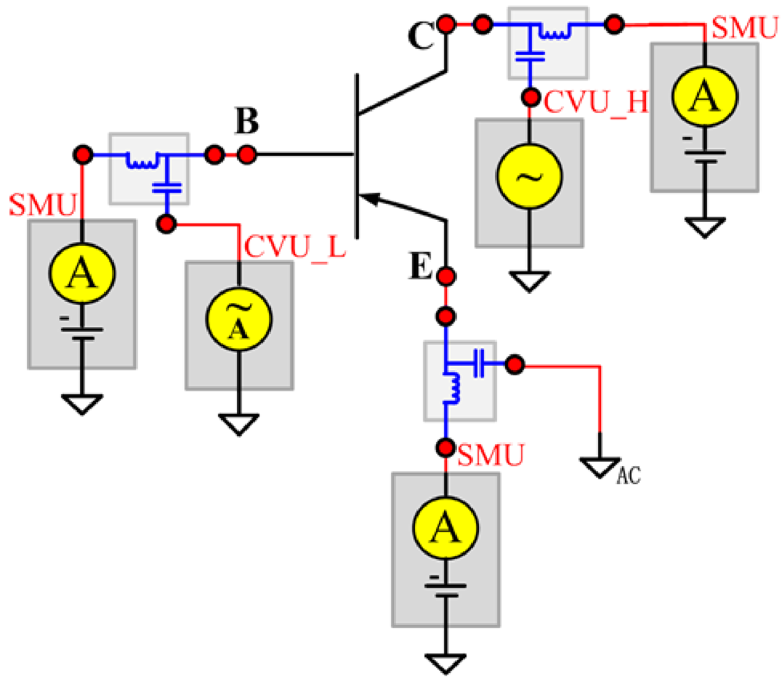
Module Name: Ccb

DUT: Three-terminal pnpPowerBJT

Function: Measures the capacitance between the Collector and Base terminals with the Emitter terminal connected to the guard terminal of a three-terminal bridge.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the collector. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the base. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the guard terminal of a three-terminal bridge through one remote bias tee to the emitter. Use the Series 2600B to supply zero voltage bias.

Figure 104: Three-terminal pnpPowerBJT Ccb pin connections



Ccb PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Cce

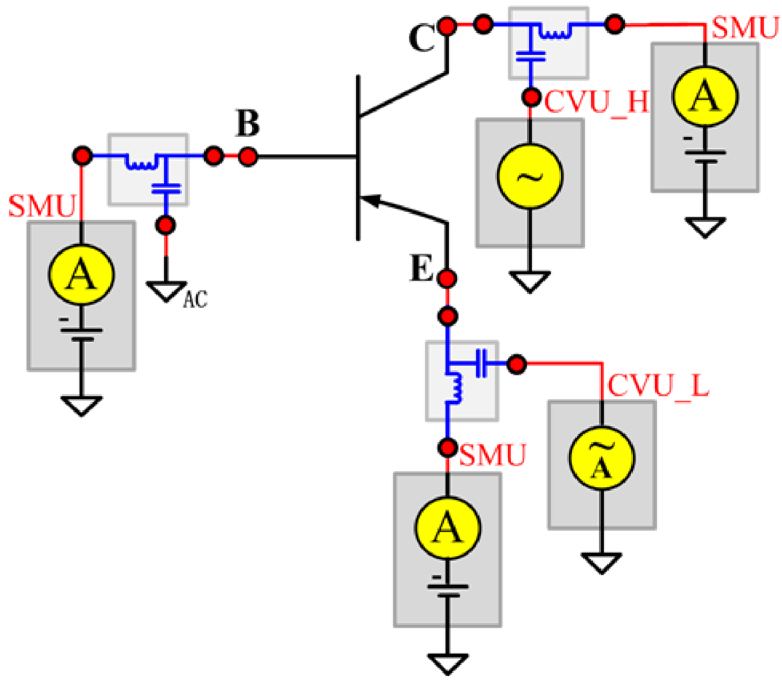
Module Name: Cce

DUT: Three-terminal pnpPowerBJT

Function: Measures the capacitance between the collector and emitter terminals with the base terminal connected to the guard terminal of a three-terminal bridge.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the collector. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the emitter. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the guard terminal of a three-terminal bridge through one remote bias tee to the base. Use the Series 2600B to supply zero voltage bias.

Figure 105: Three-terminal pnpPowerBJT Cce pin connections



Cce PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Ceb

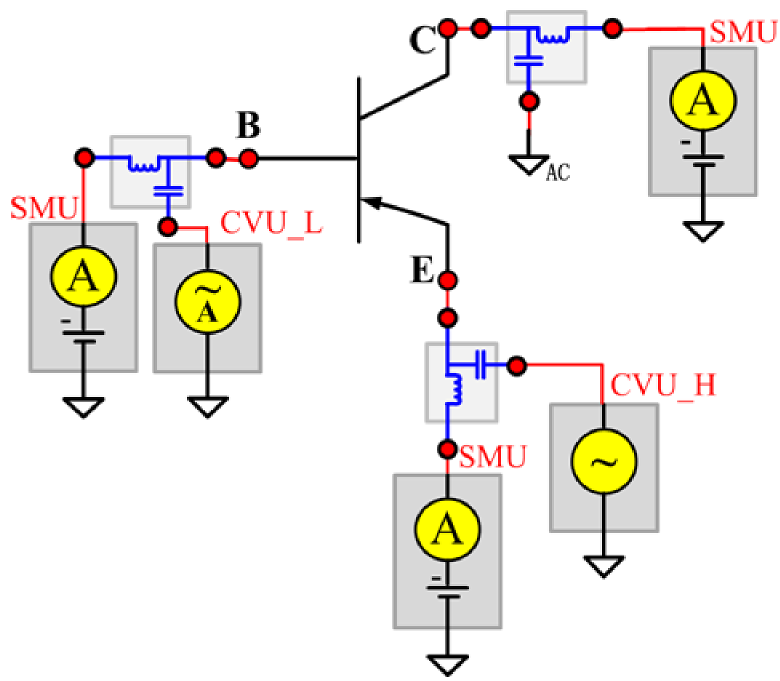
Module Name: Ceb

DUT: Three-terminal pnpPowerBJT

Function: Measures the capacitance between the emitter and base terminals with the collector terminal connected to the guard terminal of a three-terminal bridge.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the emitter. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the base. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the guard terminal of a three-terminal bridge through one remote bias tee to the collector. Use the Series 2600B to supply zero voltage bias.

Figure 106: Three-terminal pnpPowerBJT Ceb pin connections



Ceb PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Cibo

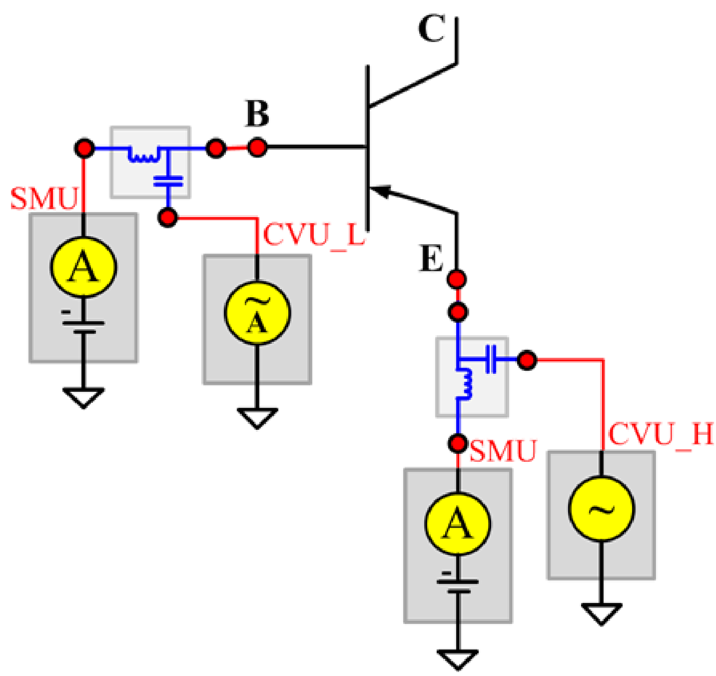
Module Name: Cibo

DUT: Three-terminal pnpPowerBJT

Function: Measures the capacitance between the input terminals (base and emitter) with the collector terminal open.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the emitter. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the base. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the guard terminal of a three-terminal bridge through one remote bias tee to the collector. Use the Series 2600B to supply zero voltage bias.

Figure 107: Three-terminal pnpPowerBJT Cibo pin connections



Cibo PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Cobo

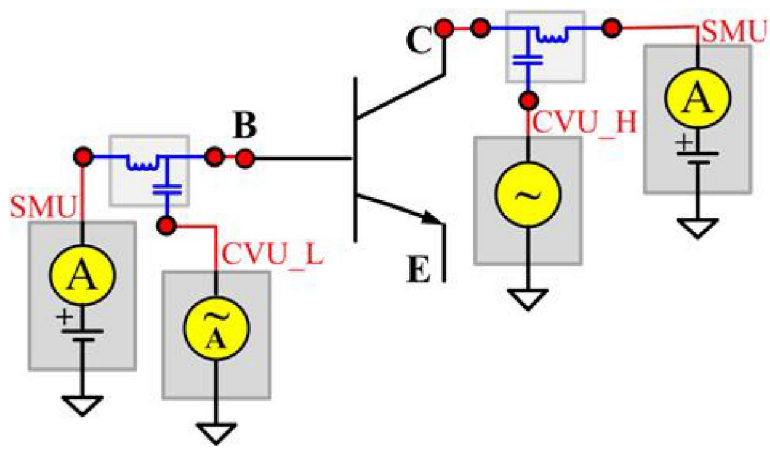
Module Name: Cobo

DUT: Three-terminal pnpPowerBJT

Function: Measures the capacitance between the output terminals (base and collector) with the emitter terminal open.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the collector. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the base. Use the Series 2600B to supply zero voltage bias. Open the circuit to the emitter.

Figure 108: Three-terminal pnpPowerBJT Cobo pin connections



Cobo PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

HFE

Module name: HFE

Module type: ITM

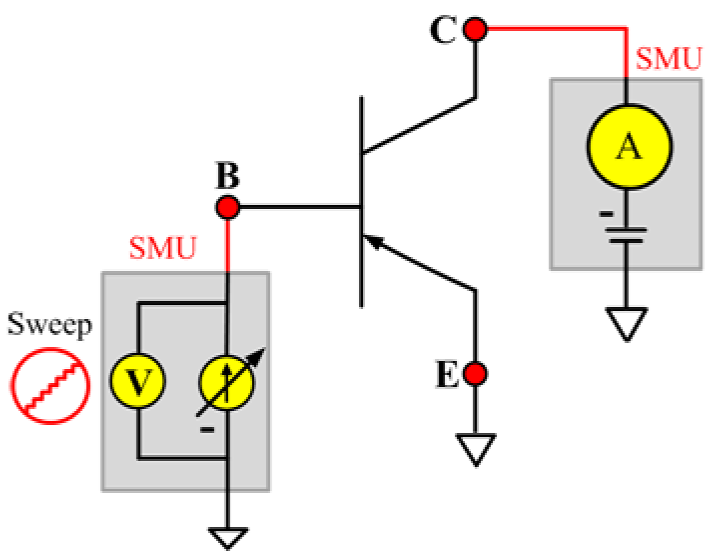
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pnpPowerBJT

Function: Measures the collector-emitter static forward current transfer ratio with the output voltage (Vce) held constant (HFE = Ic/Ib).

Pin connections: Use a SMU to apply voltage bias and make current measurements from the collector to the emitter. Use another SMU to apply a current sweep at the base. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 109: pnpPowerBJT HFE pin connections



ICBO

Module name: ICBO5

Test type: ITM

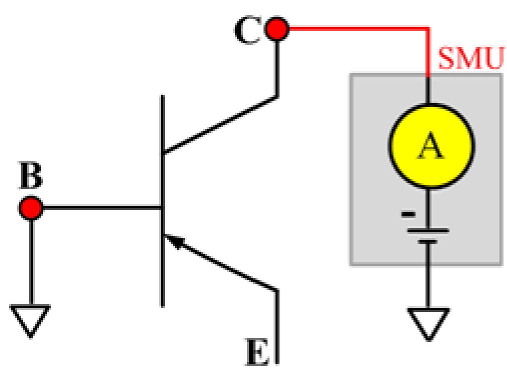
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal pnpPowerBJT

Function: Measures the collector-base cut-off current. Measures the current on the collector by reverse biasing the collector-base and with the emitter opened.

Pin connections: Use a SMU to force voltage and make a current measurement from the collector to the base. Open the circuit to the emitter or use a SMU to supply a zero-current bias. Connect the base to GND or use a SMU to supply a zero-voltage bias.

Figure 110: pnpPowerBJT ICBO pin connections



ICEO

Module name: ICEO

Test type: ITM

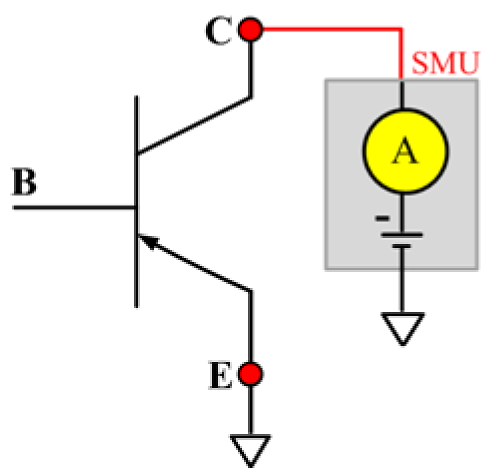
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal pnpPowerBJT

Function: Measures the collector-emitter cut-off current with the base opened.

Pin connections: Use a SMU to force voltage and make a current measurement from the collector to the emitter. Open the circuit to the base or use a SMU to supply a zero-current bias. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 111: pnpPowerBJT ICEO pin connections



ICES

Module name: ICES

Test type: ITM

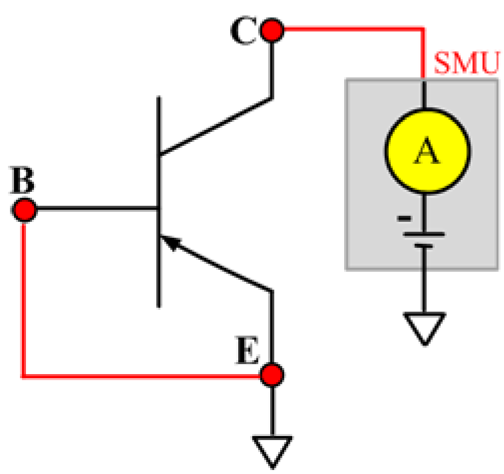
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal pnpPowerBJT

Function: Measures the collector-emitter cut-off current with the base shorted to the emitter.

Pin connections: Use a SMU to force voltage and make a current measurement from the collector to the emitter. Connect the emitter to GND or use a SMU to supply a zero-voltage bias. Short the base to the emitter or use a SMU to supply a zero-voltage bias.

Figure 112: pnpPowerBJT ICES pin connections



ICEV

Module name: ICEV

Test type: ITM

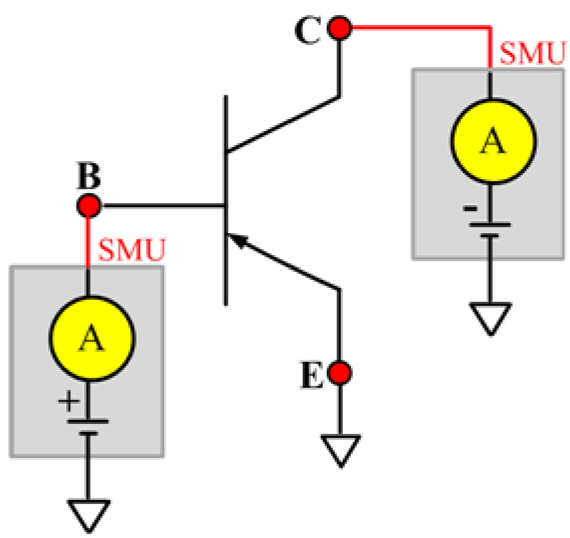
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal pnpPowerBJT

Function: Measures the collector-emitter cut-off current with reverse biasing at the emitter-base junction.

Pin connections: Use a SMU to force voltage and make a current measurement from the collector to the emitter. Use a SMU to bias the base with a specified voltage. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 113: pnpPowerBJT ICEV pin connections



IcVce_StepIb

Module name: IcVce_StepIb

Test type: ITM

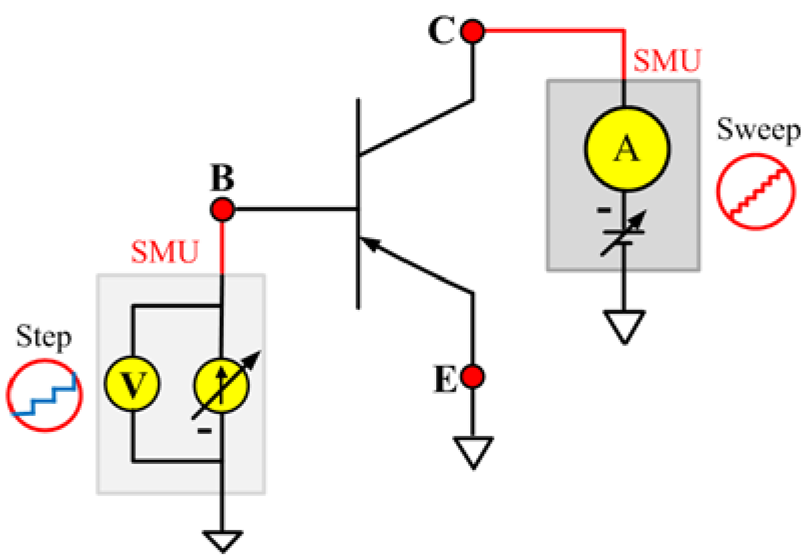
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pnpPowerBJT

Function: Measures the collector-emitter output characteristic curve with the current step at the base.

Pin connections: Use a SMU to apply a voltage sweep and make a current measurement from the collector to the emitter. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 114: pnpPowerBJT IcVce_StepIb pin connections



IcVce_StepIb_MIX

Module name: IcVce_StepIb_MIX

Module type: PTM

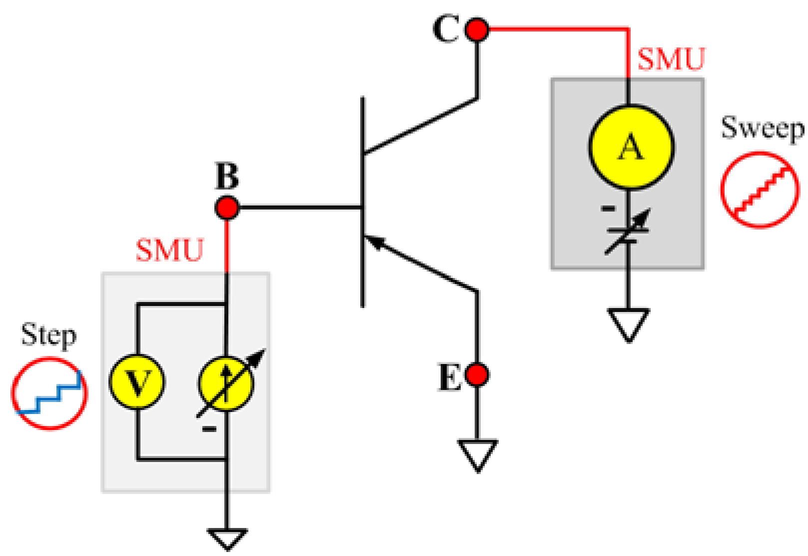
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200A-SMU

DUT: Three-terminal pnpPowerBJT

Function: Measures the collector-emitter output characteristic curve with a current step at the base.

Pin connections: Use a SMU to apply a voltage sweep and make a current measurement from the collector to the emitter. Use another SMU to apply a current step to the base. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 115: pnpPowerBJT IcVce_StepIb_MIX pin connections



IcVce_StepVbe

Module name: IcVce_StepVbe

Test type: ITM

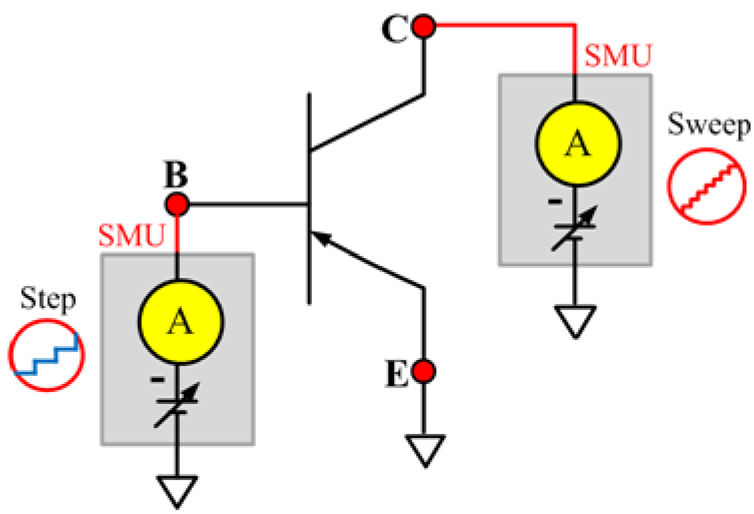
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pnpPowerBJT

Function: Measures the collector-emitter output characteristic curve with a current step at the base.

Pin connections: Use a SMU to apply a voltage sweep and make a current measurement from the collector to the emitter. Use another SMU to apply a current step to the Base-Emitter junction. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 116: pnpPowerBJT IcVce_StepVbe pin connections



IcVce_StepVbe_MIX

Module name: IcVce_StepVbe_MIX

Module type: PTM

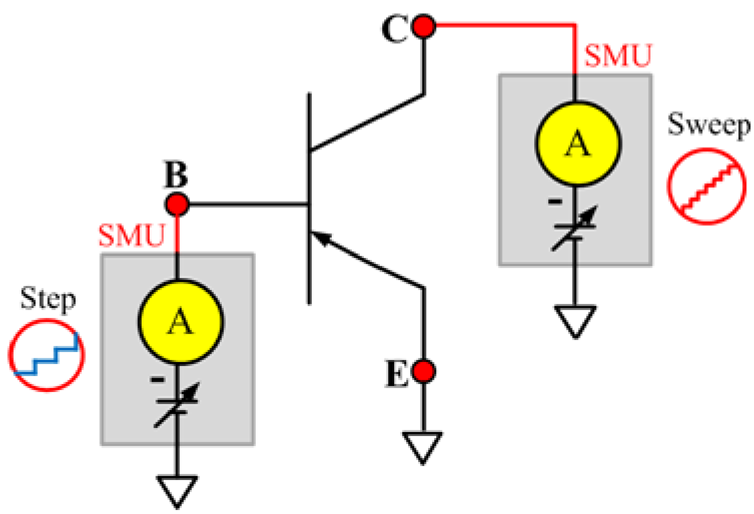
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200A-SMU

DUT: Three-terminal pnpPowerBJT

Function: Measures the collector-emitter output characteristic curve with a voltage step on the emitter-base junction.

Pin connections: Use a SMU to apply a voltage sweep and make a current measurement from the collector to the emitter. Use a SMU to apply a voltage step to the base-emitter junction. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 117: pnpPowerBJT IcVce_StepVbe_MIX pin connections



IEBO

Module name: IEBO

Test type: ITM

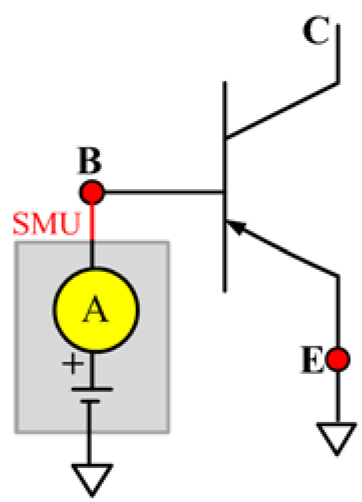
Instrument: Keithley Instruments Series 2600B

DUT: Three-terminal pnpPowerBJT

Function: Measures the emitter-base cut-off current. Measures the current on the emitter by reverse biasing the emitter-base junction with the collector opened.

Pin connections: Use a SMU to force voltage and make a current measurement from the base to emitter. Open the circuit to the collector or use a SMU to supply a zero-current bias. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 118: pnpPowerBJT IEBO pin connections



VbeON

Module name: VbeON

Test type: ITM

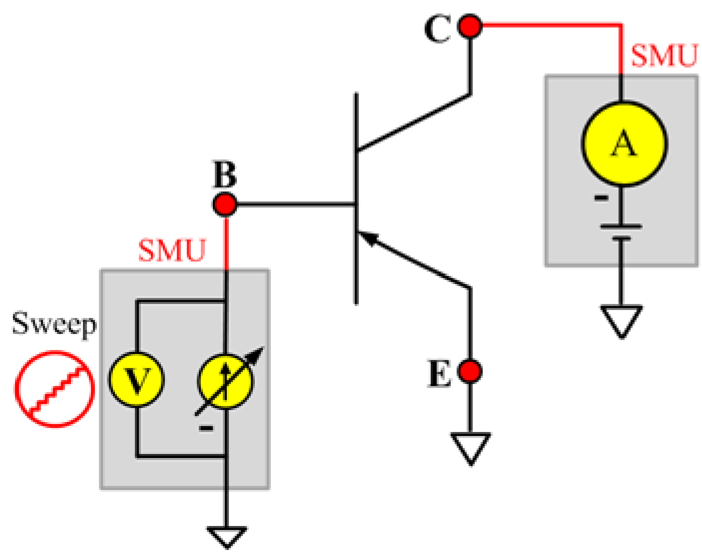
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pnpPowerBJT

Function: Measures the base-emitter junction on voltage when the BJT is in an active region. The voltage is measured with the base-emitter junction forward biased and the collector emitter voltage higher than the VceSAT.

Pin connections: Use a SMU to apply a sweep current and make a voltage measurement from base to emitter. Use another SMU to apply a voltage bias to the collector. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 119: pnpPowerBJT VbeON pin connections



VbeSAT

Module name: VbeSAT

Module type: ITM

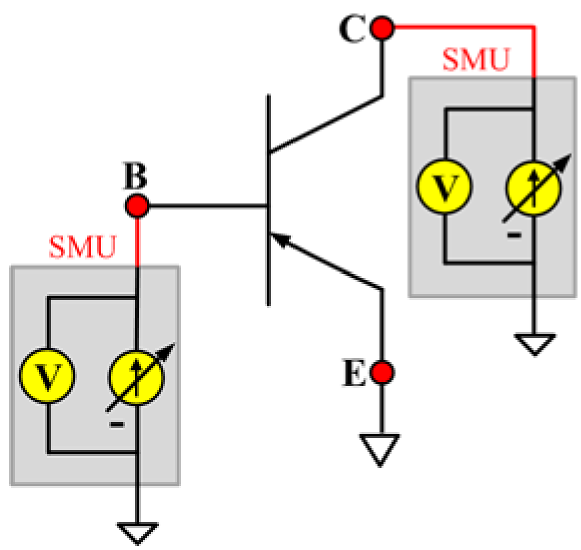
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pnpPowerBJT

Function: Measures the base-emitter saturation voltage. The voltage is measured at a specific base current and collector current that is given in the data sheet to ensure that both the emitter-base and collector-base junctions are forward biased.

Pin connection: Use a SMU to force current and make a voltage measurement from the base to emitter. Use a SMU to apply a current bias to the collector. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 120: pnpPowerBJT VbeSAT pin connections



VceSAT

Module name: VceSAT

Module type: ITM

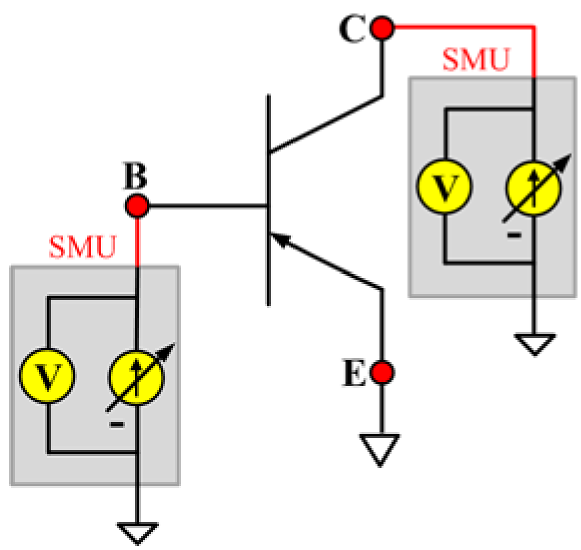
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pnpPowerBJT

Function: Measures the collector-emitter saturation voltage. The voltage is measured at a specific base current and collector current that is given in the data sheet to ensure that both the emitter-base and collector-base junctions are forward-biased.

Pin connections: Use a SMU to force current and make a voltage measurement from the collector to the emitter. Use another SMU to apply current bias to the base. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 121: pnpPowerBJT VceSAT pin connections



VceSAT_MIX

Module name: VceSAT_MIX

Module type: PTM

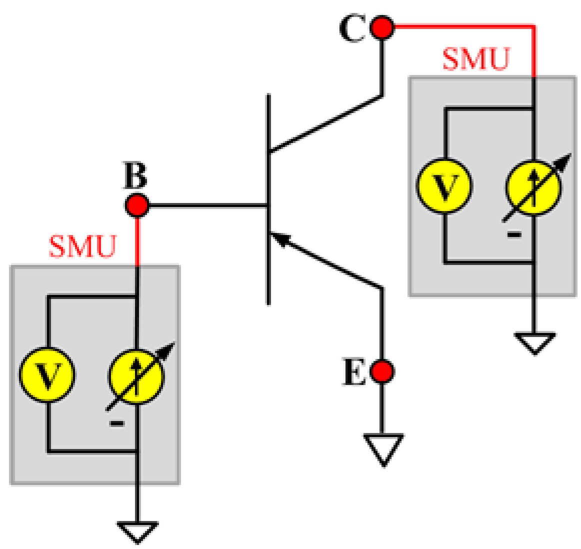
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200A-SMU

DUT: Three-terminal pnpPowerBJT

Function: Measures the collector-emitter saturation voltage. The voltage is measured at a specific base current and at the collector current that is given in data sheet to ensure that both the emitter-base and collector-base junctions are forward biased.

Pin connection: Use a SMU to force current and make a voltage measurement from the collector to emitter. Use another SMU to apply current bias to the base. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 122: pnpPowerBJT VceSAT_MIX pin connections



VCESUS

Module name: VCESUS

Module type: ITM

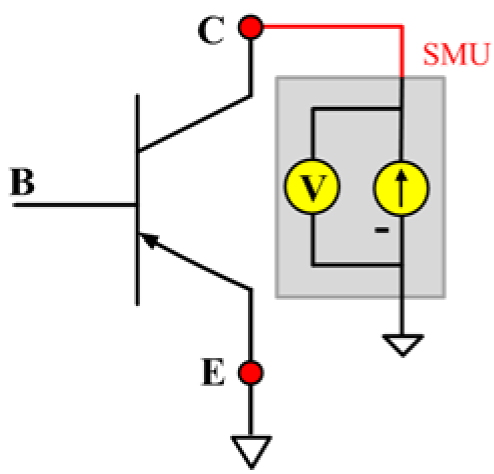
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal pnpPowerBJT

Function: Measures the collector-emitter sustaining voltage with the base opened. The voltage is measured at a specific collector current that is given in the datasheet.

Pin connections: Use a SMU to force current and make a voltage measurement from the collector to emitter. Open the circuit to the base or use a SMU to supply a zero-current bias. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 123: pnpPowerBJT VCESUS pin connections



nMOSFET library

nMOSFET library overview

The nMOSFET library components are in the following directory:

```
C:\ACS_BASIC\library\devLibrary\nMOSFET
```

The nMOSFET parameter library is used to test some parameters of an n-type power MOSFET, including leakage, breakdown, gain, on-state, capacitance, and characteristic curves.

BVDSS

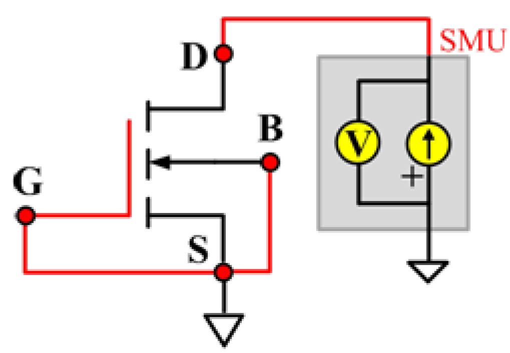
Module name: BVDSS

DUT: Four-terminal nMOSFET

Function: Measures the drain-source breakdown voltage of the nMOSFET with the gate-source shorted.

Pin connections: Use a SMU to apply a breakdown current on the drain. Short gate, source, and Bulk (connect them all to GND or use a SMU to supply a zero-voltage bias).

Figure 124: Four-terminal nMOSFET BVDSS pin connections



BVDSS ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

BVDSS General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVDSV

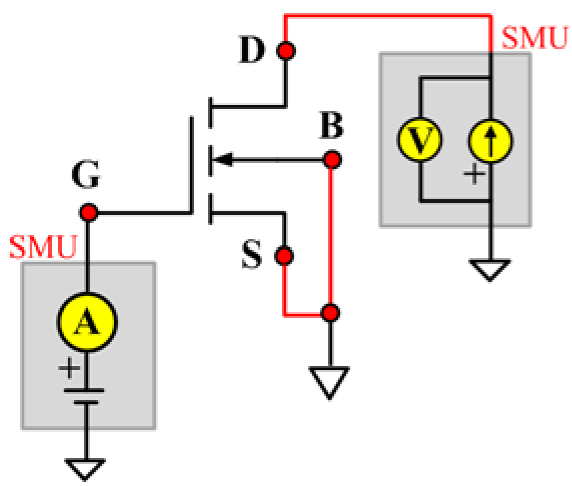
Module name: BVDSV

DUT: Four-terminal nMOSFET

Function: Measures the drain-source breakdown voltage of the nMOSFET with the gate biased.

Pin connections: Connect the source and bulk to GND or use a SMU to supply a zero-voltage bias. Use a SMU to bias the gate. Use a SMU to apply a breakdown current on the drain.

Figure 125: Four-terminal nMOSFET BVDSV pin connections



BVDSV ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

BVDSV General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVGSO

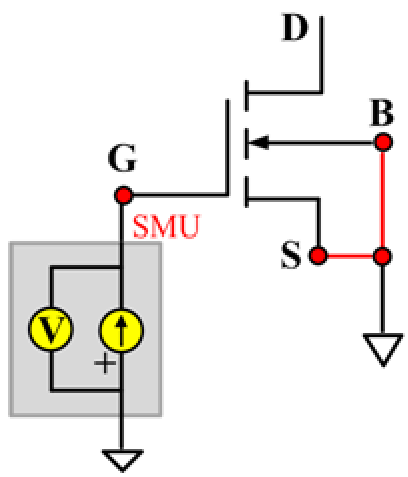
Module name: BVGSO

DUT: Four-terminal nMOSFET

Function: Measures the gate-source breakdown voltage of the nMOSFET with the drain opened.

Pin connections: Use a SMU to apply a breakdown current on the gate. Open the circuit to the drain or use a SMU to supply a zero-current bias. Short bulk and source to GND or use a SMU to supply a zero-voltage bias.

Figure 126: Four-terminal nMOSFET BVGSO pin connections



BVGSO ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

BVGSO General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVGDS

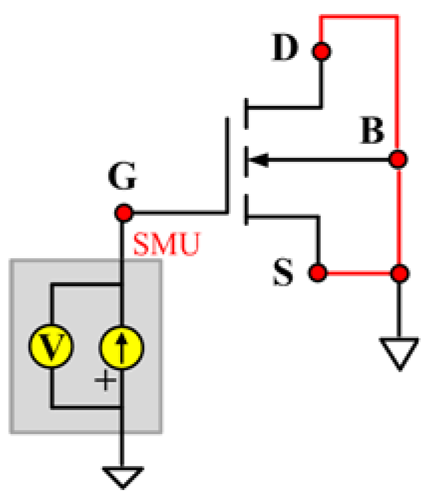
Module name: BVGDS

DUT: Four-terminal nMOSFET

Function: Measures the gate-drain breakdown voltage of the nMOSFET with the source-drain shorted.

Pin connections: Connect the source, bulk, and drain to GND or use a SMU to supply a zero-voltage bias. Use a SMU to apply a breakdown current on the gate.

Figure 127: Four-terminal nMOSFET BVGDS pin connections



BVGDS ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

BVGDS General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVGDO

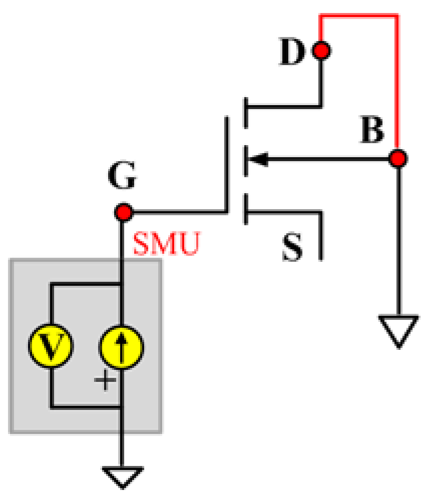
Module name: BVGDO

DUT: Four-terminal nMOSFET

Function: Measures the gate-drain breakdown voltage of the nMOSFET with the source opened.

Pin connections: Use a SMU to apply a breakdown current on the gate. Open the circuit to the source or use a SMU to supply a zero-current bias. Short bulk and drain to GND or use a SMU to supply a zero-voltage bias.

Figure 128: Four-terminal nMOSFET BVGDO pin connections



BVGDO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

BVGDO General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Cds

Description:

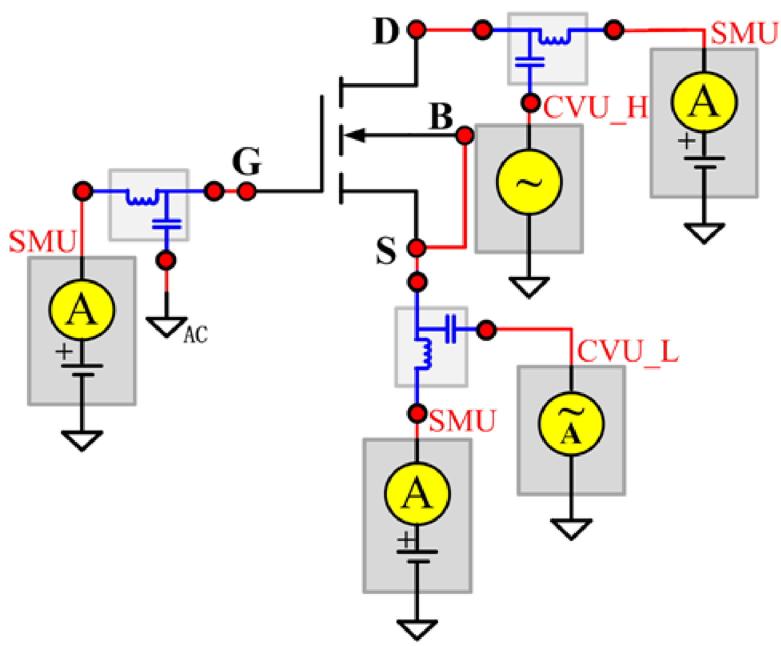
Module Name: Cds

DUT: Four-terminal nMOSFET

Function: Measures the capacitance between the Drain and Source terminals with the Gate terminal connected to the guard terminal of a three-terminal bridge. Short bulk to source.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the drain. Use the Series 2600B to sweep voltage. Short bulk to source. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the source. Use the Series 2600B to supply zero voltage bias. Connect the guard terminal of a three-terminal bridge through one remote bias tee to the gate.

Figure 129: Four-terminal nMOSFET Cds pin connections



Cds PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Cgd

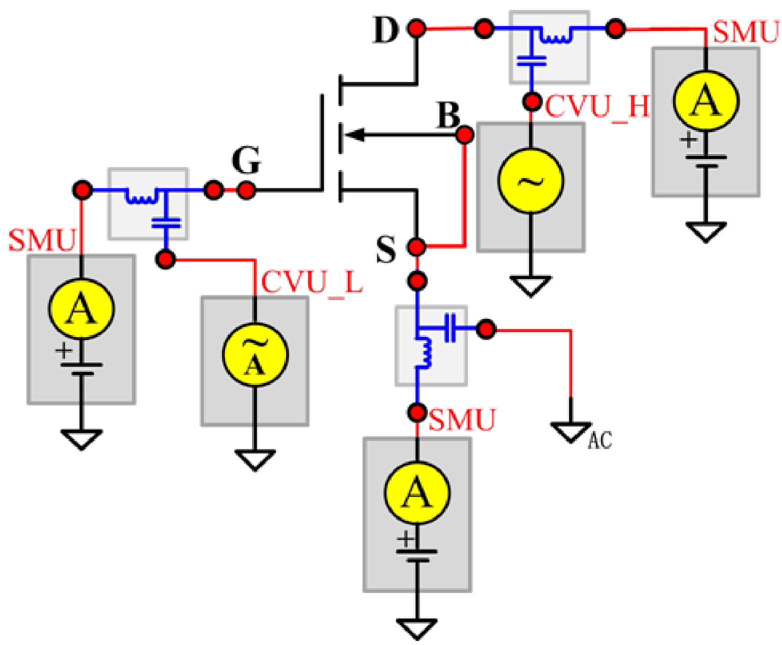
Module name: Cgd

DUT: Four-terminal nMOSFET

Function: Measures the capacitance between the Drain and Gate terminals with the Source terminal connected to the guard terminal of a three-terminal bridge. Short bulk to source.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the drain. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the ac guard of a three-terminal bridge through one remote bias tee to the source.

Figure 130: Four-terminal nMOSFET Cgd pin connections



Cgd PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Cgs

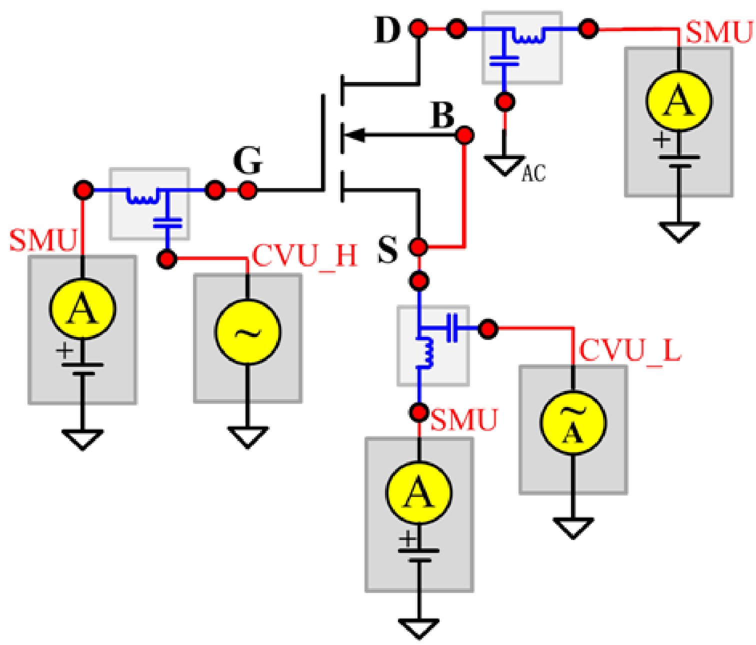
Module name: Cgs

DUT: Four-terminal nMOSFET

Function: Measures the capacitance between the Gate and Source terminals with the Drain terminal connected to the guard terminal of a three-terminal bridge. Short bulk to source.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the ac guard of a three-terminal bridge through one remote bias tee to the drain.

Figure 131: Four-terminal nMOSFET Cgs pin connections



Cgs PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Ciss

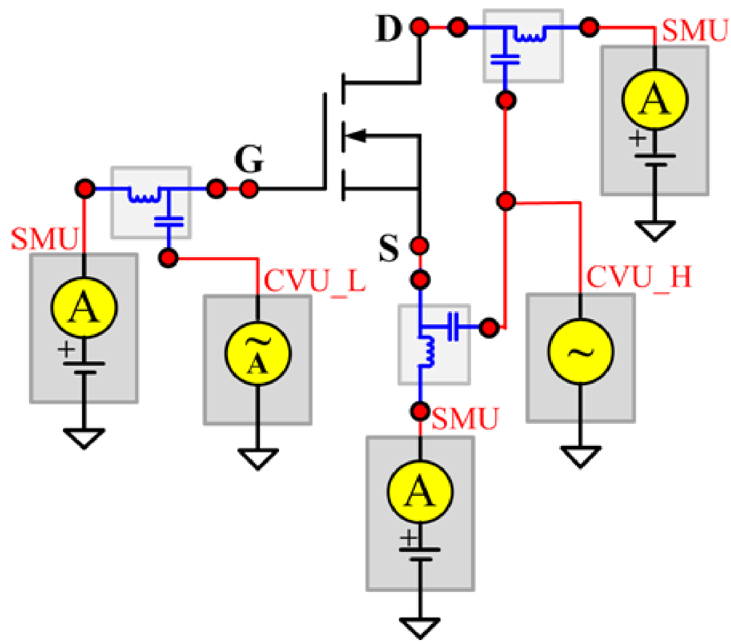
Module name: Ciss

DUT: Four-terminal nMOSFET

Function: Measures the capacitance between the Gate and Source terminals with the Drain terminal ac short-circuited to the Source terminal. Short bulk to source.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the drain. Use the Series 2600B to sweep voltage. AC short circuit the drain to the source terminal. Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to supply zero voltage bias.

Figure 132: Three-terminal nPowerMOSFET Ciss pin connections



Ciss PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Coss

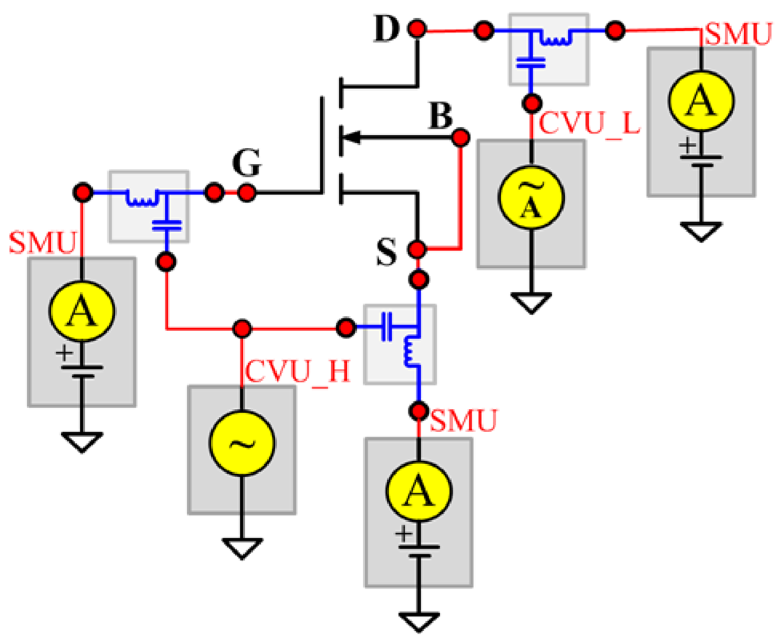
Module name: Coss

DUT: Four-terminal nMOSFET

Function: Measures the capacitance between the drain and source terminals with the gate terminal ac short-circuited to the source terminal. Short bulk to source.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to supply zero voltage bias. AC short circuit the gate to the source terminal. Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the drain. Use the Series 2600B to sweep voltage.

Figure 133: Four-terminal nMOSFET Coss pin connections



Coss PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Ciss

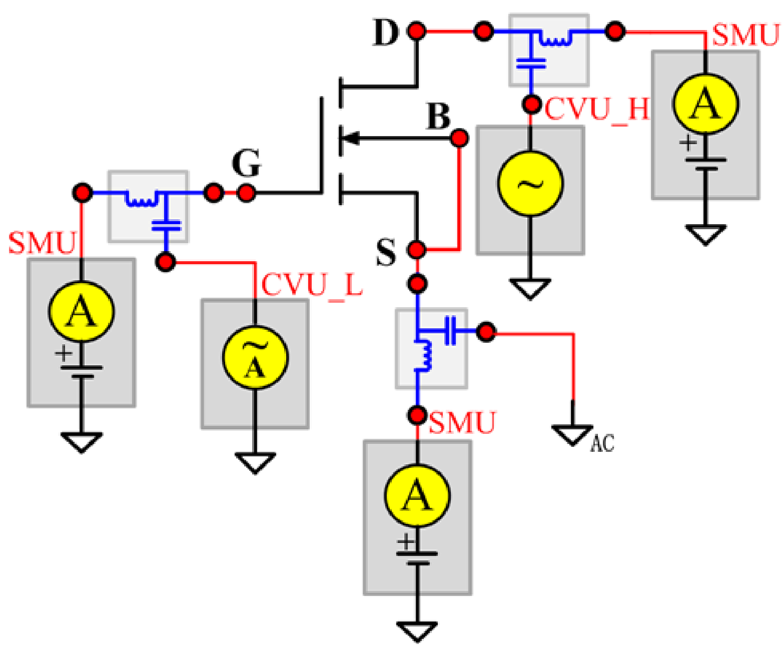
Module name: Crss

DUT: Four-terminal nMOSFET

Function: Measures the common-source short-circuit input capacitance by testing the capacitance between the Drain and Gate terminals with the Source terminal connected to the guard terminal of a three-terminal bridge. Short bulk to source.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the drain. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the ac guard of a three-terminal bridge through one remote bias tee to the source. Use the Series 2600B to supply zero voltage bias.

Figure 134: Four-terminal nMOSFET Crss pin connections



Crss PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

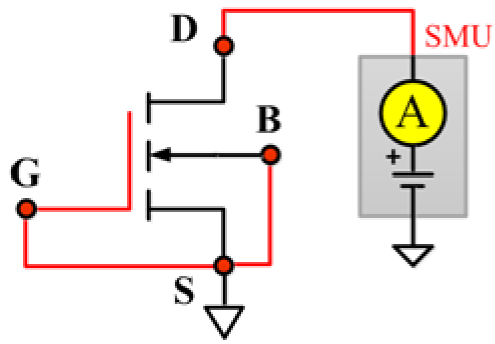
IDL

Module name: IDL

Function: Measures the drain leakage current with the gate-source shorted.

Pin connections: Short the gate and source. Apply a voltage to the drain, and connect the bulk, gate, and source to ground.

Figure 135: Four-terminal nMOSFET IDL pin connections



IDL ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IDL General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IDS_ISD

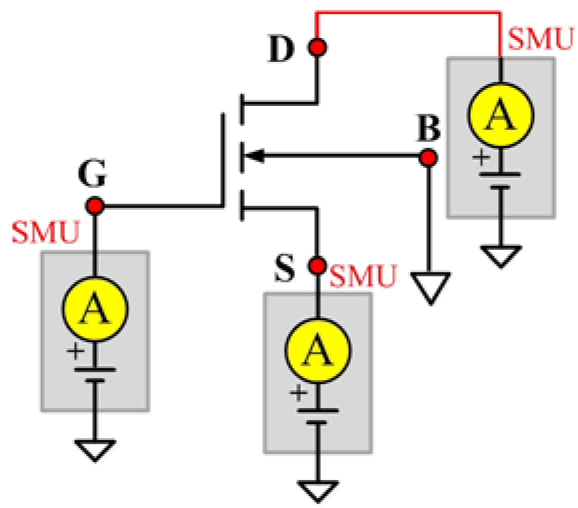
Module name: IDS_ISD

DUT: Four-terminal nMOSFET

Function: Measures the drain-source and source-drain current with the gate biased.

Pin connections: Use a SMU to force voltage to the gate. Use a SMU to force voltage to the drain. Connect source and bulk to GND or use a SMU to supply a zero-voltage bias.

Figure 136: Four-terminal nMOSFET IDS_ISD pin connections



IDS_ISD ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IDS_ISD General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVd_BiasVg

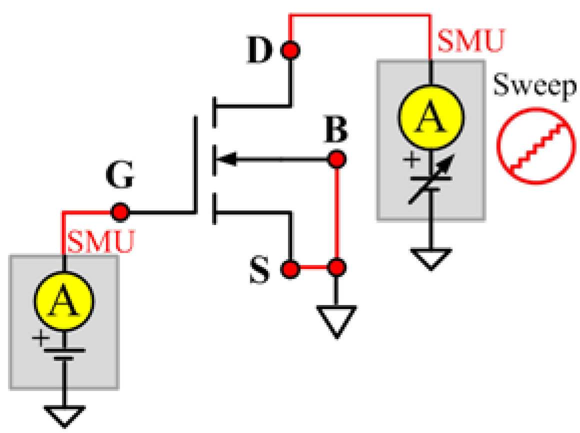
Module name: IdVd_BiasVg

DUT: Four-terminal nMOSFET

Function: Measures the drain current during a specified drain voltage sweep, and the drain current and the drain voltage curve.

Pin connections: Use a SMU to bias voltage to the gate. Use a SMU to apply a sweep voltage to the drain. Short bulk and source to GND or use a SMU to supply a zero-voltage bias.

Figure 137: Four-terminal nMOSFET IdVd_BiasVg pin connections



IdVd_BiasVg ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IdVd_BiasVg General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVd_StepVg

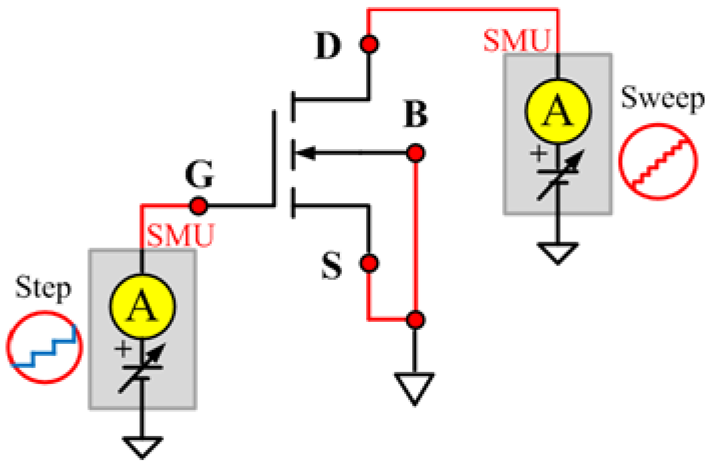
Module name: IdVd_StepVg

DUT: Four-terminal nMOSFET

Function: Measures the drain current during a specified drain voltage sweep, and the series of drain current tests and the drain voltage curve.

Pin connections: Use a SMU to sweep the drain. Use a SMU to step the gate. Short bulk and source to GND or use a SMU to supply a zero-voltage bias.

Figure 138: Four-terminal nMOSFET IdVd_StepVg pin connections



IdVd_StepVg ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IdVd_StepVg General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVg_BiasVd

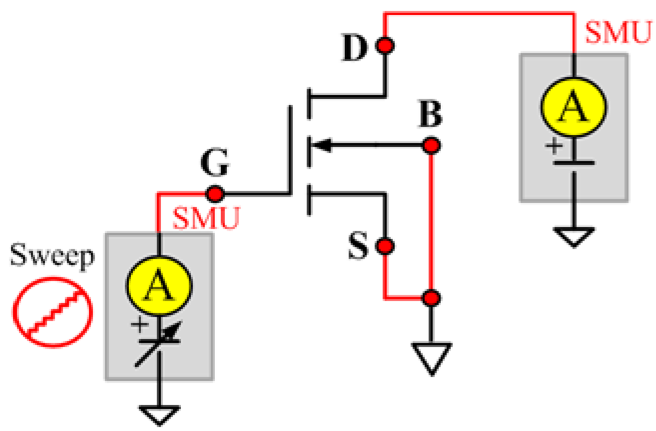
Module name: IdVg_BiasVd

DUT: Four-terminal nMOSFET

Function: Measures the drain current during a specified gate voltage sweep, and the drain current and the gate voltage curve.

Pin connections: Use a SMU to bias voltage to the drain. Use a SMU to apply a sweep voltage to the gate. Short the bulk and source or use a SMU to supply a zero-voltage bias.

Figure 139: Four-terminal nMOSFET IdVg_BiasVd pin connections



IdVg_BiasVd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IdVg_BiasVd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVg_StepVd

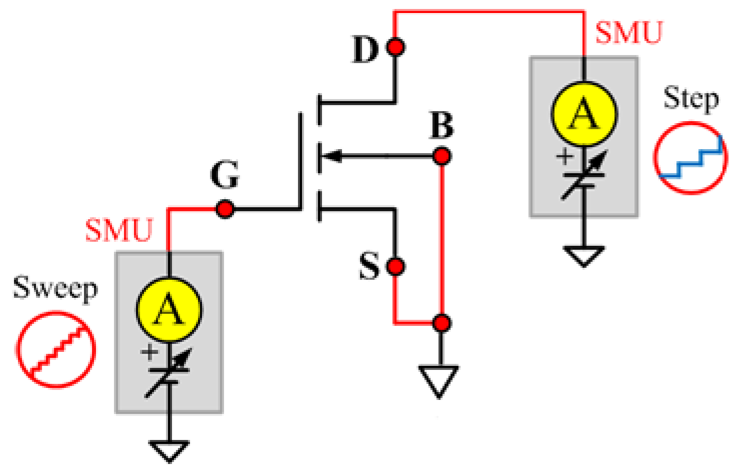
Module Name: IdVg_StepVd

DUT: Four-terminal nMOSFET

Function: Measures the drain current during a specified gate voltage sweep with the drain step, and a series of drain currents and a gate voltage curve.

Pin connections: Use a SMU to step the drain. Use a SMU to sweep the gate. Short bulk and source to GND or use a SMU to supply a zero-voltage bias.

Figure 140: Four-terminal nMOSFET IdVg_StepVd pin connections



IdVg_StepVd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IdVg_StepVd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVg_StepVsub

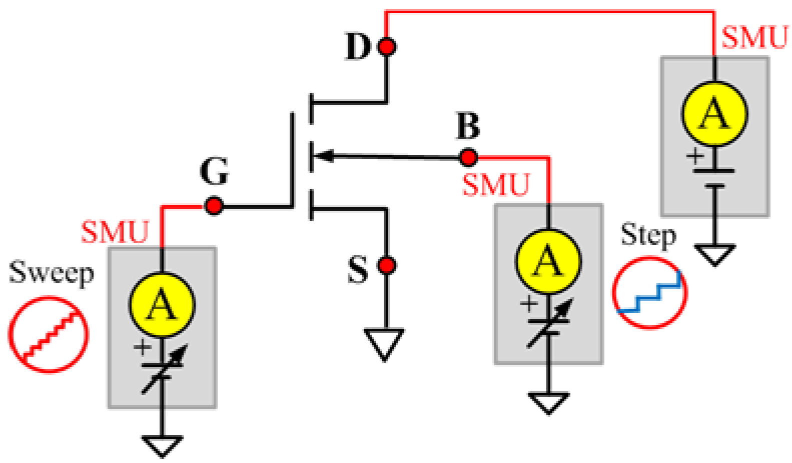
Module name: IdVg_StepVsub

DUT: Four-terminal nMOSFET

Function: Measures the drain current during a specified gate voltage sweep with a bulk step, and a series of drain currents and a gate voltage curve.

Pin connections: Use a SMU to step the bulk. Use a SMU to sweep the gate. Use a SMU to bias the drain. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 141: Four-terminal nMOSFET IdVg_StepVsub pin connections



IdVg_StepVsub ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IdVg_StepVsub General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IGL

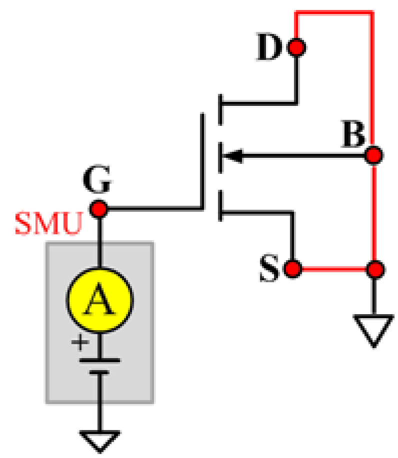
Module name: IGL

DUT: Four-terminal nMOSFET

Function: Measures the gate leakage current when the source and drain are shorted.

Pin connections: Use a SMU to force voltage to the gate. Connect the source, drain, and bulk to GND or use a SMU to supply a zero-voltage bias.

Figure 142: Four-terminal nMOSFET IGL pin connections



IGL ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IGL General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IgVg

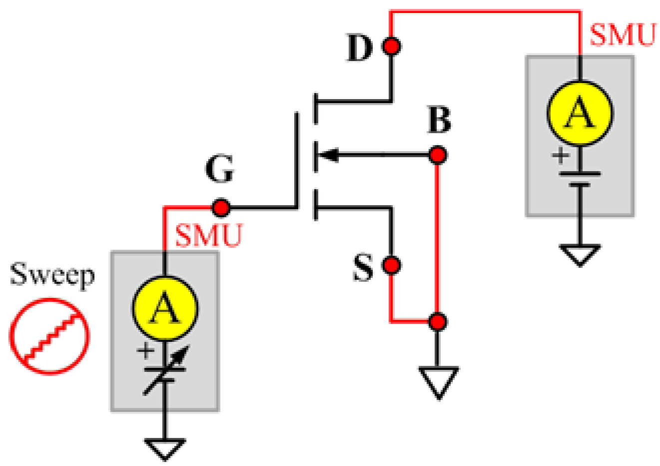
Module name: IgVg

DUT: Four-terminal nMOSFET

Function: Measures the gate current during a specified gate voltage sweep when the drain is biased, and the gate current and gate voltage curve.

Pin connections: Use a SMU to bias the drain. Use a SMU to sweep the gate. Short the bulk and source to GND or use a SMU to supply a zero-voltage bias.

Figure 143: Four-terminal nMOSFET IgVg pin connections



IgVg ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IgVg General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

ISL

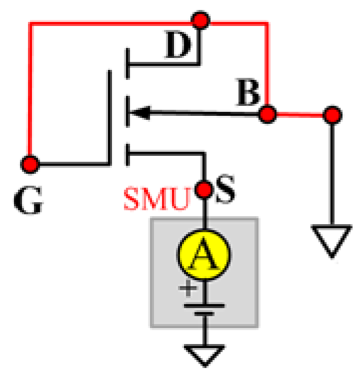
Module name: ISL

DUT: Four-terminal nMOSFET

Function: Measures the source leakage current when the gate-drain is shorted.

Pin connections: Use a SMU to force voltage to the source. Short bulk, gate, and drain to GND or use a SMU to supply a zero-voltage bias.

Figure 144: Four-terminal nMOSFET ISL pin connections



ISL ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

ISL General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Vtci

Module name: Vtci

DUT: Four-terminal nMOSFET

Function: Measures the constant current threshold voltage of the nMOSFET device, and the drain current and the gate voltage curve.

Pin connections: Use a SMU to bias the drain. Use a SMU to sweep the gate. Input source and bulk voltage when needed. Usually, they are connected to GND for NMOS and connected to the nominal power supply voltage (VDD) for PMOS.

Procedure: The constant current threshold voltage:

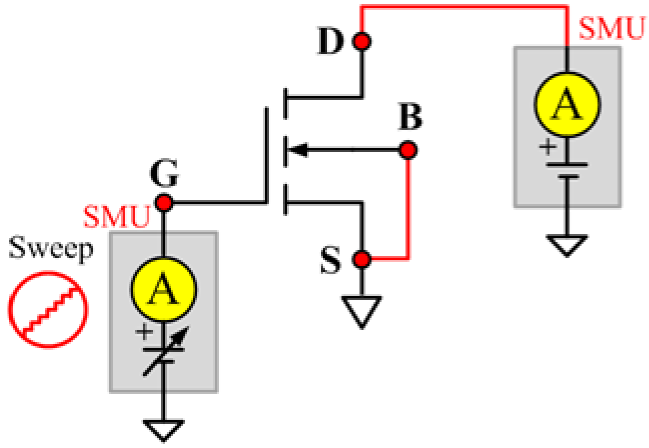
`Vth_ci=VGS (@ID=1 uA.W/L)`	NMOS
`Vth_ci=VGS (@ID=-0.025 uA.W/L)`	PMOS

Where `W` and `L` are the gate width and gate length as printed on the wafer. Set a target drain current `Id_tar (Id_tar=1uA.W/L, or -0.025uA.W/L)`, which is the sign to be near threshold, then search the gate voltage to make the drain current equal to `Id_tar`.

NOTE

The `Four_term_nMOSFET_Vth_ci` measurement procedure must determine `Vth_ci` to within a 1 mV resolution. If the VGS step size is larger than 1 mV, then a linear interpolation method may be used to achieve the 1 mV resolution.
Typical DC bias voltages for `Vth_ci` measurements are `VDS = VDS_lin`, `VBS = VBB` for linear region measurement, or `VDS = VDS_sat`, (`VBS = VBB` for saturation region measurement). Typically, for PMOS, `VDS_lin = -0.1 V(@VDD =5 V)`; for `NMOS, VDS_lin=0.1 V(@VDD = 5 V).`

Figure 145: Four-terminal nMOSFET Vtci pin connections



Vtci ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

Vtci General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Vtext

Module name: Vtext

DUT: Four-terminal nMOSFET

Function: Measures the drain current during a gate voltage sweep, extracts the trans-conductance (Gm) and measure the maximum trans-conductance (Gmmax), measures the extracted threshold voltage (Vth_ex), measures the drain current and the gate voltage curve, and measures the Gm drain current or the Gm gate voltage curve.

Pin connections: Use a SMU to bias the drain. Use a SMU to sweep the gate. Input source and bulk voltage when needed. Usually, they are connected to GND for NMOS and connected to the nominal power supply voltage (VDD) for PMOS.

Procedure: The threshold voltage is extrapolated from the measurement of the maximum slope (`Gmmax`) of the ID-VGS curve:

```
Vth_ex = VGS (@Gmmax)-ID(@Gmmax)/Gmmax
```

Where:

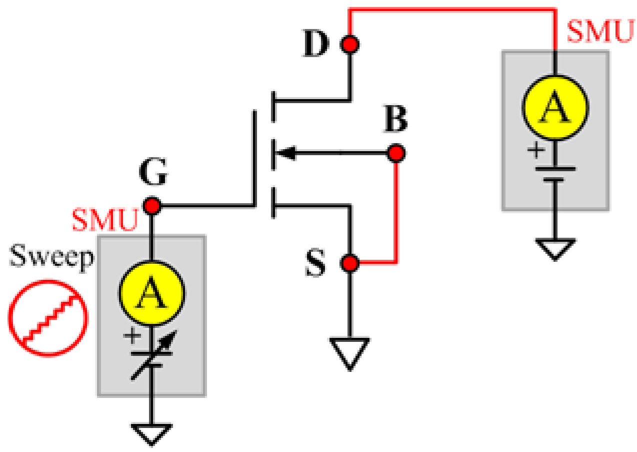
- `VGS @Gmmax)` is the gate voltage at the point of the maximum slope of the ID-VGS curve
- `ID(@Gmmax)` is the drain current at the point of the maximum slope of the ID-VGS curve
- `Gmmax` is the maximum slope of the ID-VGS curve

NOTE

DC bias voltages for `Vth_ex` measurements are `VDS = VDS_lin`, `VBS = VBB` for linear measurement.

`VDS = VDS_sat`, `VBS = VBB` for saturation. Typically, for PMOS, `VDS_lin = -0.1 V(@VDD = 5 V)`; for NMOS, `VDS_lin = 0.1 V(@VDD = 5 V)`.

Figure 146: Four-terminal nMOSFET Vtext pin connections



Vtext ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

Vtext General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Vtext_llsq

Module name: Vtext_llsq

Module type: Standard STM

Instrument: Keithley Instruments Series 2600B SMU

DUT: Four-terminal nMOSFET

Function: Measures the drain current at the gate voltage sweep, extracts the trans-conductance (Gm) and extract the maximum trans-conductance (Gmmax), measures the extracted threshold voltage (Vth_ex), measure the drain current and the gate voltage curve, and measures the Gm drain current or the Gm gate voltage curve.

Pin connections: Use a SMU to bias the drain. Use a SMU to sweep the gate. If needed, input the source and bulk voltage. Usually, they are connected to GND for NMOS and connected to the nominal power supply voltage (VDD) for PMOS.

Procedure: The threshold voltage is extrapolated from the measurement of the maximum slope (`Gmmax`) of the IDVGS curve.

```
Vth_ex = VGS (@Gmmax)-ID(@Gmmax)/Gmmax
```

Where:

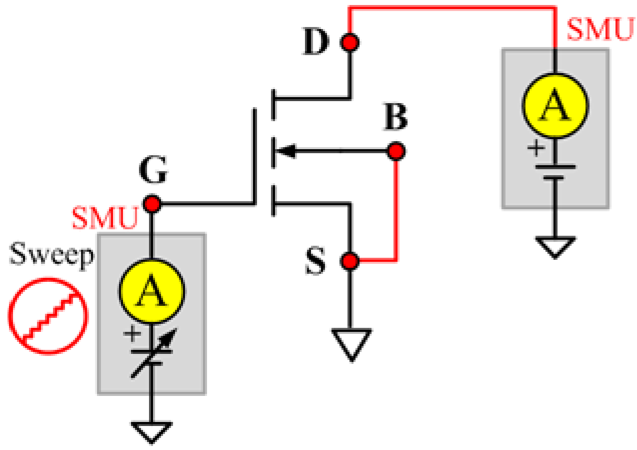
- `VGS(@Gmmax)` is the gate voltage at the point of the maximum slope of the IDVGS curve
- `ID(@Gmmax)` is the drain current at the point of the maximum slope of the IDVGS curve
- `Gmmax` is the maximum slope of the IDVGS curve

NOTE

DC bias voltages for `Vth_ex` measurements are `VDS = VDS_lin`, `VBS = VBB` for linear measurement.

`VDS = VDS_sat`, `VBS = VBB` for saturation. Typically, for PMOS, `VDS_lin = -0.1 V(@VDD = 5 V)`; for NMOS,`VDS_lin = 0.1 V(@VDD = 5 V).`

Figure 147: Four-terminal nMOSFET Vtext_Ilsq pin connections



nPowerMOSFET library

nPowerMOSFET library overview

The nPowerMOSFET library components are in the following directory:

C:\ACS_BASIC\library\devLibrary\nPowerMOSFET

The nPowerMOSFET parametric library is used to test some parameters of a n-type power MOSFET, including leakage, breakdown, gain, on-state, capacitance, and characteristic curves.

BVDSS

Module name: BVDSS

Module type: ITM

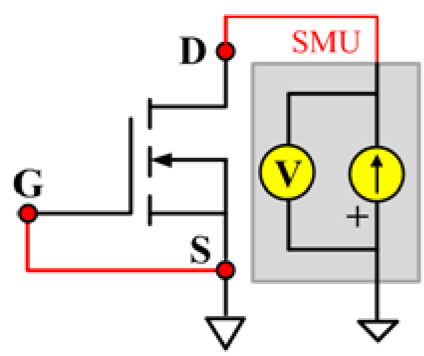
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal nPowerMOSFET

Function: Measures the breakdown voltage from the drain to the source. Measures voltage on the drain-source by applying a breakdown current to the drain and gate that is shorted to the source.

Pin connections: Use the Model 2657A instrument to apply current and make a voltage measurement at the drain. Connect the gate and source to GND or use a SMU to supply a zero-voltage bias.

Figure 148: nPowerMOSFET_BVDSS pin connections



Cds

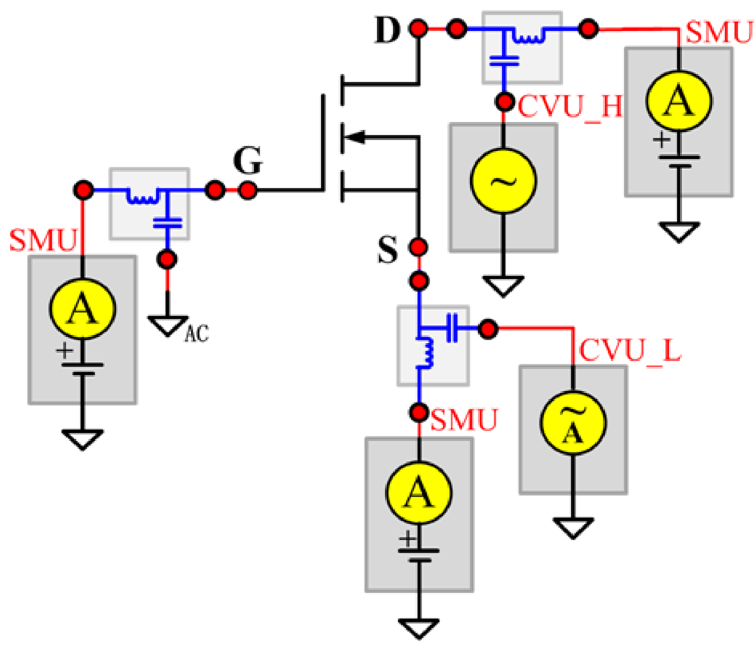
Module name: Cds

DUT: Three-terminal nPowerMOSFET

Function: Measures the capacitance between the Drain and Source terminals with the Gate terminal connected to the guard terminal of a three-terminal bridge.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the drain. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the source. Use the Series 2600B to supply zero voltage bias. Connect the guard terminal of a three-terminal bridge through one remote bias tee to the gate.

Figure 149: Three-terminal nPowerMOSFET Cds pin connections



Cds PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Cgd

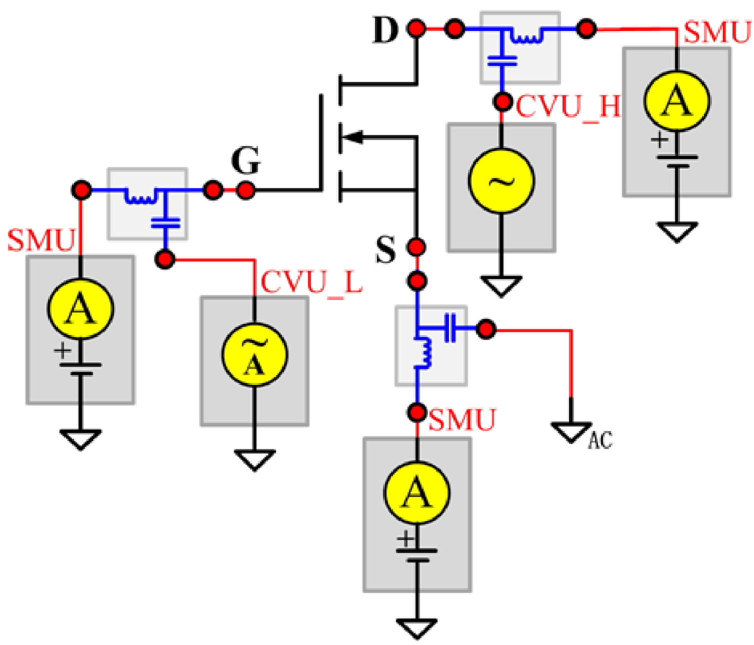
Module name: Cgd

DUT: Three-terminal nPowerMOSFET

Function: Measures the capacitance between the Drain and Gate terminals with the Source terminal connected to the guard terminal of a three-terminal bridge.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the drain. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the AC guard of a three-terminal bridge through one remote bias tee to the source.

Figure 150: Three-terminal nPowerMOSFET Cgd pin connections



Cgd PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Cgs

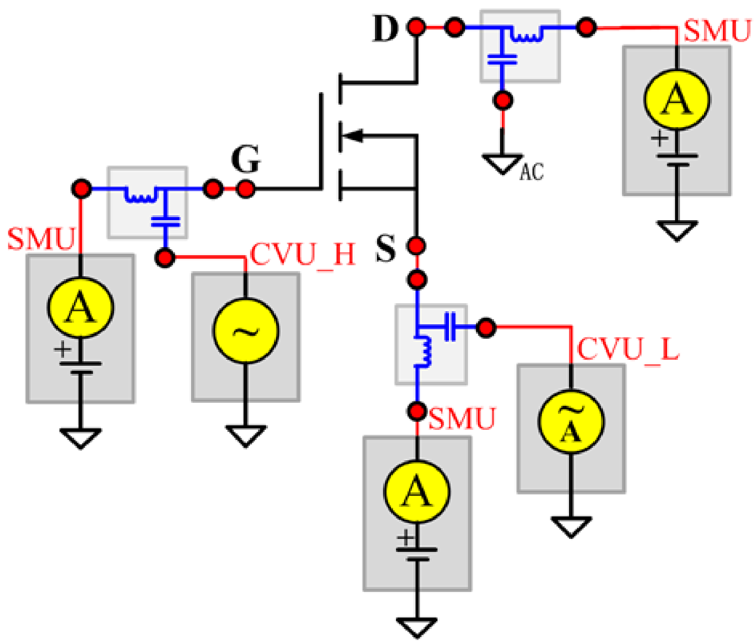
Module name: Cgs

DUT: Three-terminal nPowerMOSFET

Function: Measures the capacitance between the Gate and Source terminals with the Drain terminal connected to the guard terminal of a three-terminal bridge.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the ac guard of a three-terminal bridge through one remote bias tee to the drain. Use the Series 2600B to supply zero voltage bias.

Figure 151: Three-terminal nPowerMOSFET Cgs pin connections



Cgs PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Ciss

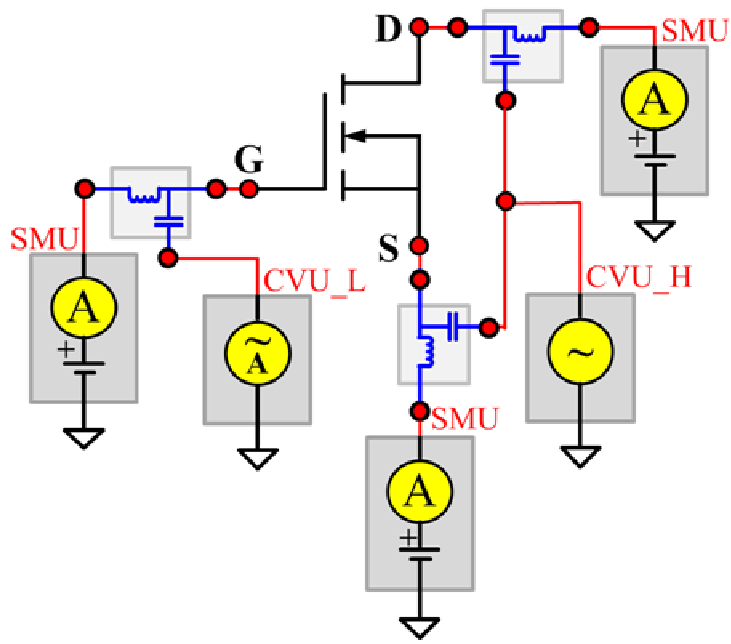
Module name: Ciss

DUT: Three-terminal nPowerMOSFET

Function: Measures the capacitance between the Gate and Source terminals with the Drain terminal ac short-circuited to the Source terminal.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the drain. Use the Series 2600B to sweep voltage. AC short circuit the drain to the source terminal. Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to supply zero voltage bias.

Figure 152: Three-terminal nPowerMOSFET Ciss pin connections



Ciss PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Coss

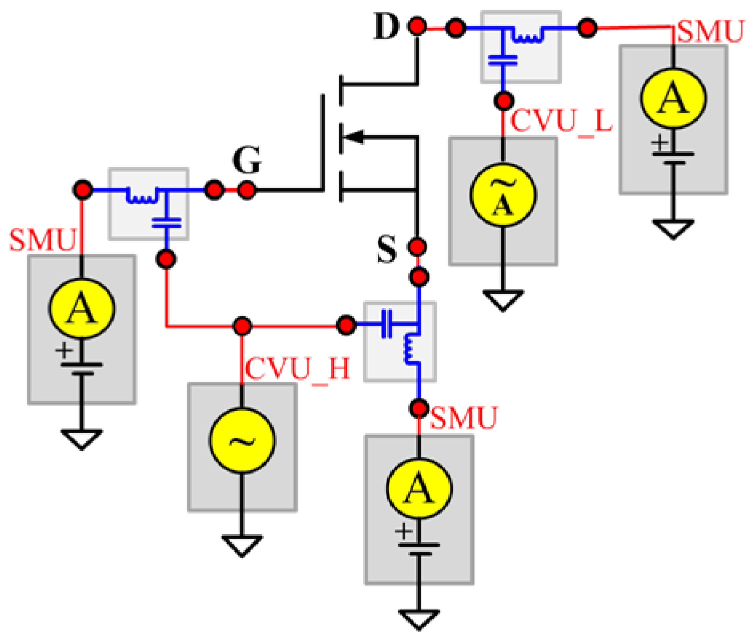
Module name: Coss

DUT: Three-terminal nPowerMOSFET

Function: Measures the capacitance between the drain and source terminals with the gate terminal ac short-circuited to the source terminal.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to supply zero voltage bias. AC short circuit the gate to the source terminal. Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the drain. Use the Series 2600B to sweep voltage.

Figure 153: Three-terminal nPowerMOSFET Coss pin connections



Coss PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Crss

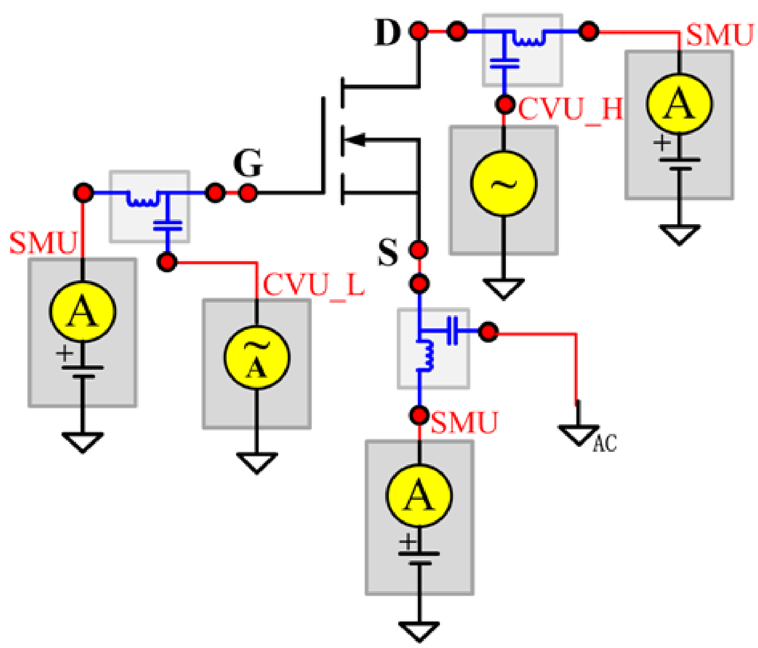
Module Name: Crss

DUT: Three-terminal nPowerMOSFET

Function: Measures the common-source short-circuit input capacitance by testing the capacitance between the Drain and Gate terminals with the Source terminal connected to the guard terminal of a three-terminal bridge.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the drain. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the AC guard of a three-terminal bridge through one remote bias tee to the source. Use the Series 2600B to supply zero voltage bias.

Figure 154: Three-terminal nPowerMOSFET Crss pin connections



Crss PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

GFS

Module name: GFS

Module type: ITM

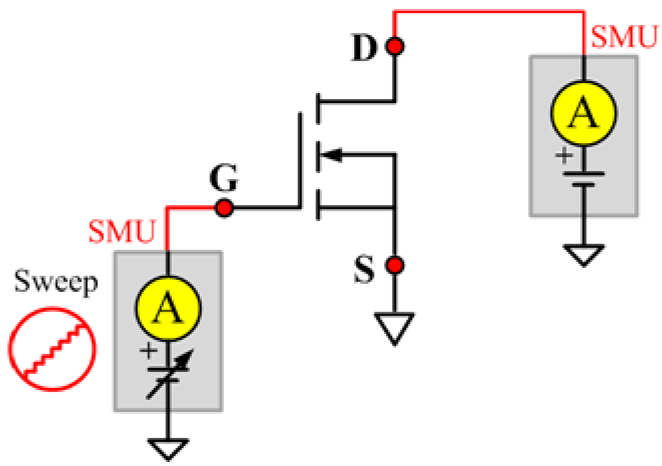
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

Function: Measures the forward transconductance. Measures the current on the drain by applying a voltage sweep from the gate to the source and calculates the ratio of change in the Id for a change in the Vgs: GFS = delta (Id)/delta(Vgs).

Pin connections: Use the Model 2651A to apply voltage and make a current measurement at the drain. Use the low power Model 2600B to sweep voltage at the gate. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 155: nPowerMOSFET GFS pin connections



IdON

Module name: IdON

Module type: ITM

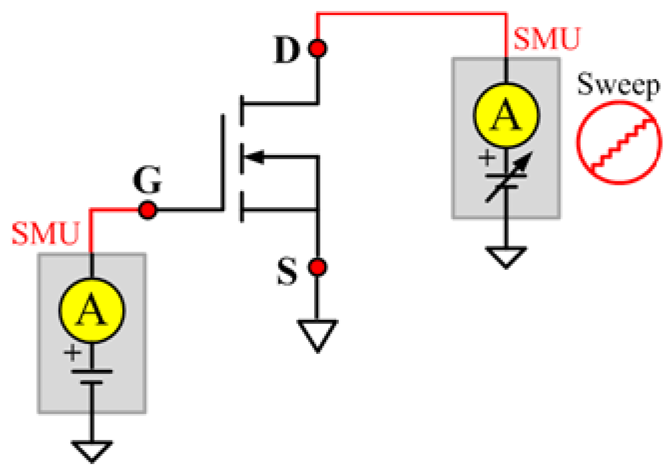
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

Function: Measures the on-state drain current. Measures the current on the drain by applying a voltage sweep to the drain-source with a specific gate voltage to turn on the device at a specific Id current value that is given in the datasheet.

Pin connections: Use the Model 2651A to apply a voltage sweep and make a current measurement at the drain. Use the low power Model 2600A to source a specific voltage at the gate. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 156: nPowerMOSFET IdON pin connections



IdON_MIX

Module name: IdON_MIX

Module type: PTM

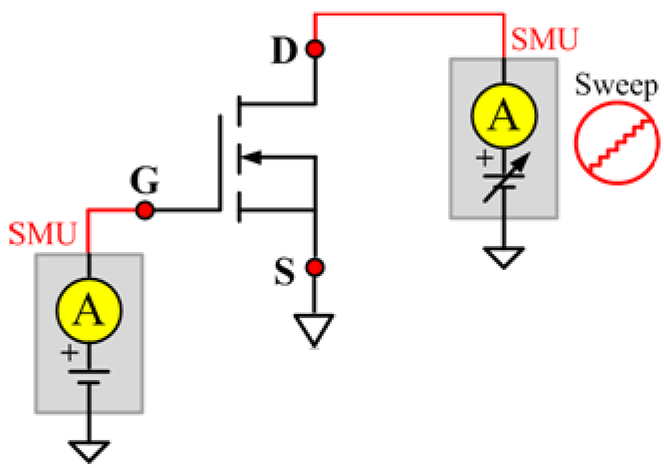
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200A-SMU

DUT: Three-terminal nPowerMOSFET

Function: Measures the on-state drain current. Measures current on the drain by applying a voltage sweep to the drain-source with a specific gate voltage to turn on the device at a certain Id current value that is given in the data sheet.

Pin connections: Use the Model 2651A SMU to apply a voltage sweep and make a current measurement at the drain. Use another SMU to force a specific voltage at the gate. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 157: nPowerMOSFET IdON_MIX pin connections



IDSS

Module name: IDSS

Module type: ITM

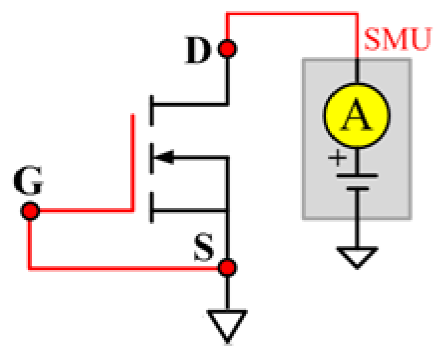
Instrument: Keithley Instruments Model 2657A, Series 2600B

DUT: Three-terminal nPowerMOSFET

Function: Measures the leakage current from the drain to the Source when the device is off. Measures the current on the drain by applying a maximum permissible voltage between the drain and source, while the gate is shorted to the source.

Pin connections: Use the Model 2657A to apply voltage and make a current measurement at the drain. Connect the gate and source to GND or use a SMU to supply a zero-voltage bias.

Figure 158: nPowerMOSFET IDSS pin connections



IdVd_StepVg

Module name: IdVd_StepVg

Module type: ITM

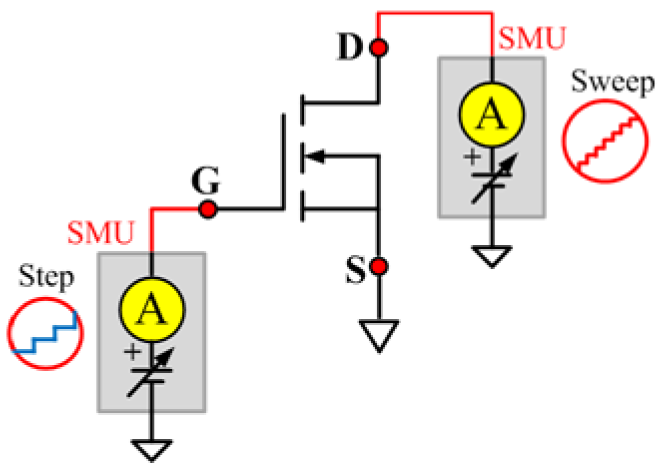
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

Function: Measures the drain current at the specified gate voltage and sweeps the drain in pulse mode. Generates the standard family of IdVd curves.

Pin connections: Use the Model 2651A to apply a voltage sweep and make a current measurement at the drain. Use the low power Model 2600A to source a specific voltage at the gate. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 159: nPowerMOSFET IdVd_StepVg pin connections



IdVd_StepVg_MIX

Module name: IdVd_StepVg_MIX

Module type: PTM

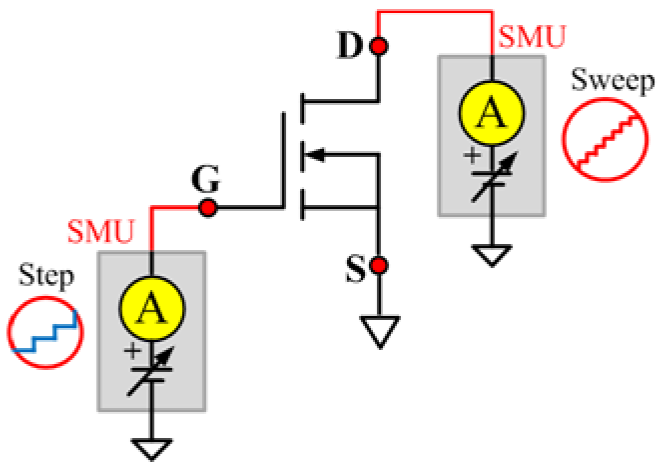
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200A-SMU

DUT: Three-terminal nPowerMOSFET

Function: Measures the standard family of IdVd curves. Each time the voltage steps on the gate-source, a voltage sweep and a set of current measurements occur on the drain.

Pin connections: Use the Model 2651A SMU to apply a voltage sweep and make a current measurement at the drain. Use a SMU to force a specific voltage at the gate. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 160: nPowerMOSFET IdVd_StepVg_MIX pin connections



IdVg_StepVd

Module name: IdVg_StepVd

Module type: ITM

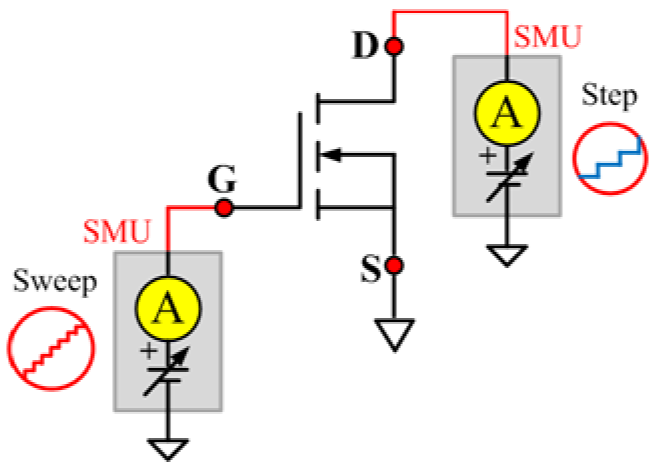
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

Function: Measures the transfer characteristic of the device. Each time the voltage steps on the drain-source, a voltage sweep is performed on the gate-source and set of current measurements occurs on the drain.

Pin connections: Use the Model 2651A to apply a voltage step and make a current measurement at the drain. Use the low power Model 2600B to sweep voltage at the gate. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 161: nPowerMOSFET IdVg_StepVd pin connections



IGSSF

Module name: IGSSF

Module type: ITM

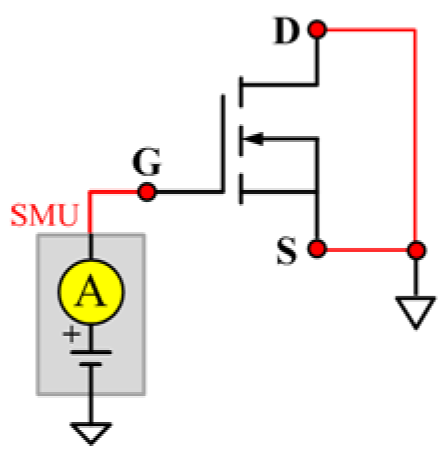
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

Function: Measures the gate forward leakage current. Measures the current on the gate at the maximum permissible positive voltage from the gate to the source.

Pin connections: Use a SMU to force voltage and make a current measurement at the gate. Connect the drain and source to GND or use a SMU to supply a zero-voltage bias.

Figure 162: nPowerMOSFET IGSSF pin connections



IGSSR

Module name: IGSSR

Module type: ITM

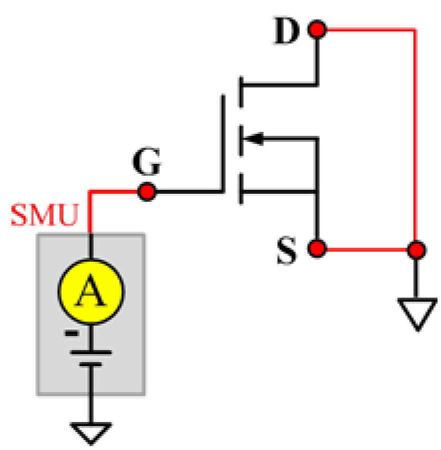
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

Function: Measures the gate body reversed leakage current. Measures current on the gate at the maximum permissible negative voltage from gate to source.

Pin connections: Use a SMU to force voltage and make a current measurement from the gate. Connect the drain and source to GND or use a SMU to supply a zero-voltage bias.

Figure 163: nPowerMOSFET IGSSR pin connections



RdsON

Module name: RdsON

Module type: ITM

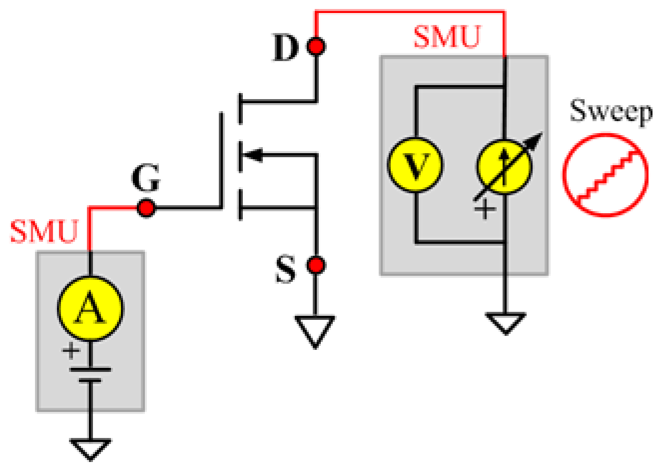
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

Function: Measures the drain to source on-state resistance. Measures resistance by applying a current sweep to the drain with a specific gate voltage that is calculated by dividing the measured drain voltage by the Sourced current: Rds = Vds/Id.

Pin connections: Use the Model 2651A to apply a current sweep and make a voltage measurement at the drain. Use the low-power Model 2600B to force a specific voltage at the gate. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 164: nPowerMOSFET RdsON pin connections



RdsON_MIX

Module name: RdsON_MIX

Module type: PTM

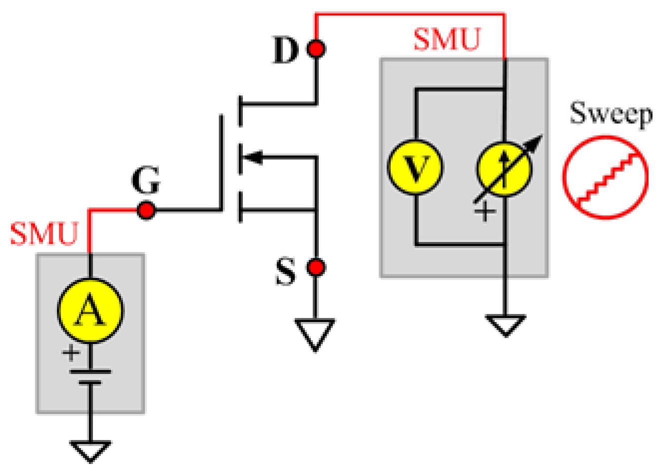
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200A-SMU

DUT: Three-terminal nPowerMOSFET

Function: Measures the drain to source on-state resistance. Measures resistance by applying a current sweep to the drain with a specific gate voltage that is calculated by dividing the measured drain voltage by the Sourced current: Rds = Vds/Id.

Pin connections: Use the Model 2651A SMU to apply a current sweep and make a voltage measurement at the drain. Use a SMU to force specific voltage at the gate. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 165: nPowerMOSFET RdsON_MIX pin connections



VdsON

Module name: VdsON

Module type: ITM

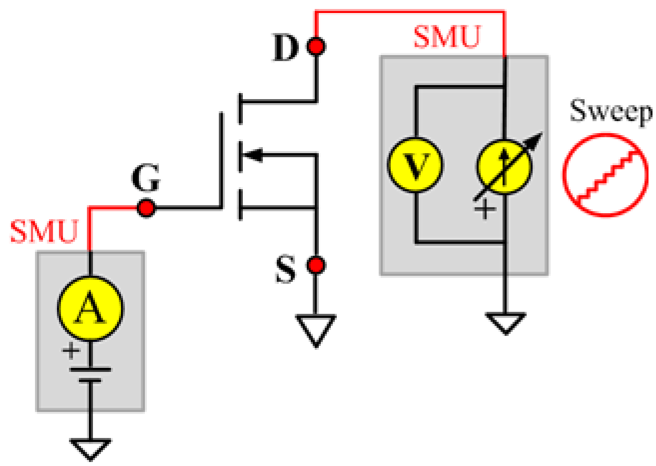
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

Function: Measures the drain to source on-state voltage. Measures voltage on the drain-source by applying a current sweep to the drain with a specific gate voltage to turn on the device at a certain resistance value.

Pin connections: Use the Model 2651A SMU to apply a current sweep and make a voltage measurement at the drain. Use the low-power Model 2600B to force a specific voltage at the gate. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 166: nPowerMOSFET VdsON pin connections



VgsON

Module name: VgsON

Module type: ITM

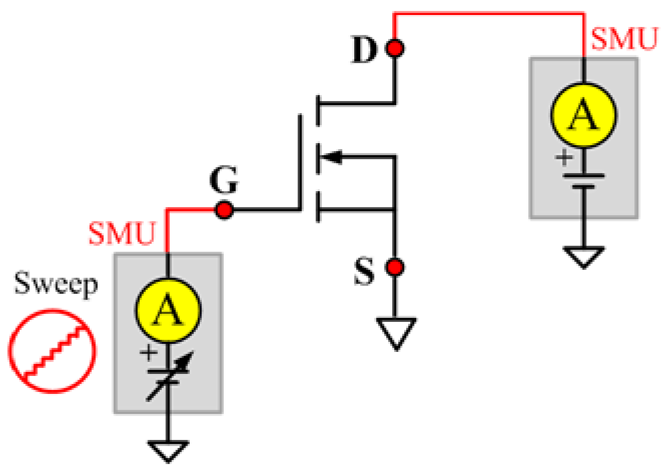
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

Function: Measures the Gate to Source on-state voltage. Measures current on the Drain by applying a voltage sweep to the Gate-Source with a specific Drain to Source voltage to turn on the device to a certain Id current value.

Pin connections: Use the Model 2651A to apply voltage and make a current measurement at the drain. Use the low-power Model 2600B to sweep voltage at the gate. Connect source to GND or use a SMU to supply a zero-voltage bias.

Figure 167: nPowerMOSFET VgsON pin connections



VgsON_MIX

Module name: VgsON_MIX

Module type: PTM

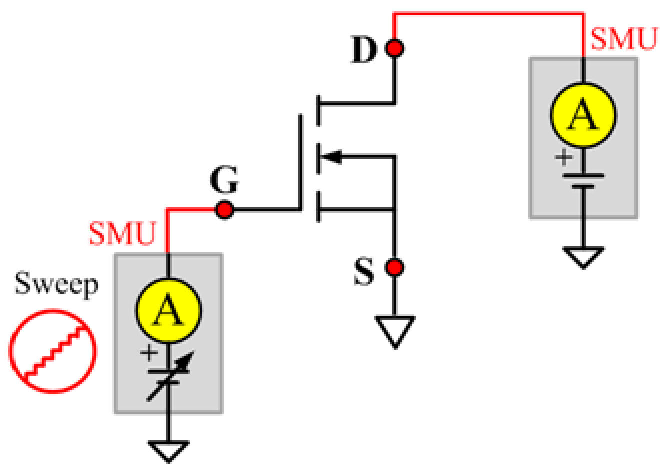
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200A SMU

DUT: Three-terminal nPowerMOSFET

Function: Measures the gate to source on-state voltage. Measures current on the drain by applying a voltage sweep to the gate-source with a specific drain to source voltage to turn on the device at a certain Id current value.

Pin connections: Use the Model 2651A SMU to apply voltage and make a current measurement at the drain. Use the low-power 2600B to sweep voltage at the gate. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 168: nPowerMOSFET VgsON_MIX pin connections



VGSTH

Module name: VGSTH

Module type: ITM

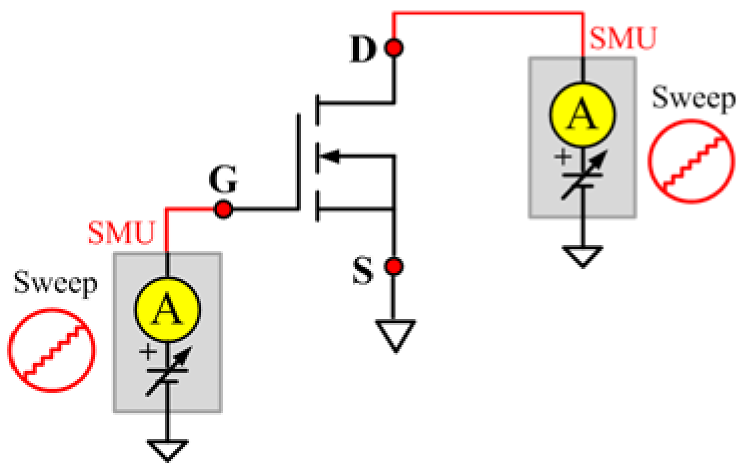
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

Function: Measures the threshold voltage from the gate to source that is required to turn on the device at a specific Id current value that is given in the data sheet.

Pin connections: Use the Model 2651A SMU to force voltage and make a current measurement at the drain. Use the low-power Model 2600B to sweep voltage at the gate. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 169: nPowerMOSFET VGSTH pin connections



VSD

Module name: VSD

Module type: ITM

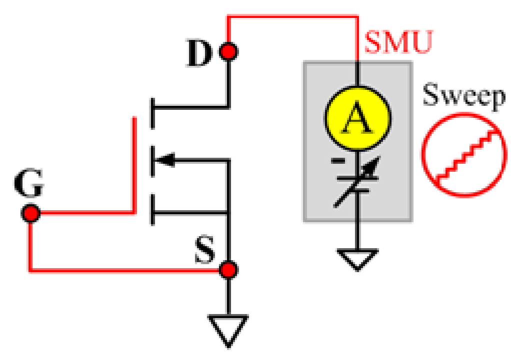
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

Function: Measures the forward voltage drop of the parasitic diode between the drain and source. Measures current on the drain by applying a voltage sweep from the source to drain with the gate shorted to the source.

Pin connections: Use the Model 2651A SMU to force voltage and make a current measurement at the Drain. Connect the gate and source to GND or use a SMU to supply a zero-voltage bias.

Figure 170: nPowerMOSFET VSD pin connections



pMOSFET library

pMOSFET library overview

The pMOSFET library components are in the following directory:

```
C:\ACS_BASIC\library\devLibrary\pMOSFET
```

The pMOSFET parametric library is used to test parameters of a p-type power MOSFET, including leakage, breakdown, gain, on-state, capacitance, and characteristic curves.

BVDSS

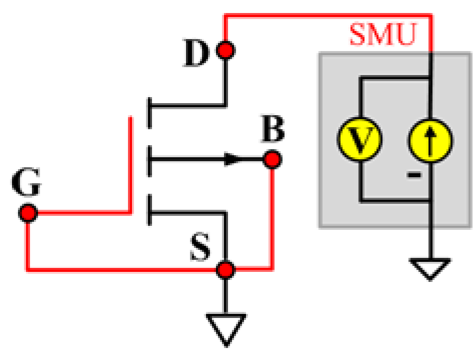
Module name: BVDSS

DUT: Four-terminal pMOSFET

Function: Measures the drain-source breakdown voltage of the pMOSFET with the gate-source shorted.

Pin connections: Use a SMU to apply a breakdown current on the drain. Short the bulk, gate, and source to GND or use a SMU to supply a zero-voltage bias.

Figure 171: Four-terminal pMOSFET BVDSS pin connections



BVDSS ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

BVDSS General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVDSV

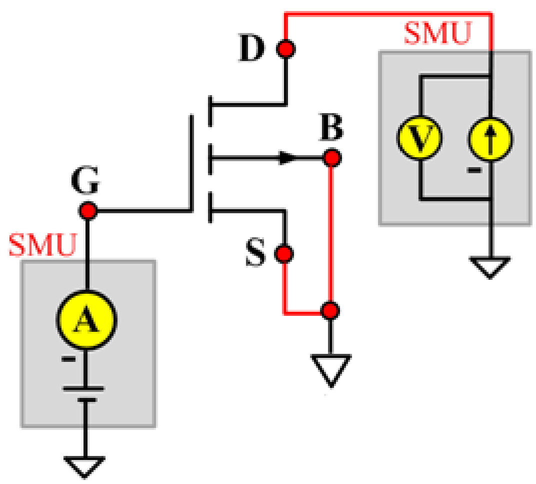
Module name: BVDSV

DUT: Four-terminal pMOSFET

Function: Measures the drain-source breakdown voltage of the pMOSFET with the gate biased.

Pin connections: Use a SMU to bias the gate. Use a SMU to apply a breakdown current on the drain. Connect the source and bulk to GND or use a SMU to supply a zero-voltage bias.

Figure 172: Four-terminal pMOSFET BVDSV pin connections



BVDSV ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

BVDSV General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVGSO

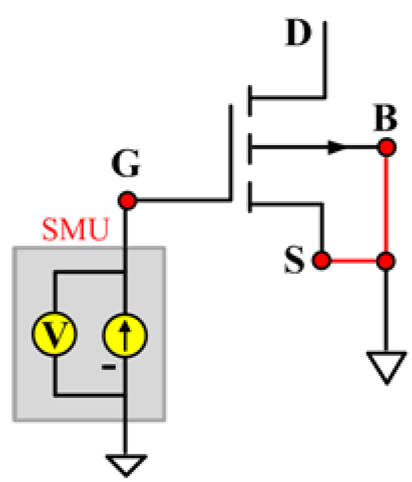
Module name: BVGSO

DUT: Four-terminal pMOSFET

Function: Measures the gate-source breakdown voltage of the pMOSFET with the drain opened.

Pin connections: Use a SMU to apply a breakdown current on the gate. Open the circuit to the drain or use a SMU to supply a zero-current bias. Connect the bulk and source to GND or use a SMU to supply a zero-voltage bias.

Figure 173: Four-terminal pMOSFET BVGSO pin connections



BVGSO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

BVGSO General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVGDS

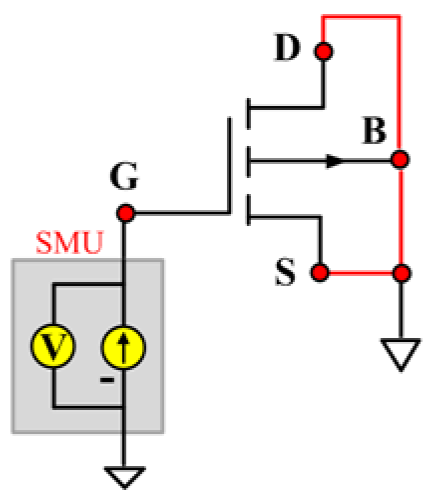
Module name: BVGDS

DUT: Four-terminal pMOSFET

Function: Measures the gate-drain breakdown voltage of the pMOSFET with the source-drain shorted.

Pin connections: Use a SMU to apply a breakdown current on the gate. Connect the source, drain, and bulk to ground or use a SMU to supply a zero-voltage bias.

Figure 174: Four-terminal pMOSFET BVGDS pin connections



BVGDS ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

BVGDS General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVGDO

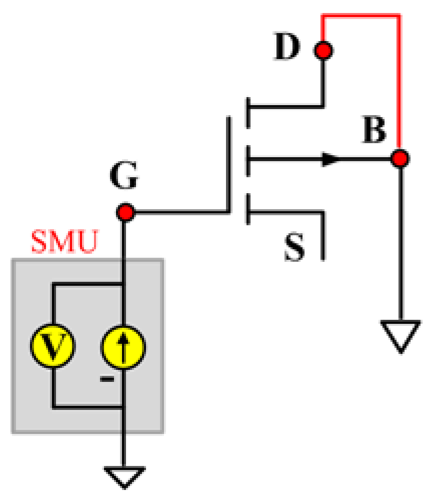
Module name: BVGDO

DUT: Four-terminal pMOSFET

Function: Measures the gate-drain breakdown voltage of the pMOSFET with the source opened.

Pin connections: Use a SMU to apply a breakdown current on the gate. Open the circuit to the source or use a SMU to supply a zero-current bias. Connect the bulk and drain to GND or use a SMU to supply a zero-voltage bias.

Figure 175: Four-terminal pMOSFET BVGDO pin connections



BVGDO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

BVGDO General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Cds

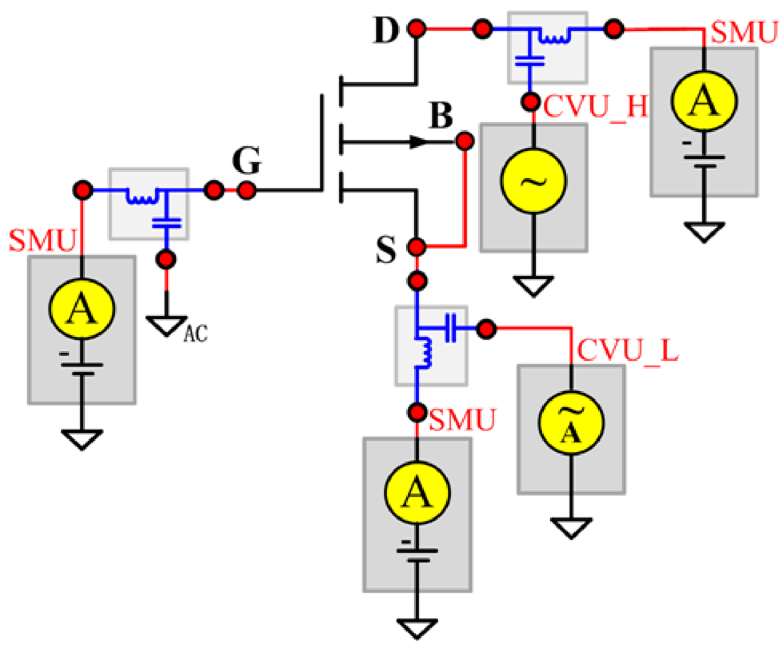
Module name: Cds

DUT: Four-terminal pMOSFET

Function: Measures the capacitance between the Drain and Source terminals with the Gate terminal connected to the guard terminal of a three-terminal bridge. Short bulk to source.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the drain. Use the Series 2600B to sweep voltage. Short bulk to source. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the source. Use the Series 2600B to supply zero voltage bias. Connect the guard terminal of a three-terminal bridge through one remote bias tee to the gate.

Figure 176: Four-terminal pMOSFET Cds pin connections



Cds PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Cgd

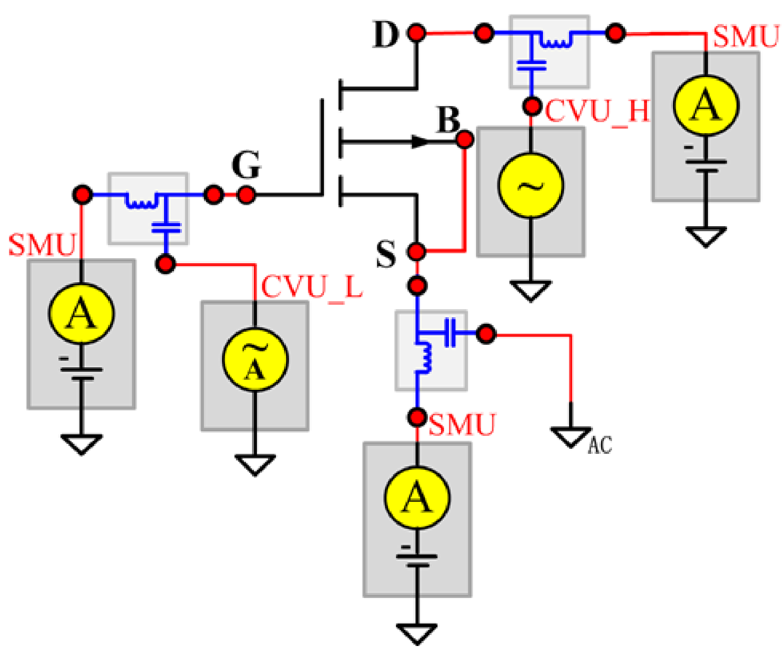
Module name: Cgd

DUT: Four-terminal pMOSFET

Function: Measures the capacitance between the Drain and Gate terminals with the Source terminal connected to the guard terminal of a three-terminal bridge. Short bulk to source.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the drain. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the ac guard of a three-terminal bridge through one remote bias tee to the source.

Figure 177: Four-terminal pMOSFET Cgd pin connections



Cgd PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Cgs

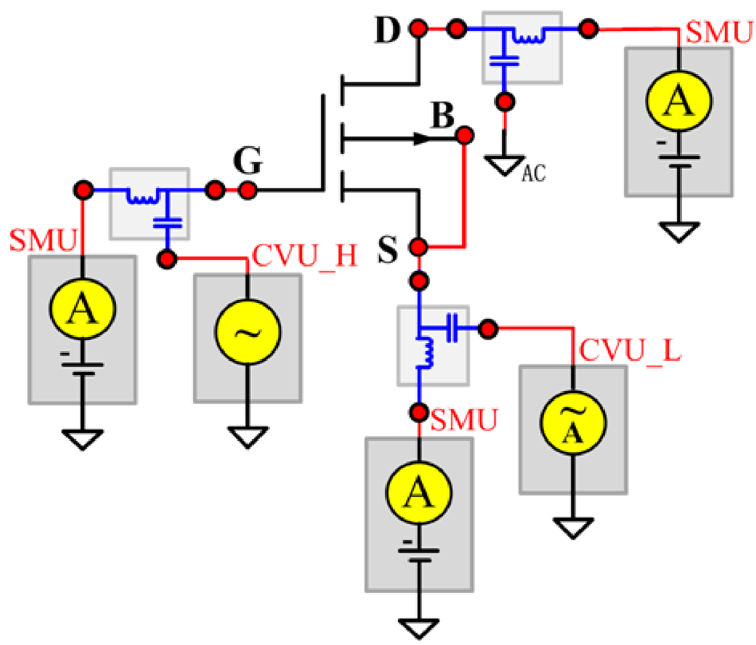
Module name: Cgs

DUT: Four-terminal pMOSFET

Function: Measures the capacitance between the Gate and Source terminals with the Drain terminal connected to the guard terminal of a three-terminal bridge. Short bulk to source.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the ac guard of a three-terminal bridge through one remote bias tee to the drain.

Figure 178: Four-terminal pMOSFET Cgs pin connections



Cgs PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Ciss

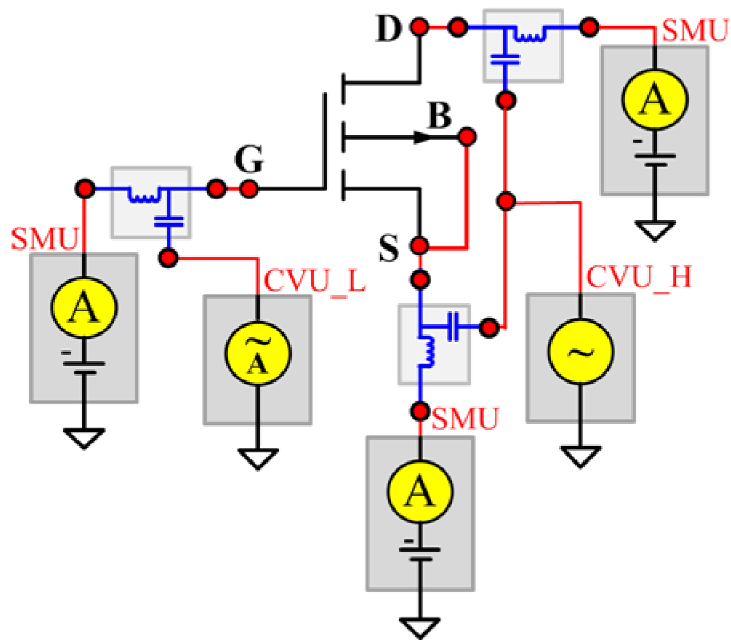
Module name: Ciss

DUT: Four-terminal pMOSFET

Function: Measures the capacitance between the Gate and Source terminals with the Drain terminal ac short-circuited to the Source terminal. Short bulk to source.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the drain. Use the Series 2600B to sweep voltage. AC short circuit the drain to the source terminal. Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to supply zero voltage bias.

Figure 179: Four-terminal pMOSFET Ciss pin connections



Ciss PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Coss

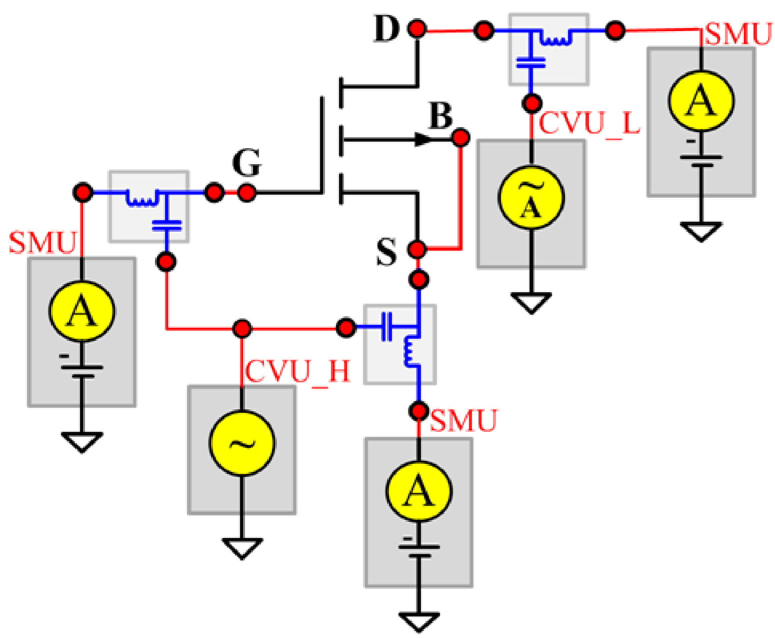
Module name: Coss

DUT: Four-terminal pMOSFET

Function: Measures the capacitance between the drain and source terminals with the gate terminal ac short-circuited to the source terminal. Short bulk to source.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to supply zero voltage bias. AC short circuit the gate to the source terminal. Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the drain. Use the Series 2600B to sweep voltage.

Figure 180: Four-terminal pMOSFET Coss pin connections



Coss PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Crss

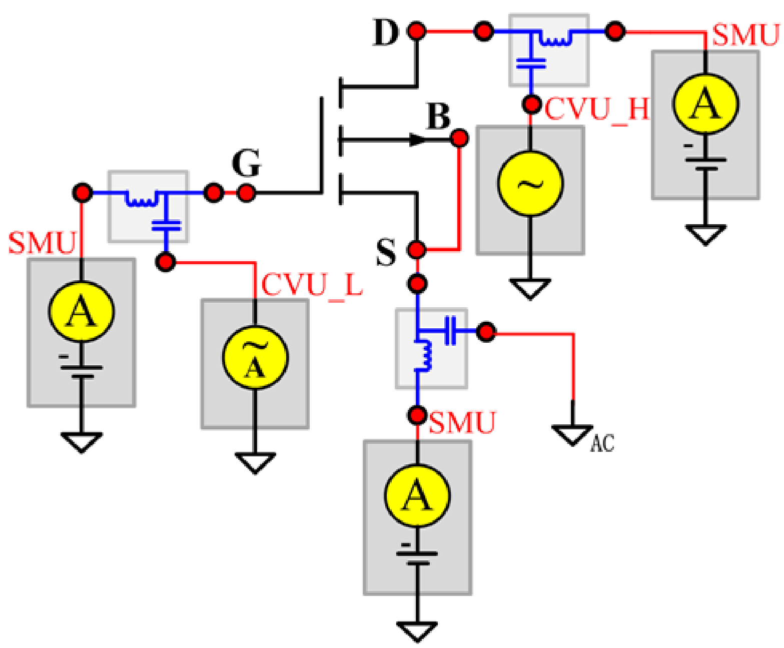
Module name: Crss

DUT: Four-terminal pMOSFET

Function: Measures the common-source short-circuit input capacitance by testing the capacitance between the Drain and Gate terminals with the Source terminal connected to the guard terminal of a three-terminal bridge. Short bulk to source.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the drain. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the ac guard of a three-terminal bridge through one remote bias tee to the source. Use the Series 2600B to supply zero voltage bias.

Figure 181: Four-terminal pMOSFET Crss pin connections



Crss PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

IDL

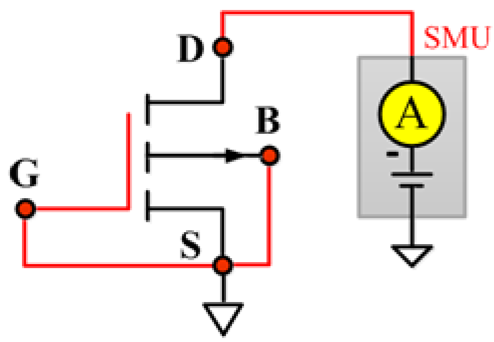
Module name: IDL

DUT: Four-terminal pMOSFET

Function: Measures the drain leakage current with the gate-source shorted.

Pin connections: Use a SMU to force voltage to the drain. Connect the gate, source, and bulk to GND or use a SMU to supply a zero-voltage bias.

Figure 182: Four-terminal pMOSFET IDL pin connections



IDL ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

IDL General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IDS

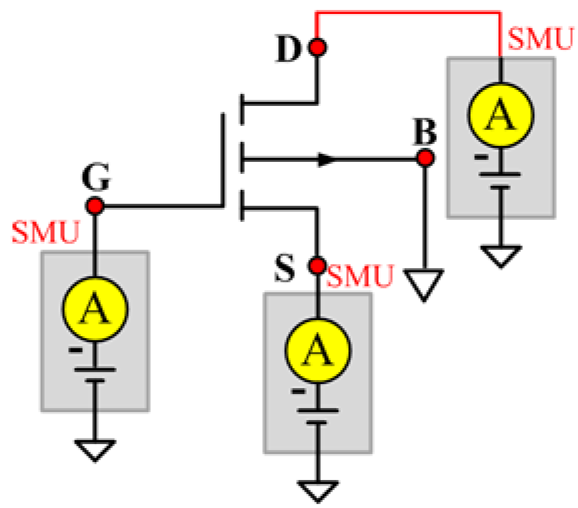
Module name: IDS

DUT: Four-terminal pMOSFET

Function: Measures the drain-source and source-drain current with the gate biased.

Pin connections: Use a SMU to force voltage to the gate. Use a SMU to force voltage to the drain. Connect source and bulk to GND or use a SMU to supply a zero-voltage bias.

Figure 183: Four-terminal pMOSFET IDS pin connections



IDS ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

IDS General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVd_BiasVg

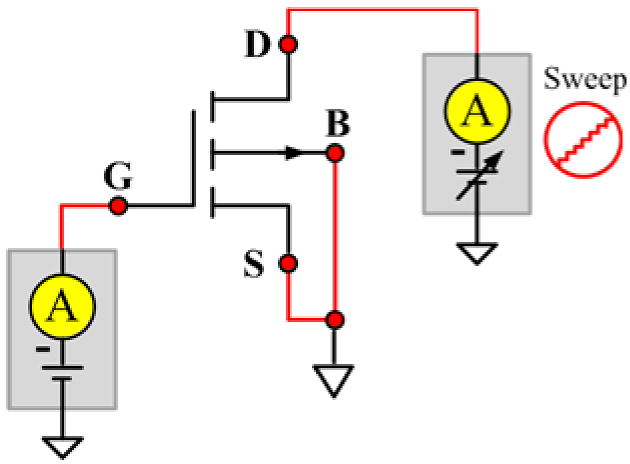
Module name: IdVd_BiasVg

DUT: Four-terminal pMOSFET

Function: Measures the drain current during a specified drain voltage sweep, and the drain current and drain voltage curve.

Pin connections: Use a SMU to bias the gate. Use a SMU to sweep the drain. Connect bulk and source to GND or use a SMU to supply a zero-voltage bias.

Figure 184: Four-terminal pMOSFET IdVd_BiasVg pin connections



IdVd_BiasVg ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

IdVd_BiasVg_General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVd_StepVg

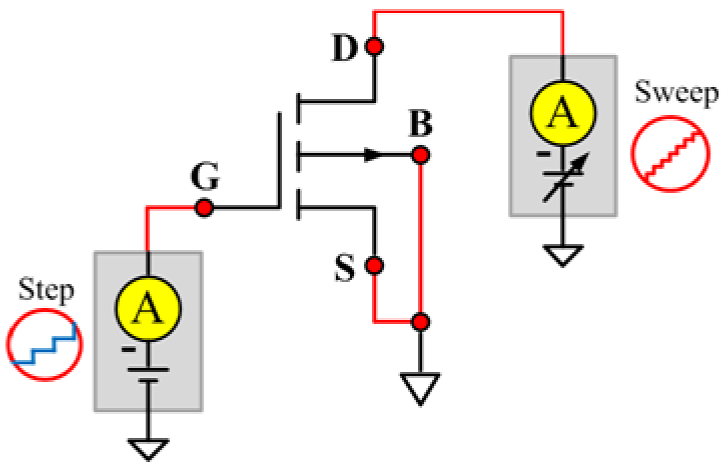
Module name: IdVd_StepVg

DUT: Four-terminal pMOSFET

Function: Measures the drain current during a specified drain voltage sweep, and a series of drain currents and the drain voltage curve.

Pin connections: Use a SMU to sweep the drain. Use a SMU to step the gate. Connect the bulk and source to ground or use a SMU to supply a zero-voltage bias.

Figure 185: Four-terminal pMOSFET IdVd_StepVg pin connections



IdVd_StepVg ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

IdVd_StepVg General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVg_BiasVd

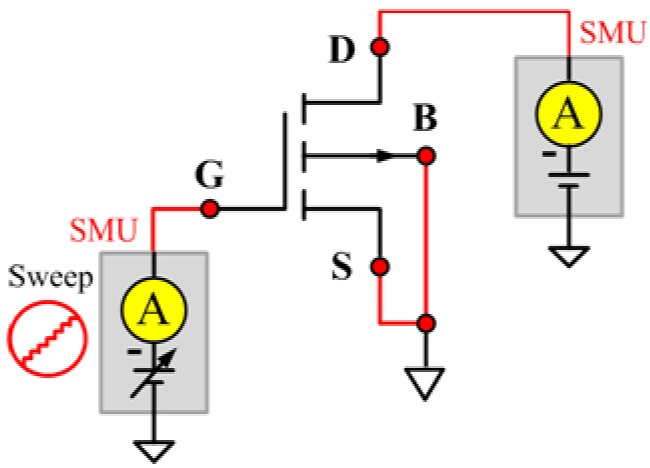
Module name: IdVg_BiasVd

DUT: Four-terminal pMOSFET

Function: Measures the drain current during a specified gate voltage sweep, and the drain current value and the gate voltage curve.

Pin connections: Use a SMU to bias the drain. Use a SMU to sweep the sweep the gate. Connect the bulk and source to GND or use a SMU to supply a zero-voltage bias.

Figure 186: Four-terminal pMOSFET IdVg_BiasVd pin connections



IdVg_BiasVd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

IdVg_BiasVd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVg_StepVd

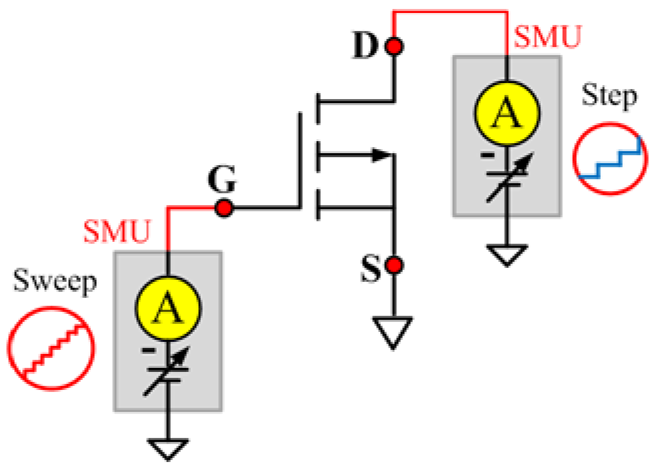
Module name: IdVg_StepVd

DUT: Four-terminal pMOSFET

Function: Measures the drain current at a specified gate voltage sweep with a drain step, and the series of drain currents and gate voltage curve.

Pin connections: Use a SMU to step the drain. Use a SMU to sweep the gate. Connect the bulk and source to GND or use a SMU to supply a zero-voltage bias.

Figure 187: Four-terminal pMOSFET IdVg_StepVd pin connections



IdVg_StepVd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

IdVg_StepVd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IGL

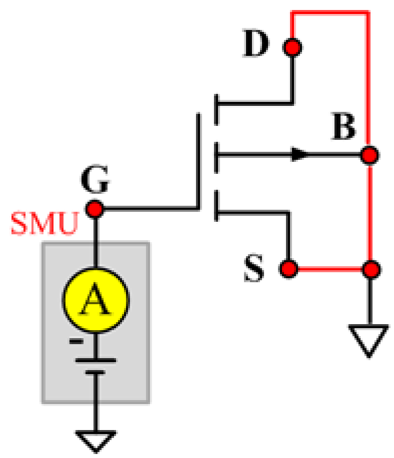
Module name: IGL

DUT: Four-terminal pMOSFET

Function: Measures the gate leakage current when the source and drain are shorted.

Pin connections: Use a SMU to force voltage to the gate. Connect the source, drain, and bulk to GND or use a SMU to supply a zero-voltage bias.

Figure 188: Four-terminal pMOSFET IGL pin connections



IGL ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

IGL General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IgVg

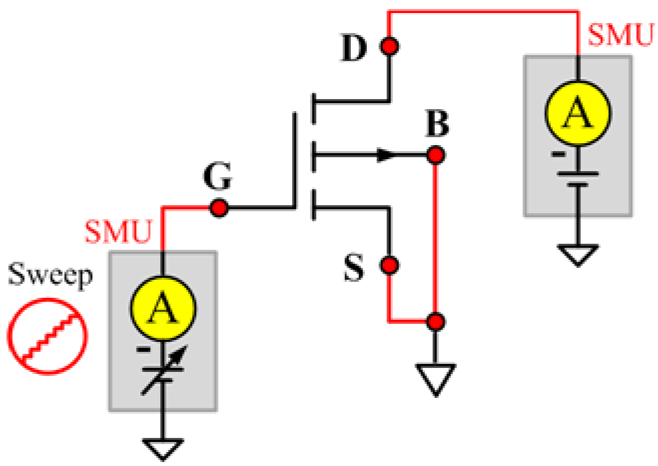
Module name: IgVg

DUT: Four-terminal pMOSFET

Function: Measures the gate current at a specified gate voltage sweep when the drain is biased, and the gate current and gate voltage curve.

Pin connections: Use a SMU to bias the drain. Use a SMU to sweep the gate. Connect the bulk and source to GND or use a SMU to supply a zero-voltage bias.

Figure 189: Four-terminal pMOSFET IgVg pin connections



IgVg ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

IgVg General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

ISL

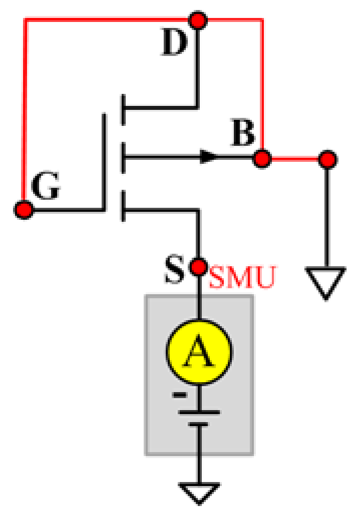
Module name: ISL

DUT: Four-terminal pMOSFET

Function: Measures the source leakage current when the gate-drain is shorted.

Pin connections: Use a SMU to force voltage to the source. Connect the bulk, gate, and drain to GND or use a SMU to supply a zero-voltage bias.

Figure 190: Four-terminal pMOSFET ISL pin connections



ISL ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

ISL General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IsubVg

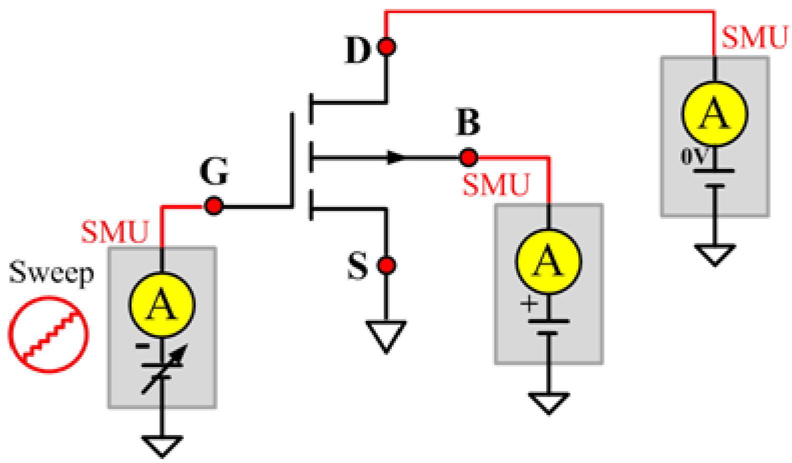
Module name: IsubVg

DUT: Four-terminal pMOSFET

Function: Measures the bulk current at a specified gate voltage sweep, the bulk current and the gate voltage curve, and the maximum bulk current and the corresponding gate voltage.

Pin connections: Use a SMU to sweep the gate. Use a SMU to bias the drain and bulk. Connect the source to ground or use a SMU to supply a zero-voltage bias.

Figure 191: Four-terminal pMOSFET IsubVg pin connections



IsubVg ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

IsubVg General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Vtci

Module name: Vtci

DUT: Four-terminal pMOSFET

Function: Measures the constant current threshold voltage of the pMOSFET device, and the drain current and the gate voltage curve.

Pin connections: Use a SMU to bias the drain. Use a SMU to sweep the gate. If needed, input voltage to source and bulk. Usually, they are connected to GND for NMOS and connected to the nominal power supply voltage (VDD) for PMOS.

Procedure: The constant current threshold voltage.

```
Vth_ci = VGS (@ID = 1uA.W/L)
```
NMOS

```
Vth_ci = VGS (@ID = -0.025uA.W/L)
```
PMOS

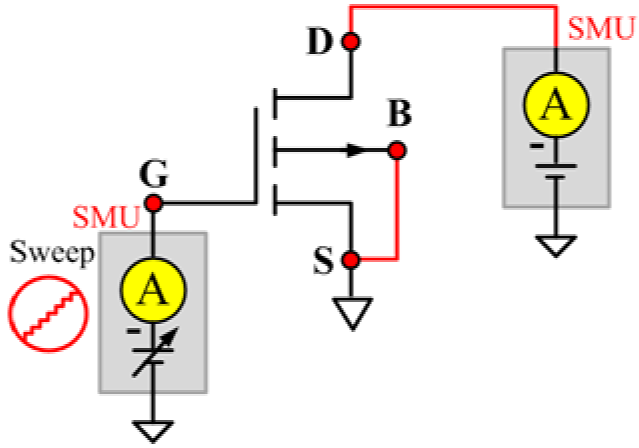
Where `W` and `L` are the gate width and gate length as printed on the wafer. Set a target drain current Id_tar (Id_tar=1 uA.W/L or −0.025 uA.W/L), which is the sign to be near threshold, then search the gate voltage to make the drain current equal to Id_tar.

NOTE

The `Four_term_pMOSFET_Vth_ci` measurement procedure must determine `Vth_ci` to within 1 mV resolution. If the VGS step size is larger than 1 mV, a linear interpolation method may be used to achieve the 1 mV resolution.

Typical DC bias voltages for `Vth_ci` measurements are VDS = VDS_lin, VBS = VBB for linear region measurement, or VDS = VDS_sat (VBS = VBB for saturation region measurement). Typically, for PMOS, `VDS_lin = -0.1 V(@VDD = 5 V)`; for NMOS, `VDS_lin = 0.1 V(@VDD = 5 V).`

Figure 192: Four-terminal pMOSFET Vtci pin connections



Vtci ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

Vtci General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Vtext

Module name: Vtext

DUT: Four-terminal pMOSFET

Function: Measures the drain current at the gate voltage sweep, extracts the trans-conductance (Gm) and measure the maximum trans-conductance (Gmmax), measures the extracted threshold voltage (Vth_ex), measures the drain current and the gate voltage curve, and measures the Gm and the drain current or the Gm and the gate voltage curve.

Pin connections: Use a SMU to bias the drain. Use a SMU to sweep the gate. If needed, input the source and bulk. Usually, they are connected to GND for NMOS and connected to the nominal power supply voltage (VDD) for PMOS.

Procedure: The threshold voltage is extrapolated from the measurement of the maximum slope (Gmmax) of the IDVGS curve:

```
Vth_ex = VGS (@Gmmax)-ID(@Gmmax)/Gmmax
```

Where:

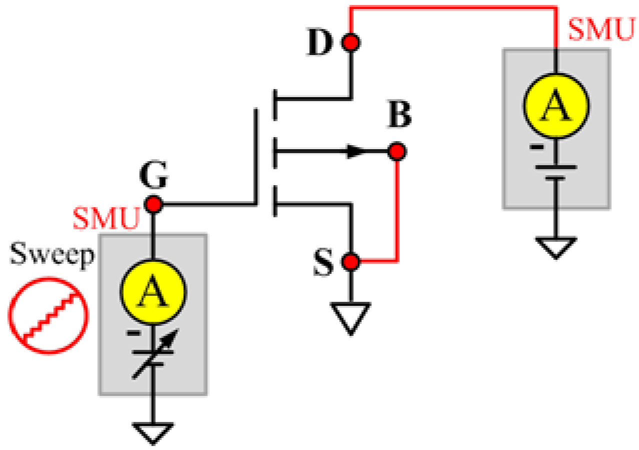
- VGS (@Gmmax) is the gate voltage at the point of the maximum slope of the IDVGS curve
- ID(@Gmmax) is the drain current at the point of the maximum slope of the IDVGS curve
- Gmmax is the maximum slope of the IDVGS curve

NOTE

DC bias voltages for the Vth_ex measurements are VDS = VDS_lin, VBS = VBB for linear measurement.

VDS = VDS_sat, VBS = VBB for saturation. Typically, for PMOS, VDS_lin = −0.1 V(@VDD = 5 V); for NMOS, VDS_lin = 0.1 V(@VDD = 5 V).

Figure 193: Four-term pMOSFET Vtext pin connections



Vtext ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

Vtext General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Vtext_llsq

Module name: Vtext_llsq

DUT: Four-terminal pMOSFET

Function: Measures the drain current at the gate voltage sweep, extracts the trans-conductance (Gm) and measure the maximum trans-conductance (Gmmax), measures the extracted threshold voltage (Vth_ex), measures the drain current and the gate voltage curve, and measures the Gm and the drain current or the Gm and the gate voltage curve.

Pin connections: Use a SMU to bias the drain. Use a SMU to sweep the gate. If needed, input the source and bulk voltages. Usually, they are connected to GND for NMOS and connected to the nominal power supply voltage (VDD) for PMOS.

Procedure: The threshold voltage is extrapolated from the measurement of the maximum slope (Gmmax) of the IDVGS curve:

```
Vth_ex = VGS (@Gmmax)-ID(@Gmmax)/Gmmax
```

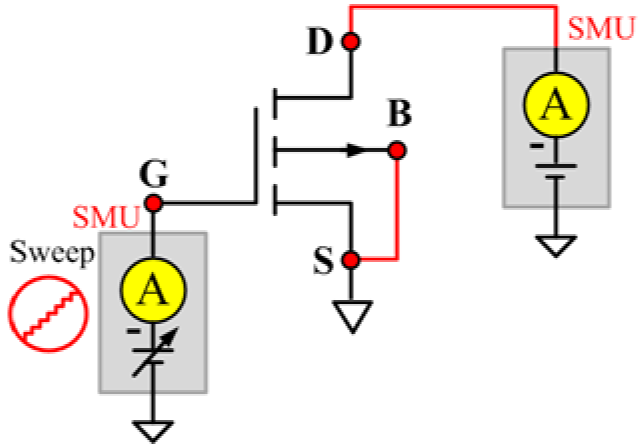
Where:

- VGS(@Gmmax) is the gate voltage at the point of the maximum slope of the IDVGS curve
- ID(@Gmmax) is the drain current at the point of the maximum slope of the IDVGS curve
- Gmmax is the maximum slope of the IDVGS curve

NOTE

DC bias voltages for the Vth_ex measurements are VDS = VDS_lin, VBS = VBB for linear measurement. VDS = VDS_sat, VBS = VBB for saturation. Typically, for PMOS, VDS_lin = −0.1 V(@VDD = 5 V); for NMOS, VDS_lin = 0.1 V(@VDD = 5 V).

Figure 194: Four-terminal pMOSFET Vtext_Ilsq pin connections



pMOSFET WLR script library

pMOSFET WLR script library overview

The WLR script components are in the following directory:

```
C:\ACS_BASIC\library\devLibrary\pMOSFET\WLR_script
```

There are four modules for the pMOSFET WLR_script Library: HCI, NBTI, NBTI_meas, and NBTI_on_the_fly.

HCI

Description: The HCI module for pMOSFET is the same as the nMOSFET. To set the HCI test module, refer to nMOSFET HCI.

The next figure shows an example setting of the pMOSFET device.

Figure 195: Set the HCI of pMOSFET in WLR_script library

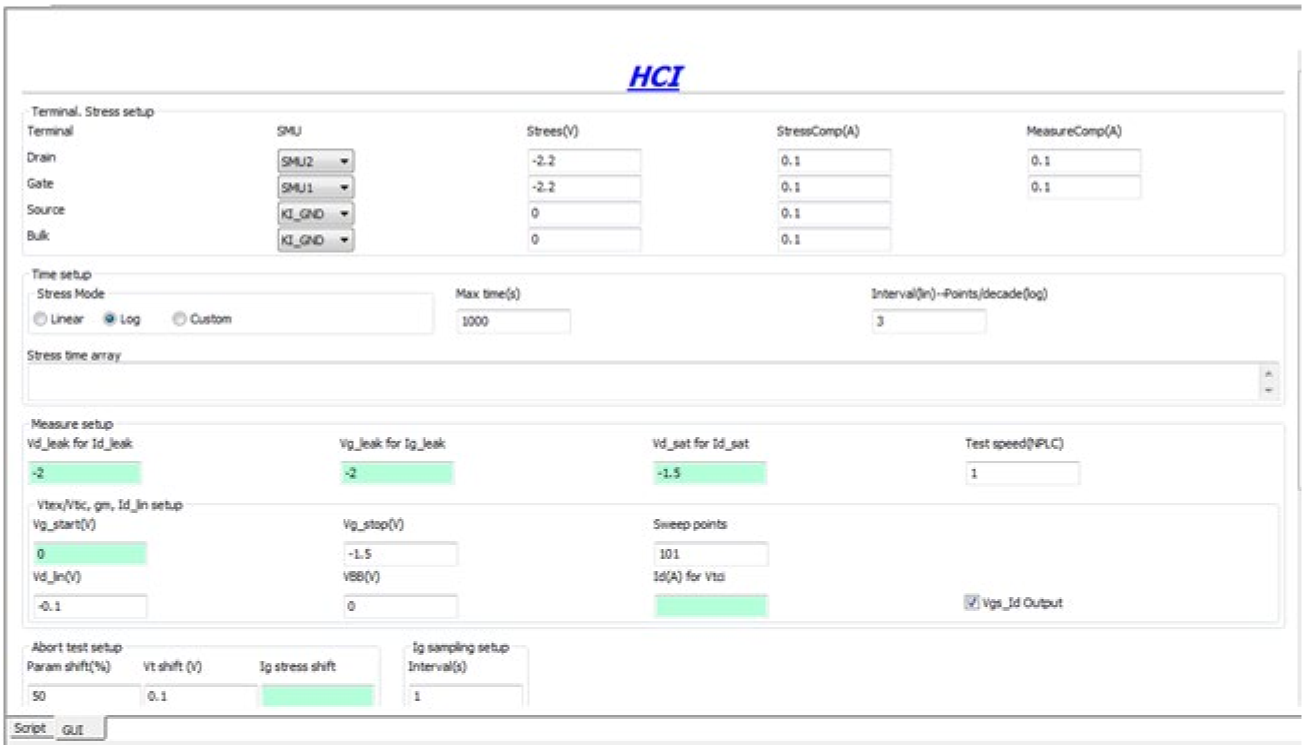


Figure 196: HCI sequence and device connection

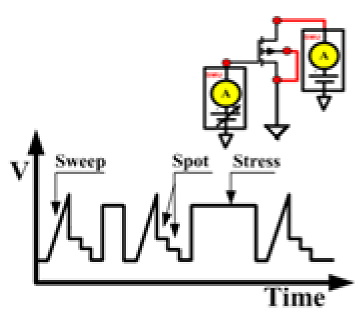
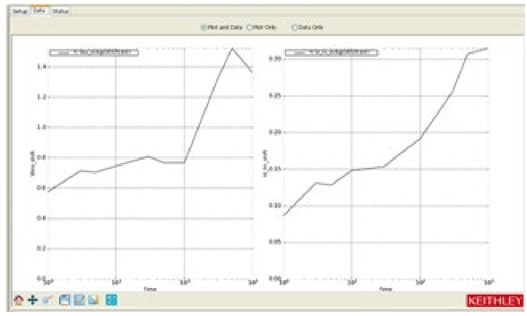


Figure 197: Data tab of HCI of pMOSFET in WLR_script library



NBTI

This test script runs a negative bias temperature instability (NBTI) test.

Usage

```
NBTI(smu_D, smu_G, smu_S, smu_B, vg_stress, vd_stress, vg_meas, vd_meas, myNPLC,
   meas_delay, navg, t_array, modeflag, compliancei, time, did)
```

Inputs	
`instid smu_D=SMU1`	`SMU1`, `SMU2`, `SMU3`, ..., `SMU64`
`instid smu_G=SMU2`	`SMU1`, `SMU2`, `SMU3`, ..., `SMU64`
`instid smu_S=KI_GND`	`SMU1`, `SMU2`, `SMU3`, ..., `SMU64`, `KI_GND`
`instid smu_B=KI_GND`	`SMU1`, `SMU2`, `SMU3`, ..., `SMU64`, `KI_GND`
`double vg_stress=-2.0 in [-40,40]`	Gate stress voltage
`double vd_stress=0 in [-40,40]`	Drain stress voltage
`double vg_meas=-1.2 in [-40,40]`	Gate measure voltage
`double vd_meas=-1.2 in [-40,40]`	Drain measure voltage
`double myNPLC=0.001 in [0.001,25]`	NPLC, `0.001` to ~ `10`
`double meas_delay=0 in [0,]`	Measure delay after stress is off
`integer navg=1 in [1,20]`	Double of points for average
`table t_array={1,2,5,10,20,50,100}`	Stress time array
`integer modeflag=1 in [0,1]`	Gate first or drain first
`double compliancei=0.1 in [0,]`	Current compliance

Outputs	
`time={}`	Timetable
`did={}`	Drain-current shift table

Details

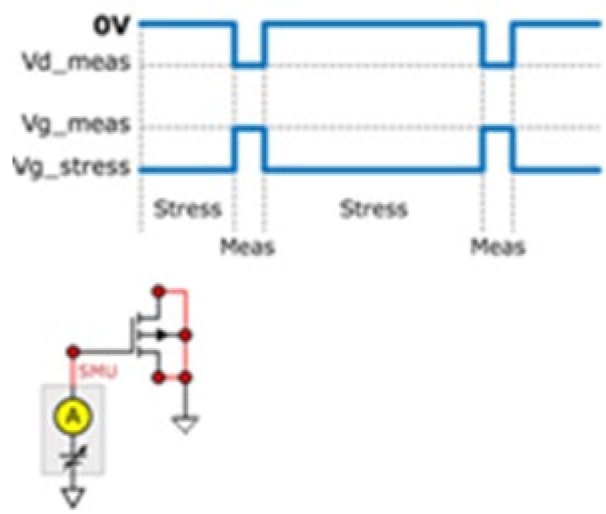
The NBTI test supports two to four SMUs.

The gate performs the stress test and the drain performs the measurement test. In most cases, the source and bulk are set to `0` or `KI_GND`.

Intended outputs: Time, id0 (fresh value of drain-current), id (absolute value of drain-current), and id_shift (relative shift of drain-current).

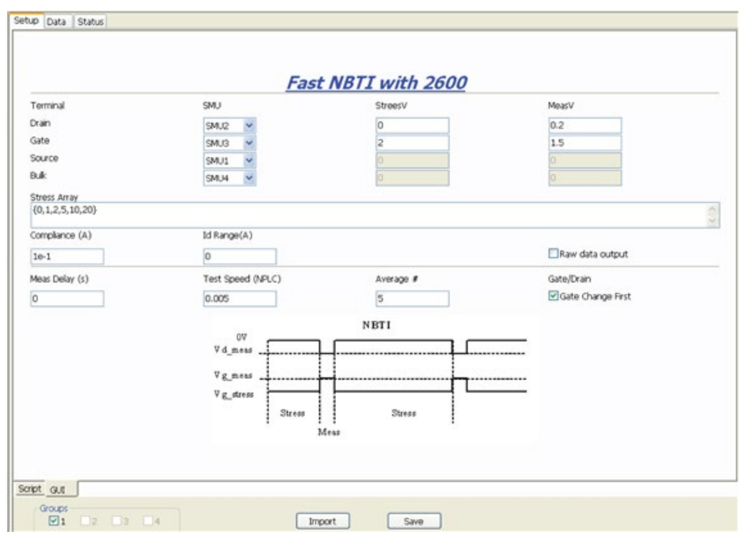
The next figure shows the NBTI GUI and illustrates the testing method.

Figure 198: NBTI sequence and device connection



The following figure shows the NBTI dialog and illustrates the testing method. A general description of this dialog is included below.

Figure 199: User interface for NBTI



NBTI user interface descriptions

- **Terminal settings:** SMUs are assigned to terminals source and bulk and KI_GND is manually set. The voltage is changeable only on the gate and drain. A measurement is made on the drain only, and compliance should be set.
- **Test Speed setting entry field:** The Meas Delay field sets the time before each measurement. The Test Speed field sets the PLC value. The Average # field specifies the number of measurements on which the average is taken.
- **Gate/Drain:** Voltages are applied on the gate and drain and change when the measurement begins and ends. The gate/drain selection box specifies which terminal changes first. If Gate Change First is selected, the gate terminal changes first. If the Gate Change First is cleared, the drain terminal changes first.
- **Stress Array:** Used to input the time array.

Example

```
local compliancei=1e-1
local modeflag=0
local vd_meas=0.1
local navg=1
local t_array={0,1,2,5,10,20}
local smu_B=SMU4
local smu_D=SMU2
local smu_G=SMU3
local myNPLC=0.01
local vg_meas=1.5
local meas_delay=0
local smu_S=SMU1
local vd_stress=0
local vg_stress=2
local time={}
local did={}
NBTI(smu_D, smu_G, smu_S, smu_B, vg_stress, vd_stress, vg_meas, vd_meas, myNPLC,
   meas_delay, navg, t_array, modeflag, compliancei, time, did)
```

Also see

None

NBTI_meas

This test script runs negative bias temperature instability (NBTI) tests with pre-Id_Vg testing and post-Id_Vg testing.

Usage

```
NBTI_meas(smuD, smuG, smuS, smuB, flag0, flag1, flag2, p_Vg_lo, p_Vg_hi,
   p_Vg_points, p_Vds, p_Drangei, p_sweepdelay, a, b, A, W, L, Vg_ini, Vd_ini,
   Vg_stress, Vd_stress, Vg_meas, Vd_meas, myNPLC, meas_delay, inter_delay, t_mode,
   t_max, npdec_delta, time_input, modeflag, Gcompi, Dcompi, rng, Nsam)
```

Inputs	
`instid smuD=SMU2`	`SMU1`, `SMU2`, `SMU3`, ..., `SMU64`
`instid smuG=SMU1`	`SMU1`, `SMU2`, `SMU3`, ..., `SMU64`
`instid smuS=KI_GND`	`SMU1`, `SMU2`, `SMU3`, ..., `SMU64`, `KI_GND`
`instid smuB=KI_GND`	`SMU1`, `SMU2`, `SMU3`, ..., `SMU64`, `KI_GND`
`integer flag0=1 in [0,1]`	Flag for idvg test `1`: Enable pre-idvg test and post-idvg test `0`: Disable the test
`integer flag1=1 in [0,1]`	Flag for NBTI test `1`: Enable NBTI stress-measure test `0`: Disable the test
`integer flag2=1 in [0,1]`	Flag for Vcti test `1`: meas enable Vcti test `0`: Disable the test
`double p_Vg_lo=0 in [-40, 40]`	Start of gate-voltage sweep in pre- and post-test
`double p_Vg_hi=2 in [-40, 40]`	Stop of gate-voltage sweep in pre- and post-test
`double p_Vg_points=21 in [0, 4096]`	Gate-voltage sweep number of points in pre- and post-test
`double p_Vds=1  in [-40, 40]`	Drain-source bias in pre- and post-test
`double p_Drangei=1e-3 in [0, 0.1]`	Drain-current range in pre- and post-test
`double p_sweepdelay=0 in [0,]`	Sweep delay in pre- and post-test
`double a=0 in [0,40]`	Low extent of Vtci sweep
`double b=1 in [0,40]`	High extent of Vtci sweep
`double A=1 in [0,]`	Target current density
`double W=1 in [0,]`	Width of device
`double L=1 in [0,]`	Length of device
`table Vg_ini in [-40, 40]`	Gate-voltage for initial drain-current measurement
`table Vd_ini in [-40, 40]`	drain-voltage for initial drain-current measurement
`double Vg_stress=-2.0 in [-40, 40]`	Gate stress voltage
`double Vd_stress=0 in [-40, 40]`	Drain stress voltage
`table Vg_meas in [-40, 40]`	Gate measure voltage
`table Vd_meas in [-40, 40]`	Drain measure voltage
`double myNPLC=0.05 in [0.001, 25]`	NPLC, `0.001` to `25`
`double meas_delay=0.001 in [0,]`	Measure delay after stress is off
`double inter_delay=0.1 in [0,]`	Delay between measure voltage train pulses

Inputs	
`integer t_mode=1 in [0,2]`	`0`: User-specified time array `1`: Logarithmic time `2`: Linear time array
`double t_max=20 in [0,]`	The maximum stress time; valid when t_mode is `1` or `2`
`double npdec_delta in [0,]`	When t_mode = `1`: Number of points-per-decade When t_mode = `2`: Delta time
`table time_input in [0,]`	When t_mode is `0`, this array is used as a stress time list
`integer modeflag=1 in [0, 1]`	Measurement force gate first or drain first modeflag=`0`: Drain first modeflag=`1`: Gate first
`double Gcompi = 100e-6 in [0, 0.1]`	Gate-voltage source compliance
`double Dcompi = 100e-6 in [0, 0.1]`	Drain-voltage source compliance
`table rng in [0, 0.1]`	Drain-current measure range
`integer Nsam = 5 in [1, 20]`	Number of samples

Outputs	
`error`	Working condition flag
`Vg_pre`	Gate voltage of pretest
`Id_pre`	Drain-current of pretest
`Vg_pos`	Gate-voltage of post-test
`Id_pos`	Drain-current of post-test
`Vtci`	Gate voltage at target drain current
`Idini`	Initial drain current
`Idend`	Drain-current after stress sequence
`time`	Timetable
`Id1`	Drain current table
`Id2`	
`Id3`	
`Id4`	
`Id5`	
`Id6`	
`Id7`	
`Id8`	
`Id9`	
`Id10`	
`Id11`	
`Id12`	
`Id13`	
`Id14`	
`Id15`	

Outputs	
Id16	
Id17	
Id18	
Id19	
Id20	

Details

The following figure shows the NBTI_meas test dialog box and illustrates the testing method.

Figure 200: GUI for NBTI_meas

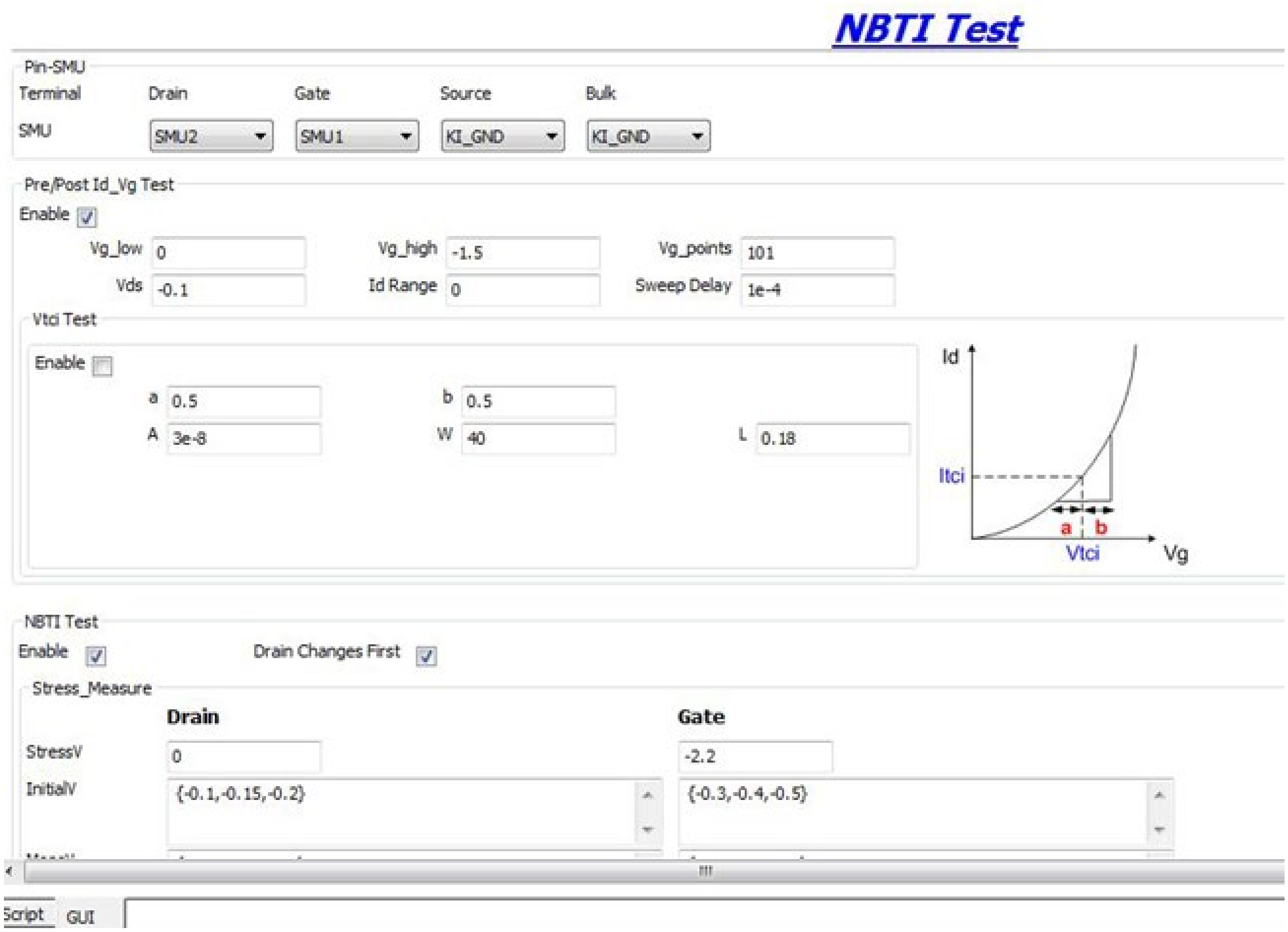
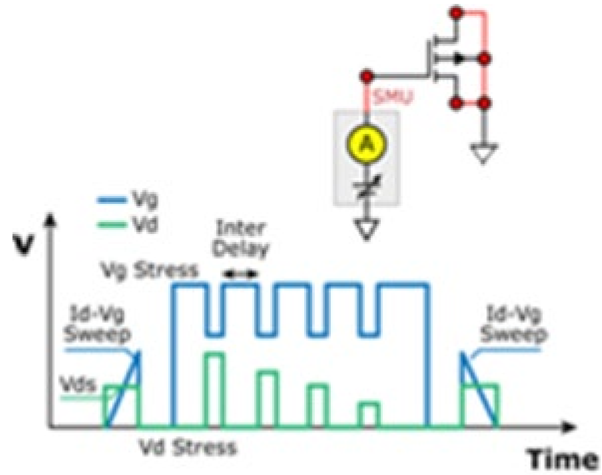


Figure 201: NBTI_meas sequence and device connection



Example

```
local p_sweepdelay=1e-4
local Vd_ini={0.6,0.7,0.8}
local modeflag=1
local p_Vds=0.5
local Nsam=5
local npdec_delta=1
local meas_delay=1e-4
local t_max=10
local Dcompi=1e-1
local t_mode=2
local Gcompi=1e-1
local time_input={0,1,2,3,4,5,6,7,8,9,10}
local inter_delay=5e-4
local flag2=1
local flag1=1
local flag0=1
local Vd_stress=0
local myNPLC=0.005
local A=1e-5
local Vg_ini={0.8,0.9,1.0}
local rng={1e-5,1e-4,1e-4}
local L=1
local p_Drangei=0
local p_Vg_hi=2
local W=1
local p_Vg_points=101
local p_Vg_lo=0
local a=0.1
local b=0.1
local Vd_meas={0.6,0.7,0.8}
local smuS=KI_GND
local smuB=KI_GND
local Vg_meas={0.8,0.9,1.0}
local smuG=SMU1
local smuD=SMU2
local Vg_stress=2
NBTI_meas(smuD,smuG,smuS,smuB,flag0,flag1,flag2,p_Vg_lo,p_Vg_hi,p_Vg_points,p_Vds
    ,p_Drangei,p_sweepdelay,a,b,A,W,L,Vg_ini,Vd_ini,Vg_stress,Vd_stress,Vg_meas,Vd
    _meas,myNPL,meas_delay,inter_delay,t_mode,t_max,npdec_delta,time_input,modefla
    g,Gcompi,Dcompi,rng,Nsam)
```

Also see

None

NBTI_on_the_fly

This test script monitors threshold voltage degradation and relaxation for NBTI and charge trapping on high K gate stacks.

Usage

```
NBTI_on_the_fly(Test_mode, Vg_stress, Vg_relax, Vg_dist, Vd, Stress_time,
   Monitor_time_stamp, GSMU, DSMU, SSMU, BSMU, myNPLC)
```

Inputs	
`integer Test_mode=2`	`0`: Monitor Vt degradation during stress only `1`: Monitor Vt relaxation during stress off only `2`: Monitor both degradation and relaxation during stress on and off period
`double Vg_stress=3`	Voltage on gate during stress; measurement during stress is also made at this voltage
`double Vg_relax=1`	Measure voltage on gate during recovery; the stress voltage recovery is set to `0`
`double Vg_dist=0.05`	Delta Vg for different Id measurement
`double Vd=0.1`	Drain voltage only applied during monitoring; other times `0` V
`integer Stress_time=1000`	Time for stress in seconds
`table Monitor_time_stamp={}`	Time in seconds; this is an input array that monitors the guiding time for two instances; the actual timestamp for monitoring might not be the same due to measurement time; also, this timestamp is the same for both stress on (degradation monitoring) and off (relaxation monitoring)
`instid GSMU=SMU1`	Gate SMU number, for example, SMU1
`instid DSMU=SMU2`	Drain SMU number, SMU2
`instid SSMU=KI_GND`	Source SMU number; if KI_GND is chosen, this terminal should be connected to GNDU manually
`instid BSMU=KI_GND`	Bulk SMU number
`double myNPLC=0.01`	NPLC setting

Outputs	
`'ERROR' (possible error type)`	`-1`: Wrong inputs
`'Time_stress', 'dVt_stress' and 'Id_stress'`	Time, Vt shift, and drain current during stress phase
`'Time_relax', 'dVt_ relax' and 'Id_ relax'`	Time, Vt shift, and drain current during relax phase

Details

This script is a method for monitoring threshold voltage degradation and relaxation for NBTI and charge trapping on high K gate stacks. The code is a Keithley Instruments copyright.

- `Vg_stress` is for stress and measurement during the stress phase.
- `Vg_relax` is for measurement during recovery.

- Recovery voltage is set to `0` during no measurement times.
- This test can only be used for one device, once during the stress-on period and once during the stress-off period.

Reference: "On-the-fly characterization of NBTI in ultra-thin gate oxide PMOSFETs," M. Denais, et. al, IEDM 2004.

The following figure shows the NBTI_on_the_fly test dialog box and illustrates the testing method. A general description of this dialog box is included below.

Figure 202: GUI for NBTI_on_the_fly

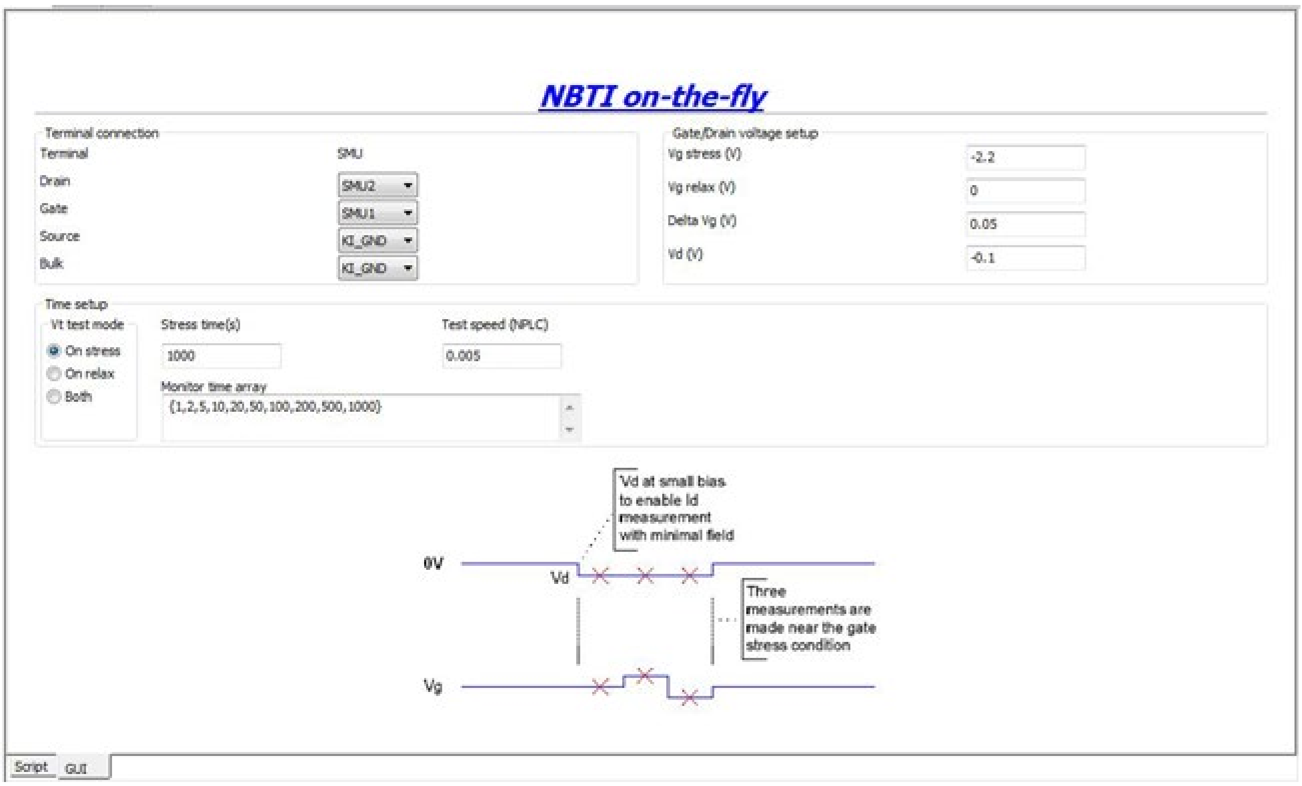
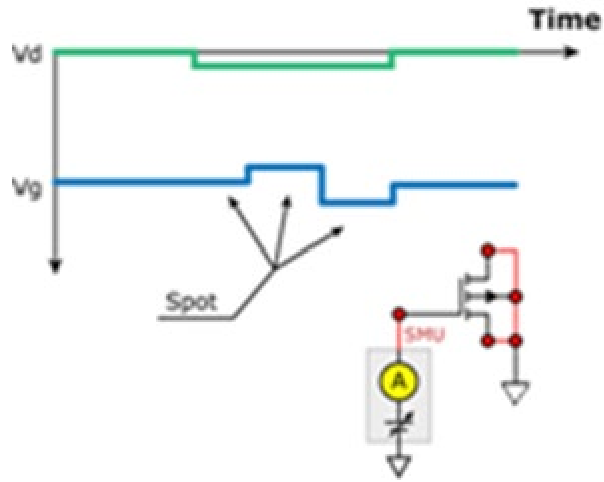


Figure 203: Sequence of NBTI_on_the_fly



NBTI user interface descriptions

- **Terminal connection:** SMUs are assigned to source and bulk terminals and KI_GND is manually set. If specific SMUs are assigned to these two terminals, 0 V is applied internally.
- **Gate/Drain voltage setup:** The voltage during the stress phase and relax phase on the gate and drain should be set here.
- **Time setup:** Specifies time during the stress and relaxation phases. For the Vt test mode, when On stress is selected, there is no relax phase and stress is applied following the monitor time array. If On relax is selected, a measurement is made during the relax phase only following the monitor time array, and stress time is specified by Stress time. If both are selected, a measurement is made during both the stress phase and the relax phase, and they both follow monitor time array.

NBTI user interface descriptions

- **Terminal connection:** SMUs are assigned to source and bulk terminals and KI_GND is manually set. If specific SMUs are assigned to these two terminals, 0 V is applied internally.
- **Gate/Drain voltage setup:** The voltage during the stress phase and relax phase on the gate and drain should be set here.
- **Time setup:** Specifies time during the stress and relaxation phases. For the Vt test mode, when On stress is selected, there is no relax phase and stress is applied following the monitor time array. If On relax is selected, a measurement is made during the relax phase only following the monitor time array, and stress time is specified by Stress time. If both are selected, a measurement is made during both the stress phase and the relax phase, and they both follow monitor time array.

Example

```
local Test_mode = 2
local Vg_stress = 3
local Vg_relax = 1.5
local Vg_dist = 0.05
local Vd = 0.1
local Stress_time = 1000
local Monitor_time_stamp = {1,5,10,20}
local GSMU = SMU2
local DSMU = SMU1
local SSMU = KI_GND
local BSMU = KI_GND
local myNPLC = 0.1
NBTI_on_the_fly(Test_mode, Vg_stress, Vg_relax, Vg_dist, Vd, Stress_time,
   Monitor_time_stamp, GSMU, DSMU, SSMU, BSMU, myNPLC)
```

Also see

None

pPowerMOSFET library

pPowerMOSFET parametric library overview

The pPowerMOSFET library components are in the following directory:

```
C:\ACS_BASIC\library\devLibrary\pPowerMOSFET
```

The pPowerMOSFET parametric library is used to test parameters of a p-type power MOSFET, including leakage, breakdown, gain, on-state, capacitance, and characteristic curves.

BVDSS

Module name: BVDSS

Module type: ITM

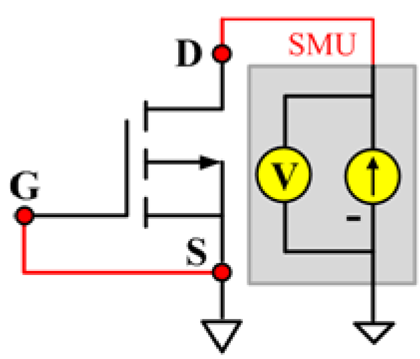
Instrument: Keithley Instruments Model 2657A, Series 2600B

DUT: Three-terminal pPowerMOSFET

Function: Measures the breakdown voltage from the drain to source. Measures voltage on the drain-source by applying a breakdown current to the drain and the gate is shorted to the source.

Pin connections: Use the Model 2657A instrument to apply current and make a voltage measurement at the drain. Connect the gate and source to GND or use a SMU to supply a zero-voltage bias.

Figure 204: pPowerMOSFET BVDSS pin connections



Cds

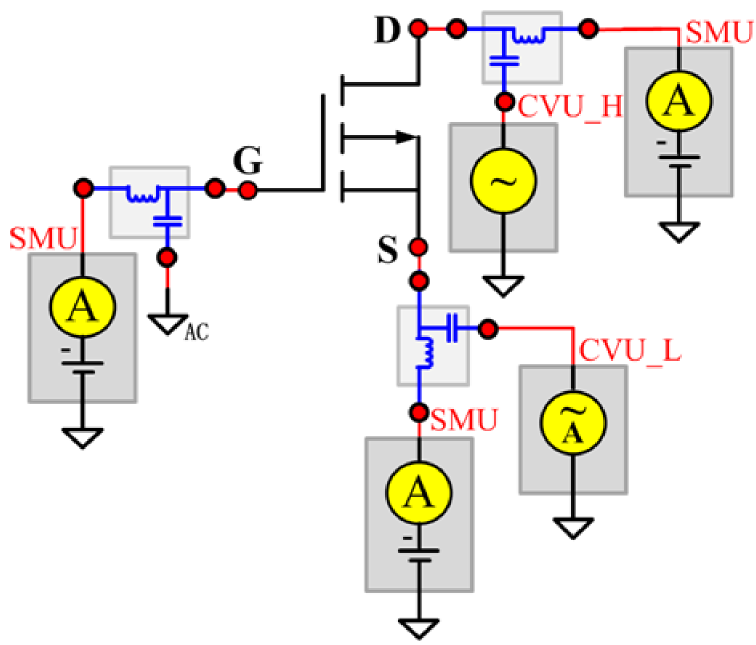
Module Name: Cds

DUT: Three-terminal pPowerMOSFET

Function: Measures the capacitance between the Drain and Source terminals with the Gate terminal connected to the guard terminal of a three-terminal bridge.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the drain. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the source. Use the Series 2600B to supply zero voltage bias. Connect the guard terminal of a three-terminal bridge through one remote bias tee to the gate.

Figure 205: Three-terminal nPowerMOSFET Cds pin connections



Cds PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Cgd

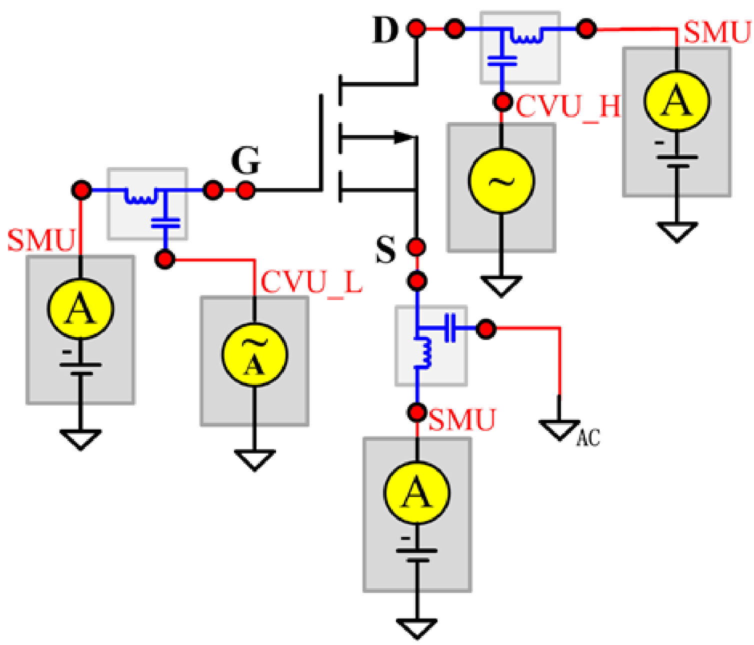
Module Name: Cgd

DUT: Three-terminal pPowerMOSFET

Function: Measures the capacitance between the Drain and Gate terminals with the Source terminal connected to the guard terminal of a three-terminal bridge.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the drain. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the AC guard of a three-terminal bridge through one remote bias tee to the source.

Figure 206: Three-terminal pPowerMOSFET Cgd pin connections



Cgd PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Cgs

Description:

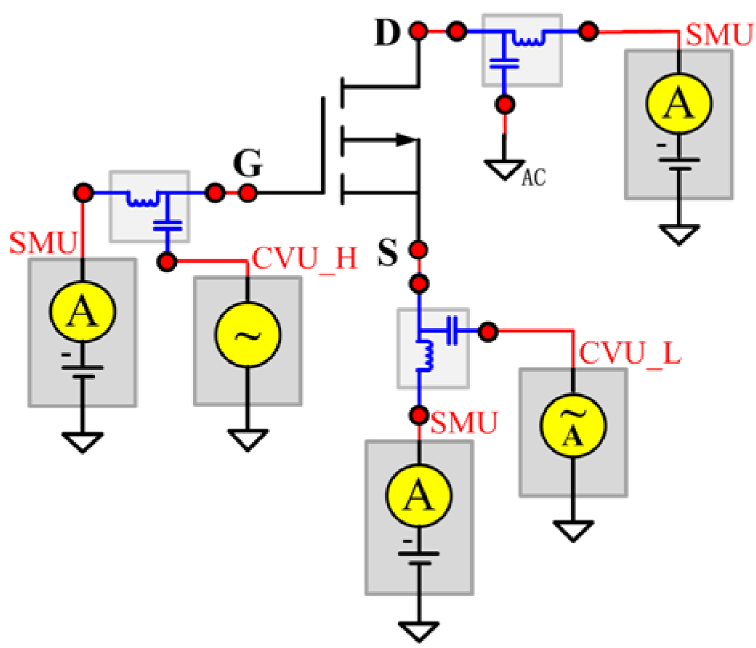
Module name: Cgs

DUT: Three-terminal pPowerMOSFET

Function: Measures the capacitance between the Gate and Source terminals with the Drain terminal connected to the guard terminal of a three-terminal bridge.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the ac guard of a three-terminal bridge through one remote bias tee to the drain. Use the Series 2600B to supply zero voltage bias.

Figure 207: Three-terminal pPowerMOSFET Cgs pin connections



Cgs PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Ciss

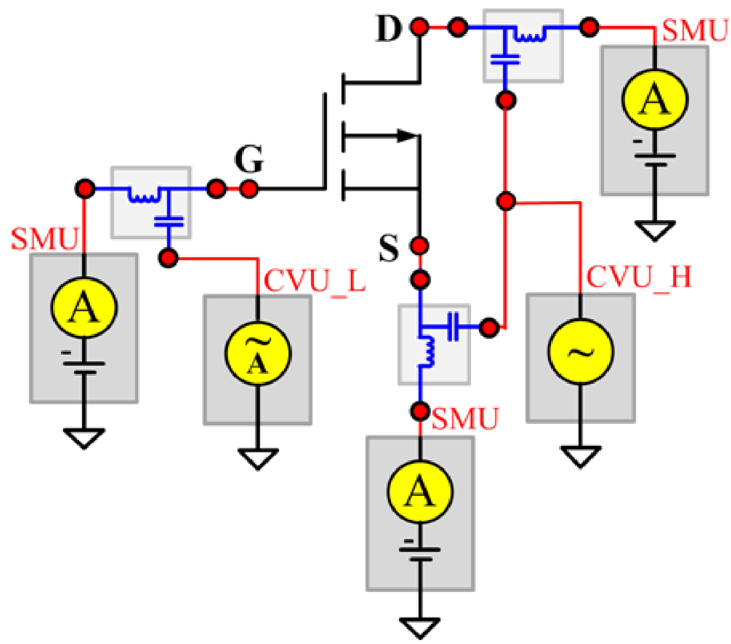
Module name: Ciss

DUT: Three-terminal pPowerMOSFET

Function: Measures the capacitance between the Gate and Source terminals with the Drain terminal ac short-circuited to the Source terminal.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the drain. Use the Series 2600B to sweep voltage. AC short circuit the drain to the source terminal. Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to supply zero voltage bias.

Figure 208: Three-terminal pPowerMOSFET Ciss pin connections



Ciss PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Coss

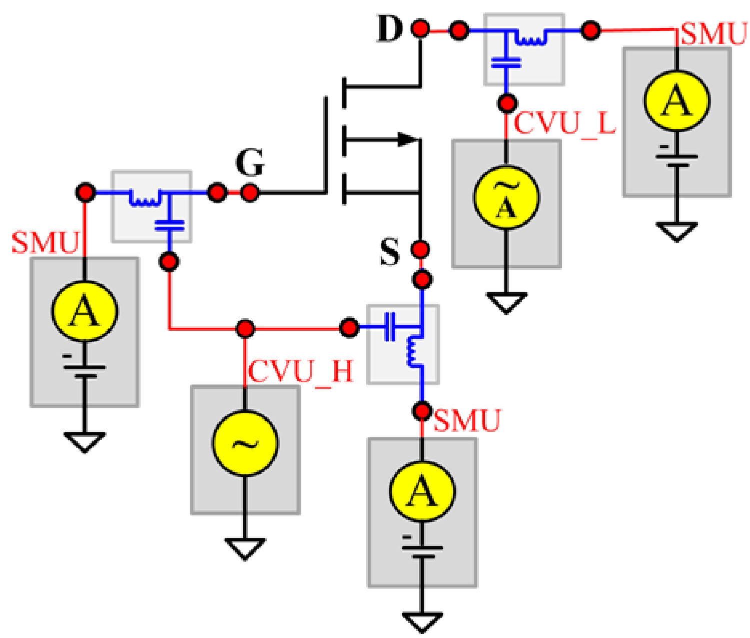
Module name: Coss

DUT: Three-terminal pPowerMOSFET

Function: Measures the capacitance between the drain and source terminals with the gate terminal ac short-circuited to the source terminal.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to supply zero voltage bias. AC short circuit the gate to the source terminal. Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the drain. Use the Series 2600B to sweep voltage.

Figure 209: Three terminal pPowerMOSFET Coss pin connections



Coss PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Crss

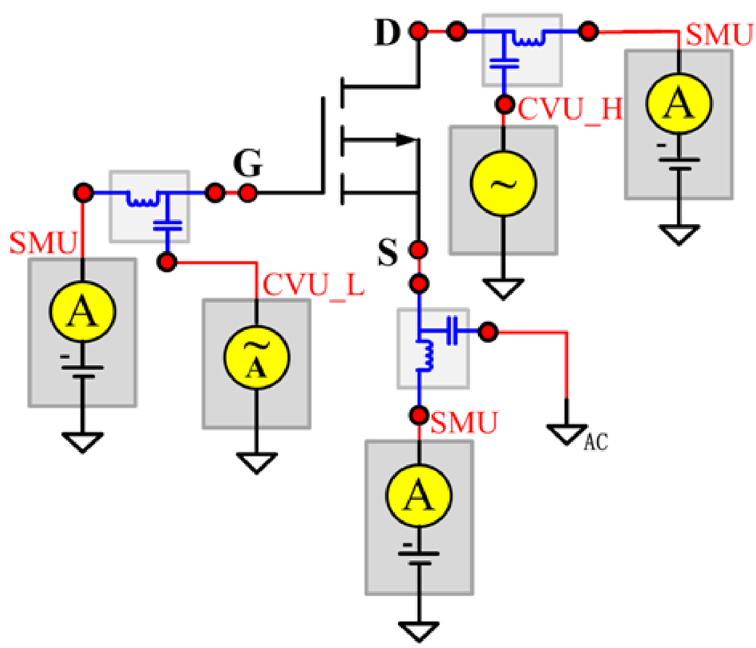
Module Name: Crss

DUT: Three-terminal pPowerMOSFET

Function: Measures the common-source short-circuit input capacitance by testing the capacitance between the Drain and Gate terminals with the Source terminal connected to the guard terminal of a three-terminal bridge.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the drain. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the ac guard of a three-terminal bridge through one remote bias tee to the source. Use the Series 2600B to supply zero voltage bias.

Figure 210: Three-terminal pPowerMOSFET Crss pin connections



Crss PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

GFS

Module name: GFS

Module type: ITM

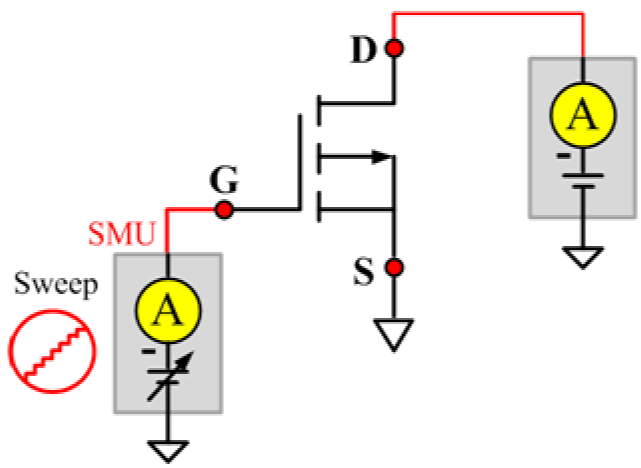
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pPowerMOSFET

Function: Measures the forward transconductance. Measures the current on the drain by applying a voltage sweep from the gate to source and calculates the ratio of change in Id for a change in the Vgs: GFS=delta(Id)/delta(Vgs).

Pin connections: Use the Model 2651A to apply voltage and make current measurements at the drain. Use the low-power Model 2600B to sweep voltage at the gate. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 211: pPowerMOSFET GFS pin connections



IdON

Module name: IdON

Module type: ITM

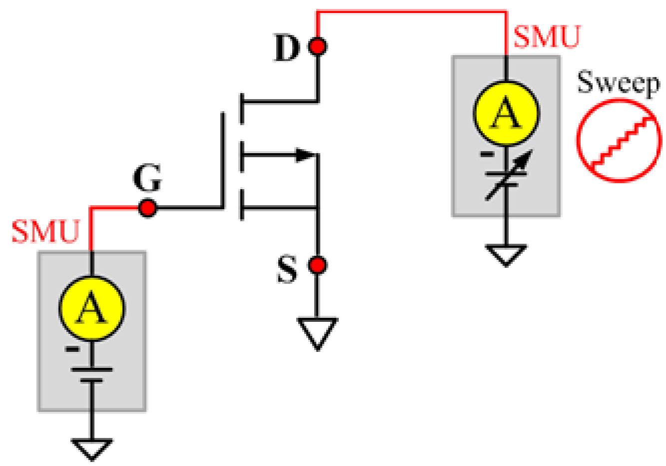
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pPowerMOSFET

Function: Measures the on-state drain current. Measures current on the drain by applying a voltage sweep to the drain-source with a specific gate voltage to turn on the device at a certain Id current value that is given in the datasheet.

Pin connections: Use the Model 2651A to apply a voltage sweep and make a current measurement at the drain. Use the low power Model 2600A to source a specific voltage at the gate. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 212: pPowerMOSFET IdON pin connections



IDSS

Module name: IDSS

Module type: ITM

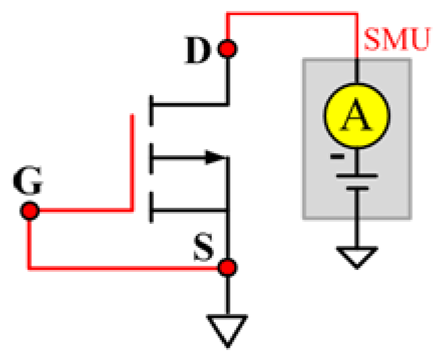
Instrument: Keithley Instruments Model 2657A, Series 2600B

DUT: Three-terminal pPowerMOSFET

Function: Measures the leakage current from the drain to the Source when the device is off. Measures the current on the drain by applying a maximum permissible voltage between the drain and source, while the gate is shorted to the source.

Pin connections: Use the Model 2657A to apply voltage and make a current measurement at the drain. Connect the gate and source to GND or use a SMU to supply a zero-voltage bias.

Figure 213: pPowerMOSFET IDSS pin connections



IdVd_StepVg

Module name: IdVd_StepVg

Module type: ITM

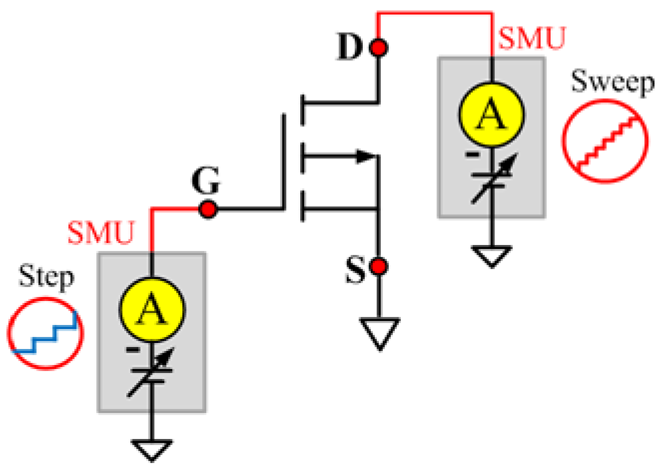
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pPowerMOSFET

Function: Measures the drain current at the specified gate voltage and sweeps the drain in pulse mode. Generates the standard family of IdVd curves.

Pin connections: Use the Model 2651A to apply a voltage sweep and make a current measurement at the drain. Use the low power Model 2600A to source a specific voltage at the gate. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 214: pPowerMOSFET IdVd_StepVg pin connections



IdVd_StepVg_MIX

Module name: IdVd_StepVg_MIX

Module type: PTM

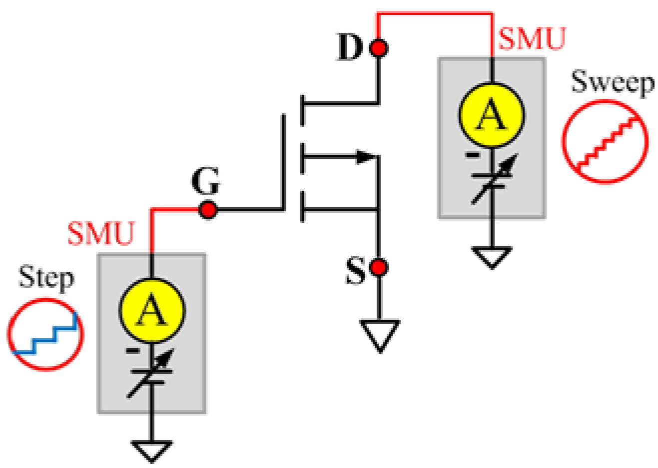
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200A-SMU

DUT: Three-terminal pPowerMOSFET

Function: Measures the drain current at the specified gate voltage and sweeps the drain in pulse mode. Generates the standard family of IdVd curves.

Pin connections: Use the Model 2651A SMU to apply a voltage sweep and make a current measurement at the drain. Use a SMU to force a specific voltage at the gate. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 215: pPowerMOSFET IdVd_StepVg_MIX pin connections



IdVg_StepVd

Module name: IdVg_StepVd

Module type: ITM

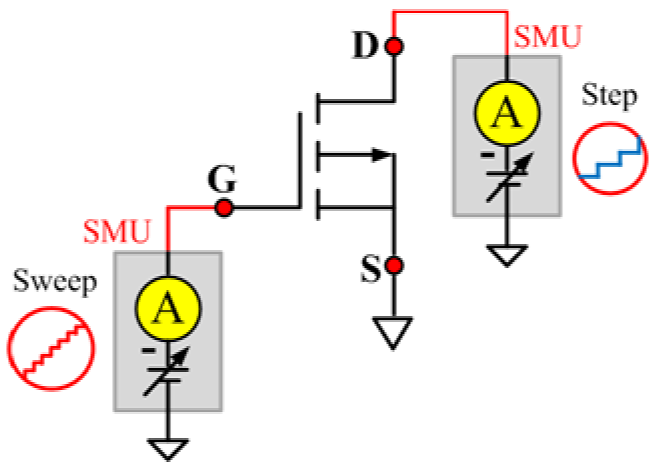
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pPowerMOSFET

Function: Measures the transfer characteristic of the device. Each time the voltage steps on the drain-source, a voltage sweep is performed on the gate-source and set of current measurements occurs on the drain.

Pin connections: Use the Model 2651A to apply a voltage step and make a current measurement at the drain. Use the low power Model 2600B to sweep voltage at the gate. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 216: pPowerMOSFET IdVg_StepVd pin connections



IGSSF

Module name: IGSSF

Module type: ITM

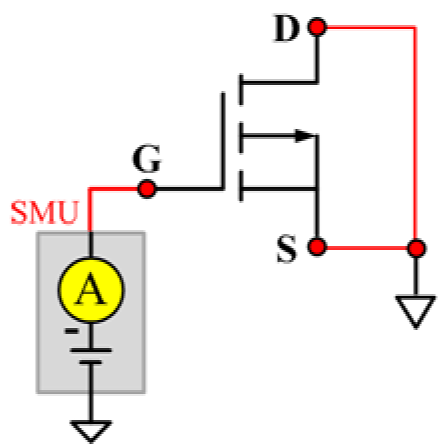
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pPowerMOSFET

Function: Measures the gate body forward leakage current. Measures current on the gate at the maximum permissible negative voltage from the gate to source.

Pin connections: One or two SMUs are used. One SMU applies voltage and takes current measurements at the gate. The drain and source are connected to ground or have no voltage bias from the other SMU. Use a SMU to force voltage and make a current measurement at the gate. Connect the drain and source to GND or use a SMU to supply a zero-voltage bias.

Figure 217: pPowerMOSFET IGSSF pin connections



IGSSR

Module name: IGSSR

Module type: ITM

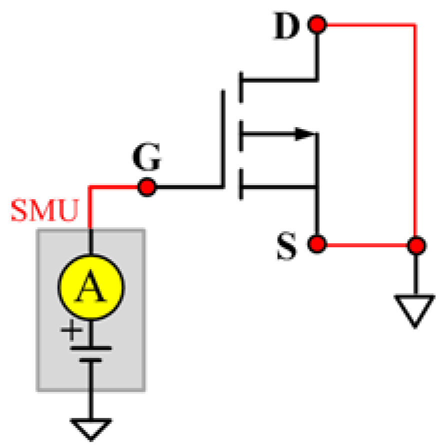
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pPowerMOSFET

Function: Measures the gate body reversed leakage current. Measures current on the gate at the maximum permissible positive voltage from the gate to source.

Pin connections: Use a SMU to force voltage and make a current measurement from the gate. Connect the drain and source to GND or use a SMU to supply a zero-voltage bias.

Figure 218: pPowerMOSFET IGSSR pin connections



RdsON

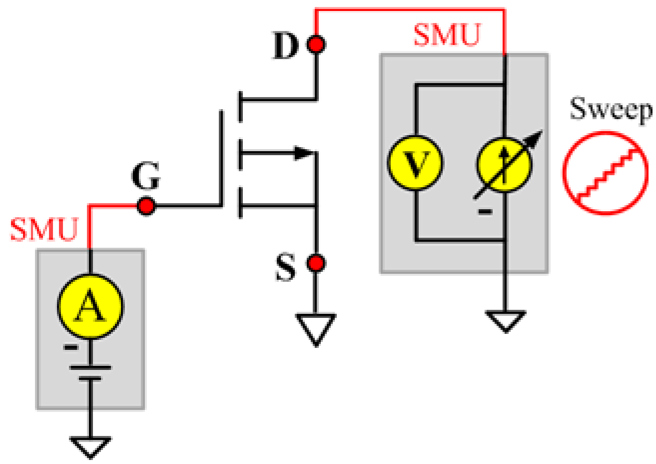
Module name: RdsON

DUT: Four-terminal pPowerMOSFET

Function: Measures the drain to source on-state resistance. Measures resistance by applying a current sweep to the drain with a specific gate voltage that is calculated by dividing the measured drain voltage by the Sourced current: Rds = Vds/Id.

Pin connections: Use the Model 2651A to apply a current sweep and make a voltage measurement at the drain. Use the low-power Model 2600B to force a specific voltage at the gate. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 219: pPowerMOSFET RdsOn pin connections



RdsON_MIX

Module name: RdsOn_MIX

Module type: PTM

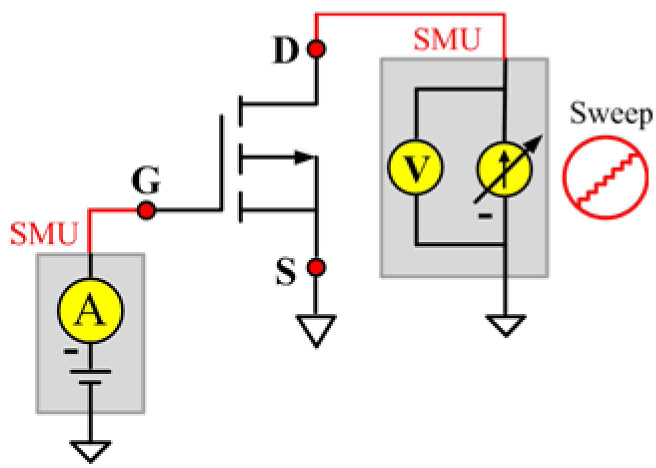
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200A-SMU

DUT: Three-terminal pPowerMOSFET

Function: Measures the drain to source on-state resistance. Measures resistance by applying a current sweep to the drain with a specific gate voltage that is calculated by dividing the measured drain voltage by the Sourced current: Rds = Vds/Id.

Pin connections: Use the Model 2651A SMU to apply a current sweep and make a voltage measurement at the drain. Use a SMU to force specific voltage at the gate. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 220: pPowerMOSFET RdsON_MIX pin connections



VdsON

Module name: VdsON

Module type: ITM

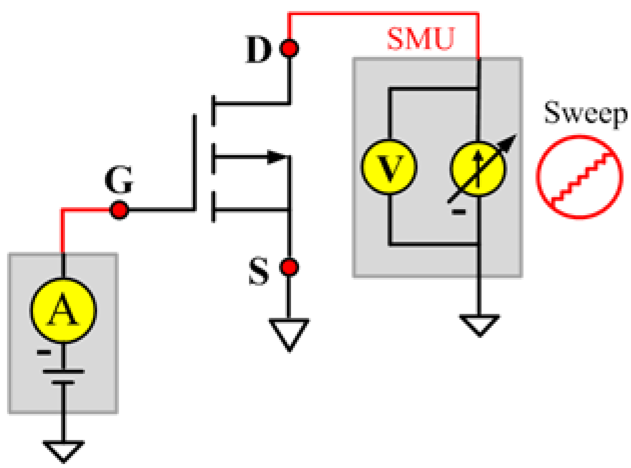
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pPowerMOSFET

Function: Measures the drain to source on-state voltage. Measures voltage on the drain-source by applying a current sweep to the drain with a specific gate voltage to turn on the device at a certain resistance value.

Pin connections: Use the Model 2651A SMU to apply a current sweep and make a voltage measurement at the drain. Use the low-power Model 2600B to force a specific voltage at the gate. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 221: pPowerMOSFET VdsON pin connections



VgsON

Module name: VgsON

Module type: ITM

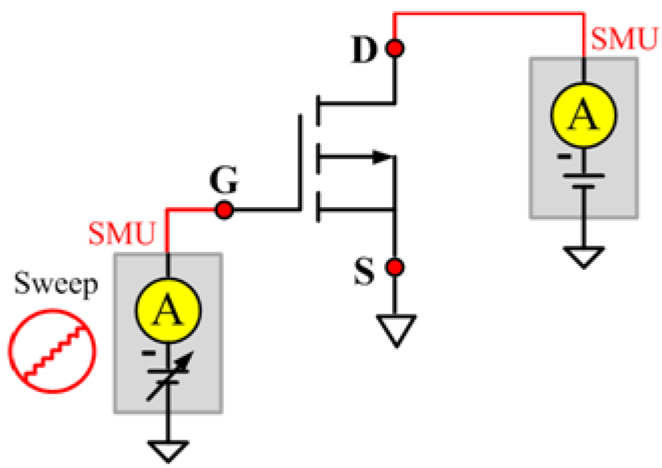
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pPowerMOSFET

Function: Measures the Gate to Source on-state voltage. Measures current on the Drain by applying a voltage sweep to the Gate-Source with a specific Drain to Source voltage to turn on the device to a certain Id current value.

Pin connections: Use the Model 2651A to apply voltage and make a current measurement at the drain. Use the low-power Model 2600B to sweep voltage at the gate. Connect source to GND or use a SMU to supply a zero-voltage bias.

Figure 222: pPowerMOSFET VgsON pin connections



VgsON_MIX

Module name: VgsON_MIX

Module type: PTM

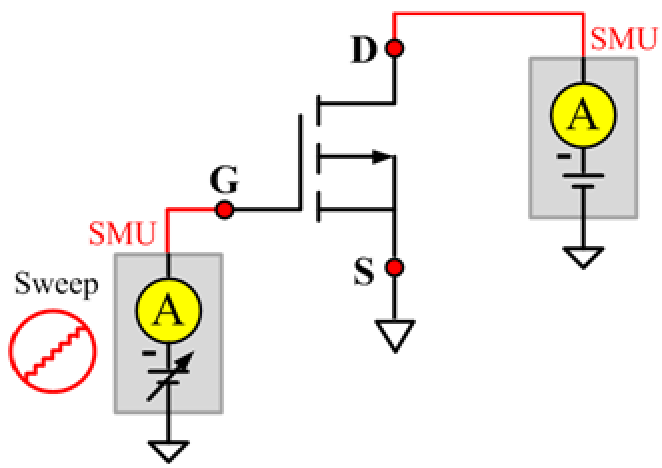
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200A SMU

DUT: Three-terminal pPowerMOSFET

Function: Measures the gate to source on-state voltage. Measures current on the drain by applying a voltage sweep to the gate-source with a specific drain to source voltage to turn on the device at a certain Id current value.

Pin connections: Use the Model 2651A SMU to apply voltage and make a current measurement at the drain. Use the low-power 2600B to sweep voltage at the gate. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 223: pPowerMOSFET VgsON_MIX pin connections



VGSTH

Module name: VGSTH

Module type: ITM

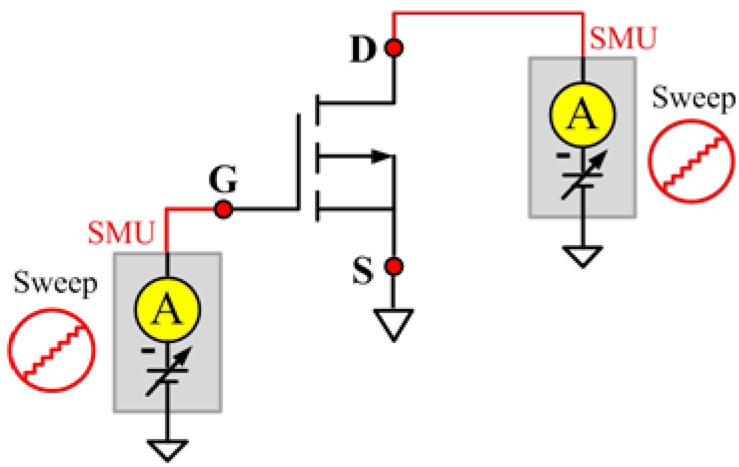
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pPowerMOSFET

Function: Measures the threshold voltage from the gate to source that is required to turn on the device at a specific Id current value that is given in the data sheet.

Pin connections: Use the Model 2651A SMU to force voltage and make a current measurement at the drain. Use the low-power Model 2600B to sweep voltage at the gate. Connect the source to GND or use a SMU to supply a zero-voltage bias.

Figure 224: pPowerMOSFET VGSTH pin connections



VSD

Module name: VSD

Module type: ITM

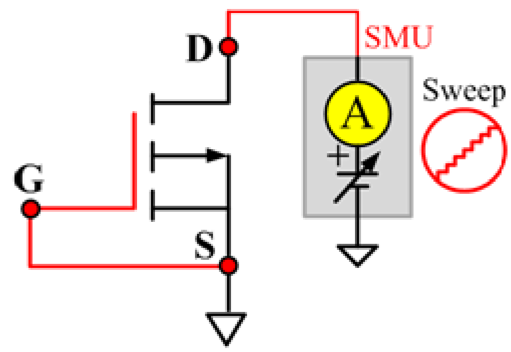
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pPowerMOSFET

Function: Measures the forward voltage drop of the parasitic diode between the drain and source. Measures current on the drain by applying a voltage sweep from the source to drain with the gate shorted to the source.

Pin connections: Use the Model 2651A SMU to force voltage and make a current measurement at the Drain. Connect the gate and source to GND or use a SMU to supply a zero-voltage bias.

Figure 225: pPowerMOSFET VSD pin connections



Diode library

Diode overview

The Diode library components are in the following directory:

```
C:\ACS_BASIC\library\devLibrary\DIODE
```

The diode test module template is used to test some parameters of a diode, such as the forward voltage and current, reverse voltage and current, I-V curve, and dynamic impedance. The TSP files are used with a Series 2600B instrument to create test script files based on the Series 2600B LPT library.

DynamicZ

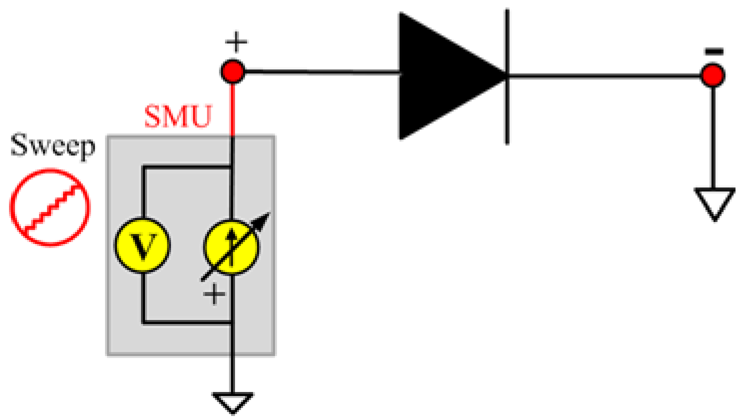
Module name: DynamicZ

DUT: Diode

Function: Measures the Dynamic Impedance based on two forward voltage measurements or two reverse voltage measurements: DynamicZ = (v2 − v1) / (I2 − I1)

Pin connections: Uses one SMU to force the forward current. Connect the other terminal to GND or use a SMU to supply a zero-voltage bias.

Figure 226: Diode DynamicZ pin connections



DynamicZ ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

DynamicZ General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

DynamicZ PTM

Module Type: Standard PTM

Instrument: Keithley Instruments Series 4200-SMU

Spot_IfdVfd

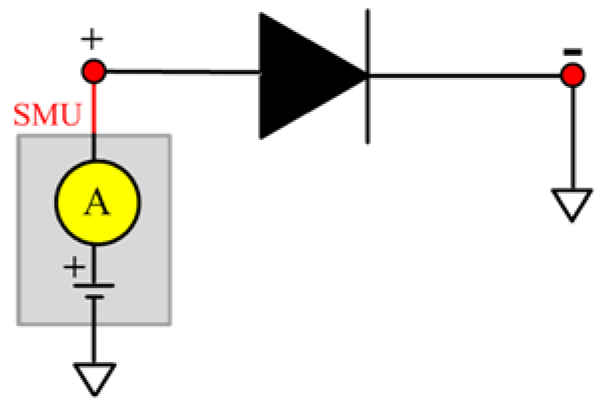
Module name: Spot_IfdVfd

DUT: Diode

Function: Measures the forward current of a diode at a specified forward voltage.

Pin connections: The P terminal forces a forward voltage. Connect the N terminal to GND or use a SMU to supply a zero-voltage bias.

Figure 227: Diode Spot_IfdVfd pin connections



Spot_IfdVfd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

Spot_IfdVfd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Spot_IfdVfd PTM

Module Type: Standard PTM

Instrument: Keithley Instruments Series 4200-SMU

Spot_IrdVrd

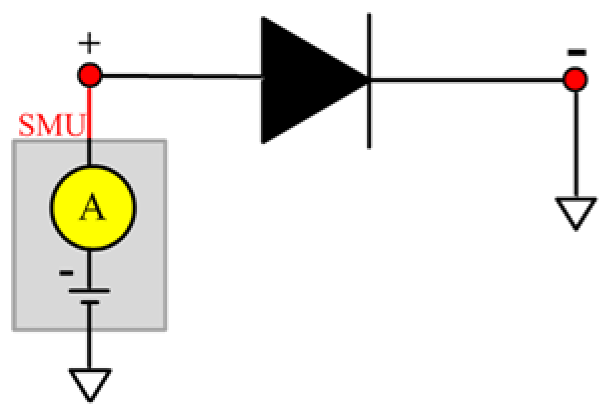
Module name: Spot_IrdVrd

DUT: Diode

Function: Measures the leakage current of a diode at a specified reverse voltage.

Pin connections: Force a reverse voltage or zero voltage to terminal P. Connect the N terminal to GND or use a SMU to supply a zero-voltage bias.

Figure 228: Diode Spot_IrdVrd pin connections



Spot_IrdVrd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

Spot_IrdVrd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Spot_IrdVrd PTM

Module Type: Standard PTM

Instrument: Keithley Instruments Series 4200-SMU

Spot_VbrIrd

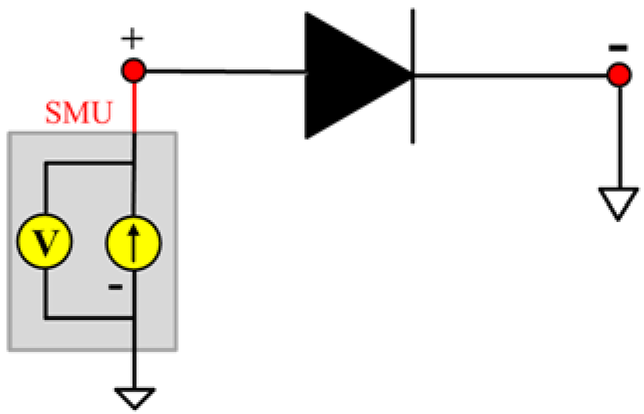
Module name: Spot_VbrIrd

DUT: Diode

Function: Measures the breakdown voltage of a diode at a specified reverse current.

Pin connections: Force a reverse current to the P terminal. Connect the N terminal to GND or use a SMU to supply a zero-voltage bias.

Figure 229: Diode Spot_VbrIrd pin connections



Spot_VbrIrd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

Spot_VbrIrd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Spot_VbrIrd PTM

Module Type: Standard PTM

Instrument: Keithley Instruments Series 4200-SMU

Spot_Vfdlfd

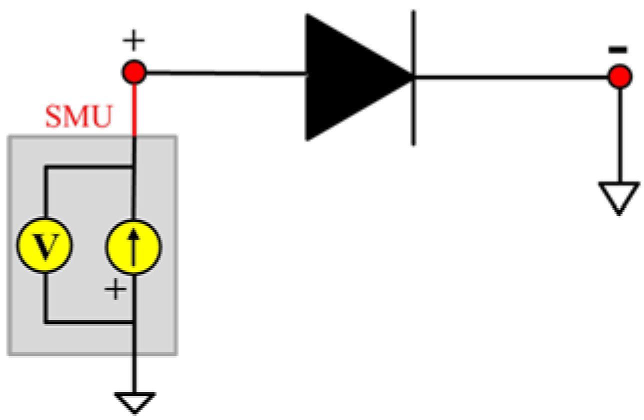
Module name: Spot_Vfdlfd

DUT: Diode

Function: Measures the forward voltage of a diode.

Pin connections: Uses one SMU to force forward current to the P terminal. Connect the N terminal to GND or use a SMU to supply a zero-voltage bias.

Figure 230: Diode Spot_Vfdlfd pin connections



Spot_Vfdlfd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

Spot_Vfdlfd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Spot_Vfdlfd PTM

Module Type: Standard PTM

Instrument: Keithley Instruments Series 4200-SMU

Spot_VrdIrd

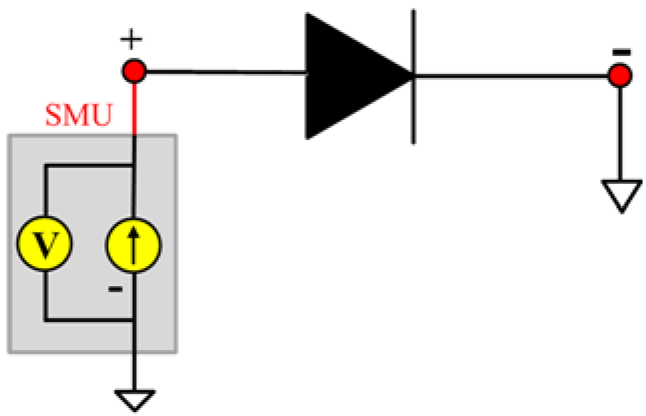
Module name: Spot_VrdIrd

DUT: Diode

Function: Measures the reverse voltage of a diode at a specified reverse current.

Pin connections: Force a reverse current to the P terminal. Connect the N terminal to GND or use a SMU to supply a zero-voltage bias.

Figure 231: Diode Spot_VrdIrd pin connections



Spot_VrdIrd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

Spot_VrdIrd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Spot_VrdIrd PTM

Module Type: Standard PTM

Instrument: Keithley Instruments Series 4200-SMU

Sweep_IfdVfd

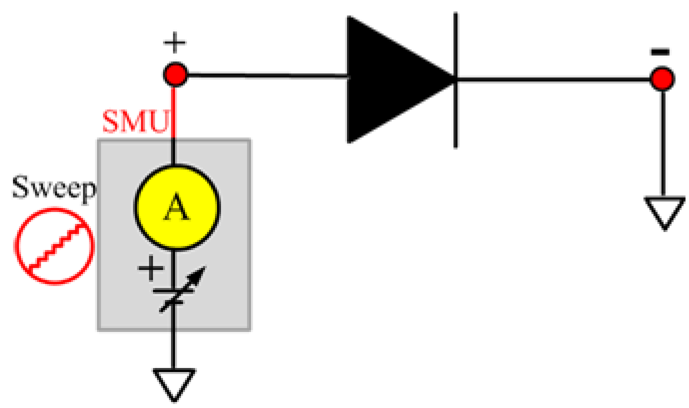
Module name: Sweep_IfdVfd

DUT: Diode

Function: Measures the forward current with a forward voltage sweep to indicate a forward I-V characteristic of a diode.

Pin connections: Apply a forward voltage sweep to terminal P. Connect the N terminal to GND or use a SMU to supply a zero-voltage bias.

Figure 232: Diode Sweep_IfdVfd pin connections



Sweep_IfdVfd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

Sweep_IfdVfd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Sweep_IfdVfd PTM

Module Type: Standard PTM

Instrument: Keithley Instruments Series 4200-SMU

Sweep_IrdVrd

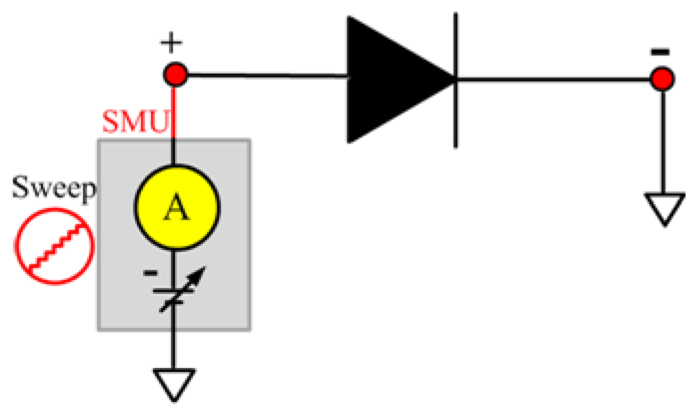
Module name: Sweep_IrdVrd

DUT: Diode

Function: Measures the reverse current with a reverse voltage sweep to indicate the reverse I-V characteristics of a diode.

Pin connections: Apply a reverse voltage sweep to the P terminal. Connect the N terminal to GND or use a SMU to supply a zero-voltage bias.

Figure 233: Diode Sweep_IrdVrd pin connections



Sweep_IrdVrd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

Sweep_IrdVrd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Sweep_IrdVrd PTM

Module Type: Standard PTM

Instrument: Keithley Instruments Series 4200-SMU

IGBT library

IGBT library overview

The IGBT library components are in the following directory:

```
C:\ACS_BASIC\library\devLibrary\IGBT
```

The IGBT parametric library is used to test parameters of an IGBT device, including leakage, breakdown, gain, on-state, capacitance, and characteristic curves.

BVCES

Module name: BVCES

Module type: ITM

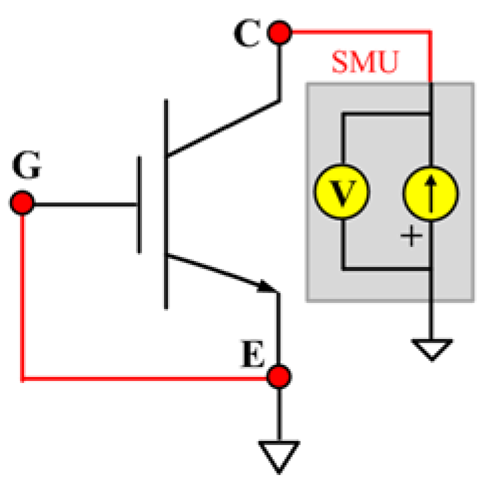
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal IGBT

Function: Measures the breakdown voltage from the collector to emitter. The voltage is measured by applying a breakdown current to the collector and the gate-emitter is shorted.

Pin connections: Use a Model 2657A to apply current and make a voltage measurement at the Collector. Connect the gate and emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 234: IGBT BVCES pin connections



Cce

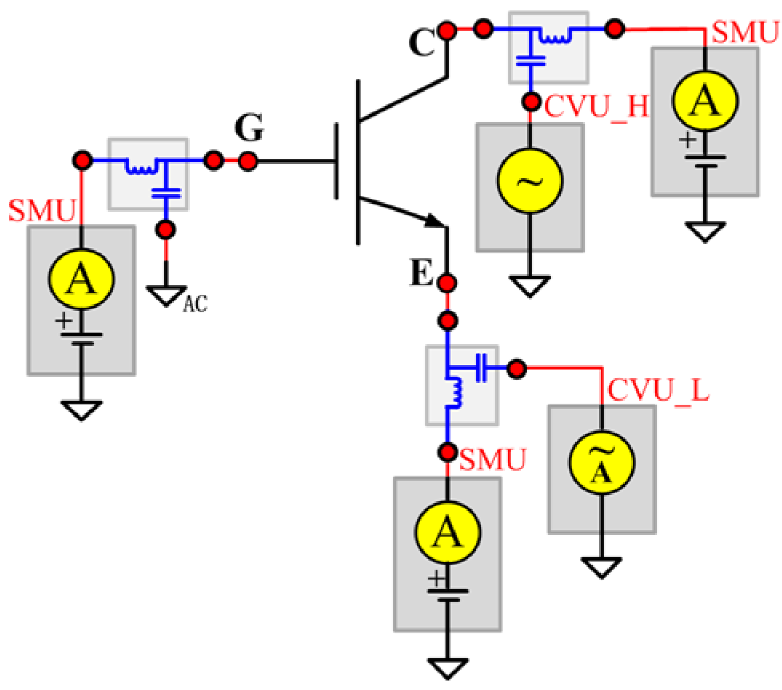
Module name: Cce

DUT: Three-terminal IGBT

Function: Measures the capacitance between the collector and emitter terminals with the gate terminal connected to the ac guard of a three-terminal bridge.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the collector. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the emitter. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the guard terminal of a three-terminal bridge through one remote bias tee to the base. Use the Series 2600B to supply zero voltage bias.

Figure 235: Three-terminal IGBT Cce pin connections



Cce PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B, Series 4200A, and Model 4200A-CVU

Cgc

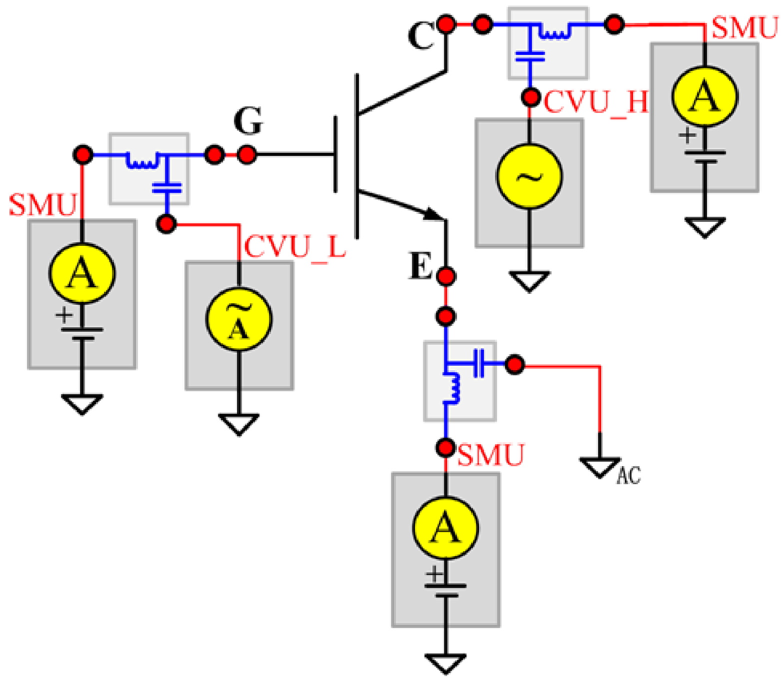
Module name: Cgc

DUT: Three-terminal IGBT

Function: Measures the capacitance between the collector and gate terminals with the emitter terminal connected to the AC guard of a three-terminal bridge.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the collector. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to supply zero voltage bias. Connect one Series 2600B and the ac guard of a three-terminal bridge through one remote bias tee to the emitter. Use the Series 2600B to supply zero voltage bias.

Figure 236: Three-terminal IGBT Cgc pin connections



Cgc PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B SMU, Model 4200-SMU, or Model 4200-CVU

Cge

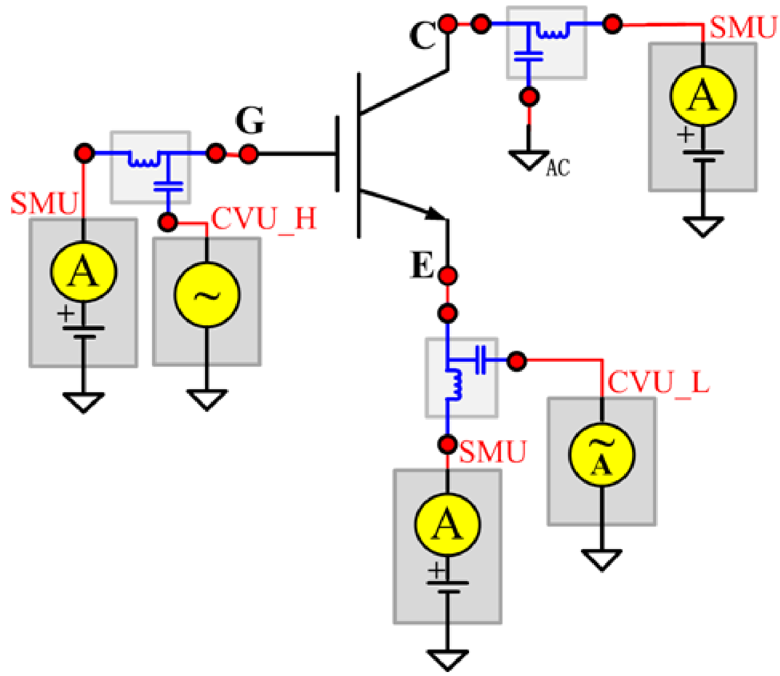
Module name: Cge

DUT: Three-terminal IGBT

Function: Measures the capacitance between the gate and emitter terminals with the collector terminal connected to the ac guard of a three-terminal bridge.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the emitter. Use the Series 2600B to supply zero voltage bias. Connect one Series 2600B the ac guard of a three-terminal bridge through one remote bias tee to the collector. Use the Series 2600B to supply zero voltage bias.

Figure 237: Three-terminal IGBT Cge pin connections



Cge PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B SMU, Model 4200-SMU, or Model 4200-CVU

Cies

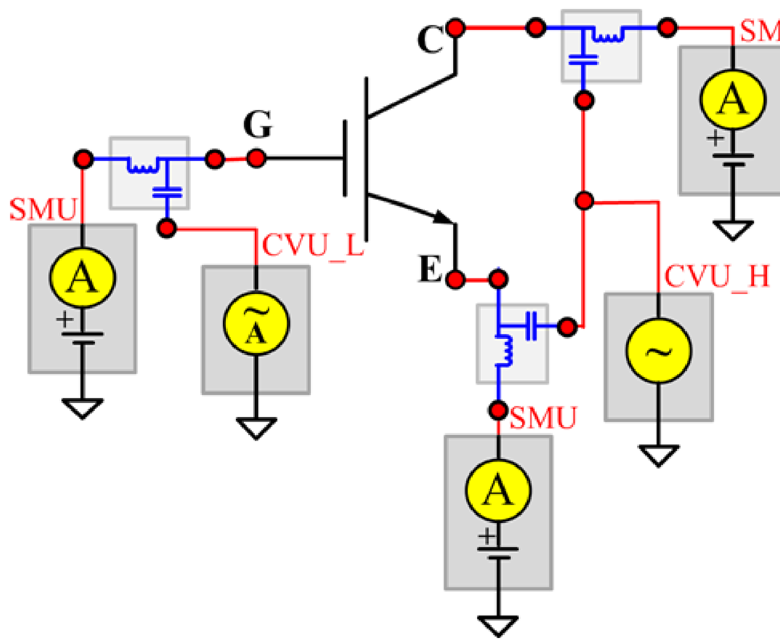
Module name: Cies

DUT: Three-terminal IGBT

Function: Measures the capacitance between the gate and emitter terminals with the collector terminal ac short-circuited to the emitter terminal.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the collector. Use the Series 2600B to sweep voltage. AC short-circuit the collector terminal to the emitter terminal. Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the emitter. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to supply zero voltage bias.

Figure 238: Three-terminal IGBT Cies pin connections



Cies PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B SMU, Series 2650 SMU, Model 4200-SMU, or Model 4200-CVU

Coes

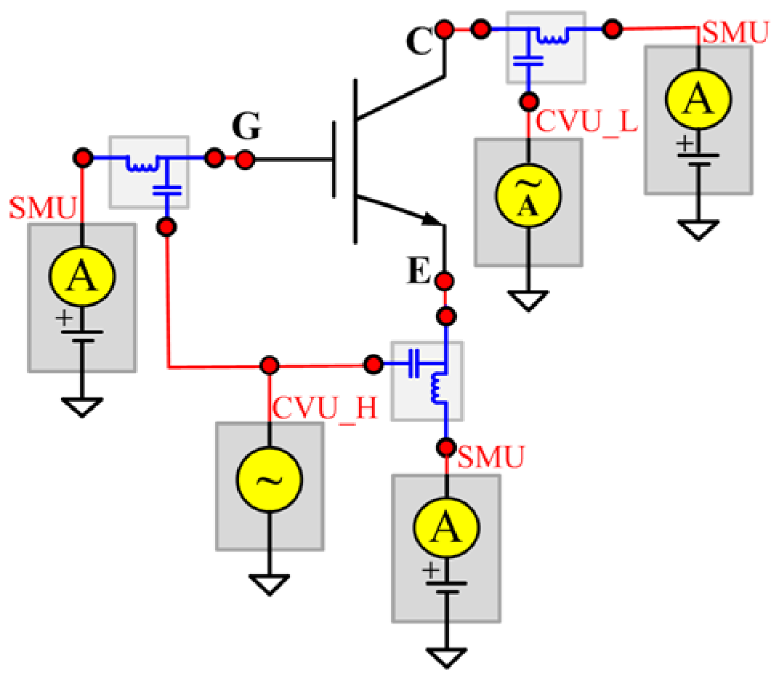
Module name: Coes

DUT: Three-terminal IGBT

Function: Measures the capacitance between the collector and emitter terminals with the gate terminal ac short-circuited to the emitter terminal.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to supply zero voltage bias. AC short-circuit the gate terminal to the emitter terminal. Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the emitter. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the collector. Use the Series 2600B to sweep voltage.

Figure 239: Three-terminal IGBT Coes pin connections



Coes PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B SMU, Series 2650 SMU, Model 4200-SMU, or Model 4200-CVU

Cres

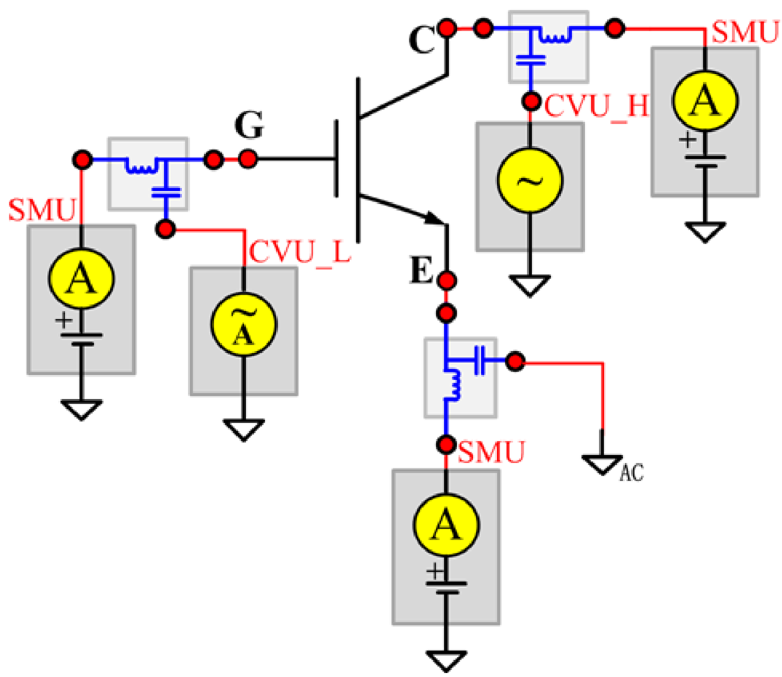
Module name: Cres

DUT: Three-terminal IGBT

Function: Measures the capacitance between the gate and collector terminals with the emitter terminal connected to the ac guard of a three-terminal bridge.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200A-CVU through one remote bias tee to the collector. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200A-CVU through one remote bias tee to the gate. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the ac guard of a three-terminal bridge through one remote bias tee to the emitter. Use the Series 2600B to supply zero voltage bias.

Figure 240: Three-terminal IGBT Cres pin connections



Cres PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B SMU, Series 2650 SMU, Model 4200-SMU, or Model 4200-CVU

ICES

Module name: ICES

Test type: ITM

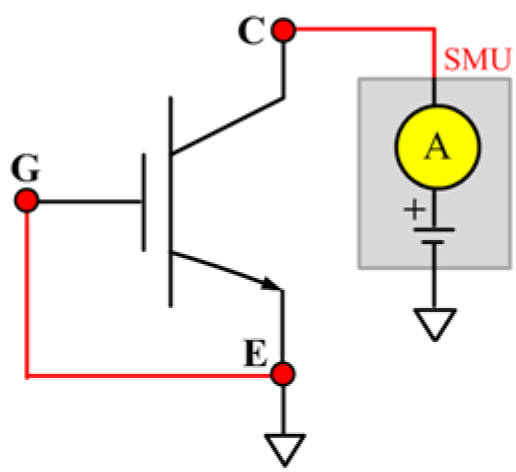
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal IGBT

Function: Measures the collector-emitter cut-off current with the gate shorted to the emitter.

Pin connections: Use a Model 2657A to apply voltage and make a current measurement from the collector to the emitter. Short the gate to the emitter or use a SMU to supply a zero-voltage bias.

Figure 241: IGBT ICES pin connections



IcON

Module name: IcON

Test type: ITM

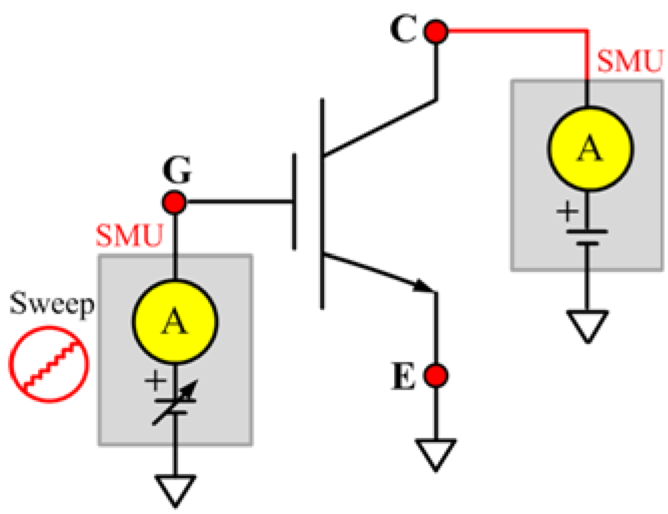
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal IGBT

Function: Measures the on-state collector current. Measures current on the collector by applying voltage to the collector-emitter with a specific gate voltage to turn on the device at a certain collector current value that is given in the data sheet.

Pin connections: Use the Model 2651A to force voltage and make a current measurement at the collector. Use the low-power Model 2600B to source sweep voltage at the gate. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 242: IGBT IcON pin connections



IcVce_StepVge

Module name: IcVce_StepVge

Test type: ITM

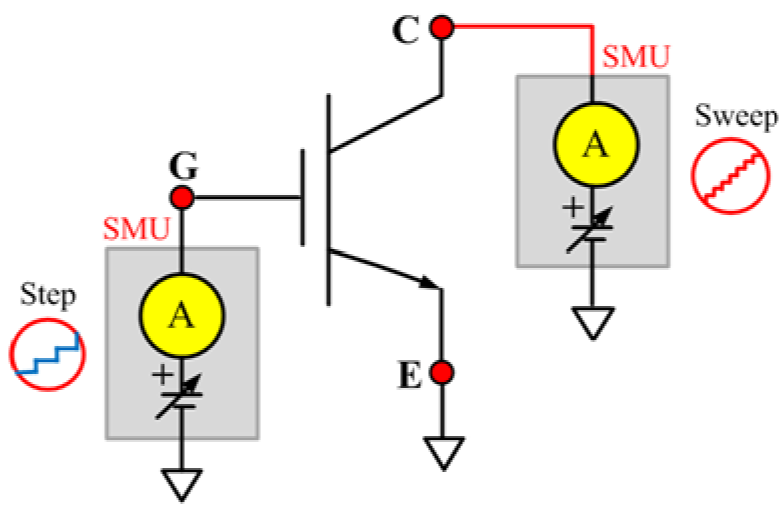
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal IGBT

Function: Measures the standard family of IcVce curves. Each time the voltage steps on the gate-emitter, a voltage sweep and a set of current measurements occur on the collector.

Pin connections: Use the Model 2651A to apply a voltage sweep and make a current measurement at the collector. Use the low-power Model 2600B to source a specific voltage at the gate. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 243: IGBT IcVce_StepVge pin connections



IcVge

Module name: IcVge

Module type: ITM

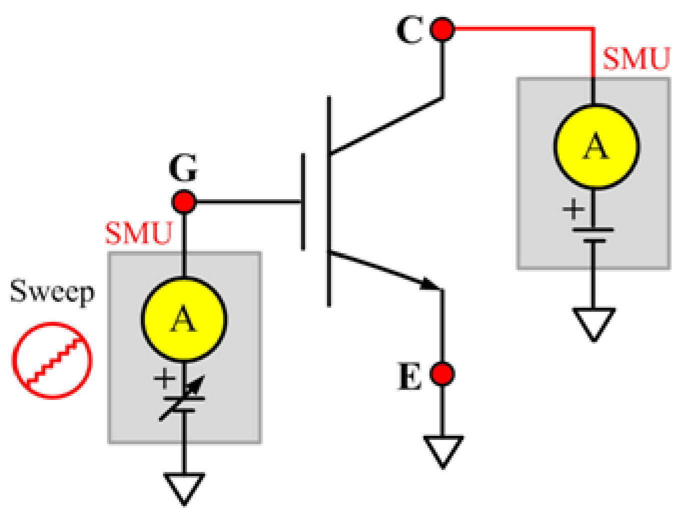
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal IGBT

Function: Measures the transfer characteristics of the IGBT with a specific voltage bias from the collector to emitter.

Pin connections: Use the Model 2651A to apply voltage and make current measurements at the collector. Use the low-power Model 2600B to sweep voltage at the gate. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 244: IGBT IcVge pin connections



IGESF

Module name: IGESF

Test type: ITM

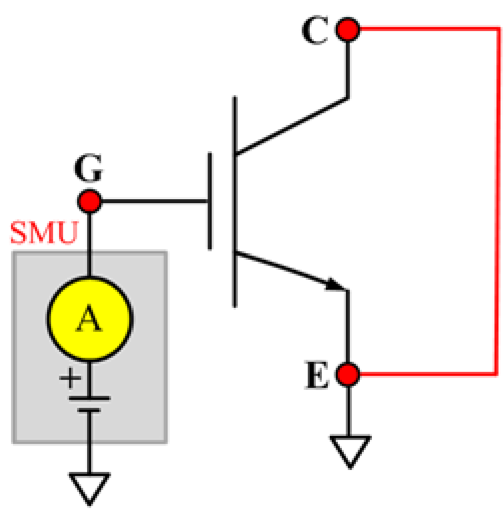
Instrument: Keithley Instruments Series 2600B

DUT: Three-terminal IGBT

Function: Measures the gate body forward leakage current. Measures current on the gate at a maximum permissible positive voltage from the gate to emitter.

Pin connections: Use a SMU to force voltage and make a current measurement from the gate to the emitter. Connect the collector and emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 245: IGBT IGESF pin connections



IGESR

Module name: IGESR

Module type: ITM

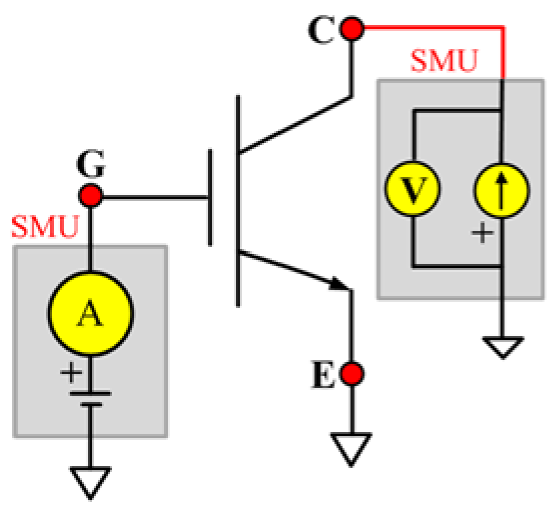
Instrument: Keithley Instruments Series 2600B

DUT: Three-terminal IGBT

Function: Measures the gate body reversed leakage current. Measures current on the gate at a maximum permissible negative voltage from the gate to emitter.

Pin connections: Use a SMU to force voltage and make a current measurement from the gate to the emitter. Connect the collector to GND or use a SMU to supply a zero-voltage bias.

Figure 246: IGBT IGESR pin connections



VceSAT

Module name: VceSAT

Module type: ITM

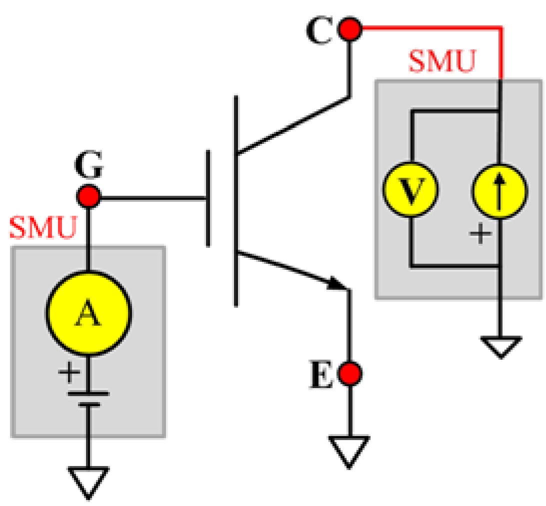
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal IGBT

Function: Measures the collector-emitter saturation voltage. The voltage is measured with a specific gate-emitter voltage and collector current that is given in the data sheet.

Pin connections: Use the Model 2651A to apply current and make voltage measurement from the collector to the emitter. Use the Model 2600B to apply a voltage bias to the gate.

Figure 247: IGBT VceSAT pin connections



VF

Module name: VF

Module type: ITM

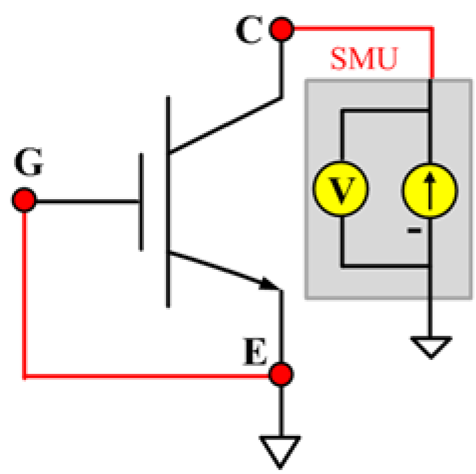
Instrument: Keithley Instruments Series 2600B

DUT: Three-terminal IGBT

Function: Measures the forward voltage of the emitter-collector diode with the gate shorted to the emitter.

Pin connections: Use a SMU to force current and make a voltage measurement from the collector to the emitter. Connect the gate to GND or use a SMU to supply a zero-voltage bias.

Figure 248: IGBT VF pin connections



VgeON

Module name: VgeON

Module type: ITM

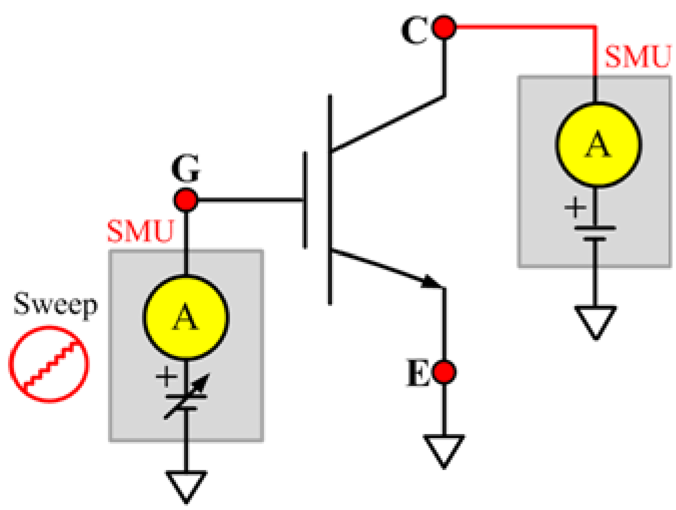
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal IGBT

Function: Measures the gate to emitter on-state voltage. Measures current on the collector by applying a voltage sweep to the gate-emitter, applying a specific collector-emitter voltage to turn on the device at a certain collector current value that is given in the data sheet, while measuring the collector current.

Pin connections: Use a Model 2651A to apply a voltage and make a current measurement at the collector. Use the low-power Model 2600B to sweep voltage at the gate. Connect the emitter to GND or use a SMU to supply a zero-voltage bias. Two SMUs are used. The Model 2651A SMU applies voltage and takes current measurements at the collector. The other SMU sweeps voltage at the gate.

Figure 249: IGBT VgeON pin connections



VGETH

Module name: VGETH

Module type: ITM

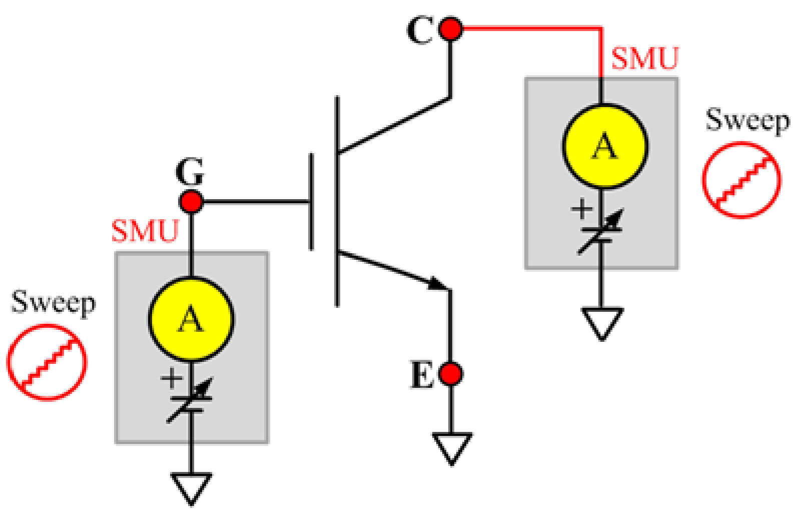
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal IGBT

Function: Measures the threshold voltage from the gate to emitter, which is required to turn on the device at a certain collector current value that is given in the data sheet.

Pin connections: Use the Model 2651A to apply voltage and make a current measurement at the collector. Use the low-power Model 2600B to sweep voltage at the gate. Connect the emitter to GND or use a SMU to supply a zero-voltage bias.

Figure 250: IGBT VGETH pin connections



IcVce_StepVge_MIX

Module name: IcVce_StepVge_MIX

Module type: PTM

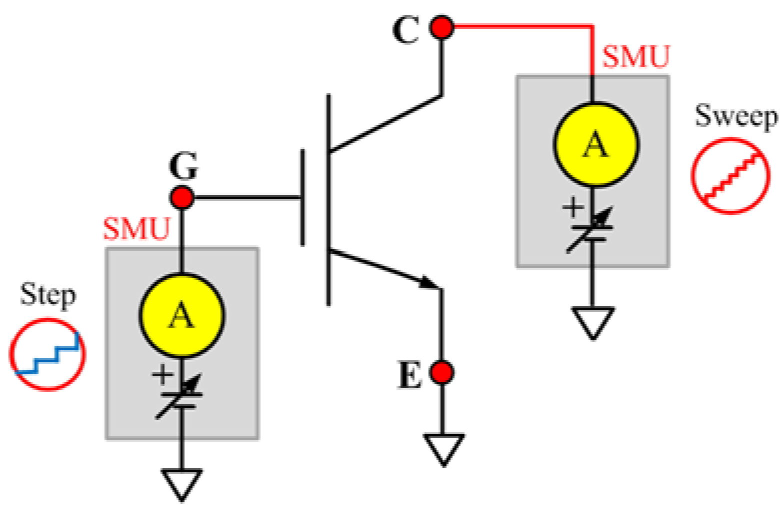
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200A-SMU

DUT: Three-terminal IGBT

Function: Measures the standard family of IcVce curves. Each time the voltage steps on the gate-emitter, a voltage sweep and a set of current measurements occur on the collector.

Pin connections: Use the Model 2651A to apply a voltage sweep and make a current measurement at the collector. Use the other SMU to source a specific voltage at the gate.

Figure 251: IGBT IcVce_StepVge_MIX pin connections



IcVge_MIX

Module name: IcVge_MIX

Module type: PTM

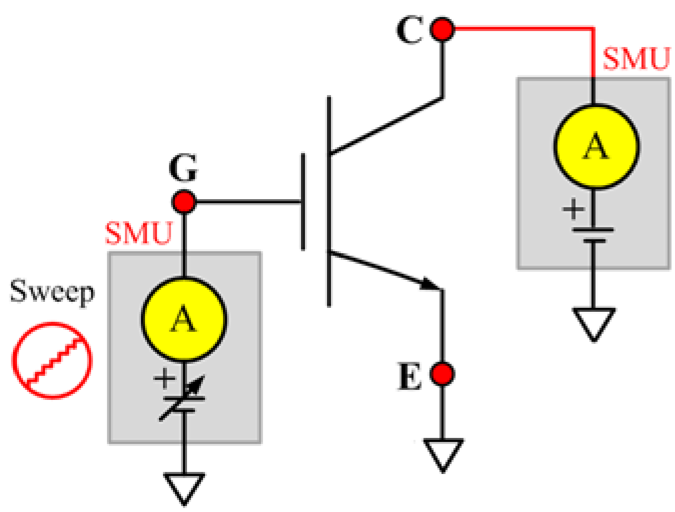
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200A-SMU

DUT: Three-terminal IGBT

Function: Measures the transfer characteristics of the IGBT with a specific voltage bias from the collector to the emitter.

Pin connections: The Model 2651A SMU applies voltage and makes current measurements at the collector. Use the other SMU to sweep voltage at the gate.

Figure 252: IGBT IcVge_MIX pin connections



VceSAT_MIX

Module name: VceSAT

Module type: PTM

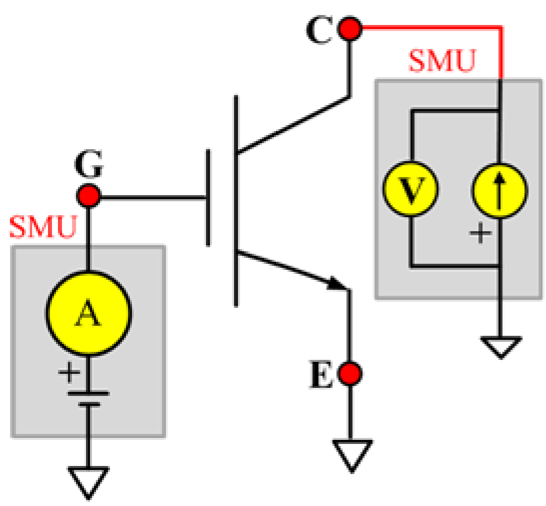
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200A-SMU

DUT: Three-terminal IGBT

Function: Measures the collector-emitter saturation voltage. The voltage is measured with a specific gate-emitter voltage and collector current that is given in the data sheet.

Pin connections: Use a SMU to force current and make a voltage measurement from the collector to the emitter. Use the other SMU to apply a voltage bias to the gate.

Figure 253: IGBT VceSAT_MIX pin connections



Two-terminal resistor library

Two-terminal resistor library overview

The two-terminal resistor library components are in the following directory:

```
C:\ACS_BASIC\library\devLibrary\RESISTOR_2T
```

The two-terminal resistor library is used to test parameters of a two-terminal resistor, such as resistance (source V measure I or source I measure V, 2-wire or 4-wire). This library is used with a Series 2600B instrument to create test script files based on Series 2600B LPT library.

Spot_IV_2SMU

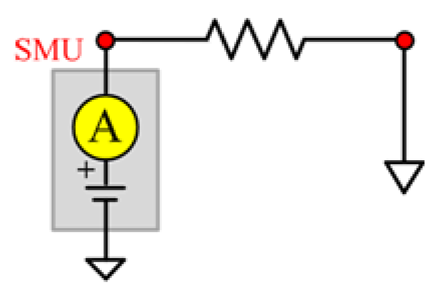
Module name: Spot_IV_2SMU

DUT: Two-terminal generic device

Function: Measures the current at a specified voltage to determine the resistance.

Pin connections: Ensure that you set the sense mode of the SMU in the software toolbar (Tools > Preferences). If remote sense mode is used, which corresponds to four-wire measurement instruments, connect the Sense High lead of the SMU closer to the device than the Force High lead.

Figure 254: Two-terminal Spot_IV_2SMU pin connections



Spot_IV_2SMU ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

Spot_IV_2SMU General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Spot_VI_2SMU

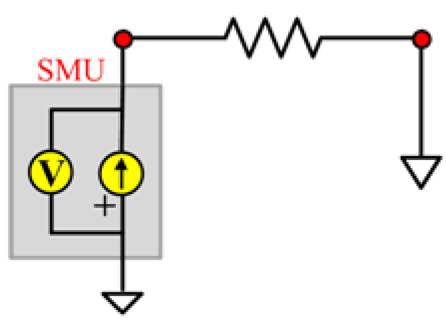
Module name: Spot_VI_2SMU

DUT: Two-terminal generic device

Function: Measures the voltage at a specified current to determine the resistance.

Pin connections: Ensure that you set the sense mode of the SMU in the software toolbar (Tools > Preferences). If remote sense mode is used, which corresponds to four-wire measurement instruments, connect the Sense High lead of the SMU closer to the device than the Force High lead.

Figure 255: Two-terminal resistor spot_VI_2SMU pin connections



Spot_VI_2SMU ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

Spot_VI_2SMU General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Sweep_IV_2SMU

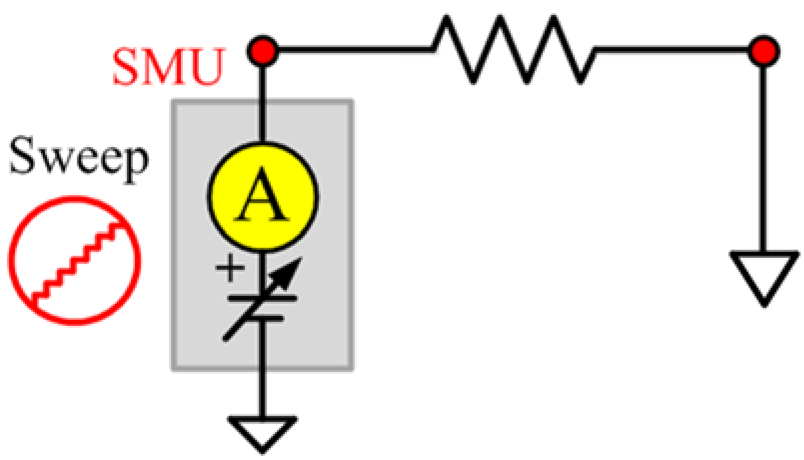
Module Name: Sweep_IV_2SMU

DUT: Two-terminal generic device

Function: Measures the current reading during a voltage sweep and use the values to calculate the resistance.

Pin connections: Ensure that you set the sense mode of the SMU in the software toolbar (Tools > Preferences). If remote sense mode is used, which corresponds to four-wire measurement instruments, connect the Sense High lead of the SMU closer to the device than the Force High lead.

Figure 256: Two-terminal resistor sweep IV 2SMU pin connections



Sweep_IV_2SMU ITM

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200A-SMU

Figure 257: Two-terminal resistor Sweep_IV_2SMU 2600B ITM settings

Device Num	SMU	Pad	Function	Force Range	Source	Measure	Compliance	Meas Range	Limits Auto
1	SMU1	Pos	Sweep V	auto	Linear:[0.1, 1, 21, 0]	I+V	0.1	auto	
	SMU2	Neg	Bias V	auto	0	None	0.1		

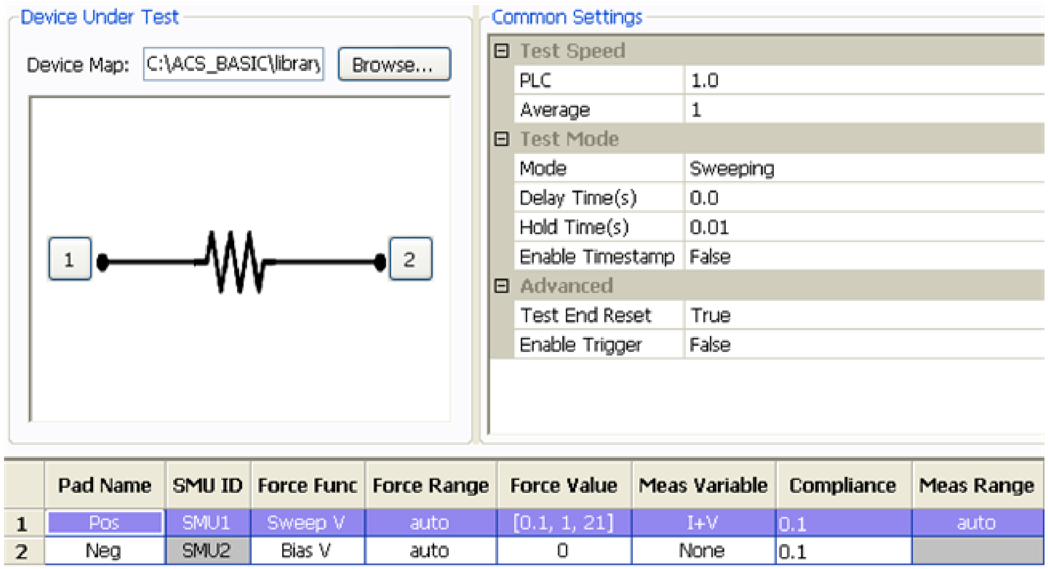
Figure 258: Two-terminal resistor sweep IV 2SMU 4200 ITM setting

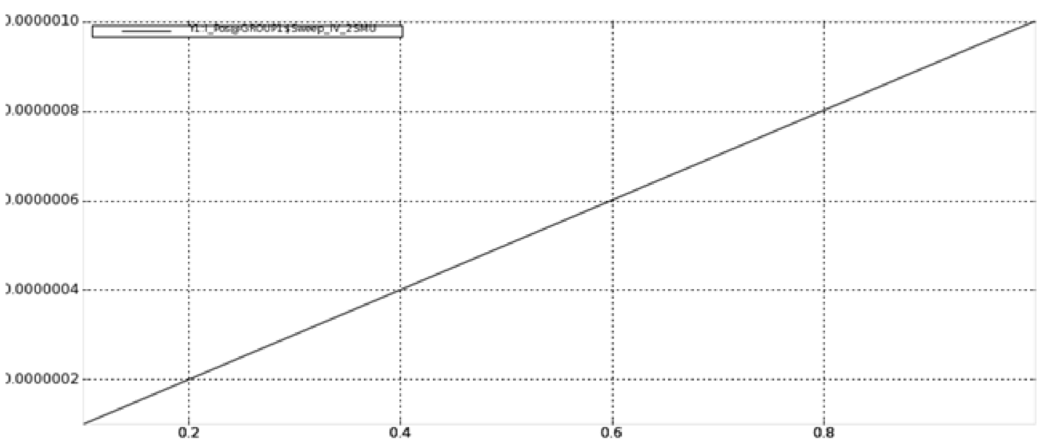
Device Num	SMU	Pad	Function	Force Range	Source	Measure	Compliance	Meas Range	Limits Auto
1	SMU1	Pos	Sweep V	auto	Linear:[0, 1, 21, 0]	I+V	0.1	auto	
	SMU2	Neg	Bias V	auto	0.0	None	0.1		

Sweep_IV_2SMU General Test Module

Module type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU





Sweep_VI_2SMU

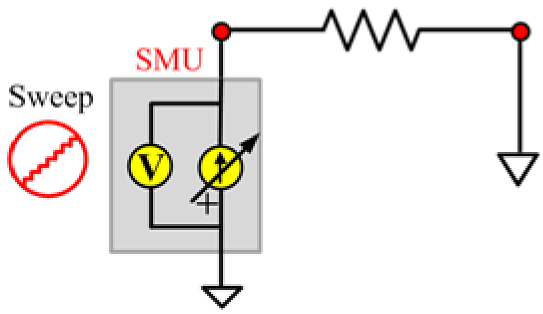
Module name: Two-terminal resistor Sweep_VI_2SMU

DUT: Two-terminal generic device

Function: Measures the voltage during a current sweep and use the values to calculate the resistance.

Pin connections: Ensure that you set the sense mode of the SMU in the software toolbar (Tools > Preferences). If remote sense mode is used, which corresponds to four-wire measurement instruments, connect the Sense High lead of the SMU closer to the device than the Force High lead.

Figure 259: Two-terminal resistor sweep VI 2SMU pin connections



Sweep_VI_2SMU ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200-SMU

Sweep_VI_2SMU General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

TRIAC library

TRIAC parametric library overview

The TRIAC library components are in the following directory:

```
C:\ACS_BASIC\library\devLibrary\TRIAC
```

The TRIAC parametric library is used to test parameters of a TRIAC device, including leakage, on-state, trigger, latch and hold properties.

IDRM

Module name: IDRM

Module type: ITM

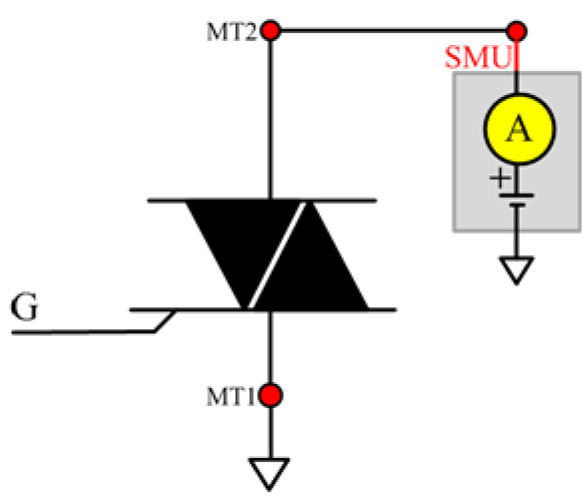
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal TRIAC

Function: Measures the peak repetitive blocking current. Measures the maximum instantaneous value of the off-state current that results from the application of repetitive peak off-state voltage.

Pin connections: Use the Model 2657A to apply voltage and measure current between terminals MT2 (or A2) to MT1 (or A1). Open the circuit to the gate or use a SMU to supply a zero-current bias.

Figure 260: TRIAC IDRM pin connections



IGT

Module name: IGT

Module type: ITM

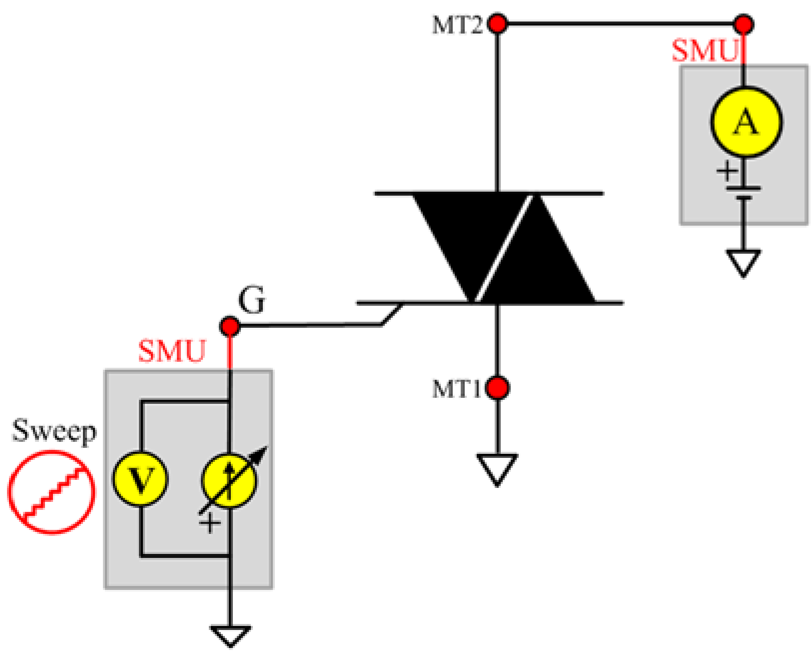
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal TRIAC

Function: Measures the gate trigger current. Measures the minimum current required between the gate and cathode (MT1) to turn on the device.

Pin connections: Use the Model 2651A to apply the specified voltage and measure the current between terminals MT2 (or A2) to MT1 (or A1). Use the Model 2600B SMU to sweep current and measure voltage between gate and cathode MT1. If required, connect a resistance load RL at specified value in series with the TRIAC device to achieve a defined on-state current IT.

Figure 261: TRIAC IGT pin connections



IHneg

Module name: IHneg

Module type: ITM

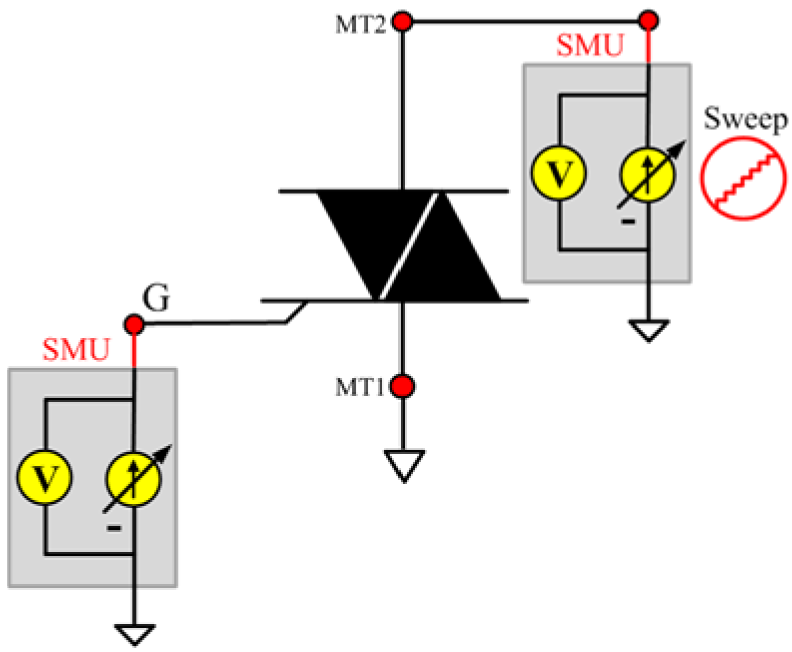
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal TRIAC

Function: Measures the holding current. Measures the minimum current across the main terminals to keep the device in the on-state.

Pin connections: Use the Model 2651A SMU to apply current between terminals MT2 (or A2) to MT1 (or A1). Use the Model 2600B SMU to apply the specified current between Gate and cathode MT1.

Figure 262: TRIAC IHneg pin connections



IHpos

Module name: IHpos

Module type: ITM

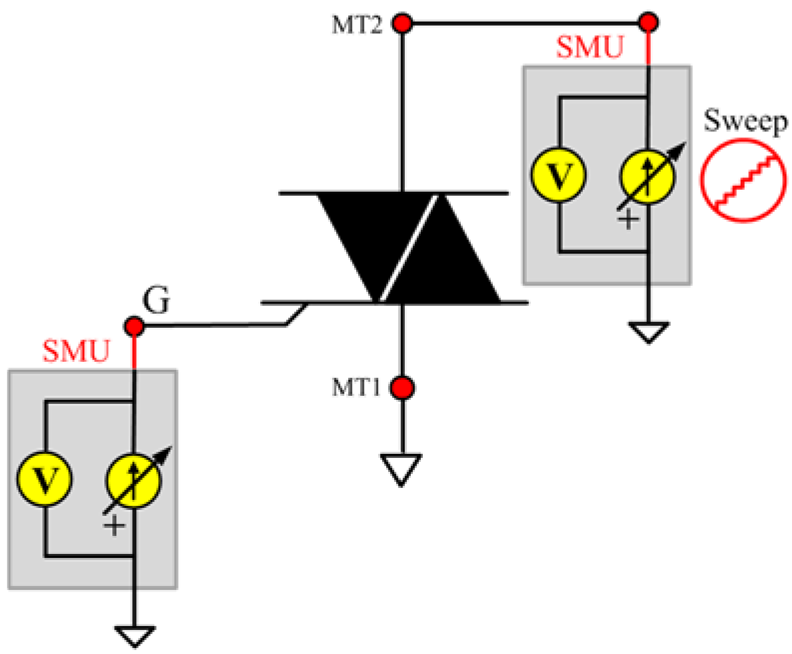
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal TRIAC

Function: Measures the holding current. Measures the minimum current across the main terminals to keep the device in the on-state.

Pin connections: Use the Model 2651A SMU to apply current between terminals MT2 (or A2) to MT1 (or A1). Use the Model 2600B SMU to apply the specified current between Gate and cathode MT1.

Figure 263: TRIAC IHpos pin connections



ILneg

Module name: ILneg

Module type: ITM

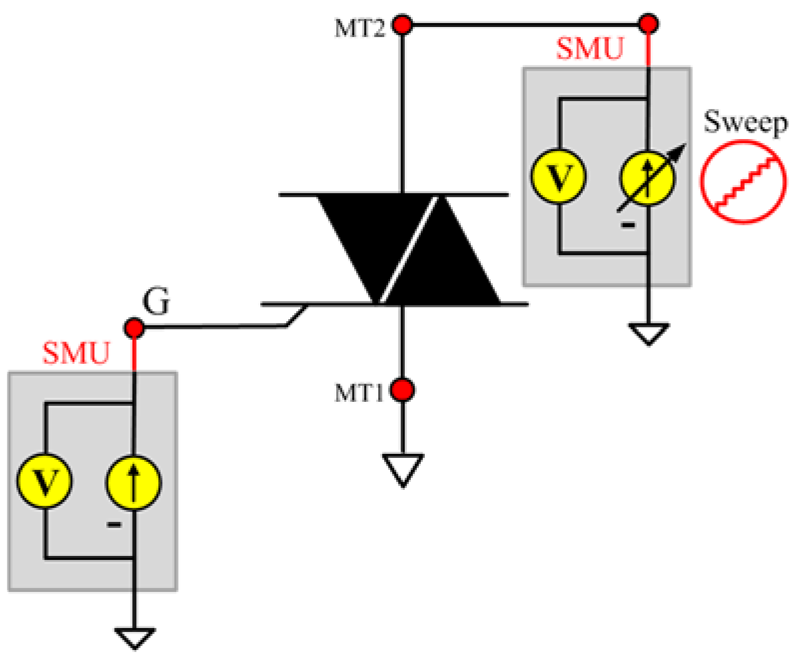
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal TRIAC

Function: Measures the latching current. Measures the minimum current across the main terminals to keep the device in the on-state. This occurs immediately after switching from off-state to on-state and the triggering gate signal has been removed.

Pin connections: Use the Model 2651A SMU to apply current between terminals MT2 (or A2) to MT1 (or A1). Use the Model 2600B SMU to apply the specified current between Gate and cathode MT1.

Figure 264: TRIAC ILneg pin connections



ILpos

Module name: ILpos

Module type: ITM

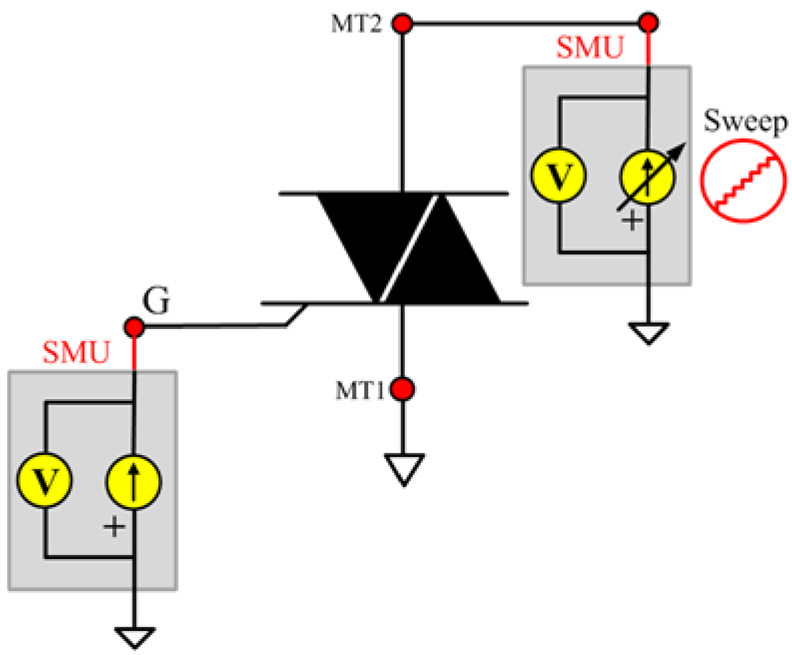
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal TRIAC

Function: Measures the latching current. Measures the minimum current across the main terminals to keep the device in the on-state. This occurs immediately after switching from off-state to on-state and the triggering gate signal has been removed.

Pin connections: Use the Model 2651A SMU to apply current between terminals MT2 (or A2) to MT1 (or A1). Use the Model 2600B SMU to apply the specified current between Gate and cathode MT1.

Figure 265: TRIAC ILpos pin connections



IRRM

Module name: IRRM

Module type: ITM

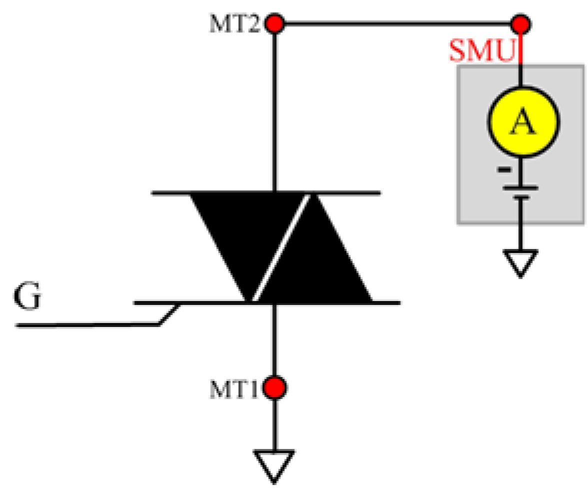
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal TRIAC

Function: Measures the peak repetitive reverse blocking current. Measures the maximum instantaneous value of the reverse off-state current that results from the application of repetitive peak off-state voltage.

Pin connections: Use the Model 2657A SMU to apply voltage and measure current between terminals MT2 (or A2) to MT1 (or A1). Connect gate to GND or use a SMU to supply a zero-voltage bias.

Figure 266: TRIAC IRRM pin connections



VGT

Module name: VGT

Module type: ITM

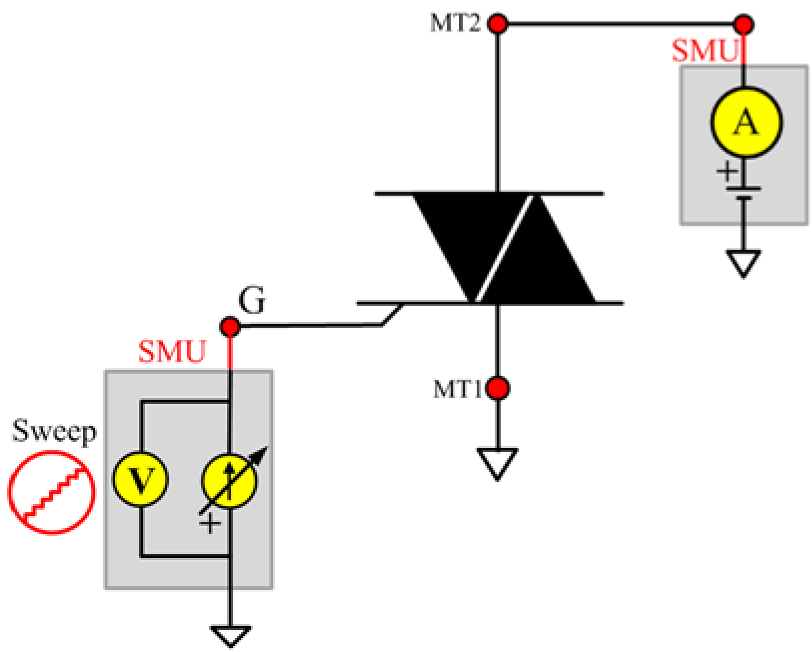
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal TRIAC

Function: Measures the gate trigger voltage. Measures the minimum voltage required between the gate and cathode to reach the gate trigger current and then to trigger the device.

Pin connections: Use the Model 2651A SMU to apply the specified voltage and measure current between terminals MT2 (or A2) to MT1 (or A1). Use the Model 2600B SMU to sweep the current and measure voltage between gate and cathode MT1. Two SMUs are used. One SMU applies a specified voltage and measures current between terminals A2 (or MT2) to A1 (or MT1). If required, connect a resistance load (RL) at a specified value in series with the TRIAC device to achieve a defined on-state current IT.

Figure 267: TRIAC VGT pin connections



VTneg

Module name: VTneg

Module type: ITM

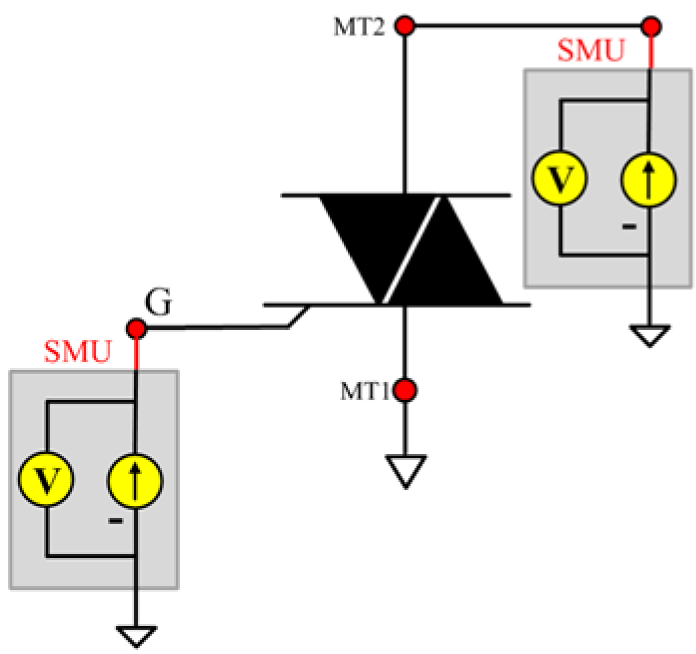
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal TRIAC

Function: Measures the peak on-state voltage. Measures the maximum voltage drop across the main terminals at stated conditions when the devices are in the on-state. Typically measured at a short pulse width and low duty cycle to prevent heating of the junction.

Pin connections: One or two SMUs are used. One SMU applies a specified current and measures voltage between terminals A2 (or MT2) to A1 (or MT1). The other SMU may be required to apply a gate current to turn the device on. The gate current >= IGT must be applied until the load current is >= IL.

Figure 268: TRIAC VTneg pin connections



VTpos

Module name: VTpos

Module type: ITM

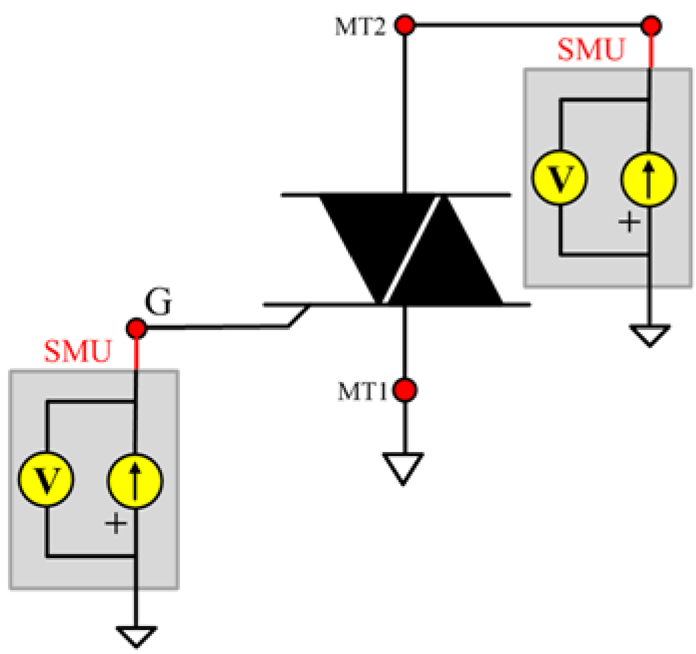
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal TRIAC

Function: Measures the peak on-state voltage. Measures the maximum voltage drop across the main terminals at stated conditions when the devices are in the on-state. Typically measured at a short pulse width and low duty cycle to prevent heating of the junction.

Pin connections: One or two SMUs are used. One SMU applies a specified current and measures voltage between terminals A2 (or MT2) to A1(or MT1). The other SMU may be required to apply a gate current to turn the device on. The gate current >= IGT must be applied until the load current is >= IL.

Figure 269: TRIAC VTpos pin connections



Zener test module templates

Zener overview

The Zener library components are in the following directory:

```
C:\ACS_BASIC\library\devLibrary\ZENER
```

The components in the Zener parametric library are used to test parameters of a Zener diode, including leakage, on-state, and breakdown properties.

BVZ

Module name: BVZ

Module type: ITM

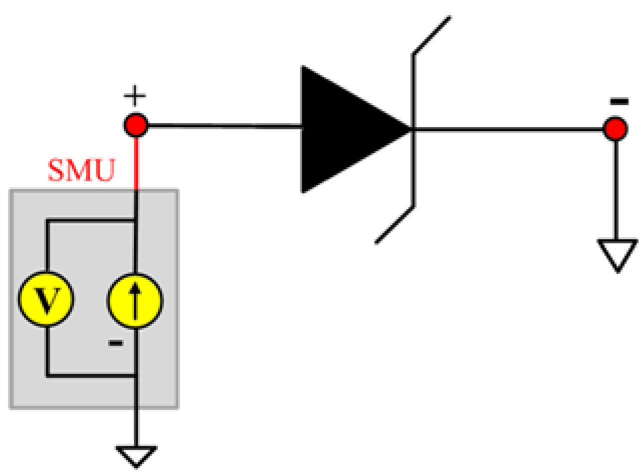
Instrument: Keithley Instruments Series 2600B

DUT: Two-terminal Zener diode

Function: Measures the regulator voltage from the cathode to anode at the maximum rated current that is given in the datasheet.

Pin connections: Use a SMU to apply a negative current (IZM) and make voltage measurements from the anode to the cathode. Connect the cathode to GND or use a SMU to supply a zero-voltage bias.

Figure 270: Zener BVZ pin connections



IR

Module name: IR

Module type: ITM

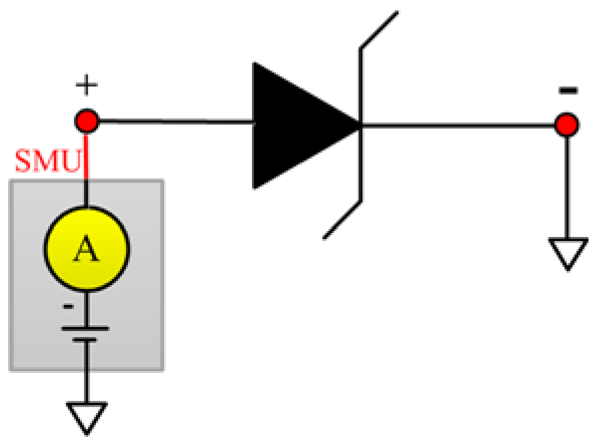
Instrument: Keithley Instruments Series 2600B

DUT: Two-terminal Zener diode

Function: Measures the reverse leakage current at a specific reverse voltage from the cathode to anode that is given in the datasheet.

Pin connections: Use a SMU to apply a negative voltage and make a current measurement from anode to cathode. Connect the cathode to GND or use a SMU to supply a zero-voltage bias.

Figure 271: Zener IR pin connections



VF

Module name: VF

Module type: ITM

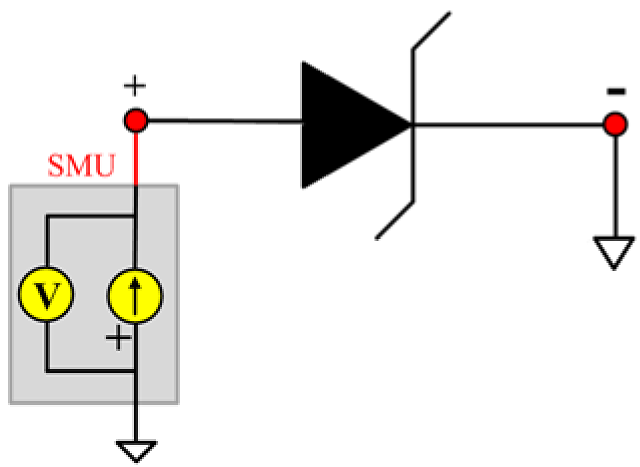
Instrument: Keithley Instruments Series 2600B

DUT: Two-terminal Zener diode

Function: Measures the forward voltage at a specific forward current from the anode to cathode.

Pin connections: Use a SMU to apply positive current and make a voltage measurement from the anode to the cathode. Connect the cathode to GND or use a SMU to supply a zero-voltage bias.

Figure 272: Zener VF pin connections



Capacitor WLR library

Capacitor WLR overview

The WLR script components are in the following directory:

```
C:\ACS_BASIC\library\devLibrary\CAPACITOR_MOS\WLR_script
```

There are four modules in the pMOSFET WLR_script Library:

1. TDDB_per_pin
2. TDDB_CCS
3. qbd_rmpj
4. qbd_rmpv

TDDB_CCS

Description:

Performs the constant current time dependent dielectric breakdown (TDDB) test. Up to four SMUs are supported and voltage is measured. A hard breakdown (HBD) occurs when:

A. If the Vg is below breakdown voltage (abs(Vg)<abs(Vmin))
B. If the Vg falls dramatically (abs(Vg[now]) <= HBDL * abs(Vg[prev])).

Syntax:

```
TDDB_CCS(sample_interval, time_max, holdtime, V_min, HBDL, myPLC, smu_1, comp1,
    stress1, meas1, smu_2, comp2, stress2, meas2, smu_3, comp3, stress3, meas3,
    smu_4, comp4, stress4, meas4).
```

INPUTS:

`double sample_interval=1 in (0, )`	--time between sample (Unit:s)
`double HBDL=0.6 in [0,0.999]`	--limit of hard BD.when Ig[now]>=Ig[prev]*HBDL then abort.
`double V_min=0.06 in [0,200]`	--minimum voltage
`double time_max=nil in (0, )/nil`	--maximum time of experiment. if 'nil' appears, test until BD
`double holdtime=0 in [0, )`	--time before stress begin (Unit:s)
`double myPLC=1 in [0.001,25]`	--PLC setting
`integer smu_1=1 in [0,1,2..64]`	--maximum 4 smus are supported. if not input '0'
`double comp1=2`	--compliance of corresponding smu (Unit:A for current;V for voltage).
`double stress1=1e-6`	--stress value required on the smu (Unit:A for current V for voltage).
`integer meas1=1 in [0,1]`	--1: current stress and make measurement 0: voltage stress no measurement
`integer smu_2=2  in [0,1,2..64]`	--maximum 4 smus are supported. if not input '0'
`double comp2=0.1`	--compliance of corresponding smu (Unit:A for current V for voltage).
`double stress2=0`	--stress value required on the smu (Unit:A for current V for voltage).
`integer meas2=0 in [0,1]`	--1: current stress and make measurement 0: voltage stress no measurement
`integer smu_3=0 in [0,1,2..64]`	--maximum 4 smus are supported. if not input '0'
`double comp3=nil`	--compliance of corresponding smu (Unit:A for current;V for voltage).
`double stress3=nil`	--stress value required on the smu (Unit:A for current V for voltage).
`integer meas3=nil`	--1: current stress and make measurement 0: voltage stress no measurement
`integer smu_4=0 in [0,1,2..64]`	--maximum 4 smus are supported. if not input '0'
`double comp4=nil`	--compliance of corresponding smu (Unit:A for current;V for voltage).
`double stress4=nil`	--stress value required on the smu (Unit:A for current V for voltage).
`integer meas4=nil`	--1: current stress and make measurement 0: voltage stress no measurement

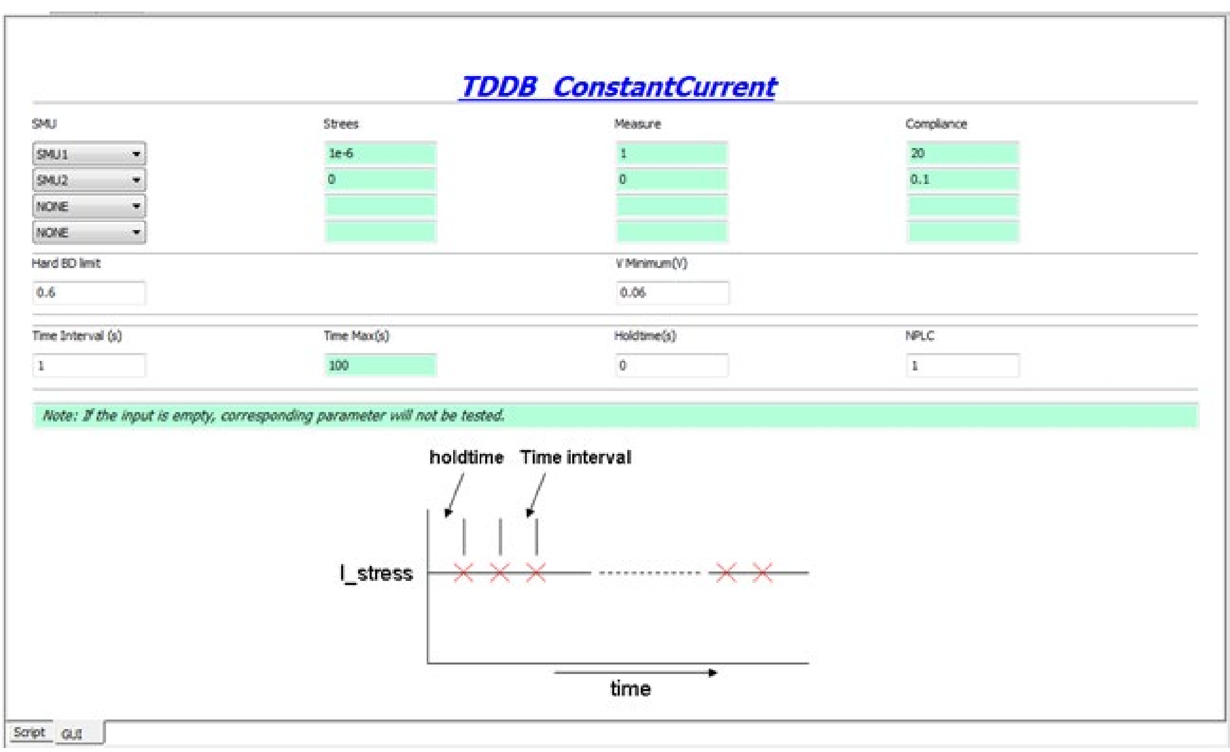
OUTPUTS:

`error`	--error message
`time1`	--time array of SMU1
`Vg1`	--voltage of SMU1
`TBD1`	--Tbd of SMU1
`BD_type1`	--breakdown type of SMU1:1 for HBD; 2 for timeout
`time2`	--time array of SMU2
`Vg2`	--voltage of SMU2
`TBD2`	--Tbd of SMU2
`BD_type2`	--breakdown type of SMU2
`time3`	--time array of SMU3
`Vg3`	--voltage of SMU3
`TBD3`	--Tbd of SMU3
`BD_type3`	--breakdown type of SMU3
`time4`	--time array of SMU4
`Vg4`	--voltage of SMU4
`TBD4`	--Tbd of SMU4
`BD_type4`	--breakdown type of SMU4

GUI related:

The next figure shows the GUI for the TDDB_CCS test. A general description of this GUI is included below.

Figure 273: GUI for TDDB_CCS



TDDB_CCS user interface descriptions

- **Terminal setting:** If the SMU is NONE, Stress, Measure and Compliance can be empty.
- **Measure:** Set the Measure column to `1` if you want to measure the SMU; set it to `0` if you only want to run a stress test.
- **Hard BD limit and V minimum:** Set the hard breakdown limit and voltage minimum. The unit is volts.
- **Time arrangement:** Time Max can be left empty. In this case, the test continues until all devices fail.

Example call:

```
local sample_interval=1
local time_max=50
local holdtime=0
local V_min = 0.06
local HBDL=0.6
local myPLC = 1
local smu_1=1
local comp1=20
local stress1=3e-6
local meas1=1
local smu_2=2
local comp2=0.1
local stress2=0
local meas2=0
local smu_3=0
local comp3=nil
local stress3=nil
local meas3=nil
local smu_4=0
local comp4=nil
local stress4=nil
local meas4=nil
TDDB_CCS(sample_interval, time_max, holdtime, V_min, HBDL, myPLC, smu_1, comp1,
   stress1, meas1, smu_2, comp2, stress2, meas2, smu_3, comp3, stress3, meas3,
   smu_4, comp4, stress4, meas4)
```

TDDB_per_pin

Description:

Performs a time dependent dielectric breakdown (TDDB) test. Up to four SMUs are supported and voltage is forced and current is measured. If breakdown mode is zero, only the hard breakdown (HBD) will be monitored. If breakdown mode is 1, a soft breakdown (SBD) will also be monitored.

HBD happens when compliance is met or Ig[now]>=HBDL*Ig[pre][now] >= HBDL*Ig[prev]

To evaluate SBD, noise of the gate current (Inoise) will be calculated using the formula listed in JESD92 (JDEX standard number 92 "Procedure for Characterizing Time-Dependent Dielectric Breakdown of Ultra-Thin gate Dielectrics"). Base noise (Inoise_Base) is calculated using the ‘Inoise’ average value (AVL) and the base number (bas_num)(see JESD92 for details).

If the DUT is a MOSFET, some of the SMUs do not require measurements and will set the corresponding 'meas' to zero.Possible outputs: time, Ig, Ig_noise (when SBD is required), and breakdown-type of SMUs requiring measurement.

Syntax:

```
TDDB_per_pin(time_interval, HBDL, BD_mode, time_max, SBDL, holdtime, , smu1, comp1,
   stress1, meas1, smu2, comp2, stress2, meas2, smu3, comp3, stress3, meas3, smu4,
   comp4, stress4, meas4)
```

INPUTS:

`double time_interval=0.01 in(0, )` --time between sample (Unit:s)

`integer HBDL=1000 in[1, )` --limit of hard BD.when Ig[now]>=Ig[prev]*HBDL then abort.

`integer BD_mode=0 in[0,1]` --0: HBD only. All the parameters related to SBD could be set to nil: also SBD

`double time_max=nil in(0, )/nil` --maximum time of experiment. if 'nil' appears, test until BD

`integer SBDL=500 in[1, )/nil` --limit of SBD. when Inoi[now] >= Inoi[Base]*SBDL then abort.

`double holdtime=0 in[0, )` --time before stress begin (Units)

`double myPLC=1 in[0.001,25]` --PLC setting

`integer smu_1=1 in[0,1,2..64]` --maximum four SMUs are supported. if not input '0'

`double comp1=0.1 in[0,0.1]`	--compliance of corresponding smu (Unit:A).
`double stress1=3 in[-200,200]`	--stress value required on the smu (Unit:V).
`integer meas1=1 in[0,1]`	--1: make measurement on this smu 0: no measurement
`integer smu_2=2 in[0,1,2..64]`	--maximum four SMUs are supported. if not input '0'
`double comp2=0.1 in[0,0.1]`	--compliance of corresponding smu (Unit:A).
`double stress2=3 in[-200,200]`	--stress value required on the smu (Unit:V).
`integer meas2=1 in[0,1]`	--1: make measurement on this smu 0: no measurement
`integer smu_3=0 in[0,1,2..64]`	--maximum four SMUs are supported. if not input '0'
`double comp3=nil in[0,0.1]`	--compliance of corresponding smu (Unit:A).
`double stress3=nil in[-200,200]`	--stress value required on the smu (Unit:V).
`integer meas3=nil in[0,1]`	--1: make measurement on this smu 0: no measurement
`integer smu_4=0 in[0,1,2..64]`	--maximum four SMUs are supported. if not input '0'
`double comp4=nil in[0,0.1]`	--compliance of corresponding smu (Unit:A).
`double stress4=nil in[-200,200]`	--stress value required on the smu (Unit:V).
`integer meas4=nil in[0,1]`	--1: make measurement on this smu 0: no measurement

Outputs:

`error`	--indicate whether the modules runs OK or not -1: illegal input 0: OK
`time1`	--time array of SMU1
`I1`	--current of SMU1
`Inoi1`	--noise current of SMU1
`BD_type1`	--breakdown type of SMU1 1: HBD 2: SBD 3: time out
`TBD1`	--time to BD of SMU1
`time2`	--time array of SMU2
`I2`	--current of SMU2
`Inoi2`	--noise current of SMU2
`BD_type2`	--breakdown type of SMU2

`TBD2`	--time to BD of SMU2
`time3`	--time array of SMU3
`I3`	--current of SMU3
`Inoi3`	--noise current of SMU3
`BD_type3`	--breakdown type of SMU3
`TBD3`	--time to BD of SMU3
`time4`	--time array of SMU4
`I4`	--current of SMU4
`Inoi4`	--noise current of SMU4
`BD_type4`	--breakdown type of SMU4
`TBD4`	--time to BD of SMU4

GUI related:

The next figure shows the GUI for the TDDB test. A general description of this GUI is included below.

Figure 274: TDDB sequence

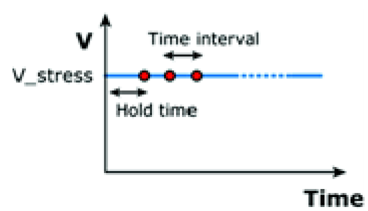
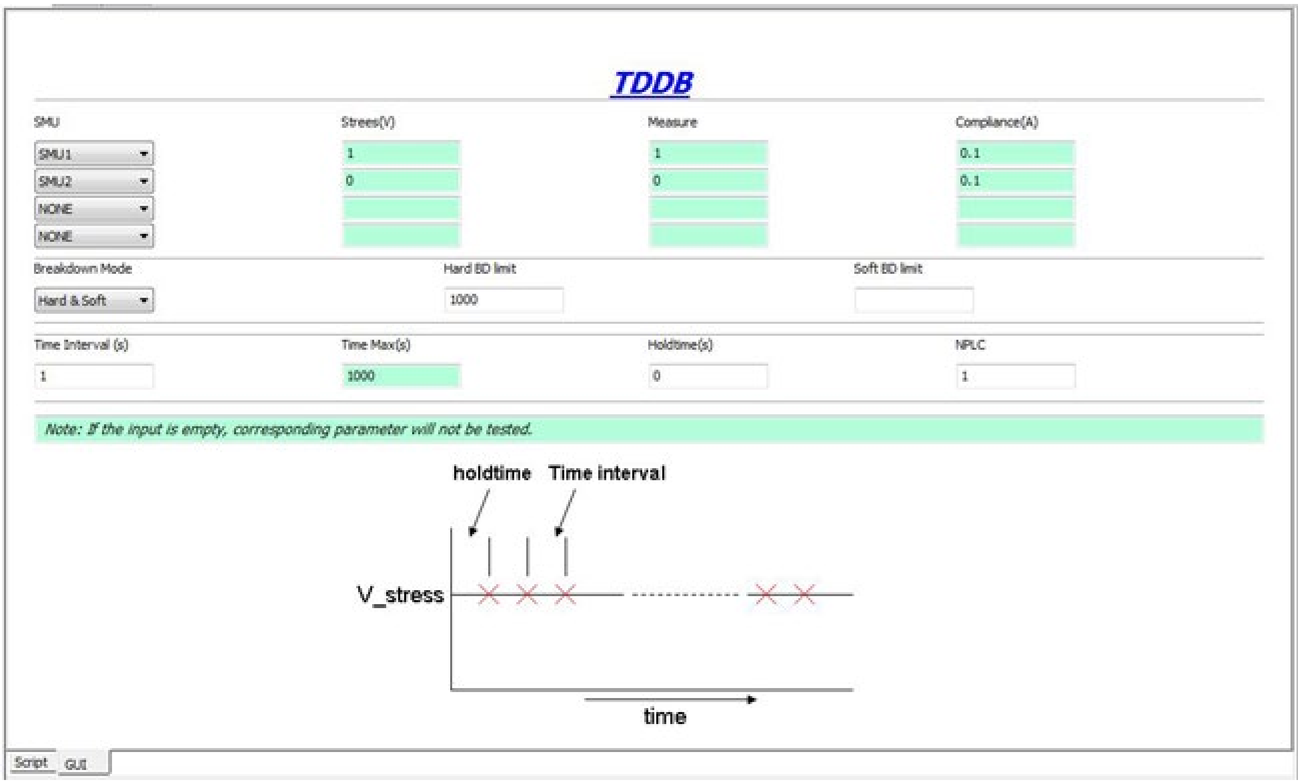


Figure 275: GUI for TDDB per pin



TDDB GUI descriptions:

Terminal: If the SMU is NONE, Stress (V), Measure and Compliance (A) can be empty.

Measure: Set the Measure column to 1 if you want to measure the SMU; set to zero if you only want to run a stress test.

Breakdown: If breakdown mode is set to Hard, the Soft BD limit can be empty. For Soft BD limit Soft breakdown details, see JESD92 (JDEX standard number 92 "Procedure for Characterizing Time-Dependent Dielectric breakdown of Ultra-Thin gate Dielectrics").

Time: Time Max can be empty. In this case, the test will continue until all devices fail.

Example call:

```
local time_interval=1
local HBDL=1000
local BD_mode=0
local time_max=20
local SBDL=500
local holdtime=0
local myPLC=1
local smu1=1
local comp1=0.1
local stress1=2
local meas1=1
local smu2=0
local comp2=nil
local stress2=nil
local meas2=nil
local smu3=0
local comp3=nil
local stress3=nil
local meas3=nil
local smu4=2
local comp4=0.1
local stress4=2
local meas4=1
TDDB_per_pin(time_interval, HBDL, BD_mode, time_max, SBDL, holdtime, myPLC smu1,
    comp1, stress1, meas1, smu2, comp2, stress2, meas2, smu3, comp3, stress3, meas3,
    smu4, comp4, stress4, meas4).
```

qbd_rmpj

Description:

Performs a charge-to-breakdown test using the QBD Ramp J test algorithm described in JESD35-A, "Procedure for Wafer Level Testing of Thin Dielectrics." This algorithm forces a logarithmic current ramp until the oxide layer breaks down. This algorithm can produce a maximum current of ±1 A if a high-power SMU is used.

Syntax:

```
function qbd_rmpj(HiSMUId, LoSMUId1, LoSMUId2, LoSMUId3, myplc, v_use, I_init,
   I_start, F, t_step, EXIT_volt_mult, V_max, I_max, q_max, area)
```

INPUTS:

`integer HiSMUId=1 in [0,1,2..64]` --maximum 4 smus are supported. if not input '0'

`integer LoSMUId1=0 in [0,1,2..64]` --maximum 4 smus are supported. if not input '0'

`integer LoSMUId2=0 in [0,1,2..64]` --maximum 4 smus are supported. if not input '0'

`integer LoSMUId3=0 in [0,1,2..64]` --maximum 4 smus are supported. if not input '0'

`double myplc=1 in [0.001,25]` --PLC setting

`double v_use=1 in [-200,200]` --oxide voltage under normal operating conditions (V). Typically the power supply voltage of the process. This voltage is to measure pre- and post-voltage ramp oxide current.

`double I_init=1e-5 in [-0.1,0.1]` --Oxide breakdown failure current when biased at v_use. (A) Typical value is 10uA/cm^2 and may change depending oxide area. For maximum sensitivity the specified value should be well above the worse case oxide current of a "good" oxide and well above system noise floor. Higher value must be specified for ultra-thin oxide because of direct tunneling effect.

`double I_start=1e-5 in [-0.1,0.1]` --starting current for current ramp (A). Typical value is I_init

`double F=1.5 in [1,100]` --Current multiplier between two successive current steps.

`double t_step=0.1 in (0,)` --current ramp step time in s `double EXIT_volt_mult=0.85 in (0,2]` --multiplier factor of successive voltage measurement. When the next measured voltage is below this factor multiplying previous measured voltage, oxide is considered breakdown and test will EXIT. Typical value, 0.85

`double V_max=20 in [-200,200]` --the voltage limit; pls. pay attention to inter lock (A)

`double I_max=0.1 in [-0.1,0.1]` --maximum ramp up current (A)

`double q_max=100 in (0,)` --Maximum accumulated oxide charge per oxide area(C/cm^2). Used to terminate a test where breakdown occurs but was not detected during the test.

`double area=2 in (0,)` --area of oxide structure (cm^2)

OUTPUTS:

`V_stress` --voltage stress array

`I_stress` --measured current array

`T_stress` --time stamp array representing when current is measured

`q_stress` --accumulated charge array

`V_init_pre` --voltage at I_init in pre test

`V_init_post` --voltage at I_init in post test

`Q_bd` --Charge to breakdown. Cumulative charge passing through the oxide prior to breakdown (C)

`q_bd` --charge to breakdown density (C/cm^2)

`v_bd` --applied voltage at the step just before oxide breakdown

`I_bd` --measured current at v_bd just before oxide breakdown

`t_bd` --time stamp when measuring I_bd

`Failure_mode` --failure mode

--1: Initial test failure

--2: Catastrophic failure (initial test pass, ramp test fail, post test fail)

--3: Masked Catastrophic (initial test pass, ramp test pass, post test fail)

--4: non-Catastrophic (initial test pass, ramp test fail, post test pass)

--5: Others (initial test pass, ramp test pass, post test pass)

Test_status

--0: no test errors (EXIT due to measured voltage < EXIT_volt_mult*V_previous)

--(-1): failed pre-stress test

--(-2): cum charge limit reached

--(-3): current limit reached

--(-4): voltage limit reached

--(-5): masked Catastrophic Failure

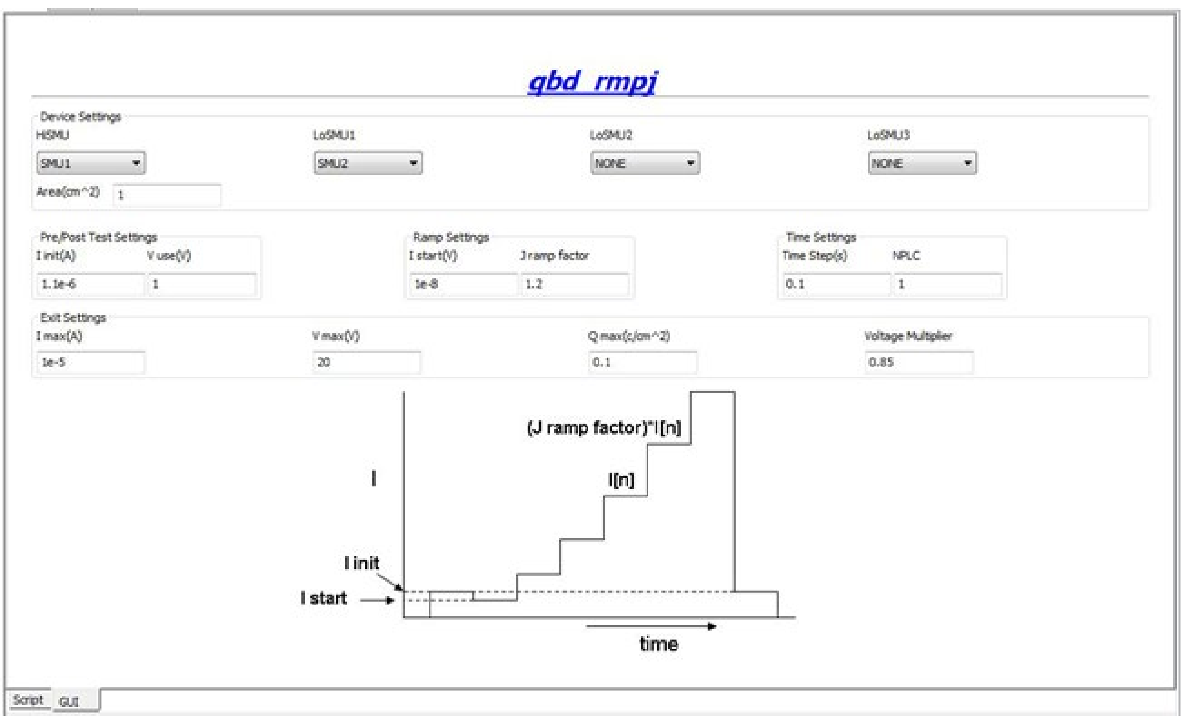
--(-6): non-Catastrophic Failure

--(-7): Invalid specified t_step

GUI related:

The next figure shows the QBD Ramp J GUI and illustrates the testing method.

Figure 276: GUI for qbd_rmpj



NOTE

If the above routine is modified, change the function name to avoid possible programming errors.

Example call:

```
local HiSMUId=1
local LoSMUId1=2
local LoSMUId2=0
local LoSMUId3=0
local myplc=1
local v_use=0.005
local I_init=1e-8
local I_start=1e-8
local F=1.5
local t_step=0.1
local EXIT_volt_mult=0.85
local V_max=20
local I_max=1e-5
local q_max=0.1
local area=1
qbd_rmpj(HiSMUId, LoSMUId1, LoSMUId2, LoSMUId3, myplc, v_use, I_init, I_start, F,
   t_step, EXIT_volt_mult, V_max, I_max, q_max, area).
```

qbd_rmpv

Description:

Performs a charge-to-breakdown test using the QBD Ramp V test algorithm described in JEDEC standard JESD35-A, *Procedure for Wafer Level Testing of Thin Dielectrics*. This algorithm forces a linear voltage ramp until the oxide layer breaks down. This algorithm can produce a maximum voltage of ±200 volts.

Syntax:

```
qbd_rmpv(HiSMUId, LoSMUId1, LoSMUId2, LoSMUId3, myplc, v_use, I_init, hold_time,
   v_start, v_step, t_step, measure_delay, I_crit, I_box, I_max, EXIT_curr_mult,
   EXIT_slope_mult, q_max, t_max, v_max, area, EXIT_mode)
```

INPUTS:

`integer HiSMUId=1 in [0,1,2..64]` --maximum 4 smus are supported. if not input '0'

`integer LoSMUId1=0 in [0,1,2..64]` --maximum 4 smus are supported. if not input '0'

`integer LoSMUId2=0 in [0,1,2..64]` --maximum 4 smus are supported. if not input '0'

`integer LoSMUId3=0 in [0,1,2..64]` --maximum 4 smus are supported. if not input '0'

`double myplc=1 in [0.001,25]` --PLC setting

`double v_use=1 in [-200,200]` --oxide voltage under normal operating conditions (V). Typically the power supply voltage of the process. This voltage is to measure pre- and post-voltage ramp oxide current.

`double I_init=0.001 in [-0.1,0.1]` --Oxide breakdown failure current when biased at v_use. Typical value is 10uA/cm^2 and may change depending oxide area. For maximum sensitivity the specified value should be well above the worst-case oxide current of a "good" oxide and well above system noise floor. Higher value must be specified for ultra-thin oxide because of direct tunneling effect.

`double holdtime=0 in [0, )` --time after Vuse is applied (Unit:s)

`double v_start=0.01 in [-200,200]` --starting ramp voltage (V). Typical value is v_use

`double v_step=0.01 in [-200,200]` --voltage ramp step size (V). This value has a maximum value of 0.1MV/cm. for example, the maximum value can be calculated using Tox*0.1MV/cm, where Tox is in unit of centimeters. This is 0.1V for a 10nm oxide.

`double t_step=0.1 in (0,)` --Voltage ramp step time(Unit:s). This is used to determine the voltage ramp rate. This time should be less or equal than 100ms. Typically 40 - 100 ms.

`double measure_delay=0.05 in (0,)` --time delay for measurement after each voltage stress step(Unit:s). This delay should be less than t_step.

`double I_crit=5e-4 in [-0.1,0.1]` --At least 10 times the test system current measurement noise floor. This oxide current is the minimum value used in determining the change of slope breakdown criteria. (A)

`double I_box=3e-4 in [-0.1,0.1]` --An optional measured current level for which a stress voltage is recorded. This value provides an additional point on the current-voltage curve. A typical value is 1uA.

`double I_max=1e-3 in [-0.1,0.1]` --Oxide breakdown criteria. I_bd is obtained from I-V curves and is the oxide current at the step just prior to breakdown.

`double EXIT_curr_mult=10 in (0,)` --Change of current failure criteria. This is the ratio of measured current over previous current level, which, if exceeded, will result in failure; recommended value: 10-100

`double EXIT_slope_mult=3 in (0,)` --Change of slope failure criteria. This is the factor of change in FN slope, which, if exceeded, will result in failure; recommended value: 3

`double q_max=100 in (0,)` --Maximum accumulated oxide charge PER OXIDE AREA! Used to terminate a test where breakdown occurs but was not detected during the test (C/cm^2).

`double t_max=10 in (0,)` --maximum stress time allowed(Unit:s). Reaching the limit will result in test finish.

`double v_max=2 in (-200,200)` --The maximum voltage limit for the voltage ramp. This limit is specified at 30MV/cm for oxides less than 20nm thick and 15MV/cm for thicker oxides. For example, v_max can be estimated from Tox*30Mv/cm where Tox is in centimeters. This is 35V for a 10.0nm Oxide

`double area=2 in (0,)` --area of oxide structure (cm^2)

`integer EXIT_mode=0 in (0,1)` --failure criteria mode 0: judge by current (I_max) and (EXIT_curr_mult) and q_max, v_max, t_max 1:also judge slope (EXIT_slope_mult)

OUTPUTS:

`V_stress` --voltage stress array

`I_stress` --measured current array

`T_stress` --time stamp array representing when current is measured `q_stress` --accumulated charge array

`I_use_pre` --Measured oxide current at v_use prior to starting the ramp

`I_use_post` --Measured oxide current at v_use after the ramp finished

`Q_bd` --Charge to breakdown. Cumulative charge passing through the oxide prior to breakdown (C)

`q_bd` --charge to breakdown density (C/cm^2)

`v_bd` --applied voltage at the step just before oxide breakdown

`I_bd` --measured current at v_bd just before oxide breakdown

`t_bd` --time stamp when measuring I_bd

`v_crit` --applied voltage at the step when the oxide current exceeds I_crit

`v_box` --applied voltage at the step when the oxide current exceeds I_box

`Failure_mode` --failure mode

--1: Initial test failure

--2: Catastrophic failure (initial test pass, ramp test fail, post test fail)

--3. Masked Catastrophic (initial test pass, ramp test pass, post test fail)

--4. non-Catastrophic (initial test pass, ramp test fail, post test pass)

--5. Others (initial test pass, ramp test pass, post test pass)

`Test_status` --2: no test errors (EXIT due to measured current > EXIT_curr_multi*I_previous

--1: no test errors (EXIT due to measured current > calculated failure slope ONLY)

--0: no test errors (EXIT due to measured current > I_max ONLY)

--(-1): failed pre-stress test

--(-2): cumulative charge limit reached

--(-3): voltage limit reached

--(-4): maximum time limit reached

--(-5): masked Catastrophic Failure

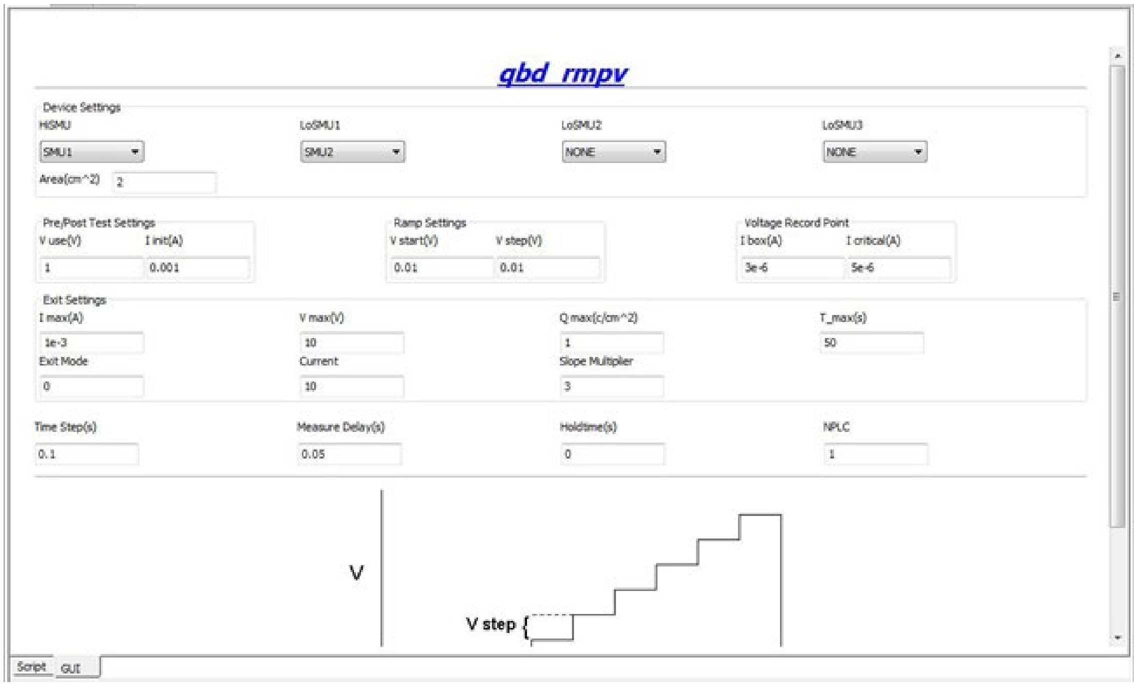
--(-6): non-Catastrophic Failure

--(-7): Invalid specified t_step, hold_time or measure_delay

GUI related:

The next figure shows the QBD Ramp V GUI and illustrates the testing method.

Figure 277: GUI for qbd_rmpv



Example call:

```
local HiSMUId=1
local LoSMUId1=2
local LoSMUId2=0
local LoSMUId3=0
local myplc=1
local v_use=1
local I_init=0.001
local hold_time=0
local v_start=0.01
local v_step=0.01
local t_step=0.1
local measure_delay=0.05
local I_crit=5e-4
local I_box=3e-4
local I_max=1e-3
local EXIT_curr_mult=10
local EXIT_slope_mult=3
local q_max=100
local t_max=100
local v_max=2
local area=2
local EXIT_mode=1
qbd_rmpv(HiSMUId, LoSMUId1, LoSMUId2, LoSMUId3, myplc, v_use, I_init, hold_time,
   v_start, v_step, t_step, measure_delay, I_crit, I_box, I_max, EXIT_curr_mult,
   EXIT_slope_mult, q_max, t_max, v_max, area, EXIT_mode).
```

Common capacitance-voltage (CV) library

Common CV library overview

ACS Basic has a common capacitance-voltage (CV) library that includes the CV test. All test modules in the Common CV library can be added to any device. You can also build a common CV library to import and use.

CV4284

Description:

Tests the capacitive parameters at a specified frequency and voltage of the AC drive, with measurements of DC voltage bias or sweep.

Instrument:

Agilent 4284 or 4980 LCR meter.

NOTE

These instruments cannot be automatically scanned by ACS Basic. You must configure them as a general purpose instruments. Refer to Connect to external instruments in the *ACS Basic Reference Manual* for more information.

Syntax:

```
CVITM.cv4284(CMTR_name,force_func,preSoak,v_bias,v_biasPts,v_start,v_stop,v_step,ho
    ld_time,delay_time,speed,freq_bias,v_AC,meas_param,meas_range,cable_length,isCmp
    stOpen,isCmpstShort,isCmpstLoad,output_DCV,output_result1,output_result2,output_
    error)
```

INPUTS:

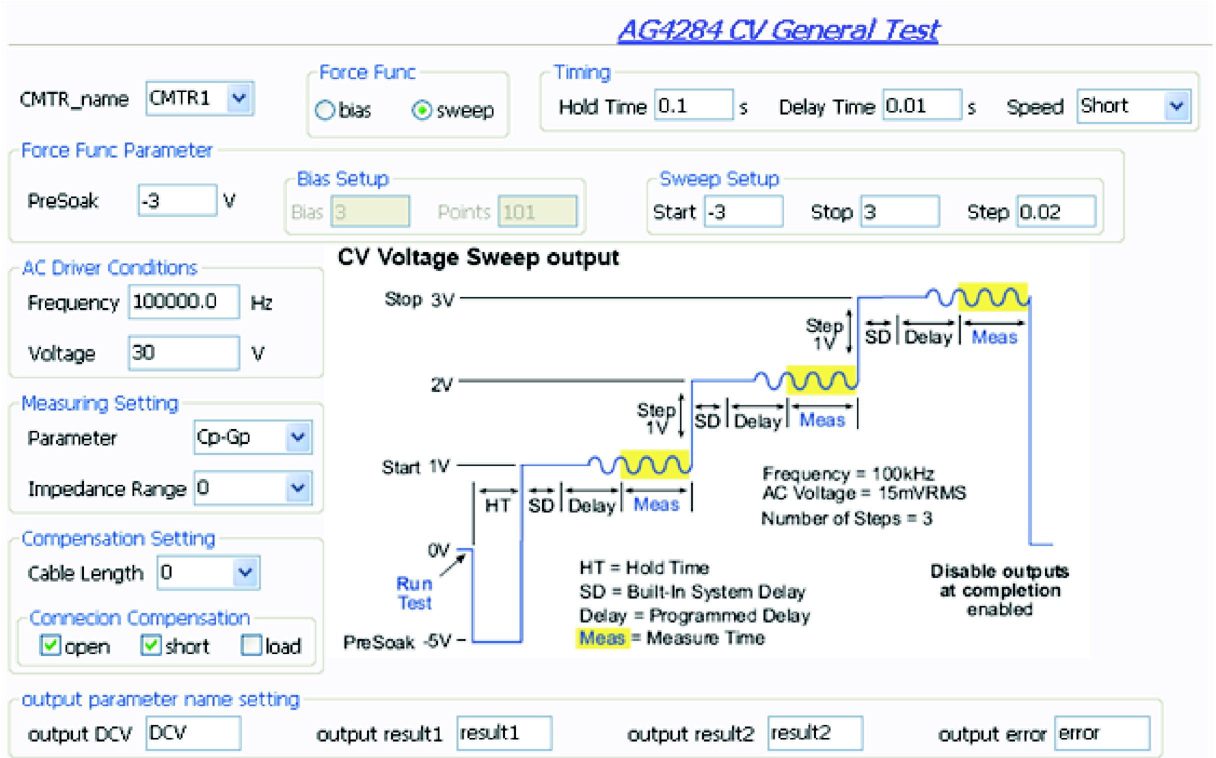
`CMTR_name:`	Instrument name defined in syscon.kcf file.
`force_func:`	0: bias, 1: sweep.
`preSoak:`	Force voltage after test start and before measurement sequence. Unit: V.
`v_bias:`	Force value for the bias. Unit: V.
`v_biasPts:`	The number of bias points.
`v_start:`	Initial force value for the sweep (-40V to 40V). Unit: V.
`v_stop:`	Final force value for the sweep (-40V to 40V). Unit: V.
`v_step:`	Step force value for the sweep (-40V to 40V). Unit: V.
`hold_time:`	Hold time after force value changed. Unit: seconds.
`delay_time:`	Delay before each measurement (0 to 999s). Unit: seconds.
`Speed:`	Measurement time setting.
`freq_bias:`	Frequency of the AC drive for normal measurement. Valid value is from 20 Hz to 2 MHz.
`vAC:`	The oscillator output voltage level, the valid input is 5 mV to 20 V. Unit: V.
`measParam:`	Valid input ['Z,Theta', 'R+jx', 'Cp-Gp', 'Cs-Rs', 'Cp-D', 'Cs-D'] KI_AGCV_TYPE_ZTR = 0 "ZTR" KI_AGCV_TYPE_RX = 1 "RX" KI_AGCV_TYPE_CPG = 2 "CPG" KI_AGCV_TYPE_CSRS = 3 "CSRS" KI_AGCV_TYPE_CPD = 4 "CPD" KI_AGCV_TYPE_CSD = 5 "CSD"
`measRange:`	The measurement range to use. Valid values for this parameter are 0 (Auto), 100, 300, 1000, 3000, 10000, 30000, and 100000 Ohms.
`cableLength:`	Cable length setting for connect compensation. Unit: meter. When you do not need compensation, cable length should be assigned to 0.
`isCmpstOpen:`	Enable or disable compensation constants for open.
`isCmpstShort:`	Enable or disable compensation constants for Short.
`isCmpstLoad:`	Enable or disable compensation constants for Load.

OUTPUTS:

`0:`	OK.
`-10000:`	Specified CVU does not exist.
`-10001:`	(INVAL_PARAM) Parameter setting error occurred.
`-10090:`	(GPIB_ERROR_OCCURED) A GPIB communications error occurred.
`result["DCV"]:`	Force DC voltage
`result["result1"]:`	The first parameter of the result according to the measurement model.
`result["result2"]:`	The second parameter of the result according to the measurement model.

GUI related:

Figure 278: CV setting example



KI42xxCVU

Description:

Use this module to test capacitive parameters under several test condition by KXCI through ethernet.

Instrument:

Keithley Instruments Model 4200-CVU

Syntax:

```
CVITM.KI42xxCVU(CVU_name,mode,force_func,DC_cond,AC_cond,adv_setting,cable_len,is_o
    pen,is_short,is_load,meas_model,speed,cust_speed,hold_time,delay_time,output_nam
    e)
```

INPUTS:

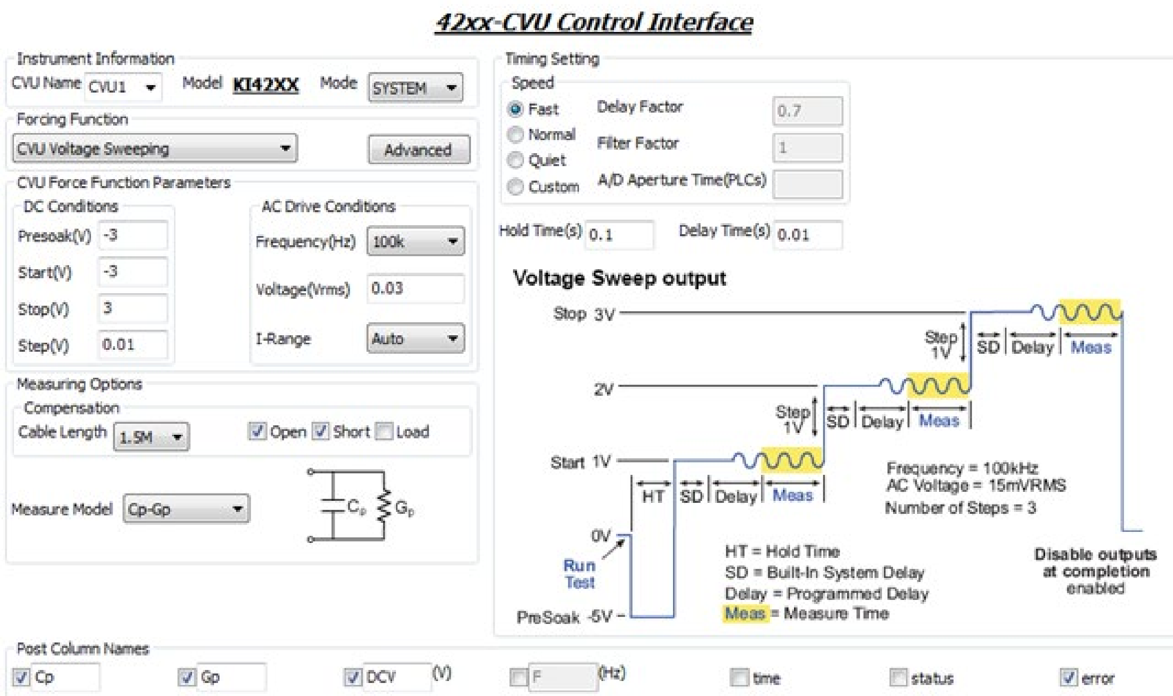
`CVU_name:`	Instrument name. To make sure the specified CVU is available in ACS, in the Hardware Configuration Panel, check the instrument tree.
`mode:`	System or User. If ACS is installed on a remote PC, system mode is available. System mode offer relatively high performance when testing. User mode is available on remote and local systems. Sweeping and sampling in User mode is realized by bias-meas FOR loop.
`force_func:`	The test condition.
`DC_cond:`	The DC force condition settings.
`AC_cond:`	The AC drive force condition settings.
`adv_setting`	Advanced settings, such as DC/AC source slice selected, DC offset, test end reset disable or enable, and auto standby in system mode.
`cable_len:`	Cable length setting for connection compensation. Supported values are 0, 1.5, and 3 m. When compensation is not needed, set to 0.
`is_open:`	Enable or disable open compensation.
`is_short:`	Enable or disable short compensation.
`is_load:`	Enable or disable load compensation.
`meas_model:`	Defines which measure model to use.
`Speed:`	Measurement speed setting. If Custom is selected, also set up `cust_speed` dictionary.
`cust_speed:`	The user-defined speed parameters.
`hold_time:`	The hold time to be applied in presoak and step beginning in step test.
`delay_time:`	The sampling or sweeping delay.

Results:

According to measParam selected.

GUI related:

Figure 279: Example of the settings for 42xxCVU



Common SMU Library

Common SMU library overview

You can add all test modules in the common SMU library to any device. You can also build a common SMU library to import and use.

FourWireResistor_3706

Module Name: FourWireResistor_3706

Module Type: PTM

Instrument: Keithley Series 3706

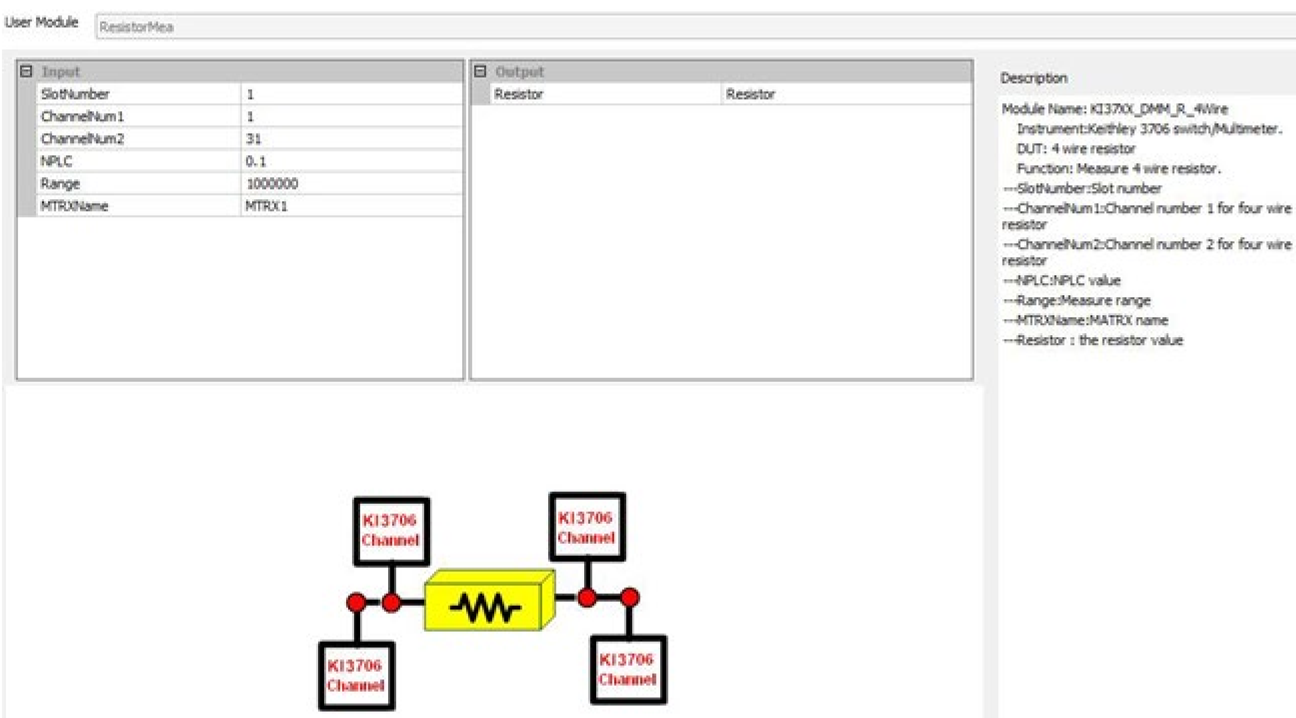
DUT: Four-wire resistor

Function: Measures a 4-wire resistor

Pin connections: If a multiplexer card is used, a channel pair is used for four-wire measurements; channels 1 through 20 are used as the INPUT terminals and channels 21 through 40 are used as the SENSE terminals. Otherwise, connect the input HI terminal of the resistor to Pin1 of the analog backplane connector, input LO terminal to Pin (2 or 9), Sense HI to Pin3, and Sense LO to Pin4.

GUI related:

Figure 280: FourWireResistor_3706 GUI



Gpibresistor_3706

Module Name: TwoWireResistor_3706

Module Type: PTM

Instrument: Keithley Model 3706

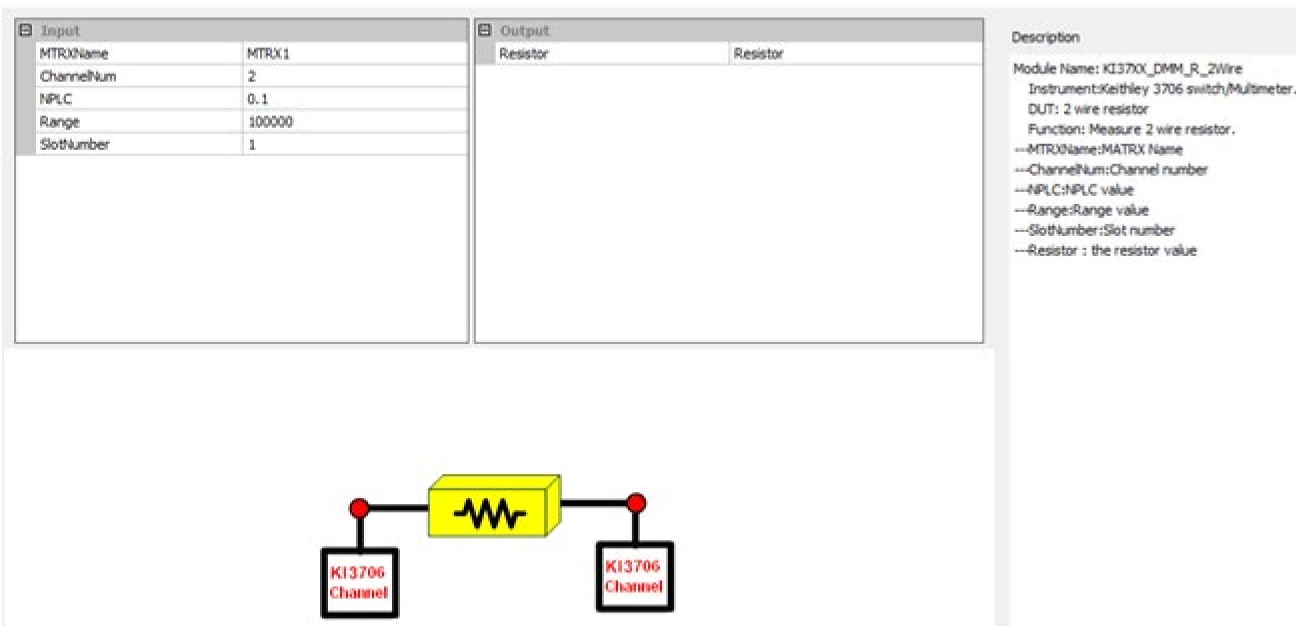
DUT: Two-wire resistor

Function: Measures a 2-wire resistor

Pin connections: If a multiplexer card is used, connect each terminal of the resistor to one channel on the multiplexer card. Otherwise, connect one terminal to Pin1 of the analog backplane connector and connect another terminal to Pin (2 or 9).

GUI related:

Figure 281: TwoWireResistor_KI3706 GUI



Mixed_SMU_Mode Library

Mixed_SMU_Mode library overview

ACS Basic has a Mixed_SMU_Mode library, including some tests which can be performed with different instruments or combinations among these instruments.

BiasIMeasV_Pulse_2430

Description: Performs current pulse and voltages measurements with a Keithley Model 2430 in pulse mode. The Model 2430 SourceMeter is controlled over the GPIB bus only.

Module name: BiasIMeasV_Pulse_24xx

Instrument: Keithley Model 2430 SourceMeter.

Results: Measures the results by forcing a current pulse.

INPUTS:

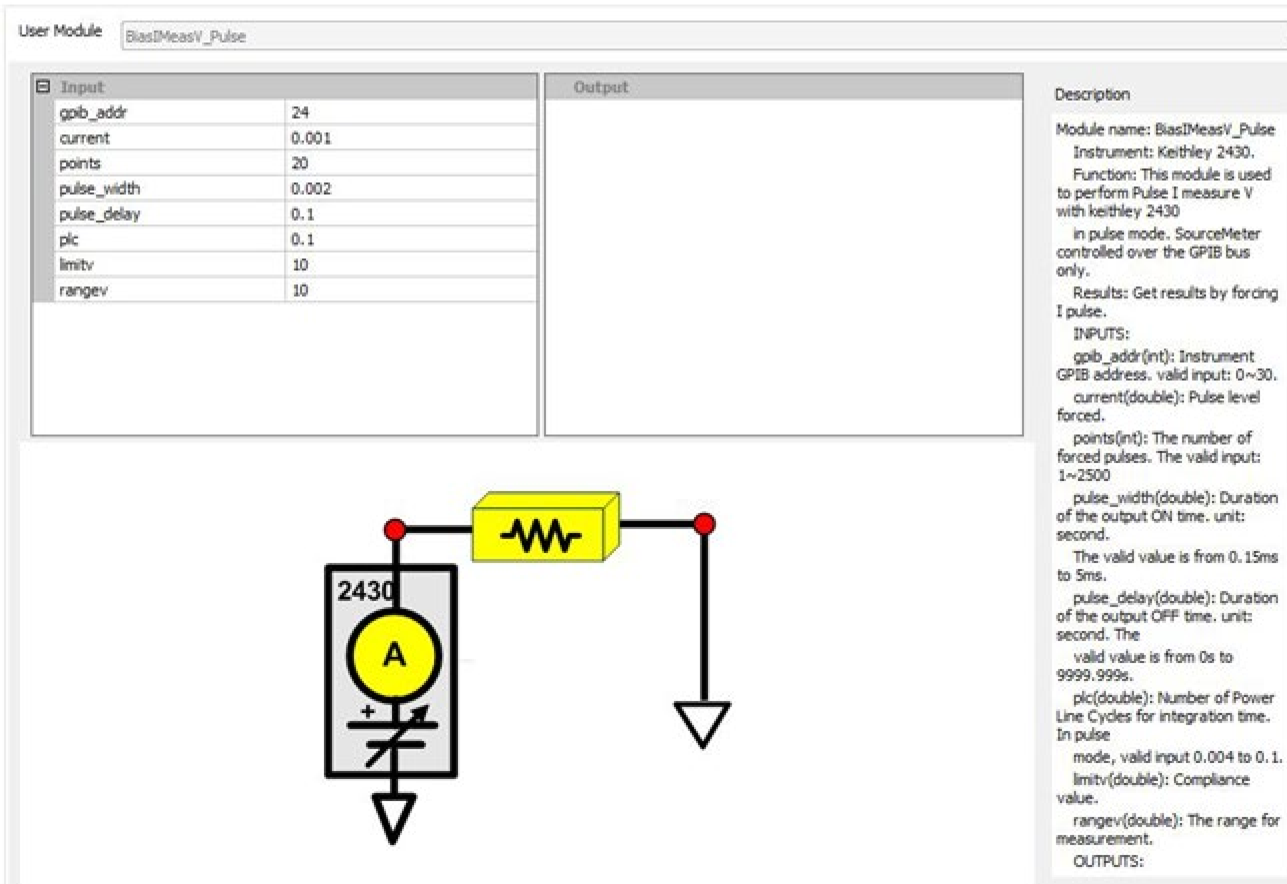
`gpib_addr (int):`	Instrument GPIB address. Valid input: 0 through 30.
`current (double):`	Pulse level forced.
`points (int):`	The number of forced pulses. The valid input: 1 through 2500.
`pulse_width (double):`	Duration of the output ON time. Unit: second. The valid value is from 0.15 ms to 5 ms.
`pulse_delay (double):`	Duration of the output OFF time. Unit: second. The valid value is from 0 s to 9999.999 s.
`plc (double):`	Number of Power Line Cycles for integration time. In pulse mode, valid input 0.004 to 0.1.
`limitv (double):`	Compliance value.
`rangev (double):`	The range for measurement.

OUTPUTS:

`I`	
`V`	
`time`	
`Error:`	Error value
`0`	OK
`-1`	24xx not found on GPIB.
`-2`	2430 not found on GPIB.
`-200`	Initialize error occurred.
`-300`	Configuration error occurred.
`-400`	Reading error occurred.
`-10000`	`(INVAL_INST_ID)`: The specified instrument ID does not exist.
`-10100`	`(INVAL_PARAM)`: An invalid input parameter is specified.
`-10090`	`(GPIB_ERROR_OCCURRED)`: A GPIB communications error occurred.
`-10091`	`(GPIB_TIMEOUT)`: A timeout occurred during communications.

GUI related:

Figure 282: BiasIMeasV_Pulse GUI



BiasVMeasI_Pulse

Description: Performs voltage pulse and current measurements with a Keithley Model 2430 in pulse mode. The Model 2430 SourceMeter is controlled over a GPIB bus only.

Module Type: PTM

Instrument: Keithley Model 2430 SourceMeter.

Results: Measures the results by forcing a voltage pulse.

INPUTS:

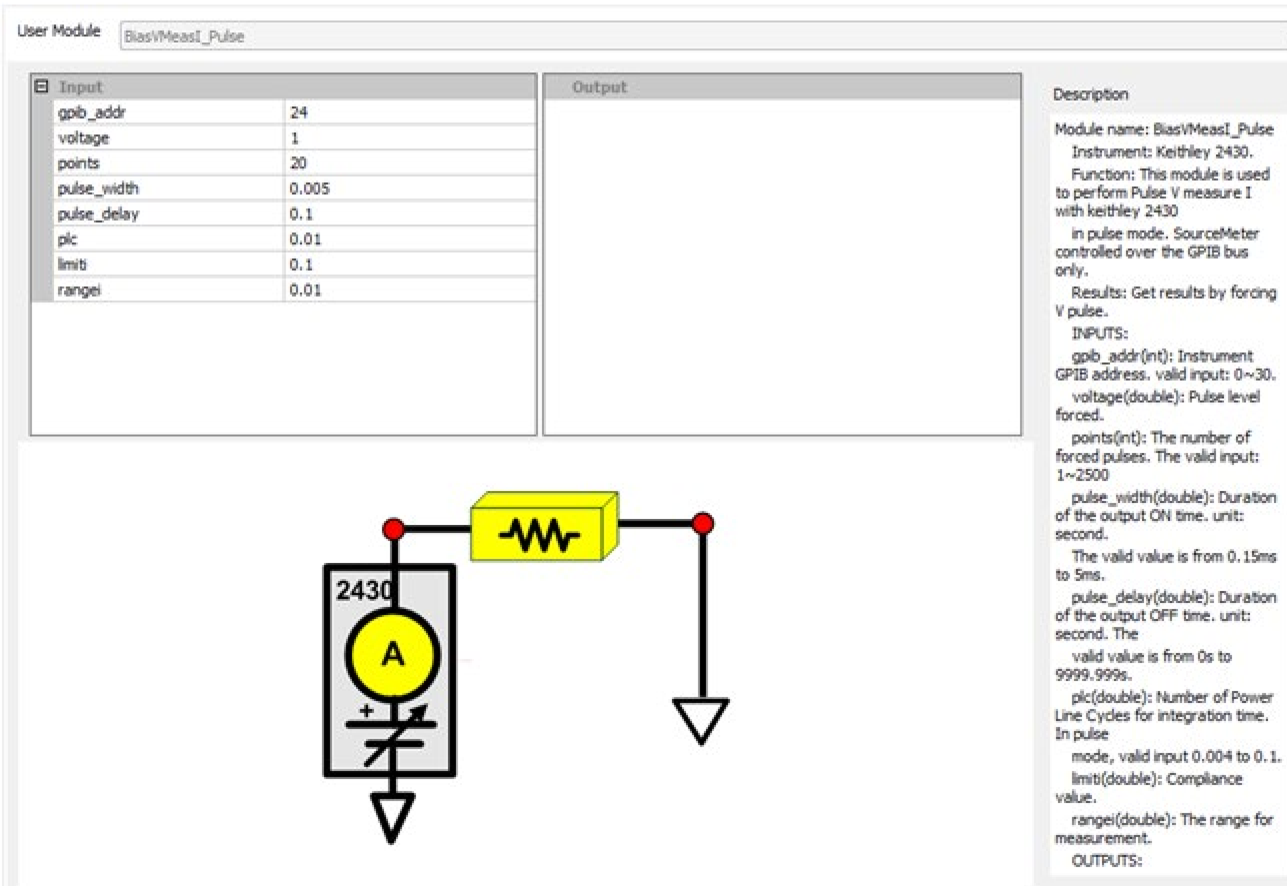
gpib_addr (int):	Instrument GPIB address. Valid input: 0 through 30.
voltage (double):	Pulse level forced.
points (int):	The number of forced pulses. The valid input: 1 through 2500.
pulse_width (double):	Duration of the output ON time. Unit: seconds. The valid value is from 0.15 ms to 5 ms.
pulse_delay (double):	Duration of the output OFF time. Unit: seconds. The valid value is from 0 s to 9999.999 s.
plc (double):	Number of power line cycles for integration time. In pulse mode, valid input 0.004 to 0.1.
limiti (double):	Compliance value.
rangei (double):	The range for measurement.

OUTPUTS:

I	
V	
time	
Error:	Error value
0	OK
-1	24xx not found on GPIB.
-2	2430 not found on GPIB.
-200	Initialize error occurred.
-300	Configuration error occurred.
-400	Reading error occurred.
-10000	(INVAL_INST_ID): The specified instrument ID does not exist.
-10100	(INVAL_PARAM): An invalid input parameter is specified.
-10090	(GPIB_ERROR_OCCURRED): A GPIB communications error occurred.
-10091	(GPIB_TIMEOUT): A timeout occurred during communications.

GUI related:

Figure 283: BiasVMeasI_Pulse GUI



BiasVolt_SampleCurr_23x

Description: Determines the bias voltage and takes current readings for the Model 236, 237, or 238.

Instrument: Keithley Model 236, 237, or 238 Source Measure Unit.

NOTE

These instruments cannot be automatically scanned by ACS Basic. You must configure them as a general purpose instruments. Refer to Connect to external instruments in the *ACS Basic Reference Manual* for more information.

INPUTS:

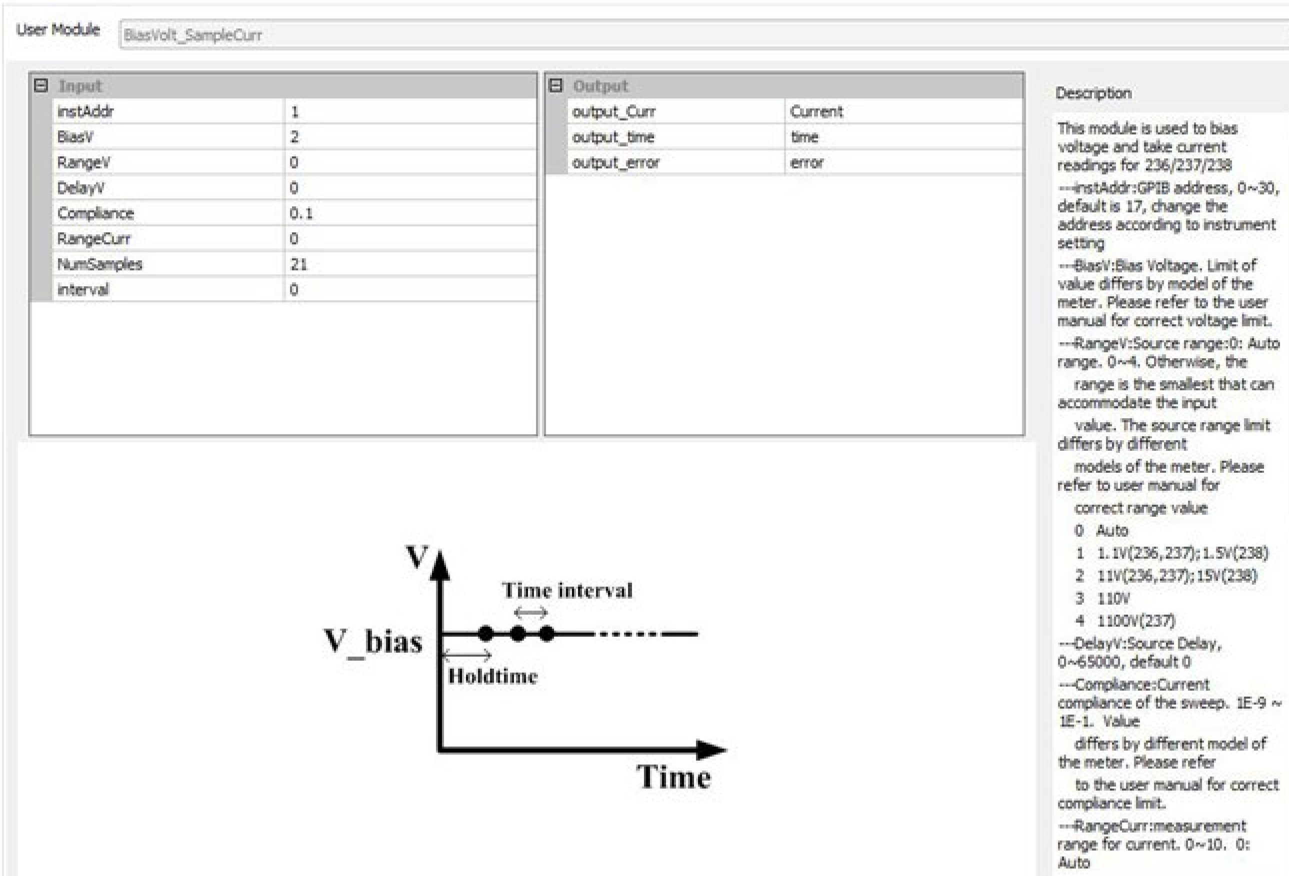
`instAddr:`	GPIB address, 0 through 30, default is 17, change the address according to instrument setting.
`BiasV:`	Bias voltage. Limit of value differs by model of the meter.
`RangeV:`	Source range: 0. Auto range. 0 through 4. Otherwise, the range is the smallest that can accommodate the input value. The source range limit differs by different models of the meter.
`DelayV:`	Source delay, 0 through 65000, default 0.
`Compliance:`	Current compliance of the sweep. 1E-9 through 1E-1. Value differs by model of the meter.
`RangeCurr:`	Measurement range for current. 0 through 9. 0: Autorange. Otherwise, the range is the smallest that can accommodate the input value. The source range limit differs by model of the meter.
`interval:`	Sampling intervals. Valid input 0 to 1000 s.

OUTPUTS:

`output_Curr:`	Measured current
`output_time:`	Timestamp at each point
`output_error:`	Error value
`0`	OK
`-10090`	A GPIB communications error occurred.

GUI related:

Figure 284: BiasVolt_SampleCurr_23x GUI



BVcei_any_SMU

Description: Use this test to test collector-emitter breakdown voltage of BJT, with base forced a current. For details, refer to BVcei in Mixed SMUs in pulse mode (on page 3-367).

BVcev_any_SMU

Description: Use this test to test collector-emitter breakdown voltage of BJT, with base forced a voltage. For details, refer to BVcev in Mixed SMUs in pulse mode (on page 3-367).

BVdsv_any_SMU

Description: Use this test to test drain-source breakdown voltage of a MOSFET with Gate-biased voltage. For details, refer to BVdsv in Mixed SMUs in pulse mode (on page 3-367).

combined_mixed_SMU

Description: This module provides a total solution for component characterization test.

Module Type: PTM

Instrument: Keithley Instruments Series 230, Series 2600, Series 2600A, Series 2400, Series 4200, and combinations of these SourceMeters

Syntax:

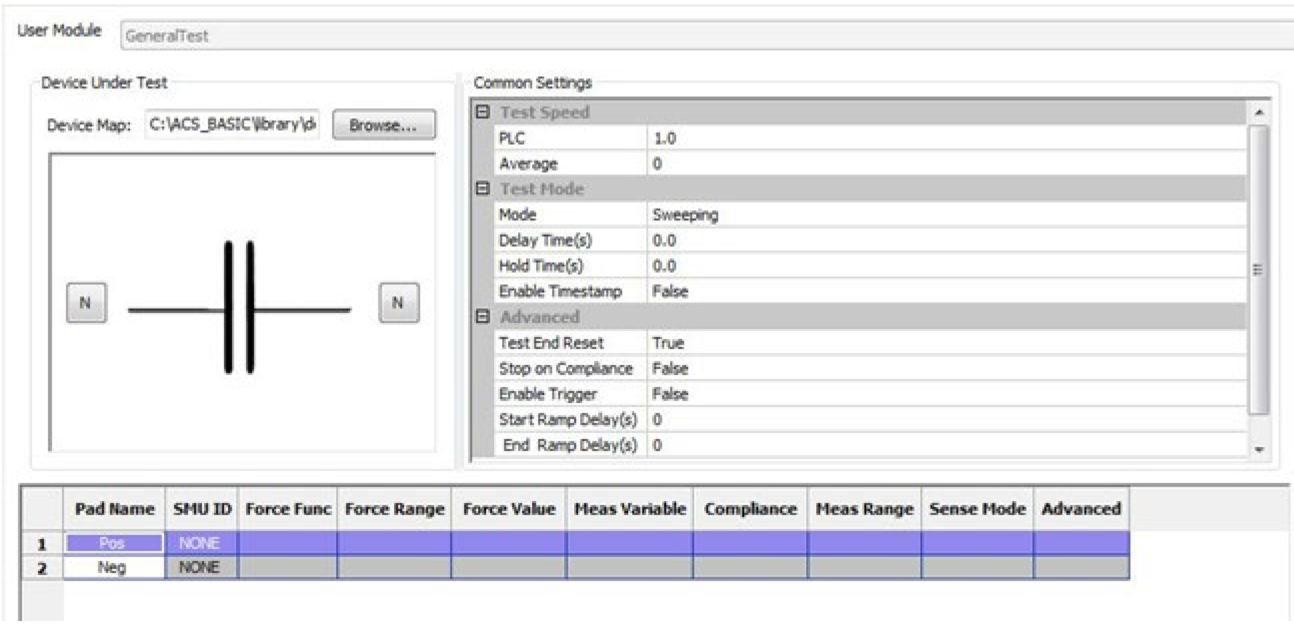
```
Combined_Test_Mixed_SMUs.GeneralTest(test_info,bias,sweep,step,open,src_range,meas_
    range,compliance,meas_pro,meas_seq,common)
```

INPUTS:

`PLC:`	Power line cycle. For optimum immunity to line cycle noise, use an integer number for the PLC (for example, 1, 2, or 3). The integration time setting is based on the number of power line cycles (NPLCs): For 60 Hz line power, 1.0 PLC = 16.67 ms (1/60) For 50 Hz line power, 1.0 PLC = 20 ms (1/50)
`Average:`	The Average edit box is only used for Series 230 and Series 2400 SMUs. For Series 2400 SMUs, the average number ranges from 0 to 1000. For Series 230 SMUs, select these numbers = [0,1,2,4,8,16,32] (note that zero [0] is used to disable the average number setup).
`Mode:`	The Mode edit box lets you choose one of two possible test modes: Sweep or Sampling.
`Delay Time:`	The delay time (DT) allows the source to settle at every step of a sweep. All SMUs in the test system are synchronized, therefore, the delay time applied by the most delayed SMU is the time applied to all the SMUs. You can specify a delay time from 0 to 1000 seconds. The default delay time is 0 seconds.
`Hold Time:`	Specifies the time delay before the first measurement is made. After the initial application of voltage or current by the SMUs, the source settling time can be substantial. To allow for settling, you can specify an extra Hold Time delay to be applied before making the first measurement. You can specify a Hold Time from 0 to 1000 seconds. Hold Time is a global setting, and is therefore the same for all SMUs in the test system.
`Test End Reset:`	Determines if the test results are cleared. You can select: False: Your test results are not cleared. True: Your test results are cleared. After the test is finished, it clears the test results.
`Stop on compliance:`	Determines what happens when compliance (limit) occurs. There are two choices: False: The test runs to completion, even if a SMU enters compliance. True: The test terminates immediately if a SMU enters compliance.
`Enable Trigger:`	Used for the Model 237 with the Model 2361 trigger controller. There are two choices: False: do not capture the measurement trigger value. True: capture the measurement trigger value.
`Start Ramp Delay:`	Time delay at each step of start ramp.
`End Ramp Delay:`	Time delay at each step of end ramp.

GUI related:

Figure 285: combined_mixed_SMU GUI



hFE_BJT_any_SMU

Description: Tests the HFE (DC current gain) of BJT.

Module Type: PTM

Instrument: Keithley Instruments Series 2650A, Series 2600A, Series Model 2400, and Series 4200-SMU

INPUTS:

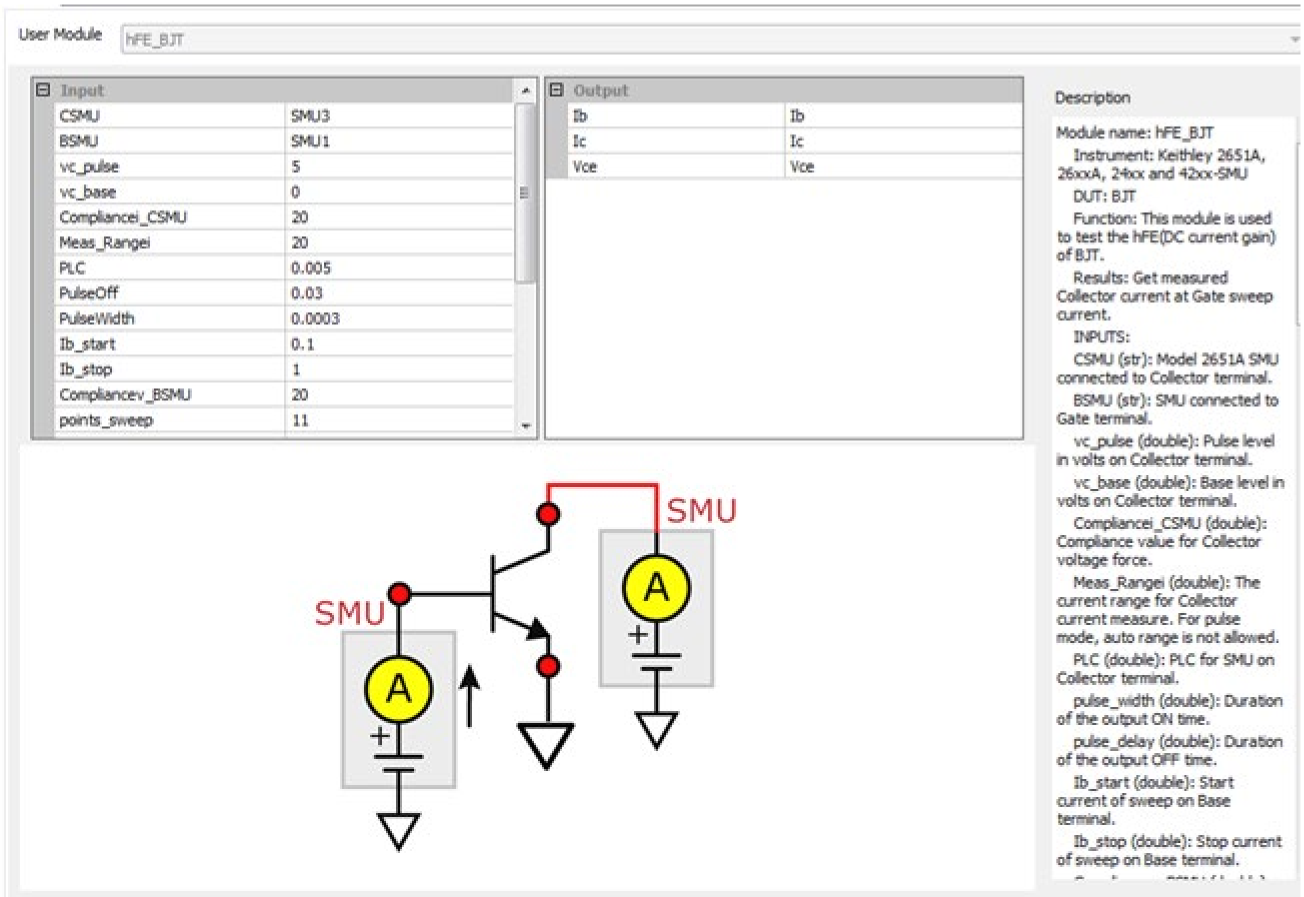
`CSMU:`	Model 2651A SMU connected to collector terminal.
`BSMU:`	SMU connected to gate terminal.
`vc_pulse:`	Pulse level in volts on collector terminal.
`vc_base:`	Base level in volts on collector terminal.
`Compliancei_CSMU:`	Compliance (limit) value for collector voltage force.
`Meas_Rangei:`	The current range for collector current measure. For pulse mode, autorange is not allowed.
`PLC:`	PLC for SMU on collector terminal.
`pulse_width:`	Duration of the output ON time.
`pulse_delay:`	Duration of the output OFF time.
`Ib_start:`	Start current of sweep on base terminal.
`Ib_stop:`	Stop current of sweep on base terminal.
`Compliancev_BSMU:`	Compliance value for base current force.
`points_sweep:`	The number of points for base sweep.
`B2C_delay:`	Gate to collector delay, the time between gate step and output of collector pulse.
`Sense_mode4BSMU:`	Sense mode for SMU on base terminal.
`Sense_mode4CSMU:`	Sense mode for SMU on collector terminal.
`Start_Ramp_Flag:`	Enable or disable soft-ramp function at the start of bias.
`End_Ramp_Flag:`	Enable or disable soft-ramp function at the end of bias.
`Start_Ramp_Delay:`	Time delay at each step of start ramp.
`End_Ramp_Delay:`	Time delay at each step of end ramp.
`Start_Ramp_Steps:`	The number of steps at the start of soft-ramp.
`End_Ramp_Steps:`	The number of steps at the end of soft-ramp.

OUTPUTS:

`Ib`	Base current programmed.
`Ic`	Collector current measured at the specified base bias current.
`Vce:`	Collector voltage measured.
`Return Values:`	
`0`	OK
`-100`	SMU configuration error
`-200`	Initialize error occurred.
`-300`	Pulse Configuration error occurred.
`-400`	Reading error occurred.
`-10100`	(INVAL_PARAM) Invalid parameter entered.

GUI related:

Figure 286: hFE_BJT_any_SMU module



IcVce_StepIb_any_SMU

Description: Use this test module to measure the voltage and current at the collector terminal while sweeping the collector voltage for each voltage step at the base terminal. For details, refer to IcVce_StepIb in Mixed SMUs in pulse mode (on page 3-367).

IcVce_StepVbe_any_SMU

Description: Use this test module to measure the voltage and current at the collector terminal while sweeping the collector voltage for each voltage step at the base terminal. For details, refer to IcVce_StepVb in Mixed SMUs in pulse mode (on page 3-367).

IcVce_StepVbe_any_SMU

Description: Use this test module to measure the voltage and current at the collector terminal while sweeping the collector voltage for each voltage step at the base terminal. For details, refer to IcVce_StepVb in Mixed SMUs in pulse mode (on page 3-367).

IcVce_StepVge_any_SMU

Description: Use this test module to measure the voltage and current at the collector terminal while sweeping the collector voltage for each voltage step at the gate terminal. For details, refer to IcVce_StepVge in Mixed SMUs in pulse mode (on page 3-367).

IcVge_any_SMU

Description: Use this module to test collector current at gate voltage sweep and specified collector voltage, with measurement at collector terminal in pulse mode.

Module Type: PTM

Instrument: Keithley Instruments Series 2650A, Series 2600A, Series 2400, and Series 4200-SMU

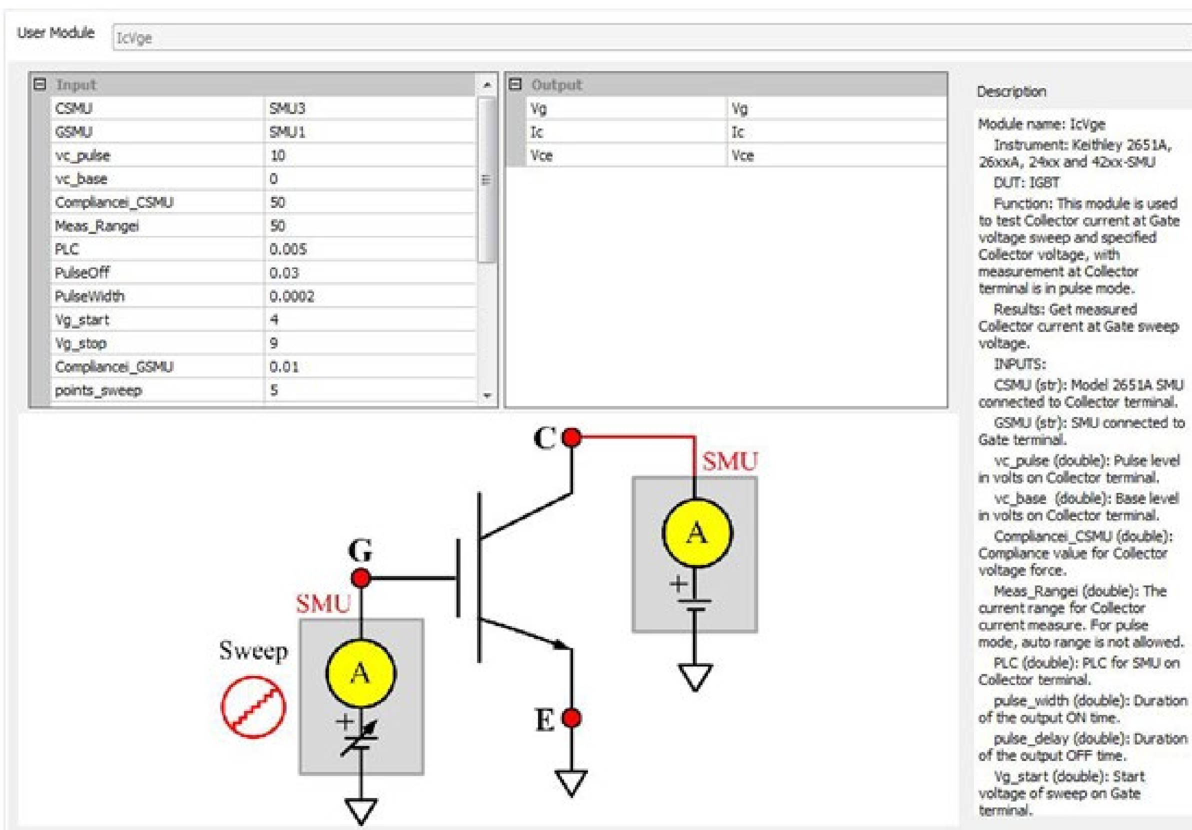
INPUTS:

`CSMU:`	Model 2651A SMU connected to collector terminal.
`BSMU:`	SMU connected to gate terminal.
`vc_pulse:`	Pulse level in volts on collector terminal.
`vc_base:`	Base level in volts on collector terminal.
`Compliancei_CSMU:`	Compliance (limit) value for collector voltage force.
`Meas_Rangei:`	The current range for collector current measure. For pulse mode, autorange is not allowed.
`PLC:`	PLC for SMU on collector terminal.
`pulse_width:`	Duration of the output ON time.
`pulse_delay:`	Duration of the output OFF time.
`Vg_start:`	Start voltage of sweep on gate terminal.
`Vg_stop:`	Stop voltage of sweep on gate terminal.
`Compliancei_GSMU:`	Compliance value for gate voltage force.
`points_sweep:`	The number of points for gate sweep.
`G2C_delay:`	Gate to collector delay, the time between gate step and output of collector pulse.
`Sense_mode4GSMU:`	Sense mode for SMU on gate terminal.
`Sense_mode4CSMU:`	Sense mode for SMU on collector terminal.
`Start_Ramp_Flag:`	Enable or disable soft-ramp function at the start of bias.
`End_Ramp_Flag:`	Enable or disable soft-ramp function at the end of bias.
`Start_Ramp_Delay:`	Time delay at each step of start ramp.
`End_Ramp_Delay:`	Time delay at each step of end ramp.
`Start_Ramp_Steps:`	The number of steps at the start of soft-ramp.
`End_Ramp_Steps:`	The number of steps at the end of soft-ramp.

OUTPUT:

`Vg:`	Gate voltage programmed.
`Ic:`	Collector current measured at the specified gate bias current.
`Vce:`	Collector voltage measured.
`Return Values:`	
`0`	OK
`-100`	SMU configuration error
`-200`	Initialize error occurred.
`-300`	Pulse Configuration error occurred.
`-400`	Reading error occurred.
`-10100`	(INVAL_PARAM) Invalid parameter entered.

GUI related:



IdVd_BiasVg_any_SMU

Description: Use this module to test drain current at drain voltage sweep and specified gate voltage with measurement at a drain terminal that is in pulse mode using the Keithley Instruments Model 265xA SourceMeter. For details, refer to IdVd_BiasVg in Mixed SMUs in pulse mode (on page 3-367).

IdON_any_SMU

Description: Use this module to determine the on-state drain current. To measure current on drain, apply a voltage sweep to drain-source. Use a specific gate voltage to turn on the device to the Id current value given in the data sheet.

Module Type: PTM

Instrument: Keithley Instruments Series 2650A, Series 2600A, Series 2400, and Series 4200-SMU

INPUTS:

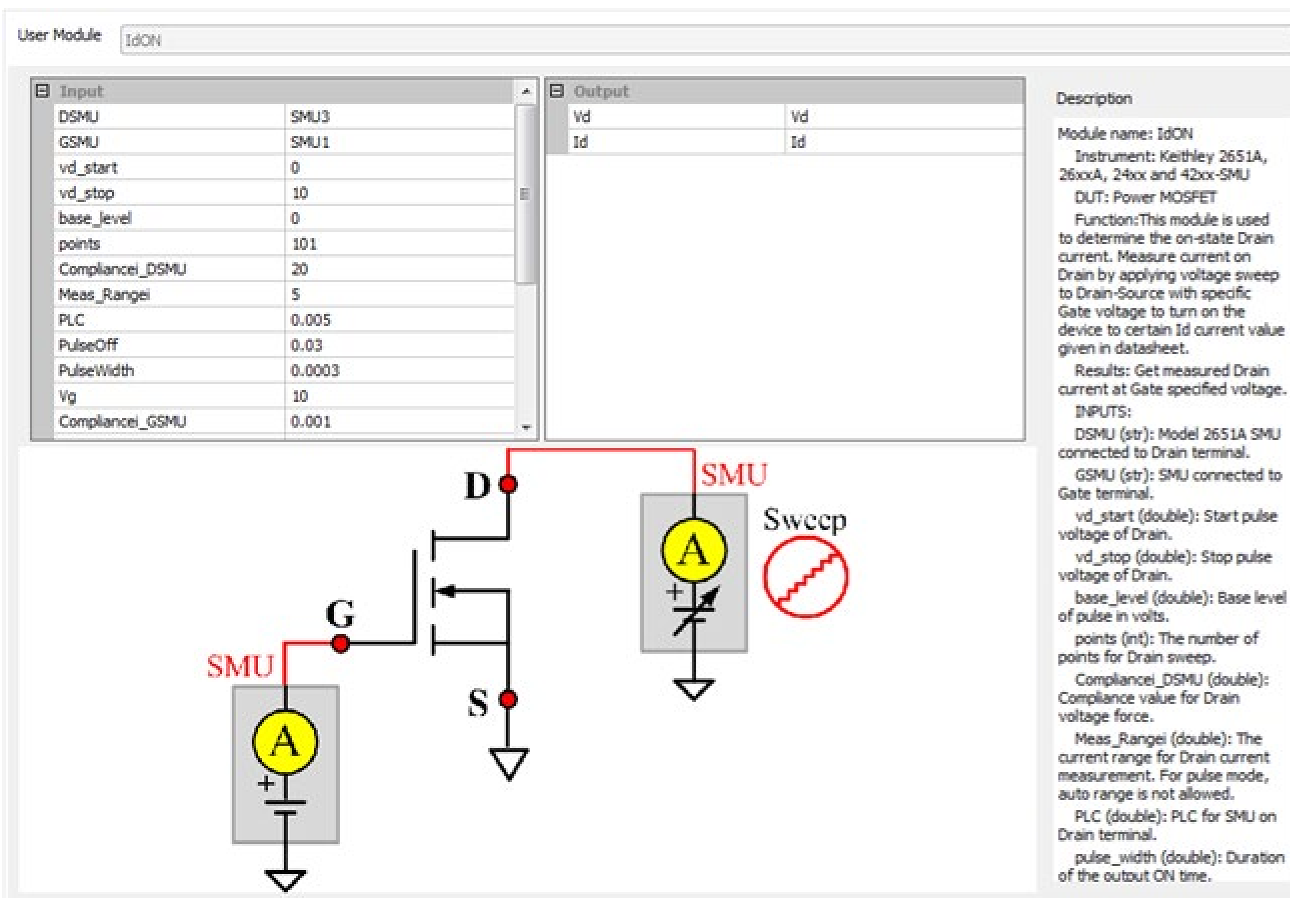
`DSMU:`	Model 2651A SMU connected to drain terminal.
`GSMU:`	SMU connected to gate terminal.
`vd_start:`	Start pulse voltage of drain.
`vd_stop:`	Stop pulse voltage of drain.
`base_level:`	Base level of pulse in volts.
`points:`	The number of points for drain sweep.
`Compliancei_DSMU:`	Compliance (limit) value for drain voltage force.
`Meas_Rangei:`	The current range for drain current measure. For pulse mode, autorange is not allowed.
`PLC:`	PLC for SMU on drain terminal.
`pulse_width:`	Duration of the output ON time.
`pulse_delay:`	Duration of the output OFF time.
`Vg:`	Voltage applied on gate terminal.
`Compliancei_GSMU:`	Compliance value for gate voltage force.
`G2D_delay:`	Gate to drain delay; the time between gate Step and the output of the first pulse in the drain Sweep.
`Sense_mode4GSMU:`	Sense mode for SMU on gate terminal.
`Sense_mode4DSMU:`	Sense mode for SMU on drain terminal.
`Start_Ramp_Flag:`	Enable or disable soft-ramp function at the start of bias.
`End_Ramp_Flag:`	Enable or disable soft-ramp function at the end of bias.
`Start_Ramp_Delay:`	Time delay at each step of start ramp.
`End_Ramp_Delay:`	Time delay at each step of end ramp.
`Start_Ramp_Steps:`	The number of steps at the start of soft-ramp.
`End_Ramp_Steps:`	The number of steps at the end of soft-ramp.

OUTPUT:

`Vd:`	Drain voltage measured.
`Id:`	Drain current measured at the specified gate bias current.
`Return Values:`	
`0`	OK
`-100`	SMU configuration error
`-200`	Initialize error occurred.
`-300`	Pulse Configuration error occurred.
`-400`	Reading error occurred.
`-10100`	(INVAL_PARAM) Invalid parameter entered.

GUI related:

Figure 287: IdON_any_SMU GUI



IdVg_24xx

Description: Use this test to test the drain current at a specified drain voltage and gate voltage sweep. For details, refer to IdVg in Mixed SMUs in pulse mode (on page 3-367).

IdVd_StepVg_any_SMU

Description: Use this module test drain current at drain voltage sweep and specified gate voltage with measurement at drain terminal that is in pulse mode using the Keithley Instruments Series 265xA SourceMeter. For details, refer to IdVd_StepVg in Mixed SMUs in pulse mode (on page 3-367).

Idvd_24xx

Description: Tests the drain current at a specified gate voltage and drain voltage sweep.

Module Type: PTM

Instrument: Keithley Model 2400 SourceMeter.

DUT: MOSFET, Source and bulk to be grounded.

Pin connections: Drain swept, gate biased. The bulk and source are connected to ground, if not applied voltage.

Results: Measures the drain current at the drain voltage sweep and the ten gate bias voltages.

INPUTS:

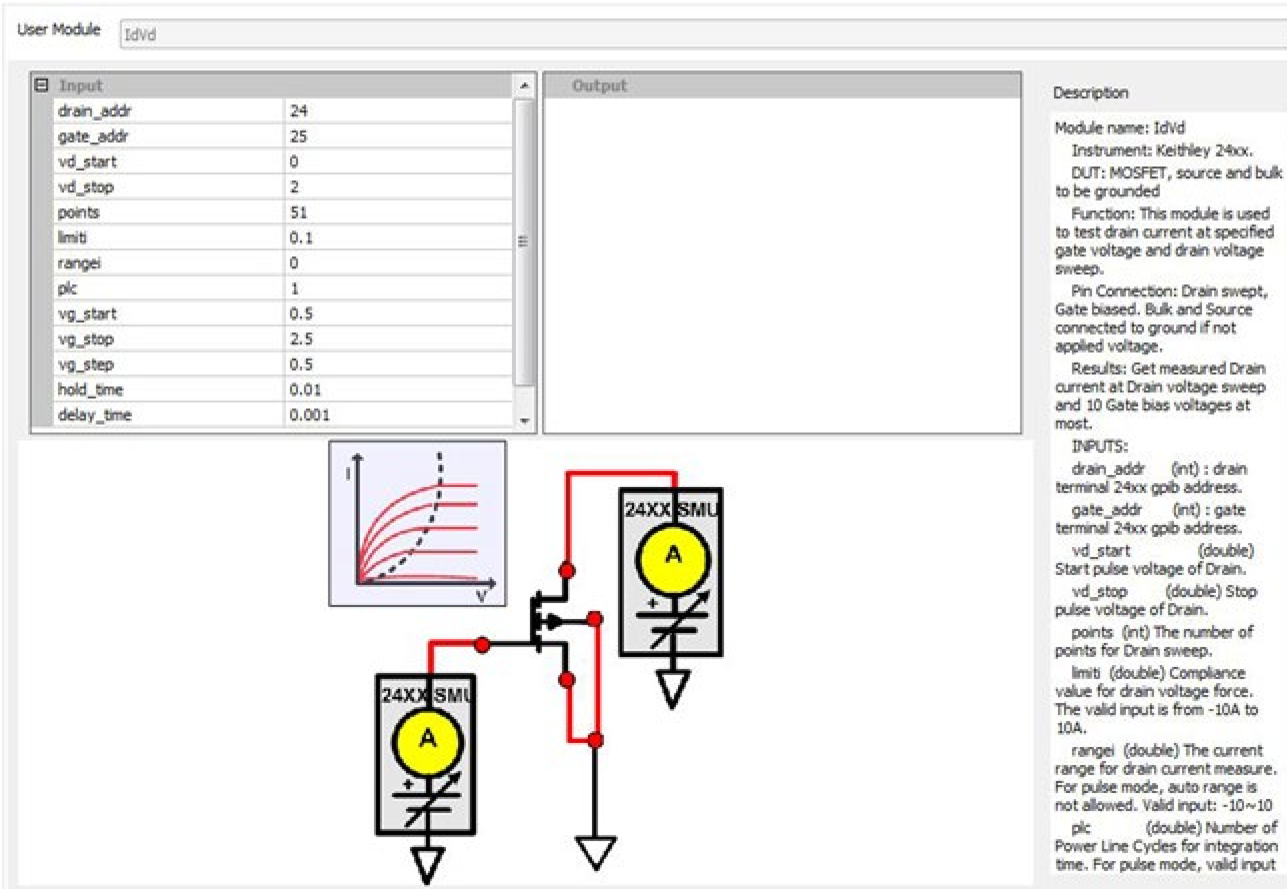
`Drain_addr (int):`	Drain terminal 24xx GPIB address.
`Gate_addr (int):`	Date terminal 24xx GPIB address.
`vd_start (double):`	Start pulse voltage of drain.
`vd_stop (double):`	Stop pulse voltage of drain.
`points (int):`	The number of points for drain sweep.
`limiti (double):`	Compliance value for drain voltage force. The valid input is from -10A to 10A.
`rangei (double):`	The current range for drain current measure. For pulse mode, autorange is not allowed. Valid input: −10 through 10.
`plc (double):`	Number of power line cycles for integration time. For pulse mode, valid input 0.004 to 0.1.
`vg_start (double):`	Start voltage of gate.
`vg_stop (double):`	Stop voltage of gate.
`vg_step (double):`	Step voltage of gate.
`hold_time (double):`	Sweep first point hold time.
`delay_time (double):`	Sweep delay time.

OUTPUT:

`Vd`	Drain voltage programmed.
`Id1`	Drain current measured at the 1st gate bias voltage.
`Id2`	Drain current measured at the 2nd gate bias voltage.
`Id3`	Drain current measured at the 3rd gate bias voltage.
`Id4`	Drain current measured at the 4th gate bias voltage.
…	
`Error:`	Error value
`0`	OK
`-1`	24xx not found on GPIB
`-200`	Initialize error occurred.
`-400`	Reading error occurred.
`-10000`	`(INVAL_INST_ID)`: The specified instrument ID does not exist.
`-10090`	`(GPIB_ERROR_OCCURRED)`: A GPIB communications error occurred.
`-10091`	`(GPIB_TIMEOUT)`: A timeout occurred during communications.
`-10100`	`(INVAL_PARAM)`: An invalid input parameter is specified

GUI related:

Figure 288: IdVd_24xx GUI



IdVd_Pulse_24xx

Description: This module tests drain current at specified gate voltage and drain voltage sweep, with measurement at drain terminal in sweep pulse mode using the Keithley 2430 SourceMeter controlled over the GPIB bus only.

Module Type: PTM

Instrument: Keithley Model 2400 SourceMeter, at least one Model 2430 SourceMeter.

INPUTS:

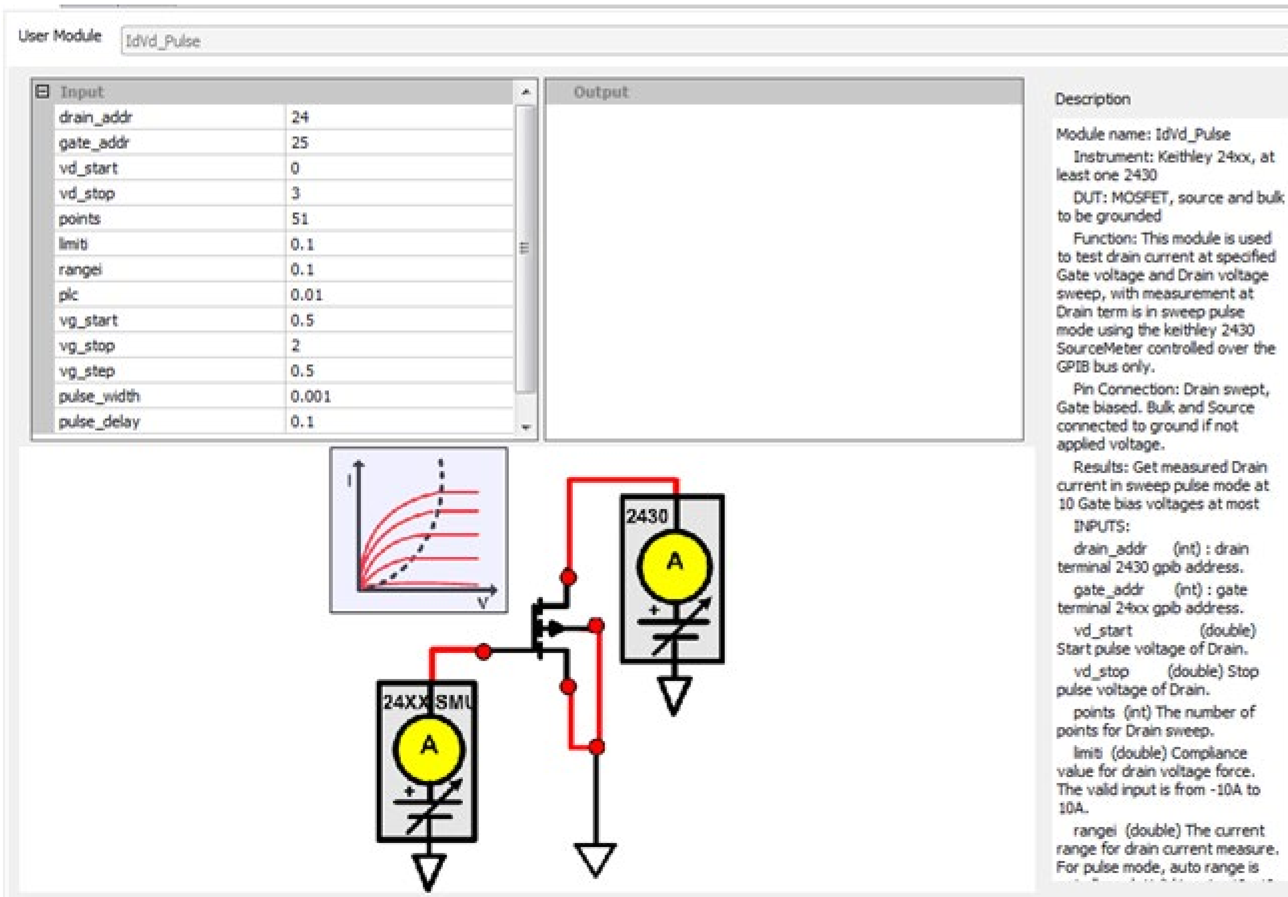
`Drain_addr (int):`	Drain terminal 2430 GPIB address.
`Gate_addr (int):`	Gate terminal 24xx GPIB address.
`vd_start (double):`	Start pulse voltage of drain.
`vd_stop (double):`	Stop pulse voltage of drain.
`points (int):`	The number of points for drain sweep.
`limiti (double):`	Compliance value for drain voltage force. The valid input is from -10A to 10A.
`rangei (double):`	The current range for drain current measure. For pulse mode, autorange is not allowed. Valid input: -10 through 10.
`plc (double):`	Number of power line cycles for integration time. For pulse mode, valid input 0.004 to 0.1.
`vg_start (double):`	Start voltage of gate.
`vg_stop (double):`	Stop voltage of gate.
`vg_step (double):`	Step voltage of gate.
`pulse_width (double):`	Duration of the output ON time. The valid value is from 0.15 ms to 5 ms.
`pulse_delay (double):`	Duration of the output OFF time. The valid value is from 0 s to 9999.999 s.

OUTPUT:

`Vd`	(D_ARRAY_T) drain voltage programmed.
`Idi`	(D_ARRAY_T) drain current measured at the first gate bias voltage.
`Error:`	Error value
`0`	OK
`-1`	24xx not found on GPIB
`-2`	2430 not found on GPIB
`-200`	Initialize error occurred.
`-300`	Configuration error occurred.
`-400`	Reading error occurred.
`-10000`	`(INVAL_INST_ID)`: The specified instrument ID does not exist.
`-10090`	`(GPIB_ERROR_OCCURRED)`: A GPIB communications error occurred.
`-10091`	`(GPIB_TIMEOUT)`: A timeout occurred during communications
`-10100`	`(INVAL_PARAM)`: An invalid input parameter is specified.

GUI related:

Figure 289: IdVd_Pulse_24xx



IdVg_BiasVd_any_SMU

Description: Use this module to test drain current at gate voltage sweep and specified drain voltage. The measurement at the drain terminal is in pulse mode.

Module Type: PTM

Instrument: Keithley Instruments Series 2650A, Series 2600A, Series 2400, and Series 4200-SMU

INPUTS:

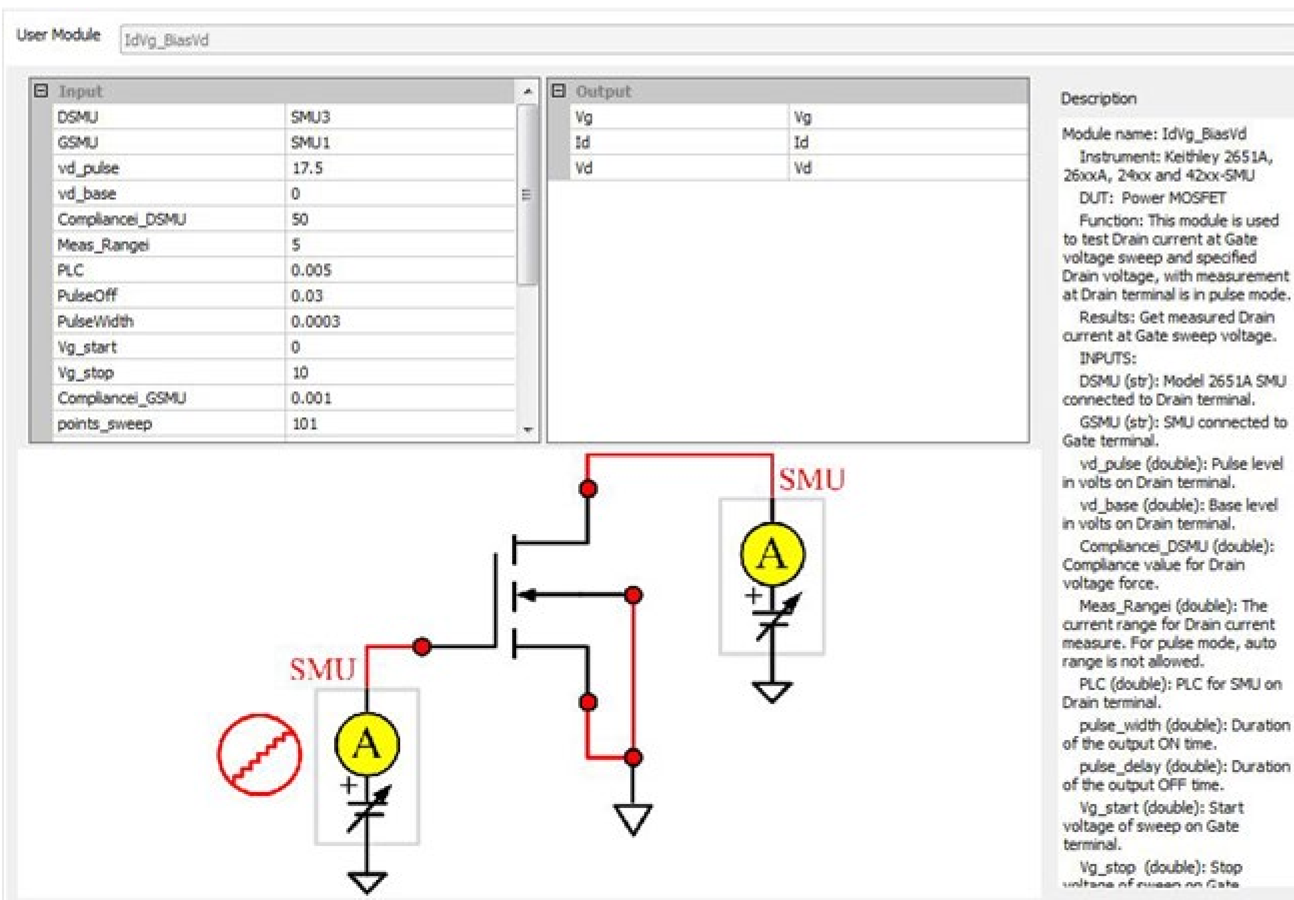
`DSMU:`	Model 2651A SMU connected to drain terminal.
`GSMU:`	SMU connected to gate terminal.
`vd_pulse:`	Pulse level in volts on drain terminal.
`vd_base:`	Base level in volts on drain terminal.
`Compliancei_DSMU:`	Compliance (limit) value for drain voltage force.
`Meas_Rangei:`	The current range for drain current measure. For pulse mode, autorange is not allowed.
`PLC:`	PLC for SMU on drain terminal.
`pulse_width:`	Duration of the output ON time.
`pulse_delay:`	Duration of the output OFF time.
`Vg_start:`	Start voltage of sweep on gate terminal.
`Vg_stop:`	Stop voltage of sweep on gate terminal.
`Compliancei_GSMU:`	Compliance (limit) value for gate voltage force.
`G2D_delay:`	Gate to drain delay; the time between gate Step and the output of the first pulse in the drain pulse.
`Sense_mode4GSMU:`	Sense mode for SMU on gate terminal.
`Sense_mode4DSMU:`	Sense mode for SMU on drain terminal.
`Start_Ramp_Flag:`	Enable or disable soft-ramp function at the start of bias.
`End_Ramp_Flag:`	Enable or disable soft-ramp function at the end of bias.
`Start_Ramp_Delay:`	Time delay at each step of start ramp.
`End_Ramp_Delay:`	Time delay at each step of end ramp.
`Start_Ramp_Steps:`	The number of steps at the start of soft-ramp.
`End_Ramp_Steps:`	The number of steps at the end of soft-ramp.

OUTPUT:

`Vg:`	Gate voltage programmed.
`Id:`	Drain current measured at the specified gate bias current.
`Vd:`	Drain voltage measured.
`Return Values:`	
`0`	OK
`-100`	SMU configuration error
`-200`	Initialize error occurred.
`-300`	Pulse Configuration error occurred.
`-400`	Reading error occurred.
`-10100`	(INVAL_PARAM) Invalid parameter entered.

GUI related:

Figure 290: IdVg_BiasVd_any_SMU GUI



IdVg_Pulse_24xx

Description: Tests the drain current at the gate voltage sweep and a specified drain voltage, with measurements at the drain terminal in pulse mode using the Keithley Model 2430 SourceMeter that is controlled through a GPIB bus only.

Module Type: PTM

Instrument: Keithley Model 2400 SourceMeter (at least one Model 2430 SourceMeter)

Pin connections: Gate sweep, drain bias. The bulk and source are connected to ground, if not applied voltage.

Results:

- Measures the drain current at the gate voltage sweep and the drain in pulse mode (see next figure).
- Measures the results of Vtx and Vt0.

INPUTS:

`Drain_addr (int):`	Drain terminal 2430 GPIB address.
`Gate_addr (int):`	Gate terminal 24xx GPIB address.
`vg_start (double):`	Start voltage of gate. The valid input is from -200 V to 200 V.
`vg_stop (double):`	Stop voltage of gate. The valid input is from -200 V to 200 V.
`points (int):`	The number of points for gate sweep.
`vd (double):`	Drain bias voltage.
`hold_time (double):`	Hold time in seconds before gate sweep. The valid value is from 0 s to 9999.999 s.
`delay_time (double):`	Delay time in seconds between each gate sweep point. The valid value is from 0 s to 9999.999 s.
`limiti (double):`	Compliance (limit) value for drain voltage force. The valid input is from -10 A to 10 A.
`rangei (double):`	The current range for drain current measure. For pulse mode, autorange is not allowed. Valid input: −10 A through 10 A.
`plc (double):`	Number of power line cycles for integration time. For pulse mode, valid input 0.004 to 0.1.
`pulse_width (double):`	Output on time of the pulse for drain voltage force. The valid input is from 150 µs to 5 ms

NOTE

Pulse width should be longer than 200 µs if measurement is in pulse mode. If pulse width is shorter than measurement time (which is based on NPLC and line frequency), pulse width broadens automatically.

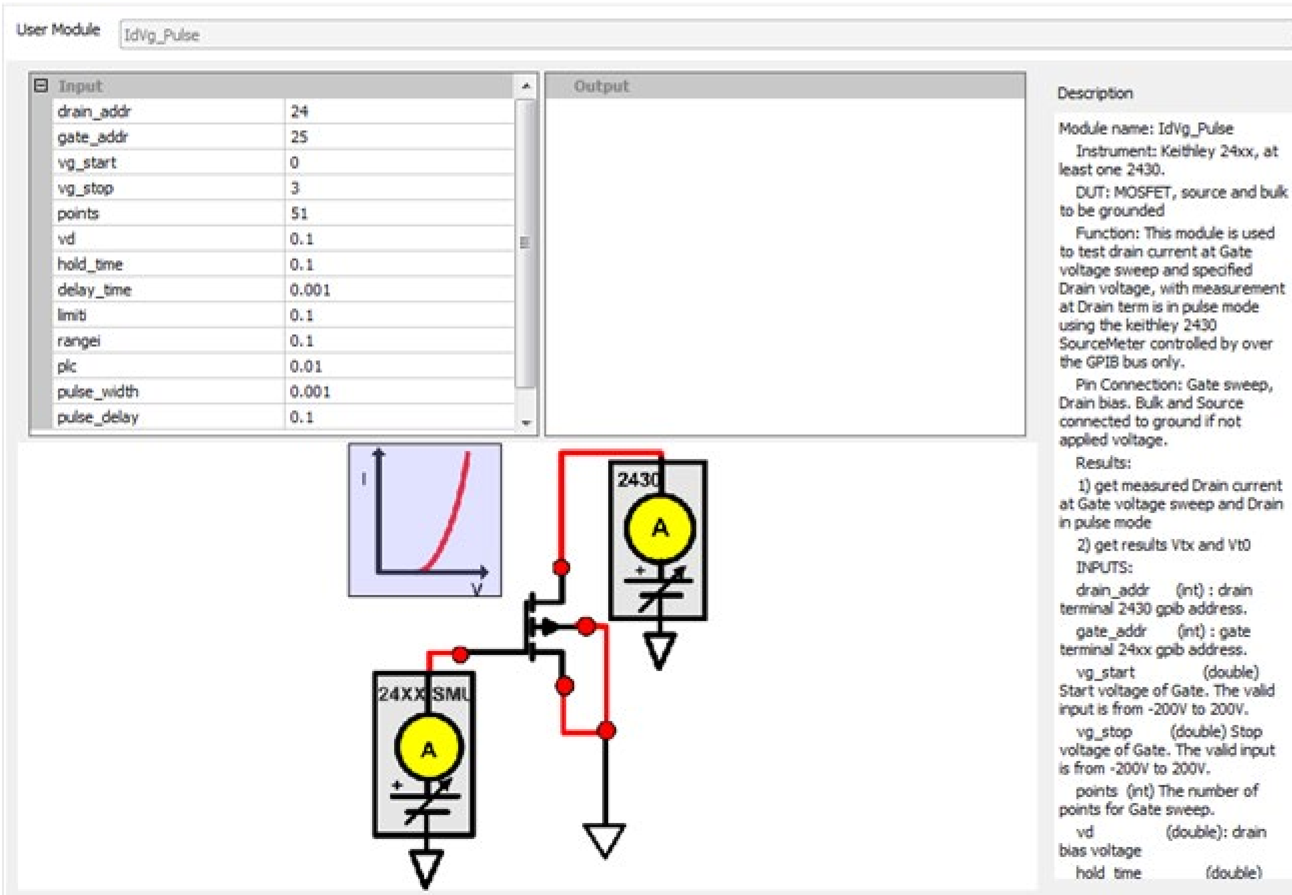
`pulse_delay (double):`	Output off of the pulse for drain voltage force. The valid input is from 0 to 9999.999.

OUTPUT:

Id	(D_ARRAY_T) Drain current measured at gate sweep voltage
Vg	(D_ARRAY_T) Gate voltage programmed
Gm	(D_ARRAY_T) Gm=dId/dVg
Vtx	(double*) Vtx= Vt0-Vs/2
Vt0	(double*) Calculate Gm=dId/dVg. Find Gmmax and extrapolate back to Ids=0 to find Vt0
Error:	Error value
0	OK
-1	24xx not found on GPIB
-2	2430 not found on GPIB
-200	Initialize error occurred
-300	Configuration error occurred
-400	Reading error occurred
-10000	(INVAL_INST_ID) The specified instrument ID does not exist
-10090	(GPIB_ERROR_OCCUR) A GPIB communications error occurred
-10091	(GPIB_TIMEOUT) A timeout occurred during communications
-10100	(INVAL_PARAM) Invalid parameter entered

GUI related:

Figure 291: IdVg_Pulse_24xx GUI



RdsOn_any_SMU

Description: Use this module to test drain current at drain voltage sweep and specified gate voltage with measurement at drain terminal that is in pulse mode using the Keithley Instruments Series 265xA SourceMeter. For details, refer to Rdson in Mixed SMUs in pulse mode (on page 3-367).

SweepCurr_23x

Description: Sweeps current and take I/V/Time readings for the Model 236, 237, or 238.

Instrument: Keithley Models 236, 237, and 238 source measure units.

NOTE

These instruments cannot be automatically scanned by ACS Basic. You must configure them as a general purpose instruments. Refer to Connect to external instruments in the ACS Basic Reference Manual for more information.

INPUTS:

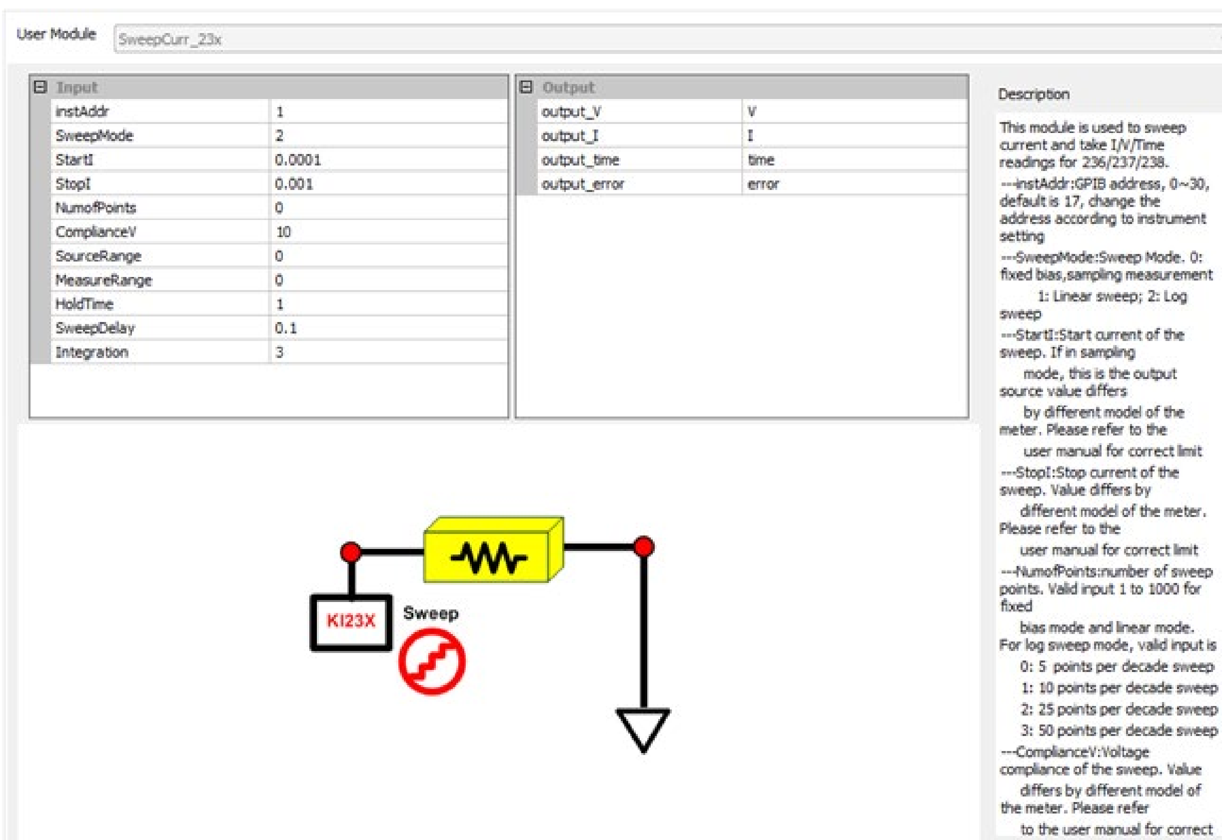
`instAddr:`	GPIB address, 0 through 30, default is 17, change the address according to instrument setting.
`SweepMode:`	Sweep Mode. 0: fixed bias, sampling measurement 1: Linear sweep; 2: Log sweep.
`StartI:`	Start current of the sweep. If in sampling mode, this is the output source value. Value differs by model of the meter.
`StopI:`	Stop current of the sweep. Value differs by model of the meter.
`NumofPoints:`	Number of sweep points. Valid input 1 to 1000 for fixed bias mode and linear mode. For log sweep mode, valid input is: 0: 5 points per decade sweep 1: 10 points per decade sweep 2: 25 points per decade sweep 3: 50 points per decade sweep
`ComplianceV:`	Voltage compliance of the sweep. Value differs by model of the meter.
`SourceRange:`	Source range. 0: Autorange. Otherwise, the range is the smallest that can accommodate the input value. The source range limit differs by model of the meter.
`MeasureRange:`	Measurement range for current. 0: Autorange. Otherwise, the range is the smallest that can accommodate the input value. The source range limit differs by model of the meter.
`HoldTime:`	Time sitting at the first point of sweep. Valid input 0 s to 9999.999 s.
`SweepDelay:`	Delay time between each sweep point. Valid input 0 s to 9999.999 s.
`Integration:`	A/D integration speed: 0: fast 1: medium 2: long, 1 PLC (60 Hz) 3: long, 1 PLC (50 Hz)

OUTPUT:

`output_V:`	Measured voltage
`output_I:`	Measured current
`output_time:`	Timestamp at each point
`output_error:`	Error value
`0`	OK
`-10090`	(GPIB_ERROR_OCCUR) A GPIB communications error occurred.
`-10100`	(INVAL_PARAM) Invalid parameter entered.

GUI related:

Figure 292: SweepCurr_23x GUI



SweepI_MeasV_24xx

Description: Sweep the current signal and make I/V/Time readings for the Model 2400, 2410, 2420, 2425, or 2430 SourceMeter.

Module name: SweepI_MeasV

Instrument: Keithley Models 2400, 2410, 2420, 2425, or 2430 SourceMeter.

These instruments cannot be hardware-scanned by ACS Basic. They must be added as a General Purpose Instruments through KI System Configuration. See the *ACS Basic Reference Manual* for instruction.

INPUTS:

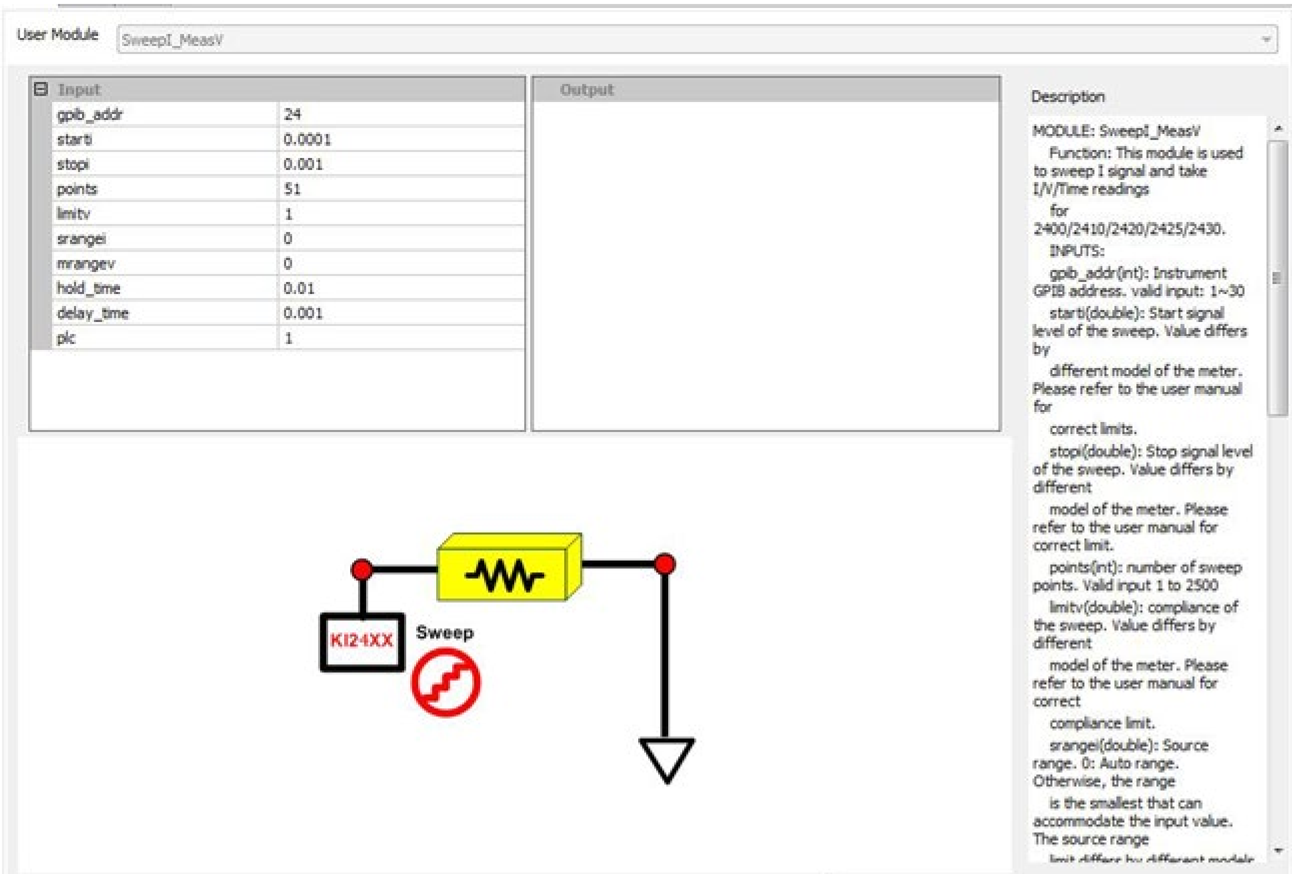
`gpib_addr (int)`	Instrument GPIB address. Valid input: 1 through 30.
`starti (double)`	Start signal level of the sweep. Value differs by model of the SourceMeter.
`stopi (double)`	Stop signal level of the sweep. Value differs by model of the SourceMeter.
`points (int)`	Number of sweep points. Valid input 1 to 2500.
`limitv (double)`	Compliance (limit) of the sweep. Value differs by model of the SourceMeter.
`srangei (double)`	Source range. 0: Autorange. Otherwise, the range is the smallest that can accommodate the input value. The source range limit differs by model of the SourceMeter.
`mrangev (double):`	Measurement range for voltage. 0: Auto range. Otherwise, the range is the smallest that can accommodate the input value. The source range limit differs by model of the SourceMeter.
`holdtime (double)`	Time sitting at the first point of sweep. Valid input 0 s to 9999.999 s.
`delay_time (double)`	Delay time between each sweep point. Valid input 0 s to 9999.999 s.
`plc (double)`	A/D integration time in terms of power line cycles (PLCs). Valid input 0.01 to 10.

OUTPUT:

`I`	
`V`	
`time`	
`Error:`	Error value
`0`	OK
`-200`	Instrument initialize error.
`-300`	Configuration error occurred.
`-400`	Reading error occurred.
`-10000`	(INVAL_INST_ID) The specified instrument ID does not exist.
`-10090`	(GPIB_ERROR_OCCUR) A GPIB communications error occurred.
`-10091`	(GPIB_TIMEOUT) A timeout occurred during communications.

GUI related:

Figure 293: SweepI_MeasV_24xx GUI



SweepVolt_23x

Description: Sweeps voltage and takes I/V/Time readings for the Model 236, 237, or 238.

Instrument: Keithley Models 236, 237, and 238 source measure units.

NOTE

These instruments cannot be automatically scanned by ACS Basic. You must configure them as a general purpose instruments. Refer to Connect to external instruments in the *ACS Basic Reference Manual* for more information.

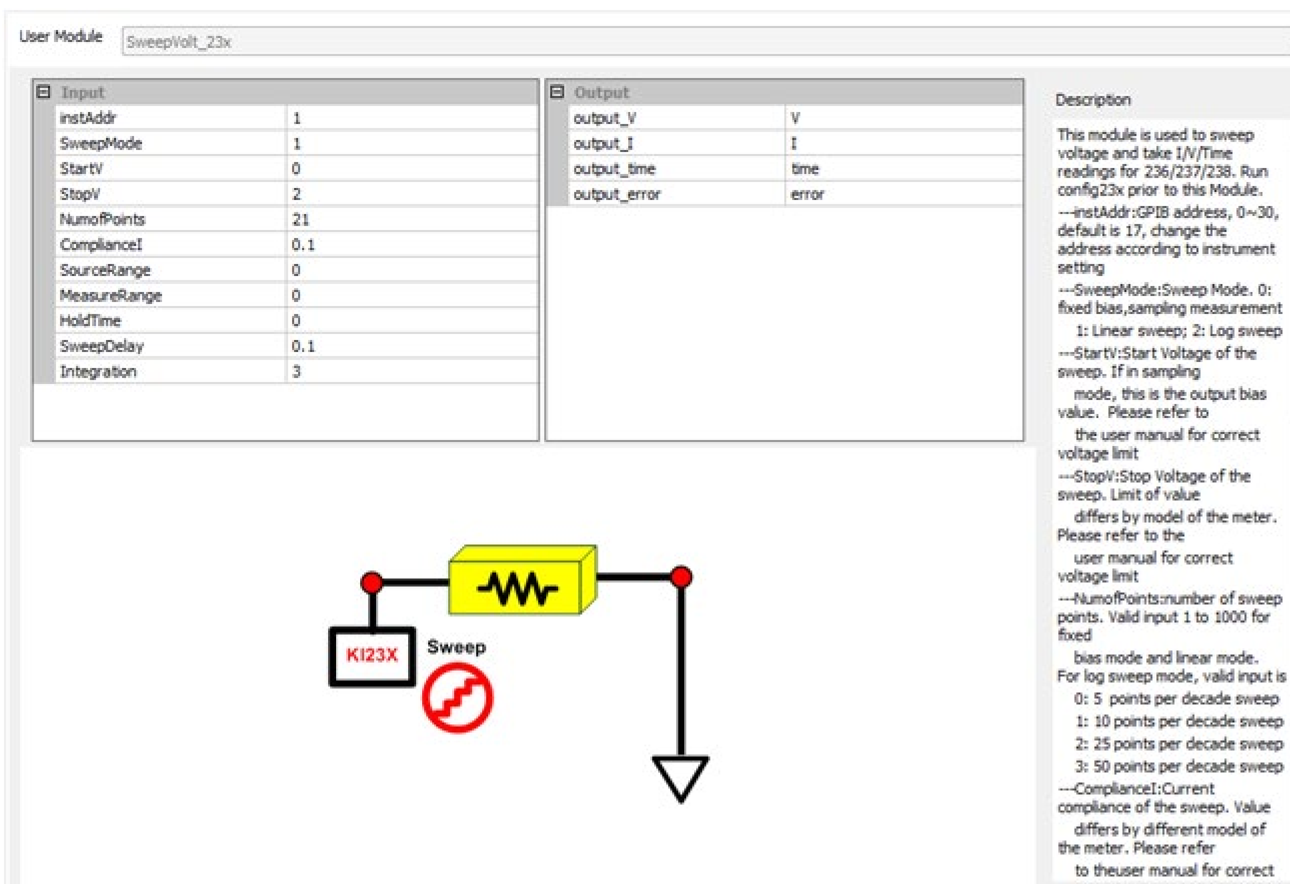
INPUTS:

`instAddr:`	GPIB address, 0 through 30, default is 17, change the address according to instrument setting.
`SweepMode:`	Sweep Mode. 0: fixed bias, sampling measurement 1: Linear sweep; 2: Log sweep.
`StartV:`	Start voltage of the sweep. If in sampling mode, this is the output bias value.
`StopV:`	Stop voltage of the sweep. The limit of the value differs by the model of the meter.
`NumofPoints:`	Number of sweep points. Valid input 1 to 1000 for fixed bias mode and linear mode. For log sweep mode, valid input is: 0: 5 points per decade sweep 1: 10 points per decade sweep 2: 25 points per decade sweep 3: 50 points per decade sweep
`ComplianceI:`	Current compliance of the sweep. Value differs by model of the meter.
`SourceRange:`	Source range. 0: Autorange. Otherwise, the range is the smallest that can accommodate the input value. The source range limit differs by model of the meter.
`MeasureRange:`	Measurement range for current. 0: Autorange. Otherwise, the range is the smallest that can accommodate the input value. The source range limit differs by model of the meter.
`HoldTime:`	Time sitting at the first point of sweep. Valid input 0 s to 9999.999 s.
`SweepDelay:`	Delay time between each sweep point. Valid input 0 s to 9999.999 s.
`Integration:`	A/D integration speed: 0: fast 1: medium 2: long, 1 PLC (60 Hz) 3: long, 1 PLC (50 Hz)

OUTPUTS:

`output_V:`	Measured voltage
`output_I:`	Measured current
`output_time:`	Timestamp at each point
`output_error:`	Error value
`0`	OK
`-1`	23x not found on GPIB
`-10000`	(INVAL_INST_ID) The specified instrument ID does not exist.
`-10090`	(GPIB_ERROR_OCCUR) A GPIB communications error occurred.
`-10091`	(GPIB_TIMEOUT) A timeout occurred during communications.
`-10100`	(INVAL_PARAM) Invalid parameter entered.

GUI related:



SweepV_MeasI_24XX

Description: Sweeps the voltage signal and takes I/V/Time readings for the Model 2400, 2410, 2420, 2425, or 2430 SourceMeter.

Module name: SweepV_MeasI

Instrument: Keithley Models Model 2400, 2410, 2420, 2425, or 2430 SourceMeter.

INPUTS:

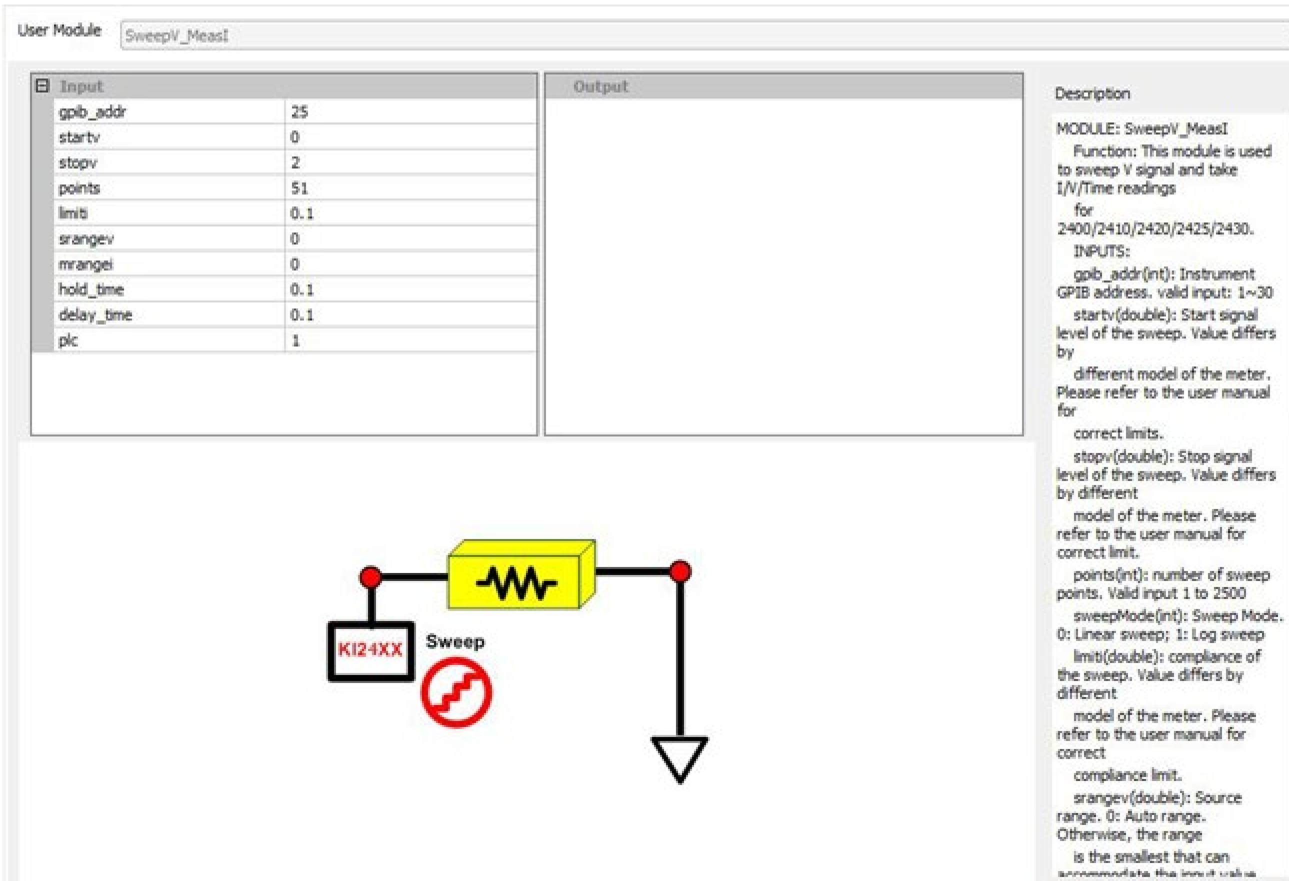
`gpib_addr (int):`	Instrument GPIB address. Valid input: 1 through 30.
`startv (double):`	Start signal level of the sweep. Value differs by model of the SourceMeter.
`stopv (double):`	Stop signal level of the sweep. Value differs by model of the SourceMeter.
`points (int):`	Number of sweep points. Valid input 1 to 2500.
`sweepMode (int):`	Sweep Mode. 0: Linear sweep; 1: Log sweep.
`limiti (double):`	Compliance (limit) of the sweep. Value differs by model of the SourceMeter.
`srangev (double):`	Source range. 0: Autorange. Otherwise, the range is the smallest that can accommodate the input value. The source range limit differs by model of the SourceMeter.
`mrangei (double):`	Measurement range for current. 0: Autorange. Otherwise, the range is the smallest that can accommodate the input value. The source range limit differs by model of the SourceMeter.
`holdtime (double):`	Time sitting at the first point of sweep. Valid input 0 s to 9999.999 s.
`delay_time (double):`	Delay time between each sweep point. Valid input 0 s to 9999.999 s.
`plc (double)`	A/D integration time in terms of power line cycles (PLCs). Valid input 0.01 to 10.

OUTPUTS:

`I`	
`V`	
`time`	
`Error:`	Error value
`0`	OK
`-200`	Instrument initialize error.
`-300`	Configuration error occurred.
`-400`	Reading error occurred.
`-10000`	(INVAL_INST_ID) The specified instrument ID does not exist.
`-10090`	(GPIB_ERROR_OCCUR) A GPIB communications error occurred.
`-10091`	(GPIB_TIMEOUT) A timeout occurred during communications.

GUI related:

Figure 294: SweepV_MeasI GUI



Vcesat_bjt_any_SMU

Description: Use this test module to measure the collector-emitter saturation voltage. A current sweep occurs at the collector terminal with a fixed current applied from base to emitter terminals. For details, refer to Vcesat_bjt in Mixed SMUs in pulse mode (on page 3-367).

Vcesat_IGBT_any_SMU

Description: Use this test module to measure the collector-emitter saturation voltage. A current sweep occurs at the collector terminal with a fixed voltage applied on the gate terminal. For details, refer to Vcesat_IGBT in Mixed SMUs in pulse mode (on page 3-367).

VdsId_237

Description: High voltage measurement of the current Id at the same time forcing Vd and stepping Vg.

Instrument: Keithley Model 236, 237, or 238 source measure unit; Model 4200-SCS.

NOTE

These instruments cannot be automatically scanned by ACS Basic. You must configure them as a general purpose instruments. Refer to Connect to external instruments in the *ACS Basic Reference Manual* for more information.

Device connections:

- **Drain:** KI237
- **Gate, sub, well:** Each corresponds with a SMU (for example, SMU1, SMU2, or SMU8 in the Model 4200).

INPUTS:

`instAddr:`	GPIB address of the Model 237. Valid from 0 through 30.
`GateSMU:`	The system terminal is attached to the gate of the MOSFET. If 'GNDU' is chosen, the terminal should be connected to GND manually.
`SourceSMU:`	The system terminal is attached to the Source of the MOSFET. If 'GNDU' is chosen, the terminal should be connected to GND manually.
`SubSMU:`	The system terminal is attached to the sub of the MOSFET. If 'GNDU' is chosen, the terminal should be connected to GND manually.
`WellSMU:`	The system terminal is attached to the well of the MOSFET. If 'GNDU' is chosen, the terminal should be connected to GND manually; if there is no well terminal, choose 'NONE'.
`VgStart:`	Start voltages of gate in volts.
`VgStop:`	End voltages of gate in volts.
`VgPoint:`	Number of intervals of forced Vg.
`VdStart:`	Start voltages of drain in volts.
`VdStop:`	End voltages of drain in volts.
`VdPoint:`	Number of intervals of forced Vd.
`IdLimit:`	Current limits on measured sites in amperes.
`Integration:`	A/D integration speed: 0: fast 1: medium 2: long, 1 PLC (60 Hz) 3: long, 1 PLC (50 Hz)
`DelayTime:`	Delay time of one measurement in seconds.
`VscForce:`	Voltage bias force to Source.
`VsbForce:`	Voltage bias force to Sub.
`VwForce:`	Voltage bias force to Well.
`VgMsrFlag:`	Flag for determining if Vg is measured.
`IgMsrFlag:`	Flag for determining if Ig is measured.
`VscMsrFlag:`	Flag for determining if Vsc is measured.
`IscMsrFlag:`	Flag for determining if Isc is measured.
`VsbMsrFlag:`	Flag for determining if Vsb is measured.
`IsbMsrFlag:`	Flag for determining if Isb is measured.
`VwMsrFlag:`	Flag for determining if Vw is measured.
`IwMsrFlag:`	Flag for determining if Iw is measured.

OUTPUTS:

output_error:	Error value
0	OK
-1	23x not found on GPIB
-10000	(INVAL_INST_ID) The specified instrument ID does not exist.
-10090	(GPIB_ERROR_OCCUR) A GPIB communications error occurred.
-10091	(GPIB_TIMEOUT) A timeout occurred during communications.
-10100	(INVAL_PARAM) Invalid parameter entered.

GUI related:

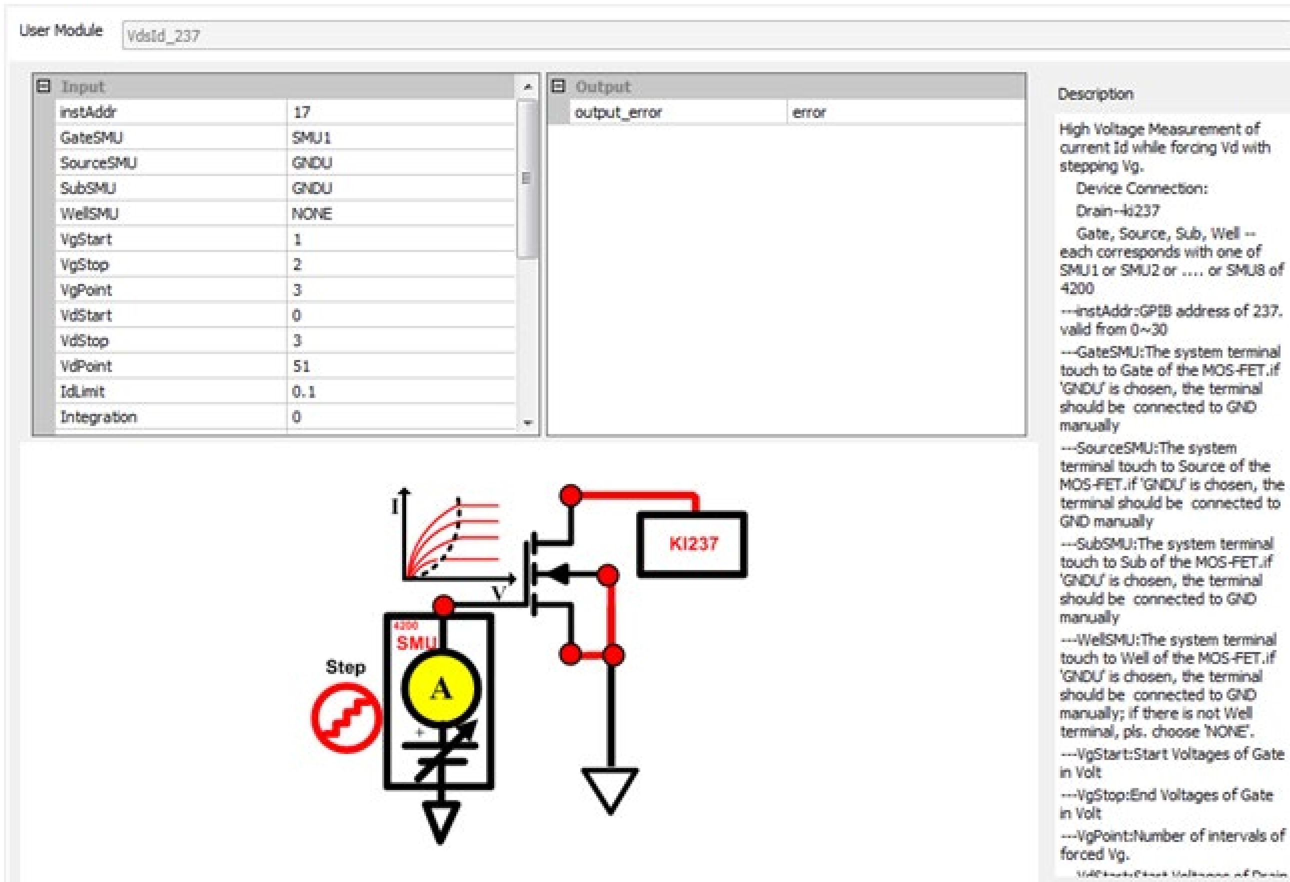
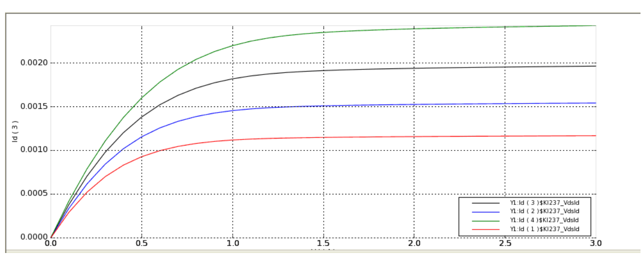


Figure 295: VdsId_237 test result



VgsON_any_SMU

Description: Use this module to test the gate to source on-state voltage. Measure the current on drain by applying a voltage sweep to the gate-source. Use a specific drain to source voltage to turn the device on to certain Id current value.

Module Type: PTM

Instrument: Keithley Instruments Series 2650A, Series 2600A, Series 2400, and Series 4200-SMU

INPUTS:

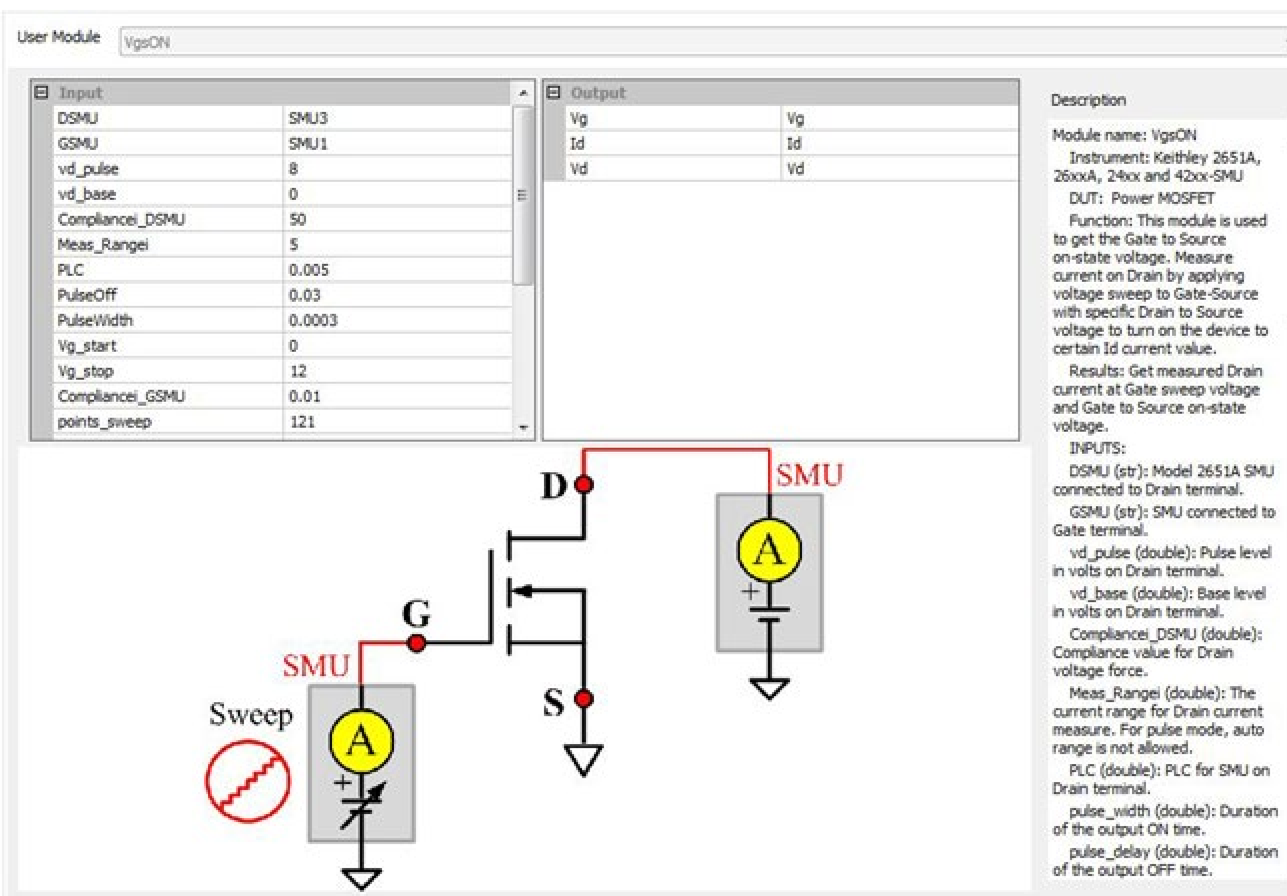
`DSMU:`	Model 2651A SMU connected to drain terminal.
`GSMU:`	SMU connected to gate terminal.
`vd_pulse:`	Pulse level in volts on drain terminal.
`vd_base:`	Base level in volts on drain terminal.
`Compliancei_DSMU:`	Compliance (limit) value for drain voltage force.
`Meas_Rangei:`	The current range for drain current measure. For pulse mode, autorange is not allowed.
`PLC:`	PLC for SMU on drain terminal.
`pulse_width:`	Duration of the output ON time.
`pulse_delay:`	Duration of the output OFF time.
`Vg_start:`	Start voltage of sweep on gate terminal.
`Vg_stop:`	Stop voltage of sweep on gate terminal.
`Compliancei_GSMU:`	Compliance (limit) value for gate voltage force.
`points_sweep:`	The number of points for gate sweep.
`G2D_delay:`	Gate to drain delay; the time between gate step and the output of the drain pulse.
`Sense_mode4GSMU:`	Sense mode for SMU on gate terminal.
`Sense_mode4DSMU:`	Sense mode for SMU on drain terminal.
`Start_Ramp_Flag:`	Enable or disable soft-ramp function at the start of bias.
`End_Ramp_Flag:`	Enable or disable soft-ramp function at the end of bias.
`Start_Ramp_Delay:`	Time delay at each step of start ramp.
`End_Ramp_Delay:`	Time delay at each step of end ramp.
`Start_Ramp_Steps:`	The number of steps at the start of soft-ramp.
`End_Ramp_Steps:`	The number of steps at the end of soft-ramp.

OUTPUTS:

`Vg:`	Gate voltage programmed.
`Id:`	Drain current measured at the specified gate bias current.
`Vd:`	Drain voltage measured.
`Return Values:`	
`0`	OK
`-100`	SMU configuration error
`-200`	Initialize error occurred.
`-300`	Pulse Configuration error occurred.
`-400`	Reading error occurred.
`-10100`	(INVAL_PARAM) Invalid parameter entered.

GUI related:

Figure 296: VgsON_any_SMU GUI



Common other library

Common other library overview

The ACS Basic common library includes matrix control, power supply, and scope control tests. All test modules in the common other library can be added to any device. You can also build a common other library to import and use.

KI37XX_DMM_Switch

Description: Supports two types of cards: 6x16, High Density, Matrix Card (3730) and Dual 1x30 Multiplexer Card (3720).

Module Type: PTM

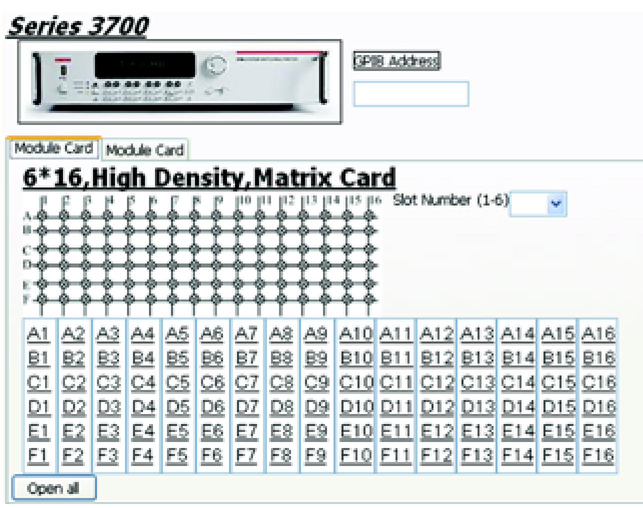
Module Name: Series 3700 Switch control

Instrument: Keithley Series 3700 System Switch/Multimeter and plug-in cards.

Pin connections: For 4-wire measurement, if you are using a multiplexer card, use a channel pair. Channels 1 through 30 are used as the INPUT terminals and channel 31 through 60 are used as the SENSE terminals.

GUI related:

Figure 297: KI37XX_DMM_Switch GUI

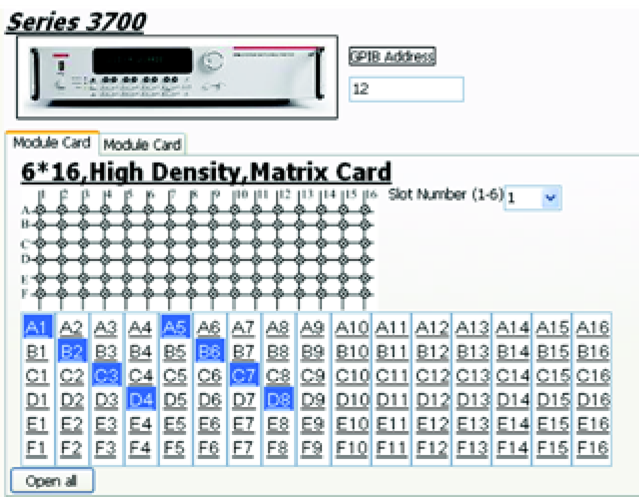


Control the 3700 matrix in the GUI (see previous figure):

- Input the GPIB address number in the GPIB edit box.
- Select the matrix card tab by clicking the matrix card.
- Select the slot number from 1 to 6.

Click the cells on the panel; the related rows and columns of the matrix will connect. For example, **click A1**, and the **1** column and the **A** row will connect. The corresponding cell will highlight (see next figure). **Click** the highlighted cells again, and the connections will be canceled.

Figure 298: Matrix control setting example

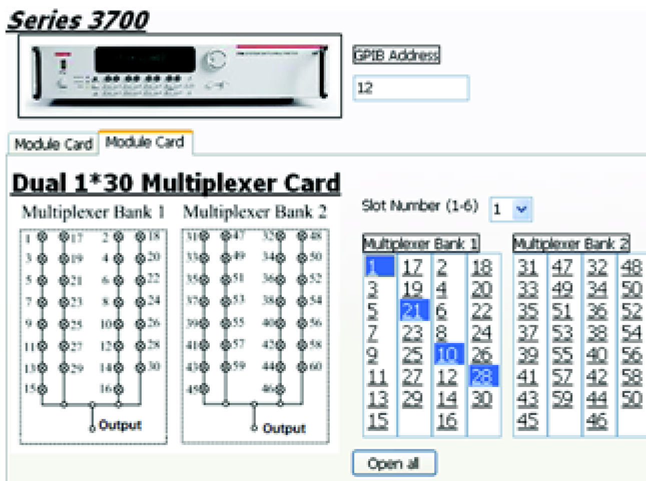


Control the multiplexer card in the GUI:

- Input the GPIB address number in the GPIB edit box.
- Select the matrix card tab by clicking the multiplexer card.
- Select the slot number from 1 to 6.

Click the cells on the panel, the related rows and columns of the matrix will connect. For example, **click A1**, and the **1** column and the **A** row will connect. The corresponding cell will highlight (see next figure). **Click** the highlighted cells again, and the connections will be canceled.

Figure 299: Multiplexer control setting example



power_supply

Description: You can use this module to make simple leakage current measurements on two-terminal and three-terminal devices using a high-voltage power supply and a SMU. This module can support the following SMUs for measuring the current through the device: Models 2611/12 A/B, Models 2635/6 A/B, Model 4200-SMU, Model 4210-SMU. These models are supported with the Model 2290-PM-200 Protection Module.

Module Name: power_supply

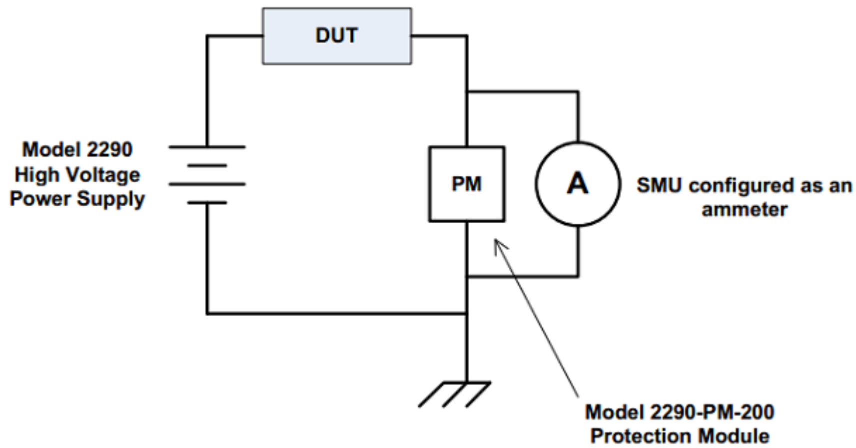
Instrument: Model 2290 power supply.

NOTE

The Model 2290 cannot be automatically scanned by ACS Basic. You must configure it as a general purpose instrument. Refer to "Connect to external instruments" in the *ACS Basic Reference Manual* for information.

Test connections:

Figure 300: power_supply test connections



INPUTS:

HV Power Supply settings

- **Global Name:** GPI1, GPI2, …, GPIn.
- **Device Connections:** List of pins to connect.

Test Mode Settings

- **Mode:** Allows you to select test mode (Bias or Sweeping) from a list.
- **Bias V:** Force value for the bias.
- **Number of Points:** The number of points for sweep.
- **Sweep start V:** Initial force value for the sweep.
- **Sweep stop V:** Final force value for the sweep.

Other Power Supply Settings

- **Current Limit:** Current limiting varies the output voltage to limit the output current to less than or equal to the programmed current limit value. The default value is 1 mA.
- **Current Trip Value:** The current trip shuts off the high voltage when the output current exceeds the trip value. The default value is 1 mA.
- **Voltage Limit:** The voltage limit is a protection feature to prevent the output voltage from being set too high or overshooting because of dramatic load changes. The output voltage cannot be set higher than the voltage limit. The default value is the maximum of power supply.

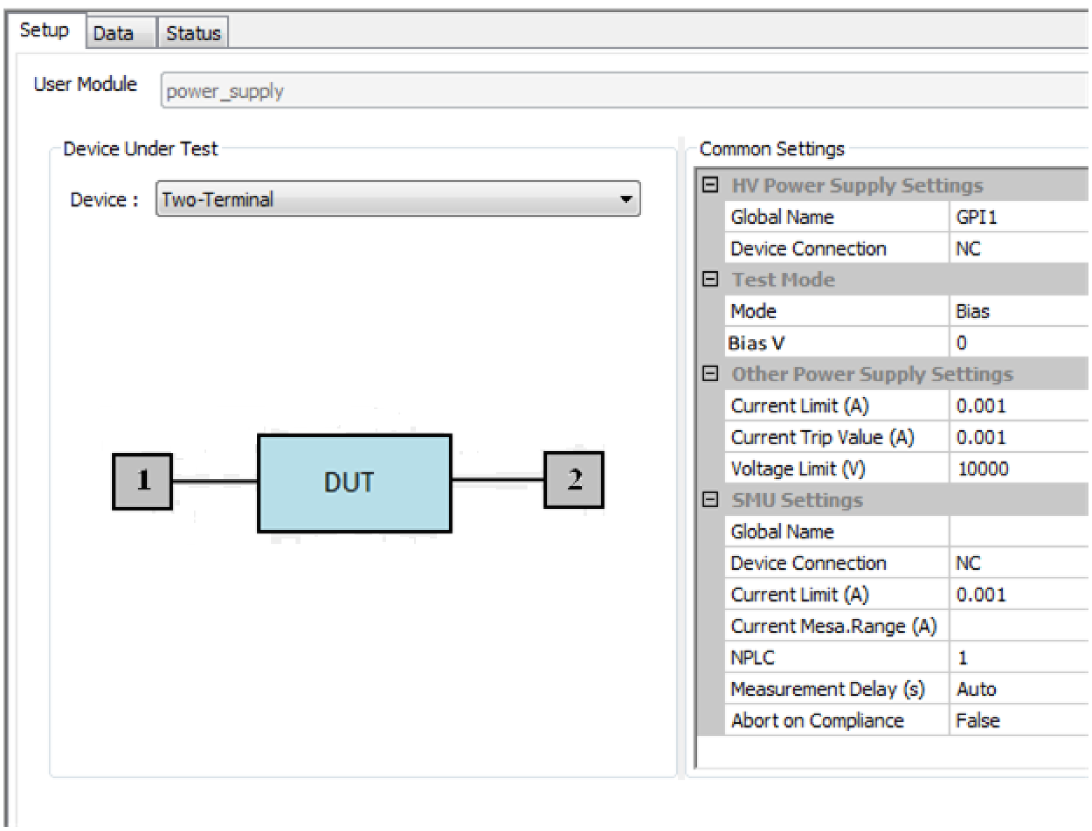
SMU Settings

- **Global Name:** SMU1, SMU2, …, SMU*n*
- **Device Connections:** List of pins to connect.
- **Current Limit:** Current Limitation on measured sites in Ampere. The default value is 1 mA; the minimum and maximum depend on the SMU used.
- **Current Meas.Range:** Specifies the SMU current measure range used. Auto option commands the SMU to automatically optimize the measurement range. This option provides the best resolution. Numerical range options allow you to manually select a fixed measurement range to suit your needs. The default is Auto.
- **NPLC:** Number of power line cycles for integration. The default value is 1.

- **Measurement Delay:** The measure delay is a specific delay applied before each measurement is made. You can either change the delay to a specific value or to auto. If the measure delay is set to auto, a range-dependent delay is applied each time the instrument performs a current measurement, or after changing current ranges during an autoranged measurement. The default measurement delay varies by model. The Auto setting only can be applied to 26XX SMU. When 42XX SMU is used, please input a specific value. If use Auto for 42XX SMU, this delay will be disabled by default (measurements are made immediately).
- **Abort on Compliance:** Determines if the test aborts if it reaches the compliance (limit) value. If you do not want to abort the text on compliance, select False. To abort the test on compliance, select True.

GUI related:

Figure 301: power_supply GUI



switchctrl_6cards_70x

The `switchctrl_6cards_70x` test module connects matrix row terminals and column pins, as specified by the user. This module is only applicable to the Keithley Instrument Models 707A and 708A. Directly send corresponding commands without HV SMU check.

The single-test model of this test module is in `CommonLib_other`. You can import a multitest version from the directory:

```
C:\ACS_BASIC\library\pyLibrary\PTMLib\switchctrl.py
```

For details, refer to Switch control PTM (on page 3-395).

switchctrl_6cards_3706

The `switchctrl_6cards_3706` test module connects specified matrix row terminals and column pins, as specified by the user.

The single-test model of this test module is in `CommonLib_other`. You can import a multitest version from the directory:

```
C:\ACS_BASIC\library\pyLibrary\PTMLib\switchctrl.py
```

For details, refer to Switch control PTM (on page 3-395).

TEKSCOPE_ReadWave

Description: Reads the waveform on the scope. It reads data one channel at a time. Some modification is needed to enable it to read data from more channels simultaneously.

Known issues: Returns 2 bytes of binary data.

Instrument: TEKSCOPE

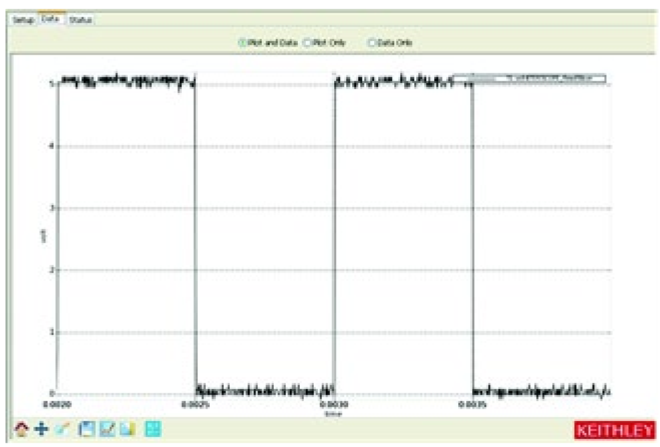
NOTE

This instrument cannot be automatically scanned by ACS Basic. You must configure it as a general purpose instrument. Refer to "Connect to external instruments" in the *ACS Basic Reference Manual* for information.

GUI related:

Figure 302: Waveform reading GUI

Figure 303: Waveform reading data



High-voltage capacitance-voltage PTM

Generic high-voltage capacitance-voltage PTM

You can make capacitance-voltage measurements using this PTM module.

The following are supported SMUs:

- 4200 SMU
- 2600 SMU
- 2657 SMU

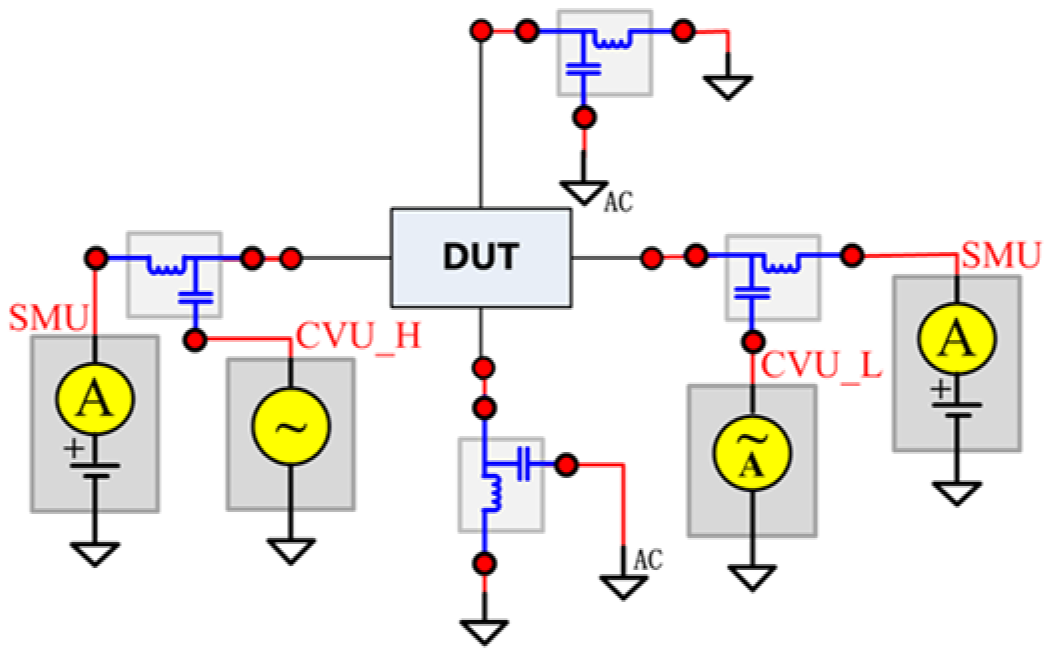
The configuration of this PTM module requires the following setup:

- Model 4200-CVU (to supply AC voltage).
- Model 4205-RBTs (200 V remote bias tee) or 3 kV remote bias tee (up to four bias tees can be used in the configuration).
- Model 8010 Test Fixture or Model 8020 Test Fixture

For supplies of ±200 V or 400 V differential DC bias or sweep voltage, either the 4200 SMU or the 2600 SMU can be used. The 4205-RBTs are connected to the device under test (DUT) through the Model 8010 test fixture.

For supplies of 3 kV DC bias or sweep voltage, the 2657A SMU is needed. The 3 kV remote bias tees are connected to the DUT through the Model 8020 test fixture.

Figure 304: HV_CV measurement hardware connections



NOTE

In the previous graphic, a 4-terminal device is shown. You can also use this test for 2-terminal and 3-terminal devices.

Generic high-voltage capacitance-voltage functions

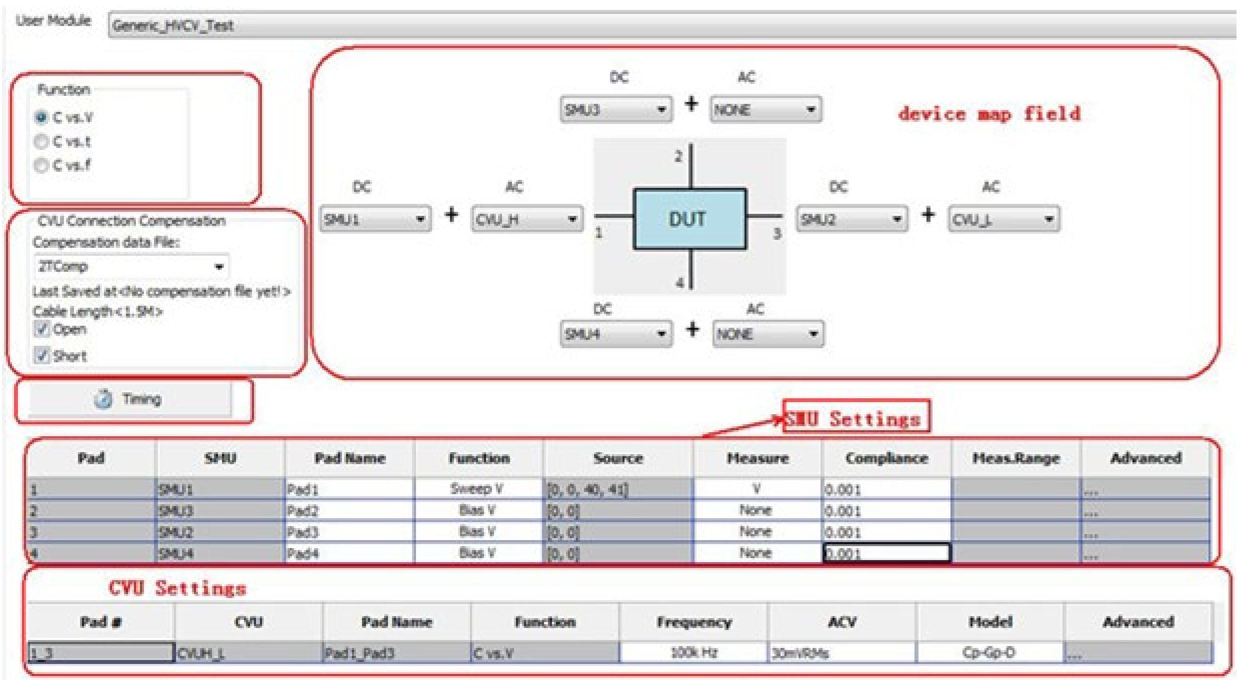
The generic high-voltage high-current PTM library module is in the following directory:

```
C:\ACS_BASIC\library\pyLibrary\PTMLib\GenericHVCVlib.py
```

To open the module, import the `.py` file to your test.

You can use this module to switch between the functions C vs. V, C vs. t, and C vs. f. The details of these functions are indicated in the following figure. Descriptions follow the figure.

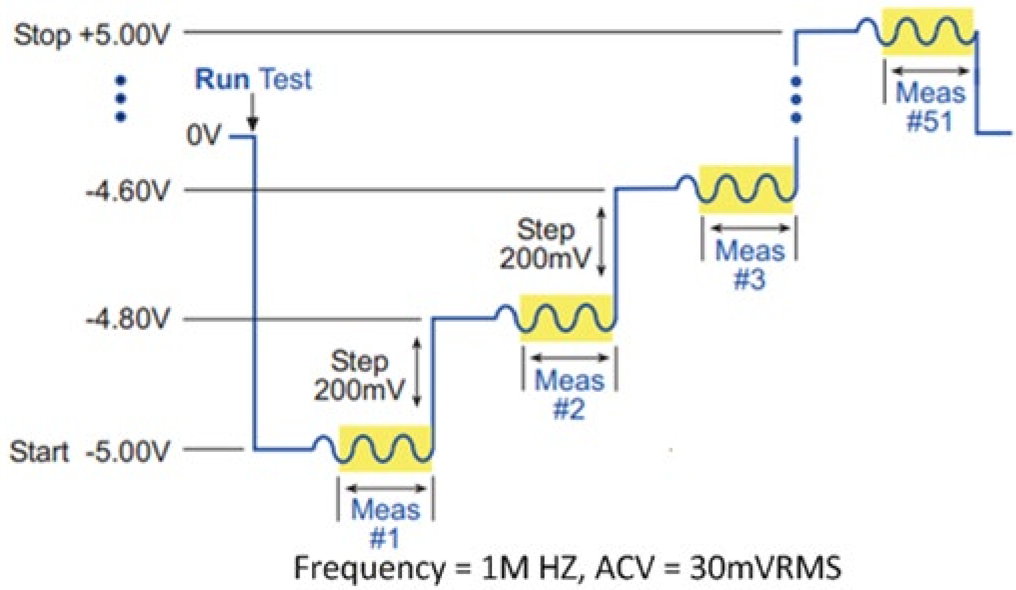
Figure 305: High-voltage capacitance-voltage PTM module GUI



C vs. V

Using a voltage sweep, capacitance is measured at every step of the sweep to generate a Capacitance versus Voltage graph. An example is shown in the following figure.

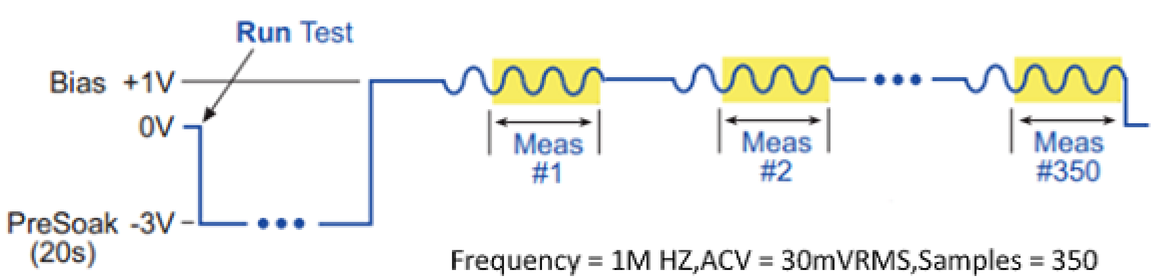
Figure 306: C vs. V waveform example



C vs. t

Performs a specified number of capacitance measurements (Sample Count) at a specified time interval (Measurement Delay) with voltage and frequency held constant. The capacitance versus time measurements is then plotted on a graph. An example is shown in the following figure.

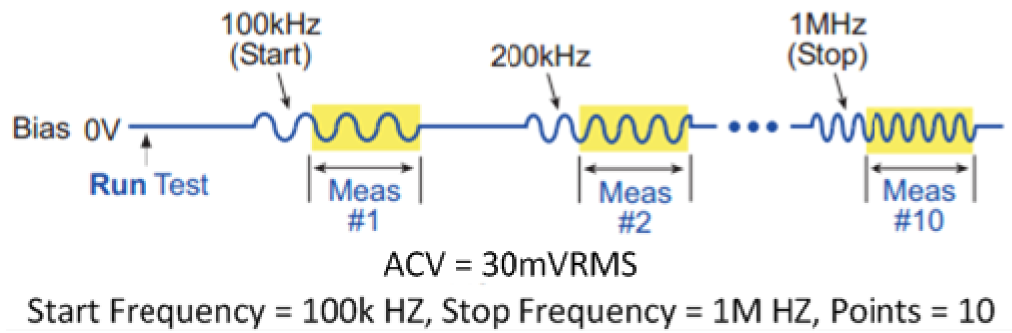
Figure 307: C vs. t waveform example



C vs. f

Using a frequency sweep, capacitance is measured at every frequency point to generate a Capacitance versus Frequency graph. An example is shown in the following figure.

Figure 308: C vs. f waveform example



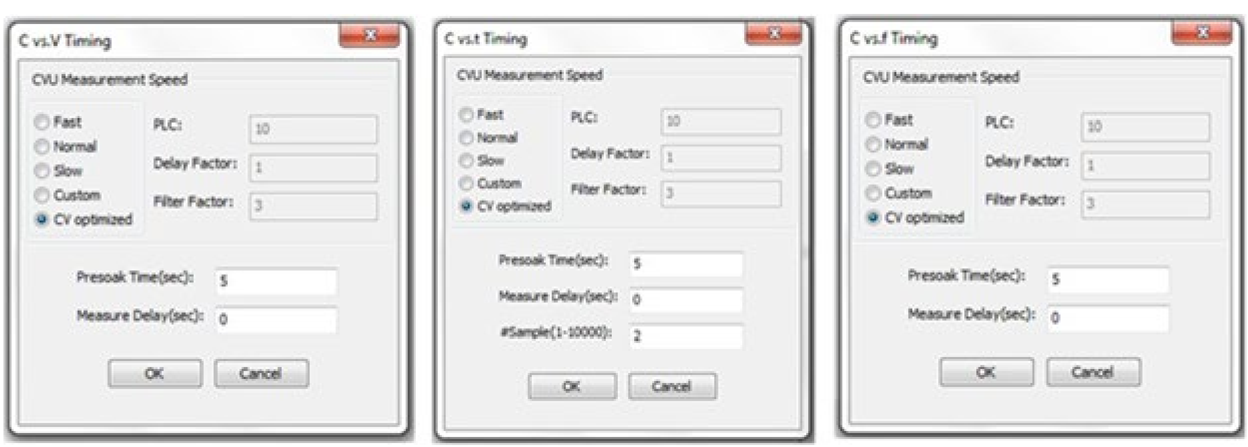
CVU connection compensation

In the CVU connection *compensation area:*

- **Compensation data file:** Select the compensation data file to be used. For more information about how to generate a compensation file, refer to "Generate connection compensation data" in the *Automated Characterization Suite (ACS) Fundamental Reference Manual* (document number ACS-914-01)
- **Open:** Enable or disable open compensation for CVU.
- **Short:** Enable or disable short compensation for CVU.

Double-click the cell to display the Timing dialog for the selected function.

Figure 309: C vs. V, C vs. t, and C vs. f Timing dialogs



Measurement Speed: Selects the SMU and CVU measure speed.

- **Fast:** Optimizes speed at the expense of noise performance. It is a good choice for fast measurements where noise and settling time are not concerns.
- **Normal:** The most commonly used setting. It provides a good combination of speed and low noise and is the best setting for most cases.
- **Slow:** Optimizes the low-noise measurements at the expense of speed. If speed is not a critical consideration, it is a good choice when you need the lowest noise and most accurate measurements.
- **Custom:** Allows you to fine-tune the timing parameters to meet a particular need. With Custom, you can configure the integration time and the number of readings to produce a composite setting. The entries in the PLC edit fields control the A/D (analog-to-digital) converter integration time used to measure a signal. A short integration time for each A/D conversion results in a relatively fast measurement speed, at the expense of noise. A long integration time results in a relatively low noise reading, at the expense of speed. The integration time setting is based on the number of power line cycles (NPLCs):
  - For 60 Hz line power, 1.0 PLC = 16.67 ms (1/60 of a second).
  - For 50 Hz line power, 1.0 PLC = 20 ms (1/50 of a second).
- **CV optimized:** This option allows you to select a setting that gives an accurate CV measurement.
- **PLC:** If you selected the Custom measurement Speed mode, you can enter any value between 0.001 NPLC and 25 NPLC. If you selected the **Fast**, **Normal**, **Slow** or **CV optimized** measurement Speed mode, ACS Basic sets the A/D Integration Time correspondingly. The following table summarizes the allowed A/D Integration Time settings for the measurement Speed modes.

Measurement speed	**PLC**
Fast	0.01
Normal	1
Slow	10
Custom	0.001 to 25
CV optimized	10

- **Delay Factor:** After applying a forced voltage or current, a SMU waits for a delay time before making a measurement. The delay time allows for source settling. The default delay time is pre-programmed and range-dependent to allow for the very long settling times needed at very low current ranges. The applied delay time is a multiple of the default delay time and the value in the Delay Factor edit box specifies this multiple.

  Applied delay time = (Default delay time) x (Delay Factor)

For example, if the default delay time is 1 ms and the Delay Factor is 0.7, the applied delay time is 0.7 ms (1 ms x 0.7).

If you select the Custom measurement speed mode, you can enter a custom Delay Factor of 0 to 100. If you select the **Fast**, **Normal**, **Slow** or **CV optimized** measurement speed mode, the SMU sets an appropriate fixed Delay Factor.

Measurement speed	Delay Factor
Fast	0.7
Normal	1.0
Slow	1.3
Custom	0 to 100
CV optimized	1

- **Filter Factor:** To reduce measurement noise, a SMU applies filtering, which may include averaging of multiple readings to make one measurement. The value entered in the Filter Factor edit box specifies a multiple of this preprogrammed filtering.

  If you select the Custom measurement speed mode, you can enter a Filter Factor value of 0 to 100. If you select the **Fast**, **Normal**, **Slow** or **CV optimized** measurement speed mode, the SMU sets an appropriate fixed Filter Factor.

Measurement speed	Filter Factor
Fast	0.2
Normal	1
Slow	3
Custom	0 to 100
CV optimized	3

Presoak Time (sec): Time in seconds to apply soak voltage.

Measurement Delay (sec): Delay time in seconds before measurement. The delay time allows for source settling.

#Sample (1-10000): Specifies the number of data points to be acquired during the test.

Generic HV CV user interface descriptions

Pad: Cannot be changed here. Pads are fixed and referenced to the diagram in the device map field.

SMU: Cannot be changed here. It can only be assigned in the device map field based on the hardware connection.

Pad Name: The header for the data related to the hardware connection.

Function: The function type for force. Double-click to select one of the following options from the list:

- **C vs. V:** Bias V/Sweep V/List V/GND/Open can be selected, but only one SMU can be set to Sweep V or List V
- **C vs. t:** Only Bias V/GND/Open can be selected
- **C vs. f:** Only Bias V/GND/Open can be selected

Source: The source value of SMU. Double-click the Source cell to display a Settings dialog.

Options for Bias V:

- **Presoak V:** When the test is started and before measurement sequence, the device is stressed at a specified voltage (Presoak V) for a specified period (Presoak Time), as shown in the following figure.
- **Bias Level:** Defines a constant and valid voltage at the terminal.

Figure 310: Bias V settings

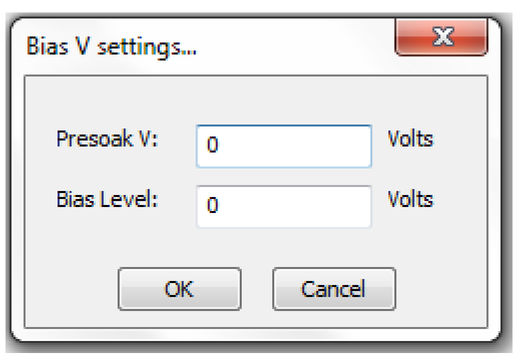
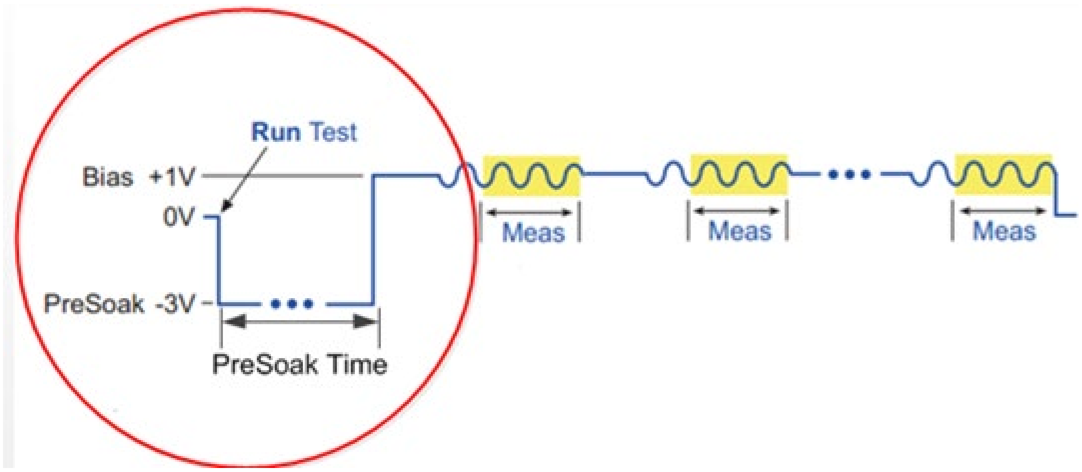


Figure 311: Presoak V and Presoak time



Options for Sweep V:

- **Dual Sweep:** You can set the SMUs in a test to perform a dual sweep. When enabled, the SMU sweeps from Start to Stop, and then continues to sweep from Stop back to Start. When it is disabled, the SMU only sweeps from Start to Stop.

Figure 312: Sweep V settings

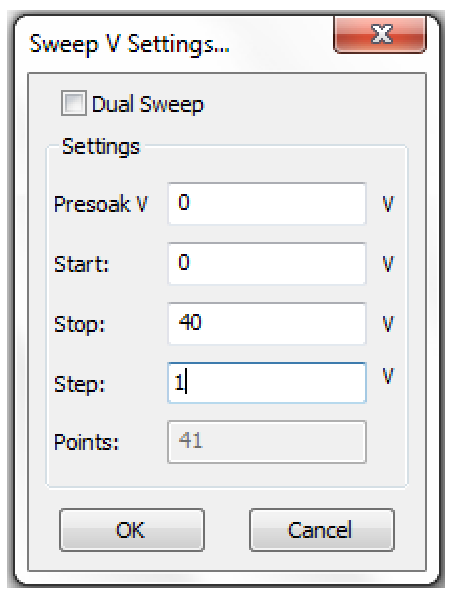
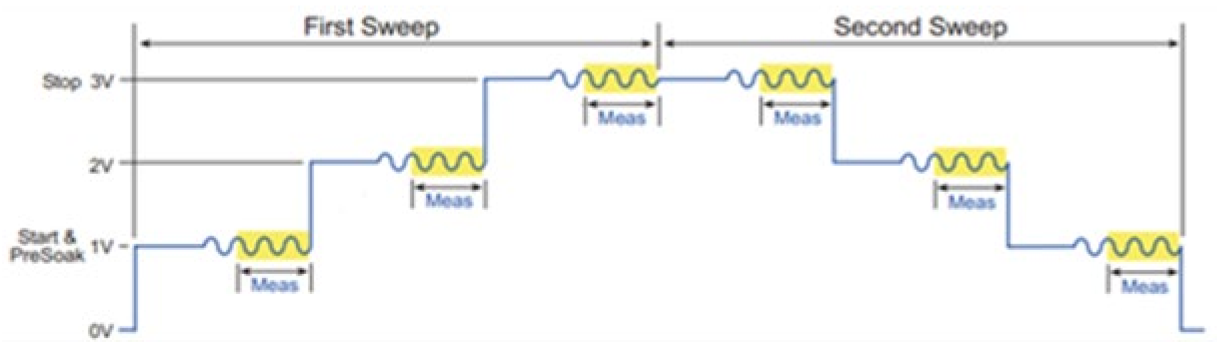


Figure 313: Dual voltage sweep example

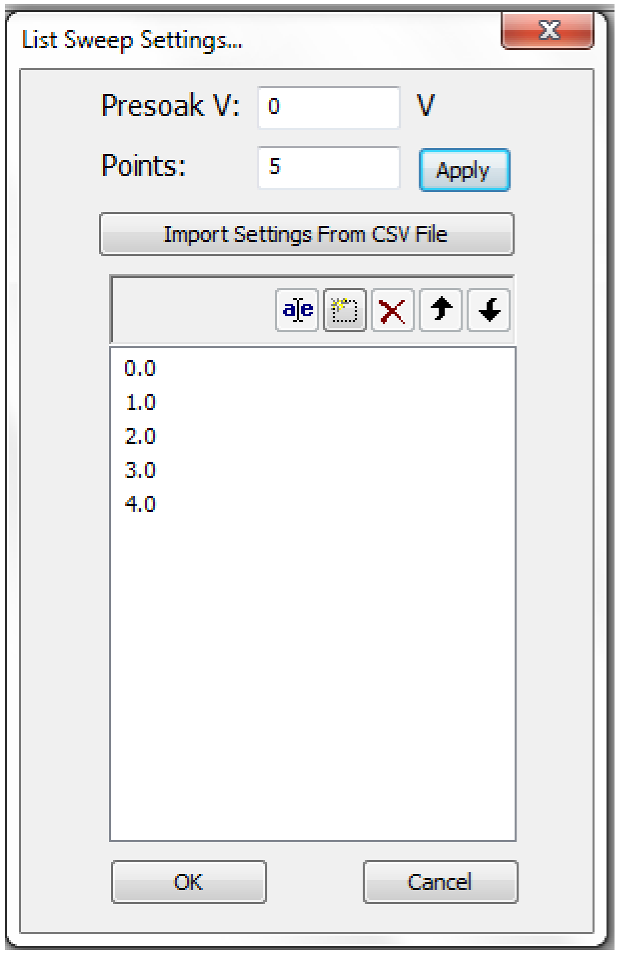


- **Presoak V:** When the test is started and before measurement sequence, the device is stressed at a specified voltage (Presoak V) for a specified period (Presoak Time).
- **Start:** The Start edit box specifies the voltage forced for the first data point of the sweep.
- **Stop:** The Stop edit box specifies the voltage forced for the last data point of the sweep.
- **Step:** The Step edit box specifies the size of the voltage increments and determines the calculated Points value
  {Points = integer value of [1 + (Stop − Start)/(Step)]}
- **Points:** Shows the number of data points that are input when a sweep is executed.

Options for **List V**:

- **Presoak V:** When the test is started and before measurement sequence, the device is stressed at a specified voltage (Presoak V) for a specified period (Presoak Time).
- **Points:** The number of points for the forcing values.
- **Import Settings From CSV File:** Allows you to import and then save a `.csv` file.
- **Edit item** **:** Change the number.
- **New item** **:** Adds a new item.
- **Delete item** **:** Delete the selected item.
- **Move up** **:** Move the selected item up.
- **Move down** **:** Move the selected item down.

Figure 314: List Sweep Settings



Measure: Measures the voltage unit in volts.

Compliance: Enables the test to abort and turn off the SMU output when it reaches the compliance (limit) value. The value is limited by the specifications of the SMU.

Meas.Range: This item is disabled.

Advanced: Double-click the Advanced cell to open a dialog that allows you to set advanced features for this SMU.

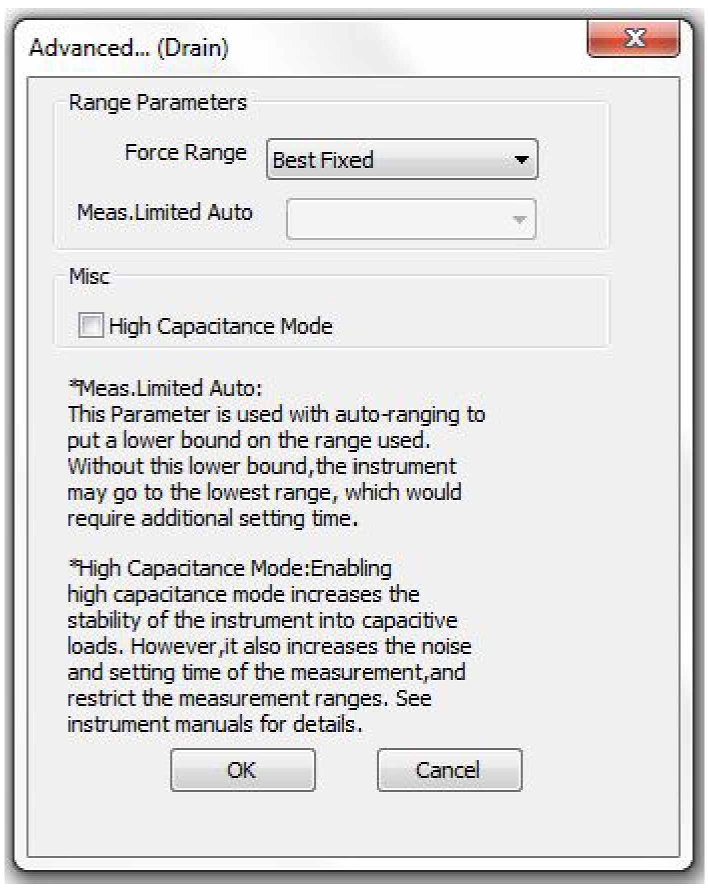
Range Parameters:

- **Force Range:** Specifies the SMU force range used to force voltage, including Best Fixed and numerical range options.
- **Meas. Limited Auto:** This item is disabled.

Misc:

- **High Capacitance Mode:** Sets the SMU to high capacitance mode.

Figure 315: SMU Advanced settings dialog



CVU Settings

Pad #: Changed with ac settings in the device map field accordingly.

CVU: Cannot be changed here. It can only be assigned in the device map field.

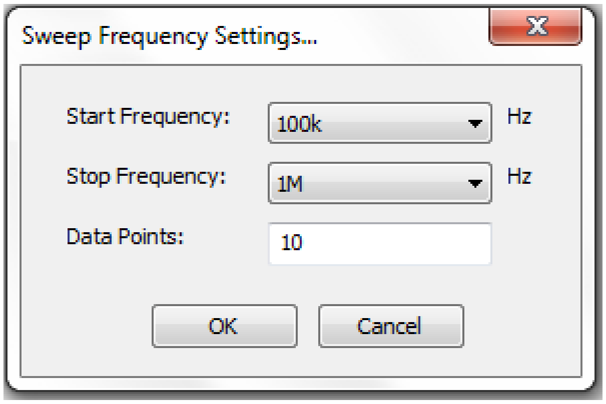
Pad Name: Changed with ac settings in the device map field accordingly.

Function: Changed with the function selected.

Frequency: Test frequency (Hz). A variable that selects the measurement frequency to use.

- In C vs. V and C vs. t, the frequency is biased (10 KHz to 2 MHz)
- In C vs. f, the frequency sweeps up or down

Figure 316: Sweep Frequency Settings



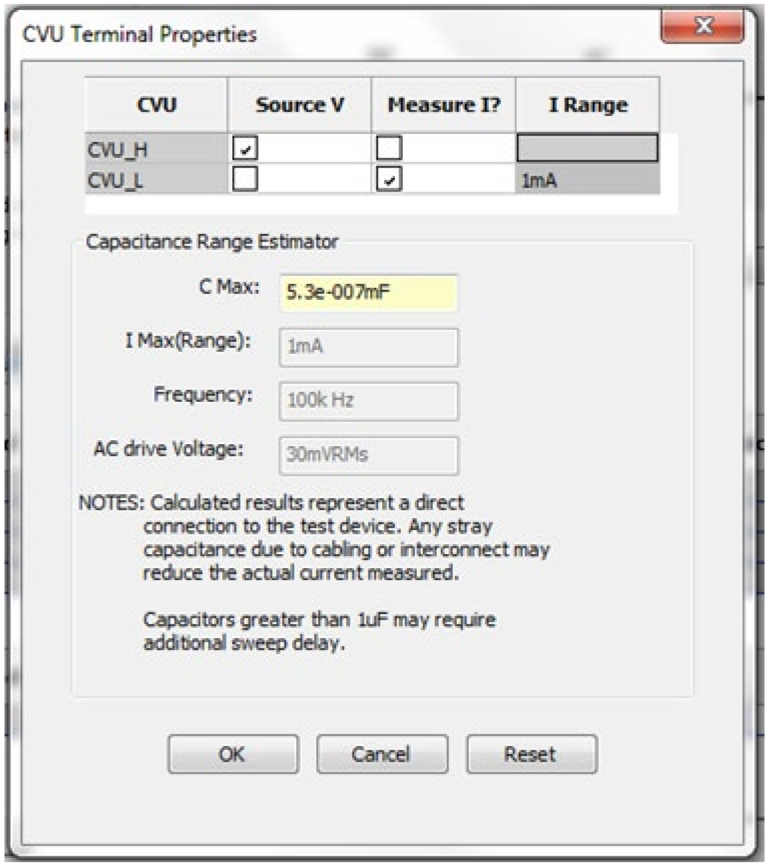
ACV: AC test voltage of CVU (10 mV to 100 mV RMS).

Model: The parameters that can be measured by the 4200-CVU:

- **Cp-Gp-D:** Parallel Capacitance and Conductance and Dissipation Factor.
- **R+jX:** Resistance and Reactance.
- **Z,Theta:** Impedance and Phase Angle.
- **Cs-Rs-D:** Series Capacitance and Conductance and Dissipation Factor.

Advanced CVU Properties

Figure 317: CVU Terminal Properties dialog



- **I Range:** Fixed 1 mA
- **Capacitance Range Estimator:** The capacitance is calculated from the capacitive impedance

The test frequency range is calculated using the following formula:

$$C_{max} \approx \frac{I_{max}}{2\pi f V_{ac}}$$

- **C Max:** The calculated capacitance
- **I Max(Range):** Fixed 1 mA
- **Frequency:** Test frequency, the value changes with the setting in CVU settings user interface accordingly
- **AC drive Voltage:** Measured ac voltage, the value changes with the setting in CVU settings user interface accordingly

Device specific high-voltage capacitance-voltage PTM

The device specific high-voltage capacitance-voltage PTM libraries are in the following directory: `ACS_BASIC\library\pyLibrary\PTMLib`. They include the following test libraries specific to different devices:

```
Specific_IGBT.py
Specific_nMOSFET.py
Specific_npnBJT.py
Specific_pMOSFET.py
Specific_pnpBJT.py
Specific_nPowerMOSFET.py
Specific_pPowerMOSFET.py
Specific_npnPowerBJT.py
Specific pnpPowerBJT.py
```

Import the `.py` file you need for your test. The device module opens.

Discharge test

The discharge test PTM library module is in the following computer directory: `ACS_BASIC\library\pyLibrary\PTMLib\Discharge_Test.py`.

This module is optional and is used to safely discharge the bias tee capacitance, especially once each CV test ends in which there is dc bias applied by the Model 2657A. You can import the `.py` file and insert it in the test sequence. This module can discharge bias tees by programming all SMUs to zero volts with 1 mA compliance and turning their outputs on for 1 second then turning off.

This module can be used for both `Generic_HVCV_Test` and device specific PTMs in MultiMode.

Device specific high-voltage capacitance-voltage PTM

The device specific high-voltage capacitance-voltage PTM libraries are in the following directory: `ACS_BASIC\library\pyLibrary\PTMLib`. They include the following test libraries specific to different devices:

```
Specific_IGBT.py
Specific_nMOSFET.py
Specific_npnBJT.py
Specific_pMOSFET.py
Specific_pnpBJT.py
Specific_nPowerMOSFET.py
Specific_pPowerMOSFET.py
Specific_npnPowerBJT.py
Specific pnpPowerBJT.py
```

Import the `.py` file you need for your test. The device module opens.

Discharge test

The discharge test PTM library module is in the following computer directory: `ACS_BASIC\library\pyLibrary\PTMLib\Discharge_Test.py`.

This module is optional and is used to safely discharge the bias tee capacitance, especially once each CV test ends in which there is dc bias applied by the Model 2657A. You can import the `.py` file and insert it in the test sequence. This module can discharge bias tees by programming all SMUs to zero volts with 1 mA compliance and turning their outputs on for 1 second then turning off.

This module can be used for both `Generic_HVCV_Test` and device specific PTMs in MultiMode.

Mixed SMUs in pulse mode

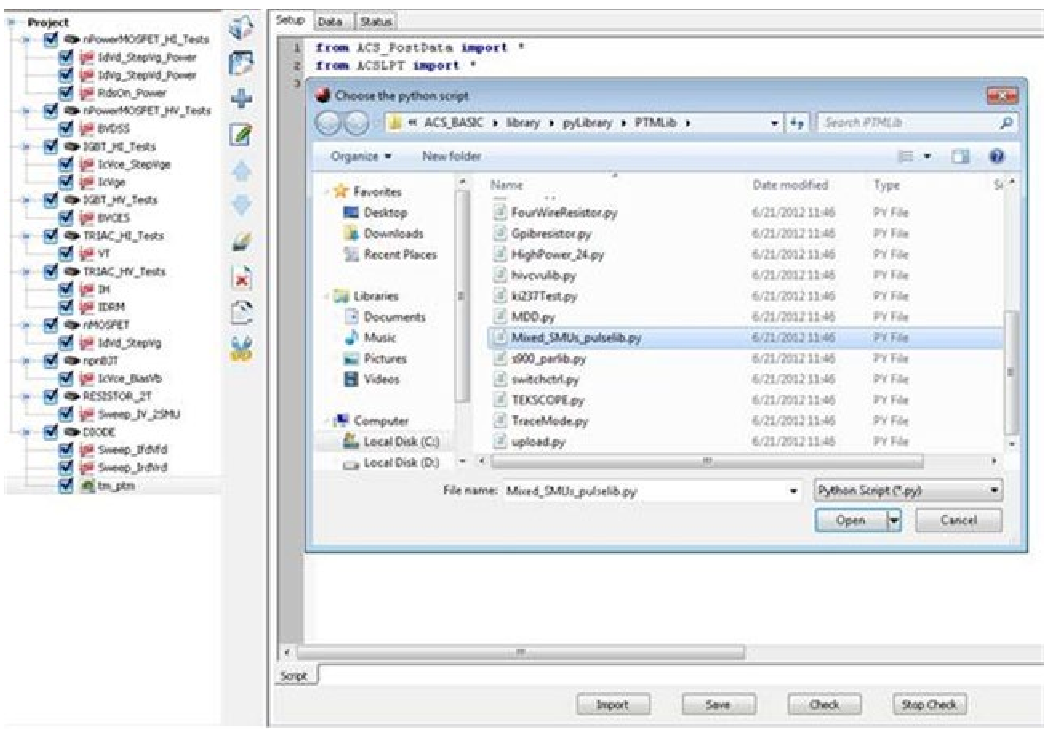
The mixed model of SMUs in pulse mode is an explanation of the mixed use-case for the Series 2650A SMU with the Series 2600 SMU, Series 2400 SMU, and Model 4200-SMU. In these tests the Series 2650A SMUs are in pulse mode, while other SMUs are in DC mode.

Mixed SMUs library overview

To open the Mixed_SMUs_pulselib PTM:

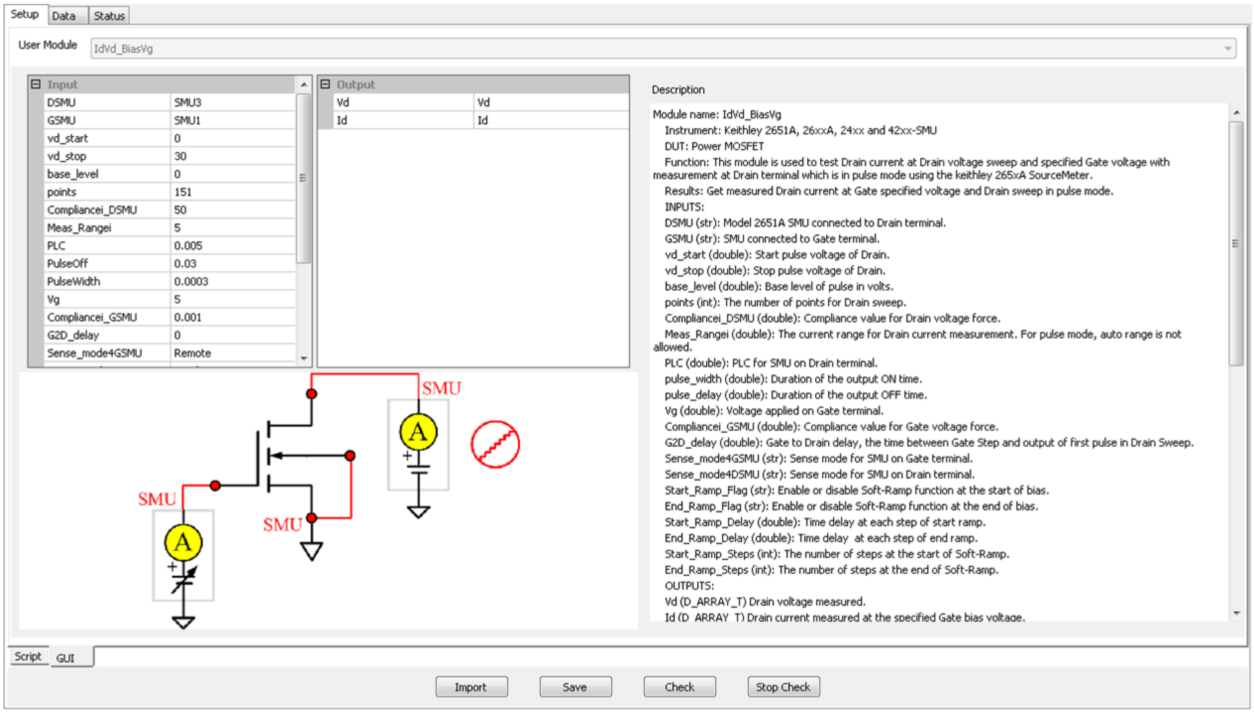
1. Select a test type in the project configuration navigator.
2. Select .
3. Select **PTM (Python Language Test Module)** to add a new PTM to the project configuration navigator.
4. Select the **Import** button.
5. Select the **Mixed_SMUs_pulselib.py** script (see next figure).

Figure 318: Import the Mixed_SMUs_pulselib PTM



The Mixed_SMUs_pulselib PTM GUI opens (see next figure).

Figure 319: Mixed_SMUs_pulselib PTM GUI



Mixed_SMUs_pulselib PTM includes the following modules:

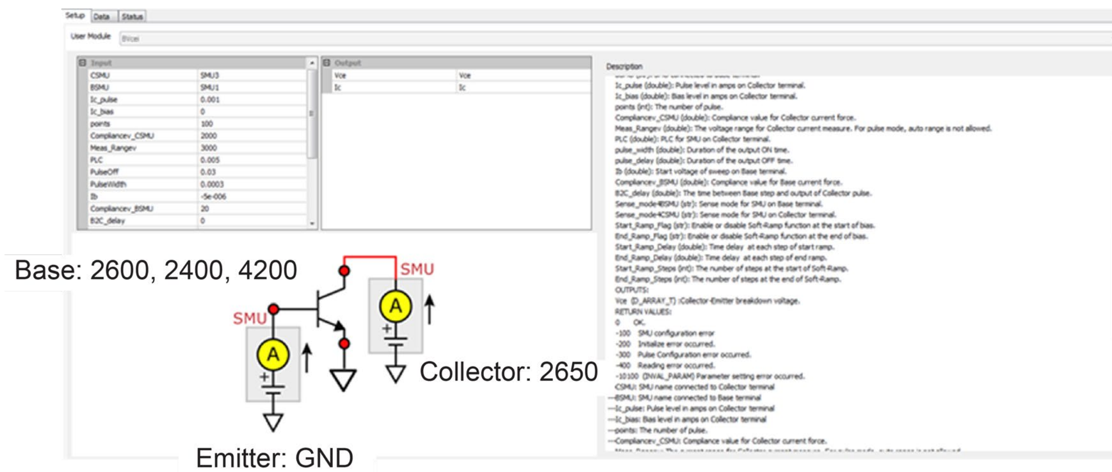
- IdVd_BiasVg
- IdVd_StepVg
- IdVg_BiasVd
- IcVce_stepVbe
- IcVce_stepIb
- Vcesat_bjt
- Vcesat_IGBT
- IcVce_StepVge
- RdsOn
- BVdsv
- BVcei
- BVcev
- IcVge
- hFE_BJT
- VgsON
- IdON

For all these tests, the high-power SMU is used in pulse mode and other SMUs are used in DC mode.

BVcei

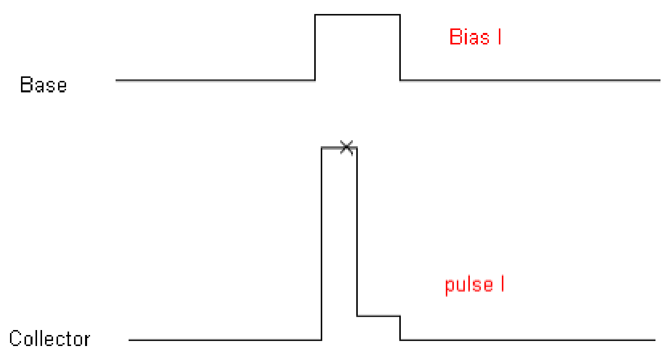
Description: Tests the collector-emitter breakdown voltage of a BJT with the base forcing current (see next figure).

Figure 320: BVcei



Test pulse sequence: Base bias I, collector pulse I (see next figure).

Figure 321: BVcei test pulse sequence



INPUTS:

`CSMU:`	Model 265xA SMU connected to collector terminal.
`BSMU:`	SMU connected to base terminal.
`Ic_pulse:`	Pulse level in amps on collector terminal.
`Ic_bias:`	Bias level in amps on collector terminal.
`points:`	The number of pulse.
`Compliancev:`	Compliance value for collector voltage force.
`Meas_Rangev:`	The voltage range for collector current measure. For pulse mode, autorange is not allowed.
`PLC:`	PLC for SMU on collector terminal.
`Pulse_Off:`	Duration of the output OFF time.
`Pulse_Width:`	Duration of the output ON time.
`Ib:`	Start voltage of sweep on base terminal.
`B2C_delay:`	The time between base step and output of collector pulse.
`Sense_mode4BSMU:`	Sense mode for SMU on base terminal.
`Sense_mode4CSMU:`	Sense mode for SMU on collector terminal.
`Start_Ramp_Flag:`	Enable or disable soft-ramp function at the start of bias.
`End_Ramp_Flag:`	Enable or disable soft-ramp function at the end of bias.
`Start_Ramp_Delay:`	Time delay at each step of start ramp.
`End_Ramp_Delay:`	Time delay at each step of end ramp.
`Start_Ramp_Steps:`	The number of steps at the start of soft-ramp.
`End_Ramp_Steps:`	The number of steps at the end of soft-ramp.

OUTPUTS:

`Vce:`	Collector-emitter breakdown voltage.
DUT:	A BJT and the instruments are Keithley Model 265xA (at least one 265xA) and a 26xxB SMU, 24xx SMU and 42xx SMU. Lower power model SMUs must be classified as the same type, for example, the Model 2651A SMUs are the same type and the Model 2657A SMUs are the same type.

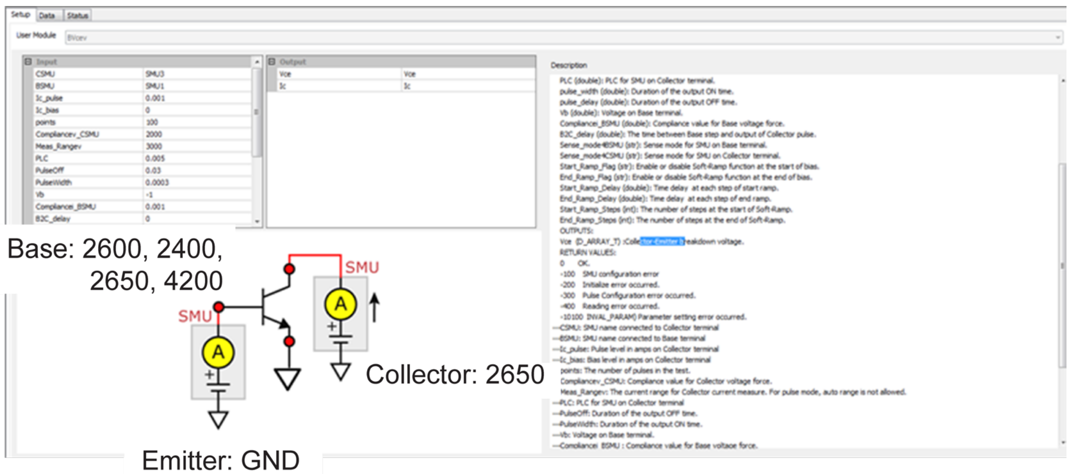
NOTE

If the base terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the collector terminal.

BVcev

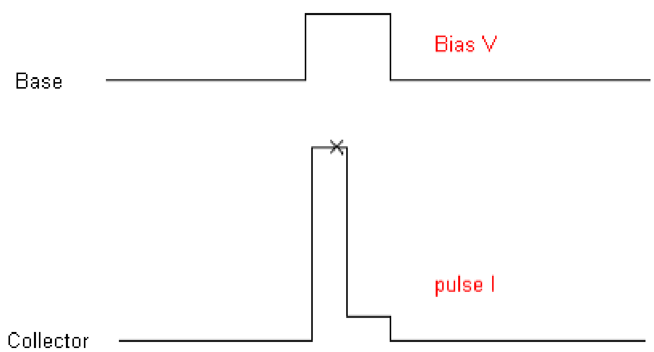
Description: Tests the collector-emitter breakdown voltage of a BJT with the base forcing voltage (see next figure).

Figure 322: BVcev



Test pulse sequence: base bias V, collector pulse I (see next figure).

Figure 323: BVcev test pulse sequence



INPUTS:

`CSMU:`	Model 265xA SMU connected to collector terminal.
`BSMU:`	SMU connected to base terminal.
`Ic_pulse:`	Pulse level in amps on collector terminal.
`Ic_bias:`	Bias level in amps on collector terminal.
`points:`	The number of pulse in the test.
`Compliancev:`	Compliance value for collector voltage force.
`Meas_Rangev:`	The voltage range for drain current measure. For pulse mode, autorange is not allowed.
`PLC:`	PLC for SMU on collector terminal.
`Pulse_Off:`	Duration of the output OFF time.
`Pulse_Width:`	Duration of the output ON time.
`Vb:`	Voltage on base terminal.
`B2C_delay:`	The time between base step and output of collector pulse.
`Sense_mode4BSMU:`	Sense mode for SMU on base terminal.
`Sense_mode4CSMU:`	Sense mode for SMU on collector terminal.
`Start_Ramp_Flag:`	Enable or disable soft-ramp function at the start of bias.
`End_Ramp_Flag:`	Enable or disable soft-ramp function at the end of bias.
`Start_Ramp_Delay:`	Time delay at each step of start ramp.
`End_Ramp_Delay:`	Time delay at each step of end ramp.
`Start_Ramp_Steps:`	The number of steps at the start of soft-ramp.
`End_Ramp_Steps:`	The number of steps at the end of soft-ramp.

OUTPUTS:

Vce:	Collector-emitter breakdown voltage.
DUT:	A BJT and the instruments are Keithley Model 265xA (at least one 265xA) and a 26xxB SMU, 24xx SMU and 42xx SMU. Lower power model SMUs must be classified as the same type, for example, the Model 2651A SMUs are the same type and the Model 2657A SMUs are the same type.

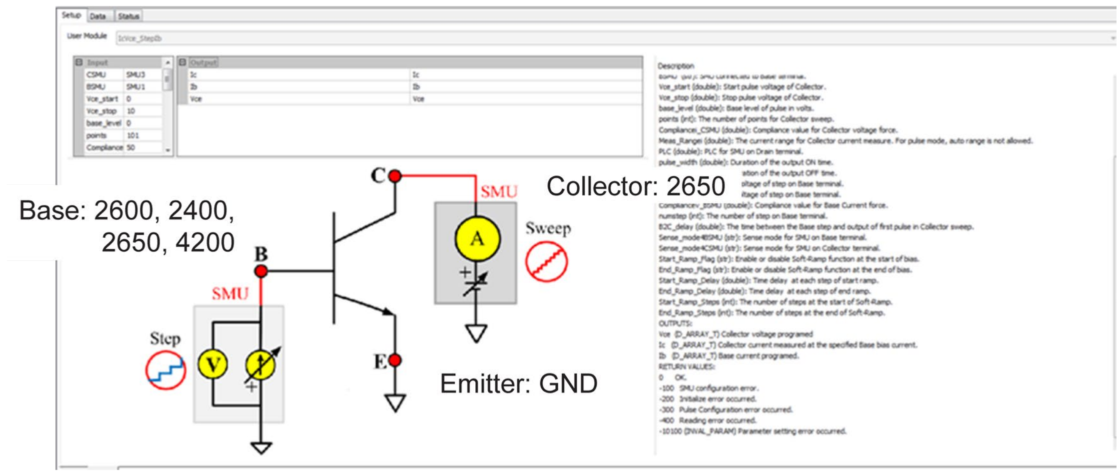
NOTE

If the base terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the collector terminal.

IcVce_StepIb

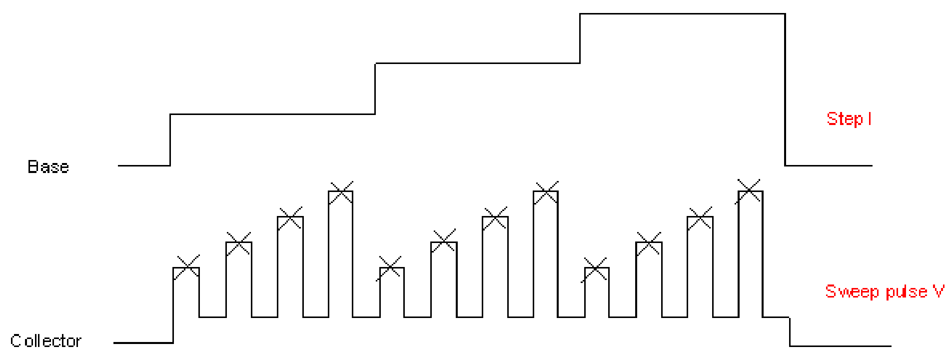
Description: Measures the voltage and current at the collector terminal while sweeping the collector voltage for each voltage step at the base terminal (see next figure).

Figure 324: IcVce_StepIb



Test pulse sequence: Collector sweep pulse V, base step I (see next figure).

Figure 325: IcVce_StepIb test pulse sequence



INPUTS:

CSMU:	Model 265xA SMU connected to collector terminal.
BSMU:	SMU connected to base terminal.
Vce_start:	Start pulse voltage of collector.
Vce_stop:	Stop pulse voltage of collector.
Base_level:	Base level of pulse in volts.
points:	The number of points for collector sweep
Compliancei:	Compliance value for collector voltage force.
Meas_Rangei:	The current range for collector current measure. For pulse mode, autorange is not allowed.
PLC:	PLC for SMU on drain terminal.
Pulse_Off:	Duration of the output OFF time.
Pulse_Width:	Duration of the output ON time.
Ib_start:	Start voltage of step on base terminal.
Ib_stop:	Stop voltage of step on base terminal.
numstep:	The number of steps on base terminal.
B2C_delay:	The time between the base step and output of first pulse in collector sweep.
Sense_mode4BSMU:	Sense mode for SMU on base terminal.
Sense_mode4CSMU:	Sense mode for SMU on collector terminal.
Start_Ramp_Flag:	Enable or disable soft-ramp function at the start of bias.
End_Ramp_Flag:	Enable or disable soft-ramp function at the end of bias.
Start_Ramp_Delay:	Time delay at each step of start ramp.
End_Ramp_Delay:	Time delay at each step of end ramp.
Start_Ramp_Steps:	The number of steps at the start of soft-ramp.
End_Ramp_Steps:	The number of steps at the end of soft-ramp.

OUTPUTS:

Vce:	Collector voltage programmed.
Ic:	Collector current measured at the specified base bias current.
DUT:	A BJT and the instruments are Keithley Model 265xA (at least one 265xA) and a 26xxB SMU, 24xx SMU and 42xx SMU. Lower power model SMUs must be classified as the same type, for example, the Model 2651A SMUs are the same type and the Model 2657A SMUs are the same type.

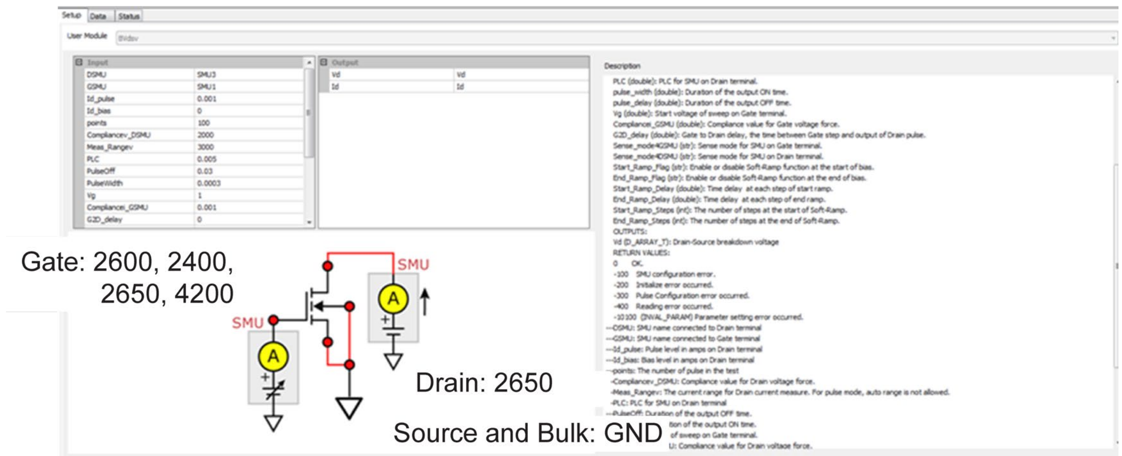
NOTE

If the base terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the collector terminal.

BVdsv

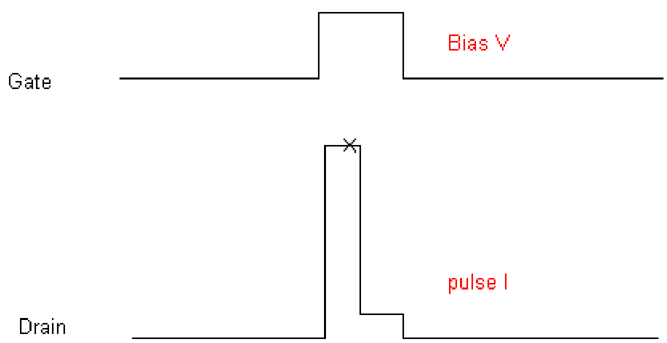
Description: Tests the drain-source breakdown voltage of a MOSFET with the gate biasing voltage (see next figure).

Figure 326: BVdsv



Test pulse sequence: Gate bias V, drain pulse I (see next figure).

Figure 327: BVdsv test pulse sequence



INPUTS:

`DSMU:`	Model 265xA SMU connected to drain terminal.
`GSMU:`	SMU connected to gate termina
`Id_pulse:`	Pulse level in amps on drain terminal.
`Id_bias:`	Bias level in amps on drain terminal.
`Points:`	The number of pulse in the test
`Compliancev:`	Compliance value for drain voltage force.
`Meas_Rangev:`	The voltage range for drain current measure. For pulse mode, autorange is not allowed.
`PLC:`	PLC for SMU on drain terminal.
`Pulse_Off:`	Duration of the output OFF time.
`Pulse_Width:`	Duration of the output ON time.
`Vg:`	Start voltage of sweep on gate terminal.
`G2D_delay:`	Gate to drain delay, the time between gate step and output of drain pulse.
`Sense_mode4GSMU:`	Sense mode for SMU on gate terminal.
`Sense_mode4DSMU:`	Sense mode for SMU on drain terminal.
`Start_Ramp_Flag:`	Enable or disable soft-ramp function at the start of bias.
`End_Ramp_Flag:`	Enable or disable soft-ramp function at the end of bias
`Start_Ramp_Delay:`	Time delay at each step of start ramp.
`End_Ramp_Delay:`	Time delay at each step of end ramp.
`Start_Ramp_Steps:`	The number of steps at the start of soft-ramp.
`End_Ramp_Steps:`	The number of steps at the end of soft-ramp.

OUTPUTS:

`Vd:`	Drain-source breakdown voltage I.
DUT:	A MOSFET and the instruments are Keithley Model 265xA (at least one 265xA) and a 26xxB SMU, 24xx SMU and 42xx SMU. Lower power model SMUs must be classified as the same type, for example, the Model 2651A SMUs are the same type and the Model 2657A SMUs are the same type.

NOTE

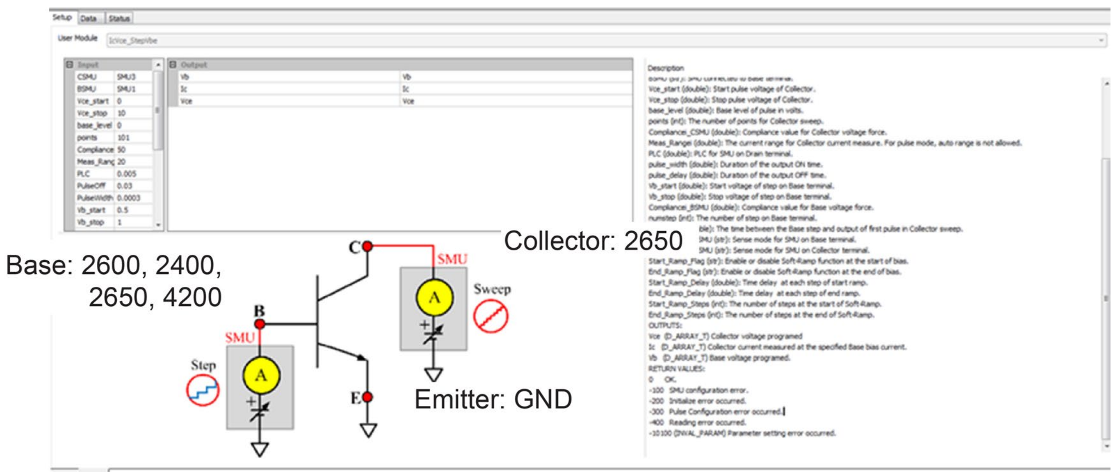
If the gate terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the drain terminal.

IcVce_StepVbe

Description:

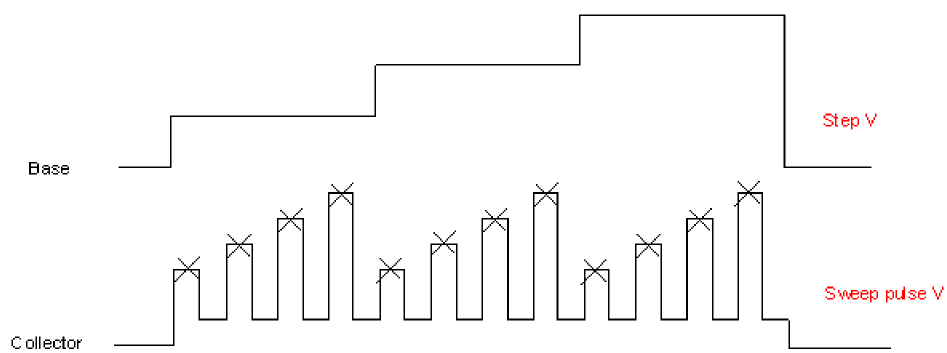
Measures the voltage and current at the collector-terminal while sweeping the collector voltage for each voltage step at the base terminal (see next figure).

Figure 328: IcVce_StepVbe



Test pulse sequence: Collector sweep pulse V, base step V (see next figure).

Figure 329: IcVce_StepVbe test pulse sequence



INPUTS:

CSMU:	Model 265xA SMU connected to collector terminal.
BSMU:	SMU connected to base terminal.
Vce_start:	Start pulse voltage of collector.
Vce_stop:	Stop pulse voltage of collector.
Base_level:	Base level of pulse in volts.
points:	The number of points for collector sweep.
Compliancei:	Compliance value for collector voltage force.
Meas_Rangei:	The current range for collector current measure. For pulse mode, autorange is not allowed.
PLC:	PLC for SMU on drain terminal.
Pulse_Off:	Duration of the output OFF time.
Pulse_Width:	Duration of the output ON time.
Vb_start:	Start voltage of step on base terminal.
Vb_stop:	Stop voltage of step on base terminal.
numstep:	The number of step on base terminal.
B2C_delay:	The time between the base step and output of first pulse in collector sweep.
Sense_mode4BSMU:	Sense mode for SMU on base terminal.
Sense_mode4CSMU:	Sense mode for SMU on collector terminal.
Start_Ramp_Flag:	Enable or disable soft-ramp function at the start of bias.
End_Ramp_Flag:	Enable or disable soft-ramp function at the end of bias.
Start_Ramp_Delay:	Time delay at each step of start ramp.
End_Ramp_Delay:	Time delay at each step of end ramp.
Start_Ramp_Steps:	The number of steps at the start of soft-ramp.
End_Ramp_Steps:	The number of steps at the end of soft-ramp.

OUTPUTS:

Vce:	Collector voltage programmed.
Ic:	Collector current measured at the specified base bias current.
DUT:	A BJT and the instruments are Keithley Model 265xA (at least one 265xA) and a 26xxB SMU, 24xx SMU and 42xx SMU. Lower power model SMUs must be classified as the same type, for example, the Modes 2651A SMUs are the same type and the Model 2657A SMUs are the same type.

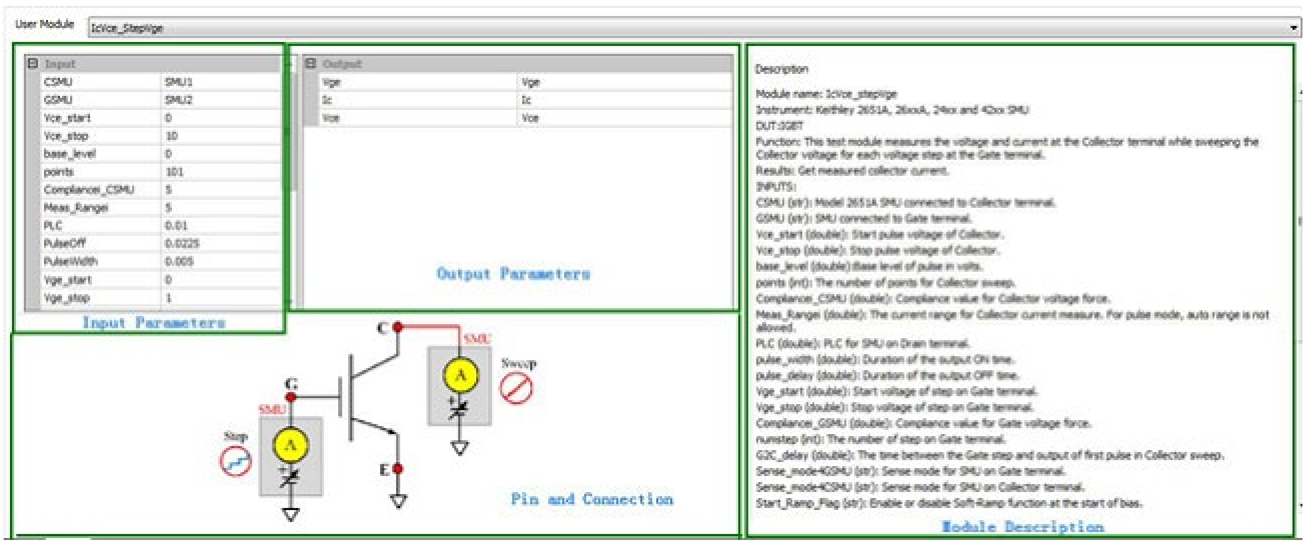
NOTE

If the base terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the collector terminal.

IcVce_StepVge

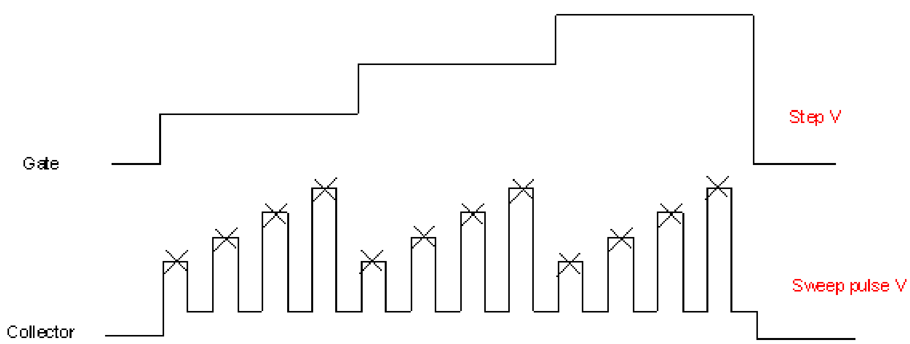
Description: Measures the voltage and current at the collector terminal while sweeping the collector voltage for each voltage step at the gate terminal (see next figure).

Figure 330: IcVce_StepVge



Test pulse sequence: Collector sweep pulse V, gate step V (see next figure).

Figure 331: IcVce_StepVge test pulse sequence



INPUTS:

`CSMU:`	Model 265xA SMU connected to collector terminal.
`GSMU:`	SMU connected to gate terminal.
`Vce_start:`	Start pulse voltage of collector.
`Vce_stop:`	Stop pulse voltage of collector.
`Base_level:`	Base level of pulse in volts.
`points:`	The number of points for collector sweep.
`Compliancei:`	Compliance value for collector voltage force.
`Meas_Rangei:`	The current range for collector current measure. For pulse mode, autorange is not allowed.
`PLC:`	PLC for SMU on drain terminal.
`Pulse_Off:`	Duration of the output OFF time.
`Pulse_Width:`	Duration of the output ON time.
`Vge_start:`	Start voltage of step on gate terminal.
`Vge_stop:`	Stop voltage of step on gate terminal.
`numstep:`	The number of step on gate terminal.
`G2C_delay:`	The time between the gate step and output of first pulse in collector sweep.
`Sense_mode4GSMU:`	Sense mode for SMU on gate terminal.
`Sense_mode4CSMU:`	Sense mode for SMU on collector terminal.
`Start_Ramp_Flag:`	Enable or disable soft-ramp function at the start of bias.
`End_Ramp_Flag:`	Enable or disable soft-ramp function at the end of bias.
`Start_Ramp_Delay:`	Time delay at each step of start ramp.
`End_Ramp_Delay:`	Time delay at each step of end ramp.
`Start_Ramp_Steps:`	The number of steps at the start of soft-ramp.
`End_Ramp_Steps:`	The number of steps at the end of soft-ramp.

OUTPUTS:

`Vce:`	Collector voltage programmed
`Ic:`	Collector current measured at the specified gate bias current.
`DUT:`	An IGBT and the instruments are Keithley Model 265xA (at least one 265xA) and a 26xxB SMU, 24xx SMU and 42xx SMU. Lower power model SMUs must be classified as the same type, for example, the Model 2651A SMUs are the same type and the Model 2657A SMUs are the same type.

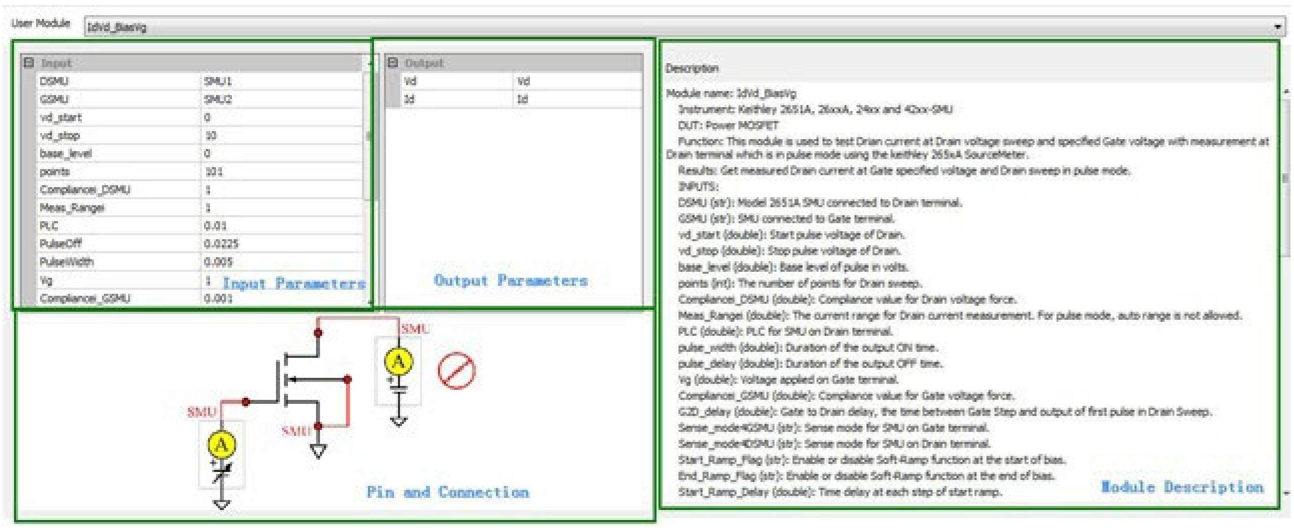
NOTE

If the gate terminal is connected to a Series 2650A SMU, make sure it is the same type as the Series 2650A SMU that is connected to the collector terminal.

IdVd_BiasVg

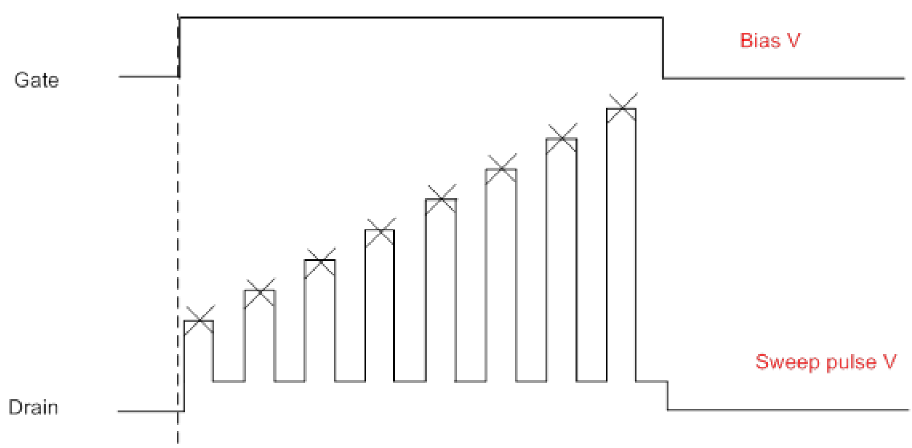
Description: Tests the current over a drain voltage sweep at a specified gate voltage, with measurements at the drain terminal, which is in pulse mode using the Keithley Series 2650A SourceMeter (see next figure).

Figure 332: IdVd_BiasVg



Test pulse sequence: Gate bias V, drain sweep pulse V (see next figure).

Figure 333: Idvd_BiasVg test pulse sequence



INPUTS:

`DSMU:`	SMU connected to drain terminal.
`GSMU:`	SMU connected to gate terminal.
`vd_start:`	Start pulse voltage of drain terminal.
`vd_stop:`	Stop pulse voltage of drain terminal.
`Base_level:`	Base level of pulse in volts.
`Points:`	The number of points for drain sweep.
`Compliancei:`	Compliance value for drain voltage force.
`Meas_Rangei:`	The current range for drain current measure. For pulse mode, autorange is not allowed.
`PLC:`	PLC for SMU on drain terminal.
`Pulse_Off:`	Duration of the output OFF time.
`Pulse_Width:`	Duration of the output ON time.
`Vg:`	Voltage applied on gate terminal.
`G2D_delay:`	Gate to drain delay, the time between gate step and output of first pulse in drain sweep.
`Sense_mode4GSMU:`	Sense mode setting for SMU on gate terminal.
`Sense_mode4DSMU:`	Sense mode setting for SMU on drain terminal.
`Start_Ramp_Flag:`	Enable or disable soft-ramp function at the start of bias.
`End_Ramp_Flag:`	Enable or disable soft-ramp function at the end of bias.
`Start_Ramp_Delay:`	Time delay at each step of start ramp.
`End_Ramp_Delay:`	Time delay at each step of end ramp.
`Start_Ramp_Steps:`	The number of steps at the start of soft-ramp.
`End_Ramp_Steps:`	The number of steps at the end of soft-ramp.

OUTPUTS:

`Vd:`	Drain voltage programmed.
`Id:`	Drain current measured at the specified gate bias voltage.
`DUT:`	A MOSFET and the instruments are Keithley Model 265xA (at least one 265xA) and a 26xxB SMU, 24xx SMU, and 42xx SMU. Lower power model SMUs must be classified as the same type, for example, the Model 2651A SMUs are the same type or the Model 2657A SMUs are the same type.

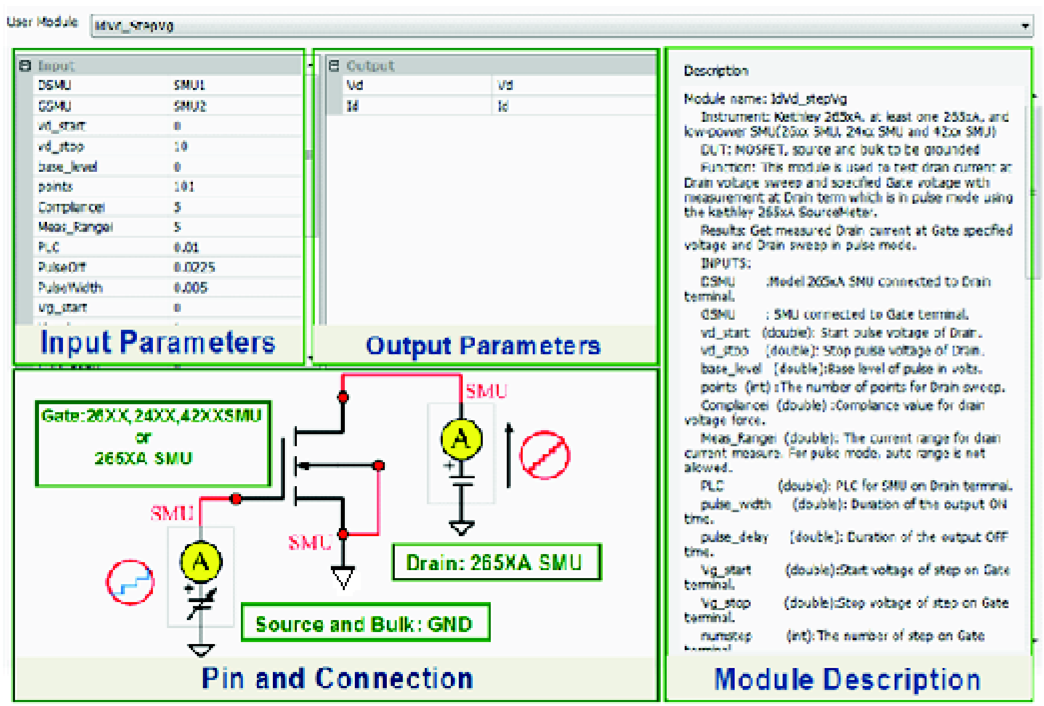
NOTE

If the gate terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the drain terminal.

IdVd_StepVg

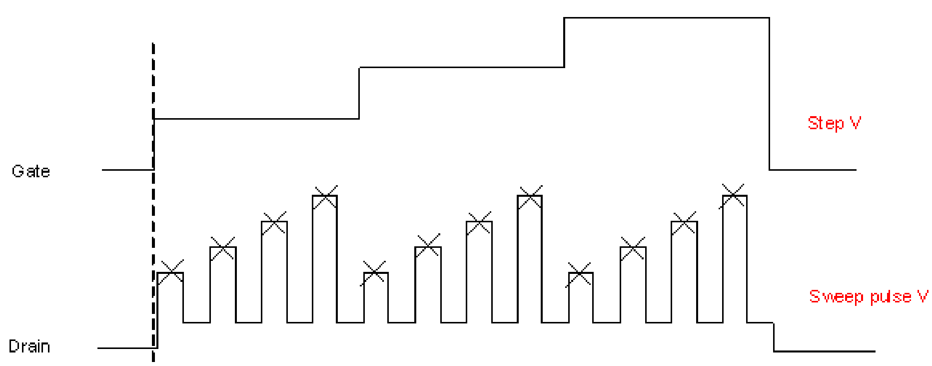
Description: Tests the drain current at the drain voltage sweep and the specified gate voltage, with measurements at the drain terminal, which is in pulse mode using the Keithley Series 2650A SourceMeter (see next figure).

Figure 334: IdVd_StepVg



Test pulse sequence: Gate step V, drain sweep pulse V (see next figure).

Figure 335: Idvd_StepVg test pulse sequence



INPUTS:

DSMU:	SMU connected to drain terminal.
GSMU:	SMU connected to gate terminal.
vd_start:	Start pulse voltage of drain terminal.
vd_stop:	Stop pulse voltage of drain terminal.
Base_level:	Base level of pulse in volts.
Points:	The number of points for drain sweep.
Compliancei:	Compliance value for drain voltage force.
Meas_Rangei:	The current range for drain current measure. For pulse mode, autorange is not allowed.
PLC:	PLC for SMU on drain terminal.
Pulse_Off:	Duration of the output OFF time.
Pulse_Width:	Duration of the output ON time.
Vg_start:	Start voltage of step on gate terminal.
Vg_stop:	Stop voltage of step on gate terminal.
Numstep:	The number of step on gate terminal.
G2D_delay:	Gate to drain delay, the time between gate step and output of first pulse in drain sweep.
Sense_mode4GSMU:	Sense mode setting for SMU on gate terminal.
Sense_mode4DSMU:	Sense mode setting for SMU on drain terminal.
Start_Ramp_Flag:	Enable or disable soft-ramp function at the start of bias.
End_Ramp_Flag:	Enable or disable soft-ramp function at the end of bias.
Start_Ramp_Delay:	Time delay at each step of start ramp.
End_Ramp_Delay:	Time delay at each step of end ramp.
Start_Ramp_Steps:	The number of steps at the start of soft-ramp.
End_Ramp_Steps:	The number of steps at the end of soft-ramp.

OUTPUTS:

Vd:	Drain voltage programmed.
Id:	Drain current measured at the specified gate bias voltage.
DUT:	A MOSFET and the instruments are Keithley Model 265xA (at least one 265xA) and a 26xxB SMU, 24xx SMU, and 42xx SMU. Lower power model SMUs must be classified as the same type, for example, the Model 2651A SMUs are the same type and the Model 2657A SMUs are the same type.

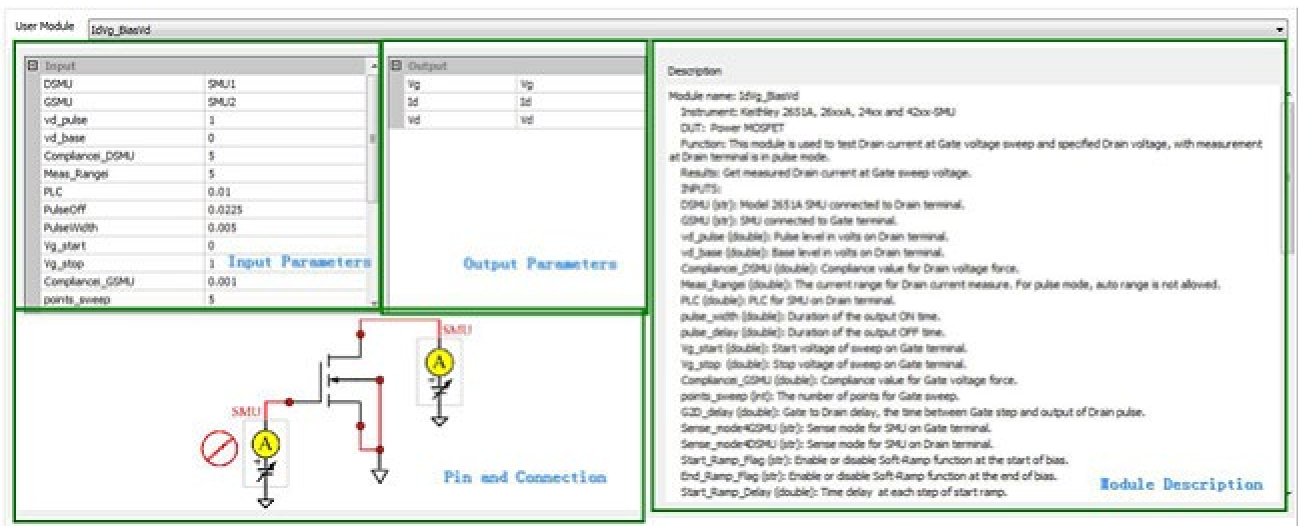
NOTE

If the gate terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the drain terminal.

IdVg_BiasVd

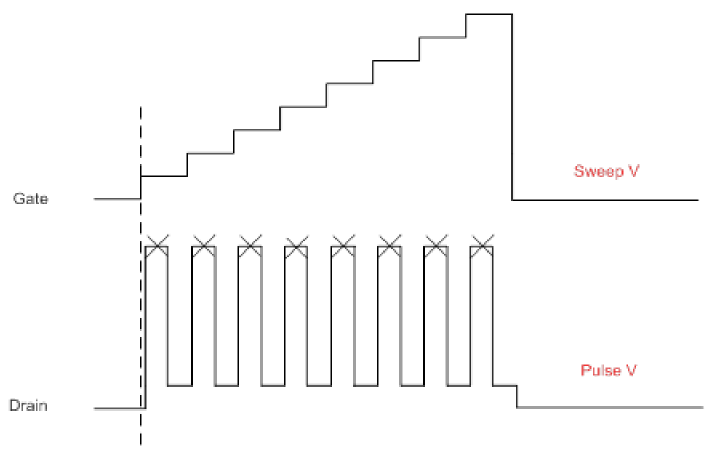
Description: Tests the drain current at the gate voltage sweep and the specified drain voltage, with measurements at the drain terminal, which is in pulse mode (see next figure).

Figure 336: Idvg_BiasVd



Test pulse sequence: Gate sweep V, drain pulse V (see next figure).

Figure 337: Idvg test pulse sequence



INPUTS:

DSMU:	SMU connected to drain terminal.
GSMU:	SMU connected to gate terminal.
vd_pulse:	Pulse level in volts on drain terminal.
vd_Base:	Base level in volts on drain terminal.
Compliancei:	Compliance value for drain voltage force.
Meas_Rangei:	The current range for drain current measure. For pulse mode, autorange is not allowed.
PLC:	PLC for SMU on drain terminal.
Pulse_Off:	Duration of the output OFF time.
Pulse_Width:	Duration of the output ON time.
Vg_start:	Start voltage of sweep on gate terminal.
Vg_stop:	Stop voltage of sweep on gate terminal.
points_sweep:	The number of points for gate sweep.
G2D_delay:	Gate to drain delay, the time between gate step and output of drain pulse.
Sense_mode4GSMU:	Sense mode for SMU on gate terminal.
Sense_mode4DSMU:	Sense mode for SMU on drain terminal.
Start_Ramp_Flag:	Enable or disable soft-ramp function at the start of bias.
End_Ramp_Flag:	Enable or disable soft-ramp function at the end of bias.
Start_Ramp_Delay:	Time delay at each step of start ramp.
End_Ramp_Delay:	Time delay at each step of end ramp.
Start_Ramp_Steps:	The number of steps at the start of soft-ramp.
End_Ramp_Steps:	The number of steps at the end of soft-ramp.

OUTPUTS:

Vg:	Gate voltage programmed.
Id:	drain current measured at the specified gate bias voltage.
DUT:	A MOSFET and the instruments are Keithley Model 265xA (at least one 265xA) and a 26xxB SMU, 24xx SMU, and 42xx SMU. Lower power model SMUs must be classified as the same type, for example, the Model 2651A SMUs are the same type and the Model 2657A SMUs are the same type.

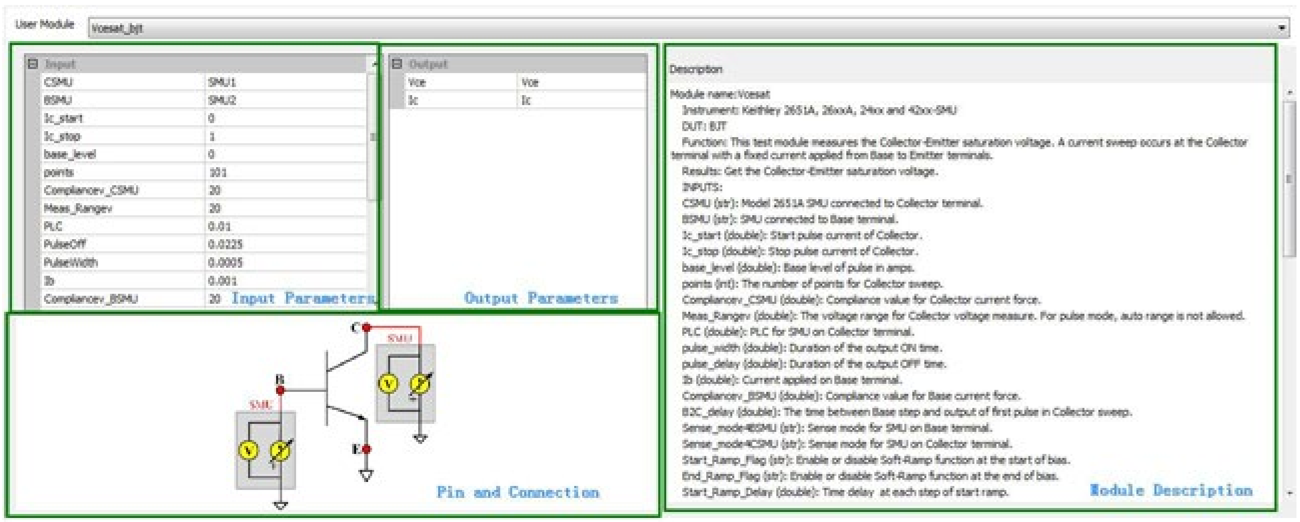
NOTE

If the gate terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the drain terminal.

Vcesat_bjt

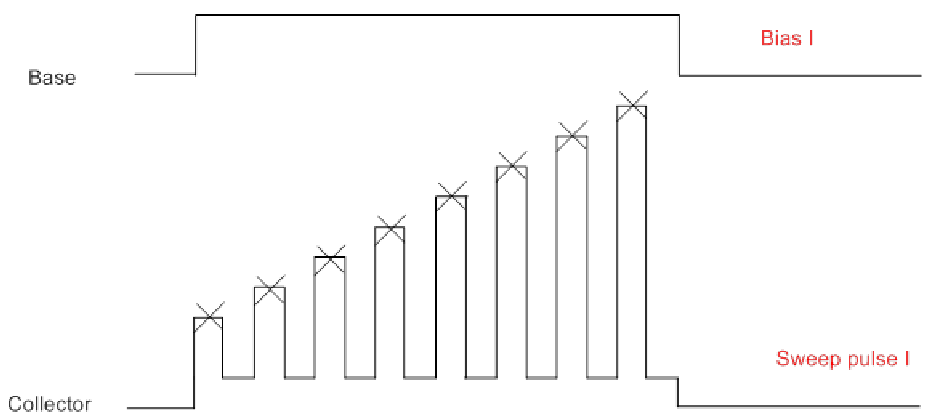
Description: Measures the collector-emitter saturation voltage. A current sweep occurs at the collector terminal with a fixed current applied to the base and emitter terminals (see next figure).

Figure 338: Vcesat_bjt



Test pulse sequence: Collector sweep pulse I, base bias I (see next figure).

Figure 339: Vcesat_BJT test pulse sequence



INPUTS:

`CSMU:`	Model 265xA SMU connected to collector terminal.
`BSMU:`	SMU connected to base terminal.
`Ic_start:`	Start pulse current of collector.
`Ic_stop:`	Stop pulse current of collector.
`Base_level:`	Base level of pulse in amps.
`points:`	The number of points for collector sweep.
`Compliancev:`	Compliance value for collector current force.
`Meas_Rangev:`	The voltage range for collector voltage measure. For pulse mode, autorange is not allowed.
`PLC:`	PLC for SMU on collector terminal.
`Pulse_Off:`	Duration of the output OFF time.
`Pulse_Width:`	Duration of the output ON time.
`Ib:`	Current applied on base terminal.
`B2C_delay:`	The time between base step and output of first pulse in collector sweep.
`Sense_mode4BSMU:`	Sense mode for SMU on base terminal.
`Sense_mode4CSMU:`	Sense mode for SMU on collector terminal.
`Start_Ramp_Flag:`	Enable or disable soft-ramp function at the start of bias.
`End_Ramp_Flag:`	Enable or disable soft-ramp function at the end of bias.
`Start_Ramp_Delay:`	Time delay at each step of start ramp.
`End_Ramp_Delay:`	Time delay at each step of end ramp.
`Start_Ramp_Steps:`	The number of steps at the start of soft-ramp.
`End_Ramp_Steps:`	The number of steps at the end of soft-ramp

OUTPUTS:

`Vce:`	Collector-emitter voltage measured at the specified base bias current.
`Ic:`	Current programmed at Collector terminal.
DUT:	A BJT and the instruments are Keithley Model 265xA (at least one 265xA) and a 26xxB SMU, 24xx SMU and 42xx SMU. Lower power model SMUs must be classified as the same type, for example, the Model 2651A SMUs are the same type and the Model 2657A SMUs are the same type.

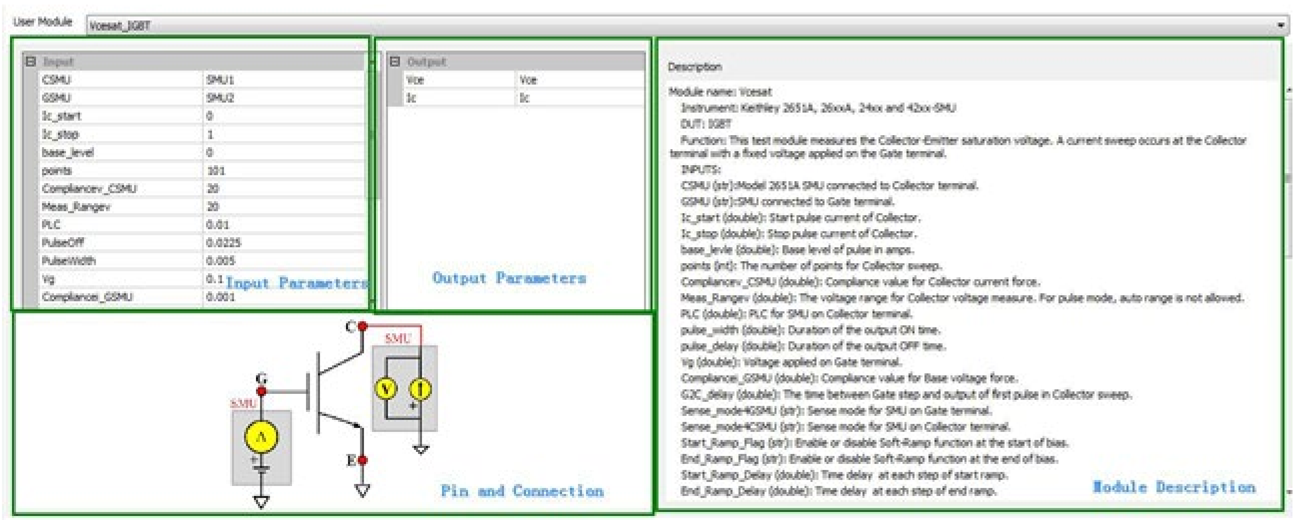
NOTE

If the base terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the collector terminal.

Vcesat_IGBT

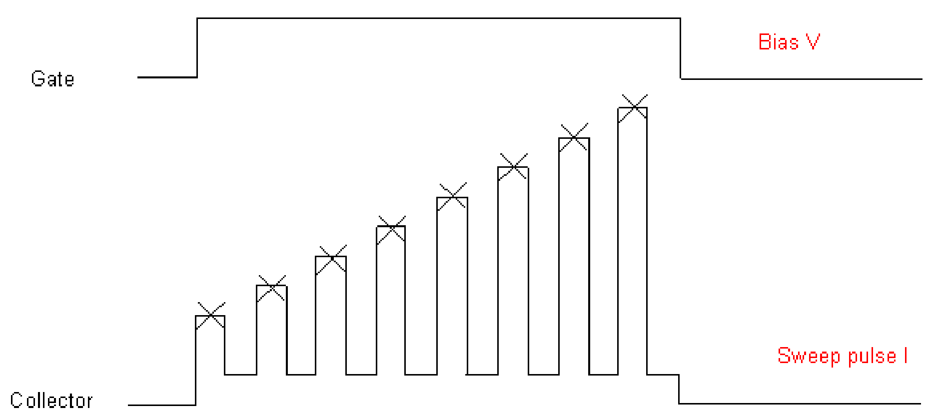
Description: Measures the collector-emitter saturation voltage. A current sweep occurs at the collector terminal with a fixed voltage applied at the gate terminal (see next figure).

Figure 340: Vcesat_IGBT



Test pulse sequence: Collector sweep pulse I, gate bias V (see next figure).

Figure 341: Vcesat_IGBT test pulse sequence



INPUTS:

`CSMU:`	Model 265xA SMU connected to collector terminal.
`GSMU:`	SMU connected to gate terminal.
`Ic_start:`	Start pulse current of collector.
`Ic_stop:`	Stop pulse current of collector.
`Base_level:`	Base level of pulse in amps.
`points:`	The number of points for collector sweep.
`Compliancev:`	Compliance value for collector current force.
`Meas_Rangev:`	The voltage range for collector voltage measure. For pulse mode, autorange is not allowed.
`PLC:`	PLC for SMU on collector terminal.
`Pulse_Off:`	Duration of the output OFF time.
`Pulse_Width:`	Duration of the output ON time.
`Vg:`	Voltage applied on gate terminal.
`G2C_delay:`	The time between gate step and output of first pulse in collector sweep.
`Sense_mode4GSMU:`	Sense mode for SMU on gate terminal.
`Sense_mode4CSMU:`	Sense mode for SMU on collector terminal.
`Start_Ramp_Flag:`	Enable or disable soft-ramp function at the start of bias.
`End_Ramp_Flag:`	Enable or disable soft-ramp function at the end of bias.
`Start_Ramp_Delay:`	Time delay at each step of start ramp.
`End_Ramp_Delay:`	Time delay at each step of end ramp.
`Start_Ramp_Steps:`	The number of steps at the start of soft-ramp.
`End_Ramp_Steps:`	The number of steps at the end of soft-ramp

OUTPUTS:

`Vce:`	Collector-emitter voltage measured at the specified gate bias voltage.
`Ic:`	Current programmed at collector terminal.
DUT:	An IGBT and the instruments are Keithley Model 265xA (at least one 265xA) and a 26xxB SMU, 24xx SMU and 42xx SMU. Lower power model SMUs must be classified as the same type, for example, the Model 2651A SMUs are the same type and the Model 2657A SMUs are the same type.

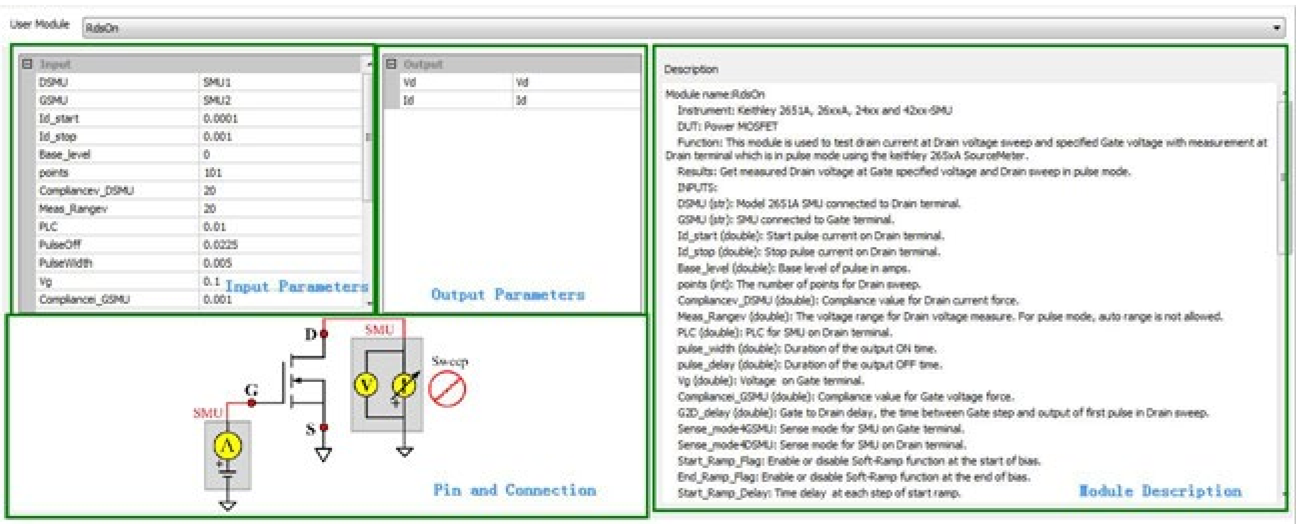
NOTE

If the gate terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to collector terminal.

Rdson

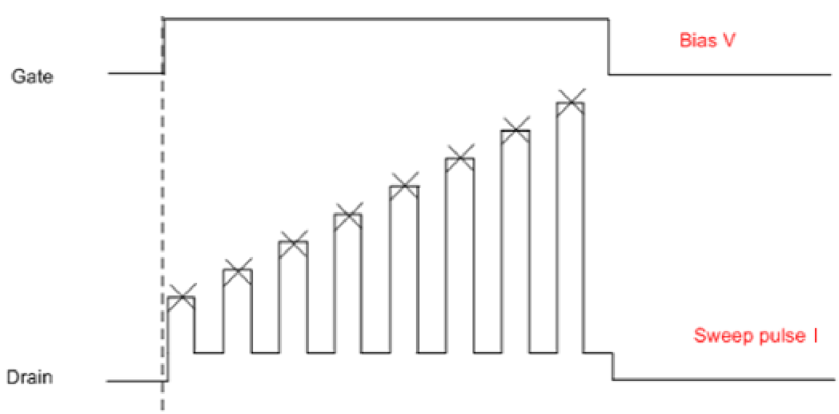
Description: Tests the drain current at the drain voltage sweep and the specified gate voltage with measurements at the drain terminal, which is in pulse mode using the Keithley Model 265xA SourceMeter (see next figure).

Figure 342: RdsOn



Test pulse sequence: Gate bias V, drain sweep pulse I (see next figure).

Figure 343: RdsOn test pulse sequence



INPUTS:

`DSMU:`	Model 265xA SMU connected to drain terminal.
`GSMU:`	SMU connected to gate terminal.
`vd_start:`	Start pulse voltage of drain.
`vd_stop:`	Stop pulse voltage of drain.
`Base_level:`	Base level of pulse in amps.
`points:`	The number of points for drain sweep.
`Compliancev:`	Compliance value for drain current force.
`Meas_Rangev:`	The voltage range for drain voltage measure. For pulse mode, autorange is not allowed.
`PLC:`	PLC for SMU on drain terminal.
`Pulse_Off:`	Duration of the output OFF time.
`Pulse_Width:`	Duration of the output ON time.
`Vg:`	Voltage on gate terminal.
`G2D_delay:`	Gate to drain delay, the time between gate step and output of first pulse in drain sweep.
`Sense_mode4GSMU:`	Sense mode for SMU on gate terminal.
`Sense_mode4DSMU:`	Sense mode for SMU on drain terminal.
`Start_Ramp_Flag:`	Enable or disable soft-ramp function at the start of bias.
`End_Ramp_Flag:`	Enable or disable soft-ramp function at the end of bias.
`Start_Ramp_Delay:`	Time delay at each step of start ramp.
`End_Ramp_Delay:`	Time delay at each step of end ramp.
`Start_Ramp_Steps:`	The number of steps at the start of soft-ramp.
`End_Ramp_Steps:`	The number of steps at the end of soft-ramp.

OUTPUTS:

`Id:`	Drain current programmed.
`Vd:`	Drain voltage measured at the specified gate bias voltage.
`RdsOn:`	Drain-source resistance when the MOSFET is fully on.
DUT:	An IGBT and the instruments are Keithley Model 265xA (at least one 265xA) and a 26xxB SMU, 24xx SMU and 42xx SMU. Lower power model SMUs must be classified as the same type, for example, the Model 2651A SMUs are the same type and the Model 2657A SMUs are the same type.

NOTE

If the gate terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the drain terminal.

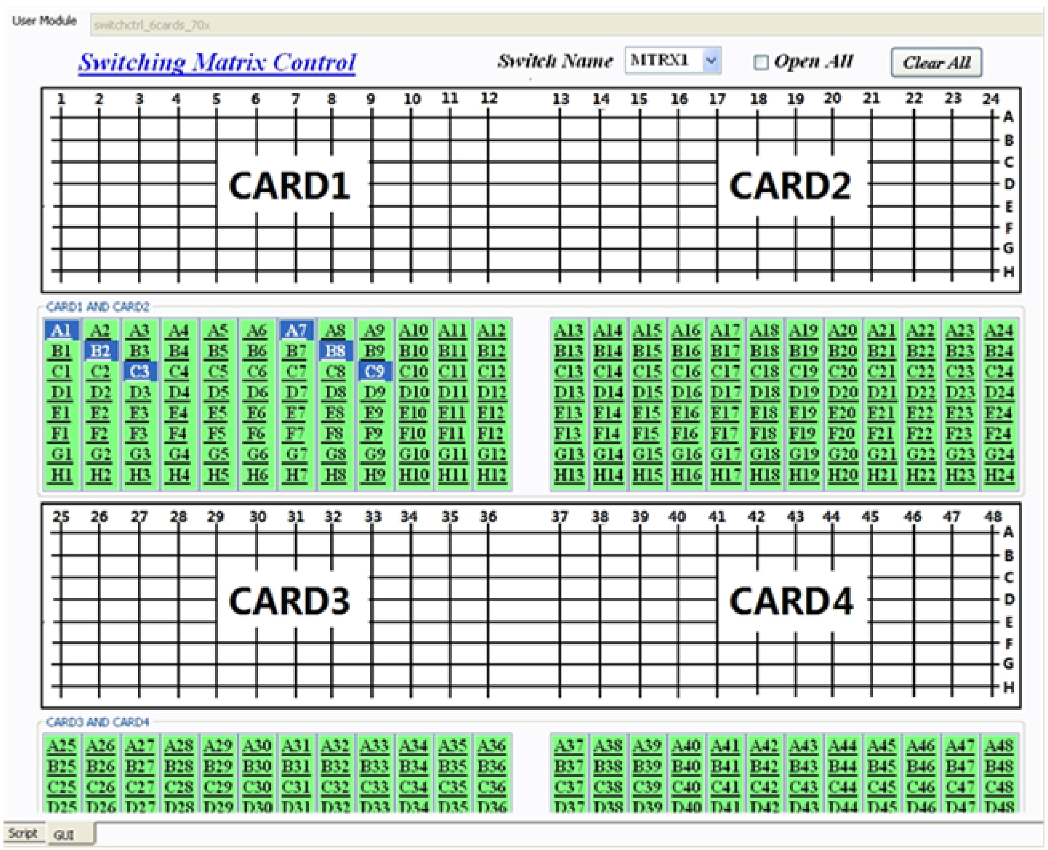
Switch control PTM

You can use this PTM module to control the Model 707A, 707B, 708A, or 708B Matrix. This module supports both DDC mode and TSP mode. The PTM module opens or closes any specific relays of the matrix cards. It can be used before you connect the SMU, CVU, or other instruments to the device under test (DUT).

This test module is in single-test mode in `CommonLib_other`. You can also import it in multitest mode from the following directory:

```
C:\ACS_BASIC\library\pyLibrary\PTMLib\switchctrl.py
```

Figure 344: Switch control module



This module lists six cards (the maximum supported). You must select the relays on the matrix card that you have in your matrix. For example, if you only have card 2 and card 3 in your matrix, you can ignore cards 1,4,5, and 6 in this module. The Model 708A and 708B matrices have only one card, so cards 2, 3, 4, 5, and 6 are not available.

Switch Name: Select the matrix that you want to control for relay opening or closing.

Open All: If it is selected, the module first opens all the relays before closing any selected relays.

Clear All: Clears all the selected relays in the relays selecting area.

Select relays: Select any relay that you want to close. Select the selected relay to clear it.

After selecting all the relays that you want to close, select **Run** on the toolbar to close these relays in the matrix. To open all the closed relays, select the **Open All** option and clear all relays that are selected, then run the module.

Shared Stress Reliability Test Application

ACS BASIC provides libraries and functions to support Shared Stress Reliability Test Application.

Shared Stress Reliability tests usually use instruments and hardware including SMU, CVU/LCR/Z analyzer (optional), Function Generator (optional), Power Amplifier (optional), Switching Matrix, and Probe Card. The typical hardware configuration of Shared Stress Reliability test is shown in Figure A. Figure B shows the use case and procedure of Shared Stress Reliability test.

Figure 345: Typical hardware configuration of a shared stress reliability test

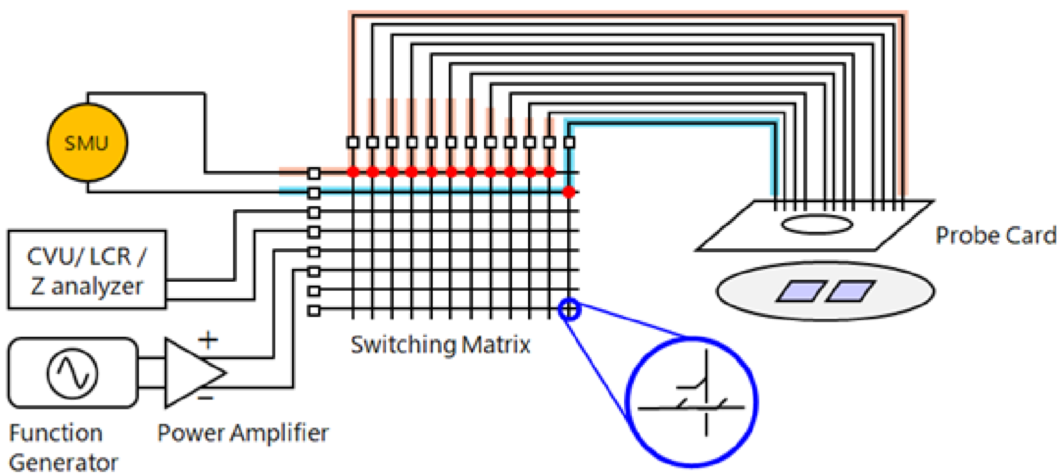
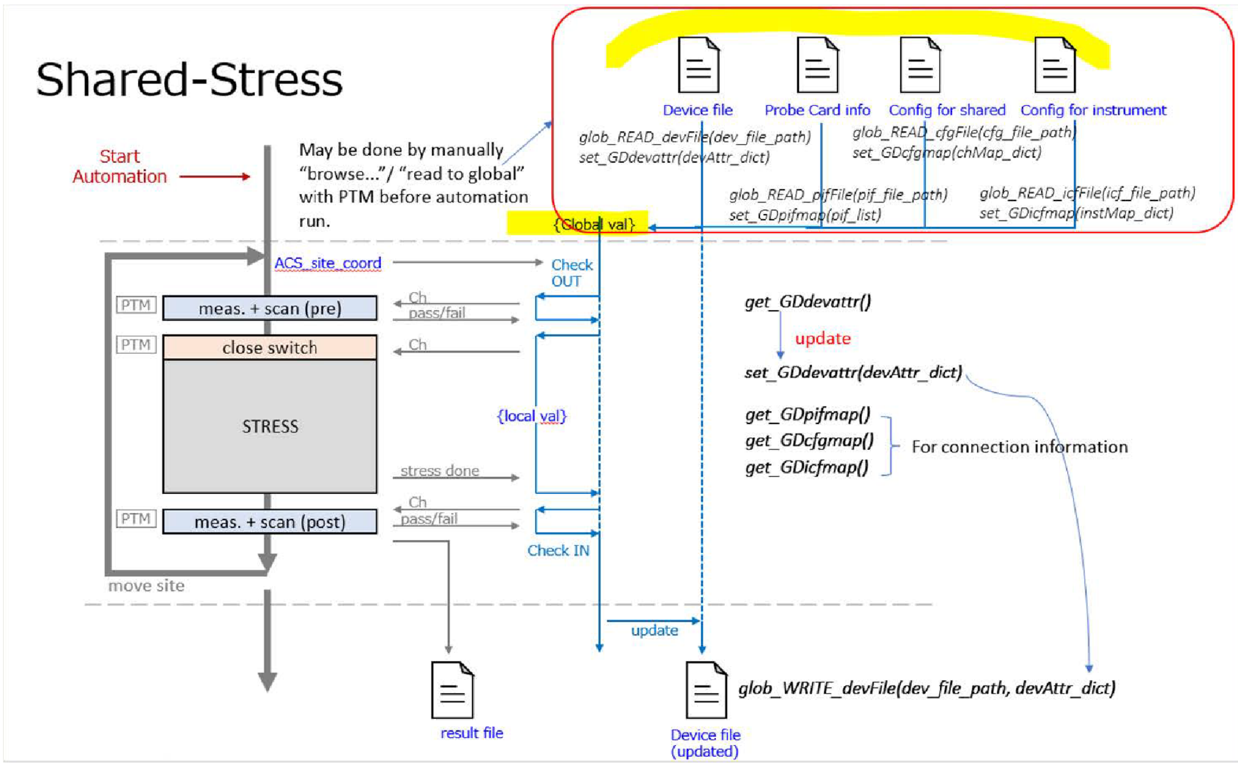
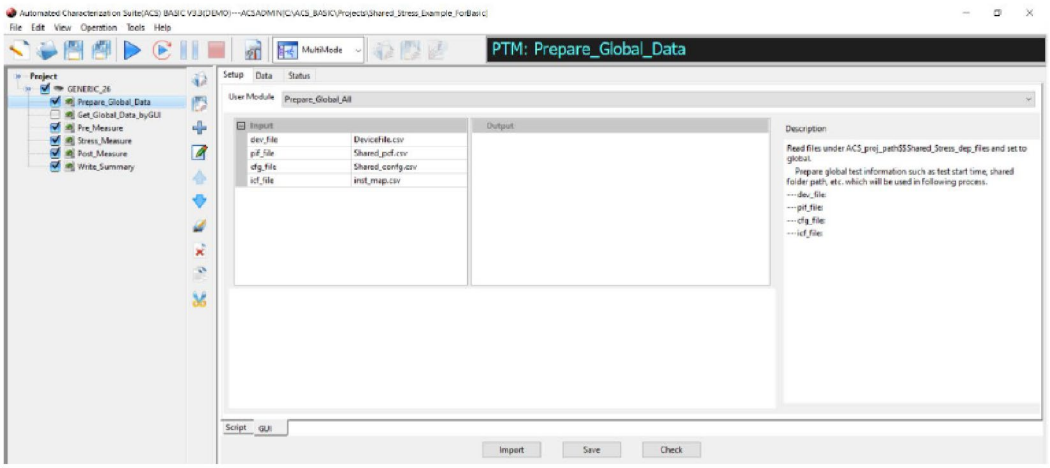


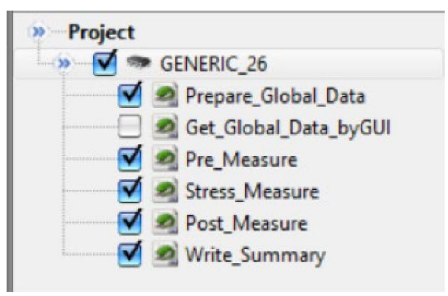
Figure 346: Use case and procedure of the shared stress reliability test



A demonstration project of Shared Stress Reliability Test is provided in ACS, name Shared_Stress_Example. This project contains UAP and PTM modules that are used to perform Shared Stress Reliability application.

Figure 347: Demonstration Project Shared_Stress_Example_For Basic





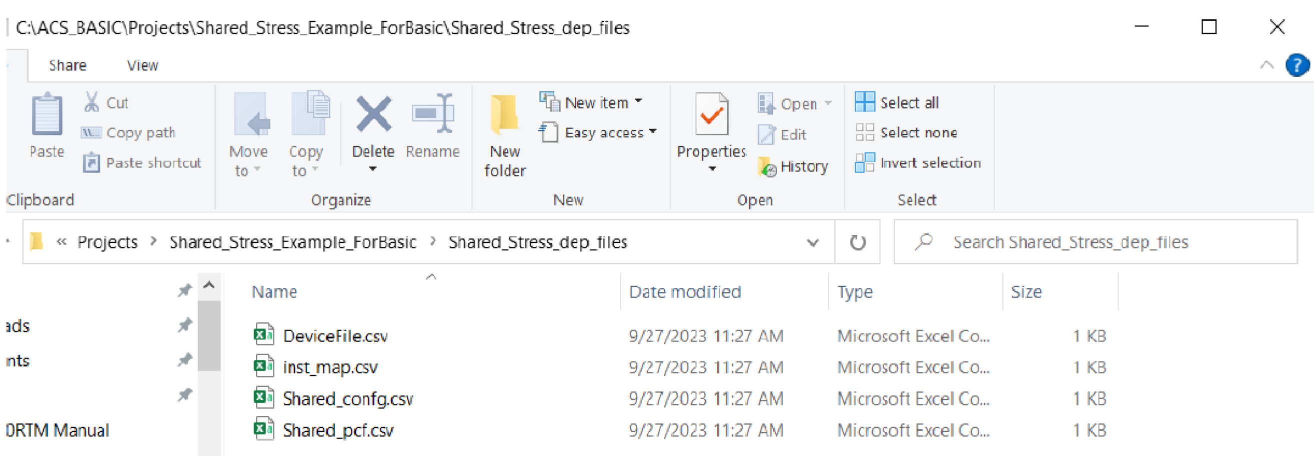
Shared_stress_app library

The library Shared_Stress_app.py is provided in `C: \library\pyLibrary\PTMLib` with modules to read the configuration information files of Share Stress Reliability. User can load the library to set up a PTM, as PTM Get_Global_Data_by GUI in the demonstration project Shared_Stress_Example shown in Figure B. In this PTM, user can read the configuration files stored under path `ACS_BASIC_proj_path\Shared_Stress_dep_file` as shown in the following Figure, show the information on the GUI for confirmation, and can set the information to global data. Also, you can get information from global data and check it on the GUI.

NOTE

The PTM Prepare_Global_Data should be run first before running the PTM Get_Global_Data_by GUI. And Get_Global_Data_by GUI should not be checked when running automation.

Figure 348: Path of configuration files



The library Shared_Stress_app.py contains four modules to read different information files:

- `Open_DevFile`
- `Open_icfFile`
- `Open_CfgFile`
- `Open_PifFile.`

Open_DevFile

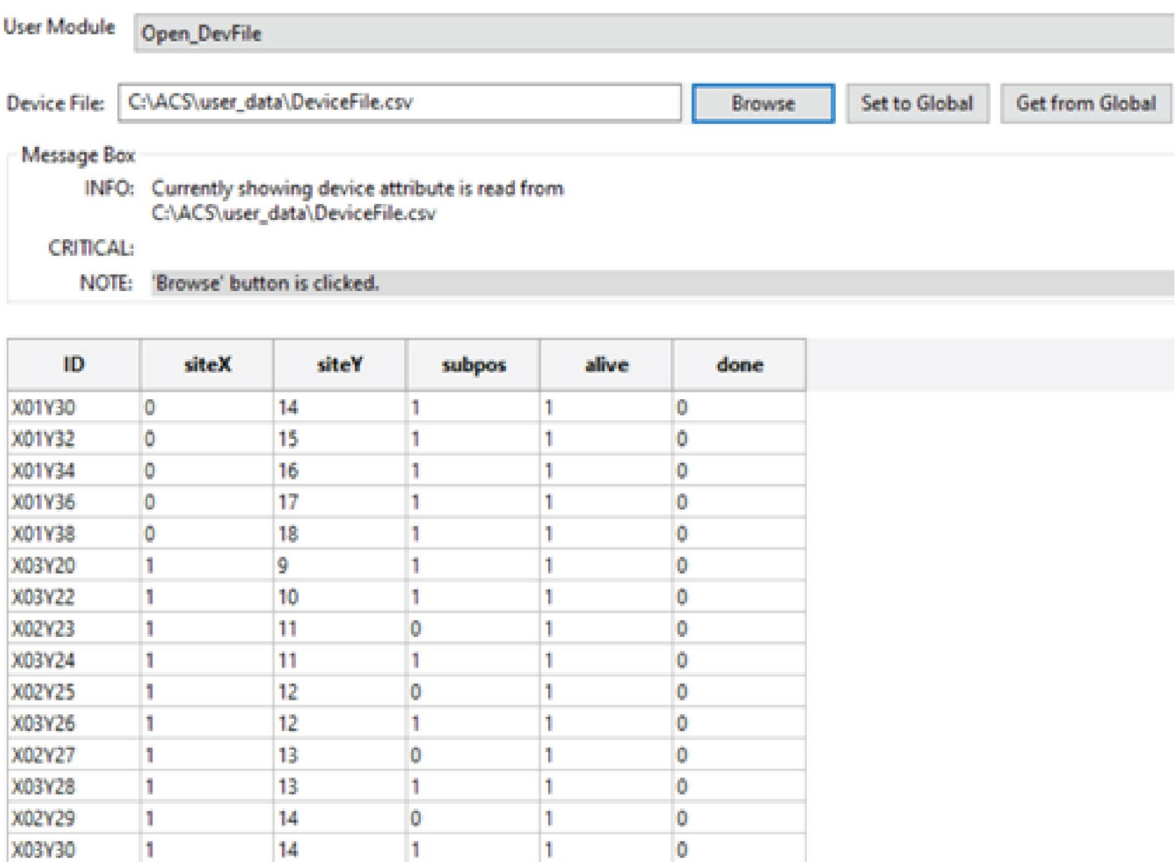
This module can read the device information file, for instance, the *DeviceFile.csv*, and display the information on the GUI. You can also set the information as global data by selecting **Set to Global**, see the following figure. You can also review the device information in the global data and on the GUI to confirm the **Get from Global** device file.

Browse: Normally device information is stored in the *ACS_proj_path\Shared_Stress_dep_file*. You can select the file, and the information will be displayed, as shown in the following figure, for confirmation.

Set to Global: Select to set the information displayed in the table for the global data.

Get from Global: Select to get device information from the global data and display it in the table for confirmation, as shown in the following figure.

Figure 349: Opening the device configuration file



ID	siteX	siteY	subpos	alive	done
X01Y30	0	14	1	1	0
X01Y32	0	15	1	1	0
X01Y34	0	16	1	1	0
X01Y36	0	17	1	1	0
X01Y38	0	18	1	1	0
X03Y20	1	9	1	1	0
X03Y22	1	10	1	1	0
X02Y23	1	11	0	1	0
X03Y24	1	11	1	1	0
X02Y25	1	12	0	1	0
X03Y26	1	12	1	1	0
X02Y27	1	13	0	1	0
X03Y28	1	13	1	1	0
X02Y29	1	14	0	1	0
X03Y30	1	14	1	1	0

Device Information File

- **ID:** Identity name of device.
- **siteX:** X coordinate of site that the device is in.
- **siteY:** Y coordinate of site that the device is in.
- **subpos:** Sub position of the device.
- **alive:** Situation status of the device. 1 for alive, 0 for not alive.
- **done:** Test status of the device. 1 for done, 0 for not done.

Open_icfFile

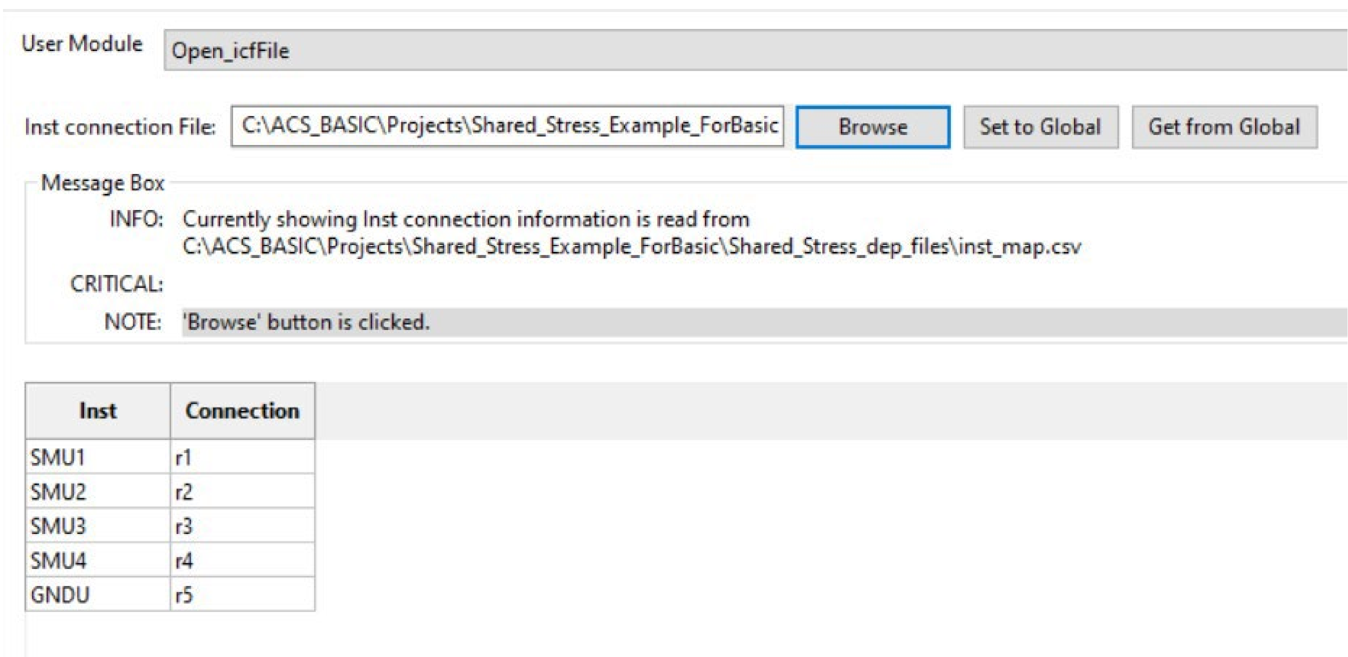
This module can read the instrument configuration file like inst_map.csv and display the information on the GUI for user to confirm. And user can set the information to global data by clicking Set to Global. User can also read the instrument configuration information from global data and display it on the GUI to confirm by clicking Get from Global.

Browse: Normally the instrument configuration file is stored under *ACS_BASIC_proj_path\Shared_Stress_dep_file*. User can select the file, and the information will be displayed in the table below for confirmation.

Set to Global: Click to set the information displayed in the table into global data.

Get from Global: Click to get the instrument configuration information from global data and display it in the table below for confirmation.

Figure 350: Open the instrument configuration file



Instrument Configuration File

Inst: Instrument name.

Connection: Channel connected to the instrument. ‘r1’, ’r2’ indicates row or backplane on matrix. Integer number represents the channel ID defined in channel configuration file.

Open_CfgFile

This module can read the channel configuration file like `Shared_confg.csv` and display the information on the GUI for user to confirm. You can set the information to global data by clicking **Set to Global.** You can also read the channel configuration information from global data and display it on the GUI to confirm by clicking **Get from Global.**

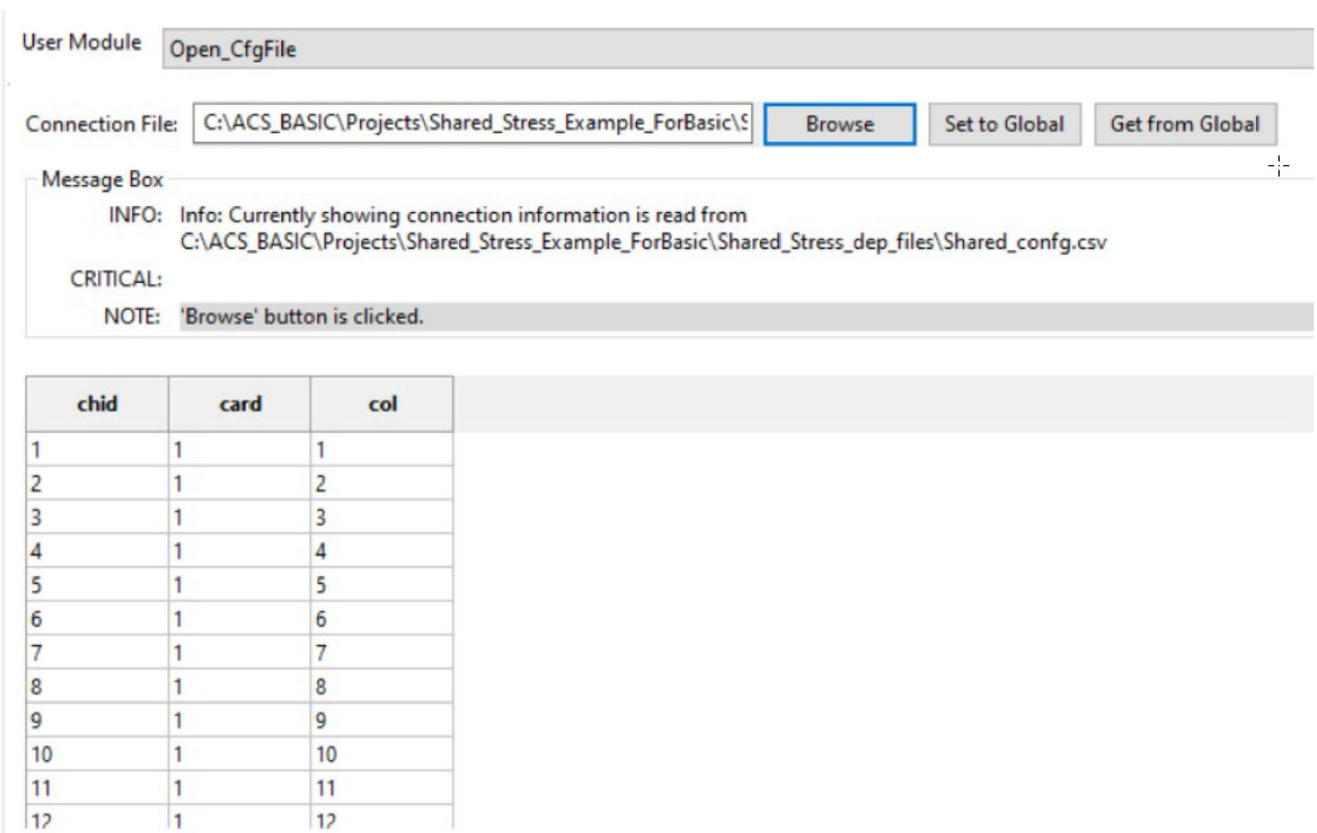
Browse: Normally the channel configuration file is stored under `ACS_BASIC_proj_path\`

Shared_Stress_dep_file. You can select the file, and the information will be displayed in the table for confirmation.

Set to Global: Click to set the information displayed in the table into global data.

Get from Global: Click to get the channel configuration information from global data and display it in the table below for confirmation.

Figure 351: Open the channel configuration file



Channel Configuration File

chid: Channel id.

card: Card number on which the channel is defined.

Col: Column number of which the channel is defined.

Open_PifFile

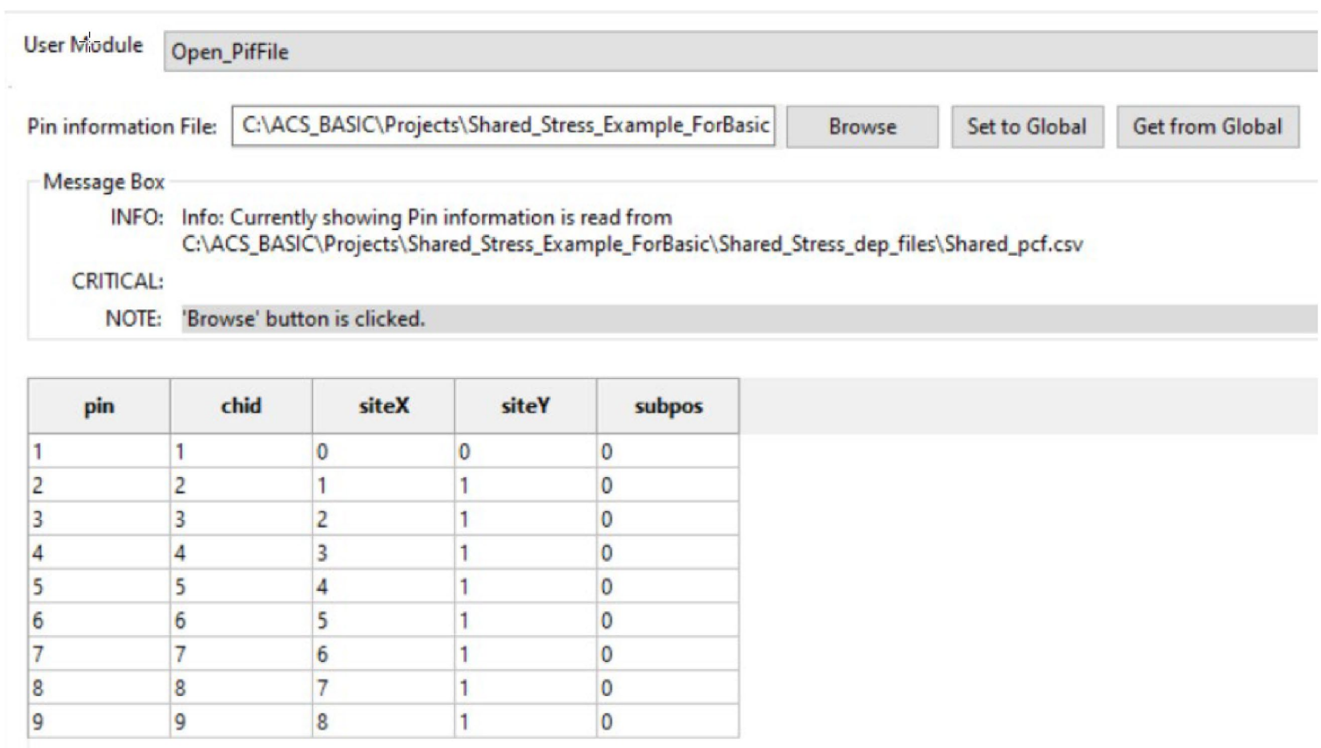
This module can read the pin configuration file like `Shared_pcf.csv` and display the information on the GUI for user to confirm. You can set the information to global data by clicking **Set to Global**. You can also read the pin configuration information from global data and display it on the GUI to confirm by clicking **Get from Global**.

Browse: Normally the pin configuration is stored under *ACS_BASIC_proj_path\ACS_BASIC_proj_path\ Shared_Stress_dep_file*. You can select the file, and the information will be displayed in the table below for confirmation.

Set to Global: Click to set the information displayed in the table into global data. table.

Get from Global: Click to get the pin configuration information from global data and display it in the table below for confirmation.

Figure 352: Open the pin configuration file



pin	chid	siteX	siteY	subpos
1	1	0	0	0
2	2	1	1	0
3	3	2	1	0
4	4	3	1	0
5	5	4	1	0
6	6	5	1	0
7	7	6	1	0
8	8	7	1	0
9	9	8	1	0

Pin Configuration File

- **pin:** Pin number.
- **chid:** Channel id connected to the pin.
- **siteX:** X coordinate of site that the pin is in.
- **siteY:** Y coordinate of site that the pin is in.
- **subpos:** Sub position of the pin.

shared_stress_Demo library

A library shared_stress_Demo.py is provided in *C:\ACS_BASIC\library\pyLibrary\PTMLib* with template test modules Pre-Measure, Stress-Measure, and Post_Measure. You can develop more test routines based on these template test modules. For how to develop a test module, please refer to the *ACS Programmer's Manual, Section 1 Programming overview,* Creating PTM or STM test libraries and modules.

These modules are loaded and used to set up PTM pre_scan_test, stress_measure_test and post_scan_test in the demonstration project Shared_Stress_Example as shown in Figure C.

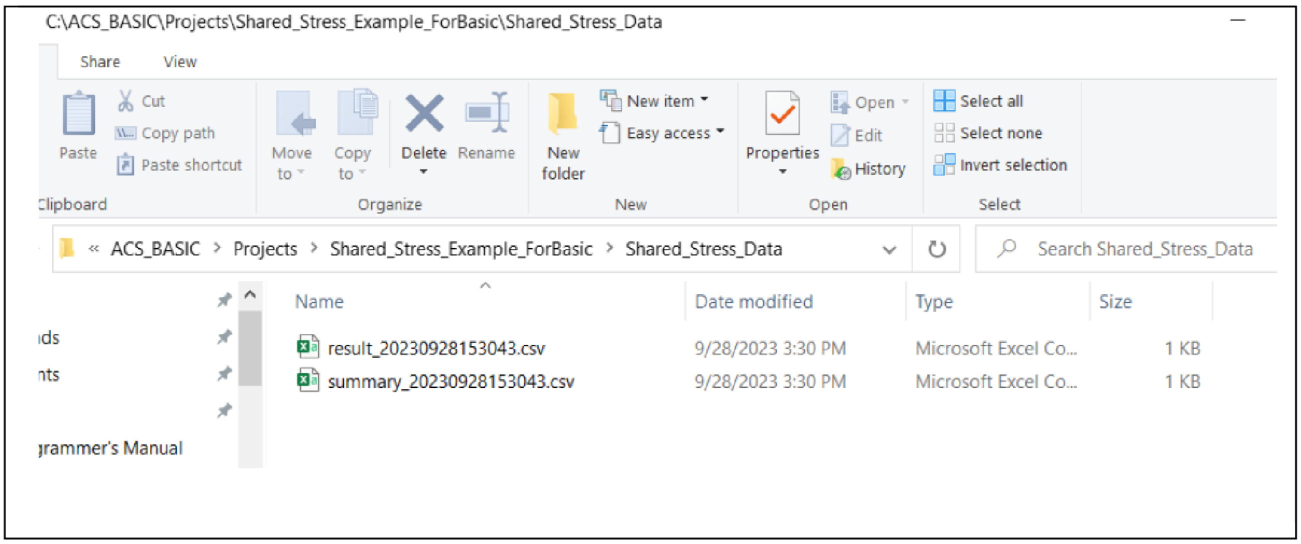
The library also contains the module **Prepare_Global_All** that prepares global data at the beginning of the test flow, and Write_Summary that writes summary file at the end of the test flow. In the demonstration project **Shared_Stress_Example** these modules are used in the beginning, **PTM Prepare_Global_Data** and the end **PTM Write_Summary**.

Pre_Measure

Template test module for Pre-Measure. You can extend the example code adding more pre-measurement routines as needed such as IV, CV, and temperature measurements.

Also, Pre_Measure will create raw data file and log data real time. The raw data file will be saved in the path *ACS_BASIC_proj_path\Shared_Stress_Data* as shown in the following figure. The naming rule is `result_automationStartTime.csv`.

Figure 353: Path of Row Data Files and Summary Data files



Stress_Measure

Template test module for Stress-Measure. You can extend the example code adding more pre-measurement routines as needed such as IV, CV, temperature measurements.

Post_Measure

Template test module for Post-Measure. User can extend the example code adding more pre-measurement routines as needed such as IV, CV, temperature measurements.

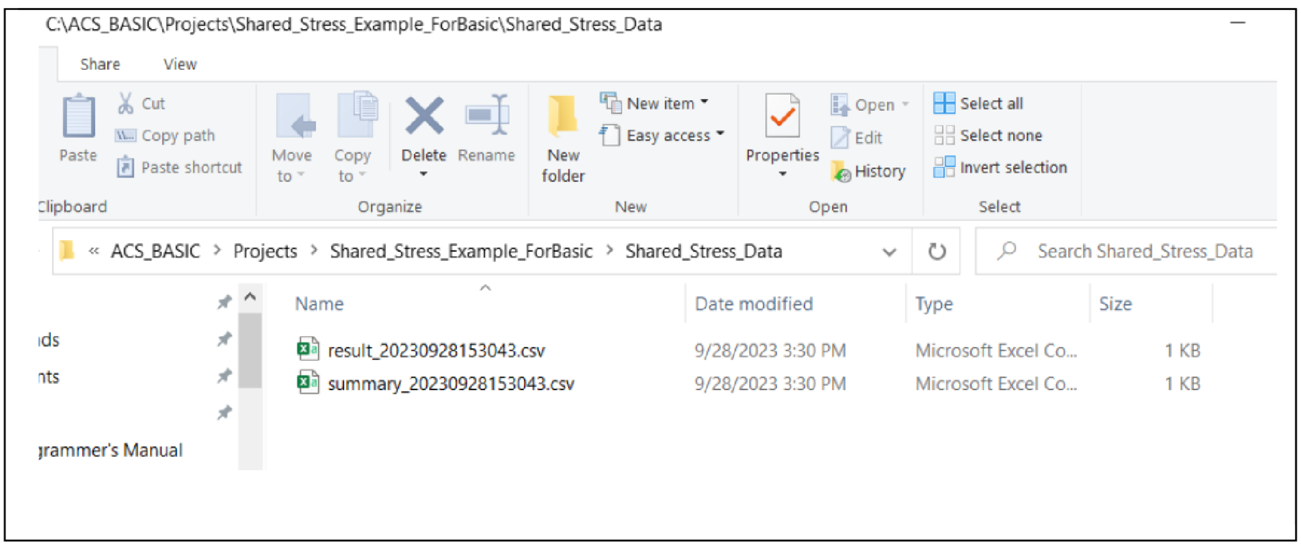
Prepare_Global_All (dev_file, pic_file, cfg_file, icf_file)

This module reads the configuration files that are located under the path *ACS_BASIC_proj_path\Shared_Stress_dep_files,* as shown in the figure below, and writes the information into global data. The module also prepares global test information such as test start time, configuration file path, and data file path. which will be used in the following process.

- **dev_file:** File of device attributes. Example: '`DeviceFile.csv`'.
- **pif_file:** File of pin configuration. Example: '`Shared_pcf.csv`',
- **cfg_file:** File of channel configuration. Example: '`Shared_confg.csv`',
- **icf_file:** File of instrument configuration. Example: '`inst_map.csv`'

In the demonstration project, this module is used in `automation_begin UAP`: `prepare_global_UAP`.

Figure 354: Path of Row Data Files and Summary Data files

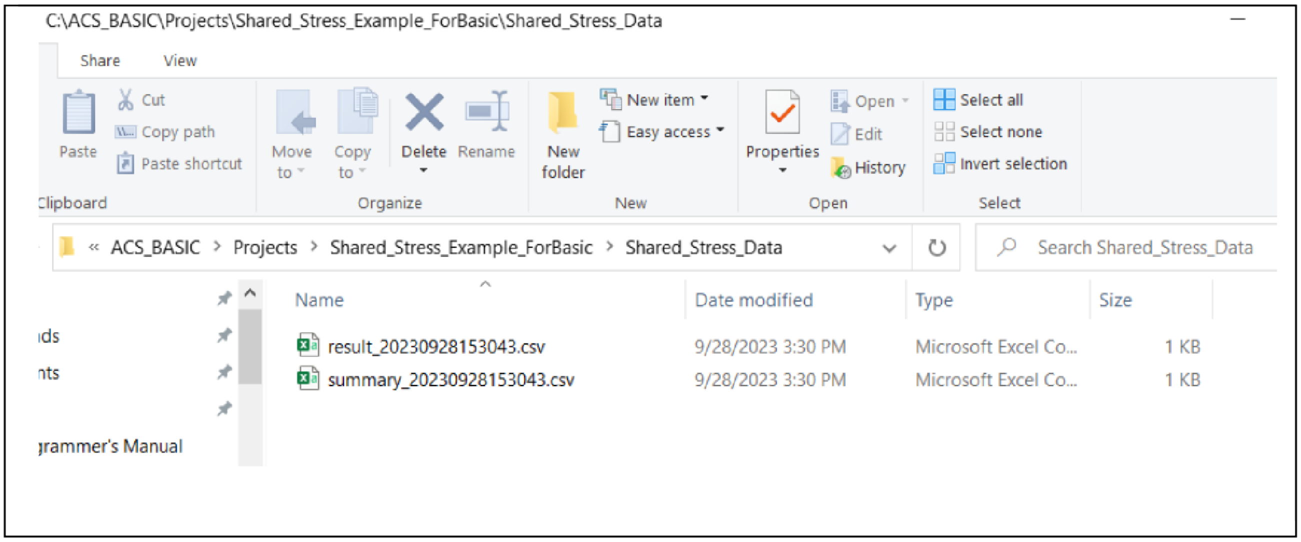


Write summary

This module writes the summary file of the test data and save the file, as shown in the figure below, in the path *ACS_proj_path\Shared_Stress_Data*. The naming rule is `summary_automationStartTime.csv`.

In the demonstration project, this module is used in a *PTM: Write_Summary*.

Figure 355: Path of Row Data Files and Summary Data files



shared_stress_lib commands

The `shared_stress_lib.py` library is located at `C:\ACS_BASIC\library\pyLibrary\ptmlpt`. The library contains commands used to manage global data of different kind attribute and configuration information for Shared Stress Reliability test application, that is device attributes, instrument configuration, channel ACS Basic Automated Characterization Suite (ACS) Libraries Reference Manual Section 2: ACS Basic device library configuration, and pin configuration.

These commands can be used in development of PTMs and UAPs for the Shared Stress Reliability test application. Brief descriptions of the commands are provided in the following tables.

get_GDdevattr(global_dict)

Function	Retrieves the global data for the device attributes
	`global_dict`: Global dictionary for current scope
Example	`devattr_dict = get_GDdevattr(globals().copy())`

set_GDdevattr(devAttr_dict)

Function	Sets the global data for the device attributes
Example	`set_GDdevattr(devattr_dict)`

get_GDinstmap(global_dict)

Function	Retrieves the global data for the instrument configuration `global_dict:` Global directory for current scope
Example	`instMap_dict = get_GDinstmap(globals().copy())`

set_GDinstmap(instMap_dict)

Function	Sets the global data for the instrument configuration
Example	`set_GDinstmap(instMap_dict)`

get_GDcfgmap(global_dict)

Function	Retrieves the global data for the channel configuration `global_dict`: Global dictionary for current scope
Example	`cfgMap_dict = get_GDcfgmap(globals().copy())`

set_GDcfgmap(global_dict)

Function	Sets the global data for the channel configuration
Example	`set_GDcfgmap(cfgMap_dict)`

get_GDpifmap(global_dict)

Function	Retrieves the global data for the pin configuration `global_dict`: Global dictionary for current scope
Example	`pifMap_list = get_GDpifmap(globals().copy())`

set_GDpifmap(pifMap_list)

Function	Sets the global data for the pin configuration
Example	`set_GDpifmap(pifMap_list)`

Programming example

We take python library Shared_Stress_Demo.py, and PTM Prepare_Global_Data as examples to explain the usage of the global data management commends in PTM development.

Shared_Stress_Demo.py

```
from Keithley import *
import os
import time
import copy
import math
import random
from ACS_PostData import *
from ACS_Global import *
import shared_stress_lib
set_globals(shared_stress_lib, "shared_stress_lib", locals().copy())
```

This imports `shared_stress_lib` and set all the current variables `(locals.copy())` into `shared_stress_lib` space.

NOTE

The code, shown above, must be included to use the global data management commands in the library.

```
#define gloabl variable and update it in code realtime if needed.
G_devattr_dict ={}
G_instmap_dict = {}
G_chmap_dict ={}
G_pif_list ={}
G_testinfo_dict = {}
```

Declare global variables in the test execution library can make get_GDxxx(globals().copy()) function work more real-time. Global variables set both before the test and inside test module can be accessed.

```
def Post_Measure(v_check_post=10, hi_limit=1e-09, lo_limit=0, acs_site_coord='',
    Channel='Channel', Post_Current='Post_Current', Alive='Alive', Done='Done'):
   global G_devattr_dict
   global G_testinfo_dict
   #currently probed ACS_site_coord
   if ACS_run_mode == "manual":
      if "[" in acs_site_coord or "(" in acs_site_coord:
         site_coord = eval(acs_site_coord)
      else:
         tmp = acs_site_coord.split(",")
         site_coord = (int(tmp[0]), int(tmp[1]))
      DprbDEVs = util_SHARED_PROBING_DEVID(site_coord)
   else:
      DprbDEVs = util_SHARED_PROBING_DEVID(ACS_site_coord) # acs global
ACS_site_coord
   DeffDEVs = util_SHARED_EFFECTIVE_DEVID(DprbDEVs)
   if len(DeffDEVs["$ID_List"])==0:
      shared_stress_lib.util_logInfo("Post_Measure: Length of DeffDEVs is 0. Please
    double check device file to see if all the probed devices are alive and not
    done.")
      return
   G_testinfo_dict = shared_stress_lib.get_GDtestinfo(globals().copy())
   G_testinfo_dict["TEST_INFO"]["v_check_post"] = v_check_post
   shared_stress_lib.set_GDtestinfo(G_testinfo_dict)
   postmeas_smu = "SMU1"

   #scan
   test_phase = "Post"
   result = []
   G_devattr_dict = shared_stress_lib.get_GDdevattr(globals().copy())
   for sID in DeffDEVs["$ID_List"]:
      iCH = DeffDEVs[sID]['chid']
      util_SHARED_CLOSE_CH(MTRX1, postmeas_smu, [iCH])

      #measurement done by premeas_smu
      curr = util_SHARED_PREPOST_MEAS(pre_or_post="post")
      if abs(curr) > hi_limit:
         DprbDEVs[sID]["alive"] = 0
      DprbDEVs[sID]["done"] = 1
      G_devattr_dict[sID] = copy.copy(DprbDEVs[sID])
      result.append(",".join(["Post", str(sID), "%g"%curr]))
      # post data to data sheet for realtime monitor
      ACSPostDataDouble(Channel, iCH)
      ACSPostDataDouble(Post_Current, curr)
      ACSPostDataDouble(Alive, DprbDEVs[sID]["alive"])
```

```
      ACSPostDataDouble(Done, DprbDEVs[sID]["done"])

   # write data + update global
   if len(result)>0:
      util_Write_Data([",".join(["Test_Phase", "ID", "Current"])])
      util_Write_Data(result)
   shared_stress_lib.set_GDdevattr(G_devattr_dict)
   G_testinfo_dict = shared_stress_lib.get_GDtestinfo(globals().copy())
   shared_dep_folder = G_testinfo_dict["PATH"]["shared_dep_folder"]
   dev_file_path = os.path.join(shared_dep_folder, 'DeviceFile.csv')
   shared_stress_lib.glob_WRITE_devFile(dev_file_path, G_devattr_dict)
```

Global variable `G_devattr_dict` is updated in code, in real time.

To get global value in next test or UAP, users have to call function `get_GDxxx()` through parameter `globals().copy()`.

Always call `get_GDxxx` with input parameter `globals().copy()`. In this way `get_GDxxx` will find value from global pool in present name space.

Prepare_Global_Data

```
from ACS_Global import *
import Shared_Stress_Demo
set_globals(Shared_Stress_Demo, "Shared_Stress_Demo", locals().copy())
Shared_Stress_Demo.Prepare_Global_All(dev_file='DeviceFile.csv',
   pif_file='Shared_pcf.csv', cfg_file='Shared_confg.csv', icf_file='inst_map.csv')
```

These lines are essential to underly global data management.

It will transfer all the current variables through `locals().copy()` into `Shared_Stress_Demo` space. In `Shared_Stress_Demo.py`, similar lines are used to transfer locals().copy() into next space `Shared_Stress_lib` as mentioned in the `Share_Stress_Demo.py` example.

Configure a Model 622x and Model 2182A library

The following module will help you to configure your library of Keithley Instruments using the Model 662x and Model 2182A to perform delta tests to measure very low resistance.

Model 622x and Model 2182A delta test

To add a Model 622x and Model 2182A delta test module:

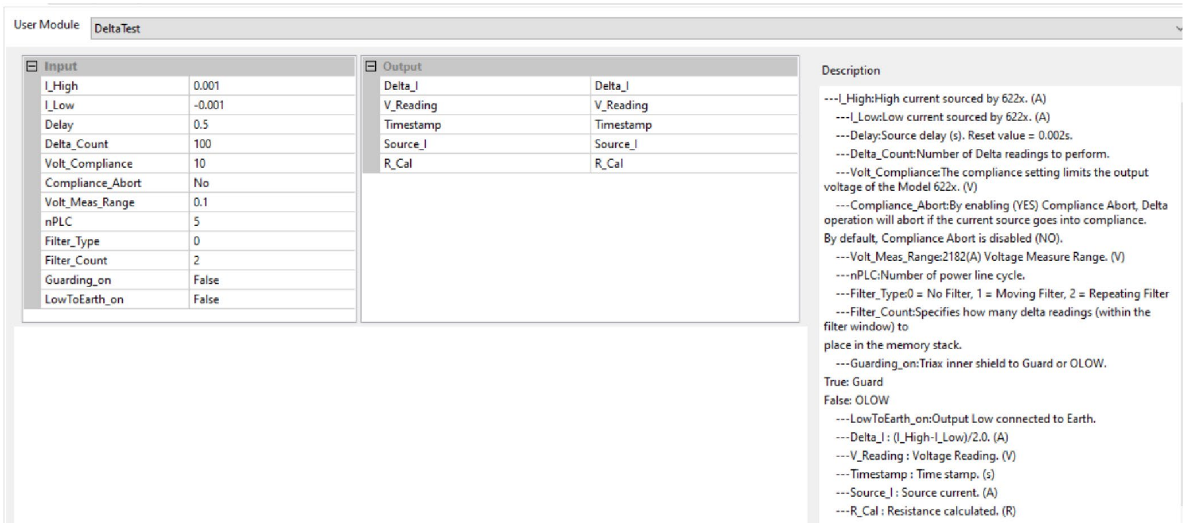
1. Add a PTM to the configuration navigator.
2. Import the `KI662x_2182_Lib.py` module from the PTMLib library. Choose the `DeltaTest` module from test module drop-down list.

This module is used to measure very low resistances with Model 622x and Model 2182A. A good method of doing this is called the delta method, with a Model 2182A sourcing the current and a Model 622x measuring the resistance.

Inputs	Description
`I_High`	High current sourced by 622x (A)
`I_Low`	Low current sourced by 622x (A)
`Delay`	Source delay (s) Reset value = 0.002s
`Delta_Count`	Number of Delta readings to perform
`Volt_Compliance`	The compliance setting limits the output voltage of the Model 622x (V)
`Compliance_Abort`	By enabling (YES) Compliance Abort, Delta operation will abort if the current source goes into compliance; By default, Compliance Abort is disabled (NO)
`Volt_Meas_Range`	2182(A) Voltage Measure Range (V)
`nPLC`	Number of power line cycles
`Filter_Type`	0 = No Filter, 1 = Moving Filter, 2 = Repeating Filter
`Filter_Count`	Specifies how many delta readings (within the filter window) to place in the memory stack
`Guarding_on`	Triaxial inner shield to Guard or OLOW
`LowToEarth_on`	Output Low connection
`Delta_I`	(I_High-I_Low)/2.0 (A)
`V_Reading`	Voltage Reading. (V)
`Timestamp`	Time stamp (s)
`Source_I`	Source current. (A)
`R_Cal`	Resistance calculated (R)

Outputs	Description
`Delta_I`	(I_High-I_Low)/2.0 (A)
`V_Reading`	Voltage Reading (V)
`Timestamp`	Time stamp (s)
`Source_I`	Source current (A)
`R_Cal`	Resistance calculated (R)

Figure 356: Delta test standard GUI



Model 622x and Model 2182A differential test

To add a Model 622x and Model 2182A differential test

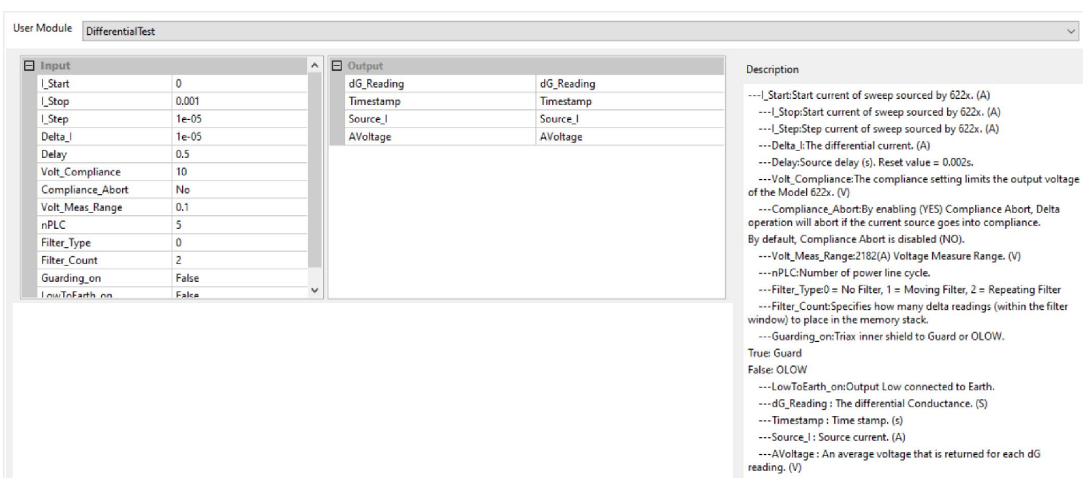
1. Add a PTM to the configuration navigator
2. Import the `KI622x_2182_Lib.py` module from the PTMLib library. Choose the Differential Test module from test module drop-down list.

This module is used to measure differential conductance, with Model 2182A sourcing sweep current and Model 622x measure the differential conductance.

Inputs	Description
`I_Start:`	Start current of sweep sourced by 622x (A)
`I_Stop:`	Start current of sweep sourced by 622x (A)
`I_Step:`	Step current of sweep sourced by 622x (A)
`Delta_I:`	The differential current. (A)
`Delay:`	Source delay (s). Reset value = 0.002s
`Volt_Compliance:`	The compliance setting limits the output voltage of the Model 622x (V)
`Compliance_Abort:`	By enabling (YES) Compliance Abort, Delta operation will abort if the current source goes into compliance. By default, Compliance Abort is disabled (NO)
`Volt_Meas_Range`	2182(A) Voltage Measure Range (V)
`nPLC`	Number of power line cycles
`Filter_Type`	0 = No Filter, 1 = Moving Filter, 2 = Repeating Filter
`Filter_Count`	Specifies how many delta readings (within the filter window) to place in the memory stack
`Guarding_on`	Triaxial inner shield to Guard or OLOW
`LowToEarth_on`	Output Low connection

Outputs	Description
`dG_Reading`	Differential conductance (S)
`Timestamp`	Time stamp (s)
`Source_I`	Source current (A)
`AVoltage`	Average voltage that is returned for each dG reading (V)

Figure 357: Model 622x/2182A differential test



LIV library

The following information helps you to configure a LIV library using Keithley Instruments Model 2610B-PULSE SourceMeter and DMM7510, or a DMM6500. The LIV (light output, current, and voltage) characterization is an important and commonly used way to verify the performance of all types of optical devices. For example, light emitting diodes (LED), laser diodes, vertical cavity surface emitting lasers (VCSELs), and edge emitting lasers (EEL).

The following information provides an example of how to create, and subsequently call, a single function, which uses the Model 2601B-PULSE current pulser to output a current pulse sweep. The sweep is generated with the instrument's Asynchronous Trigger Model. With the dual 1MS/s digitizers built into the current pulser, the voltage and current are measured simultaneously at the top of each pulse, and the photodiode (PD) current is measured by the DMM7510 or DMM6500. Upon completion of the sweep, the tested data is printed to the Test Script Builder Instrument Console in a format suitable for copying and pasting into Microsoft® Excel® for graphing and analysis.

The library is based on the Application Note: *Timing Considerations for Constructing LIV Measurement Trigger Models Using the Keithley 2601B-PULSE System SourceMeter® Instrument and DMM7510 Graphical Sampling Digital Multimeter*, which can be accessed on tek.com (tek.com/en).

measurementLIV_CaseI_2601B_PULSE_DMM

To add a measurementLIV_CaseI_2601B_PULSE_DMM Test module:

1. Add a STM to the configuration navigator.
2. Import the `LIV.tsp` module from the TSPLib library. Choose the `measurementLIV_CaseI_2601B_PULSE_DMM` module from the test module list.

Required equipment:

- Model 2601B-PULSE System SourceMeter
- DMM7510 or DMM6500 Multimeter

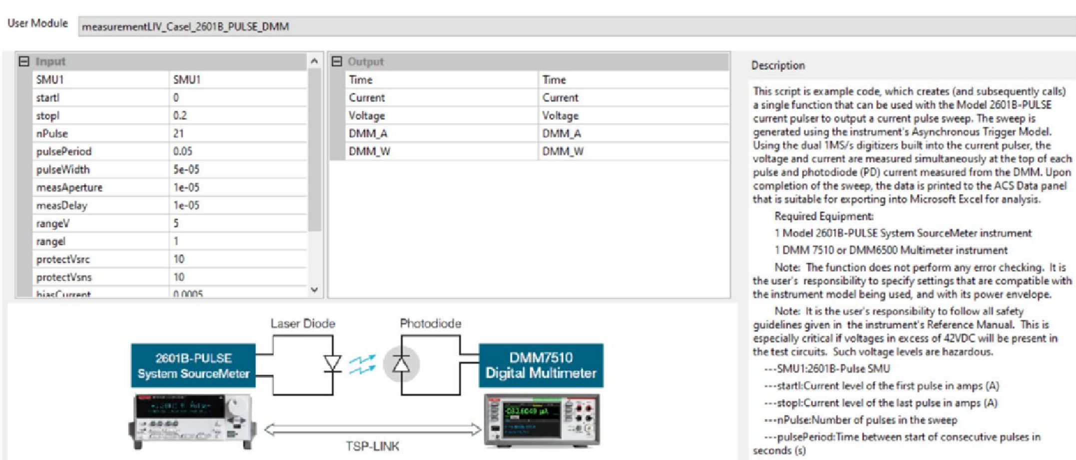
CAUTION

This function does not perform any error checking. It is the user's responsibility to follow all safety guidelines given in the instrument documentation and to specify settings that are compatible with the instrument model and with its power envelope. This is critical if voltages exceeding 42 VDC are present in the test circuits.

Input	Description
`SMU1`	2601B-Pulse SMU
`startI`	Current level of the first pulse (A)
`stopI`	Current level of the last pulse (A)
`nPulse`	Number of pulses in the sweep
`pulsePeriod`	Time between start of consecutive pulses (s)
`pulseWidth`	Width of current pulses (s)
`measAperture`	Effective integration time (s)
`measDelay`	Time from pulse start to measure start (s)
`rangeV`	Voltage measure range (V)
`rangeI`	Current source and measure range (V)
`protectVsrc`	Protection Voltage on Source side (V)
`protectVsns`	Protection Voltage on Sense side (V)
`biasCurrent`	Idle current level (base level for pulses) (A)
`rangeDMM`	Range of DMM (A)
`optoFactor`	Proportional Constant to calculate optical power based on the photodiode (PD) current
`printData`	1: print test data in the Data panel.

Output	Description
`Time`	Time stamp. (s)
`Current`	Current reading. (A)
`Voltage`	Voltage reading. (V)
`DMM_A`	DMM measured current. (A)
`DMM_W`	DMM measured power. (W)

Figure 358: ACSBasic_measurementIV_caseI_2601B



DMM_SMU_lib library

The following module helps you to configure a library to measure metal line or low resistance with low voltage for 2-terminal or 3-terminal devices with the Keithley Instruments Series 2400 Graphical Series SourceMeter or Series 2600B SourceMeter as source, and DMM7510 or DMM6500 to do the measurement.

DMM_SMU_FIMV_Sample

To add a DMM_SMU_FIMV_Sample Test module:

1. Add a STM to the configuration navigator.
2. Import the `DMM_SMU_lib.tsp` module from the TSPLib library. Choose the `DMM_SMU_FIMV_Sample` module from test module list.

Required equipment:

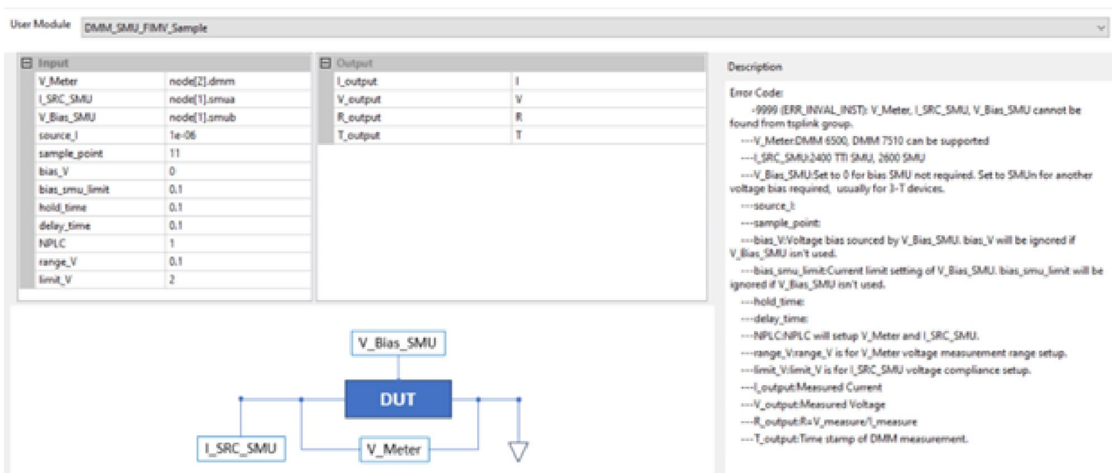
- Series 2400 Graphical Series SourceMeter or Series 2600B SourceMeter
- DMM7510 or DMM6500 Multimeter

This module sources current with the SourceMeter and measures voltage using the multimeter according to the sample point and delay time and outputs the tested data.

Input	Description
V_Meter	Multimeter
I_SRC_SMU	SMU
V_Bias_SMU	Set to 0 if bias SMU is not required. Set to SMUn if bias SMU is required, usually for 3-terminal devices.
source_I	Source current (A)
sample_point	Sample point. Set to 1 for spot measurement.
bias_V	Voltage bias sourced by V_Bias_SMU (V) Ignored if bias SMU is not required and V_Bias_SMU is set to 0.
hold_time	Hold time (s)
delay_time	Delay time (s)
NPLC	Number of power line cycles. Applied for V_Meter and I_SRC_SMU.
range_V	Voltage measure range for V_Meter (V)
limit_V	Voltage compliance for I_SRC_SMU (V)

Output	Description
Error	−9999 (ERR_INVAL_INST): V_Meter, I_SRC_SMU, V_Bias_SMU cannot be found from TSP-Link group.
I_output	Output current (A)
V_output	Output voltage (V)
R_output	Output resistor (ohm)

Figure 359: DMM SMU FIMV Sample standard GUI



DMM_SMU_FIMV_Sweep

To add a DMM_SMU_FIMV_Sweep Test module:

1. Add a STM to the configuration navigator.
2. Import the `DMM_SMU_lib.tsp` module from the TSPLib library. Choose the `DMM_SMU_FIMV_Sweep` module from test module list.

Required Equipment:

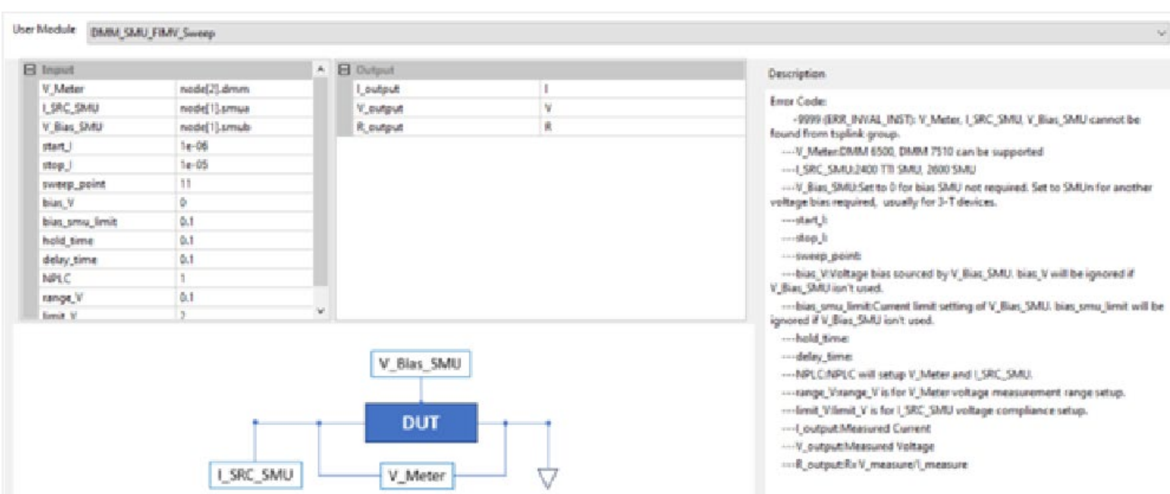
- Series 2400 Graphical Series SourceMeter or Series 2600B SourceMeter SMU
- DMM7510 or DMM6500 Multimeter

This module sources current as a sweep with the SourceMeter, measures voltage with the multimeter, and outputs the tested data.

Input	Description
V_Meter	Multimeter
I_SRC_SMU	SMU
V_Bias_SMU	Set to 0 if bias SMU is not required. Set to SMUn if bias SMU is required, usually for 3-terminal devices.
start_I	Start current of sweep (A)
stop_I	Stop current of sweep (A)
sweep_point	Sweep point
bias_V	Voltage bias sourced by V_Bias_SMU. (V) Ignored if bias SMU is not required and V_Bias_SMU is set to 0.
hold_time	Hold time (s)
delay_time	Delay time (s)
NPLC	Number of pulse line cycle. Will be applied for V_Meter and I_SRC_SMU.
range_V	Voltage measurement range for V_Meter (V)
limit_V	Voltage compliance for I_SRC_SMU (V)

Output	Description
Error	-9999 (ERR_INVAL_INST): V_Meter, I_SRC_SMU, V_Bias_SMU cannot be found from TSP-Link group.
I_output	Output current (A)
V_output	Output voltage (V)
R_output	Output resistor (ohm)

Figure 360: Standard user interface for the DMM_SMU_FIMV_Sweep test module



VthSiC_JEP183_library

The following information helps you to configure a VthSiC_JEP183 library with Keithley Instruments Model 2600B SourceMeter. The VthSiC_JEP183 library provides modules to measure threshold voltage (*Vth)* for SiC devices based on the test principle as determined by the JEDEC standards (jedec.org) JEP183.

The threshold voltage (*VT*) is a key parameter for evaluating SiC MOSFETs. Without accurately measuring the threshold voltage, it is impossible to monitor how the stress applied to the device changes the device characteristics.

There are four modules in the library based on different test methods and sequence to measure *VT* for SiC MOSFETs:

1. VgSweepVdFixed (on page 3-424)
2. VgDualSweepVdFixed (on page 3-428)
3. VgVdBothSweep (on page 3-430)
4. VgVdBothFixedBias (on page 3-434)

VgSweepVdFixed

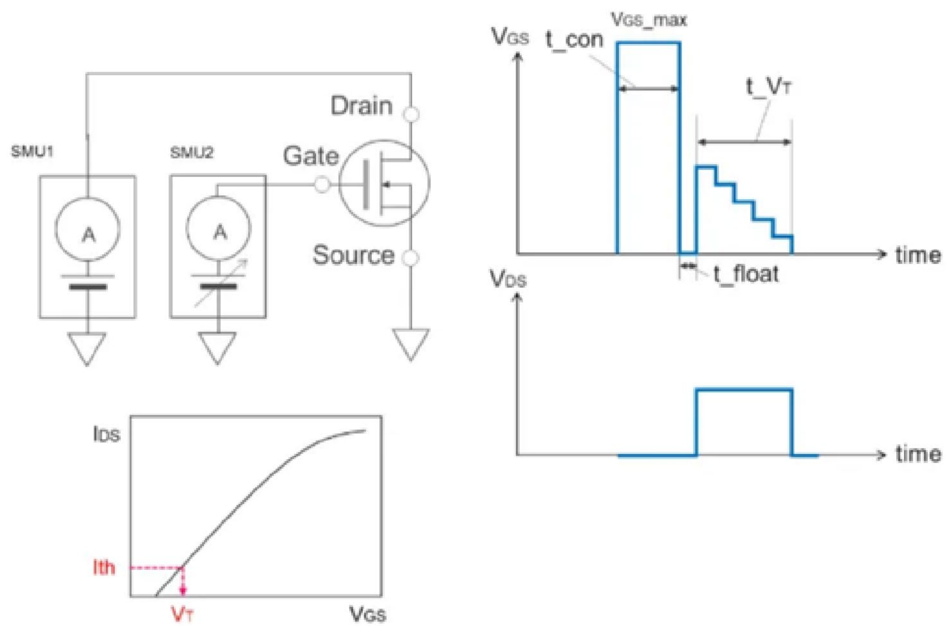
To add a VgSweepVdFixed test module:

1. Add a script test module (STM) to the configuration navigator.
2. Import the `VthSiC_JEP183.tsp` module from the TSPLib library.
3. Select the `VgSweepVdFixed` module from test module drop-down list.

Required equipment: Keithley Instruments Series 2600B System SourceMeter(R) instrument.

This module applies a positive Gate pulse (conditioning pulse) prior to measuring the Vth to eliminate the hysteresis (refer to JEDEC standards (on page 3-423) JEP183 for more information). Next, the module performs the GateV and DrainI measurement by sweeping the Gate voltage with a downward staircase sweep. The measured data of GateV and DrainI will be used to calculate the Vth. The following figure shows the Vth test circuit and timing diagram.

Figure 361: VgSweepVdFixed test circuit timing diagram



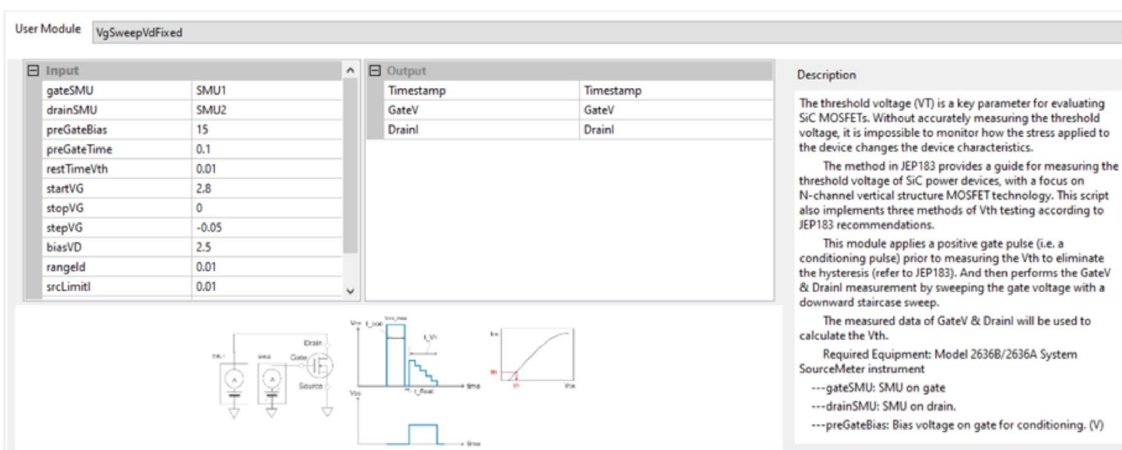
The following table provides the input and the description of the instrument testing when performing the `VgSweepVdFixed` sample test.

Input	Description
gateSMU	SMU on Gate
drainSMU	SMU on Drain
preGateBias	Bias voltage on Gate for conditioning (V)
preGateTime	Time for conditioning (s)
restTimeVth	Rest time after conditioning before Vth measurement (s)
startVG	Start voltage of sweep on Gate (V)
stopVG	Stop voltage of sweep on Gate (V)
stepVG	Step voltage of sweep on Gate (V)
biasVD	Bias voltage on drain (V)
rangeId	Current range on drain (A)
srcLimitI	Source current limit (A)
nPLC	Number of power line cycle
sweepDelay	Delay time for each step of sweep before measurement (s)

The following table provides the output and the description of the instrument testing when performing the `VgSweepVdFixed` sample test.

Output	Description
Timestamp	Time stamp reading. (s)
GateV	Gate voltage reading. (V)
DrainI	Drain current reading. (A)

Figure 362: ACSBasic_VgSweepVdFixed_GUI



You can calculate the VT with a formula and test data. By adding a formula VTLINGM(DrainI, GateV) in the formulator, VT can be calculated with linear GM, as shown in the following two figures.

Figure 363: Calculate the VT with a formula

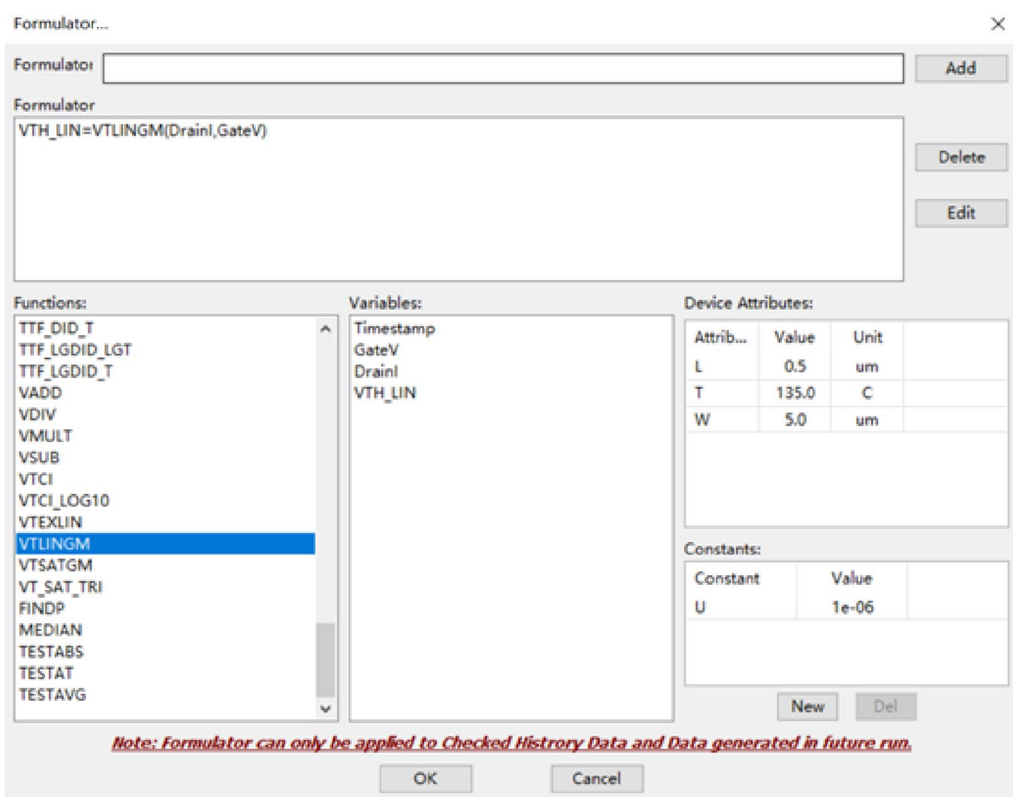
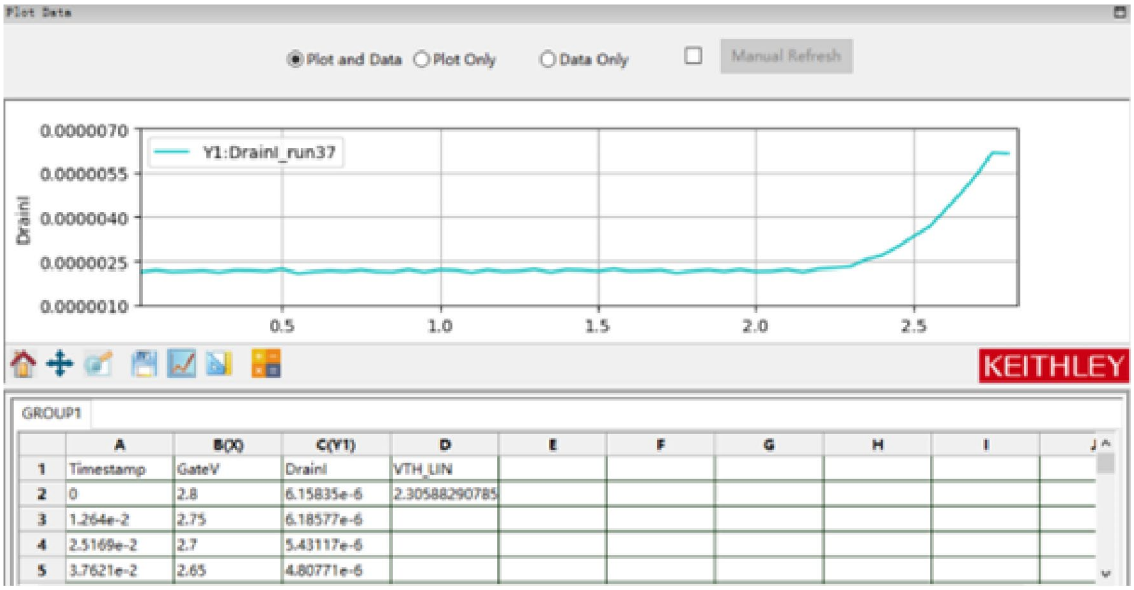


Figure 364: Plot data of the VGSweepVdFixed test



VgDualSweepVdFixed test

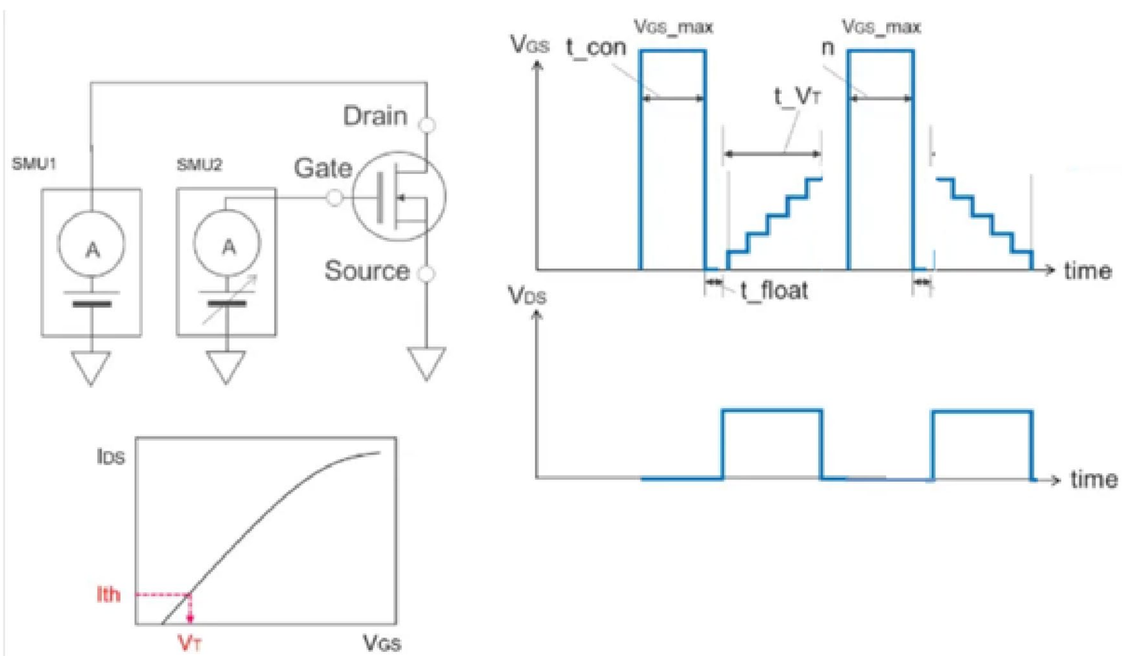
To add a VgDualSweepVdFixed test module:

1. Add a STM to the configuration navigator.
2. Import the `VthSiC_JEP183.tsp` module from the TSPLib library.
3. Select the `VgDualSweepVdFixed` module from test module drop-down list.

Required equipment: Series 2600 SourceMeter

This module applies a positive gate pulse prior to measuring the Vth to eliminate the hysteresis (refer to JEDEC standards (on page 3-423) JEP183 for more information). Next, it performs the GateV and DrainI measurement by dual sweeping the gate voltage with an upward staircase sweep and a downward staircase sweep. The measured data of GateV and DrainI will be used to calculate the Vth. The following figure shows the Vth test circuit and timing diagram.

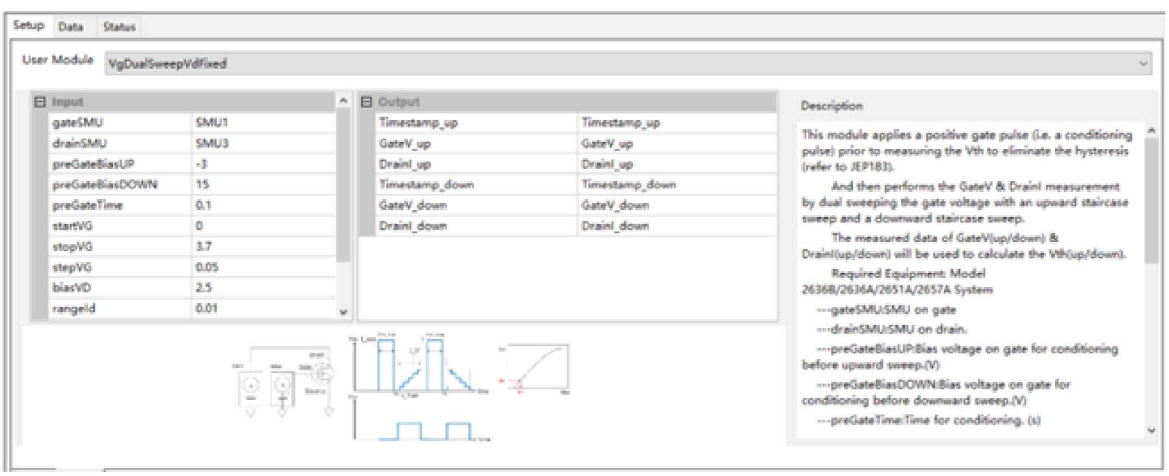
Figure 365: Vg dual sweep Vd fixed test circuit and timing diagram



Input	Description
gateSMU	SMU on Gate.
drainSMU	SMU on Drain.
preGateBiasUP	Bias voltage on gate for conditioning before upward sweep..(V)
preGateBiasDOWN	Bias voltage on gate for conditioning before downward sweep.(V)
preGateTime	Time for conditioning.(s)
restTimeVth	Rest time after pre-measurement before Vth measurement.(s)
startVG	Start voltage of sweep on Gate. (V)
stopVG	Stop voltage of sweep on Gate. (V)
stepVG	Step voltage of sweep on Gate. (V)
biasVD	Bias voltage on drain. (V)
rangeId	Current range on drain. (V)
srcLimitI	Source current limit. (V)
nPLC	Number of power line cycle. (V)
sweepDelay	Idle current level (base level for pulses) (A)

Output	Description
`Time_up`	Time stamp of upward sweep. (s)
`GateV_up`	Gate voltage reading of upward sweep. (V)
`DrainI_up`	Drain current reading of upward sweep. (A)
`Time_down`	Time stamp of downward sweep. (s)
`GateV_down`	Gate voltage reading of downward sweep. (V)
`DrainI_down`	Drain current reading of downward sweep. (A)

Figure 366: Vg dual sweep Vd fixed standard GUI



You can calculate the VT using a formula and test data. Refer to the Figure 361 for more information regarding how to calculate the VT using the VTLINGM formula.

VgVdBothSweep

To add a* VgVdBothSweep *test module:

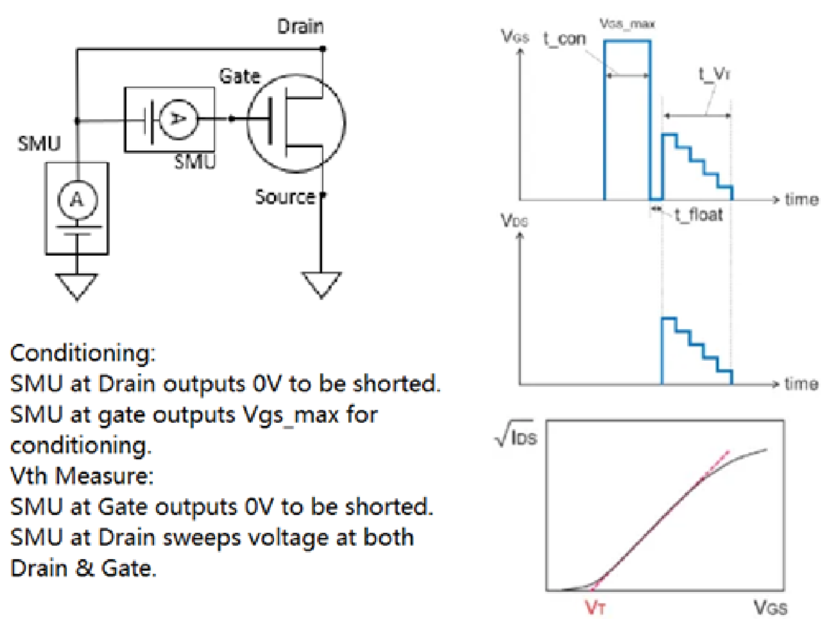
1. Add a script test module (STM) to the configuration navigator.
2. Import the `VthSiC_JEP183.tsp` module from the TSPLib library.
3. Select the `VgVdBothSweep` module from test module drop-down list.

Required Equipment: Series 2600 SourceMeter

This module applies a positive Gate pulse (conditioning pulse) prior to measuring the Vth to eliminate the hysteresis (refer to JEDEC standards (on page 3-423) JEP183 for more information). And then performs the GateV and DrainI measurement by sweeping the voltage on both the gate and drain synchronously with a downward staircase sweep. The measured data of GateV and DrainI are be used to calculate the Vth.

The following figure shows the Vth test circuit and timing diagram. Note that the SMU gate and SMU drain need to be connected in series, for instance the SMU-Drain is connected to HI, and the SMU-Gate is connected to LO.

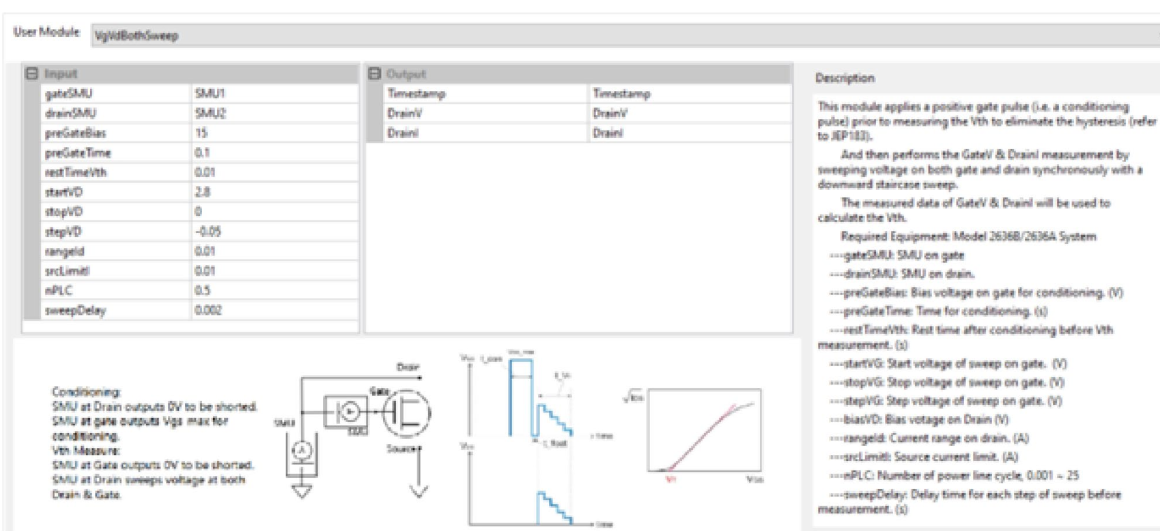
Figure 367: Vg Vd both sweep test circuit and timing diagram



Input	Description
gateSMU	SMU on gate.
drainSMU	SMU on drain.
preGateBias	Bias voltage on gate for conditioning.(V)
preGateTime	Time for conditioning.(s)
restTimeVth	Rest time after conditioning before Vth measurement.(s)
startVG	Start voltage of sweep on gate. (V)
stopVG	Stop voltage of sweep on gate. (V)
stepVG	Step voltage of sweep on gate. (V)
biasVD	Bias voltage on drain. (V)
rangeId	Current range on drain. (A)
srcLimitI	Source current limit. (A)
nPLC	Number of power line cycle.
sweepDelay	Delay time for each step of sweep before measurement. (s)

Output	Description
Timestamp	Time stamp reading. (s)
GateV	Gate voltage reading. (V)
DrainI	Drain current reading. (A)

Figure 368: Vg and Vd sweep standard GUI



You can calculate the VT with formula and test data by adding the formula VTSATGM (GateV and DrainI) in the formulator. VT is calculated using the GM saturation, as shown in the following figures.

Figure 369: Calculate VT with the VTSATGM formula

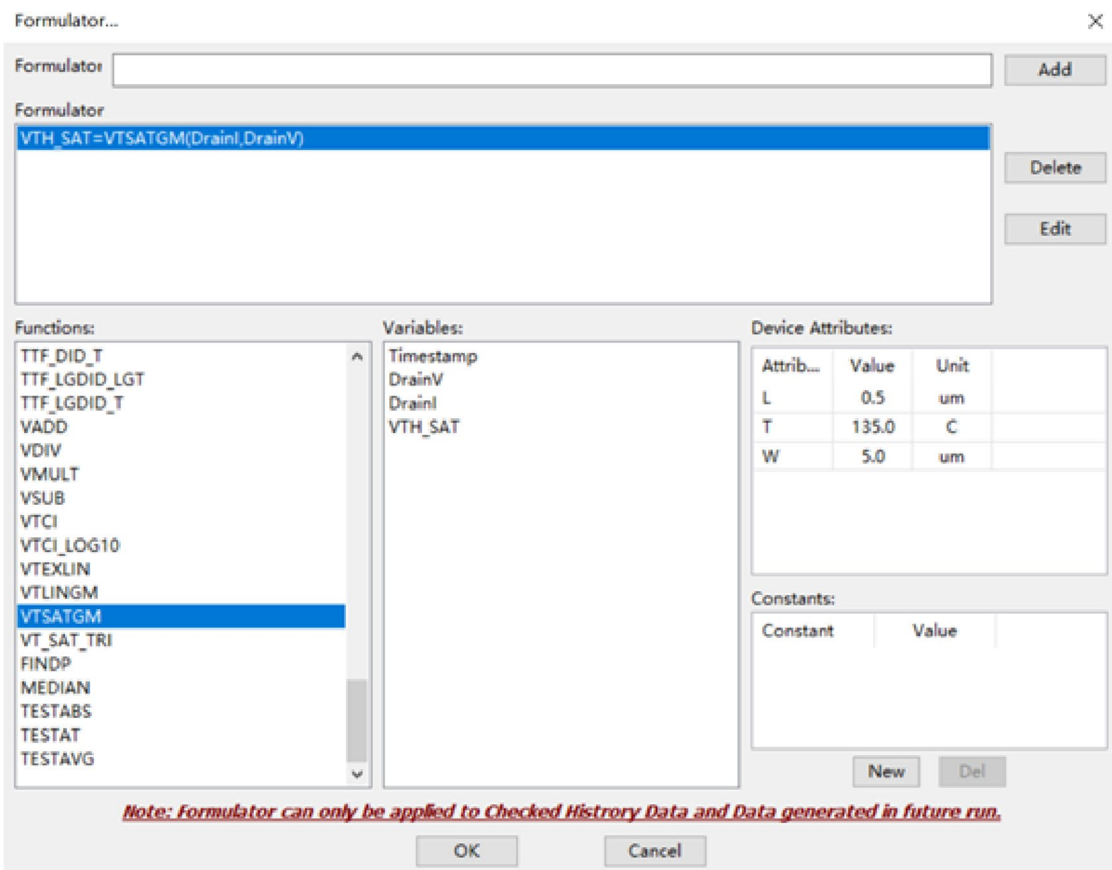
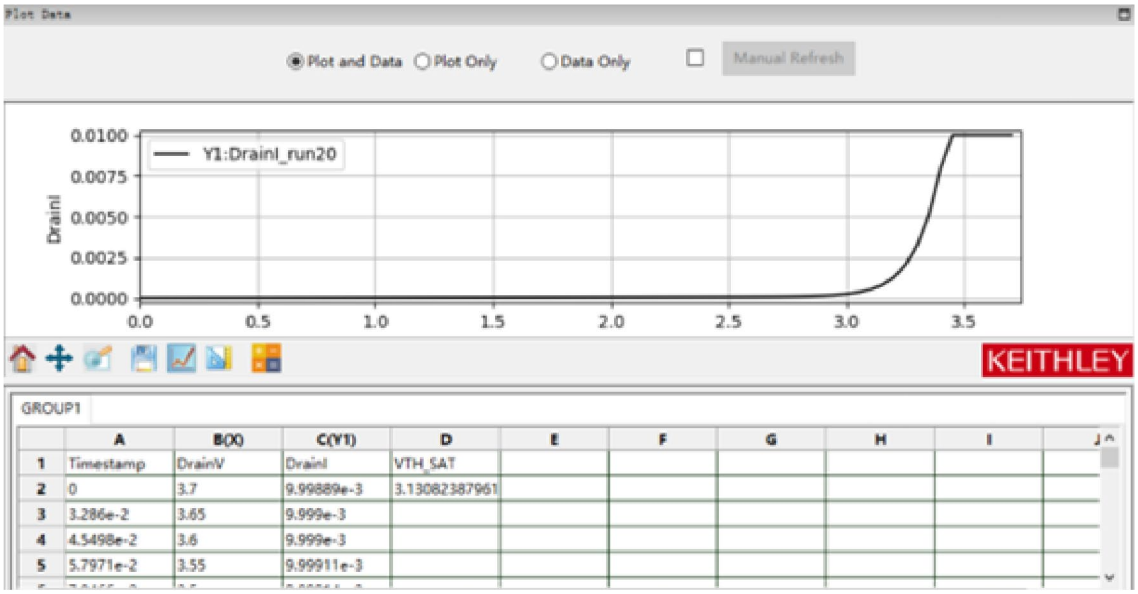


Figure 370: Plot Data for the VTSATGM



VgVdBothFixedBias

To add a VgVdBothFixedBias module:

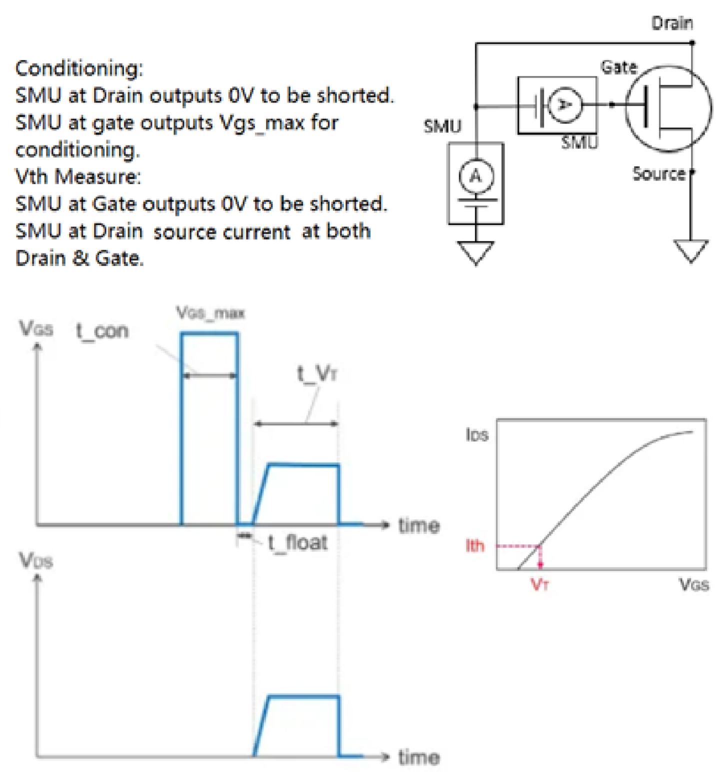
1. Add a STM to the configuration navigator.
2. Import the `VthSiC_JEP183.tsp` module from the TSPLib library.
3. Select the `VgVdBothFixedBias` module from test module drop-down list.

Required equipment: Series 2600 SourceMeter

This module applies a positive gate pulse prior to measuring the *Vth* to eliminate the hysteresis (refer to JEP183). And then sources a threshold current as *biasID* on the drain and gate at the same time, next it performs the gate voltage measurement. The measured gate voltage is the aimed threshold voltage *Vth*.

The following figure shows the *Vth* test circuit and timing diagram. Note that SMU on the gate and the SMU on drain must be connected in series (HI of the SMU-Drain connected to LO of the SMU-Gate).

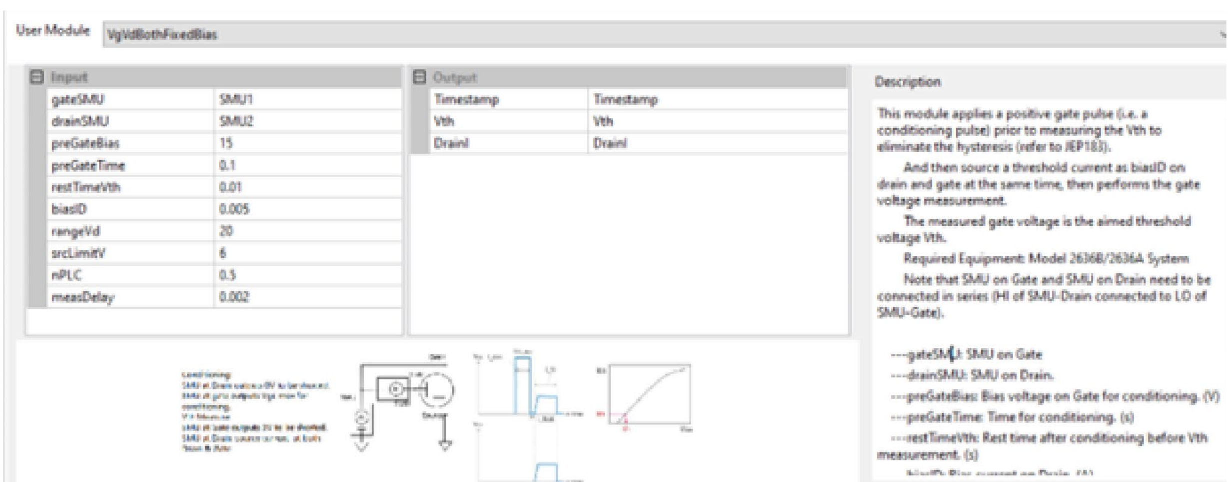
Figure 371: VgVd both fixed bias test circuit and timing diagram



Input	Description
gateSMU	SMU on Gate.
drainSMU	SMU on Drain.
preGateBias	Bias voltage on Gate for conditioning.(V)
preGateTime	Time for conditioning.(s)
restTimeVth	Rest time after conditioning before Vth measurement.(s)
biasID	Bias current on Drain. (A)
rangeVd	Voltage range on Drain. (V)
srcLimitI	Source current limit. (V)
nPLC	Number of power line cycle. 0.001~25.
sweepDelay	Idle current level (base level for pulses) (A)

Output	Description
`Timestamp`	Time stamp reading. (s)
`Vth`	Threshold voltage. (V)
`DrainI`	Drain current reading. (A)

Figure 372: Vg Vd both fixed bias GUI



Gate charge library

The following module helps you to configure a gate charge library with a Model 4200A SMU to perform the gate charge test on a power MOSFET. This test is based on the method in the JEDEC standard JESD24-2, *Gate Charge Test Method*, available at jedec.org.

gatecharge test

To add a gate charge module:

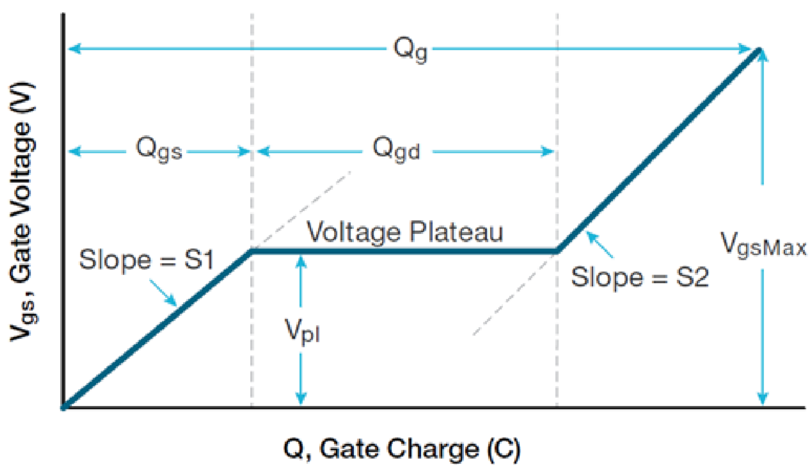
1. Add a PTM to the configuration navigator.
2. Import the gateCharge.py module from the PTMLib library. Choose the gatecharge module from test module drop-down list.

Required Equipment: Keithley Instrument 4200A SMU.

This module performs a gate-charge test with the 4200A SMU. In this module, a fixed test current (Ig) is forced into the gate of a MOS transistor and the measured gate-source voltage (Vgs) is plotted against the charge flowing into the gate. A fixed voltage bias is applied to the drain terminal. From the resulting gate-voltage waveform, the gate-source charge (Qgs), gate-drain charge (Qgd), and gate-charge (Qg) are derived.

The following figure shows a typical gate-voltage versus a gate-charge curve of a power MOSFET.

Figure 373: Typical gate voltage vs. gate charge curve of a power MOSFET

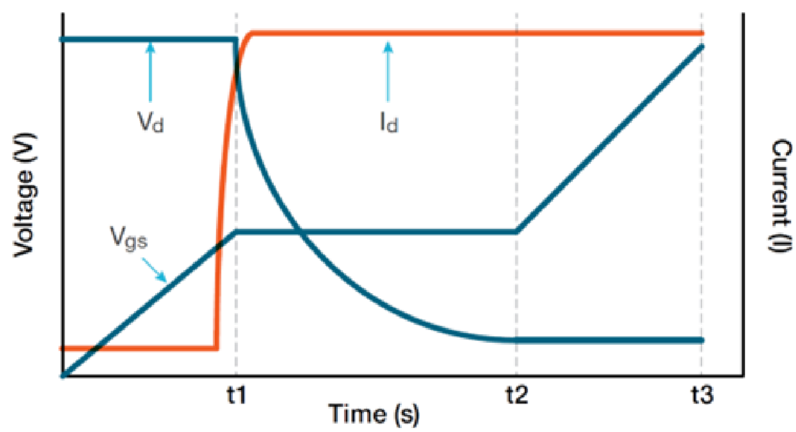


The gate-charge (Qg) is derived from the forced gate-current and time (Igdt). The gate-source charge (Qgs) is the charge required to reach the beginning of the plateau region where the gate-source voltage (Vgs) is almost constant (as shown in the following figure). The plateau voltage (Vpl) is defined, according to the JEDEC standards (jedec.org), as the gate-source voltage when `dVgs/dt` is at a minimum.

The voltage plateau is the region when the transistor is switching from the OFF state to the ON state. The gate-charge required to complete this switching is the same charge needed to switch the device from the start of the plateau region to the end. It is defined as gate-drain charge (Qgd) and is known as the *Miller* charge. The Qg is the charge from the origin to the point where the gate-source voltage (Vgs) is equal to a specified maximum (VgsMax).

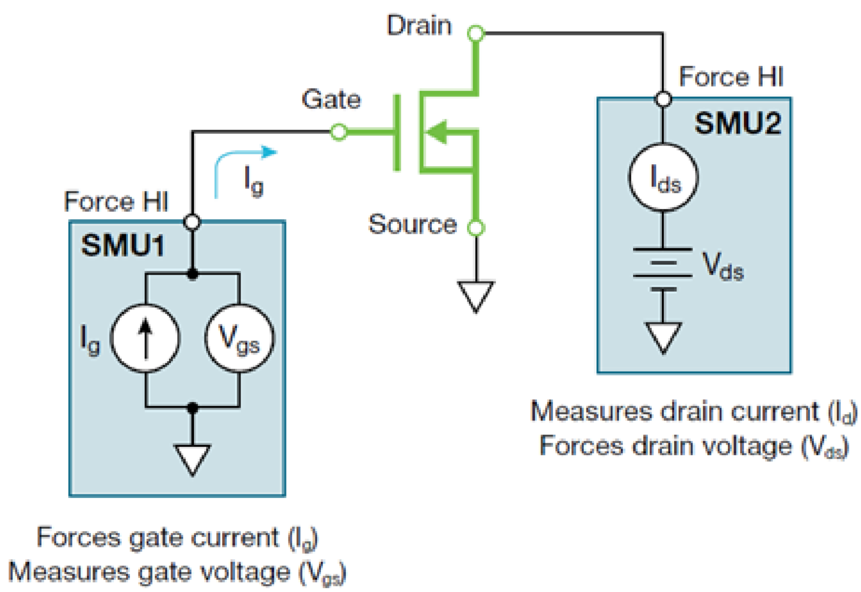
The following figure shows a typical gate and drain waveform as a function of time. As current is forced to the gate, the Vgs increases until it reaches the threshold voltage. At this point, the drain current (Id) begins to flow. When Cgs is charged up at time t1, the current drain (Id) stays constant and the drain voltage (Vd) decreases. The Vgs remains constant until it reaches the end of the plateau. Once the Cgd is charged at time t2, the gate-source voltage (Vgs) starts to increase again until it reaches the specified maximum gate-voltage (VgsMax).

Figure 374: Vgs, Vd, and Id vs. time of MOSFET



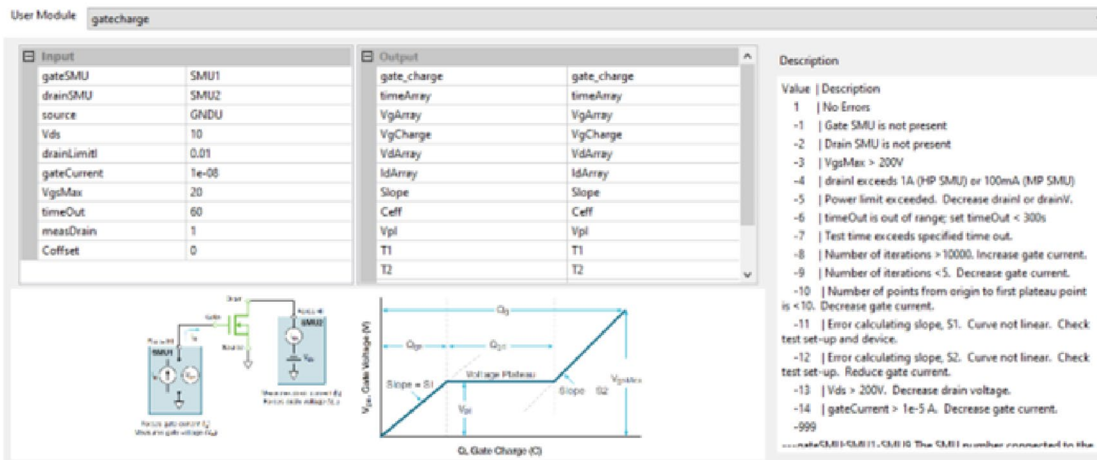
The 4200A-SCS measures the gate-charge of a power MOSFET using two SMU instruments. The following figure illustrates the basic circuit diagram of the gate-charge test. The Force HI terminal of one SMU (SMU1) is connected to the gate terminal of the MOSFET and forces the gate-current (Ig) and measures the gate-source voltage (Vgs) as a function of time. A second SMU (SMU2) applies a fixed voltage (Vds) to the drain at a specified current compliance (Ids). The MOSFET's source terminal is connected to the Force LO terminal or GNDU of the 4200A-SCS chassis.

Figure 375: Gate charge test using two SMU instruments



The following figure, and the input and output tables, indicate the input and output parameters for the gate-charge module and the standard GUI.

Figure 376: Gate charge standard GUI



Input	Description
gateSMU	SMU on gate (SMU1~SMU9)
drainSMU	SMU on drain (SMU1~SMU9)
source	The source terminal; GNDU as default
Vds	The drain bias voltage (V)
drainLimitI	Current compliance of the drain SMU
gateCurrent	The gate current (A)
VgsMax	The maximum voltage level of the gate SMU (V)
timeOut	The number of seconds prior to a time out (s)
measDrain	1: Return measured drain current 0: Not return measured drain current
Coffset	Run test with open circuit and enter the Ceff value returned in the Output data

Output	Description
gate_charge	Test status values
	Value | Description
	1 | No Errors
	-1 | Gate SMU is not present
	-2 | Drain SMU is not present
	-3 | VgsMax > 200V
	-4 | drainI exceeds 1A (HP SMU) or 100mA (MP SMU)
	-5 | Power limit exceeded; decrease drainI or drainV
	-6 | timeOut is out of range; set timeOut < 300s
	-7 | Test time exceeds specified time out
	-8 | Number of iterations >10000 Increase gate current
	-9 | Number of iterations <5; decrease gate current
	-10 | Number of points from origin to first plateau point is <10; decrease gate current
	-11 | Error calculating slope, S1; curve not linear; check test set-up and device
	-12 | Error calculating slope, S2; curve not linear; check test set-up; reduce gate current
	-13 | Vds > 200V; decrease drain voltage
	-14 | gateCurrent > 1e-5 A; decrease gate current
timeArray	Measured time (s)
VgArray	Measured gate-source voltage (V)
VgCharge	Measured gate charge (C)
VdArray	Measured drain voltage (V)
IdArray	Measured drain current (A)
Slope	Dynamic slope (dVg/dt) of gate voltage
Ceff	Ratio of gate charge to maximum gate voltage
Vpl	Plateau or Miller voltage (V)
T1	Timestamp where the plateau area begins (s)
T2	Timestamp where the plateau area ends (s)
Qgs	Gate charge from the origin to the first inflection point, or the voltage plateau (C)
Qgd	Gate charge between the two inflection points in the gate charge curve (C)
Qg	Gate charge from the origin to VgsMax (C)

Correcting for Offset Capacitances

Depending on the cabling and connections of the measurement system, the offset capacitance can be in the single picofarads to hundreds of picofarads ranges. These capacitances can be corrected by executing the gate-charge module with an open circuit, obtaining the offset capacitance, then entering the offset capacitance value back in the gate-charge module as the input parameter *Coffset* for the compensation of the subsequent tests.

1. To measure the offset capacitance.

To measure the offset capacitance, set up the test parameters, including the input gate current as though the device were connected to the SMUs. However, increase the *VgsMax* just for the *Ceff* measurement. Prior to executing the test, lift the probes, or remove the device from the test fixture. Execute the gate-charge test with an open circuit.

2. To obtain the offset capacitance.

To obtain the offset capacitance, after the test is executed, the measured offset capacitance of the system is calculated and appears in the *Ceff* column in the data panel. *Ceff* is derived from the maximum gate voltage, gate current, and time. Because an open circuit is measured during this step, a test status value of –9 or –12 may appear in the data panel after the test is executed. This is because no device is measured, so there is no plateau region. However, the *Ceff* value is correct and can be entered as the input parameter *Coffset* in the GUI the of gate-charge module.

3. To enter the measured offset capacitance and execute.

Enter the value of the measured offset capacitance *Ceff* as the input parameter *Coffset* on the GUI of gate-charge module. By default, *Coffset* is 0 F. Compensation will be made based on the offset capacitance *Coffset* in the subsequent runs of the gate-charge module.

Keithley Instruments
Corporate Headquarters • 28775 Aurora Road • Cleveland, Ohio 44139 • 440-248-0400 • 1-800-833-9200 • tek.com/keithley

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