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Automated Characterization Suite (ACS) Basic Edition

Libraries Reference Manual

ACSBASIC-908-01 Rev. A / August 2012

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ACSBASIC-908-01

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Automated Characterization Suite (ACS) Basic Edition

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Document number: ACSBASIC-908-01 Rev. A / August 2012

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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 qualified 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 Instruments products are designed for use with electrical signals that are rated Measurement Category I and Measurement Category II, as described in the International Electrotechnical Commission (IEC) Standard IEC 60664. Most measurement, control, and data I/O signals are Measurement Category I and must not be directly connected to mains voltage or to voltage sources with high transient overvoltages. Measurement Category II connections require protection for high transient overvoltages often associated with local AC mains connections. Assume all measurement, control, and data I/O connections are for connection to Category I sources unless otherwise marked or described in the user documentation.

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.

The instrument and accessories must be used in accordance with its specifications and operating instructions, or the safety of the equipment may be impaired.

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

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 safety earth 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 safety earth ground using the wire recommended in the user documentation.

The ⚠ symbol on an instrument means caution, risk of danger. The user should 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 caution, 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 dangers 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.

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 Instruments. Standard fuses with applicable national safety approvals may be used if the rating and type are the same. 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 Instruments to maintain accuracy and functionality of the product). If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean an instrument, use a damp cloth 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.

Table of Contents

LPT Library Reference 1-1

TSP LPT library 1-1
- Series 2600B TSP LPT library commands 1-2

Python LPT library 1-15
- Introduction 1-15
- LPT Functions 1-16
- ACS Basic LPT library commands 1-18
- PTM Examples 1-47

Device Library 2-1

Introduction 2-1
- General notes 2-5

npnBJT library 2-6
- npnBJT overview 2-6
- npnBJT parametric library 2-7

npnPowerBJT library 2-31
- npnPowerBJT overview 2-31
- npnPowerBJT parametric library 2-32

pnpBJT library 2-50
- pnpBJT device overview 2-50
- pnpBJT parametric library 2-51

pnpPowerBJT library 2-75
- pnpPowerBJT overview 2-75
- pnpPowerBJT library 2-76

nMOSFET parametric library 2-94
- nMOSFET parametric library overview 2-94
- nMOSFET parametric library 2-95
- nMOSFET WLR script library overview 2-115
- nMOSFET WLR script library command 2-115

nPowerMOSFET library 2-119
- nPowerMOSFET overview 2-119
- nPowerMOSFET parametric library 2-120

pMOSFET library 2-137
- pMOSFET overview 2-137
- pMOSFET parametric library 2-138
- pMOSFET WLR script library overview 2-158
- pMOSFET WLR script library 2-158

pPowerMOSFET library 2-171
- pPowerMOSFET overview 2-171
- pPowerMOSFET parametric library 2-172

Diode parametric library 2-188
- Diode parametric overview 2-188
- Diode parametric library 2-189

IGBT parametric library 2-197
- IGBT parametric overview 2-197
- IGBT parametric library 2-198

Two-terminal resistor library 2-212

Two-terminal resistor overview ... 2-212
Two-terminal resistor library ... 2-213

Four-terminal resistor library ... 2-217
Four-terminal resistor overview ... 2-217
Four-terminal resistor library ... 2-218

TRIAC parametric library ... 2-222
TRIAC parametric overview ... 2-222
TRIAC parametric library ... 2-223

Zener parametric library ... 2-233
Zener parametric overview ... 2-233
Zener parametric library ... 2-234

Capacitor WLR script library ... 2-237
Capacitor WLR script overview ... 2-237
Capacitor WLR script library ... 2-238

Common library ... 2-253
Common library introduction ... 2-253
Common library ... 2-254

High-voltage and high-current PTM ... 2-293
High-voltage and high-current PTM overview ... 2-293

Mixed SMUs in pulse mode ... 2-298
Mixed SMUs introduction ... 2-298
Mixed SMUs library ... 2-300

Switch control PTM ... 2-324

Section 1

LPT Library Reference

In this section:

TSP LPT library 1-1
Series 2600B TSP LPT library commands 1-2
Python LPT library 1-15

TSP LPT library

NOTE

When the Series 2600B System SourceMeter® instruments are referenced, it also includes the Series 2600A System SourceMeter instruments, since these two series of instruments are fully interchangeable. However, the following instruments are not supported in ACS Basic: Model 2604B, Model 2614B, and Model 2634B.

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's instrumentation.

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

NOTE

The Keithley Instruments Series 2600B System SourceMeter includes its own instrument control library (ICL). Refer to the Series 2600B Reference Manual for detailed information.

Series 2600B TSP LPT library commands

NOTE

The Series 2600B LPT commands are listed in alphabetical order.

avgi/avgv

Purpose: Performs a series of measurements and averages the results.

Format:

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

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

`Itable` = The table created by you; the measured current value is saved to `Itable[1]`.

`Vtable` = The table created by you; the measured voltage value is saved to `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 0.0001s (nplc must be set as 0.001).

clrscn

Purpose: Clears the measurement scan tables associated with a sweep.

Format:

```
clrscn()
```

crtbf

Purpose: Creates a buffer for a specified SMU to store its measurements.

Format:

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

`X` = SMU number(1,2,3,…)

`buff_name` = The name of the buffer.

`buff_cap` = The capacity of the buffer.

`append_flag` = Use KI_EBAP to enable buffer append mode and KI_DBAP to disable buffer append mode.

`timestamp_flag` = Use KI_EBTS to enable collecting buffer timestamps and KI_DBTS to disable collecting buffer timestamps.

delay/rdelay

Purpose: Provides user-programmable delay within a test sequence. The units are in seconds.

Format:

```
delay(second)
rdelay(second)
```

devclr

Purpose: Sets all sources to zero.

Format:

```
devclr()
```

devint

Purpose: Resets all instruments.

Format:

```
devint()
```

disable

Purpose: Stops the timer and sets the time value to zero. Timer reading is also stopped.

Format:

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

Y = Timer number (1,2,3,…)

enable

Purpose: Provides real-time measurements of voltage, current, conductance, and capacitance.

Format:

```
enable(ntimer[Y])  Y = Timer number(1,2,3,…)
```

forceclr

Purpose: Turns the Source output off on the specified SMU.

Format:

```
forceclr(SMUX)
```

X = SMU number (1,2,3,…)

forcei/forcev

Purpose: Programs a sourcing instrument to generate a voltage or current at a specific level.

Format:

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

X = SMU number (1,2,3,…)

intgi/intgv

Purpose: Performs voltage or current measurements averaged over a user-defined period (usually one AC-line cycle). This averaging is done in the hardware by integration of the analog measurement signal over a specified time period. The integration is automatically corrected for 50 or 60Hz power mains.

Format:

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

`X` = SMU number (1,2,3,…)
`Itable` = The table created by You; the measured value is saved to `Itable[1]`.

`Vtable` = The table created by You, the measured value is saved to `Vtable[1]`.

ioli/iolv/ioliv

Purpose: Measure current, voltage, or current and voltage using overlap mode. The integration time is set by `setmode()`, and the measure count is set by `setcount()`. The only difference between this function and `msoli()` is the integration time (`msoli()` uses fixed 0.001 nplc).

Format:

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

`X` = SMU number (1,2,3,…)
`i_buff_name` = The buffer to store current measurements. The buffer must be created by `crtbf()`, and must be created for the same SMU.

`v_buff_name` = The buffer to store voltage measurements. The buffer must be created by `crtbf()`, and must be created for the same SMU.

limiti/limitv/limitp

Purpose: Allows the programmer to specify a current, voltage, or power limit other than the instrument's default limit.

Format:

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

`X` = SMU number (1,2,3,…)

lorangei/lorangev

Purpose: Defines the bottom auto range limit for current or voltage measurements.

Format:

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

`X` = SMU number (1,2,3,…)

measi/measv/meast

Purpose: Allows the measurement of voltage, current, or time.

Format:

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

`X` = SMU number (1,2,3,…)

`Y` = Timer number (1,2,3,…)

`Itable` = The table created by you. The measured current value is saved to `Itable[1]`.

`Ttable` = The table created by you. The measured time value is saved to `Ttable[1]`.

`Vtable` = The table created by you. The measured voltage value is saved to `Vtable[1]`.

moli/molv/moliv

Purpose: Measures current (moli), voltage (molv), or current/voltage using overlap mode (moliv) using a fixed 0.001 nplc.

Format:

```
moli(SMUX, i_buff_name)
molv(SMUX, v_buff_name)
moliv(SMUX, i_buff_name, v_buff_name)
```

`X` = SMU number (1,2,3,…)

`i_buff_name` = The buffer to store current measurements. The buffer must be created by `crtbf()`, and must be created for the same SMU.

`v_buff_name` = The buffer to store voltage measurements. The buffer must be created by `crtbf()`, and must be created for the same SMU.

postscript

Purpose: Prints a list of scripts that are currently stored in the parent of the Series 2600B instruments, according to the location parameter.

Format:

```
postscript(location)
```

`location` = 0: volatile memory

`location` = 1: non-volatile memory

Default `location` value: 1

postbuffer

Purpose: Prints buffered data to a GPIB output buffer in binary format. ACS Basic software can only recognize buffered data printed by the `postbuffer` function.

Format:

```
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 will automatically calculate the average result of each `avg_num` value. If this parameter is not given by you, the system will give a default value of 1 (print every value point).

postbuftime

Purpose: Prints timestamps of buffered data in binary format. ACS Basic software can only recognize buffered `timestamp` data printed by the `postbuftime` function.

Format:

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

`name` = A string that presents the values in the script, defined by 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 will automatically calculate the average result of each `avg_num` value.

NOTE

In the same buffer, always use the same `avg_num` with the one in `postbuffer()`, or the timestamps' number will not match with the values' number. If this parameter is not given by you, the system will give a default value of 1 (print every value point).

postdata

Purpose: Prints a single value. ACS Basic software only recognizes single values printed by the post data function.

Format:

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

`name` = A string that represents the value in the script, defined by the script writer.

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

posterror

Purpose: Prints all errors in the error queue separately.

Format:

```
posterror()
```

postsmuinfo

Purpose: Prints information for all SMUs.

Format:

```
postsmuinfo()
```

posttable

Purpose: Prints table data. Each item in the table must be a numeric value.

Format:

```
posttable("name", table_name)
```

rangei/rangev

Purpose: Selects the current/voltage measurement range and prevents the selected instrument from auto ranging. By selecting a range, the time required for auto ranging is eliminated.

Format:

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

`X` = SMU number (1,2,3,…)

savgi/savgv

Purpose: Performs an averaging current or voltage measurement for every point in a sweep.

Format:

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

`X` = SMU number(1,2,3,…)

`Itable` = The table created by you. The measured value is saved to `Itable[1]`.

`Vtable` = The table created by you. The measured value is saved to `Vtable[1]`.

`step_num` = The number of measurements made at each point before the average is calculated.

`step_time` = The time delay in seconds between each measurement within a given ramp step.

scnmeas

Purpose: To perform a single measurement on multiple instruments at the same time.

Format:

```
scnmeas()
```

Remarks: 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.

setauto

Purpose: Sets SMU measurement auto range.

Format:

```
setauto(SMUX)
```

`X` = SMU number (1,2,3,…)

setcount

Purpose: Sets the number of measurements performed when a measurement is requested.

- 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.

Format:

```
setcount(SMUX, value)
```

`X` = SMU number (1,2,3,…)

setitv

Purpose: Sets the interval between multiple measurements. The unit of value is seconds.

- 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 will be made as fast as possible.
- The reset function sets the measure interval to 0.

Format:

```
setitv(SMUX, value)
```

`X` = SMU number (1,2,3,…)

setmode

Purpose: Set instrument-specific operating mode parameters. Modifies instruments' specific operating characteristics (see next table).

Format:

```
setmode(SMUX, modifier, value)
```

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

Setmode parameters:

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	

sintgi/sintgv

Purpose: Performs an integrated current or voltage measurement for every point in a sweep.

Format:

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

`X` = SMU number (1,2,3,…)

`Itable` = The table created by You, the measured current value is saved to `Itable[1]`.

`Vtable` = The table created by You, the measured voltage value is saved to `Vtable[1]`.

slorangei/slorangev

Purpose: Defines the bottom auto range limit for current or voltage Source.

Format:

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

`X` = SMU number (1,2,3,…)

smeasi/smeasv/smeast

Purpose: Allows a number of current/voltage/time measurements to be made by a specified instrument during a `sweepX` function. The results of the measurements are stored in the defined array.

Format:

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

`X` = SMU number (1,2,3,…)

`Y` = Timer number (1,2,3,…)

`Itable` = The table created by you. The measured current value is appended into `Itable`.

`Vtable` = The table created by you. The measured voltage value is appended into `Vtable`.

`Ttable` = The table created by you. The measured time value is appended into `Ttable`.

srangei/srangev

Purpose: Selects the current/voltage Source range and prevents the selected instrument from auto-ranging. By selecting a range, the time required for auto-ranging is eliminated.

Format:

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

`X` = SMU number (1,2,3,…)

ssetauto

Purpose: Sets SMU Source to auto range.

Format:

```
ssetauto(SMUX)
```

`X` = SMU number (1,2,3,…)

sweepi/sweepv

Purpose: Generates a ramp consisting of ascending or descending currents or voltages. The sweep consists of a sequence of steps, each with a user-specified duration.

Format:

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

`X` = SMU number (1,2,3,…)

`start` = The initial voltage or current level output from the sourcing instrument 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_num` = 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.

sysinit

Purpose: Sets nplc to 0.001 and measure count to 1. It affects every SMU in the system. Clears the error queues and resets all registers.

Format:

```
sysinit()
```

syquery

Purpose: Queries every node and every SMU in the system and gives every SMU a unique name, for instance, SMUX. Displays node number and SMU number on every Series 2600B instruments' screen. Sets the integration nplc to 1 and average mode to `KI_MEASX` on every SMU in the system.

Format:

```
sysquery()
```

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)
```

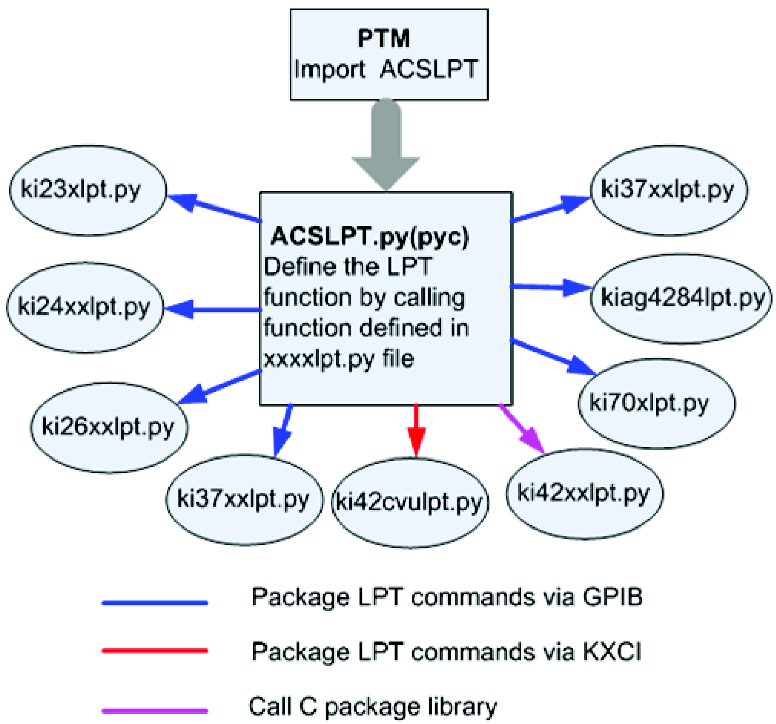
Python LPT library

Introduction

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

The commands in ACSLPT can be used to configure some general instruments. To use these commands, first, you need to import ACSLPT to a PTM. The commands can control the following instruments: Series 23x, Series 2400 SourceMeter, Series 2600B SourceMeter, Series 3700 System Switch, Model 4200 CVU, Model 4200/4210 SMU, Switch Matrix 707/707A/707B and 708/708A/708B, and LCR 4284/4980 capacitance meter (see next figure). For more information about Configuring a PTM, refer to the Configure a PTM topic in the ACS Basic Reference manual.

Figure 1: LPT call flow



NOTE

In the following table, you will learn how the CTM modules and the ACS Basic software function and interact.

ACS Basic software and CTM modules table:

ACS Basic installed on	Interface	Compatible library
Model 4200-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 SMUs and general operations are listed alphabetically.

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 auto range, no matter what value the parameter is set to.

Series 2400 LPT function list

Series 2400 SourceMeter instruments LPT functions			
delay	devclr	devint	forcei
forcev	intgi	intgv	limiti
limitv	measi	measv	rangi
rangev	setauto	setmode	srangei
srangev	sweepi	sweepv	

Series 2600B LPT function list

Series 2600B SourceMeter instruments LPT functions			
avgi	avgv	devclr	devint
forcei	forcev	intgi	intgv
limiti	limitv	lorangei	lorangev
measi	measv	rangi	rangev
setauto	setmode	srangei	srangev

Series 3700 LPT function list

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

Model 4200-SCS LPT function list

Model 4200-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_sweepv	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 4200 CVU (KXCI) LPT function list

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

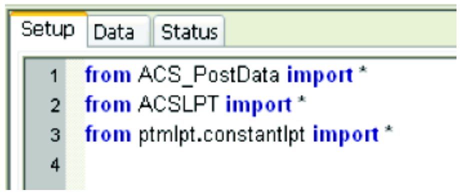
Capacitance Meter LPT function list

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

ACS Basic LPT library commands

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

Figure 2: Import ACSLPT



addcon

Purpose: Add terminal-pin connections.

Format:

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

`instMTRX` = The matrix name in the hardware configuration (this is optional).

`ter` = List of terminals to connect.

`pin` = List of pins to connect.

`more_pin` = More pins to connect.

Remarks: Terminal and pin lists must have the same number of items. Terminals and pins will be matched according to the sequence. If the numbers in the terminal and pin lists are not the same, a connection will be performed according to the shorter list.

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

For more information on the how to set the INSTRUMENT_CARD mode and ROW_COLUMN mode, refer to the Hardware Configuration topic in the ACS Basic Reference manual.

Example:

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

addconrc

Purpose: Add connections of rows and columns in matrix.

Format:

```
addconrc(unitname, row_list, col_list)
```

`unitname` = The matrix name in the hardware configuration.

`row_list` = List of rows to be connected.

`col_list` = List of columns to be connected.

Remarks: For more information on the how to set the INSTRUMENT_CARD mode and ROW_COLUMN mode, refer to the Hardware Configuration topic in the ACS Basic Reference manual.

Example:

Model 70X

```
addconrc(MTRX1,1,’A’)
addconrc(MTRX1,[1,2],[‘A’, ’B’])
```

Series 3700 System Switch

```
addconrc(MTRX1, 1, ’1’)
addconrc(MTRX1, [1,2], [‘1’,’2’])
```

addpth

Purpose: Add terminal-pin connections by path.

Format:

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

`instMTRX` = The matrix name in hardware configuration (this is optional).

`ter` = List of terminals to be connected.

`pin` = List of pins to be connect.

`row` = The row used to connect terminals and pins.

Example:

Model 70X

```
addpth(MTRX1,SMU1,1,'A')
addpth(SMU1,1,'A')
addpth(SMU1H,1,'A')
addpth(SMU1L,1,'A')
addpth([SMU1,SMU2],[1,2],'A')
addpth(MTRX1,[SMU1,SMU2],[],'A')
addpth([],[1,2],'A')
```

Series 3700 System Switch

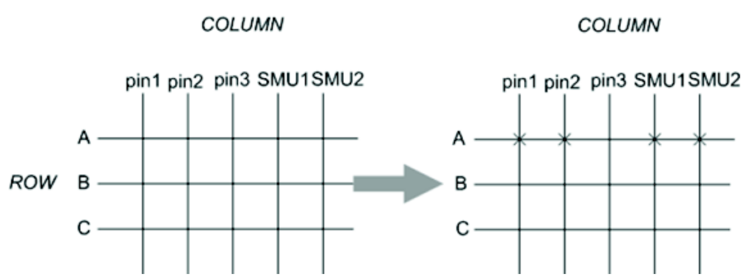
```
addpth(MTRX1,SMU1,1,'1')
addpth(SMU1,1,'1')
addpth(SMU1H,1,'1')
addpth(SMU1L,1,'1')
addpth([SMU1,SMU2],[1,2],'1')
addpth(MTRX1,[SMU1,SMU2],[],'1')
addpth([],[1,2],'1')
```

Remarks: All terminals and pins will be connected together in the row. One command cannot connect paths in multiple matrices (see next figure).

You can only connect terminals or pins with this function. However, when connecting terminals only `instMTRX` is required, otherwise the function will not know which instrument to send the command to.

For more information on the how to set the INSTRUMENT_CARD mode and ROW_COLUMN mode, refer to the Hardware Configuration topic in the ACS Basic Reference manual.

Figure 3: Example add path connections



avgi/avgv

Purpose: Performs a series of measurements and averages the results.

Format:

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

`iStepNo` = The number of steps averaged in the measurement. This number ranges from 1 to 160,000 (for Model 4200-SCS the limit is 32,767).

`dStepTime` = The interval in seconds between each measurement. Minimum practical time is approximately 0.0001s (nplc must be set as 0.001, for Model 4200-SCS set as 2.5us).

Example:

```
I1= avgi(SMU1, 100, 0.001)
```

checkparam

Purpose: Checks the hardware limits parameter according to the `hwlimits` file. Only applies to the DC range and limit check.

Format:

```
checkparam(unitname, **kwargs)
```

`unitname` = The instrument name that is found in the ACS_hdcon_Online.kcf file.

`**kwargs` = (dictionary type) A dictionary of arbitrary keyword arguments supplied using callback. The names are the same as defined in C:\S4200\sys\kcon\hwlimits.ini. ["dc_srange_v","dc_srange_i", "dc_range_v","dc_range_i", "dc_lmt_v", "dc_lmt_i"]

Example usage:

dc_range_v=10, dc_i_lmt=0.1

return value: dictionary/number

dc_range_v---(INVAL_PARAM,correct_range) / (OK, the lowest range if input value less than it) / (OK, input_range)

dc_lmt_i---(ERR_CHECKPARAM, input_range) / (INVAL_PARAM, correct_lmt) / (OK, input_range)

INVAL_INST_ID---invalid instrument ID

ERR_CHECKPARAM---An error will be reported if check limits and no Source range in input dict.

Example:

```
checkparam(SMU1,dc_lmti_i=1, dc_srange_v = 10)
```

clrattrset

Purpose: Clear current instrument setting in memory.

Format:

```
clrattrset( *args)
```

`*args` = A tuple of arbitrary positional arguments supplied using the `callback_args` option attribute.

Example:

```
Clrattrset(SMU1, SMU2)
```

clrcon

Purpose: Clear all connections of all the matrices or specified matrices (for example, MTRX1)(see next figure)..

Format:

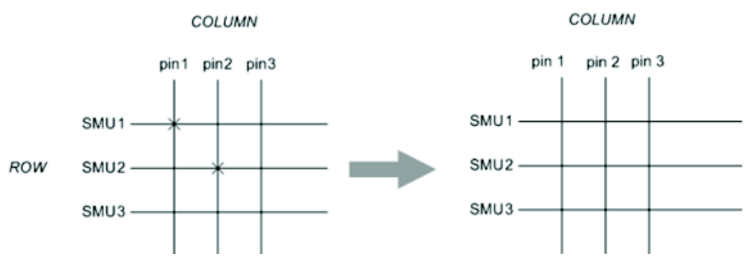
```
clrcon(unitname)
```

`unitname` = The instrument name that is found in the ACS_hdcon_Online.kcf file.

Example:

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

Figure 4: Example clear all connections



clrscn

Purpose: Clears the measurement scan tables associated with a sweep, only used in the Model 4200-SCS.

Format:

```
clrscn(*args)
```

`*args` = A tuple of arbitrary positional arguments supplied using the `callback_args` option attribute.

Example:

```
clrscn()
clrscn(SMU1,SMU2,CVU1)
```

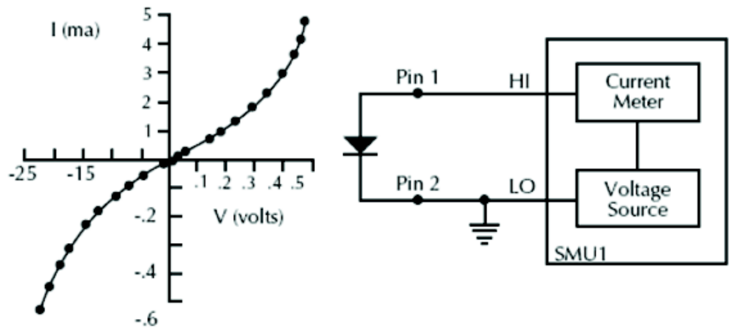
clrtrg

Purpose: Clears the user-selected voltage or current level used to set trigger points. This permits the use of `trigXl` or `trigXg` more than once with different levels within a single test sequence. Only used in Model 4200-SCS (see next figure).

Format:

```
clrtrg(*args)
```

Figure 5: Example clear trigger points




```
conpin(SMU1, 1, 0)
conpin(GND, SMU1L, 2, 0)
trigil(SMU1, 5.0e-3)# Increase ramp to I = 5mA.
smeasi(SMU1, forcur’)# Measure forward
sweepv(SMU1, 0.0, 0.5, 10, 5.0e-3)# Output 0 to 0.5V in 10 steps, each 5ms
   duration. clrtrg() # Clear 5mA trigger point.
clrscn() # Clear sweepv
trigil(SMU1, -0.5e-3)# Decrease ramp to  I = -0.5mA.
cur=smeasi(‘SMU1’)# Measure reverse
sweepv(SMU1, 0.0, -30.0, 10, 5.00e-3)
```

conpin

Purpose: Clear old connections and adds new terminal-pin connections

Format:

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

`instMTRX` = The matrix name in the hardware configuration (this is optional).

`ter` = List of terminals to connect.

`pin` = List of pins to connect.

`more_pin` = More pins to connect.

Remarks: Normally conpin() supports ROW_COLUMN mode of matrix. When matrix is set to INSTRUMENT_CARD mode, rows will be assigned automatically to connect the terminals and pins.

For more information on the how to set the INSTRUMENT_CARD mode and ROW_COLUMN mode, refer to the Hardware Configuration topic in the ACS Basic Reference manual.

Example:

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

conpth

Purpose: Clear all connections and adds new terminal-pin connections by path.

Format:

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

`instMTRX` = The matrix name in the hardware configuration (this is optional).

`ter` = List of terminals to connect.

`pin` = List of pins to connect.

`row` = The row used to connect terminals and pins

Remarks: All terminals and pins will be connected together by the assigned row. One command cannot connect two paths. One command cannot connect paths in multiple matrices.

You can only connect terminals or pins with this function. But when connecting only terminals, `instMTRX` is required. Otherwise, the function does not know which instrument to send the commend to.

Example:

Model 70X

```
conpth(MTRX1,SMU1,1,'A')
conpth(SMU1,1,'A')
conpth(SMU1H,1,'A')
conpth(SMU1L,1,'A')
conpth([SMU1,SMU2],[1,2],'A')
conpth(MTRX1,[SMU1,SMU2],[],'A')
conpth([],[1,2],'A')
```

Series 3700 System Switch

```
conpth(MTRX1,SMU1,1,'1')
conpth(SMU1,1,'1')
conpth(SMU1H,1,'1')
conpth(SMU1L,1,'1')
conpth([SMU1,SMU2],[1,2],'1')
conpth(MTRX1,[SMU1,SMU2],[],'1')
conpth([],[1,2],'1')
```

conrowcol

Purpose: Clear old connections and add new row-column connections.

Format:

```
conrowcol(unitname, row_list, col_list)
```

`unitname` = The matrix name in the hardware configuration.

`row_list` = List of rows to be connected.

`col_list` = List of columns to be connected.

Example:

Model 70X

```
conrowcol(MTRX1,1,'A')
conrowcol(MTRX1,[1,2],['A','B'])
Series 3700 System Switch
conrowcol(MTRX1,1,'1')
conrowcol(MTRX1,[1,2],['1','2'])
```

delay

Purpose: Provides user-programmable delay within a test sequence. The units are in milliseconds.

Format:

```
delay(iDelayTime)
```

delcon

Purpose: Delete terminal-pin connections.

Format:

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

`instMTRX` = The matrix name in the hardware configuration (this is optional).

`ter` = List of terminals to connect.

`pin` = List of pins to connect.

`more_pin` = More pins to connect.

Remarks: Normally `delcon()` supports ROW_COLUMN mode for a matrix. For more information on the how to set the INSTRUMENT_CARD mode and ROW_COLUMN mode, refer to the Series 3700 System Properties dialog box and 70x Switch matrix.

Example:

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

delconrc

Purpose: Delete connections of rows and columns in matrix.

Format:

```
delconrc(unitname, row_list, col_list)
```

`unitname` = The matrix name in the hardware configuration.

`row_list` = List of rows to be disconnected.

`col_list` = List of columns to be disconnected.

Remarks: Terminal and pin lists must have the same number of items. Terminals and pins will be matched according to the sequence. If the number of terminal and pin lists are not the same, connections will be disconnected according to the shorter list.

Example:

Model 70X

```
delconrc(MTRX1,1,’A’)
delconrc(MTRX1,[1,2],[‘A’,’B’])
Series 3700 System Switch
delconrc(MTRX1,1,’1’)
delconrc(MTRX1,[1,2],[‘1’,’2’])
```

delpth

Purpose: Delete terminal-pin connections by specified path.

Format:

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

`instMTRX` = The matrix name in hardware configuration, it's optional.

`ter` = List of terminals to be disconnected.

`pin` = List of pins to be disconnected.

`row` = The row used to connecting the terminals and pins.

Remarks: Note that the `ter-pin-row` has to be the actual group when they were connected, otherwise there is no action on the matrix.

Example:

Model 70X

```
delpth(MTRX1,SMU1,1,'A')
delpth(SMU1,1,'A')
delpth(SMU1H,1,'A')
delpth(SMU1L,1,'A')
delpth([SMU1,SMU2],[1,2],'A')
delpth(MTRX1,[SMU1,SMU2],[],'A')
delpth([],[1,2],'A')
```

Series 3700 System Switch

```
delpth(MTRX1,SMU1,1,'1')
delpth(SMU1,1,'1')
delpth(SMU1H,1,'1')
delpth(SMU1L,1,'1')
delpth([SMU1,SMU2],[1,2],'1')
delpth(MTRX1,[SMU1,SMU2],[],'1')
delpth([],[1,2],'1')
```

devclr

Purpose: Sets all sources to a zero state.

Format:

```
devclr(*args)
```

Example:

```
devclr()
devclr(SMU1)
devclr(SMU1, CVU1)
```

Remarks: This function will send output off commands or call the Model 4200 `devclr` function. It will not work on a matrix. If the system is configured using KCON the Model 4200 `devclr` function will execute. This function will clear all sources sequentially. Prior to clearing all Keithley Instruments supported instruments, GPIB based instruments will be cleared by sending all strings defined with `kibdefclr`. `Devclr` is implicitly called by `clrcon`, `devint`, `execut`, and `tstdsl`.

devint

Purpose: Resets the instruments and clears the system by opening all relays and disconnecting the pathways. Meters and sources are reset to the default states. Refer to the specific hardware manuals for listings of the default conditions and ranges for the instrumentation.

Format:

```
devint(*args)
```

Example:

```
devint()
devint(SMU1)
```

Remarks: This function will send reset commands or call the Model 4200 `devint` function. If the system is configured using KCON the Model 4200 `devclr` function will execute. The Model 4200 `devclr` function will execute as follows:

- Reset all instruments in the system to their default states.
- Perform the following actions prior to resetting the instruments:
  - Clear all sources by calling `devclr`.
  - Clear the matrix cross-points by calling `clrcon`.
  - Clear the trigger tables by calling `clrtrg`.
  - Clear the sweep tables by calling `clrscn`.
  - Reset GPIB instruments by sending the string defined with `kibdefint`.
  - Stop the pulse generator card, and check the standard pulse mode and its default settings (like `*RST`).
- `devint` is implicitly called by `execut` and `tstdsl`.

disable

Purpose: Stops the timer and sets the time value to zero. Timer reading is also stopped.

Format:

```
disable(unitname)
```

`unitname` = The instrument name of the timer module.

Example:

```
disable('TIMER1')
```

enable

Purpose: Provides correlation of real time to measurements of voltage, current, conductance, and capacitance.

Format:

```
enable(unitname)
```

`unitname` = The instrument name of the timer module.

Example:

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

execut

Purpose: Causes the system to wait for the preceding test sequence to be executed.

Format:

```
execut(*args)
```

Example:

```
execut()
execut(SMU1)
```

Remarks: For the Model 4200-SCS or Series 2600B SourceMeter instruments, this function will wait for all of the previous LPT commands to finish testing and then will issue a devint.

forcei/forcev

Purpose: Programs a sourcing instrument to generate a voltage or current at a specific level.

Format:

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

`unitname` = The instrument name that is found in the ACS_hdcon_Online.kcf file.

`dValue` = The level of the bipolar voltage or current forced in volts or amperes

get common

Purpose: Get common attributes from the global_dict and return the key list: [UNITLIST, PLC, pin]

Format:

```
getcommon()
```

Example:

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

getinstattr

NOTE

You can programmatically read the GPIB address, and other instrument properties, on the system configuration using the LPTLib `getinstattr` function. Proper usage of `getinstattr` allows you to develop user libraries in an independent configuration manner.

Purpose: Get instrument attributes from the attribute string.

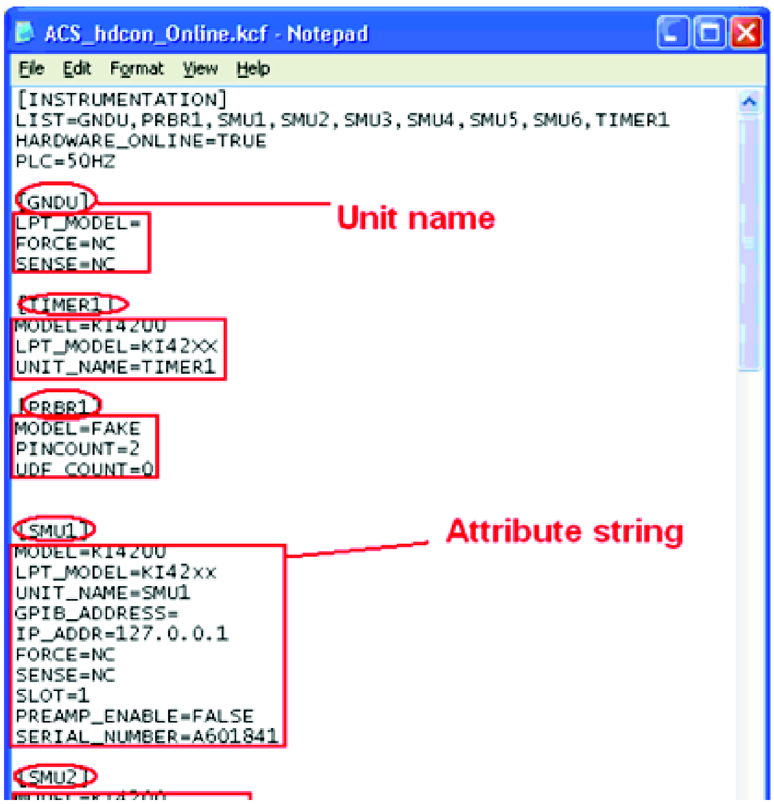
Format:

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

`unitname` = The instrument name in that is found in the ACS_hdcon_Online.kcf file (see next figure).

`attr_str` = The attribute string list that is found in the ACS_hdcon_Online.kcf file.

Figure 6: Unit name and attribute string in .kcf file



Return value:

```
INVAL_INST_ID
-1 (this function does not apply on this unit)
None (nothing to get from the unit's attribute)
attribute value
```

Example:

```
getinstattr(SMU1, "GPIB_ADDRESS")
print getinstattr(SMU1, "MODEL")
KI4200
```

getinstid

Purpose: Get the instrument identifier (ID) from the instrument name string (only used for the Model 4200).

Format:

```
getinstid(unitname)
```

`unitname` = The instrument name in that is found in the ACS_hdcon_Online.kcf file.

Return value:

```
instrument identifier (ID)
Example: print getinstid(SMU1)
4100
```

getstatus

Purpose: Returns the operating state of the desired instrument (only used for the Model 4200).

Format:

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

`unitname` = The instrument name that is found in the ACS_hdcon_Online.kcf file.

`iCode` = The parameter of query.

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

Valid Errors: 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 the selected device.

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

Getstatus: query 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 auto-range)
KI_VPRANGE		Voltage range (full-scale range value, or 0.0 for auto-range)
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 auto-range, the range at which the previous I measurement was performed
KI_VMRANGE		For auto-range, 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

Valid Errors: 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.

Example:

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

gpibenter

Purpose: Used to read a device dependent string from an instrument connected to the GPIB interface.

Format:

```
gpibenter(unitname, max_size)
```

`unitname` = The instrument name that is found in the ACS_hdcon_Online.kcf file.

`max_size` = A value specifying the maximum number of characters you want to receive. `maxlength` can be a number from 0 to 65535.

Return value: (tupple type)(receive str, length, status) or error code

Example:

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

gpibsend

Purpose: Sends a device dependent command to an instrument connected to the GPIB interface.

Format:

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

`unitname` = The instrument name that is found in the ACS_hdcon_Online.kcf file.

`cmd_str` = A string to be sent to the device. Note: Terminating character(s) are automatically added to the end of this string when it is sent. The default terminator is a line feed character.

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

Example:

gpibsend(SMU1, ‘devint()’)

gpibsend(GPI1, "L2X")

gpibspl

Purpose: A serial poll reads the status of an instrument connected to the GPIB interface.

Format:

```
gpibspl(unitname)
```

`unitname` = The instrument name that is found in the ACS_hdcon_Online.kcf file.

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

Example:

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

imeast

Purpose: Force a read of the timer and return the result.

Format:

```
imeast(unitname)
```

`unitname` = The instrument name that is found in the ACS_hdcon_Online.kcf file.

Return value: Elapsed time from enable (TIMER1).

Remarks: This command applies to all timers. Must call enable (TIMERn) first.

Example:

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

intgi/intgv

Purpose: Performs voltage or current measurements averaged over a user-defined period (usually one AC line cycle). This averaging is done in the hardware by integration of the analog measurement signal over a period of specified time. The integration is automatically corrected for 50 or 60Hz power mains.

Format:

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

`unitname` = The instrument name that is found in the ACS_hdcon_Online.kcf file.

Return value: Result data

Example:

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

limiti/limitv/limitp

Purpose: Allows the programmer to specify a current, voltage, or power limit other than the instrument's default limit.

Format:

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

`unitname` = The instrument name that is found in the ACS_hdcon_Online.kcf file.

`dValue` = The maximum level of the 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.

Remarks: 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.

lorangei/lorangev

Purpose: Defines the bottom auto-range limit.

Format:

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

`unitname` = The instrument name that is found in the ACS_hdcon_Online.kcf file.

`dValue` = The value of the desired instrument range, in volts or amperes.

Remarks: `lorange` is used with auto-ranging to limit the number of range changes which saves test time.

For the Model 4200-SCS, if the instrument was on a range lower than the one specified by `lorange`, the range is changed. Model 4200-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 the Model 23x instruments, this function works as auto-range. The second `dValue` will be ignored.

It cannot be used for the Series 2400 SourceMeter instruments.

Example:

```
lorangei(SMU1, 2.0E-6)
```

measi/measv

Purpose: Allows the measurement of voltage or current.

Format:

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

`unitname` = The instrument name that is found in the ACS_hdcon_Online.kcf file.

Return value: Result data.

Remarks: For this measurement, the signal is sampled for a specific period of time. This sampling time for the measurement is called the integration time. For the `measX` function, the integration time is fixed at 0.01PLC. For 60Hz line power, 0.01PLC = 166.67µs (0.01PLC/60Hz). For 50Hz line power, 0.01PLC = 200µs (0.01PLC/50Hz).

Example:

```
i1= measi(SMU1)
```

measz

Purpose: Performs an impedance measurement on a CVU or other capacitance measuring instrument.

Format:

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

`unitname` = The instrument name that is found in the ACS_hdcon_Online.kcf file. Only CVUn and CMRTn are supported.

`iModel` = Measurement Model (see next table).

`iSpeed` = Measure speed: `KI_CVU_SPEED_FAST`, `KI_CVU_SPEED_NORMAL`, or `KI_CVU_SPEED_QUIET`

Return value: [result1, result2]

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

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

Remarks: The measurement models are listed in the next table..

Measurement speed settings: `KI_CVU_SPEED_FAST` performs fast measurements (higher noise)

Measurement mode table

Model name	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
	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 capacitance	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)
```

rangei/rangev

Purpose: Selects the measurement range and prevents the selected instrument from auto-ranging. By selecting a range, the time required for auto-ranging is eliminated.

Format:

```
rangei(unitname_str,dvalue)
rangev(unitname_str,dvalue)
```

`unitname` = The instrument name that is found in the ACS_hdcon_Online.kcf file.

`dvalue` = The value of the highest measurement to be taken. The most appropriate range for this measurement will be selected. If range is set to 0, the instrument will auto-range. However, auto-range will not occur on the Series 2600B SourceMeter instruments.

Example:

```
rangei(SMU1, 2.0E-3)  # Click current range of 2mA.
```

rdelay

Purpose: A user-programmable delay in seconds.

Format:

```
rdelay(dDelayTime)
```

Example:

```
rdelay(0.02)# Pause for 20ms
```

setauto

Purpose: Re-enables auto-ranging and cancels any previous `rangeX` command for the specified instrument.

Format:

```
setauto(unitname)
```

`unitname` = The instrument name that is found in the ACS_hdcon_Online.kcf file.

Remarks: When an instrument is returned to the auto-range mode, it will remain in its present range for measurement purposes. The Source range will change immediately.

Due to the dual mode operation of the SMU (v versus i) `setauto` places both voltage and current ranges in auto-range mode.

Example:

```
setauto(SMU1) # Enable auto range mode.
```

setfreq

Purpose: A CV test command. Sets the frequency for the AC drive.

Format:

```
setfreq(unitname,dFreq)
```

`unitname` = The instrument name that is found in the ACS_hdcon_Online.kcf file. Only CVUn and CMRTn are supported.

`frequency` = Frequency of the AC drive in hertz.

Example:

```
status = setfreq(CVU1,10000)
```

setlevel

Purpose: A CV test command. Sets the AC drive voltage level.

Format:

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

`unitname` = The instrument name that is found in the ACS_hdcon_Online.kcf file. Only CVUn and CMRTn are supported.

`dSignalLevel` = Voltage level of the AC drive (10mV to 100mVRMS) in volts. Different valid ranges for CVU and CMTR

Example:

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

setmode

Purpose: Sets the instrument's specific operating mode parameters.

Format:

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

Remarks: Setmode allows control over certain instrument specific operating characteristics. Refer to the specific instrument documentation for more information on what each instrument supports.

Setmode: Model 23x table

Model 23x LPT parameters			Comments
Model name	**Modifier**	**Value**	
	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_SENSE	KI_SENSE_LOCA (or 0)	Set remote, local, sense mode: KI_SENSE_LOCA: selects local sense (2-wire)
		KI_SENSE_REMO(or 1)	KI_SENSE_REMO: selects remote sense (4-wire)
	KI_TRIG_IN	KI_TRIG_IN_CONT = 0	Input triggers. Input trigger are used to control when Source, delay, and measure operations occur: KI_TRIG_IN_CONT: Continuously process all SDM (Source delay measure) cycles.
		KI_TRIG_IN_SRC = 1	KI_TRIG_IN_SRC: Each trigger will process an SDM cycle.

SMU1		KI_TRIG_IN_DLY = 2	KI_TRIG_IN_DLY: Initial trigger sets Source. Each subsequent trigger initiates a delay and measure then sets Source of next SDM cycle.
		KI_TRIG_IN_SRCDLY = 3	KI_TRIG_IN_SRCDLY: Two trigger process each SDM cycle. First trigger sets Source. Second trigger initiates a delays and measure.
		KI_TRIG_IN_MSR = 4	KI_TRIG_IN_MSR: Initial trigger sets Source and causes a delay. Second trigger initiates measure, and then, for next SDM cycle, sets Source and initiates a delay.
		KI_TRIG_IN_SRCMSR = 5	KI_TRIG_IN_SRCMSR: Two triggers process each SDM cycle. First trigger sets Source and initiates a delay. Second trigger initiates a measure.
		KI_TRIG_IN_DLYMSR = 6	KI_TRIG_IN_DLYMSR: Initial trigger sets Source. Two triggers process each SDM cycle. First trigger initiates a delay. Second trigger initiates a measure and sets Source of nest SDM cycle.
		KI_TRIG_IN_SRCDLYMSR = 7	KI_TRIG_IN_SRCDLYMSR: Three triggers process each SDM cycle. First trigger sets Source. Second trigger initiates a delay. Third trigger initiates a measure.
		KI_TRIG_IN_PULSE = 8	KI_TRIG_IN_PULSE: Pulse sweep trigger. Each trigger process the on the 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 front manual trigger function, and external device that applies a TTL level pulse to the TRIGGER connector on the rear panel, or an appropriate IEEE-488 operation. KI_TRIG_X: IEEE X origin. "X" sent over IEEE-488 bus.
		KI_TRIG_GET = 1	KI_TRIG_GET: Group execute trigger.
		KI_TRIG_TALK = 2	KI_TRIG_TALK: Unit address to talk over IEEE-488 bus.
		KI_TRIG_EXTERNAL = 3	KI_TRIG_EXTERNAL: Negative going TTL level pulse applied to TRIGGER connector.
		KI_TRIG_INTERNAL = 4	KI_TRIG_INTERNAL: Front panel MANUAL trigger function or HO command over IEEE-488 bus.
	KI_TRIG_OUT	KI_TRIG_OUT_NONE = 0	Output trigger generation: KI_TRIG_OUT_NONE: No output triggers.
		KI_TRIG_OUT_SRC = 1	KI_TRIG_OUT_SRC: Output trigger pulse after every Source phase.
		KI_TRIG_OUT_DLY = 2	KI_TRIG_OUT_DLY: Out put trigger pulse after every delay phase.
		KI_TRIG_OUT_SRCDLY = 3	KI_TRIG_OUT_SRCDLY: Out put trigger pulse after every Source phase and delay phase.
		KI_TRIG_OUT_MSR = 4	KI_TRIG_OUT_MSR: Out put trigger pulse after every Source phase and measure phase.
		KI_TRIG_OUT_SRCMSR = 5	KI_TRIG_OUT_SRCMSR: Output trigger pulse after every Source phase and measure phase.
		KI_TRIG_OUT_DLYMSR = 6	KI_TRIG_OUT_DLYMSR: Out put trigger pulse after every delay phase and measure phase.

		KI_TRIG_OUT_SRCDLYMSR = 7	KI_TRIG_OUT_SRCDLYMSR: Out put trigger pulse after every Source phase, delay phase and measure phase.
		KI_TRIG_OUT_PULSE = 8	KI_TRIG_OUT_PULSE: For pulse sweeps . Output trigger pulse after 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 take average. 0 means disable average filter.

Setmode: Series 2400 SourceMeter table

Series 2400 instruments LPT parameters			Comments
Model name	**Modifier**	**Value**	
SMU1	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 0.01~10(DC) and 0.004~0.1(2430 Pulse mode).
SMU1 (only 2430 SMU)	KI_TRIG_IN_CONT	<value>	Sets the output pulse count.
SMU1	PULSE_MODE_PULSE	VOLT	Select pulse mode and pulse Source function: VOLT: voltage Source CURR: current Source
	PULSE_MODE_WID	<value>	Select pulse mode and set pulse width.
	PULSE_MODE_DELAY	<value>	Select pulse mode and set pulse delay.

Setmode: Series 2600B SourceMeter table

Series 2600B instruments LPT parameters			Comments
Model name	**Modifier**	**Value**	
SMU1	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 KI_INTEGRATE	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 call.
	KI_OFFMODE	KI_OFF_NORM	Set Source output-off mode. KI_OFF_NORM: Outputs 0V when the output is turned off.
		KI_OFF_ZERO	KI_OFF_ZERO: Zero the output (in either volts or current) when off.
		KI_OFF_OPEN	KI_OFF_OPEN: Opens the output relay when the output is turned off.
	KI_SENSE	KI_SENSE_LOCA	Set remote, local, sense mode, or calibration. KI_SENSE_LOCA: Selects local sense (2-wire).
		KI_SENSE_REMO	KI_SENSE_REMO: Selects remote sense (4-wire).
		KI_SENSE_CALA	KI_SENSE_CALA: Selects calibration sense mode.

Setmode: Model 4200 CVU table

Model 4200 CVU LPT parameters			Comments
Model name	**Modifier**	**Value**	
CVU1	KI_CVU_CABLE_CORRECT	0, 1.5 or 3	Cable length setting (in meters), can be set to any floating point number between 0 and 3.0, but will be coerced to 0, 1.5 or 3.
	KI_CVU_OPEN_COMPENSATE KI_CVU_SHORT_COMPENSATE KI_CVU_LOAD_COMPENSATE	0 = OFF 1 = ON	Enables or disables compensation constants for open load and short.
	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 the `measz` library topic.
	KI_CVU_MODE	0 or 1	0: sets CVU to user mode 1: sets CVU to system mode

Setmode: Model 4284 table

Model 4284 LPT parameters			Comments
Model name	**Modifier**	**Value**	
	KI_CVU_CABLE_CORRECT	0, 1.5 or 3	Cable length setting (in meters), can be set to any floating point number between 0 and 3.0, but will be coerced to 0, 1.5 or 3.
	KI_CVU_OPEN_COMPENSATE KI_CVU_SHORT_COMPENSATE KI_CVU_LOAD_COMPENSATE	0 = OFF 1 = ON	Enables or disables compensation constants for open load and short.
	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 the `measz` library topic.
	KI_CVU_MODE	0 or 1	0: sets CVU to user mode 1: sets CVU to system mode

CMTR1	KI_AGCV_CORRECT_METHOD	KI_AGCV_CORRECT_METHOD_MULT = 0 KI_AGCV_CORRECT_METHOD_SING = 1	Selects the correction mode (single or multi). Scanner I/F should be installed for multi-mode. KI_AGCV_CORRECT_METHOD_SING: Sets the correction mode to "SINGLE." KI_AGCV_CORRECT_METHOD_MULT: Sets the correction mode to "MULTI."
	KI_AGCV_TRIG_SOURCE	KI_AGCV_TRIG_INTERNAL = 0 KI_AGCV_TRIG_HOLD = 1 KI_AGCV_TRIG_EXTERNAL = 2 KI_AGCV_TRIG_BUS = 3	Selects the trigger mode: KI_AGCV_TRIG_INTERNAL: Sets trigger Source to "internal." KI_AGCV_TRIG_HOLD: Sets trigger Source to "manual." KI_AGCV_TRIG_EXTERNAL: Sets trigger Source to "external connector on the rear panel." KI_AGCV_TRIG_BUS: Sets trigger Source to "GPIB/LAN/USB."
	KI_AGCV_INIT_CONTINUE	0 = OFF 1 = ON	Enables the automatic trigger to change state from the "Idle" to "Wait for Trigger." ON or 1: Enables automatic trigger state change. OFF or 0 (preset value): Disables automatic trigger state change.

	KI_AGCV_DISPLAY_PAGE	KI_AGCV_DISPLAY_MEAS = 0 KI_AGCV_DISPLAY_BNUMBER = 1 KI_AGCV_DISPLAY_BCOUNT = 2 KI_AGCV_DISPLAY_LIST = 3 KI_AGCV_DISPLAY_MSETUP = 4 KI_AGCV_DISPLAY_CSETUP = 5 KI_AGCV_DISPLAY_LTABLE = 6 KI_AGCV_DISPLAY_LSETUP = 7 KI_AGCV_DISPLAY_CATALOG = 8 KI_AGCV_DISPLAY_SYSTEM = 9 KI_AGCV_DISPLAY_SELF = 10 KI_AGCV_DISPLAY_MLARGE = 11 KI_AGCV_DISPLAY_SCONFIG = 12 KI_AGCV_DISPLAY_SERVICE = 13	Selects the page to be displayed. KI_AGCV_DISPLAY_MEAS: Sets displayed page to <MEAS DISPLAY> KI_AGCV_DISPLAY_BNUMBER: Sets displayed page to <BIN No. DISPLAY> KI_AGCV_DISPLAY_BCOUNT: Sets displayed page to <BIN COUNT DISPLAY> KI_AGCV_DISPLAY_LIST: Sets displayed page to <LIST SWEEP DISPLAY> KI_AGCV_DISPLAY_MSETUP: Sets displayed page to <MEAS SETUP> KI_AGCV_DISPLAY_CSETUP: Sets displayed page to <CORRECTION> KI_AGCV_DISPLAY_LTABLE: Sets displayed page to <LIMIT TABLE SETUP> KI_AGCV_DISPLAY_LSETUP: Sets displayed page to <LIST SWEEP SETUP> KI_AGCV_DISPLAY_CATALOG: Sets displayed page to <CATALOG> KI_AGCV_DISPLAY_SYSTEM: Sets displayed page to <SYSTEM INFO> KI_AGCV_DISPLAY_SELF: Sets display page to <SELF TEST> KI_AGCV_DISPLAY_MLARGE: Sets page to display measurement results in large characters. KI_AGCV_DISPLAY_SCONFIG: Sets displayed page to <SYSTEM CONFIG> KI_AGCV_DISPLAY_SERVICE: Sets displayed page to <SERVICE>

Setmode: Model 4200 table

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>	Number of readings to take when KI_TRIGMODE is to KI_AVERAGE.
		KI_AVGTIME	<value> (in unit of seconds)	Time between readings when KI_TRIGMODE is set to KI_AVERAGE.

No operations performed[2]	KI_SYSTEM	KI_MX_DEFMODE	KI_HIGH KI_LOW	Sets the default mode to high current mode or low current mode. This setting will remain in effect until the end of the current session and is not reset by devint.
		KI_HICURRENT	KI_ON	Forces the matrix into high current mode. The mode will revert to the default at the next devint unless the configuration file sets this parameter to reset on a clrcon.
		KI_CC_AUTO	KI_ON KI_OFF	Turns automatic compliance clear processing on or off (devint will reset 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 after a Source value change that takes the circuit under test to settle and prevent false compliance detection due to transients.
		KI_CC_COMP_DLY	<value>	The time between compliance scans while processing compclr. This also represents the time after a Source value change that takes the circuit under test to settle and prevent 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 level desired for the subsequent measurements.
Supported	SMUn	KI_INTGPLC	<value> (in units of line cycles)	Specifies the integration time the SMU will use for the intgx and sintgx commands. The default devint value is 1.0. The valid range is 0.01 to 10.0.
		KI_AVGMODE	KI_MEASX KI_INTEGRATE	Controls what kind of readings are taken for avgX calls. The devint default value is KI_MEASX. When KI_INTEGRATE is specified, the integration time used is that specified by the KI_INTGPLC setmode call.
No operations performed[2]	SMUn	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 will turn 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 = 100µa). 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 what measured value 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 over range, or 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 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 preamp range. Value may be negative to shorten rather than lengthen the overall range change delay. In no event will the overall delay time be less than the preamp 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 will delay when changing a preamp range. Value is specified in percent settling accuracy, although at present only six percent values are valid. 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 volt meter. The ranges used are representative of the type of instrument being simulated. Note, this setmode will turn 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.

[2]These modifiers do not perform any operations in the Model 4200-SCS. These are included for compatibility reference only for existing S600 programs that use the `setmode` function which can be ported to the Model 4200-SCS.

Example:

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

smeasz_sweepv

Purpose: Performs and returns CD measurements for a voltage sweep with a specified frequency bias. Posts data after the sweep is completed.

Format:

```
smeasz_sweepv(unitname,iSpeed,dVStart,dVStop,iStepNum,dDelayTime)
```

Return value: [rvalue1, rvalue2]

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

`result2` = The first result data of the selected measure model.

Example:

```
smeasz_sweepv(CVU1, KI_CVU_SPEED_FAST,-3,3,10,0.01)
```

srangei/srangev

Purpose: Selects the current/voltage Source range and prevents the selected instrument from auto-ranging. By selecting a range, the time required for auto-ranging is eliminated.

Format:

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

`X` = SMU number(1,2,3,…)

tstsel

Purpose: Used to enable or disable a test station. Only used for the Model 4200-SCS. To relinquish control of an individual test station, a new test station must now be selected using `tstsel` before any subsequent test control functions are run. The `tstdsl` command has the same effect as the `tstsel (0)` command

Format:

```
tstsel(iStatus = 1)
```

Remarks: `tstsel` is normally called at the beginning of a test program.

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:              # auto range
        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 2

Device Library

In this section:

Introduction 2-1
npnBJT library 2-6
npnPowerBJT library 2-31
pnpBJT library 2-49
pnpPowerBJT library 2-75
nMOSFET library 2-93
nPowerMOSFET library 2-119
pMOSFET library 2-136
pPowerMOSFET library 2-171
Diode library 2-187
IGBT library 2-197
Two-terminal resistor library 2-211
Four-terminal resistor library 2-216
TRIAC library 2-221
Zener library 2-233
Capacitor WLR library 2-236
Common library 2-252
High-voltage and high-current PTM 2-293
Mixed SMUs in pulse mode 2-297
Switch control PTM 2-324

Introduction

ACS Basic has a large device test library, including the parametric libraries, WLR library, and common library. In ACS Basic, you can also build a library to import and use. The tables below indicate all of the test modules in the device libraries, WLR libraries, and common libraries.

npnBJT parametric library		
BVCBO	BVCEI	BVCEO
BVCEV	BVEBO	BVECO
HFE_SW	IBCO	IBEO
IbIcVbe	IbVbe	ICBO
ICEO	ICEV	IcVcb
IcVce_BiasIb	IcVce_BiasVb	StepIb
IcVce_StepVb	IEBO	IECO
IeVeb	VBCO	VCE

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

pnpBJT device parametric library		
BVCBO	BVCEI	BVCEO
BVCEV	BVEBO	BVECO
HFE_SW	IBCO	IBEO
IbIcVbe	IbVbe	ICBO
ICEO	ICEV	IcVcb
IcVce_BiasIb	BiasVb	StepIb
IcVce_StepVb	IEBO	IECO
IeVeb	VBCO	VCE

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

nMOSFET parametric library		
BVDSS	BVDSV	BVGSO
BVGDS	BVGDO	IDL
IDS_ISD	IdVd_BiasVg	IdVd_StepVg
IdVg_BiasVd	IdVg_StepVd	IdVg_StepVsub
IGL	MOSFET_IgVg	ISL
IsubVg	MOSFET_Vtci	Vtext
Vtext_llsq		

nMOSFET WLR_script library
HCI

nPowerMOSFET parametric library		
BVDSS	IGSSF	VSD
GFS	IGSSR	IdON_MIX
IdON	RdsON	IdVd_StepVg_MIX
IDSS	VdsON	RdsON_MIX
IdVd_StepVg	VgsON	VgsON_MIX
IdVd_StepVd	VGSTH	

pMOSFET parametric library		
BVDSS	BVDSV	BVGSO
BVGDS	BVGDO	IDL
IDS	IdVd_BiasVg	dVd_StepVg
IdVg_BiasVd	IdVg_StepVd	IdVg_StepVsub
IGL	IgVg	MOSFET_ISL
IsubVg	Vtci	Vtext
Vtext_llsq		

pMOSFET WLR_script library	
HCI	NBTI
NBTI_on_the _fly	NBTI_meas

pPowerMOSFET parametric library		
BVDSS	IGSSF	VSD
GFS	IGSSR	IdON_MIX
IdON	RdsON	IdVd_StepVg_MIX
IDSS	VdsON	RdsON_MIX
IdVd_StepVg	VgsON	VgsON_MIX
IdVd_StepVd	VGSTH	

Diode parametric library		
DynamicZ	Spot_IfdVfd	Spot_IrdVrd
Spot_VbrIrd	Spot_VfdIfd	Spot_VrdIrd
Sweep_IfdVfd	Sweep_IrdVrd	

IGBT parametric library		
BVCES	IGESF	VGETH
ICES	IGESR	IcVce_StepVge_MIX
IcON	VceSAT	IcVge_MIX
IcVce_StepVge	VF	VceSAT_MIX
IcVge	VgeON	

Two-terminal resistor parametric library	
Spot_IV_2SMU	Spot_VI_2SMU
Sweep_IV_2SMU	Sweep_VI_2SMU

Four-terminal resistor parametric library	
Spot_IV_4SMU	Spot_VI_4SMU
Sweep_IV_4SMU	Sweep_VI_4SMU

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

Common library		
CV_4200CVU	CV_HP4284	Switch_Control
TEKSCOPE_ReadWave	KI237_VdsId	KI37XX_DMM_R_2Wire
KI23X_SweepV	KI237_VdsId	KI37XX_DMM_R_2Wire
KI37XX_DMM_R_4Wire	KI37XX_DMM_Switch	KI24XX_IdVg
KI24XX_IdVg_Pulse	KI24XX_IdVd	KI24XX_IdVd_Pulse
KI24XX_BiasV_Pulse	KI24XX_BiasI_Pulse	KI24XX_SweepV
KI24XX_SweepI		

General notes

NOTE

When the Series 2600B System SourceMeter® instruments are referenced, it also includes the Series 2600A System SourceMeter instruments, since these two series of instruments are fully interchangeable. However, the following instruments are not supported in ACS Basic: Model 2604B, Model 2614B, and Model 2634B.

You can use the Test Script Language on the Keithley Instruments Series 2600B System SourceMeter or the Linear Parametric Test Library (LPT Library) or the python language or Script Editor in ACS Basic to create a new library. The TSP script must use the `postdata`, `postbuffer`, or the `posttable` function to retrieve data from the Series 2600B. For examples, refer to the directory: \\ACS \Library\26Library folder. 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 test. They are STM with a GUI.

If you would like to create a test library with a graphical user interface (GUI), the following rules apply:

- The first line must be the name of the .xrc GUI file, and the .xrc GUI file must be saved to the \\ACS \Library\26Library\xrc folder. ACS Basic will then load 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:

```
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' will reset instruments after test, '0' will 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

Refer to the following directory for examples: \\ACS \Library\26Library\WLR.

npnBJT library

npnBJT overview

The BJT library components are located in the following directory:
\\ACS\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, and characteristic curves.

npnBJT parametric library

BVCBO

Description:

Module Name: BVCBO

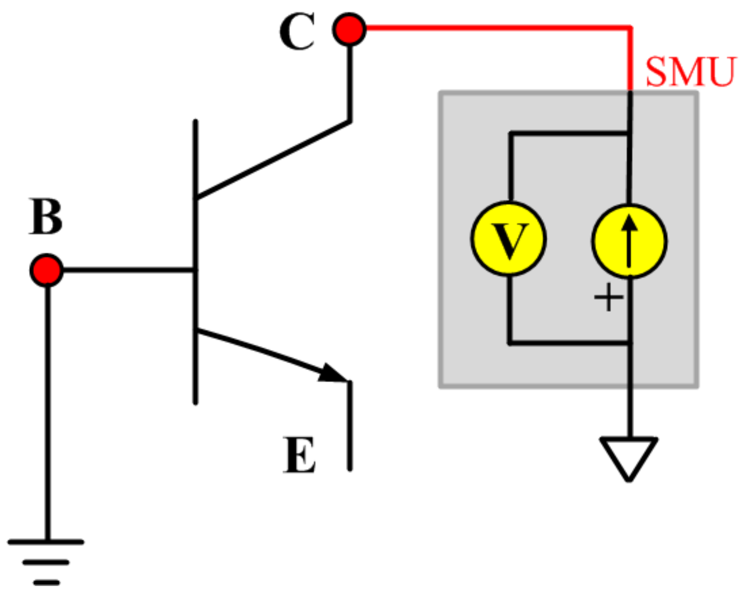
DUT: Three-terminal BJT

Function: Tests the Collector-Base breakdown voltage of the BJT, with the Emitter open.

Pin connections: Open the Emitter, and apply the desired current to the Collector. The Base connects to ground.

Intended results: Measure the Collector-Base breakdown voltage (see next figure).

Figure 7: Three_term_npnBJT_BVCBO



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

Description:

Module Name: BVCEI

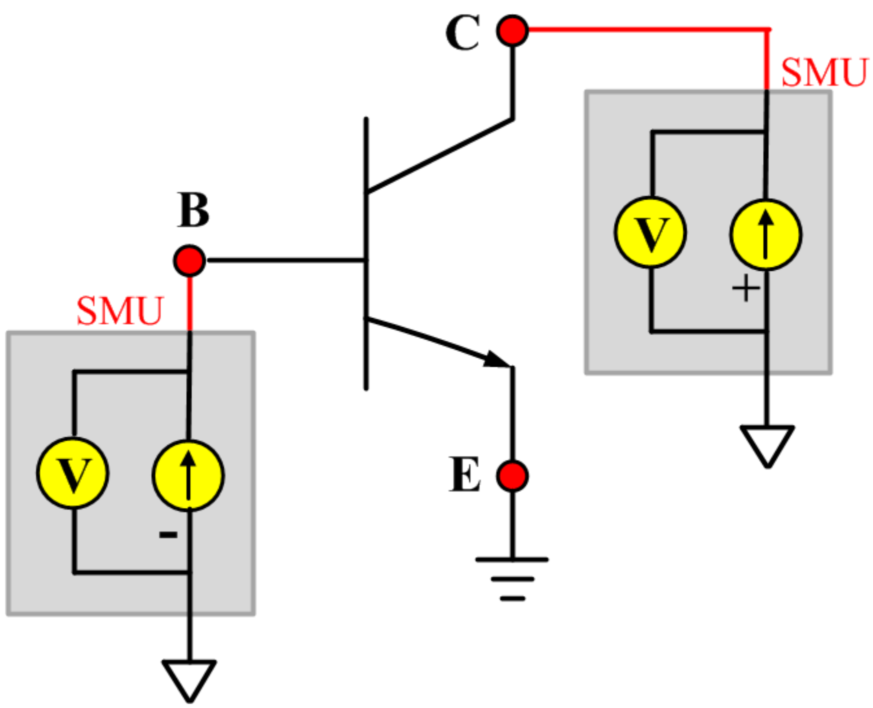
DUT: Three-terminal npnBJT

Function: Tests the Collector-Emitter breakdown voltage of the npnBJT with a bias Base-forced current.

Pin connections: Apply the desired current to the Collector, and set the Base bias current (emitters usually connect to ground)(see next figure).

Intended results: Measure the Collector-Emitter breakdown voltage.

Figure 8: Three_term_npnBJT_BVCEI pin connection



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

Description:

Module Name: BVCEO

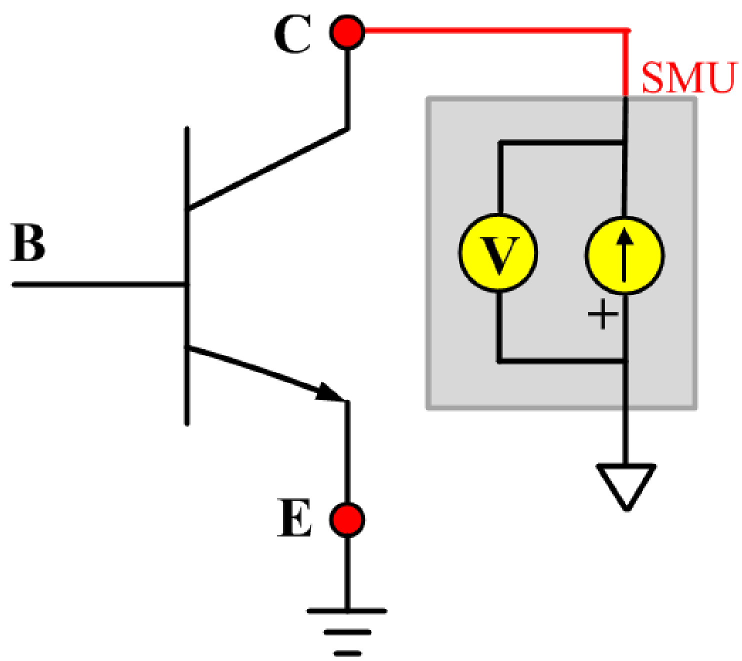
DUT: Three-terminal npnBJT

Function: Tests the Collector-Emitter breakdown voltage, with the Base opened.

Pin connections: Open the Base; apply the desired current to the Collector; the Emitter connects to ground (see next figure).

Intended results: Measure the Collector-Emitter breakdown voltage.

Figure 9: Three_term_npnBJT_BVCEO pin connection



BVCEO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

BVCEO General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVCEV

Description:

Module Name: BVCEV

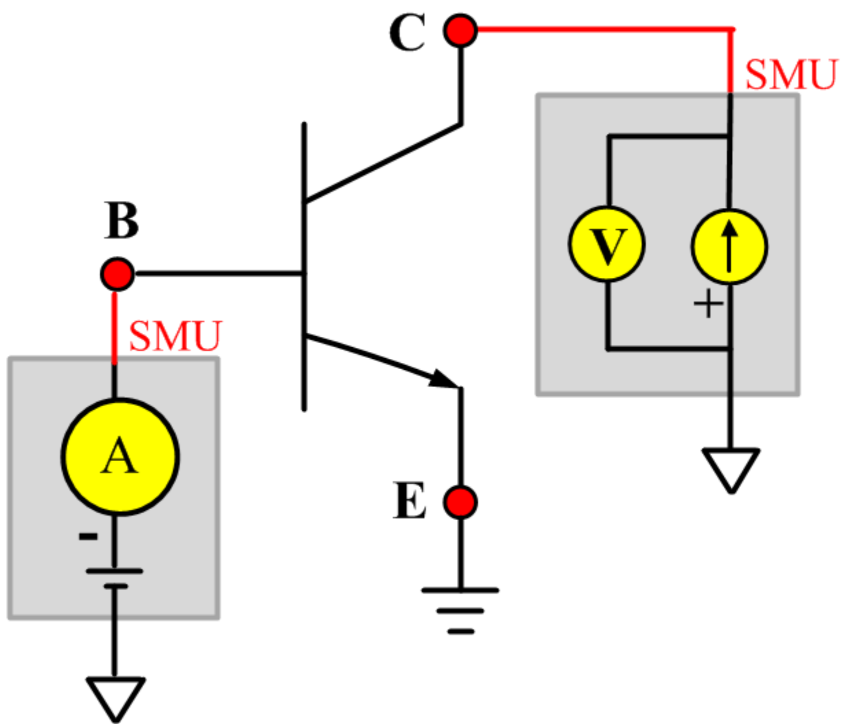
DUT: Three-terminal npnBJT

Function: Tests the Collector-Emitter breakdown voltage with a biased Base.

Pin connections: Apply the desired current to the Collector; set the Base as bias voltage, and connect the Emitter to ground (see next figure).

Intended results: Measure the Collector-Emitter breakdown voltage.

Figure 10: Three_term_npnBJT_BVCEV pin connection



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

Description:

Module Name: BVEBO

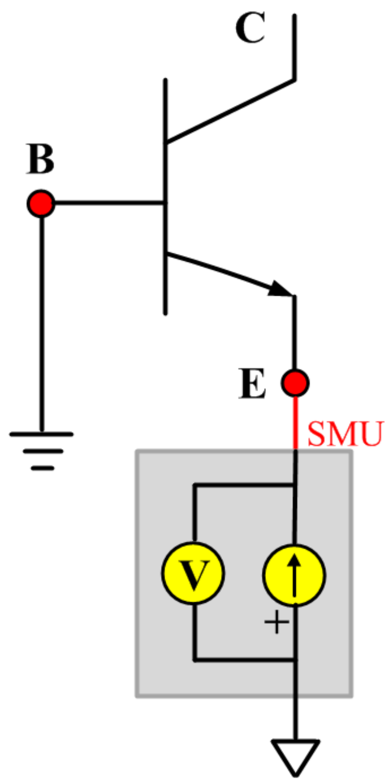
DUT: Three-terminal npnBJT

Function: Tests the Emitter-Base breakdown voltage of the npnBJT with the Collector opened.

Pin connections: Open the Collector, set the Emitter at the desired current, and connect the Base to ground (see next figure).

Intended results: Measure the Emitter-Base breakdown voltage.

Figure 11: Three_term_npnBJT_BVEBO pin connection



BVEBO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

BVECO

Description:

Module Name: BVECO

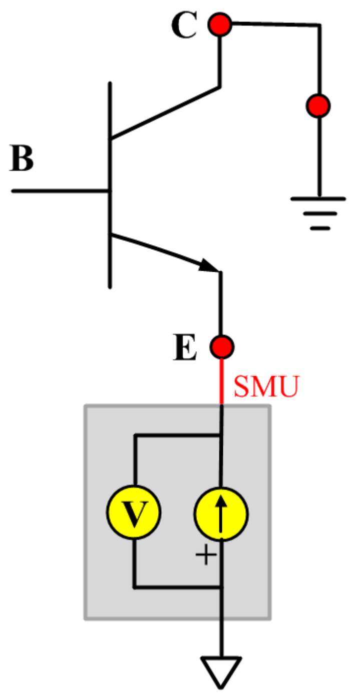
DUT: Three-terminal npnBJT

Function: Tests the Emitter-Collector breakdown voltage of the npnBJT with the Base opened.

Pin connections: Open Base, apply the desired current to Emitter, and connect Collector to the ground (see next figure).

Intended results: Measure the Emitter-Collector breakdown voltage.

Figure 12: Three_term_npnBJT_BVECO pin connection



BVECO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

HFE

Description:

Module Name: HFE

DUT: Three-terminal npnBJT

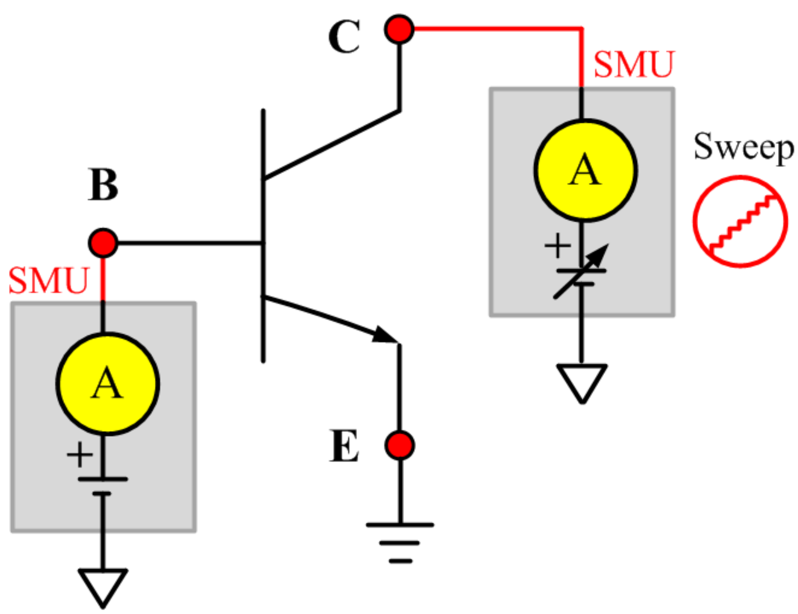
Function: Tests the HFE (DC current gain) of the npnBJT with a sweeping Collector voltage.

Pin connections: Share the Base connection, apply a sweep voltage on the Collector, and connect the Emitter to ground. The Base is typically connected to ground, but can be set to a desired bias voltage (see next figure):.

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

Intended results: Measure the Collector current, Base current, and DC current gain based on the Collector sweep voltage.

Figure 13: Three_term_npnBJT_HFE_SW pin connection



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

Description:

Module Name: IBCO

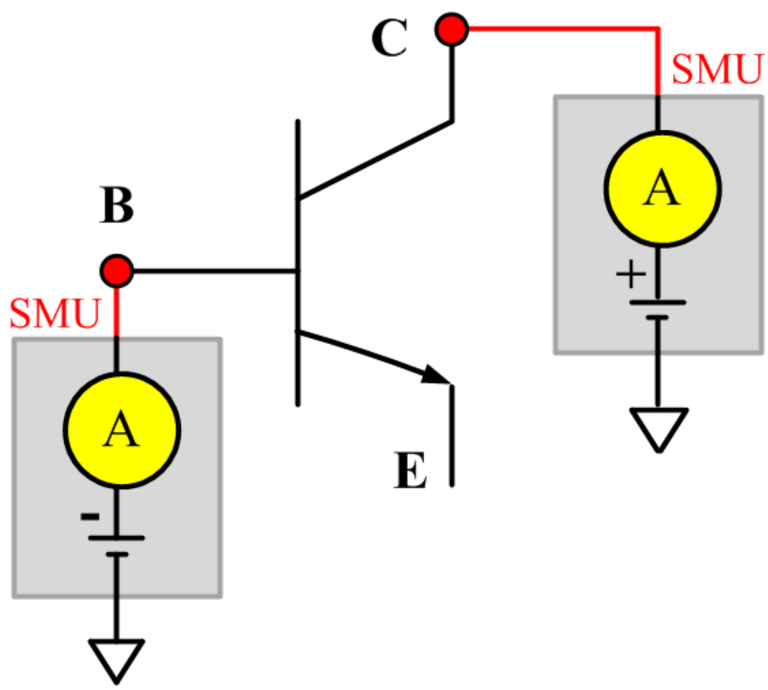
DUT: Three-terminal npnBJT

Function: Tests the Base-Collector current with the Emitter opened.

Pin connections: Open the Emitter, apply a voltage on the Base, and apply a voltage to the Collector (if not connected to ground)(see next figure).

Intended results: Measure the Base-Collector current.

Figure 14: Three_term_npnBJT_IBCO pin connection



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

Description:

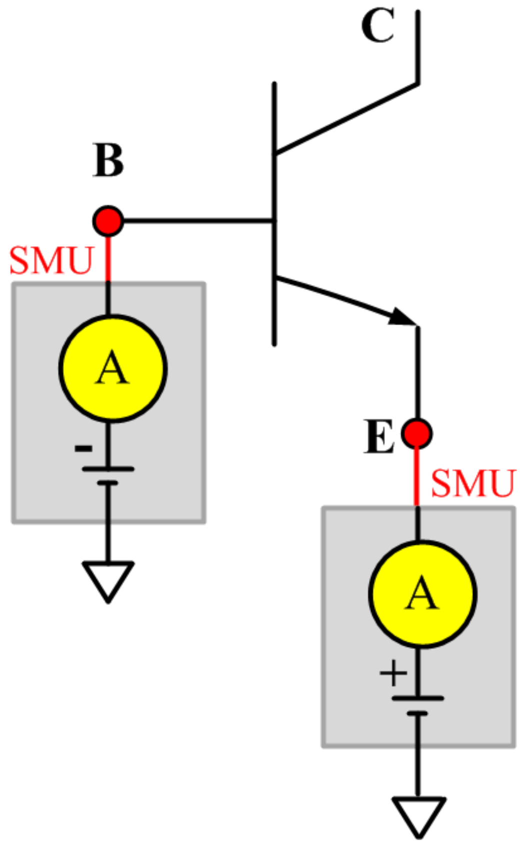
Module Name: IBEO

DUT: Four-terminal npnBJT

Function: Tests the Base-Emitter current with the Collector opened.

Pin connections: The Collector is open, 0 volts are applied to the Emitter, and a bias voltage is applied to the (see next figure).

Figure 15: Three_term_npnBJT_IBEO pin connection



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

Description:

Module Name: IbIcVbe

DUT: Three-terminal npnBJT

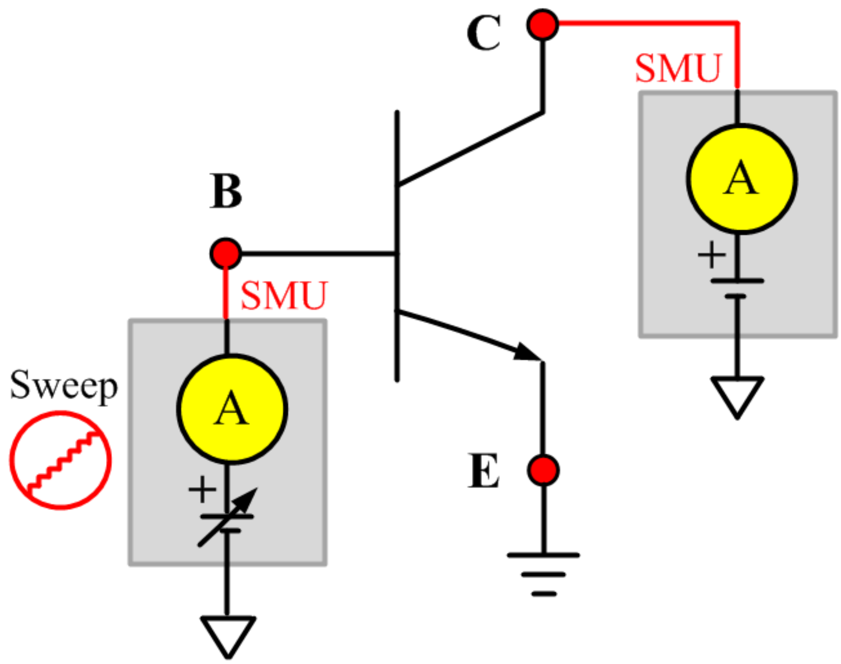
Function: Tests the Base current and Collector current of the npnBJT by sweeping a specified Base voltage.

Pin connections: Share the Emitter connection, apply a sweep voltage to the Base, and apply a bias voltage to the Collector. The Emitter is typically connected to ground, but can be set to the desired bias voltage (see next figure).

Intended results:

- Measure Base current and Collector current of npnBJT
- Measure the Ib-Vbe and IcVbe curves
- Measure the gummel plot if the axis properties of result have changed (logarithm instead of right-angle coordinate)

Figure 16: Three_term_npnBJT_ IbIcVbe pin connection



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

Description:

Module Name: IbVbe

DUT: Three-terminal npnBJT

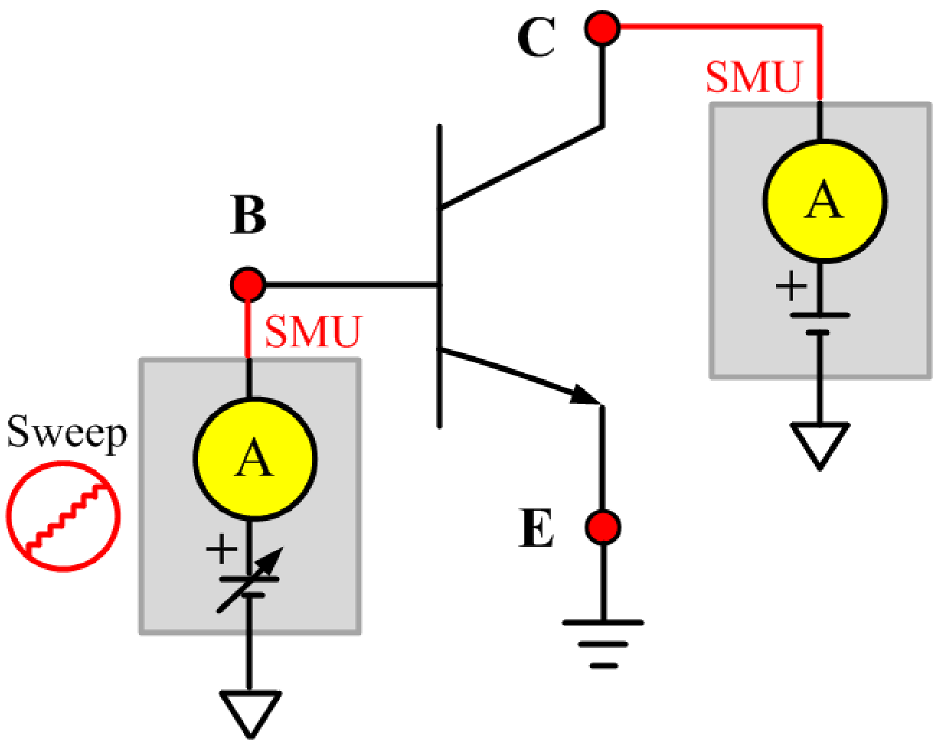
Function: Tests the Base current of the npnBJT by sweeping a specified Base voltage.

Pin connections: Share the Emitter connection, apply a sweep voltage to the Base, and apply a bias voltage to the Collector. The Emitter is typically connected to ground, but can be set to a desired bias voltage (see next figure).

Intended results:

- Measure the Base current based on the Base voltage sweep
- Measure the Ib-Vbe curve

Figure 17: Three_term_npnBJT_IbVbe pin connection



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

Description:

Module Name: ICBO

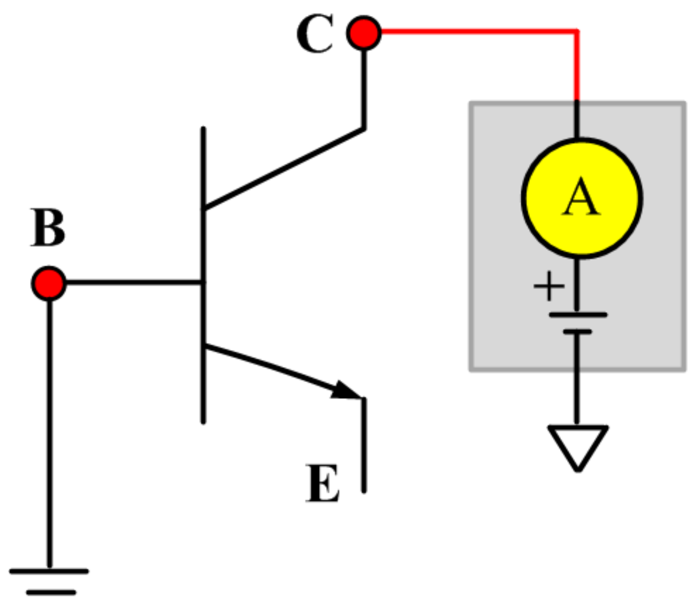
DUT: Three-terminal npnBJT

Function: Tests the Collector-Base cut off current with the Emitter opened.

Pin connections: Open the Emitter, apply a desired voltage to the Collector, and connect the Base to ground (see next figure).

Intended results: Measure the Collector-Base cut off current.

Figure 18: Three_term_npnBJT_ICBO pin connection



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

Description:

Module Name: ICEO

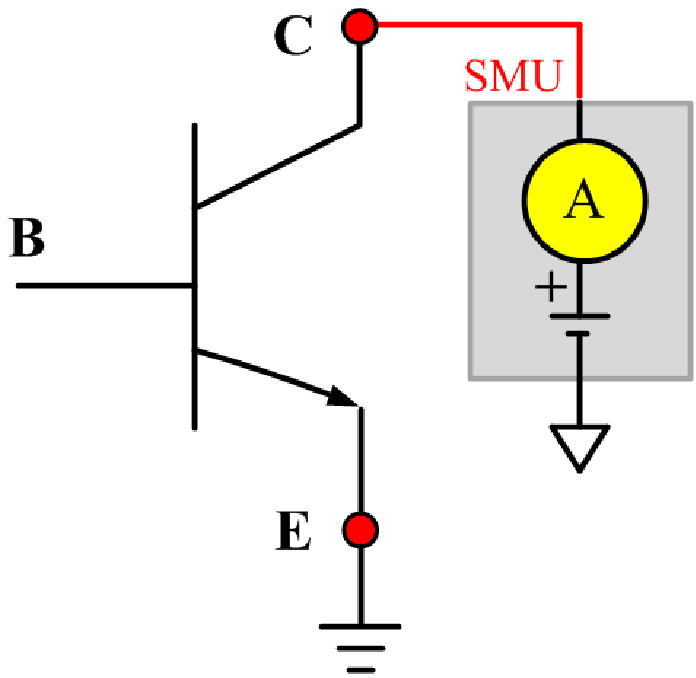
DUT: Three-terminal npnBJT

Function: Tests the Collector-Emitter cut off current with the Base opened.

Pin connections: Open the Base, apply a desired voltage to the Collector, and connect the Emitter to ground (see next figure).

Intended results: Measure the Collector-Emitter cut off current.

Figure 19: Three_term_npnBJT_ICEO pin connection



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

Description:

Module Name: ICEV

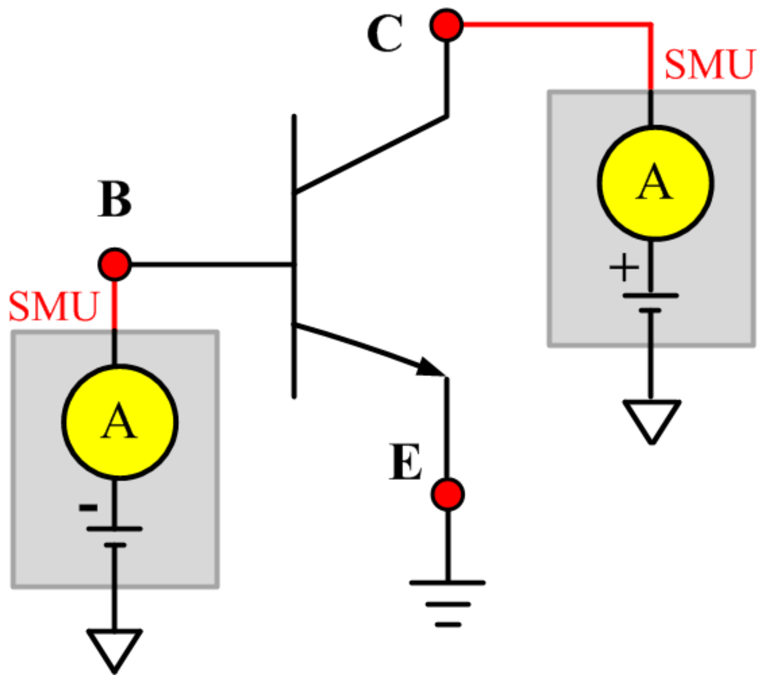
DUT: Three-terminal npnBJT

Function: Tests the Collector-Emitter cut off current with a bias Base voltage.

Pin connections: Apply a desired voltage to the Collector, apply a voltage bias to the Base, and connect the Emitter to ground (see next figure).

Intended results: Measure the Collector-Emitter cut off current.

Figure 20: Three_term_npnBJT_ICEV pin connection



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

Description:

Module Name: IcVcb

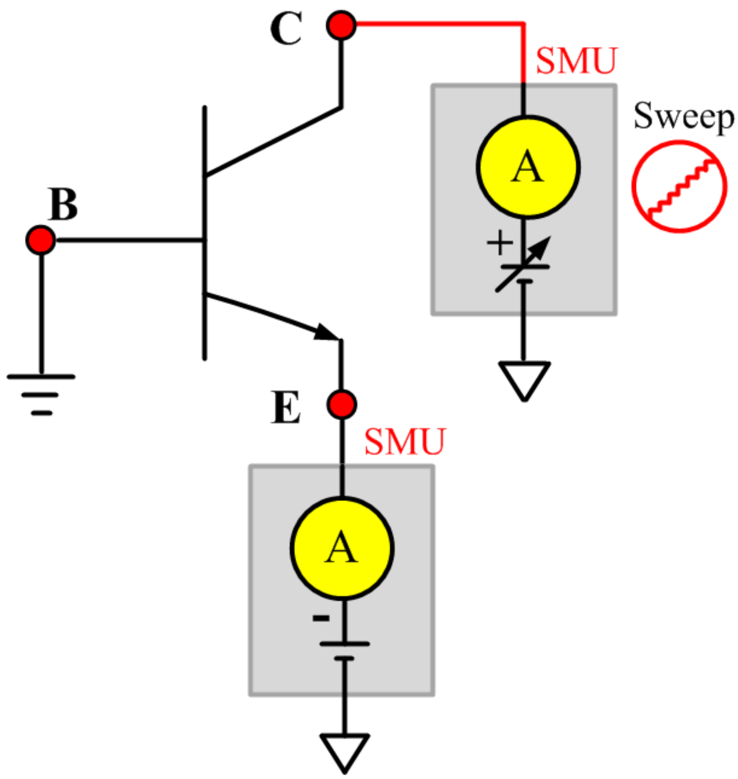
DUT: Three-terminal npnBJT

Function: Tests the Collector current of the npnBJT by sweeping a specified Collector voltage.

Pin connections: Share the Base connection (connected to ground), apply a sweep voltage to the Collector, and apply a bias voltage to the Emitter (see next figure).

Intended results: Measure the Collector current based on sweeping the Collector voltage.

Figure 21: Three_term_npnBJT_IcVcb pin connection



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

Description:

Module Name: IcVce_BiasIb

DUT: Three-terminal npnBJT

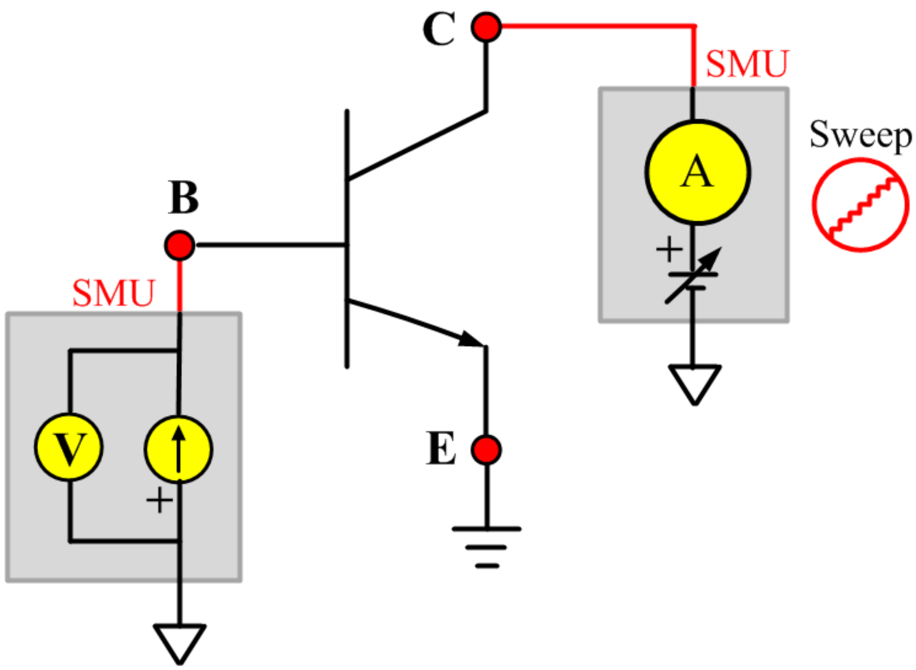
Function: Tests a series of IcVce curves of the npnBJT while stepping the Base current.

Pin connections: Share the Emitter connection (connect Emitter to ground), step the Base current, and sweep the Collector voltage (see next figure).

Intended results:

- Measure the Collector current based on a Base step current and a Collector sweep voltage
- Measure a series of IcVce curves with a Base current step

Figure 22: Three_term_npnBJT_IcVce_BiasIb pin connection



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

Description:

Module Name: IcVce_BiasVb

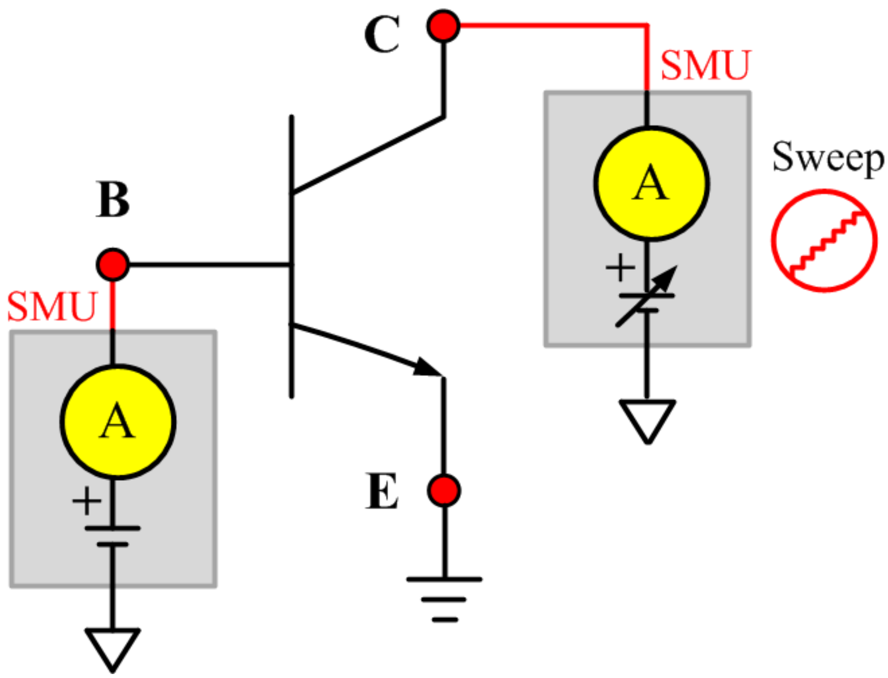
DUT: Three-terminal npnBJT

Function: Tests a series of IcVce curves of the npnBJT with a fixed Base voltage.

Pin connections: Share the Emitter connection (connect Emitter to ground), bias the Base voltage, and sweep the Collector voltage (see next figure).

Intended results: Measure the Collector current based on the Collector sweep voltage and a fixed based voltage.

Figure 23: Three_term_npnBJT_IcVce_BiasVb pin connection



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

Description:

Module Name: IcVce_StepIb

DUT: Three-terminal npnBJT

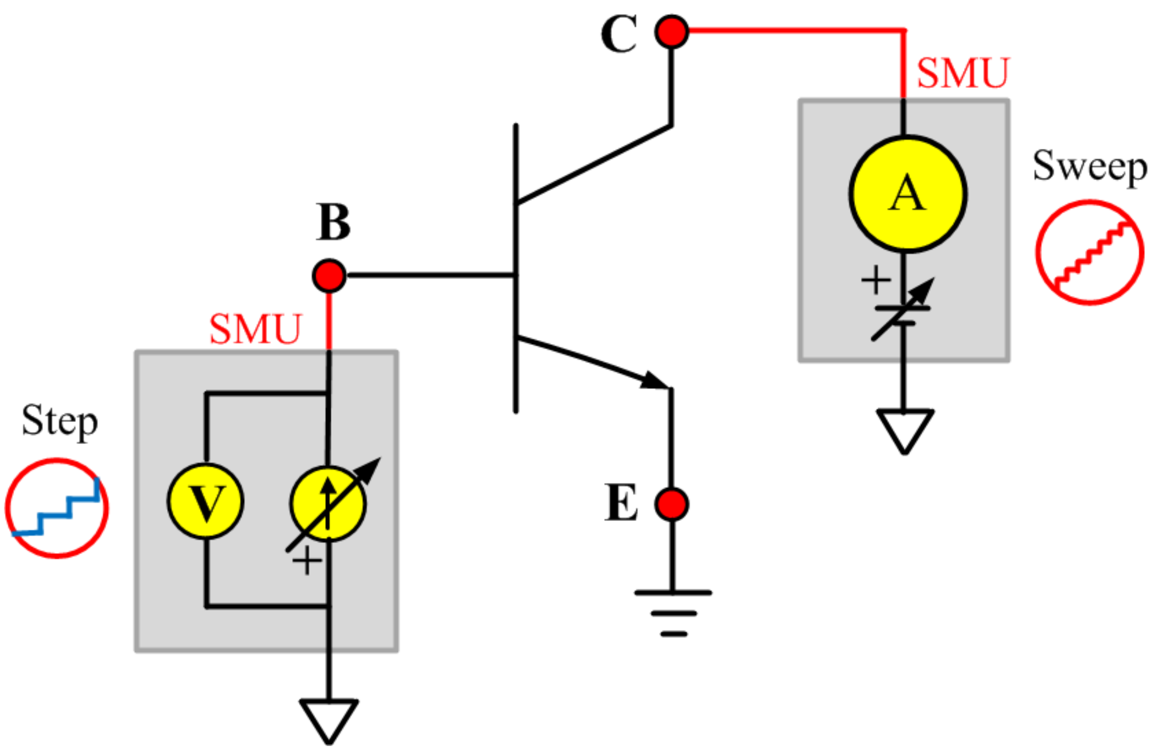
Function: Tests a series of IcVce curves of the npnBJT while stepping the Base current.

Pin connections: Share the Emitter connection (connect Emitter to ground), step the Base current, and sweep the Collector voltage (see next figure).

Intended results:

- Measure the Collector current based on the Base step current and the Collector sweep voltage
- Measure a series of IcVce curves with a Base current step

Figure 24: Three_term_npnBJT_IcVce_StepIb pin connection



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

Description:

Module Name: IcVce_StepVb

DUT: Three-terminal npnBJT

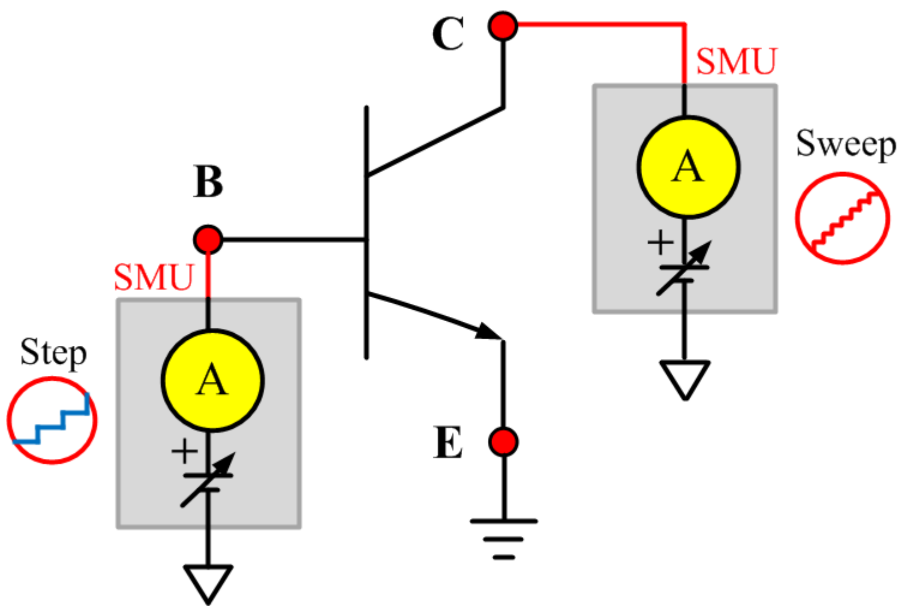
Function: Tests a series of IcVce curves of the npnBJT while stepping the Base voltage.

Pin connections: Share the Emitter connection (connect Emitter to ground), step the Base voltage, and sweep the Collector voltage (see next figure).

Intended results:

- Measure the Collector current based on the Base step and the Collector sweep voltage
- Measure the series of IcVce curves with a Base voltage step

Figure 25: Three_term_npnBJT_IcVce_StepVb pin connection



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

Description:

Module Name: IEBO

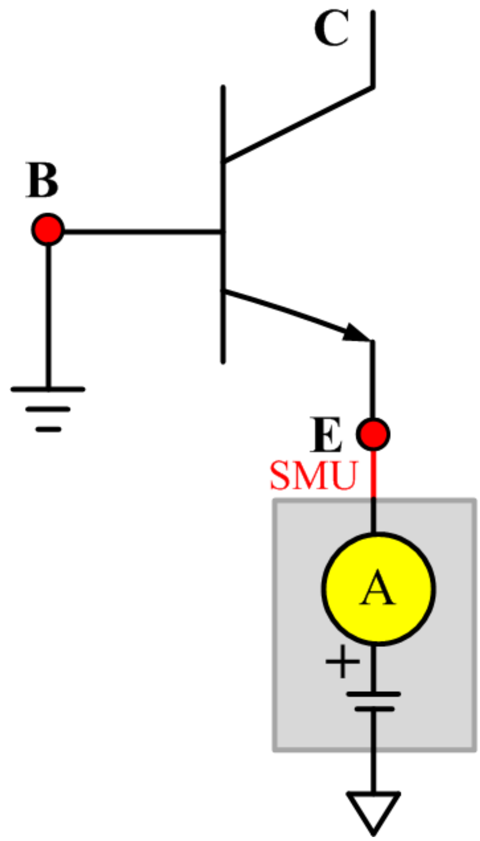
DUT: Three-terminal npnBJT

Function: Tests the Emitter-Base cut off current with the Collector opened.

Pin connections: Open the Collector, apply a desired voltage to the Emitter, and connect the Base to ground (see next figure).

Intended results: Measure the Emitter-Base cut-off current.

Figure 26: Three_term_npnBJT_IEBO pin connection



IEBO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IECO

Description:

Module Name: IECO

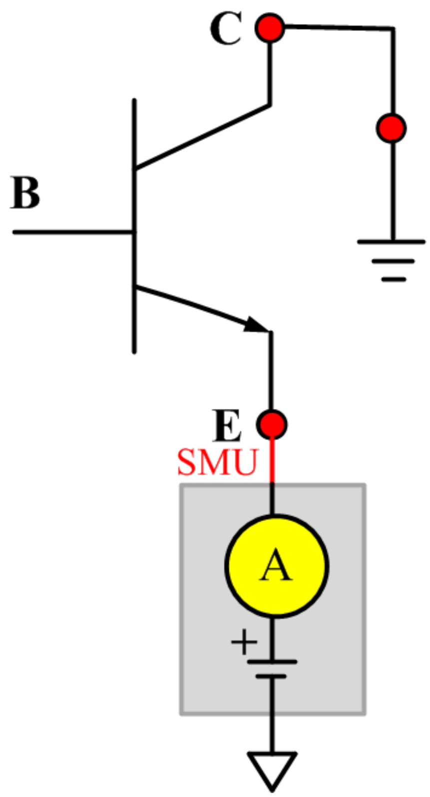
DUT: Three-terminal npnBJT

Function: Tests the Emitter-Collector current with the Base opened.

Pin connections: Open the Base, and apply a desired voltage to the Emitter. The Emitter is typically connected to ground, if voltage is not applied (see next figure).

Intended results: Measure the Emitter-Collector current.

Figure 27: Three_term_npnBJT_IECO pin connection



IECO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IeVeb

Description:

Module Name: IeVeb

DUT: Three-terminal npnBJT

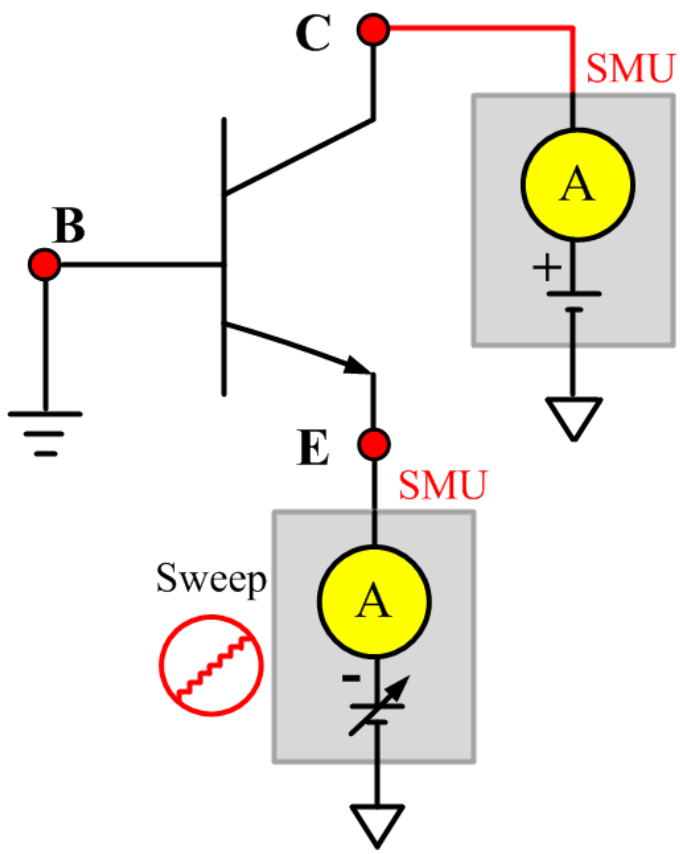
Function: Tests the Emitter current of the npnBJT with a specified sweeping Emitter voltage.

Pin connections: Share the Base connection, apply a sweep voltage to the Emitter, and apply a bias voltage to the Collector. Connect the Base to ground, if voltage is not applied (see next figure).

Intended results:

- Measure the Emitter current based on the Emitter voltage sweep
- Measure the IeVeb curves

Figure 28: Three_term_npnBJT_IeVeb pin connection



IeVeb ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

VBCO

Description:

Module Name: VBCO

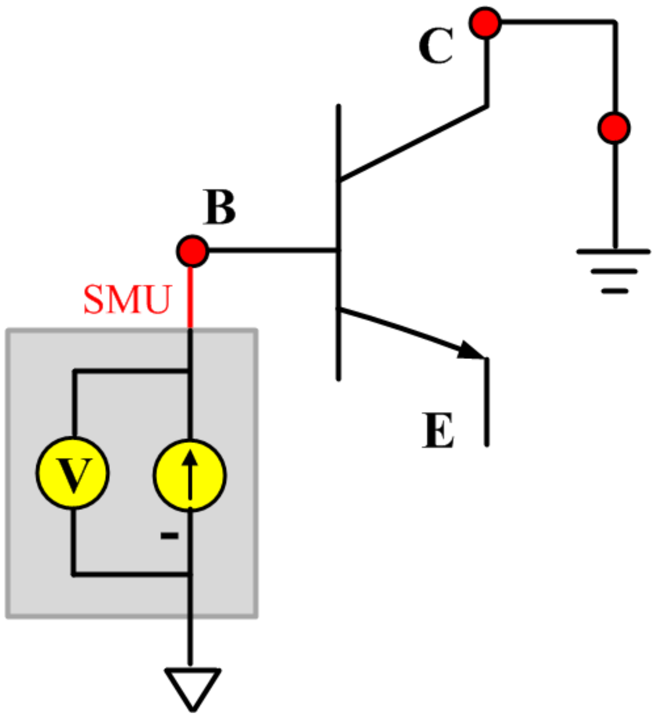
DUT: Three-terminal npnBJT

Function: Tests the Base-Collector voltage of the npnBJT with the Emitter opened.

Pin connections: Open the Emitter, and apply a current to the Base. The Emitter usually connects to ground, but can be set to the desired bias voltage (see next figure).

Intended results: Measure the Base-Collector voltage.

Figure 29: Three_term_npnBJT_VBCO pin connection



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

Description:

Module Name: VCE

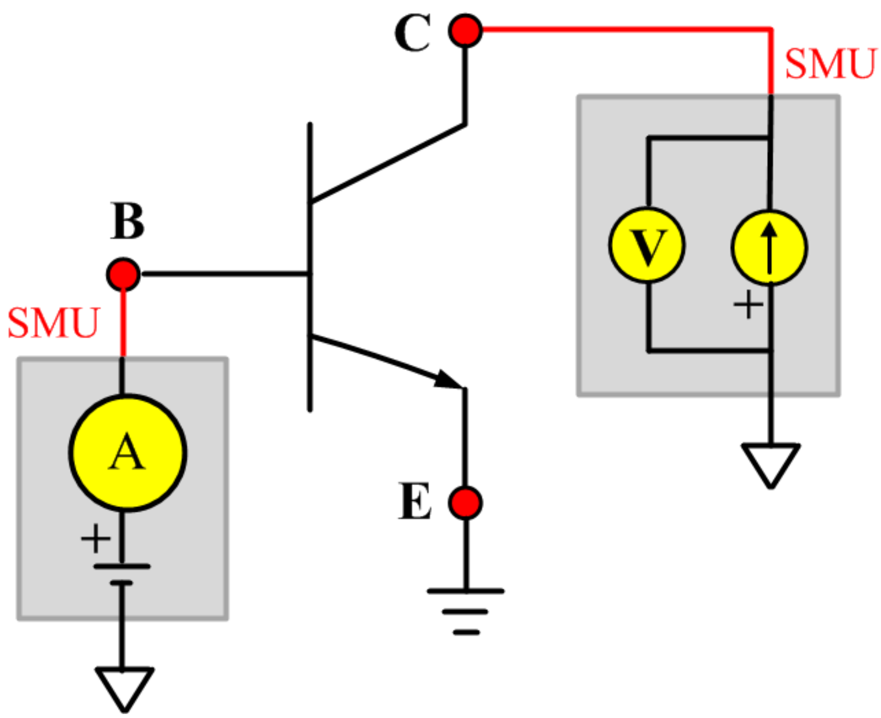
DUT: Three-terminal npnBJT

Function: Tests the Collector-Emitter voltage the npnBJT.

Pin connections: Apply a voltage to the Base, set the Collector current to a desired level, and connect the Emitter to ground (see next figure).

Intended results: Measure the Collector-Emitter voltage.

Figure 30: Three_term_npnBJT_VCE pin connection



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

npnPowerBJT library

npnPowerBJT overview

The npnPowerBJT library components are located in the following directory:
\\ACS_BASIC\library\devLibrary\npnPowerBJT

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

npnPowerBJT parametric library

BVCBO

Description:

Module Name: BVCBO

Test Type: ITM

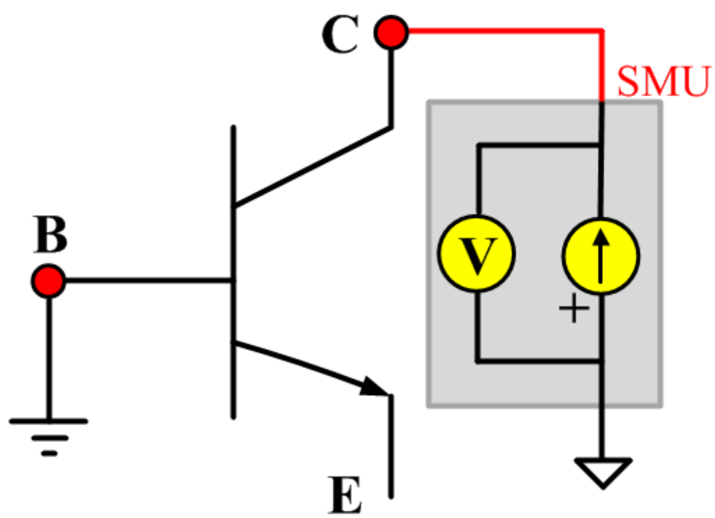
Instrument: KI2657A

DUT: Three-terminal npnPowerBJT

Function: Determines 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: One SMU is used. The SMU applies current and takes voltage measurements from the Collector to Base. The Emitter is open or has no current bias from a SMU (see next figure).

Figure 31: npnPowerBJT BVCBO pin connection



BVCEO

Description:

Module Name: BVCEO

Test Type: ITM

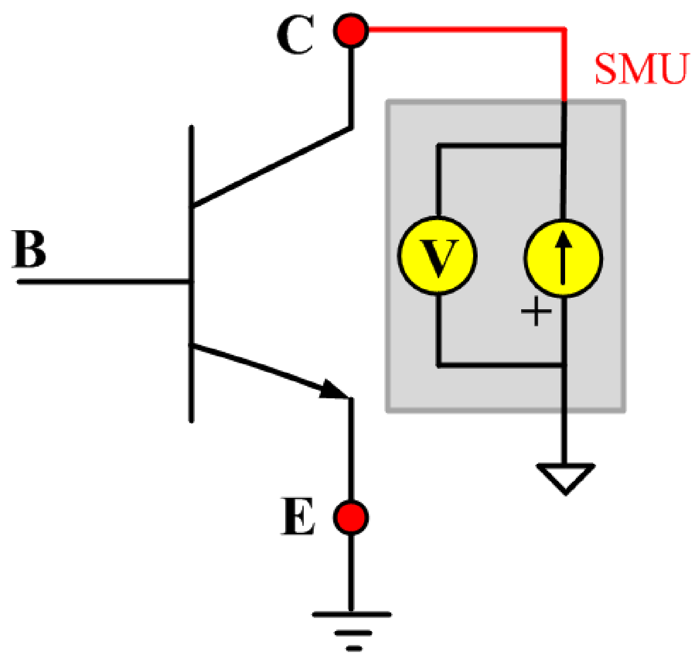
Instrument: KI2657A

DUT: Three-terminal npnPowerBJT

Function: Determines 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 Connection: One SMU is used. The SMU applies current and takes voltage measurements from the Collector to Emitter. The Base is opened or has no current bias from a SMU.

Figure 32: npnPowerBJT BVCEO pin connection



BVEBO

Description:

Module Name: BVEBO

Test Type: ITM

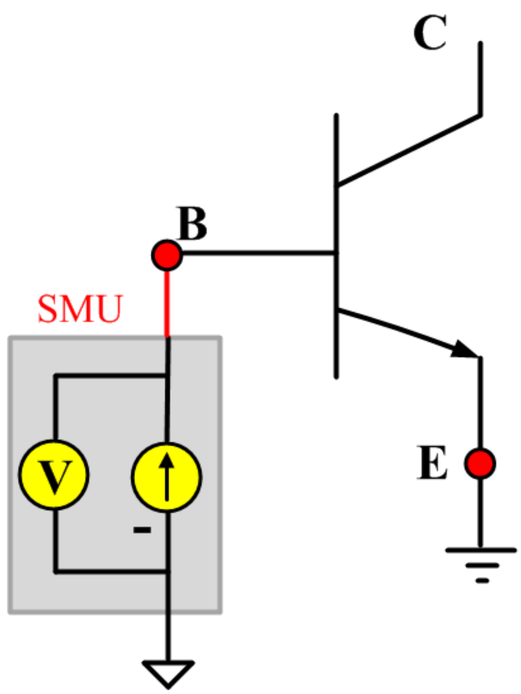
Instrument: KI2657A

DUT: Three-terminal npnPowerBJT

Function: Determines 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 Connection: One SMU is used. The SMU applies current and takes voltage measurements from the Base to Emitter. The Collector is opened or has no current bias from a SMU.

Figure 33: npnPowerBJT BVEBO pin connection



HFE

Description:

Module Name: HFE

Test Type: ITM

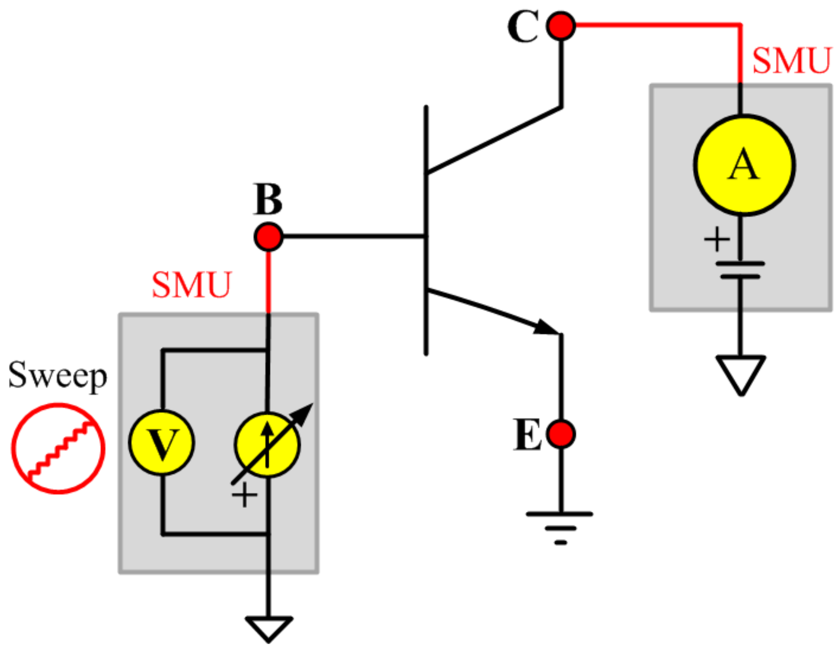
Instrument: KI2651A, KI2600B

DUT: Three-terminal npnPowerBJT

Function: Determines the Collector-Emitter static forward current transfer ratio with the output voltage (Vce) held constant (HFE = Ic/Ib).

Pin Connection: Two SMUs are used. One SMU applies voltage bias and takes current measurements from the Collector to Emitter. The other SMU applies a current sweep at the Base.

Figure 34: npnPowerBJT HFE pin connection



ICBO

Description:

Module Name: ICBO

Test Type: ITM

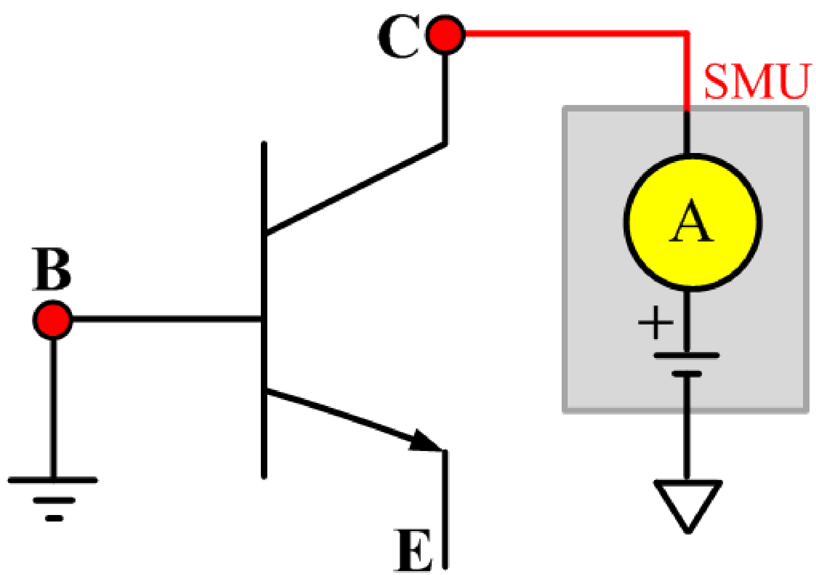
Instrument: KI2657A

DUT: Three-terminal npnPowerBJT

Function: Determines 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 Connection: One SMU is used. The SMU applies voltage and takes current measurements from the Collector to Base. The Emitter is opened or has no current bias from a SMU.

Figure 35: npnPowerBJT ICBO pin connection



ICEO

Description:

Module Name:ICEO

Test Type:ITM

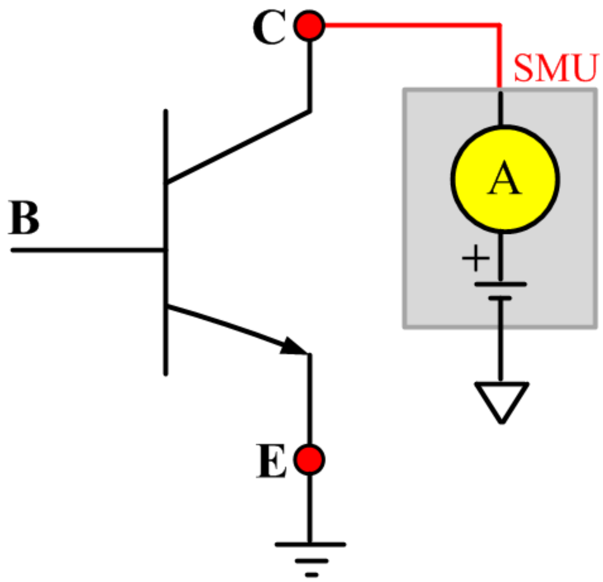
Instrument:KI2657A

DUT: Three-terminal npnPowerBJT

Function: Determines the Collector-Emitter cut-off current with the Base opened.

Pin Connection: One SMU is used. The SMU applies voltage and takes current measurements from the Collector to Emitter. The Base is opened or has no current bias from a SMU.

Figure 36: npnPowerBJT ICEO pin connection



ICES

Description:

Module Name: ICES

Test Type: ITM

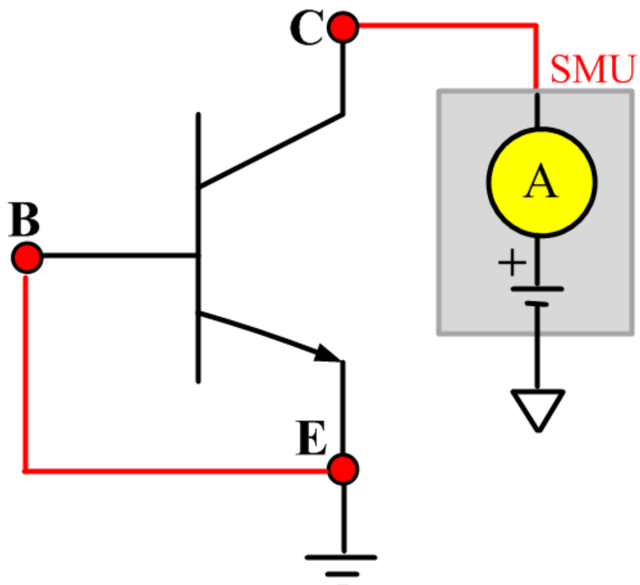
Instrument: KI2657A

DUT: Three-terminal npnPowerBJT

Function: Determines the Collector-Emitter cut-off current with the Base short-circuited to the Emitter.

Pin Connection: One SMU is used. The SMU applies voltage and takes current measurements from the Collector to Emitter. The Base is shorted to the Emitter, or has no voltage bias from the other SMU.

Figure 37: npnPowerBJT ICES pin connection



ICEV

Description:

Module Name: ICEV

Test Type: ITM

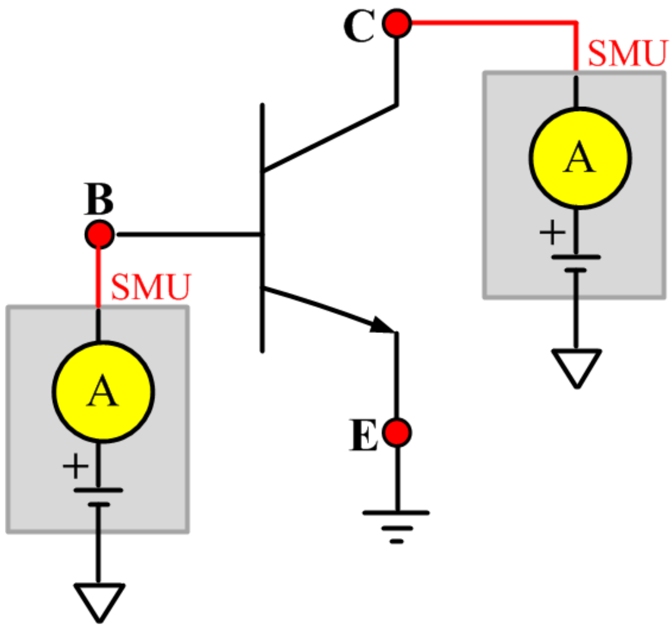
Instrument: KI2657A

DUT: Three-terminal npnPowerBJT

Function: Determines the Collector-Emitter cut-off current with a reverse bias on the Emitter-Base.

Pin Connection: Two SMU are used. One SMU applies voltage and takes current measurements from the Collector to Emitter. The Base is biased with a specified voltage from the other SMU.

Figure 38: npnPowerBJT ICEV pin connection



IcVce_StepIb

Description:

Module Name: IcVce_StepIb

Test Type: ITM

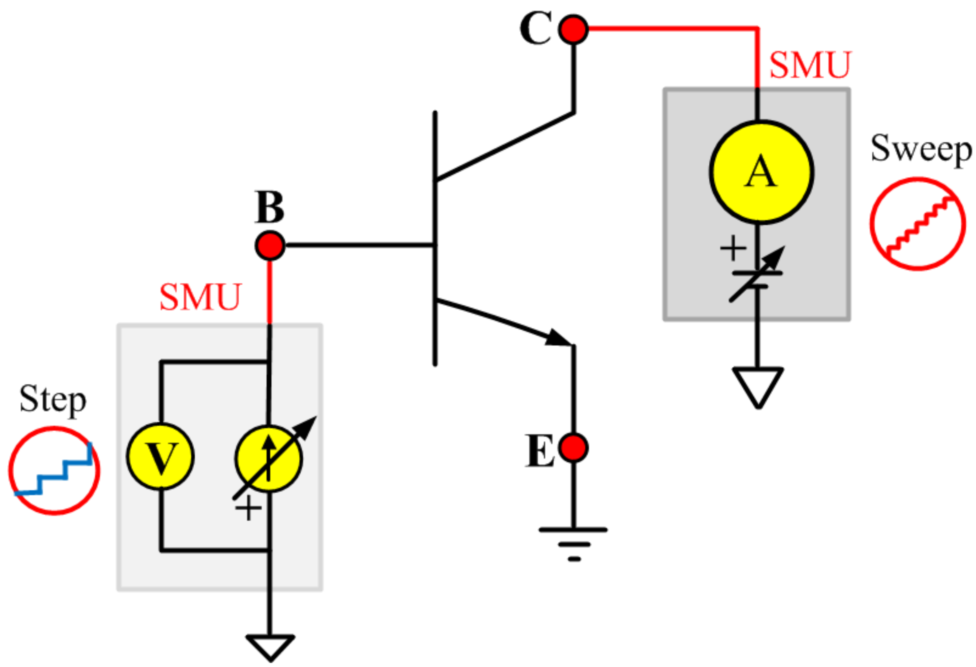
Instrument: 2651A, 2600B

DUT: Three-terminal npnPowerBJT

Function: Determines the Collector-Emitter output characteristic curve with a current step at the Base.

Pin Connection: Two SMUs are used. One SMU applies a voltage sweep and takes current measurements from the Collector to Emitter. The other SMU applies a current step to the Base.

Figure 39: npnPowerBJT IcVce_StepIb pin connection



IcVce_StepVbe

Description:

Module Name: IcVce_StepIb

Test Type: ITM

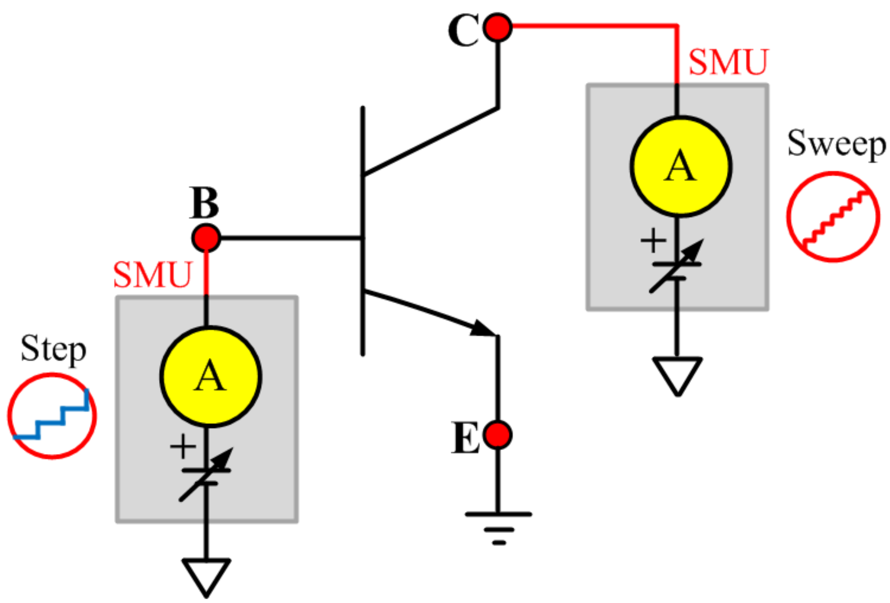
Instrument: 2651A, 2600B

DUT: Three-terminal npnPowerBJT

Function: Determines the Collector-Emitter output characteristic curve with a voltage step at the Base.

Pin Connection: Two SMUs are used. One SMU applies a voltage sweep and takes current measurements from the Collector to Emitter. The other SMU applies a voltage step to the Base.

Figure 40: npnPowerBJT IcVce_StepVbe pin connection



IEBO

Description:

Module Name: IEBO

Test Type: ITM

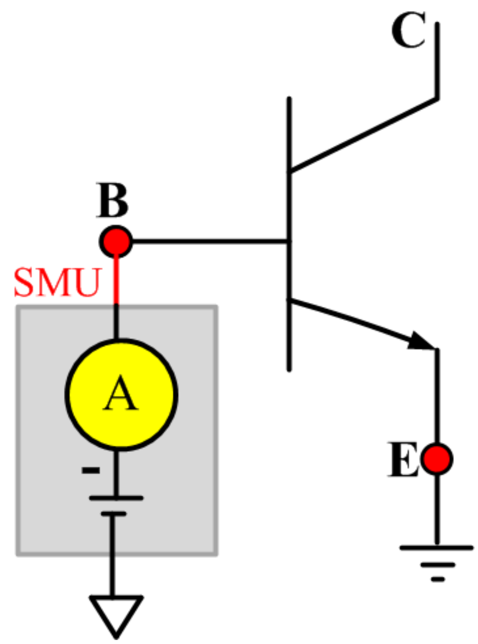
Instrument: KI2600B

DUT: Three-terminal npnPowerBJT

Function: Determines 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 Connection: One SMU is used. The SMU applies voltage and takes current measurements from the Base to Emitter. The Collector is opened or has no current bias from a SMU.

Figure 41: npnPowerBJT IEBO pin connection



VbeON

Description:

Module Name: VbeON

Test Type: ITM

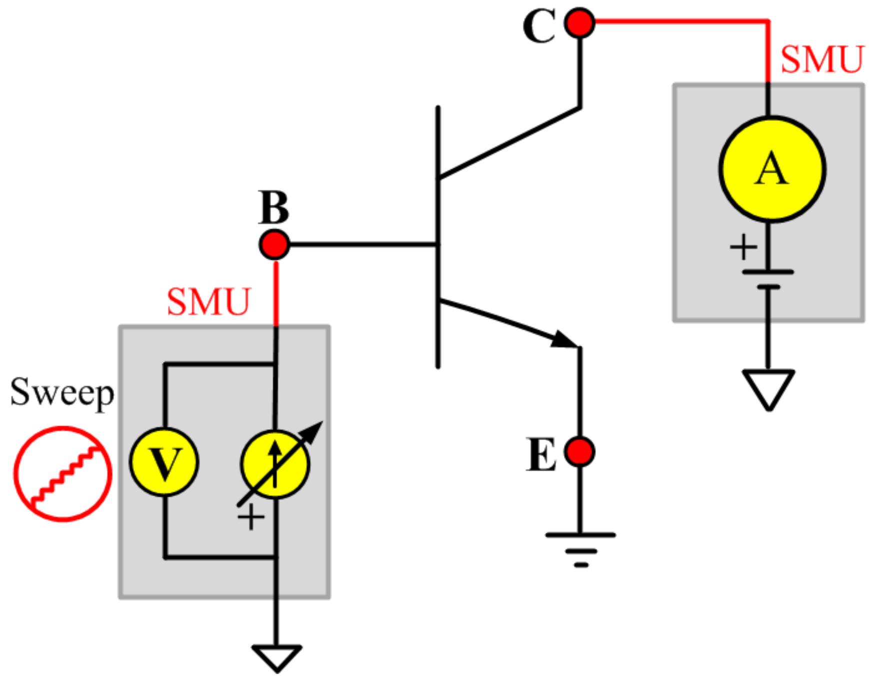
Instrument: KI2651A, KI2600B

DUT: Three-terminal npnPowerBJT

Function: Determines 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 Connection: Two SMUs are used. One SMU applies a current sweep and takes voltage measurements from the Base to Emitter. The other SMU applies a voltage bias to the Collector.

Figure 42: npnPowerBJT VbeON pin connection



VbeSAT

Description:

Module Name: VbeSAT

Test Type: ITM

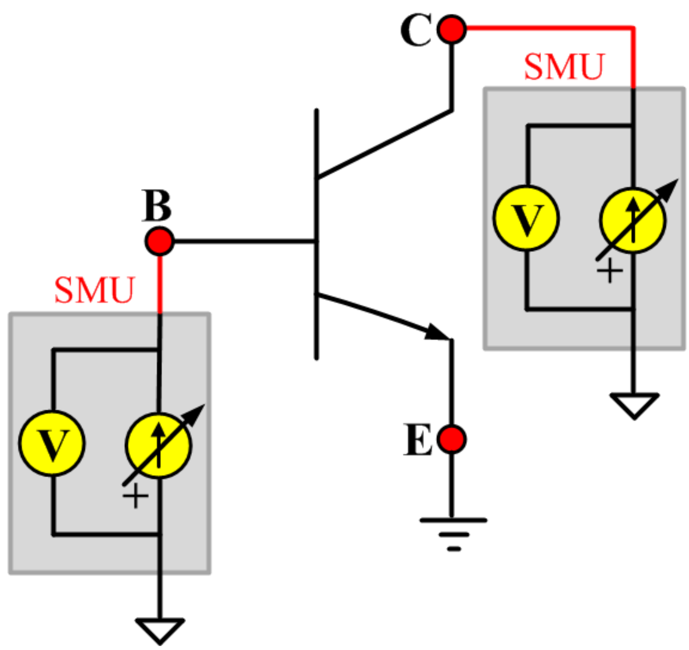
Instrument: KI2651A, KI2600B

DUT: Three-terminal npnPowerBJT

Function: Determines 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: Two SMUs are used. One SMU applies current and takes voltage measurements from the Base to Emitter. The other SMU applies a current bias to the Collector.

Figure 43: npnPowerBJT VbeSAT pin connection



VceSAT

Description:

Module Name: VceSAT

Test Type: ITM

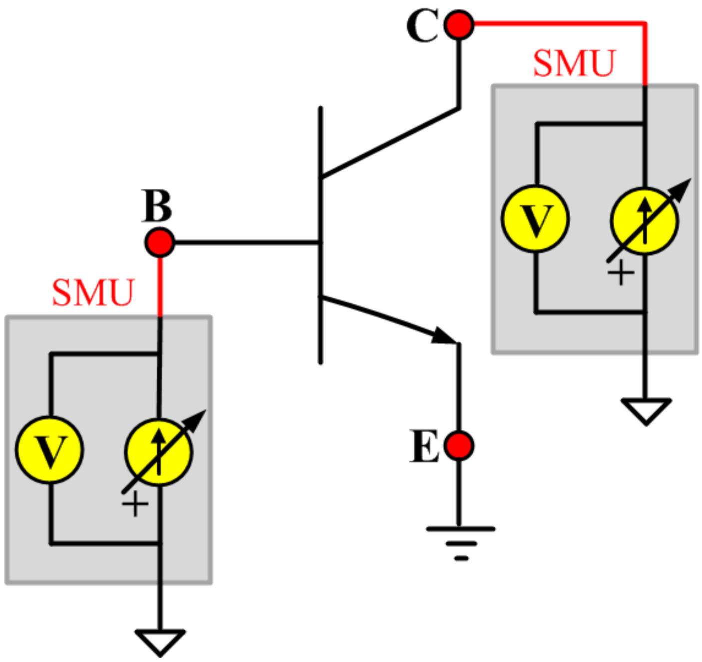
Instrument: 2651A, 2600B

DUT: Three-terminal npnPowerBJT

Function: Determines 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 Connection: Two SMUs are used. One SMU applies current and takes voltage measurements from the Collector to Emitter. The other SMU applies a current bias to the Base.

Figure 44: npnPowerBJT VceSAT pin connection



VCESUS

Description:

Module Name: VCESUS

Test Type: ITM

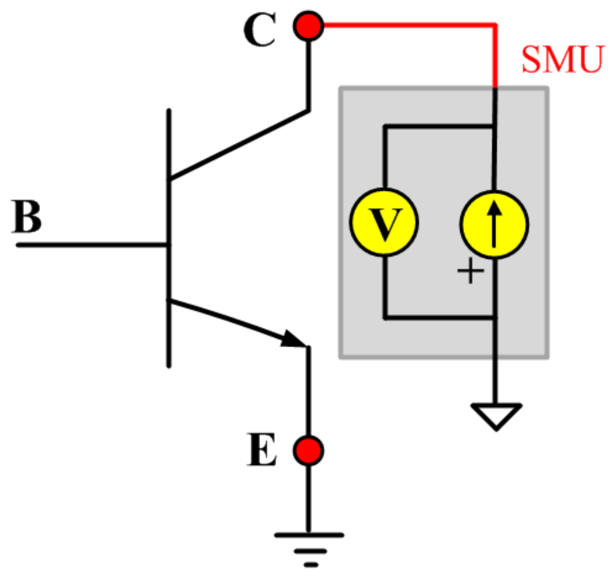
Instrument: KI2657A

DUT: Three-terminal npnPowerBJT

Function: Determines 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 Connection: One SMU is used. The SMU applies current and takes voltage measurements from the Collector to Emitter. The Base is opened or has no current bias from a SMU.

Figure 45: npnPowerBJT VCESUS pin connection



VceSAT_MIX

Description:

Module Name: VceSAT_MIX

Test Type: PTM

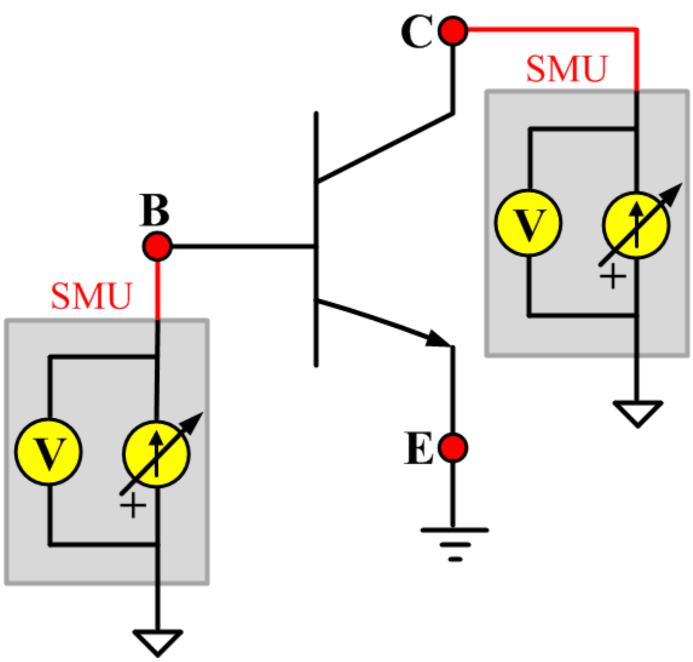
Instrument: KI2651A, KI2600B, KI24XX, KI42XX-SMU.

DUT: Three-terminal npnPowerBJT

Function: Determines 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 Connection: Two SMUs are used. One SMU applies current and takes voltage measurements from the Collector to Emitter. The other SMU applies a current bias to the Base.

Figure 46: npnPowerBJT VceSAT_MIX pin connection



IcVce_StepIb_MIX

Description:

Module Name: IcVce_StepIb_MIX

Test Type: PTM

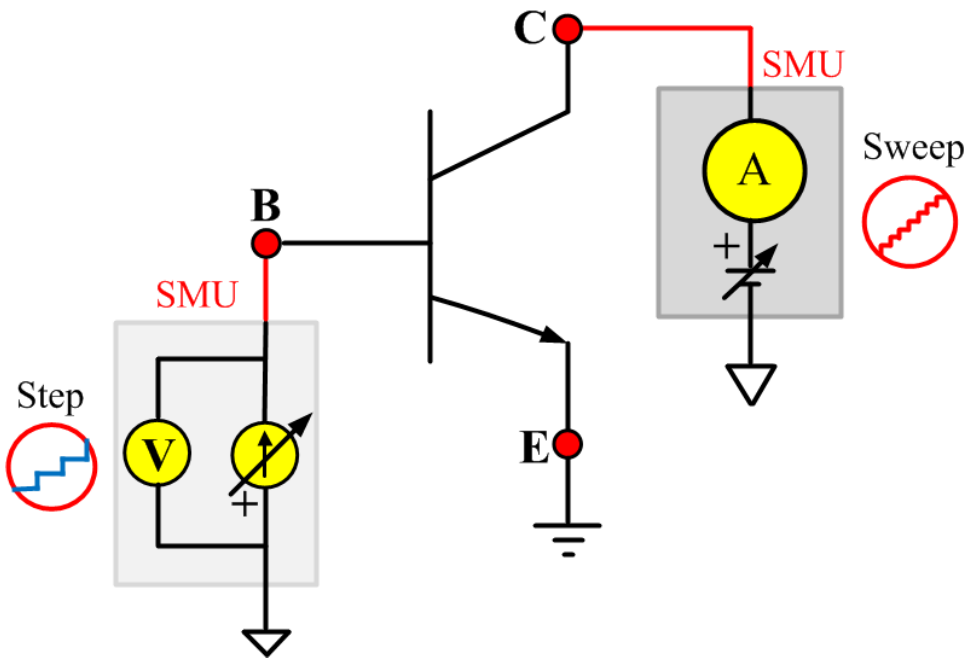
Instrument: KI2651A, KI2600B, KI24XX, KI42XX-SMU

DUT: Three-terminal npnPowerBJT

Function: Determines the Collector-Emitter output characteristic curve with a current step at the Base.

Pin Connection: Two SMUs are used. One SMU applies a voltage sweep and takes current measurements from the Collector to Emitter. The other SMU applies a current step to the Base.

Figure 47: npnPowerBJT IcVce_StepIb_MIX pin connection



IcVce_StepVbe_MIX

Description:

Module Name: IcVce_StepVbe

Test Type: PTM

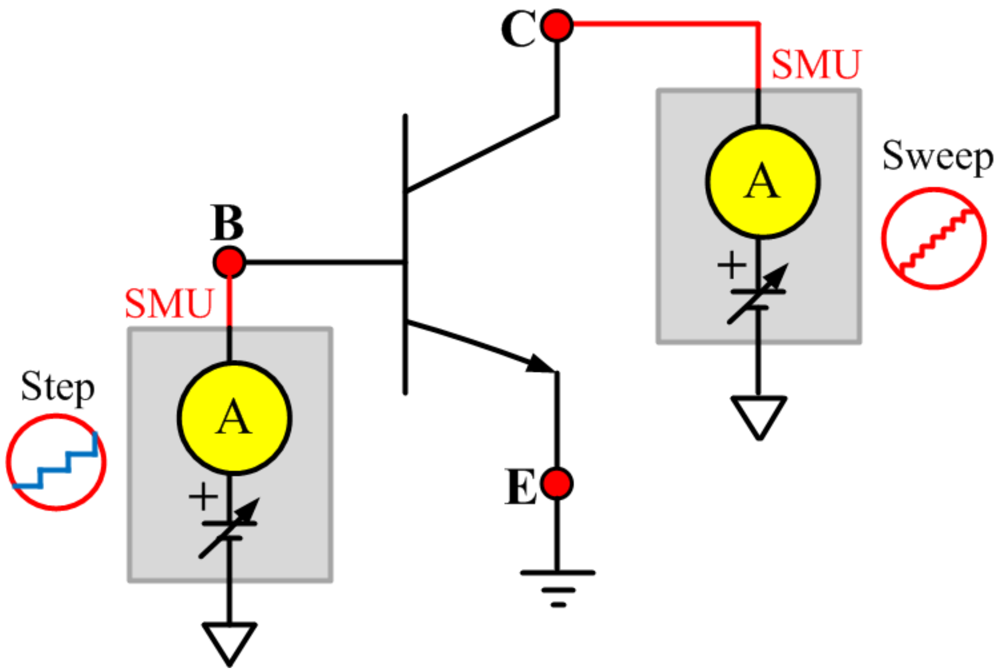
Instrument: KI2651A, KI2600B, KI24XX, KI42XX-SMU

DUT: Three-terminal npnPowerBJT

Function: Determines the Collector-Emitter output characteristic curve with a voltage step on the Emitter-Base junction.

Pin Connection: Two SMUs are used. One SMU applies a voltage sweep and takes current measurements from the Collector to Emitter. The other SMU applies a voltage step to the Base-Emitter junction

Figure 48: npnPowerBJT IcVce_StepVbe_MIX pin connection



pnpBJT library

pnpBJT device overview

The pnpBJT device library components are located in the following directory:
\\ACS_BASIC\library\devLibrary\pnpBJT

The pnpBJT device parametric library is used to test parameters of a pnp-type BJT, including leakage, breakdown, gain, on-state and characteristic curves.

pnpBJT parametric library

BVCBO

Description:

Module Name: BVCBO

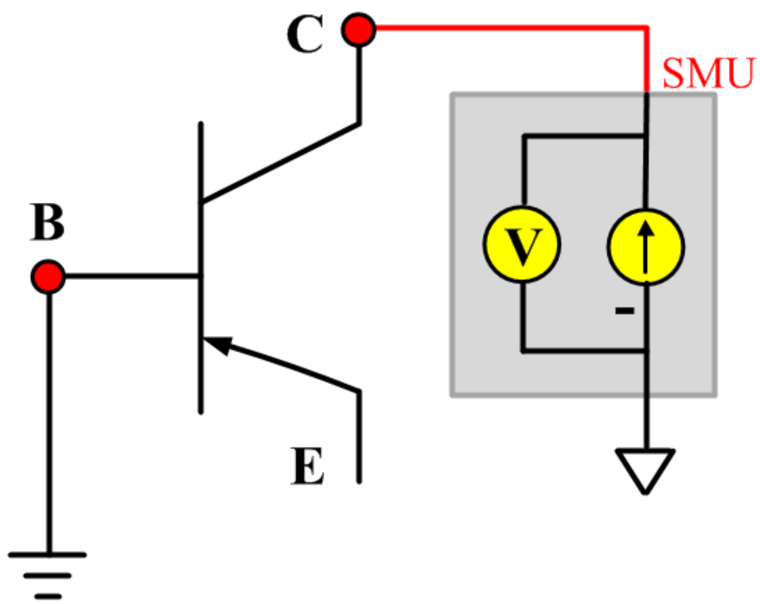
DUT: Three-terminal pnpBJT

Function: Tests the Collector-Base breakdown voltage of the pnpBJT device with the Emitter opened.

Pin connections: Open the Emitter, apply a desired current to the Collector, and connect the Base to ground (see next figure).

Intended results: Measure the Collector-Base breakdown voltage.

Figure 49: Three_term_pnpBJT_BVCBO pin connection



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

Description:

Module Name: BVCEI

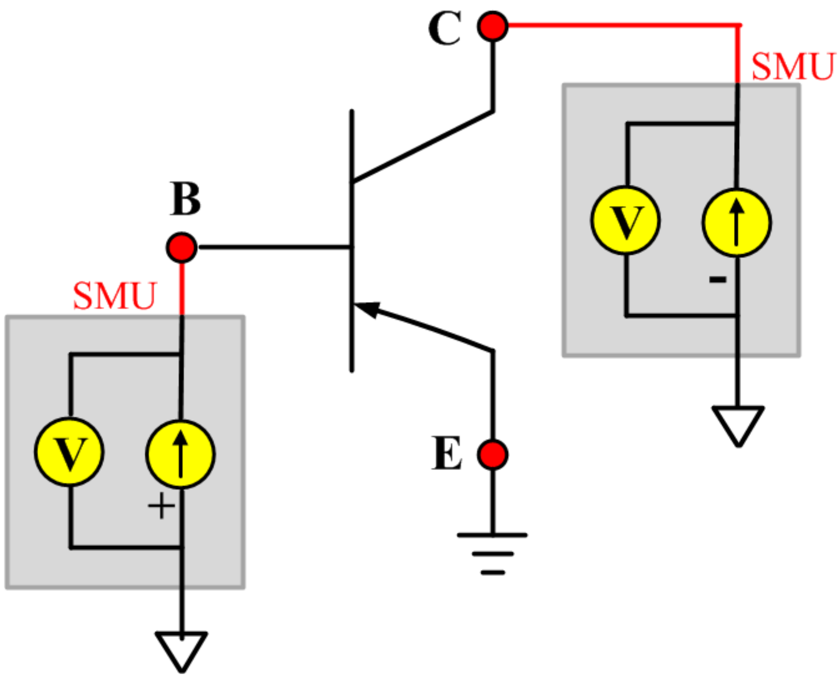
DUT: Three-terminal pnpBJT

Function: Tests the Collector-Emitter breakdown voltage of the pnpBJT device with a bias Base-forced current.

Pin connections: Apply a desired current to the Collector, and set the Base bias current (emitters usually connect to ground)(see next figure).

Intended results: Measure the Collector-Emitter breakdown voltage.

Figure 50: Three_term_pnpBJT_BVCEI pin connection



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

Description:

Module Name: BVCEO

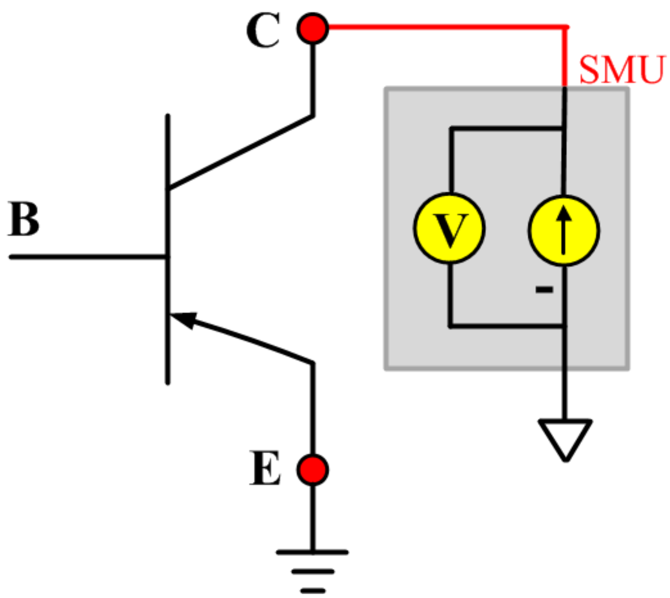
DUT: Three-terminal pnpBJT

Function: Tests the Collector-Emitter breakdown voltage with the Base opened.

Pin connections: Open the Base, and apply a desired current to the Collector. The Emitter should be connected to ground (see next figure).

Intended results: Measure the Collector-Emitter breakdown voltage.

Figure 51: Three_term_pnpBJT_BVCEO pin connection



BVCEO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

BVCEO General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVCEV

Description:

Module Name: BVCEV

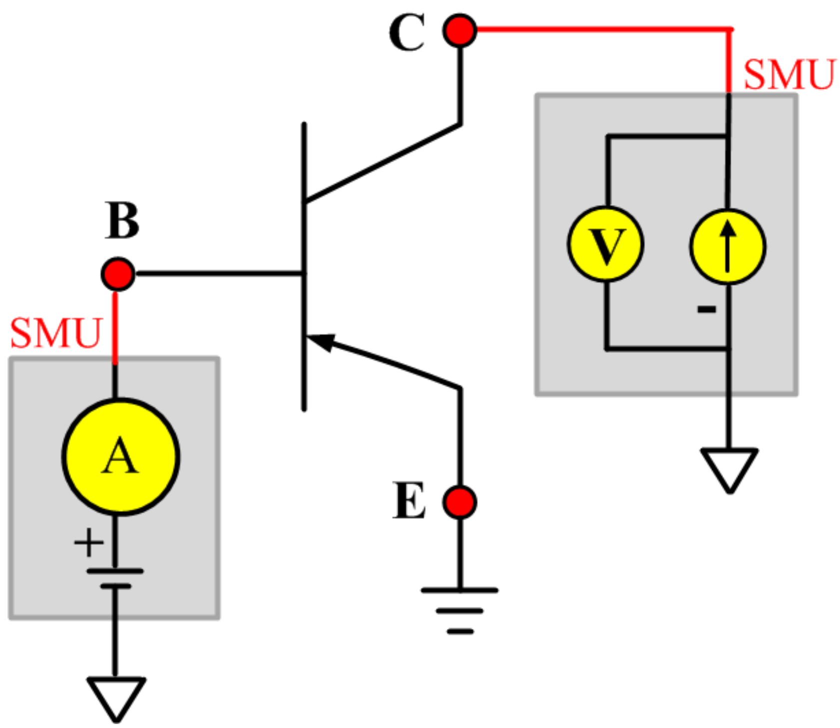
DUT: Three-terminal pnpBJT

Function: Tests the Collector-Emitter breakdown voltage with the Base forced with a voltage bias.

Pin connections: Apply a desired current to the Collector, set the Base with a bias voltage, and connect the Emitter to ground (see next figure).

Intended results: Measure the Collector-Emitter breakdown voltage.

Figure 52: Three_term_pnpBJT_BVCEV pin connection



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

Description:

Module Name: BVEBO

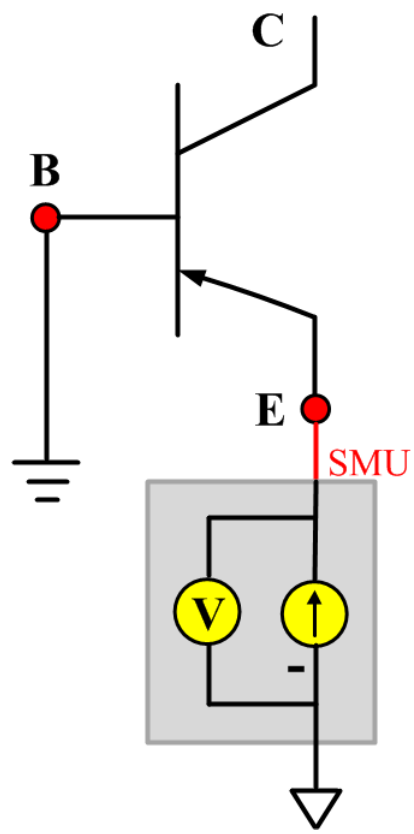
DUT: Three-terminal pnpBJT

Function: Tests the Emitter-Base breakdown voltage of the pnpBJT device with the Collector opened.

Pin connections: Open the Collector, set the Emitter at a desired current, and connect the Base to ground (see next figure).

Intended results: Measure the Emitter-Base breakdown voltage.

Figure 53: Three_term_pnpBJT_BVEBO pin connection



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

Description:

Module Name: BVECO

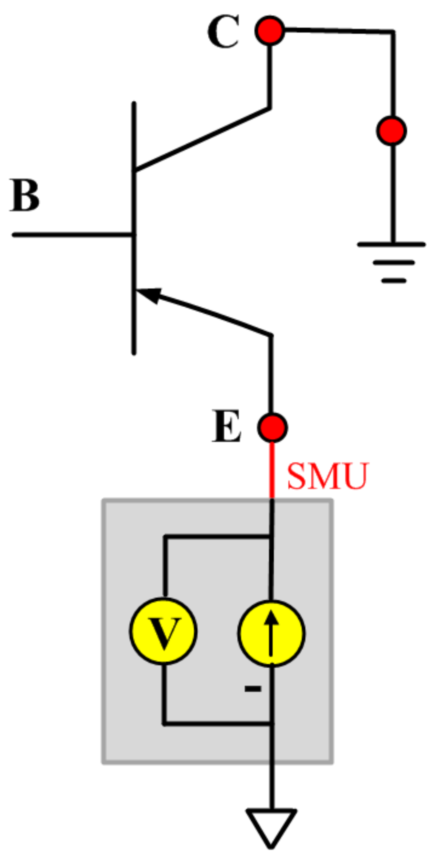
DUT: Three-terminal pnpBJT

Function: Tests the Emitter-Collector breakdown voltage of the pnpBJT device with the Base opened.

Pin connections: Open the Base, apply a desired current to the Emitter, and connect the Collector to ground (see next figure).

Intended results: Measure the Emitter-Collector breakdown voltage.

Figure 54: Three_term_pnpBJT_BVECO pin connection



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

HFE

Description:

Module Name: HFE

DUT: Three-terminal pnpBJT

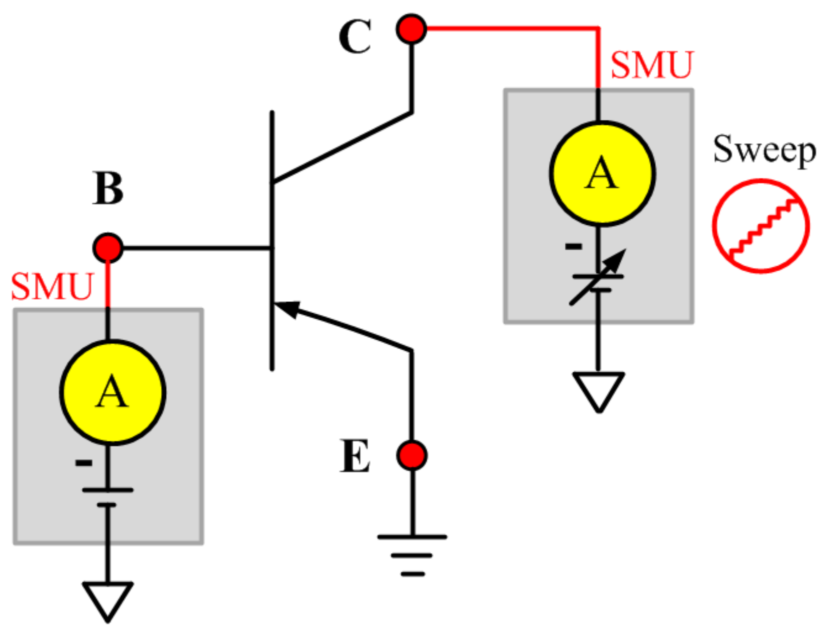
Function: Tests the HFE (DC current gain) of the pnpBJT device with a Collector voltage sweep.

Pin connections: Sharing the Emitter connection, apply a sweep voltage on the Collector, and apply a bias voltage to the Base (see next figure):

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

Intended results: Measure the Collector current, Base current, and DC current gain based on the Collector sweep voltage.

Figure 55: Three_term_pnpBJT_HFE_sw pin connection



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

Description:

Module Name: IBCO

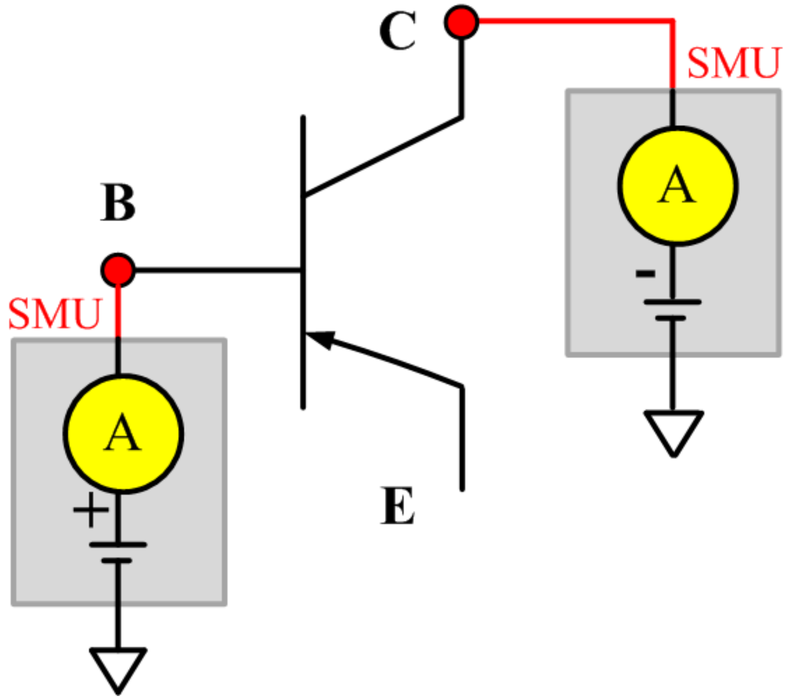
DUT: Three-terminal pnpBJT

Function: Tests the Base-Collector current with the Emitter opened.

Pin connections: Open the Emitter, apply a voltage to the Base, and apply a voltage to the Collector (if not connected to ground)(see next figure).

Intended results: Measure the Base-Collector current.

Figure 56: Three_term_pnpBJT_IBCO pin connection



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

Description:

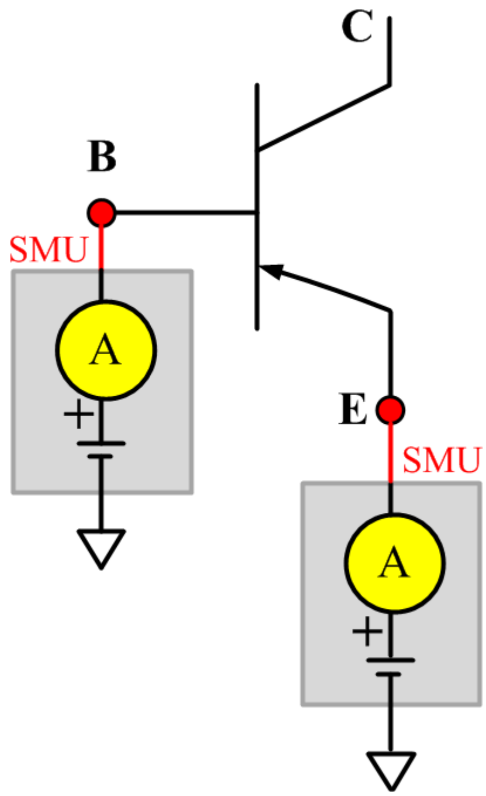
Module Name: IBEO

DUT: Three-terminal pnpBJT

Function: Test the Base-Emitter current with the Collector opened.

Pin connections: Open the Collector and apply a voltage to the Base and Emitter (if not connected to ground)(see next figure).

Figure 57: Three_term_pnpBJT_IBEO pin connection



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

Description:

Module Name: IbIcVbe

DUT: Three-terminal pnpBJT

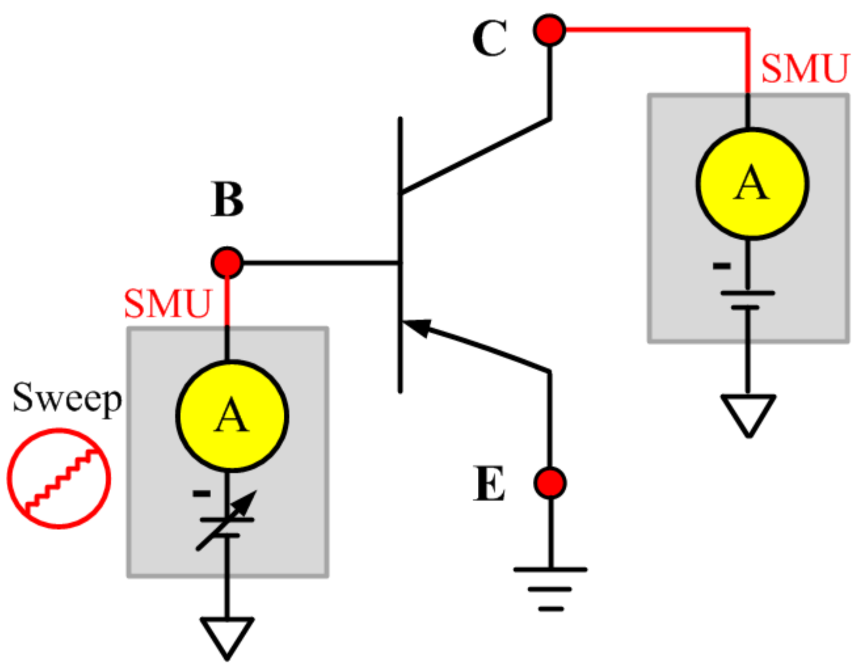
Function: Tests the Base current and Collector current of the pnpBJT device with a specified Base voltage sweep.

Pin connections: Sharing the Emitter connection, apply a sweep voltage to the Base, and apply a bias voltage to the Collector. The Emitter is typically connected to ground, but can be set to a desired bias voltage (see next figure).

Intended results:

- Measure the Base current and Collector current of the pnpBJT device
- Measure the IbVbe and IcVbe curves
- Measure the gummel plot if the axis properties of the data plot have changed (the logarithm instead of right-angle coordinate).

Figure 58: Three_term_pnpBJT_Iblcvbe pin connection



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

Description:

Module Name: IbVbe

DUT: Three-terminal pnpBJT

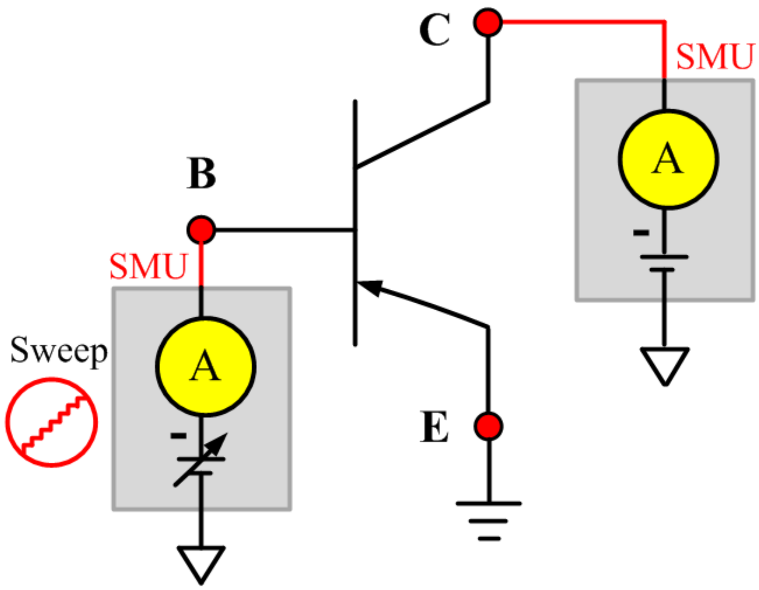
Function: Tests the Base current of the pnpBJT device with a specified Base voltage sweep.

Pin connections: Sharing the Emitter connection, apply a sweep voltage to the Base, and apply a bias voltage to the Collector. The Emitter is typically connected to ground, but can be set to a desired bias voltage (see next figure).

Intended results:

- Measure the Base current based on the Base voltage sweep
- Measure the IbVbe curve

Figure 59: Three_term_pnpBJT_IbVbe pin connection



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

Description:

Module Name: ICBO

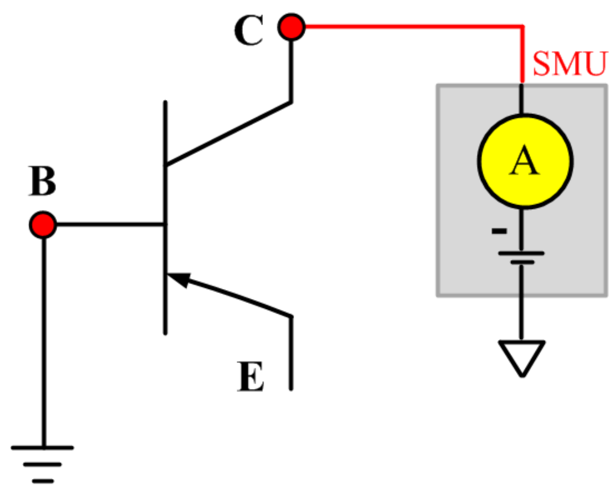
DUT: Three-terminal pnpBJT

Function: Tests the Collector-Base cut off current with the Emitter opened.

Pin connections: Open the Emitter, apply a desired voltage to the Collector, and connect the Base to ground (see next figure).

Intended results: Measure the Collector-Base to cut off current.

Figure 60: Three_term_pnpBJT_ICBO pin connection



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

Description:

Module Name: ICEO

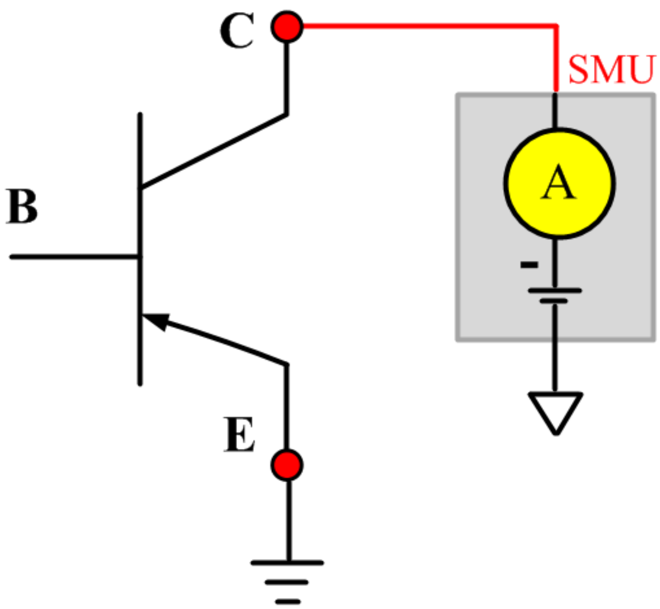
DUT: Three-terminal pnpBJT

Function: Tests the Collector-Emitter cut off current with the Base opened.

Pin connections: Open the Base, apply a desired voltage to the Collector, and connect the Emitter to ground (see next figure).

Intended results: Measure the Collector-Emitter to cut off current.

Figure 61: Three_term_pnpBJT_ICEO pin connection



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

Description:

Module Name: ICEV

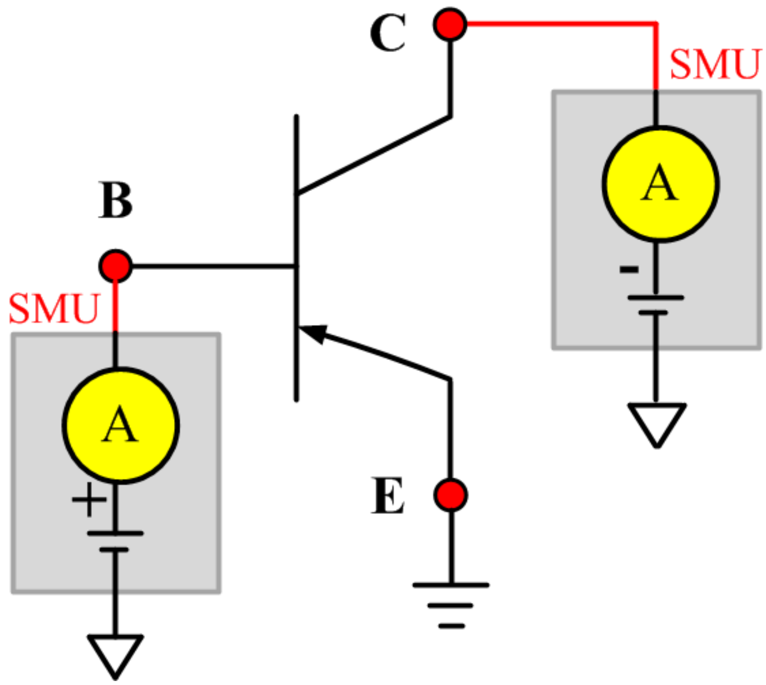
DUT: Three-terminal pnpBJT

Function: Tests the Collector-Emitter cut off current with the Base voltage biased.

Pin connections: Apply a desired voltage to the Collector, apply a voltage bias to the Base, and connect the Emitter to ground (see next figure).

Intended results: Measure the Collector-Emitter to cut off current.

Figure 62: Three_term_pnpBJT_ICEV pin connection



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

Description:

Module Name: IcVcb

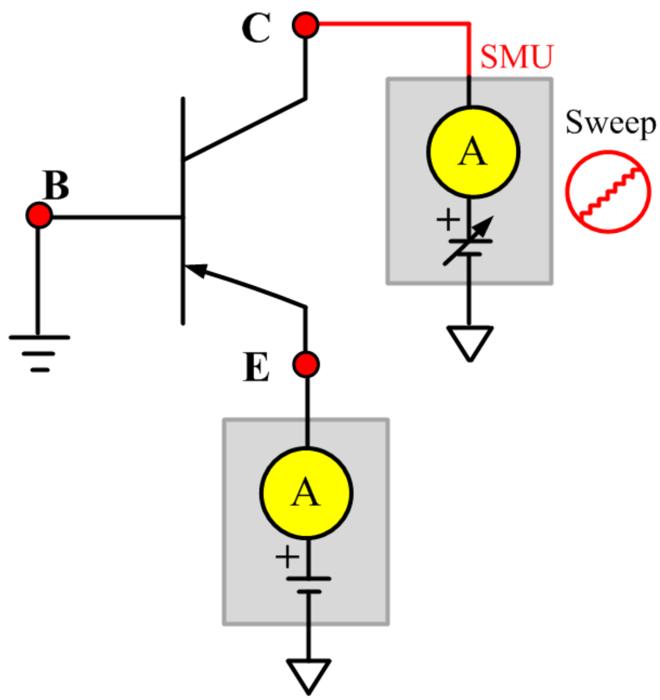
DUT: Three-terminal pnpBJT

Function: Tests the Collector current of the pnpBJT device with a specified Collector voltage sweep.

Pin connections: Sharing the Base connection, apply a sweep voltage to the Collector, and apply a bias voltage to the Emitter (see next figure).

Intended results: Measure the Collector current based on the Collector voltage sweep.

Figure 63: Three_term_pnpBJT_IcVcb pin connection



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

Description:

Module Name: IcVce_BiasIb

DUT: Three-terminal pnpBJT

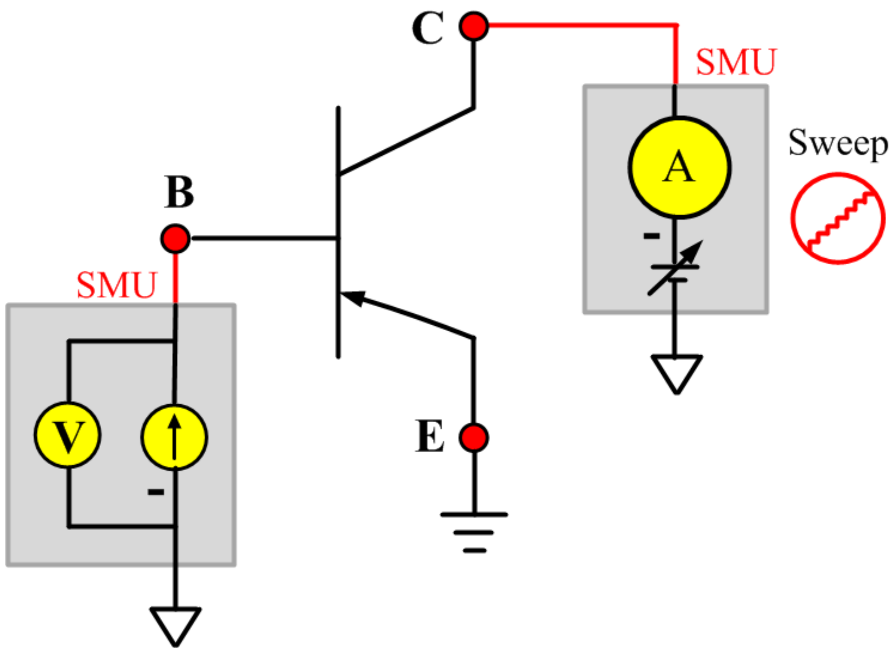
Function: Collects an IcVce curve of a pnpBJT device at a fixed Base current.

Pin connections: Sharing the Emitter connection (connect Emitter to ground), bias the Base current, and sweep the Collector voltage (see next figure).

Intended results:

- Measure the Collector current based on the Base bias current and Collector sweep voltage
- Measure the IcVce curve

Figure 64: Three_term_pnpBJT_IcVce_BiasIb pin connection



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

Description:

Module Name: IcVce_BiasVb

DUT: Three-terminal pnpBJT

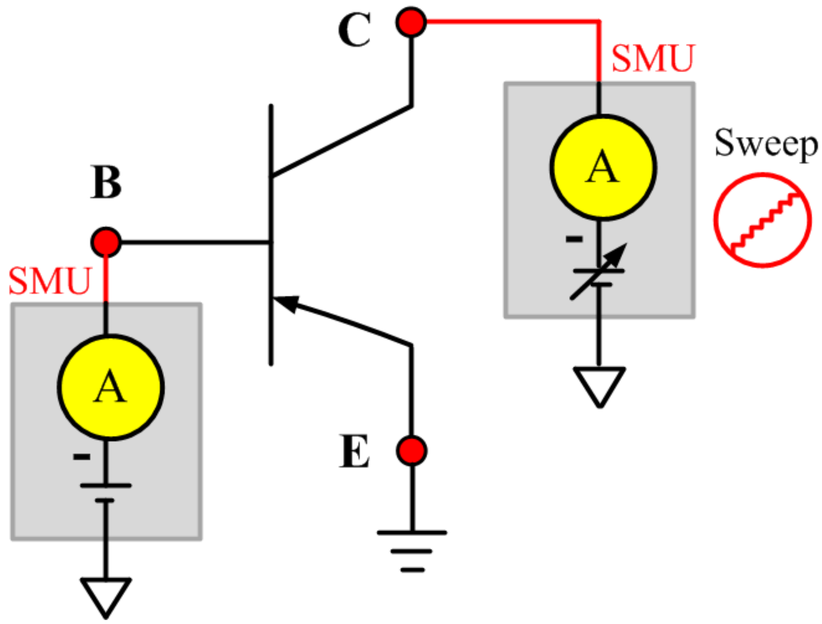
Function: Collects an IcVce curve of a pnpBJT device at a fixed Base voltage.

Pin connections: Sharing the Emitter connection (connect Emitter to ground), bias the Base voltage, and sweep the Collector voltage (see next figure).

Intended results:

- Measure the Collector current based on the Base bias voltage and the Collector sweep voltage
- Measure the IcVce curve

Figure 65: Three_term_pnpBJT_IcVce_BiasVb pin connection



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

Description:

Module Name: IcVce_StepIb

DUT: Three-terminal pnpBJT

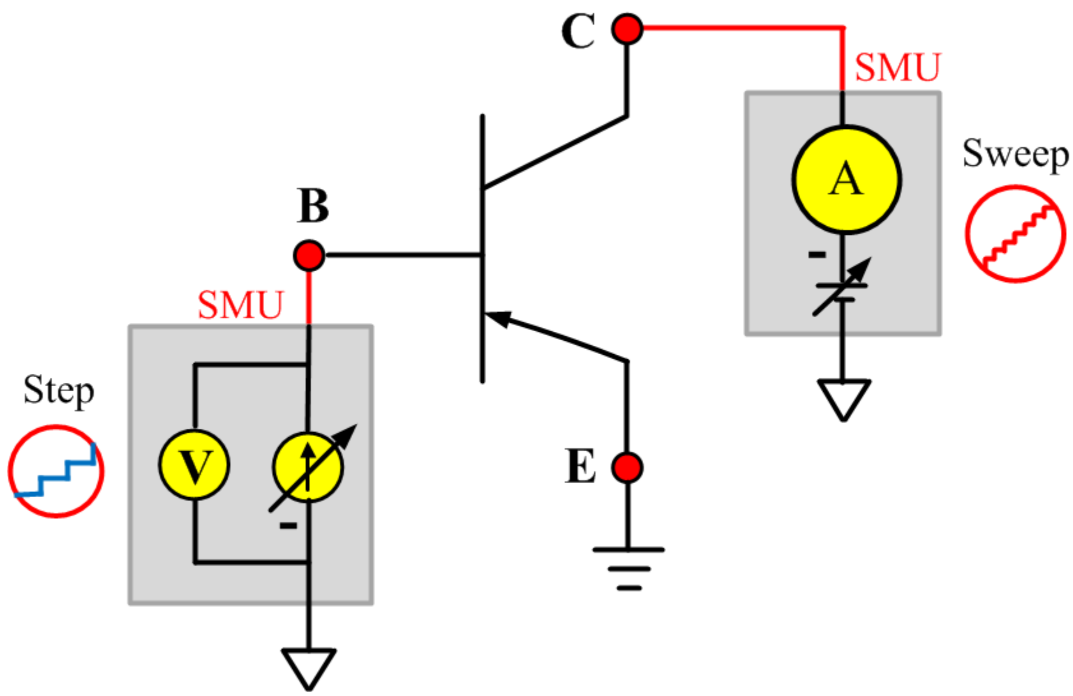
Function: Tests a series of IcVce curves of the pnpBJT device when stepping the Base current.

Pin connections: Sharing the Emitter connection (connect Emitter to ground), step the Base current, and sweep the Collector voltage (see next figure).

Intended results:

- Measure the Collector current based on the Base step current and the Collector sweep voltage
- Measure the series of IcVce curves with a Base current step

Figure 66: Three_term_pnpBJT_IcVce_StepIb pin connection



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

Description:

Module Name: IcVce_StepVb

DUT: Three-terminal pnpBJT

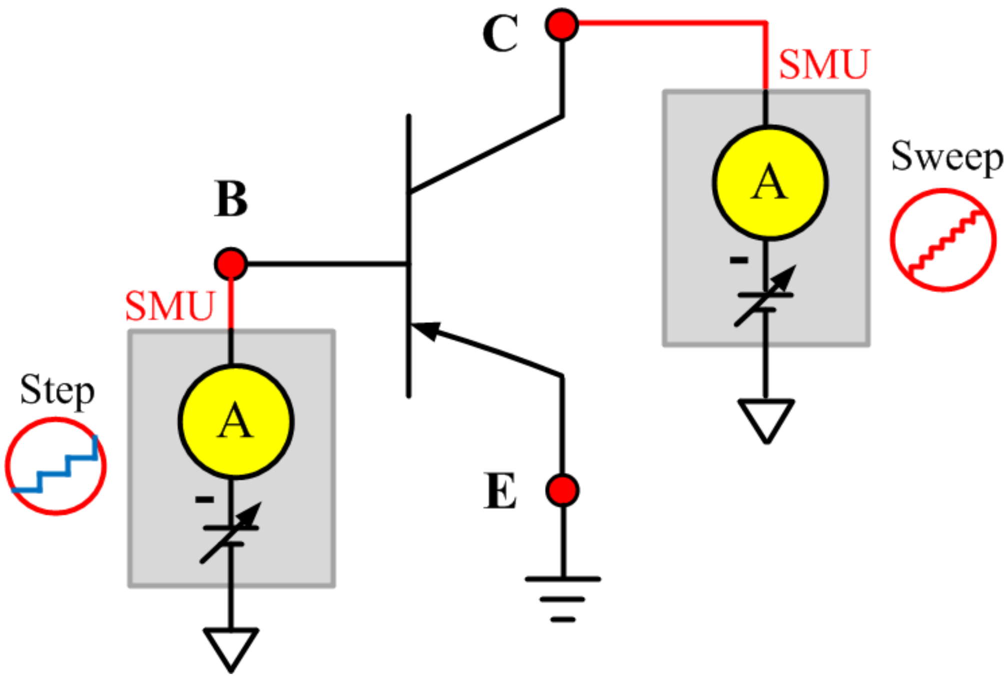
Function: Tests a series of IcVce curves of the pnpBJT device when stepping the Base voltage.

Pin connections: Sharing the Emitter connection (connect Emitter to ground), step the Base voltage, and sweep the Collector voltage (see next figure).

Intended results:

- Measure the Collector current based on Base step and the Collector sweep voltage
- Measure the series of IcVce curves with a Base voltage step

Figure 67: Three_term_pnpBJT_IcVce_StepVb pin connection



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

Description:

Module Name: IEBO

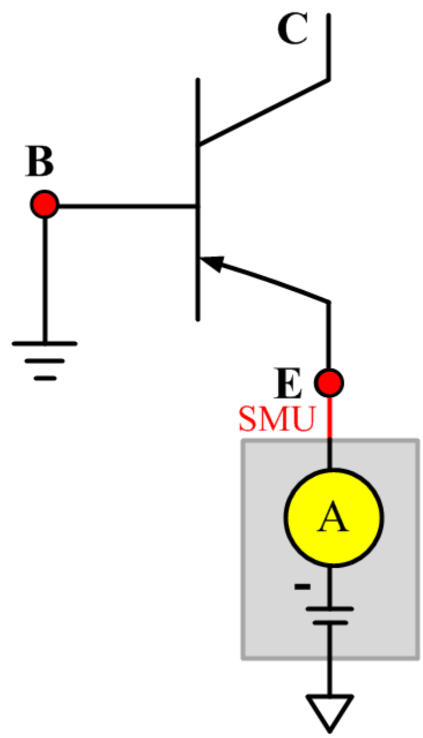
DUT: Three-terminal pnpBJT

Function: Tests the Emitter-Base cut off current with the Collector opened.

Pin connections: Open the Collector, apply a desired voltage to the Emitter, and connect the Base to ground (see next figure).

Intended results: Measure the Emitter-Base cut-off current.

Figure 68: Three_term_pnpBJT_IEBO pin connection



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

Description:

Module Name: IECO

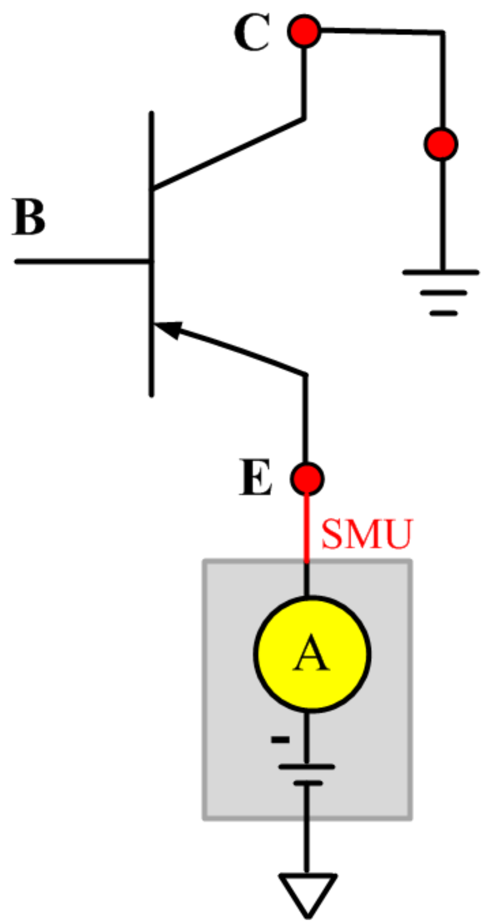
DUT: Three-terminal pnpBJT

Function: Tests the Emitter-Collector current with the Base opened.

Pin connections: Open the Base, and apply a desired voltage to the Emitter. The Collector is typically connected to ground, if voltage is not applied (see next figure).

Intended results: Measure the Emitter-Collector current.

Figure 69: Three_term_pnpBJT_IECO pin connection



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

Description:

Module Name: IeVeb

DUT: Three-terminal pnpBJT

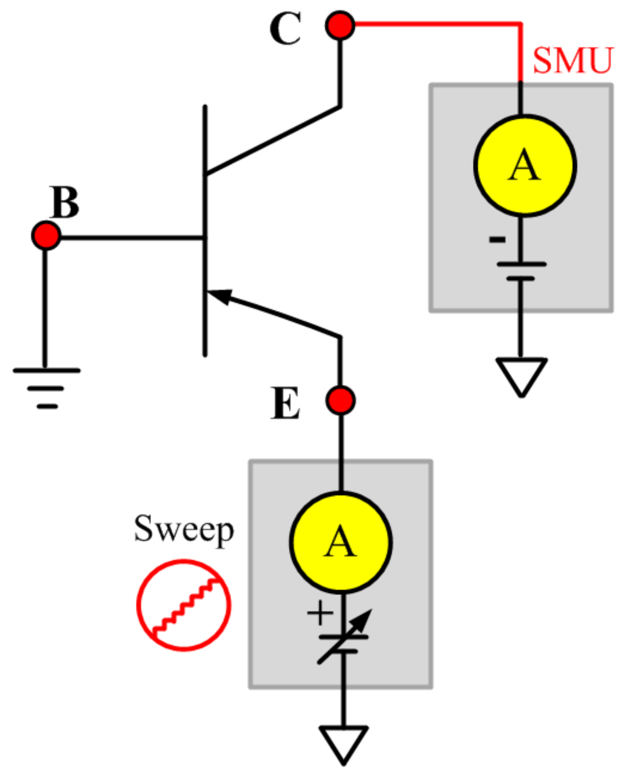
Function: Tests the Emitter current of the pnpBJT device with a specified Emitter voltage sweep.

Pin connections: Sharing the Base connection, apply a sweep voltage on the Emitter, and apply a bias voltage on the Collector. Connect the Base to ground, if voltage is not applied (see next figure).

Intended results:

- Measure the Emitter current based on the Emitter voltage sweep
- Measure the IeVeb curves

Figure 70: Three_term_pnpBJT_IeVeb pin connection



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

Description:

Module Name: VBCO

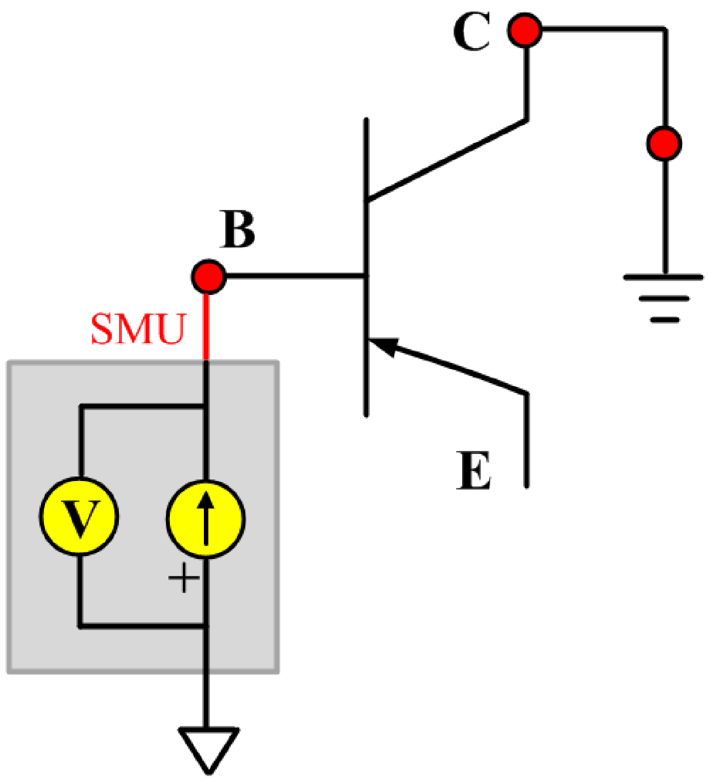
DUT: Three-terminal pnpBJT

Function: Tests the Base-Collector voltage of the pnpBJT device with the Emitter opened.

Pin connections: Open the Emitter, and apply a current to the Base. The Collector usually connects to ground, but can be set to the desired bias voltage (see next figure).

Intended results: Measure the Base-Collector voltage.

Figure 71: Three_term_pnpBJT_VBCO pin connection



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

Description:

Module Name: VCE

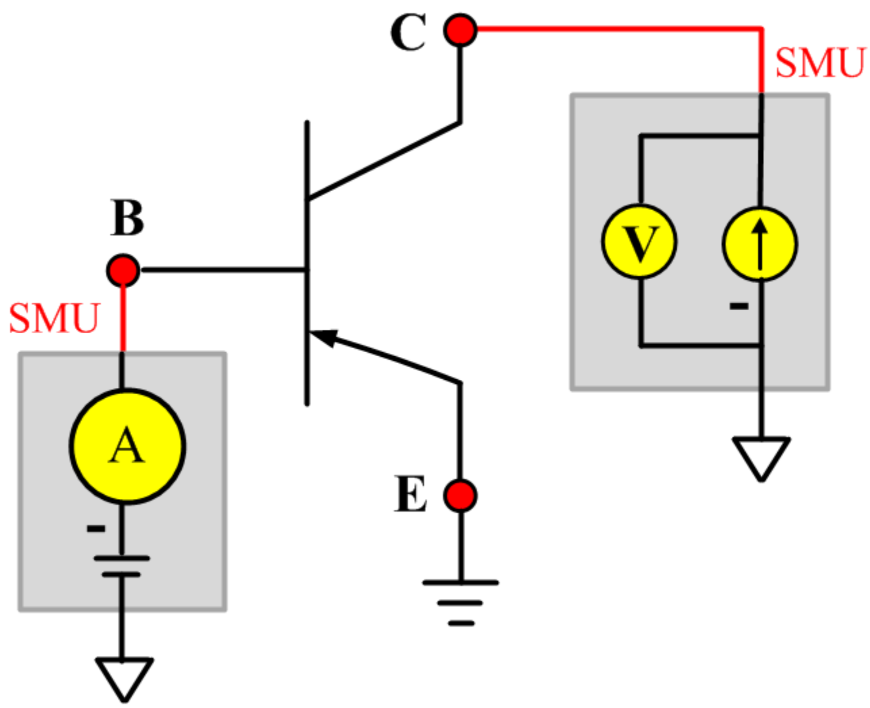
DUT: Three-terminal pnpBJT

Function: Tests the Collector-Emitter voltage of the pnpBJT device.

Pin connections: Apply a voltage to the Base, set the Collector current to the desired level, and connect the Emitter to ground (see next figure).

Intended results: Measure the Collector-Emitter voltage.

Figure 72: Three_term_pnpBJT_VCE pin connection



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 overview

The pnpPowerBJT library components are located in the following directory:
\\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 and characteristic curves.

pnpPowerBJT library

BVCBO

Description:

Module Name: BVCBO

Test Type: ITM

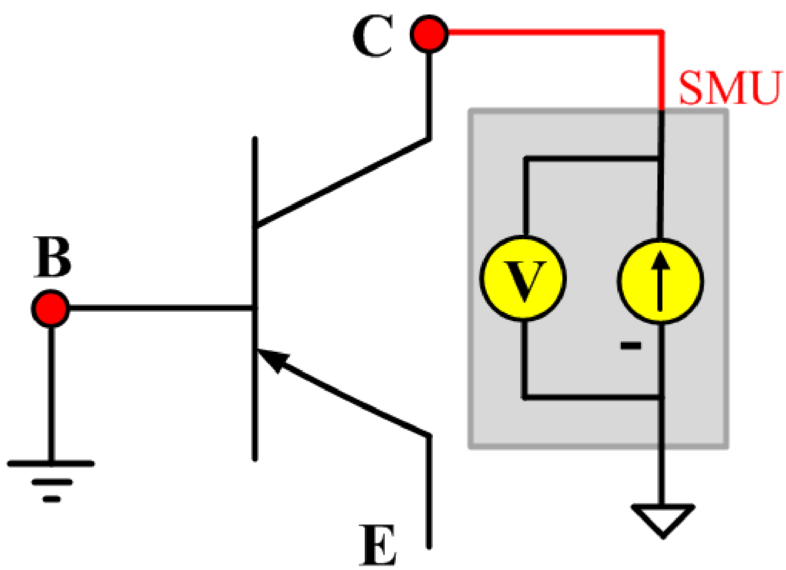
Instrument: KI2657A

DUT: Three-terminal pnpPowerBJT

Function: Determines 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: One SMU is used. The SMU applies current and takes voltage measurements from the Collector to Base. The Emitter is open or has no current bias from a SMU (see next figure).

Figure 73: pnpPowerBJT BVCBO pin connection



BVCEO

Description:

Module Name: BVCEO

Test Type: ITM

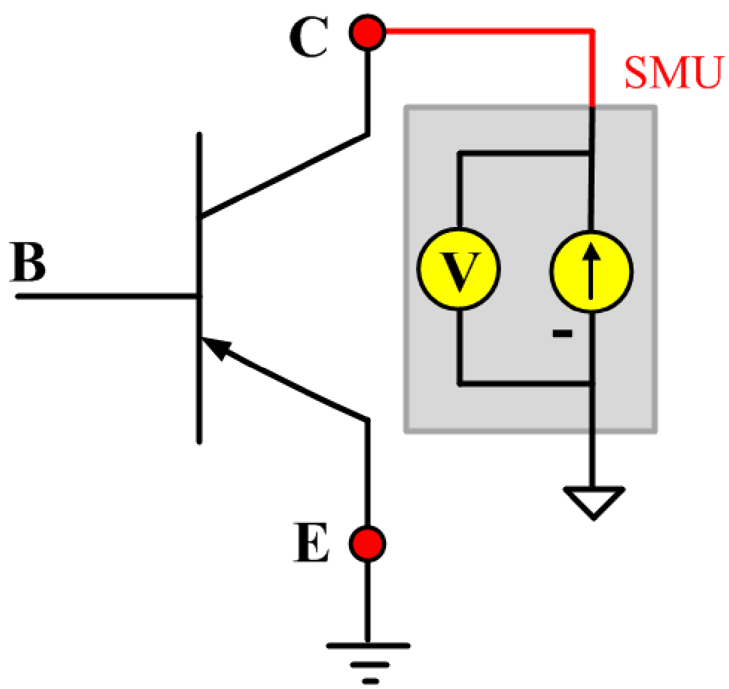
Instrument: KI2657A

DUT: Three-terminal pnpPowerBJT

Function: Determines 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 Connection: One SMU is used. The SMU applies current and takes voltage measurements from the Collector to Emitter. The Base is open, or has no current bias from a SMU.

Figure 74: pnpPowerBJT BVCEO pin connection



BVEBO

Description:

Module Name: BVEBO

Test Type: ITM

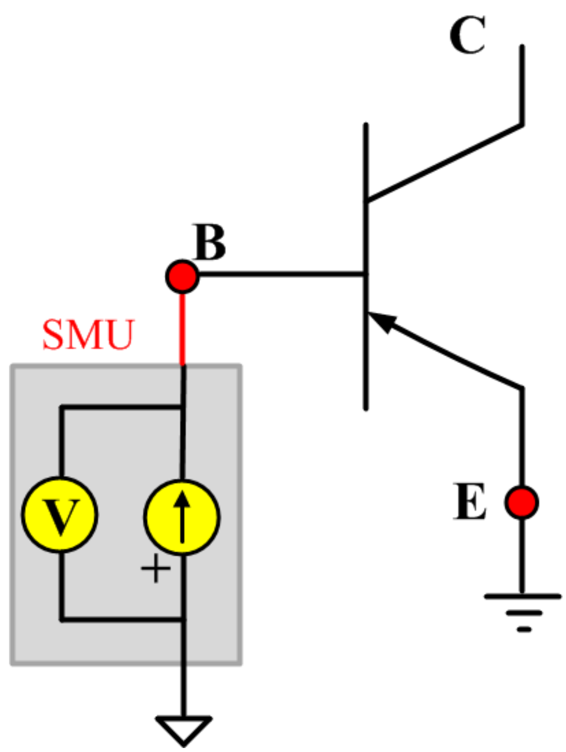
Instrument: KI2657A

DUT: Three-terminal pnpPowerBJT

Function: Determines 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 Connection: One SMU is used. The SMU applies current and takes voltage measurements from the Base to Emitter. The Collector is open, or has no current bias from a SMU.

Figure 75: pnpPowerBJT BVEBO pin connection



HFE

Description:

Module Name: HFE

Test Type: ITM

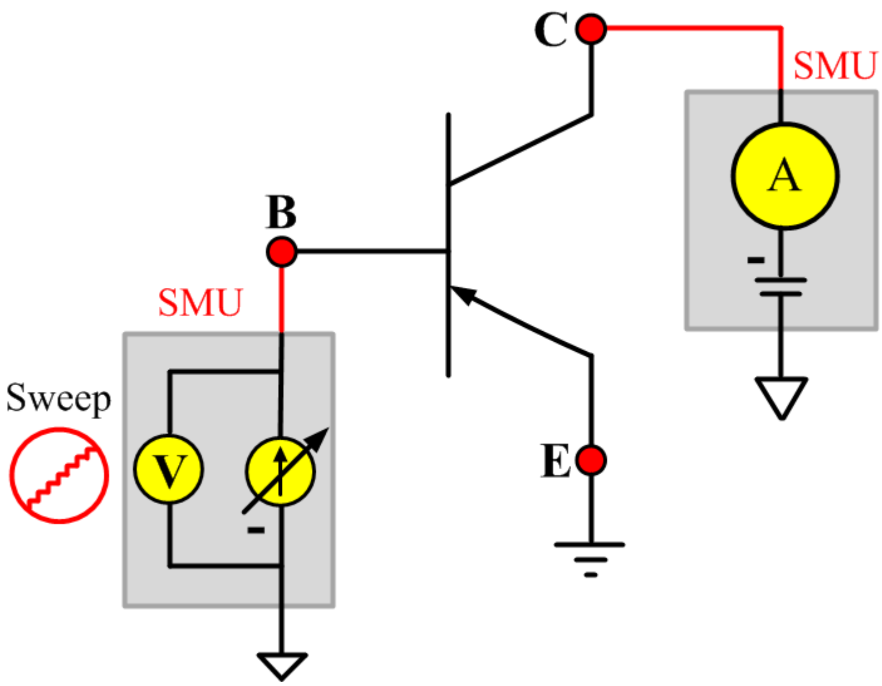
Instrument: KI2651A, KI2600B

DUT: Three-terminal pnpPowerBJT

Function: Determines the Collector-Emitter static forward current transfer ratio with the output voltage (Vce) held constant (HFE = Ic/Ib).

Pin Connection: Two SMUs are used. One SMU applies voltage bias and takes current measurements from the Collector to Emitter. The other SMU applies a current sweep to the Base.

Figure 76: pnpPowerBJT HFE pin connection



ICBO

Description:

Module Name: ICBO

Test Type: ITM

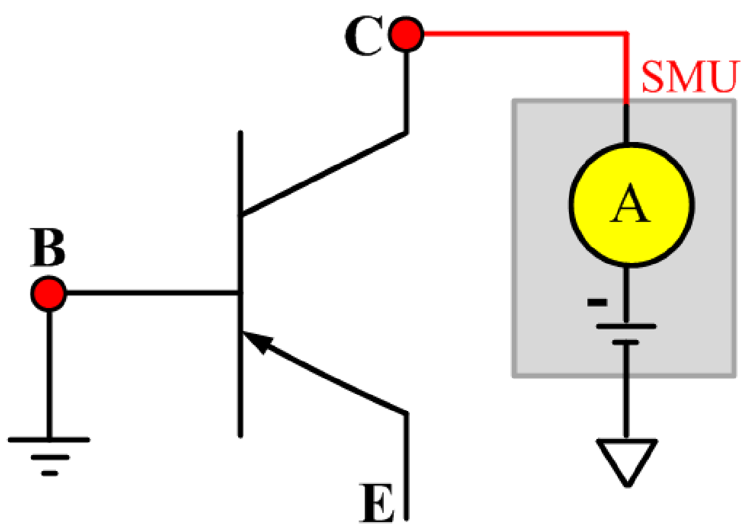
Instrument: KI2657A

DUT: Three-terminal pnpPowerBJT

Function: Determines the Collector-Base cut-off current. Measures the current on the Collector by reverse biasing the Collector-Base and with the Emitter opened.

Pin Connection: One SMU is used. The SMU applies voltage and takes current measurements from the Collector to Base. The Emitter is open.

Figure 77: pnpPowerBJT ICBO pin connection



ICEO

Description:

Module Name:ICEO

Test Type:ITM

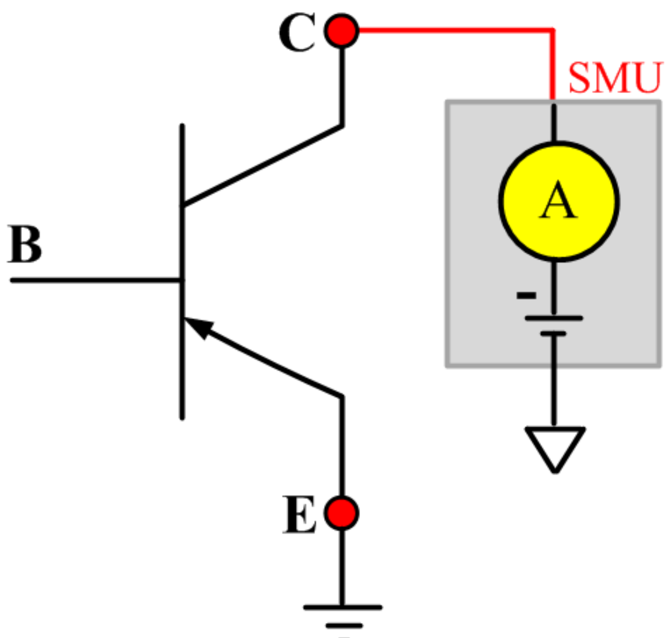
Instrument:KI2657A

DUT: Three-terminal pnpPowerBJT

Function: Determines the Collector-Emitter cut-off current with the Base opened.

Pin Connection: One SMU is used. The SMU applies voltage and takes current measurements from the Collector to Emitter. The Base is open, or has no current bias from a SMU.

Figure 78: pnpPowerBJT ICEO pin connection



ICES

Description:

Module Name: ICES

Test Type: ITM

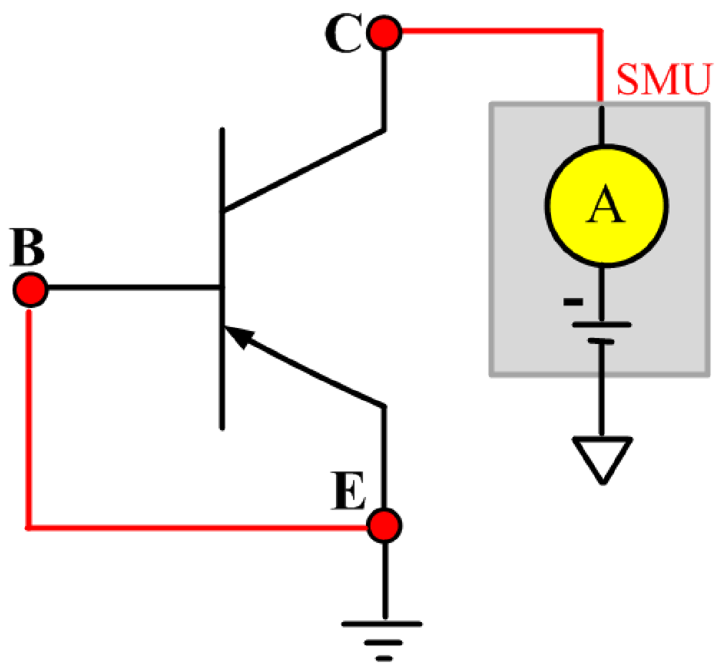
Instrument: KI2657A

DUT: Three-terminal pnpPowerBJT

Function: Determines the Collector-Emitter cut-off current with the Base shorted to the Emitter.

Pin Connection: One SMU is used. The SMU applies voltage and takes current measurements from Collector to Emitter. The Base is shorted to the Emitter, or has no voltage bias from the other SMU.

Figure 79: pnpPowerBJT ICES pin connection



ICEV

Description:

Module Name: ICEV

Test Type: ITM

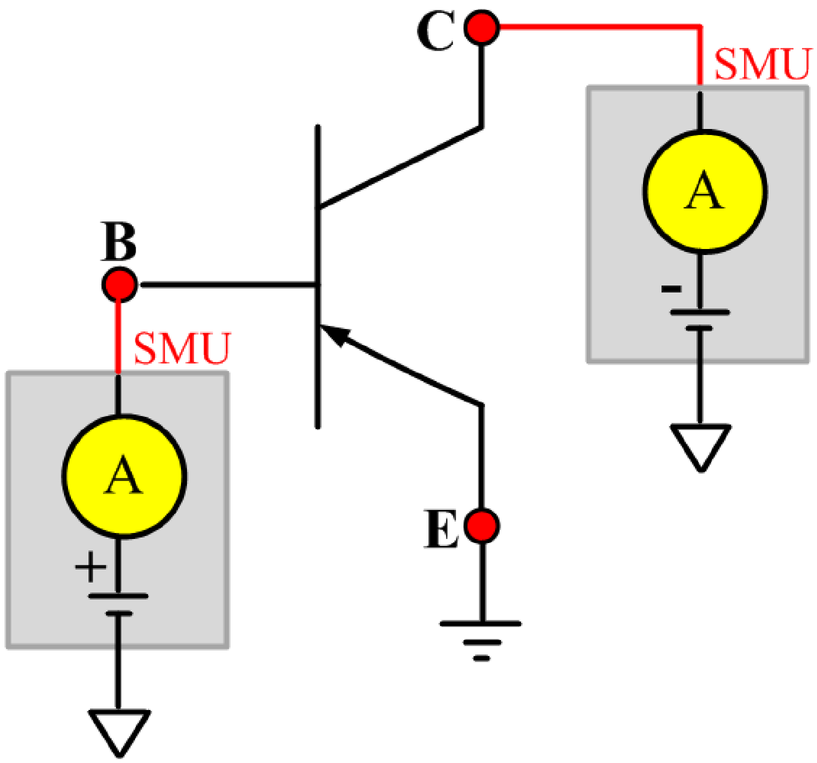
Instrument: KI2657A

DUT: Three-terminal pnpPowerBJT

Function: Determines the Collector-Emitter cut-off current with reverse biasing at the Emitter-Base junction.

Pin Connection: Two SMUs are used. One SMU applies voltage and takes current measurements from the Collector to Emitter. The Base is biased with a specified voltage from the other SMU.

Figure 80: pnpPowerBJT ICEV pin connection



IcVce_StepIb

Description:

Module Name: IcVce_StepIb

Test Type: ITM

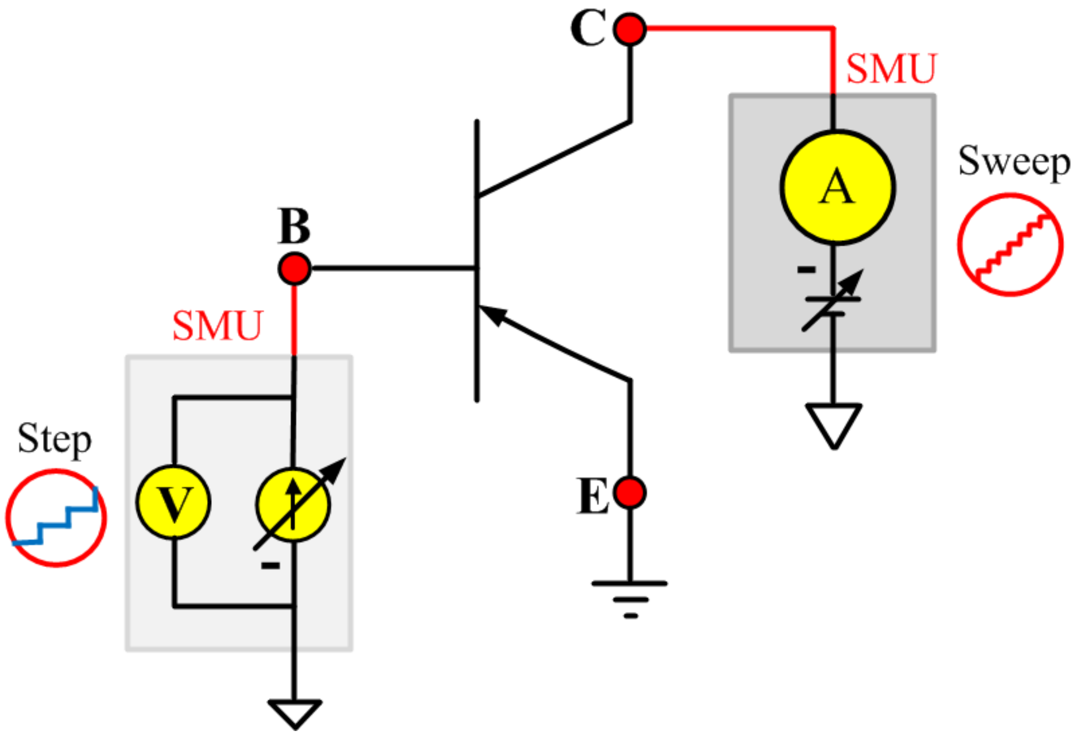
Instrument: 2651A, 2600B

DUT: Three-terminal pnpPowerBJT

Function: Determines the Collector-Emitter output characteristic curve with the current step at the Base.

Pin Connection: Two SMUs are used. One SMU applies a voltage sweep and takes current measurements from the Collector to Emitter. The other SMU applies a current step to the Base.

Figure 81: pnpPowerBJT IcVce_StepIb pin connection



IcVce_StepVbe

Description:

Module Name: IcVce_StepVbe

Test Type: ITM

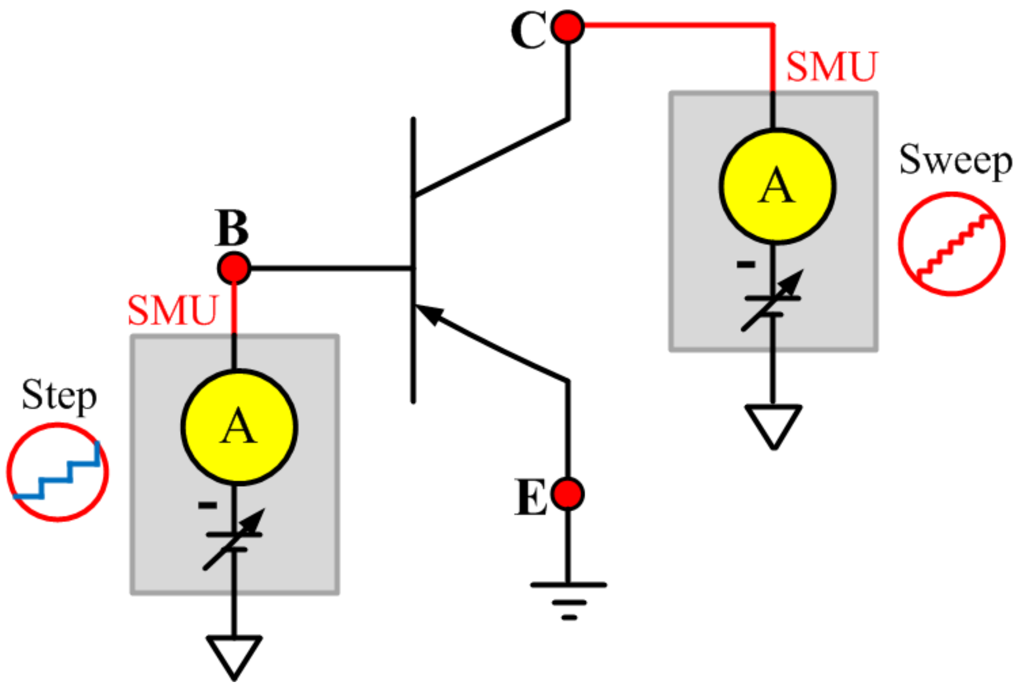
Instrument: 2651A, 2600B

DUT: Three-terminal pnpPowerBJT

Function: Determines the Collector-Emitter output characteristic curve with a voltage step at the Base.

Pin Connection: Two SMUs are used. One SMU applies a voltage sweep and takes current measurements from the Collector to Emitter. The other SMU applies a voltage step to the Base-Emitter junction.

Figure 82: pnpPowerBJT IcVce_StepVbe pin connection



IEBO

Description:

Module Name: IEBO

Test Type: ITM

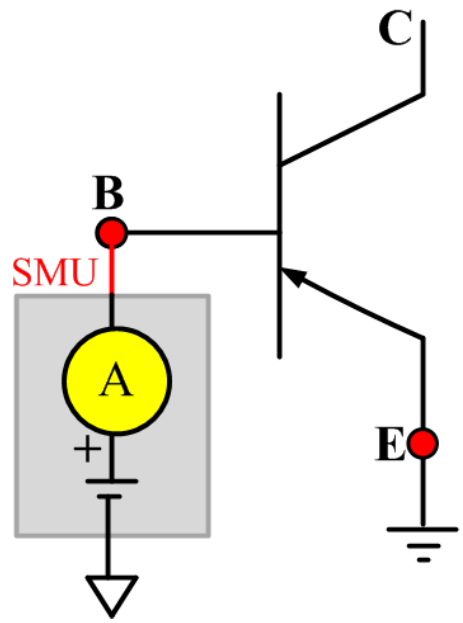
Instrument: KI2600B

DUT: Three-terminal pnpPowerBJT

Function: Determines the Emitter-Base cut-off current. Measures the current on the Emitter by reverse biasing the Emitter-Base junction with the Collector opened.

Pin Connection: One SMU is used. The SMU applies voltage and takes current measurements from the Base to Emitter. The Collector is open, or has no current bias from a SMU.

Figure 83: pnpPowerBJT IEBO pin connection



VbeON

Description:

Module Name: VbeON

Test Type: ITM

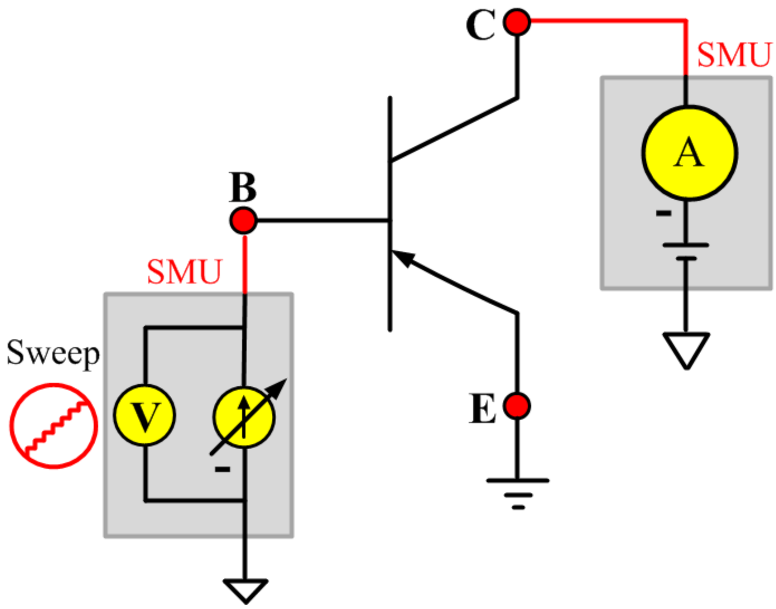
Instrument: KI2651A, KI2600B

DUT: Three-terminal pnpPowerBJT

Function: Determines 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 Connection: Two SMUs are used. One SMU applies a current sweep and takes voltage measurements from the Base to Emitter. The other SMU applies a voltage bias to the Collector.

Figure 84: pnpPowerBJT VbeON pin connection



VbeSAT

Description:

Module Name: VbeSAT

Test Type: ITM

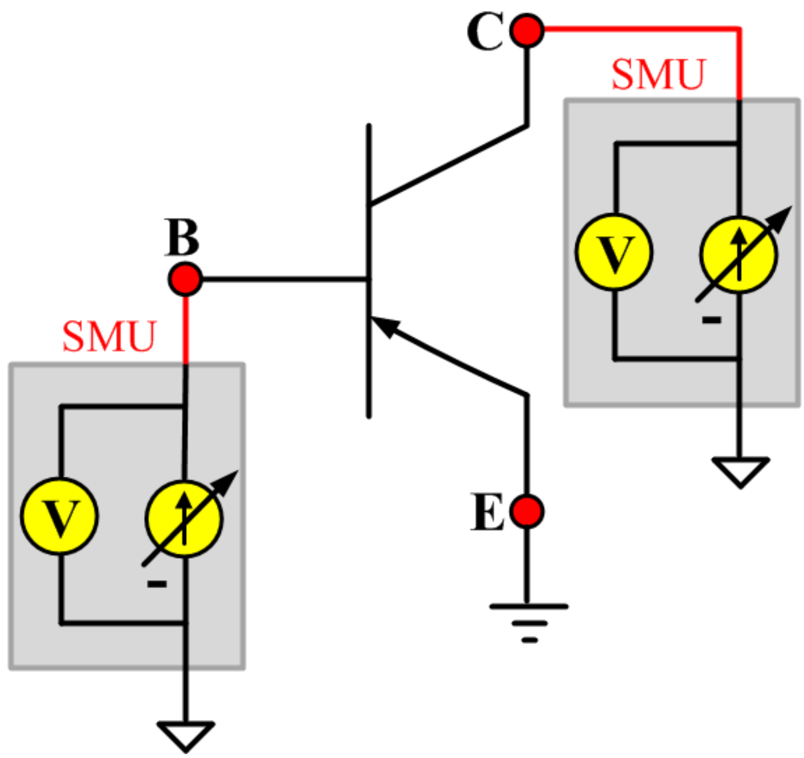
Instrument: KI2651A, KI2600B

DUT: Three-terminal pnpPowerBJT

Function: Determines 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: Two SMUs are used. One SMU applies current and takes voltage measurements from the Base to Emitter. The other SMU applies current bias to the Collector.

Figure 85: pnpPowerBJT VbeSAT pin connection



VceSAT

Description:

Module Name: VceSAT

Test Type: ITM

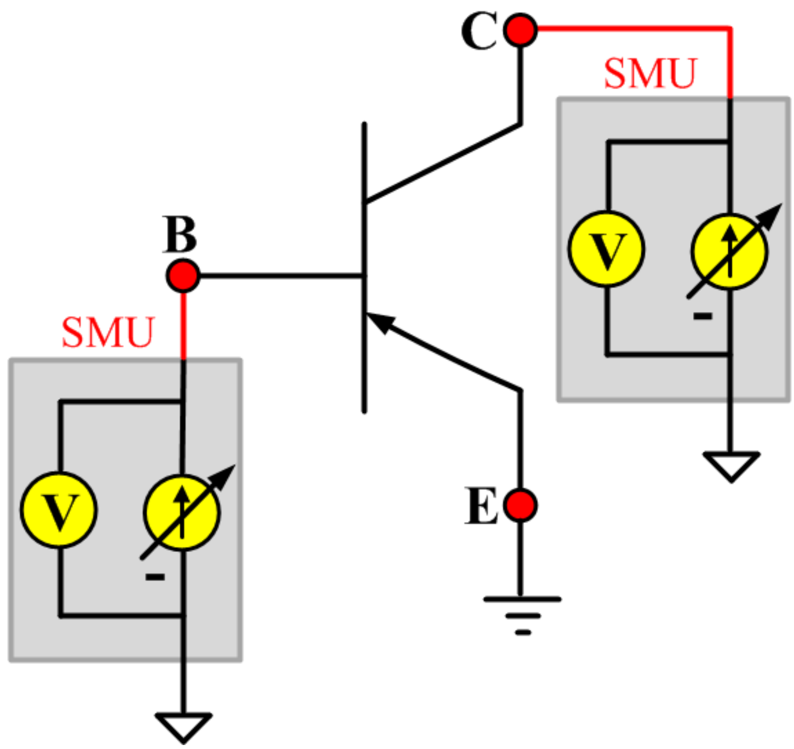
Instrument: 2651A, 2600B

DUT: Three-terminal pnpPowerBJT

Function: Determines 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 Connection: Two SMUs are used. One SMU applies current and takes voltage measurements from the Collector to Emitter. The other SMU applies current bias to the Base.

Figure 86: pnpPowerBJT VceSAT pin connection



VCESUS

Description:

Module Name: VCESUS

Test Type: ITM

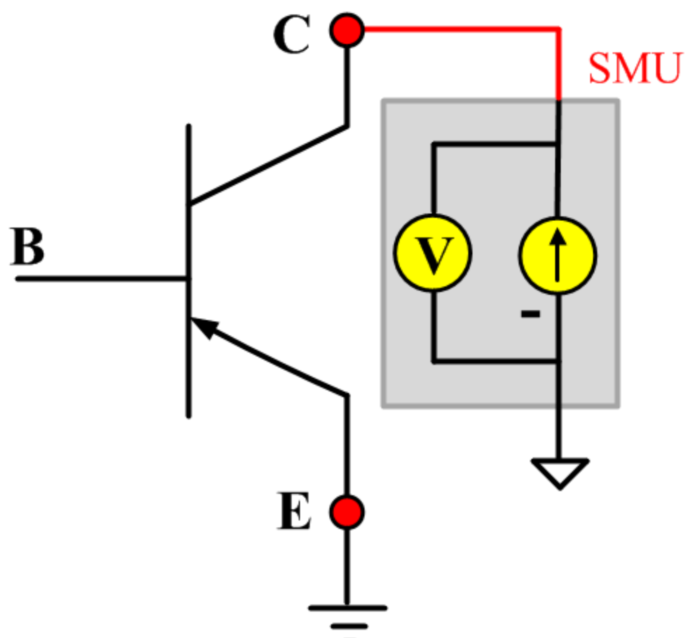
Instrument: KI2657A

DUT: Three-terminal pnpPowerBJT

Function: Determines 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 Connection: One SMU is used. The SMU applies current and takes voltage measurements from the Collector to Emitter. The Base is open, or has no current bias from a SMU.

Figure 87: pnpPowerBJT VCESUS pin connection



VceSAT_MIX

Description:

Module Name: VceSAT_MIX

Test Type: PTM

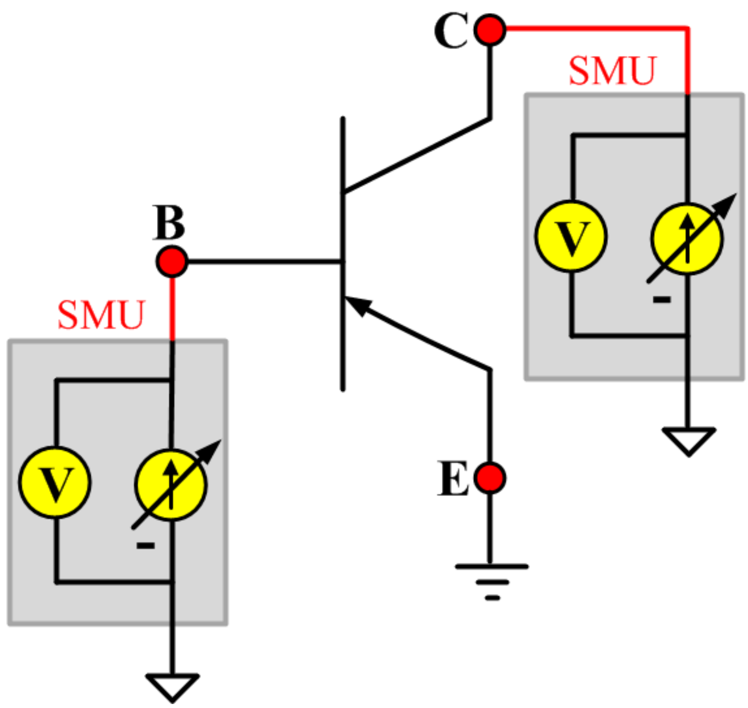
Instrument: KI2651A, KI2600B, KI24XX, KI42XX-SMU

DUT: Three-terminal pnpPowerBJT

Function: Determines the Collector-Emitter saturation voltage. The voltage is measured at a specific Base current and Collector current that is given in data sheet to ensure that both the Emitter-Base and Collector-Base junctions are forward biased.

Pin Connection: Two SMUs are used. One SMU applies current and takes voltage measurements from the Collector to Emitter. The other SMU applies current bias to the Base.

Figure 88: pnpPowerBJT VceSAT_MIX pin connection



IcVce_StepIb_MIX

Description:

Module Name: IcVce_StepIb_MIX

Test Type: PTM

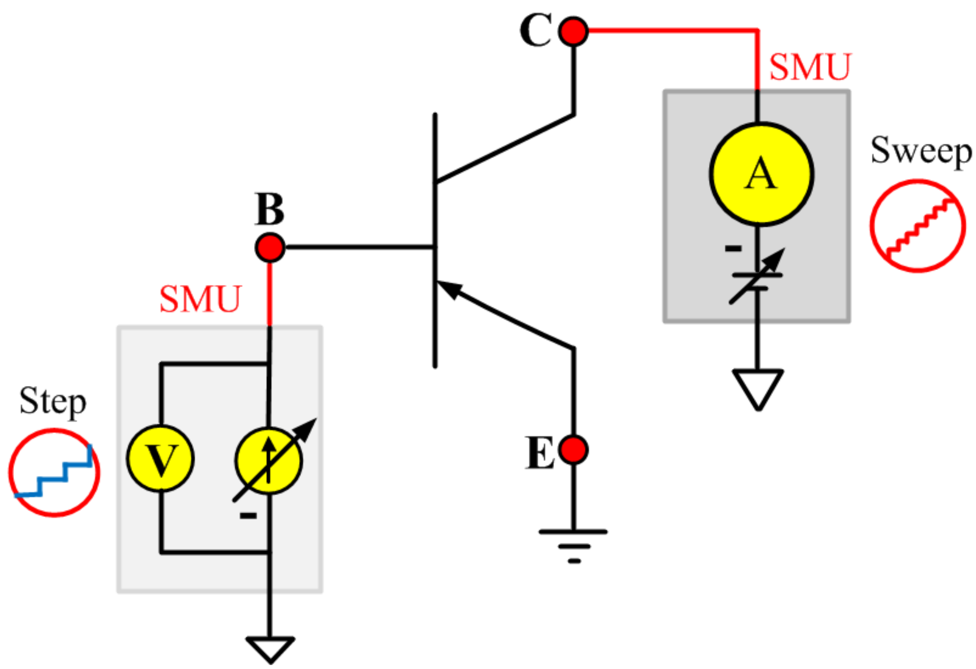
Instrument: KI2651A, KI2600B, KI24XX, KI42XX-SMU

DUT: Three-terminal pnpPowerBJT

Function: Determines the Collector-Emitter output characteristic curve with a current step at the Base.

Pin Connection: Two SMUs are used. One SMU applies a voltage sweep and takes voltage measurements from the Collector to Emitter. The other SMU applies current step to the Base.

Figure 89: pnpPowerBJT IcVce_StepIb_MIX pin connection



IcVce_StepVbe_MIX

Description:

Module Name: IcVce_StepVbe_MIX

Test Type: PTM

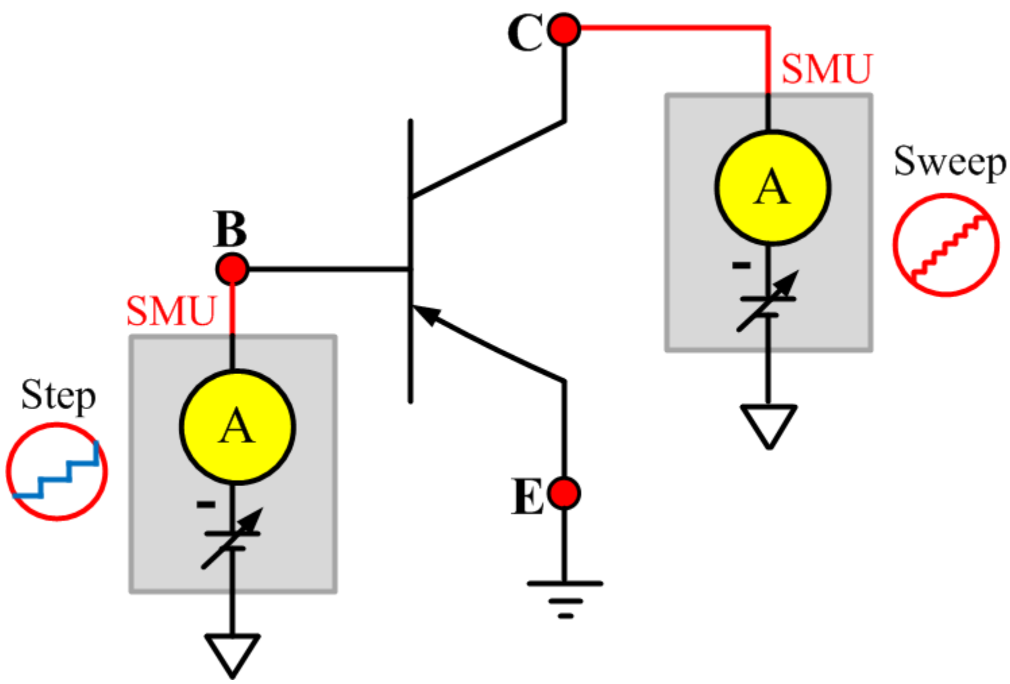
Instrument: KI2651A, KI2600B, KI24XX, KI42XX-SMU

DUT: Three-terminal pnpPowerBJT

Function: Determines the Collector-Emitter output characteristic curve with a voltage step on the Emitter-Base junction.

Pin Connection: Two SMUs are used. One SMU applies a voltage sweep and takes current measurements from the Collector to Emitter. The other SMU applies a voltage step to the Base-Emitter junction.

Figure 90: pnpPowerBJT IcVce_StepVbe_MIX pin connection



nMOSFET parametric library

nMOSFET parametric library overview

The nMOSFET library components are located in the following directories:

\\ACS_BASIC\library\dev_library\nMOSFET

\\ACS_BASIC\library\dev_library\nMOSFET\WLR_script\

The nMOSFET parameter library is used to test some parameters of a n-type power MOSFET, including leakage, breakdown, gain, on-state and characteristic curves.

The WLR script library provides certain wafer-level reliability tests on devices with Series 2600B instruments, with an XRC GUI. Note that the HCI module is a test script file based on the Series 2600B LPT library and is available in this library. .

nMOSFET parametric library

BVDSS

Description:

Module Name: BVDSS

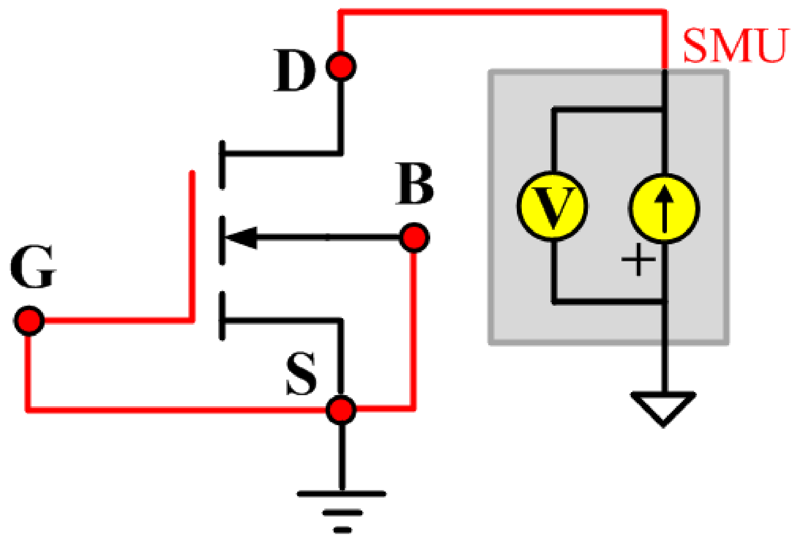
DUT: Four-terminal nMOSFET

Function: Tests the Drain-Source breakdown voltage of the nMOSFET with the Gate-Source shorted.

Pin connections: Apply a breakdown current on the Drain. Connect the bulk to ground, or force the voltage to zero. Connect the Gate and Source to ground, or you can force the voltage to zero (see next figure).

Intended results: Measure the breakdown voltage between the Drain and Source with the Gate-Source shorted.

Figure 91: nMOSFET_BVDSS pin connection



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

Description:

Module Name: BVDSV

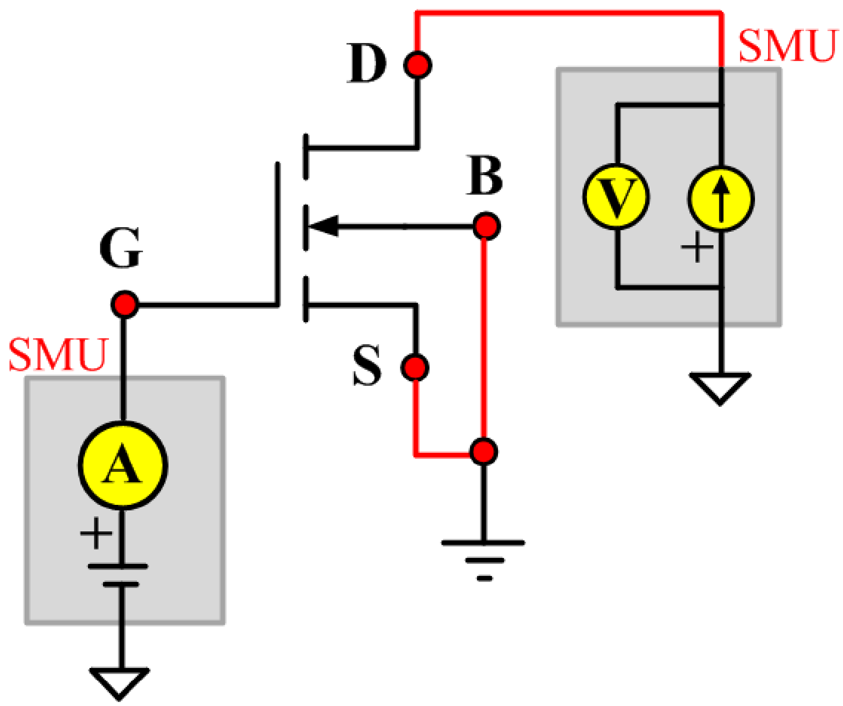
DUT: Four-terminal nMOSFET

Function: Tests the Drain-Source breakdown voltage of the nMOSFET with the Gate biased.

Pin connections: Connect the Source and bulk to ground. With the Gate biased, apply a breakdown current on the Drain (see next figure).

Intended results: Measure the breakdown voltage between the Drain and Source with the Gate biased.

Figure 92: Four_term_nMOSFET_BVDSV pin connection



BVDSV ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

BVDSV General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVGSO

Description:

Module Name: BVGSO

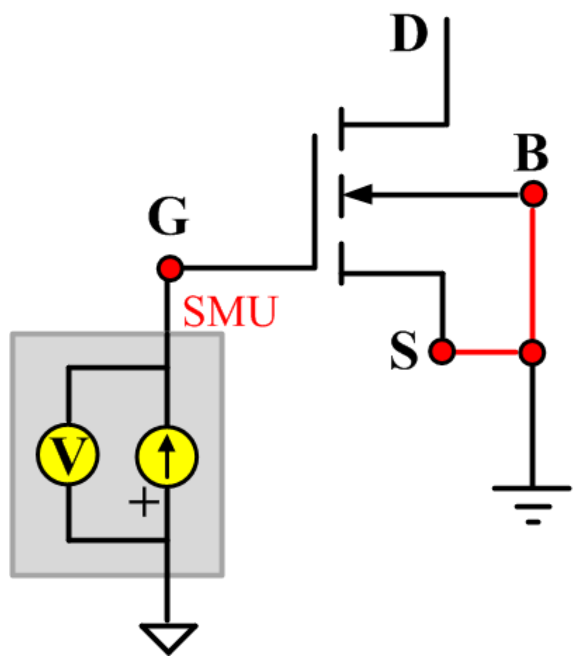
DUT: Four-terminal nMOSFET

Function: Tests the Gate-Source breakdown voltage of the nMOSFET with the Drain opened.

Pin connections: Open the Drain, and connect the bulk and Source to ground. Apply a breakdown current on the Gate (see next figure).

Intended results: Measure the breakdown voltage between the Gate and Source with the Drain opened.

Figure 93: Four_term_nMOSFET_BVGSO pin connection



BVGSO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

BVGSO General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVGDS

Description:

Module Name: BVGDS

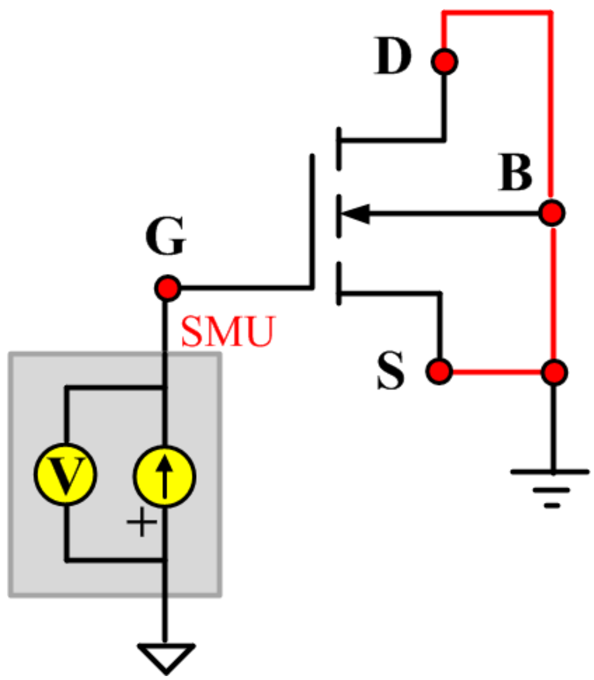
DUT: Four-terminal nMOSFET

Function: Tests the Gate-Drain breakdown voltage of the nMOSFET with the Source-Drain shorted.

Pin connections: Connect the Source, bulk, and Drain to ground. Apply a breakdown current on the Gate (see next figure).

Intended results: Measure the breakdown voltage between the Gate and Drain with the Source-Drain shorted.

Figure 94: Four_term_nMOSFET_BVGDS pin connection



BVGDS ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

BVGDS General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVGDO

Description:

Module Name: BVGDO

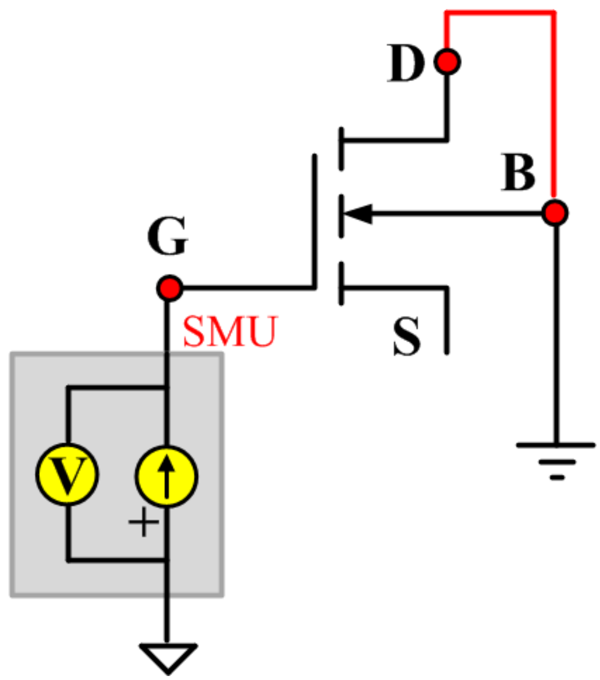
DUT: Four-terminal nMOSFET

Function: Tests the Gate-Drain breakdown voltage of the nMOSFET with the Source opened.

Pin connections: Open the Source, and connect the bulk and Drain to ground. Apply a breakdown current on the Gate (see next figure).

Intended results: Measure the breakdown voltage between the Gate and Drain when the Source is open.

Figure 95: Four_term_nMOSFET_BVGDO pin connection



BVGDO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

BVGDO General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IDL

Description:

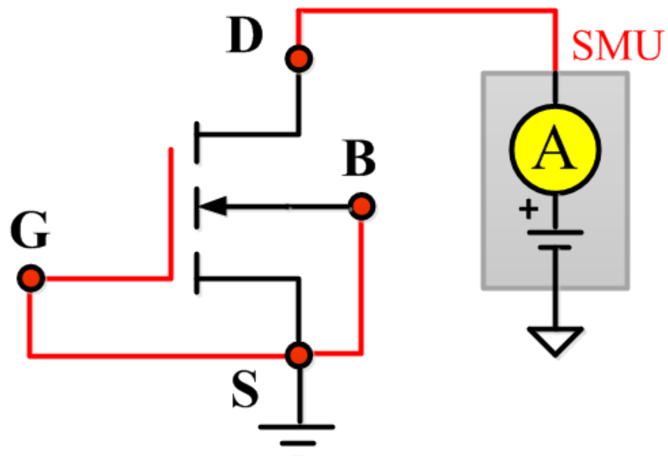
Module Name: IDL

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 (see next figure).

Intended results: Measure the Drain leakage current with the Gate-Source shorted.

Figure 96: Four_term_nMOSFET_IDL pin connection



IDL ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IDL General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IDS_ISD

Description:

Module Name: IDS_ISD

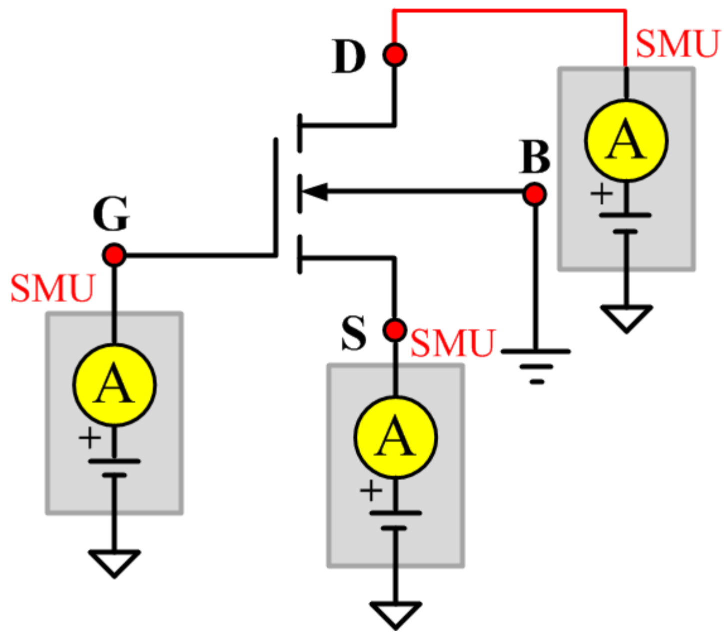
DUT: Four-terminal nMOSFET

Function: Measures the Drain-Source and Source-Drain current with the Gate biased.

Pin connections: Apply a separate voltage on the Gate, Source, and Drain. The bulk is typically connected to ground, but can be set to a desired bias voltage (see next figure).

Intended results: Measure the Drain-Source and Source-Drain current with the Gate biased.

Figure 97: Four_term_nMOSFET_IDS_ISD pin connection



IDS_ISD ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IDS_ISD General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVd_BiasVg

Description:

Module Name: IdVd_BiasVg

DUT: Four-terminal nMOSFET

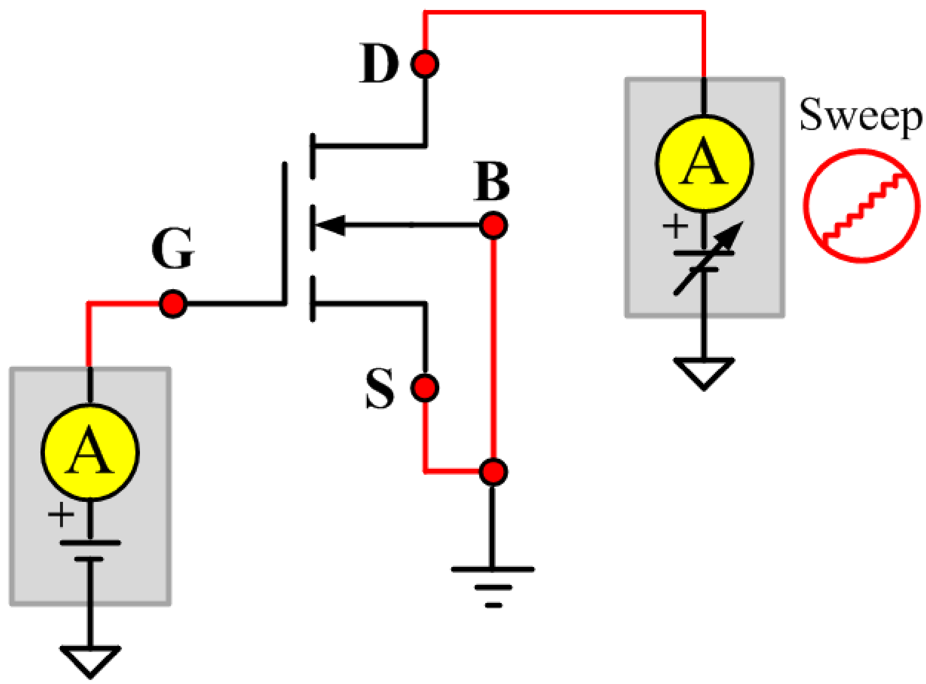
Function: Tests the Drain current during a specified Drain voltage sweep.

Pin connections: Apply a voltage bias to the Gate, and sweep the Drain. Connect the bulk and Source to ground, if voltage is not applied (see next figure).

Intended results:

- Measure the Drain current during a specified Drain voltage sweep
- Measure the Drain current and the Drain voltage curve

Figure 98: Four_term_nMOSFET_IdVd_BiasVg pin connection



IdVd_BiasVg ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IdVd_BiasVg General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVd_StepVg

Description:

Module Name: IdVd_StepVg

DUT: Four-terminal nMOSFET

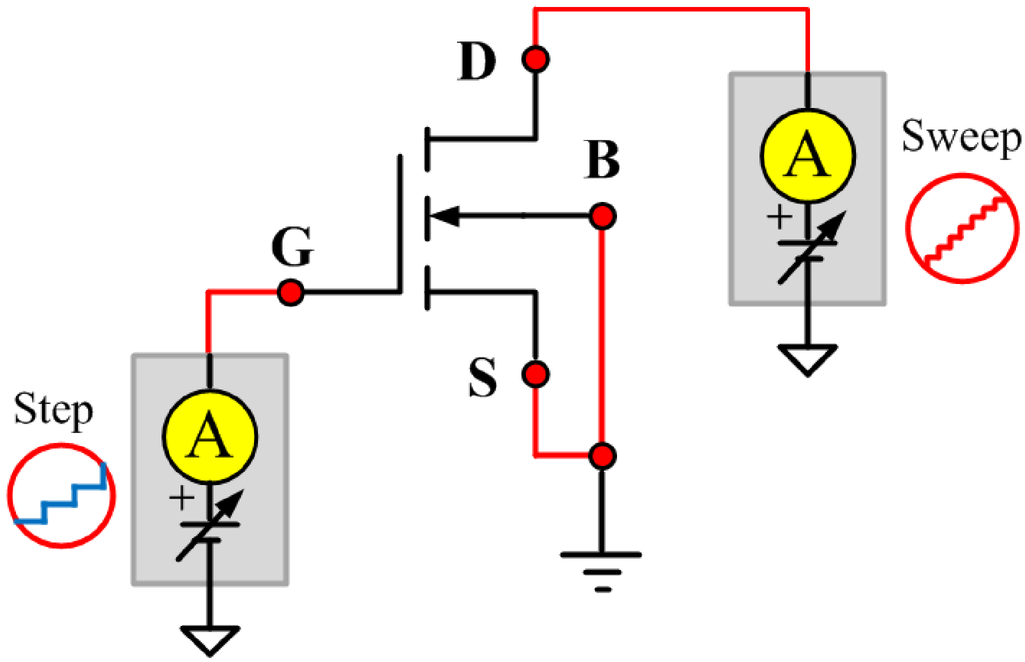
Function: Tests a series of IdVd curves for a four-terminal nMOSFET device that executes tests on the Series 2600B instruments.

Pin connections: Sweep the Drain, and step the Gate. Connect the bulk and Source to ground, if voltage is not applied (see next figure).

Intended results:

- Measure the Drain current during a specified Drain voltage sweep
- Measure the series of Drain current tests and the Drain voltage curve

Figure 99: Four_term_nMOSFET_IdVd_StepVg pin connection



IdVd_StepVg ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IdVd_StepVg General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVg_BiasVd

Description:

Module Name: IdVg_BiasVd

DUT: Four-terminal nMOSFET

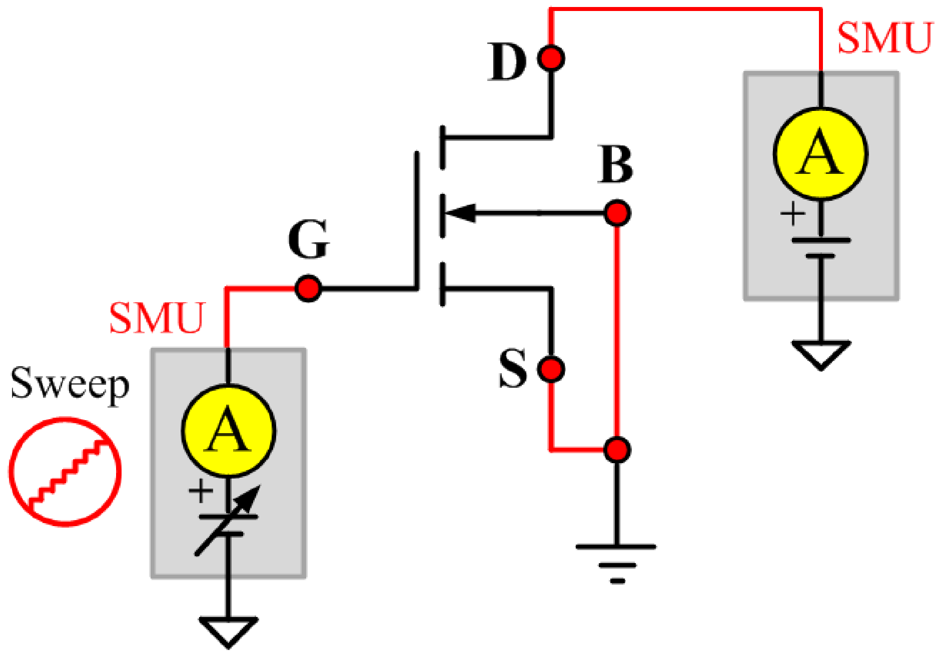
Function: Tests the Drain current during a specified Gate voltage sweep.

Pin connections: Apply a voltage bias to the Drain, and sweep the Gate. Connect the bulk and Source to ground, if voltage is not applied (see next figure).

Intended results:

- Measure the Drain current at the Gate voltage sweep
- Measure the Drain current and the Gate voltage curve

Figure 100: Four_term_nMOSFET_IdVg_BiasVd pin connection



IdVg_BiasVd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IdVg_BiasVd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVg_StepVd

Description:

Module Name: IdVg_StepVd

DUT: Four-terminal nMOSFET

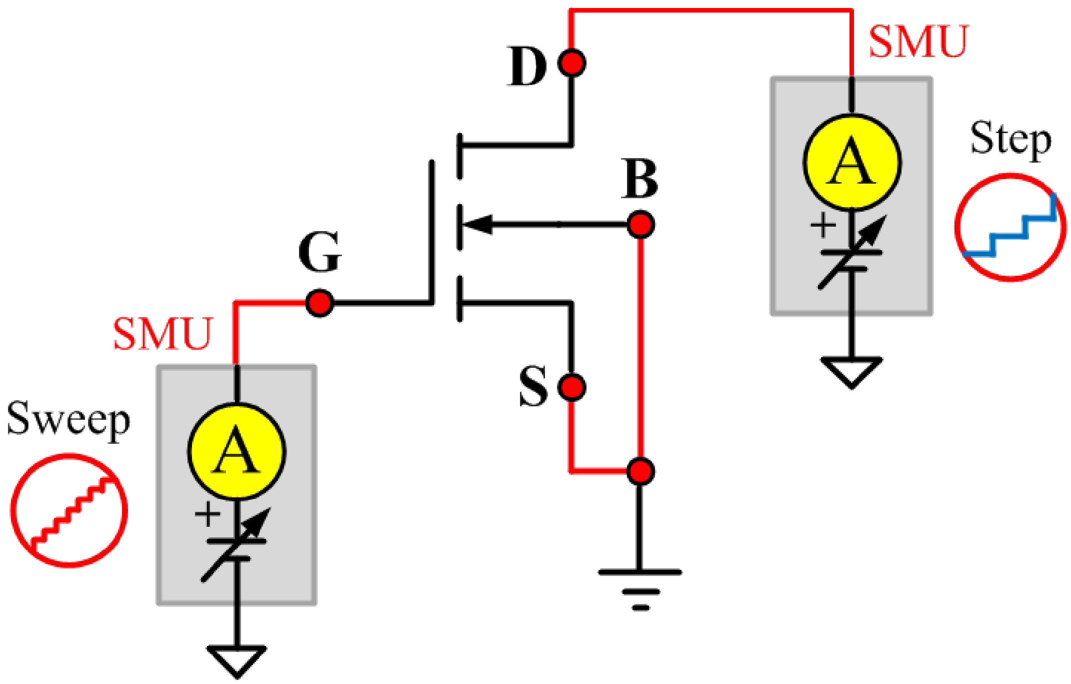
Function: Tests the Drain current during a specified Gate voltage sweep with the Drain step.

Pin connections: Step the Drain, and sweep the Gate. Connect the bulk and Source to ground, if voltage is not applied (see next figure).

Intended results:

- Measure the Drain current during a Gate voltage sweep
- Measure a series of Drain currents and a Gate voltage curve

Figure 101: Four_term_nMOSFET_IdVg_StepVd pin connection



IdVg_StepVd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IdVg_StepVd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVg_StepVsub

Description:

Module Name: IdVg_StepVsub

DUT: Four-terminal nMOSFET

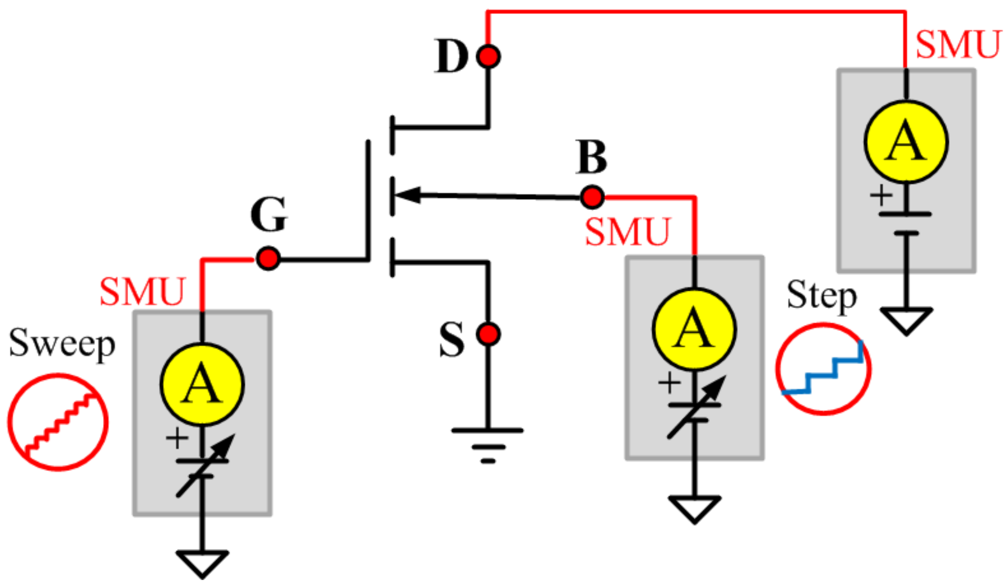
Function: Tests the Drain current during a specified Gate voltage sweep with a bulk step.

Pin connections: Step the bulk, sweep the Gate, and apply a voltage bias to the Drain. Connect the Source to ground, if voltage is not applied (see next figure).

Intended results:

- Measure the Drain current during a Gate voltage sweep
- Measure a series of Drain currents and a Gate voltage curve

Figure 102: Four_term_nMOSFET_IdVg_StepVsub pin connection



IdVg_StepVsub ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IdVg_StepVsub General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IGL

Description:

Module Name: IGL

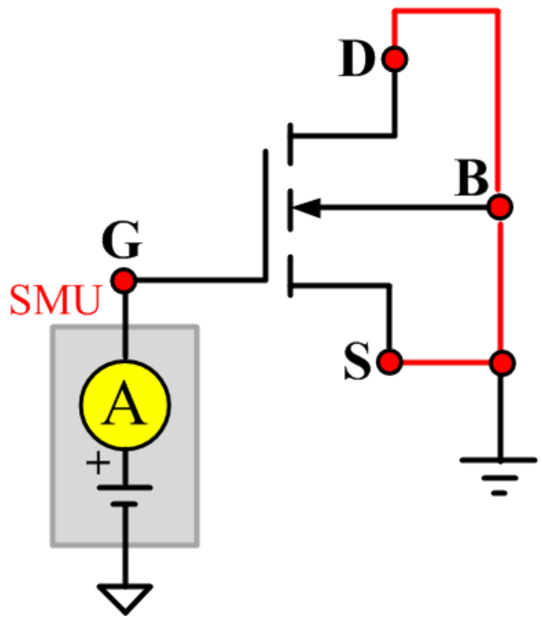
DUT: Four-terminal nMOSFET

Function: Measures the Gate leakage current with the Source-Drain shorted.

Pin connections: Apply voltage to the Gate, and connect the Source, Drain, and bulk to ground (see next figure).

Intended results: Measure the Gate leakage current when the Source and Drain are shorted.

Figure 103: Four_term_nMOSFET_IGL pin connection



IGL ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IGL General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IgVg

Description:

Module Name: IgVg

DUT: Four-terminal nMOSFET

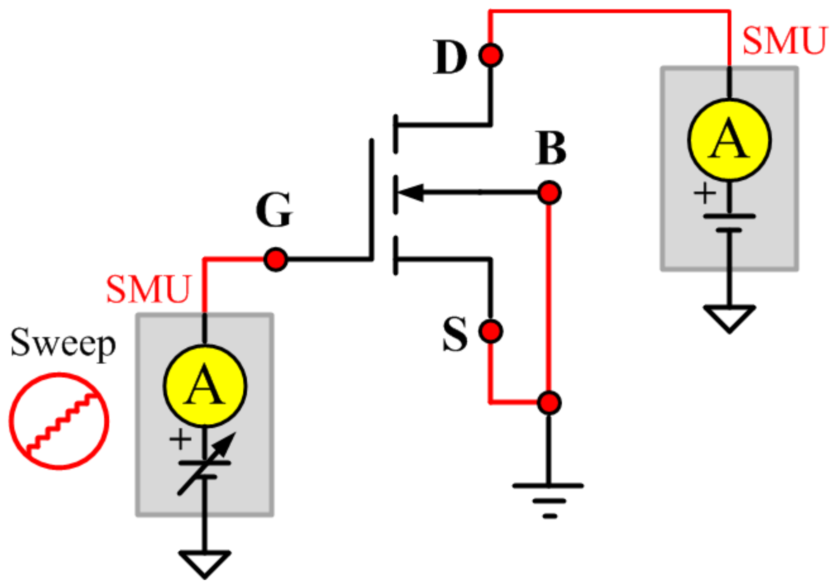
Function: Tests the Gate current during a specified Gate voltage sweep when the Drain is biased.

Pin connections: Apply a voltage bias to the Drain and sweep the Gate. Connect the bulk and Source to ground (see next figure).

Intended results:

- Measure the Gate current during a Gate voltage sweep
- Measure the Gate current and Gate voltage curve

Figure 104: Four_term_nMOSFET_IgVg pin connection



IgVg ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IgVg General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

ISL

Description:

Module Name: ISL

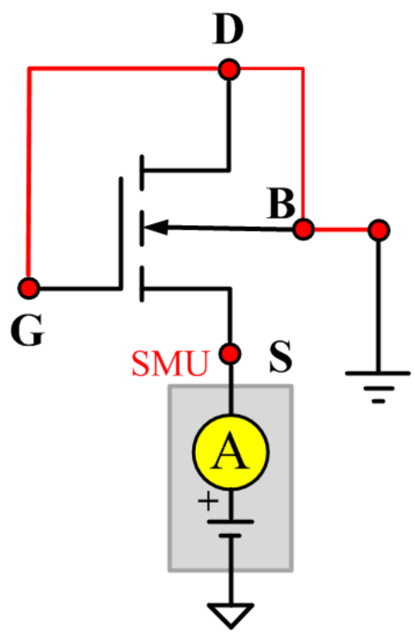
DUT: Four-terminal nMOSFET

Function: Measures the Source leakage current when the Gate-Drain is shorted.

Pin connections: Apply a voltage to the Source. Connect the bulk, Gate, and Drain to ground (see next figure).

Intended results: Measure the Source leakage current when the Gate-Drain is shorted.

Figure 105: Four_term_nMOSFET_ISL pin connection



ISL ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

ISL General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Vtci

Description:

Module Name: Vtci

DUT: Four-terminal nMOSFET

Function: Determines the constant current threshold voltage of the nMOSFET device.

Pin connections: Apply a voltage bias to the Drain, and sweep the Gate. The input of the Source and bulk voltage are usually connected to ground for NMOS, and connected to the normal power supply voltage (VDD) for PMOS (see next figure).

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=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.

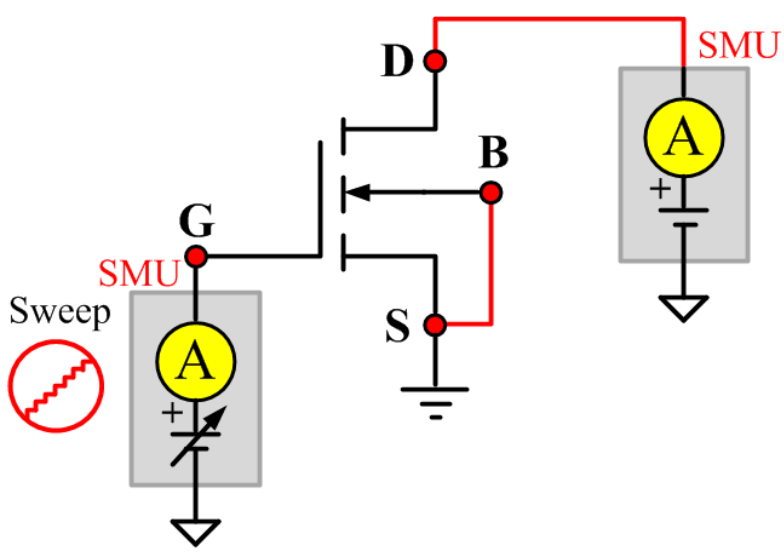
NOTE

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=5V)`; for `NMOS, VDS_lin=0.1V(@VDD=5V).`

Intended results:

- Measure the constant current threshold voltage
- Measure the Drain current and the Gate voltage curve

Figure 106: Four_term_nMOSFET_Vtci pin connection



Vtci ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

Vtci General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Vtext

Description:

Module Name: Vtext

DUT: Four-terminal nMOSFET

Function: Determines the threshold voltage while measuring the maximum slope.

Pin connections: Apply a voltage bias to the Drain and sweep the Gate voltage. Input the Source and bulk voltage when needed. Usually, they are connected to ground for NMOS, and connected to the normal power supply voltage (VDD) for PMOS (see next figure).

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

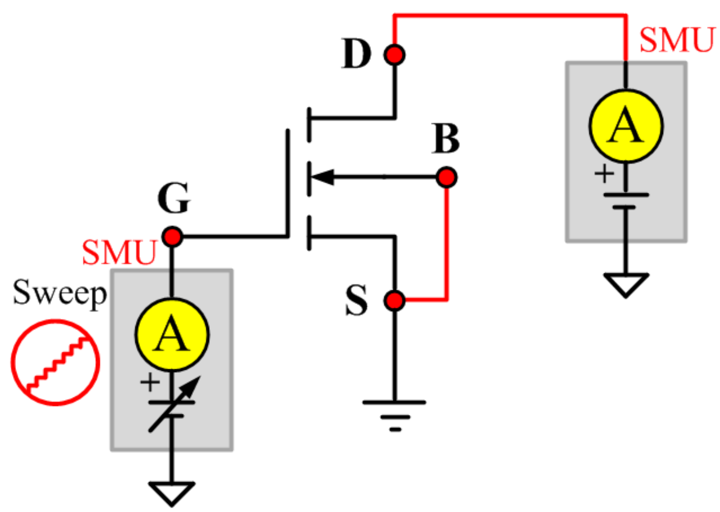
DC bias voltages for `Vth_ex` measurements are `VDS = VDS_lin`, `VBS = VBB` for linear measurement.

`VDS=VDS_sat`, `VBS=VBB` for saturation. Typically, for PMOS, `VDS_lin = -0.1 V(@VDD=5V)`; for NMOS, `VDS_lin=0.1V(@VDD=5V).`

Intended results:

- Measure the Drain current during a Gate voltage sweep
- Extract the trans-conductance (Gm) and measure the maximum trans-conductance (Gmmax)
- Measure the extracted threshold voltage (Vth_ex)
- Measure the Drain current and the Gate voltage curve
- Measure the Gm Drain current or the Gm Gate voltage curve

Figure 107: Four_term_nMOSFET_Vtext pin connection



Vtext ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

Vtext General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Vtext_llsq

Description:

Module Name: Vtext_llsq

Module Type: Standard STM

Instrument: Keithley Instruments Series 2600B SMU

DUT: Four-terminal nMOSFET

Function: Extracts the threshold voltage from the measurement of the slope. In this test, the least-square approximation is used as the result.

Pin connections: Apply a voltage bias to the Drain and sweep the Gate voltage. Input the Source and bulk voltage when needed. Typically, they are connected to ground for NMOS, and connected to the normal power supply voltage (VDD) for PMOS (see next figure).

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

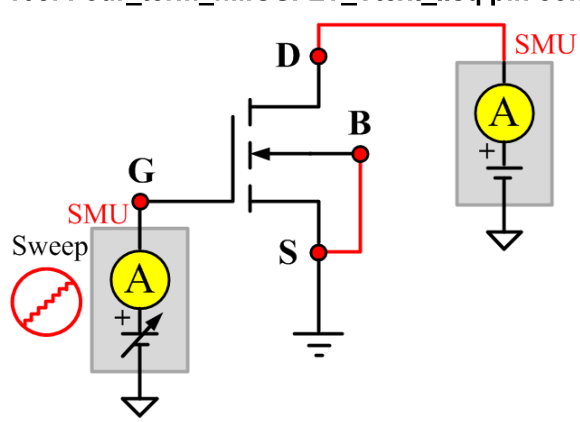
DC bias voltages for `Vth_ex` measurements are `VDS = VDS_lin`, `VBS = VBB` for linear measurement.

`VDS=VDS_sat`,`VBS = VBB` for saturation. Typically, for PMOS, `VDS_lin = -0.1 V(@VDD = 5V)`; for NMOS,`VDS_lin = 0.1V(@VDD = 5V)`.

Intended results:

- Measure the Drain current at the Gate voltage sweep
- Extract the trans-conductance (Gm) and extract the maximum trans-conductance (Gmmax)
- Measure the extracted threshold voltage (Vth_ex)
- Measure the Drain current and the Gate voltage curve
- Measure the Gm Drain current or the Gm Gate voltage curve

Figure 108: Four_term_nMOSFET_Vtext_llsq pin connection



nMOSFET WLR script library overview

The WLR script components are located in the following directory:
C:\ACS\library\devLibrary\nMOSFET\WLR_script\tsp\HCI

nMOSFET WLR script library command

nMOSFET HCI

Description:

Pin connection: A four-terminal nMOSFET is considered in this test. Source and bulk could be connected to ground manually and two to four SMUs are needed. The test consists of a TEST and a STRESS.

The stress time setting: linear/logarithmic/input-array is supported according to a different time mode determined by the user. Addtionally, the Gate current can also be monitored during stress.

Supported tests:

Threshold voltage 'Vtex' / 'Vtic', maximum conductance 'gm' and linear Drain current 'Id_lin' tests. If start Gate voltage 'Vg_start' is not empty, this test will be performed. If Id_target is not empty, Vtic (Vt extracted by constant current method) will be provided instead of Vtex (Vt extracted by maximum gm method).

Saturate Drain current 'Id_sat' test. If saturate Drain voltage 'Vd_sat' is not empty, measure:
`Id_sat@Vd=Vd_sat, Vg=Vd_sat`.

Drain leakage current 'Id_leak' test. If Drain leakage voltage 'Vd_leak' is not empty, measure:
`Id_leak@Vd=Vd_leak, Vg=Vb`.

Gate leakage current 'Ig_leak' test. If Gate leakage voltage 'Vg_leak' is not nil, measure:
`Ig_leak@Vg=Vg_leak, Vd=Vs`.

NOTE

The test will stop if a parameter exceeds its preset limit, or the period (set by the user) is completed.

Intended outputs:

'Time' --- stress time section

'Vtci', 'Vtex', 'gm', 'Id_lin', 'Id_sat', 'Id_leak', 'Ig_leak'
--- absolute value of measured parameters

'Vtci_shift', 'Vtex_shift', 'gm_shift', 'Id_lin_shift', 'Id_sat_shift', 'Id_leak_shift' and 'Ig_leak_shift'
--- relative shift of measured parameter

'Idi' and 'Vgi' (I = 1,2,3) --- Id_Vg curves

'Ig' and 'Ig_time' --- monitored Gate leakage current and time during stress

Syntax:

HCI(t_mode, t_max, npdec_delta, time_input, SSMU, BSMU, GSMU, DSMU, myNPLC, VSS, S_comp, VBB, B_comp, Id_Vg, Vg_start, Vg_stop, Vg_points, G_comp, Vd_lin, D_comp, Id_target, Vd_sat, Vd_leak, Vg_leak, Abort_shift, Abort_Vt, Abort_Ig, time_interval, Vg_stress, Vd_stress, Vb_stress, G_stress_comp, D_stress_comp).

INPUTS:

`integer t_mode=0 in [0,2]` --0: linear 1: logarithmic 2: take input time array

`integer t_max=1000 in [0,]`	--maximum time for the test. Not in use when t_mode is 2
`integer npdec_delta=3 in [0,]`	--when t_mode is 0 is the time interval; when t_mode is 1 is the number of point --in one decade
	table time_input={0,1,2,5,10} --when t_mode is 2 time array should be input from outside
`instid SSMU=KI_GND`	-- SMU1, SMU2, SMU3,..., SMU64, if KI_GND is chosen, the Source terminal should be connected to GND manually'
`instid BSMU=KI_GND`	-- SMU1, SMU2, SMU3,..., SMU64, if KI_GND is chosen, the bulk terminal should be connected to GND manually'
`instid GSMU=SMU1`	--Gate SMU
`instid DSMU=SMU2`	--Drain SMU
`double myNPLC=0.001 in [0.001,25]`	-- set PLC value
`double VSS=0`	--voltage applied on Source if not connected to GND
`double S_comp=0.1 in [0,]`	--compliance on Source during test and stress (Unit:A)
`double VBB=0`	--voltage applied on substrate if not connected to GND
`double B_comp=0.1 in [0,]`	--compliance on Source during test and stress (Unit:A)
`integer Id_Vg=0 in [0,1]`	--1: Id_Vg curve will be outputted 0: the curve will not be outputted
`double Vg_start=0`	--if 'nil', no Vth output. Start voltage for sweep on Gate (Unit:V)
`double Vg_stop=1.5`	--stop voltage for sweep on Gate (Unit:V)
`integer Vg_points=101 in [0,]`	--number of points of sweep
`double G_comp=0.1 in [0,]`	--compliance on Gate during test (Unit:A)
`double Vd_lin=0.1`	--Drain voltage in linear district (Unit:V)
`double D_comp=0.1 in [0,]`	--compliance on Drain during test (Unit:A)
`double Id_target=1e-4`	--if not nil, Vtci will be calculated and outputted instead of Vtex
	--Enter positive value for NMOS and negative value for PMOS
`double Vd_sat=1.5`	--nil: not measure Id_sat double: measure Id_sat (Unit:V)
`double Vd_leak=1.5`	--nil: not measure Id_leak double: measure Id_leak under given Vd_leak (Unit:V)
`double Vg_leak=1`	--nil: not measure Ig_leak double: measure Ig_leak under given Vg_leak (Unit:V)
`double Abort_shift=10 in [0,]`	--when relative shift of parameters ((value[now] - value[fresh])/value[fresh]) reaches this value, abort (Vt does not use this criteria)
`double Abort_Vt=0.05 in [0,]`	--when absolute shift of Vt (value[now] - value[fresh]) reaches this value, abort --(Unit:V)
`integer Abort_Ig=1000 in [0,]`	--nil: not monitor on Gate current during stress Integer: when --Ig[now]>=Ig[fresh]*Abort_Ig, abort

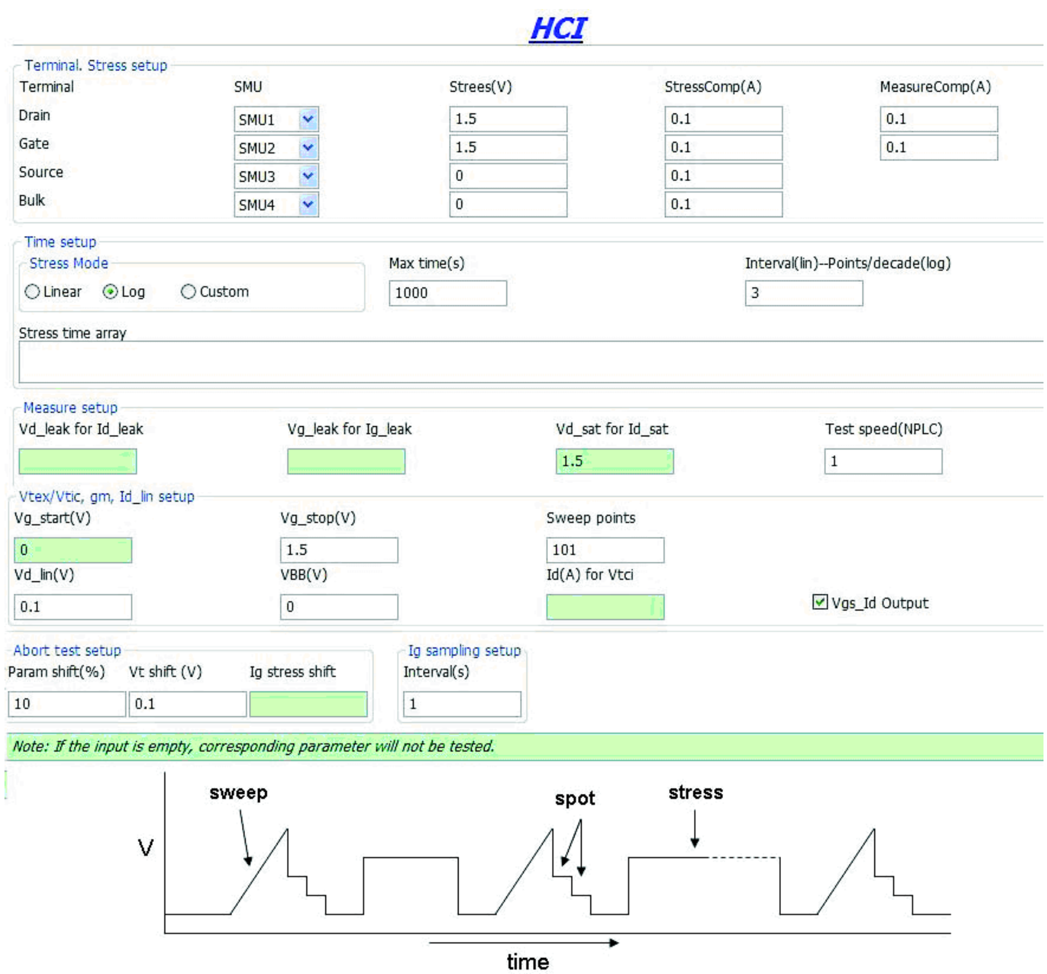
`double time_interval=1e-3 in [0,]`	--time interval between sampling of Ig if Ig is to be monitored during stress (Unit:s)
`double Vg_stress=3`	--stress voltage on Gate (Unit:V)
`double Vd_stress=3.5`	--stress voltage on Drain (Unit:V)
`double Vb_stress=0`	--stress voltage on bulk (Unit:V)
`double G_stress_comp=0.1 in [0,]`	--current limit on Gate during stress (Unit:A)
`double D_stress_comp=0.1 in [0,]`	--current limit on Drain during stress (Unit:A)

GUI related:

The next figure shows the GUI for HCI testing. If the Test Script Processor (TSP™) file imported has a corresponding .xrc GUI file, ACS Basic automatically loads and opens the GUI.

Refer to Configure an XRC STM and Configure a standard STM in the ACS Basic Reference manual for more information on importing .xrc files.

Figure 109: GUI for HCI



HCI GUI descriptions

Terminal Stress: Set the SMUs arranged to each terminal, voltage applied and corresponding compliances during STRESS and TEST. If Source and/or bulk are set to KI_GND, they should be connected to ground manually.

Time: Set the STRESS time. If Linear or Log is selected, the Stress time array edit box can be left blank. If Custom is selected, the time array must be entered into the Stress time array edit box.

Measure: Several tests can be performed. If any green items are empty, the corresponding test will not be performed.

NOTE

If the Vg_start edit box is completed, but the Id(A) for Vtci edit box is empty, the threshold voltage (Vth) will be extracted through the method of maximum gm. If the Id(A) for Vtci edit box is also completed, the Vth will be extracted through the method of constant current instead.

Abort test: Set parameters controlling the procedure of the test. If the Ig stress shift edit box is completed, the Gate current Ig will be monitored during stress and if Ig[now] >= 'Ig stress shift'*Ig[fresh] the test ends.

Example call:

```
local VBB=0
local npdec_delta=4
local Abort_shift=50
local Vd_sat=nil
local B_comp=0.1
local t_max=20
local D_comp=0.1
local Vg_stop=1.4
local DSMU=SMU1
local t_mode=1
local time_input=nil
local G_stress_comp=0.1
local Id_Vg=1
local Vd_stress=0.5
local myNPLC=0.001
local time_interval=1
local D_stress_comp=0.1
local BSMU=KI_GND
local SSMU=KI_GND
local Vg_start=nil
local Vd_leak=2
local Vg_points=141
local Vd_lin=0.1
local Id_target=nil
local Abort_Ig=1000
local Vb_stress=0
local G_comp=0.1
local Vg_leak=2
local S_comp=0.1
local Abort_Vt=0.1
local VSS=0
local GSMU=SMU2
local Vg_stress=0.5
HCI(t_mode, t_max, npdec_delta, time_input, SSMU, BSMU, GSMU, DSMU, myNPLC, VSS,
   S_comp, VBB, B_comp, Id_Vg, Vg_start, Vg_stop, Vg_points, G_comp, Vd_lin,
   D_comp, Id_target, Vd_sat, Vd_leak, Vg_leak, Abort_shift, Abort_Vt, Abort_Ig,
   time_interval, Vg_stress, Vd_stress, Vb_stress, G_stress_comp, D_stress_comp)
```

nPowerMOSFET library

nPowerMOSFET overview

The nPowerMOSFET library components are located in the following directory:
\\ACS_BASIC\library\dev_library\nPowerMOSFET

The nPowerMOSFET parametric library is used to test some parameters of a n-type power MOSFET, including leakage, breakdown, gain, on-state and characteristic curves.

nPowerMOSFET parametric library

BVDSS

Description:

Module Name: BVDSS

Module Type: ITM

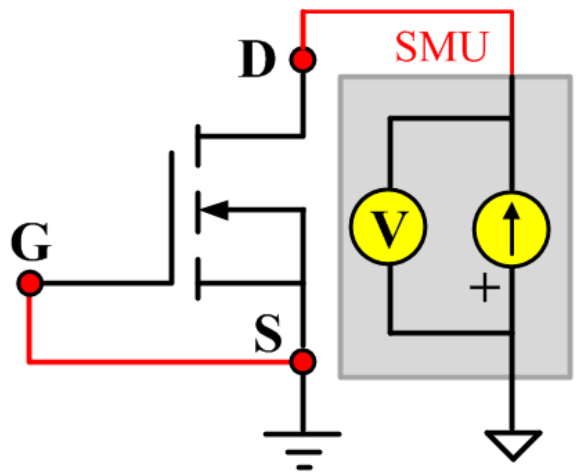
Instrument: KI2657A

DUT: Three-terminal nPowerMOSFET

Function: Determines the breakdown voltage from the Drain to Source. Measures voltage on the Drain-Source by applying a breakdown current to the Drain and Gate that is shorted to the Source.

Pin Connection: One or two SMUs are used. The Model 2657A instrument applies current and takes voltage measurements at the Drain. The Gate and Source are connected to ground or have no voltage bias from the other SMU.

Figure 110: nPowerMOSFET_BVDSS pin connection



GFS

Description:

Module Name: GFS

Module Type: ITM

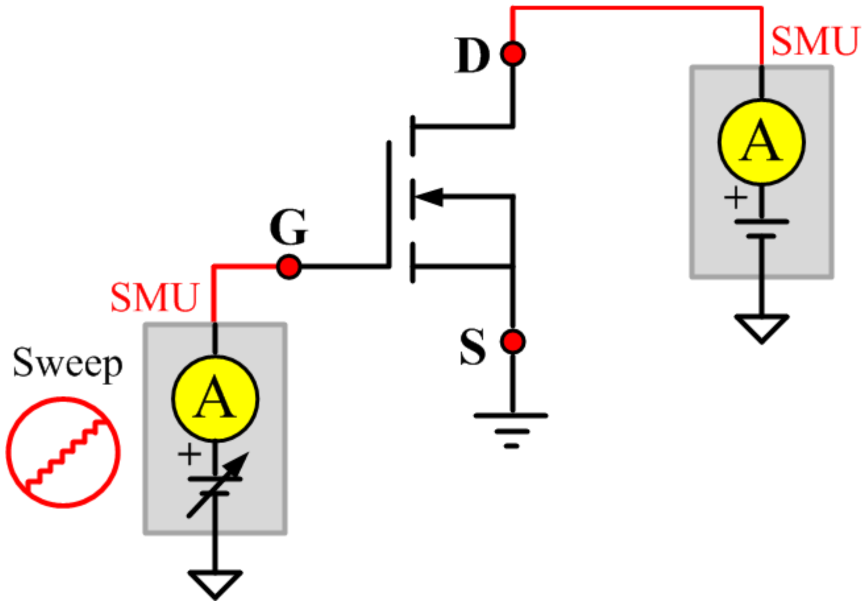
Instrument: KI2651A, KI2600B

DUT: Three-terminal nPowerMOSFET

Function: Determines 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 Connection: Two SMUs are used. The Model 2651A SMU applies voltage and takes current measurements at the Drain. The other SMU sweeps voltage at the Gate.

Figure 111: nPowerMOSFET GFS pin connection



IdON

Description:

Module Name: IdON

Module Type: ITM

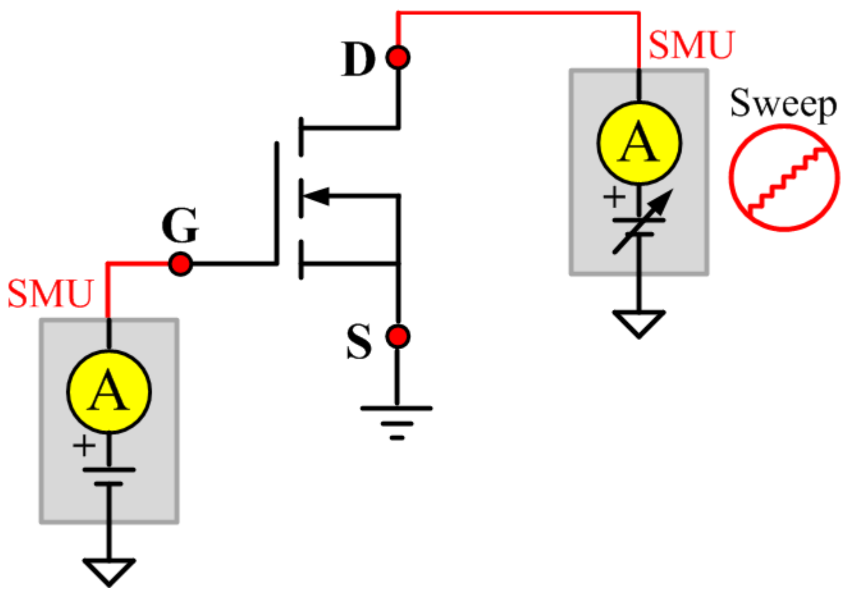
Instrument: KI2651A, KI2600B

DUT: Three-terminal nPowerMOSFET

Function: Determines 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 data sheet.

Pin Connection: Two SMUs are used. The Model 2651A SMU applies a voltage sweep and takes current measurements at the Drain. The other SMU sources a specific voltage at the Gate.

Figure 112: nPowerMOSFET IdON pin connection



IDSS

Description:

Module Name: IDSS

Module Type: ITM

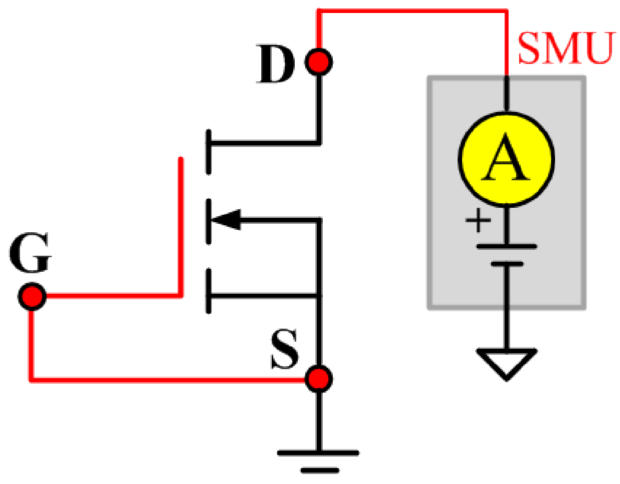
Instrument: KI2657A

DUT: Three-terminal nPowerMOSFET

Function: Determines 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 Connection: One or two SMUs are used. The Model 2657A SMU applies voltage and takes current measurements at the Drain. The Gate and Source are connected to ground, or has no voltage bias from the other SMU.

Figure 113: nPowerMOSFET IDSS pin connection



IdVd_StepVg

Description:

Module Name: IdVd_StepVg

Module Type: ITM

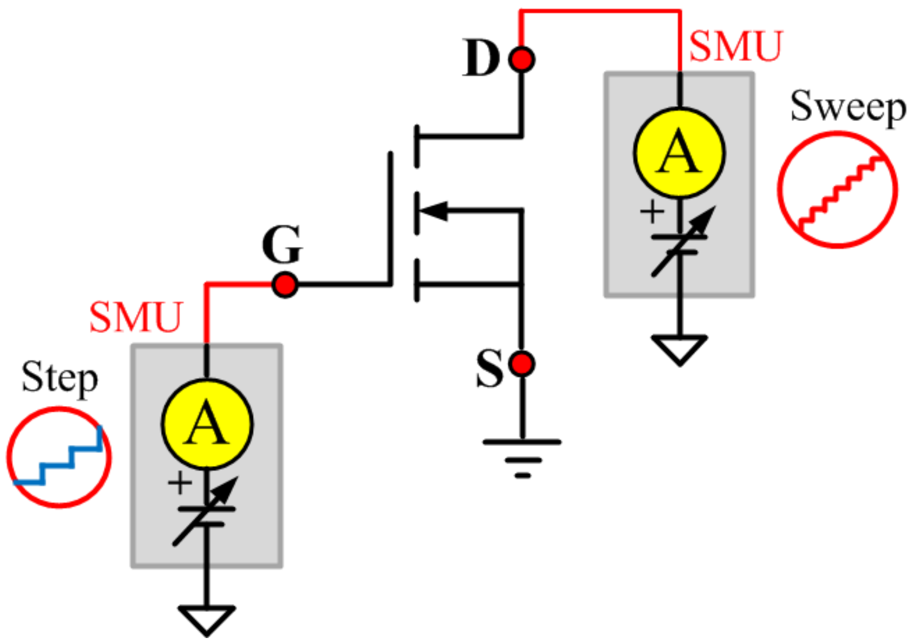
Instrument: KI2651A, KI2600B

DUT: Three-terminal nPowerMOSFET

Function: Generates 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 Connection: Two SMUs are used. The Model 2651A SMU applies a voltage sweep and takes current measurements at the Drain. The other SMU sources a specific voltage at the Gate.

Figure 114: nPowerMOSFET IdVd_StepVg pin connection



IdVg_StepVd

Description:

Module Name: IdVg_StepVd

Module Type: ITM

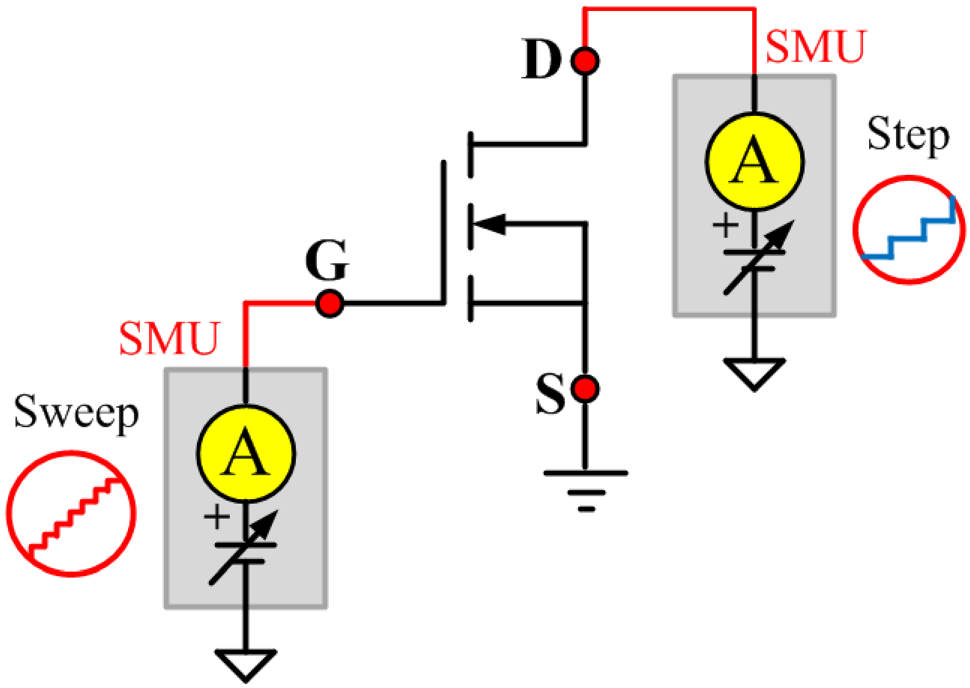
Instrument: KI2651A, KI2600B

DUT: Three-terminal nPowerMOSFET

Function: Tests the transfer characteristic of the nPowerMOSFET. 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 Connection: Two SMUs are used. The Model 2651A SMU applies a voltage step and takes current measurements at the Drain. The other SMU sweeps voltage at the Gate.

Figure 115: nPowerMOSFET IdVg_StepVd pin connection



IGSSF

Description:

Module Name: IGSSF

Module Type: ITM

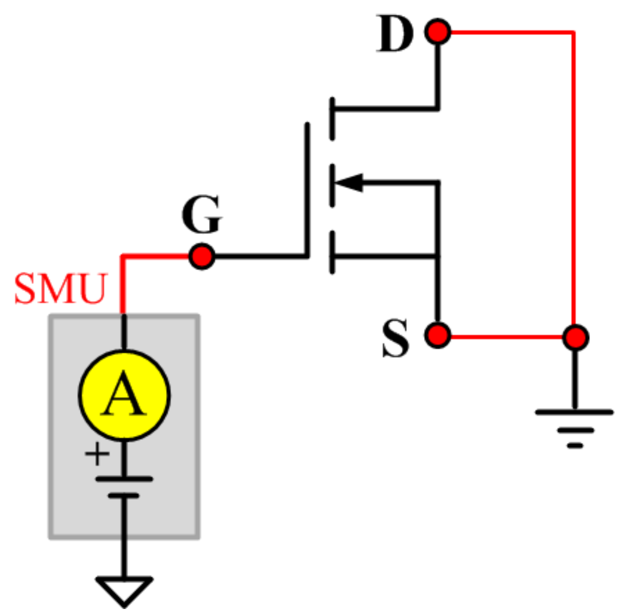
Instrument: KI2651A, KI2600B

DUT: Three-terminal nPowerMOSFET

Function: Determines the Gate forward leakage current. Measures the current on the Gate at the maximum permissible positive voltage from the Gate to the Source.

Pin Connection: 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.

Figure 116: nPowerMOSFET IGSSF pin connection



IGSSR

Description:

Module Name: IGSSR

Module Type: ITM

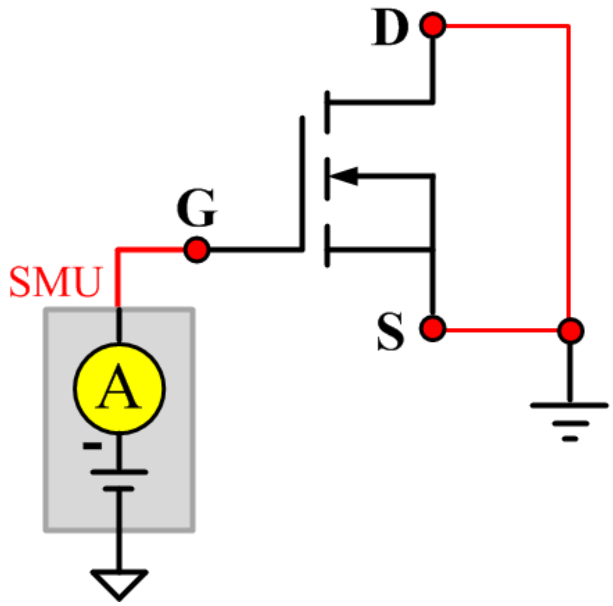
Instrument: KI2651A, KI2600B

DUT: Three-terminal nPowerMOSFET

Function: Determines the Gate body reversed leakage current. Measures current on the Gate at the maximum permissible negative voltage from Gate to Source.

Pin Connection: One or two SMUs are used. One SMU applies voltage and takes current measurements at the Gate. The Drain and Source are set to ground, or have no voltage bias from the other SMU.

Figure 117: nPowerMOSFET IGSSR pin connection



RdsON

Description:

Module Name: RdsON

Module Type: ITM

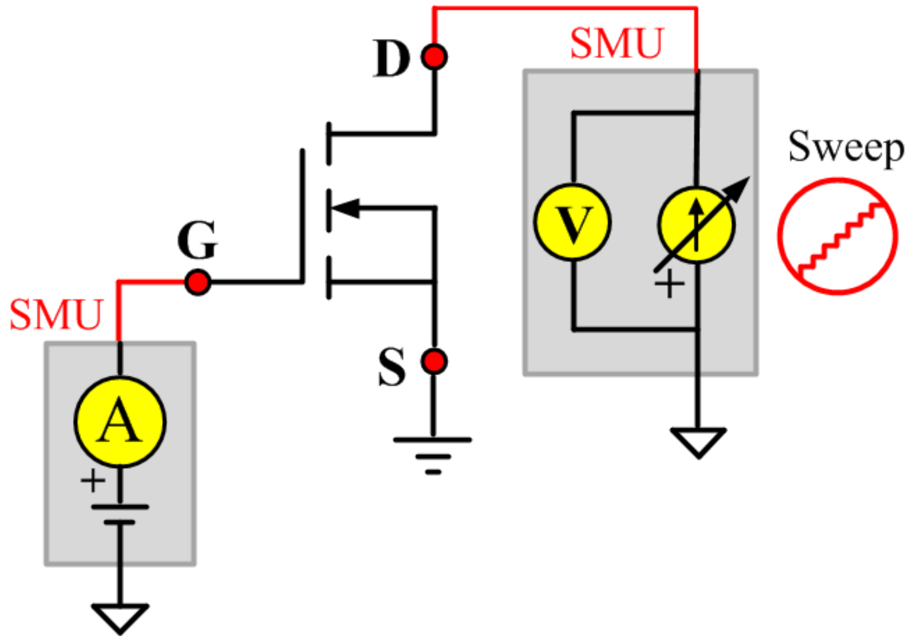
Instrument: KI2651A, KI2600B

DUT: Three-terminal nPowerMOSFET

Function: Determines 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 Connection: Two SMUs are used. The Model 2651A SMU applies a current sweep and takes voltage measurements at the Drain. The other SMU sources a specific voltage at the Gate.

Figure 118: nPowerMOSFET RdsON pin connection



VdsON

Description:

Module Name: VdsON

Module Type: ITM

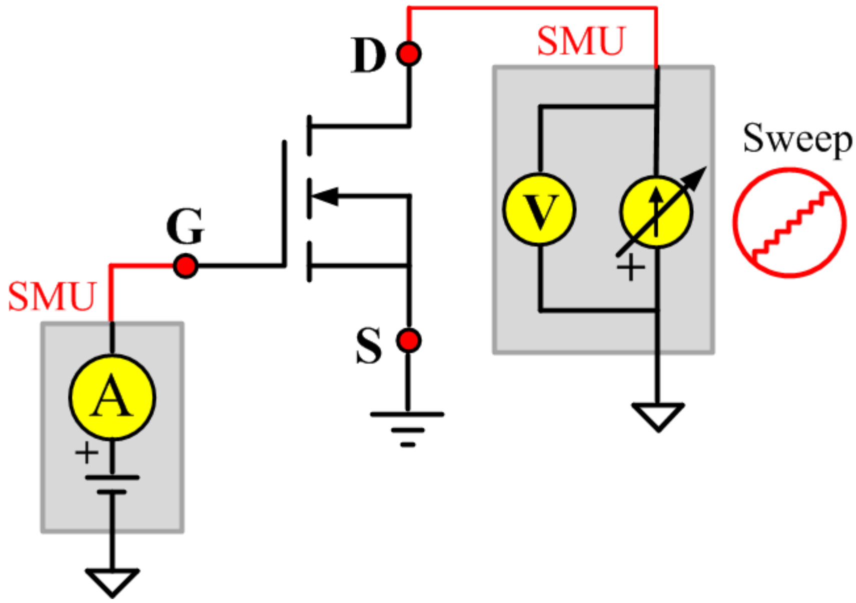
Instrument: KI2651A, KI2600B

DUT: Three-terminal nPowerMOSFET

Function: Determines the Drain to Source on-state voltage. Measures voltage on Drain-Source by applying a current sweep to the Drain with a specific Gate voltage to turn on the device to a certain resistance value.

Pin Connection: Two SMUs are used. The Model 2651A SMU applies a current sweep and takes voltage measurements at the Drain. The other SMU sources a specific voltage at the Gate.

Figure 119: nPowerMOSFET VdsON pin connection



VgsON

Description:

Module Name: VgsON

Module Type: ITM

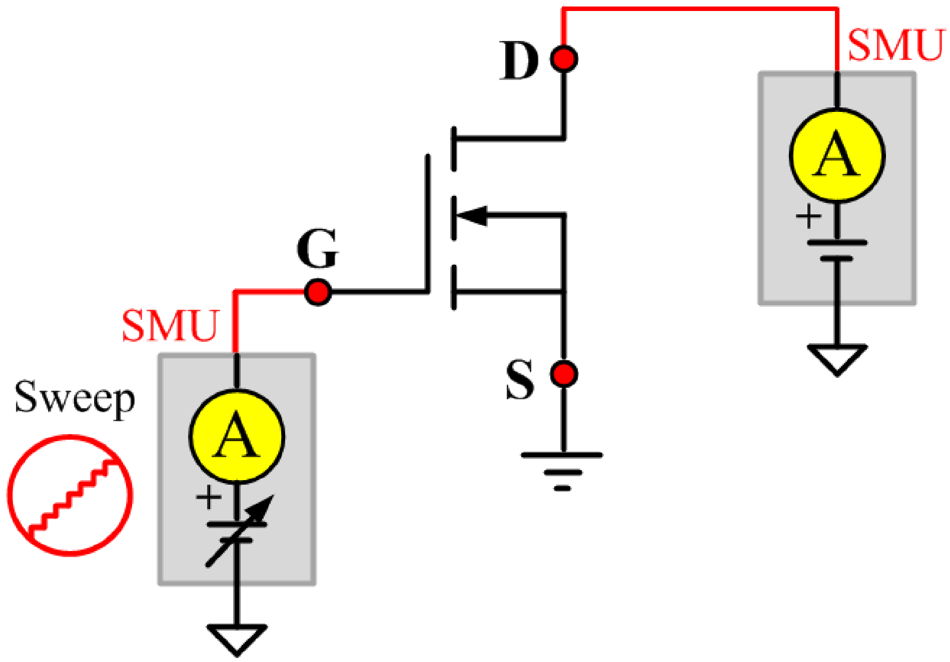
Instrument: KI2651A, KI2600B

DUT: Three-terminal nPowerMOSFET

Function: Determines 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 Connection: Two SMUs are used. The Model 2651A SMU applies voltage and takes current measurements at the Drain. The other SMU sweeps voltage at the Gate.

Figure 120: nPowerMOSFET VgsON pin connection



VGSTH

Description:

Module Name: VGSTH

Module Type: ITM

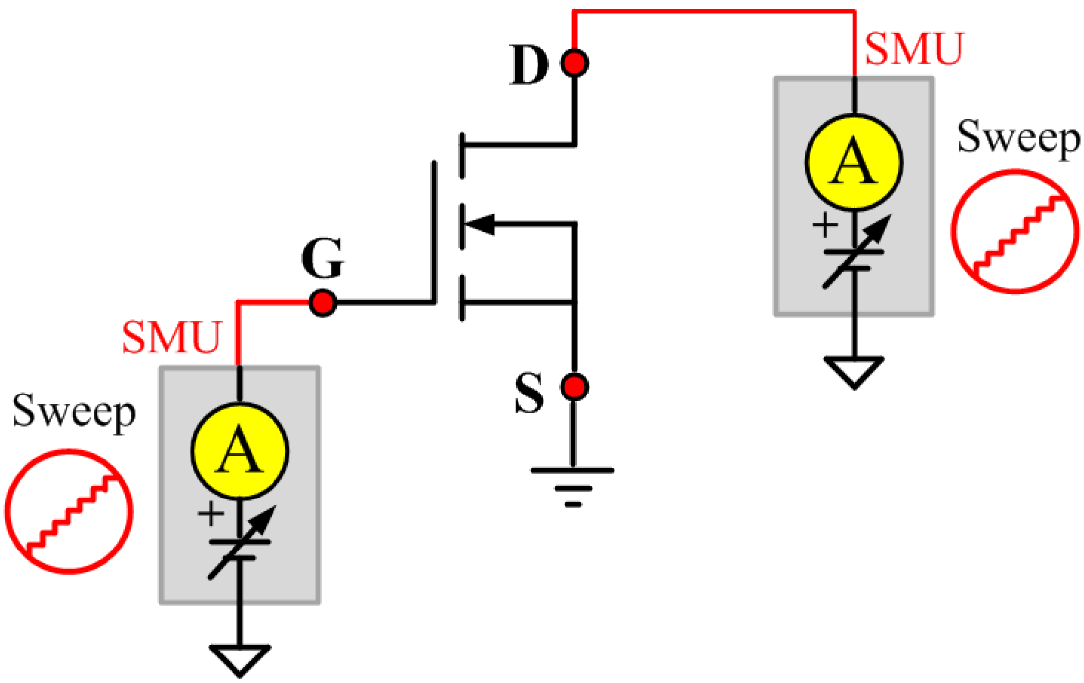
Instrument: KI2651A, KI2600B

DUT: Three-terminal nPowerMOSFET

Function: Determines the threshold voltage from the Gate to Source which is required to turn on the device at a specific Id current value that is given in the data sheet.

Pin Connection: Two SMUs are used. The Model 2651A SMU sweeps voltage and takes current measurements at the Drain. The other SMU sweeps voltage at the Gate.

Figure 121: nPowerMOSFET VGSTH pin connection



VSD

Description:

Module Name: VSD

Module Type: ITM

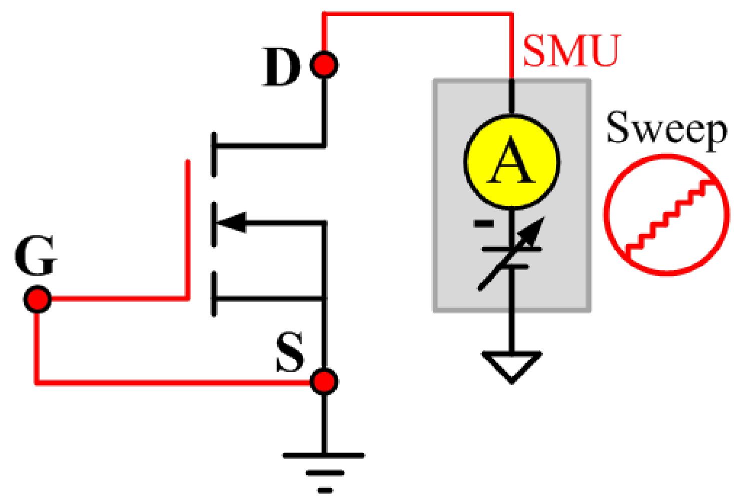
Instrument: KI2651A, KI2600B

DUT: Three-terminal nPowerMOSFET

Function: Determines 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 Connection: One or two SMUs are used. The Model 2651A applies a voltage sweep and takes current measurements at the Drain. The Gate and Source are connected to ground, or has no voltage bias from the other SMU.

Figure 122: nPowerMOSFET VSD pin connection



IdON_MIX

Description:

Module Name: IdON_MIX

Module Type: PTM

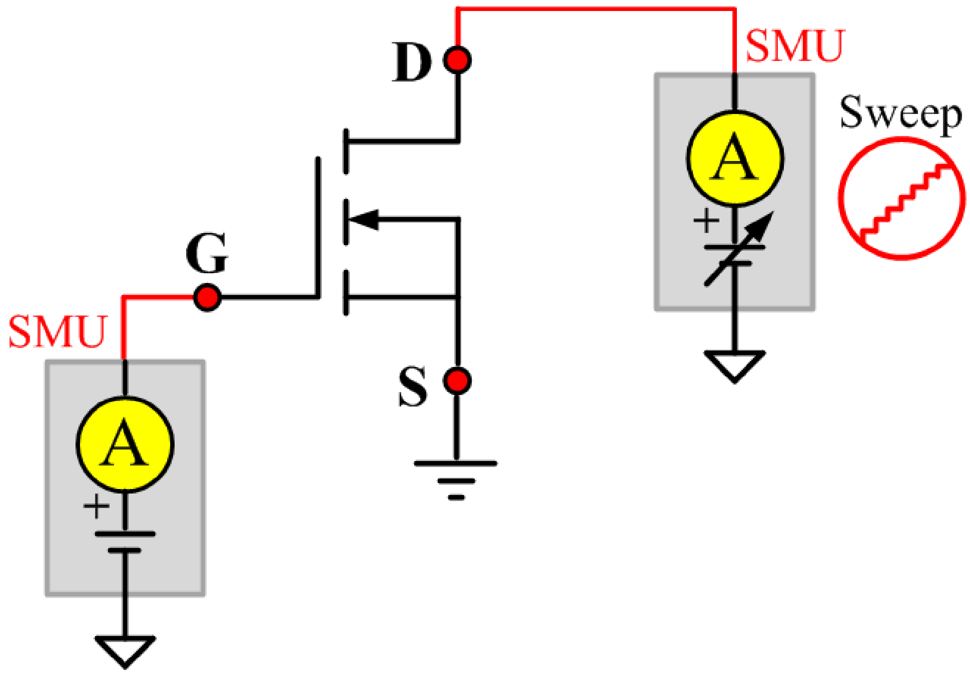
Instrument: KI2651A, KI2600B, KI24XX, KI42XX-SMU

DUT: Three-terminal nPowerMOSFET

Function: Determines 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 Connection: Two SMUs are used. The Model 2651A SMU applies a voltage sweep and takes current measurements at the Drain. The other SMU sources a specific voltage at the Gate.

Figure 123: nPowerMOSFET IdON_MIX pin connection



IdVd_StepVg_MIX

Description:

Module Name: IdVd_StepVg_MIX

Module Type: PTM

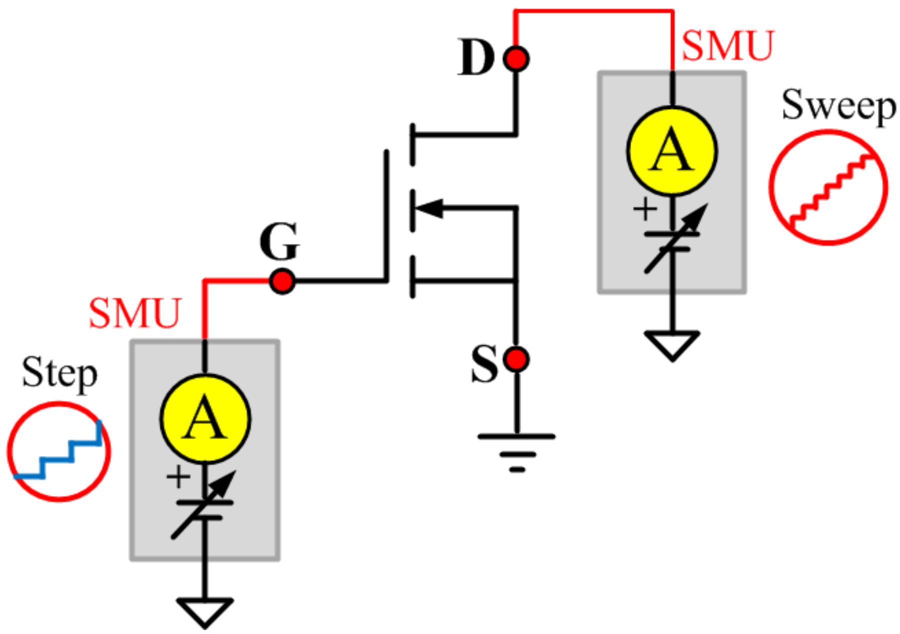
Instrument: KI2651A, KI2600B, KI24XX, KI42XX-SMU

DUT: Three-terminal nPowerMOSFET

Function: Generates 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 Connection: Two SMUs are used. The Model 2651A SMU applies a voltage sweep and takes current measurements at the Drain. The other SMU sources a step voltage at the Gate.

Figure 124: nPowerMOSFET IdVd_StepVg_MIX pin connection



RdsON_MIX

Description:

Module Name: RdsON

Module Type: PTM

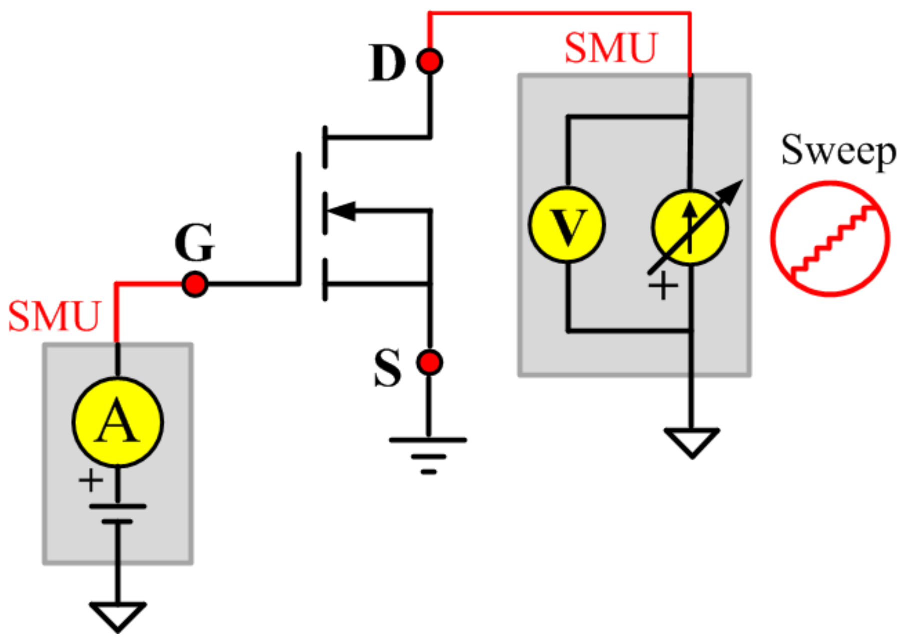
Instrument: KI2651A, KI2600B, KI24XX, KI42XX-SMU

DUT: Three-terminal nPowerMOSFET

Function: Determines 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 Connection: Two SMUs are used. The Model 2651A SMU applies a current sweep and takes voltage measurements at the Drain. The other SMU sources a specific voltage at the Gate.

Figure 125: nPowerMOSFET RdsON_MIX pin connection



VgsON_MIX

Description:

Module Name: VgsON

Module Type: PTM

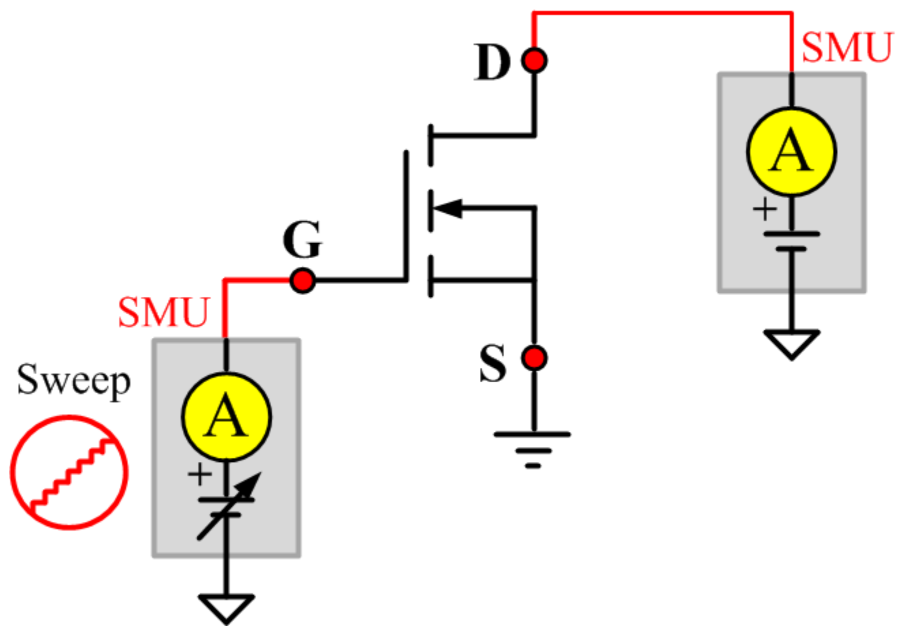
Instrument: KI2651A, KI2600B, KI24XX, KI42XX-SMU

DUT: Three-terminal nPowerMOSFET

Function: Determines 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 Connection: Two SMUs are used. The Model 2651A SMU applies voltage and takes current measurements at the Drain. The other SMU sweeps voltage at the Gate.

Figure 126: nPowerMOSFET VgsON_MIX pin connection



pMOSFET library

pMOSFET overview

The pMOSFET library components are located in the following directory:
\\ACS_BASIC\library\dev_library\pMOSFET

The pMOSFET parametric library is used to test parameters of a p-type power MOSFET, including leakage, breakdown, gain, on-state and characteristic curves.

pMOSFET parametric library

BVDSS

Description:

Module Name: BVDSS

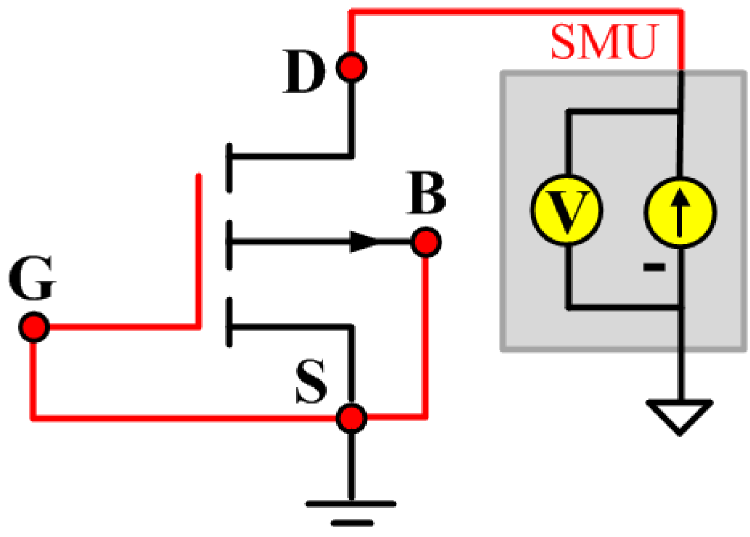
DUT: Four-terminal pMOSFET

Function: Tests the Drain-Source breakdown voltage of the pMOSFET with the Gate-Source shorted.

Pin connections: Apply a breakdown current on the Drain. Connect the bulk to ground, or force the voltage to zero. Connect the Gate and Source to ground, or force the voltage to zero (see next figure).

Intended results: Measure the breakdown voltage between the Drain and Source with the Gate-Source shorted.

Figure 127: Four_term_pMOSFET_BVDSS pin connection



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

Description:

Module Name: BVDSV

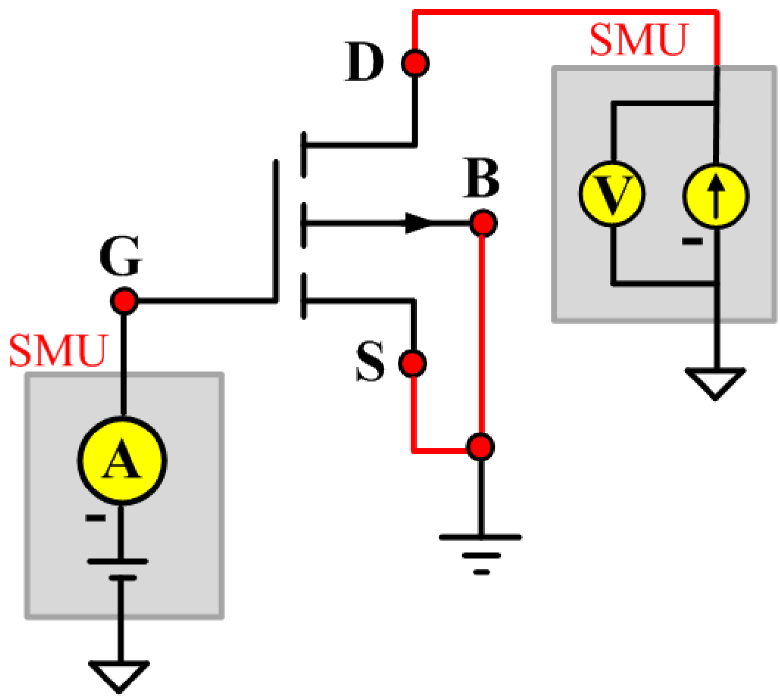
DUT: Four-terminal pMOSFET

Function: Tests the Drain-Source breakdown voltage of the pMOSFET with the Gate biased.

Pin connections: Connect the Source and bulk to ground and apply a voltage bias to the Gate. Apply a breakdown current on the Drain (see next figure).

Intended results: Measure the breakdown voltage between the Drain and Source with the Gate biased.

Figure 128: Four_term_pMOSFET_BVDSV pin connection



BVDSV ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

BVDSV General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVGSO

Description:

Module Name: BVGSO

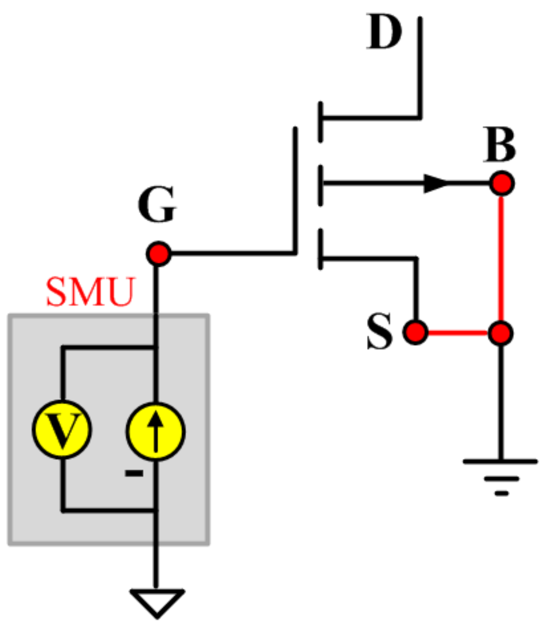
DUT: Four-terminal pMOSFET

Function: Tests the Gate-Source breakdown voltage of the pMOSFET with the Drain opened.

Pin connections: Open the Drain and connect the bulk and Source to ground. Apply a breakdown current on the Gate (see next figure).

Intended results: Measure the breakdown voltage between the Gate and Source with the Drain opened.

Figure 129: Four_term_pMOSFET_BVGSO pin connection



BVGSO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

BVGSO General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVGDS

Description:

Module Name: BVGDS

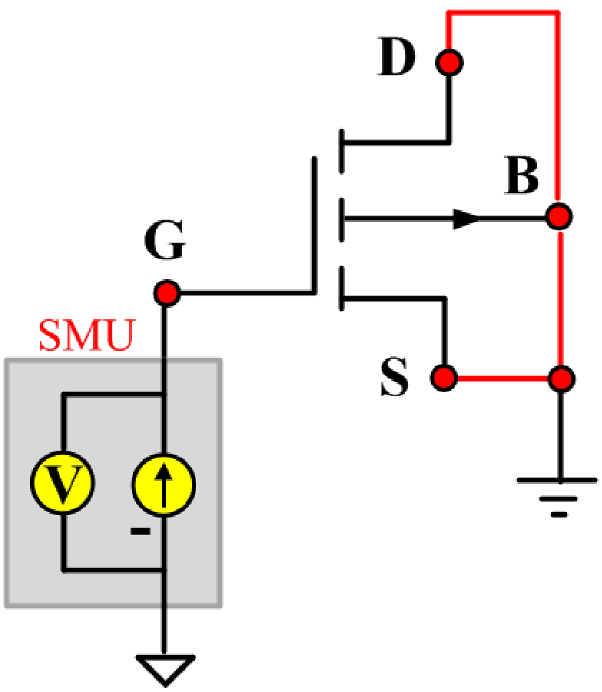
DUT: Four-terminal pMOSFET

Function: Tests the Gate-Drain breakdown voltage of the pMOSFET with the Source-Drain shorted.

Pin connections: Connect the Source and Drain to ground. Apply a breakdown current on the Gate (see next figure).

Intended results: Measure the breakdown voltage between the Gate and Drain with the Source-Drain shorted.

Figure 130: Four_term_pMOSFET_BVGDS pin connection



BVGDS ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

BVGDS General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVGDO

Description:

Module Name: BVGDO

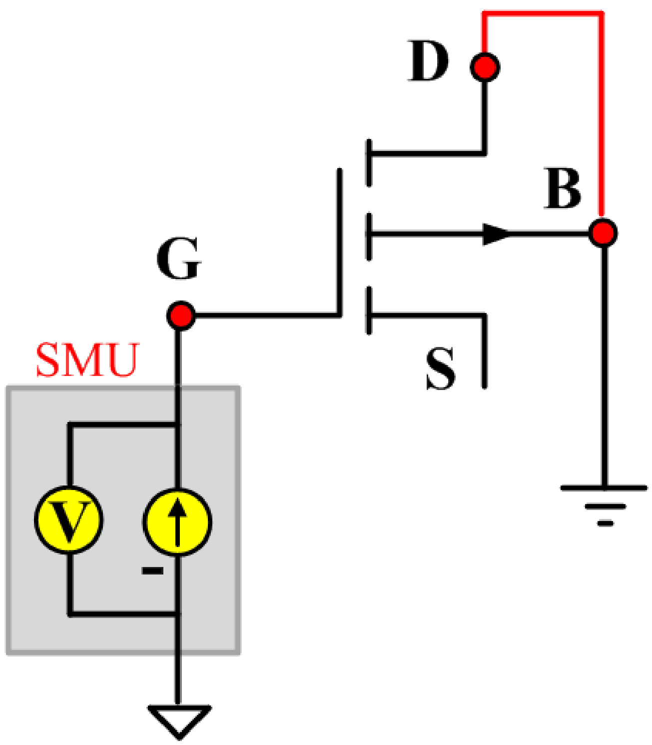
DUT: Four-terminal pMOSFET

Function: Tests the Gate-Drain breakdown voltage of the pMOSFET with the Source opened.

Pin connections: Open the Source and connect the bulk and Drain to ground. Apply a breakdown current on Gate (see next figure).

Intended results: Measure the breakdown voltage between the Gate and the Drain when Source is open.

Figure 131: Four_term_pMOSFET_BVGDO pin connection



BVGDO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

BVGDO General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IDL

Description:

Module Name: IDL

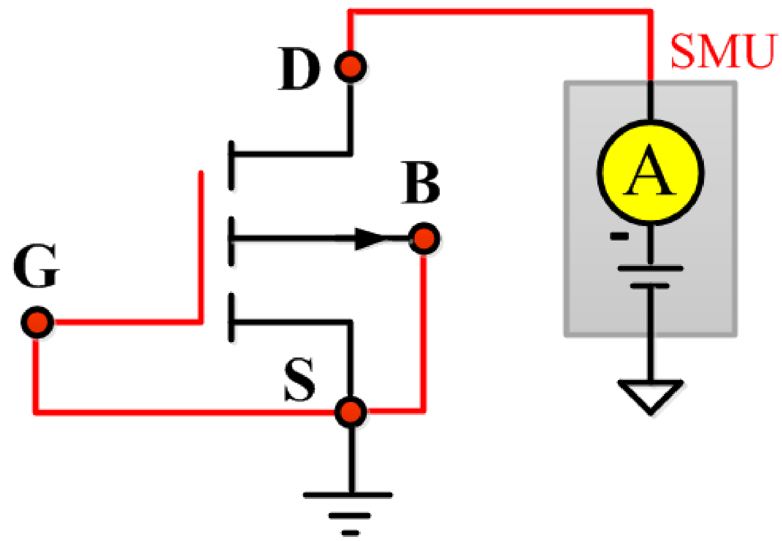
DUT: Four-terminal pMOSFET

Function: Measures the Drain leakage current with the Gate-Source shorted.

Pin connections: Short the Gate and Source and apply a voltage on the Drain. Connect the bulk, Gate, and Source to ground (see next figure).

Intended results: Measure the Drain leakage current with the Gate-Source shorted.

Figure 132: Four_term_pMOSFET_IDL pin connection



IDL ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IDL General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IDS

Description:

Module Name: IDS

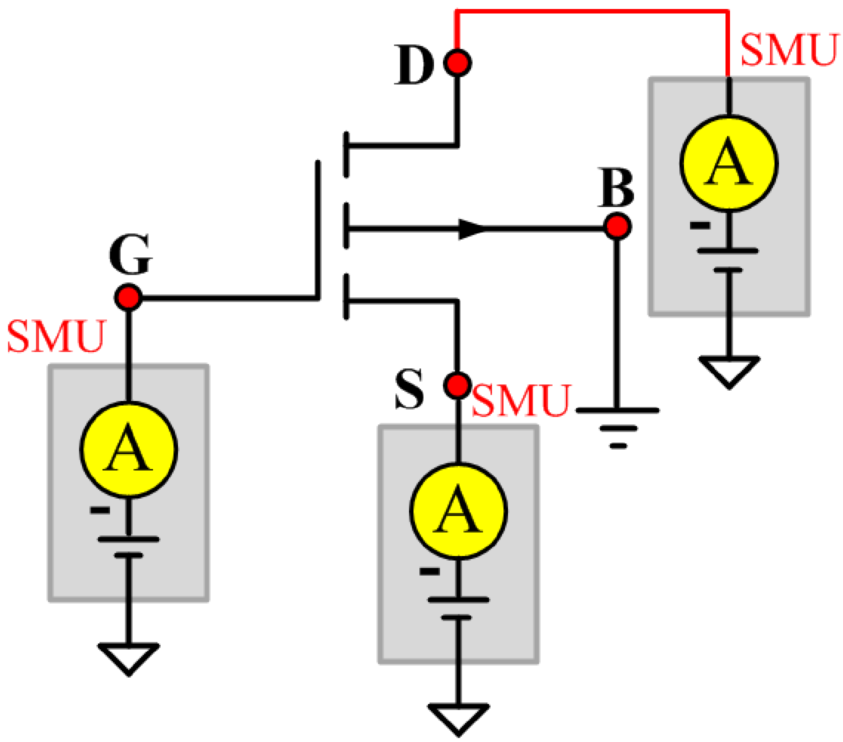
DUT: Four-terminal pMOSFET

Function: Measures the Drain-Source and Source-Drain current with the Gate biased.

Pin connections: Apply a separate voltage to the Gate, Source, and Drain. The bulk is typically connected to ground, but can be set to a desired bias voltage (see next figure).

Intended results: Measure the Drain-Source and Source-Drain current with the Gate biased.

Figure 133: Four_term_pMOSFET_IDS pin connection



IDS ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IDS General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVd_BiasVg

Description:

Module Name: IdVd_BiasVg

DUT: Four-terminal pMOSFET

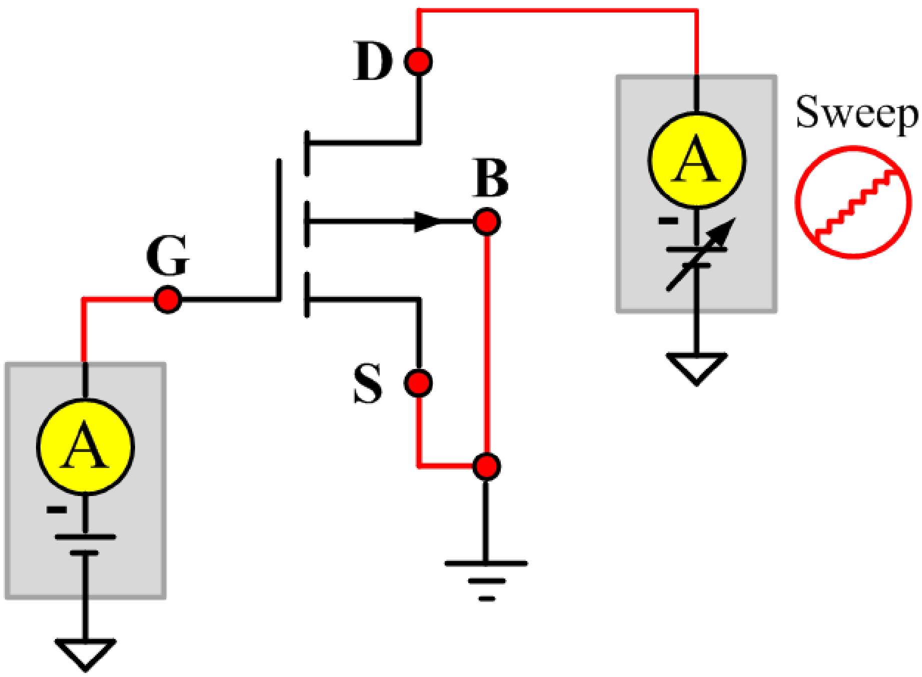
Function: Tests the Drain current during a specified Drain voltage sweep.

Pin connections: Apply a voltage bias to the Gate and sweep the Drain. Connect the bulk and Source to ground, if voltage is not applied (see next figure).

Intended results:

- Measure the Drain current at a specified Drain voltage sweep
- Measure the Drain current and Drain voltage curve

Figure 134: Four_term_pMOSFET_IdVd_BiasVg pin connection



IdVd_BiasVg ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IdVd_BiasVg_General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVd_StepVg

Description:

Module Name: IdVd_StepVg

DUT: Four-terminal pMOSFET

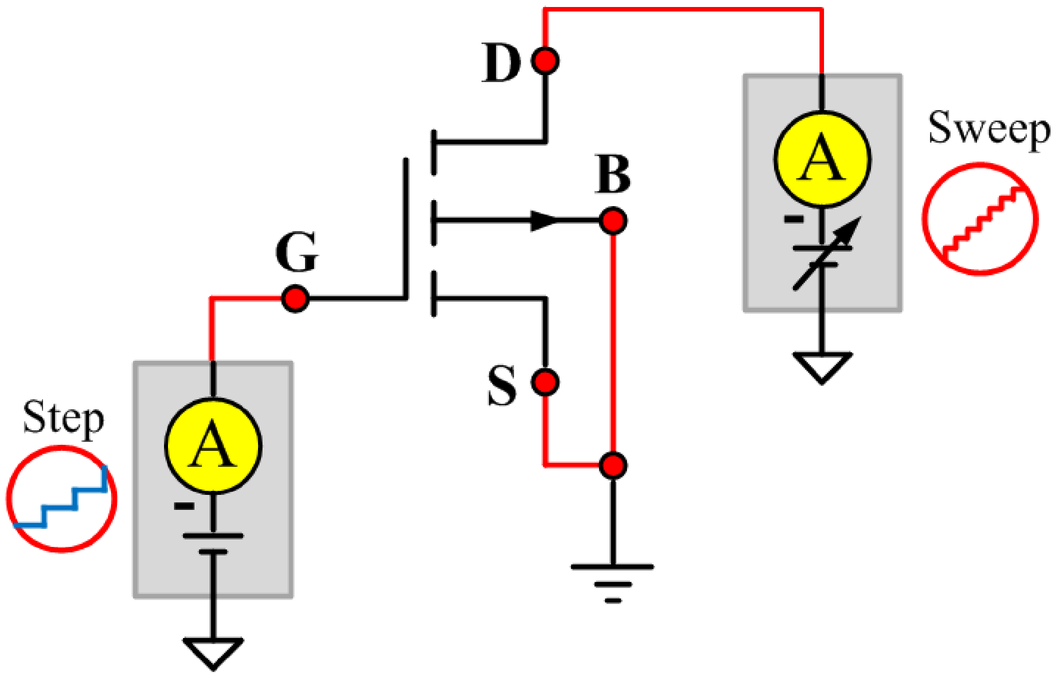
Function: Tests a series of IdVd curves for the four-terminal pMOSFET which performs on the Series 2600B instruments.

Pin connections: Sweep the Drain and step the Gate. Connect the bulk and Source to ground, if voltage is not applied (see next figure).

Intended results:

- Measure the Drain current during a specified Drain voltage sweep
- Measure a series of Drain currents and the Drain voltage curve (see next figure)

Figure 135: Four_term_pMOSFET_IdVd_StepVg pin connection



IdVd_StepVg ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IdVd_StepVg General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVg_BiasVd

Description:

Module Name: IdVg_BiasVd

DUT: Four-terminal pMOSFET

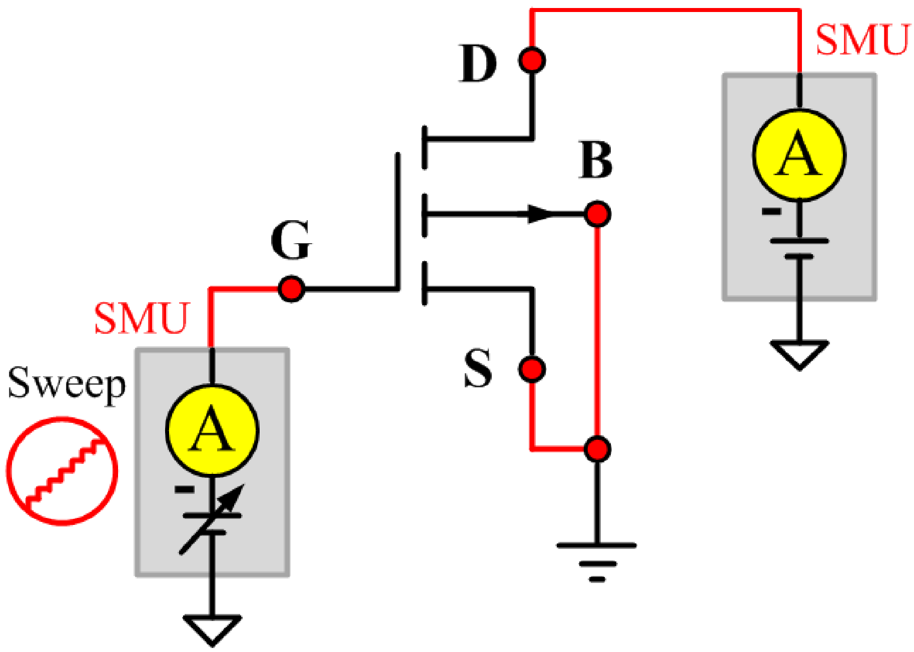
Function: Tests the Drain current during a specified Gate voltage sweep.

Pin connections: Apply a voltage bias to the Drain, and sweep the Gate. Connect the bulk and Source to ground, if voltage is not applied (see next figure).

Intended results:

- Measure the Drain current value at the Gate voltage sweep
- Measure the Drain current value and the Gate voltage curve

Figure 136: Four_term_pMOSFET_IdVg_BiasVd pin connection



IdVg_BiasVd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IdVg_BiasVd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVg_StepVd

Description:

Module Name: IdVg_StepVd

DUT: Four-terminal pMOSFET

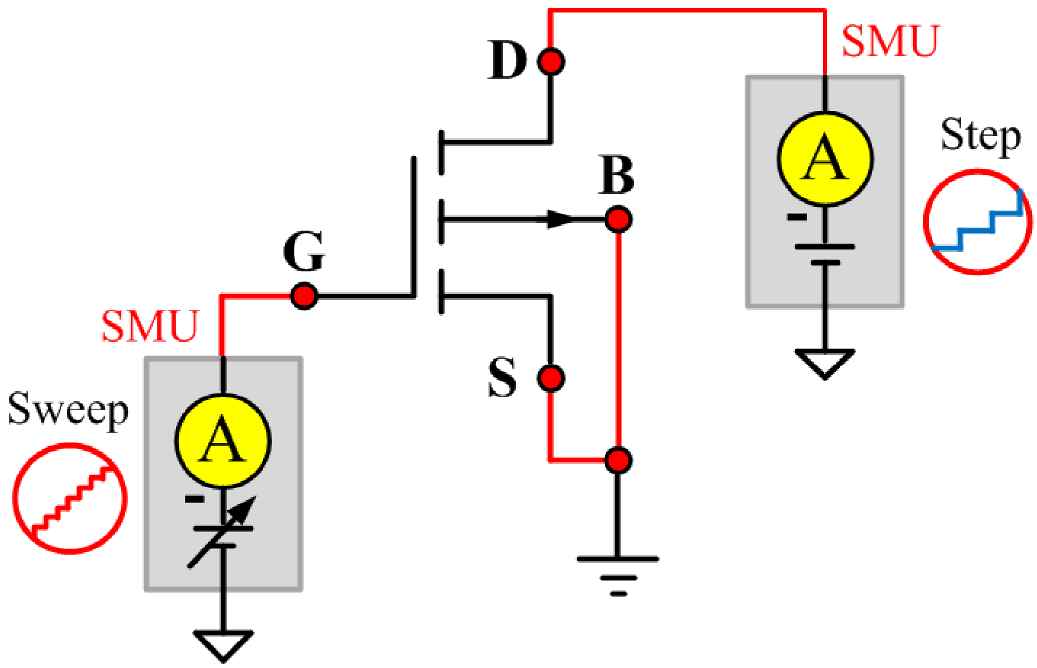
Function: Tests the Drain current at a specified Gate voltage sweep with a Drain step.

Pin connections: Step the Drain and sweep the Gate. Connect the bulk and Source to ground, if voltage is not applied (see next figure).

Intended results:

- Measure the Drain current at the Gate voltage sweep
- Measure the series of Drain currents and Gate voltage curve

Figure 137: Four_term_pMOSFET_IdVg_StepVd pin connection



IdVg_StepVd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IdVg_StepVd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IGL

Description:

Module Name: IGL

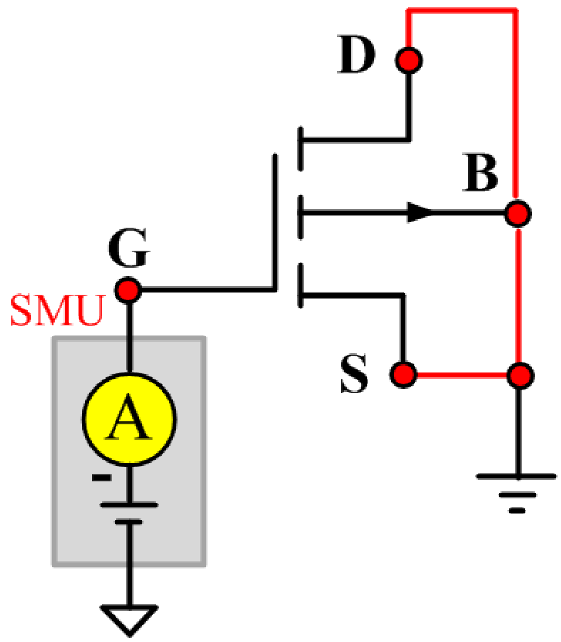
DUT: Four-terminal pMOSFET

Function: Measures the Gate leakage current with a Source-Drain short.

Pin connections: Apply a voltage to the Gate. Connect the Source, Drain, and bulk to ground.

Intended results: Measure the Gate leakage current when the Source and Drain are shorted (see next figure).

Figure 138: Four_term_pMOSFET_IGL pin connection



IGL ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IGL General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IgVg

Description:

Module Name: IgVg

DUT: Four-terminal pMOSFET

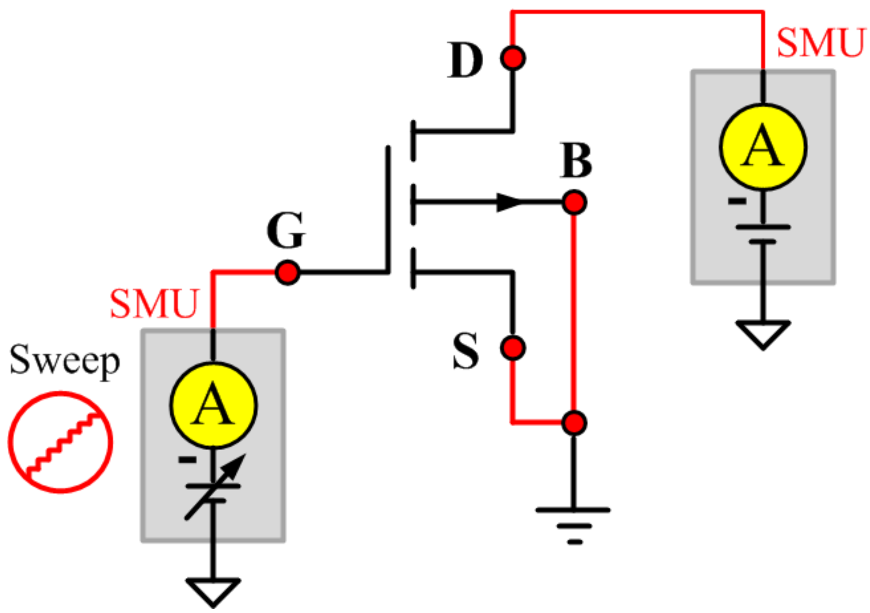
Function: Tests the Gate current at a specified Gate voltage sweep when the Drain is biased.

Pin connections: Apply a voltage bias to the Drain and sweep the Gate. Connect the bulk and Source to ground, or force the voltage to zero (see next figure).

Intended results:

- Measure the Gate current at the Gate voltage sweep
- Measure the Gate current and Gate voltage curve

Figure 139: Four_term_pMOSFET_IgVg pin connection



IgVg ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IgVg General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

ISL

Description:

Module Name: ISL

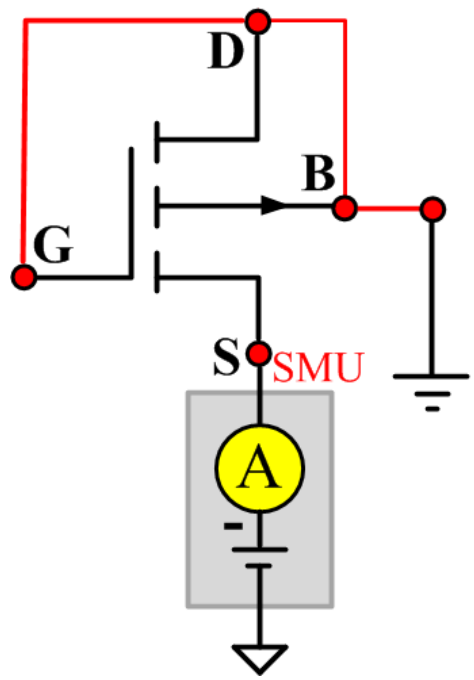
DUT: Four-terminal pMOSFET

Function: Measures the Source leakage current when the Gate-Drain is shorted.

Pin connections: Apply a voltage to the Source. Connect the bulk, Gate, and Drain to ground (see next figure).

Intended results: Measure the Source leakage current when the Gate-Drain is shorted.

Figure 140: Four_term_pMOSFET_ISL pin connection



ISL ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

ISL General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IsubVg

Description:

Module Name: IsubVg

DUT: Four-terminal pMOSFET

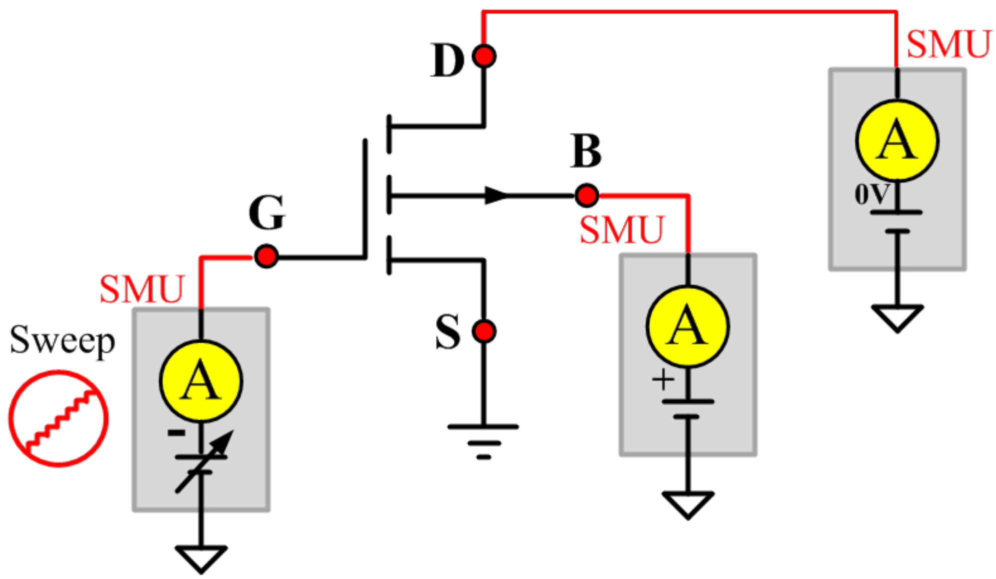
Function: Tests the bulk current at a specified Gate voltage sweep.

Pin connections: Apply a voltage bias to the Drain and bulk, and sweep the Gate. Connect the Source to ground, if voltage is not applied (see next figure).

Intended results:

- Measure the bulk current at the Gate voltage sweep
- Measure the bulk current and the Gate voltage curve
- Measure the maximum bulk current and the corresponding Gate voltage

Figure 141: Four_term_pMOSFET_IsubVg pin connection



IsubVg ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

IsubVg General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Figure -: Four_term_pMOSFET _IsubVg General PTM Setting

Vtci

Description:

Module Name: Vtci

DUT: Four-terminal pMOSFET

Function: Determines the constant current threshold voltage of the pMOSFET device.

Pin connections: Apply a voltage bias to the Drain and sweep the Gate. The input of the Source and bulk voltages are usually connected to ground for NMOS, and connected to the normal power supply voltage (VDD) for PMOS (see next figure).

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=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.

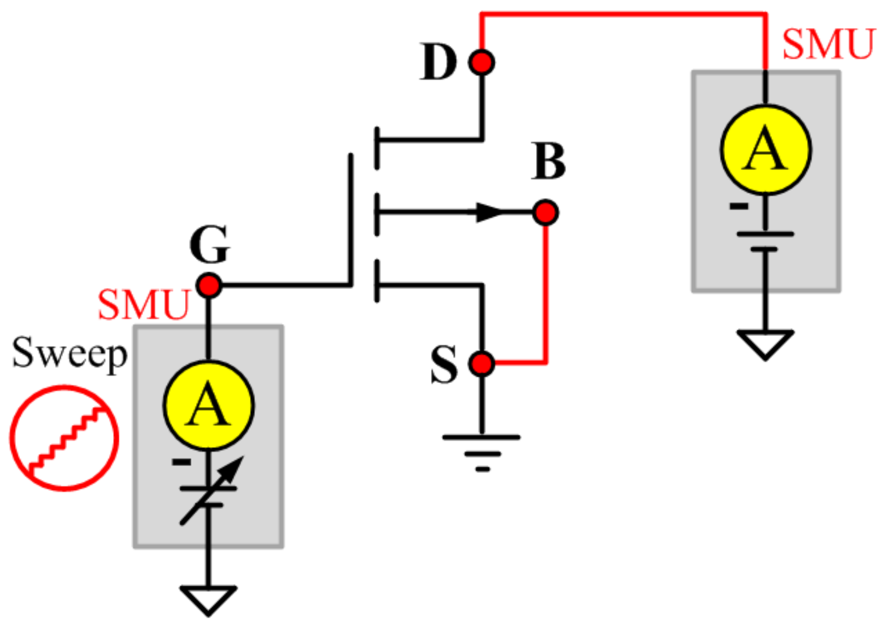
NOTE

The Four_term_pMOSFET_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=5V); for NMOS, VDS_lin=0.1V(@VDD=5V).

Intended results:

- Measure the constant-current threshold voltage
- Measure the Drain current and the Gate voltage curve

Figure 142: Four_term_pMOSFET_Vtci pn connection



Vtci ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

Vtci General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Vtext

Description:

Module Name: Vtext

DUT: Four-terminal pMOSFET

Function: Determines the threshold voltage from measurement of the maximum slope.

Pin connections: Apply a voltage bias to the Drain and sweep the Gate voltage. Input the Source and bulk voltages when needed. Typically, they are connected to ground for NMOS, and connected to the normal power supply voltage (VDD) for PMOS (see next figure).

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
```

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

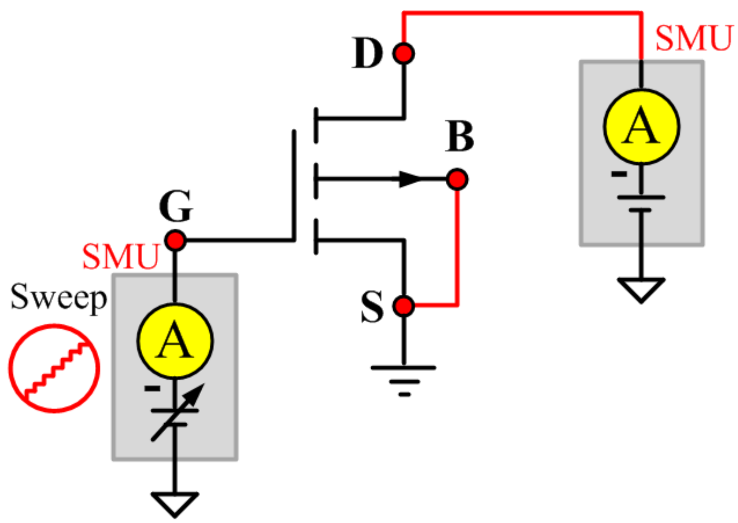
DC bias voltages for the Vth_ex measurements are VDS = VDS_lin, VBS = VBB for linear measurement.

VDS=VDS_sat, VBS=VBB for saturation. Typically, for PMOS, VDS_lin = -0.1 V(@VDD=5V); for NMOS, VDS_lin=0.1V(@VDD=5V).

Intended results:

- Measure the Drain current at the Gate voltage sweep
- Extract the trans-conductance (Gm) and measure the maximum trans-conductance (Gmmax)
- Measure the extracted threshold voltage (Vth_ex)
- Measure the Drain current and the Gate voltage curve
- Measure the Gm and the Drain current or the Gm and the Gate voltage curve

Figure 143: Four_term_pMOSFET_Vtext pin connection



Vtext ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

Vtext General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Vtext_Ilsq

Description:

Module Name: Vtext_Ilsq

DUT: Four-terminal pMOSFET

Function: Extract the threshold voltage from the measurement of the slope. In this test, the least-square approximation is used.

Pin connections: Apply a voltage bias to the Drain and sweep the Gate voltage. Input the Source and bulk voltages when needed. Typically, they are connected to ground for NMOS, and connected to the normal power supply voltage (VDD) for PMOS (see next figure).

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
```

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

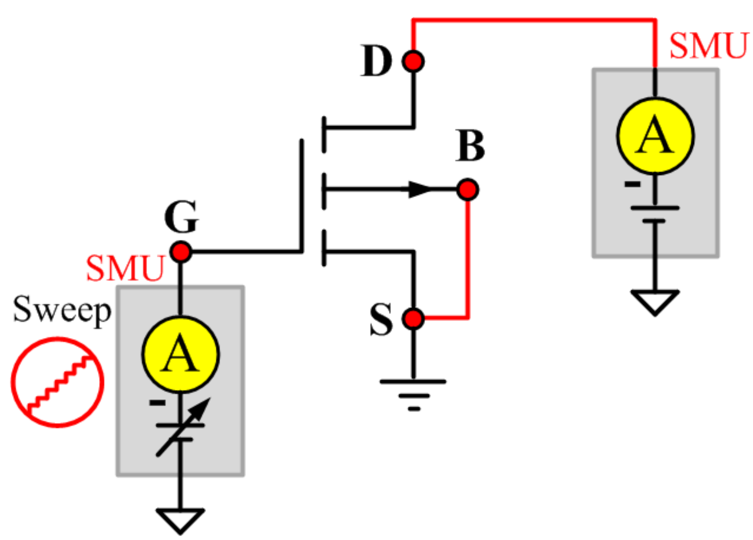
DC bias voltages for the Vth_ex measurements are VDS = VDS_lin, VBS = VBB for linear measurement.

VDS=VDS_sat,VBS = VBB for saturation. Typically, for PMOS, VDS_lin = -0.1 V(@VDD = 5V); for NMOS,VDS_lin = 0.1V(@VDD = 5V).

Intended results:

- Measure the Drain current at the Gate voltage sweep
- Extract the trans-conductance (Gm) and measure the maximum trans-conductance (Gmmax)
- Measure the extracted threshold voltage (Vth_ex)
- Measure the Drain current and the Gate voltage curve
- Measure the Gm and the Drain current or the Gm and the Gate voltage curve

Figure 144: Four_term_pMOSFET_Vtext_Ilsq pin connection



pMOSFET WLR script library overview

The WLR script components are located in the following directory:
C:\ACS\library\devLibrary\pMOSFET\WLR_script

There are four modules for pMOSFET WLR_script Library: HCI, NBTI, NBTI_meas, and NBTI_on_the_fly.

pMOSFET WLR script library

HCI

Description:

The pMOSFET's HCI module is same as the nMOSFET. To set the HCI test module, refer to the nMOSFET HCI topic.

The next figure shows an example setting of the pMOSFET device.

Figure 145: Set the HCI of pMOSFET in WLR_script library

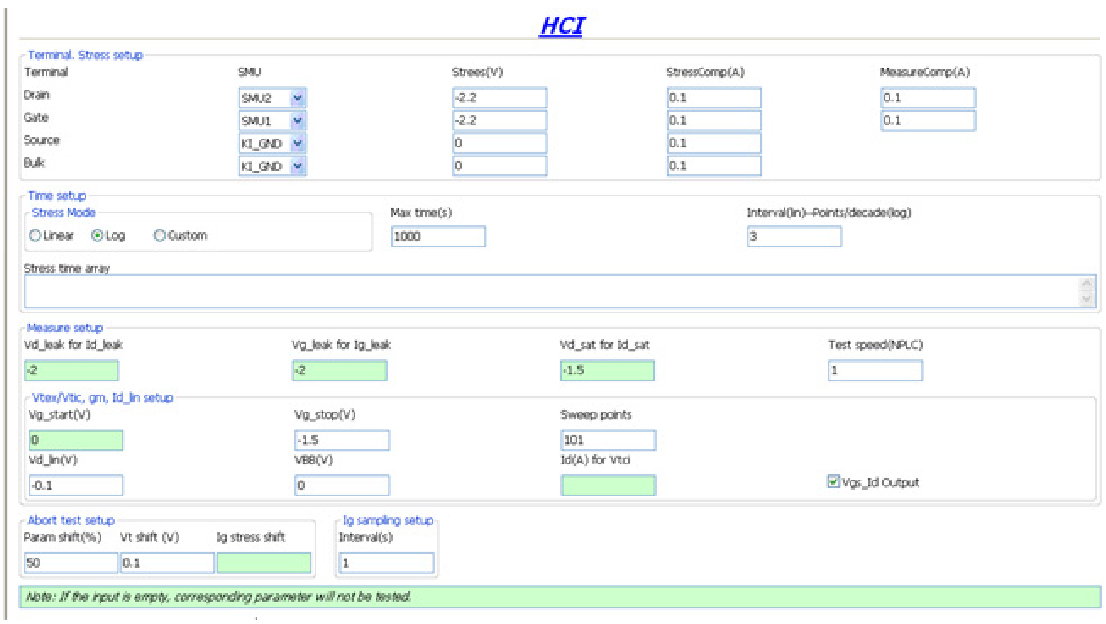


Figure 146: HCI sequence and device connection

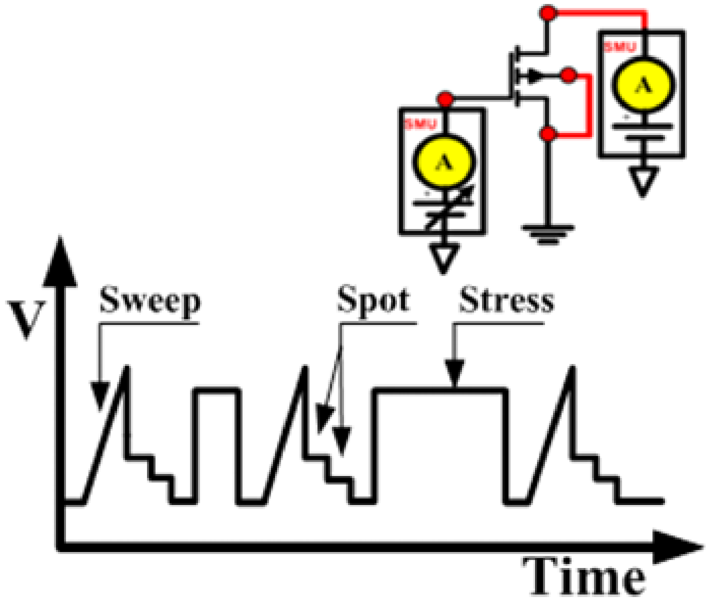
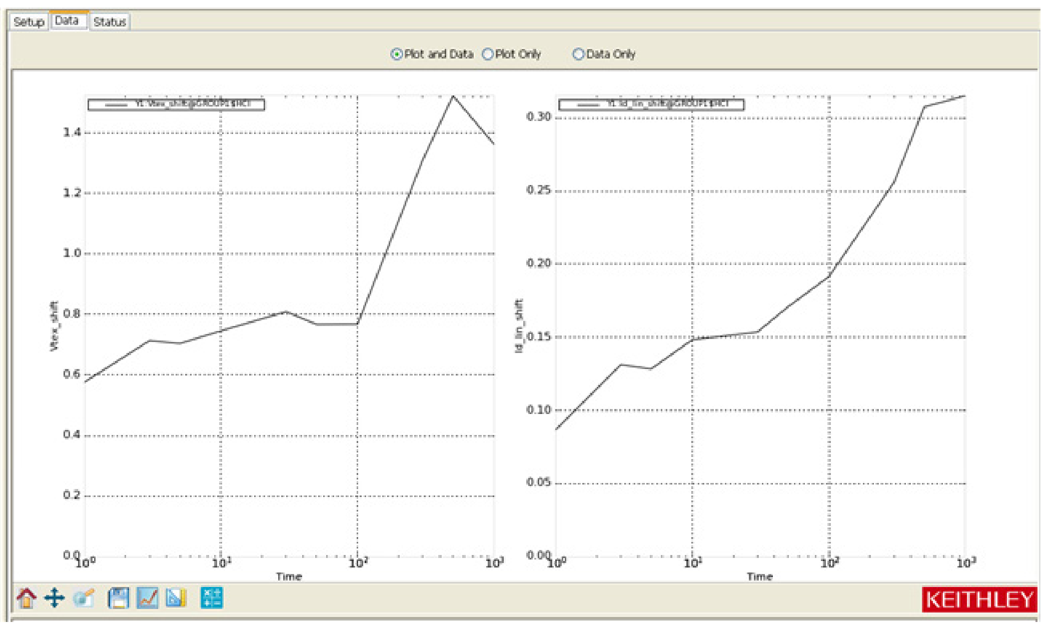


Figure 147: Data tab of HCI of pMOSFET in WLR_script library



NBTI

Description:

This is a script used to perform the NBTI test. It supports two or four SMUs, with Gate to do the STRESS, and Drain to do the measurement. Usually Source and bulk are set to be zero or KI_GND.

Possible outputs: time, id0 (fresh value of Drain current), id (absolute value of Drain current), and id_shift (relative shift of Drain current).

Syntax:

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 vlotage
double vd_meas=-1.2 in [-40,40]        -- Drain measure voltage
double myNPLC=0.001 in [0.001,25]      -- NPLC, 0.001 ~ 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
```

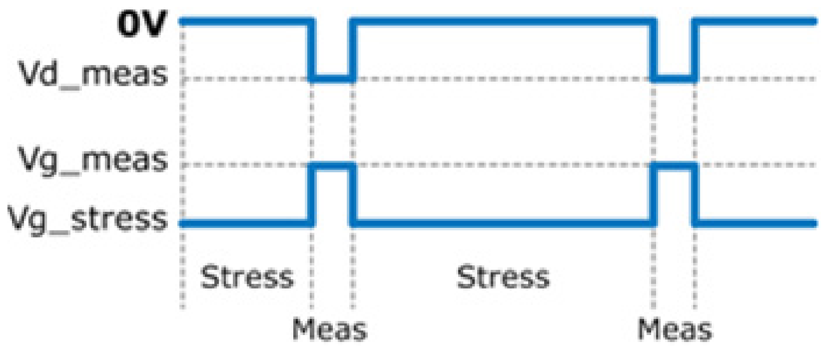
OUTPUTS:

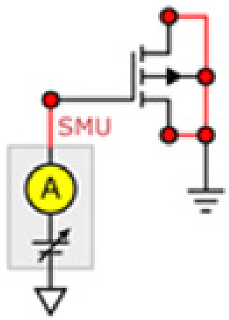
time={} -- time table
did={} -- Drain current shift table

GUI related:

The next figure shows the NBTI GUI and illustrates the testing method. A general description of this GUI is included below.

Figure 148: NBTI sequence and device connection





NBTI GUI descriptions

Terminal: SMUs are assigned to terminals. For Source and bulk, KI_GND could be set (manual connection). Voltage is changeable only on Gate and Drain. Measurement is made on Drain only, and compliance should be set.

Test Speed: The Meas Delay edit box sets the time before each measurement. The Test Speed edit box sets the PLC value. The Average # edit box decides the number of measurements on which average is taken.

Gate/Drain: As shown in the inner plot of the figure, voltages applied on Gate and Drain change when measurement begins and ends. The Gate/Drain checkbox is used to determine which terminal will change first. If the Gate Change First checkbox is selected, the Gate terminal changes first. If the Gate Change First checkbox is left deselected, the Drain terminal changes first.

Stress array: Used to input the time array.

Example call:

```
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)
```

NBTI_meas

Description:

This module performs NBTI test xx, with pre and post Id_Vg testing.

Syntax:

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 of idvg test. "1" meas enable pre/post idvg test, "0" meas disable it.
`integer flag1=1 in [0,1]`	-- flag of NBTI test. "1" means enable NBTI stress-measure test, "0" means disable it.
`integer flag2=1 in [0,1]`	-- flag of Vcti test. "1" meas enable Vcti test, "0" meas disable it.
`double p_Vg_lo=0 in [-40, 40]`	-- start of Gate voltage sweep in pre/post test
`double p_Vg_hi=2 in [-40, 40]`	-- stop of Gate voltage sweep in pre/post test
`double p_Vg_points=21 in [0, 4096]`	-- Gate voltage sweep number of points in pre/post test
`double p_Vds=1 in [-40, 40]`	-- Drain-Source bias in pre/post test
`double p_Drangei=1e-3 in [0, 0.1]`	-- Drain current range in pre/post test
`double p_sweepdelay=0 in [0,]`	-- sweep delay in pre/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,]`	-- wide 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 ~ 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 trian pulses.

`integer t_mode=1 in [0,2]`	-- "0" for time array given by customer; "1" for logrithmic time; "2" for 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,]`	-- means number-of-point-per-decade when t_mode is 1; means delta time when t_mode is 2
`table time_input in [0,]`	-- if t_mode is 0, this array will be taken as 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 sampling.

Outputs:

`error`	-- working condition flag
`Vg_pre`	-- Gate voltage of pre test
`Id_pre`	-- Drain current of pre test
`Vg_pos`	-- Gate voltage of post test
`Id_pos`	-- Drain current of post test
`Vtci`	-- Gate voltage at target Drain current
`Idini`	-- initial current of Drain
`Idend`	-- current of Drain after stress sequence
`time`	-- time table
`Id1`	-- Drain current table
`Id2`	
`Id3`	
`Id4`	
`Id5`	
`Id6`	
`Id7`	
`Id8`	
`Id9`	
`Id10`	
`Id11`	
`Id12`	
`Id13`	
`Id14`	
`Id15`	
`Id16`	
`Id17`	
`Id18`	
`Id19`	

`Id20`

GUI related:

The next figure shows the NBTI_meas test GUI and illustrates the testing method. A general description of this GUI is included below.

Figure 149: NBTI_meas sequence and device connection

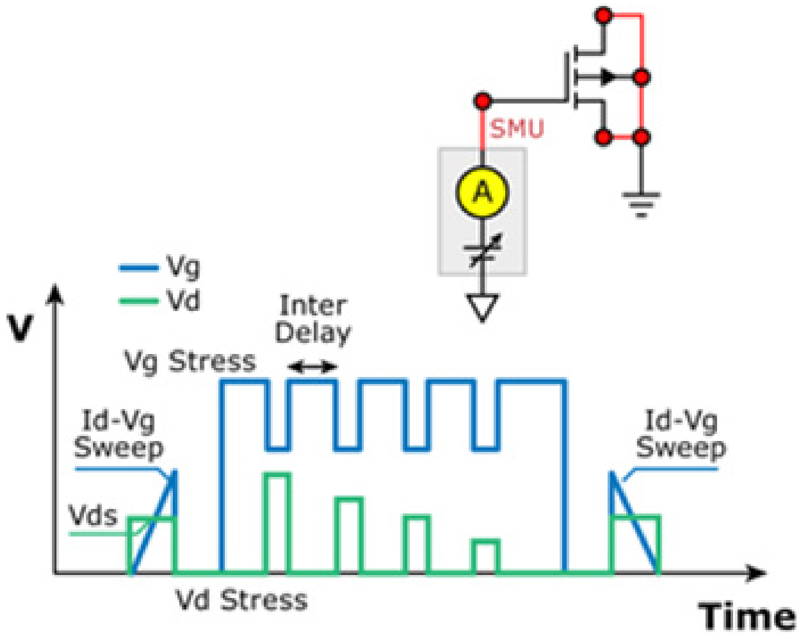
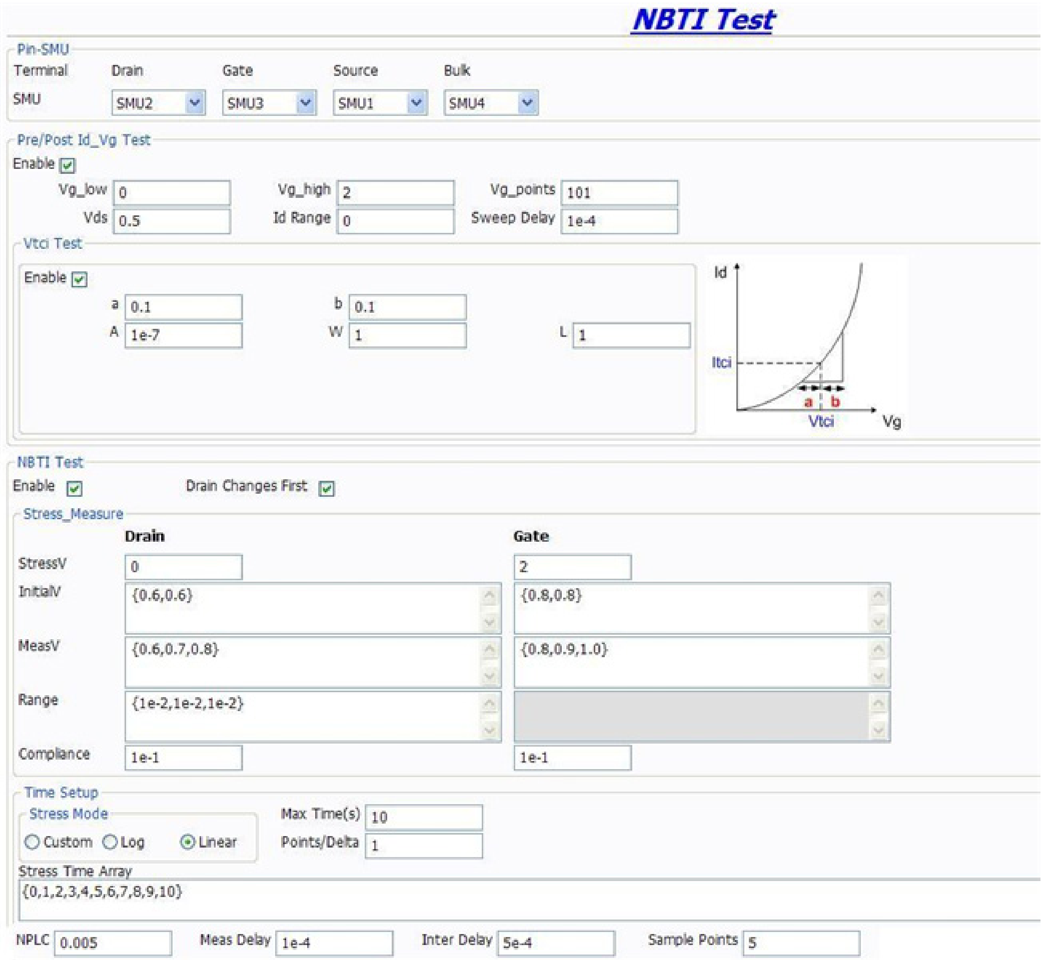


Figure 150: GUI for NBTI_meas



Example call:

```
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_mea
    s,myNPL,meas_delay,inter_delay,t_mode,t_max,npdec_delta,time_input,modeflag,Gcom
    pi,Dcompi,rng,Nsam)
```

NBTI_on_the_fly

Description:

Reference: " 'On-the-fly' characterization of NBTI in ultra-thin Gate oxide PMOSFET's", M. Denais, et. al, IEDM 2004. This code is copyright of Keithley Instruments, Inc.

This is a method to monitoring threshold voltage degradation and relaxation for NBTI and Charge trapping on high K Gate stacks.

Vg_stress is for stress and measurement during STRESS phase.

Vg_relax is for measurement during recovery.

Zero is set for recovery voltage during time other than measurement.

This program can only be used for one device, one stress on period, and one stress off period.

Possible outputs:

'ERROR' (possible error type) --- -1 stands for 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

Syntax:

```
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: monitoring both degradation and relaxation during stress on and off period
`double Vg_stress=3`	--voltage on Gate during stress. measurement during stress is made at this voltage, too.
`double Vg_relax=1`	--measure voltage on Gate during recovery; the stress voltage during recovery is set as 0
`double Vg_dist=0.05`	--delta Vg for different Id measurement
`double Vd=0.1`	--Drain voltage only applied during monitoring, other time it is 0V
`integer Stress_time=1000`	--Time for stress in seconds
`table Monitor_time_stamp={}`	--Time in seconds. This is an input array for guiding time between two monitorings. The actual time stamp for monitoring might not be exactly the same due to measurement time. Also, this time stamp is the same for both stress on (degradation monitoring) and off (relaxation monitoring).
`instid GSMU=SMU1`	--Gate SMU number, SMU1 for example
`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`	--PLC setting

Outputs:

ERROR
Time_stress
dVt_stress
Id_stress
Time_relax
dVt_relax
Id_relax

GUI related:

The next figure shows the NBTI_on_the_fly test GUI and illustrates the testing method. A general description of this GUI is included below.

Figure 151: Sequence of NBTI_on_the_fly

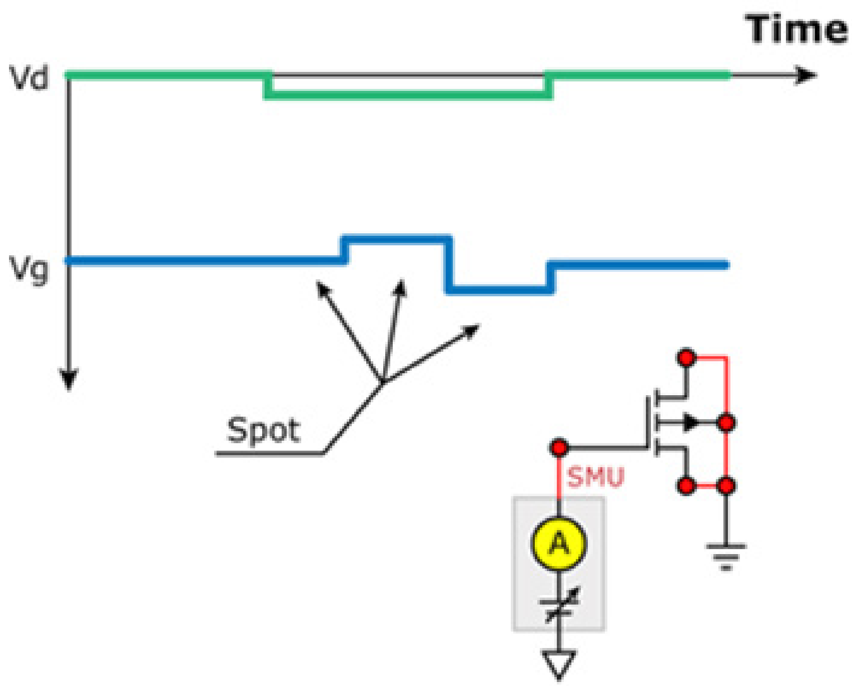
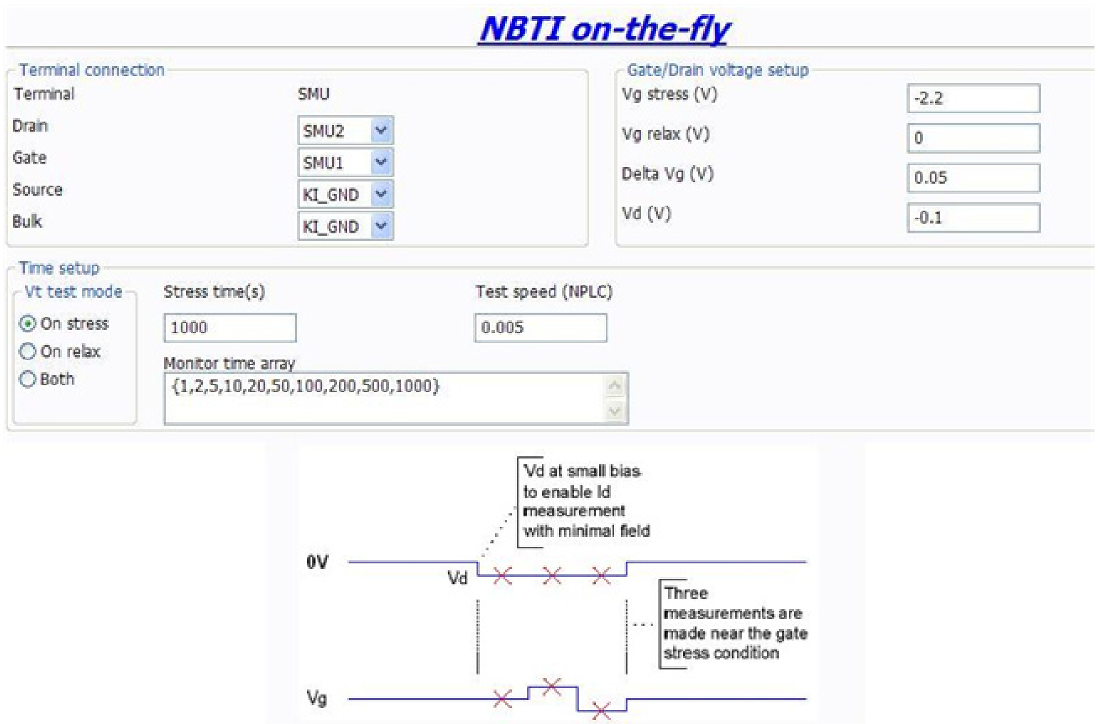


Figure 152: GUI for NBTI_on_the_fly



NBTI on-the-fly GUI descriptions

Terminal: For Source and bulk, KI_GND could be set (manual connection to ground). If specific SMUs are assigned to these two terminals, 0V will be applied internally.

Gate/Drain: Voltage during stress phase and relax phase on Gate and Drain should be set here.

Time: Arranges time during stress and relaxation. For 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, measurement is made during relax phase only following the monitor time array, and stress time is decided by Stress time. If both are selected, measurement is made during both the stress phase and the relax phase, and they both follow monitor time array.

Example call:

```
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)
```

pPowerMOSFET library

pPowerMOSFET overview

The pPowerMOSFET library components are located in the following directory:
\\ACS_BASIC\library\dev_library\pPowerMOSFET

The pPowerMOSFET parametric library is used to test parameters of a p-type power MOSFET, including leakage, breakdown, gain, on-state and characteristic curves.

pPowerMOSFET parametric library

BVDSS

Description:

Module Name: BVDSS

Module Type: ITM

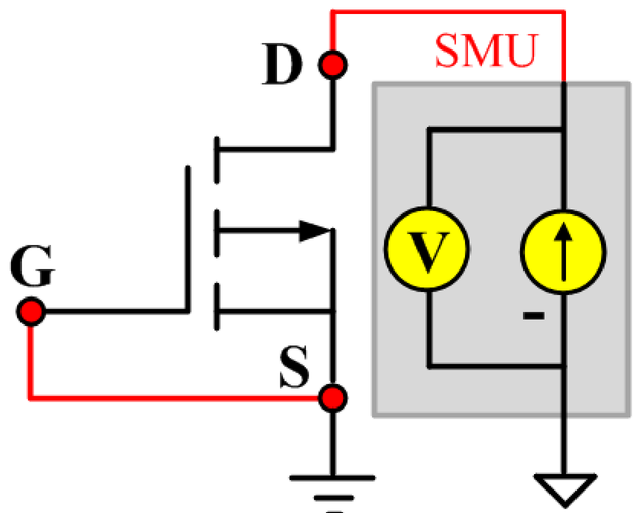
Instrument: KI2657A, KI2600B

DUT: Three-terminal pPowerMOSFET

Function: Determines 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 Connection: One or two SMUs are used. The Model 2657A applies current and takes voltage measurements at the Drain. The Gate and Source are connected to ground, or has no voltage bias from the other SMU.

Figure 153: pPowerMOSFET_BVDSS pin connection



GFS

Description:

Module Name: GFS

Module Type: ITM

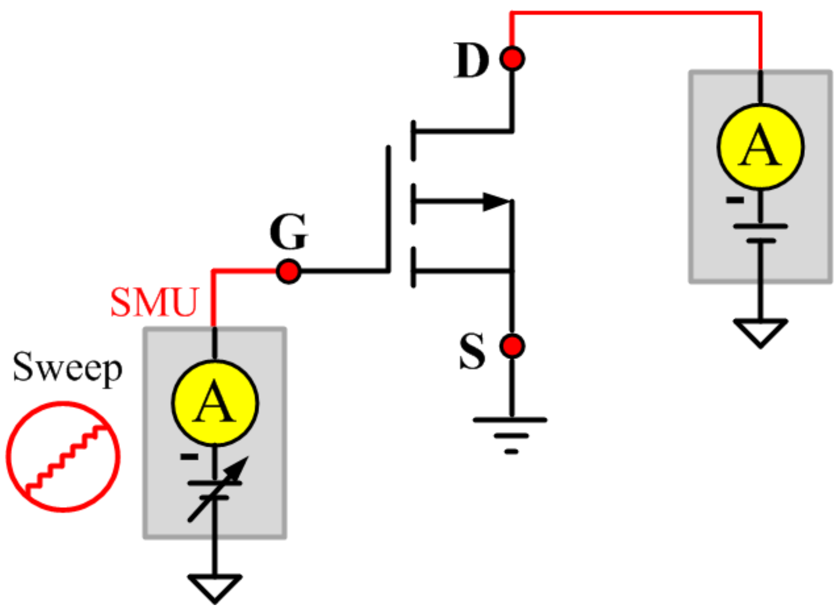
Instrument: KI2651A, KI2600B

DUT: Three-terminal pPowerMOSFET

Function: Determines 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 Connection: Two SMUs are used. The Model 2651A SMU applies voltage and takes current measurements at the Drain. The other SMU sweeps voltage at the Gate.

Figure 154: pPowerMOSFET GFS pin connection



IdON

Description:

Module Name: IdON

Module Type: ITM

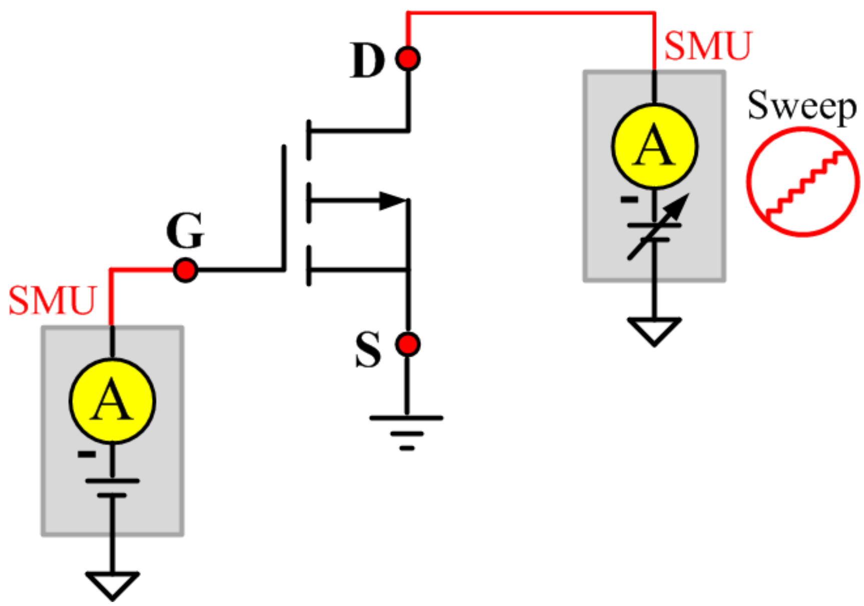
Instrument: KI2651A, KI2600B

DUT: Three-terminal pPowerMOSFET

Function: Determines 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 Connection: Two SMUs are used. The Model 2651A SMU applies a voltage sweep and takes current measurements at the Drain. The other SMU sources a specific voltage at the Gate.

Figure 155: pPowerMOSFET IdON pin connection



IDSS

Description:

Module Name: IDSS

Module Type: ITM

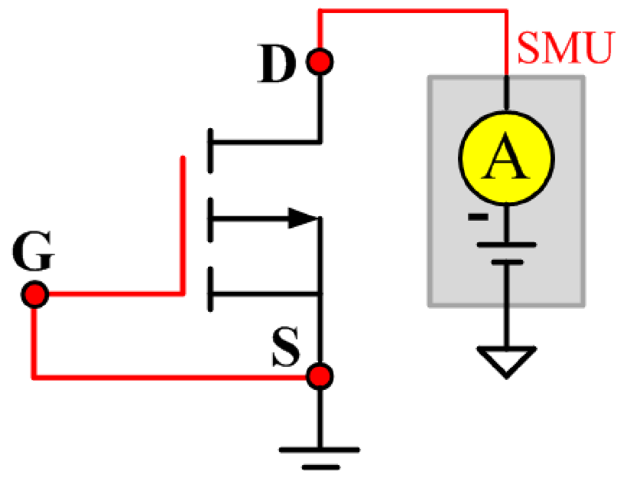
Instrument: KI2657A, KI2600B

DUT: Three-terminal pPowerMOSFET

Function: Determines the leakage current from the Drain to Source when device off. Measures current on the Drain by applying a maximum permissible voltage between the Drain and Source and the Gate is shorted to Source.

Pin Connection: One or two SMUs are used. The Model 2657A applies voltage and takes current measurements at the Drain. The Gate and Source are connected to ground, or has no voltage bias from the other SMU.

Figure 156: pPowerMOSFET IDSS pin connection



IdVd_StepVg

Description:

Module Name: IdVd_StepVg

Module Type: ITM

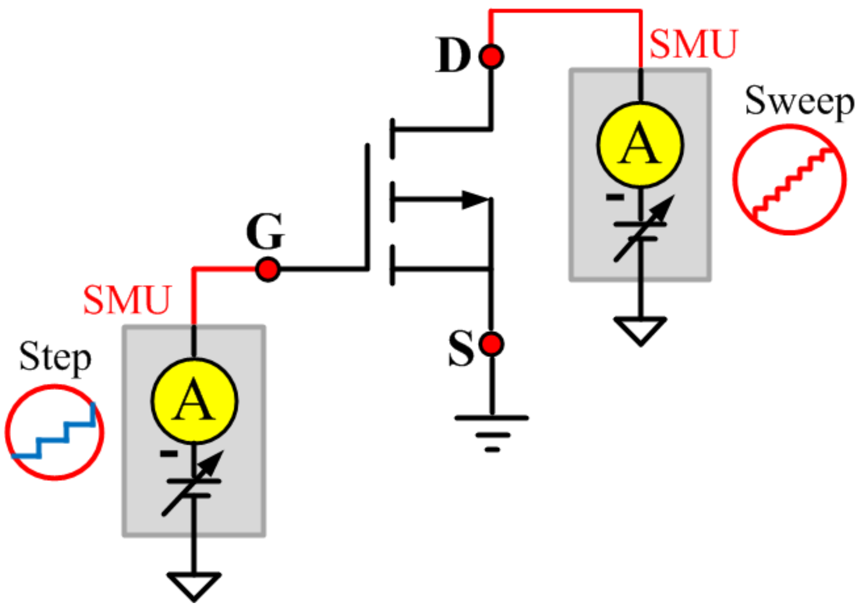
Instrument: KI2651A, KI2600B

DUT: Three-terminal pPowerMOSFET

Function: Generates 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 Connection: Two SMUs are used. The Model 2651A SMU applies a voltage sweep and takes current measurements at the Drain. The other SMU sources a specific voltage at the Gate.

Figure 157: pPowerMOSFET IdVd_StepVg pin connection



IdVg_StepVd

Description:

Module Name: IdVg_StepVd

Module Type: ITM

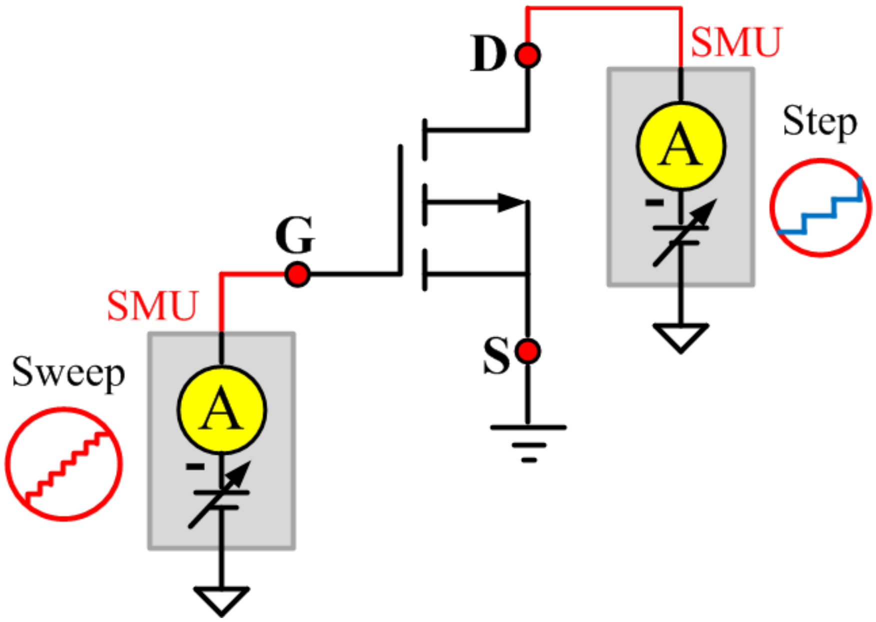
Instrument: KI2651A, KI2600B

DUT: Three-terminal pPowerMOSFET

Function: Tests the transfer characteristics of the pPowerMOSFET device. Each time the voltage steps on the Drain-Source a voltage sweep is performed on the Gate-Source and a set of current measurements occur on the Drain.

Pin Connection: Two SMUs are used. The Model 2651A SMU applies a voltage step and takes current measurements at the Drain. The other SMU sweeps voltage at the Gate.

Figure 158: pPowerMOSFET IdVg_StepVd pin connection



IGSSF

Description:

Module Name: IGSSF

Module Type: ITM

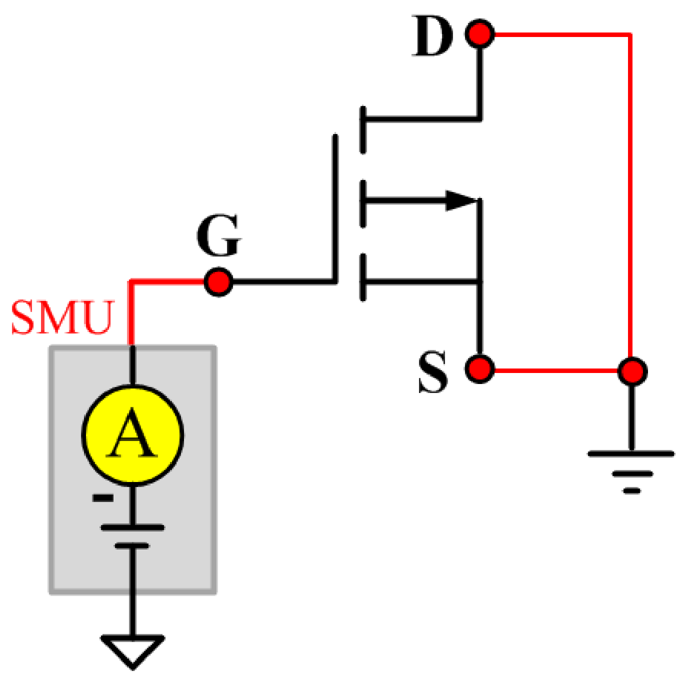
Instrument: KI2651A, KI2600B

DUT: Three-terminal pPowerMOSFET

Function: Determines the Gate body forward leakage current. Measures current on the Gate at the maximum permissible negative voltage from the Gate to Source.

Pin Connection: 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 has no voltage bias from the other SMU.

Figure 159: pPowerMOSFET IGSSF pin connection



IGSSR

Description:

Module Name: IGSSR

Module Type: ITM

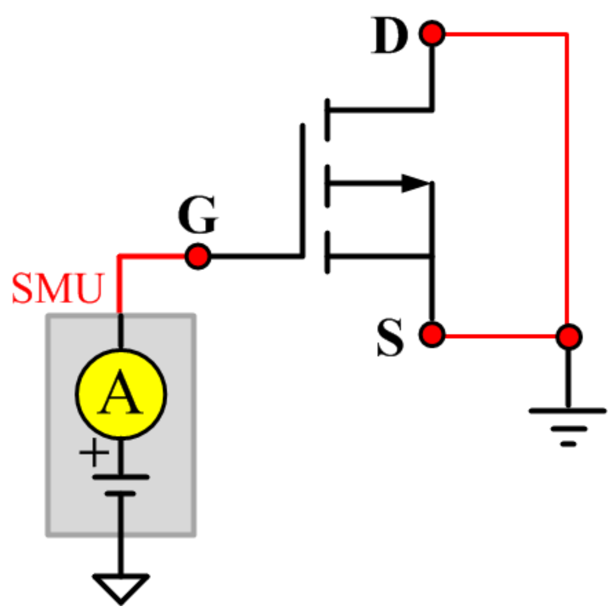
Instrument: KI2651A, KI2600B

DUT: Three-terminal pPowerMOSFET

Function: Determines the Gate body reversed leakage current. Measures current on the Gate at the maximum permissible positive voltage from the Gate to Source.

Pin Connection: One or two SMUs are used. One SMU applies voltage and takes current measurements at the Gate. The Drain and Source are set to ground, or has no voltage bias from the other SMU.

Figure 160: pPowerMOSFET IGSSR pin connection



RdsON

Description:

Module Name: RdsON

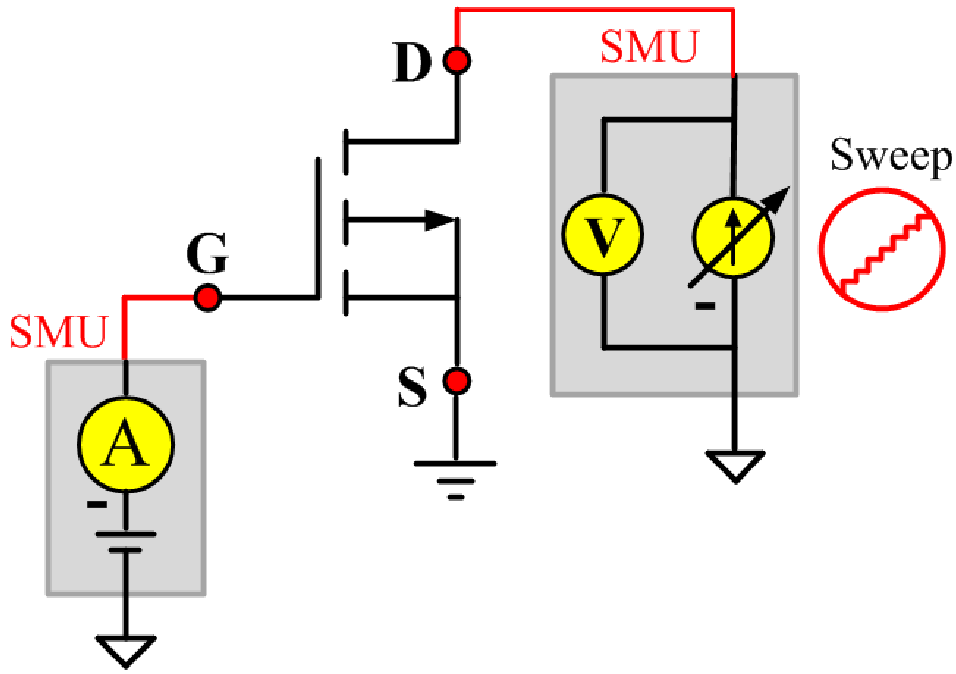
DUT: Four-terminal pPowerMOSFET

Function: Determines 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 Connection: Two SMUs are used. The Model 2651A SMU applies a current sweep and takes voltage measurements at the Drain. The other SMU sources a specific voltage at the Gate.

Intended results: Measure the Drain-Source voltage at a specified Drain current sweep.

Figure 161: pPowerMOSFET RdsOn pin connection



VdsON

Description:

Module Name: VdsON

Module Type: ITM

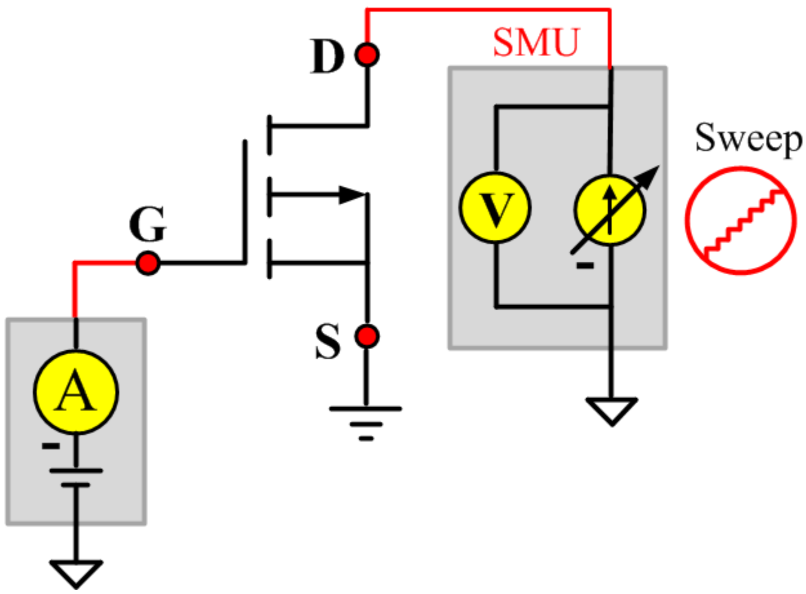
Instrument: KI2651A, KI2600B

DUT: Three-terminal pPowerMOSFET

Function: Determines 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 Connection: Two SMUs are used. The Model 2651A SMU applies a current sweep and takes voltage measurements at the Drain. The other SMU sources a specific voltage at the Gate.

Figure 162: pPowerMOSFET VdsON pin connection



VgsON

Description:

Module Name: VgsON

Module Type: ITM

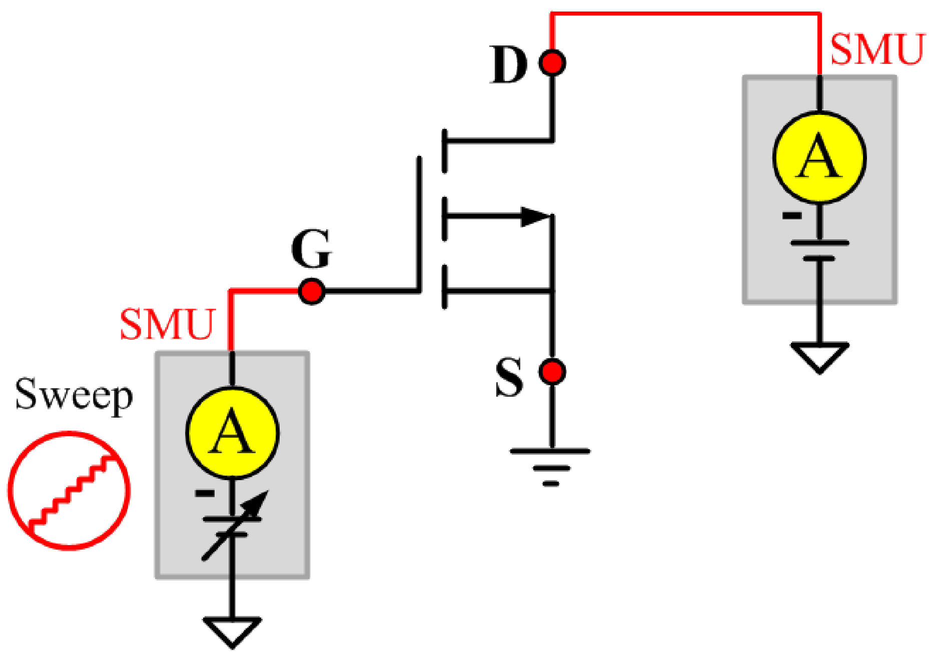
Instrument: KI2651A, KI2600B

DUT: Three-terminal pPowerMOSFET

Function: Determines the Gate to Source the 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 Connection: Two SMUs are used. The Model 2651A SMU applies voltage and takes current measurements at the Drain. The other SMU sweeps voltage at the Gate.

Figure 163: pPowerMOSFET VgsON pin connection



VGSTH

Description:

Module Name: VGSTH

Module Type: ITM

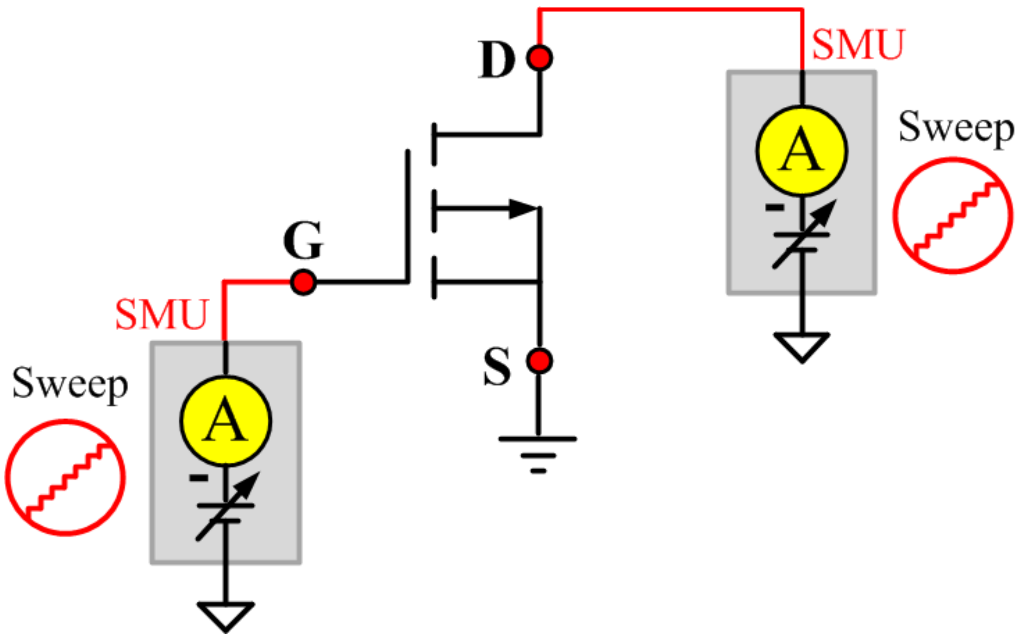
Instrument: KI2651A, KI2600B

DUT: Three-terminal pPowerMOSFET

Function: Determines the threshold voltage from the Gate to Source which is required to turn on the device at a certain Id current value that is given in the data sheet.

Pin Connection: Two SMUs are used. The Model 2651A SMU applies sweep voltage and takes current measurements at the Drain. The other SMU sweeps voltage at the Gate.

Figure 164: pPowerMOSFET VGSTH pin connection



VSD

Description:

Module Name: VSD

Module Type: ITM

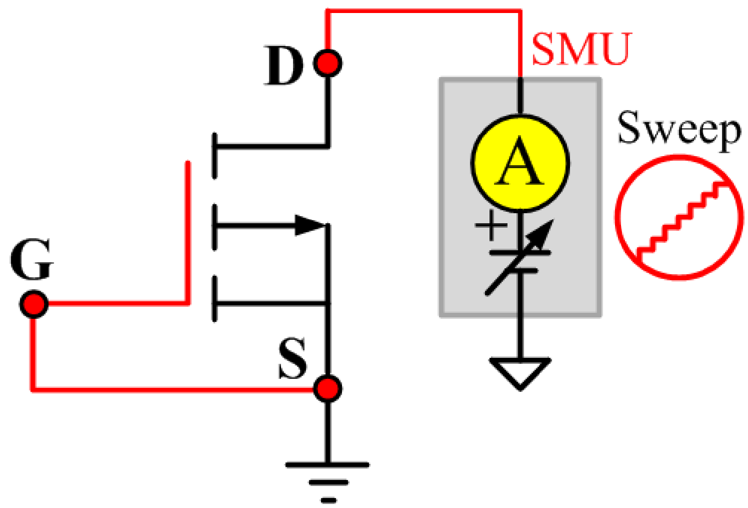
Instrument: KI2651A, KI2600B

DUT: Three-terminal pPowerMOSFET

Function: Determines 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 Connection: One or two SMUs are used. The Model 2651A applies a voltage and takes current measurements at the Drain. The Gate and Source are connected to ground, or has no voltage bias from the other SMU.

Figure 165: pPowerMOSFET VSD pin connection



IdVd_StepVg_MIX

Description:

Module name: IdVd_StepVg_MIX

Test Type: PTM

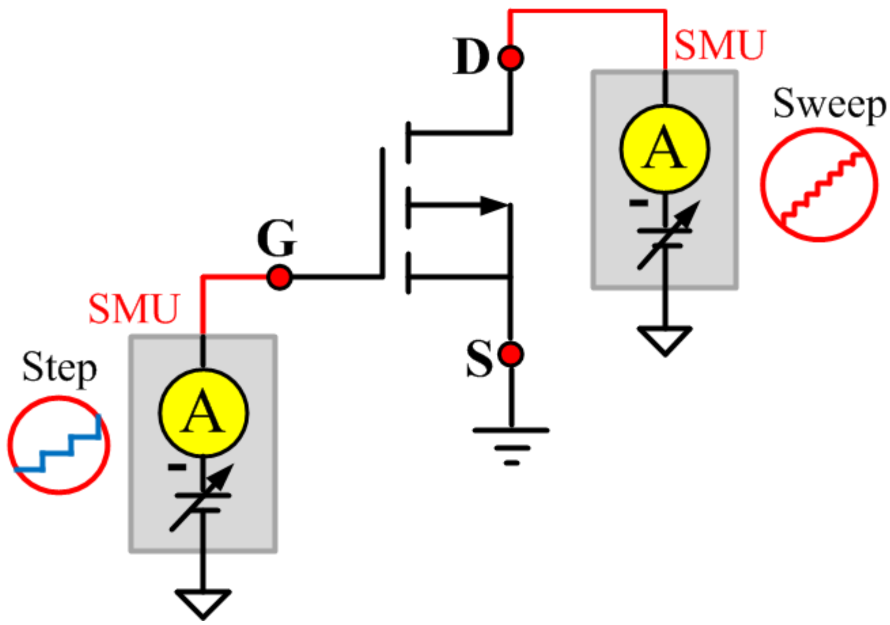
Instrument: Keithley 265xA, 26xxB SMU, 24xx SMU and 42xx SMU

DUT: Three-terminal pPowerMOSFET

Function: Tests the Drain current at the Drain voltage sweep and specified Gate voltage with measurements at the Drain terminal while it is in pulse mode using the Keithley 265xA instrument.

Intended results: Measure the Drain current at the specified Gate voltage and sweep the Drain in pulse mode.

Figure 166: pPowerMOSFET IdVd_StepVg_MIX pin connection



RdsON_MIX

Description:

Module name: RdsOn_MIX

Test Type: PTM

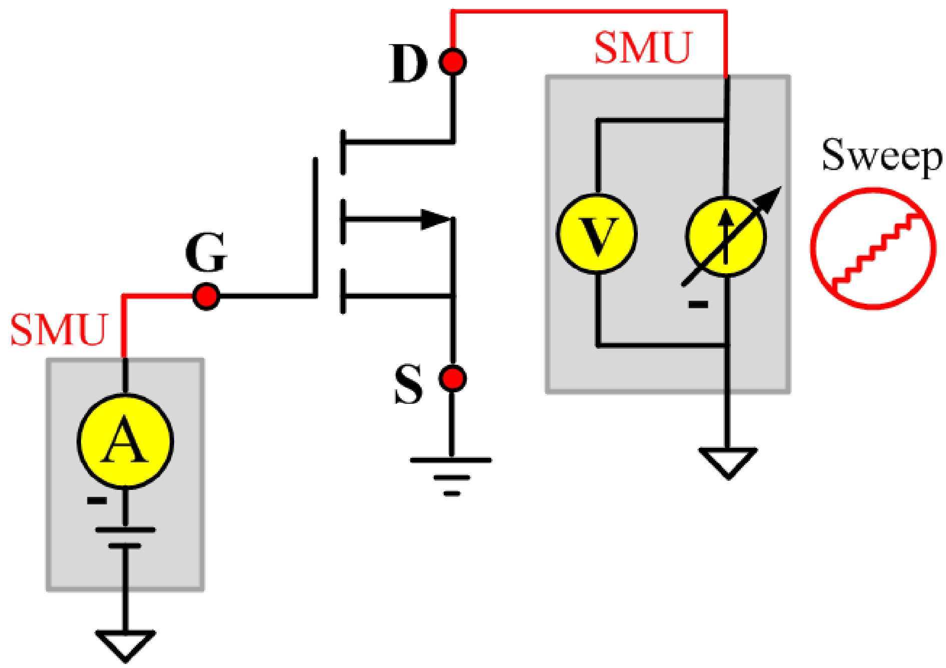
Instrument: Keithley 265xA, 26xxB SMU, 24xx SMU and 42xx SMU

DUT: Three-terminal pPowerMOSFET

Function: Tests the Drain current at the Drain voltage sweep and specified Gate voltage with measurements at the Drain terminal while it is in pulse mode. And it calculates the Rds: Rds = Vds/Id.

Intended results: Measure the Drain voltage at the specified Gate voltage and sweep the Drain in pulse mode.

Figure 167: pPowerMOSFET RdsON_MIX pin connection



VgsON_MIX

Description:

Module Name: VgsON_MIX

Module Type: PTM

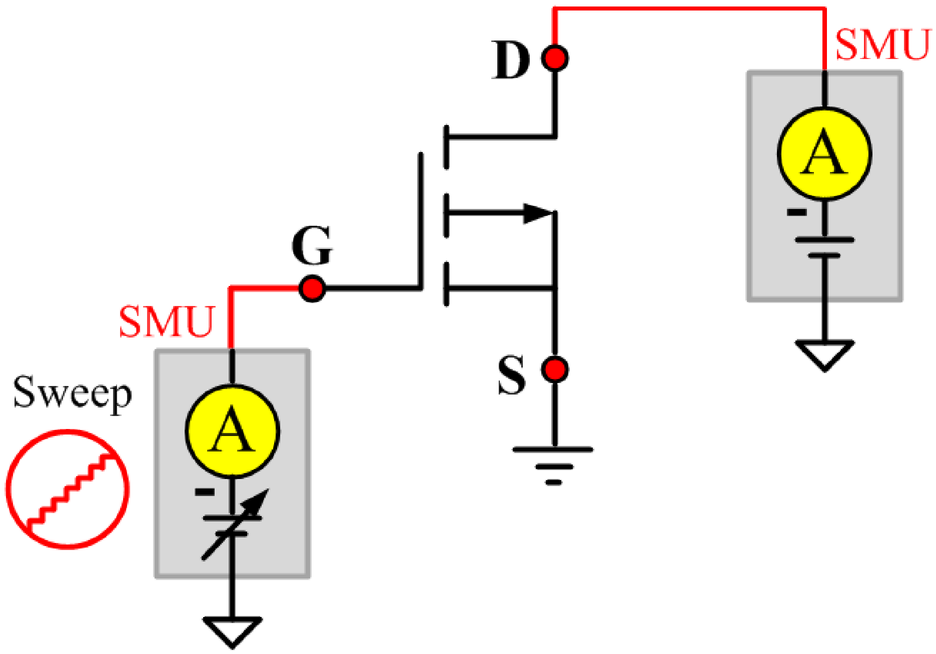
Instrument: KI2651A, KI2600B, KI24XX, KI42XX-SMU

DUT: Three-terminal pPowerMOSFET

Function: Determines 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 Connection: Two SMUs are used. The Model 2651A SMU applies voltage and takes current measurements at the Drain. The other SMU sweeps voltage at the Gate.

Figure 168: pPowerMOSFET VgsON_MIX pin connection



Diode parametric library

Diode parametric overview

The Diode library components are located in the following directory:
\\ACS_BASIC\library\dev_library\DIODE

The diode test library 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.

Diode parametric library

DynamicZ

Description:

Module Name: DynamicZ

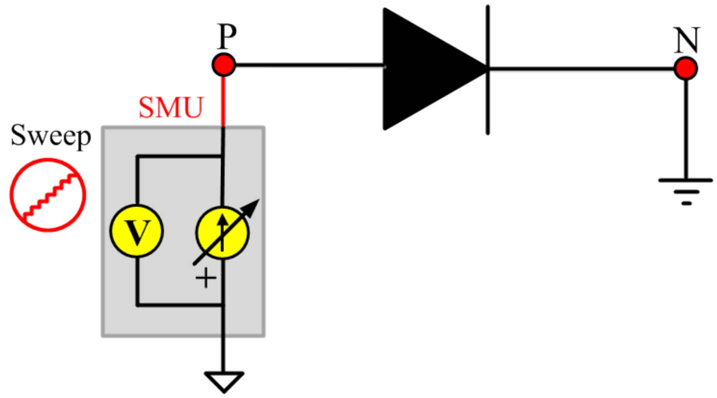
DUT: Diode

Function: Calculates 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, while the other terminal is connected to ground (see next figure).

Intended results: Measure the dynamic impedance.

Figure 169: Diode DynamicZ pin connection



DynamicZ ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 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

Description:

Module Name: Spot_IfdVfd

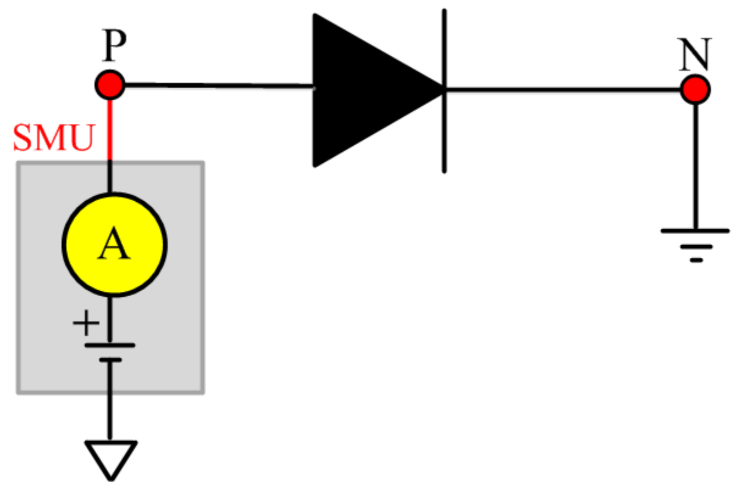
DUT: Diode

Function: Tests the forward current of a diode at a specified forward voltage.

Pin connections: The P terminal forces a forward voltage, and the N terminal is grounded (see next figure).

Intended results: Measure the forward current.

Figure 170: Diode_ Spot_IfdVfd pin connection



Spot_IfdVfd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 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

Description:

Module Name: Spot_IrdVrd

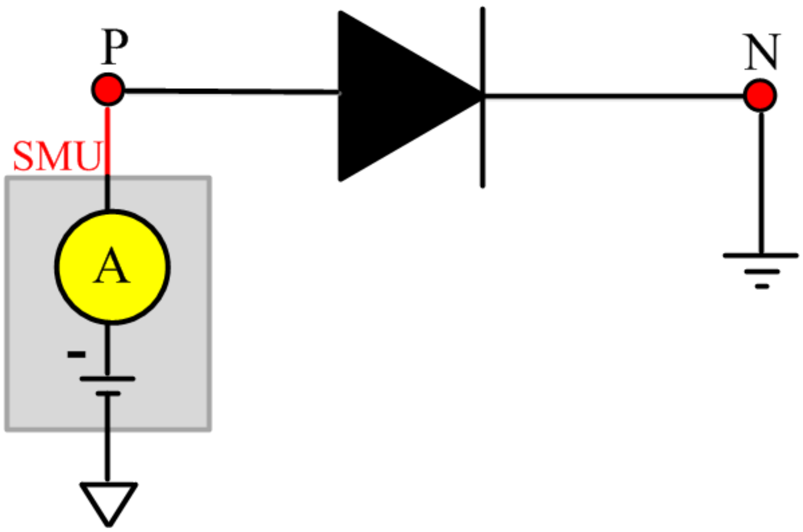
DUT: Diode

Function: Tests the leakage current of a diode at a specified reverse voltage.

Pin connections: Force a reverse voltage to terminal N; connect the P terminal to ground (see next figure).

Intended results: Measure the reverse leakage current.

Figure 171: Diode_Spot_IrdVrd pin connection



Spot_IrdVrd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 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

Description:

Module Name: Spot_VbrIrd

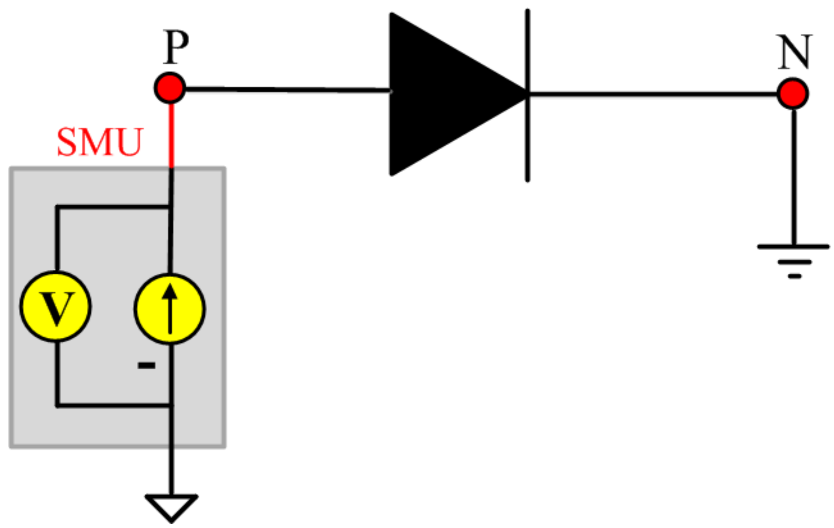
DUT: Diode

Function: Tests the breakdown voltage of a diode at a specified reverse current.

Pin connections: Force a reverse current to the P terminal and connect the N terminal to ground (see next figure).

Intended results: Measure the breakdown voltage.

Figure 172: Diode_Spot_VbrIrd pin connection



Spot_VbrIrd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 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_VfdIfd

Description:

Module Name: Spot_VfdIfd

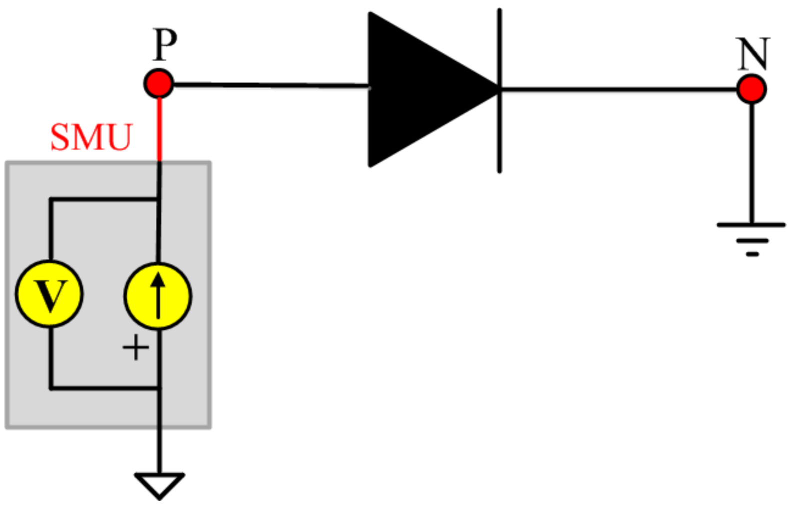
DUT: Diode

Function: Tests the forward voltage of a diode.

Pin connections: Uses one SMU to force forward current, while the other terminal is grounded. The forward voltage is measured at the current (see next figure).

Intended results: Measure the forward voltage.

Figure 173: Diode_Spot_VfdIfd pin connection



Spot_VfdIfd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

Spot_VfdIfd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Spot_VfdIfd PTM

Module Type: standard PTM

Instrument: Keithley Instruments Series 4200 SMU

Spot_VrdIrd

Description:

Module Name: Spot_VrdIrd

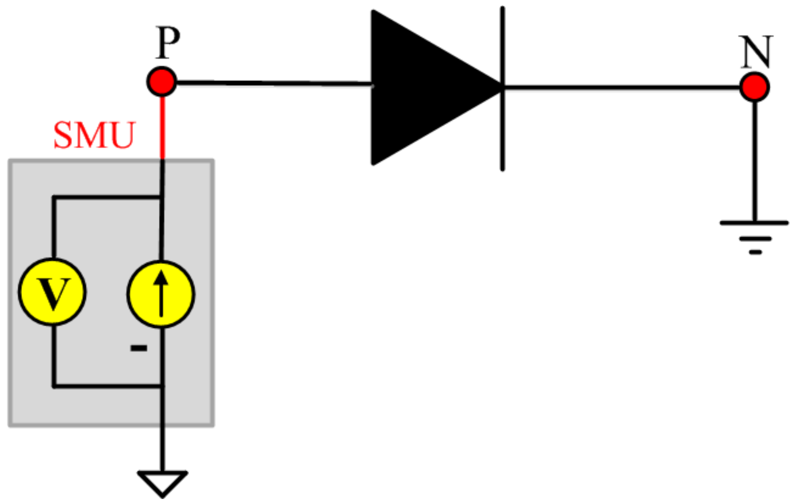
DUT: Diode

Function: Tests the reverse voltage of a diode at a specified reverse current.

Pin connections: Force a reverse current to terminal P and connect the N terminal to ground (see next figure).

Intended results: Measure the reverse voltage.

Figure 174: Diode_Spot_VrdIrd pin connection



Spot_VrdIrd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 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

Description:

Module Name: Sweep_IfdVfd

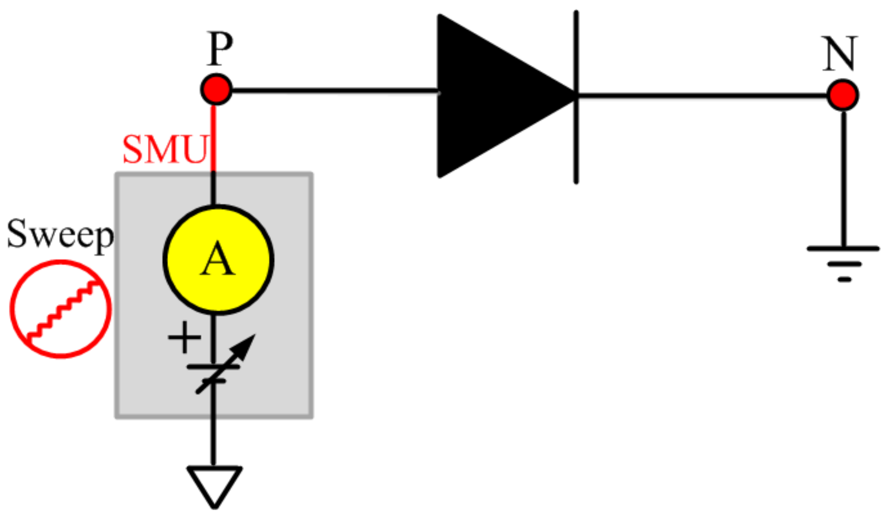
DUT: Diode

Function: Tests 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, and connect the N terminal to ground (see next figure).

Intended results: Measure the forward voltage based on the forward current sweep.

Figure 175: Diode_Sweep_IfdVfd pin connection



Sweep_IfdVfd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 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

Description:

Module Name: Sweep_IrdVrd

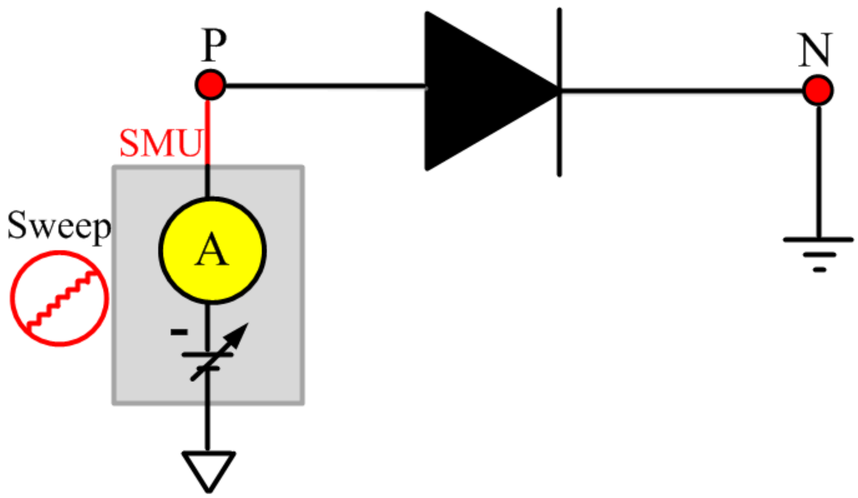
DUT: Diode

Function: Tests 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 N terminal, and connect the P terminal to ground (see next figure).

Intended results: Measure the reverse current at each reverse voltage sweep point.

Figure 176: Diode_Sweep_IrdVrd pin connection



Sweep_IrdVrd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 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 parametric library

IGBT parametric overview

The IGBT library components are located in the following directory:
\\ACS_BASIC\library\dev_library\IGBT

The IGBT parametric library is used to test parameters of an IGBT device, including leakage, breakdown, gain, on-state and characteristic curves.

IGBT parametric library

BVCES

Description:

Module Name: BVCES

Test Type: ITM

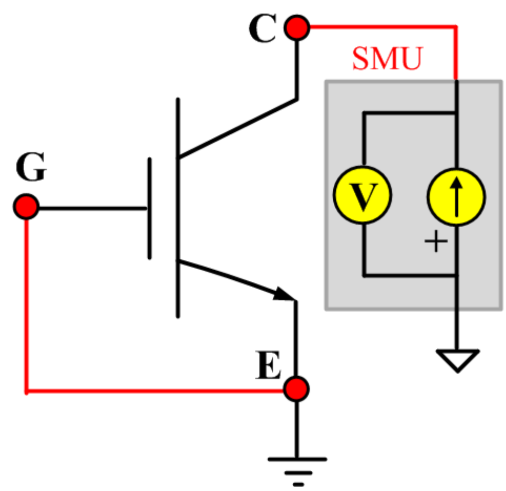
Instrument: KI2657A

DUT: Three-terminal IGBT

Function: Determines 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 Connection: One SMU is used. The SMU applies current and takes voltage measurements at the Collector. The Gate and Emitter are connected to ground, or has no voltage bias from the other SMU.

Figure 177: IGBT BVCES pin connection



ICES

Description:

Module Name: ICES

Test Type: ITM

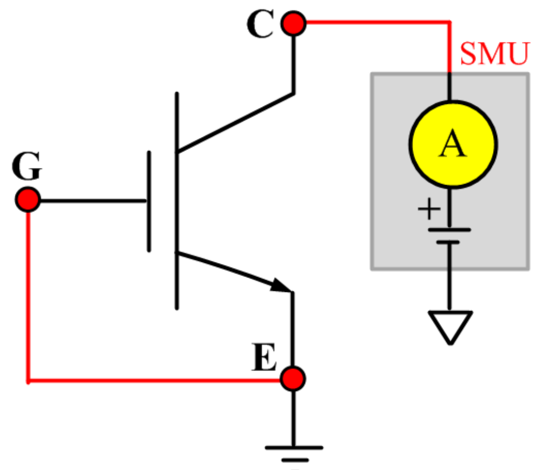
Instrument: KI2657A

DUT: Three-terminal IGBT

Function: Determines the Collector-Emitter cut-off current with the Gate shorted to the Emitter.

Pin Connection: One SMU is used. The SMU applies voltage and takes current measurements from the Collector to Emitter. The Gate is shorted to the Emitter, or has no voltage bias from the other SMU.

Figure 178: IGBT ICES pin connection



IcON

Description:

Module Name: IcON

Test Type: ITM

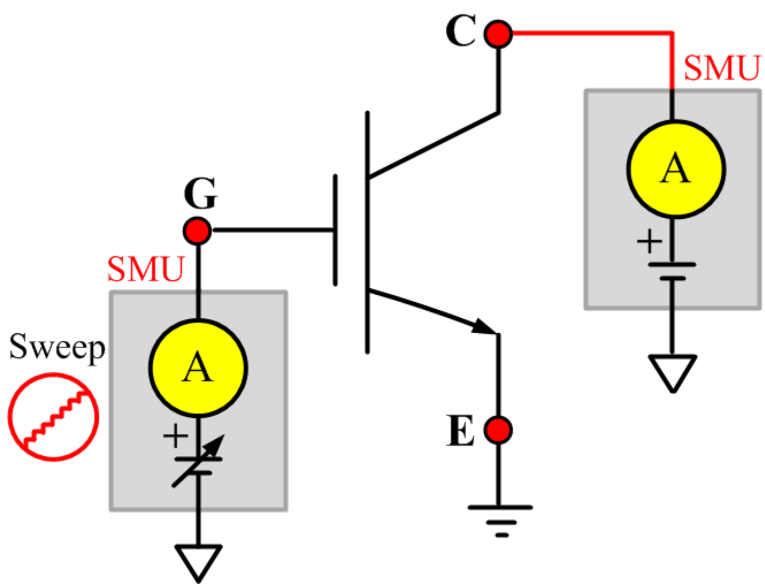
Instrument: KI2651A, KI2600B

DUT: Three-terminal IGBT

Function: Determines 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 Connection: Two SMUs are used. The Model 2651A SMU applies voltage and takes current measurements at the Collector. The other SMU sources a sweep voltage at the Gate.

Figure 179: IGBT IcON pin connection



IcVce_StepVge

Description:

Module Name: IcVce_StepVge

Test Type: ITM

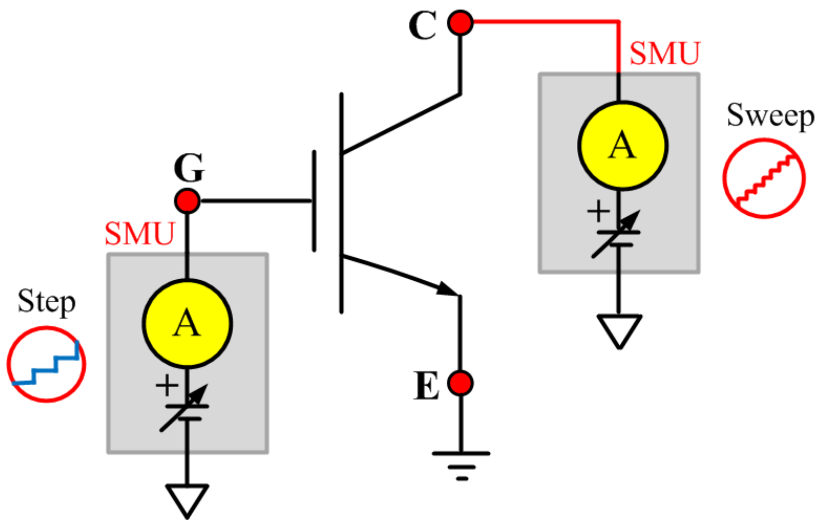
Instrument: KI2651A, KI2600B

DUT: Three-terminal IGBT

Function: Generates 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 Connection: Two SMUs are used. The Model 2651A SMU applies a voltage sweep and takes current measurements at the Collector. The other SMU sources a step voltage at the Gate.

Figure 180: IGBT IcVce_StepVge pin connection



IcVge

Description:

Module Name: IcVge

Test Type: ITM

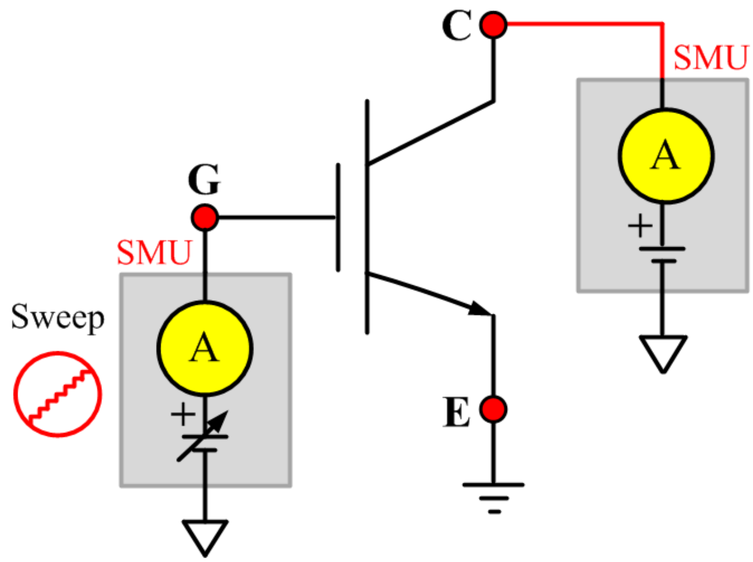
Instrument: KI2651A, KI2600B

DUT: Three-terminal IGBT

Function: Tests the transfer characteristics of the IGBT with a specific voltage bias from the Collector to Emitter.

Pin Connection: 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 181: IGBT IcVge_StepVce pin connection



IGESF

Description:

Module Name: IGESF

Test Type: ITM

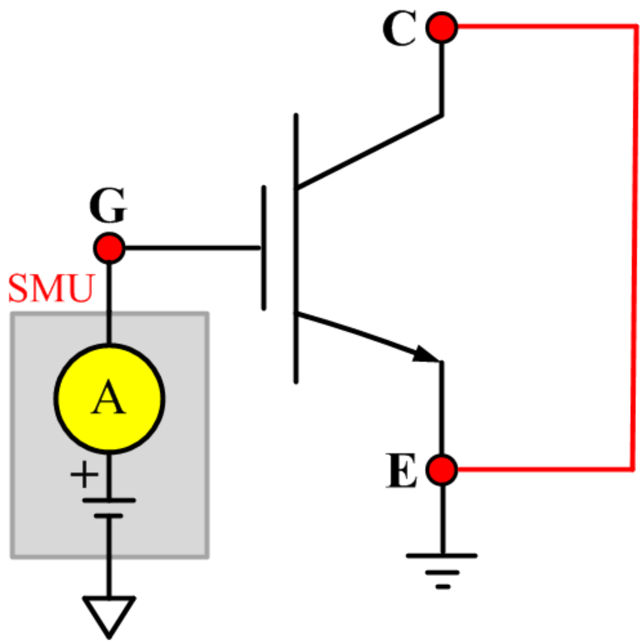
Instrument: KI2600B

DUT: Three-terminal IGBT

Function: Determines the Gate body forward leakage current. Measures current on the Gate at a maximum permissible positive voltage from the Gate to Emitter.

Pin Connection: One SMU is used. The SMU applies voltage and takes current measurements from the Gate to Emitter. The Collector is connected to ground, or has no voltage bias from the other SMU.

Figure 182: IGBT IGESF pin connection



IGESR

Description:

Module Name: IGESR

Test Type: ITM

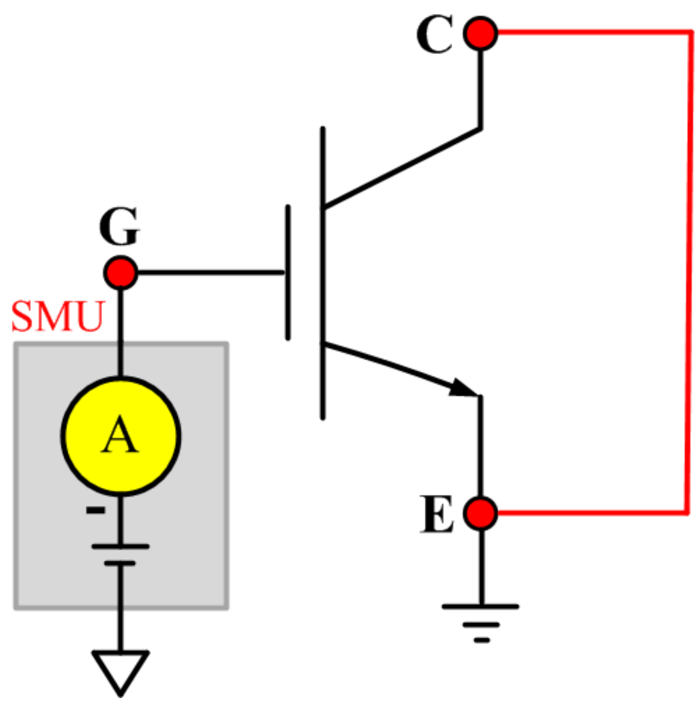
Instrument: KI2600B

DUT: Three-terminal IGBT

Function: Determines the Gate body reversed leakage current. Measures current on the Gate at a maximum permissible negative voltage from the Gate to Emitter.

Pin Connection: One SMU is used. The SMU applies voltage and takes current measurements from Gate to the Emitter. The Collector is connected to ground, has no voltage bias from the other SMU.

Figure 183: IGBT IGESR pin connection



VceSAT

Description:

Module Name: VceSAT

Test Type: ITM

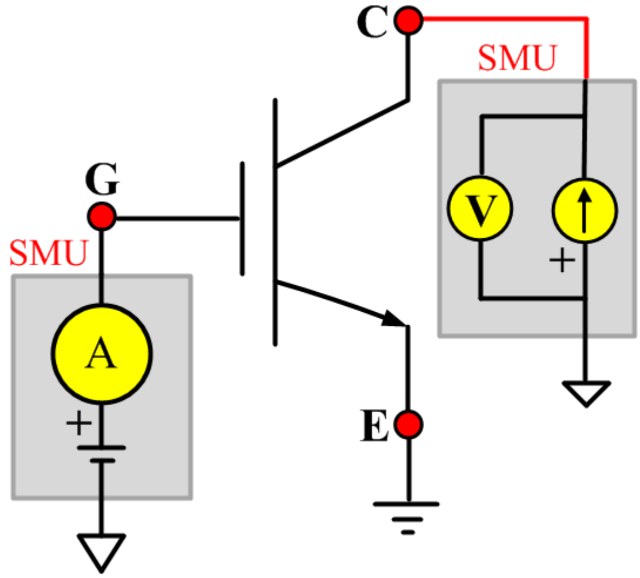
Instrument: KI2651A, KI2600B

DUT: Three-terminal IGBT

Function: Determines 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 Connection: Two SMUs are used. One SMU applies current and takes voltage measurements from the Collector to Emitter. The other SMU applies a voltage bias to the Gate.

Figure 184: IGBT VceSAT pin connection



VF

Description:

Module Name: VF

Test Type: ITM

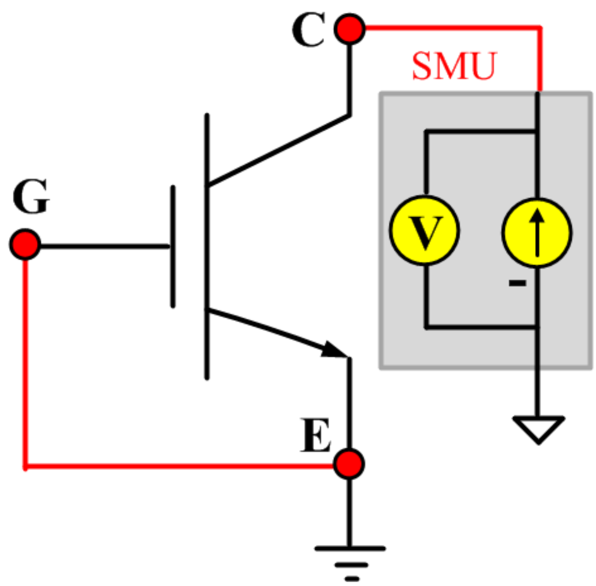
Instrument: KI2600B

DUT: Three-terminal IGBT

Function: Determines the forward voltage of the Emitter-Collector diode with the Gate shorted to the Emitter.

Pin Connection: One SMU is used. The SMU applies a specific current and takes voltage measurements from the Collector to Emitter. The Gate is connected to ground, or has no voltage bias from the other SMU.

Figure 185: IGBT VF pin connection



VgeON

Description:

Module Name: VgeON

Test Type: ITM

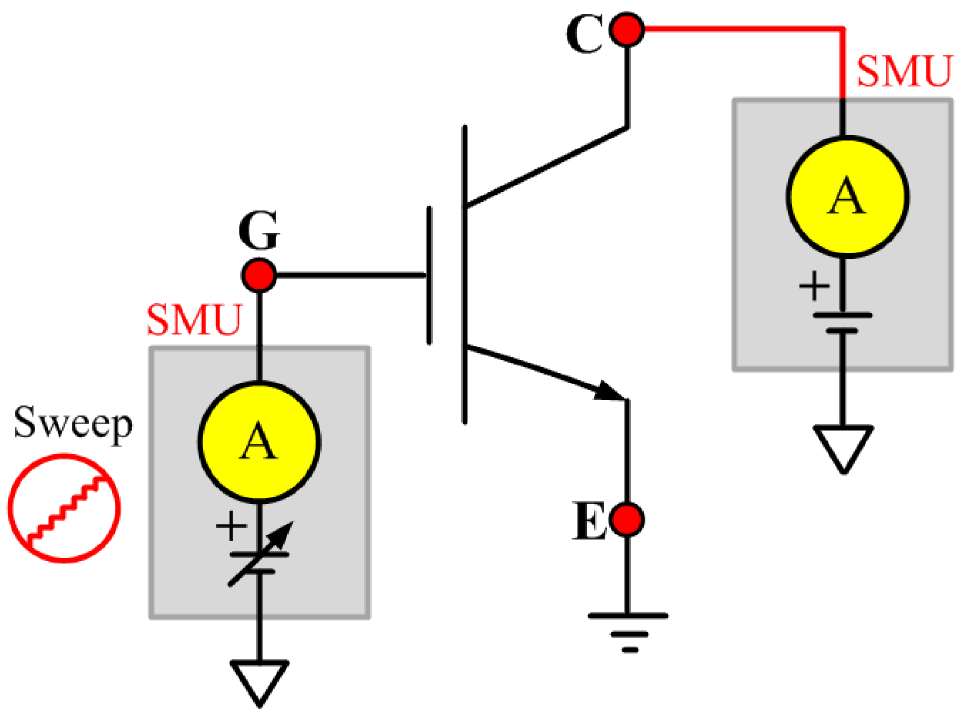
Instrument: KI2651A, KI2600B

DUT: Three-terminal IGBT

Function: Determines 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 Connection: 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 186: IGBT VgeON pin connection



VGETH

Description:

Module Name: VGETH

Test Type: ITM

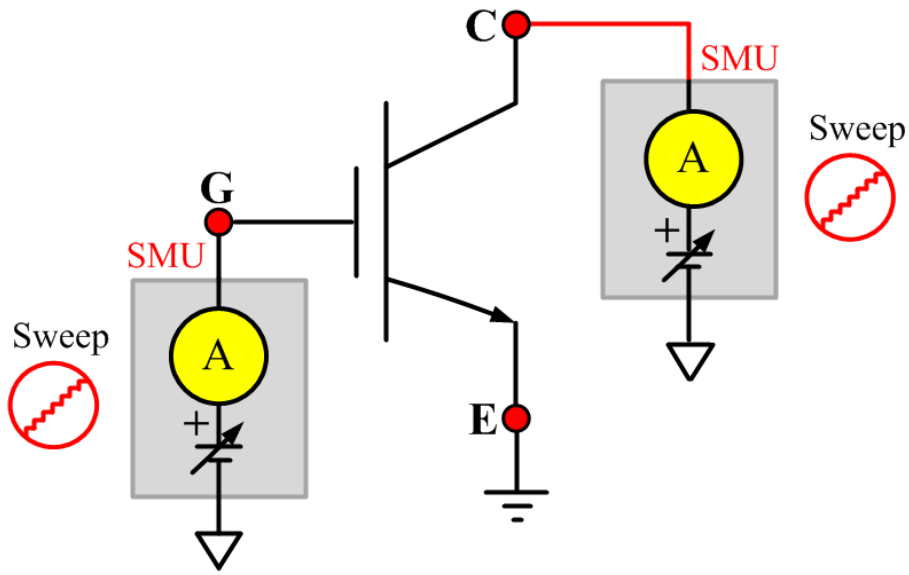
Instrument: KI2651A, KI2600B

DUT: Three-terminal IGBT

Function: Determines 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 Connection: Two SMUs are used. The Model 2651A SMU sweeps voltage and takes current measurements at the Collector. The other SMU sweeps voltage at the Gate.

Figure 187: IGBT VGETH pin connection



IcVce_StepVge_MIX

Description:

Module Name: IcVce_StepVge_MIX

Test Type: PTM

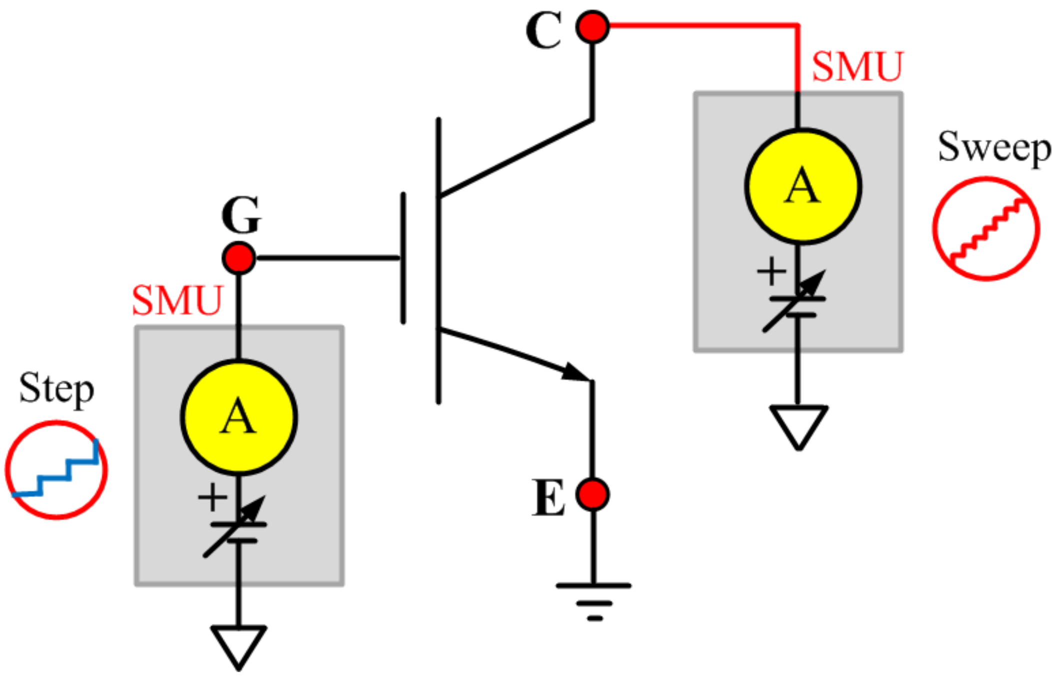
Instrument: KI2651A, KI2600B, KI24XX, KI42XX-SMU

DUT: Three-terminal IGBT

Function: Generates 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 Connection: Two SMUs are used. The Model 2651A SMU applies a voltage sweep and takes current measurements at the Collector. The other SMU sources a voltage step at the Gate.

Figure 188: IGBT IcVce_StepVge_MIX pin connection



IcVge_MIX

Description:

Module Name: IcVge_MIX

Test Type: PTM

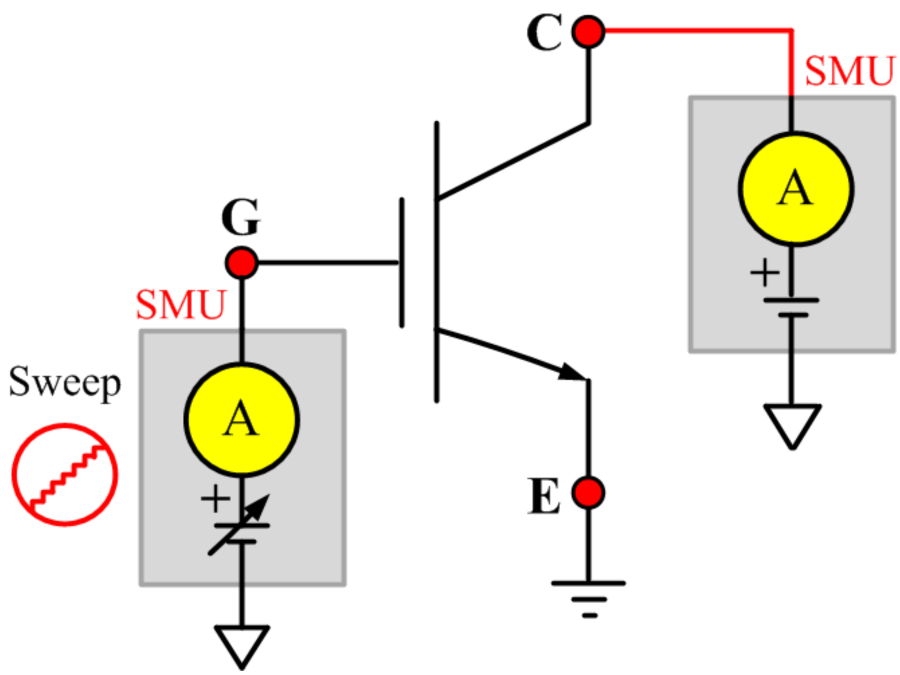
Instrument: KI2651A, KI2600B, KI24XX, KI42XX-SMU

DUT: Three-terminal IGBT

Function: Tests the transfer characteristics of the IGBT with a specific voltage bias from the Collector to Emitter.

Pin Connection: 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 189: IGBT IcVge_MIX pin connection



VceSAT_MIX

Description:

Module Name: VceSAT

Test Type: PTM

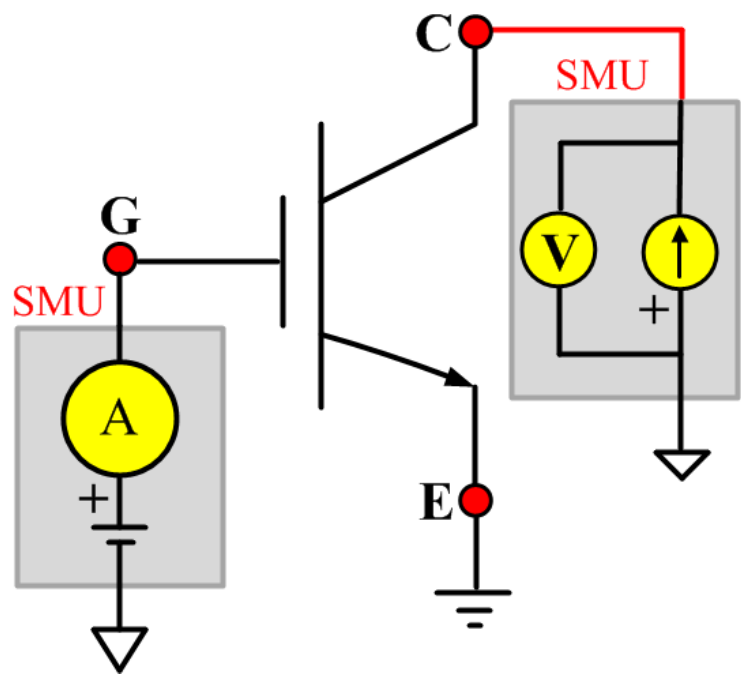
Instrument: KI2651A, KI2600B, KI24XX, KI42XX-SMU

DUT: Three-terminal IGBT

Function: Determines 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 Connection: Two SMUs are used. One SMU applies current and takes voltage measurements from the Collector to Emitter. The other SMU applies a voltage bias to the Gate.

Figure 190: IGBT VceSAT_MIX pin connection



Two-terminal resistor library

Two-terminal resistor overview

The two-terminal resistor library components are located in the following directory:
\\ACS_BASIC\library\dev_library\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.

Two-terminal resistor library

Spot_IV_2SMU

Description:

Module Name: Spot_IV_2SMU

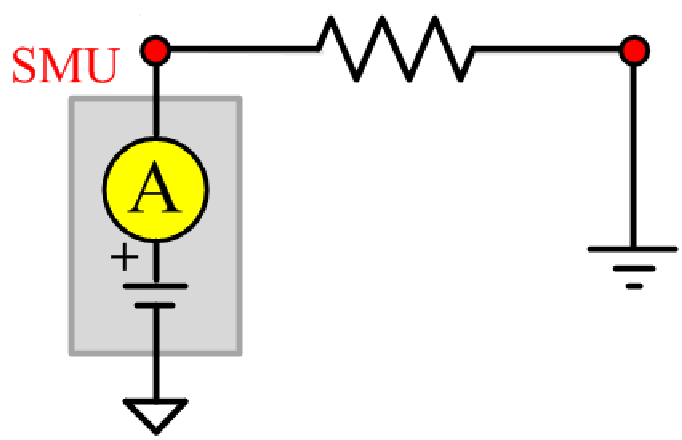
DUT: Two-terminal generic device

Function: Measures resistance at a specified voltage.

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 Sense High of the SMU closer to the device than the Force High (see next figure).

Intended results: Measure the current at a specified voltage to determine the resistance.

Figure 191: Two_term_resistor_spot_IV_2SMU pin connection



Spot_IV_2SMU ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

Spot_IV_2SMU General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Spot_VI_2SMU

Description:

Module Name: Spot_VI_2SMU

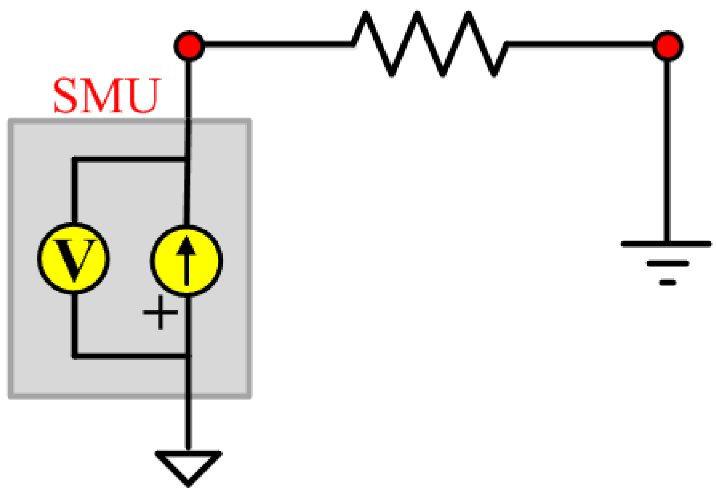
DUT: Two-terminal generic device

Function: Measures resistance at a specified current.

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 a four-wire measurement instruments, connect Sense High of the SMU closer to the device than the Force High (see next figure).

Intended results: Measure the voltage at a specified current to determine the resistance.

Figure 192: Two_term_resistor_spot_VI_2SMU pin connection



Spot_VI_2SMU ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

Spot_VI_2SMU General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Sweep_IV_2SMU

Description:

Module Name: Sweep_IV_2SMU

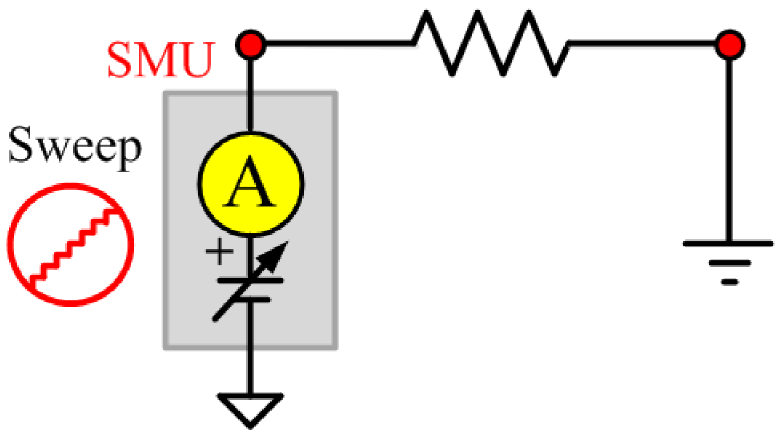
DUT: Two-terminal generic device

Function: Measures resistance during a voltage sequence.

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 Sense High of the SMU closer to the device than the Force High (see next figure).

Intended results: Measure the current reading during a voltage sweep and use the values to calculate the resistance.

Figure 193: Two_term_resistor_sweep_IV_2SMU pin connection



Sweep_IV_2SMU ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

Sweep_IV_2SMU General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Sweep_VI_2SMU

Description:

Module Name: Two-terminal Resistor_ Sweep_VI_2SMU

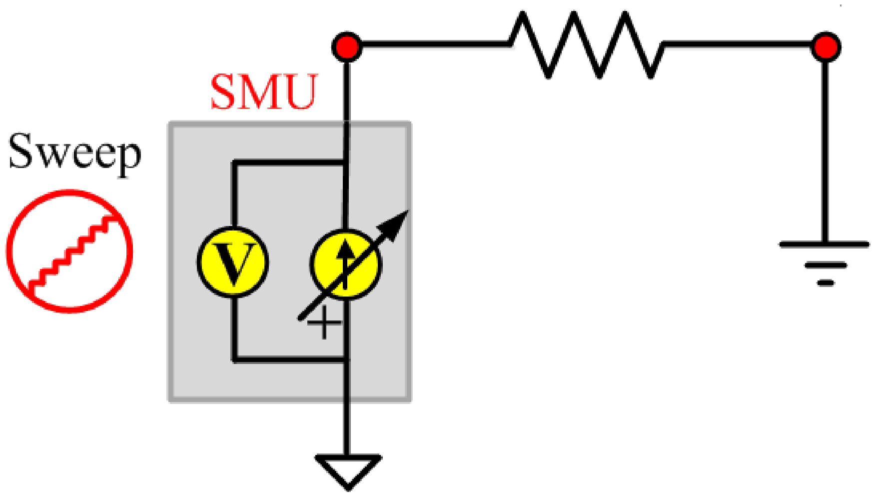
DUT: Two-terminal generic device

Function: Measure resistance during a current sequence.

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 Sense High of the SMU closer to the device than the Force High (see next figure).

Intended results: Measure the resistance reading during a current sequence.

Figure 194: Two_term_resistor_sweep_VI_2SMU pin connection



Sweep_VI_2SMU ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

Sweep_VI_2SMU General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Four-terminal resistor library

Four-terminal resistor overview

The four-terminal resistor library components are located in the following directory:
\\ACS_BASIC\library\dev_library\RESISTOR_4T

The four-terminal resistor library is used to test parameters of a four-terminal resistor, such as resistance (Source V measure I or Source I measure V, 2-wire or 4-wire).

Four-terminal resistor library

Spot_IV_4SMU

Description:

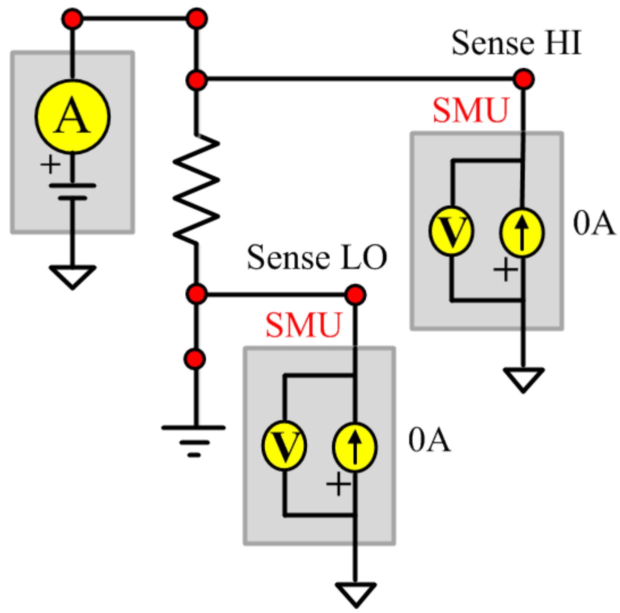
Module Name: Spot_IV_4SMU

DUT: Four-terminal generic device

Function: Measures resistance at a specified voltage.

Pin connections: One SMU can be used. Any Series 2400 or Series 2600B instrument is capable of forcing and sensing (see next figure).

Figure 195: Four_term_resistor_spot_IV_4SMU pin connection



Spot_IV_4SMU ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

Spot_IV_4SMU General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Spot_VI_4SMU

Description:

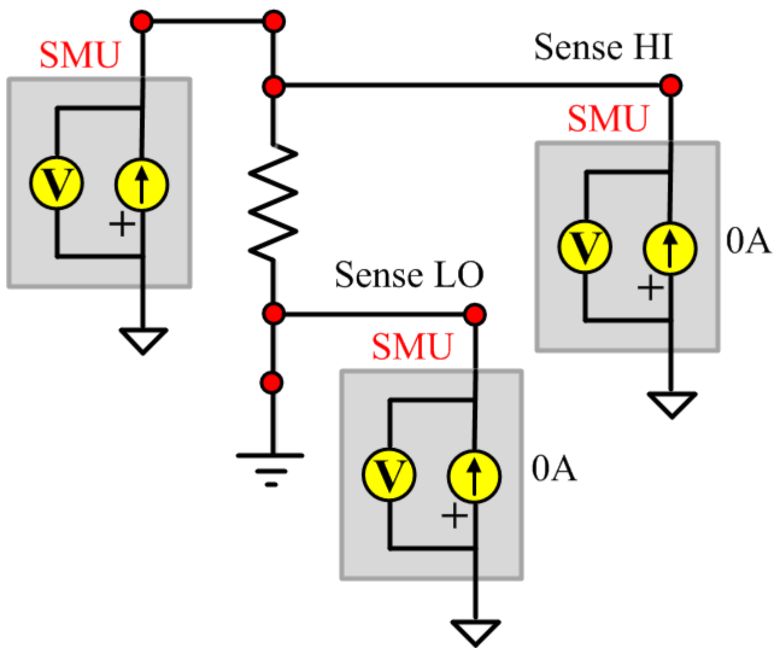
Module Name: Spot_VI_4SMU

DUT: Four-terminal generic device

Function: Measure resistance at a specified current.

Pin connections: One SMU can be used. Any Series 2400 or Series 2600B instrument is capable of forcing and sensing (see next figure).

Figure 196: Four_term_resistor_spot_VI_4SMU pin connection



Spot_VI_4SMU ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

Spot_VI_4SMU General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Sweep_IV_4SMU

Description:

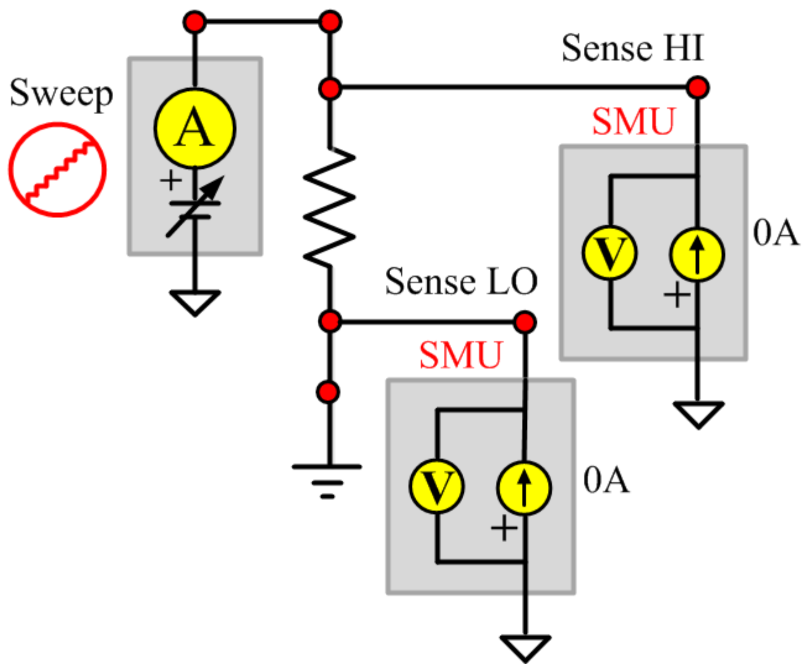
Module Name: Sweep_IV_4SMU

DUT: Four-terminal generic device

Function: Measures resistance during a voltage sequence.

Pin connections: One SMU can be used. Any Series 2400 or Series 2600B instrument is capable of forcing and sensing (see next figure).

Figure 197: Four_term_resistor_sweep_IV_4SMU pin connection



Sweep_IV_4SMU ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

Sweep_IV_4SMU General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Sweep_VI_4SMU

Description:

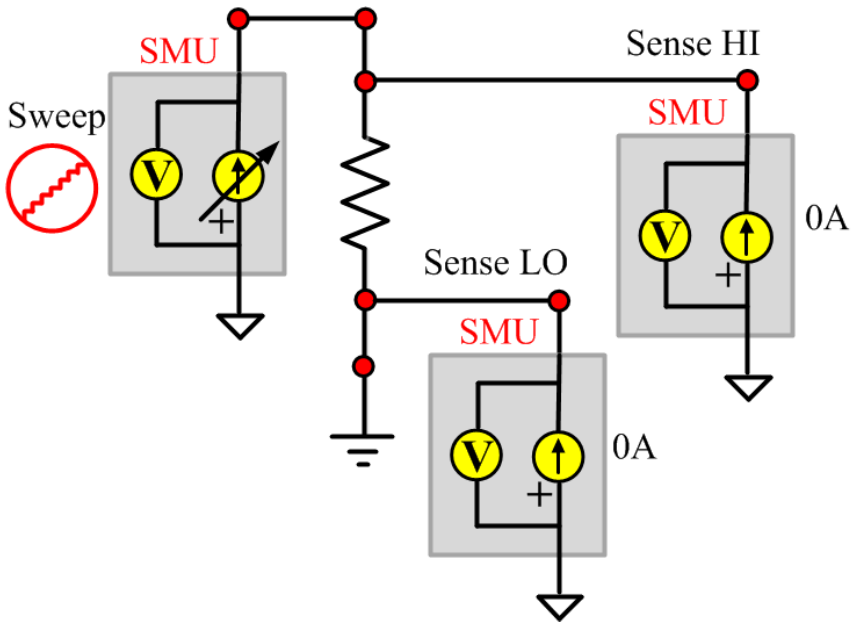
Module Name: Sweep_VI_4SMU

DUT: Four-terminal generic device

Function: Measure resistance during a current sequence.

Pin connections: One SMU can be used. Any Series 2400 or Series 2600B instrument is capable of forcing and sensing (see next figure).

Figure 198: Four_term_resistor_sweep_VI_4SMU pin connection



Sweep_VI_4SMU ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

Sweep_VI_4SMU General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

TRIAC parametric library

TRIAC parametric overview

The TRIAC library components are located in the following directory:
\\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.

TRIAC parametric library

IDRM

Description:

Module Name: IDRM

Module Type: ITM

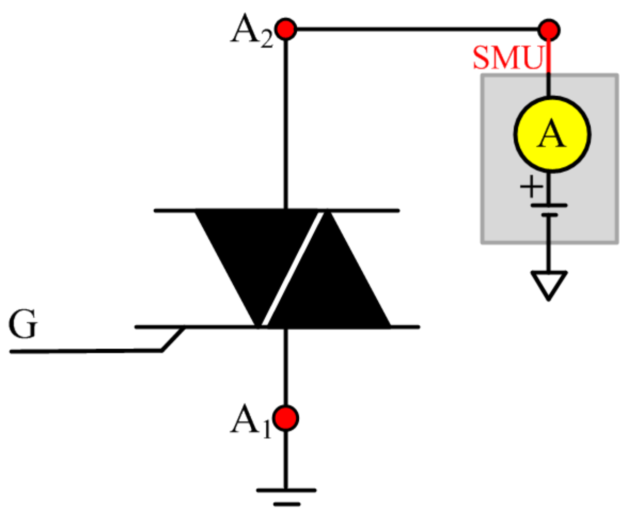
Instrument: KI2657A

DUT: Three-terminal TRIAC

Function: Determines 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 Connection: One SMU is used. The SMU applies voltage and measures current between terminals A2 (or MT2) to A1 (or MT1) with the Gate open.

Figure 199: TRIAC IDRM pin connection



IGT

Description:

Module Name: IGT

Module Type: ITM

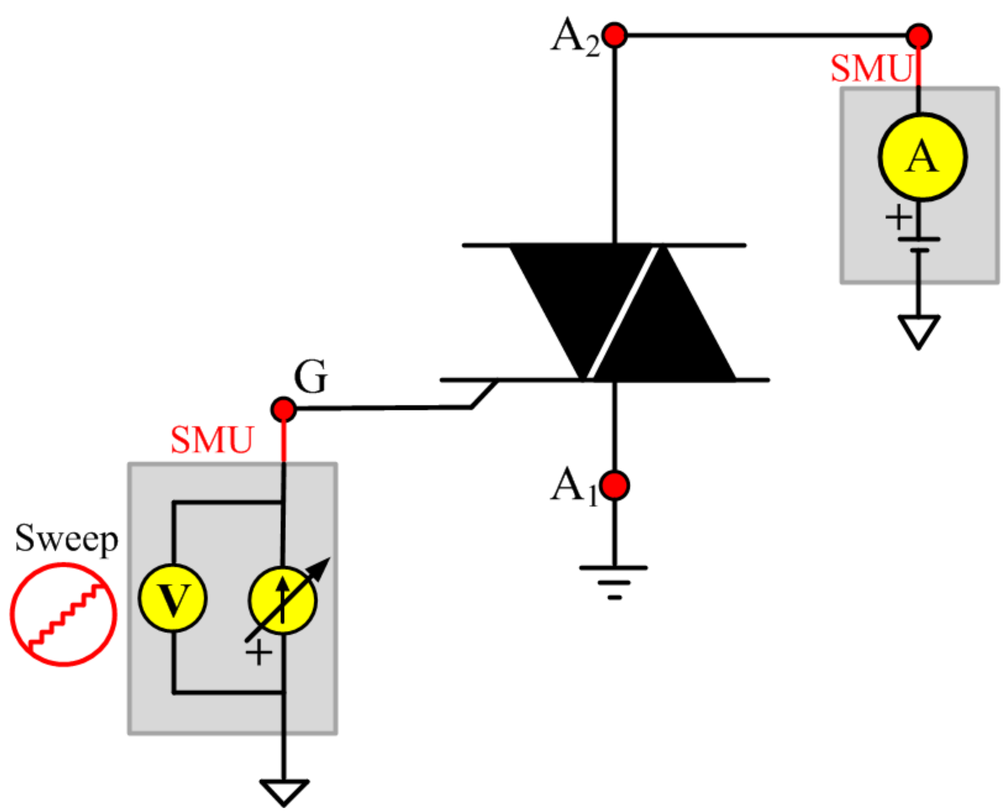
Instrument: KI2651A, KI2600B

DUT: Three-terminal TRIAC

Function: Determines the Gate trigger current. Measures the minimum current required between the Gate and cathode (MT1) to turn on the device.

Pin Connection: Two SMUs are used. One SMU applies a specified voltage and measures the current between terminals A2 (or MT2) to A1 (or MT1). The other SMU applies voltage and measures current between the Gate and cathode (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 200: TRIAC IGT pin connection



IHneg

Description:

Module Name: IHneg

Module Type: ITM

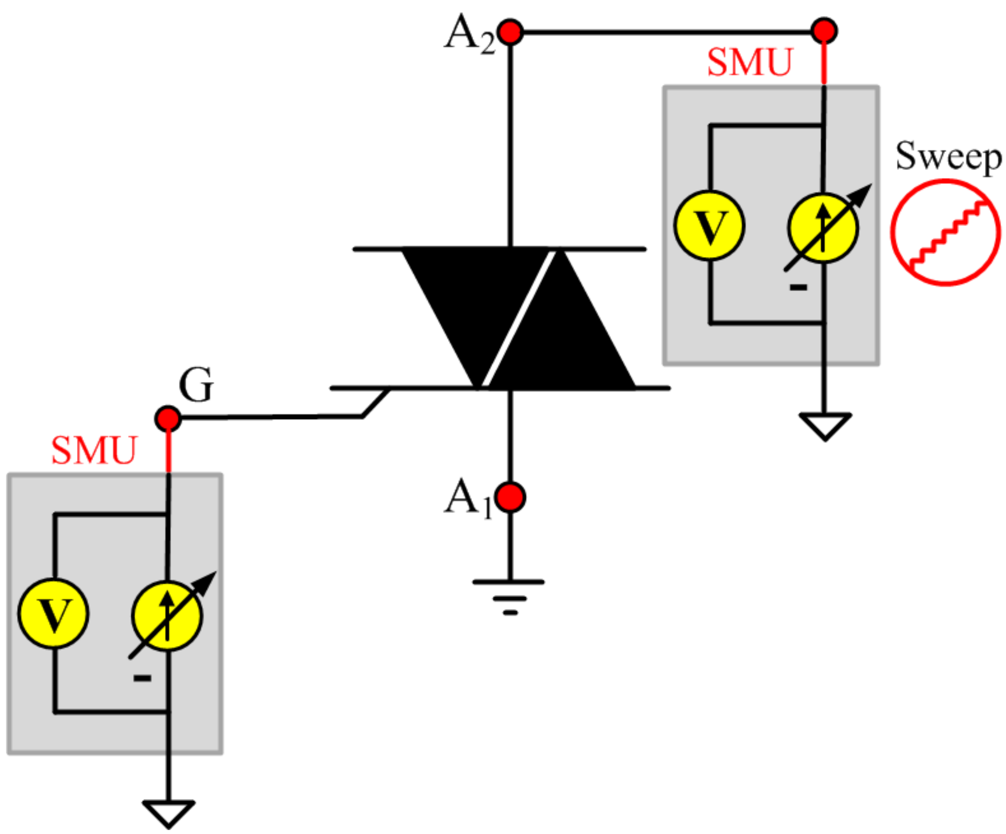
Instrument: KI2651A, KI2600B

DUT: Three-terminal TRIAC

Function: Determines the holding current. Measures the minimum current across the main terminals to keep the device in the on-state.

Pin Connection: Two SMUs are used. One SMU applies current between terminals A2 (or MT2) to A1 (or MT1). The other SMU applies a specified current between the Gate and cathode (MT1).

Figure 201: TRIAC IHneg pin connection



IHpos

Description:

Module Name: IHpos

Module Type: ITM

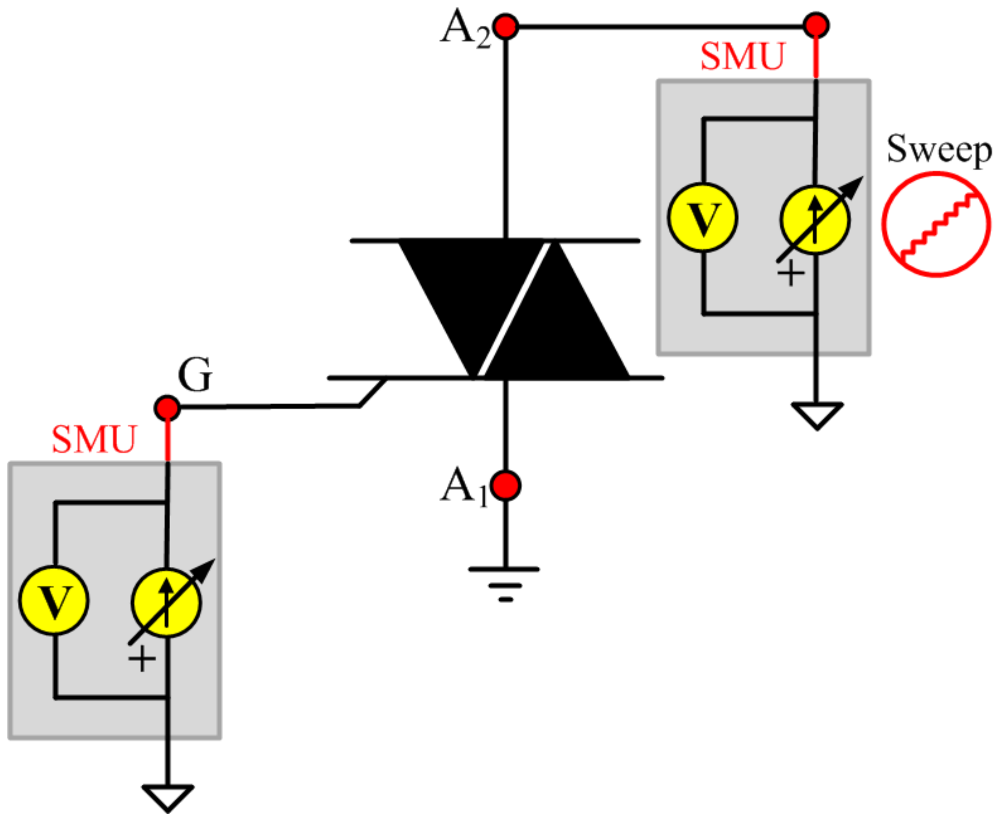
Instrument: KI2651A, KI2600B

DUT: Three-terminal TRIAC

Function: Determines the holding current. Measures the minimum current across the main terminals to keep the device in the on-state.

Pin Connection: Two SMUs are used. One SMU applies current between terminals A2 (or MT2) to A1 (or MT1). The other SMU applies a specified current between the Gate and cathode (MT1).

Figure 202: TRIAC IHpos pin connection



ILneg

Description:

Module Name: ILneg

Module Type: ITM

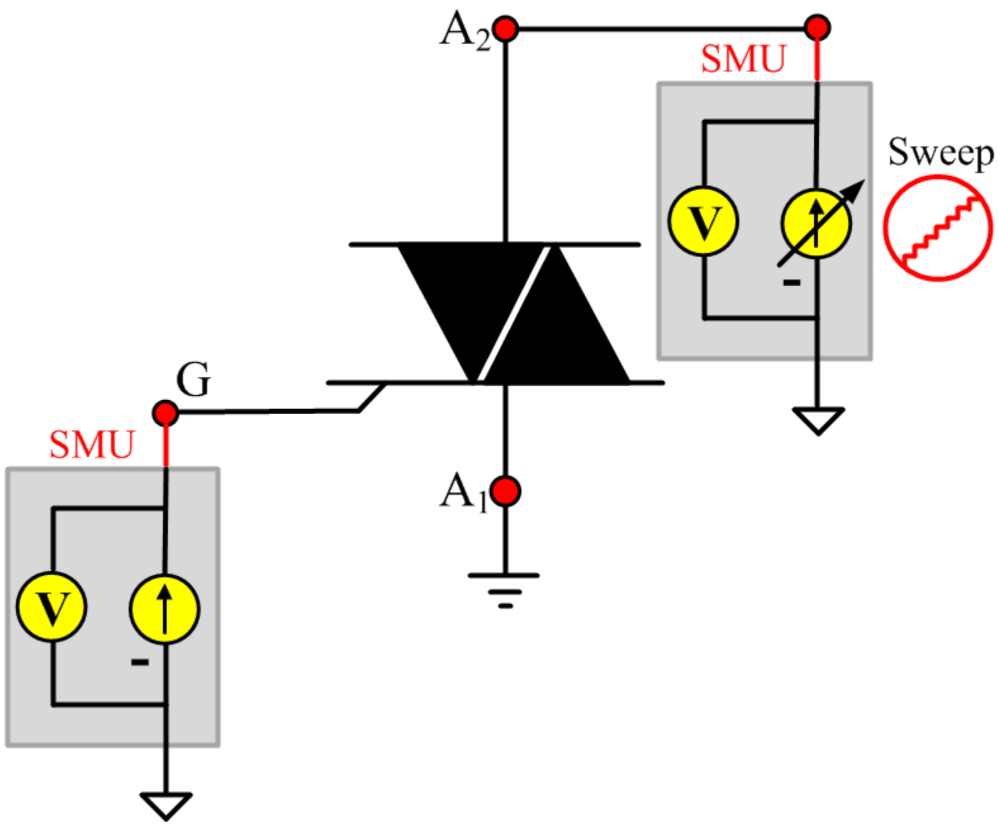
Instrument: KI2651A, KI2600B

DUT: Three-terminal TRIAC

Function: Determines 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 Connection: Two SMUs are used. One SMU applies current between terminals A2 (or MT2) to A1 (or MT1). The other SMU applies a specified current between the Gate and cathode (MT1).

Figure 203: TRIAC ILneg pin connection



ILpos

Description:

Module Name: ILpos

Module Type: ITM

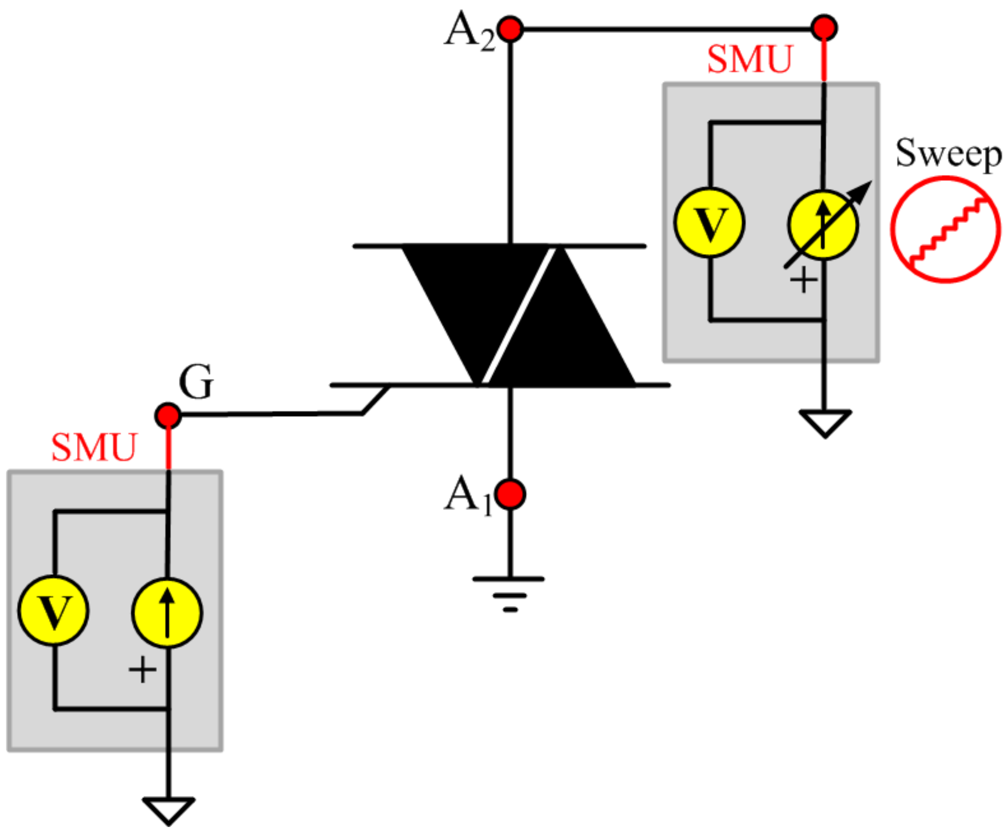
Instrument: KI2651A, KI2600B

DUT: Three-terminal TRIAC

Function: Determines 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 Connection: Two SMUs are used. One SMU applies current between terminals A2 (or MT2) to A1 (or MT1). The other SMU applies a specified current between the Gate and cathode (MT1).

Figure 204: TRIAC ILpos pin connection



IRRM

Description:

Module Name: IRRM

Module Type: ITM

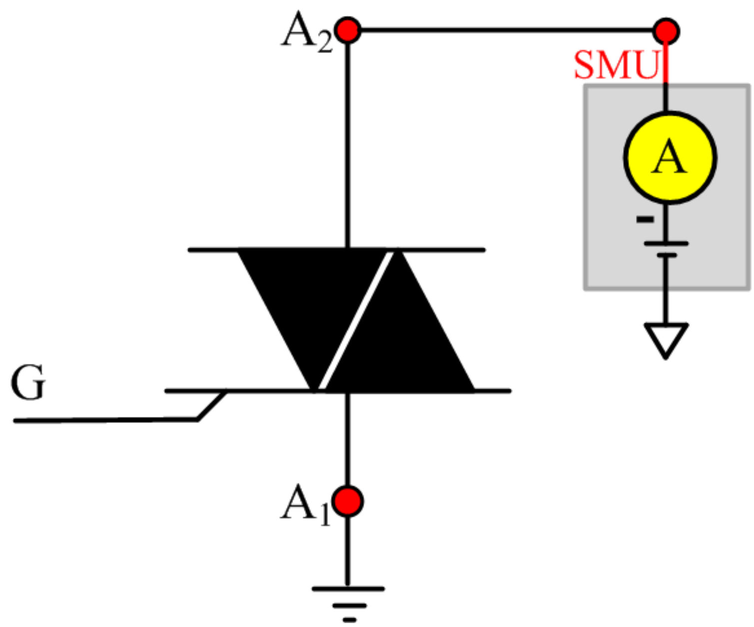
Instrument: KI2657A

DUT: Three-terminal TRIAC

Function: Determines 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 Connection: One SMU is used. The SMU applies voltage and measures current between terminals A2 (or MT2) to A1 (or MT1) with the Gate open.

Figure 205: TRIAC IRRM pin connection



VGT

Description:

Module Name: VGT

Module Type: ITM

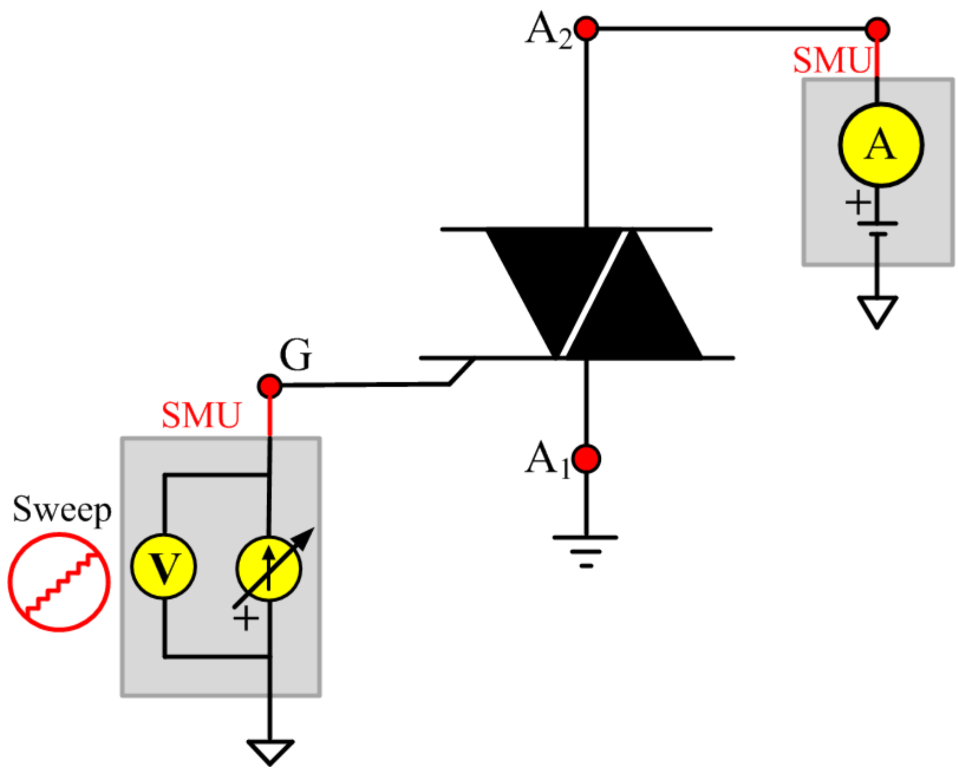
Instrument: KI2651A, KI2600B

DUT: Three-terminal TRIAC

Function: Determines the Gate trigger voltage. Measures the minimum voltage required between the Gate and cathode in order to reach the Gate trigger current and then to trigger the device.

Pin Connection: Two SMUs are used. One SMU applies a specified voltage and measures current between terminals A2 (or MT2) to A1 (or MT1). The other SMU applies voltage and measures current between the Gate and cathode (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 206: TRIAC VGT pin connection



VTneg

Description:

Module Name: VTneg

Module Type: ITM

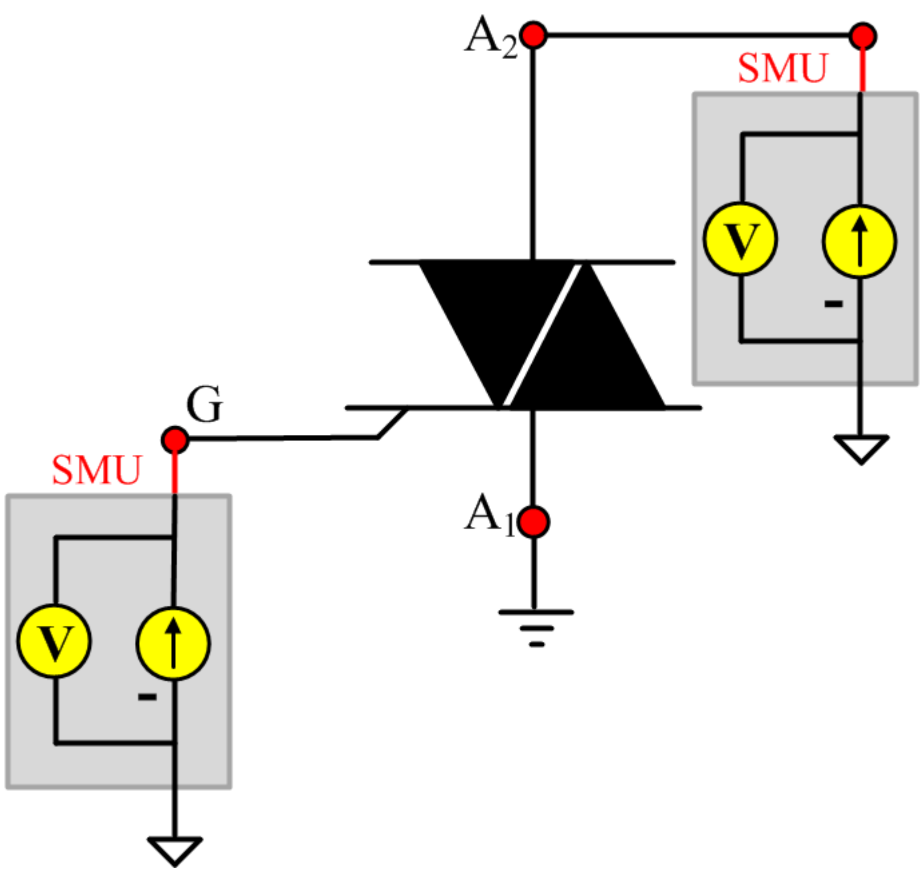
Instrument: KI2651A, KI2600B

DUT: Three-terminal TRIAC

Function: Determines 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 Connection: 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 207: TRIAC VTneg pin connection



VTpos

Description:

Module Name: VTpos

Module Type: ITM

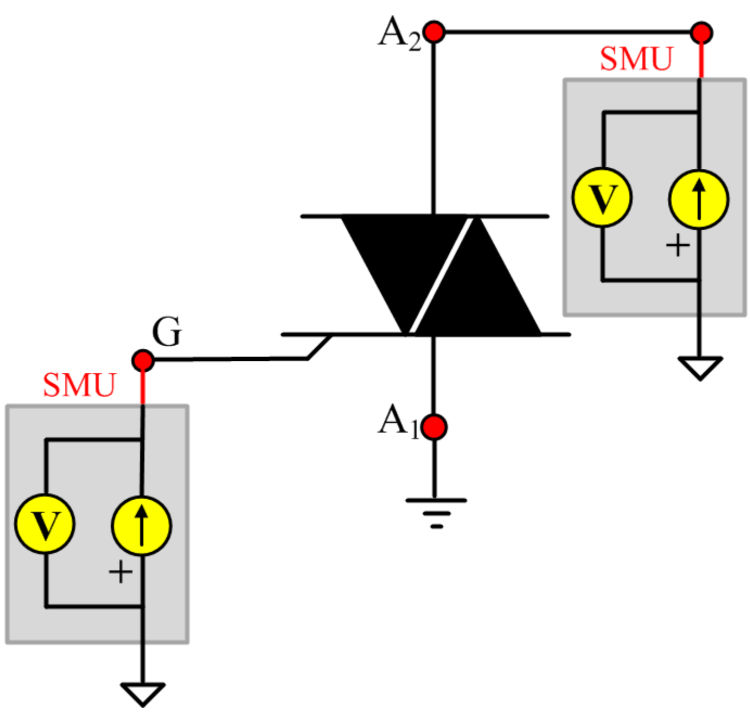
Instrument: KI2651A, KI2600B

DUT: Three-terminal TRIAC

Function: Determines 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 Connection: 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 208: TRIAC VTpos pin connection



Zener parametric library

Zener parametric overview

The ZENER library components are located in the following directory:
\\ACS_BASIC\library\devLibrary\ZENER

The ZENER parametric library is used to test parameters of a ZENER device, including leakage, on-state, and breakdown properties.

Zener parametric library

BVZ

Description:

Module Name: BVZ

Module Type: ITM

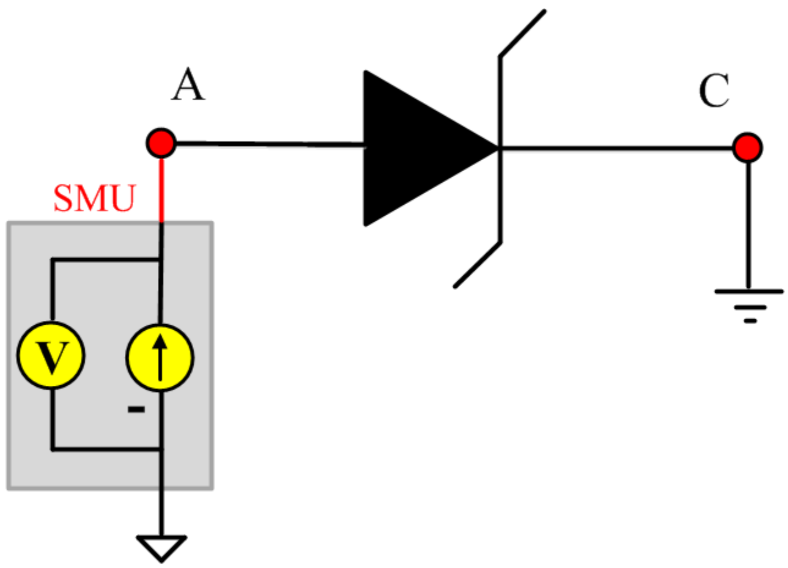
Instrument: KI2600B

DUT: Two-terminal ZENER

Function: Determines the regulator voltage from the cathode to anode at the maximum rated current that is given in the data sheet.

Pin Connection: One SMU used. The SMU applies a negative current (IZM) and takes voltage measurements from the anode to cathode.

Figure 209: ZENER BVZ pin connection



IR

Description:

Module Name: IR

Module Type: ITM

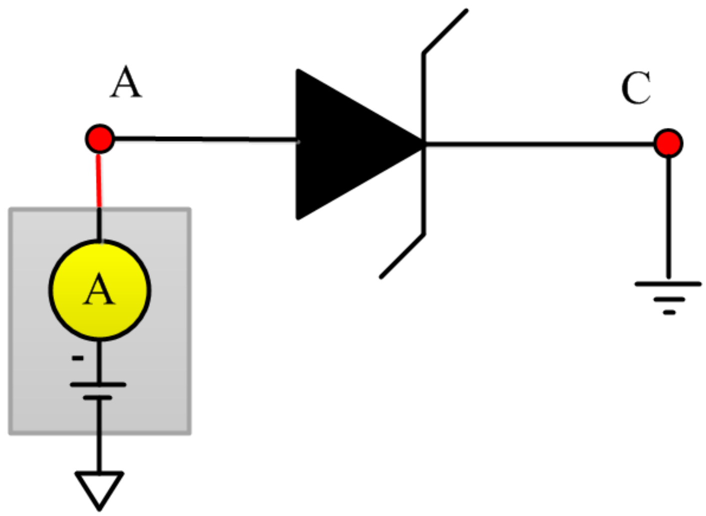
Instrument: KI2600B

DUT: Two-terminal ZENER

Function: Determines the reverse leakage current at a specific reverse voltage from the cathode to anode that is given in the data sheet.

Pin Connection: One SMU used. The SMU applies a negative voltage and takes current measurements from the anode to cathode.

Figure 210: ZENER IR pin connection



VF

Description:

Module Name: VF

Module Type: ITM

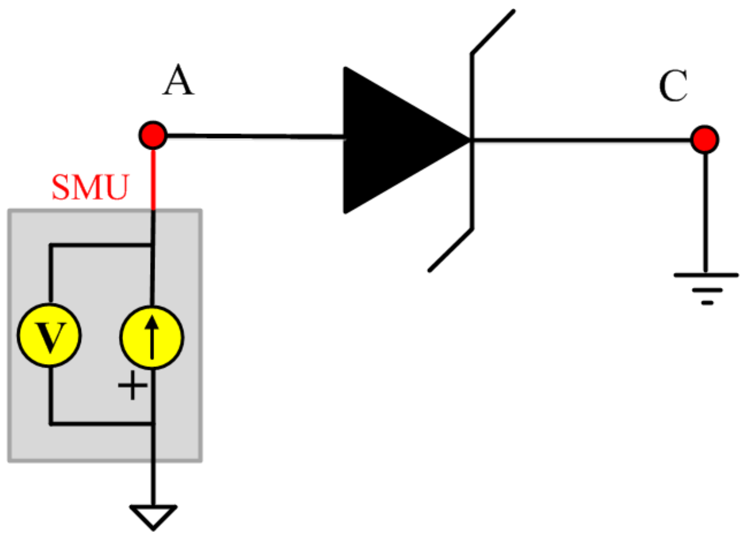
Instrument: KI2600B

DUT: Two-terminal ZENER

Function: Determines the forward voltage at a specific forward current from the anode to cathode.

Pin Connection: One SMU used. The SMU applies a positive current and takes voltage measurements from the anode to cathode.

Figure 211: ZENER VF pin connection



Capacitor WLR script library

Capacitor WLR script overview

The WLR script components are located in the following directory:
\\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

Capacitor WLR script library

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`	--max 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

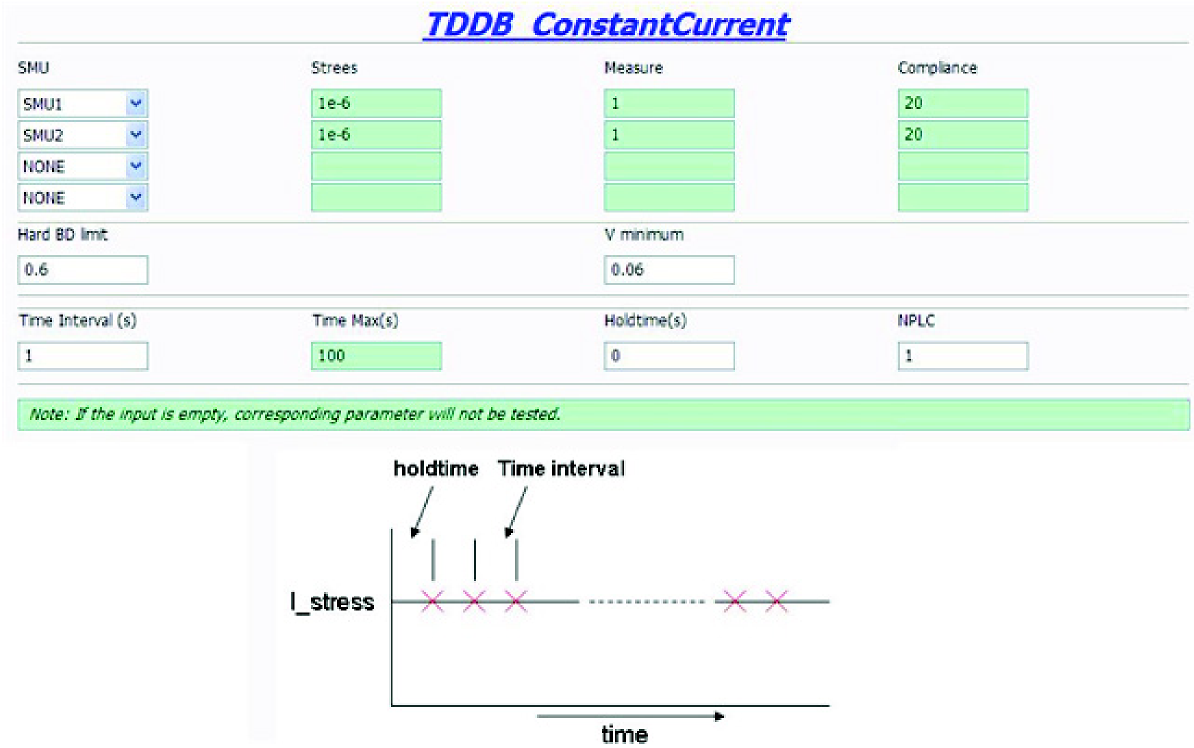
OUTPUTS:

`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 212: GUI for TDDB_CCS



TDDB CCS 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.

Hard BD limit & V minimum: Set the hard breakdown limit and voltage minimum. The unit is volts.

Time: Time Max can be left empty. In this case, the test will continue 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`	--max 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 (Unit:s)
`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 corrensponding 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 corrensponding 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 corrensponding 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 corrensponding 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 213: TDDB sequence

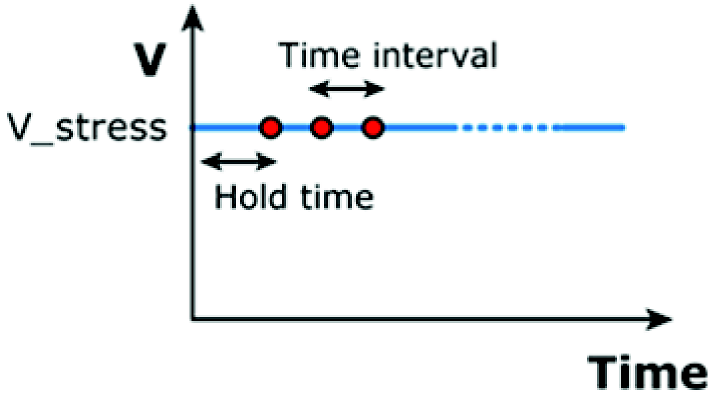
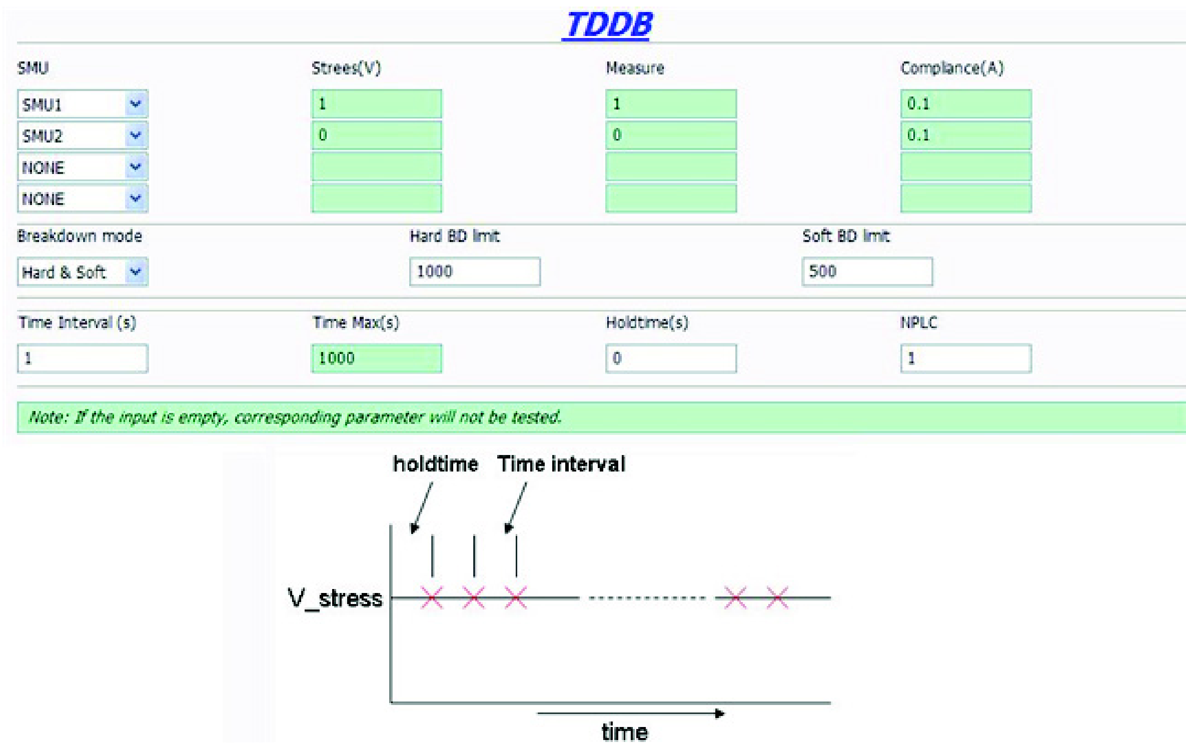


Figure 214: GUI for TDDB per pin



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 is capable of a maximum current of +/- 1A 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

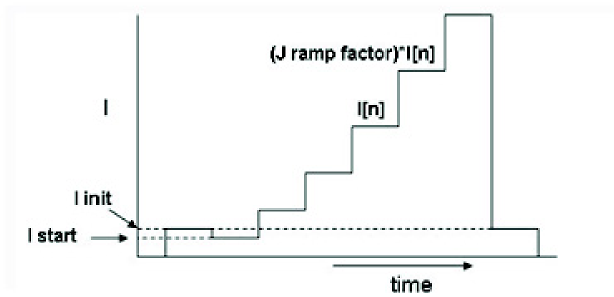
--(-6): non-Catastrophic Failure

--(-7): Invalid specified t_step

GUI related:

The next figure shows the QBD Ramp J GUI and illustrates the testing method.

Figure 215: 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 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 is capable of 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

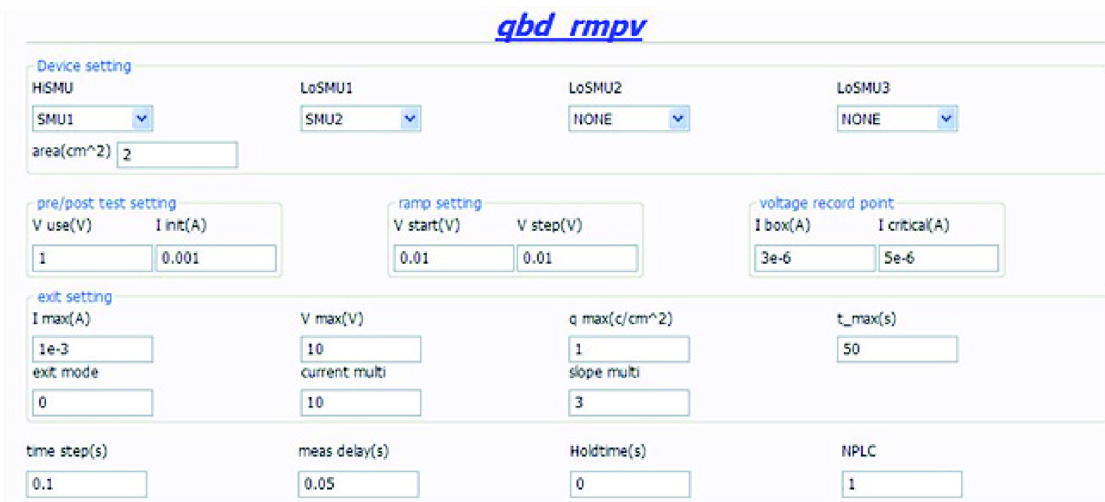
--(-6): non-Catastrophic Failure

--(-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 216: 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 library

Common library introduction

ACS Basic has a common library, including the CV test, matrix control, and scope control. All test modules in the Common Library can be added to any device. You can also build a common library to import and use.

Common library

CV_HP4284

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.

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 (string):`	Instrument name defined in syscon.kcf file.
`force_func (int):`	0: bias, 1: sweep.
`preSoak (double):`	Force voltage after test start and before measurement sequence. Unit: V.
`v_bias (double):`	Force value for the bias. Unit: V.
`v_biasPts (int):`	The number of bias points.
`v_start (double):`	Initial force value for the sweep (-40V to 40V). Unit: V.
`v_stop (double):`	Final force value for the sweep (-40V to 40V). Unit: V.
`v_step (double):`	Step force value for the sweep (-40V to 40V). Unit: V.
`hold_time (double):`	Hold time after force value changed. Unit: seconds.
`delay_time (double):`	Delay before each measurement (0 to 999s). Unit: seconds.
`Speed (string):`	Measurement time setting.
`freq_bias (double):`	Frequency of the AC drive for normal measurement. Valid value is from 20 Hz to 2MHz.
`vAC (double):`	The oscillator output voltage level, the valid input is 5mV to 20V. 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 (float):`	Cable length setting for connect compensation. Unit: meter. When you do not need compensation, cable length should be assigned to 0.

`isCmpstOpen (bool):`	Enable or disable compensation constants for open.
`isCmpstShort (bool):`	Enable or disable compensation constants for Short.
`isCmpstLoad (bool):`	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.
`return dictionary:`	
`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 217: CV_HP4284 setting example

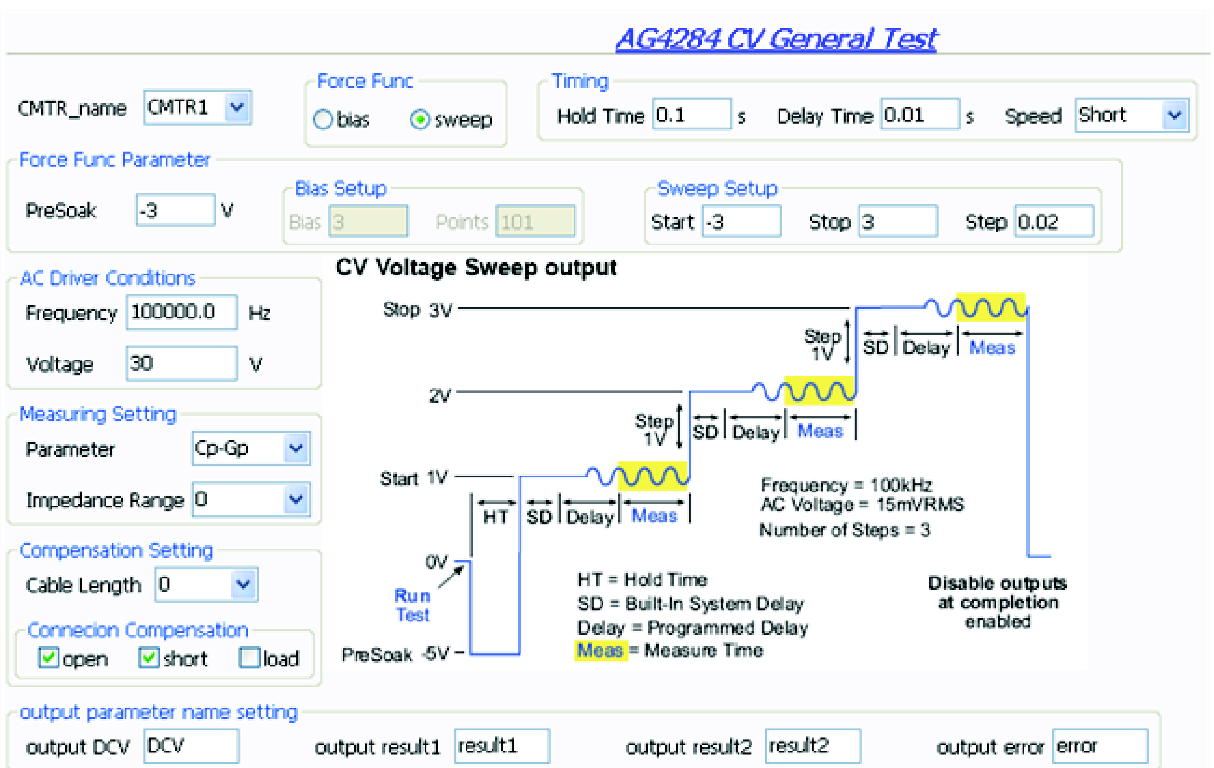
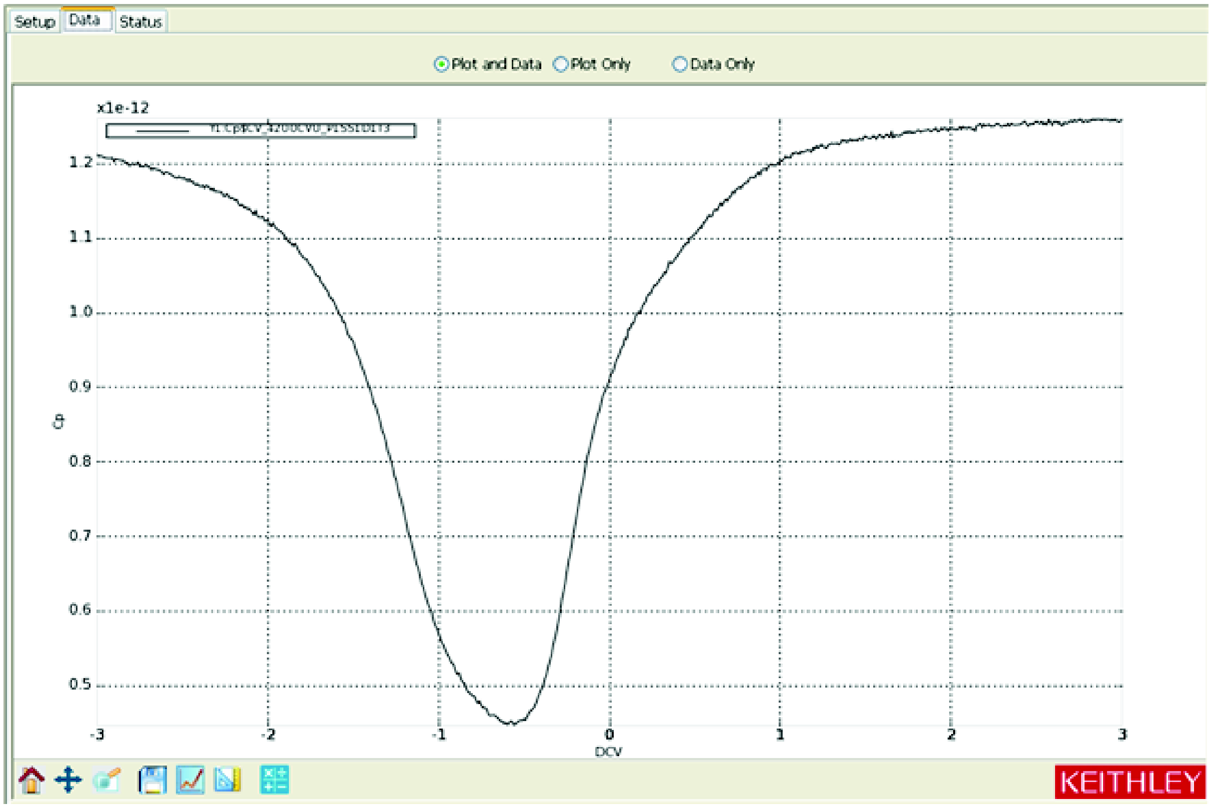


Figure 218: CV_HP4284 Data Tab



CV_4200CVU

Description:

Tests the capacitive parameters at a specified frequency and voltage of the AC drive, with measurements at the DC voltage bias or sweep using a Model 4200-CVU.

Syntax:

```
CVITM.cv42CVU(CVU_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:

`CVU_name (string):`	Instrument ID of the Model 4200-CVU: CVU1.
`force_func (string):`	0: bias, 1: sweep.
`preSoak (double):`	Force voltage after test start and before measurement sequence. Unit: V.
`v_bias (double):`	Force value for the bias. Unit: V.
`v_biasPts (int):`	The number of bias points.
`v_start (double):`	Initial force value for the sweep (0.001V to 30V). Unit: V.
`v_stop (double):`	Final force value for the sweep (-30V to 30V). Unit: V.
`v_step (double):`	Step force value for the sweep (-30V to 30V). Unit: V.
`hold_time (double):`	Hold time after force value changed. Unit: second.
`delay_time (double):`	Delay before each measurement (0 to 999s). Unit: second.
`Speed (int):`	KI_CVU_SPEED_FAST = 0 KI_CVU_SPEED_NORMAL = 1 KI_CVU_SPEED_QUIET = 2
`freq_bias (double):`	Frequency of the AC drive. Supported frequency: 10kHz to 100kHz in 10kHz steps, 100kHz to 1MHz in 100kHz steps, 1MHz to 10MHz in 1MHz steps. If an entered value is not a supported frequency, the closest supported frequency will be selected (for example, 15kHz input will select 20kHz). Unit: Hz.
`V AC (double):`	Voltage level of the AC drive (10mV to 100mVRMS). Unit: mVRMS
`measParam:`	Valid input ['Z,Theta', 'R+jx', 'Cp-Gp', 'Cs-Rs', 'Cp-D', 'Cs-D'] 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
`measRange:`	Current measure range for impedance measurements. Setting range to zero selects auto range.
`cableLength (float):`	Cable length setting for connect compensation. unit: meter. Values from zero to 3 are valid, but only 0, 1.5, and 3 are supported lengths. Any other number from zero to 3 will be changed to one of the three values. When you do not need compensation, cable length should be assigned to zero.

`isCmpstOpen (bool):`	Enable or disable compensation constants for open.
`isCmpstShort (bool):`	Enable or disable compensation constants for Short.
`isCmpstLoad (bool):`	Enable or disable compensation constants for Load.

OUTPUTS:

Error list:

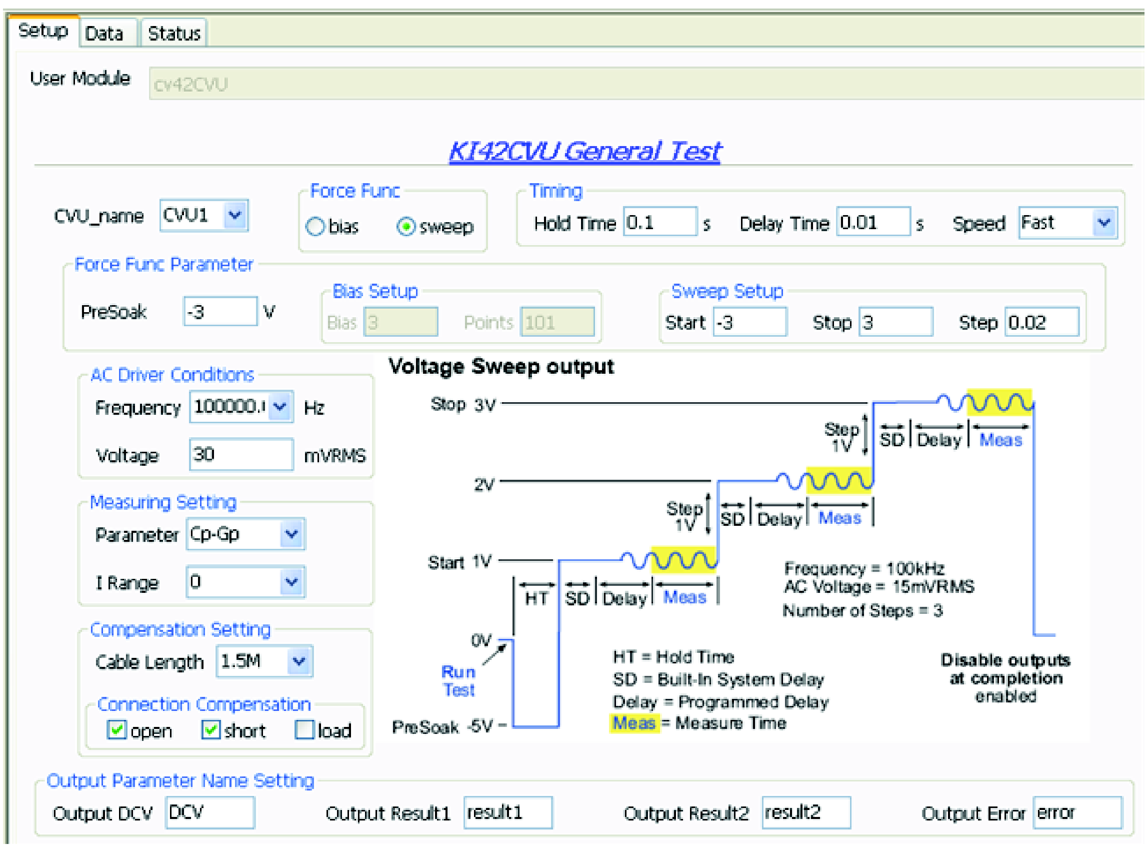
`0:`	OK.
`-10000:`	Specified CVU does not exist.
`-10001:`	(INVAL_PARAM) Parameter setting error occurred.
`-10090:`	(GPIB_ERROR_OCCURED) A GPIB communications error occurred.

`return dictionary:`

`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 219: CV_4200CVU setting example



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.

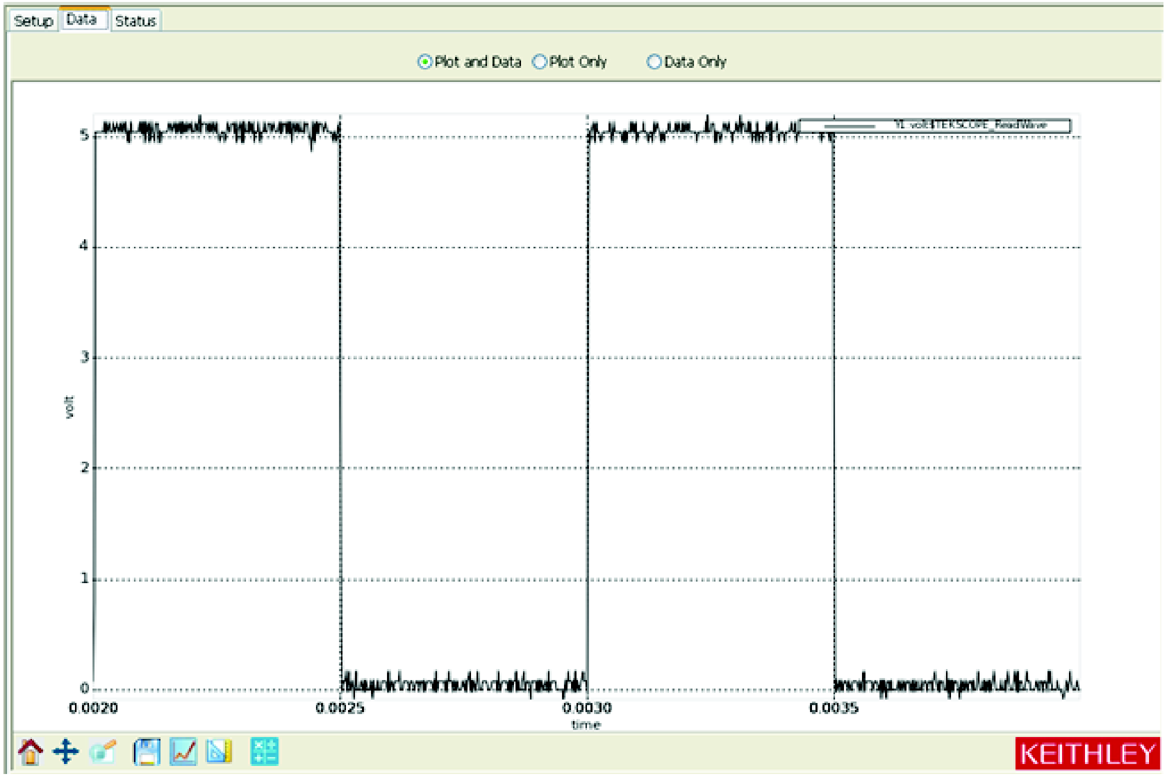
Known issues: Returns 2 bytes of binary data.

Instrument: TEKSCOPE

GUI related:

Figure 220: Waveform reading GUI

Figure 221: Waveform reading data



KI23X_BiasVSampleI

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.

INPUTS:

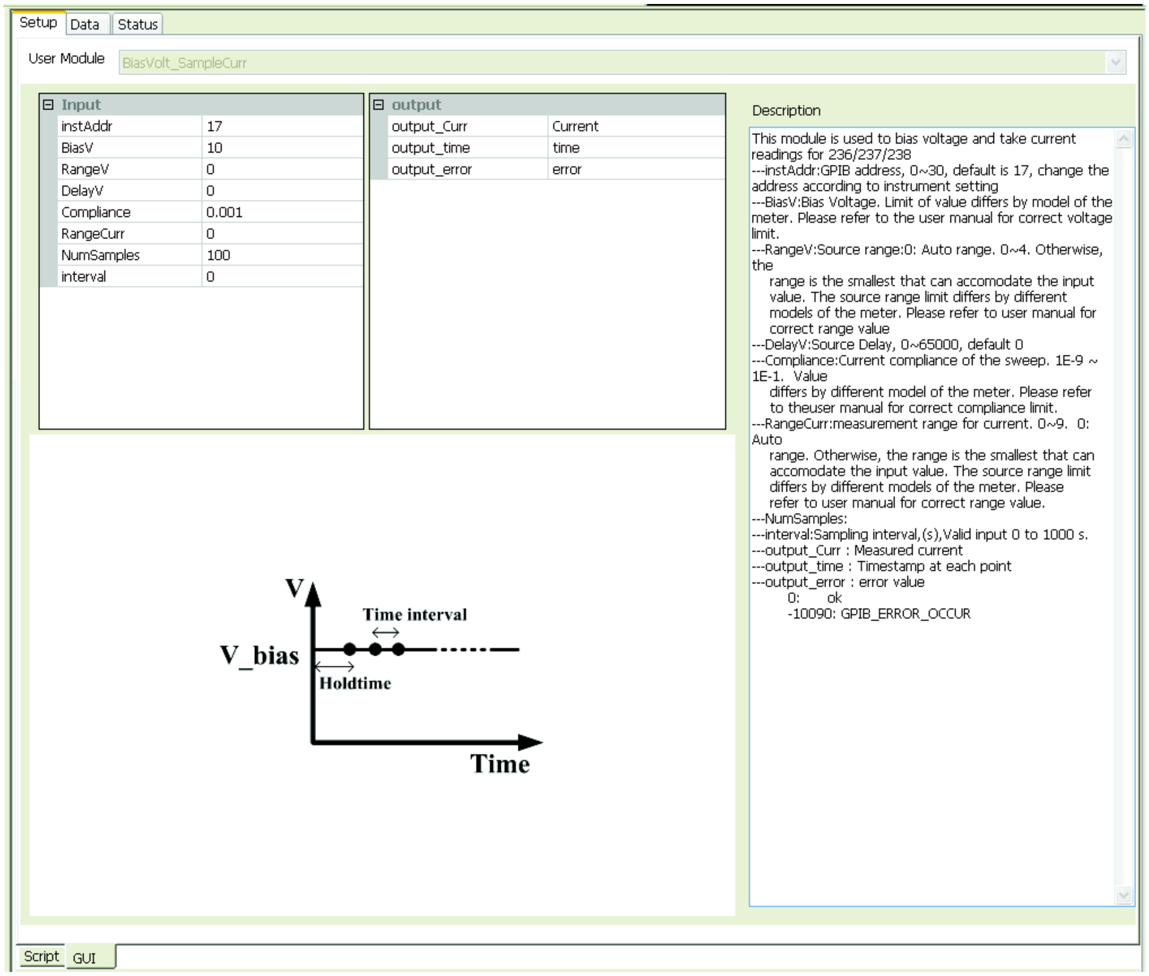
`instAddr:`	GPIB address, 0 through 30, default is 17, change the address according to instrument setting.
`BiasV:`	Bias Voltage. Limit of value differs by model of the meter.
`RangeV:`	Source range: 0. Auto range. 0 through 4. Otherwise, the range is the smallest that can accommodate the input value. 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: Auto range. Otherwise, the range is the smallest that can accommodate the input value. The Source range limit differs by model of the meter.
`NumSamples:`	
`interval:`	Sampling interval,(s),Valid input 0 to 1000 s.

OUTPUTS:

`output_Curr:`	Measured current
`output_time:`	Timestamp at each point
`output_error:`	Error value
`0`	OK
`-10090`	(GPIB_ERROR_OCCURRED) A GPIB communications error occurred.

GUI related:

Figure 222: KI23X_BiasVSampleI standard GUI



KI23X_SweepI

Description:

Sweeps current and takea I/V/Time readings for the Model 236, 237, or 238.

Instrument: Keithley Models 236, 237, and 238 Source measure units.

INPUTS:

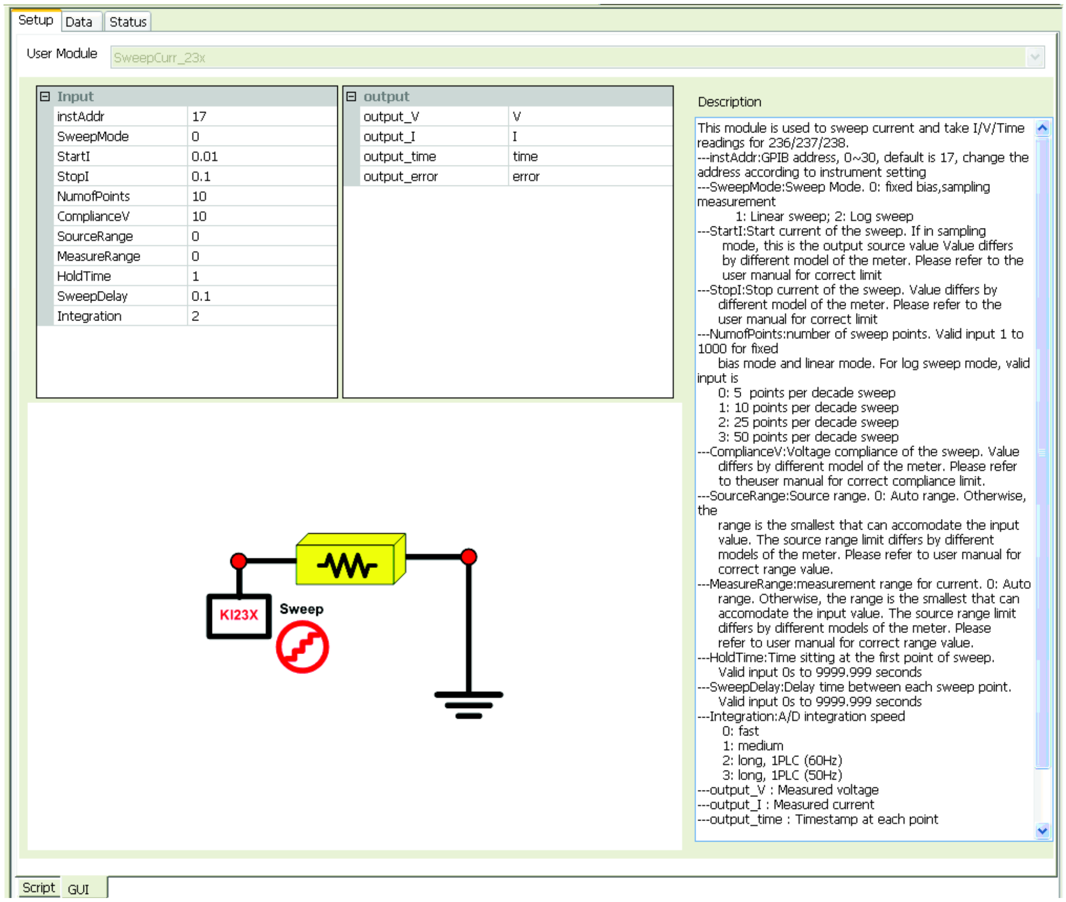
`instAddr`:	GPIB address, 0 through 30, default is 17; change the address according to instrument setting.
`SweepMode`:	Sweep Mode. 0: fixed bias, sampling measurement 1: Linear sweep; 2: Log sweep.
`StartI`:	Start current of the sweep. If in sampling mode, this is the output Source value. Value differs 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: Auto range. 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: Auto range. 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 0s to 9999.999 seconds.
`SweepDelay`:	Delay time between each sweep point. Valid input 0s to 9999.999 seconds.
`Integration`:	A/D integration speed: 0: fast 1: medium 2: long, 1PLC (60Hz) 3: long, 1PLC (50Hz)

OUTPUTS:

`output_V`:	Measured voltage
`output_I`:	Measured current
`output_time`:	Timestamp at each point
`output_error`:	Error value 0: OK -10090: GPIB_ERROR_OCCUR -10100: INVAL_PARAM

GUI Related:

Figure 223: KI23X_SweepI standard GUI



KI23X_SweepV

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.

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. Limit of 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
`ComplianceI`:	Current compliance of the sweep. Value differs by different model of the meter.
`SourceRange`:	Source range. 0: Auto range. 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: Auto range. 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 0s to 9999.999 seconds.
`SweepDelay`:	Delay time between each sweep point. Valid input 0s to 9999.999 seconds.
`Integration`:	A/D integration speed: 0: fast 1: medium 2: long, 1PLC (60Hz) 3: long, 1PLC (50Hz)

OUTPUTS:

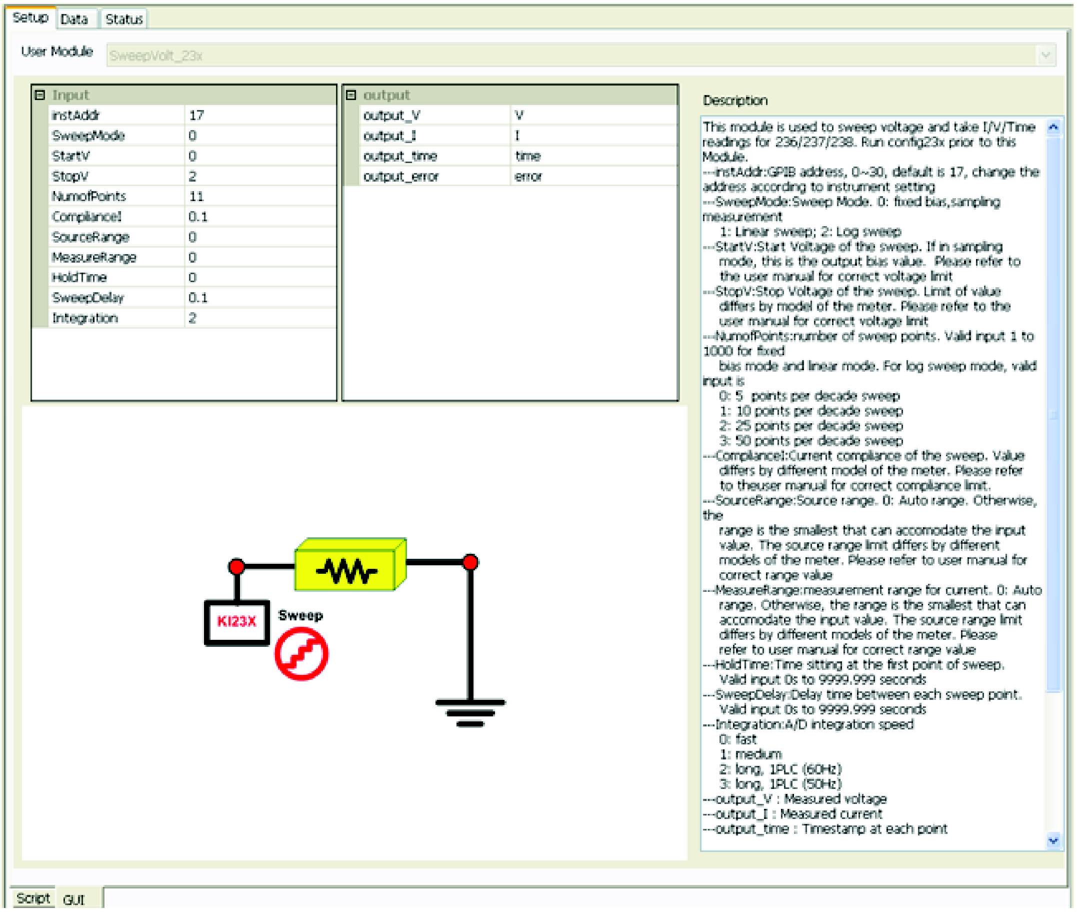
`output_V`:	Measured voltage
`output_I`:	Measured current
`output_time`:	Timestamp at each point
`output_error`:	Error value 0 OK. -1 23x not found on GPIB -10000 (INVAL_INST_ID) The specified instrument ID does not exist.

-10090 (GPIB_ERROR_OCCURRED) A GPIB communications error occurred.

-10091 (GPIB_TIMEOUT) A timeout occurred during communications.

-10100 (Invalid Parameter) An error occurred on an input parameter.

GUI Related:



KI237_VdsId

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.

Device connection:

Drain: KI237

Gate, sub, well: Each corresponds with a SMU (for example, SMU1, SMU2, etc. or SMU8 of in the Model 4200).

INPUTS:

`instAddr`:	GPIB address of 237. Valid from 0 through 30.
`GateSMU`:	The system terminal is attached to the Gate of the MOS-FET. If 'GNDU' is chosen, the terminal should be connected to GND manually.
`SourceSMU`:	The system terminal is attached to the Source of the MOS-FET. If 'GNDU' is chosen, the terminal should be connected to GND manually.
`SubSMU`:	The system terminal is attached to the sub of the MOS-FET. If 'GNDU' is chosen, the terminal should be connected to GND manually.
`WellSMU`:	The system terminal is attached to the well of the MOS-FET. If 'GNDU' is chosen, the terminal should be connected to GND manually; if there is not a 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 Limitation on measured sites in Ampere.
`Integration`:	A/D integration speed: 0: fast 1: medium 2: long, 1PLC (60Hz) 3: long, 1PLC (50Hz)
`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_OCCURRED) A GPIB communications error occurred.

-10091 (GPIB_TIMEOUT) A timeout occurred during communications.

-10100 (Invalid Parameter) An error occurred on an input parameter

GUI related:

Figure 224: KI237_VdsId standard GUI

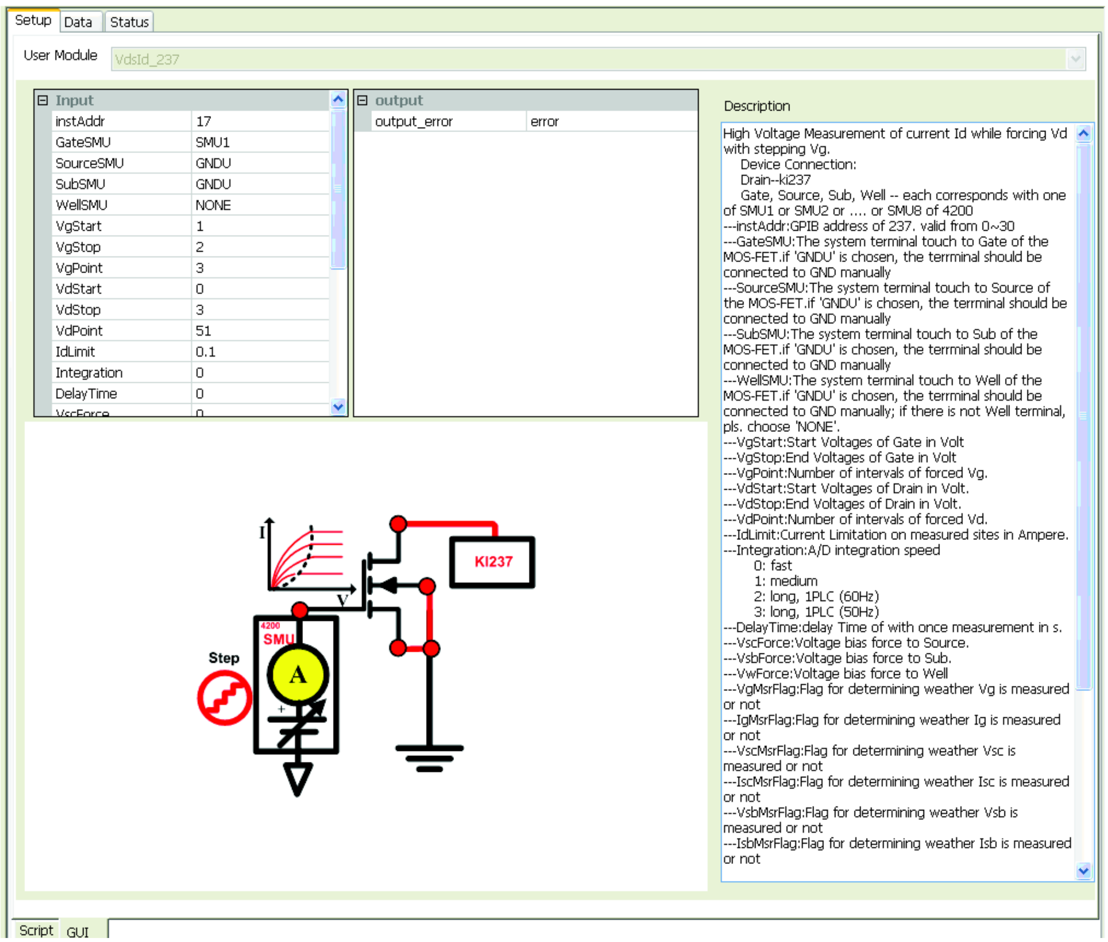
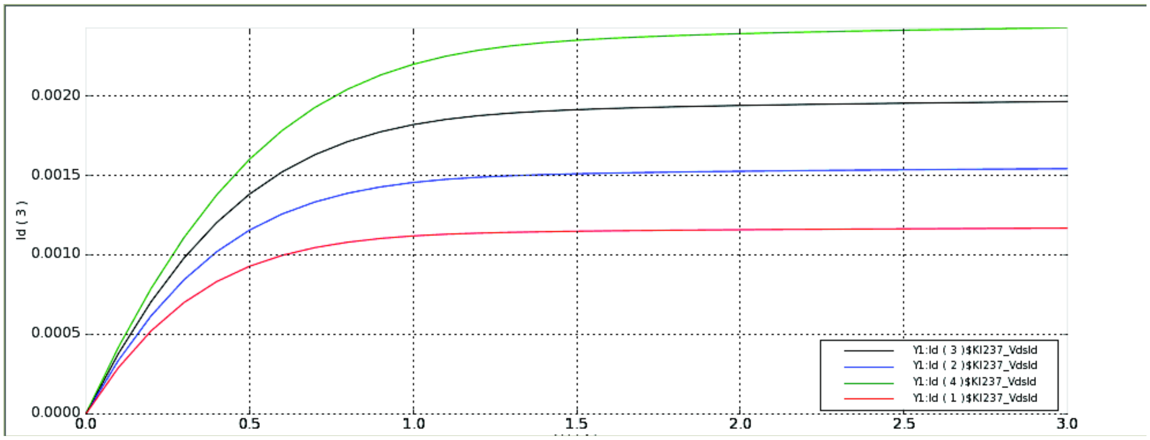


Figure 225: KI237_VdsId test result



KI24XX_BiasI_Pulse

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

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 0.15ms to 5ms.
`pulse_delay (double):`	Duration of the output OFF time. Unit: second. The valid value is from 0s to 9999.999s.
`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`

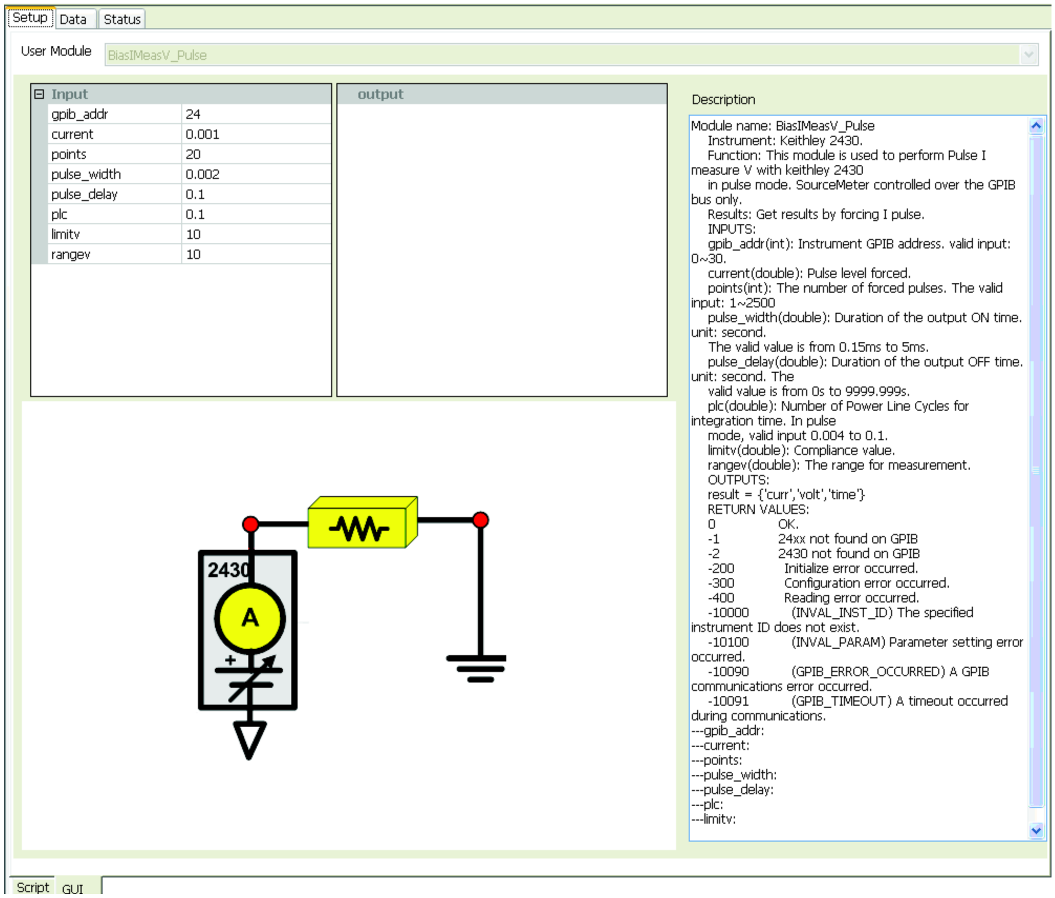
`time`

`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) Parameter setting error occurred.
-10090	(GPIB_ERROR_OCCURRED) A GPIB communications error occurred.
-10091	(GPIB_TIMEOUT) A timeout occurred during communications.

GUI related:

Figure 226: KI24XX_BiasI_Pulse standard GUI



KI24XX_BiasV_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: second. The valid value is from 0.15ms to 5ms.
`pulse_delay (double):`	Duration of the output OFF time. Unit: second. The valid value is from 0s to 9999.999s.
`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:

`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) Parameter setting error occurred.
-10090	(GPIB_ERROR_OCCURRED) A GPIB communications error occurred.
-10091	(GPIB_TIMEOUT) A timeout occurred during communications.

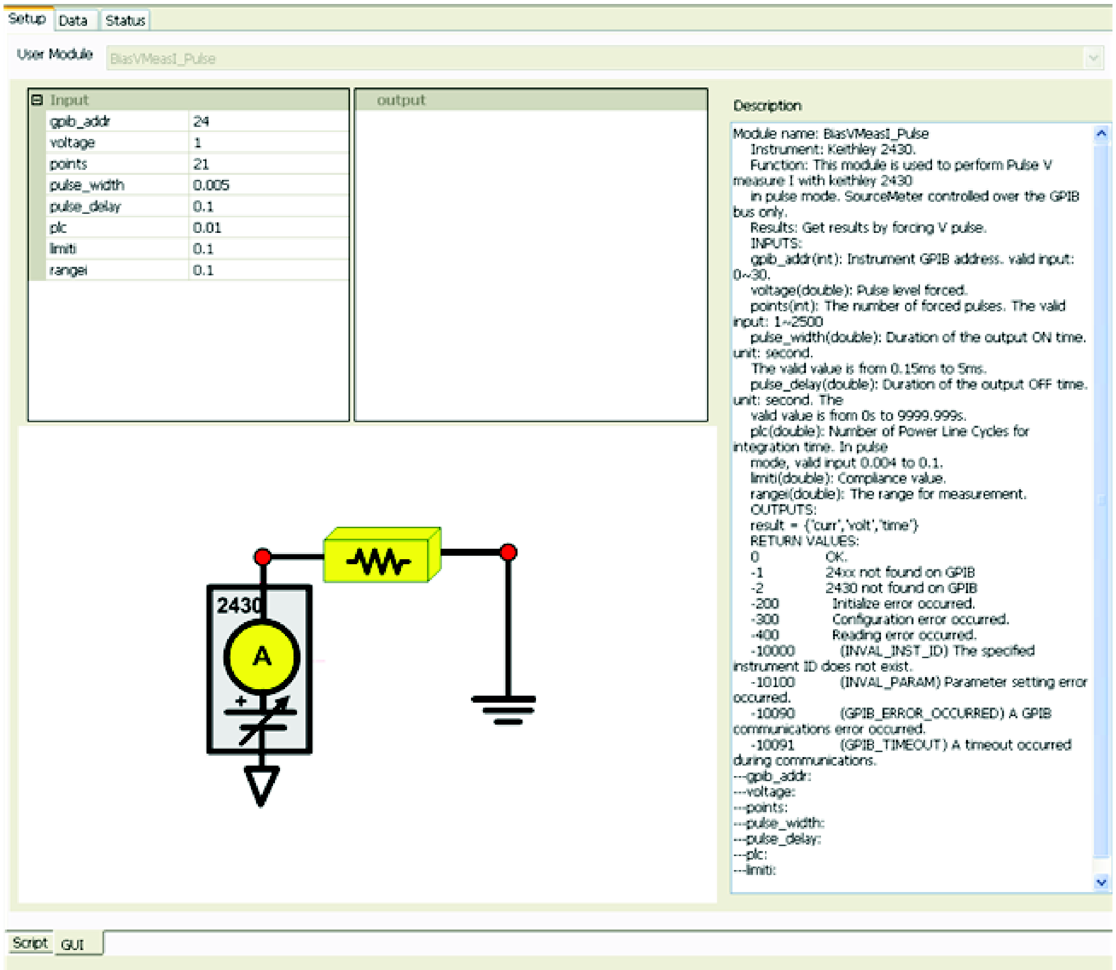
`time`

`I`

`V`

GUI related:

Figure 227: KI24XX_BiasV_Pulse standard GUI



KI24XX_IdVd

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 connection: 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, auto range 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.

OUTPUTS:

`Vd` (D_ARRAY_T) Drain voltage programmed.

`Id1` (D_ARRAY_T) Drain current measured at the 1st Gate bias voltage.

`Id2` (D_ARRAY_T) Drain current measured at the 2nd Gate bias voltage.

`Id3` (D_ARRAY_T) Drain current measured at the 3rd Gate bias voltage.

`Id4` (D_ARRAY_T) 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.
-10100	(INVAL_PARAM) Parameter setting error occurred.

-10090 (GPIB_ERROR_OCCURRED) A GPIB communications error occurred.
-10091 (GPIB_TIMEOUT) A timeout occurred during communications.

GUI related:

Figure 228: KI24XX_IdVd

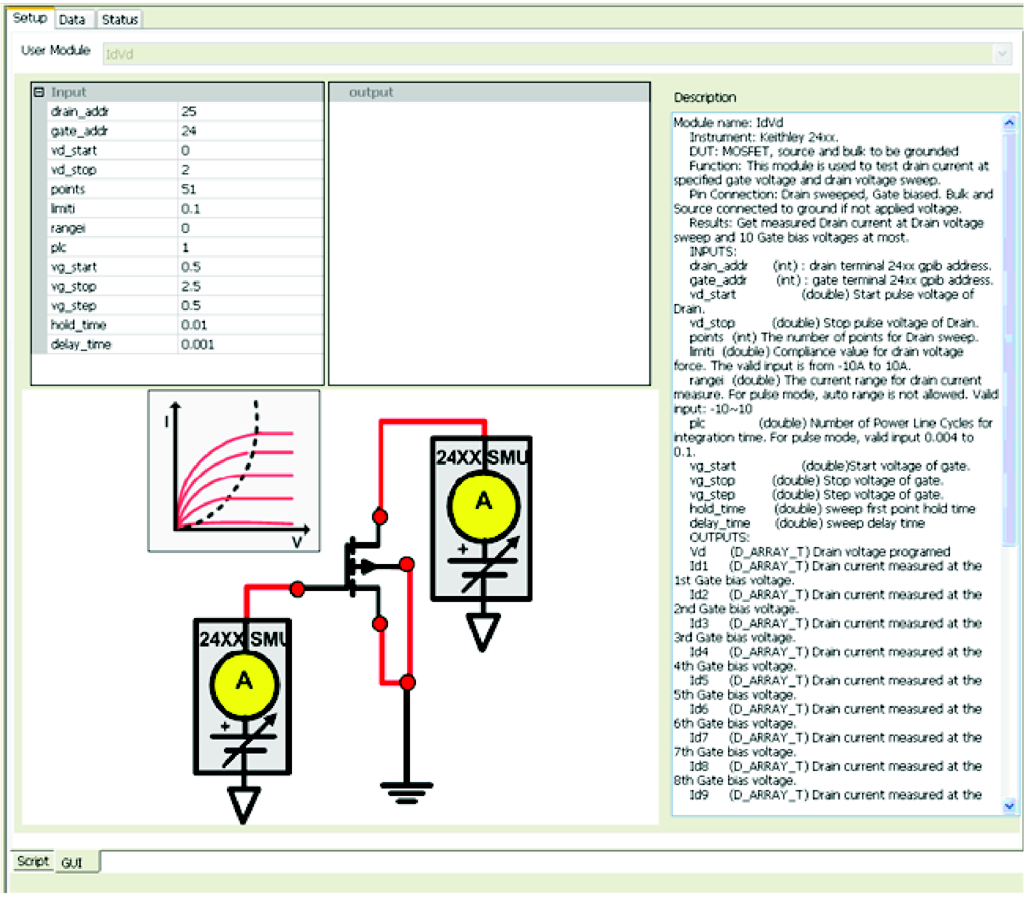
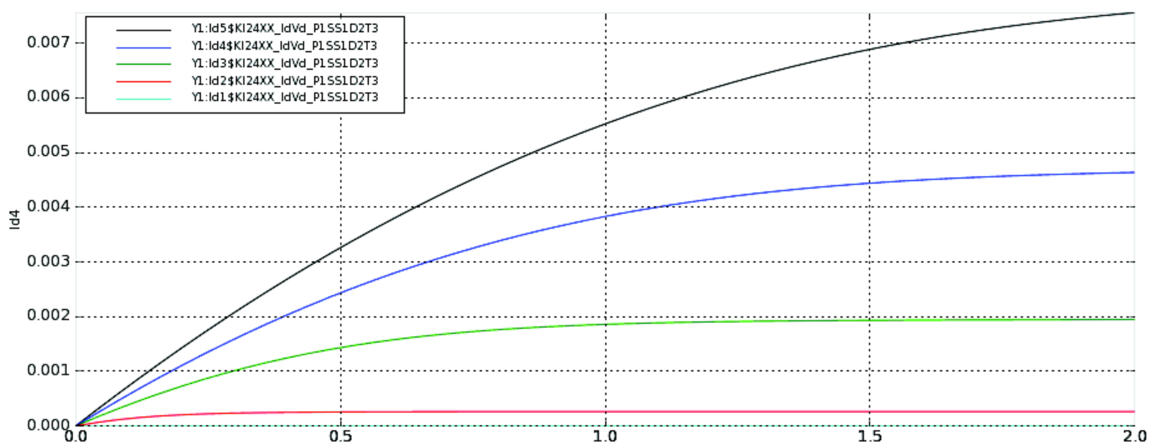


Figure 229: KI24XX_IdVd test result



KI24XX_IdVd_Pulse

Description:

This module is 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, auto range 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 0.15ms to 5ms.
`pulst_delay (double)`:	Duration of the output OFF time. The valid value is from 0s to 9999.999s.

OUTPUTS:

`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.
-10100	(INVAL_PARAM) Parameter setting error occurred.
-10090	(GPIB_ERROR_OCCURRED) A GPIB communications error occurred.
-10091	(GPIB_TIMEOUT) A timeout occurred during communications.

GUI related:

Figure 230: KI24XX_IdVd_Pulse

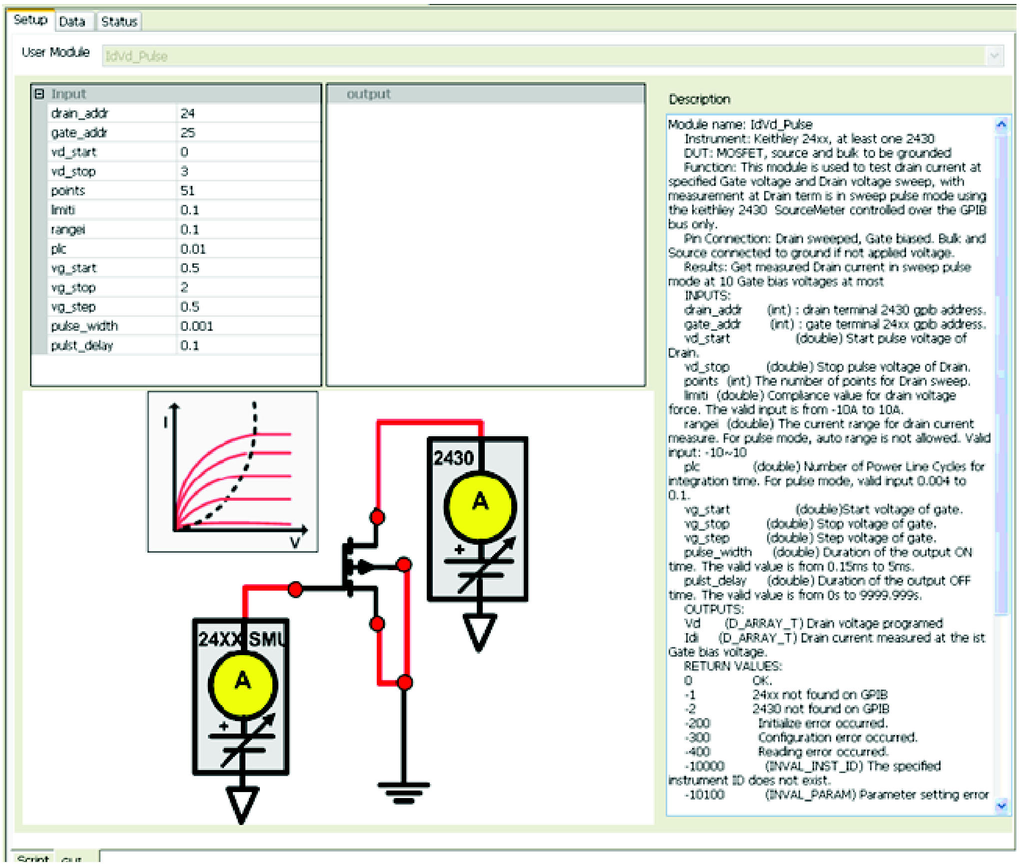
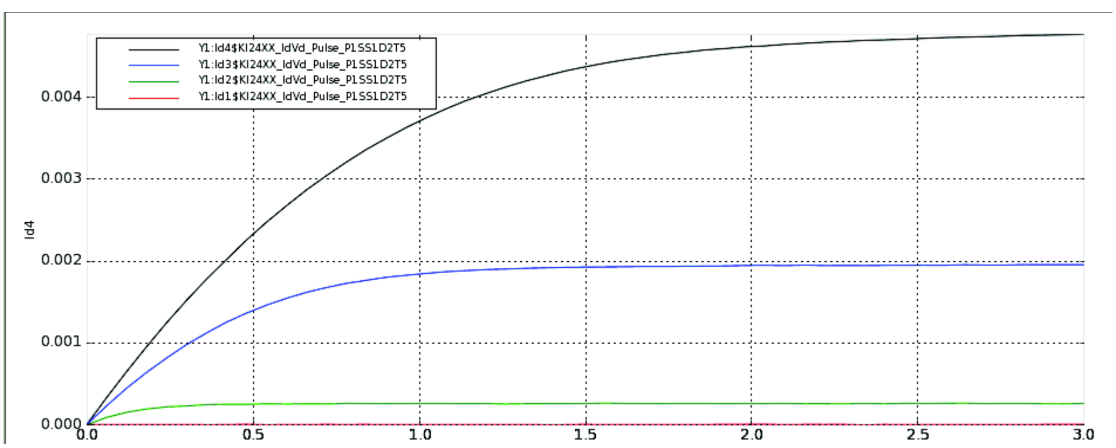


Figure 231: KI24XX_IdVd_Pulse test result



KI24XX_IdVg

Description:

Tests the Drain current at a specified Drain voltage and Gate voltage sweep.

Module Type: PTM

Instrument: Keithley Model 2400 SourceMeter.

Pin connection: Gate swept, Drain biased. The bulk and Source are connected to ground, if not applied voltage.

Results:

- Measures the Drain current at the Gate voltage sweep (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.
`vg_stop (double):`	Stop voltage of Gate.
`points (int):`	The number of points for Gate sweep.
`vd (double):`	Drain bias voltage.
`hold_time (double):`	Hold time in second before Gate sweep. The valid value is from 0 to 9999.999.
`delay_time (double):`	Delay time in seconds between each Gate sweep point. The valid value is from 0 to 9999.999.
`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, auto range 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.

OUTPUTS:

`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
`Error`:	Error value

0	OK.
-1	24xx not found on GPIB.
-200	Initialize error occurred.
-10000	(INVAL_INST_ID) The specified instrument ID does not exist.
-10100	(INVAL_PARAM) Parameter setting error occurred.
-10090	(GPIB_ERROR_OCCURRED) A GPIB communications error occurred.
-10091	(GPIB_TIMEOUT) A timeout occurred during communications.

GUI Related:

Figure 232: KI24XX_IdVg

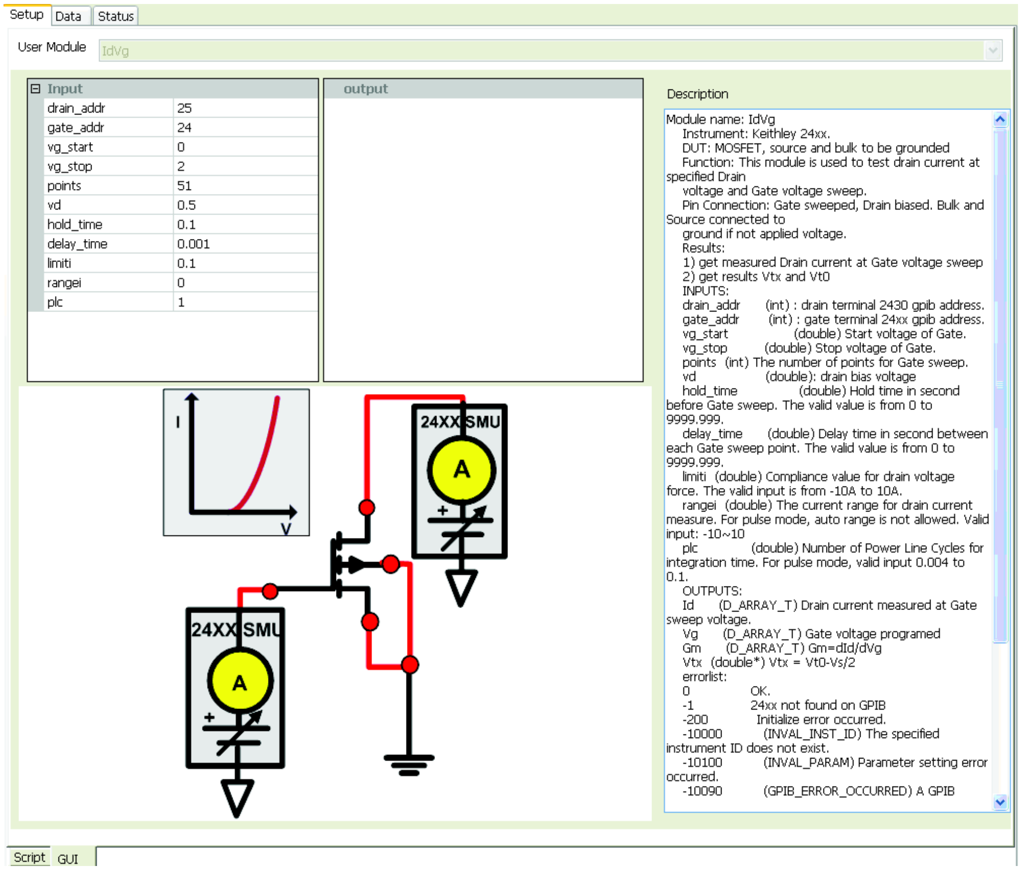
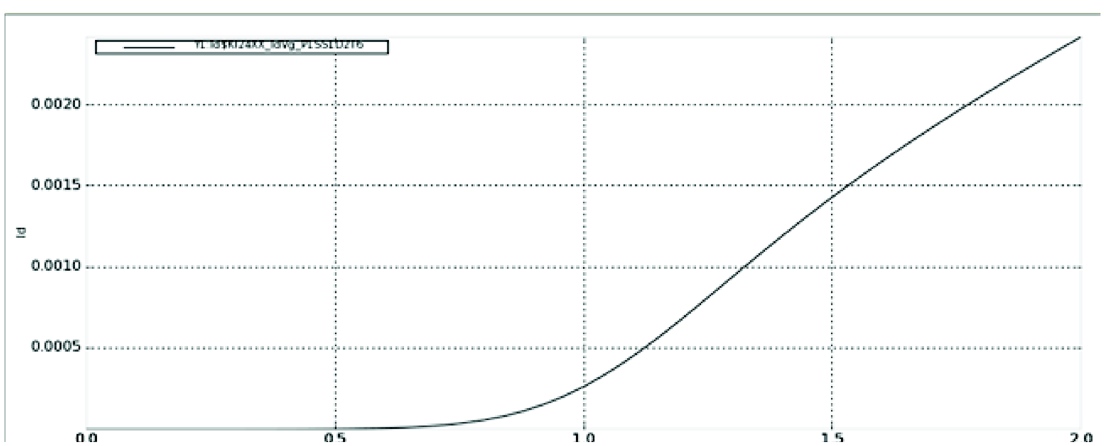


Figure 233: KI24XX_IdVg test result



KI24XX_IdVg_Pulse

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 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 connection: 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 -200V to 200V.
`vg_stop (double):`	Stop voltage of Gate. The valid input is from -200V to 200V.
`points (int):`	The number of points for Gate sweep.
`vd (double):`	Drain bias voltage.
`hold_time (double):`	Hold time in second before Gate sweep. The valid value is from 0 to 9999.999.
`delay_time (double):`	Delay time in second between each Gate sweep point. The valid value is from 0 to 9999.999.
`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, auto range 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.
`pulse_width (double):`	Output on time of the pulse for Drain voltage force. The valid input is from 150µs to 5ms

NOTE

Pulse width should be longer than 200µs if measurement is in pulse mode. If pulse width is shorter than measurement time (which is based on NPLC and line frequency) pulse width will broaden automatically.

`pulse_delay (double):`	Output off of the pulse for Drain voltage force. The valid input is from 0 to 9999.999.

OUTPUTS:

`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.
-10100	(INVAL_PARAM) Parameter setting error occurred.
-10090	(GPIB_ERROR_OCCURRED) A GPIB communications error occurred.
-10091	(GPIB_TIMEOUT) A timeout occurred during communications.

GUI related:

Figure 234: KI24XX_IdVg_Pulse

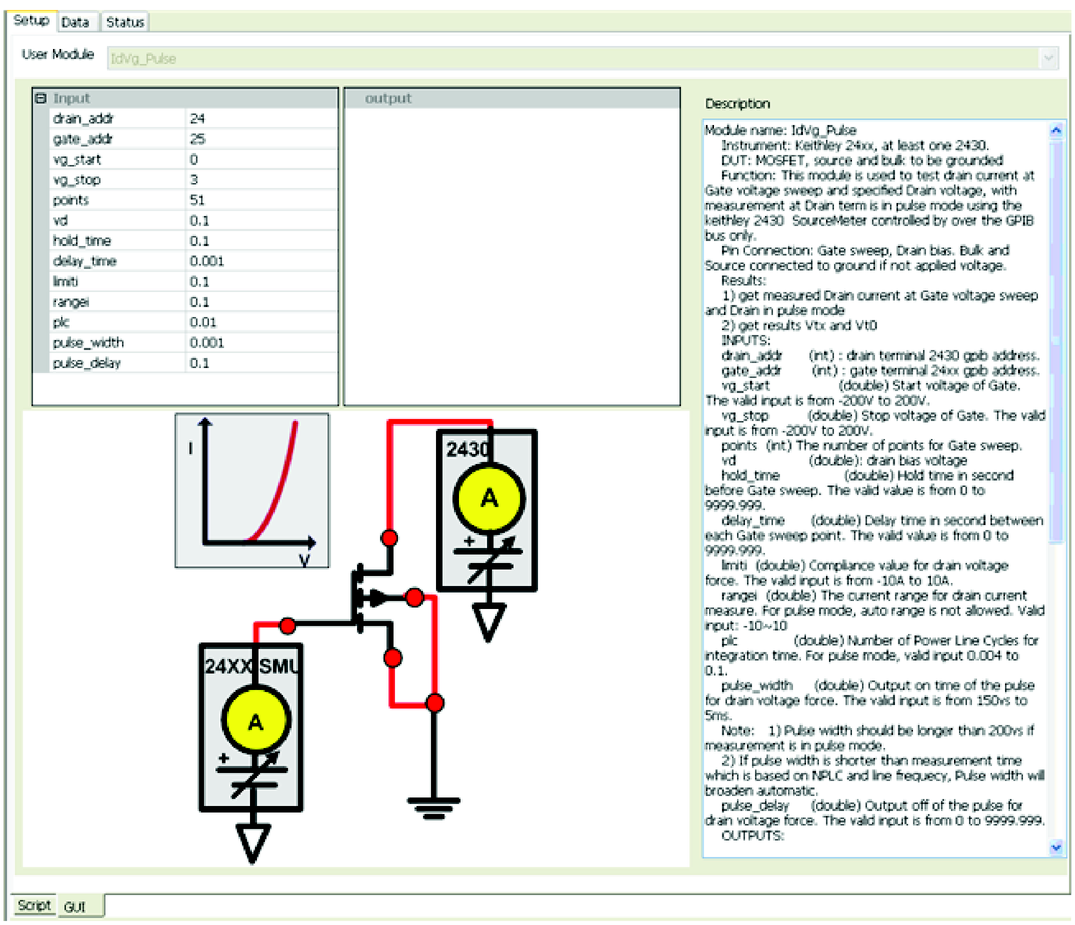
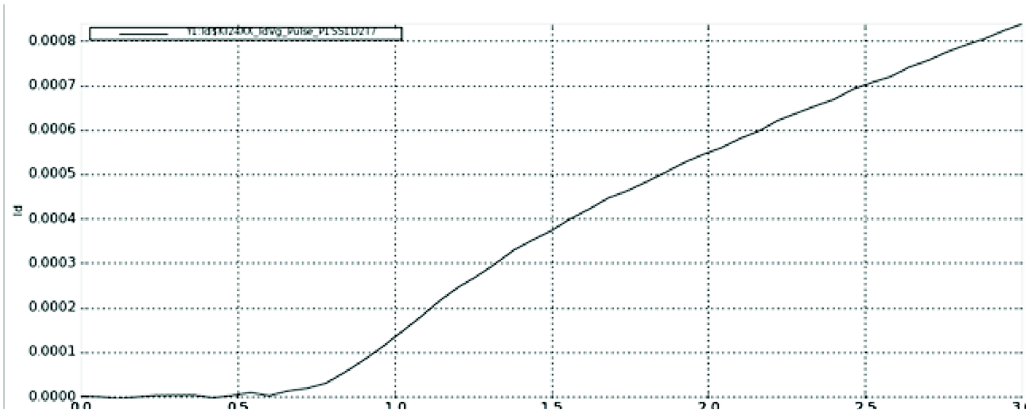


Figure 235: KI24XX_IdVg_Pulse test result



KI24XX_SweepI

Description:

Sweep the current signal and takes 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.

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 meter.
`stopi (double)`:	Stop signal level of the sweep. Value differs by model of the meter.
`points (int)`:	Number of sweep points. Valid input 1 to 2500.
`limitv (double)`:	Compliance of the sweep. Value differs by model of the meter.
`srangei (double)`:	Source range. 0: Auto range. Otherwise, the range is the smallest that can accommodate the input value. The Source range limit differs by model of the meter.
`mrangev (double)`:	Measurement range for current. 0: Auto range. Otherwise, the range is the smallest that can accommodate the input value. The Source range limit differs by model of the meter.
`hold_time (double)`:	Time sitting at the first point of sweep. Valid input: 0s to 9999.999 seconds.
`delay_time (double)`:	Delay time between each sweep point. Valid input 0s to 9999.999 seconds.
`plc (double)`:	A/D integration time in terms of Power Line Cycles (PLCs). Valid input 0.01 to 10.

OUTPUTS:

`I`

`V`

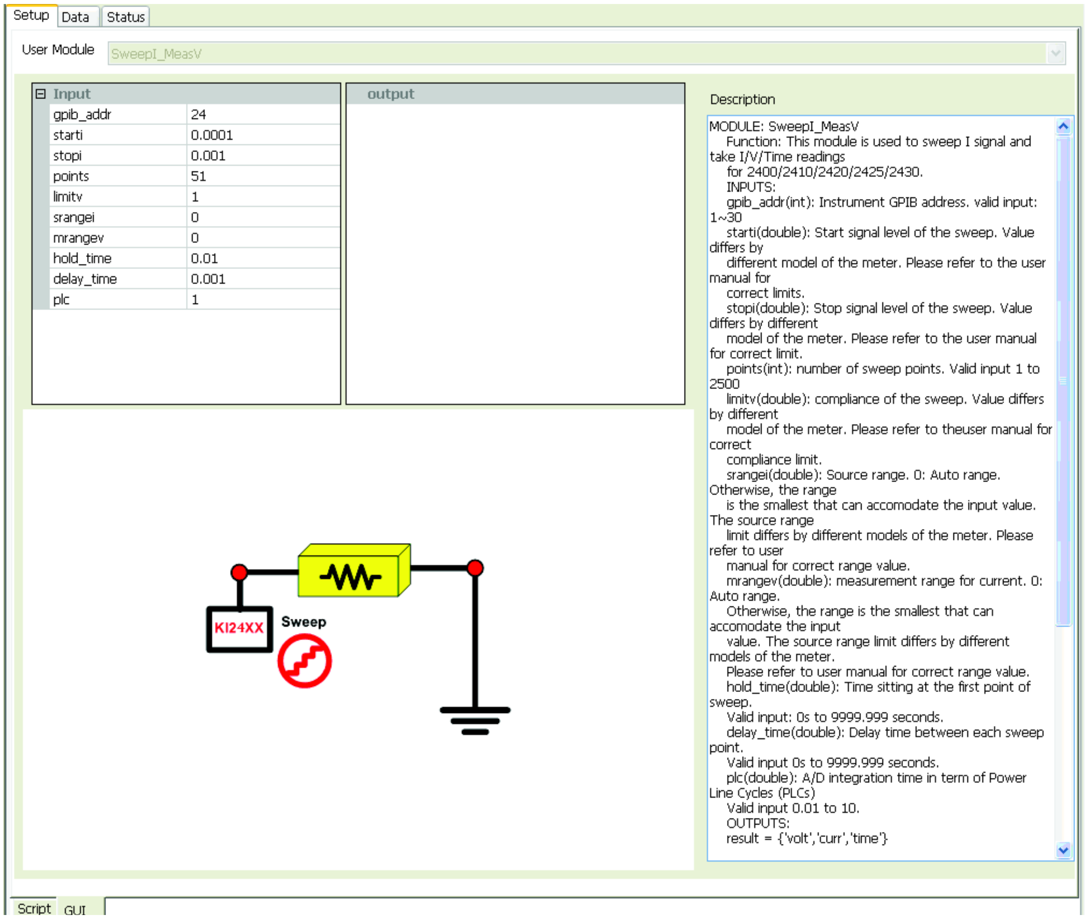
`time`

`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_OCCURRED) A GPIB communications error occurred.
-10091	(GPIB_TIMEOUT) A timeout occurred during communications.

GUI related:

Figure 236: KI24XX_SweepI standard GUI



KI24XX_SweepV

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 meter.
`stopv (double):`	Stop signal level of the sweep. Value differs by model of the meter.
`points (int):`	Number of sweep points. Valid input 1 to 2500.
`sweepMode (int):`	Sweep Mode. 0: Linear sweep; 1: Log sweep.
`limiti (double):`	Compliance of the sweep. Value differs by model of the meter.
`srangev (double):`	Source range. 0: Auto range. Otherwise, the range is the smallest that can accommodate the input value. The Source range limit differs by model of the meter.
`mrangei (double):`	Measurement range for current. 0: Auto range. Otherwise, the range is the smallest that can accommodate the input value. The Source range limit differs by model of the meter.
`hold_time (double):`	Time sitting at the first point of sweep. Valid input: 0s to 9999.999 seconds.
`delay_time (double):`	Delay time between each sweep point. Valid input: 0s to 9999.999 seconds.
`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.

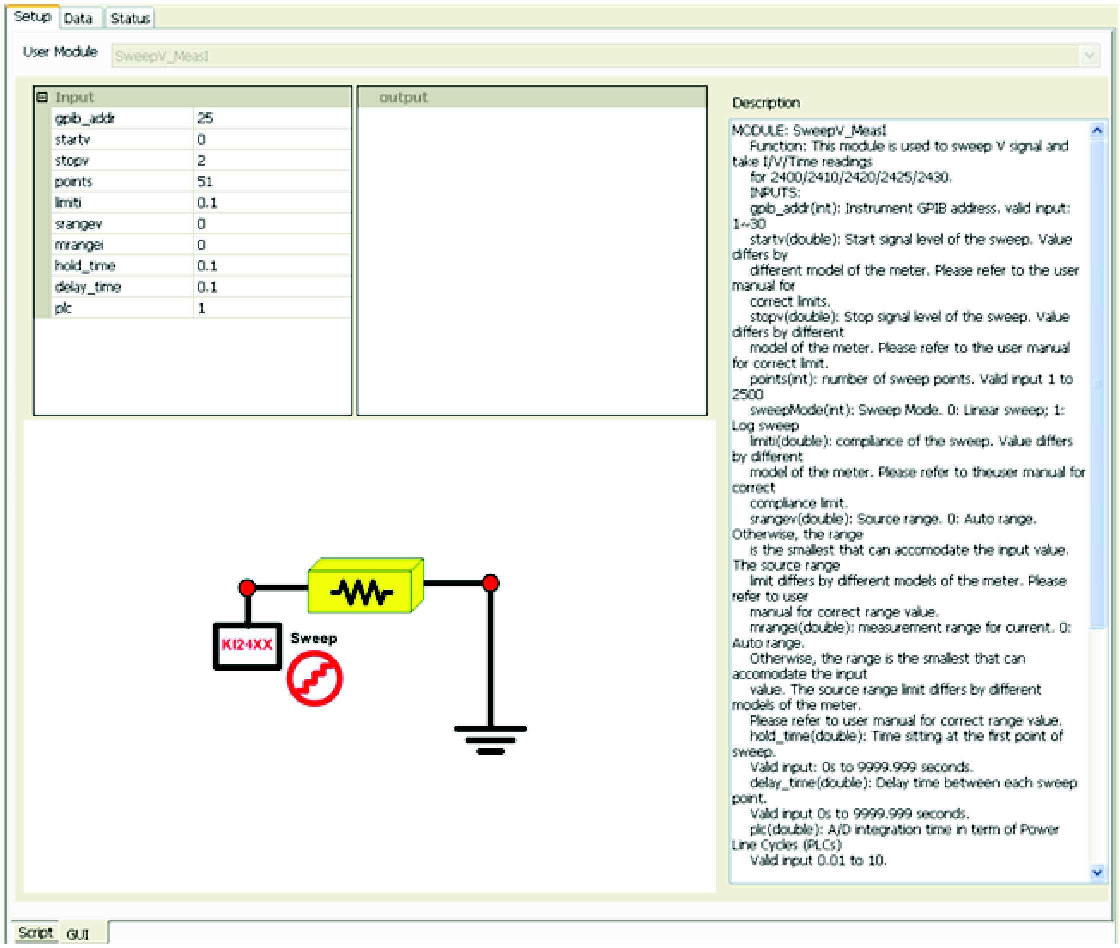
-10000 (INVAL_INST_ID) The specified instrument ID does not exist.

-10090 (GPIB_ERROR_OCCURRED) A GPIB communications error occurred.

-10091 (GPIB_TIMEOUT) A timeout occurred during communications.

GUI related:

Figure 237: KI24XX_SweepV standard GUI



KI37XX_DMM_R_2Wire

Description:

Measures resistance using a DMM.

Module type: STM

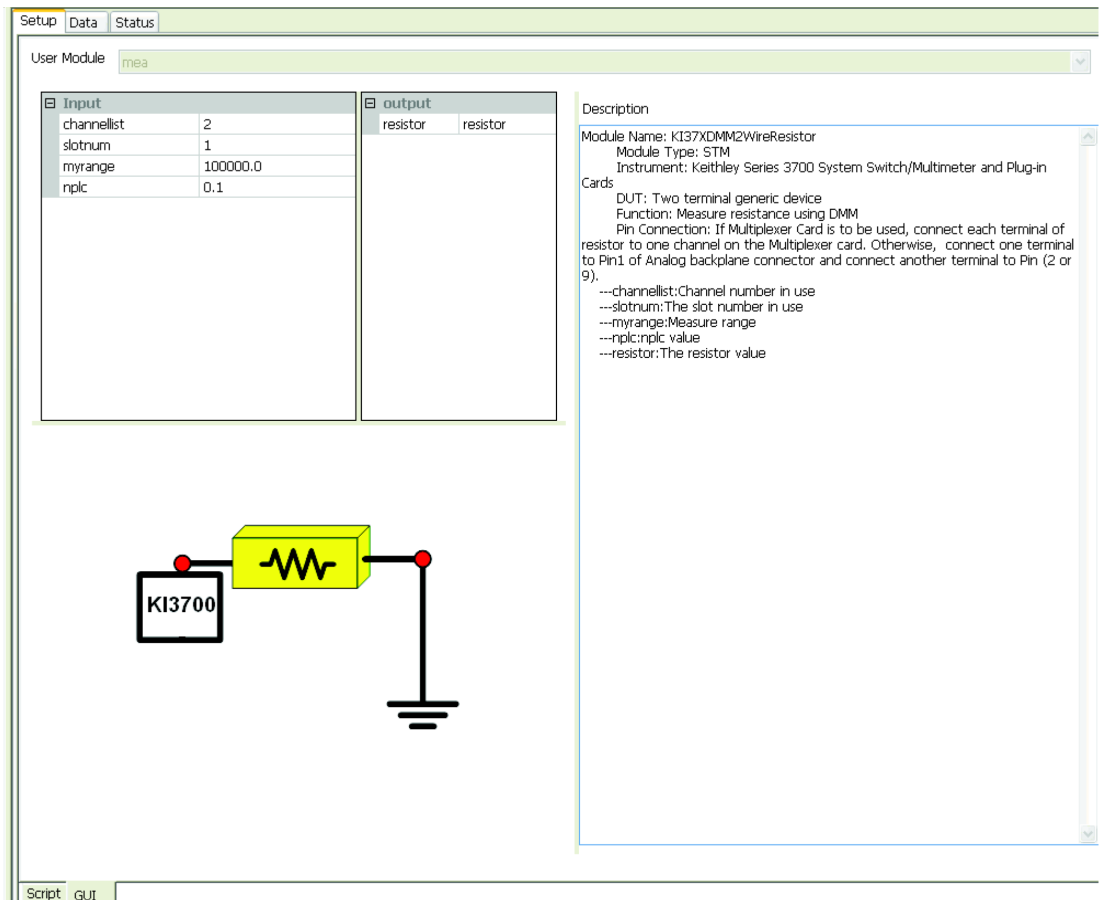
Instrument: Keithley Series 3700 System Switch/Multimeter and plug-in cards.

DUT: Two-terminal generic device.

Pin connection: 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 238: KI37XX_DMM_R_2Wire standard GUI



KI37XX_DMM_R_4Wire

Description:

Measures resistance using a DMM.

Module type: STM

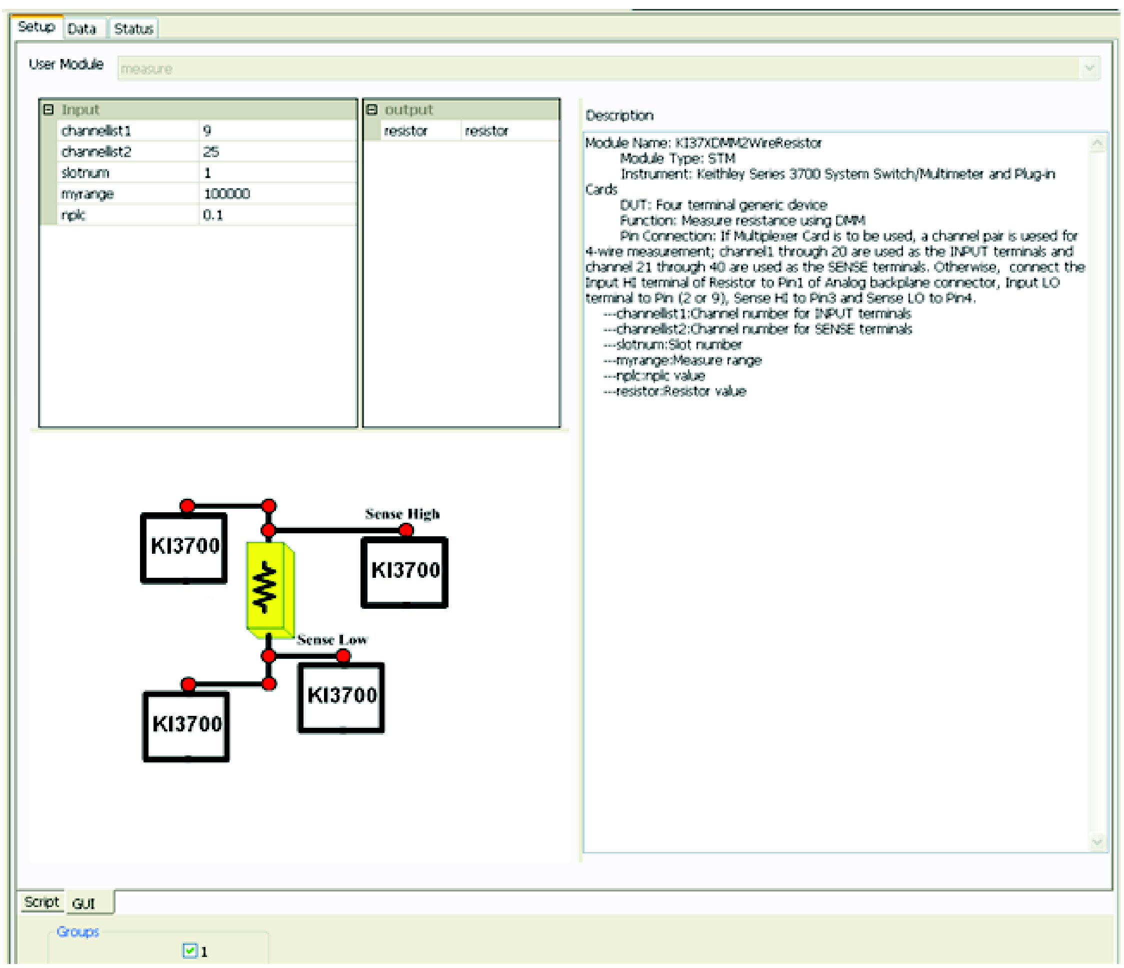
Instrument: Keithley Series 3700 System Switch/Multimeter and plug-in cards.

DUT: Four-terminal generic device.

Pin connection: 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 239: KI37XX_DMM_R_4Wire standard GUI



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

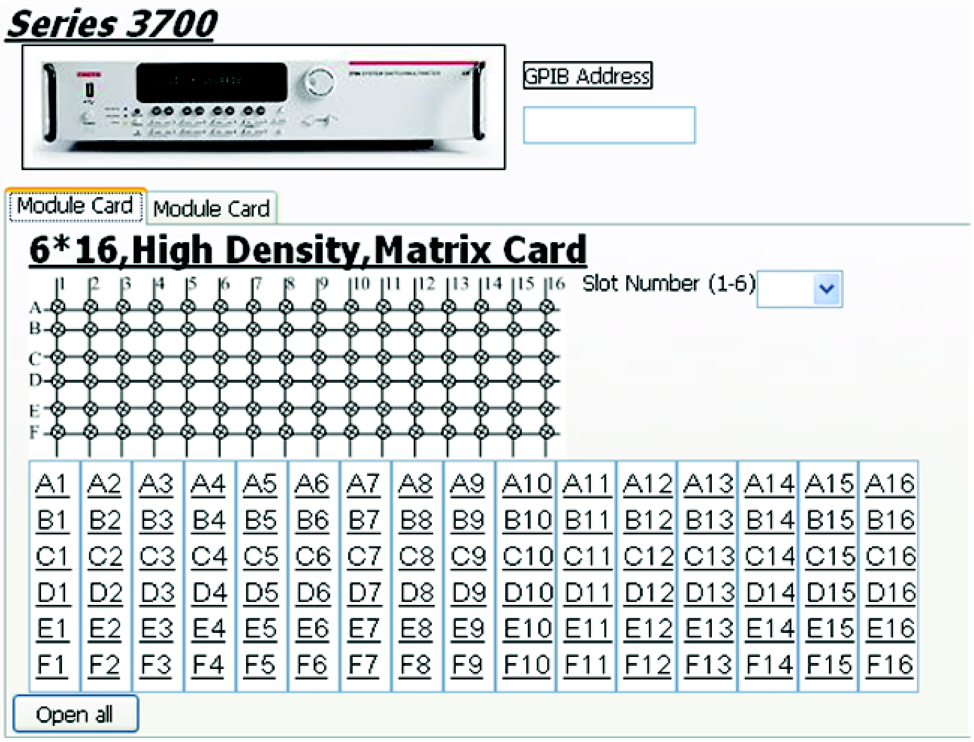
Instrument: Keithley Series 3700 System Switch/Multimeter and plug-in cards.

INPUTS:

`GPIB_Address`:	GPIB address
`Open_all`:	Open all the channels
`S1Channel1`:	Channel list for 6*16 High Density, Matrix Card
`S1Channel1`	
`S1Channel2`	
`S1Channel3`	
`S1Channel4`	
......	
`S1Channel16`	
`List_1`:	Channel list for Multiplexer Card
`List_1`	
`List_2`	
......	
`List_8`	
`SlotNumberCard1`:	Slot number for Matrix Card
`SlotNumberCard2`:	Slot number for Multiplexer Card
`ModuleCardNum`:	

GUI related:

Figure 240: KI37XX_DMM_Switch GUI

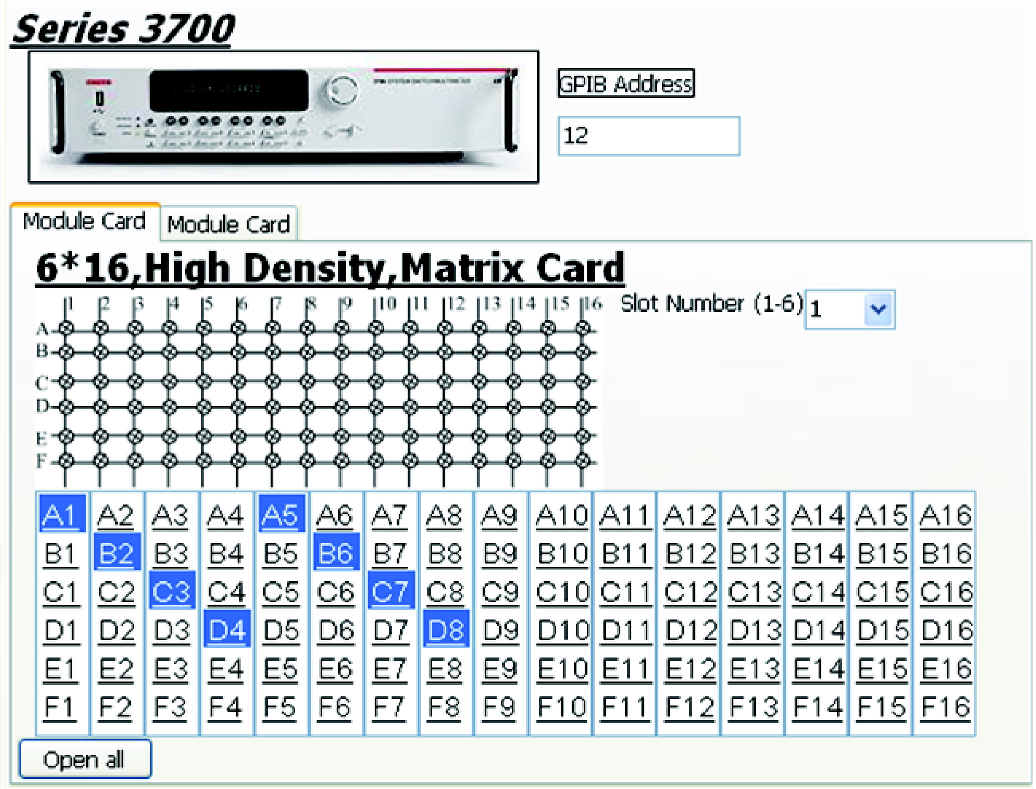


Control the 3700 matrix in the GUI (see previous figure):

- 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 241: Matrix control setting example

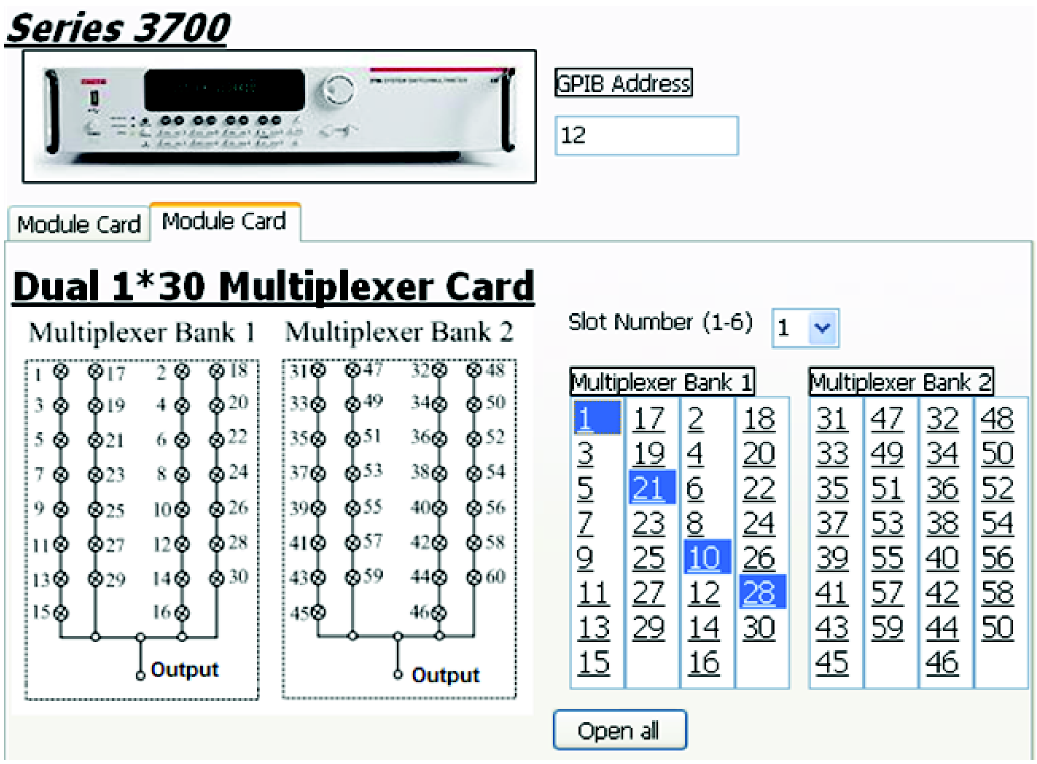


Control the multiplexer card in the GUI:

- 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 242: Multiplexer control setting example

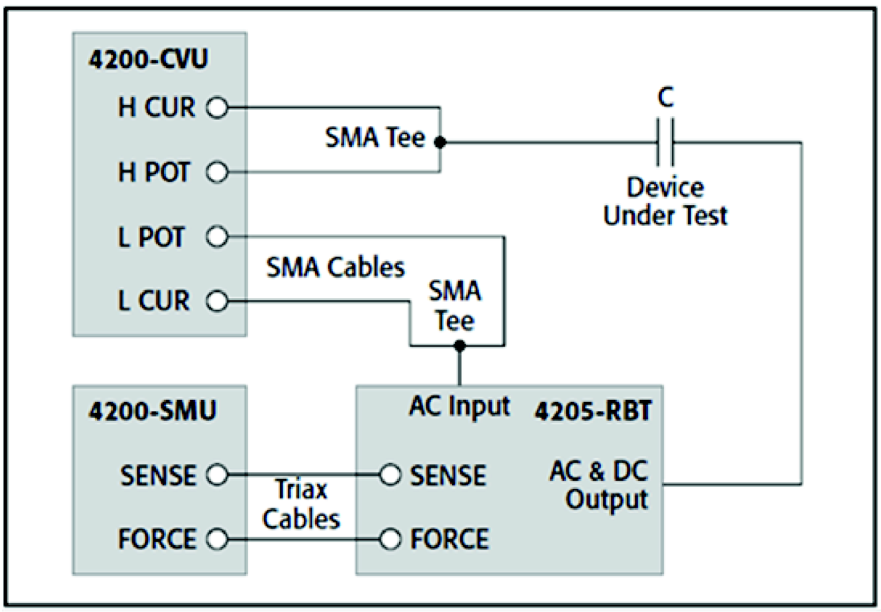


High-voltage and high-current PTM

High-voltage and high-current PTM overview

This PTM module is for the Model 4200-CVU-PWR C-V power package (in the Model 4200-SCS) where you can take C-V measurements with a DC voltage bias of up to ±200V or 400V differential (0 to ±400V), and a current output of up to 300mA. In this module, the Model 4200-CVU measures the capacitance and either one or two 4200-SMUs (or Model 4210-SMUs for current up to 300mA) are used to supply the DC bias or sweep voltage. The hardware of the C-V power package includes two bias tees that enable coupling of the AC signals from the Model 4200-CVU and the DC signals from the Model 4200-SMU (see next figure). For more details about the principle of the C-V power package and high-voltage and high-current CV measurements, you can refer to the related application note that is located at http://www.keithley.com/.

Figure 243: HIV_CV measurement hardware connections



The high-voltage and high-current PTM library module is located in the following directory: \\ACS_BASIC\library\pyLibrary\hivcvulib.py.

Import the .py file to your test and the module will open. This module has two functions:

- CvsT = uses a constant DC bias voltage.
- SweepV. = uses sweeping DC bias voltages.

CvsT

CVU_name: selects the CVU that does the HIV CV measurements.

MeasI_SMU: selects the SMU that does the current measurements.

Timing:

- **Interval**: The interval time in the Sample Count times of measurements.
- **Speed**: Selects the CVU measure speed. Fast: fast measurements (higher noise). Normal: balance between speed and low noise.
- **Quiet**: Low-noise measurements.
- **Force Func Parameter**: Sets the four SMU DC voltage bias values.In addition to an SMU supplying a voltage for the C-V sweep, up to four more SMUs can be used to bias other parts of the test circuit. Only the Model 4200 SMU can be selected.
- **AC Driver Conditions**:

  Frequency - Test frequency of CVU, which can be set to 10kHz, 20kHz, 30kHz, 40kHz, 50kHz, 60kHz, 70kHz, 80kHz, 90kHz, 100kHz, 200kHz, 300kHz, 400kHz, 500kHz, 600kHz, 700kHz, 800kHz, 900kHz, 1MHz, 2MHz, 3MHz, 4MHz, 5MHz, 6MHz, 7MHz, 8MHz, 9MHz, and 10MHz. For higher capacitance values, the test frequency may need to be lowered through the bias tee to avoid errors due to resonance.

  Voltage (mVRMS) - The amplitude of the AC voltage output of the CVU.
- **Measuring Setting**: Sets the AC measurement conditions.
- **Sample Count**: Number of samples to acquire during test (0-10000).
- **I Range**: Current measure range for impedance measurements. 0 for auto range.

Compensation Setting:

- **Cable Length**: Selects the cable length, 0, 1.5M or 3M.
- **Connection Compensation**: enables open or short compensation constants.

Output Parameter Name Setting: Input the output parameter names, which lists in the Data Tab.

Error: If an error occurs, an error code displays in the data tab under "error."

Error Code:

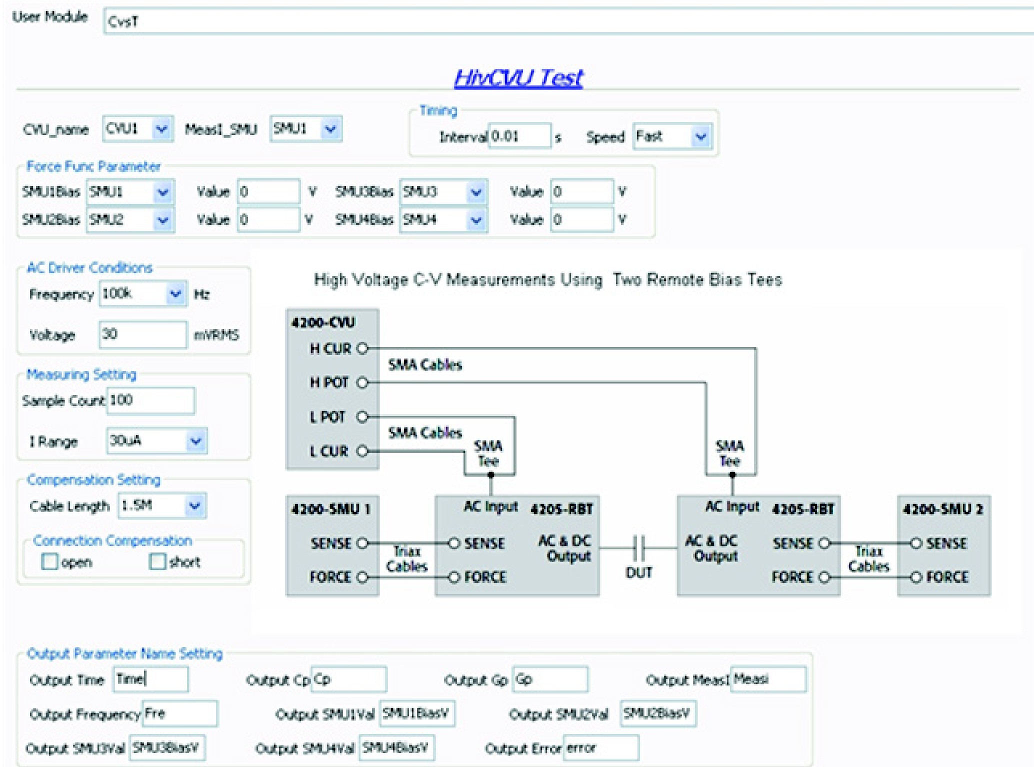
0: OK, test completes successfully.

-10000(INVAL_INST_ID):	Specified CVU or SMU not exist. If an instrument specified by the input parameter is not present in the system.
-10100(INVAL_PARAM):	Parameter setting error occurred.
-10090(GPIB_ERROR_OCCURED):	A GPIB communications error occurred.

- The following error codes are returned if the measurement status of a CVU reading indicates a problem:

CVU_MEAS_TIMEOUT	-900
CVU_MEAS_CVHI1_ABB_UNLOCK	-901
CVU_MEAS_CVHI1_VOFLO	-902
CVU_MEAS_CVHI1_IOFLO	-903
CVU_MEAS_CVLO1_ABB_UNLOCK	-904
CVU_MEAS_CVLO1_VOFLO	-905
CVU_MEAS_CVLO1_IOFLO	-906

Figure 244: CvsT module GUI settings



SweepV

CVU_name: Selects the CVU that does the HIV CV measurements.

SweepSMU: Selects the SMU that does the sweeping voltage.

MeasI_SMU: Selects the SMU that does the current measurements.

Timing:

- **Hold Time**: Time to apply soak voltage.
- **SweepDelay**: Time between voltage steps.
- **Speed**: Selects the CVU measure speed. Fast: fast measurements (higher noise). Normal: balance between speed and low noise.
- **Quiet**: Low-noise measurements.

Force Func Parameter:

- **Presoak**: Sets the pre-soak voltage, the voltage bias by the SweepSMU prior to the start of sweep.
- **Bias setup**: Sets the four SMU DC voltage bias values. In addition to an SMU supplying a voltage for the C-V sweep, up to four more SMUs can be used to bias other parts of the test circuit. Only the Model 4200 SMU can be selected.
- **Sweep setup**: Sets the start voltage, stop voltage, and step voltage of sweep.
- **AC Driver Condition**s: Sets the AC conditions, frequency and voltage (mVRMS).
- **Measuring Setting**: Sets the AC measurement conditions.
- **I Range**: Current measure range for impedance measurements. 0 for auto range.

Compensation Setting:

- **Cable Length**: Selects the cable length, 0, 1.5M or 3M.
- **Connection Compensation**: Enables open or short compensation constants.

Output Parameter Name Setting: Input the output parameter names, which lists in the Data Tab.

Error: If an error occurs, an error code displays in the data tab under "error."

Error Code:

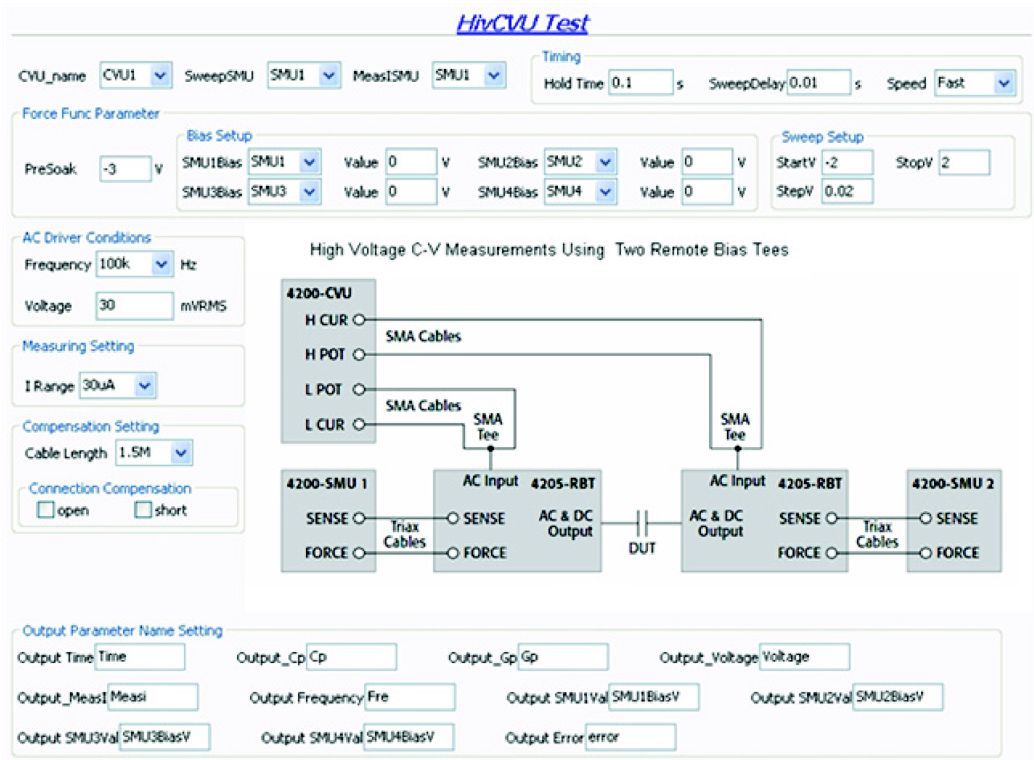
0:	OK, test completes successfully.
-10000(INVAL_INST_ID):	Specified CVU or SMU not exist. If an instrument specified by the input parameter is not present in the system.
-10100(INVAL_PARAM):	Parameter setting error occurred.
-10090(GPIB_ERROR_OCCURED):	A GPIB communications error occurred.

- The following error codes are returned if the measurement status of a CVU reading indicates a problem:

CVU_MEAS_TIMEOUT	-900
CVU_MEAS_CVHI1_ABB_UNLOCK	-901
CVU_MEAS_CVHI1_VOFLO	-902
CVU_MEAS_CVHI1_IOFLO	-903
CVU_MEAS_CVLO1_ABB_UNLOCK	-904
CVU_MEAS_CVLO1_VOFLO	-905

CVU_MEAS_CVLO1_IOFLO -906

Figure 245: SweepV module GUI settings



Mixed SMUs in pulse mode

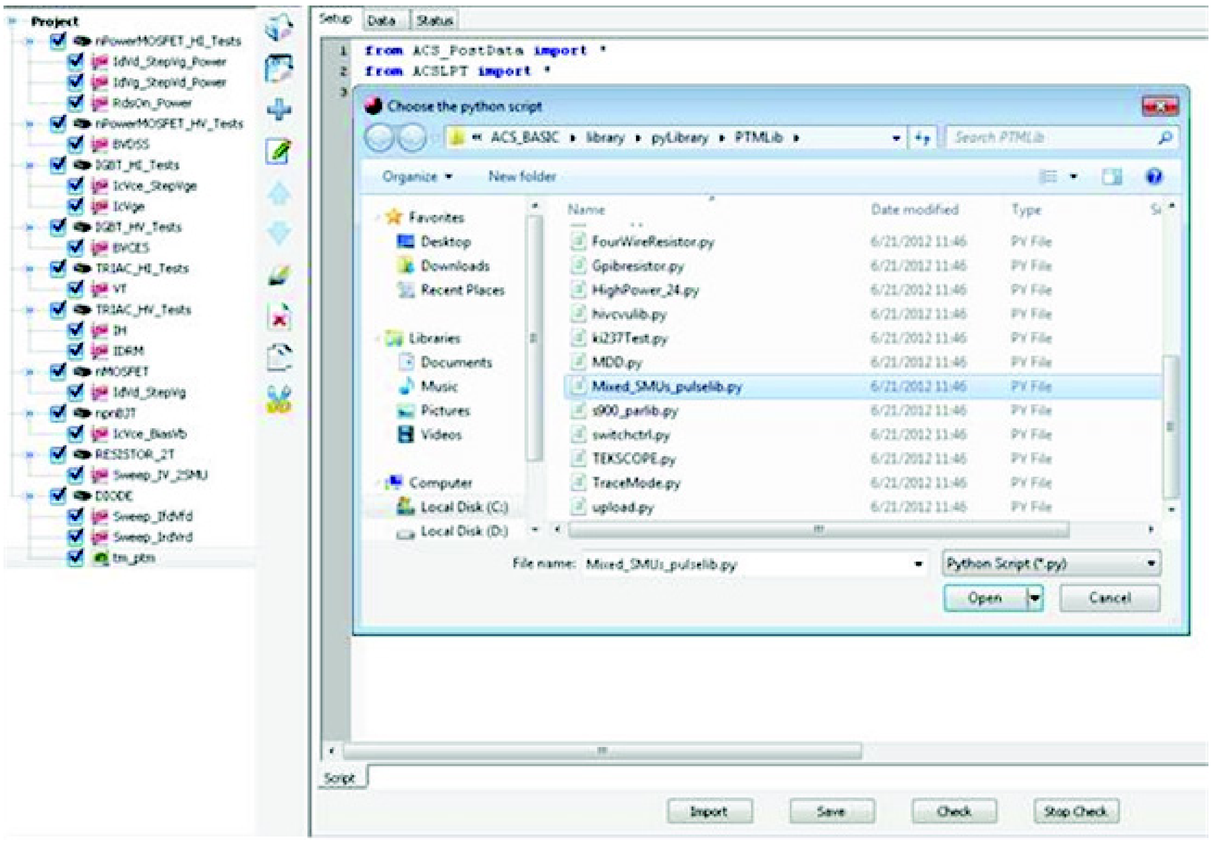
The mixed model of SMUs in pulse mode is an explanation of the mixed use-case for the Model 265xA SMU with the 26xx(B) SMU, 24xx SMU, and 4200 SMU. In these tests the 265xA SMUs are in pulse mode, while other SMUs are in DC mode.

Mixed SMUs introduction

Open the Mixed_SMUs_pulselib PTM

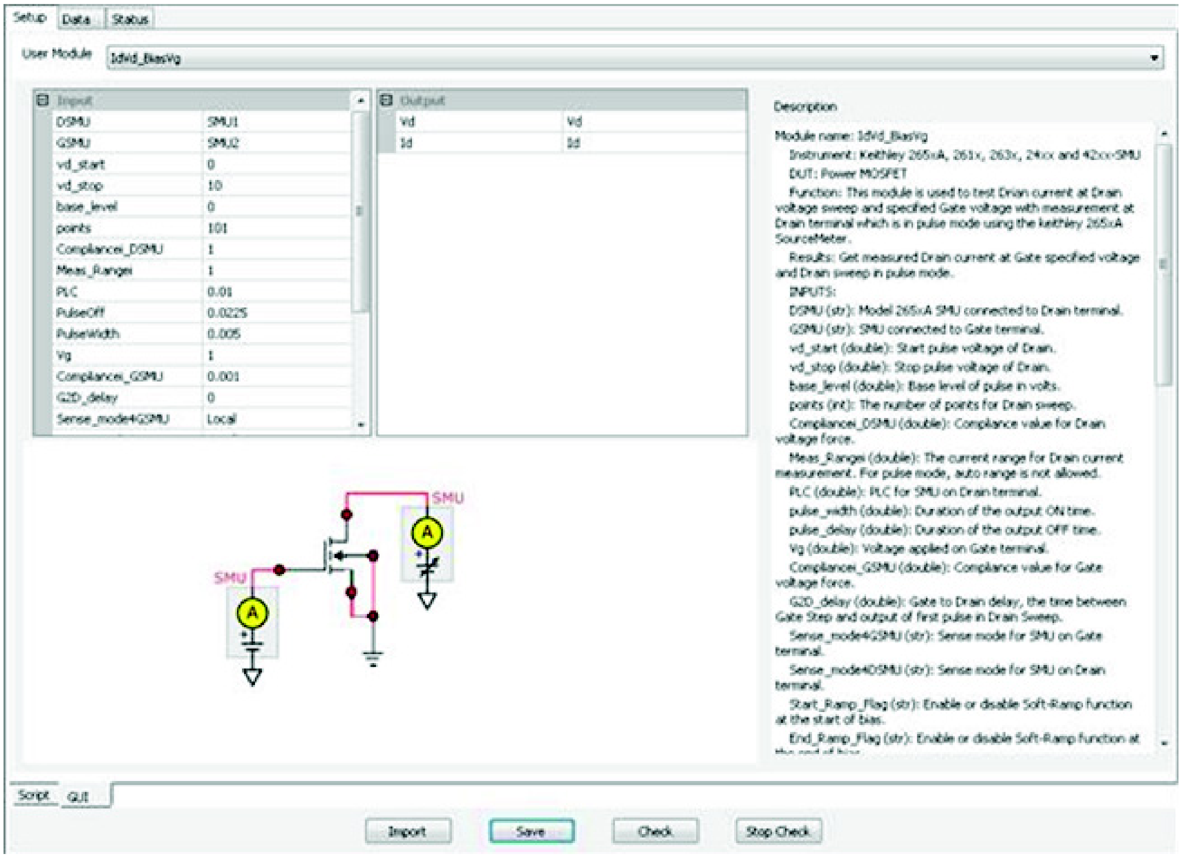
Click the **PTM** icon to add a new PTM to the project configuration navigator. Open the PTM, and click the **Import** button. In the dialog box that opens, choose a python test script. Select the Mixed_SMUs_pulselib.py script (see next figure).

Figure 246: Import the Mixed_SMUs_pulselib PTM



The Mixed_SMUs_pulselib PTM GUI opens (see next figure).

Figure 247: Mixed_SMUs_pulselib PTM GUI



Test modules of Mixed_SMUs_pulselib PTM

Mixed_SMUs_pulselib PTM includes twelve modules: IdVd_BiasVg, IdVd_stepVg, IdVg, RdsOn, BVdsv, IcVce_stepIb, IcVce_stepVb, Vcesat, BVcei, BVcev, IcVce_StepVge, Vcesat. For all of these tests the high-power SMU is used in pulse mode and other SMUs are used in DC mode.

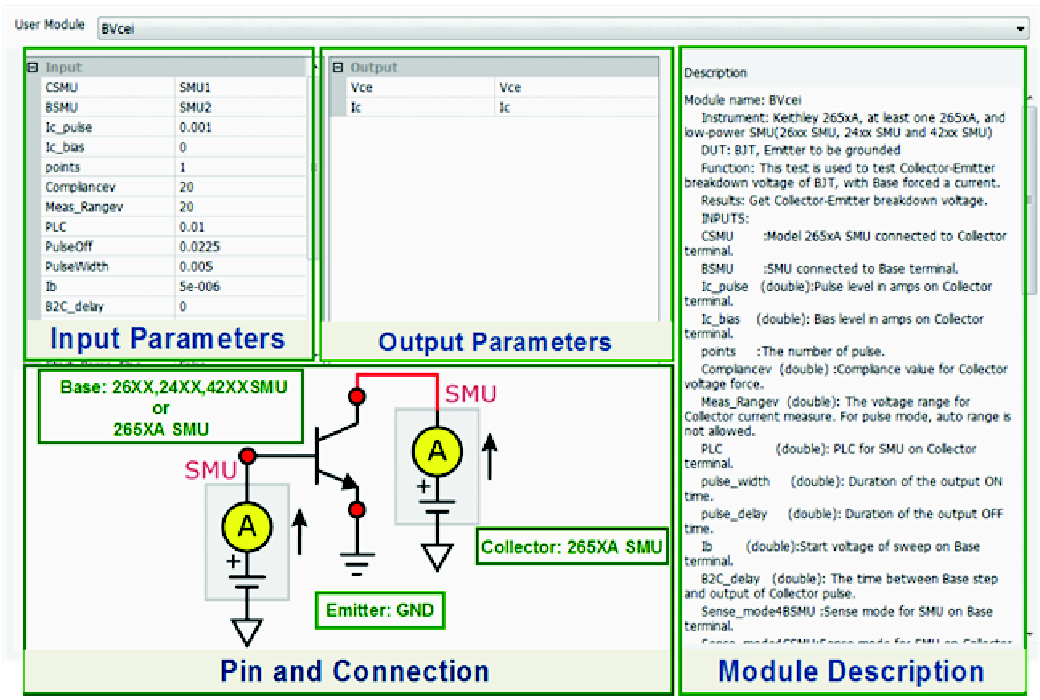
Mixed SMUs library

BVcei

Description:

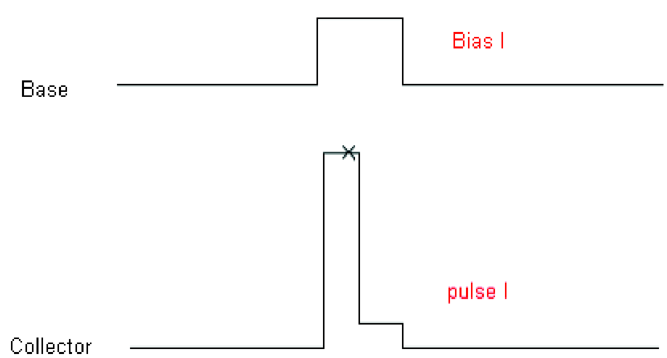
Tests the Collector-Emitter breakdown voltage of a BJT with the Base forcing current (see next figure).

Figure 248: BVCEI



Test pulse sequence: Base bias I, Collector pulse I (see next figure).

Figure 249: 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, auto range 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

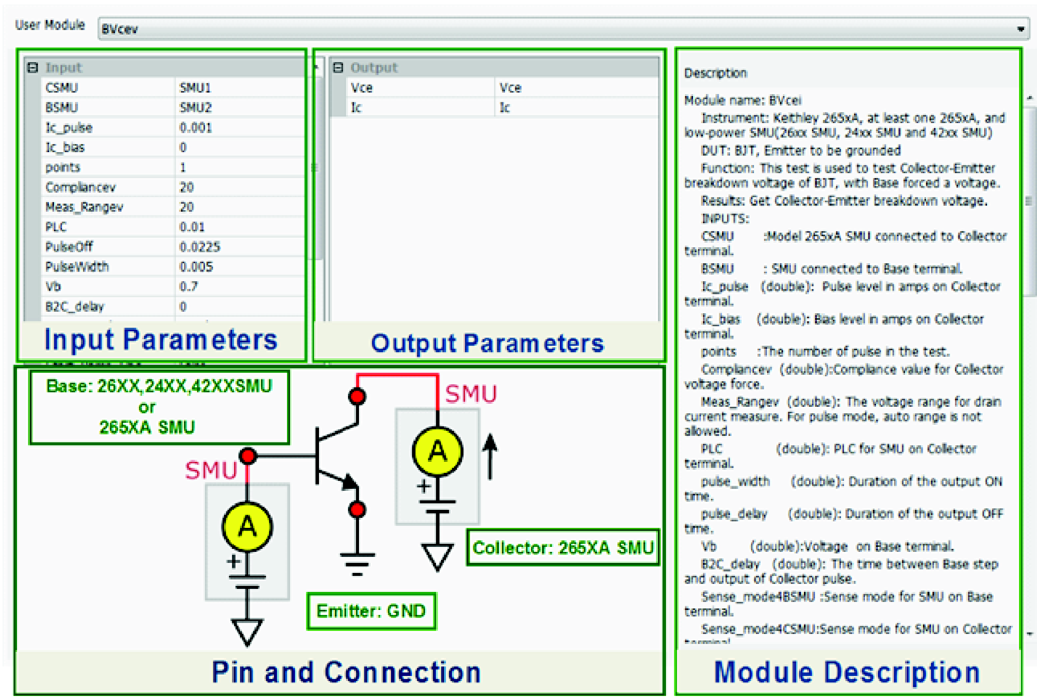
If the Base terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the Collector terminal.

BVcev

Description:

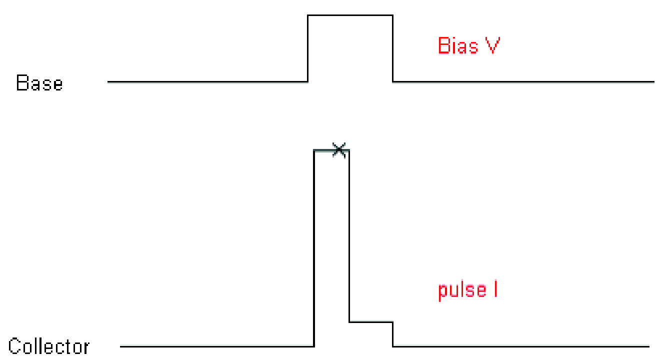
Tests the Collector-Emitter breakdown voltage of a BJT with the Base forcing voltage (see next figure).

Figure 250: BVcev



Test pulse sequence: Base bias V, Collector pulse I (see next figure).

Figure 251: 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, auto range 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

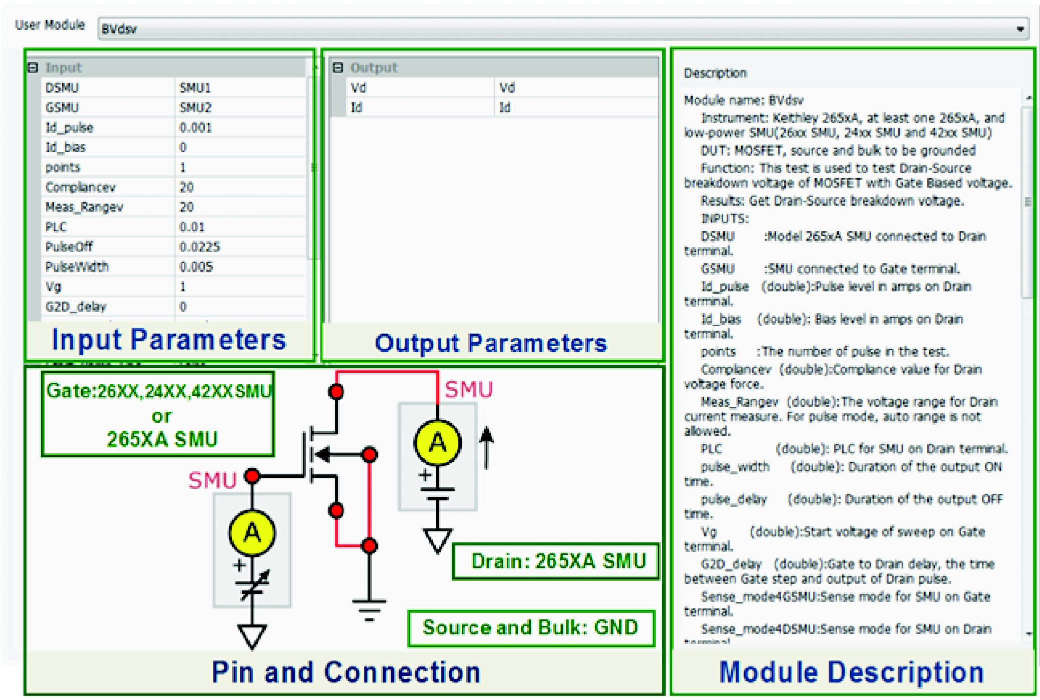
If the Base terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the Collector terminal.

BVdsv

Description:

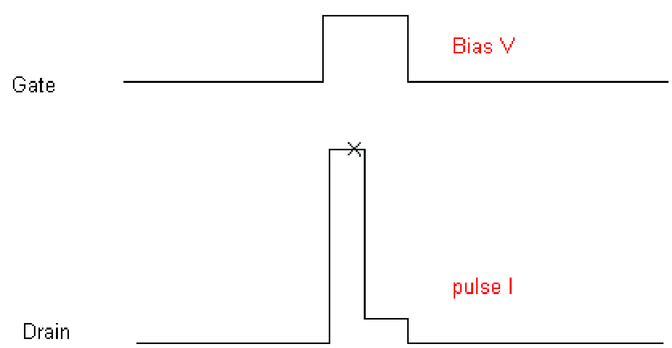
Tests the Drain-Source breakdown voltage of a MOSFET with the Gate biasing voltage (see next figure).

Figure 252: BVdsv



Test pulse sequence: Gate bias V, Drain pulse I (see next figure).

Figure 253: BVdsv test pulse sequence



INPUTS:

`DSMU`:	Model 265xA SMU connected to Drain terminal.
`GSMU`:	SMU connected to Gate terminal.
`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, auto range 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

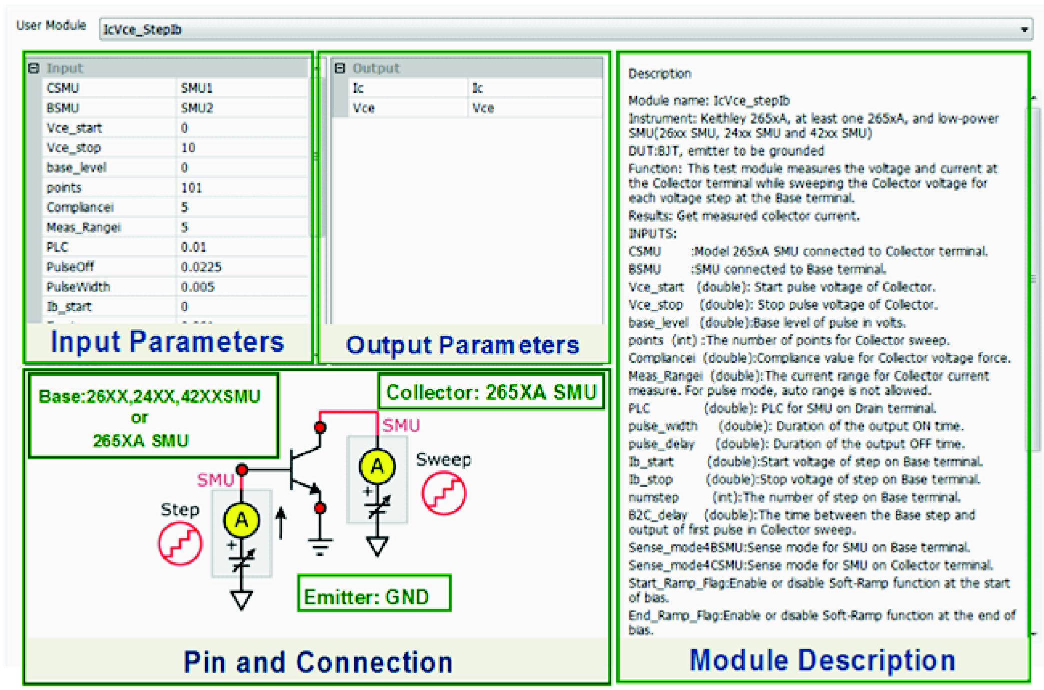
If the Gate terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the Drain terminal.

IcVce_StepIb

Description:

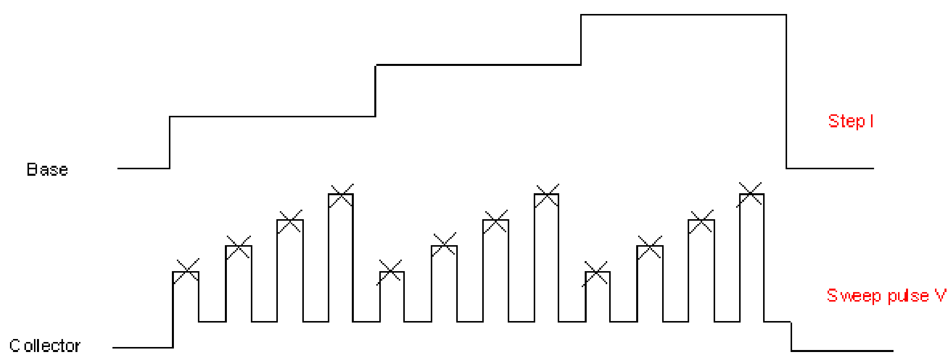
Measures the voltage and current at the Collector terminal while sweeping the Collector voltage for each voltage step at the Base terminal (see next figure).

Figure 254: IcVce_StepIb



Test pulse sequence: Collector sweep pulse V, Base step I (see next figure).

Figure 255: 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, auto range 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 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 Model 2651A SMUs are the same type and the Model 2657A SMUs are the same type.

NOTE

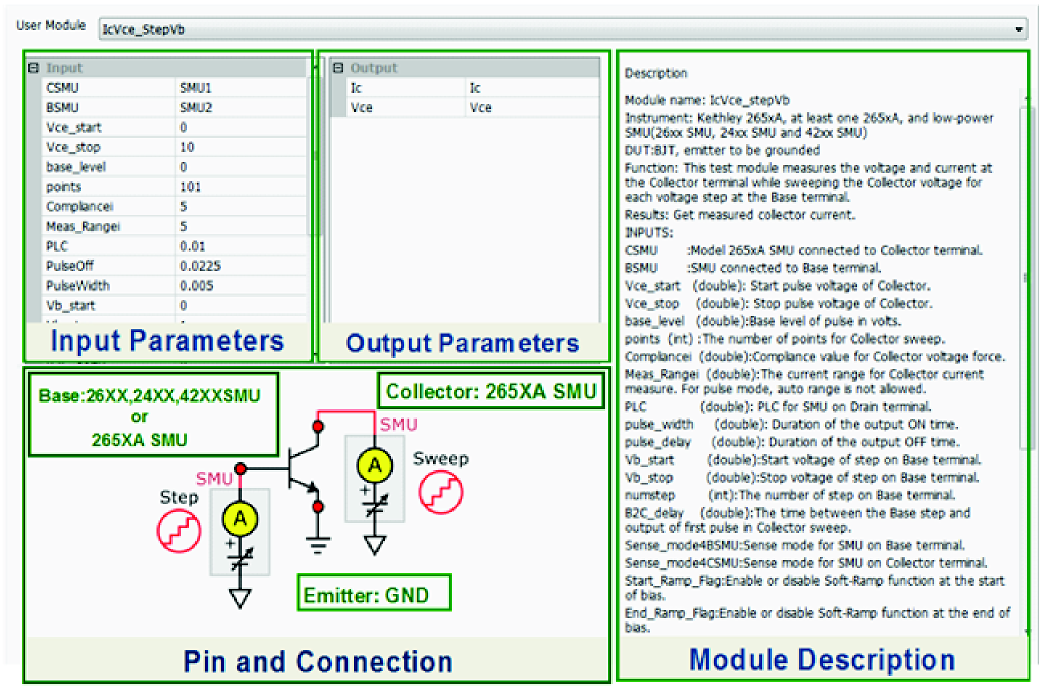
If the Base terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the Collector terminal.

IcVce_StepVb

Description:

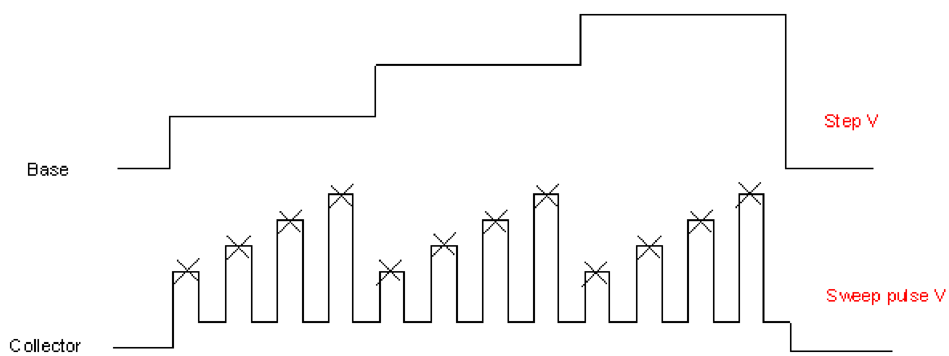
Measures the voltage and current at the Collector-terminal while sweeping the Collector voltage for each voltage step at the Base terminal (see next figure).

Figure 256: IcVce_StepVb



Test pulse sequence: Collector sweep pulse V, Base step V (see next figure).

Figure 257: IcVce_StepVb 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, auto range 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

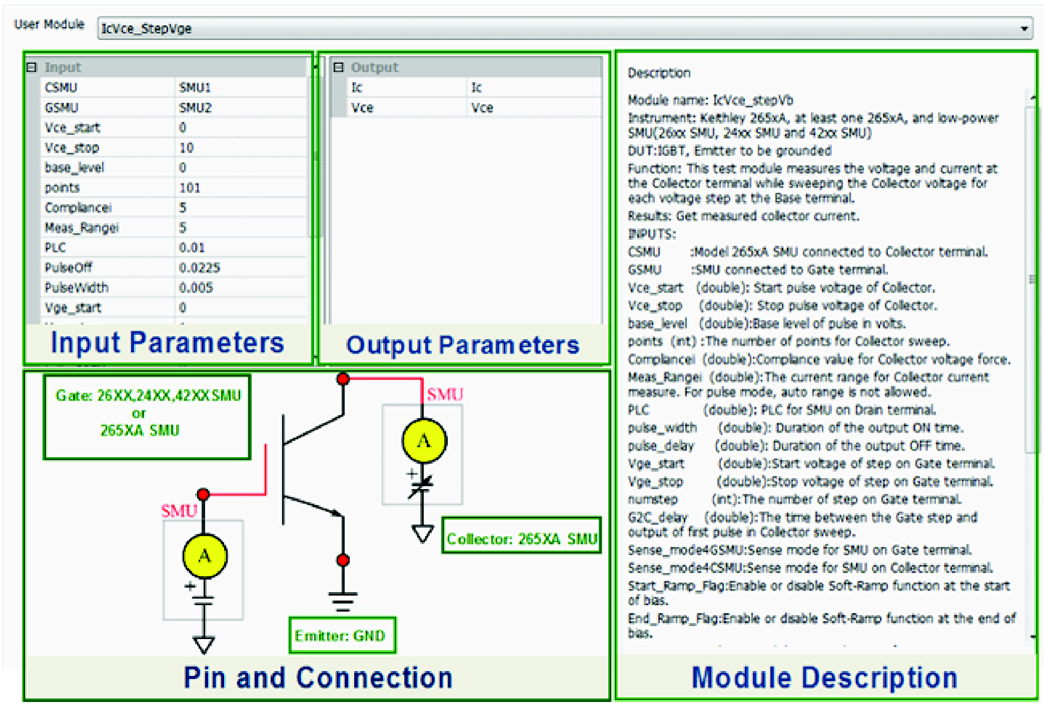
If the Base terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the Collector terminal.

IcVce_StepVge

Description:

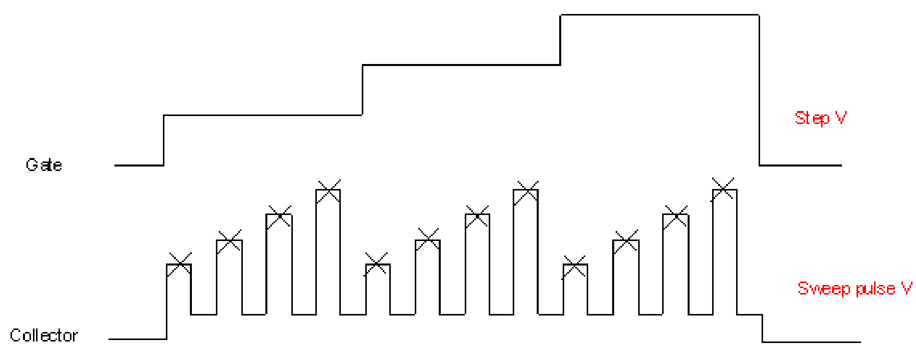
Measures the voltage and current at the Collector terminal while sweeping the Collector voltage for each voltage step at the Gate terminal (see next figure).

Figure 258: IcVce_StepVge



Test pulse sequence: Collector sweep pulse V, Gate step V (see next figure).

Figure 259: 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, auto range 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

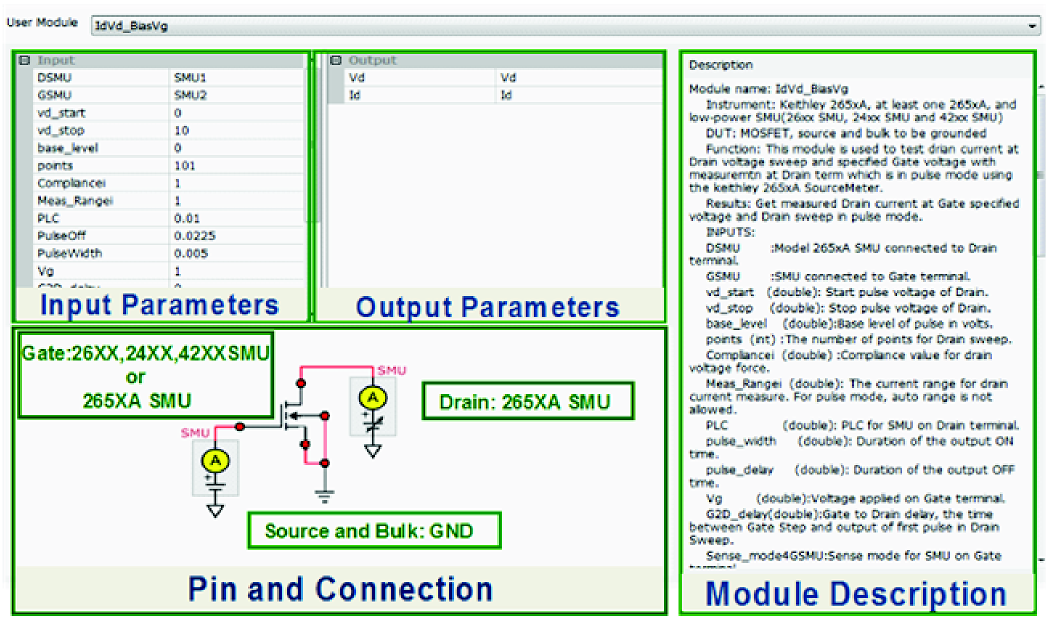
If the Gate terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the Collector terminal.

IdVd_BiasVg

Description:

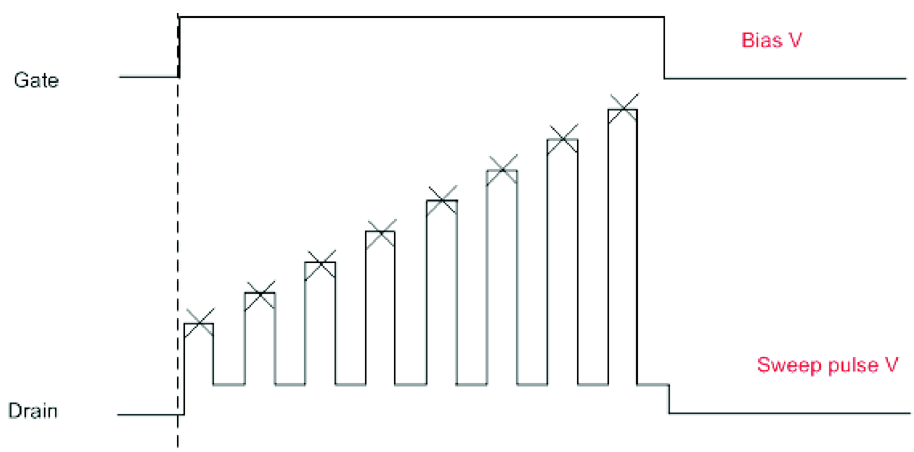
Tests the Drain current over a Drain voltage sweep at a specified Gate voltage, with measurements at the Drain terminal, which is in pulse mode using the Keithley Model 265xA SourceMeter (see next figure).

Figure 260: Idvd_BiasVg



Test pulse sequence: Gate bias V, Drain sweep pulse V(see next figure).

Figure 261: 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, auto range 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

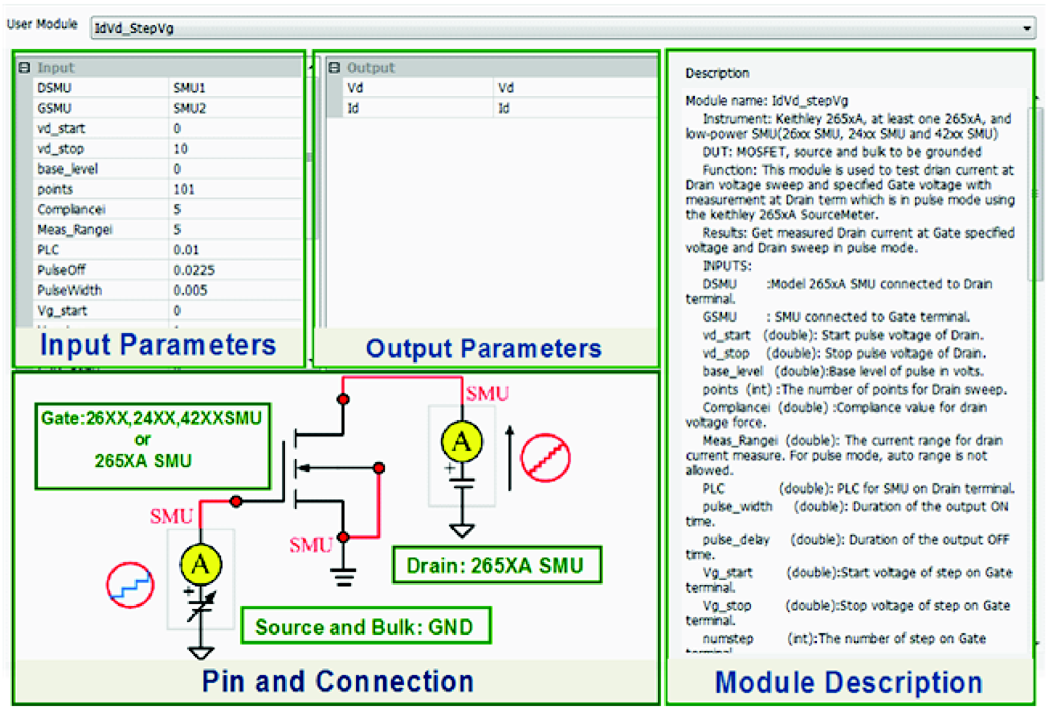
If the Gate terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the Drain terminal.

IdVd_StepVg

Description:

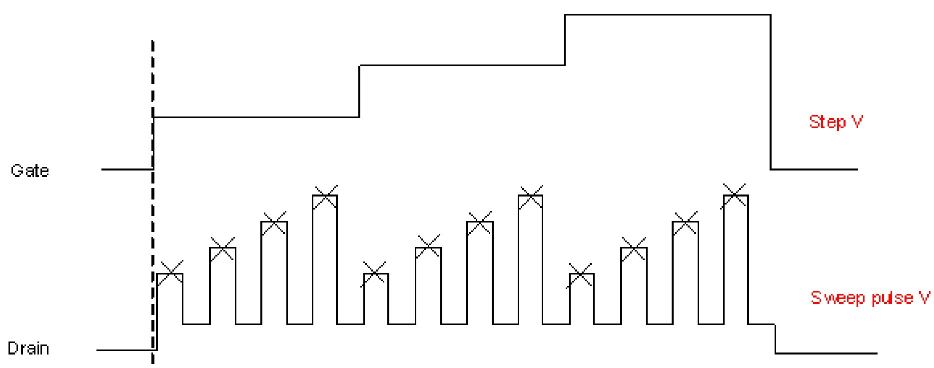
Tests the Drain current at the Drain voltage sweep and the specified Gate voltage, with measurements at the Drain terminal, which is in pulse mode using the Keithley Model 265xA SourceMeter (see next figure).

Figure 262: Idvd_StepVg



Test pulse sequence: Gate step V, Drain sweep pulse V (see next figure).

Figure 263: 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, auto range 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

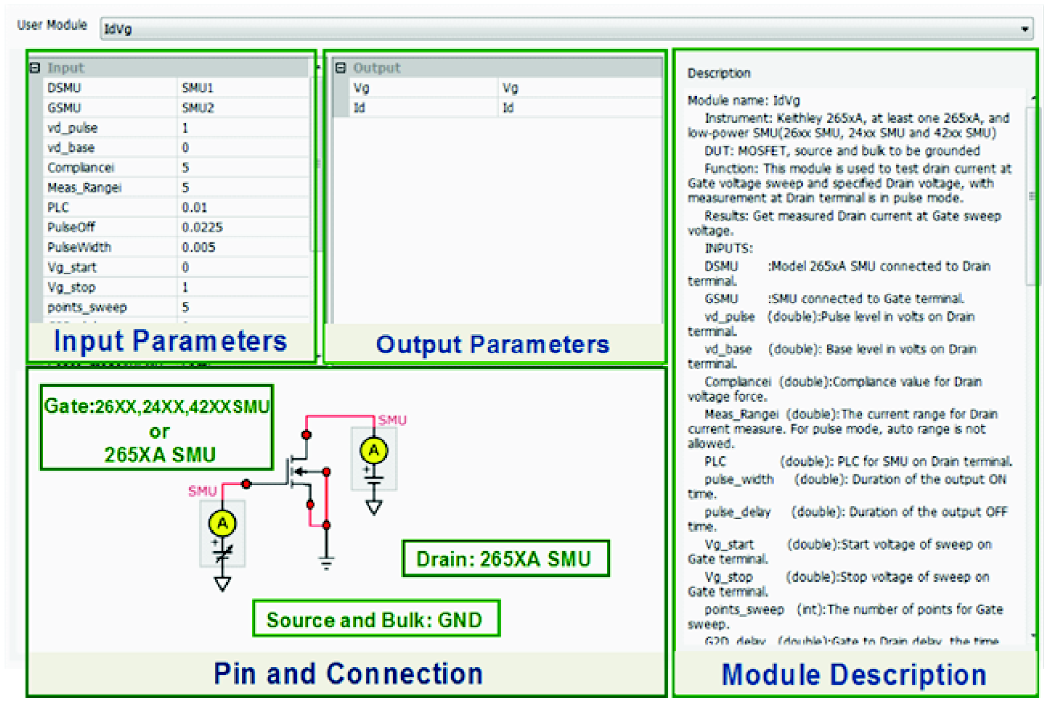
If the Gate terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the Drain terminal.

IdVg

Description:

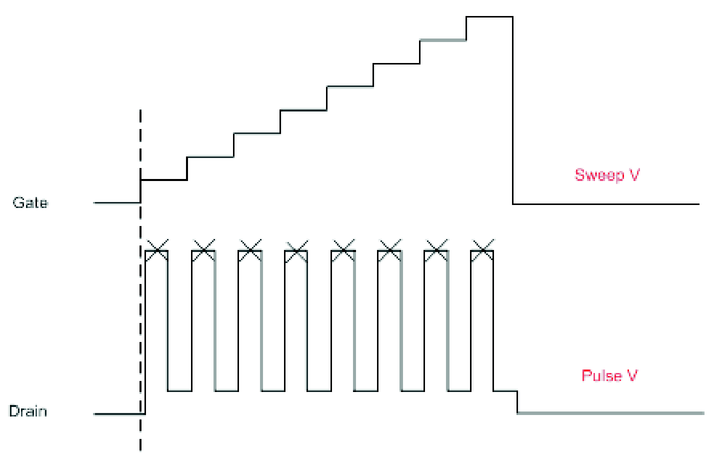
Tests the Drain current at the Gate voltage sweep and the specified Drain voltage, with measurements at the Drain terminal, which is in pulse mode (see next figure).

Figure 264: Idvg



Test pulse sequence: Gate sweep V, Drain pulse V (see next figure).

Figure 265: 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, auto range 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

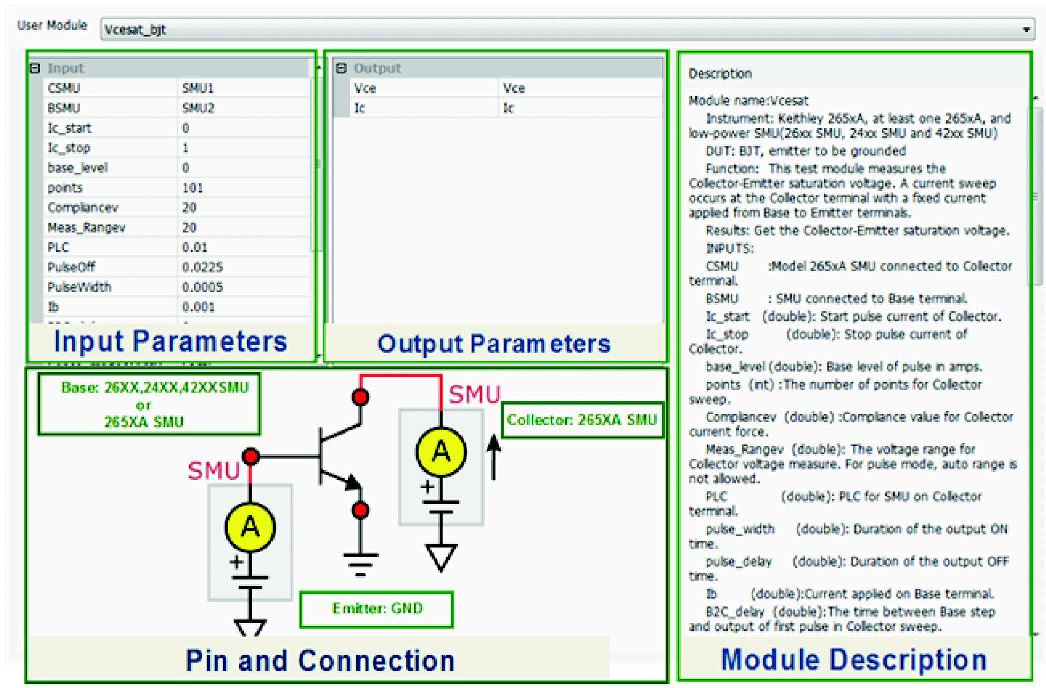
If the Gate terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the Drain terminal.

Vcesat_bjt

Description:

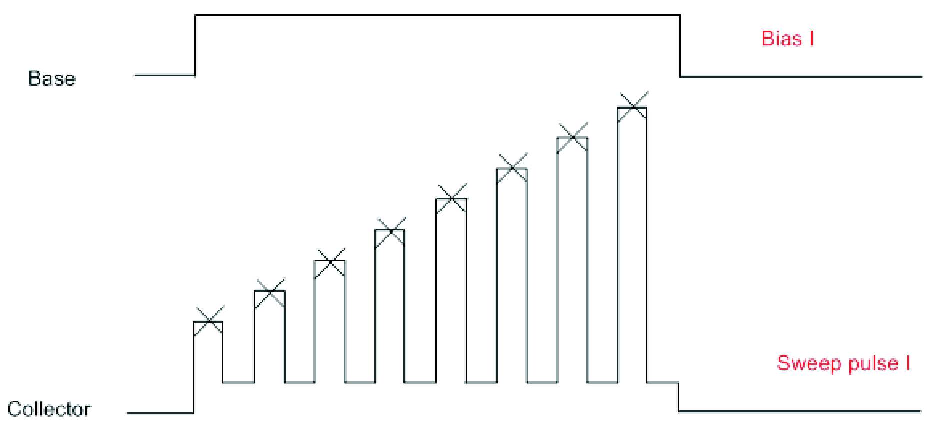
Measures the Collector-Emitter saturation voltage. A current sweep occurs at the Collector terminal with a fixed current applied to the Base and Emitter terminals (see next figure).

Figure 266: Vcesat_BJT



Test pulse sequence: Collector sweep pulse I, Base bias I (see next figure).

Figure 267: 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, auto range 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

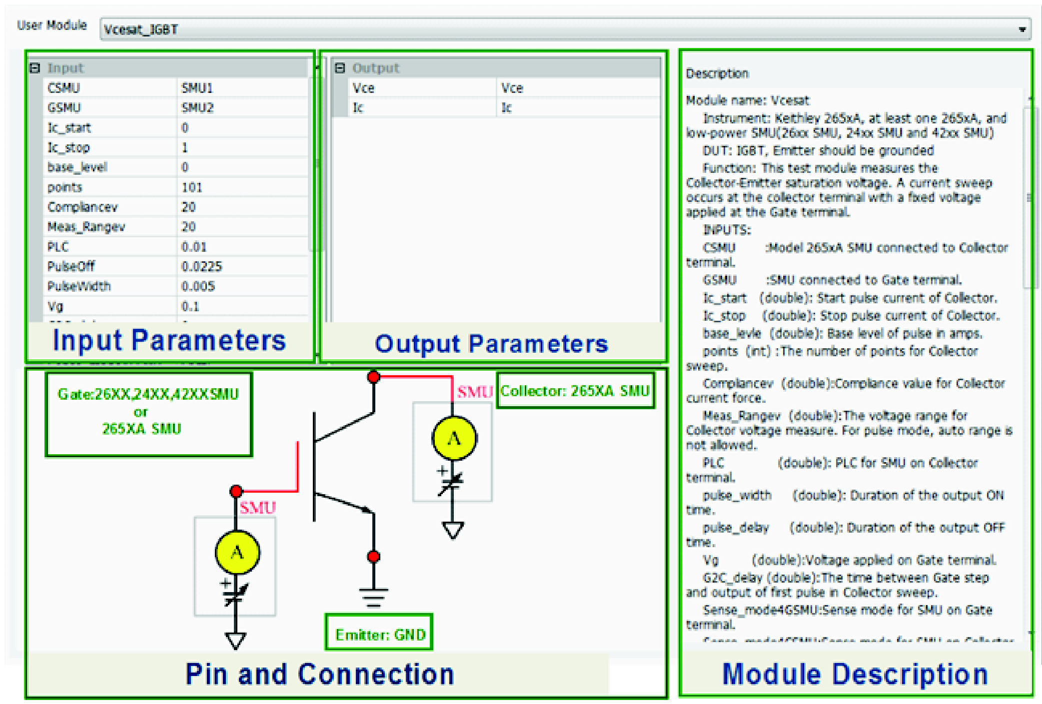
If the Base terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the Collector terminal.

Vcesat_IGBT

Description:

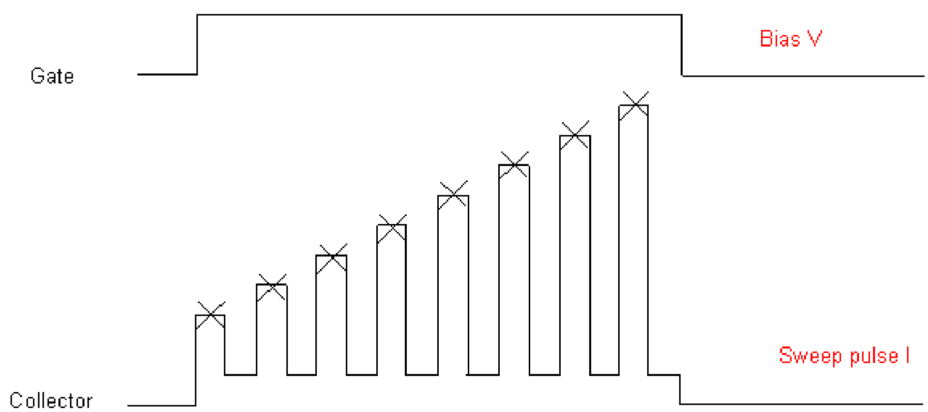
Measures the Collector-Emitter saturation voltage. A current sweep occurs at the Collector terminal with a fixed voltage applied at the Gate terminal (see next figure).

Figure 268: Vcesat_IGBT



Test pulse sequence: Collector sweep pulse **I**, Gate bias V (see next figure).

Figure 269: 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, auto range 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

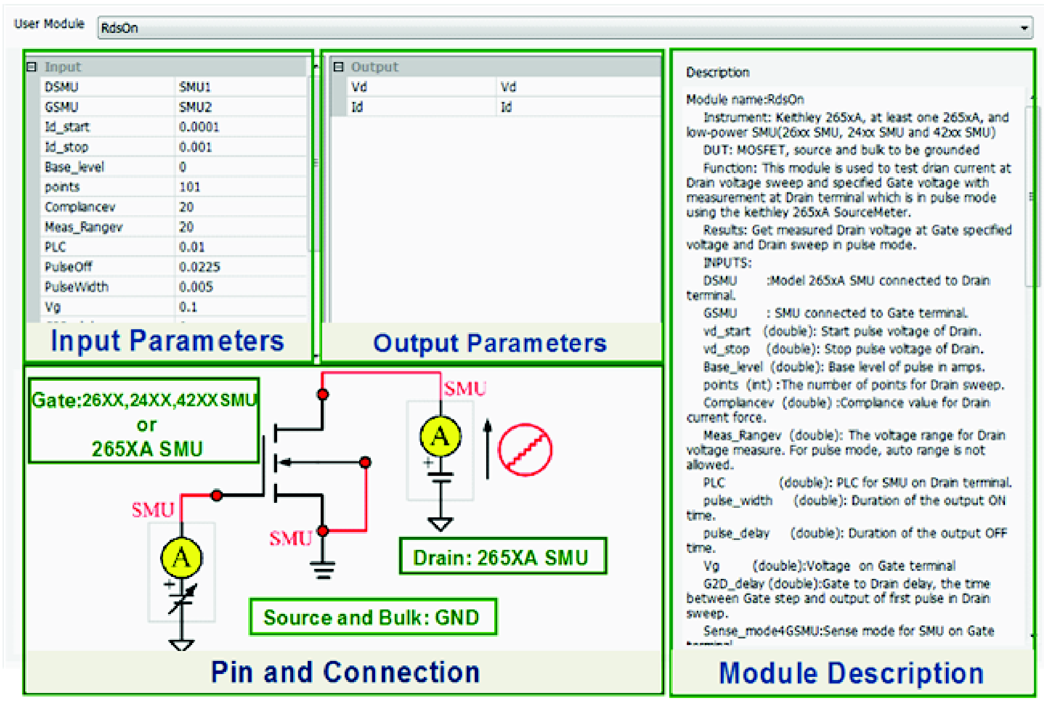
If the Gate terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to Collector terminal.

Rdson

Description:

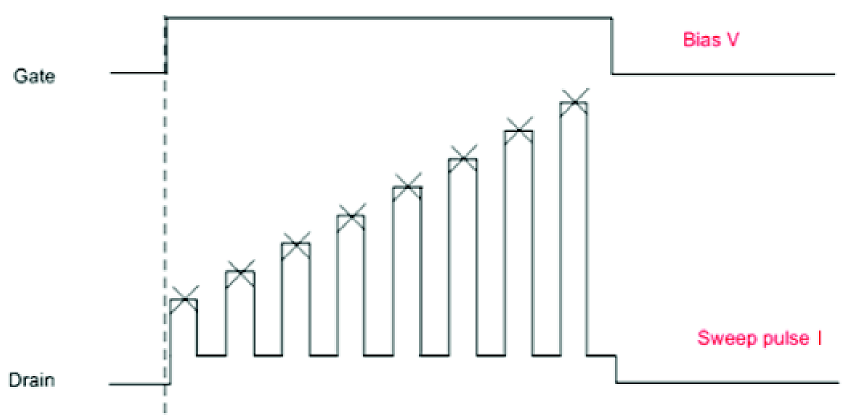
Tests the Drain current at the Drain voltage sweep and the specified Gate voltage with measurements at the Drain terminal, which is in pulse mode using the Keithley Model 265xA SourceMeter (see next figure).

Figure 270: RdsOn



Test pulse sequence: Gate bias V, Drain sweep pulse I (see next figure).

Figure 271: 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, auto range 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

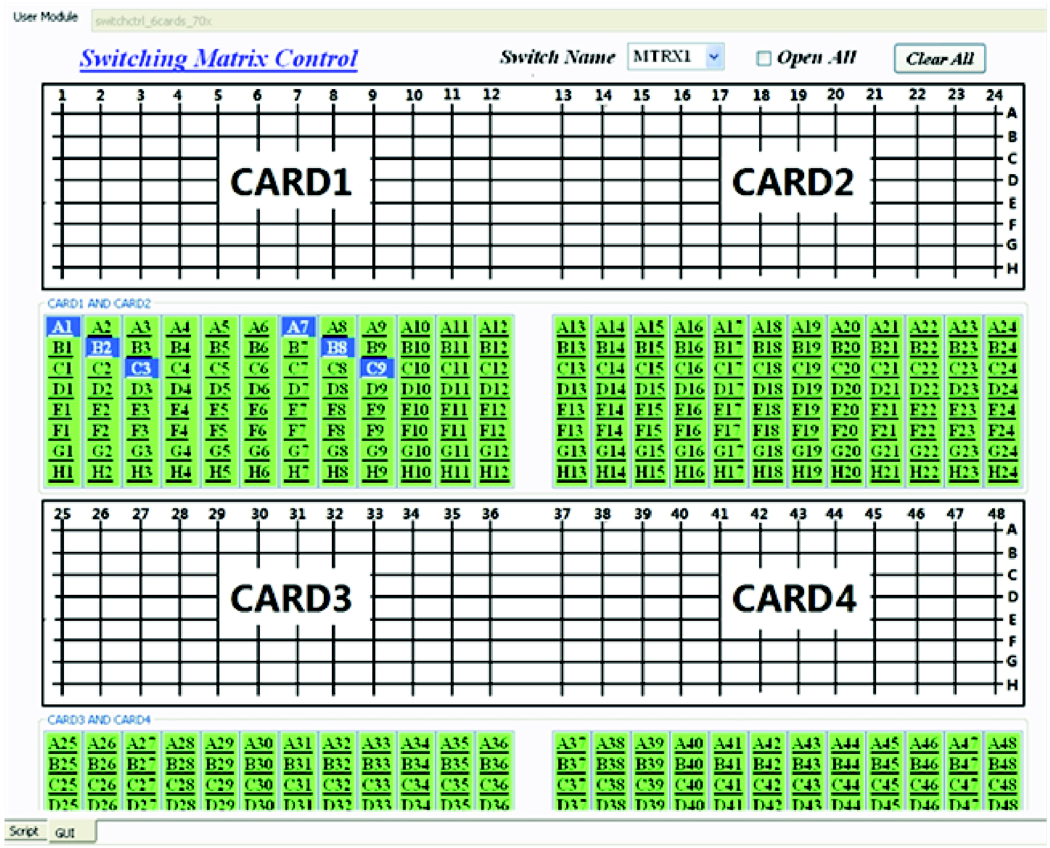
If the Gate terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the Drain terminal.

Switch control PTM

This PTM module is used to control the Model 707 or 708 Matrix. This module supports both Model 707A/708A and Model 707B/708B (both DDC mode and ICL mode). It's used to open or close any specific relays of the matrix cards and it can be done before you connect the SMU, CVU or other instruments to the device under test (DUT).

This test module can be found in single-test mode in the CommonLib, or it can be imported in multi-test mode from the following directory: \ACS\library\pyLibrary\PTMLib\switchctrl.py.

Figure 272: 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, 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 708 matrix has only one card (that means 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 checked, the module will first open all the relays before closing any selected relays.

Clear All: Clears all of the selected relays in the relays selecting area.

Select relays: Select any relay that you want to close. Clicking on the selected relay will de-select it.

After selecting all the relays that you want to close, click the **Run** icon on the tool bar, and these relays will close in the matrix. If you want to open all of the closed relays, check the **Open All** option and de-select all relays that are selected, then Run the module.

Specifications are subject to change without notice.

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12/06