

Automated Characterization Suite (ACS) Basic Edition

Libraries Reference Manual

ACSBASIC-908-01 Rev. B / September 2014



ACSBASIC-908-01

A Greater Measure of Confidence



ACS Basic
Automated Characterization Suite (ACS)
Libraries Reference Manual

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Cleveland, Ohio, U.S.A.

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

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

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

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

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

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

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

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

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


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


Do not exceed the maximum signal levels of the instruments and accessories, 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 protective earth (safety ground) connections.

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


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

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

The  symbol on an instrument means 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  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.

Safety precaution revision as of January 2013.

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LPT Library Reference

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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 and 2650A 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/2650A System SourceMeters, Series 2400 instruments, and Series 23X instruments. In addition, the Python LPT library contains commands that allow you to control other GPIB-based instruments.

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 `postdata` 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_ZERO	KI_OFF_NORM: Outputs 0V when the output is turned off.
		KI_OFF_OPEN	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_SENSE	KI_SENSE_LOCA	Sets the sense mode to remote, local, or calibration.
		KI_SENSE_REMO	KI_SENSE_LOCA: selects local sense (2-wire).
		KI_SENSE_CALA	KI_SENSE_REMO: selects remote sense (4-wire). KI_SENSE_CALA: selects calibration sense mode.

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()
```

sysquery

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)
```

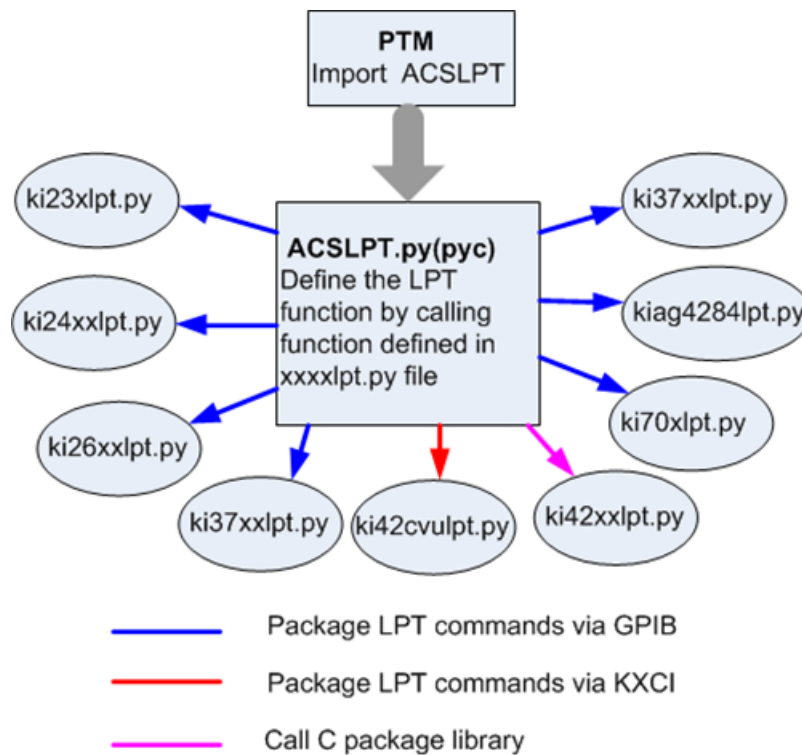
Python LPT library

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

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			
avgv	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			
avgv	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

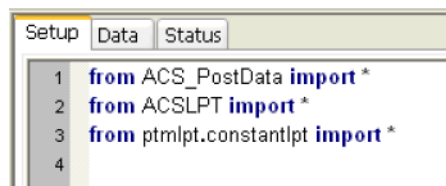
Capacitance Meter LPT function list

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 ptmplt.constantlpt to the header lines of a PTM (see next figure). The ACSLPT commands are listed in alphabetical order.

Figure 2: Import ACSLPT



```

Setup Data Status
1 from ACS_PostData import *
2 from ACSLPT import *
3 from ptmplt.constantlpt import *
4

```

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

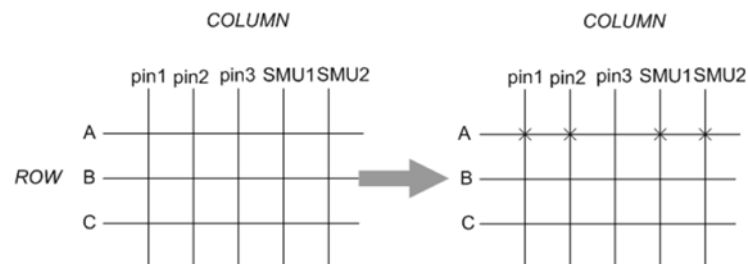
```
addpth(MTRX1, SMU1, 1, '1')
addpth(SMU1, 1, '1')
addpth(SMU1H, 1, '1')
addpth(SMU1L, 1, '1')
addpth([SMU1, SMU2], [1, 2], '1')
addpth(MTRX1, [SMU1, SMU2], [], '1')
addpth([], [1, 2], '1')
```

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

`dc_lmt_i---`(`ERR_CHECKPARAM`, `input_range`) / (`INVALID_PARAM`, `correct_lmt`) / (OK, `input_range`)

`INVALID_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_lmt_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:

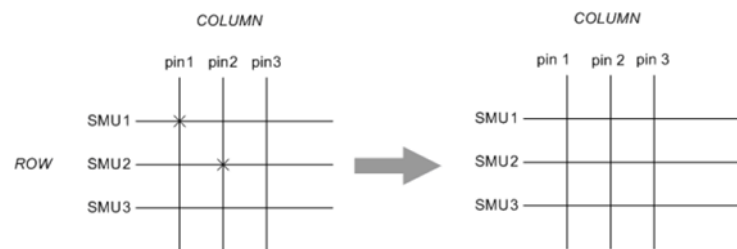
```
clrcon(unitname)
```

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)
```

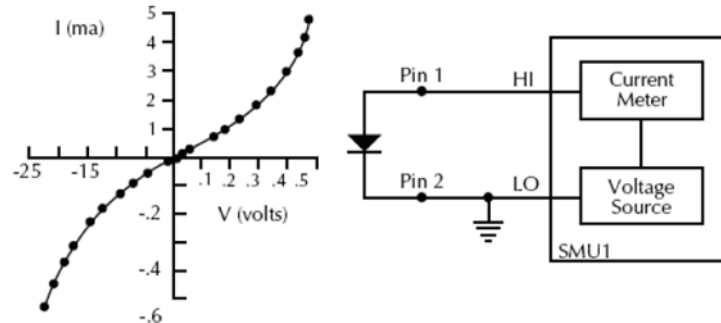
clrtrg

Purpose: Clears the user-selected voltage or current level used to set trigger points. This permits the use of `trigX1` 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 command 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.

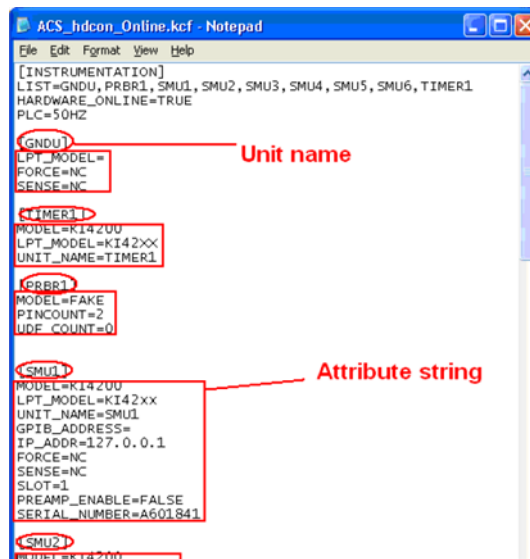
Format:

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

`unitname` = The instrument name 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:

```
INVALID_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 a 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: (tuple 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: (tuple 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 $\pm 10.0V$. A `limiti` ("SMU1", 1.5E-3) limits the current of the voltage source of SMU1 to $\pm 1.5mA$. And `limitp` ("SMU1", 20) limits the power of the source of SMU1 to $\pm 20W$.

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 = 166.67 μ s (0.01PLC/60Hz). For 50Hz line power, 0.01PLC = 200 μ s (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	
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_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.
		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_MSRC = 4	KI_TRIG_IN_MSRC: 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_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	
	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 call.
		KI_INTEGRATE	

SMU1	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	0 = OFF 1 = ON	Enables or disables compensation constants for open load and short.
	KI_CVU_SHORT_COMPENSATE		
	KI_CVU_LOAD_COMPENSATE		
	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 <code>measz</code> 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	0 = OFF 1 = ON	Enables or disables compensation constants for open load and short.
	KI_CVU_SHORT_COMPENSATE		
	KI_CVU_LOAD_COMPENSATE		
	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.	

CMTR 1	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 <code>measz</code> library topic.
	KI_CVU_MODE	0 or 1	0: sets CVU to user mode 1: sets CVU to system mode
	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 "GPIO/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.

	<p>KI_AGCV_DISPLAY_PAGE</p>	<p> 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 </p>	<p> 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> </p>
--	-----------------------------	---	--

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.

²These 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 ptmplt.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 INVALID_PARAM
    if GateVStop < -200 or GateVStop > 200:
        return INVALID_PARAM
    if numberofpoint < 1 or numberofpoint > 4096:
        return INVALID_PARAM
    if SweepDelay < 0 or SweepDelay > 100:
        return INVALID_PARAM
    if DrainV < -200 or DrainV > 200:
        return INVALID_PARAM
    if SourceV < -200 or SourceV > 200:
        return INVALID_PARAM
    if BulkV < -200 or BulkV > 200:
        return INVALID_PARAM
    if RangeDrainI < 1 or RangeDrainI > 12:
        return INVALID_PARAM
    if ComplianceDrainI < -0.1 or ComplianceDrainI > 0.1:
        return INVALID_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:
    setauto(DrainSMU)
elif RangeDrainI == 2:
    lorangei(DrainSMU, 1e-11)
elif RangeDrainI == 3:
    lorangei(DrainSMU, 1e-10)
elif RangeDrainI == 4:
    lorangei(DrainSMU, 1e-9)
elif RangeDrainI == 5:
    lorangei(DrainSMU, 1e-8)
elif RangeDrainI == 6:
    lorangei(DrainSMU, 1e-7)
elif RangeDrainI == 7:
    lorangei(DrainSMU, 1e-6)
elif RangeDrainI == 8:
    lorangei(DrainSMU, 1e-5)
elif RangeDrainI == 9:
    lorangei(DrainSMU, 1e-4)
elif RangeDrainI == 10:
    lorangei(DrainSMU, 1e-3)
elif RangeDrainI == 11:
    lorangei(DrainSMU, 1e-2)
```

```
# auto range
# limited auto 10pA
#limited auto 100pA
#limited auto 1nA
#limited auto 10nA
#limited auto 100nA
#limited auto 1uA
# limited auto 10uA
# limited auto 100uA
# limited auto 1mA
# 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
vgsidl(DrainSMU, DrainPin, GateSMU, GatePin, SourceSMU, SourcePin, BulkSMU,
      BulkPin, GateVStart, GateVStop, numberofpoint, SweepDelay, DrainV, SourceV,
      BulkV, RangeDrainI, ComplianceDrainI, StoponCompliance, NPLC)
```

Device Library

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Introduction

ACS Basic has a large device test library, including the following libraries:

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

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

In ACS Basic, you can also build a library to import and use.

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

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

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

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

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

nMOSFET WLR_script library
HCI

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

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

pMOSFET WLR_script library	
HCI	NBTI
NBTI_meas	NBTI_on_the_fly

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

Diode parametric library		
DynamicZ	Spot_IldVfd	Spot_IrdVrd
Spot_VbrIrd	Spot_VfdIld	Spot_VrdIrd
Sweep_IldVfd	Sweep_IrdVrd	

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

Two-terminal resistor parametric library	
Spot_IV_2SMU	Spot_VI_2SMU
Sweep_IV_2SMU	Sweep_VI_2SMU

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

Zener parametric library		
BVZ	IR	VF

Capacitor_MOS WLR_script library	
qbd_rmpj	qbd_rmpv
TDDB_CCS	TDDB_per_pin

CommonLib_CV		
Cv4282	Generic_HVCV_Test	KI42xxCVU

CommonLib_other		
KI37XX_DMM_Switch	power_supply	switchctrl_6cards_3706
switchctrl_6cards_70x	TEKSCOPE_ReadWave	

Mixed_SMU_Mode library		
BiasMeasV_Pulse_2430	BiasVMeasI_Pulse_2430	BiasVolt_SampleCurr_23x
BVcei_any_SMU	BVcev_any_SMU	BVdsv_any_SMU
combined_mixed_SMU	hFE_BJT_any_SMU	IcVce_StepIb_any_SMU
IcVce_StepVbe_any_SMU	IcVce_StepVge_any_SMU	IcVge_any_SMU
IdON_any_SMU	Idvd_24xx	IdVd_BiasVg_any_SMU
IdVd_Pulse_24xx	IdVd_StepVg_any_SMU	IdVg_24xx
IdVg_BiasVd_any_SMU	IdVg_Pulse_24xx	RdsOn_any_SMU
SweepCurr_23x	SweepI_MeasV_24xx	SweepV_MeasI_24xx
SweepVolt_23x	Vcesat_bjt_any_SMU	Vcesat_IGBT_any_SMU
vdsId_237	VgsON_any_SMU	

Common library	
FourWireResistor_3706	Gpibresistor_3706

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.

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

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

TSP script must use the ACS Basic functions `postdata`, `postbuffer`, or `posttable` to retrieve data from the Series 2600B. For examples, refer to the folder:

```
C:\ACS_BASIC\library\26Library
```

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

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

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

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 folder:

```
\ACS_BASIC\Library\26Library\xrc
```

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:

C:\ACS_BASIC\library\26Library\WLR

npnBJT library

npnBJT overview

The BJT library components are located in the following folder:

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

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

npnBJT parametric library

BVCBO

Description:

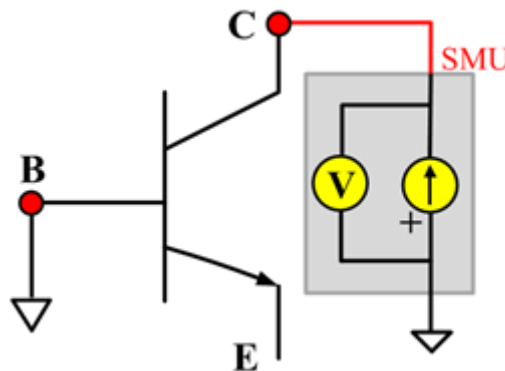
Module Name: BVCBO

DUT: Three-terminal BJT

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

Pin connections: Use one SMU to force a reverse current to the Collector. Open the circuit to the Emitter or use a SMU to supply zero current bias. Connect the Base to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 7: Three_term_npnBJT_BVCBO

**BVCBO ITM**

Module type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

BVCBO General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVCEI

Description:

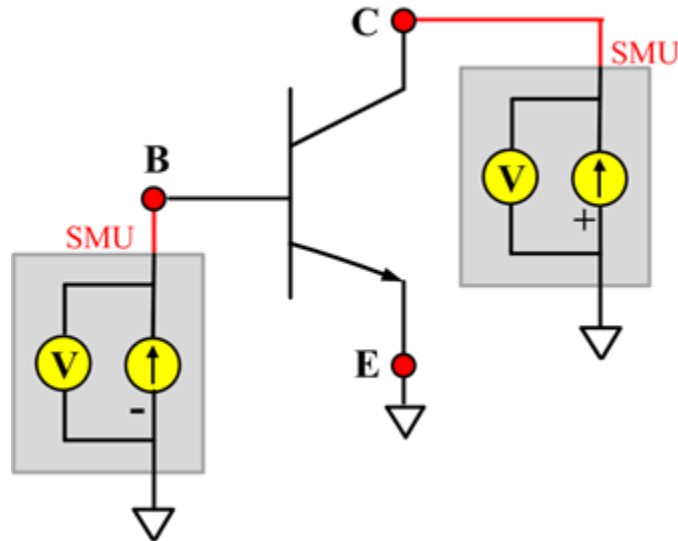
Module Name: BVCEI

DUT: Three-terminal npnBJT

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

Pin connections: Use a SMU to force current to the Collector. Connect the Emitter to GND or use a SMU to supply a zero voltage bias.(See next figure.)

Figure 8: Three_term_npnBJT_BVCEI pin connection



BVCEI ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

BVCEI General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVCEO

Description:

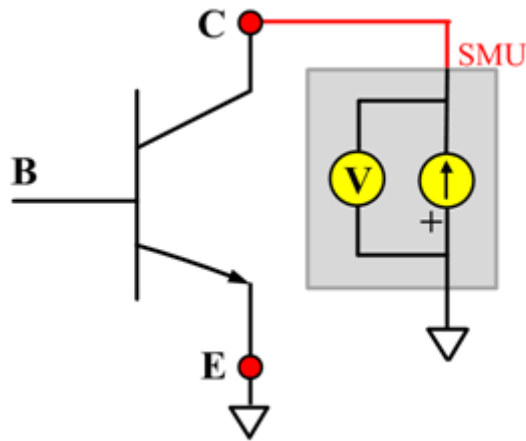
Module Name: BVCEO

DUT: Three-terminal npnBJT

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

Pin connections: Use a SMU to force current to the Collector. Open the circuit to the Base or use a SMU to supply zero current bias to the Base. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 9: Three_term_npnBJT_BVCEO pin connection



BVCEO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

BVCEO General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVCEV

Description:

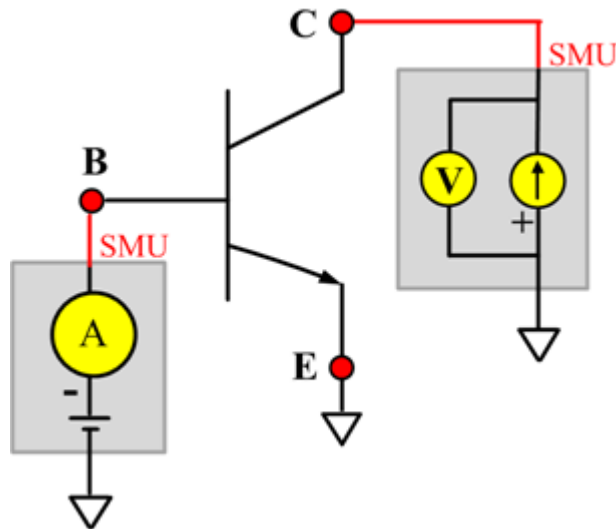
Module Name: BVCEV

DUT: Three-terminal npnBJT

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

Pin connections: Use a SMU to force voltage to the Base. Use a SMU to force current to the Collector. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 10: Three_term_npnBJT_BVCEV pin connection



BVCEV ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

BVCEV General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVEBO

Description:

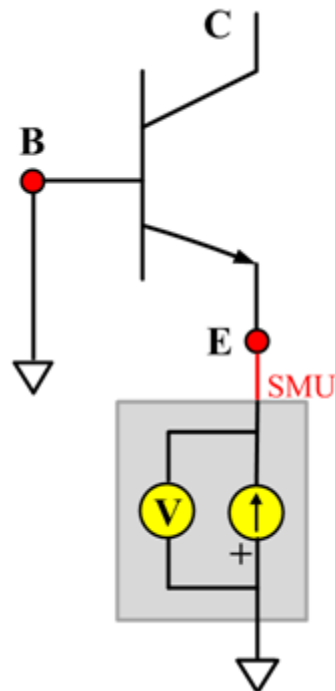
Module Name: BVEBO

DUT: Three-terminal npnBJT

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

Pin connections: Use a SMU to force current to the Emitter. Connect the Base to GND or use a SMU to supply a zero voltage bias. Open the circuit to the Collector or use a SMU to supply zero current bias. (See next figure.)

Figure 11: Three_term_npnBJT_BVEBO pin connection



BVEBO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

BVECO

Description:

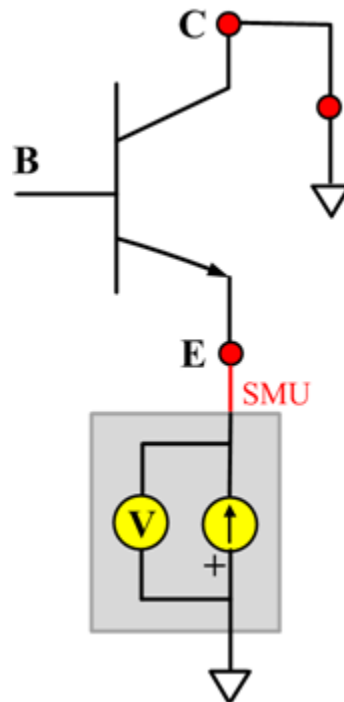
Module Name: BVECO

DUT: Three-terminal npnBJT

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

Pin connections: Use a SMU to force current to the Emitter. Connect the Collector to GND or use a SMU to supply a zero voltage bias. Open the circuit to the Base or use a SMU to supply zero current bias. (See next figure.)

Figure 12: Three_term_npnBJT_BVECO pin connection

**BVECO ITM**

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

Ccb

Description:

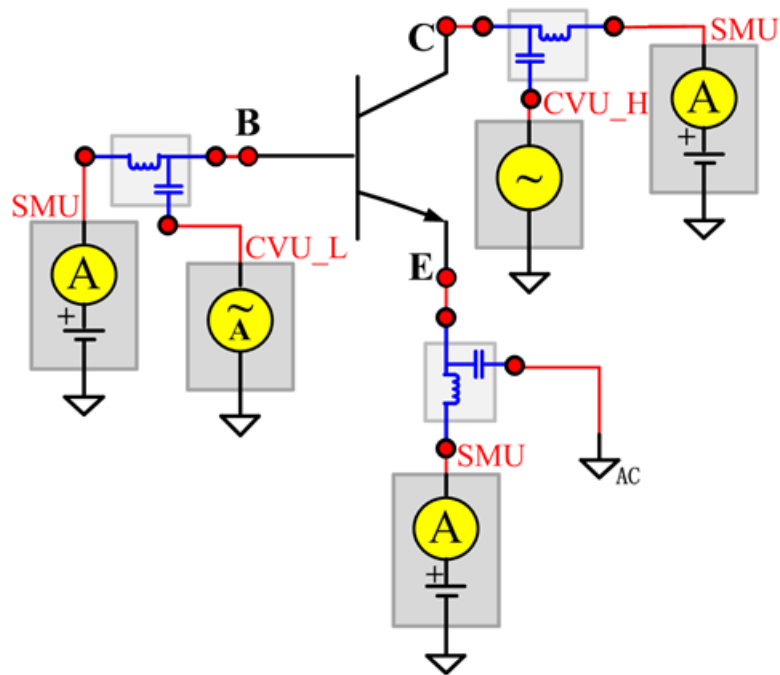
Module Name: Ccb

DUT: Three-terminal npnBJT

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

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

Figure 13: Three_term_npnBJT_Ccb pin connection



Ccb PTM

Module type: PTM

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

Cce

Description:

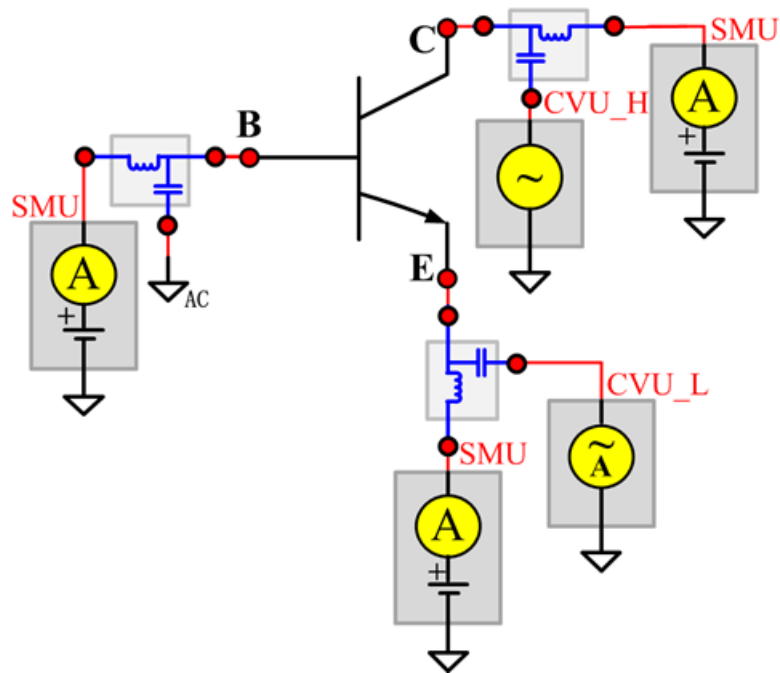
Module Name: Cce

DUT: Three-terminal npnBJT

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

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

Figure 14: Three_term_npnBJT_Cce pin connection



Cce PTM

Module type: PTM

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

Ceb

Description:

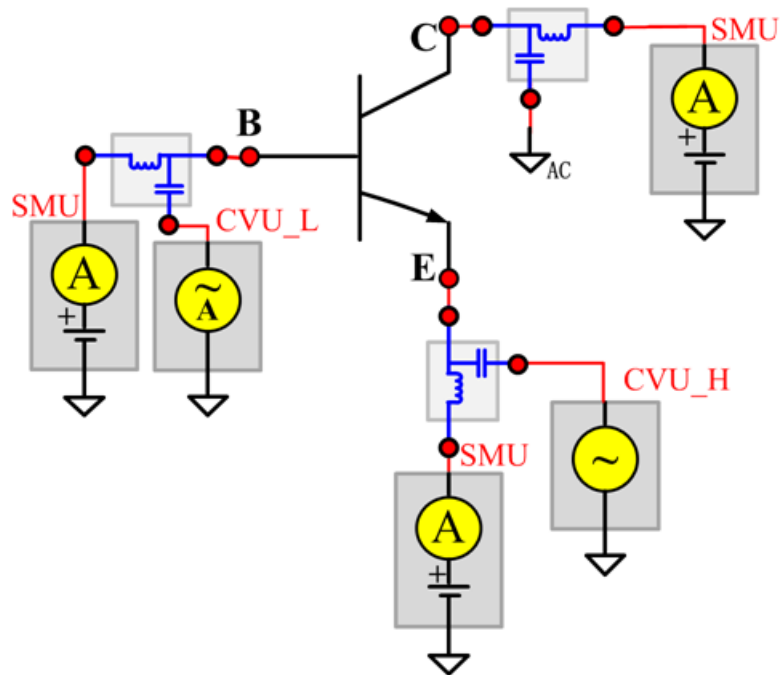
Module Name: Ceb

DUT: Three-terminal npnBJT

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

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

Figure 15: Three_term_npnBJT_Ceb pin connections



Ceb PTM

Module type: PTM

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

Cibo

Description:

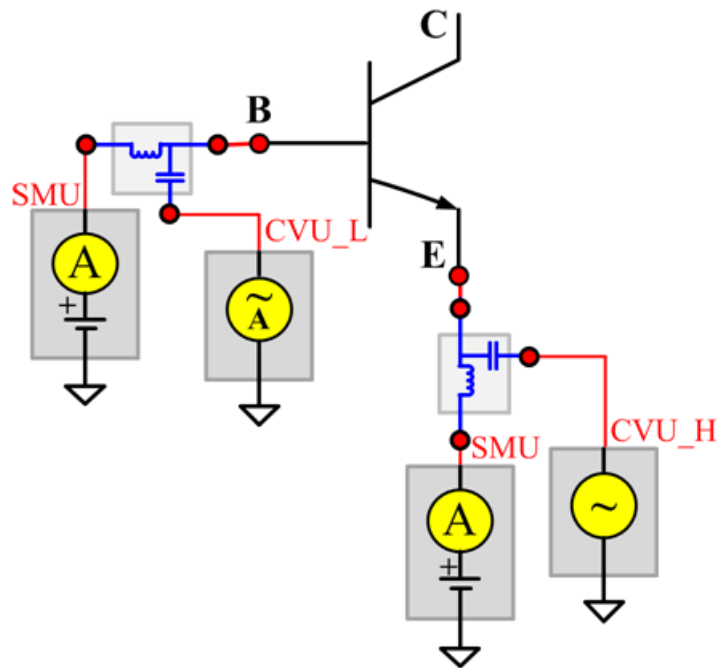
Module Name: Cibo

DUT: Three-terminal npnBJT

Function: Measures the capacitance between the input terminals (Base and Emitter) with the Collector terminal open.

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

Figure 16: Three_term_npnBJT_Cibo pin connection



Cibo PTM

Module type: PTM

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

Cobo

Description:

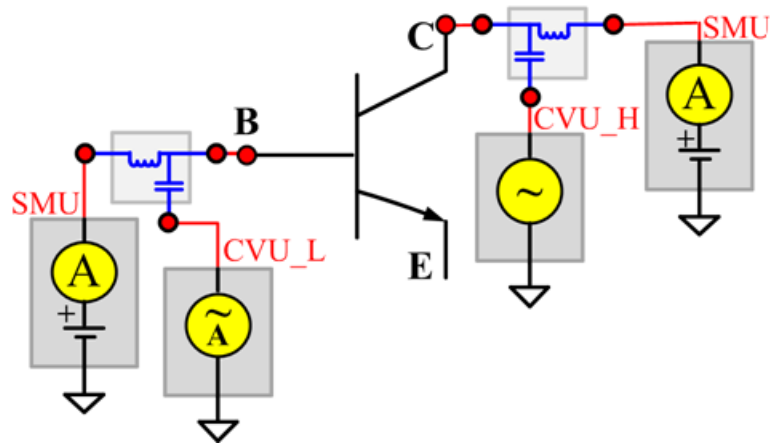
Module Name: Cobo

DUT: Three-terminal npnBJT

Function: Measures the capacitance between the output terminals (Base and Collector) with the Emitter terminal open.

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

Figure 17: Three_term_npnBJT_Cobo pin connection



Cobo PTM

Module type: PTM

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

HFE_SW

Description:

Module Name: HFE_SW

DUT: Three-terminal npnBJT

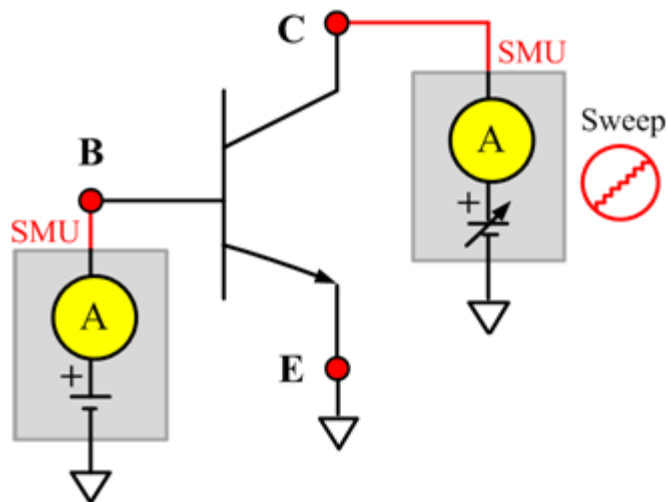
Function: Measures the Collector current, Base current, and DC current gain based on the Collector sweep voltage.

Pin connections: Use a SMU to apply a sweep voltage to the Collector. Use a SMU to bias the Base. C or u.

HFE= I_c/I_b :

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

Figure 18: Three_term_npnBJT_HFE_SW pin connection



HFE_SW ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

HFE_SW General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IBCO

Description:

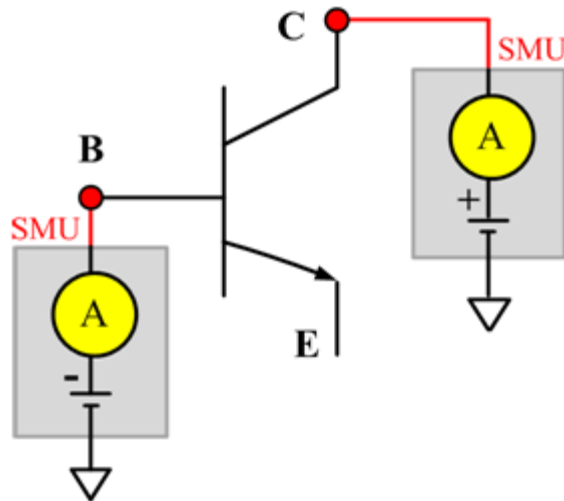
Module Name: IBCO

DUT: Three-terminal npnBJT

Function: Measures the base-Collector current with the Emitter opened.

Pin connections: Use a SMU to force voltage to the Base. Connect the Collector to GND or use a SMU to supply a zero voltage bias. Open the circuit to the Emitter or use a SMU to supply zero current bias. (See next figure.)

Figure 19: Three_term_npnBJT_IBCO pin connection



IBCO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IBCO General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IBEO

Description:

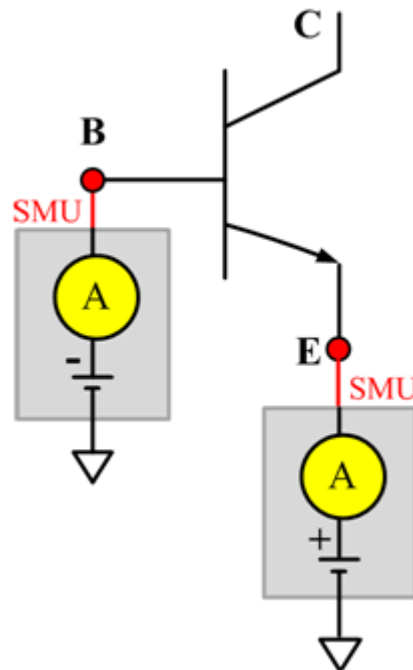
Module Name: IBEO

DUT: Four-terminal npnBJT

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

Pin connections: Use a SMU to force voltage to the Base. Connect the Collector to GND or use a SMU to supply a zero voltage bias. Open the circuit to the Emitter or use a SMU to supply zero current bias. (See next figure.)

Figure 20: Three_term_npnBJT_IBEO pin connection



IBEO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IBEO General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IbIcVbe

Description:

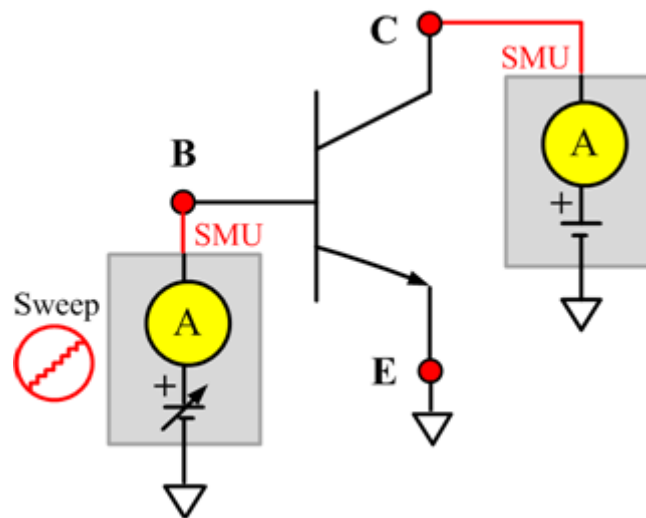
Module Name: IbIcVbe

DUT: Three-terminal npnBJT

Function: Measures the Base current and Collector current of the npnBJT by sweeping a specified Base voltage, and measures the I_b - V_{be} and I_c - V_{be} curves and the gummel plot if the axis properties of result have changed (logarithm instead of right-angle coordinate).

Pin connections: Use a SMU to apply a voltage sweep to the Base. Use a SMU to bias the Collector. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 21: Three_term_npnBJT_IbIcVbe pin connection



IbIcVbe ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IbIcVbe General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IbVbe

Description:

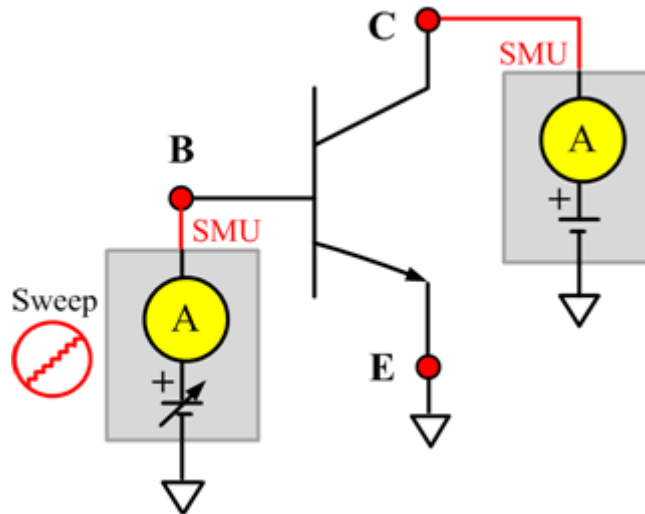
Module Name: IbVbe

DUT: Three-terminal npnBJT

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

Pin connections: Use a SMU to apply a voltage sweep to the Base. Use a SMU to bias the Collector. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 22: Three_term_npnBJT_IbVbe pin connection



IbVbe ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IbVbe General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

ICBO

Description:

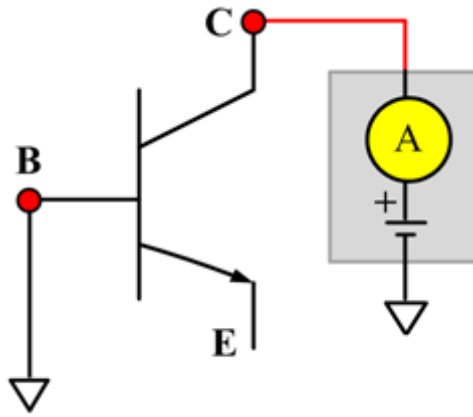
Module Name: ICBO

DUT: Three-terminal npnBJT

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

Pin connections: Use a SMU to force voltage to the Collector. Connect the Base to GND or use a SMU to supply a zero voltage bias. Open the circuit to the Emitter or use a SMU to supply zero current bias.

Figure 23: Three_term_npnBJT_ICBO pin connection



ICBO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

ICBO General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

ICEO

Description:

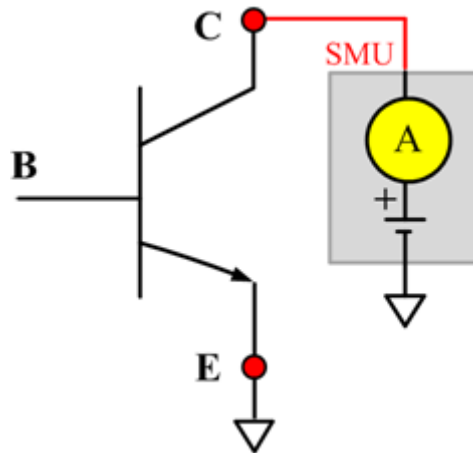
Module Name: ICEO

DUT: Three-terminal npnBJT

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

Pin connections: Use a SMU to force voltage to the Collector. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. Open the circuit to the Base or use a SMU to supply zero current bias. (See next figure.)

Figure 24: Three_term_npnBJT_ICEO pin connection



ICEO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

ICEO General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

ICEV

Description:

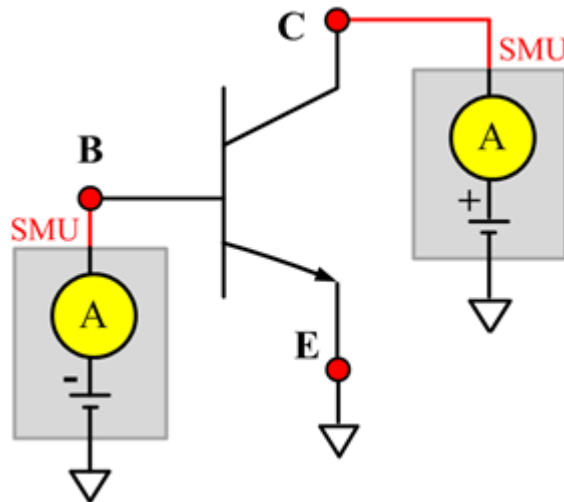
Module Name: ICEV

DUT: Three-terminal npnBJT

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

Pin connections: Use a SMU to force voltage to the Base and the Collector. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 25: Three_term_npnBJT_ICEV pin connection



ICEV ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

ICEV General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IcVcb

Description:

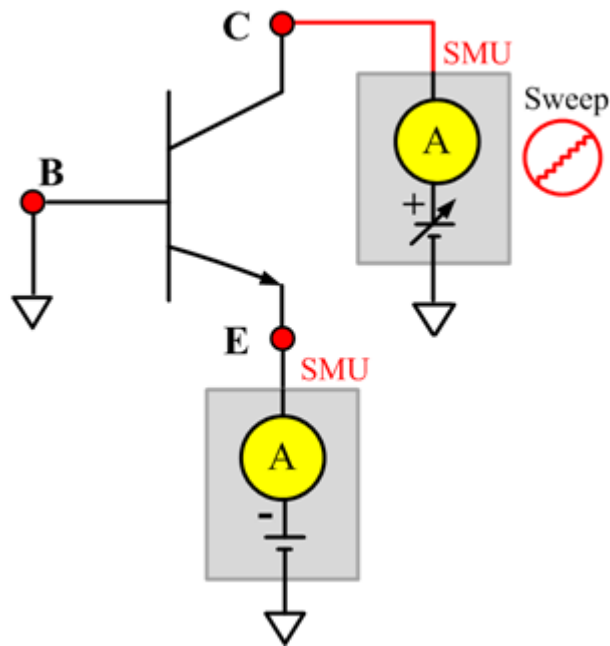
Module Name: IcVcb

DUT: Three-terminal npnBJT

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

Pin connections: Use a SMU to apply a sweep voltage to the Collector. Use a SMU to bias the Emitter. Connect the Base to GND or use a SMU to supply a zero voltage bias.

Figure 26: Three_term_npnBJT_IcVcb pin connection



IcVcb ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IcVcb General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IcVce_BiasIb

Description:

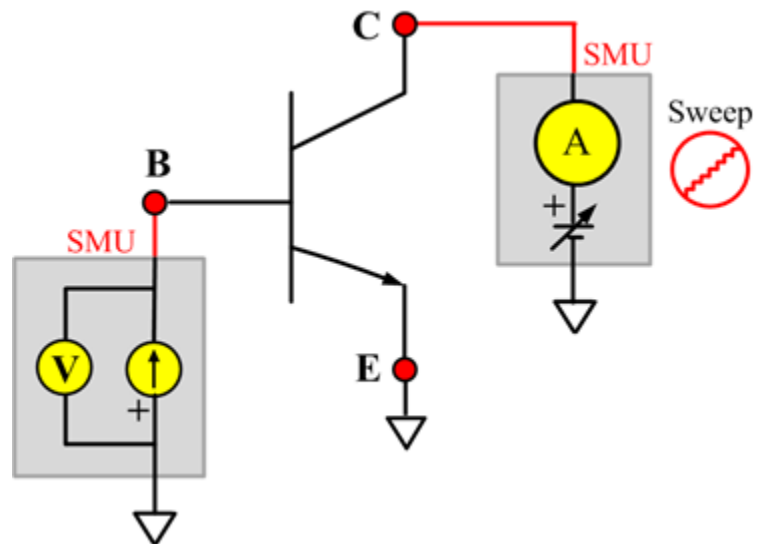
Module Name: IcVce_BiasIb

DUT: Three-terminal npnBJT

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

Pin connections: Use a SMU to apply a sweep voltage to the Collector. Use a SMU to bias the current to the Base. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 27: Three_term_npnBJT_IcVce_BiasIb pin connection



IcVce_BiasIb ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IcVce_BiasIb General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IcVce_BiasVb

Description:

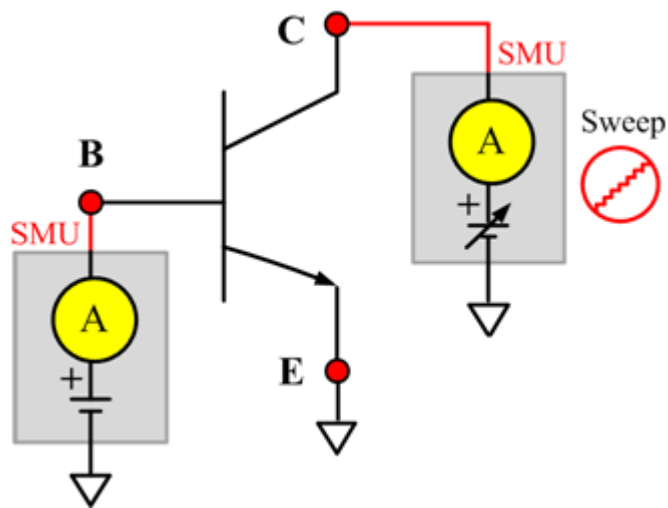
Module Name: IcVce_BiasVb

DUT: Three-terminal npnBJT

Function: Measures the Collector current based on the Collector sweep voltage and a fixed based voltage, and measures a series of IcVce curves with a fixed Base voltage.

Pin connections: Use a SMU to apply a sweep voltage to the Collector. Use a SMU to supply a zero voltage bias to the Base. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 28: Three_term_npnBJT_IcVce_BiasVb pin connection



IcVce_BiasVb ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IcVce_BiasVb General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IcVce_StepIb

Description:

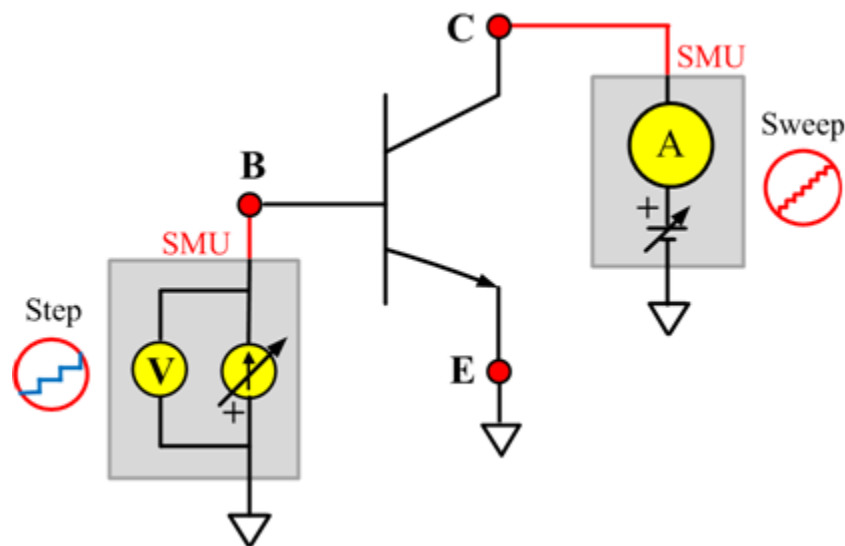
Module Name: IcVce_StepIb

DUT: Three-terminal npnBJT

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

Pin connections: Use a SMU to apply a sweep voltage to the Collector. Use a SMU to apply a step current to the Base. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 29: Three_term_npnBJT_IcVce_StepIb pin connection



IcVce_StepIb ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IcVce_StepIb General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IcVce_StepVb

Description:

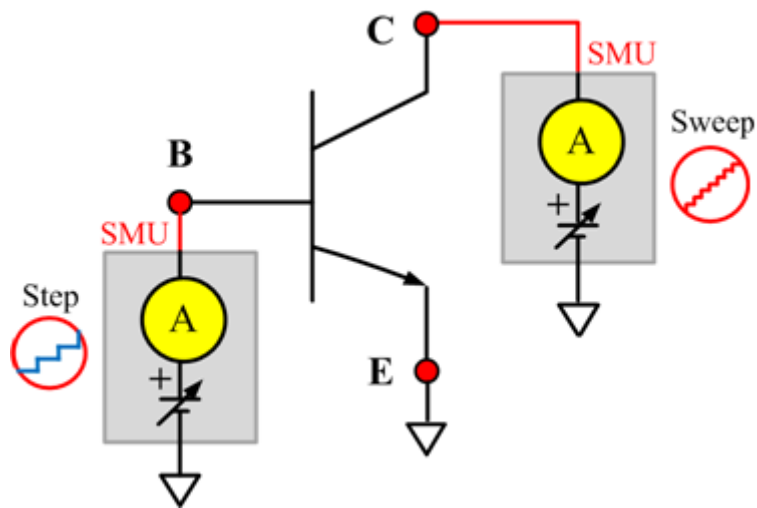
Module Name: IcVce_StepVb

DUT: Three-terminal npnBJT

Function: Measures the Collector current based on the Base step and the Collector sweep voltage, and measures a series of IcVce curves with a Base voltage step.

Pin connections: Use a SMU to apply a sweep voltage to the Collector. Use a SMU to apply a step voltage to the Base. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 30: Three_term_npnBJT_IcVce_StepVb pin connection



IcVce_StepVb ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IcVce_StepVb General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IEBO

Description:

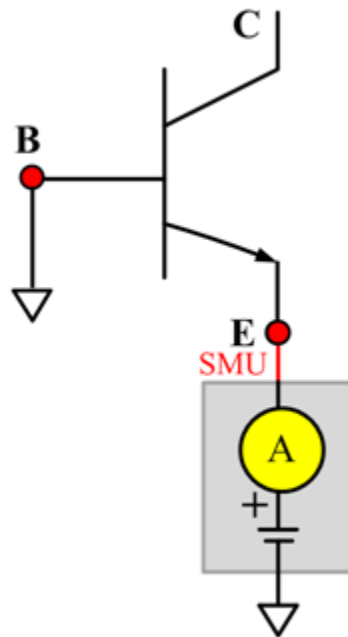
Module Name: IEBO

DUT: Three-terminal npnBJT

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

Pin connections: Use a SMU to force voltage to the Emitter. Connect the Base to GND or use a SMU to supply a zero voltage bias. Open the circuit to the Collector or use a SMU to supply zero current bias. (See next figure.)

Figure 31: Three_term_npnBJT_IEBO pin connection



IEBO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IECO

Description:

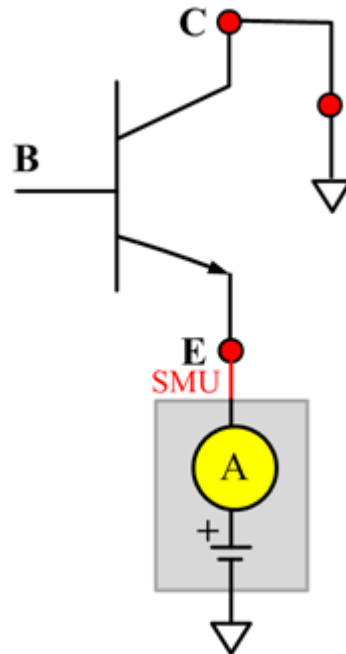
Module Name: IECO

DUT: Three-terminal npnBJT

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

Pin connections: Use a SMU to force voltage to the Emitter. Open the circuit to the Collector or use a SMU to supply a zero voltage bias. Open the circuit to the Base or use a SMU to supply zero current bias. (See next figure.)

Figure 32: Three_term_npnBJT_IECO pin connection



IECO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

leVeb

Description:

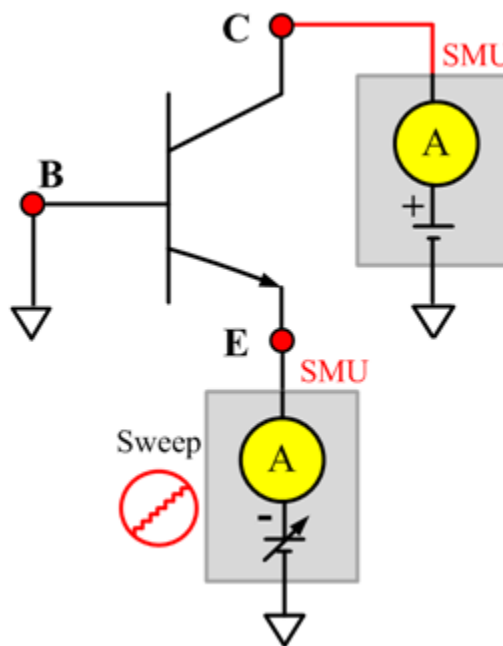
Module Name: leVeb

DUT: Three-terminal npnBJT

Function: Measures the Emitter current of the npnBJT with a specified sweeping Emitter voltage, and measures the leVeb curves.

Pin connections: Use a SMU to apply a sweep voltage to the Emitter. Use a SMU to apply biased voltage to the Collector. Connect the Base to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 33: Three_term_npnBJT_leVeb pin connection



leVeb ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

VBCO

Description:

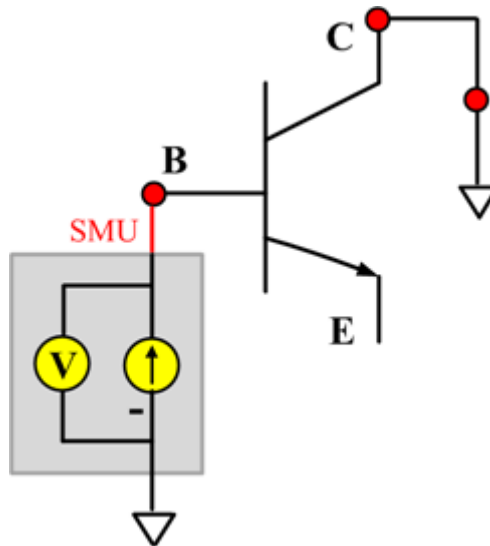
Module Name: VBCO

DUT: Three-terminal npnBJT

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

Pin connections: Use a SMU to apply a biased current to the Base. Connect the Collector to GND or use a SMU to supply a zero voltage bias. Open the circuit to the Emitter or use a SMU to supply zero current bias. (See next figure.)

Figure 34: Three_term_npnBJT_VBCO pin connection



VBCO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

VBCO General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

VCE

Description:

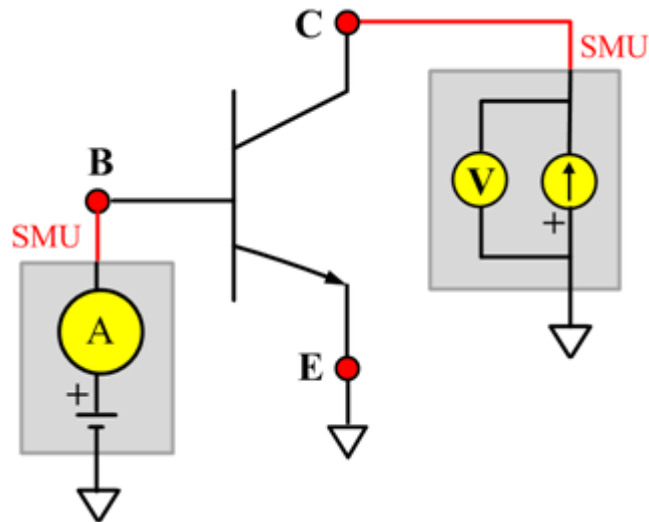
Module Name: VCE

DUT: Three-terminal npnBJT

Function: Measures the Collector-Emitter voltage the npnBJT.

Pin connections: Use a SMU to apply a biased current to the Collector. Use a SMU to apply a biased voltage to the Base. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 35: Three_term_npnBJT_VCE pin connection



VCE ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

VCE General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

nnpPowerBJT library

nnpPowerBJT overview

The nnpPowerBJT library components are in the following directory:

C:\ACS_BASIC\library\devLibrary\nnpPowerBJT

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

npnPowerBJT parametric library

BVCBO

Description:

Module Name: BVCBO

Test Type: ITM

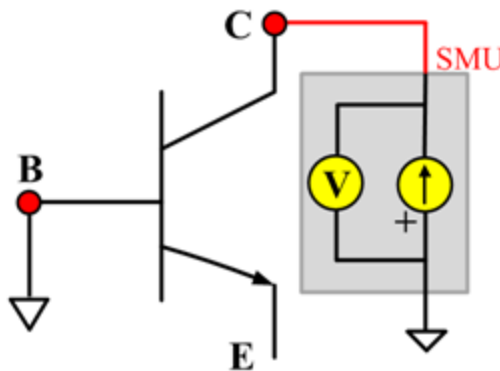
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal npnPowerBJT

Function: Measures the Collector-Base breakdown voltage with the Emitter opened. The voltage is measured with a specific Collector current that is given in the data sheet.

Pin Connections: Use a SMU to force current and make a voltage measurement from the Collector to the Base. Connect the Base to GND or use a SMU to supply a zero voltage bias. Open the circuit to the Emitter or use a SMU to supply zero current bias. (See next figure.)

Figure 36: npnPowerBJT BVCBO pin connection



BVCEO

Description:

Module Name: BVCEO

Test Type: ITM

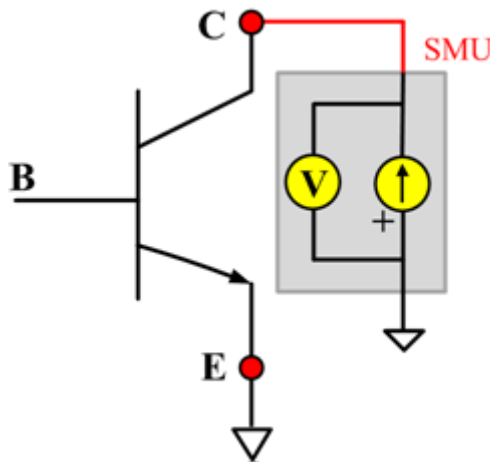
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal npnPowerBJT

Function: Measures the Collector-Emitter breakdown voltage with the Base opened. The voltage is measured with a specific Collector current that is given in the data sheet.

Pin Connection: Use a SMU to force current and make a voltage measurement from the Collector to Emitter. Connect the Emitter to GND or use a SMU to supply zero current bias. Open the circuit to the Base or use a SMU to supply zero current bias. (See next figure.)

Figure 37: npnPowerBJT BVCEO pin connection



BVEBO

Description:

Module Name: BVEBO

Test Type: ITM

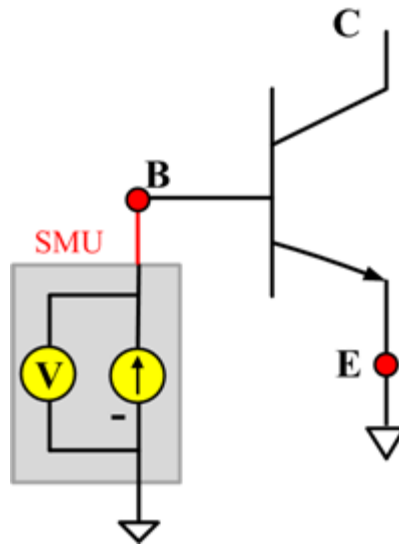
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal npnPowerBJT

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

Pin Connection: Use a SMU to force current and make a voltage measurement from the Base to the Emitter. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. Open the circuit to the Collector or use a SMU to supply zero current bias. (See next figure.)

Figure 38: npnPowerBJT BVEBO pin connection



Ccb

Description:

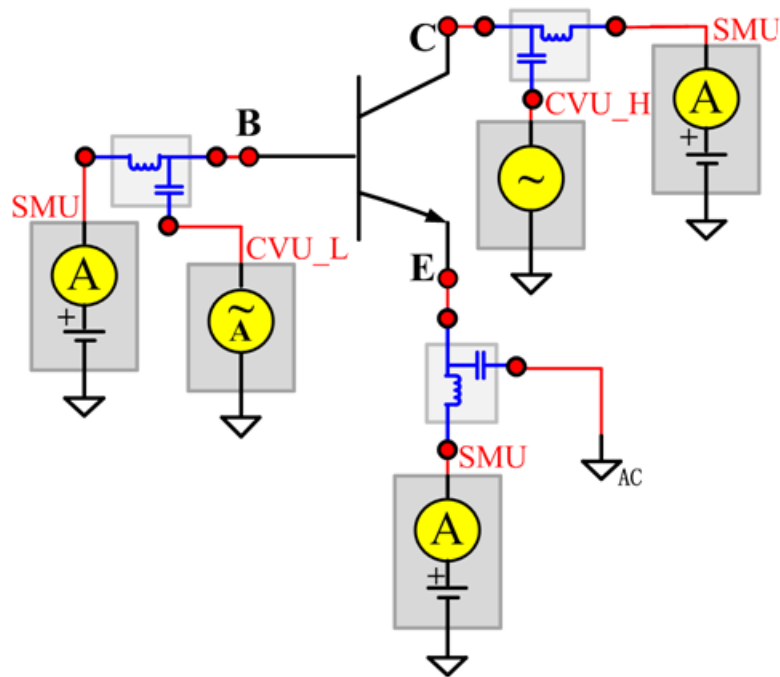
Module Name: Ccb

DUT: Three-terminal npnPowerBJT

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

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

Figure 39: Three_term_npnPowerBJT_Ccb pin connections



Ccb PTM

Module type: PTM

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

Cce

Description:

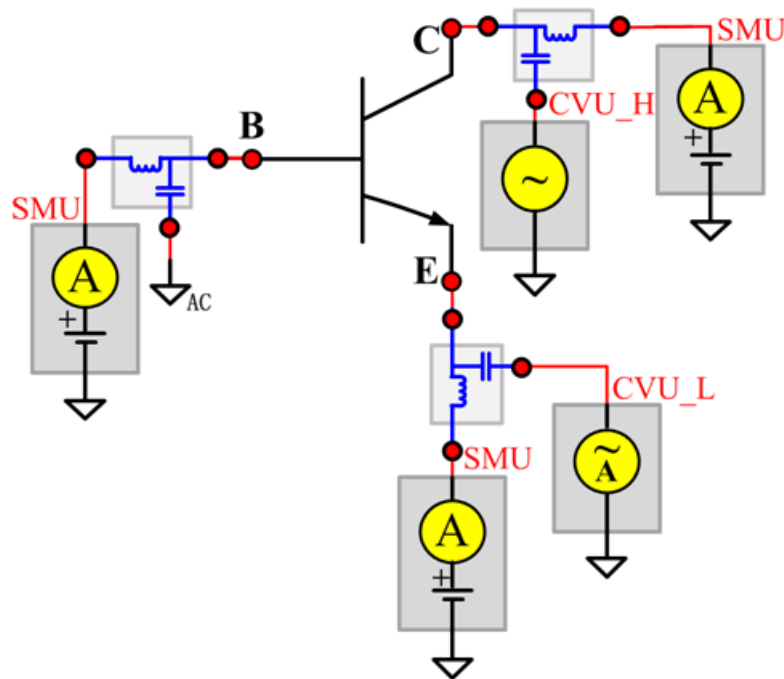
Module Name: Cce

DUT: Three-terminal npnPowerBJT

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

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

Figure 40: Three_term_npnPowerBJT_Cce pin connection



Cce PTM

Module type: PTM

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

Ceb

Description:

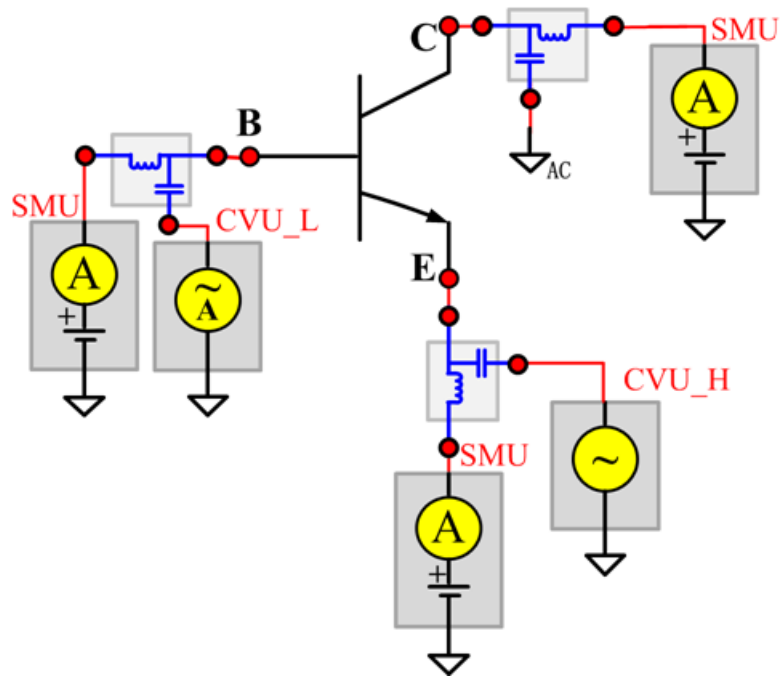
Module Name: Ceb

DUT: Three-terminal npnPowerBJT

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

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

Figure 41: Three_term_npnPowerBJT_Ceb pin connections



Ceb PTM

Module type: PTM

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

Cibo

Description:

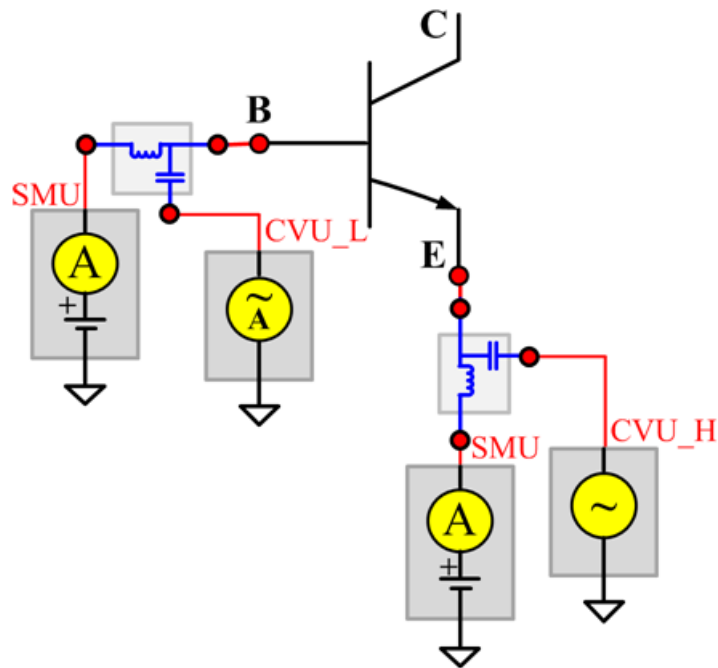
Module Name: Cibo

DUT: Three-terminal npnPowerBJT

Function: Measures the capacitance between the input terminals (Base and Emitter) with the Collector terminal open.

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

Figure 42: Three_term_npnPowerBJT_Cibo pin connections



Cibo PTM

Module type: PTM

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

Cobo

Description:

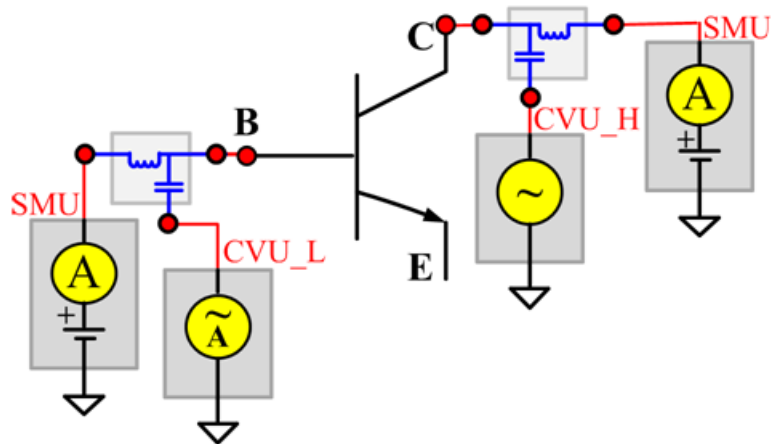
Module Name: Cobo

DUT: Three-terminal npnPowerBJT

Function: Measures the capacitance between the output terminals (Base and Collector) with the Emitter terminal open.

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

Figure 43: Three_term_npnPowerBJT_Cobo pin connections



Cobo PTM

Module type: PTM

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

HFE

Description:

Module Name: HFE

Test Type: ITM

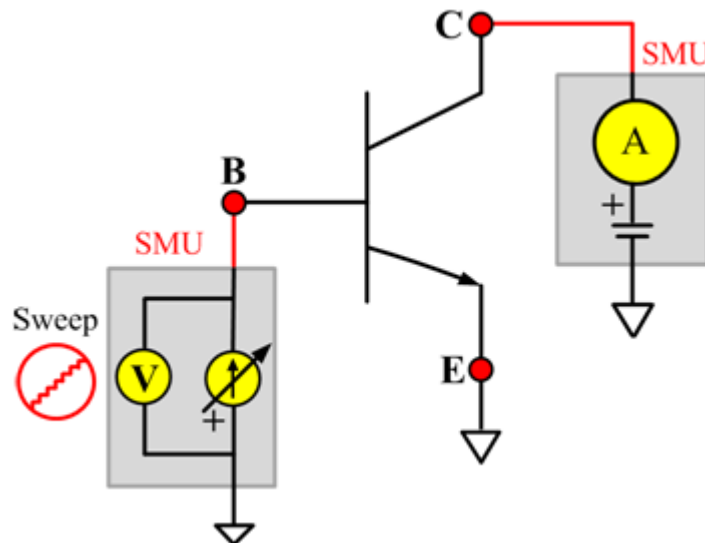
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal npnPowerBJT

Function: Measures the Collector-Emitter static forward current transfer ratio with the output voltage (V_{ce}) held constant ($HFE = I_c/I_b$).

Pin Connection: Use one SMU to apply voltage bias and make a current measurement from the Collector to the Emitter. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. Use a SMU to apply a sweep current to the Base. (See next figure.)

Figure 44: npnPowerBJT HFE pin connection



ICBO

Description:

Module Name: ICBO

Test Type: ITM

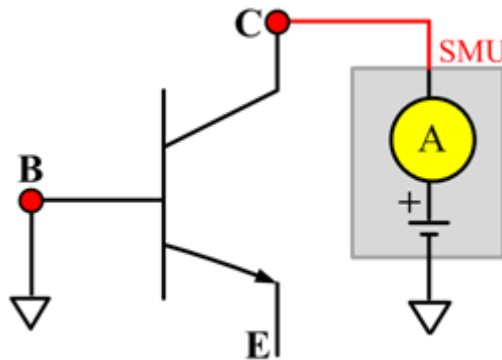
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal npnPowerBJT

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

Pin Connection: Use a SMU to force voltage and make a current measurement from the Collector to Base. Connect the Base to GND or use a SMU to supply a zero voltage bias. Open the circuit to the Emitter or use a SMU to supply zero current bias. (See next figure.)

Figure 45: npnPowerBJT ICBO pin connection



ICEO

Description:

Module Name:ICEO

Test Type:ITM

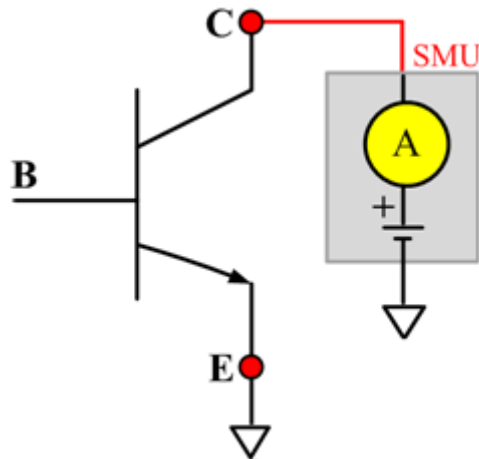
Instrument:Keithley Instruments Model 2657A

DUT: Three-terminal npnPowerBJT

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

Pin Connection: Use a SMU to force voltage and make a current measurement from the Collector to the Emitter. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. Open the circuit to the Base or use a SMU to supply zero current bias. (See next figure.)

Figure 46: npnPowerBJT ICEO pin connection



ICES

Description:

Module Name: ICES

Test Type: ITM

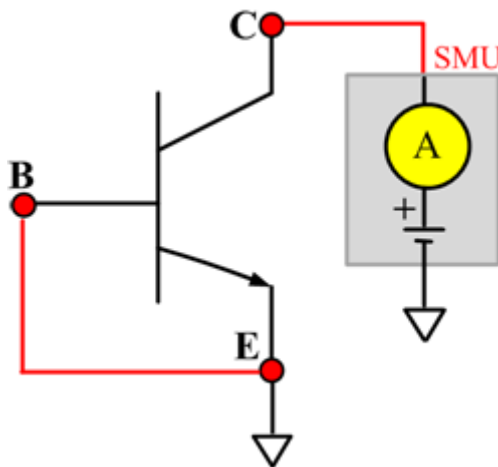
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal npnPowerBJT

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

Pin Connection: Use a SMU to force voltage and make a current measurement from the Collector to the Emitter. Short the Base to the Emitter or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 47: npnPowerBJT ICES pin connection



ICEV

Description:

Module Name: ICEV

Test Type: ITM

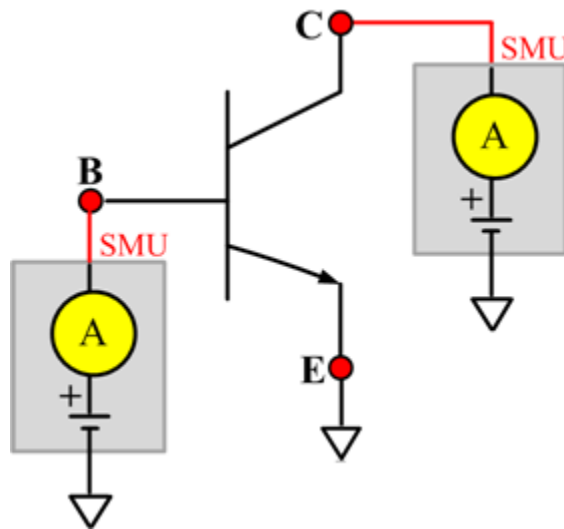
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal npnPowerBJT

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

Pin Connection: Use a SMU to force voltage and make a current measurement from the Collector to the Emitter. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. Use another SMU to bias the Base with a specified voltage. (See next figure.)

Figure 48: npnPowerBJT ICEV pin connection



IcVce_StepIb

Description:

Module Name: IcVce_StepIb

Test Type: ITM

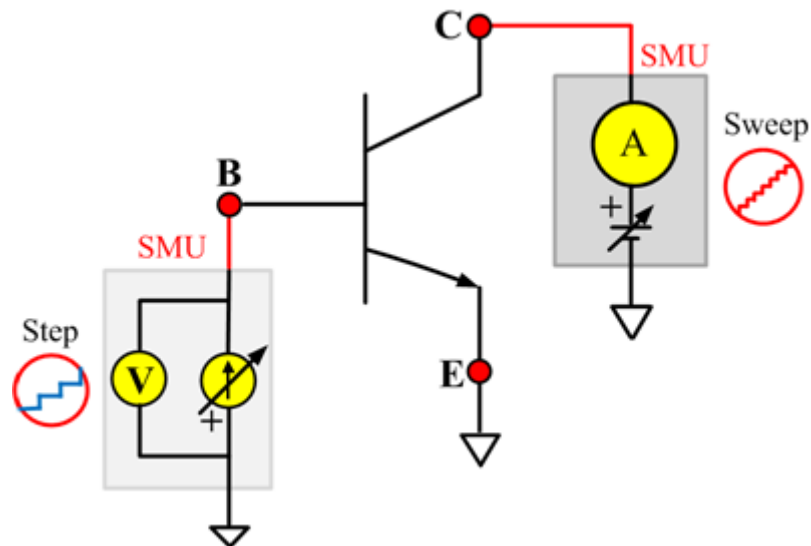
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal npnPowerBJT

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

Pin Connection: Use one SMU to apply a voltage sweep and make a current measurement from Collector to Emitter. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. Use a SMU to apply a current step to the Base.

Figure 49: npnPowerBJT IcVce_StepIb pin connection



IcVce_StepIb_MIX

Description:

Module Name: IcVce_StepIb_MIX

Test Type: PTM

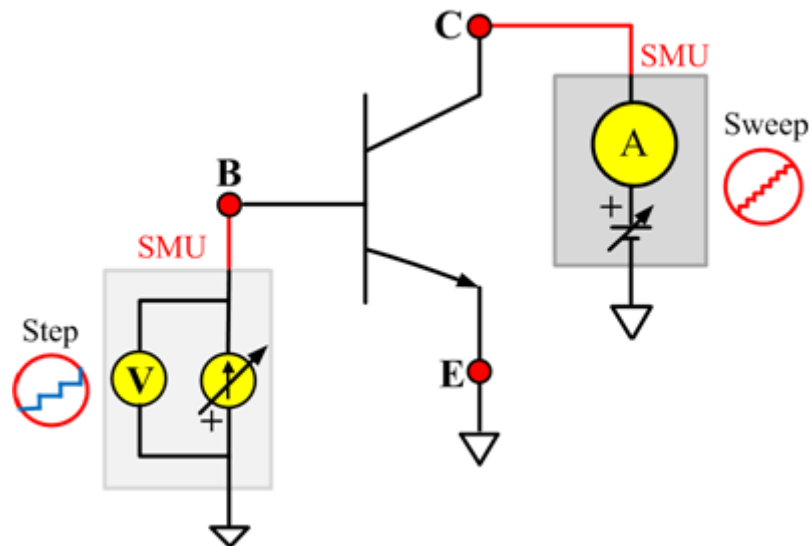
Instrument: Keithley Instruments Model 2657A, and Series 2600B, Series 2400, Model 4200-SMU

DUT: Three-terminal npnPowerBJT

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

Pin Connection: Use a SMU to apply a voltage sweep and make a current measurement from the Collector to the Emitter. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. Use a SMU to apply current step to Base. (See next figure.)

Figure 50: npnPowerBJT IcVce_StepIb_MIX pin connection



IcVce_StepVbe

Description:

Module Name: IcVce_StepVbe

Test Type: ITM

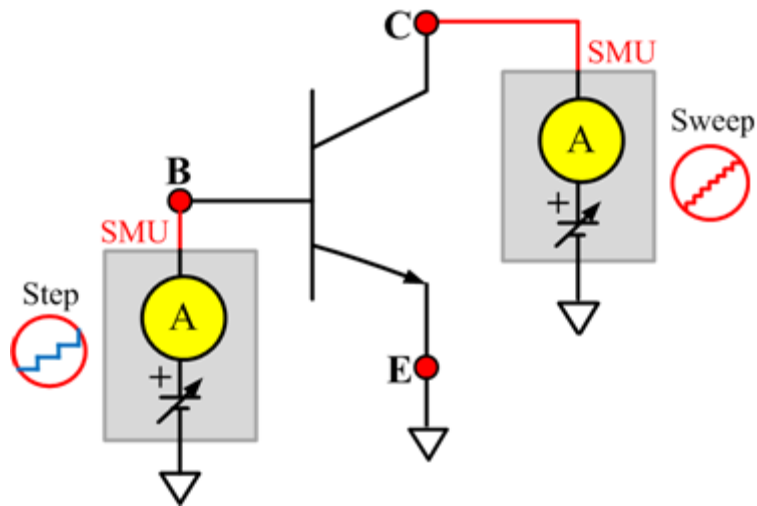
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal npnPowerBJT

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

Pin Connection: Use a SMU to apply a voltage sweep and make a current measurement from Collector to Emitter. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. Use a SMU to apply a voltage step to the Base-Emitter junction. (See next figure.)

Figure 51: npnPowerBJT IcVce_StepVbe pin connection



IcVce_StepVbe_MIX

Description:

Module Name: IcVce_StepVbe

Test Type: PTM

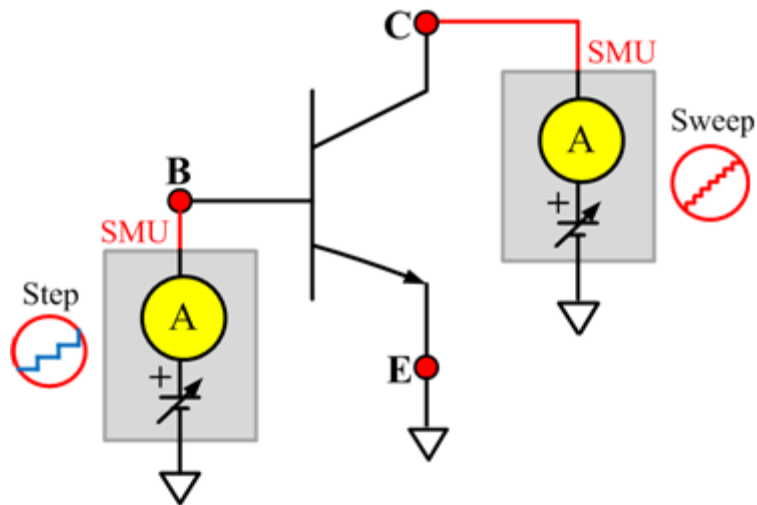
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200-SMU

DUT: Three-terminal npnPowerBJT

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

Pin Connection: Use a SMU to apply a voltage sweep and make a current measurement from the Collector to the Emitter. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. Use a SMU to apply a voltage step to the Base-Emitter junction. (See next figure.)

Figure 52: npnPowerBJT IcVce_StepVbe_MIX pin connection



IEBO

Description:

Module Name: IEBO

Test Type: ITM

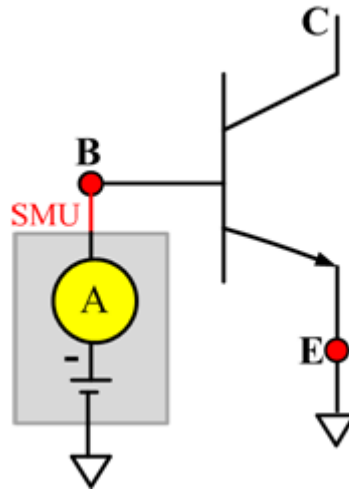
Instrument: Keithley Instruments Series 2600B

DUT: Three-terminal npnPowerBJT

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

Pin Connection: Use a SMU to force voltage and make a current measurement from the Base to the Emitter. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. Open the circuit to the Collector or use a SMU to supply zero current bias. (See next figure.)

Figure 53: npnPowerBJT IEBO pin connection



VbeON

Description:

Module Name: VbeON

Test Type: ITM

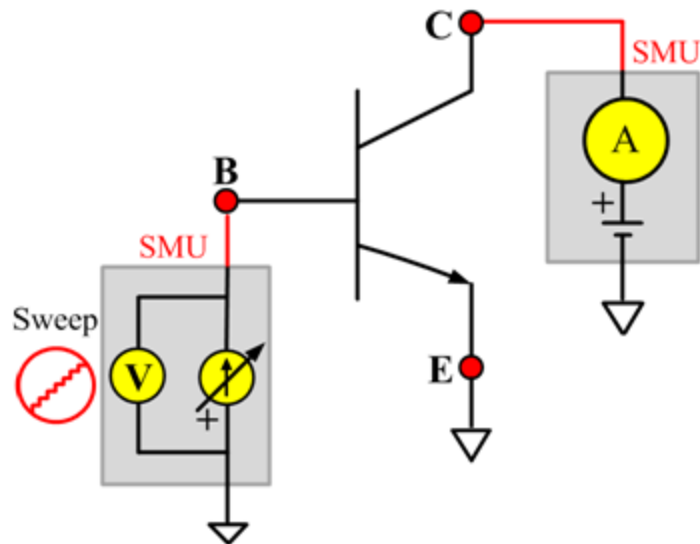
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal npnPowerBJT

Function: Measures the on voltage of the Base-Emitter when the BJT is in the active region. The voltage is measured with the Base-Emitter forward biased and the Collector-Emmitter voltage higher than the V_{ceSAT} .

Pin Connection: Use a SMU to apply a current sweep and make a voltage measurement from the Base to the Emitter. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. Use a SMU to apply voltage bias to the Collector. (See next figure.)

Figure 54: npnPowerBJT VbeON pin connection



VbeSAT

Description:

Module Name: VbeSAT

Test Type: ITM

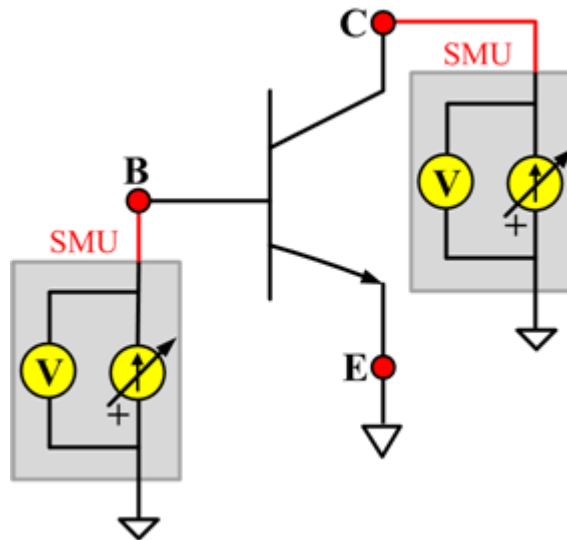
Instrument: Keithley Instruments Models 2651A, Series 2600B

DUT: Three-terminal npnPowerBJT

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

Pin Connection: Use a SMU to force current and make a voltage measurement from the Base to the Emitter. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. Use one SMU to apply current bias to the Collector. (See next figure.)

Figure 55: npnPowerBJT VbeSAT pin connection



VceSAT

Description:

Module Name: VceSAT

Test Type: ITM

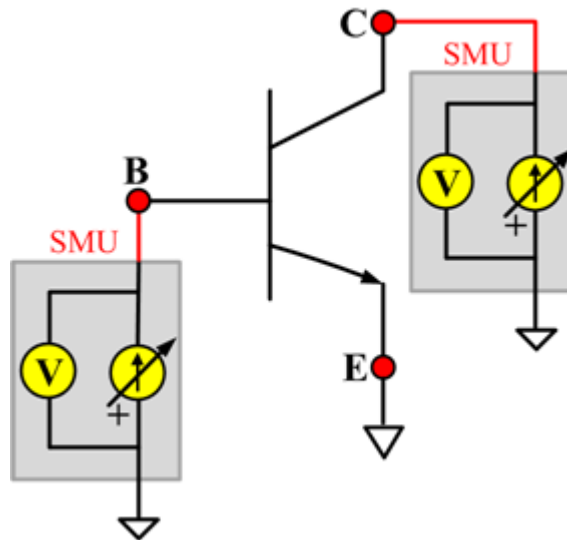
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal npnPowerBJT

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

Pin Connection: Use a SMU to force current and make a voltage measurement from the Collector to the Emitter. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. Use a SMU to apply a current bias to the Base. (See next figure.)

Figure 56: npnPowerBJT VceSAT pin connection



VceSAT_MIX

Description:

Module Name: VceSAT_MIX

Test Type: PTM

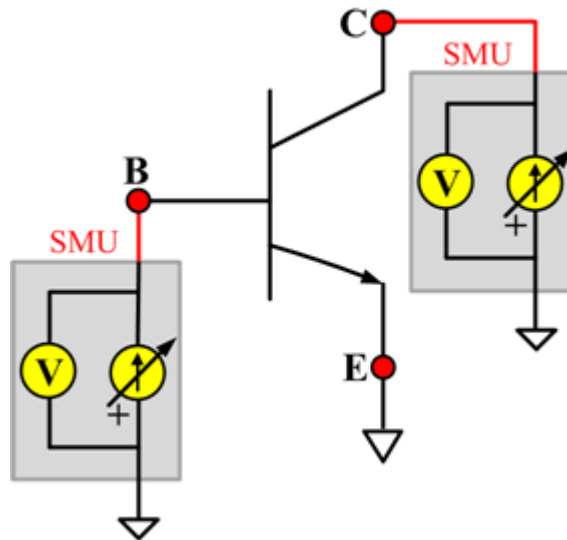
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200-SMU

DUT: Three-terminal npnPowerBJT

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

Pin Connection: Use a SMU to force current and make a voltage measurement from the Collector to the Emitter. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. Use a SMU to apply current bias to the Base. (See next figure.)

Figure 57: npnPowerBJT VceSAT_MIX pin connection



VCESUS

Description:

Module Name: VCESUS

Test Type: ITM

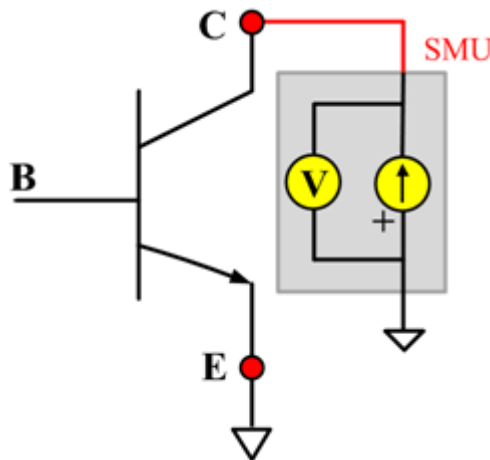
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal npnPowerBJT

Function: Measures the Collector-Emitter sustaining voltage with the Base opened. The voltage is measured at a specific Collector current that is given in the data sheet.

Pin Connection: Use a SMU to force current and make a voltage measurement from the Collector to the Emitter. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. Open the circuit to the Base or use a SMU to supply zero current bias. (See next figure.)

Figure 58: npnPowerBJT VCESUS pin connection



pnpBJT library

pnpBJT device overview

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

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

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

pnpBJT parametric library

BVCBO

Description:

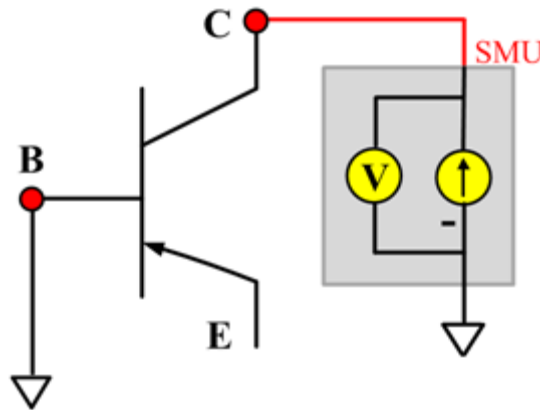
Module Name: BVCBO

DUT: Three-terminal pnpBJT

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

Pin connections: Use a SMU to apply a reverse current to the Collector. Connect the Base to GND or use a SMU to supply a zero voltage bias. Open the circuit to the Emitter or use a SMU to supply zero current bias. (See next figure.)

Figure 59: 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:

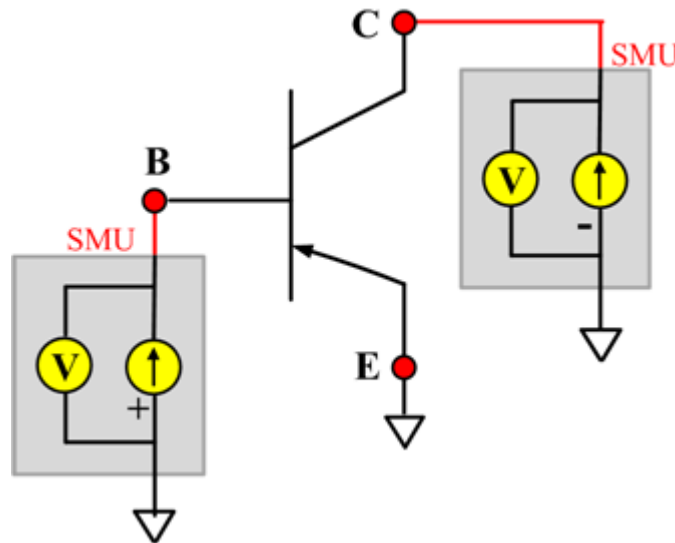
Module Name: BVCEI

DUT: Three-terminal pnpBJT

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

Pin connections: Use two SMUs to force current to the Base and Collector. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 60: 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:

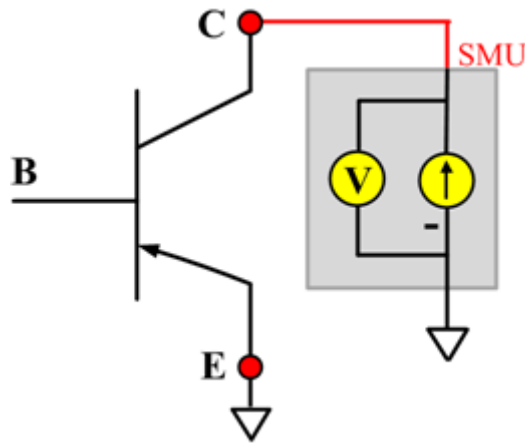
Module Name: BVCEO

DUT: Three-terminal pnpBJT

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

Pin connections: Use a SMU to force current to the Collector. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. Open the circuit to the Base or use a SMU to supply zero current bias. (See next figure.)

Figure 61: 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:

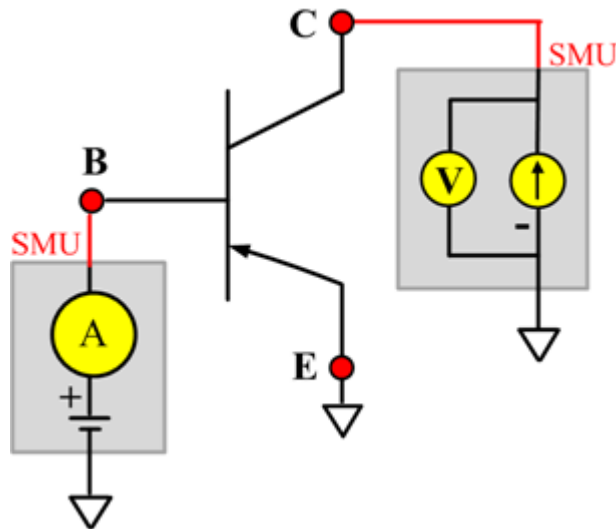
Module Name: BVCEV

DUT: Three-terminal pnpBJT

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

Pin connections: Use two SMUs to force voltage to the Base and Collector. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 62: 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:

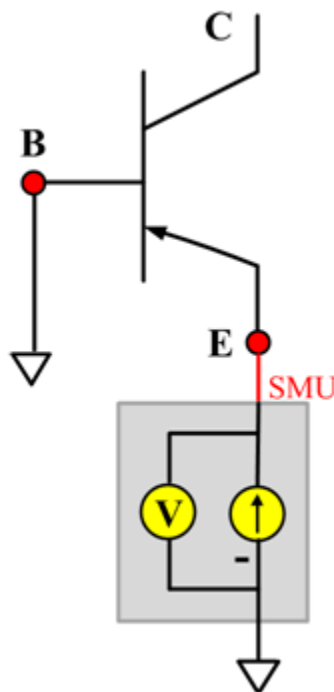
Module Name: BVEBO

DUT: Three-terminal pnpBJT

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

Pin connections: Use a SMU to force current to the Emitter. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. Open the circuit to the Collector or use a SMU to supply zero current bias. (See next figure.)

Figure 63: 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:

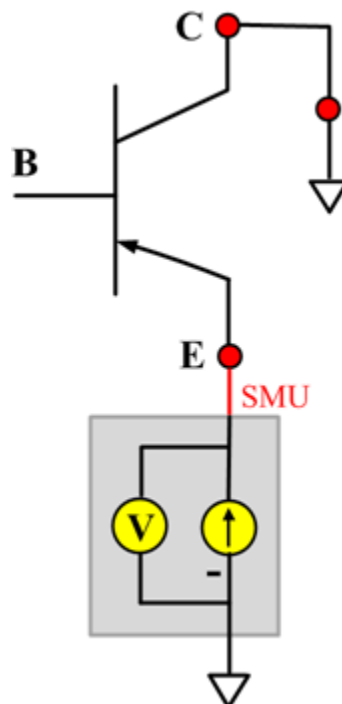
Module Name: BVECO

DUT: Three-terminal pnpBJT

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

Pin connections: Use a SMU to force current to the Emitter. Open the circuit to the Base or use a SMU to supply zero current bias. Connect the Collector to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 64: 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

Ccb

Description:

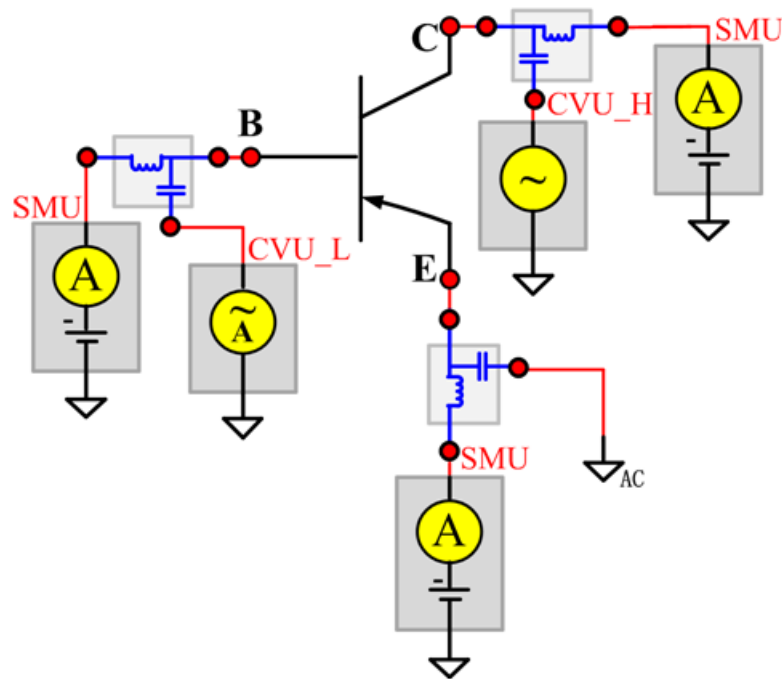
Module Name: Ccb

DUT: Three-terminal pnpBJT

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

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

Figure 65: Three_term_pnpBJT_Ccb pin connections



Ccb PTM

Module type: PTM

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

Cce

Description:

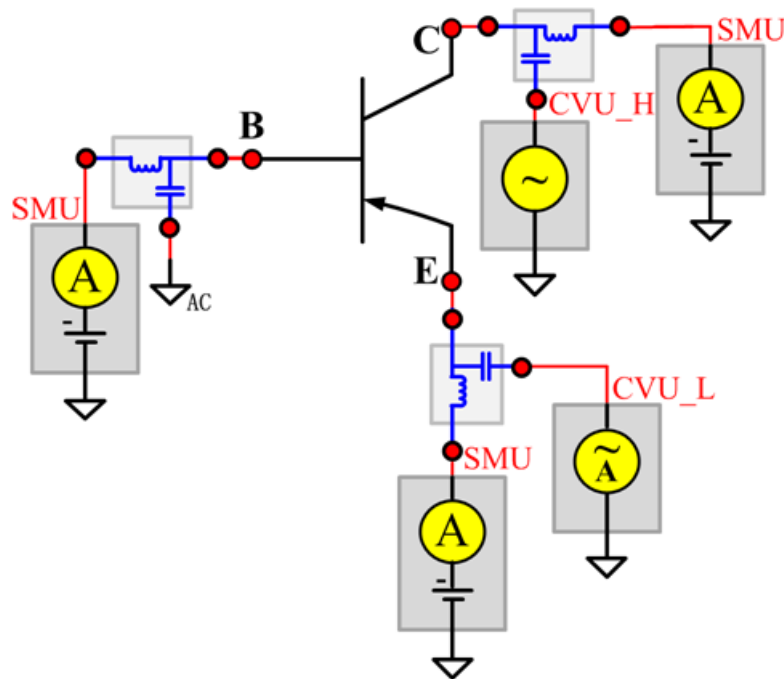
Module Name: Cce

DUT: Three-terminal pnpBJT

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

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

Figure 66: Three_term_pnpBJT_Cce pin connections



Cce PTM

Module type: PTM

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

Ceb

Description:

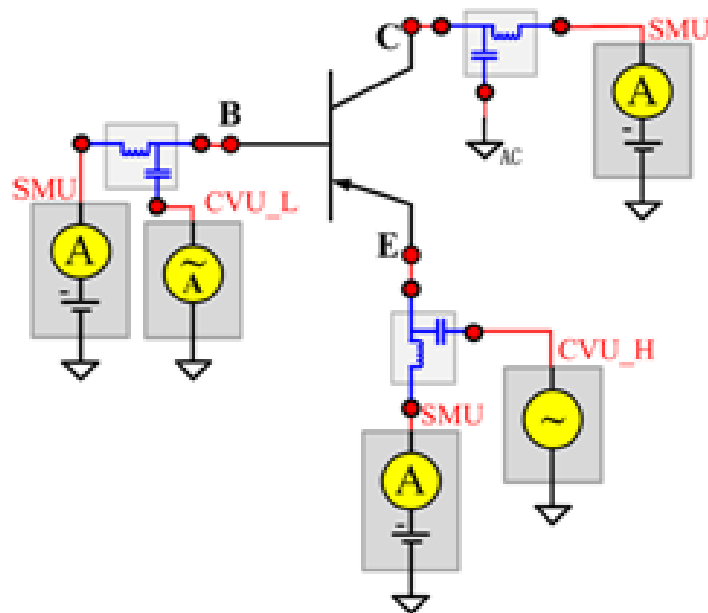
Module Name: Ceb

DUT: Three-terminal pnpBJT

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

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

Figure 67: Three_term_pnpBJT_Ceb pin connections



Ceb PTM

Module type: PTM

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

Cibo

Description:

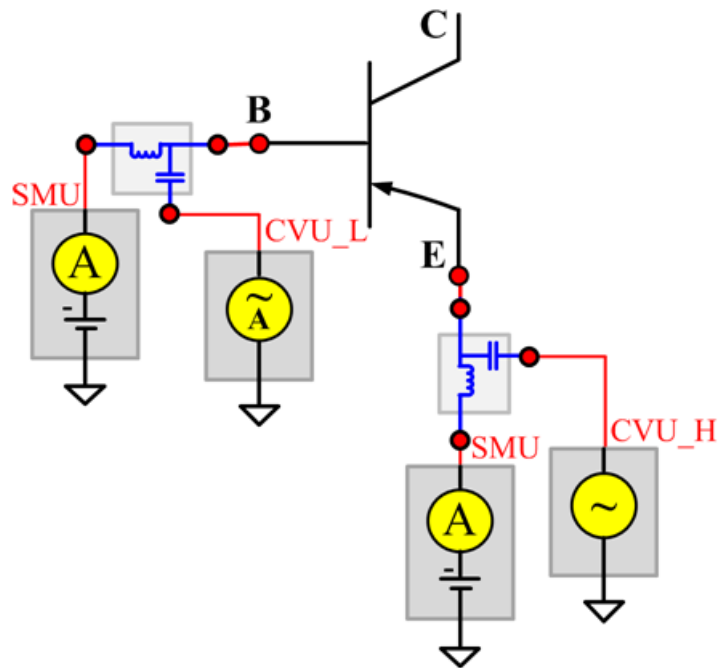
Module Name: Cibo

DUT: Three-terminal pnpBJT

Function: Measures the capacitance between the input terminals (Base and Emitter) with the Collector terminal open.

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

Figure 68: Three_term_pnpBJT_Cibo pin connections



Cibo PTM

Module type: PTM

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

Cobo

Description:

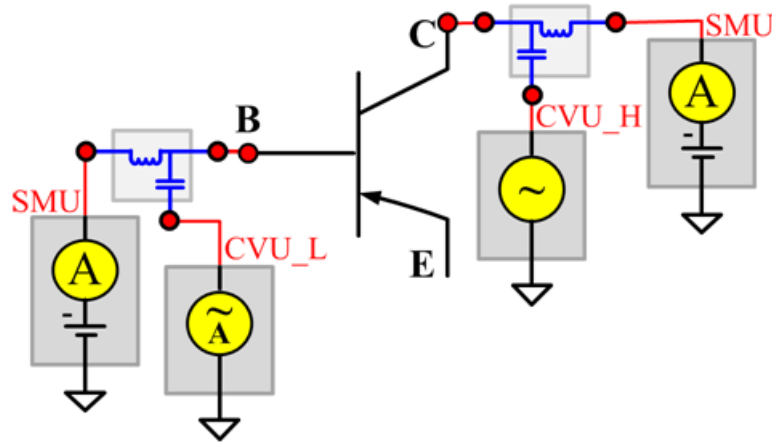
Module Name: Cobo

DUT: Three-terminal pnpBJT

Function: Measures the capacitance between the output terminals (Base and Collector) with the Emitter terminal open.

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

Figure 69: Three_term_pnpBJT_Cobo pin connections



Cobo PTM

Module type: PTM

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

HFE

Description:

Module Name: HFE

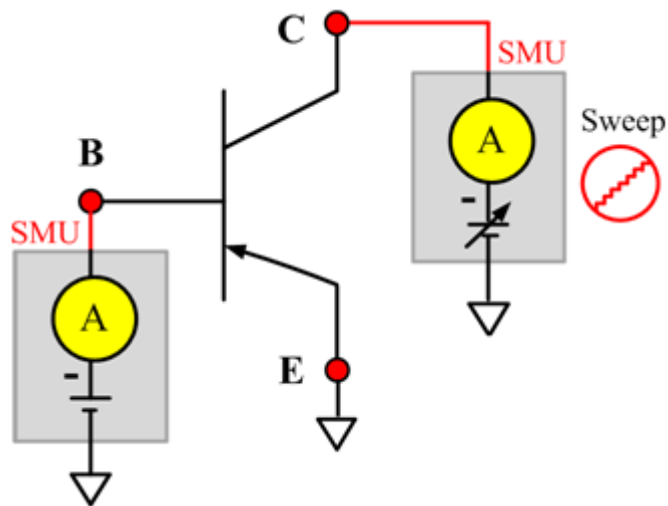
DUT: Three-terminal pnpBJT

Function: Measures the Collector current, Base current, and DC current gain based on the Collector sweep voltage.

Pin connections: Use a SMU to apply a sweep voltage to the Collector. Use a SMU to bias the Base. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.) $HFE = I_c/I_b$:

- Force CollectorV sweep
- Measure I_b and I_c
- Check for measurement problems
- Calculate $HFE = I_c/I_b$

Figure 70: 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:

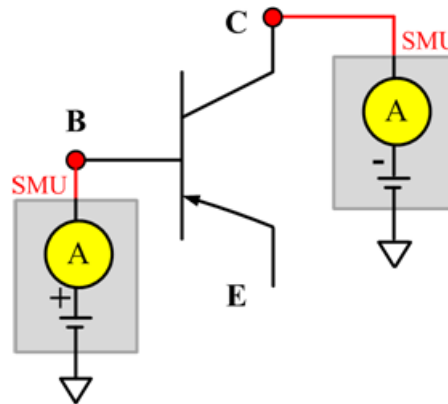
Module Name: IBCO

DUT: Three-terminal pnpBJT

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

Pin connections: Use a SMU to force voltage to the Base. Connect the Collector to GND or use a SMU to supply a zero voltage bias. Open the circuit to the Emitter or use a SMU to supply zero current bias.(See next figure.)

Figure 71: 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:

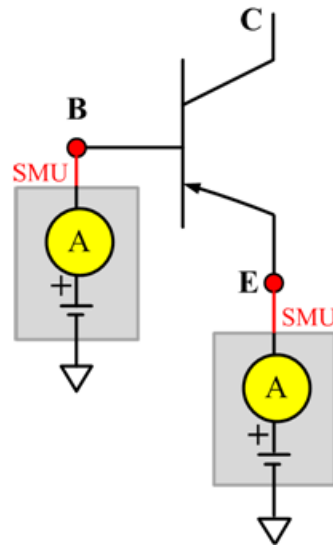
Module Name: IBEO

DUT: Three-terminal pnpBJT

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

Pin connections: Use a SMU to force voltage to the Base. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. Open the circuit to the Collector or use a SMU to supply zero current bias. (See next figure.)

Figure 72: 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:

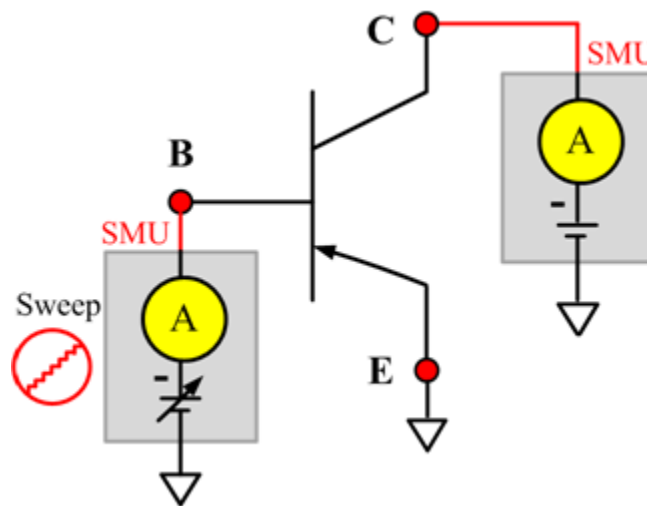
Module Name: IbIcVbe

DUT: Three-terminal pnpBJT

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

Pin connections: Use a SMU to apply a sweep voltage to the Base. Use a SMU to bias the Collector. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 73: Three_term_pnpBJT_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:

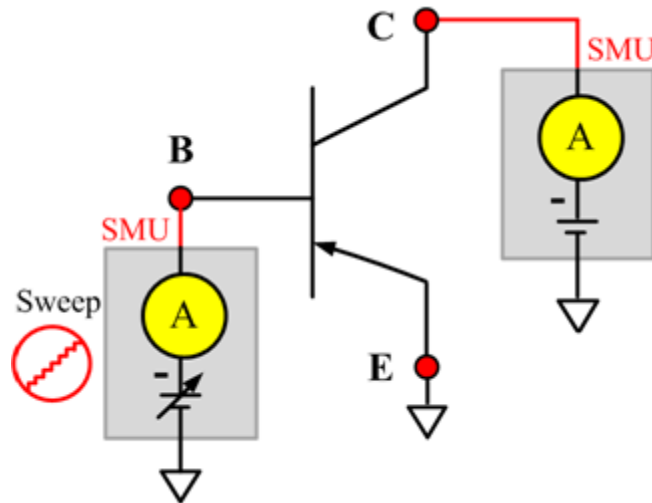
Module Name: IbVbe

DUT: Three-terminal pnpBJT

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

Pin connections: Use a SMU to apply a sweep voltage to the Base. Use a SMU to bias the Collector. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 74: 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:

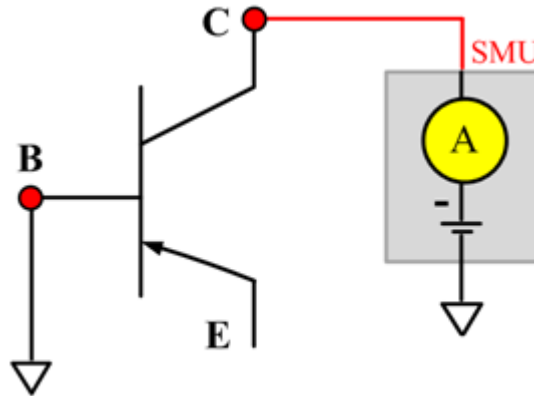
Module Name: ICBO

DUT: Three-terminal pnpBJT

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

Pin connections: Use a SMU to force voltage to the Collector. Connect the Base to GND or use a SMU to supply a zero voltage bias. Open the circuit to the Emitter or use a SMU to supply zero current bias. (See next figure.)

Figure 75: 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:

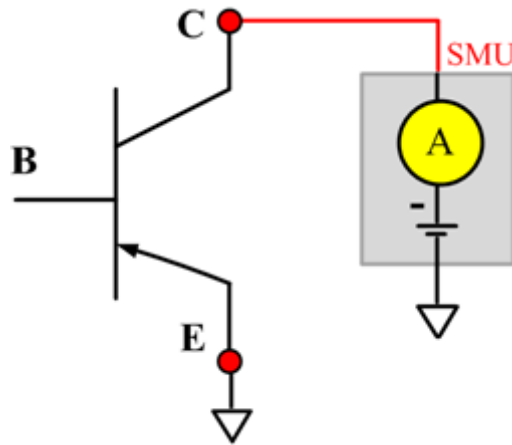
Module Name: ICEO

DUT: Three-terminal pnpBJT

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

Pin connections: Use a SMU to force voltage to the Collector. Open the circuit to the Base or use a SMU to supply zero current bias. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 76: 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:

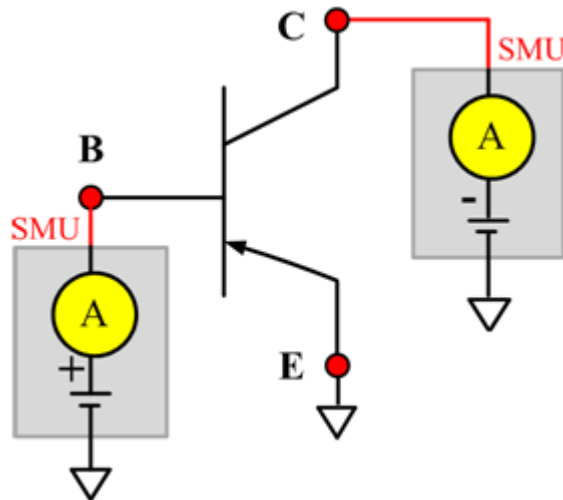
Module Name: ICEV

DUT: Three-terminal pnpBJT

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

Pin connections: Use two SMUs to force voltage to the Base and Collector. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 77: 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:

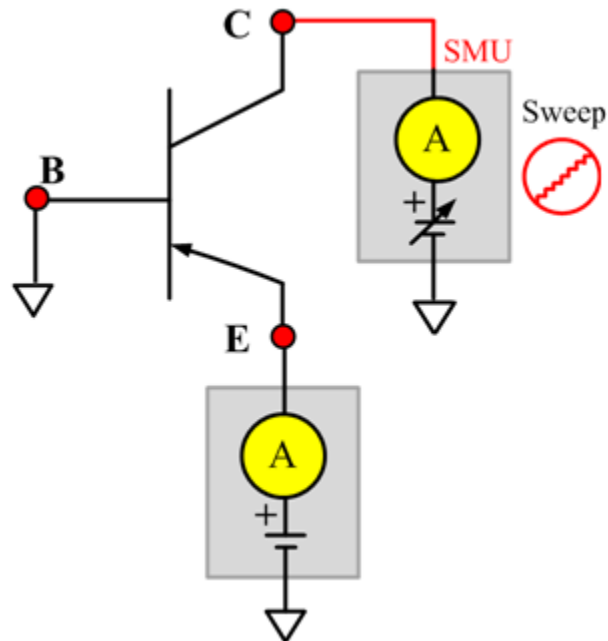
Module Name: IcVcb

DUT: Three-terminal pnpBJT

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

Pin connections: Use a SMU to apply a sweep voltage to the Collector. Use a SMU to bias the Emitter. Connect the Base to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 78: 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:

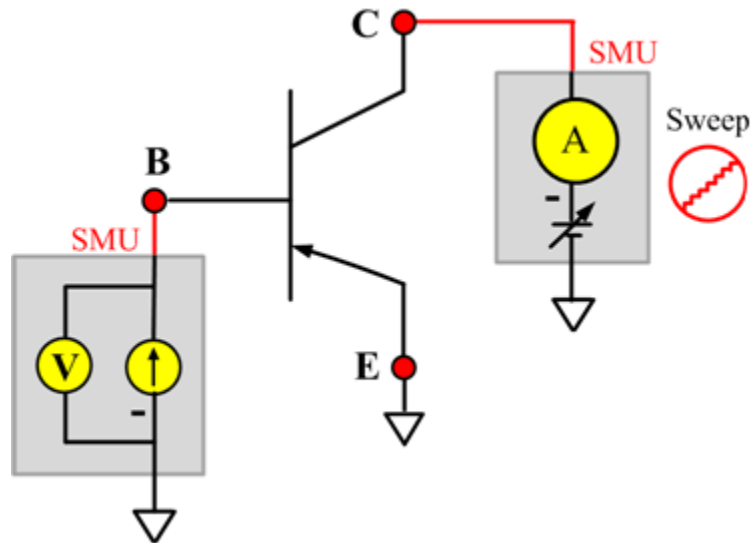
Module Name: IcVce_BiasIb

DUT: Three-terminal pnpBJT

Function: Measures the Collector current based on the Base bias current and Collector sweep voltage, and measure the IcVce curve.

Pin connections: Use a SMU to apply a sweep voltage to the Collector. Use a SMU to bias current to the Base. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 79: 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:

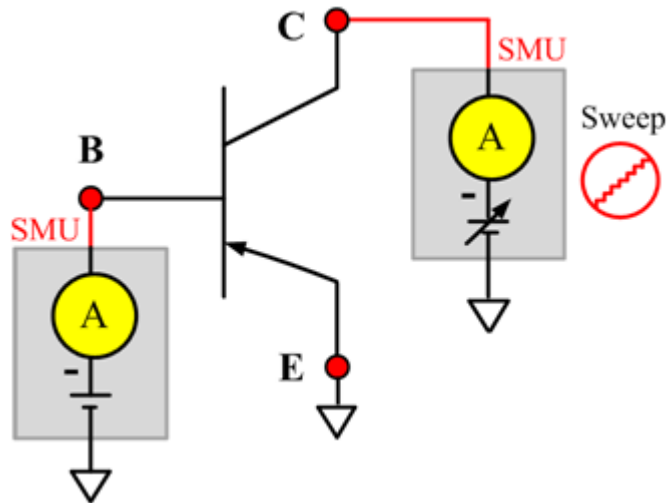
Module Name: IcVce_BiasVb

DUT: Three-terminal pnpBJT

Function: Measure the Collector current based on the Base bias voltage and the Collector sweep voltage, and measures the IcVce curve.

Pin connections: Use a SMU to apply a sweep voltage to the Collector. Use a SMU to bias voltage to the Base. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 80: 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:

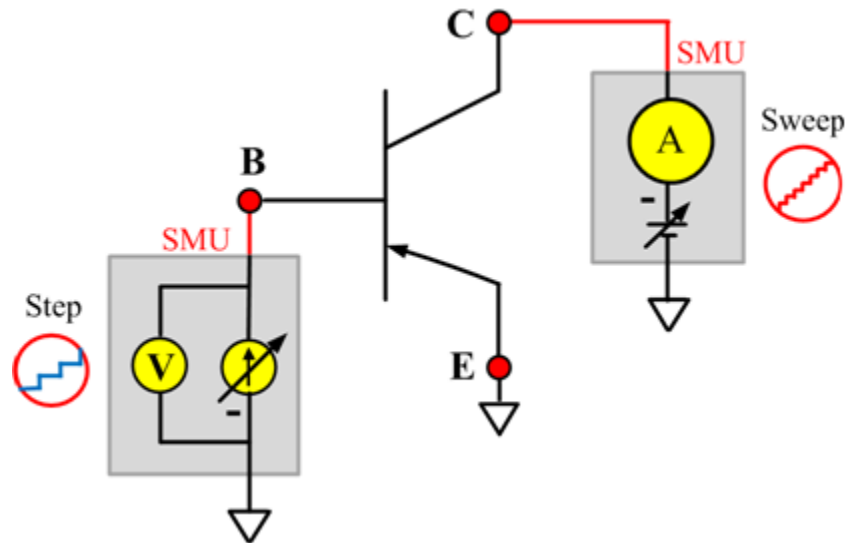
Module Name: IcVce_StepIb

DUT: Three-terminal pnpBJT

Function: Measures the Collector current based on the Base step current and the Collector sweep voltage, and measures the series of IcVce curves with a Base current step.

Pin connections: Use a SMU to apply a sweep voltage to the Collector. Use a SMU to step current to the Base. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 81: 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:

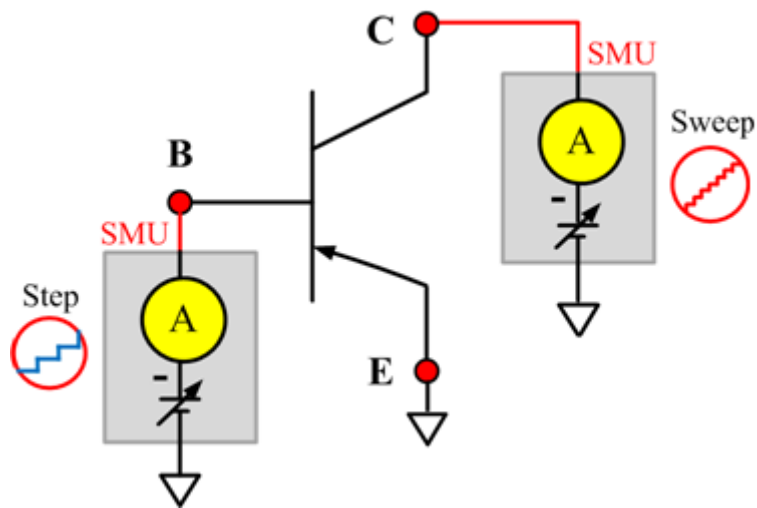
Module Name: IcVce_StepVb

DUT: Three-terminal pnpBJT

Function: Measure the Collector current based on Base step and the Collector sweep voltage, and measures the series of IcVce curves with at Base voltage step.

Pin connections: Use a SMU to apply a sweep voltage to the Collector. Use a SMU to apply a step voltage to the Base. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 82: 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:

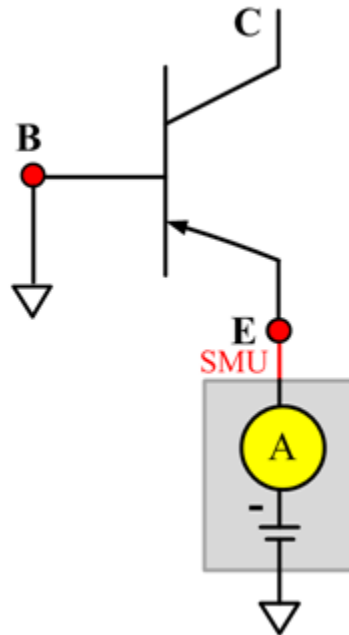
Module Name: IEBO

DUT: Three-terminal pnpBJT

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

Pin connections: Use a SMU to force voltage to the Emitter. Connect the Base to GND or use a SMU to supply a zero voltage bias. Open the circuit to the Collector or use a SMU to supply zero current bias. (See next figure.)

Figure 83: 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:

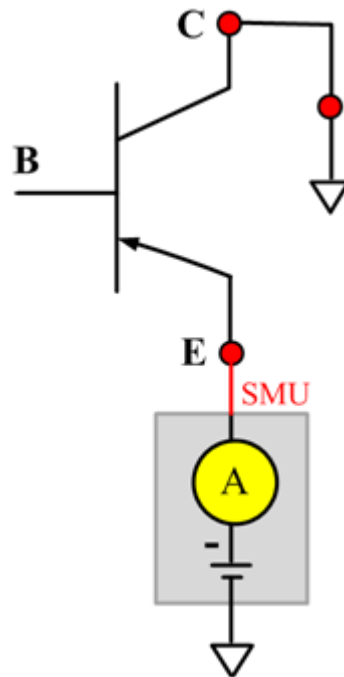
Module Name: IECO

DUT: Three-terminal pnpBJT

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

Pin connections: Use a SMU to force voltage to the Emitter. Open the circuit to the Base or use a SMU to supply zero current bias. Connect the Collector to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 84: 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

leVeb

Description:

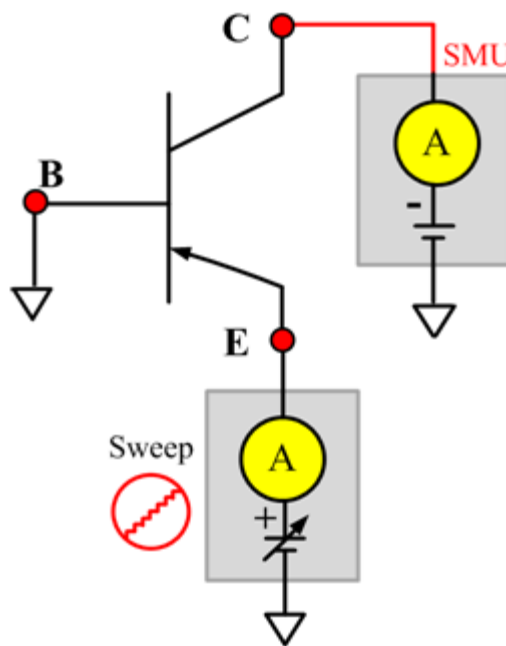
Module Name: leVeb

DUT: Three-terminal pnpBJT

Function: Measure the Emitter current based on the Emitter voltage sweep, and measures the leVeb curves.

Pin connections: Use a SMU to force voltage to the Emitter. Open the circuit to the Base or use a SMU to supply zero current bias. Connect the Collector to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 85: Three_term_pnpBJT_leVeb pin connection



leVeb ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B SMU / 4200 SMU

leVeb General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

VBCO

Description:

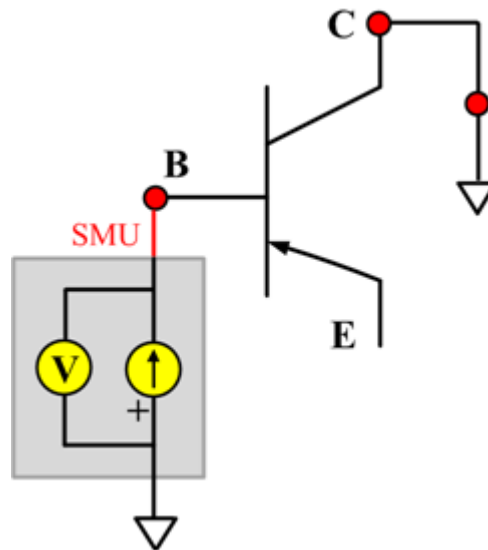
Module Name: VBCO

DUT: Three-terminal pnpBJT

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

Pin connections: Use a SMU to apply a bias current to the Base. Open the circuit to the Emitter or use a SMU to supply zero current bias. Connect the Collector to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 86: 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:

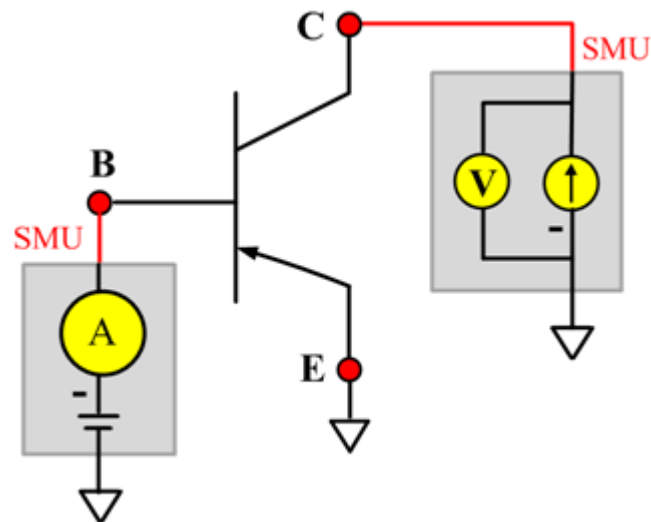
Module Name: VCE

DUT: Three-terminal pnpBJT

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

Pin connections: Use a SMU to apply bias current to the Collector. Use a SMU to apply bias voltage to the Base. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 87: 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:

```
C:\ACS_BASIC\library\devLibrary\pnpPowerBJT
```

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

pnpPowerBJT library

BVCBO

Description:

Module Name: BVCBO

Test Type: ITM

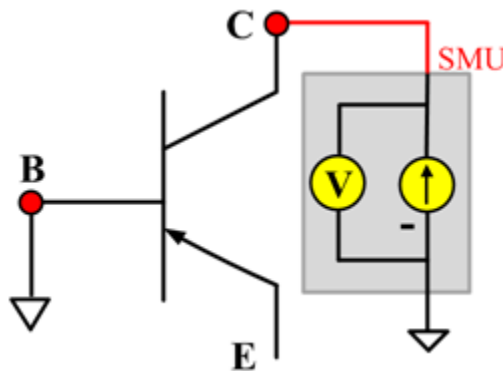
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal pnpPowerBJT

Function: Measures the Collector Base breakdown voltage with the Emitter opened. The voltage is measured with a specific Collector current that is given in the data sheet.

Pin Connections: Use a SMU to force current and make a voltage measurement from the Collector to Base. Open the circuit to the Emitter or use a SMU to supply zero current bias. Connect the Base to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 88: pnpPowerBJT BVCBO pin connection



BVCEO

Description:

Module Name: BVCEO

Test Type: ITM

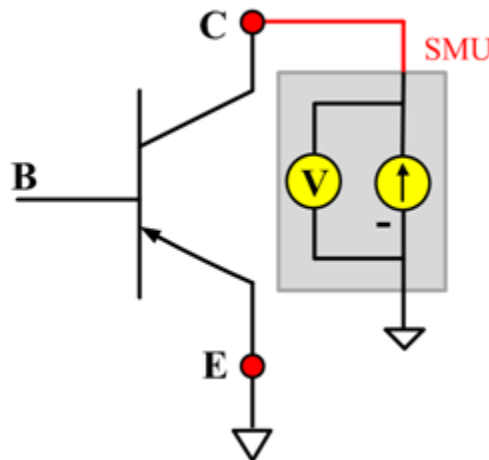
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal pnpPowerBJT

Function: Measures the Collector-Emitter breakdown voltage with the Base opened. The voltage is measured with a specific Collector current that is given in the data sheet.

Pin Connection: Use a SMU to force current and make a voltage measurement from the Collector to Emitter. Open the circuit to the Base or use a SMU to supply zero current bias. Connect the Emitter to GND or use a SMU to supply a zero voltage bias.

Figure 89: pnpPowerBJT BVCEO pin connection



BVEBO

Description:

Module Name: BVEBO

Test Type: ITM

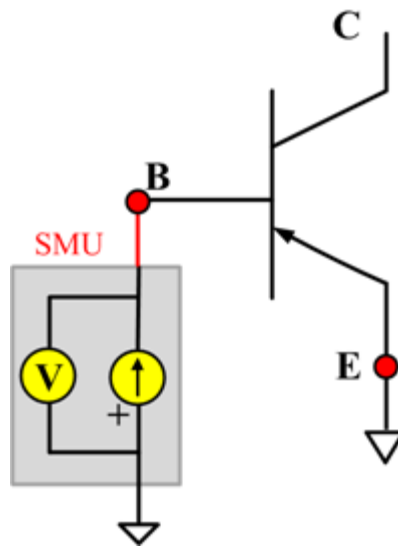
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal pnpPowerBJT

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

Pin Connection: Use a SMU to force current and make a voltage measurement from the Base to the Emitter. Open the circuit to the Collector or use a SMU to supply zero current bias. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 90: pnpPowerBJT BVEBO pin connection



Ccb

Description:

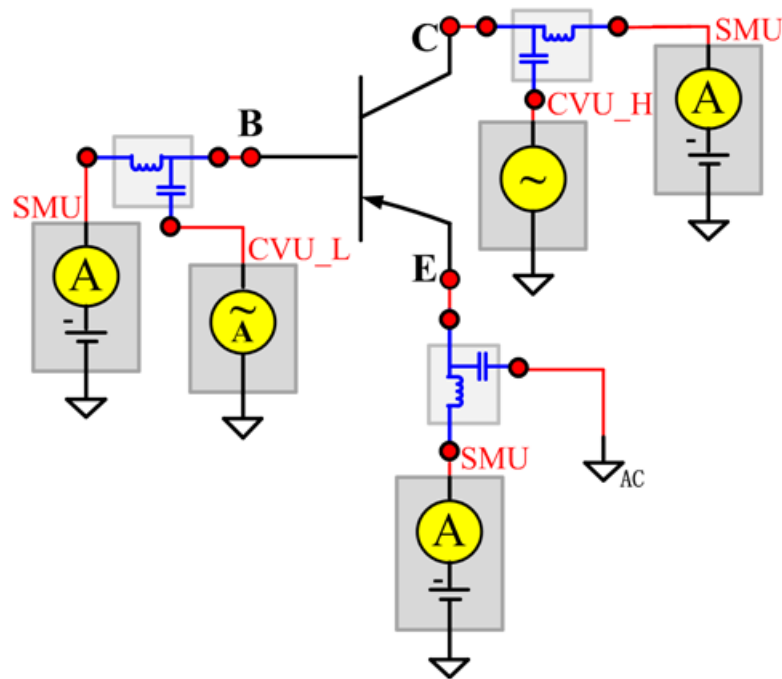
Module Name: Ccb

DUT: Three-terminal pnpPowerBJT

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

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

Figure 91: Three_term_pnpPowerBJT_Ccb pin connections



Ccb PTM

Module type: PTM

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

Cce

Description:

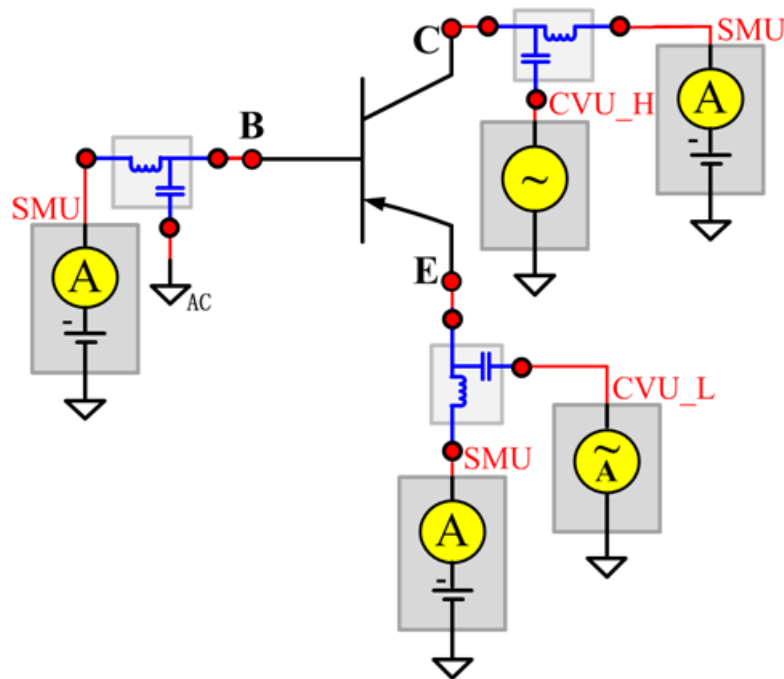
Module Name: Cce

DUT: Three-terminal pnpPowerBJT

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

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

Figure 92: Three_term_pnpPowerBJT_Cce pin connection



Cce PTM

Module type: PTM

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

Ceb

Description:

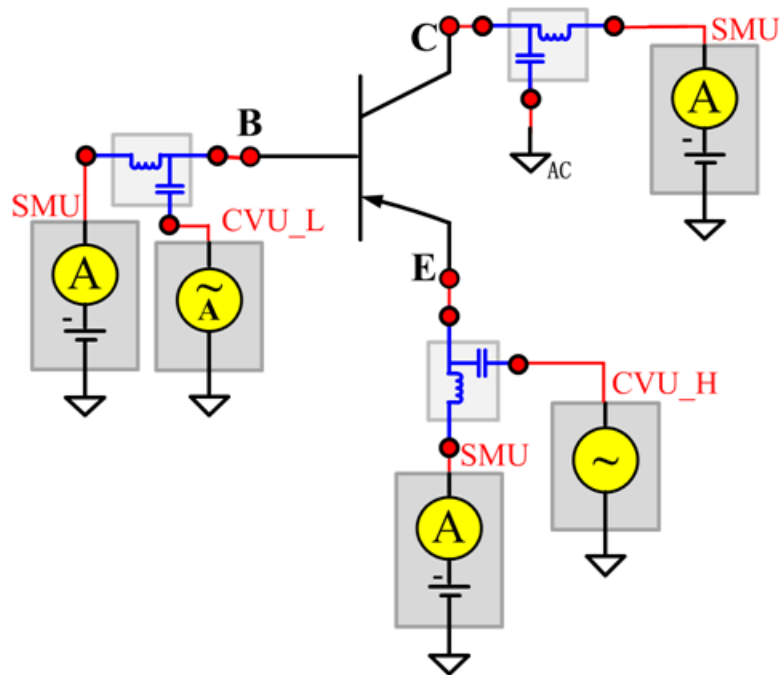
Module Name: Ceb

DUT: Three-terminal pnpPowerBJT

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

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

Figure 93: Three_term_pnpPowerBJT_Ceb pin connections



Ceb PTM

Module type: PTM

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

Cibo

Description:

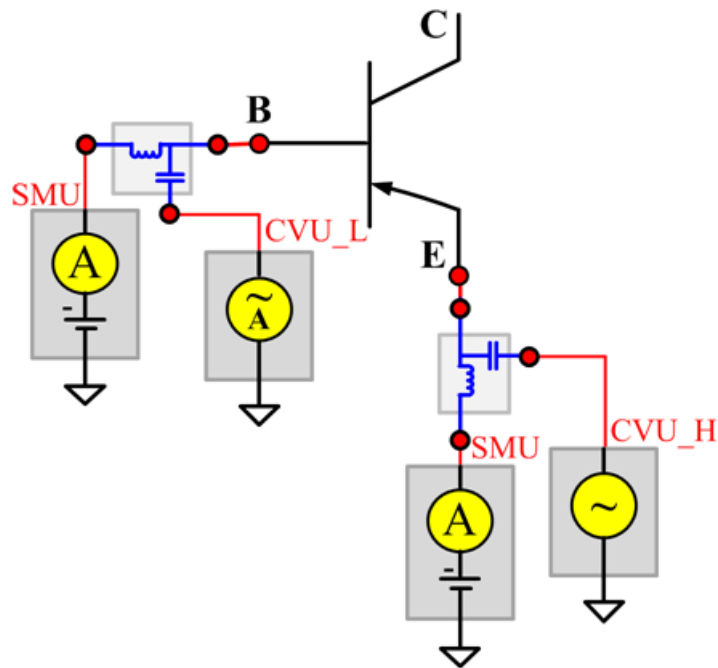
Module Name: Cibo

DUT: Three-terminal pnpPowerBJT

Function: Measures the capacitance between the input terminals (Base and Emitter) with the Collector terminal open.

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

Figure 94: Three_term_pnpPowerBJT_Cibo pin connections



Cibo PTM

Module type: PTM

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

Cobo

Description:

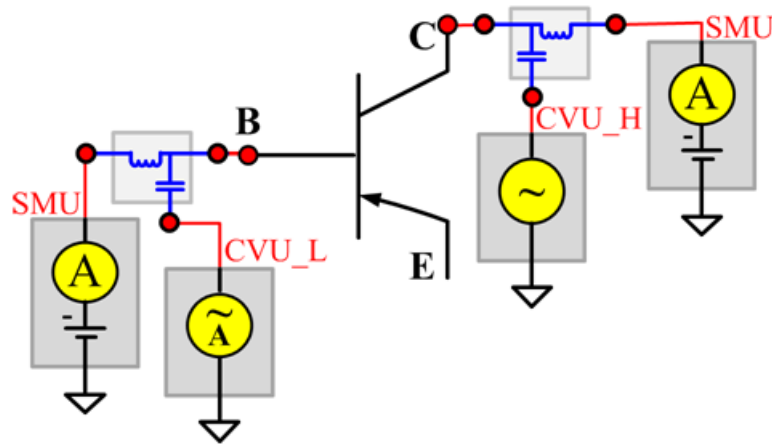
Module Name: Cobo

DUT: Three-terminal pnpPowerBJT

Function: Measures the capacitance between the output terminals (Base and Collector) with the Emitter terminal open.

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

Figure 95: Three_term_pnpPowerBJT_Cobo pin connections



Cobo PTM

Module type: PTM

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

HFE

Description:

Module Name: HFE

Test Type: ITM

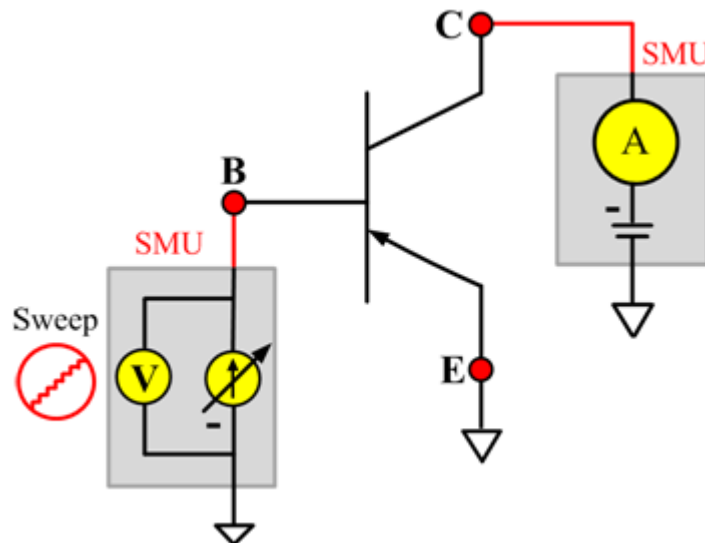
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pnpPowerBJT

Function: Measures the Collector-Emitter static forward current transfer ratio with the output voltage (V_{ce}) held constant ($HFE = I_c/I_b$).

Pin Connection: Use a SMU to apply voltage bias and make current measurements from the Collector to the Emitter. Use another SMU to apply a current sweep at the Base. Connect the Emitter to GND or use a SMU to supply a zero voltage bias.

Figure 96: pnpPowerBJT HFE pin connection



ICBO

Description:

Module Name: ICBO5

Test Type: ITM

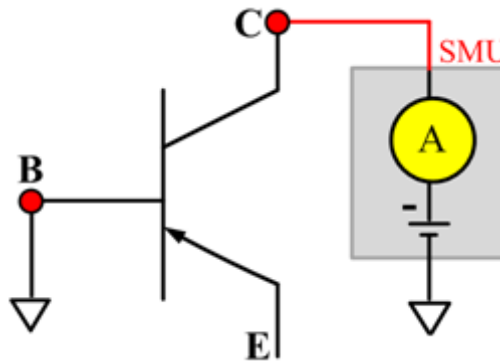
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal pnpPowerBJT

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

Pin Connection: Use a SMU to force voltage and make a current measurement from the Collector to the Base. Open the circuit to the Emitter or use a SMU to supply zero current bias. Connect the Base to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 97: pnpPowerBJT ICBO pin connection



ICEO

Description:

Module Name: ICEO

Test Type: ITM

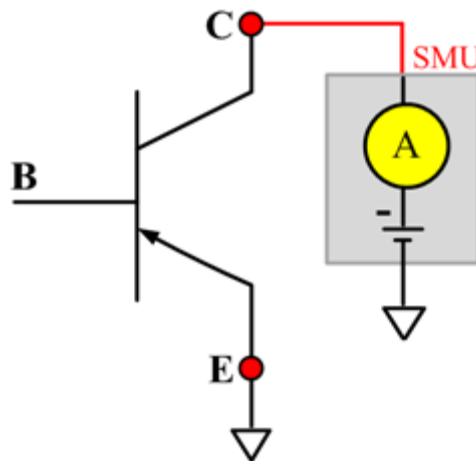
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal pnpPowerBJT

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

Pin Connection: Use a SMU to force voltage and make a current measurement from the Collector to the Emitter. Open the circuit to the Base or use a SMU to supply zero current bias. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 98: pnpPowerBJT ICEO pin connection



ICES

Description:

Module Name: ICES

Test Type: ITM

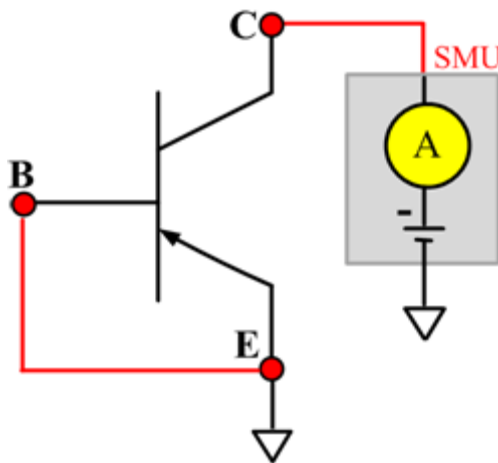
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal pnpPowerBJT

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

Pin Connection: Use a SMU to force voltage and make a current measurement from the Collector to the Emitter. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. Short the Base to the Emitter or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 99: pnpPowerBJT ICES pin connection



ICEV

Description:

Module Name: ICEV

Test Type: ITM

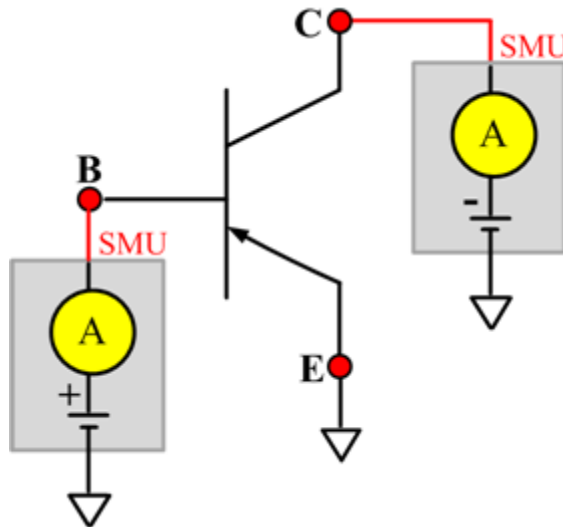
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal pnpPowerBJT

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

Pin Connection: Use a SMU to force voltage and make a current measurement from the Collector to the Emitter. Use a SMU to bias the Base with a specified voltage. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 100: pnpPowerBJT ICEV pin connection



IcVce_StepIb

Description:

Module Name: IcVce_StepIb

Test Type: ITM

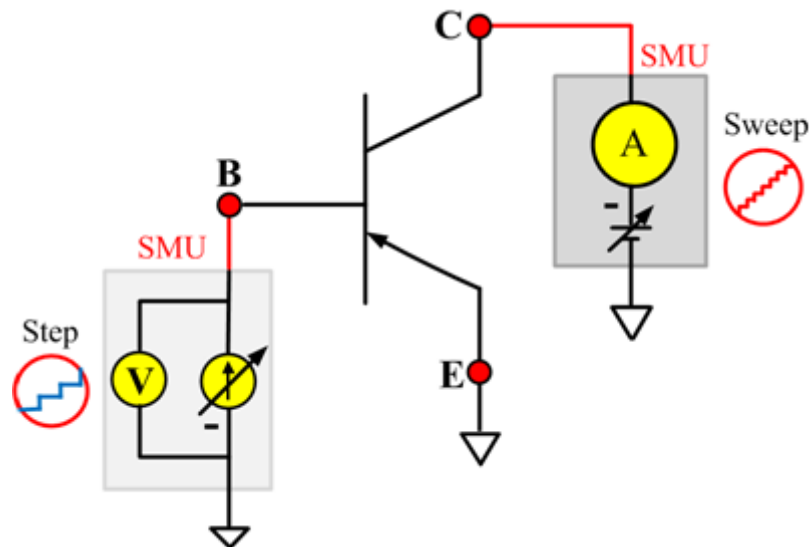
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pnpPowerBJT

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

Pin Connection: Use a SMU to apply a voltage sweep and make a current measurement from the Collector to the Emitter. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 101: pnpPowerBJT IcVce_StepIb pin connection



IcVce_StepIb_MIX

Description:

Module Name: IcVce_StepIb_MIX

Test Type: PTM

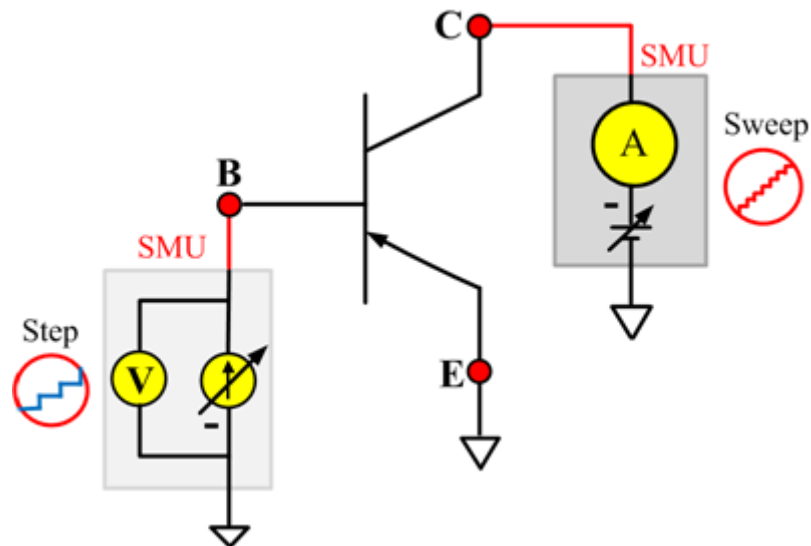
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200-SMU

DUT: Three-terminal pnpPowerBJT

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

Pin Connection: Use a SMU to apply a voltage sweep and make a current measurement from the Collector to the Emitter. Use another SMU to apply a current step to the Base. Connect the Emitter to GND or use a SMU to supply a zero voltage bias.

Figure 102: pnpPowerBJT IcVce_StepIb_MIX pin connection



IcVce_StepVbe

Description:

Module Name: IcVce_StepVbe

Test Type: ITM

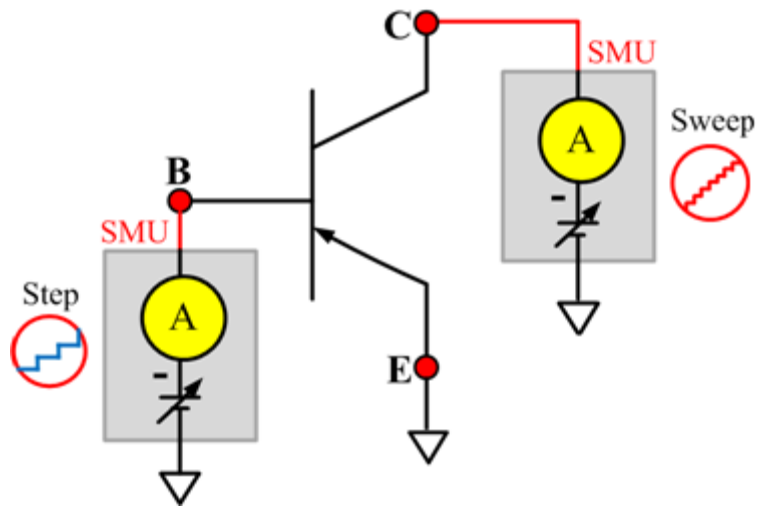
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pnpPowerBJT

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

Pin Connection: Use a SMU to apply a voltage sweep and make a current measurement from the Collector to the Emitter. Use another SMU to apply a voltage step to the Base-Emitter junction. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 103: pnpPowerBJT IcVce_StepVbe pin connection



IcVce_StepVbe_MIX

Description:

Module Name: IcVce_StepVbe_MIX

Test Type: PTM

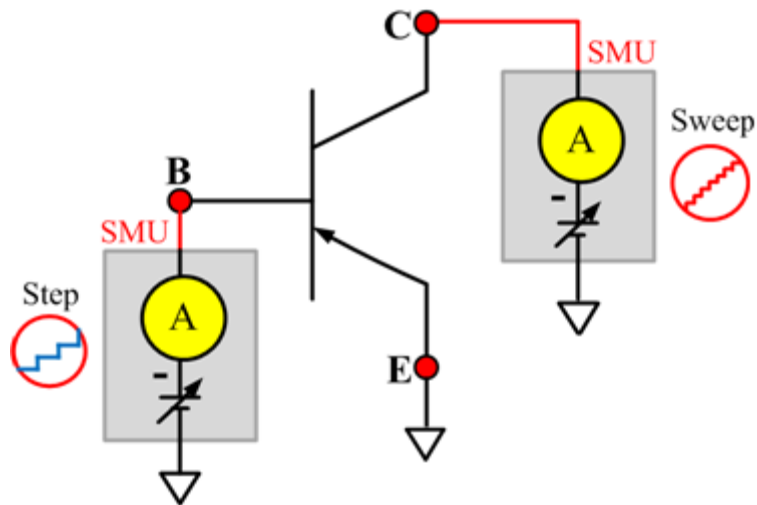
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200-SMU

DUT: Three-terminal pnpPowerBJT

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

Pin Connection: Use a SMU to apply a voltage sweep and make a current measurement from the Collector to the Emitter. Use a SMU to apply a voltage step to the Base-Emitter junction. Connect the Emitter to GND or use a SMU to supply a zero voltage bias.

Figure 104: pnpPowerBJT IcVce_StepVbe_MIX pin connection



IEBO

Description:

Module Name: IEBO

Test Type: ITM

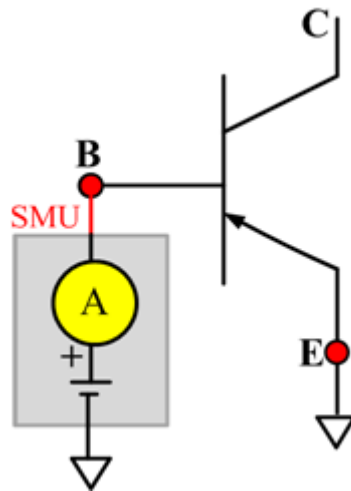
Instrument: Keithley Instruments Series 2600B

DUT: Three-terminal pnpPowerBJT

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

Pin Connection: Use a SMU to force voltage and make a current measurement from the Base to Emitter. Open the circuit to the Collector or use a SMU to supply zero current bias. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 105: pnpPowerBJT IEBO pin connection



VbeON

Description:

Module Name: VbeON

Test Type: ITM

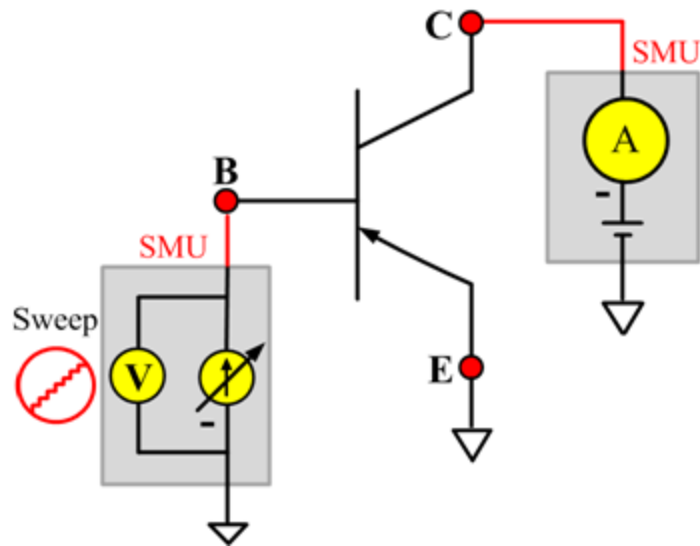
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pnpPowerBJT

Function: Measures the Base-Emitter junction on voltage when the BJT is in an active region. The voltage is measured with the Base-Emitter junction forward biased and the Collector Emitter voltage higher than the V_{ceSAT} .

Pin Connection: Use a SMU to apply a sweep current and make a voltage measurement from Base to Emitter. Use another SMU to apply a voltage bias to the Collector. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 106: pnpPowerBJT VbeON pin connection



VbeSAT

Description:

Module Name: VbeSAT

Test Type: ITM

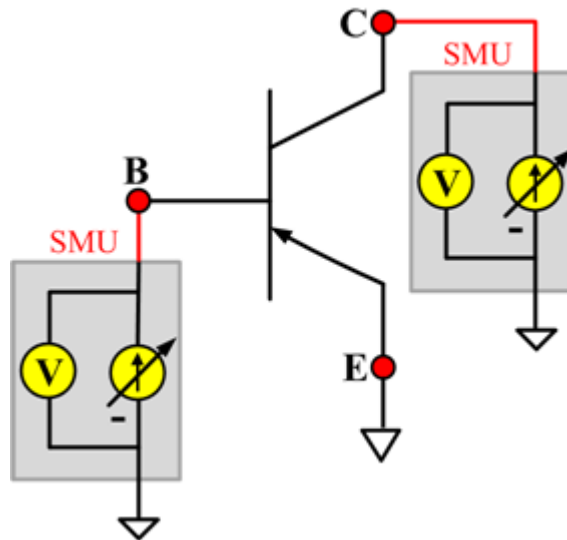
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pnpPowerBJT

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

Pin Connection: Use a SMU to force current and make a voltage measurement from the Base to Emitter. Use a SMU to apply a current bias to the Collector. Connect the Emitter to GND or use a SMU to supply a zero voltage bias.

Figure 107: pnpPowerBJT VbeSAT pin connection



VceSAT

Description:

Module Name: VceSAT

Test Type: ITM

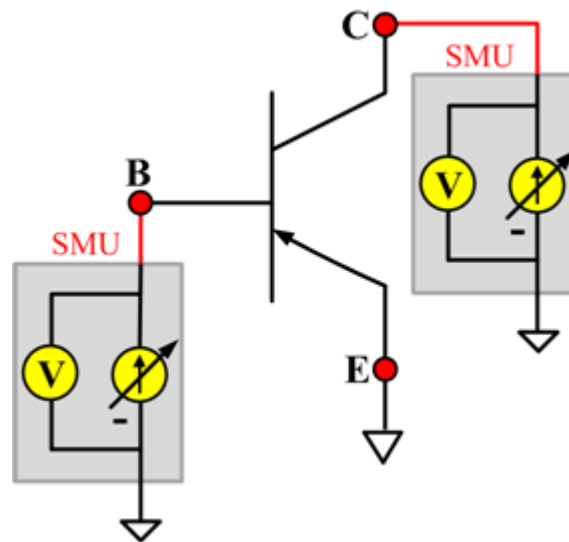
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pnpPowerBJT

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

Pin Connection: Use a SMU to force current and make a voltage measurement from the Collector to the Emitter. Use another SMU to apply current bias to the Base. Connect the Emitter to GND or use a SMU to supply a zero voltage bias.

Figure 108: pnpPowerBJT VceSAT pin connection



VceSAT_MIX

Description:

Module Name: VceSAT_MIX

Test Type: PTM

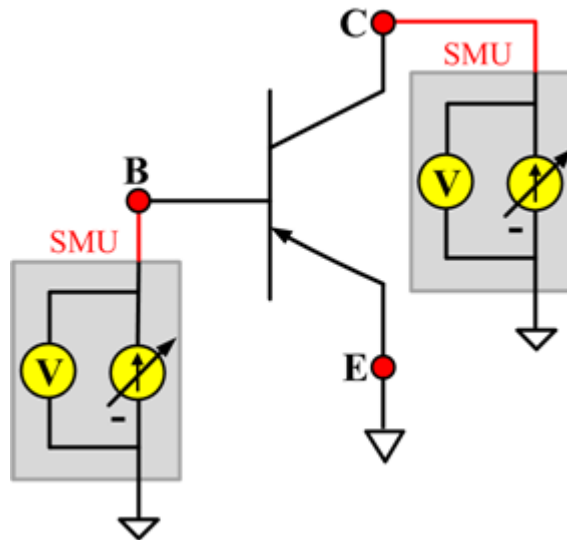
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200-SMU

DUT: Three-terminal pnpPowerBJT

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

Pin Connection: Use a SMU to force current and make a voltage measurement from the Collector to Emitter. Use another SMU to apply current bias to the Base. Connect the Emitter to GND or use a SMU to supply a zero voltage bias.

Figure 109: pnpPowerBJT VceSAT_MIX pin connection



VCESUS

Description:

Module Name: VCESUS

Test Type: ITM

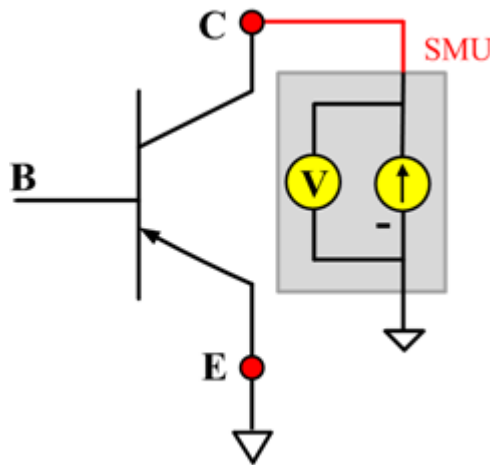
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal pnpPowerBJT

Function: Measures the Collector-Emitter sustaining voltage with the Base opened. The voltage is measured at a specific Collector current that is given in the data sheet.

Pin Connection: Use a SMU to force current and make a voltage measurement from the Collector to Emitter. Open the circuit to the Base or use a SMU to supply zero current bias. Connect the Emitter to GND or use a SMU to supply a zero voltage bias.

Figure 110: pnpPowerBJT VCESUS pin connection



nMOSFET library

nMOSFET overview

The nMOSFET library components are located in the following directory:

C:\ACS_BASIC\library\devLibrary\nMOSFET

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

nMOSFET parametric library

BVDSS

Description:

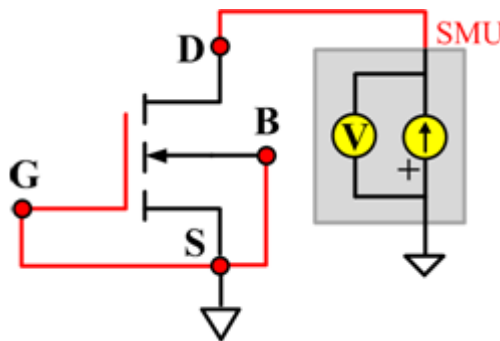
Module Name: BVDSS

DUT: Four-terminal nMOSFET

Function: Measures the drain-Source breakdown voltage of the nMOSFET with the Gate-Source shorted.

Pin connections: Use a SMU to apply a breakdown current on the Drain. Short Gate, Source, and Bulk (connect all of them to GND or use a SMU to supply a zero voltage bias). (See next figure.)

Figure 111: 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:

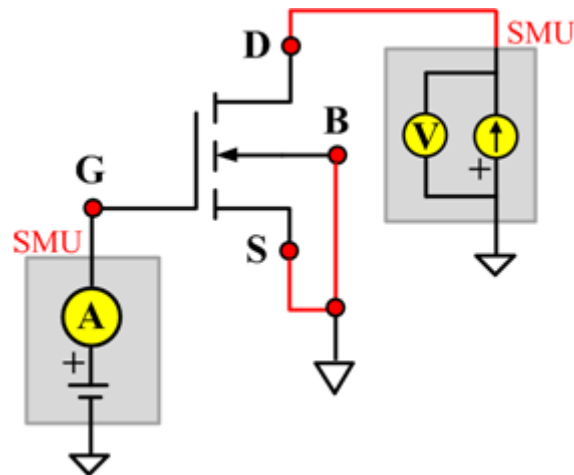
Module Name: BVDSV

DUT: Four-terminal nMOSFET

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

Pin connections: Connect the Source and Bulk to GND or use a SMU to supply a zero voltage bias. Use a SMU to bias the Gate. Use a SMU to apply a breakdown current on the Drain. (See next figure.)

Figure 112: Four_term_nMOSFET_BVDSV pin connection



BVDSV ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

BVDSV General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVGSO

Description:

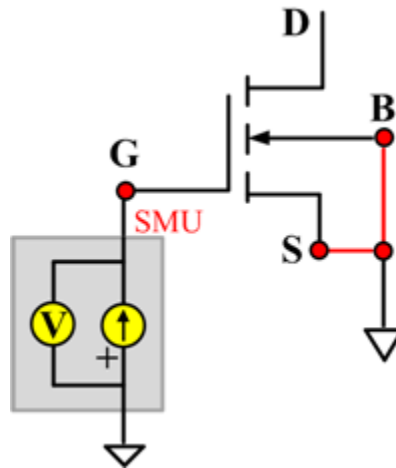
Module Name: BVGSO

DUT: Four-terminal nMOSFET

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

Pin connections: Use a SMU to apply a breakdown current on the Gate. Open the circuit to the Drain or use a SMU to supply zero current bias. Short Bulk and Source to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 113: Four_term_nMOSFET_BVGSO pin connection



BVGSO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

BVGSO General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVGDS

Description:

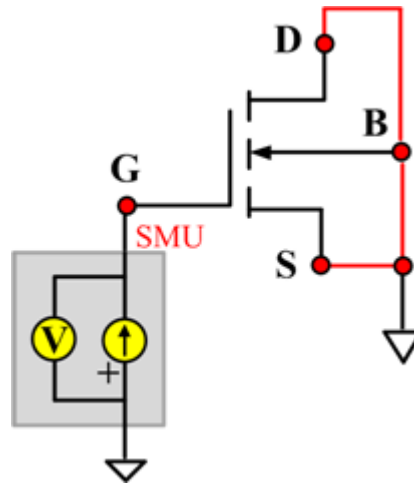
Module Name: BVGDS

DUT: Four-terminal nMOSFET

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

Pin connections: Connect the Source, Bulk, and Drain to GND or use a SMU to supply a zero voltage bias. Use a SMU to apply a breakdown current on the Gate. (See next figure.)

Figure 114: Four_term_nMOSFET_BVGDS pin connection



BVGDS ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

BVGDS General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVGDO

Description:

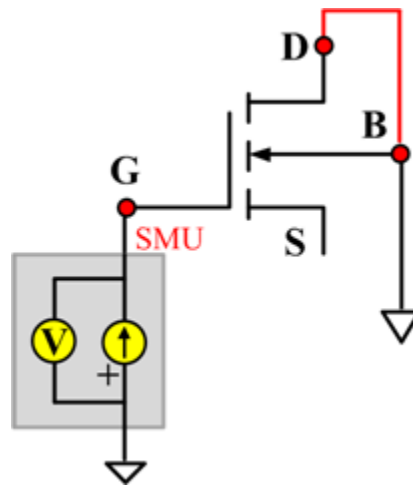
Module Name: BVGDO

DUT: Four-terminal nMOSFET

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

Pin connections: Use a SMU to apply a breakdown current on the Gate. Open the circuit to the Source or use a SMU to supply zero current bias. Short Bulk and Drain to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 115: Four_term_nMOSFET_BVGDO pin connection



BVGDO ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

BVGDO General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Cds

Description:

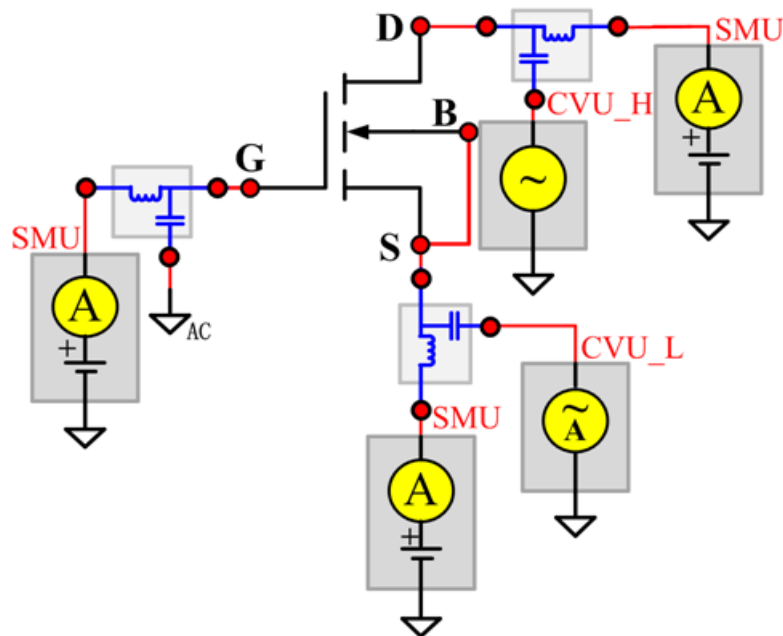
Module Name: Cds

DUT: Four-terminal nMOSFET

Function: Measures the capacitance between the Drain and Source terminals with the Gate terminal connected to the AC guard of a three-terminal bridge. Short Bulk to Source.

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

Figure 116: Four_term_nMOSFET_Cds pin connections



Cds PTM

Module type: PTM

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

Cgd

Description:

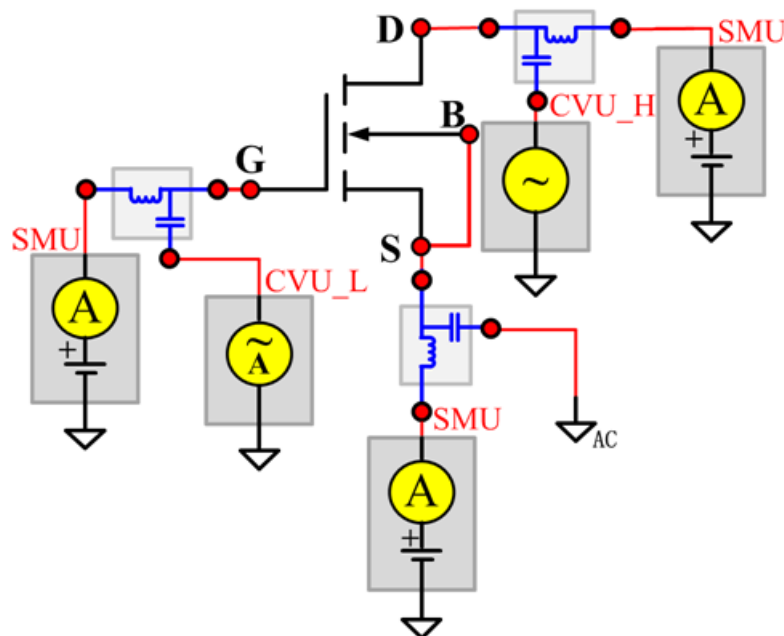
Module Name: Cgd

DUT: Four-terminal nMOSFET

Function: Measures the capacitance between the Drain and Gate terminals with the Source terminal connected to the AC guard of a three-terminal bridge. Short Bulk to Source.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Drain. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the AC guard of a three-terminal bridge through one remote bias tee to the Source. (See next figure.)

Figure 117: Four_term_nMOSFET_Cgd pin connections



Cgd PTM

Module type: PTM

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

Cgs

Description:

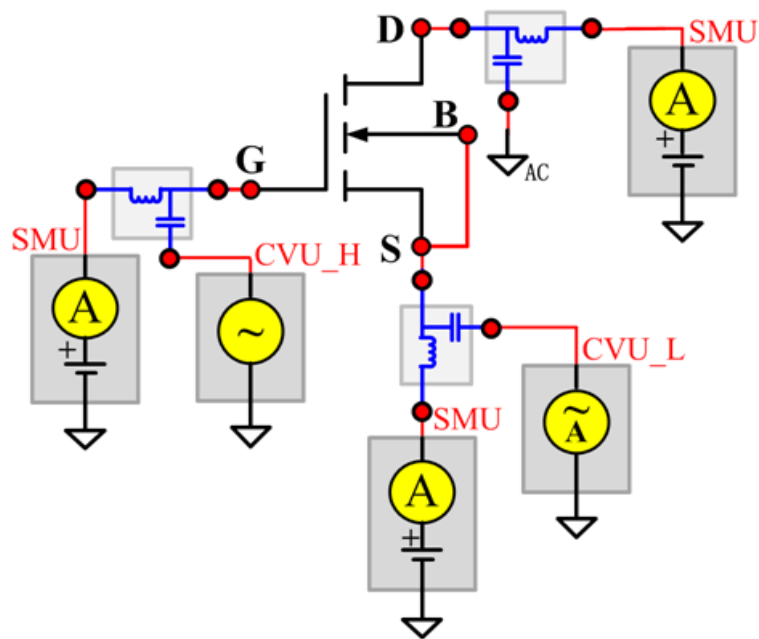
Module Name: Cgs

DUT: Four-terminal nMOSFET

Function: Measures the capacitance between the Gate and Source terminals with the Drain terminal connected to the AC guard of a three-terminal bridge. Short Bulk to Source.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the AC guard of a three-terminal bridge through one remote bias tee to the Drain. (See next figure.)

Figure 118: Four_term_nMOSFET_Cgs pin connections



Cgs PTM

Module type: PTM

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

Ciss

Description:

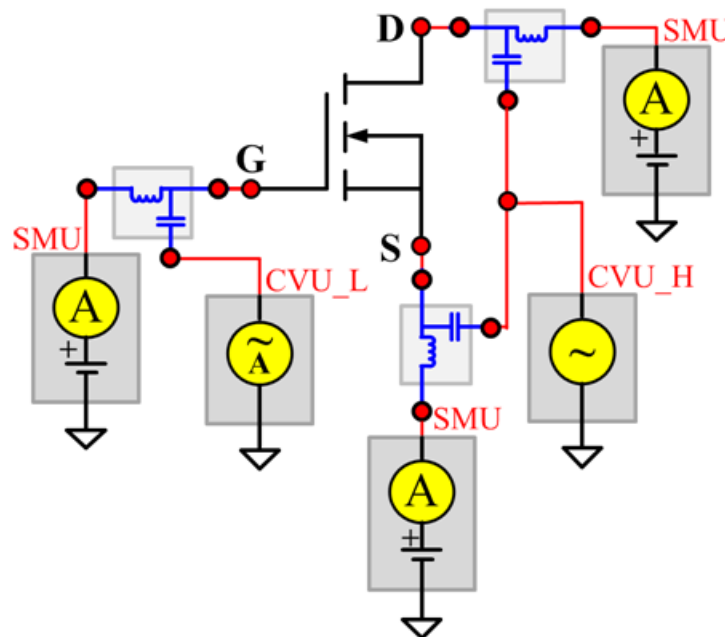
Module Name: Ciss

DUT: Four-terminal nMOSFET

Function: Measures the capacitance between the Gate and Source terminals with the Drain terminal AC short-circuited to the Source terminal. Short Bulk to Source.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Drain. Use the Series 2600B to sweep voltage. AC short circuit the Drain to the Source terminal. Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Source. Use the Series 2600B to supply zero voltage bias. AC short circuit the Drain to the Source terminal. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to supply zero voltage bias. (See next figure.)

Figure 119: Three_term_nPowerMOSFET_Ciss pin connections



Ciss PTM

Module type: PTM

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

Coss

Description:

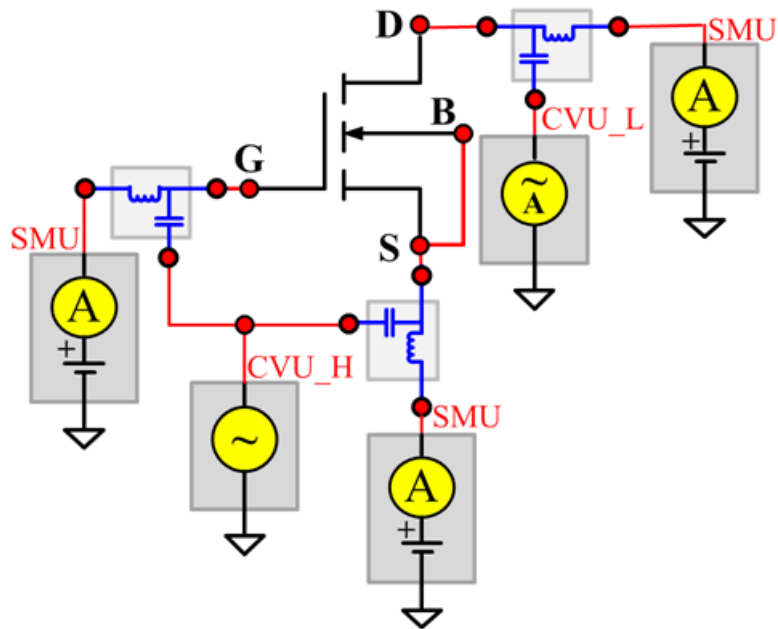
Module Name: Coss

DUT: Four-terminal nMOSFET

Function: Measures the capacitance between the Drain and Source terminals with the Gate terminal AC short-circuited to the Source terminal. Short Bulk to Source.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to supply zero voltage bias. AC short circuit the Gate to the Source terminal. Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Drain. Use the Series 2600B to sweep voltage. (See next figure.)

Figure 120: Four_term_nMOSFET_Coss pin connections



Coss PTM

Module type: PTM

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

Ciss

Description:

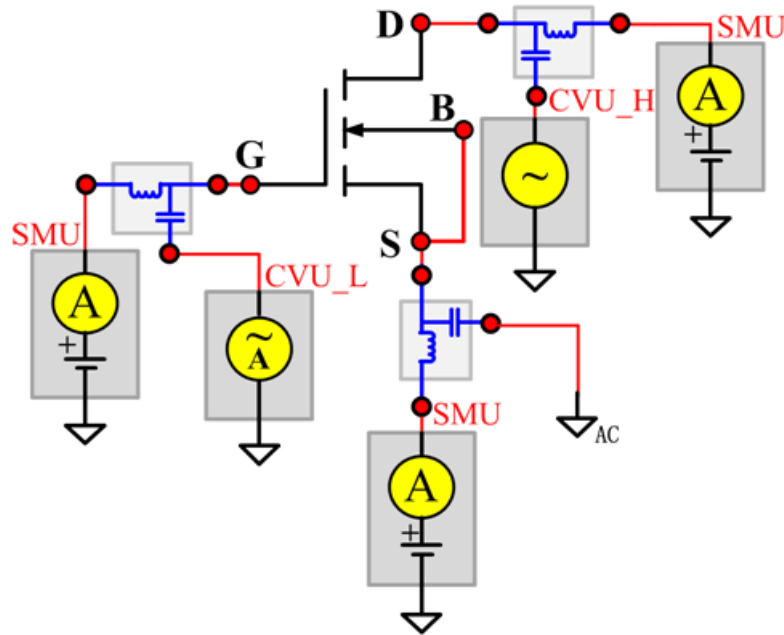
Module Name: Crss

DUT: Four-terminal nMOSFET

Function: Measures the common-source short-circuit input capacitance by testing the capacitance between the Drain and Gate terminals with the Source terminal connected to the AC guard of a three-terminal bridge. Short Bulk to Source.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Drain. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the AC guard of a three-terminal bridge through one remote bias tee to the Source. Use the Series 2600B to supply zero voltage bias. (See next figure.)

Figure 121: Four_term_nMOSFET_Crss pin connections



Crss PTM

Module type: PTM

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

IDL

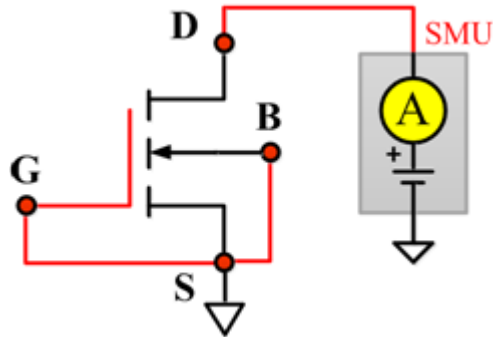
Description:

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).

Figure 122: Four_term_nMOSFET_IDL pin connection



IDL ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IDL General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IDS_ISD

Description:

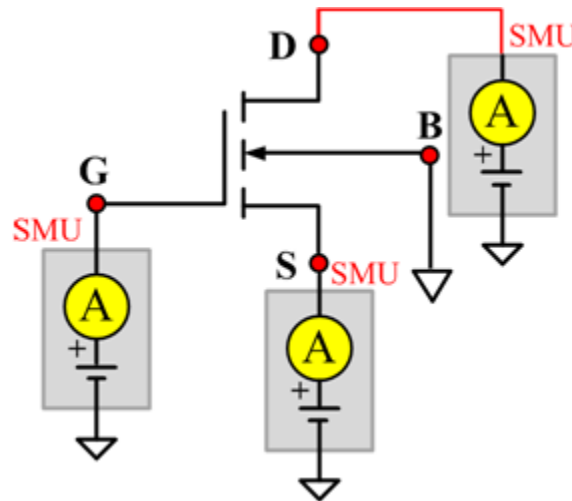
Module Name: IDS_ISD

DUT: Four-terminal nMOSFET

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

Pin connections: Use a SMU to force voltage to the Gate. Use a SMU to force voltage to the Drain. Connect Source and Bulk to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 123: Four_term_nMOSFET_IDS_ISD pin connection



IDS_ISD ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IDS_ISD General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVd_BiasVg

Description:

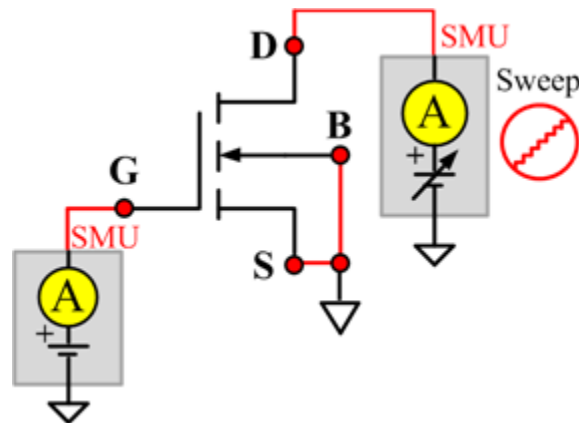
Module Name: IdVd_BiasVg

DUT: Four-terminal nMOSFET

Function: Measures the Drain current during a specified Drain voltage sweep, and the Drain current and the Drain voltage curve.

Pin connections: Use a SMU to bias voltage to the Gate. Use a SMU to apply a sweep voltage to the Drain. Short Bulk and Source to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 124: Four_term_nMOSFET_IdVd_BiasVg pin connection



IdVd_BiasVg ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IdVd_BiasVg General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVd_StepVg

Description:

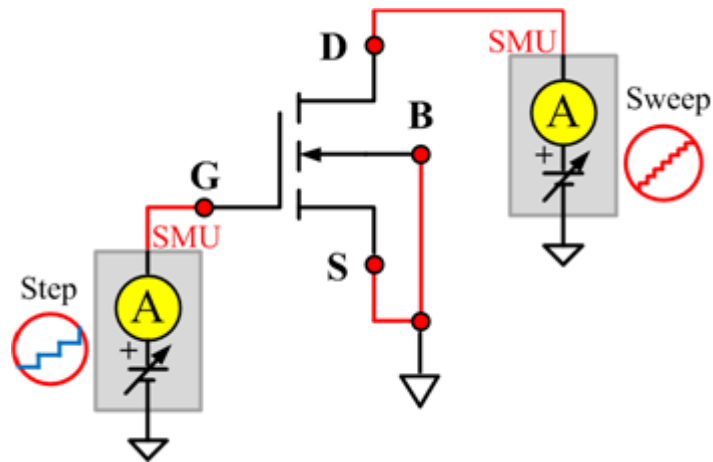
Module Name: IdVd_StepVg

DUT: Four-terminal nMOSFET

Function: Measure the Drain current during a specified Drain voltage sweep, and the series of Drain current tests and the Drain voltage curve.

Pin connections: Use a SMU to sweep the Drain. Use a SMU to step the Gate. Short Bulk and Source to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 125: Four_term_nMOSFET_IdVd_StepVg pin connection



IdVd_StepVg ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IdVd_StepVg General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVg_BiasVd

Description:

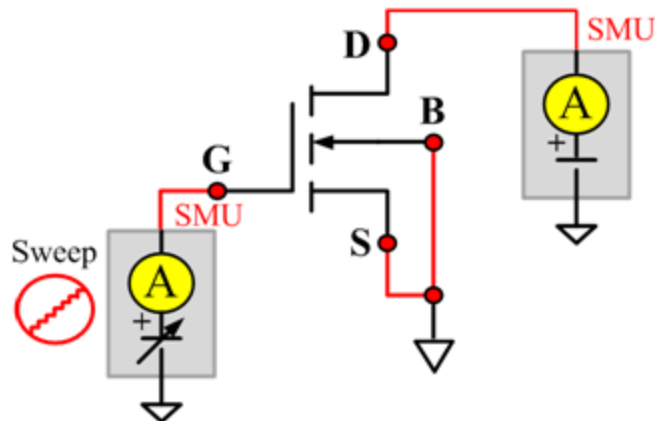
Module Name: IdVg_BiasVd

DUT: Four-terminal nMOSFET

Function: Measures the Drain current during a specified Gate voltage sweep, and the Drain current and the Gate voltage curve.

Pin connections: Use a SMU to bias voltage to the Drain. Use a SMU to apply a sweep voltage to the Gate. Short the Bulk and Source or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 126: Four_term_nMOSFET_IdVg_BiasVd pin connection



IdVg_BiasVd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IdVg_BiasVd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVg_StepVd

Description:

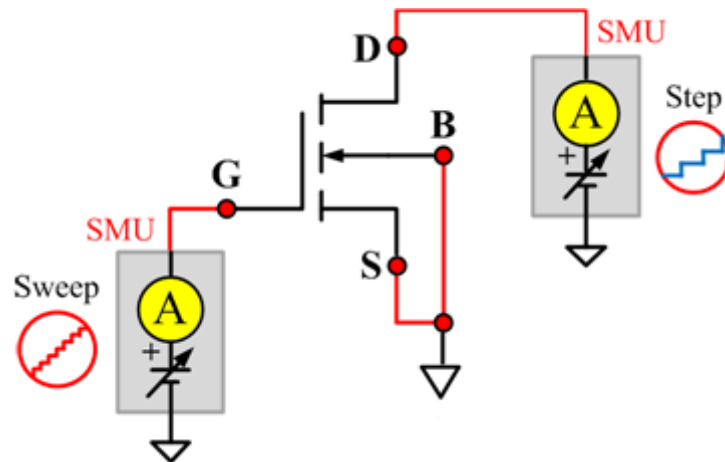
Module Name: IdVg_StepVd

DUT: Four-terminal nMOSFET

Function: Measures the Drain current during a specified Gate voltage sweep with the Drain step, and a series of Drain currents and a Gate voltage curve.

Pin connections: Use a SMU to step the Drain. Use a SMU to sweep the Gate. Short Bulk and Source to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 127: Four_term_nMOSFET_IdVg_StepVd pin connection



IdVg_StepVd ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IdVg_StepVd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVg_StepVsub

Description:

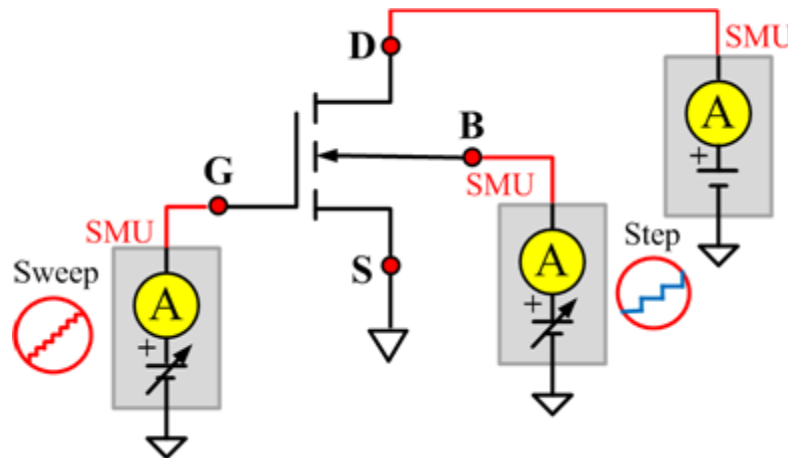
Module Name: IdVg_StepVsub

DUT: Four-terminal nMOSFET

Function: Measures the Drain current during a specified Gate voltage sweep with a bulk step, and a series of Drain currents and a Gate voltage curve.

Pin connections: Use a SMU to step the Bulk. Use a SMU to sweep the Gate. Use a SMU to bias the Drain. Connect the Source to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 128: Four_term_nMOSFET_IdVg_StepVsub pin connection



IdVg_StepVsub ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IdVg_StepVsub General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IGL

Description:

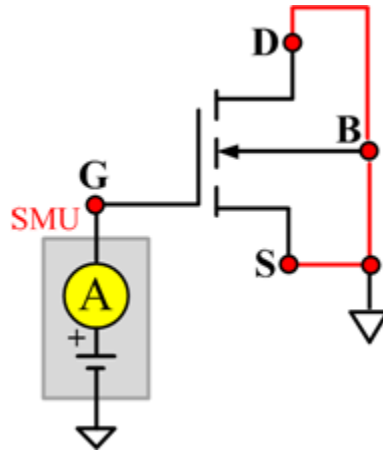
Module Name: IGL

DUT: Four-terminal nMOSFET

Function: Measures the Gate leakage current when the Source and Drain are shorted.

Pin connections: Use a SMU to force voltage to the Gate. Connect the Source, Drain, and Bulk to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 129: Four_term_nMOSFET_IGL pin connection



IGL ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IGL General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IgVg

Description:

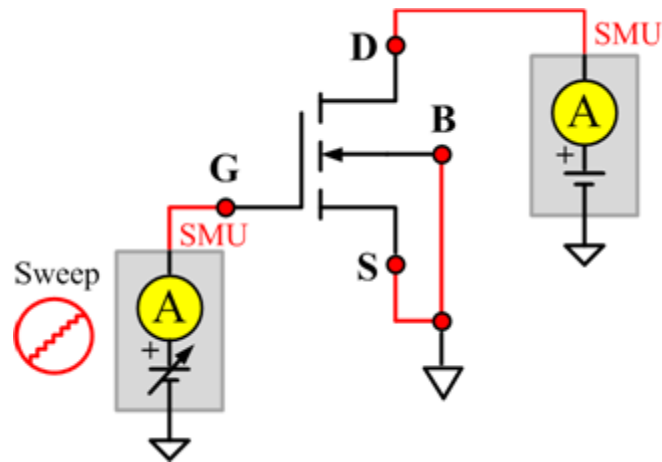
Module Name: IgVg

DUT: Four-terminal nMOSFET

Function: Measures the Gate current during a specified Gate voltage sweep when the Drain is biased, and the Gate current and Gate voltage curve.

Pin connections: Use a SMU to bias the Drain. Use a SMU to sweep the Gate. Short the Bulk and Source to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 130: Four_term_nMOSFET_IgVg pin connection



IgVg ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

IgVg General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

ISL

Description:

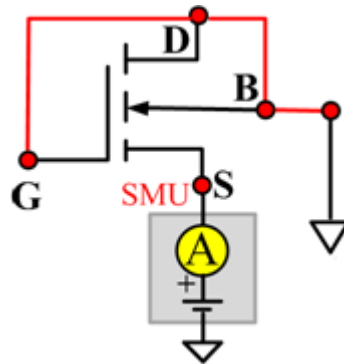
Module Name: ISL

DUT: Four-terminal nMOSFET

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

Pin connections: Use a SMU to force voltage to the Source. Short Bulk, Gate, and Drain to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 131: Four_term_nMOSFET_ISL pin connection



ISL ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

ISL General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Vtci

Description:

Module Name: Vtci

DUT: Four-terminal nMOSFET

Function: Measures the constant current threshold voltage of the nMOSFET device, and the Drain current and the Gate voltage curve.

Pin connections: Use a SMU to bias the Drain. Use a SMU to sweep the Gate. Input Source and Bulk voltage when needed. Usually, they are connected to GND for NMOS, and connected to the nominal power supply voltage (VDD) for PMOS. (See next figure.)

Procedure: The constant current threshold voltage:

$V_{th_ci} = V_{GS}$ (@ID=1uA.W/L) -- NMOS

$V_{th_ci} = V_{GS}$ (@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 I_{d_tar} ($I_{d_tar}=1\mu A.W/L$, or $-0.025\mu A.W/L$), which is the sign to be near threshold, then search the Gate voltage to make the Drain current equal to I_{d_tar} .

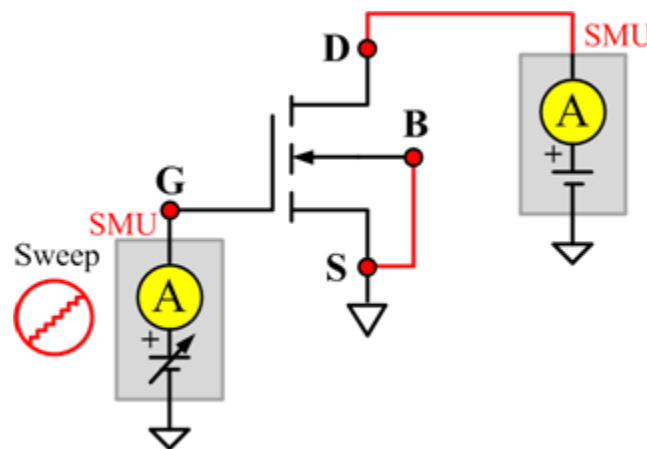
NOTE

The `Four_term_nMOSFET_Vth_ci` measurement procedure must determine V_{th_ci} to within a 1 mV resolution. If the V_{GS} 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 V_{th_ci} measurements are $V_{DS} = V_{DS_lin}$, $V_{BS} = V_{BB}$ for linear region measurement, or $V_{DS} = V_{DS_sat}$, ($V_{BS} = V_{BB}$ for saturation region measurement).

Typically, for PMOS, $V_{DS_lin} = -0.1\text{ V} (@V_{DD}=5\text{V})$; for NMOS, $V_{DS_lin}=0.1\text{V} (@V_{DD}=5\text{V})$.

Figure 132: Four_term_nMOSFET_Vtci pin connection



Vtci ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

Vtci General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Vtext

Description:

Module Name: Vtext

DUT: Four-terminal nMOSFET

Function: Measures the Drain current during a Gate voltage sweep, extracts the trans-conductance (Gm) and measure the maximum trans-conductance (Gmmax), measures the extracted threshold voltage (Vth_ex), measures the Drain current and the Gate voltage curve, and measures the Gm Drain current or the Gm Gate voltage curve.

Pin connections: Use a SMU to bias the Drain. Use a SMU to sweep the Gate. Input Source and Bulk voltage when needed. Usually, they are connected to GND for NMOS, and connected to the nominal power supply voltage (VDD) for PMOS. (See next figure.)

Procedure: The threshold voltage is extrapolated from the measurement of the maximum slope (Gmmax) of the ID-VGS curve:

$$V_{th_ex} = V_{GS} (@G_{mmax}) - ID (@G_{mmax}) / G_{mmax}$$

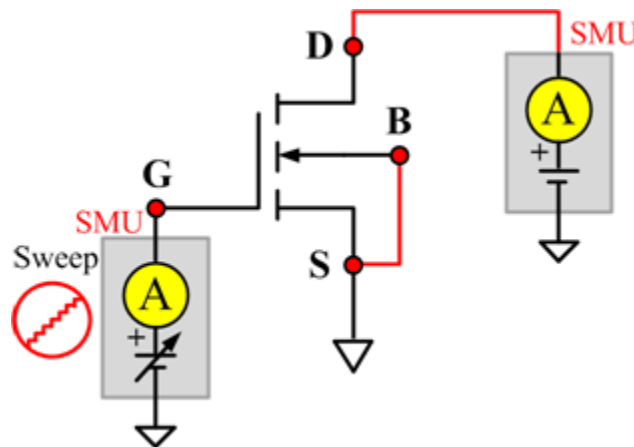
Where: $V_{GS} (@G_{mmax})$ is the Gate voltage at the point of the maximum slope of the ID-VGS curve; $ID (@G_{mmax})$ is the Drain current at the point of the maximum slope of the ID-VGS curve; G_{mmax} is the maximum slope of the ID-VGS curve.

NOTE

DC bias voltages for V_{th_ex} measurements are $V_{DS} = V_{DS_lin}$, $V_{BS} = V_{BB}$ for linear measurement.

$V_{DS} = V_{DS_sat}$, $V_{BS} = V_{BB}$ for saturation. Typically, for PMOS, $V_{DS_lin} = -0.1 \text{ V} (@V_{DD} = 5\text{V})$; for NMOS, $V_{DS_lin} = 0.1 \text{ V} (@V_{DD} = 5\text{V})$.

Figure 133: Four_term_nMOSFET_Vtext pin connection



Vtext ITM

Module Type: ITM

Instrument: Keithley Instruments Series 2600B, Model 4200 SMU

Vtext General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Vtext_llsq

Description:

Module Name: Vtext_llsq

Module Type: Standard STM

Instrument: Keithley Instruments Series 2600B SMU

DUT: Four-terminal nMOSFET

Function: Measures the Drain current at the Gate voltage sweep, extracts the trans-conductance (G_m) and extract the maximum trans-conductance (G_{mmax}), measures the extracted threshold voltage (V_{th_ex}), measure the Drain current and the Gate voltage curve, and measures the G_m Drain current or the G_m Gate voltage curve.

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

Pin connections: Use a SMU to bias the Drain. Use a SMU to sweep the Gate. If needed, input the Source and Bulk voltage. Usually, they are connected to GND for NMOS, and connected to the nominal power supply voltage (VDD) for PMOS. (See next figure.)

Procedure: The threshold voltage is extrapolated from the measurement of the maximum slope (G_{mmax}) of the IDVGS curve:

$$V_{th_ex} = V_{GS} (@G_{mmax}) - I_{D} (@G_{mmax}) / G_{mmax}$$

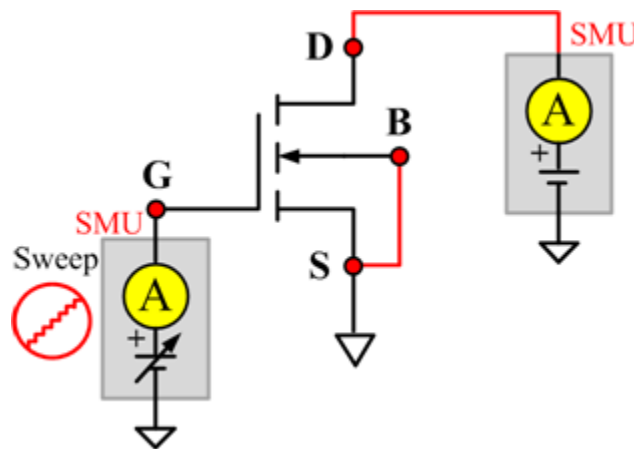
Where: $V_{GS} (@G_{mmax})$ is the Gate voltage at the point of the maximum slope of the IDVGS curve; $I_{D} (@G_{mmax})$ is the Drain current at the point of the maximum slope of the IDVGS curve; G_{mmax} is the maximum slope of the IDVGS curve.

NOTE

DC bias voltages for V_{th_ex} measurements are $V_{DS} = V_{DS_lin}$, $V_{BS} = V_{BB}$ for linear measurement.

$V_{DS} = V_{DS_sat}$, $V_{BS} = V_{BB}$ for saturation. Typically, for PMOS, $V_{DS_lin} = -0.1 V (@V_{DD} = 5V)$; for NMOS, $V_{DS_lin} = 0.1V (@V_{DD} = 5V)$.

Figure 134: Four_term_nMOSFET_Vtext_llsq pin connection



nPowerMOSFET library

nPowerMOSFET overview

The nPowerMOSFET library components are in the following directory:

C:\ACS_BASIC\library\devLibrary\nPowerMOSFET

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

nPowerMOSFET parametric library

BVDSS

Description:

Module Name: BVDSS

Module Type: ITM

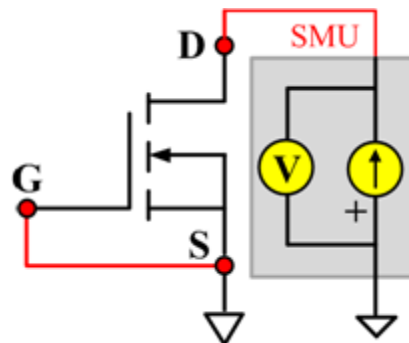
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal nPowerMOSFET

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

Pin Connection: Use the Model 2657A instrument to apply current and make a voltage measurement at the Drain. Connect the Gate and Source to GND or use a SMU to supply a zero voltage bias.

Figure 135: nPowerMOSFET_BVDSS pin connection



Cds

Description:

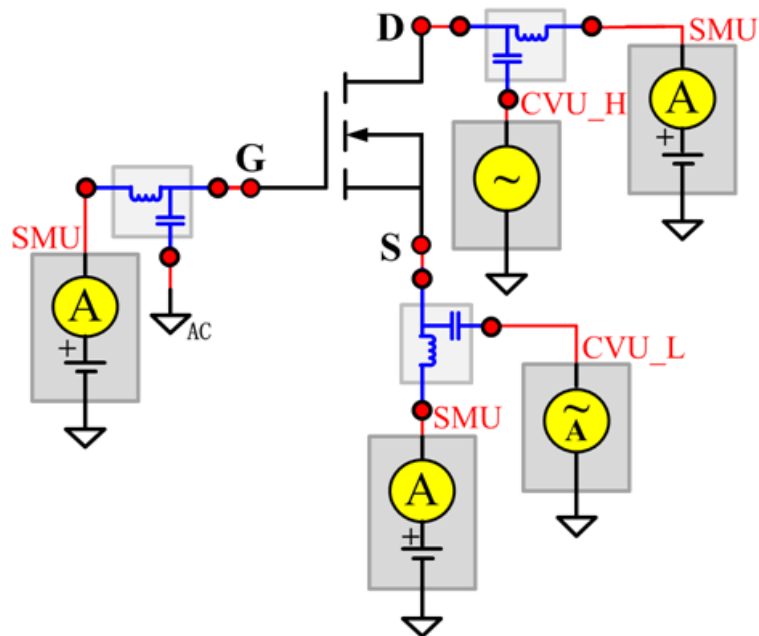
Module Name: Cds

DUT: Three-terminal nPowerMOSFET

Function: Measures the capacitance between the Drain and Source terminals with the Gate terminal connected to the AC guard of a three-terminal bridge.

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

Figure 136: Three_term_nPowerMOSFET_Cds pin connections



Cds PTM

Module type: PTM

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

Cgd

Description:

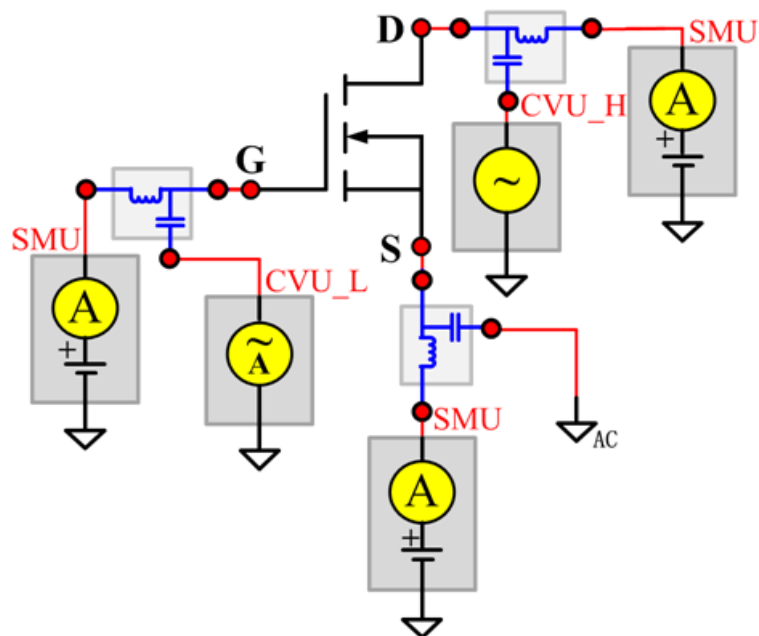
Module Name: Cgd

DUT: Three-terminal nPowerMOSFET

Function: Measures the capacitance between the Drain and Gate terminals with the Source terminal connected to the AC guard of a three-terminal bridge.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Drain. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the AC guard of a three-terminal bridge through one remote bias tee to the Source. (See next figure.)

Figure 137: Three_term_nPowerMOSFET_Cgd pin connections



Cgd PTM

Module type: PTM

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

Cgs

Description:

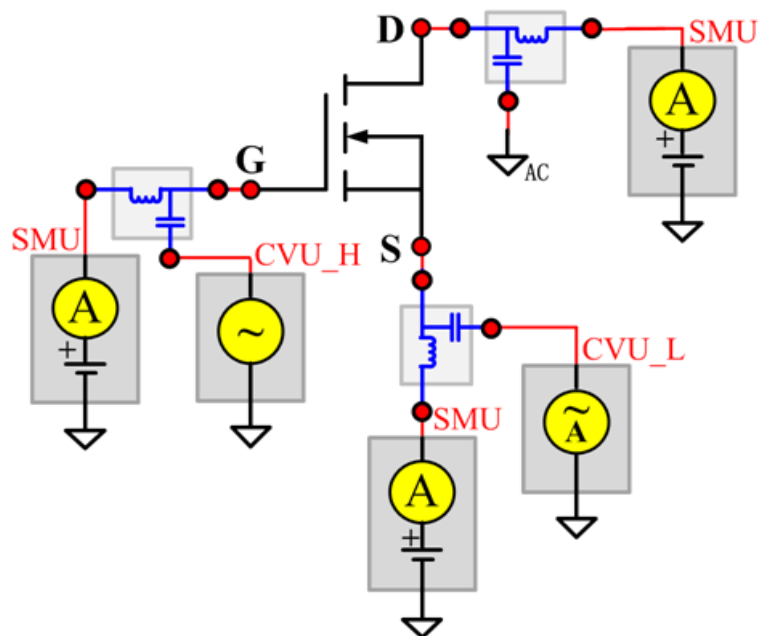
Module Name: Cgs

DUT: Three-terminal nPowerMOSFET

Function: Measures the capacitance between the Gate and Source terminals with the Drain terminal connected to the AC guard of a three-terminal bridge.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the AC guard of a three-terminal bridge through one remote bias tee to the Drain. Use the Series 2600B to supply zero voltage bias. (See next figure.)

Figure 138: Three_term_nPowerMOSFET_Cgs pin connections



Cgs PTM

Module type: PTM

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

Ciss

Description:

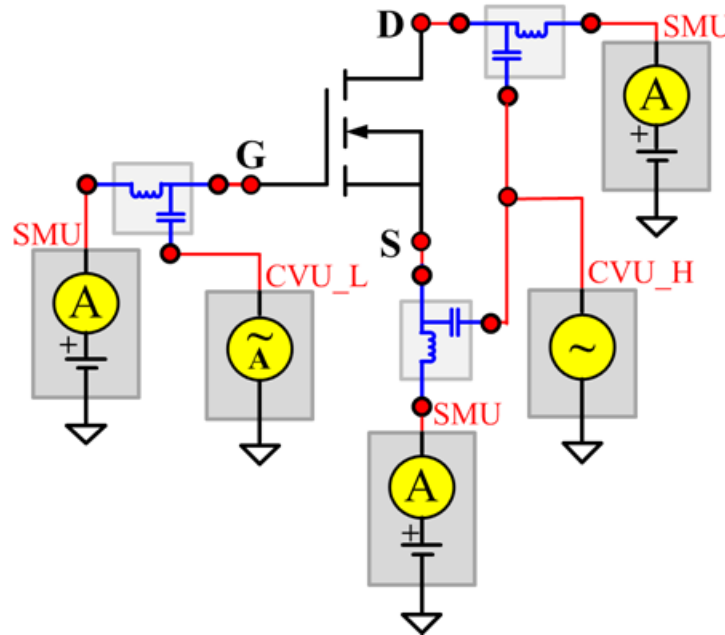
Module Name: Ciss

DUT: Three-terminal nPowerMOSFET

Function: Measures the capacitance between the Gate and Source terminals with the Drain terminal AC short-circuited to the Source terminal.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Drain. Use the Series 2600B to sweep voltage. AC short circuit the Drain to the Source terminal. Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to supply zero voltage bias. (See next figure.)

Figure 139: Three_term_nPowerMOSFET_Ciss pin connections



Ciss PTM

Module type: PTM

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

Coss

Description:

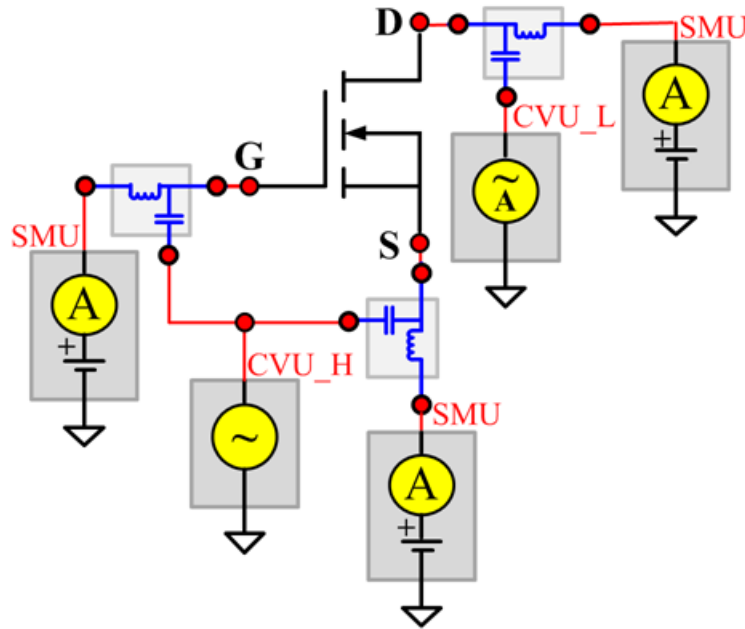
Module Name: Coss

DUT: Three-terminal nPowerMOSFET

Function: Measures the capacitance between the Drain and Source terminals with the Gate terminal AC short-circuited to the Source terminal.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to supply zero voltage bias. AC short circuit the Gate to the Source terminal. Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Drain. Use the Series 2600B to sweep voltage. (See next figure.)

Figure 140: Three_term_nPowerMOSFET_Coss pin connections



Coss PTM

Module type: PTM

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

Ciss

Description:

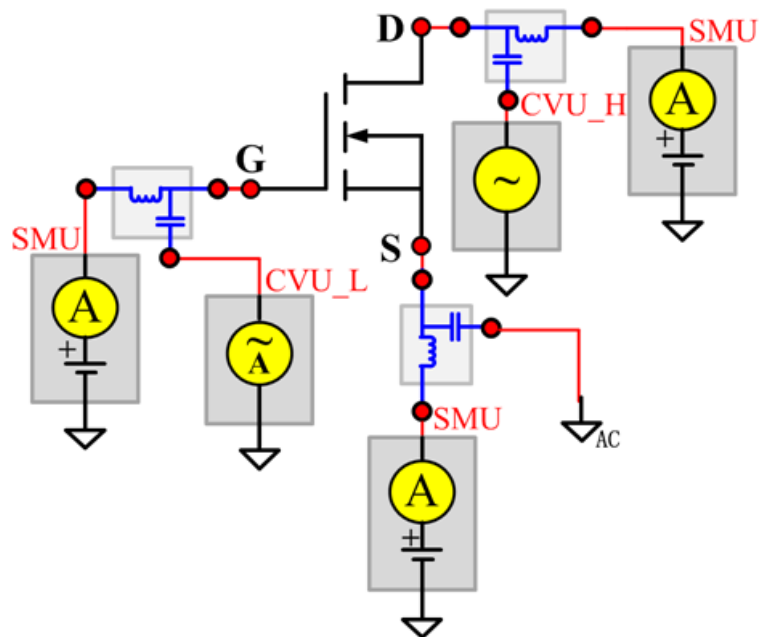
Module Name: Crss

DUT: Three-terminal nPowerMOSFET

Function: Measures the common-source short-circuit input capacitance by testing the capacitance between the Drain and Gate terminals with the Source terminal connected to the AC guard of a three-terminal bridge.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Drain. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the AC guard of a three-terminal bridge through one remote bias tee to the Source. Use the Series 2600B to supply zero voltage bias.

Figure 141: Three_term_nPowerMOSFET_Crss pin connections



Crss PTM

Module type: PTM

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

GFS

Description:

Module Name: GFS

Module Type: ITM

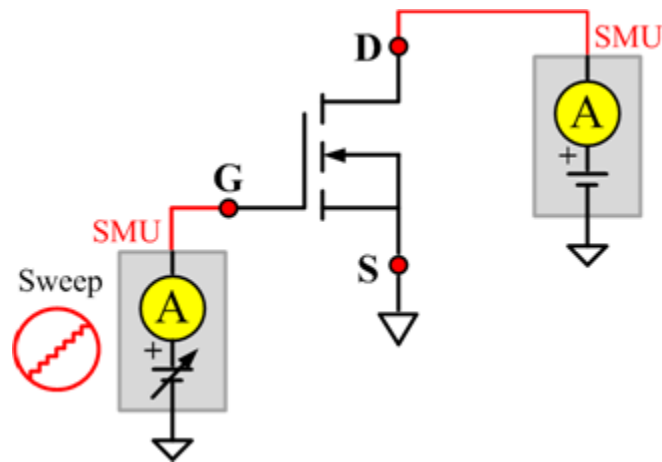
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

Function: Measures the forward transconductance. Measures the current on the Drain by applying a voltage sweep from the Gate to the Source and calculates the ratio of change in the I_d for a change in the V_{gs} : $GFS = \Delta(I_d)/\Delta(V_{gs})$.

Pin Connection: Use the Model 2651A to apply voltage and make a current measurement at the Drain. Use the low power Model 2600B to sweep voltage at the Gate. Connect the Source to GND or use a SMU to supply a zero voltage bias.

Figure 142: nPowerMOSFET GFS pin connection



IdON

Description:

Module Name: IdON

Module Type: ITM

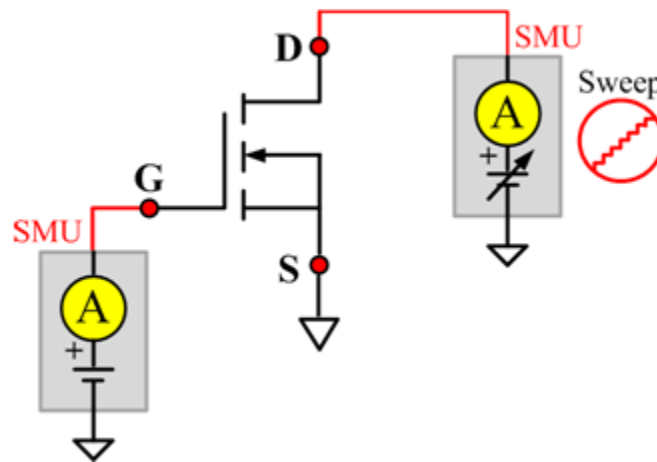
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

Function: Measures the on-state Drain current. Measures the current on the Drain by applying a voltage sweep to the Drain-Source with a specific Gate voltage to turn on the device at a specific I_d current value that is given in the data sheet.

Pin Connection: Use the Model 2651A to apply a voltage sweep and make a current measurement at the Drain. Use the low power Model 2600A to source a specific voltage at the Gate. Connect the Source to GND or use a SMU to supply a zero voltage bias.

Figure 143: nPowerMOSFET IdON pin connection



IdON_MIX

Description:

Module Name: IdON_MIX

Module Type: PTM

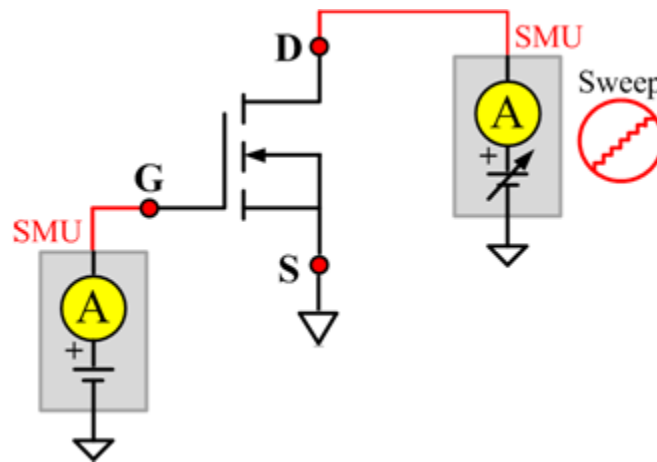
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200-SMU

DUT: Three-terminal nPowerMOSFET

Function: Measures the on-state Drain current. Measures current on the Drain by applying a voltage sweep to the Drain-Source with a specific Gate voltage to turn on the device at a certain I_d current value that is given in the data sheet.

Pin Connection: Use the Model 2651A SMU to apply a voltage sweep and make a current measurement at the Drain. Use another SMU to force a specific voltage at the Gate. Connect the Source to GND or use a SMU to supply a zero voltage bias.

Figure 144: nPowerMOSFET IdON_MIX pin connection



IDSS

Description:

Module Name: IDSS

Module Type: ITM

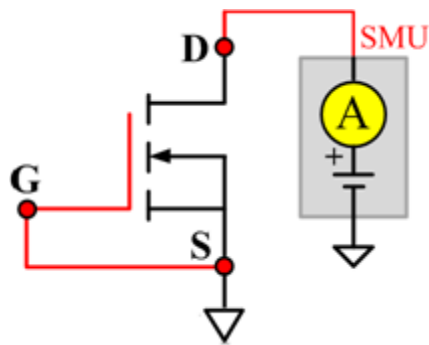
Instrument: Keithley Instruments Model 2657A, Series 2600B

DUT: Three-terminal nPowerMOSFET

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

Pin Connection: Use the Model 2657A to apply voltage and make a current measurement at the Drain. Connect the Gate and Source to GND or use a SMU to supply a zero voltage bias.

Figure 145: nPowerMOSFET IDSS pin connection



IdVd_StepVg

Description:

Module Name: IdVd_StepVg

Module Type: ITM

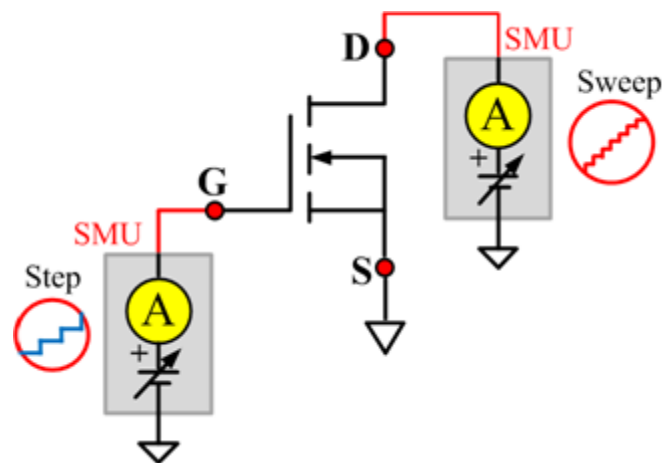
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

Function: Measures the Drain current at the specified Gate voltage and sweeps the Drain in pulse mode. Generates the standard family of IdVd curves.

Pin Connection: Use the Model 2651A to apply a voltage sweep and make a current measurement at the Drain. Use the low power Model 2600A to source a specific voltage at the Gate. Connect the Source to GND or use a SMU to supply a zero voltage bias.

Figure 146: nPowerMOSFET IdVd_StepVg pin connection



IdVd_StepVg_MIX

Description:

Module Name: IdVd_StepVg_MIX

Module Type: PTM

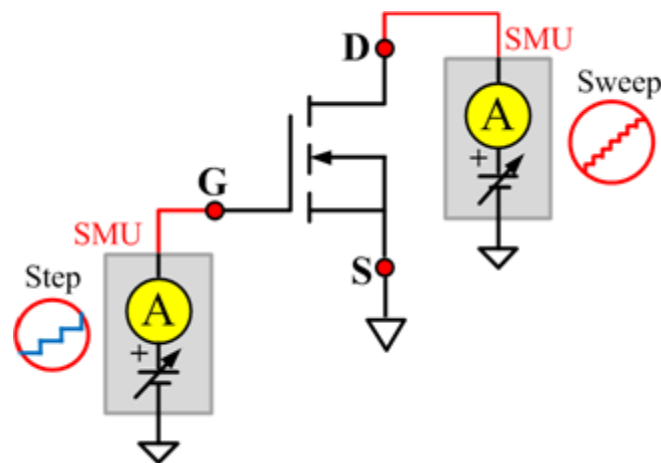
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200-SMU

DUT: Three-terminal nPowerMOSFET

Function: Measures the standard family of IdVd curves. Each time the voltage steps on the Gate-Source, a voltage sweep and a set of current measurements occur on the Drain.

Pin Connection: Use the Model 2651A SMU to apply a voltage sweep and make a current measurement at the Drain. Use a SMU to force a specific voltage at the Gate. Connect the Source to GND or use a SMU to supply a zero voltage bias.

Figure 147: nPowerMOSFET IdVd_StepVg_MIX pin connection



IdVg_StepVd

Description:

Module Name: IdVg_StepVd

Module Type: ITM

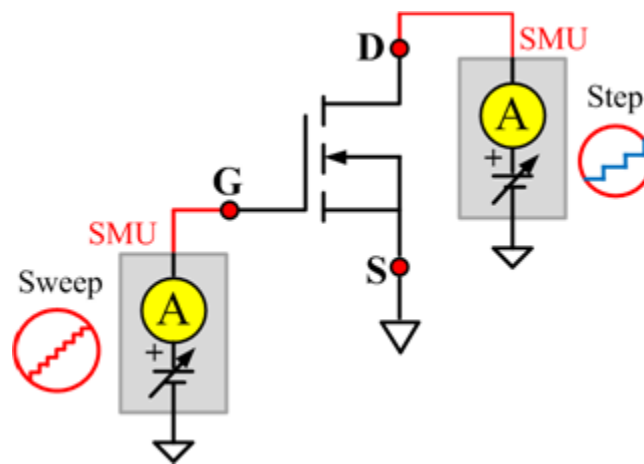
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

Function: Measures the transfer characteristic of the device. Each time the voltage steps on the Drain-Source, a voltage sweep is performed on the Gate-Source and set of current measurements occurs on the Drain.

Pin Connection: Use the Model 2651A to apply a voltage step and make a current measurement at the Drain. Use the low power Model 2600B to sweep voltage at the Gate. Connect the Source to GND or use a SMU to supply a zero voltage bias.

Figure 148: nPowerMOSFET IdVg_StepVd pin connection



IGSSF

Description:

Module Name: IGSSF

Module Type: ITM

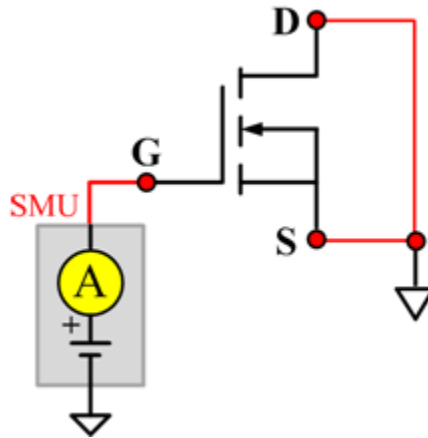
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

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

Pin Connection: Use a SMU to force voltage and make a current measurement at the Gate. Connect the Drain and Source to GND or use a SMU to supply a zero voltage bias.

Figure 149: nPowerMOSFET IGSSF pin connection



IGSSR

Description:

Module Name: IGSSR

Module Type: ITM

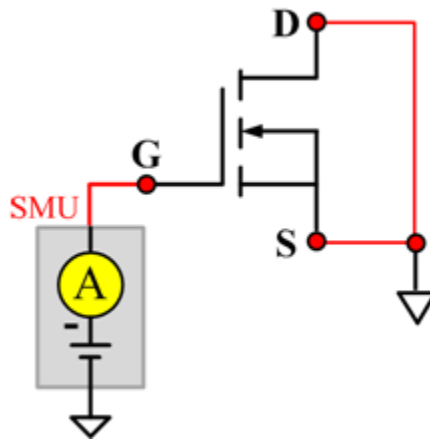
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

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

Pin Connection: Use a SMU to force voltage and make a current measurement from the Gate. Connect the Drain and Source to GND or use a SMU to supply a zero voltage bias.

Figure 150: nPowerMOSFET IGSSR pin connection



RdsON

Description:

Module Name: RdsON

Module Type: ITM

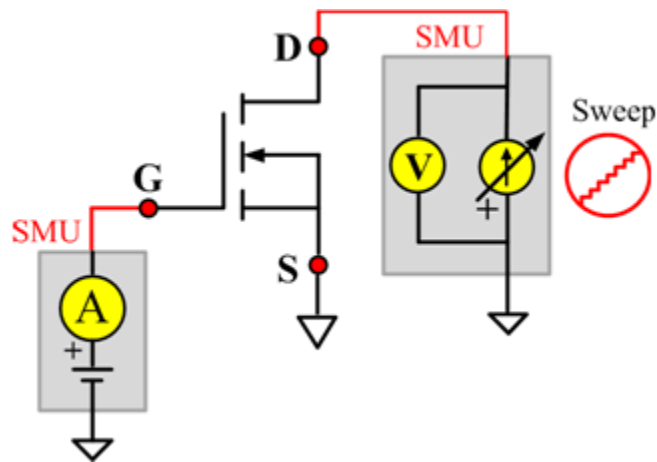
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

Function: Measures the Drain to Source on-state resistance. Measures resistance by applying a current sweep to the Drain with a specific Gate voltage that is calculated by dividing the measured Drain voltage by the Sourced current: $R_{ds} = V_{ds}/I_d$.

Pin Connection: Use the Model 2651A to apply a current sweep and make a voltage measurements at the Drain. Use the low-power Model 2600B to force a specific voltage at the Gate. Connect the Source to GND or use a SMU to supply a zero voltage bias.

Figure 151: nPowerMOSFET RdsON pin connection



RdsON_MIX

Description:

Module Name: RdsON

Module Type: PTM

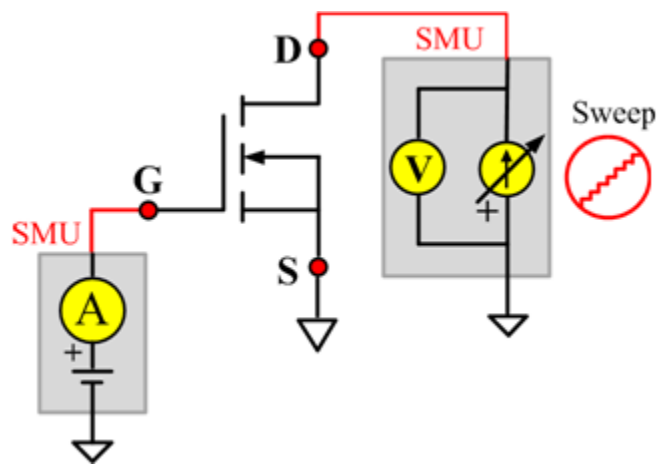
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200-SMU

DUT: Three-terminal nPowerMOSFET

Function: Measures the Drain to Source on-state resistance. Measures resistance by applying a current sweep to the Drain with a specific Gate voltage that is calculated by dividing the measured Drain voltage by the Sourced current: $R_{ds} = V_{ds}/I_d$.

Pin Connection: Use the Model 2651A SMU to apply a current sweep and make a voltage measurement at the Drain. Use a SMU to force specific voltage at the Gate. Connect the Source to GND or use a SMU to supply a zero voltage bias.

Figure 152: nPowerMOSFET RdsON_MIX pin connection



VdsON

Description:

Module Name: VdsON

Module Type: ITM

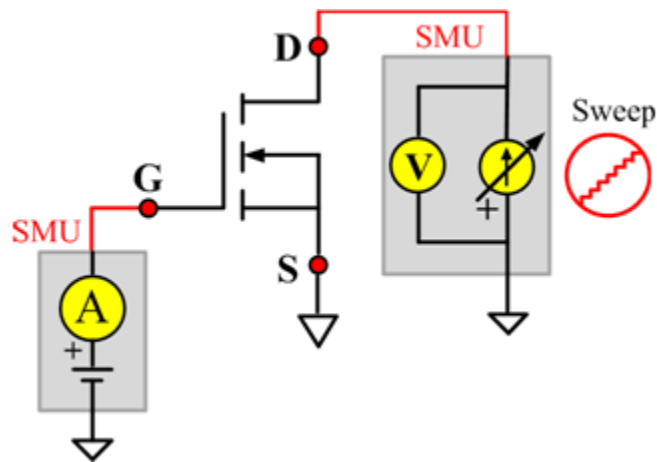
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

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

Pin Connection: Use the Model 2651A SMU to apply a current sweep and make a voltage measurement at the Drain. Use the low-power Model 2600B to force a specific voltage at the Gate. Connect the Source to GND or use a SMU to supply a zero voltage bias.

Figure 153: nPowerMOSFET VdsON pin connection



VgsON

Description:

Module Name: VgsON

Module Type: ITM

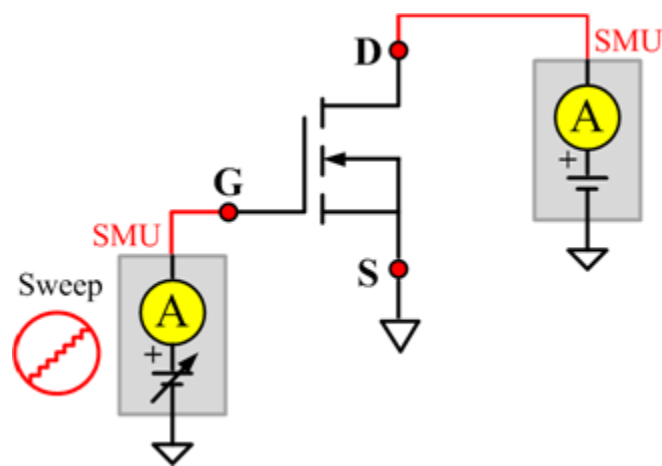
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

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

Pin Connection: Use the Model 2651A to apply voltage and make a current measurement at the Drain. Use the low-power Model 2600B to sweep voltage at the Gate. Connect Source to GND or use a SMU to supply a zero voltage bias.

Figure 154: nPowerMOSFET VgsON pin connection



VgsON_MIX

Description:

Module Name: VgsON

Module Type: PTM

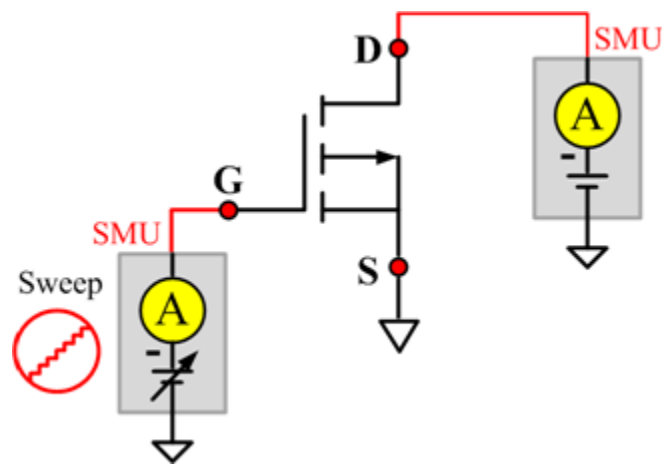
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200-SMU

DUT: Three-terminal nPowerMOSFET

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

Pin Connection: Use the Model 2651A SMU to apply voltage and make a current measurement at the Drain. Use the low-power 2600B to sweep voltage at the Gate. Connect the Source to GND or use a SMU to supply a zero voltage bias.

Figure 155: nPowerMOSFET VgsON_MIX pin connection



VGSTH

Description:

Module Name: VGSTH

Module Type: ITM

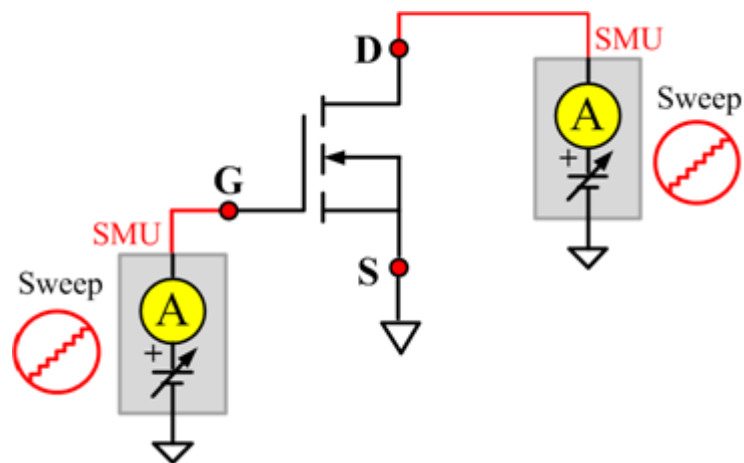
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

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

Pin Connection: Use the Model 2651A SMU to force voltage and make a current measurement at the Drain. Use the low-power Model 2600B to sweep voltage at the Gate. Connect the Source to GND or use a SMU to supply a zero voltage bias.

Figure 156: nPowerMOSFET VGSTH pin connection



VSD

Description:

Module Name: VSD

Module Type: ITM

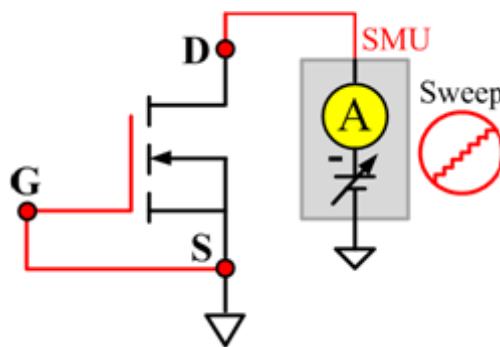
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal nPowerMOSFET

Function: Measures the forward voltage drop of the parasitic diode between the Drain and Source. Measures current on the Drain by applying a voltage sweep from the Source to Drain with the Gate shorted to the Source.

Pin Connection: Use the Model 2651A SMU to force voltage and make a current measurement at the Drain. Connect the Gate and Source to GND or use a SMU to supply a zero voltage bias.

Figure 157: nPowerMOSFET VSD pin connection



pMOSFET library

pMOSFET overview

The pMOSFET library components are in the following directory:

```
C:\ACS_BASIC\library\devLibrary\pMOSFET
```

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

pMOSFET parametric library

BVDSS

Description:

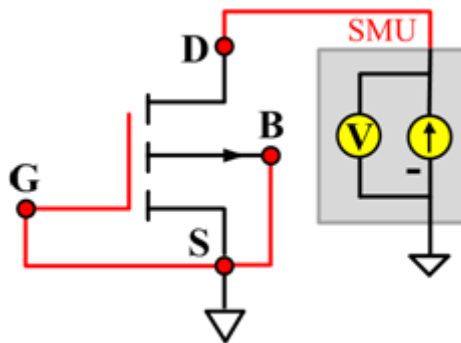
Module Name: BVDSS

DUT: Four-terminal pMOSFET

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

Pin connections: Use a SMU to apply a breakdown current on the Drain. Short the Bulk, Gate, and Source to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 158: Four_term_pMOSFET_BVDSS pin connection

**BVDSS ITM**

Module Type: ITM

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

BVDSS General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVDSV

Description:

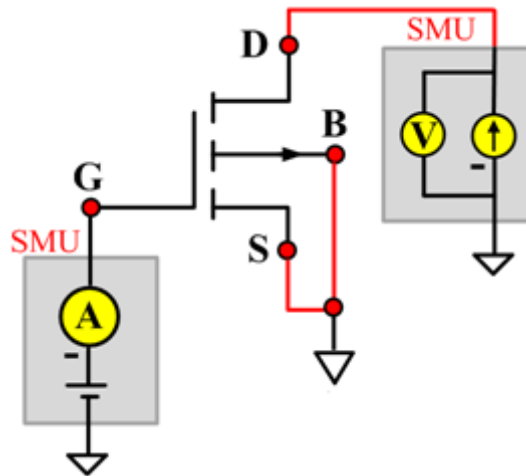
Module Name: BVDSV

DUT: Four-terminal pMOSFET

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

Pin connections: Use a SMU to bias the Gate. Use a SMU to apply a breakdown current on the Drain. Connect the Source and Bulk to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 159: Four_term_pMOSFET_BVDSV pin connection



BVDSV ITM

Module Type: ITM

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

BVDSV General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVGSO

Description:

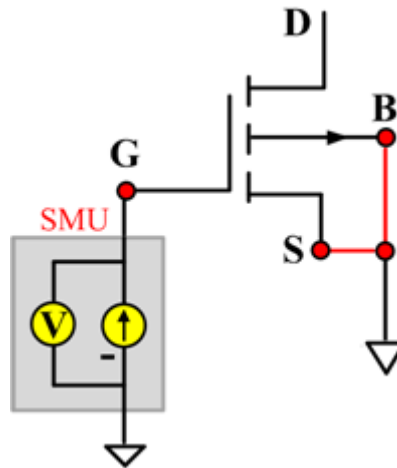
Module Name: BVGSO

DUT: Four-terminal pMOSFET

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

Pin connections: Use a SMU to apply a breakdown current on the Gate. Open the circuit to the Drain or use a SMU to supply zero current bias. Connect the Bulk and Source to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 160: Four_term_pMOSFET_BVGSO pin connection



BVGSO ITM

Module Type: ITM

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

BVGSO General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVGDS

Description:

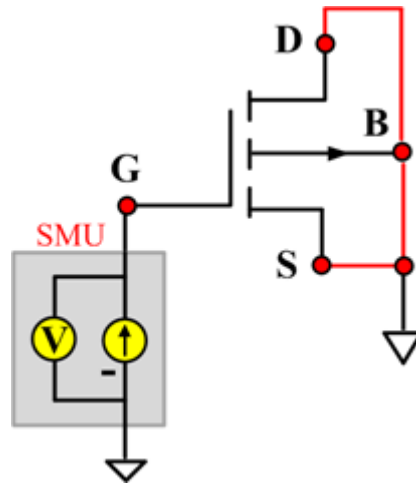
Module Name: BVGDS

DUT: Four-terminal pMOSFET

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

Pin connections: Use a SMU to apply a breakdown current on the Gate. Connect the Source, Drain, and Bulk to ground or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 161: Four_term_pMOSFET_BVGDS pin connection



BVGDS ITM

Module Type: ITM

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

BVGDS General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

BVGDO

Description:

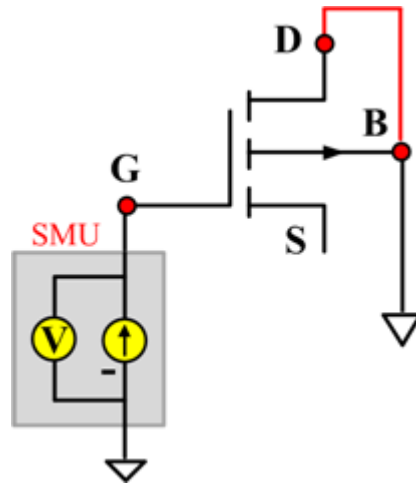
Module Name: BVGDO

DUT: Four-terminal pMOSFET

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

Pin connections: Use a SMU to apply a breakdown current on the Gate. Open the circuit to the Source or use a SMU to supply zero current bias. Connect the Bulk and Drain to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 162: Four_term_pMOSFET_BVGDO pin connection



BVGDO ITM

Module Type: ITM

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

BVGDO General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Cds

Description:

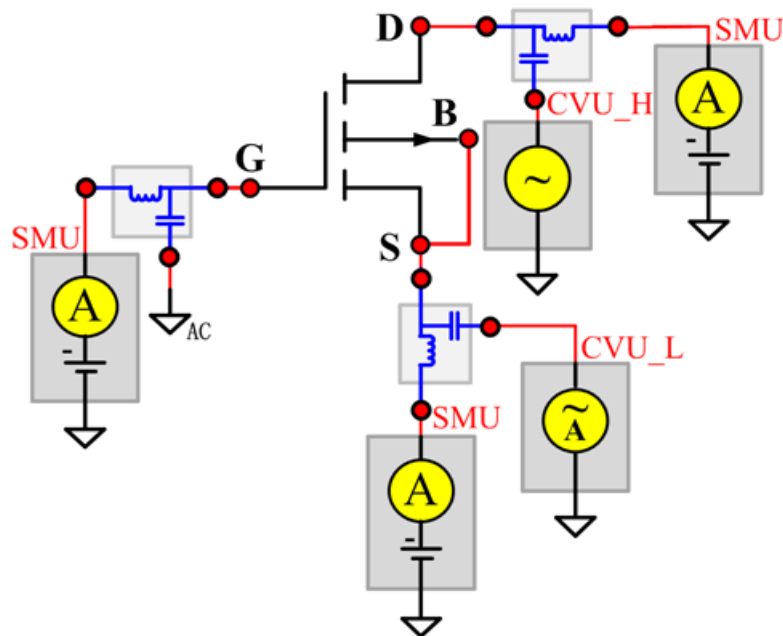
Module Name: Cds

DUT: Four-terminal pMOSFET

Function: Measures the capacitance between the Drain and Source terminals with the Gate terminal connected to the AC guard of a three-terminal bridge. Short Bulk to Source.

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

Figure 163: Four_term_pMOSFET_Cds pin connections



Cds PTM

Module type: PTM

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

Cgd

Description:

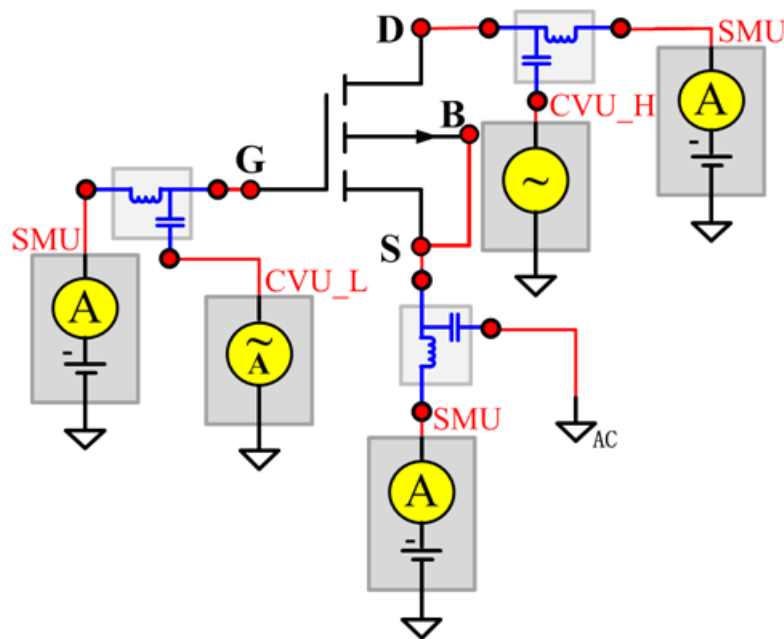
Module Name: Cgd

DUT: Four-terminal pMOSFET

Function: Measures the capacitance between the Drain and Gate terminals with the Source terminal connected to the AC guard of a three-terminal bridge. Short Bulk to Source.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Drain. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the AC guard of a three-terminal bridge through one remote bias tee to the Source. (See next figure.)

Figure 164: Four_term_pMOSFET_Cgd pin connections



Cgd PTM

Module type: PTM

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

Cgs

Description:

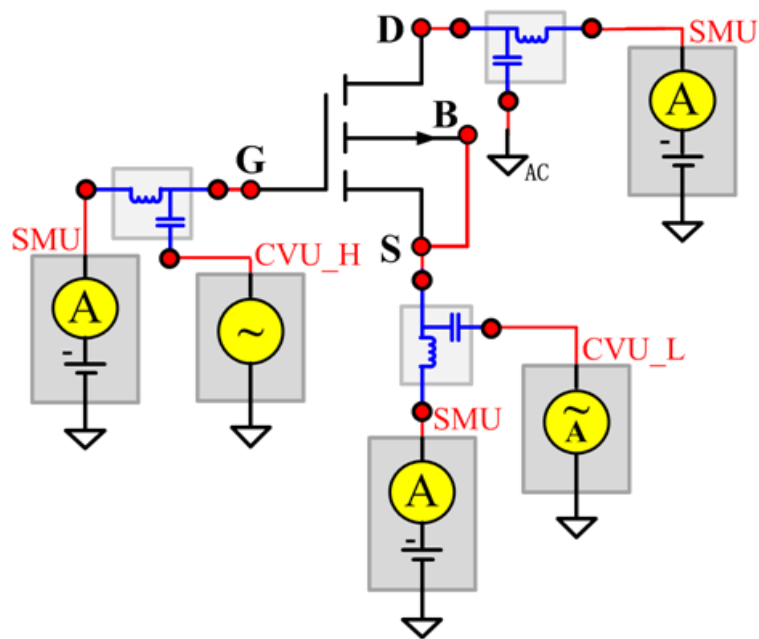
Module Name: Cgs

DUT: Four-terminal pMOSFET

Function: Measures the capacitance between the Gate and Source terminals with the Drain terminal connected to the AC guard of a three-terminal bridge. Short Bulk to Source.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the AC guard of a three-terminal bridge through one remote bias tee to the Drain. (See next figure.)

Figure 165: Four_term_pMOSFET_Cgs pin connections



Cgs PTM

Module type: PTM

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

Ciss

Description:

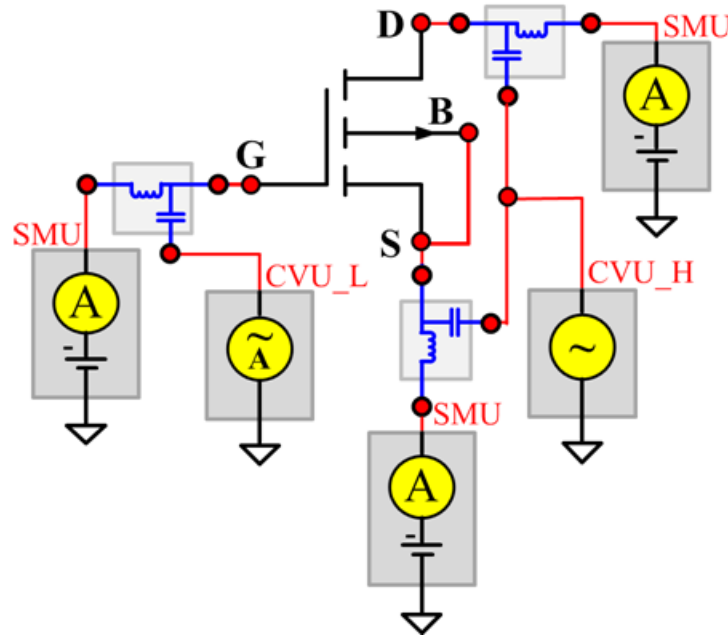
Module Name: Ciss

DUT: Four-terminal pMOSFET

Function: Measures the capacitance between the Gate and Source terminals with the Drain terminal AC short-circuited to the Source terminal. Short Bulk to Source.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Drain. Use the Series 2600B to sweep voltage. AC short circuit the Drain to the Source terminal. Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to supply zero voltage bias. (See next figure.)

Figure 166: Four_term_pMOSFET_Ciss pin connections



Ciss PTM

Module type: PTM

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

Coss

Description:

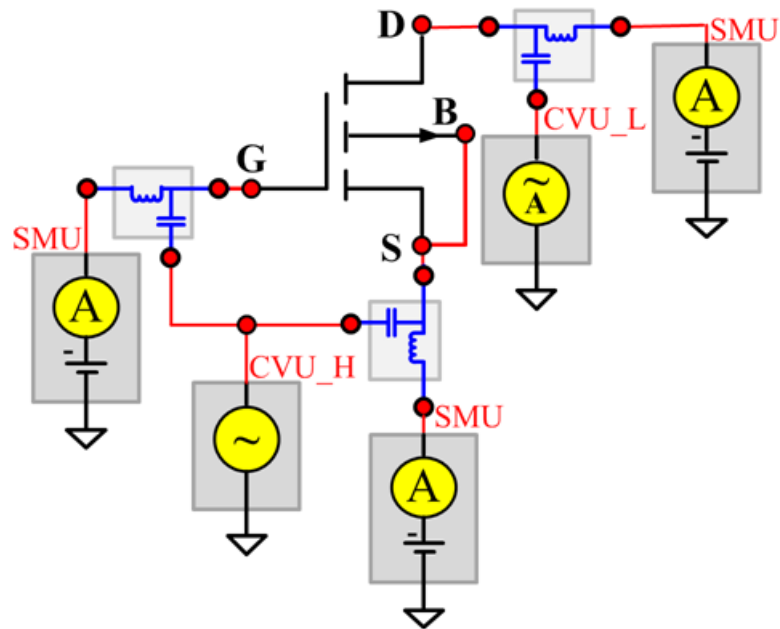
Module Name: Coss

DUT: Four-terminal pMOSFET

Function: Measures the capacitance between the Drain and Source terminals with the Gate terminal AC short-circuited to the Source terminal. Short Bulk to Source.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to supply zero voltage bias. AC short circuit the Gate to the Source terminal. Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Drain. Use the Series 2600B to sweep voltage. (See next figure.)

Figure 167: Four_term_pMOSFET_Coss pin connections



Coss PTM

Module type: PTM

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

Ciss

Description:

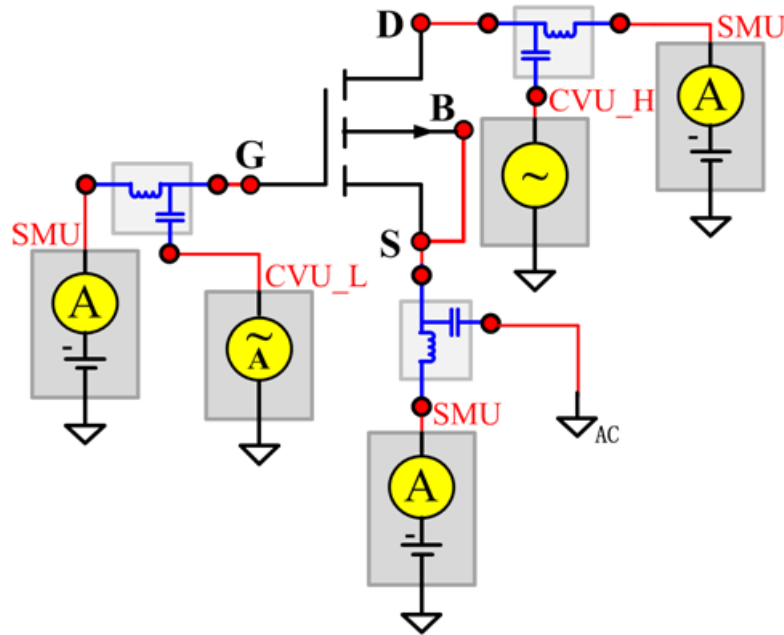
Module Name: Crss

DUT: Four-terminal pMOSFET

Function: Measures the common-source short-circuit input capacitance by testing the capacitance between the Drain and Gate terminals with the Source terminal connected to the AC guard of a three-terminal bridge. Short Bulk to Source.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Drain. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the AC guard of a three-terminal bridge through one remote bias tee to the Source. Use the Series 2600B to supply zero voltage bias. (See next figure.)

Figure 168: Four_term_pMOSFET_Crss pin connections



Crss PTM

Module type: PTM

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

IDL

Description:

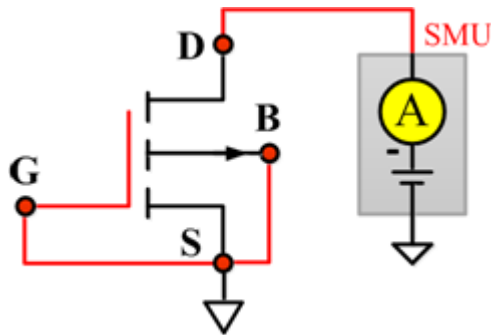
Module Name: IDL

DUT: Four-terminal pMOSFET

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

Pin connections: Use a SMU to force voltage to the Drain. Connect the Gate, Source, and Bulk to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 169: Four_term_pMOSFET_IDL pin connection



IDL ITM

Module Type: ITM

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

IDL General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IDS

Description:

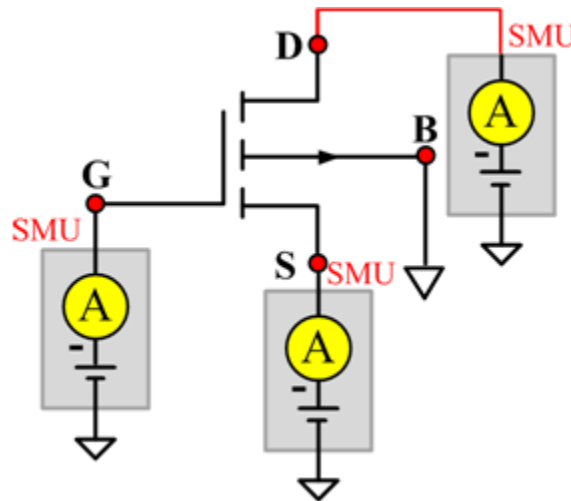
Module Name: IDS

DUT: Four-terminal pMOSFET

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

Pin connections: Use a SMU to force voltage to the Gate. Use a SMU to force voltage to the Drain. Connect Source and Bulk to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 170: Four_term_pMOSFET_IDS pin connection



IDS ITM

Module Type: ITM

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

IDS General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVd_BiasVg

Description:

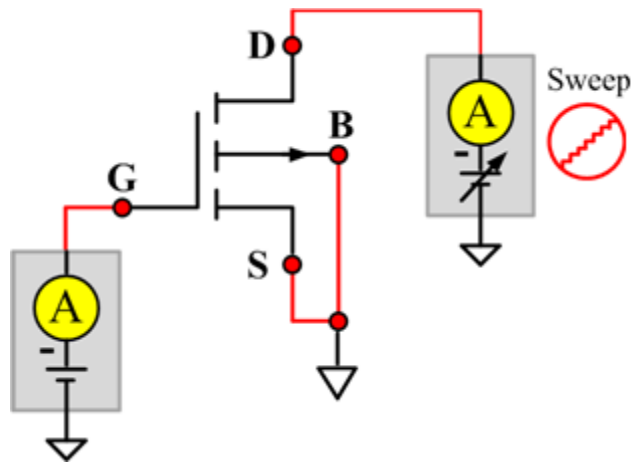
Module Name: IdVd_BiasVg

DUT: Four-terminal pMOSFET

Function: Measures the Drain current during a specified Drain voltage sweep, and the Drain current and Drain voltage curve.

Pin connections: Use a SMU to bias the Gate. Use a SMU to sweep the Drain. Connect Bulk and Source to GND, or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 171: Four_term_pMOSFET_IdVd_BiasVg pin connection



IdVd_BiasVg ITM

Module Type: ITM

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

IdVd_BiasVg_General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVd_StepVg

Description:

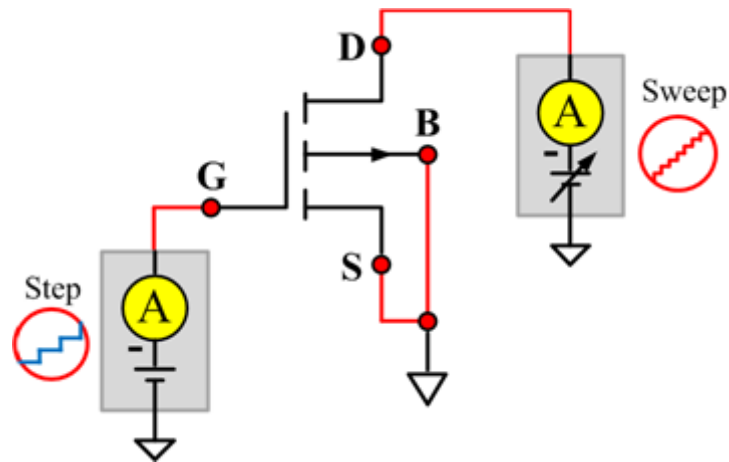
Module Name: IdVd_StepVg

DUT: Four-terminal pMOSFET

Function: Measures the Drain current during a specified Drain voltage sweep, and a series of Drain currents and the Drain voltage curve.

Pin connections: Use a SMU to sweep the Drain. Use a SMU to step the Gate. Connect the Bulk and Source to ground or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 172: Four_term_pMOSFET_IdVd_StepVg pin connection



IdVd_StepVg ITM

Module Type: ITM

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

IdVd_StepVg General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVg_BiasVd

Description:

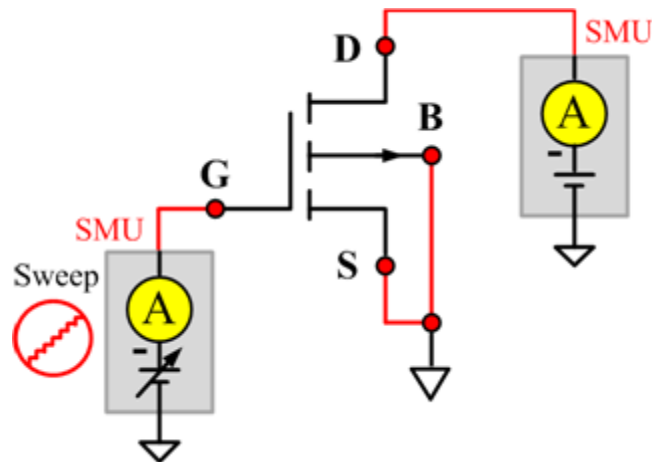
Module Name: IdVg_BiasVd

DUT: Four-terminal pMOSFET

Function: Measures the Drain current during a specified Gate voltage sweep, and the Drain current value and the Gate voltage curve.

Pin connections: Use a SMU to bias the the Drain. Use a SMU to sweep the sweep the Gate. Connect the Bulk and Source to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 173: Four_term_pMOSFET_IdVg_BiasVd pin connection



IdVg_BiasVd ITM

Module Type: ITM

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

IdVg_BiasVd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IdVg_StepVd

Description:

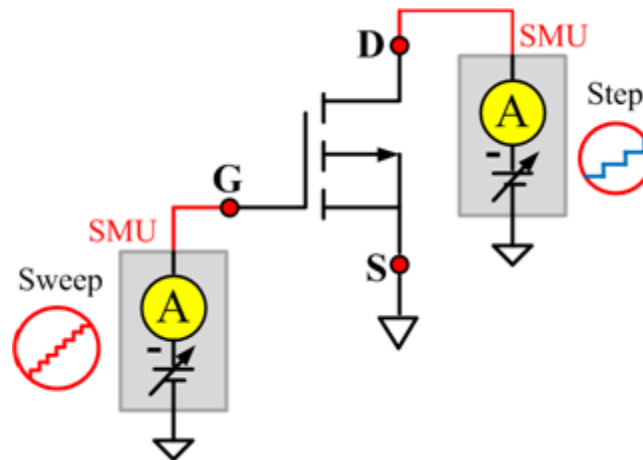
Module Name: IdVg_StepVd

DUT: Four-terminal pMOSFET

Function: Measures the Drain current at a specified Gate voltage sweep with a Drain step, and the series of Drain currents and Gate voltage curve.

Pin connections: Use a SMU to step the Drain. Use a SMU to sweep the Gate. Connect the Bulk and Source to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 174: Four_term_pMOSFET_IdVg_StepVd pin connection



IdVg_StepVd ITM

Module Type: ITM

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

IdVg_StepVd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IGL

Description:

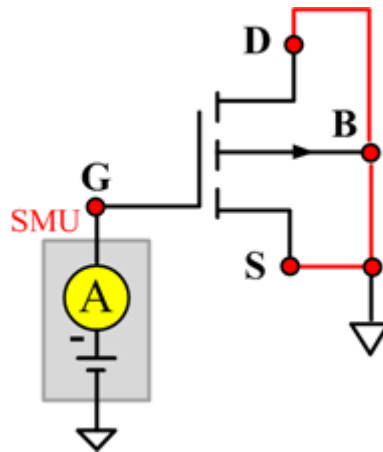
Module Name: IGL

DUT: Four-terminal pMOSFET

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

Pin connections: Use a SMU to force voltage to the Gate. Connect the Source, Drain, and Bulk to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 175: Four_term_pMOSFET_IGL pin connection



IGL ITM

Module Type: ITM

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

IGL General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IgVg

Description:

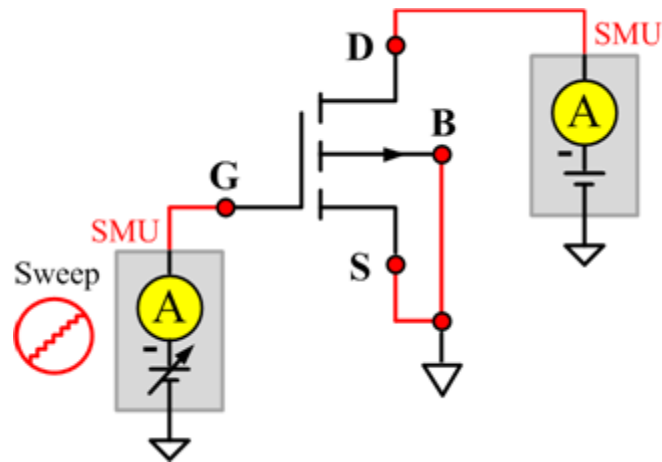
Module Name: IgVg

DUT: Four-terminal pMOSFET

Function: Measures the Gate current at a specified Gate voltage sweep when the Drain is biased, and the Gate current and Gate voltage curve.

Pin connections: Use a SMU to bias the Drain. Use a SMU to sweep the Gate. Connect the Bulk and Source to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 176: Four_term_pMOSFET_IgVg pin connection



IgVg ITM

Module Type: ITM

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

IgVg General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

ISL

Description:

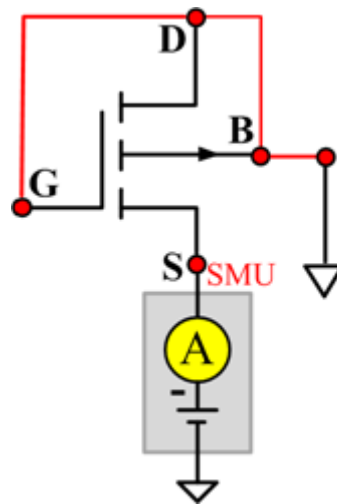
Module Name: ISL

DUT: Four-terminal pMOSFET

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

Pin connections: Use a SMU to force voltage to the Source. Connect the Bulk, Gate, and Drain to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 177: Four_term_pMOSFET_ISL pin connection



ISL ITM

Module Type: ITM

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

ISL General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

IsubVg

Description:

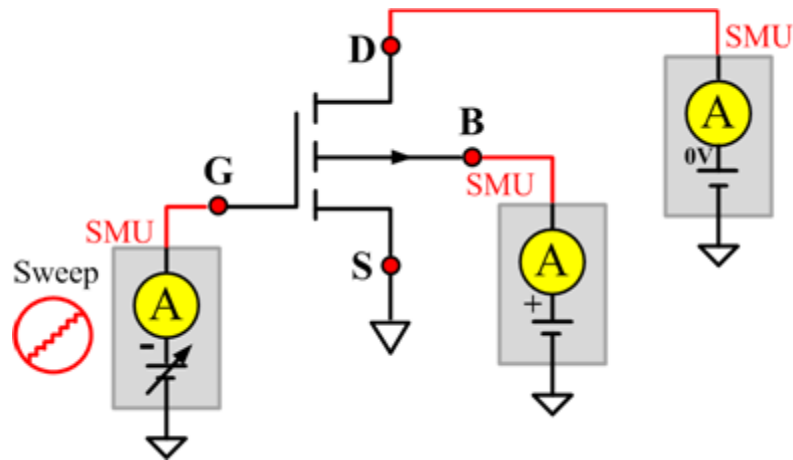
Module Name: IsubVg

DUT: Four-terminal pMOSFET

Function: Measures the bulk current at a specified Gate voltage sweep, the bulk current and the Gate voltage curve, and the maximum bulk current and the corresponding Gate voltage.

Pin connections: Use a SMU to sweep the Gate. Use a SMU to bias the Drain and Bulk. Connect the Source to ground or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 178: Four_term_pMOSFET_IsubVg pin connection



IsubVg ITM

Module Type: ITM

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

IsubVg General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Vtci

Description:

Module Name: Vtci

DUT: Four-terminal pMOSFET

Function: Measures the constant current threshold voltage of the pMOSFET device, and the Drain current and the Gate voltage curve.

Pin connections: Use a SMU to bias the Drain. Use a SMU to sweep the Gate. If needed, input voltage to Source and Bulk. Usually, they are connected to GND for NMOS, and connected to the nominal power supply voltage (VDD) for PMOS. (See next figure.)

Procedure: The constant current threshold voltage:

$V_{th_ci} = V_{GS} (@ID = 1\mu A \cdot W/L)$ -- NMOS

$V_{th_ci} = V_{GS} (@ID = -0.025\mu A \cdot W/L)$ -- PMOS

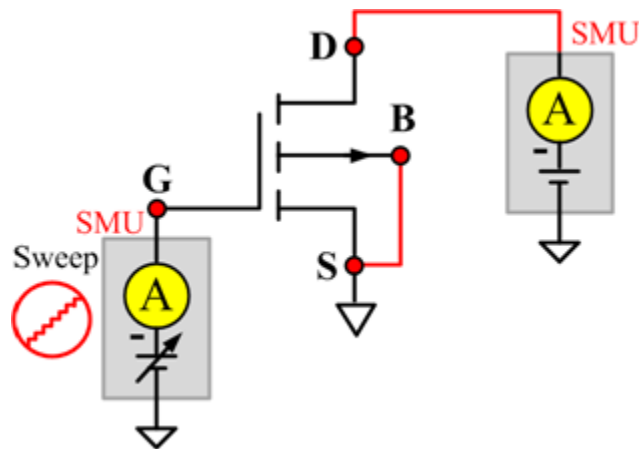
Where W and L are the Gate width and Gate length as printed on the wafer. Set a target Drain current I_{d_tar} ($I_{d_tar} = 1\mu A \cdot W/L$, or $-0.025\mu A \cdot W/L$), which is the sign to be near threshold, then search the Gate voltage to make the Drain current equal to I_{d_tar} .

NOTE

The Four_term_pMOSFET_Vth_ci measurement procedure must determine V_{th_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 V_{th_ci} measurements are $V_{DS} = V_{DS_lin}$, $V_{BS} = V_{BB}$ for linear region measurement, or $V_{DS} = V_{DS_sat}$, ($V_{BS} = V_{BB}$ for saturation region measurement). Typically, for PMOS, $V_{DS_lin} = -0.1 V (@V_{DD} = 5V)$; for NMOS, $V_{DS_lin} = 0.1V (@V_{DD} = 5V)$.

Figure 179: Four_term_pMOSFET_Vtci pn connection



Vtci ITM

Module Type: ITM

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

Vtci General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Vtext

Description:

Module Name: Vtext

DUT: Four-terminal pMOSFET

Function: Measures the Drain current at the Gate voltage sweep, extracts the trans-conductance (Gm) and measure the maximum trans-conductance (Gmmax), measures the extracted threshold voltage (Vth_ex), measures the Drain current and the Gate voltage curve, and measures the Gm and the Drain current or the Gm and the Gate voltage curve.

Pin connections: Use a SMU to bias the Drain. Use a SMU to sweep the Gate. If needed, input the Source and Bulk. Usually, they are connected to GND for NMOS, and connected to the nominal power supply voltage (VDD) for PMOS. (See next figure.)

Procedure: The threshold voltage is extrapolated from the measurement of the maximum slope (Gmmax) of the IDVGS curve:

$$V_{th_ex} = V_{GS} (@G_{mmax}) - ID(@G_{mmax}) / G_{mmax}$$

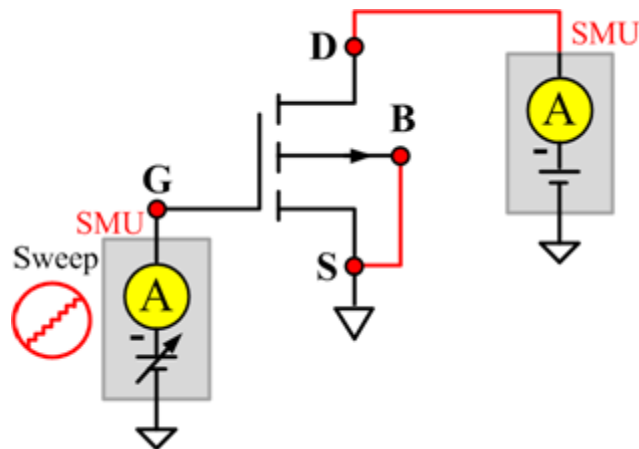
VGS (@Gmmax) is the Gate voltage at the point of the maximum slope of the IDVGS curve; ID(@Gmmax) is the Drain current at the point of the maximum slope of the IDVGS curve; Gmmax is the maximum slope of the IDVGS curve.

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).

Figure 180: Four_term_pMOSFET_Vtext pin connection



Vtext ITM

Module Type: ITM

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

Vtext General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Vtext_llsq

Description:

Module Name: Vtext_llsq

DUT: Four-terminal pMOSFET

Function: Measures the Drain current at the Gate voltage sweep, extracts the trans-conductance (Gm) and measure the maximum trans-conductance (Gmmax), measures the extracted threshold voltage (Vth_ex), measures the Drain current and the Gate voltage curve, and measures the Gm and the Drain current or the Gm and the Gate voltage curve.

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

Pin connections: Use a SMU to bias the Drain. Use a SMU to sweep the Gate. If needed, input the Source and Bulk voltages. Usually, they are connected to GND for NMOS, and connected to the nominal power supply voltage (VDD) for PMOS. (See next figure.)

Procedure: The threshold voltage is extrapolated from the measurement of the maximum slope (Gmmax) of the IDVGS curve:

$$V_{th_ex} = V_{GS} (@G_{mmax}) - ID(@G_{mmax}) / G_{mmax}$$

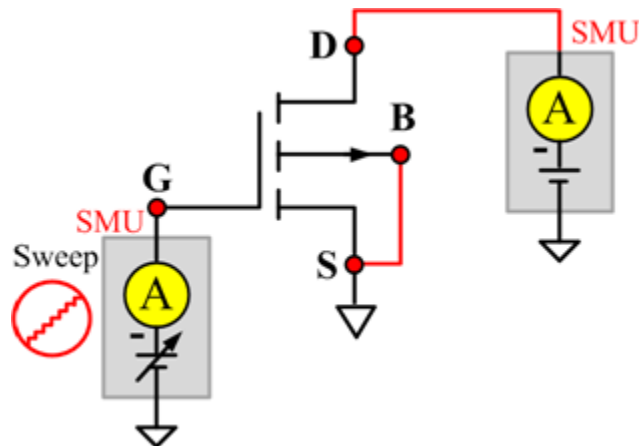
$V_{GS}(@G_{mmax})$ is the Gate voltage at the point of the maximum slope of the IDVGS curve; $ID(@G_{mmax})$ is the Drain current at the point of the maximum slope of the IDVGS curve; G_{mmax} is the maximum slope of the IDVGS curve.

NOTE

DC bias voltages for the Vth_ex measurements are $V_{DS} = V_{DS_lin}$, $V_{BS} = V_{BB}$ for linear measurement.

$V_{DS} = V_{DS_sat}$, $V_{BS} = V_{BB}$ for saturation. Typically, for PMOS, $V_{DS_lin} = -0.1 V (@V_{DD} = 5V)$; for NMOS, $V_{DS_lin} = 0.1V (@V_{DD} = 5V)$.

Figure 181: Four_term_pMOSFET_Vtext_llsq pin connection



pMOSFET WLR script library

pMOSFET WLR script library overview

The WLR script components are in the following directory:

C:\ACS_BASIC\library\devLibrary\pMOSFET\WLR_script

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

HCI

Description:

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

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

Figure 182: Set the HCI of pMOSFET in WLR_script library



Figure 183: HCI sequence and device connection

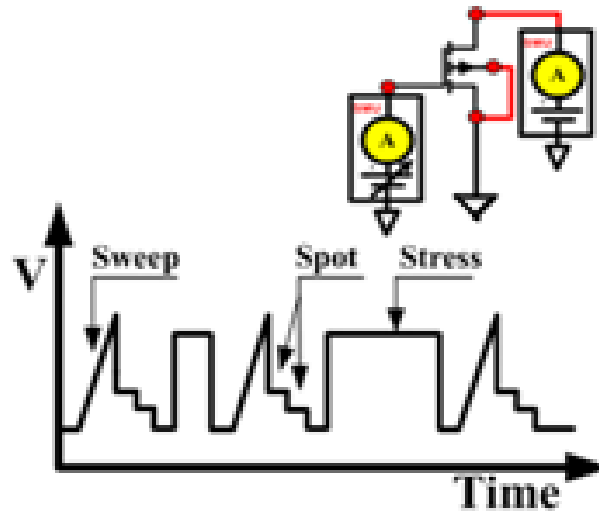
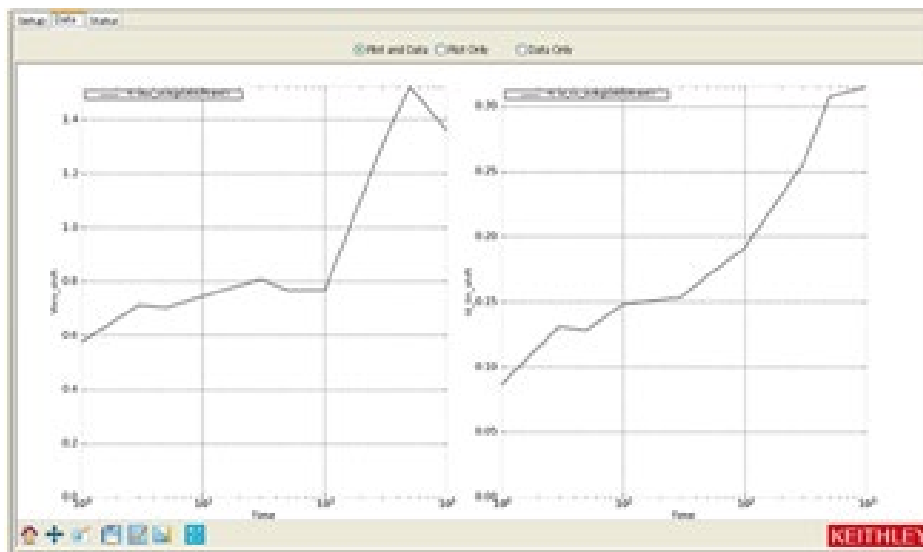


Figure 184: Data tab of HCI of pMOSFET in WLR_script library



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, complianceni, 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 vltage
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 complianceni=0.1 in [0,] -- current compliance

```

OUTPUTS:

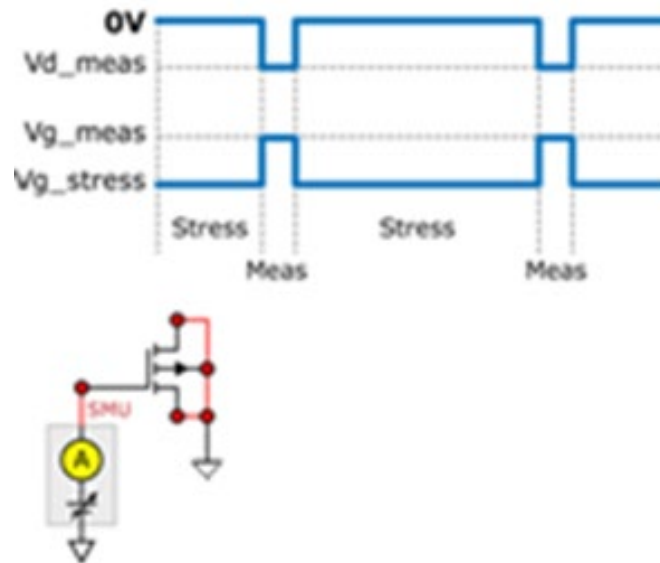
```

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 185: 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 compliancex=1e-1
local modelflag=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,modelflag,compliance, 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_Dran
gei,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,ring,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
                               logarithmic 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 Gcomp_i = 100e-6 in [0, 0.1] -- Gate voltage Source compliance
double Dcomp_i = 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 186: NBTI_meas sequence and device connection

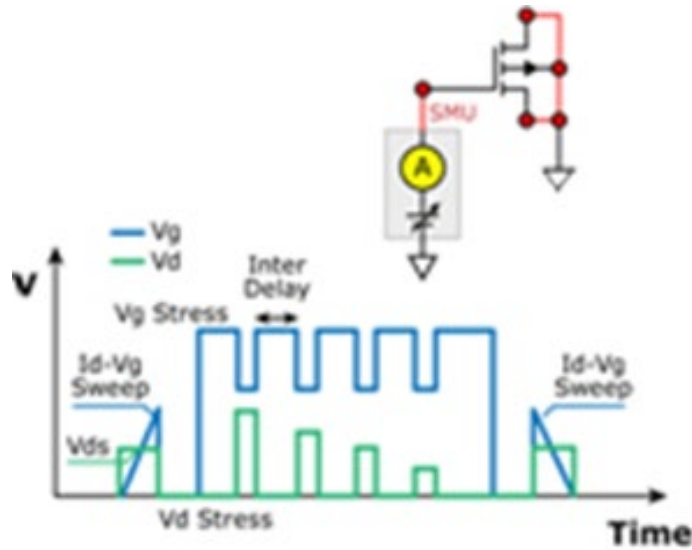


Figure 187: GUI for NBTI_meas

NBTI Test

Pin-SMU
 Terminal Drain Gate Source Bulk
 SMU SMU2 SMU1 KI_GND KI_GND

Pre/Post Id_Vg Test
 Enable
 Vg_low 0 Vg_high -1.5 Vg_points 101
 Vds -0.1 Id Range 0 Sweep Delay 1e-4

Vtci Test
 Enable
 a 0.5 b 0.5
 A 3e-8 W 40 L 0.18

Itci
Vtci
Vg

NBTI Test
 Enable Drain Changes First
 Stress_Measure
 Drain Gate
 StressV 0 -2.2
 InitialV {-0.1,-0.15,-0.2} {-0.3,-0.4,-0.5}

Script GUI

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 188: Sequence of NBTI_on_the_fly

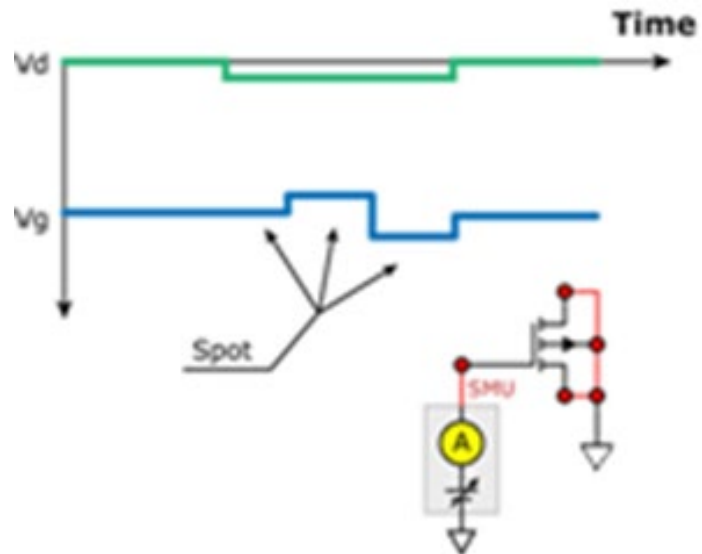
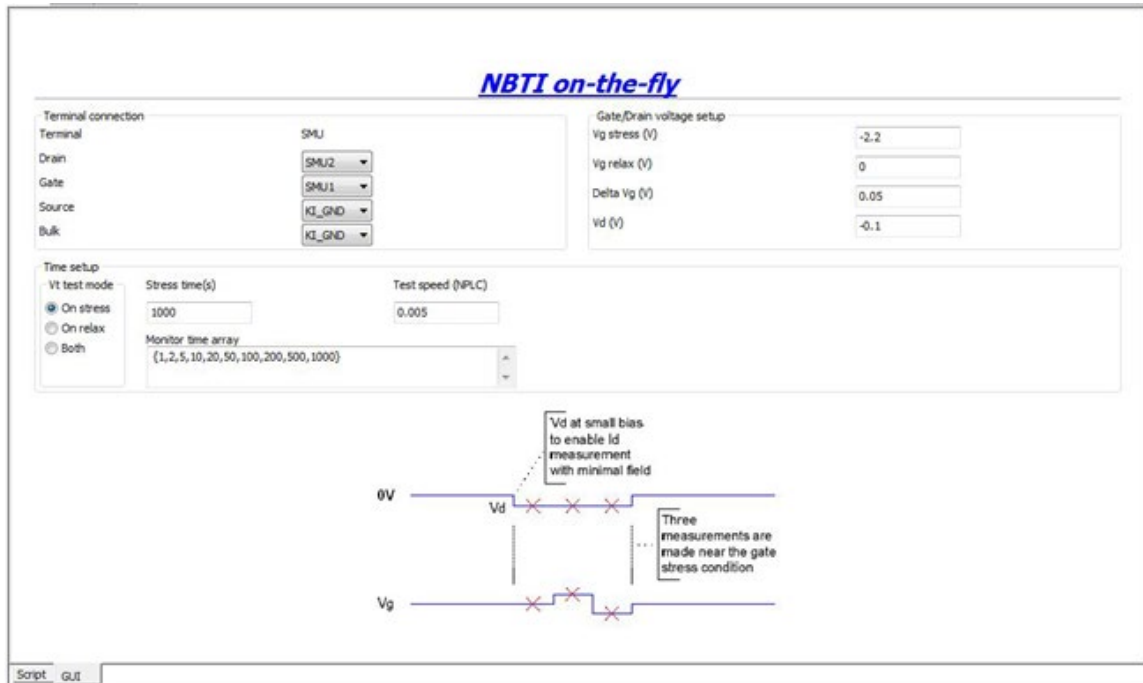


Figure 189: GUI for NBTI_on_the_fly



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 in the following directory:

```
C:\ACS_BASIC\library\devLibrary\pPowerMOSFET
```

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

pPowerMOSFET parametric library

BVDSS

Description:

Module Name: BVDSS

Module Type: ITM

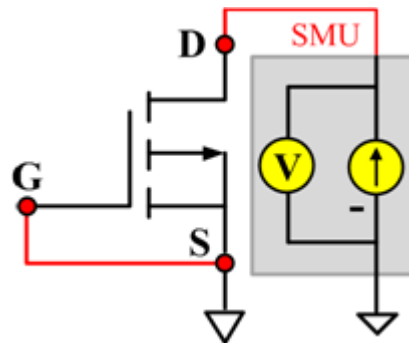
Instrument: Keithley Instruments Model 2657A, Series 2600B

DUT: Three-terminal pPowerMOSFET

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

Pin Connection: Use the Model 2657A instrument to apply current and make a voltage measurement at the Drain. Connect the Gate and Source to GND or use a SMU to supply a zero voltage bias.

Figure 190: pPowerMOSFET_BVDSS pin connection



Cds

Description:

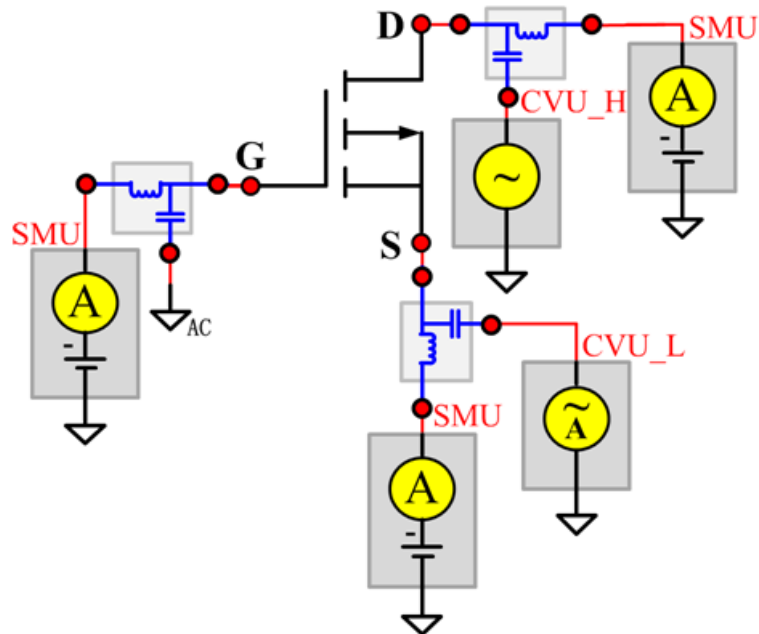
Module Name: Cds

DUT: Three-terminal pPowerMOSFET

Function: Measures the capacitance between the Drain and Source terminals with the Gate terminal connected to the AC guard of a three-terminal bridge.

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

Figure 191: Three_term_pPowerMOSFET_Cds pin connections



Cds PTM

Module type: PTM

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

Cgd

Description:

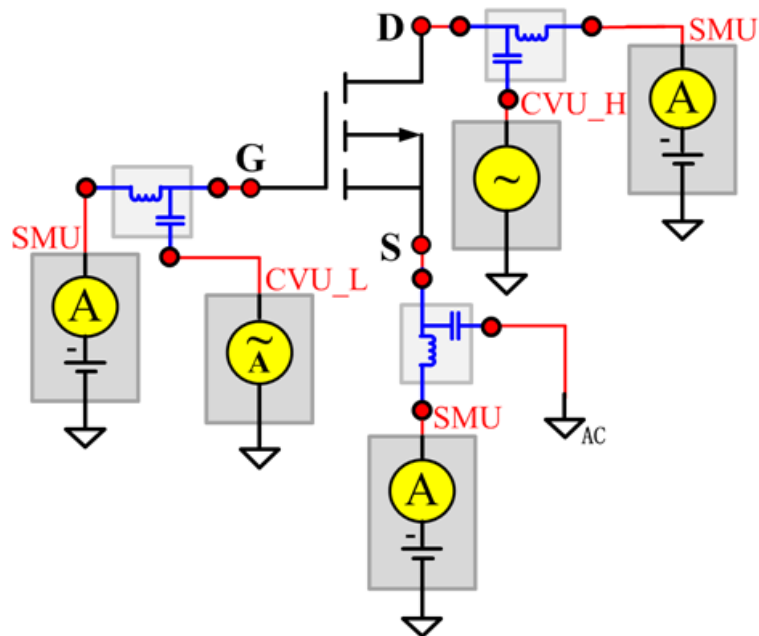
Module Name: Cgd

DUT: Three-terminal pPowerMOSFET

Function: Measures the capacitance between the Drain and Gate terminals with the Source terminal connected to the AC guard of a three-terminal bridge.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Drain. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the AC guard of a three-terminal bridge through one remote bias tee to the Source.

Figure 192: Three_term_pPowerMOSFET_Cgd pin connections



Cgd PTM

Module type: PTM

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

Cgs

Description:

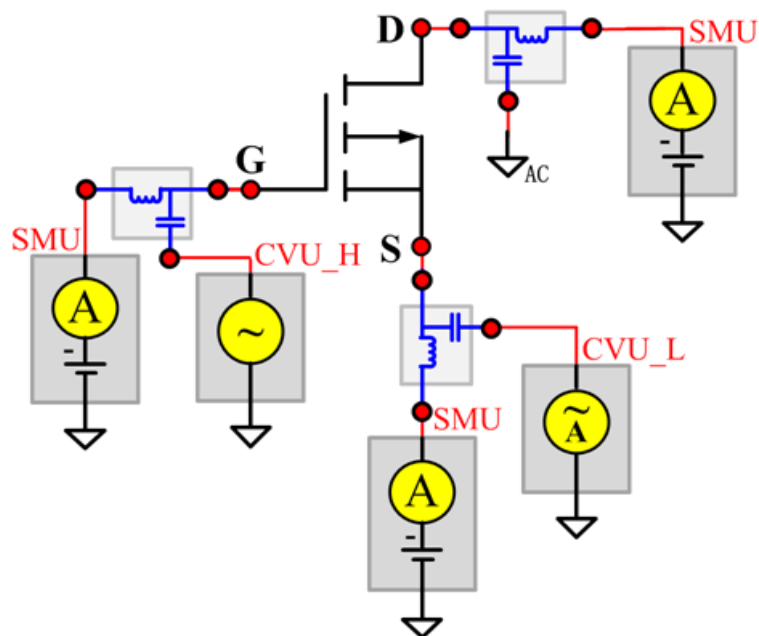
Module Name: Cgs

DUT: Three-terminal pPowerMOSFET

Function: Measures the capacitance between the Gate and Source terminals with the Drain terminal connected to the AC guard of a three-terminal bridge.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the AC guard of a three-terminal bridge through one remote bias tee to the Drain. Use the Series 2600B to supply zero voltage bias. (See next figure.)

Figure 193: Three_term_pPowerMOSFET_Cgs pin connections



Cgs PTM

Module type: PTM

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

Ciss

Description:

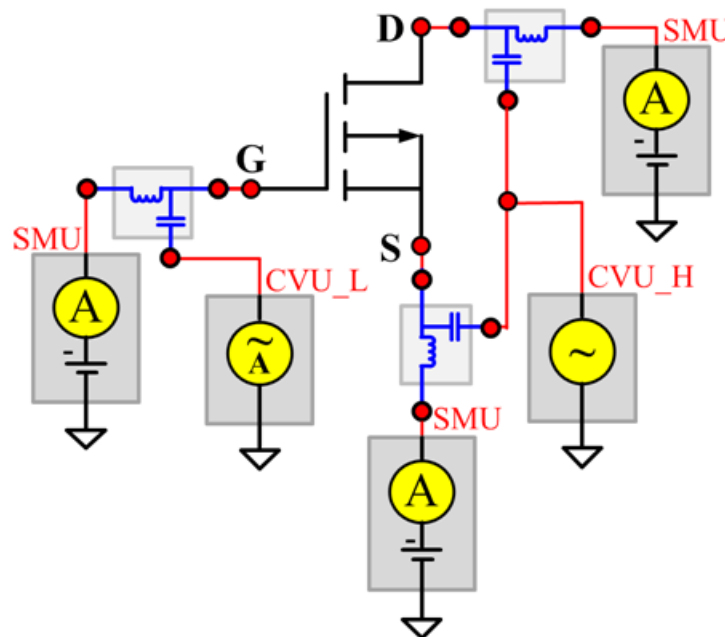
Module Name: Ciss

DUT: Three-terminal pPowerMOSFET

Function: Measures the capacitance between the Gate and Source terminals with the Drain terminal AC short-circuited to the Source terminal.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Drain. Use the Series 2600B to sweep voltage. AC short circuit the Drain to the Source terminal. Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to supply zero voltage bias. (See next figure.)

Figure 194: Three_term_pPowerMOSFET_Ciss pin connections



Ciss PTM

Module type: PTM

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

Coss

Description:

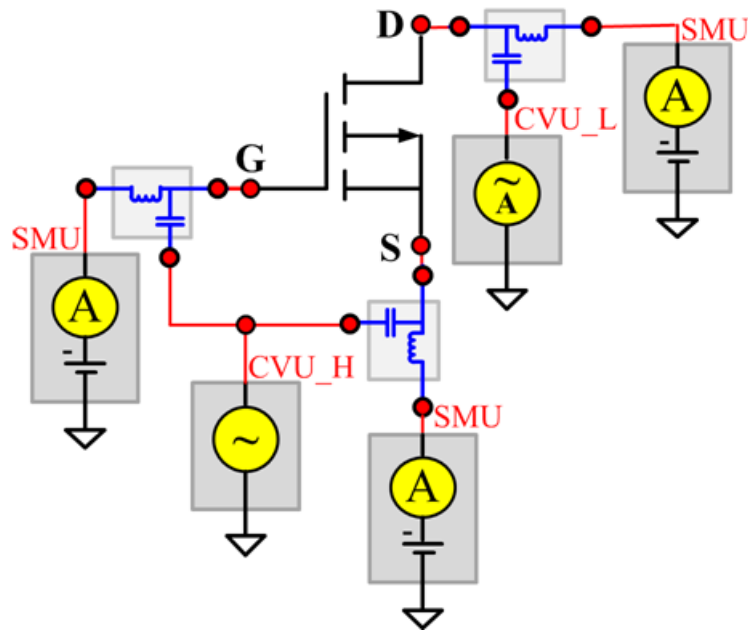
Module Name: Coss

DUT: Three-terminal pPowerMOSFET

Function: Measures the capacitance between the Drain and Source terminals with the Gate terminal AC short-circuited to the Source terminal.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to supply zero voltage bias. AC short circuit the Gate to the Source terminal. Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Source. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Drain. Use the Series 2600B to sweep voltage. (See next figure.)

Figure 195: Copy of Three_term_pPowerMOSFET_Coss pin connections



Coss PTM

Module type: PTM

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

Ciss

Description:

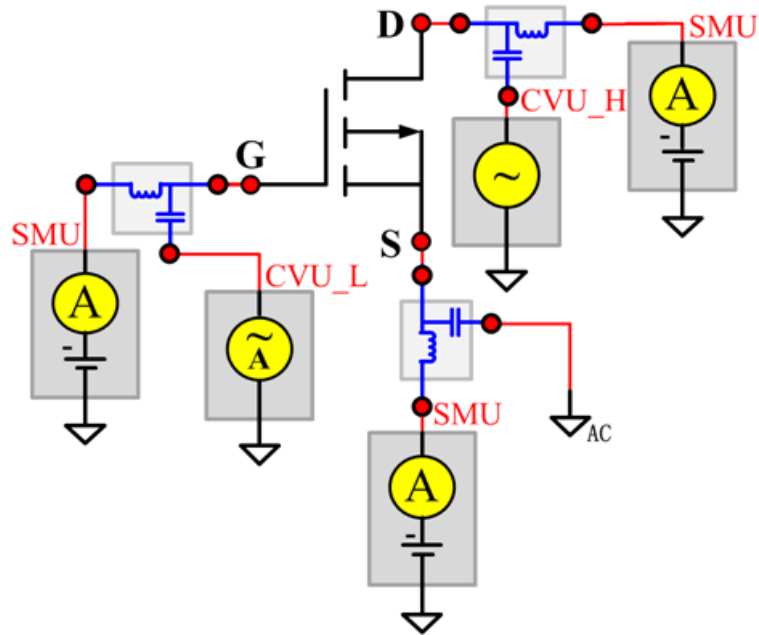
Module Name: Crss

DUT: Three-terminal pPowerMOSFET

Function: Measures the common-source short-circuit input capacitance by testing the capacitance between the Drain and Gate terminals with the Source terminal connected to the AC guard of a three-terminal bridge.

Pin Connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Drain. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the AC guard of a three-terminal bridge through one remote bias tee to the Source. Use the Series 2600B to supply zero voltage bias.

Figure 196: Three_term_pPowerMOSFET_Crсс pin connections



Crсс PTM

Module type: PTM

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

GFS

Description:

Module Name: GFS

Module Type: ITM

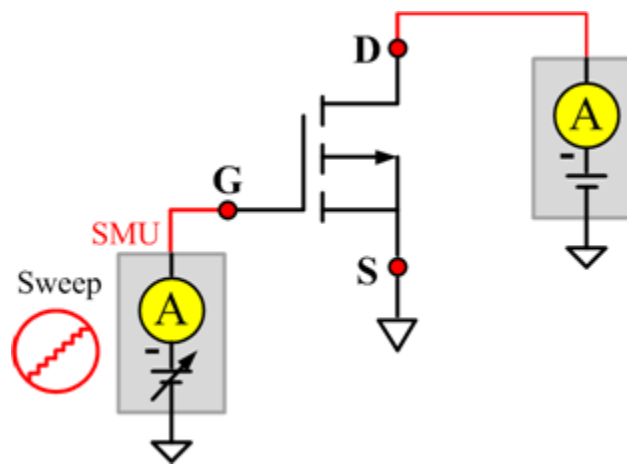
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pPowerMOSFET

Function: Measures the forward transconductance. Measures the current on the Drain by applying a voltage sweep from the Gate to Source and calculates the ratio of change in I_d for a change in the V_{gs} : $GFS = \Delta(I_d) / \Delta(V_{gs})$.

Pin Connection: Use the Model 2651A to apply voltage and make current measurements at the Drain. Use the low-power Model 2600B to sweep voltage at the Gate. Connect the Source to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 197: pPowerMOSFET GFS pin connection



IdON

Description:

Module Name: IdON

Module Type: ITM

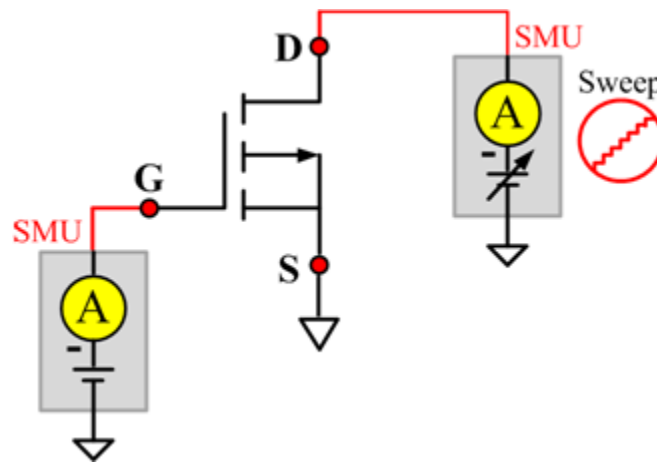
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pPowerMOSFET

Function: Measures the on-state Drain current. Measures current on the Drain by applying a voltage sweep to the Drain-Source with a specific Gate voltage to turn on the device at a certain Id current value that is given in the data sheet.

Pin Connection: Use the Model 2651A to apply a voltage sweep and make a current measurement at the Drain. Use the low power Model 2600A to source a specific voltage at the Gate. Connect the Source to GND or use a SMU to supply a zero voltage bias.

Figure 198: pPowerMOSFET IdON pin connection



IDSS

Description:

Module Name: IDSS

Module Type: ITM

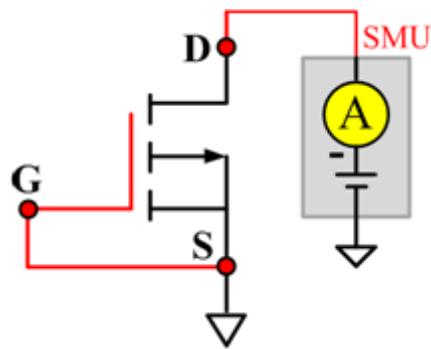
Instrument: Keithley Instruments Model 2657A, Series 2600B

DUT: Three-terminal pPowerMOSFET

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

Pin Connection: Use the Model 2657A to apply voltage and make a current measurement at the Drain. Connect the Gate and Source to GND or use a SMU to supply a zero voltage bias.

Figure 199: pPowerMOSFET IDSS pin connection



IdVd_StepVg

Description:

Module Name: IdVd_StepVg

Module Type: ITM

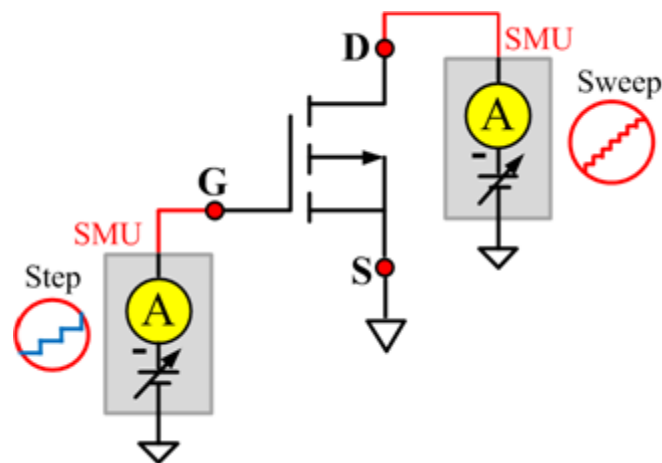
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pPowerMOSFET

Function: Measures the Drain current at the specified Gate voltage and sweeps the Drain in pulse mode. Generates the standard family of IdVd curves.

Pin Connection: Use the Model 2651A to apply a voltage sweep and make a current measurement at the Drain. Use the low power Model 2600A to source a specific voltage at the Gate. Connect the Source to GND or use a SMU to supply a zero voltage bias.

Figure 200: pPowerMOSFET IdVd_StepVg pin connection



IdVd_StepVg_MIX

Description:

Module name: IdVd_StepVg_MIX

Test Type: PTM

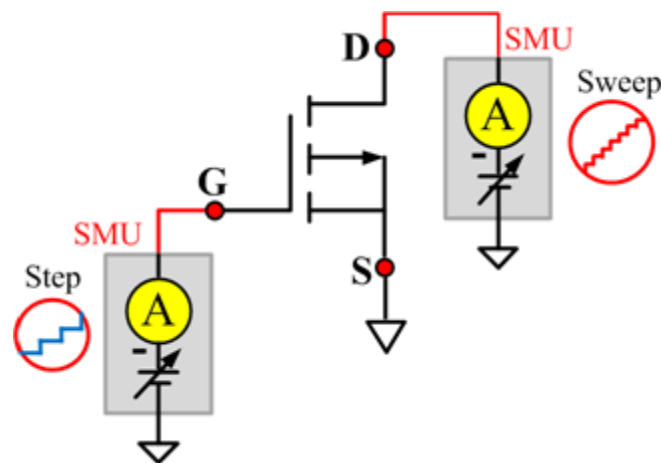
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200-SMU

DUT: Three-terminal pPowerMOSFET

Function: Measures the Drain current at the specified Gate voltage and sweeps the Drain in pulse mode. Generates the standard family of IdVd curves.

Pin Connection: Use the Model 2651A SMU to apply a voltage sweep and make a current measurement at the Drain. Use a SMU to force a specific voltage at the Gate. Connect the Source to GND or use a SMU to supply a zero voltage bias.

Figure 201: pPowerMOSFET IdVd_StepVg_MIX pin connection



IdVg_StepVd

Description:

Module Name: IdVg_StepVd

Module Type: ITM

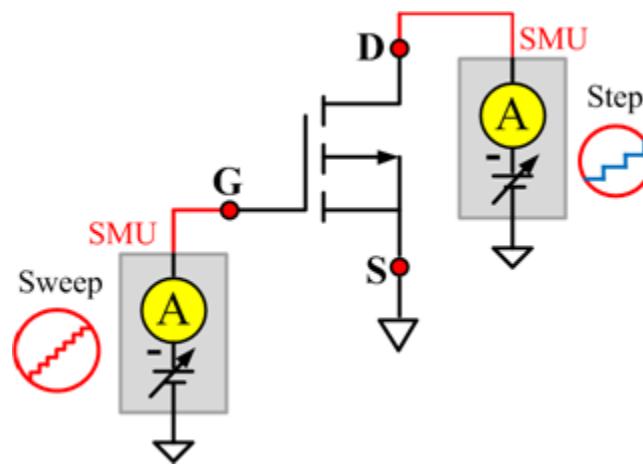
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pPowerMOSFET

Function: Measures the transfer characteristic of the device. Each time the voltage steps on the Drain-Source, a voltage sweep is performed on the Gate-Source and set of current measurements occurs on the Drain.

Pin Connection: Use the Model 2651A to apply a voltage step and make a current measurement at the Drain. Use the low power Model 2600B to sweep voltage at the Gate. Connect the Source to GND or use a SMU to supply a zero voltage bias.

Figure 202: pPowerMOSFET IdVg_StepVd pin connection



IGSSF

Description:

Module Name: IGSSF

Module Type: ITM

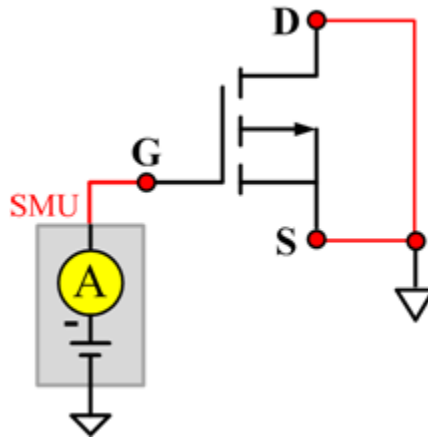
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pPowerMOSFET

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

Pin 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. Use a SMU to force voltage and make a current measurement at the Gate. Connect the Drain and Source to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 203: pPowerMOSFET IGSSF pin connection



IGSSR

Description:

Module Name: IGSSR

Module Type: ITM

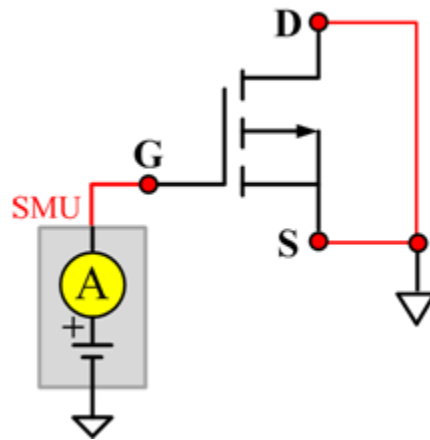
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pPowerMOSFET

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

Pin Connection: Use a SMU to force voltage and make a current measurement from the Gate. Connect the Drain and Source to GND or use a SMU to supply a zero voltage bias.

Figure 204: pPowerMOSFET IGSSR pin connection



RdsON

Description:

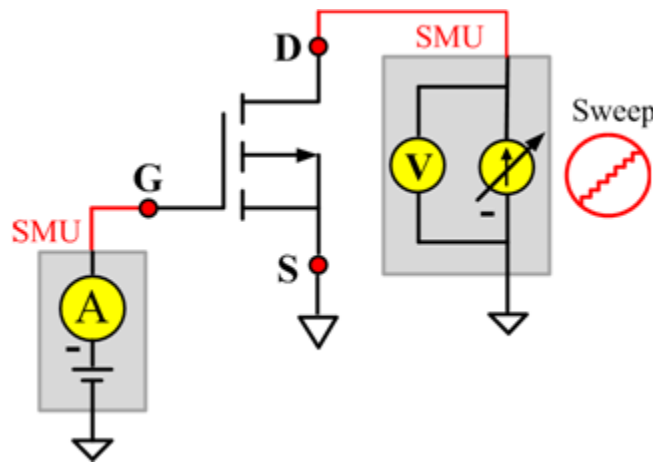
Module Name: RdsON

DUT: Four-terminal pPowerMOSFET

Function: Measures the Drain to Source on-state resistance. Measures resistance by applying a current sweep to the Drain with a specific Gate voltage that is calculated by dividing the measured Drain voltage by the Sourced current: $R_{ds} = V_{ds}/I_d$.

Pin Connection: Use the Model 2651A to apply a current sweep and make a voltage measurements at the Drain. Use the low-power Model 2600B to force a specific voltage at the Gate. Connect the Source to GND or use a SMU to supply a zero voltage bias.

Figure 205: pPowerMOSFET RdsOn pin connection



RdsON_MIX

Description:

Module name: RdsOn_MIX

Test Type: PTM

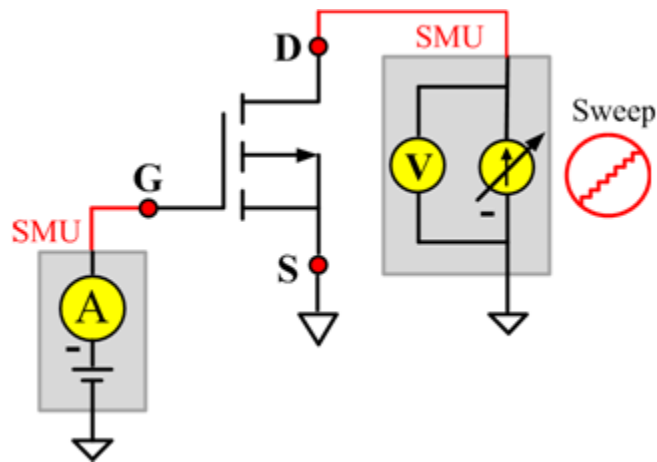
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200-SMU

DUT: Three-terminal pPowerMOSFET

Function: Measures the Drain to Source on-state resistance. Measures resistance by applying a current sweep to the Drain with a specific Gate voltage that is calculated by dividing the measured Drain voltage by the Sourced current: $R_{ds} = V_{ds}/I_d$.

Pin Connection: Use the Model 2651A SMU to apply a current sweep and make a voltage measurement at the Drain. Use a SMU to force specific voltage at the Gate. Connect the Source to GND or use a SMU to supply a zero voltage bias.

Figure 206: pPowerMOSFET RdsON_MIX pin connection



VdsON

Description:

Module Name: VdsON

Module Type: ITM

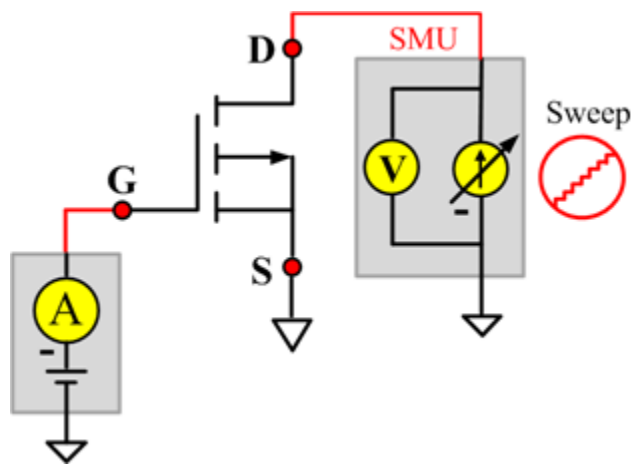
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pPowerMOSFET

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

Pin Connection: Use the Model 2651A SMU to apply a current sweep and make a voltage measurement at the Drain. Use the low-power Model 2600B to force a specific voltage at the Gate. Connect the Source to GND or use a SMU to supply a zero voltage bias.

Figure 207: pPowerMOSFET VdsON pin connection



VgsON

Description:

Module Name: VgsON

Module Type: ITM

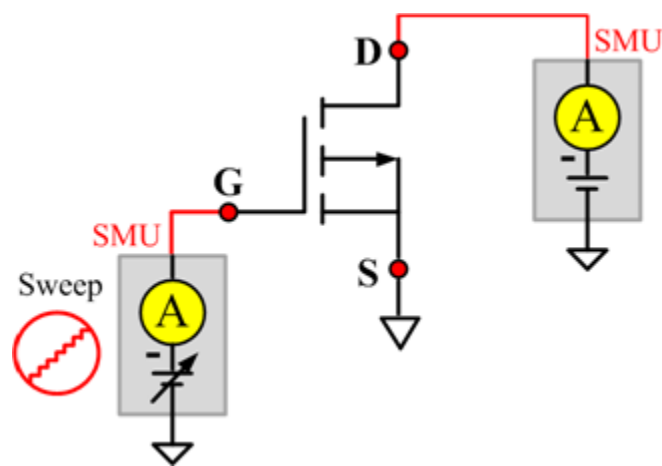
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pPowerMOSFET

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

Pin Connection: Use the Model 2651A to apply voltage and make a current measurement at the Drain. Use the low-power Model 2600B to sweep voltage at the Gate. Connect Source to GND or use a SMU to supply a zero voltage bias.

Figure 208: pPowerMOSFET VgsON pin connection



VgsON_MIX

Description:

Module Name: VgsON_MIX

Module Type: PTM

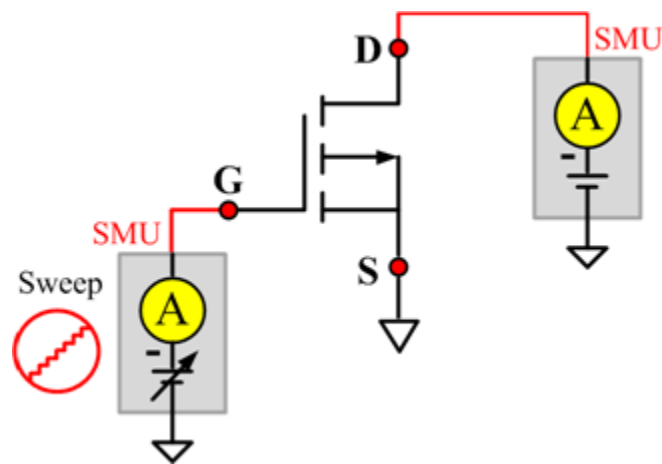
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200-SMU

DUT: Three-terminal pPowerMOSFET

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

Pin Connection: Use the Model 2651A SMU to apply voltage and make a current measurement at the Drain. Use the low-power 2600B to sweep voltage at the Gate. Connect the Source to GND or use a SMU to supply a zero voltage bias.

Figure 209: pPowerMOSFET VgsON_MIX pin connection



VGSTH

Description:

Module Name: VGSTH

Module Type: ITM

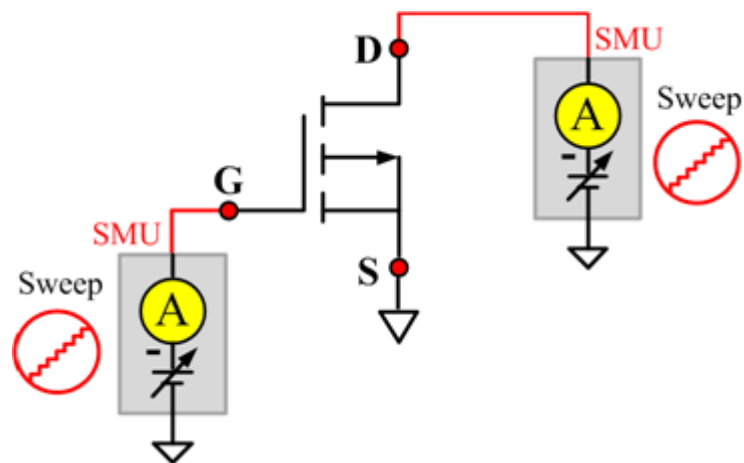
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pPowerMOSFET

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

Pin Connection: Use the Model 2651A SMU to force voltage and make a current measurement at the Drain. Use the low-power Model 2600B to sweep voltage at the Gate. Connect the Source to GND or use a SMU to supply a zero voltage bias.

Figure 210: pPowerMOSFET VGSTH pin connection



VSD

Description:

Module Name: VSD

Module Type: ITM

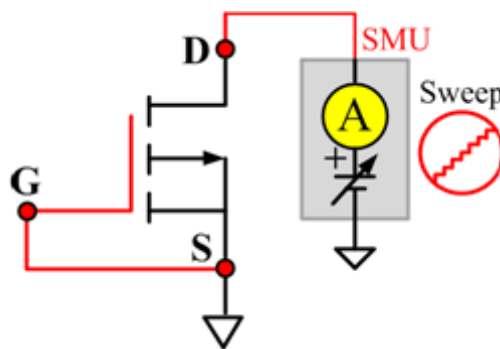
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal pPowerMOSFET

Function: Measures the forward voltage drop of the parasitic diode between the Drain and Source. Measures current on the Drain by applying a voltage sweep from the Source to Drain with the Gate shorted to the Source.

Pin Connection: Use the Model 2651A SMU to force voltage and make a current measurement at the Drain. Connect the Gate and Source to GND or use a SMU to supply a zero voltage bias.

Figure 211: pPowerMOSFET VSD pin connection



Diode library

Diode overview

The Diode library components are in the following directory:

```
C:\ACS_BASIC\library\devLibrary\DIODE
```

The diode test module template is used to test some parameters of a diode, such as the forward voltage and current, reverse voltage and current, I-V curve, and dynamic impedance. The TSP files are used with a Series 2600B instrument to create test script files based on the Series 2600B LPT library.

Diode library

DynamicZ

Description:

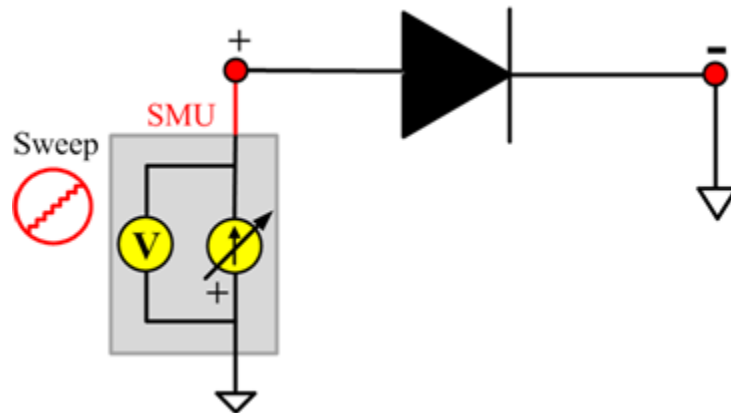
Module Name: DynamicZ

DUT: Diode

Function: Measures the Dynamic Impedance based on two forward voltage measurements or two reverse voltage measurements: $\text{DynamicZ} = (v_2 - v_1) / (I_2 - I_1)$

Pin connections: Uses one SMU to force the forward current. Connect the other terminal to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 212: Diode DynamicZ pin connection



DynamicZ ITM

Module Type: ITM

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

DynamicZ General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

DynamicZ PTM

Module Type: Standard PTM

Instrument: Keithley Instruments Series 4200-SMU

Spot_IfdVfd

Description:

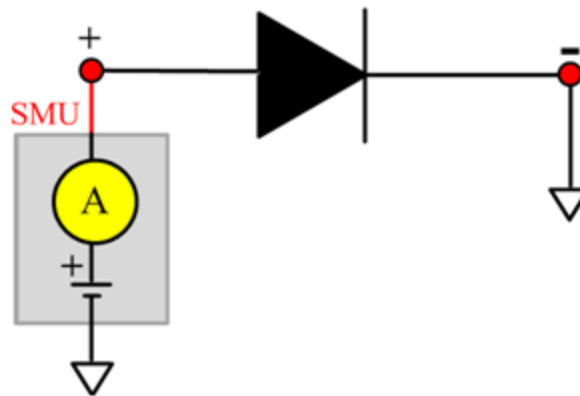
Module Name: Spot_IfdVfd

DUT: Diode

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

Pin connections: The P terminal forces a forward voltage. Connect the N terminal to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 213: Diode_ Spot_IfdVfd pin connection



Spot_IfdVfd ITM

Module Type: ITM

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

Spot_IfdVfd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Spot_IfdVfd PTM

Module Type: Standard PTM

Instrument: Keithley Instruments Series 4200-SMU

Spot_IrdVrd

Description:

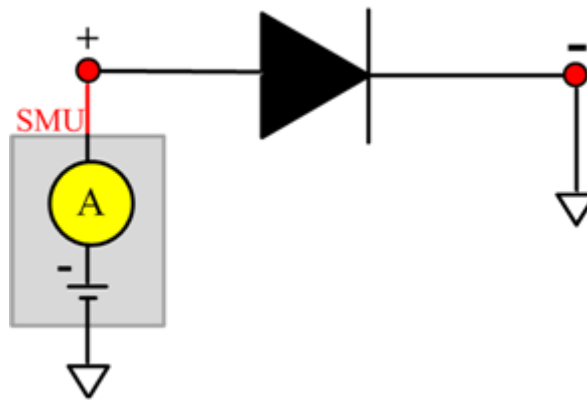
Module Name: Spot_IrdVrd

DUT: Diode

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

Pin connections: Force a reverse voltage or zero voltage to terminal P. Connect the N terminal to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 214: Diode_Spot_IrdVrd pin connection

**Spot_IrdVrd ITM**

Module Type: ITM

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

Spot_IrdVrd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Spot_IrdVrd PTM

Module Type: Standard PTM

Instrument: Keithley Instruments Series 4200-SMU

Spot_VbrIrd

Description:

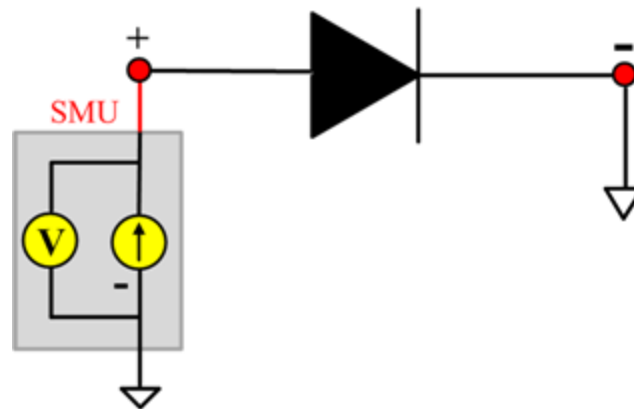
Module Name: Spot_VbrIrd

DUT: Diode

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

Pin connections: Force a reverse current to the P terminal. Connect the N terminal to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 215: Diode_Spot_VbrIrd pin connection



Spot_VbrIrd ITM

Module Type: ITM

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

Spot_VbrIrd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Spot_VbrIrd PTM

Module Type: Standard PTM

Instrument: Keithley Instruments Series 4200-SMU

Spot_Vfdlfd

Description:

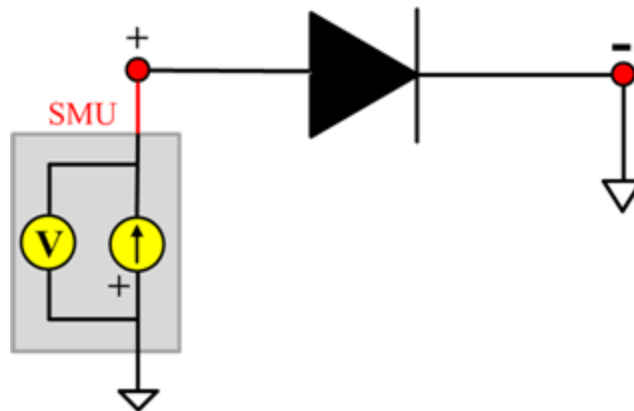
Module Name: Spot_Vfdlfd

DUT: Diode

Function: Measures the forward voltage of a diode.

Pin connections: Uses one SMU to force forward current to the P terminal. Connect the N terminal to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 216: Diode_Spot_Vfdlfd pin connection

**Spot_Vfdlfd ITM**

Module Type: ITM

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

Spot_Vfdlfd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Spot_Vfdlfd PTM

Module Type: Standard PTM

Instrument: Keithley Instruments Series 4200-SMU

Spot_VrdIrd

Description:

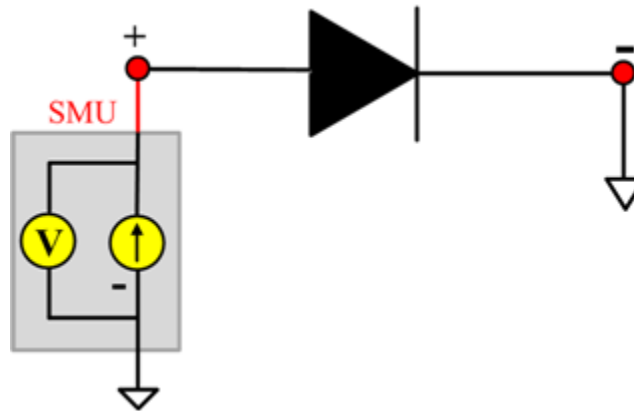
Module Name: Spot_VrdIrd

DUT: Diode

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

Pin connections: Force a reverse current to the P terminal. Connect the N terminal to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 217: Diode_Spot_VrdIrd pin connection



Spot_VrdIrd ITM

Module Type: ITM

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

Spot_VrdIrd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Spot_VrdIrd PTM

Module Type: Standard PTM

Instrument: Keithley Instruments Series 4200-SMU

Sweep_IfdVfd

Description:

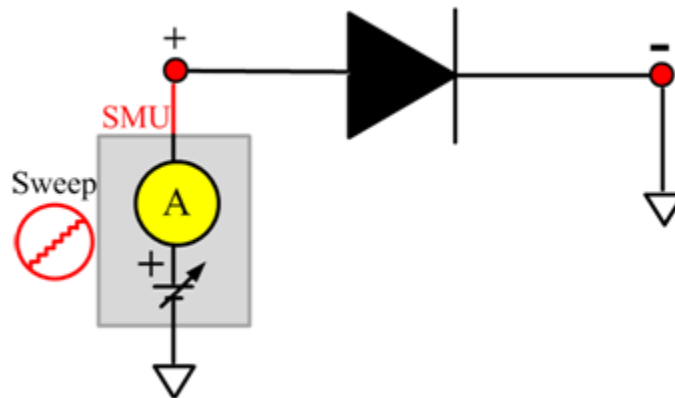
Module Name: Sweep_IfdVfd

DUT: Diode

Function: Measures the forward current with a forward voltage sweep to indicate a forward I-V characteristic of a diode.

Pin connections: Apply a forward voltage sweep to terminal P. Connect the N terminal to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 218: Diode_Sweep_IfdVfd pin connection

**Sweep_IfdVfd ITM**

Module Type: ITM

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

Sweep_IfdVfd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Sweep_IfdVfd PTM

Module Type: Standard PTM

Instrument: Keithley Instruments Series 4200-SMU

Sweep_IrdVrd

Description:

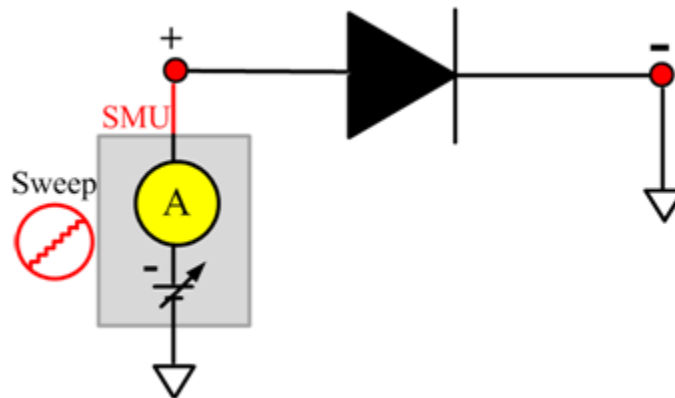
Module Name: Sweep_IrdVrd

DUT: Diode

Function: Measures the reverse current with a reverse voltage sweep to indicate the reverse I-V characteristics of a diode.

Pin connections: Apply a reverse voltage sweep to the P terminal. Connect the N terminal to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 219: Diode_Sweep_IrdVrd pin connection



Sweep_IrdVrd ITM

Module Type: ITM

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

Sweep_IrdVrd General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Sweep_IrdVrd PTM

Module Type: Standard PTM

Instrument: Keithley Instruments Series 4200-SMU

IGBT library

IGBT overview

The IGBT library components are in the following directory:

```
C:\ACS_BASIC\library\devLibrary\IGBT
```

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

IGBT library

BVCES

Description:

Module Name: BVCES

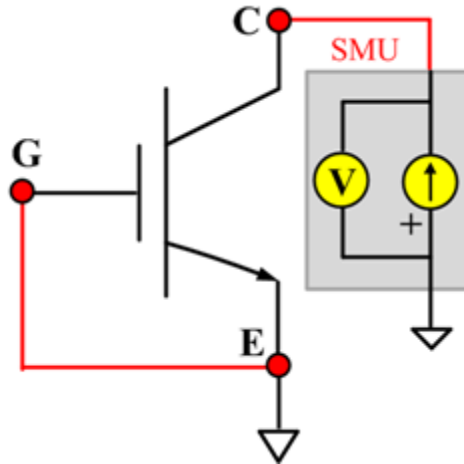
Test Type: ITM

Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal IGBT

Function: Measures the breakdown voltage from the Collector to Emitter. The voltage is measured by applying a breakdown current to the Collector and the Gate-Emitter is shorted.

Pin Connection: Use a Model 2657A to apply current and make a voltage measurement at the Collector. Connect the Gate and Emitter to GND or use a SMU to supply a zero voltage bias.

Figure 220: IGBT BVCES pin connection

Cce

Description:

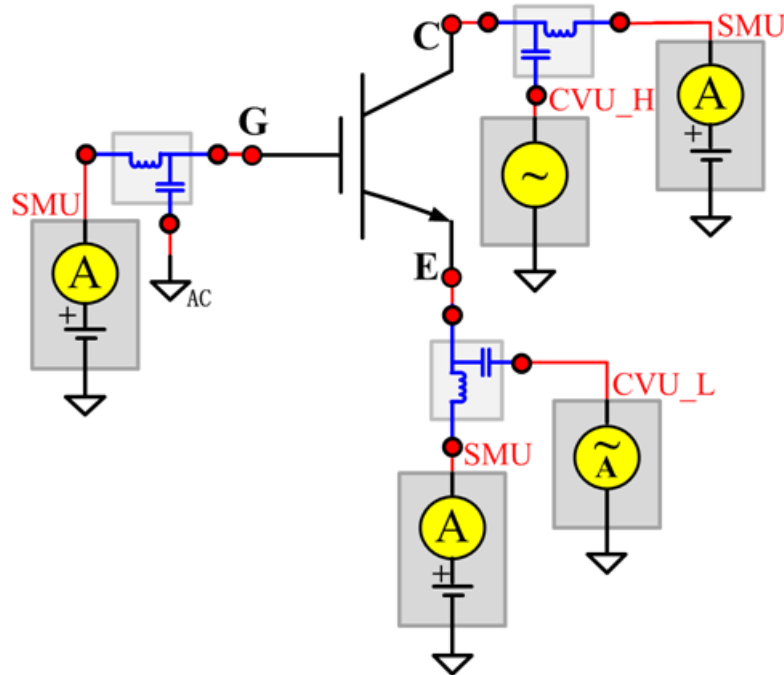
Module Name: Cce

DUT: Three-terminal IGBT

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

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Collector. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Emitter. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the AC guard of a three-terminal bridge through one remote bias tee to the Base. Use the Series 2600B to supply zero voltage bias. (See next figure.)

Figure 221: Three_term_IGBT_Cce pin connections



Cce PTM

Module type: PTM

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

Cgc

Description:

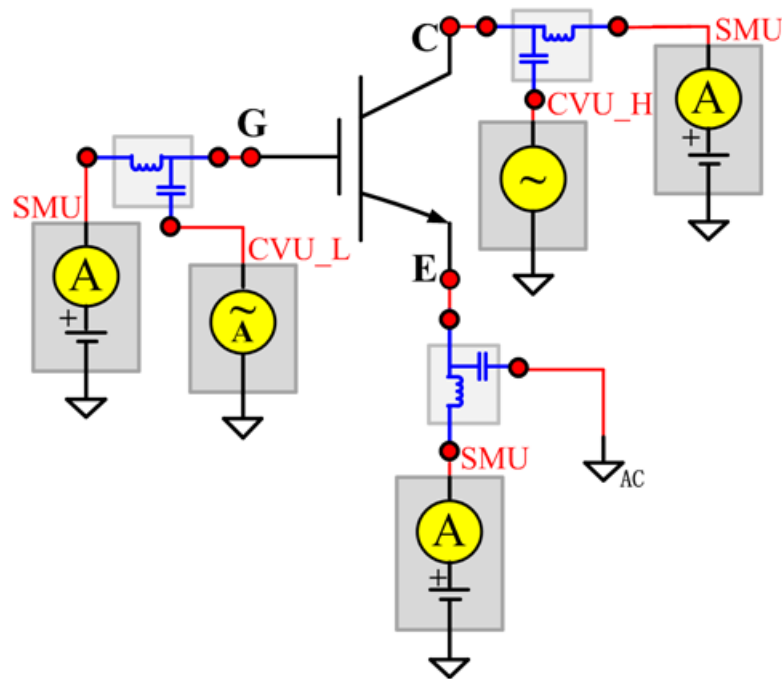
Module Name: Cgc

DUT: Three-terminal IGBT

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

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

Figure 222: Three_term_IGBT_Cgc pin connections



Cgc PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B SMU, Model 4200-SMU, or Model 4200-CVU

Cge

Description:

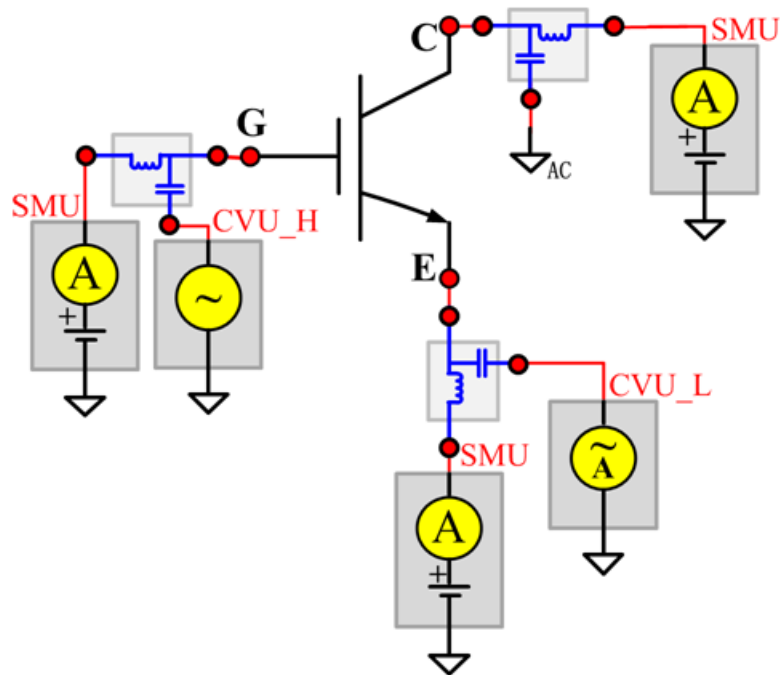
Module Name: Cge

DUT: Three-terminal IGBT

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

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Emitter. Use the Series 2600B to supply zero voltage bias. Connect one Series 2600B the AC guard of a three-terminal bridge through one remote bias tee to the Collector. Use the Series 2600B to supply zero voltage bias. (See next figure.)

Figure 223: Three_term_IGBT_Cge pin connections



Cge PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B SMU, Model 4200-SMU, or Model 4200-CVU

Cies

Description:

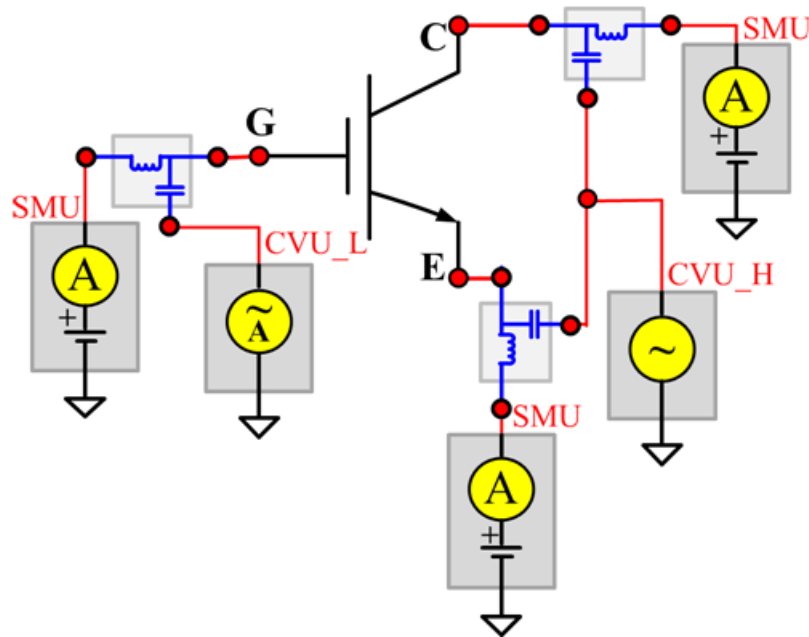
Module Name: Cies

DUT: Three-terminal IGBT

Function: Measures the capacitance between the Gate and Emitter terminals with the Collector terminal AC short-circuited to the Emitter terminal.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Collector. Use the Series 2600B to sweep voltage. AC short-circuit the Collector terminal to the Emitter terminal. Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Emitter. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to supply zero voltage bias. (See next figure.)

Figure 224: Three_term_IGBT_Cies pin connections



Cies PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B SMU, Series 2650 SMU, Model 4200-SMU, or Model 4200-CVU

Coes

Description:

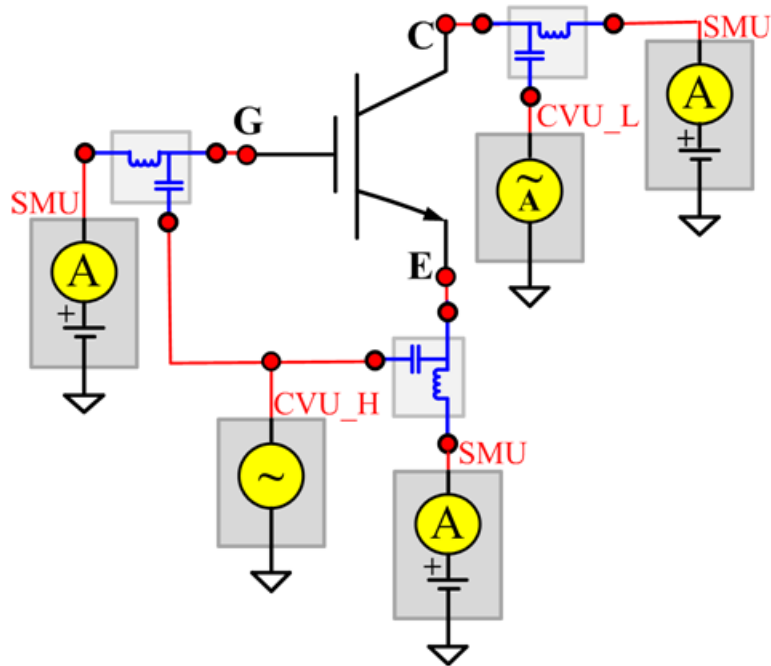
Module Name: Coes

DUT: Three-terminal IGBT

Function: Measures the capacitance between the Collector and Emitter terminals with the Gate terminal AC short-circuited to the Emitter terminal.

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to supply zero voltage bias. AC short-circuit the Gate terminal to the Emitter terminal. Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Emitter. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Collector. Use the Series 2600B to sweep voltage. (See next figure.)

Figure 225: Three_term_IGBT_Coes pin connections



Coes PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B SMU, Series 2650 SMU, Model 4200-SMU, or Model 4200-CVU

Cres

Description:

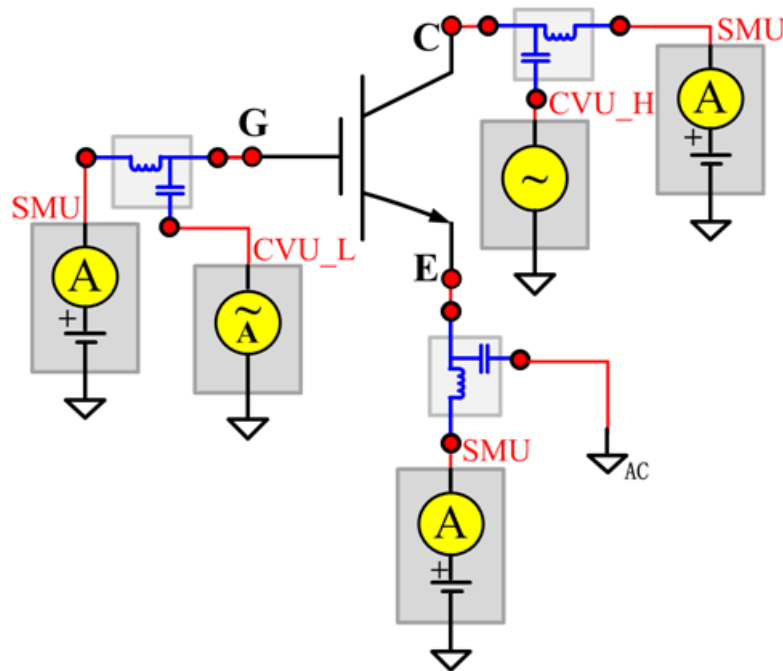
Module Name: Cres

DUT: Three-terminal IGBT

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

Pin connections: Connect a Series 2600B and the CVH1 (HPOT and HCUR) terminals of the Model 4200-CVU through one remote bias tee to the Collector. Use the Series 2600B to sweep voltage. Connect a Series 2600B and the CVL1 (LPOT and LCUR) terminals of the Model 4200-CVU through one remote bias tee to the Gate. Use the Series 2600B to supply zero voltage bias. Connect a Series 2600B and the AC guard of a three-terminal bridge through one remote bias tee to the Emitter. Use the Series 2600B to supply zero voltage bias. (See next figure.)

Figure 226: Three_term_IGBT_Cres pin connections



Cres PTM

Module type: PTM

Instrument: Keithley Instruments Series 2600B SMU, Series 2650 SMU, Model 4200-SMU, or Model 4200-CVU

ICES

Description:

Module Name: ICES

Test Type: ITM

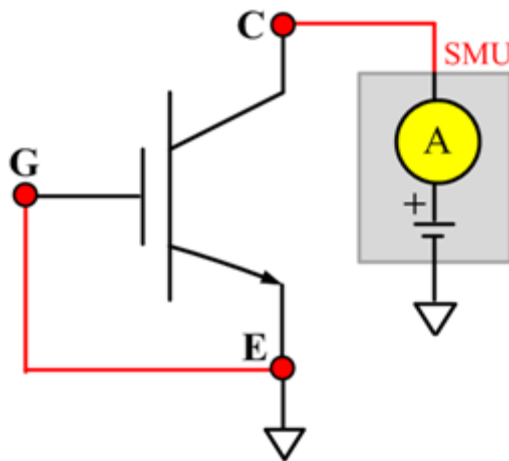
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal IGBT

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

Pin Connection: Use a Model 2657A to apply voltage and make a current measurement from the Collector to the Emitter. Short the Gate to the Emitter or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 227: IGBT ICES pin connection



IcON

Description:

Module Name: IcON

Test Type: ITM

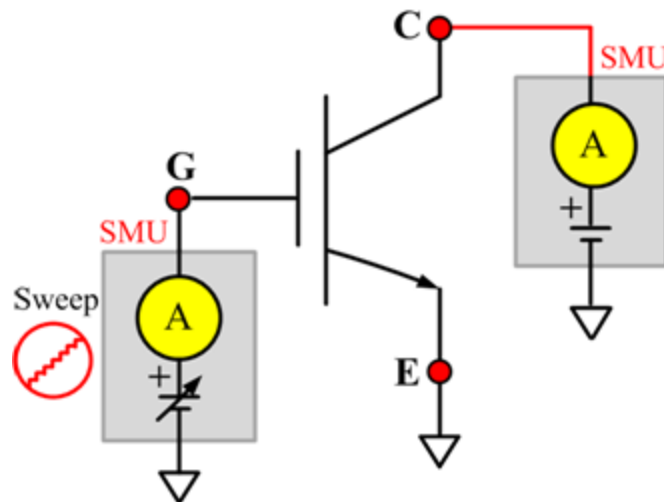
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal IGBT

Function: Measures the on-state Collector current. Measures current on the Collector by applying voltage to the Collector-Emitter with a specific Gate voltage to turn on the device at a certain Collector current value that is given in the data sheet.

Pin Connection: Use the Model 2651A to force voltage and make a current measurement at the Collector. Use the low-power Model 2600B to source sweep voltage at the Gate. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 228: IGBT IcON pin connection



IcVce_StepVge

Description:

Module Name: IcVce_StepVge

Test Type: ITM

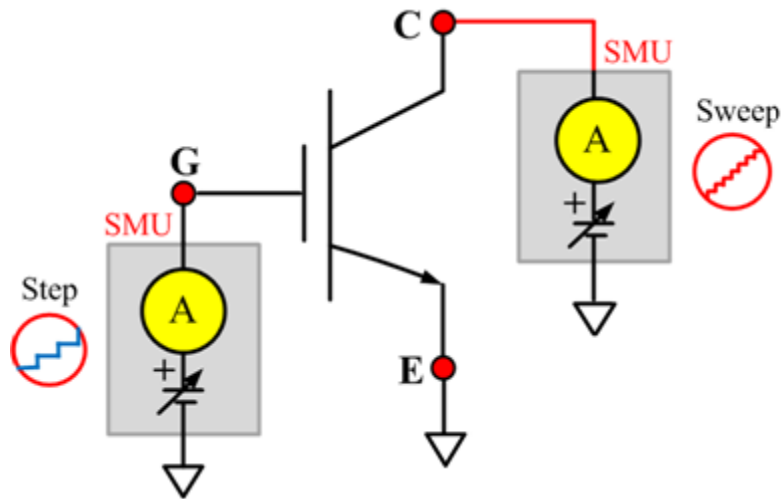
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal IGBT

Function: Measures the standard family of IcVce curves. Each time the voltage steps on the Gate-Emitter, a voltage sweep and a set of current measurements occur on the Collector.

Pin Connection: Use the Model 2651A to apply a voltage sweep and make a current measurement at the Collector. Use the low-power Model 2600B to source a specific voltage at the Gate. Connect the Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.).

Figure 229: IGBT IcVce_StepVge pin connection



IcVge

Description:

Module Name: IcVge

Test Type: ITM

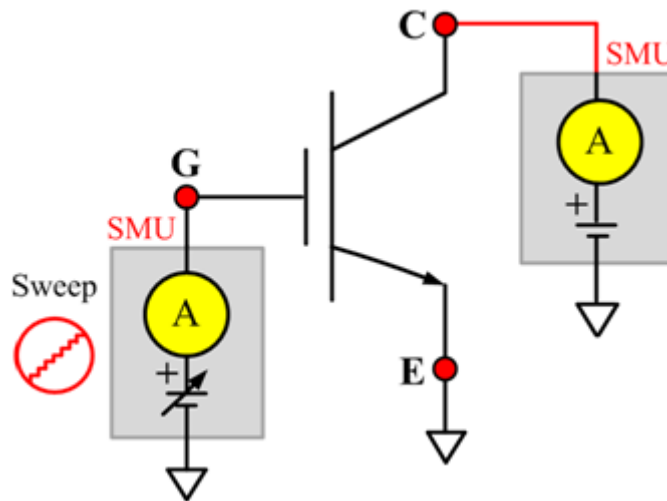
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal IGBT

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

Pin Connection: Use the Model 2651A to apply voltage and make current measurements at the Collector. Use the low-power Model 2600B to sweep voltage at the Gate. Connect the Emitter to GND or use a SMU to supply a zero voltage bias.

Figure 230: IGBT IcVge pin connection



IGESF

Description:

Module Name: IGESF

Test Type: ITM

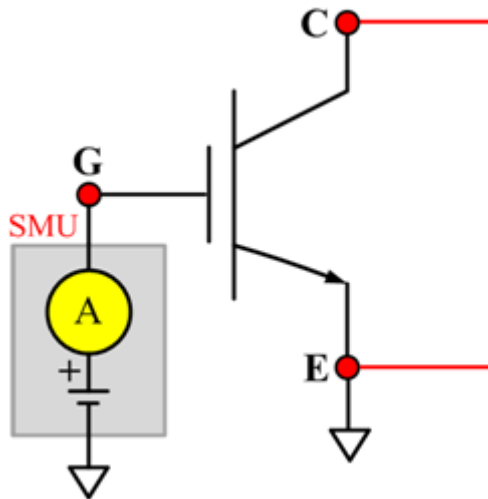
Instrument: Keithley Instruments Series 2600B

DUT: Three-terminal IGBT

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

Pin Connection: Use a SMU to force voltage and make a current measurement from the Gate to the Emitter. Connect the Collector and Emitter to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 231: IGBT IGESF pin connection



IGESR

Description:

Module Name: IGESR

Test Type: ITM

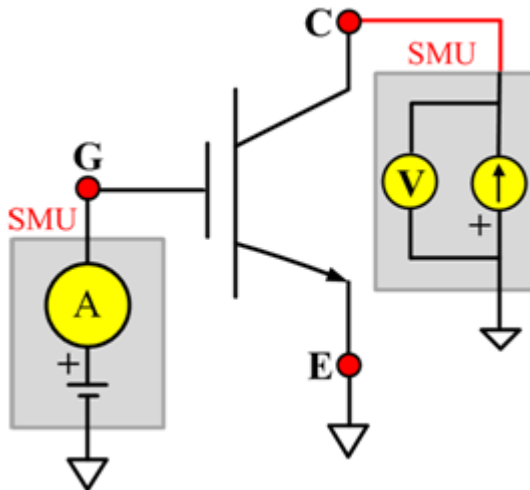
Instrument: Keithley Instruments Series 2600B

DUT: Three-terminal IGBT

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

Pin Connection: Use a SMU to force voltage and make a current measurement from the Gate to the Emitter. Connect the Collector to GND or use a SMU to supply a zero voltage bias.

Figure 232: IGBT IGESR pin connection



VceSAT

Description:

Module Name: VceSAT

Test Type: ITM

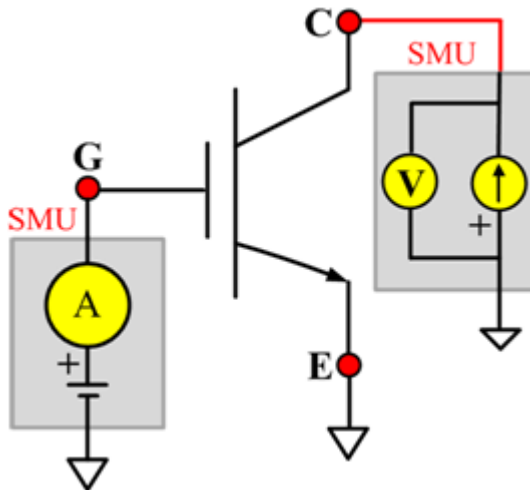
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal IGBT

Function: Measures the Collector-Emitter saturation voltage. The voltage is measured with a specific Gate-Emitter voltage and Collector current that is given in the data sheet.

Pin Connection: Use the Model 2651A to apply current and make voltage measurement from the Collector to the Emitter. Use the Model 2600B to apply a voltage bias to the Gate.

Figure 233: IGBT VceSAT pin connection



VF

Description:

Module Name: VF

Test Type: ITM

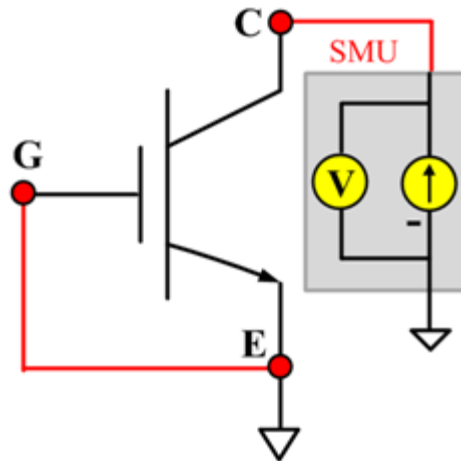
Instrument: Keithley Instruments Series 2600B

DUT: Three-terminal IGBT

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

Pin Connection: Use a SMU to force current and make a voltage measurement from the Collector to the Emitter. Connect the Gate to GND or use a SMU to supply a zero voltage bias.

Figure 234: IGBT VF pin connection



VgeON

Description:

Module Name: VgeON

Test Type: ITM

Instrument: Keithley Instruments Model 2651A, Series 2600B

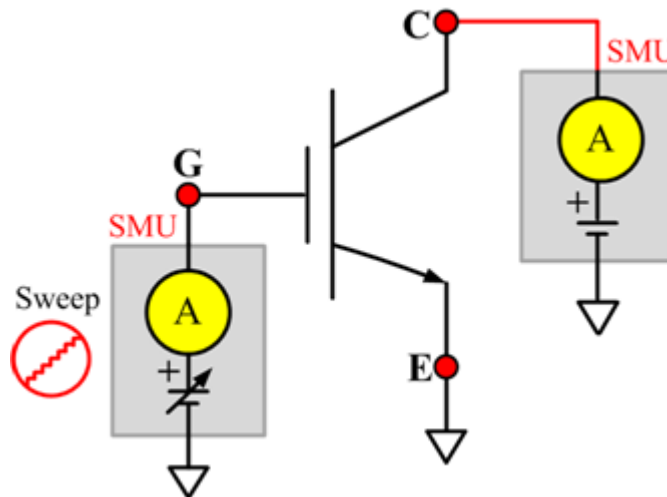
DUT: Three-terminal IGBT

Function: Measures the Gate to Emitter on-state voltage. Measures current on the Collector by applying a voltage sweep to the Gate-Emitter, applying a specific Collector-Emitter voltage to turn on the device at a certain Collector current value that is given in the data sheet, while measuring the Collector current.

Pin Connection: Use a Model 2651A to apply a voltage and make a current measurement at the Collector. Use the low-power Model 2600B to sweep voltage at the Gate. Connect the Emitter to GND or use a SMU to supply a zero voltage bias.

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

Figure 235: IGBT VgeON pin connection



VGETH

Description:

Module Name: VGETH

Test Type: ITM

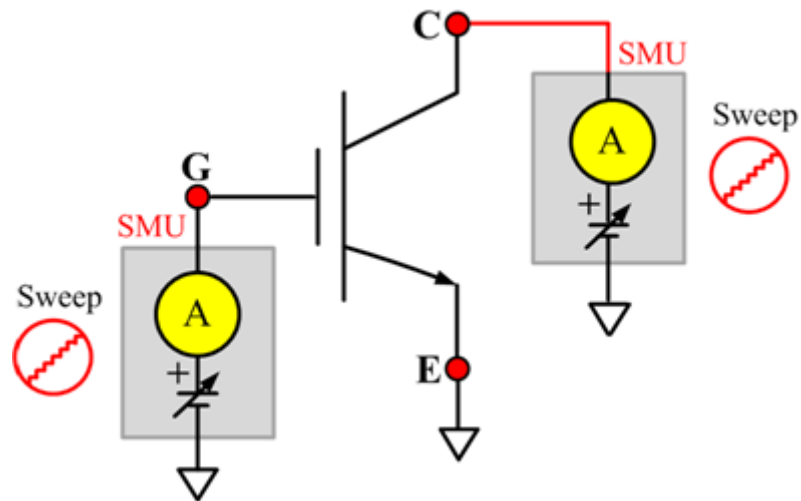
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal IGBT

Function: Measures the threshold voltage from the Gate to Emitter, which is required to turn on the device at a certain Collector current value that is given in the data sheet.

Pin Connection: Use the Model 2651A to apply voltage and make a current measurement at the Collector. Use the low-power Model 2600B to sweep voltage at the Gate. Connect the Emitter to GND or use a SMU to supply a zero voltage bias.

Figure 236: IGBT VGETH pin connection



IcVce_StepVge_MIX

Description:

Module Name: IcVce_StepVge_MIX

Test Type: PTM

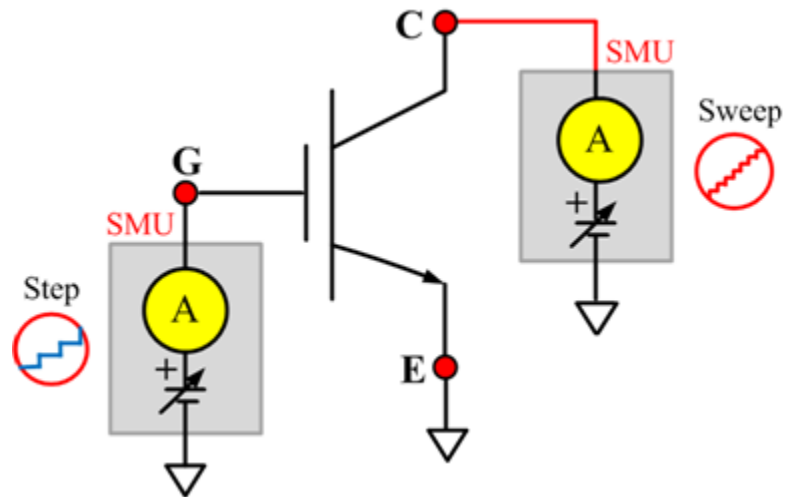
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200-SMU

DUT: Three-terminal IGBT

Function: Measures the standard family of IcVce curves. Each time the voltage steps on the Gate-Emitter, a voltage sweep and a set of current measurements occur on the Collector.

Pin Connection: Use the Model 2651A to apply a voltage sweep and make a current measurement at the Collector. Use the other SMU to source a specific voltage at the Gate.

Figure 237: IGBT IcVce_StepVge_MIX pin connection



IcVge_MIX

Description:

Module Name: IcVge_MIX

Test Type: PTM

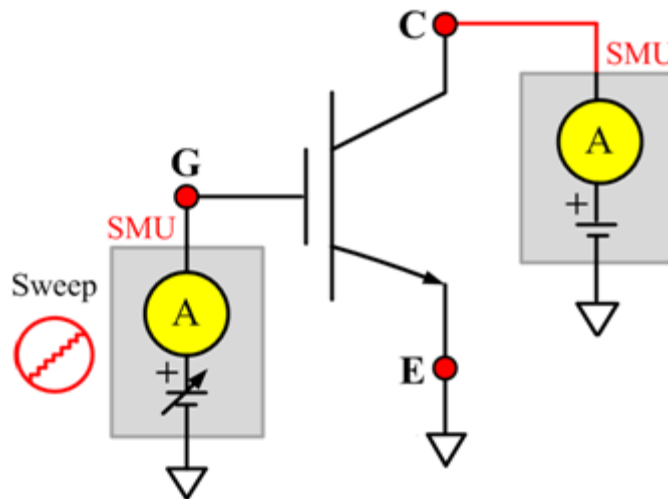
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200-SMU

DUT: Three-terminal IGBT

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

Pin Connection: The Model 2651A SMU applies voltage and makes current measurements at the Collector. Use the other SMU to sweep voltage at the Gate.

Figure 238: IGBT IcVge_MIX pin connection



VceSAT_MIX

Description:

Module Name: VceSAT

Test Type: PTM

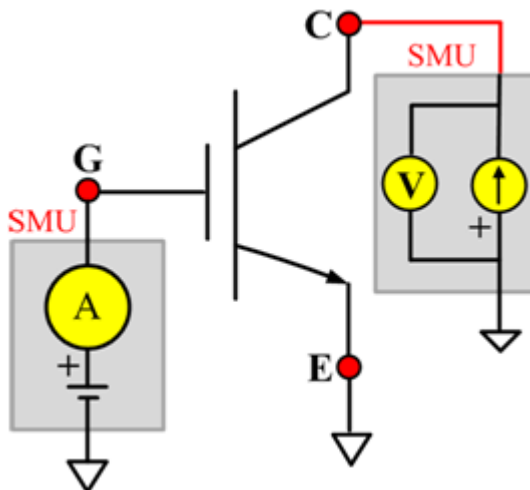
Instrument: Keithley Instruments Model 2651A, Series 2600B, Series 2400, Model 4200-SMU

DUT: Three-terminal IGBT

Function: Measures the Collector-Emitter saturation voltage. The voltage is measured with a specific Gate-Emitter voltage and Collector current that is given in the data sheet.

Pin Connection: Use a SMU to force current and make a voltage measurement from the Collector to the Emitter. Use the other SMU to apply a voltage bias to the Gate.

Figure 239: IGBT VceSAT_MIX pin connection



Two-terminal resistor library

Two-terminal resistor overview

The two-terminal resistor library components are in the following directory:

```
C:\ACS_BASIC\library\devLibrary\RESISTOR_2T
```

The two-terminal resistor library is used to test parameters of a two-terminal resistor, such as resistance (Source V measure I or Source I measure V, 2-wire or 4-wire). This library is used with a Series 2600B instrument to create test script files based on Series 2600B LPT library.

Two-terminal resistor parameter library

Spot_IV_2SMU

Description:

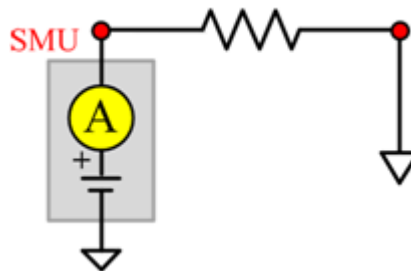
Module Name: Spot_IV_2SMU

DUT: Two-terminal generic device

Function: Measures the current at a specified voltage to determine the resistance.

Pin connections: Ensure that you set the sense mode of the SMU in the software toolbar (Tools > Preferences). If remote sense mode is used, which corresponds to four-wire measurement instruments, connect the Sense High lead of the SMU closer to the device than the Force High lead (see next figure).

Figure 240: Two_term_resistor_spot_IV_2SMU pin connection

**Spot_IV_2SMU ITM**

Module Type: ITM

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

Spot_IV_2SMU General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Spot_VI_2SMU

Description:

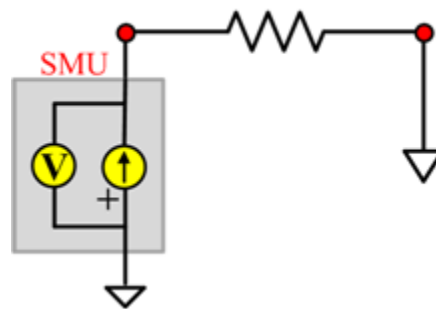
Module Name: Spot_VI_2SMU

DUT: Two-terminal generic device

Function: Measures the voltage at a specified current to determine the resistance.

Pin connections: Ensure that you set the sense mode of the SMU in the software toolbar (Tools > Preferences). If remote sense mode is used, which corresponds to four-wire measurement instruments, connect the Sense High lead of the SMU closer to the device than the Force High lead (see next figure).

Figure 241: Two_term_resistor_spot_VI_2SMU pin connection



Spot_VI_2SMU ITM

Module Type: ITM

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

Spot_VI_2SMU General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Sweep_IV_2SMU

Description:

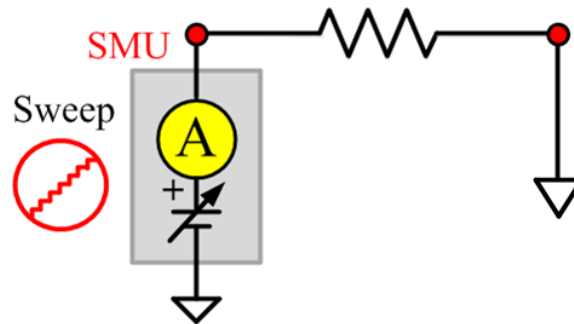
Module Name: Sweep_IV_2SMU

DUT: Two-terminal generic device

Function: Measures the current reading during a voltage sweep and use the values to calculate the resistance.

Pin connections: Ensure that you set the sense mode of the SMU in the software toolbar (Tools > Preferences). If remote sense mode is used, which corresponds to four-wire measurement instruments, connect the Sense High lead of the SMU closer to the device than the Force High lead (see next figure).

Figure 242: Two_term_resistor_sweep_IV_2SMU pin connection



Sweep_IV_2SMU ITM

Module Type: ITM

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

Sweep_IV_2SMU General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

Sweep_VI_2SMU

Description:

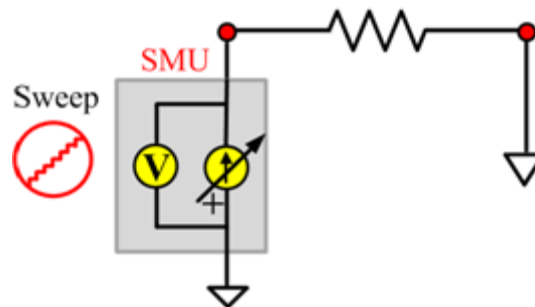
Module Name: Two-terminal Resistor_ Sweep_VI_2SMU

DUT: Two-terminal generic device

Function: Measures the voltage during a current sweep and use the values to calculate the resistance.

Pin connections: Ensure that you set the sense mode of the SMU in the software toolbar (Tools > Preferences). If remote sense mode is used, which corresponds to four-wire measurement instruments, connect the Sense High lead of the SMU closer to the device than the Force High lead (see next figure).

Figure 243: Two_term_resistor_sweep_VI_2SMU pin connection



Sweep_VI_2SMU ITM

Module Type: ITM

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

Sweep_VI_2SMU General Test Module

Module Type: General Test Module

Instrument: Keithley Instruments Series 2400 SMU

TRIAC library

TRIAC overview

The TRIAC library components are in the following directory:

```
C:\ACS_BASIC\library\devLibrary\TRIAC
```

The TRIAC parametric library is used to test parameters of a TRIAC device, including leakage, on-state, trigger, latch and hold properties.

TRIAC parametric library

IDRM

Description:

Module Name: IDRM

Module Type: ITM

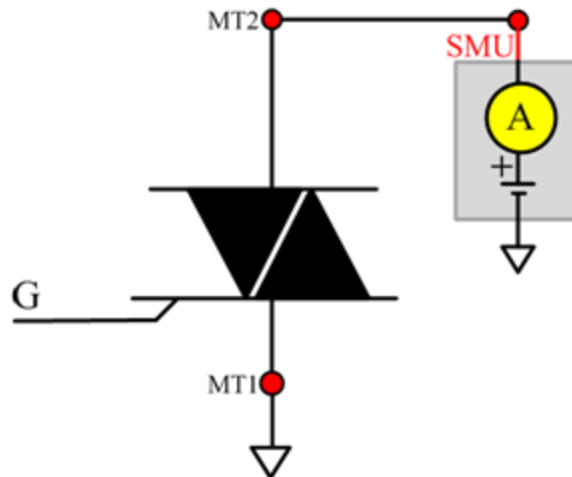
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal TRIAC

Function: Measures the peak repetitive blocking current. Measures the maximum instantaneous value of the off-state current that results from the application of repetitive peak off-state voltage.

Pin Connection: Use the Model 2657A to apply voltage and measure current between terminals MT2 (or A2) to MT1 (or A1). Open the circuit to the Gate or use a SMU to supply zero current bias.

Figure 244: TRIAC IDRM pin connection



IGT

Description:

Module Name: IGT

Module Type: ITM

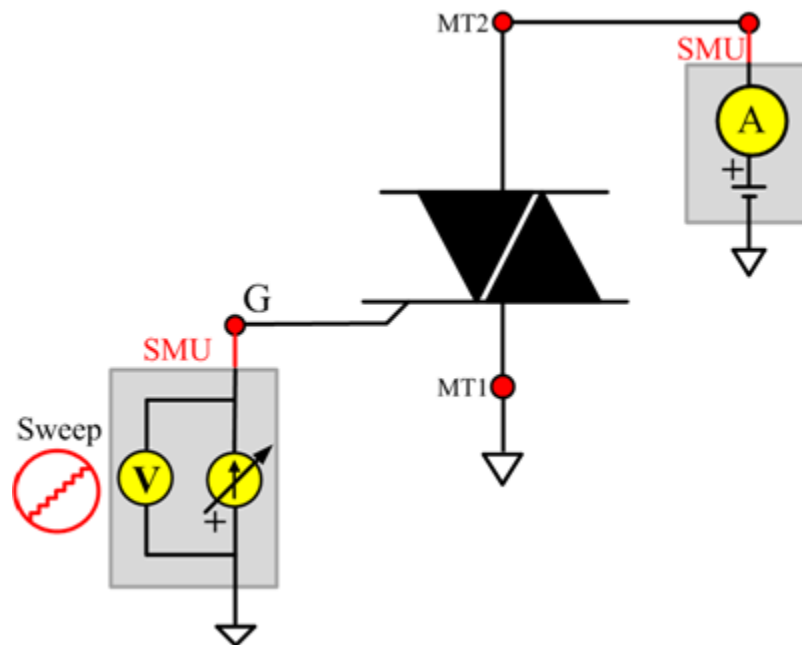
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal TRIAC

Function: Measures the Gate trigger current. Measures the minimum current required between the Gate and cathode (MT1) to turn on the device.

Pin Connection: Use the Model 2651A to apply the specified voltage and measure the current between terminals MT2 (or A2) to MT1 (or A1). Use the Model 2600B SMU to sweep current and measure voltage between Gate and cathode MT1. If required, connect a resistance load R_L at specified value in series with the TRIAC device to achieve a defined on-state current I_T .

Figure 245: TRIAC IGT pin connection



IHneg

Description:

Module Name: IHneg

Module Type: ITM

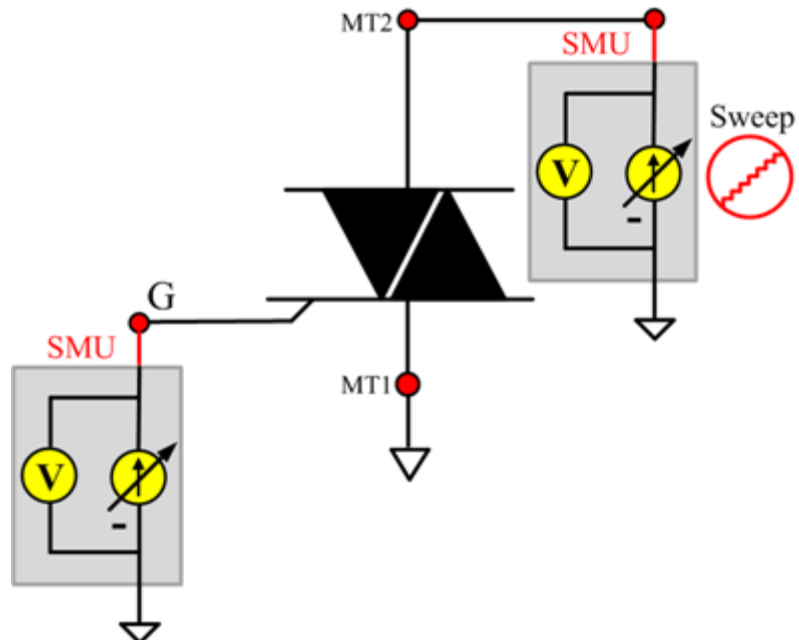
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal TRIAC

Function: Measures the holding current. Measures the minimum current across the main terminals to keep the device in the on-state.

Pin Connection: Use the Model 2651A SMU to apply current between terminals MT2 (or A2) to MT1 (or A1). Use the Model 2600B SMU to apply the specified current between Gate and cathode MT1.

Figure 246: TRIAC IHneg pin connection



IHpos

Description:

Module Name: IHpos

Module Type: ITM

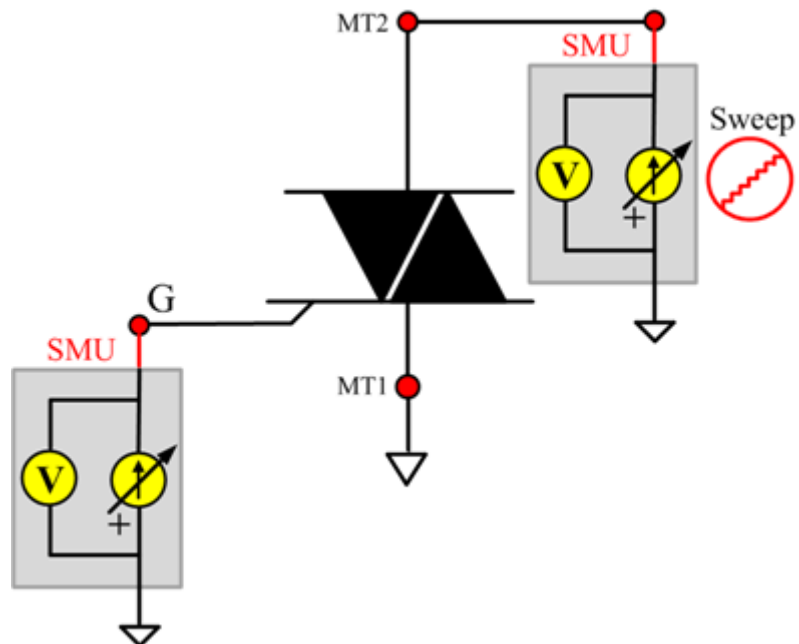
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal TRIAC

Function: Measures the holding current. Measures the minimum current across the main terminals to keep the device in the on-state.

Pin Connection: Use the Model 2651A SMU to apply current between terminals MT2 (or A2) to MT1 (or A1). Use the Model 2600B SMU to apply the specified current between Gate and cathode MT1.

Figure 247: TRIAC IHpos pin connection



ILneg

Description:

Module Name: ILneg

Module Type: ITM

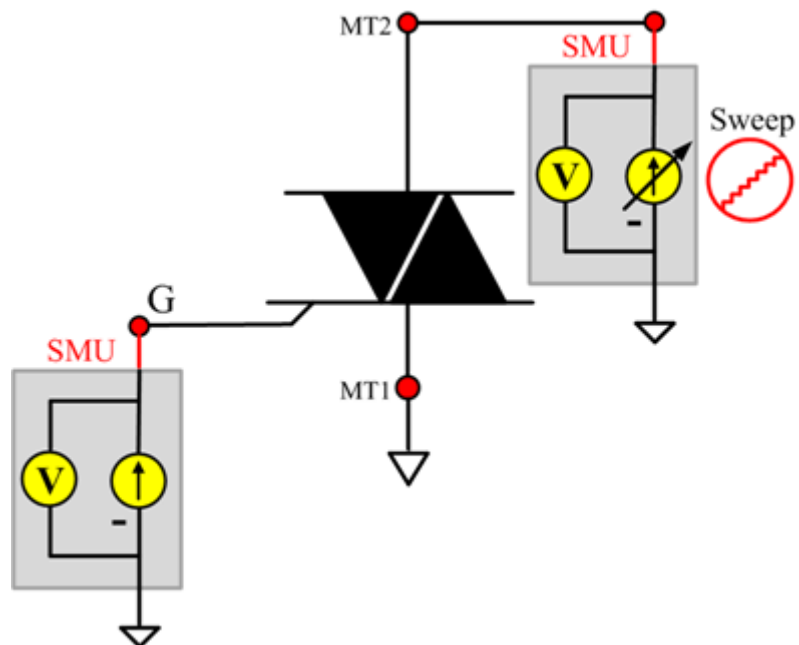
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal TRIAC

Function: Measures the latching current. Measures the minimum current across the main terminals to keep the device in the on-state. This occurs immediately after switching from off-state to on-state and the triggering Gate signal has been removed.

Pin Connection: Use the Model 2651A SMU to apply current between terminals MT2 (or A2) to MT1 (or A1). Use the Model 2600B SMU to apply the specified current between Gate and cathode MT1.

Figure 248: TRIAC ILneg pin connection



ILpos

Description:

Module Name: ILpos

Module Type: ITM

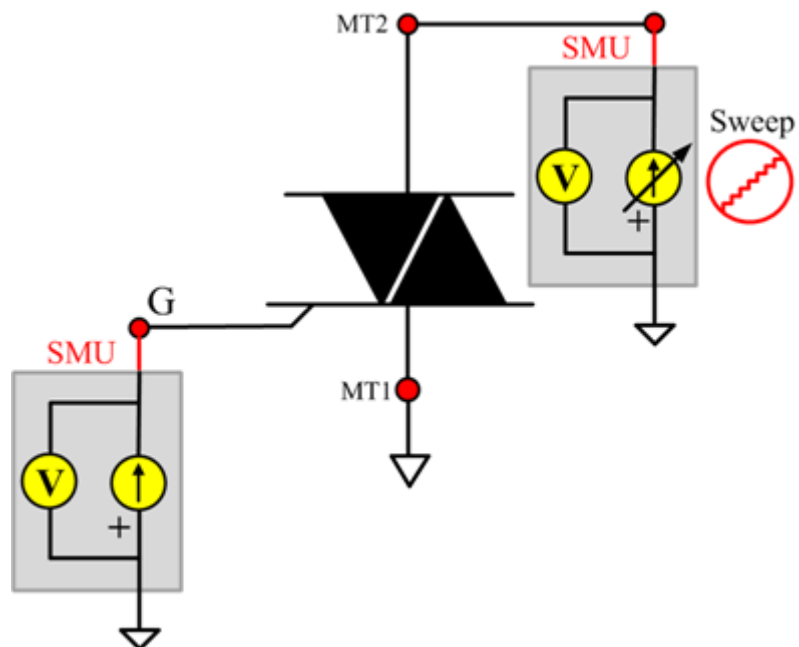
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal TRIAC

Function: Measures the latching current. Measures the minimum current across the main terminals to keep the device in the on-state. This occurs immediately after switching from off-state to on-state and the triggering Gate signal has been removed.

Pin Connection: Use the Model 2651A SMU to apply current between terminals MT2 (or A2) to MT1 (or A1). Use the Model 2600B SMU to apply the specified current between Gate and cathode MT1.

Figure 249: TRIAC ILpos pin connection



IRRM

Description:

Module Name: IRRM

Module Type: ITM

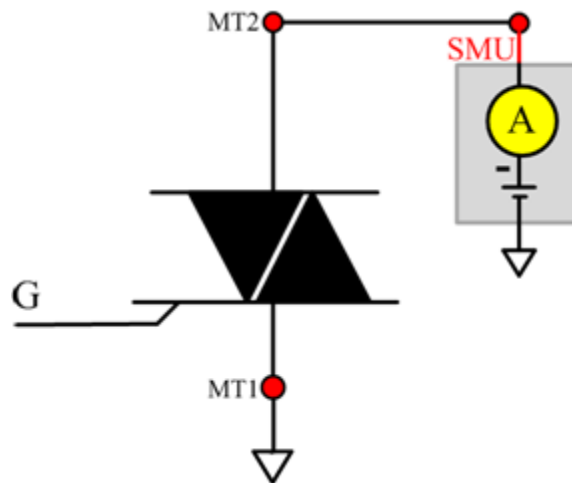
Instrument: Keithley Instruments Model 2657A

DUT: Three-terminal TRIAC

Function: Measures the peak repetitive reverse blocking current. Measures the maximum instantaneous value of the reverse off-state current that results from the application of repetitive peak off-state voltage.

Pin Connection: Use the Model 2657A SMU to apply voltage and measure current between terminals MT2 (or A2) to MT1 (or A1). Connect Gate to GND or use a SMU to supply a zero voltage bias.

Figure 250: TRIAC IRRM pin connection



VGT

Description:

Module Name: VGT

Module Type: ITM

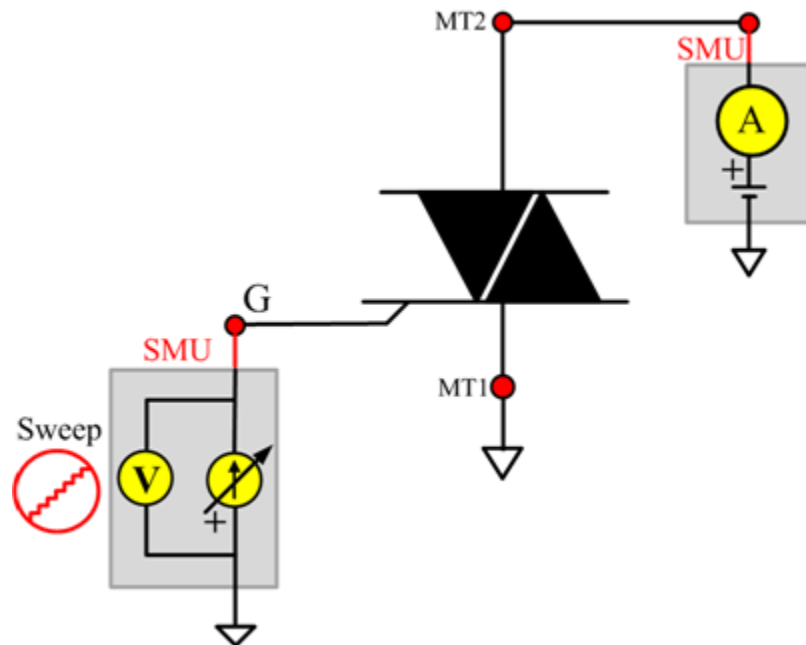
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal TRIAC

Function: Measures the Gate trigger voltage. Measures the minimum voltage required between the Gate and cathode in order to reach the Gate trigger current and then to trigger the device.

Pin Connection: Use the Model 2651A SMU to apply the specified voltage and measure current between terminals MT2 (or A2) to MT1 (or A1). Use the Model 2600B SMU to sweep the current and measure voltage between Gate and cathode MT1. Two SMUs are used. One SMU applies a specified voltage and measures current between terminals A2 (or MT2) to A1 (or MT1). If required, connect a resistance load (RL) at a specified value in series with the TRIAC device to achieve a defined on-state current I_T .

Figure 251: TRIAC VGT pin connection



VTneg

Description:

Module Name: VTneg

Module Type: ITM

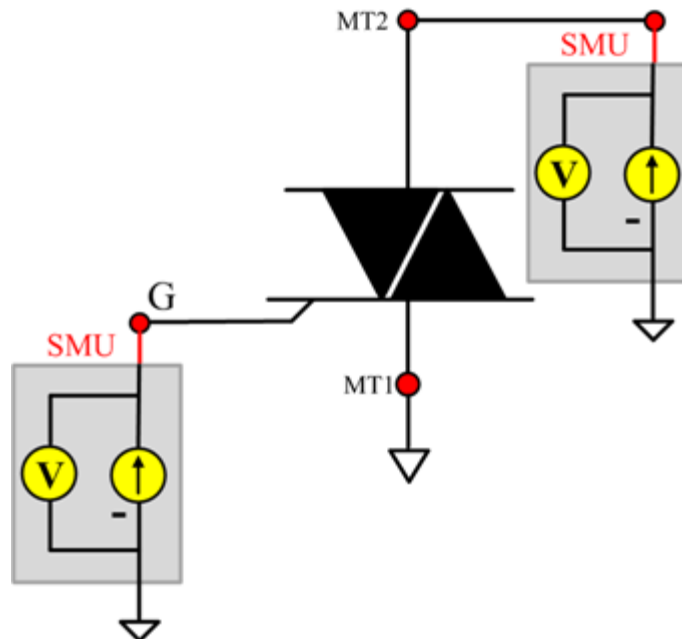
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal TRIAC

Function: Measures the peak on-state voltage. Measures the maximum voltage drop across the main terminals at stated conditions when the devices are in the on-state. Typically measured at a short pulse width and low duty cycle to prevent heating of the junction.

Pin 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 $\geq I_G$ must be applied until the load current is $\geq I_L$.

Figure 252: TRIAC VTneg pin connection



VTpos

Description:

Module Name: VTpos

Module Type: ITM

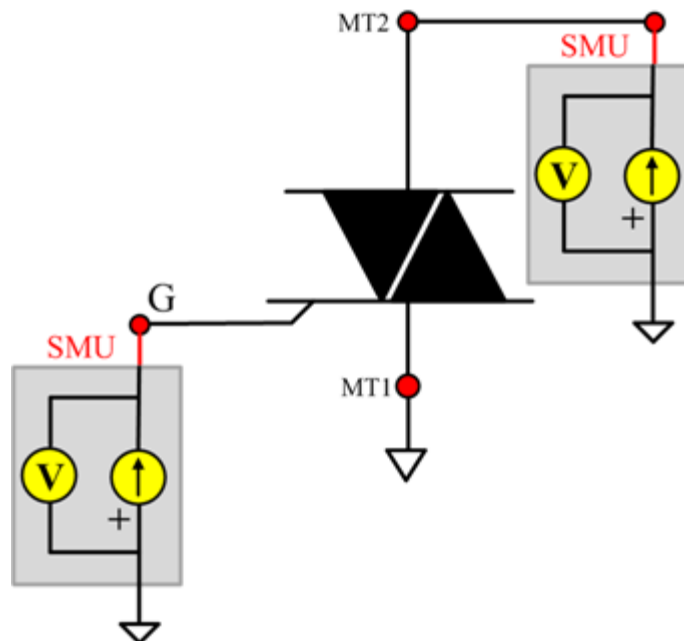
Instrument: Keithley Instruments Model 2651A, Series 2600B

DUT: Three-terminal TRIAC

Function: Measures the peak on-state voltage. Measures the maximum voltage drop across the main terminals at stated conditions when the devices are in the on-state. Typically measured at a short pulse width and low duty cycle to prevent heating of the junction.

Pin 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 $\geq I_{GT}$ must be applied until the load current is $\geq I_L$.

Figure 253: TRIAC VTpos pin connection



Zener test module template

Zener overview

The ZENER library components are in the following directory:

`C:\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 library

BVZ

Description:

Module Name: BVZ

Module Type: ITM

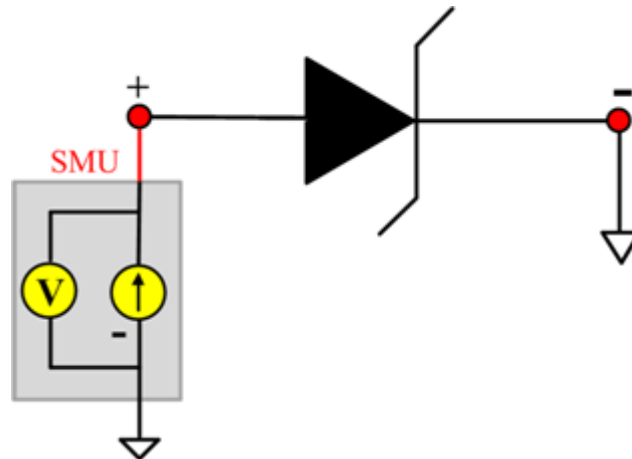
Instrument: Keithley Instruments Series 2600B

DUT: Two-terminal ZENER

Function: Measures the regulator voltage from the cathode to anode at the maximum rated current that is given in the data sheet.

Pin Connection: Use a SMU to apply a negative current (I_{ZM}) and make voltage measurements from the anode to the cathode. Connect the cathode to GND or use a SMU to supply a zero voltage bias. (See next figure.)

Figure 254: ZENER BVZ pin connection



IR

Description:

Module Name: IR

Module Type: ITM

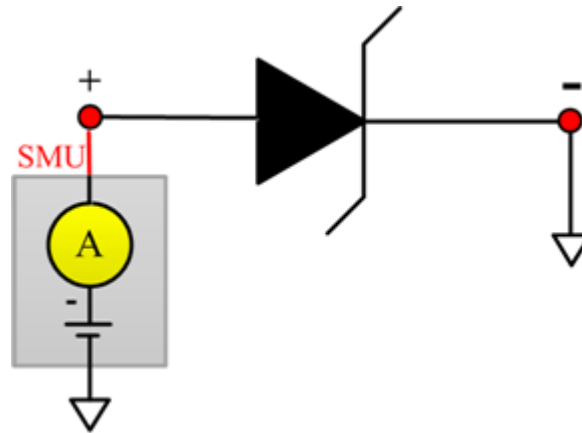
Instrument: Keithley Instruments Series 2600B

DUT: Two-terminal ZENER

Function: Measures the reverse leakage current at a specific reverse voltage from the cathode to anode that is given in the data sheet.

Pin Connection: Use a SMU to apply a negative voltage and make a current measurement from anode to cathode. Connect the cathode to GND or use a SMU to supply a zero voltage bias.

Figure 255: ZENER IR pin connection



VF

Description:

Module Name: VF

Module Type: ITM

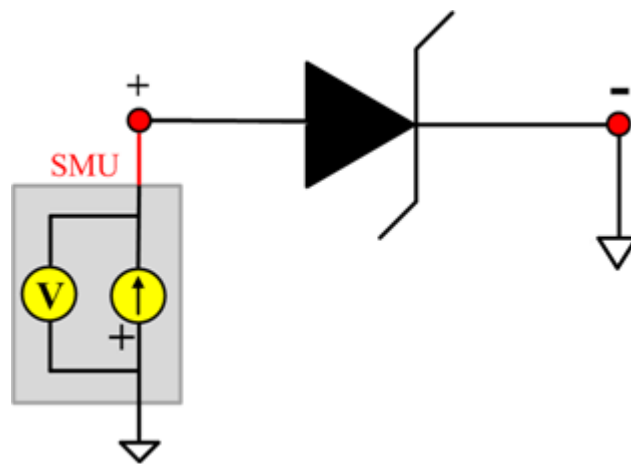
Instrument: Keithley Instruments Series 2600B

DUT: Two-terminal ZENER

Function: Measures the forward voltage at a specific forward current from the anode to cathode.

Pin Connection: Use a SMU to apply positive current and make a voltage measurement from the anode to the cathode. Connect the cathode to GND or use a SMU to supply a zero voltage bias.

Figure 256: ZENER VF pin connection



Capacitor WLR library

Capacitor WLR overview

The WLR script components are in the following directory:

```
C:\ACS_BASIC\library\devLibrary\CAPACITOR_MOS\WLR_script
```

There are four modules in the pMOSFET WLR_script Library:

1. TDDB_per_pin
2. TDDB_CCS
3. qbd_rmpj
4. qbd_rmpv

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 V_g is below breakdown voltage ($\text{abs}(V_g) < \text{abs}(V_{\text{min}})$)
- B. If the V_g falls dramatically ($\text{abs}(V_g[\text{now}]) \leq \text{HBDL} * \text{abs}(V_g[\text{prev}])$).

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 $\lg[\text{now}] \geq \lg[\text{prev}] * \text{HBDL}$ 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'

<code>double comp4=nil</code>	--compliance of corresponding smu (Unit:A for current;V for voltage).
<code>double stress4=nil</code>	--stress value required on the smu (Unit:A for current V for voltage).
<code>integer meas4=nil</code>	--1: current stress and make measurement 0: voltage stress no measurement

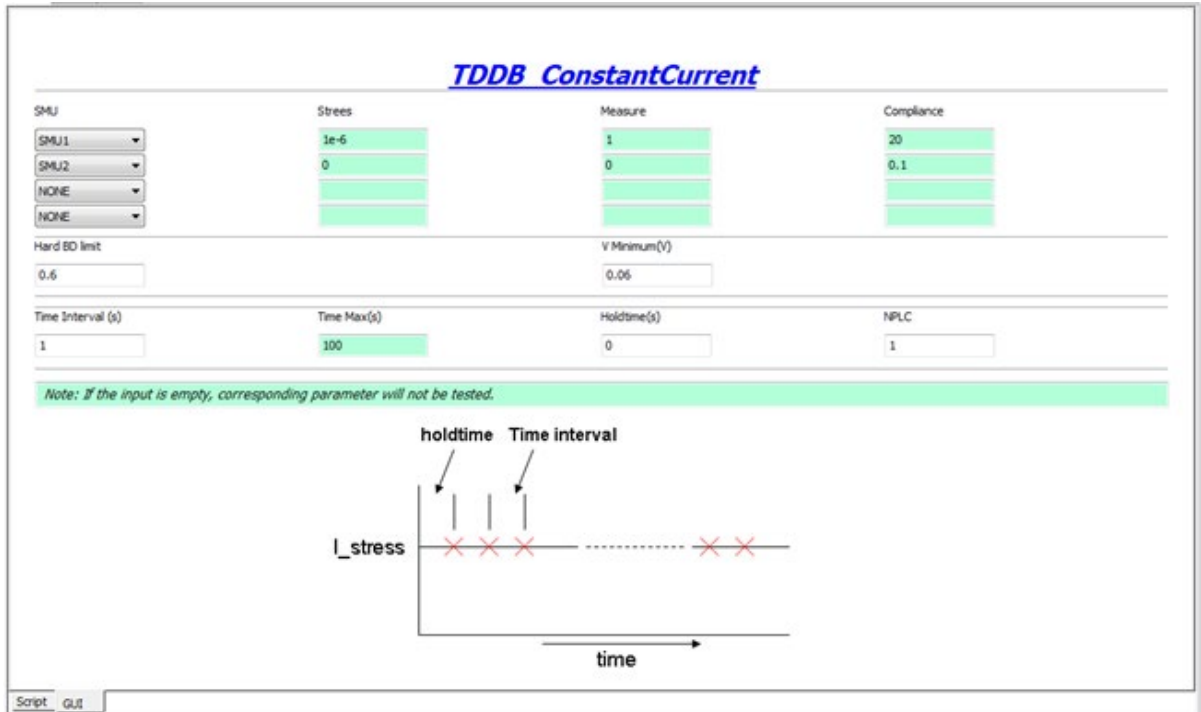
OUTPUTS:

<code>error</code>	--error message
<code>time1</code>	--time array of SMU1
<code>Vg1</code>	--voltage of SMU1
<code>TBD1</code>	--Tbd of SMU1
<code>BD_type1</code>	--breakdown type of SMU1:1 for HBD; 2 for timeout
<code>time2</code>	--time array of SMU2
<code>Vg2</code>	--voltage of SMU2
<code>TBD2</code>	--Tbd of SMU2
<code>BD_type2</code>	--breakdown type of SMU2
<code>time3</code>	--time array of SMU3
<code>Vg3</code>	--voltage of SMU3
<code>TBD3</code>	--Tbd of SMU3
<code>BD_type3</code>	--breakdown type of SMU3
<code>time4</code>	--time array of SMU4
<code>Vg4</code>	--voltage of SMU4
<code>TBD4</code>	--Tbd of SMU4
<code>BD_type4</code>	--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 257: GUI for TDDB_CCS



TDDDB 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
TDDDB_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 $I_g[\text{now}] \geq \text{HBDL} * I_g[\text{pre}]$ $I_g[\text{now}] \geq \text{HBDL} * I_g[\text{prev}]$

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, I_g , I_g _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 $I_g[\text{now}] \geq I_g[\text{prev}] * \text{HBDL}$ 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 $I_{\text{noi}}[\text{now}] \geq I_{\text{noi}}[\text{Base}] * \text{SBDL}$ 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 corresponding smu (Unit:A).
double stress1=3 in[-200,200]	--stress value required on the smu (Unit:V).
integer meas1=1 in[0,1]	--1: make measurement on this smu 0: no measurement
integer smu_2=2 in[0,1,2..64]	--maximum four SMUs are supported. if not input '0'
double comp2=0.1 in[0,0.1]	--compliance of corresponding smu (Unit:A).
double stress2=3 in[-200,200]	--stress value required on the smu (Unit:V).
integer meas2=1 in[0,1]	--1: make measurement on this smu 0: no measurement

```

integer smu_3=0 in[0,1,2..64]      --maximum four SMUs are supported. if not input
                                   '0'
double comp3=nil in[0,0.1]        --compliance of corresponding smu (Unit:A).
double stress3=nil in[-200,200]   --stress value required on the smu (Unit:V).
integer meas3=nil in[0,1]        --1: make measurement on this smu 0: no
                                   measurement
integer smu_4=0 in[0,1,2..64]      --maximum four SMUs are supported. if not input
                                   '0'
double comp4=nil in[0,0.1]        --compliance of corresponding smu (Unit:A).
double stress4=nil in[-200,200]   --stress value required on the smu (Unit:V).
integer meas4=nil in[0,1]        --1: make measurement on this smu 0: no
                                   measurement

```

Outputs:

```

error          --indicate whether the modules runs OK or not -1: illegal input  0: OK
time1          --time array of SMU1
I1             --current of SMU1
Inoi1         --noise current of SMU1
BD_type1      --breakdown type of SMU1  1: HBD  2: SBD  3: time out
TBD1          --time to BD of SMU1
time2         --time array of SMU2
I2            --current of SMU2
Inoi2        --noise current of SMU2
BD_type2     --breakdown type of SMU2
TBD2        --time to BD of SMU2
time3       --time array of SMU3
I3          --current of SMU3
Inoi3      --noise current of SMU3
BD_type3   --breakdown type of SMU3
TBD3      --time to BD of SMU3
time4     --time array of SMU4
I4        --current of SMU4
Inoi4    --noise current of SMU4
BD_type4 --breakdown type of SMU4
TBD4    --time to BD of SMU4

```

GUI related:

The next figure shows the GUI for the TDDB test. A general description of this GUI is included below.

Figure 258: TDDB sequence

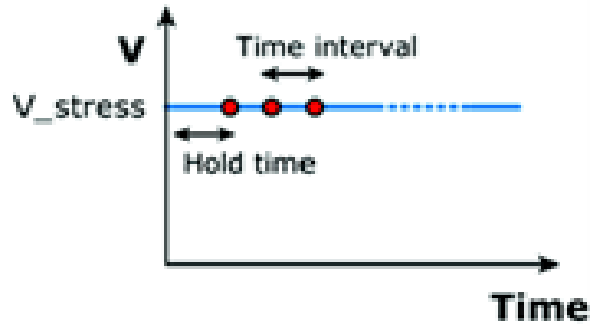


Figure 259: GUI for TDDB per pin

TDDB

SMU	Stress(V)	Measure	Compliance(A)
SMU1	1	1	0.1
SMU2	0	0	0.1
NONE			
NONE			

Breakdown Mode: Hard & Soft Hard ED limit: Soft ED limit:

Time Interval (s): Time Max(s): Holdtime(s): NPLC:

Note: If the input is empty, corresponding parameter will not be tested.

Script GUI

TDDDB 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 compl=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 compl=0.1
local stress4=2
local meas4=1

TDDDB_per_pin(time_interval, HBDL, BD_mode, time_max, SBDL, holdtime, myPLC smu1,
  compl, stress1, meas1, smu2, comp2, stress2, meas2, smu3, comp3, stress3, meas3,
  smu4, compl, 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 (cm²)

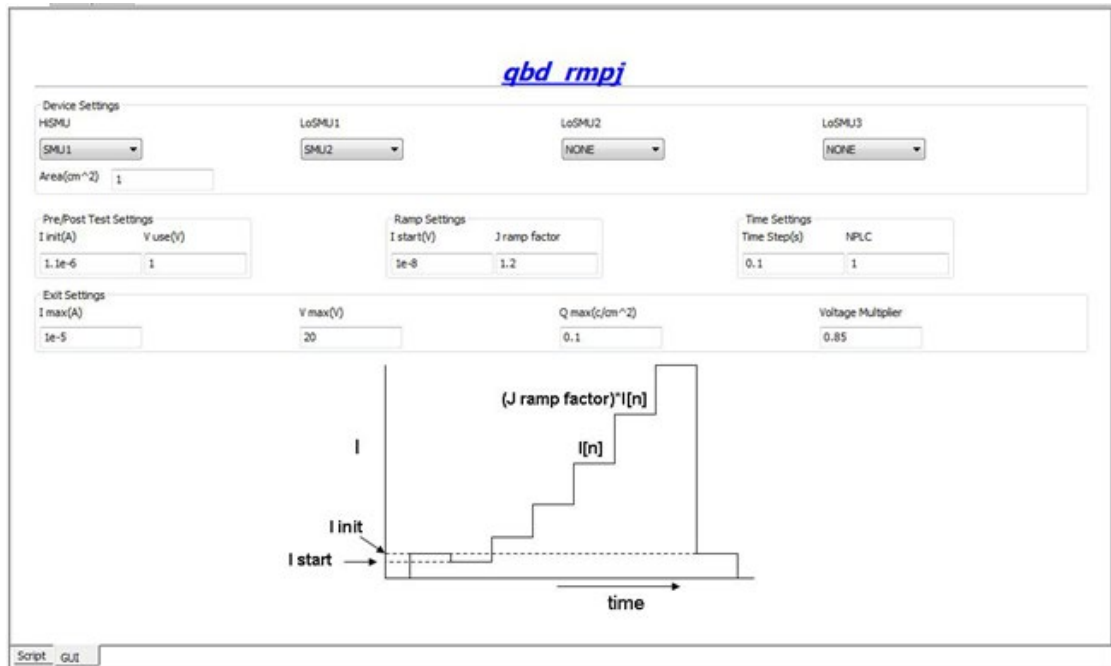
OUTPUTS:

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/cm²)
 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
 measured voltage < EXIT_volt_mult*V_previous --0: no test errors (EXIT due to
 --(-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 260: GUI for qbd_rmpj



NOTE

If the above routine is modified, change the function name to avoid possible programming errors.

Example call:

```

local HiSMUIId=1
local LoSMUIId1=2
local LoSMUIId2=0
local LoSMUIId3=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(HiSMUIId, LoSMUIId1, LoSMUIId2, LoSMUIId3, 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

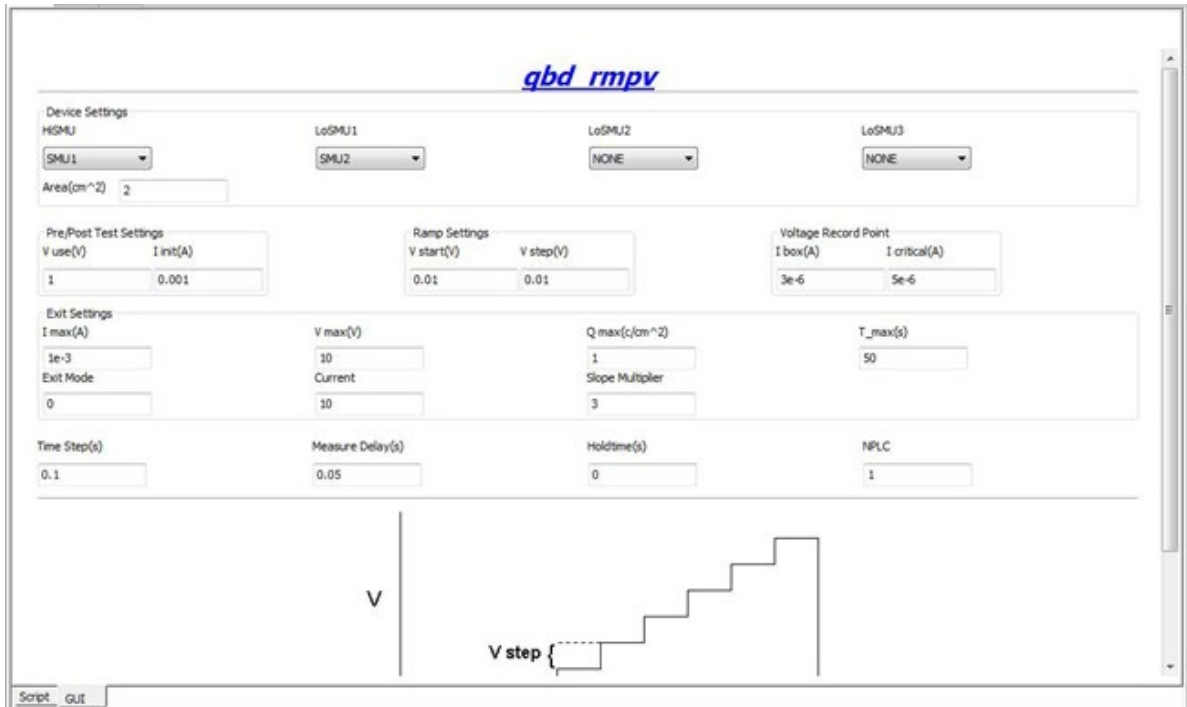
Test_status

- 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)
- 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 261: GUI for qbd_rmpv



Example call:

```
local HiSMUIId=1
local LoSMUIId1=2
local LoSMUIId2=0
local LoSMUIId3=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(HiSMUIId, LoSMUIId1, LoSMUIId2, LoSMUIId3, myplc, v_use, I_init, hold_time,
v_start, v_step, t_step, measure_delay, I_crit, I_box, I_max, EXIT_curr_mult,
EXIT_slope_mult, q_max, t_max, v_max, area, EXIT_mode).
```

Common capacitance-voltage (CV) library

Common CV library overview

ACS Basic has a common capacitance-voltage (CV) library that includes the CV test. All test modules in the Common CV library can be added to any device. You can also build a common CV library to import and use.

Common CV library

CV4284

Description:

Tests the capacitive parameters at a specified frequency and voltage of the AC drive, with measurements of DC voltage bias or sweep.

Instrument:

Agilent 4284 or 4980 LCR meter.

NOTE

These instruments cannot be automatically scanned by ACS Basic. You must configure them as a general purpose instruments. Refer to "Connect to external instruments" in the *ACS Basic Reference Manual* for information.

Syntax:

```
CVITM.cv4284(CMTR_name,force_func,preSoak,v_bias,v_biasPts,v_start,v_stop,v_step,hold_time,delay_time,speed,freq_bias,v_AC,meas_param,meas_range,cable_length,isCmpstOpen,isCmpstShort,isCmpstLoad,output_DCV,output_result1,output_result2,output_error)
```

INPUTS:

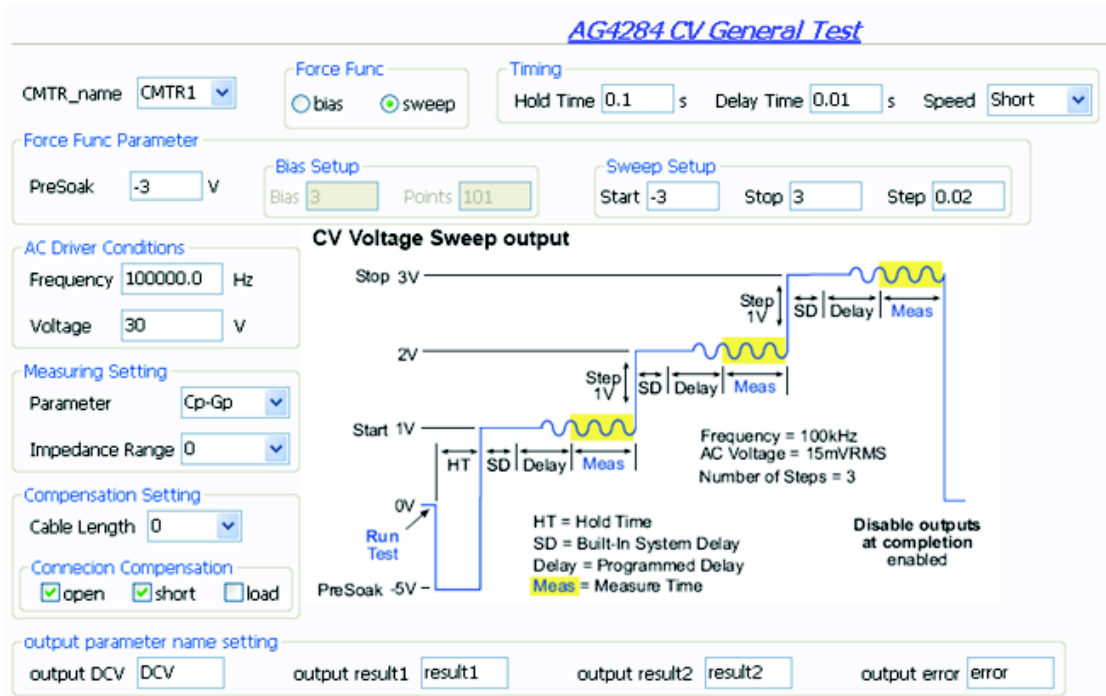
CMTR_name:	Instrument name defined in syscon.kcf file.
force_func:	0: bias, 1: sweep.
preSoak:	Force voltage after test start and before measurement sequence. Unit: V.
v_bias:	Force value for the bias. Unit: V.
v_biasPts:	The number of bias points.
v_start:	Initial force value for the sweep (-40V to 40V). Unit: V.
v_stop:	Final force value for the sweep (-40V to 40V). Unit: V.
v_step:	Step force value for the sweep (-40V to 40V). Unit: V.
hold_time:	Hold time after force value changed. Unit: seconds.
delay_time:	Delay before each measurement (0 to 999s). Unit: seconds.
Speed:	Measurement time setting.
freq_bias:	Frequency of the AC drive for normal measurement. Valid value is from 20 Hz to 2 MHz.
vAC:	The oscillator output voltage level, the valid input is 5 mV to 20 V. Unit: V.
measParam:	Valid input ['Z,Theta', 'R+jx', 'Cp-Gp', 'Cs-Rs', 'Cp-D', 'Cs-D'] KI_AGCV_TYPE_ZTR = 0 "ZTR" KI_AGCV_TYPE_RX = 1 "RX" KI_AGCV_TYPE_CPG = 2 "CPG" KI_AGCV_TYPE_CSRS = 3 "CSRS" KI_AGCV_TYPE_CPD = 4 "CPD" KI_AGCV_TYPE_CSD = 5 "CSD"
measRange:	The measurement range to use. Valid values for this parameter are 0 (Auto), 100, 300, 1000, 3000, 10000, 30000, and 100000 Ohms.
cableLength:	Cable length setting for connect compensation. Unit: meter. When you do not need compensation, cable length should be assigned to 0.
isCmpstOpen:	Enable or disable compensation constants for open.
isCmpstShort:	Enable or disable compensation constants for Short.
isCmpstLoad:	Enable or disable compensation constants for Load.

OUTPUTS:

0: OK.
 -10000: Specified CVU does not exist.
 -10001: (INVAL_PARAM) Parameter setting error occurred.
 -10090: (GPIB_ERROR_OCCURED) A GPIB communications error occurred.
 result["DCV"]: Force DC voltage
 result["result1"]: The first parameter of the result according to the measurement model.
 result["result2"]: The second parameter of the result according to the measurement model.

GUI related:

Figure 262: CV setting example



KI42xxCVU

Description:

Use this module to test capacitive parameters under several test condition by KXCI through Ethernet.

Instrument:

Keithley Instruments Model 4200-CVU

Syntax:

```
CVITM.KI42xxCVU(CVU_name,mode,force_func,DC_cond,AC_cond,adv_setting,cable_len,is_o
pen,is_short,is_load,meas_model,speed,cust_speed,hold_time,delay_time,output_nam
e)
```

INPUTS:

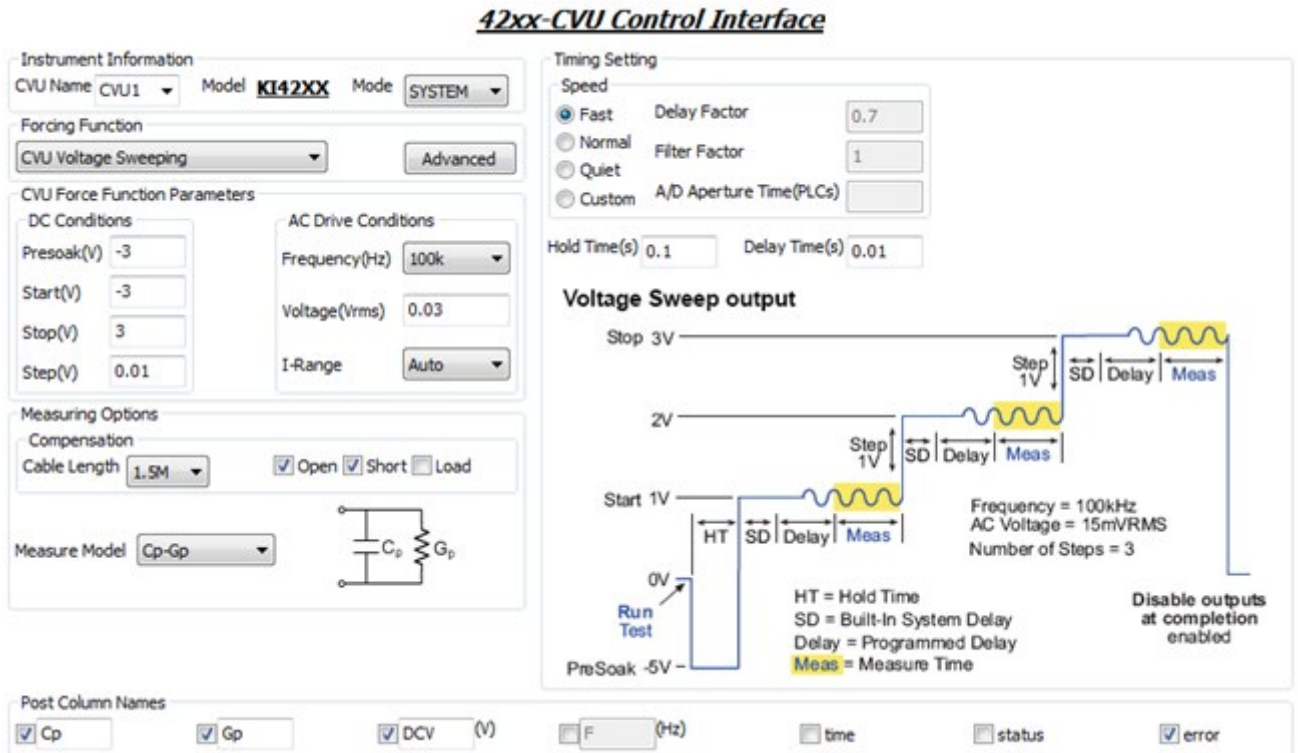
CVU_name:	Instrument name. To make sure the specified CVU is available in ACS, in the Hardware Configuration Panel, check the instrument tree.
mode:	System or User. If ACS is installed on a remote PC, system mode is available. System mode offer relatively high performance when testing. User mode is available on remote and local systems. Sweeping and sampling in User mode is realized by bias-meas FOR loop.
force_func:	The test condition.
DC_cond:	The DC force condition settings.
AC_cond:	The AC drive force condition settings.
adv_setting	Advanced settings, such as DC/AC source slice selected, DC offset, test end reset disable or enable, and auto standby in system mode.
cable_len:	Cable length setting for connection compensation. Supported values are 0, 1.5, and 3 m. When compensation is not needed, set to 0.
is_open:	Enable or disable open compensation.
is_short:	Enable or disable short compensation.
is_load:	Enable or disable load compensation.
meas_model:	Defines which measure model to use.
Speed:	Measurement speed setting. If Custom is selected, also set up cust_speed dictionary.
cust_speed:	The user-defined speed parameters.
hold_time:	The hold time to be applied in presoak and step beginning in step test.
delay_time:	The sampling or sweeping delay.

Results:

According to measParam selected.

GUI related:

Figure 263: Example of the settings for 42xxCVU



Common SMU Library

Common SMU library overview

You can add all test modules in the common SMU library to any device. You can also build a common SMU library to import and use.

Common SMU library

FourWireResistor_3706

Description:

Module Name: FourWireResistor_3706

Module Type: PTM

Instrument: Keithley Series 3706

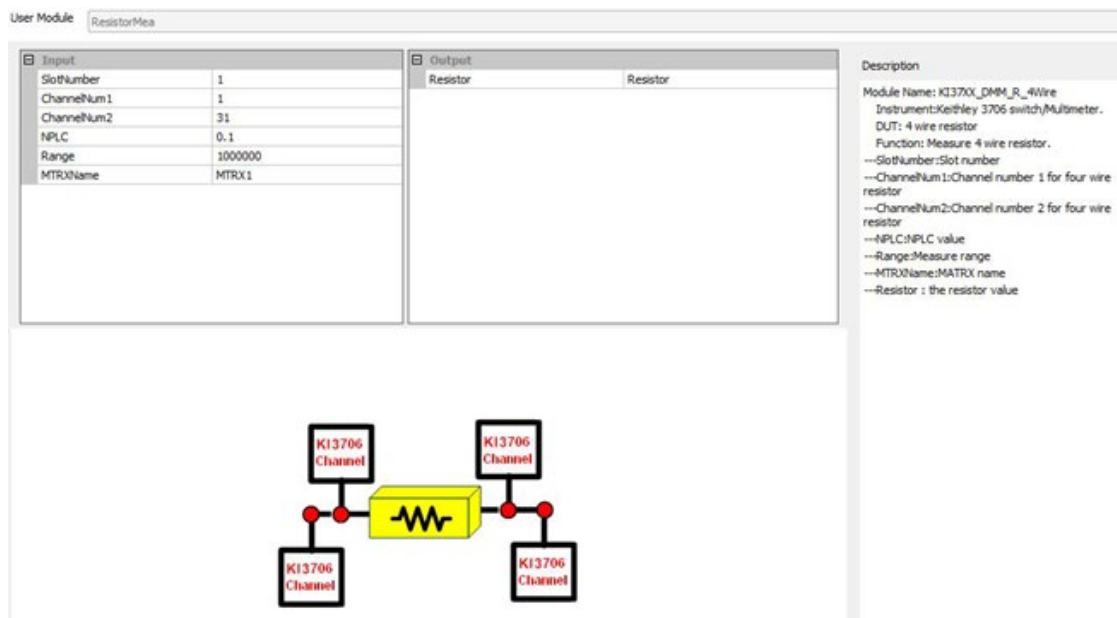
DUT: Four-wire resistor

Function: Measures a 4-wire resistor

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 264: FourWireResistor_3706 GUI



Gpibresistor_3706

Description:

Module Name: TwoWireResistor_3706

Module Type: PTM

Instrument: Keithley Model 3706

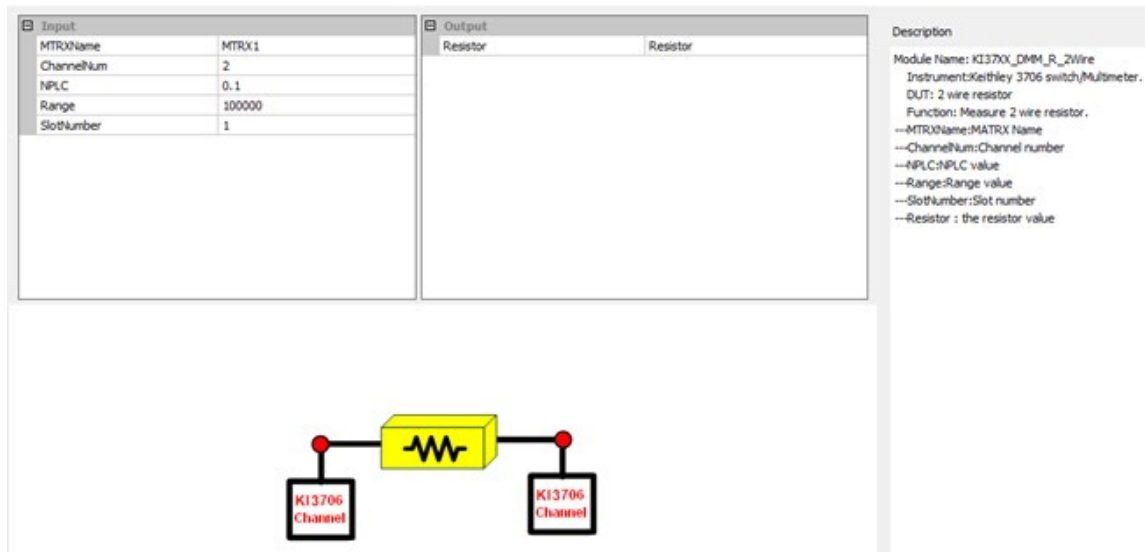
DUT: Two-wire resistor

Function: Measures a 2-wire resistor

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 265: TwoWireResistor_KI3706 GUI



Mixed_SMU_Mode Library

Mixed_SMU_Mode library overview

ACS Basic has a Mixed_SMU_Mode library, including some tests which can be performed with different instruments or combinations among these instruments.

Mixed_SMU_Mode library

BiasMeasV_Pulse_2430

Description:

Performs current pulse and voltages measurements with a Keithley Model 2430 in pulse mode. The Model 2430 SourceMeter is controlled over the GPIB bus only.

Module name: BiasMeasV_Pulse_24xx

Instrument: Keithley Model 2430 SourceMeter.

Results: Measures the results by forcing a current pulse.

INPUTS:

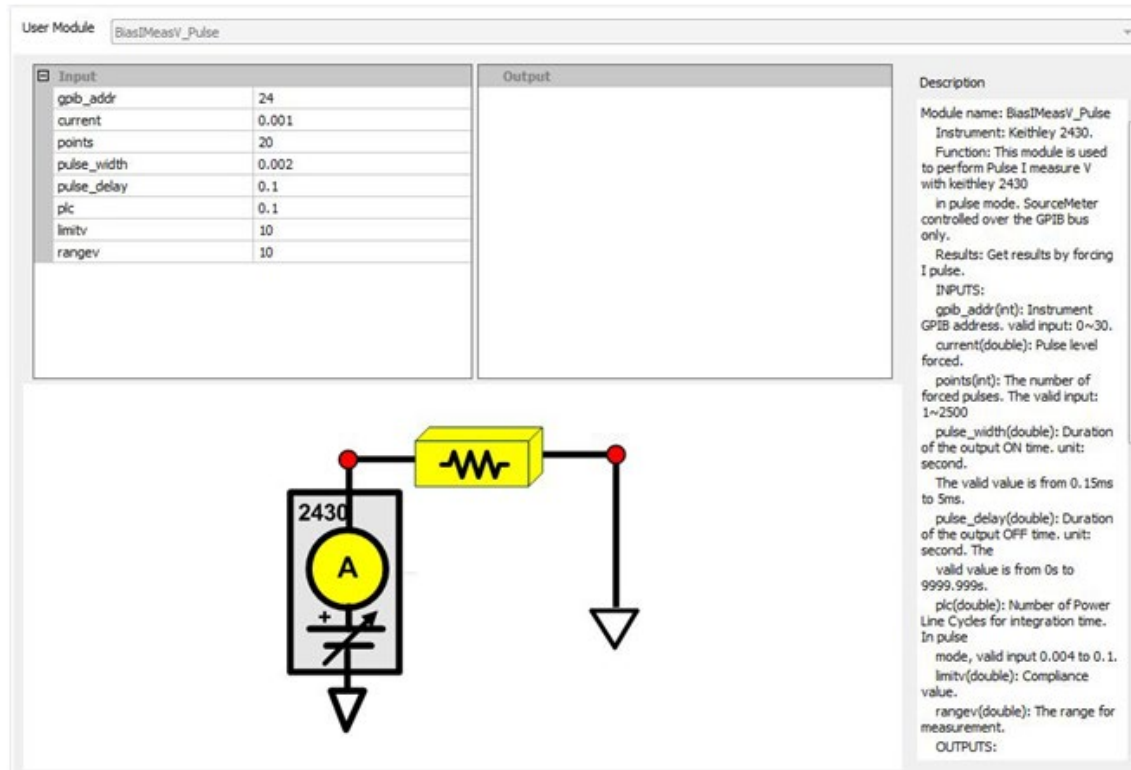
<code>gpiib_addr (int):</code>	Instrument GPIB address. Valid input: 0 through 30.
<code>current (double):</code>	Pulse level forced.
<code>points (int):</code>	The number of forced pulses. The valid input: 1 through 2500.
<code>pulse_width (double):</code>	Duration of the output ON time. Unit: second. The valid value is from 0.15 ms to 5 ms.
<code>pulse_delay (double):</code>	Duration of the output OFF time. Unit: second. The valid value is from 0 s to 9999.999 s.
<code>plc (double):</code>	Number of Power Line Cycles for integration time. In pulse mode, valid input 0.004 to 0.1.
<code>limitv (double):</code>	Compliance value.
<code>rangev (double):</code>	The range for measurement.

OUTPUTS:

<code>I</code>	
<code>V</code>	
<code>time</code>	
<code>Error:</code>	Error value
<code>0</code>	OK
<code>-1</code>	24xx not found on GPIB.
<code>-2</code>	2430 not found on GPIB.
<code>-200</code>	Initialize error occurred.
<code>-300</code>	Configuration error occurred.
<code>-400</code>	Reading error occurred.
<code>-10000</code>	(INVALID_INST_ID) The specified instrument ID does not exist.
<code>-10100</code>	(INVALID_PARAM) Parameter setting error occurred.
<code>-10090</code>	(GPIB_ERROR_OCCURRED) A GPIB communications error occurred.
<code>-10091</code>	(GPIB_TIMEOUT) A timeout occurred during communications.

GUI related:

Figure 266: BiasMeasV_Pulse GUI



BiasVMeasI_Pulse

Description:

Performs voltage pulse and current measurements with a Keithley Model 2430 in pulse mode. The Model 2430 SourceMeter is controlled over a GPIB bus only.

Module Type: PTM

Instrument: Keithley Model 2430 SourceMeter.

Results: Measures the results by forcing a voltage pulse.

INPUTS:

gpib_addr (int):	Instrument GPIB address. Valid input: 0 through 30.
voltage (double):	Pulse level forced.
points (int):	The number of forced pulses. The valid input: 1 through 2500.
pulse_width (double):	Duration of the output ON time. Unit: seconds. The valid value is from 0.15 ms to 5 ms.
pulse_delay (double):	Duration of the output OFF time. Unit: seconds. The valid value is from 0 s to 9999.999 s.
plc (double):	Number of power line cycles for integration time. In pulse mode, valid input 0.004 to 0.1.
limiti (double):	Compliance value.
rangei (double):	The range for measurement.

OUTPUTS:

I	
V	
time	
Error:	Error value
0	OK
-1	24xx not found on GPIB.
-2	2430 not found on GPIB.
-200	Initialize error occurred.
-300	Configuration error occurred.
-400	Reading error occurred.
-10000	(INVAL_INST_ID) The specified instrument ID does not exist.
-10100	(INVAL_PARAM) Parameter setting error occurred.
-10090	(GPIB_ERROR_OCCURRED) A GPIB communications error occurred.
-10091	(GPIB_TIMEOUT) A timeout occurred during communications.

GUI related:**Figure 267: BiasVMeasI_Pulse GUI**

The screenshot shows the BiasVMeasI_Pulse GUI interface. It includes an 'Input' table, a circuit diagram, and a 'Description' panel.

Input	
gpb_addr	24
voltage	1
points	20
pulse_width	0.005
pulse_delay	0.1
plc	0.01
limit	0.1
range	0.01

The circuit diagram shows a Keithley 2430 current source connected in series with a resistor, which is then connected to a load (represented by a downward-pointing triangle). The current source is labeled '2430' and 'A'.

Description

Module name: BiasVMeasI_Pulse
Instrument: Keithley 2430.
Function: This module is used to perform Pulse V measure I with keithley 2430
in pulse mode. SourceMeter controlled over the GPIB bus only.
Results: Get results by forcing V pulse.
INPUTS:
gpb_addr(int): Instrument GPIB address, valid input: 0~30.
voltage(double): Pulse level forced.
points(int): The number of forced pulses. The valid input: 1~2500
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.
limit(double): Compliance value.
range(double): The range for measurement.
OUTPUTS:

BiasVolt_SampleCurr_23x

Description:

Determines the bias voltage and takes current readings for the Model 236, 237, or 238.

Instrument: Keithley Model 236, 237, or 238 Source measure unit.

NOTE

These instruments cannot be automatically scanned by ACS Basic. You must configure them as a general purpose instruments. Refer to "Connect to external instruments" in the *ACS Basic Reference Manual* for information.

INPUTS:

instAddr:	GPIB address, 0 through 30, default is 17, change the address according to instrument setting.
BiasV:	Bias Voltage. Limit of value differs by model of the meter.
RangeV:	Source range: 0. Auto range. 0 through 4. Otherwise, the range is the smallest that can accommodate the input value. The Source range limit differs by different models of the meter.
DelayV:	Source Delay, 0 through 65000, default 0.
Compliance:	Current compliance of the sweep. 1E-9 through 1E-1. Value differs by model of the meter.
RangeCurr:	Measurement range for current. 0 through 9. 0: Auto range. Otherwise, the range is the smallest that can accommodate the input value. The Source range limit differs by model of the meter.
interval:	Sampling intervals. Valid input 0 to 1000 s.

OUTPUTS:

output_Curr:	Measured current
output_time:	Timestamp at each point
output_error:	Error value
0	OK
-10090	A GPIB communications error occurred.

GUI related:

Figure 268: BiasVolt_SampleCurr_23x GUI

The screenshot shows the GUI for the BiasVolt_SampleCurr_23x module. It features two tables for input and output parameters, a description of the module, and a timing diagram.

Input	
InstAddr	1
BiasV	2
RangeV	0
DelayV	0
Compliance	0.1
RangeCurr	0
NumSamples	21
Interval	0

Output	
output_Curr	Current
output_time	time
output_error	error

Description

This module is used to bias voltage and take current readings for 236/237/238

- InstAddr: GPIB address, 0~30, default is 17, change the address according to instrument setting
- BiasV: Bias Voltage. Limit of value differs by model of the meter. Please refer to the user manual for correct voltage limit.
- RangeV: Source range: 0: Auto range, 0~4. Otherwise, the range is the smallest that can accommodate the input value. The source range limit differs by different models of the meter. Please refer to user manual for correct range value
- 0 Auto
- 1 1.1V(236,237);1.5V(238)
- 2 11V(236,237);15V(238)
- 3 110V
- 4 1100V(237)
- DelayV: Source Delay, 0~65000, default 0
- Compliance: Current compliance of the sweep. 1E-9 ~ 1E-1. Value differs by different model of the meter. Please refer to the user manual for correct compliance limit.
- RangeCurr: measurement range for current. 0~10. 0: Auto

Timing Diagram: A graph showing Voltage (V) on the vertical axis and Time on the horizontal axis. A horizontal line represents the bias voltage V_{bias} . A horizontal arrow labeled "Holdtime" indicates the duration before the measurement. A horizontal double-headed arrow labeled "Time interval" indicates the duration of the current measurement.

BVcei_any_SMU

Description:

Use this test to test Collector-Emitter breakdown voltage of BJT, with Base forced a current. For details, refer to BVcei in [Mixed SMUs in pulse mode](#) (on page 2-339).

BVcev_any_SMU

Description:

Use this test to test Collector-Emitter breakdown voltage of BJT, with Base forced a voltage. For details, refer to BVcev in [Mixed SMUs in pulse mode](#) (on page 2-339).

BVdsv_any_SMU

Description:

Use this test to test Drain-Source breakdown voltage of a MOSFET with Gate-biased voltage. For details, refer to BVdsv in [Mixed SMUs in pulse mode](#) (on page 2-339).

combined_mixed_SMU

Description: This module provides a total solution for component characterization test.

Module Type: PTM

Instrument: Keithley Instruments Series 230, Series 2600, Series 2600A, Series 2400, Series 4200, and combinations of these SourceMeters

Syntax:

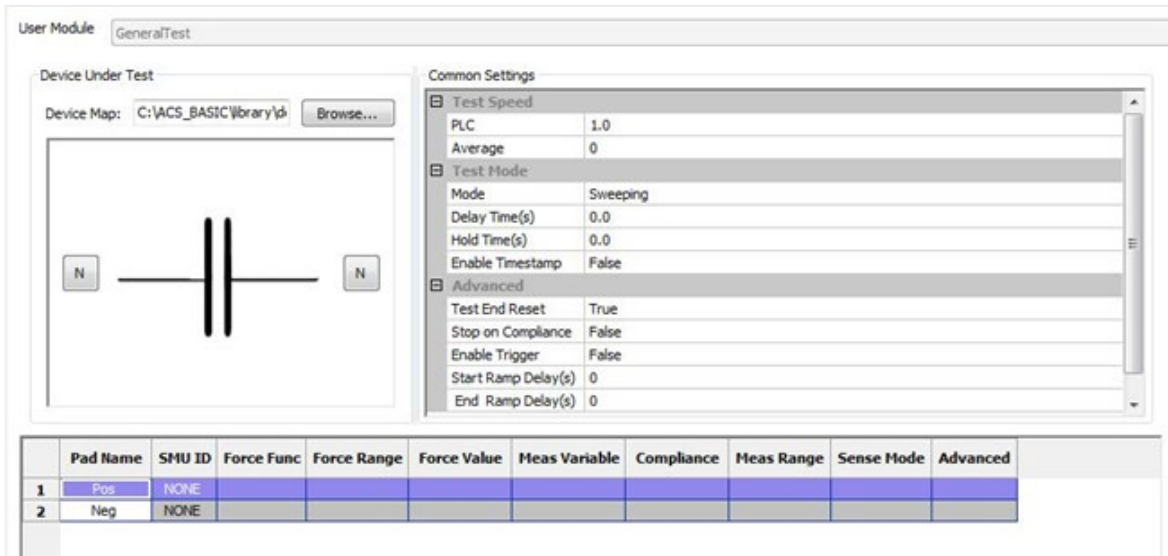
```
Combined_Test_Mixed_SMUs.GeneralTest(test_info,bias,sweep,step,open,src_range,meas_range,compliance,meas_pro,meas_seq,common)
```

INPUTS:

PLC:	Power line cycle. For optimum immunity to line cycle noise, use an integer number for the PLC (for example, 1, 2, or 3). The integration time setting is based on the number of power line cycles (NPLCs): For 60 Hz line power, 1.0 PLC = 16.67 msec (1/60) For 50 Hz line power, 1.0 PLC = 20 msec (1/50)
Average:	The Average edit box is only used for Series 230 and Series 2400 SMUs. For Series 2400 SMUs, the average number ranges from 0 to 1000. For Series 230 SMUs, select these numbers = [0,1,2,4,8,16,32] (note that zero [0] is used to disable the average number setup).
Mode:	The Mode edit box lets you choose one of two possible test modes: Sweep or Sampling.
Delay Time:	The delay time (DT) allows the source to settle at every step of a sweep. All SMUs in the test system are synchronized, therefore, the delay time applied by the most delayed SMU is the time applied to all of the SMUs. You can specify a delay time from 0 to 1000 seconds. The default delay time is 0 seconds.
Hold Time:	Specifies the time delay before the first measurement is taken. After the initial application of voltage or current by the SMUs, the source settling time can be substantial. To allow for settling, you can specify an extra Hold Time delay to be applied before making the first measurement. You can specify a Hold Time from 0 to 1000 seconds. Hold Time is a global setting, and is therefore the same for all of the SMUs in the test system.
Test End Reset:	Determines if the test results are cleared. You can select: False: Your test results are not cleared. True: Your test results are cleared. After the test is finished, it clears the test results.
Stop on compliance:	Determines what happens when compliance (limit) occurs. There are two choices: False: The test runs to completion, even if a SMU enters compliance. True: The test terminates immediately if a SMU enters compliance.
Enable Trigger:	Used for the Model 237 with the Model 2361 trigger controller. There are two choices: False: do not capture the measurement trigger value. True: capture the measurement trigger value.
Start Ramp Delay:	Time delay at each step of start ramp.
End Ramp Delay:	Time delay at each step of end ramp.

GUI related:

Figure 269: combined_mixed_SMU GUI



hFE_BJT_any_SMU

Description: Tests the HFE (DC current gain) of BJT.

Module Type: PTM

Instrument: Keithley Instruments Series 2650A, Series 2600A, Series Model 2400, and Series 4200-SMU

INPUTS:

CSMU:	Model 2651A SMU connected to Collector terminal.
BSMU:	SMU connected to Gate terminal.
vc_pulse:	Pulse level in volts on Collector terminal.
vc_base:	Base level in volts on Collector terminal.
Compliancei_CSMU:	Compliance (limit) value for Collector voltage force.
Meas_Rangei:	The current range for Collector current measure. For pulse mode, auto range is not allowed.
PLC:	PLC for SMU on Collector terminal.
pulse_width:	Duration of the output ON time.
pulse_delay:	Duration of the output OFF time.
Ib_start:	Start current of sweep on Base terminal.
Ib_stop:	Stop current of sweep on Base terminal.
Compliancev_BSMU:	Compliance value for Base current force.
points_sweep:	The number of points for Base sweep.
B2C_delay:	Gate to Collector delay, the time between Gate step and output of Collector pulse.
Sense_mode4BSMU:	Sense mode for SMU on Base terminal.
Sense_mode4CSMU:	Sense mode for SMU on Collector terminal.
Start_Ramp_Flag:	Enable or disable Soft-Ramp function at the start of bias.
End_Ramp_Flag:	Enable or disable Soft-Ramp function at the end of bias.
Start_Ramp_Delay:	Time delay at each step of start ramp.
End_Ramp_Delay:	Time delay at each step of end ramp.
Start_Ramp_Steps:	The number of steps at the start of Soft-Ramp.
End_Ramp_Steps:	The number of steps at the end of Soft-Ramp.

OUTPUTS:

Ib	Base current programmed.
Ic	Collector current measured at the specified Base bias current.
Vce:	Collector voltage measured.
Return Values:	
0	OK
-100	SMU configuration error
-200	Initialize error occurred.
-300	Pulse Configuration error occurred.
-400	Reading error occurred.
-10100	(INVAL_PARAM) Invalid parameter entered.

GUI related:

Figure 270: hFE_BJT_any_SMU module

The screenshot shows the GUI for the hFE_BJT module. It features an 'Input' table, an 'Output' table, and a 'Description' section. Below these is a circuit diagram of a BJT transistor with two SMU sources connected to its base and collector terminals.

Input	
CSMU	SMU3
BSMU	SMU1
vc_pulse	5
vc_base	0
Compliance_CSMU	20
Meas_RangeI	20
PLC	0.005
PulseOff	0.03
PulseWidth	0.0003
Ib_start	0.1
Ib_stop	1
Compliancev_BSMU	20
points_sweep	11

Output	
Ib	Ib
Ic	Ic
Vce	Vce

Description

Module name: hFE_BJT
Instrument: Keithley 2651A, 26xxA, 24xx and 42xx-SMU
DUT: BJT
Function: This module is used to test the hFE(DC current gain) of BJT.
Results: Get measured Collector current at Gate sweep current.
INPUTS:
CSMU (str): Model 2651A SMU connected to Collector terminal.
BSMU (str): SMU connected to Gate terminal.
vc_pulse (double): Pulse level in volts on Collector terminal.
vc_base (double): Base level in volts on Collector terminal.
Compliance_CSMU (double): Compliance value for Collector voltage force.
Meas_RangeI (double): The current range for Collector current measure. For pulse mode, auto range is not allowed.
PLC (double): PLC for SMU on Collector terminal.
pulse_width (double): Duration of the output ON time.
pulse_delay (double): Duration of the output OFF time.
Ib_start (double): Start current of sweep on Base terminal.
Ib_stop (double): Stop current of sweep on Base terminal.

IcVce_StepIb_any_SMU

Description:

Use this test module to measure the voltage and current at the Collector terminal while sweeping the Collector voltage for each voltage step at the Base terminal. For details, refer to [IcVce_StepIb in Mixed SMUs in pulse mode](#) (on page 2-339).

IcVce_StepVbe_any_SMU

Description:

Use this test module to measure the voltage and current at the Collector terminal while sweeping the Collector voltage for each voltage step at the Base terminal. For details, refer to [IcVce_StepVb in Mixed SMUs in pulse mode](#) (on page 2-339).

IcVce_StepVbe_any_SMU

Description:

Use this test module to measure the voltage and current at the Collector terminal while sweeping the Collector voltage for each voltage step at the Base terminal. For details, refer to IcVce_StepVb in [Mixed SMUs in pulse mode](#) (on page 2-339).

IcVce_StepVge_any_SMU

Description:

Use this test module to measure the voltage and current at the Collector terminal while sweeping the Collector voltage for each voltage step at the Gate terminal. For details, refer to IcVce_StepVge in [Mixed SMUs in pulse mode](#) (on page 2-339).

IcVge_any_SMU

Description: Use this module to test Collector current at Gate voltage sweep and specified Collector voltage, with measurement at Collector terminal in pulse mode.

Module Type: PTM

Instrument: Keithley Instruments Series 2650A, Series 2600A, Series 2400, and Series 4200-SMU

INPUTS:

CSMU:	Model 2651A SMU connected to Collector terminal.
BSMU:	SMU connected to Gate terminal.
vc_pulse:	Pulse level in volts on Collector terminal.
vc_base:	Base level in volts on Collector terminal.
Compliancei_CSMU:	Compliance (limit) value for Collector voltage force.
Meas_Rangei:	The current range for Collector current measure. For pulse mode, auto range is not allowed.
PLC:	PLC for SMU on Collector terminal.
pulse_width:	Duration of the output ON time.
pulse_delay:	Duration of the output OFF time.
Vg_start:	Start voltage of sweep on Gate terminal.
Vg_stop:	Stop voltage of sweep on Gate terminal.
Compliancei_GSMU:	Compliance value for Gate voltage force.
points_sweep:	The number of points for Gate sweep.
G2C_delay:	Gate to Collector delay, the time between Gate step and output of Collector pulse.
Sense_mode4GSMU:	Sense mode for SMU on Gate terminal.
Sense_mode4CSMU:	Sense mode for SMU on Collector terminal.
Start_Ramp_Flag:	Enable or disable Soft-Ramp function at the start of bias.
End_Ramp_Flag:	Enable or disable Soft-Ramp function at the end of bias.
Start_Ramp_Delay:	Time delay at each step of start ramp.
End_Ramp_Delay:	Time delay at each step of end ramp.
Start_Ramp_Steps:	The number of steps at the start of Soft-Ramp.
End_Ramp_Steps:	The number of steps at the end of Soft-Ramp.

OUTPUT:

Vg:	Gate voltage programmed.
Ic:	Collector current measured at the specified Gate bias current.
Vce:	Collector voltage measured.
Return Values:	
0	OK
-100	SMU configuration error
-200	Initialize error occurred.
-300	Pulse Configuration error occurred.
-400	Reading error occurred.
-10100	(INVAL_PARAM) Invalid parameter entered.

GUI related:

User Module: IcVge

Input	
CSMU	SMU3
GSMU	SMU1
vc_pulse	10
vc_base	0
Compliance_CSMU	50
Meas_RangeI	50
PLC	0.005
PulseOff	0.03
PulseWidth	0.0002
Vg_start	4
Vg_stop	9
Compliance_GSMU	0.01
points_sweep	5

Output	
Vg	Vg
Ic	Ic
Vce	Vce

Description

Module name: IcVge
Instrument: Keithley 2651A, 26xxA, 24xx and 42xx-SMU
DUT: IGBT
Function: This module is used to test Collector current at Gate voltage sweep and specified Collector voltage, with measurement at Collector terminal is in pulse mode.
Results: Get measured Collector current at Gate sweep voltage.
INPUTS:
CSMU (str): Model 2651A SMU connected to Collector terminal.
GSMU (str): SMU connected to Gate terminal.
vc_pulse (double): Pulse level in volts on Collector terminal.
vc_base (double): Base level in volts on Collector terminal.
Compliance_CSMU (double): Compliance value for Collector voltage force.
Meas_RangeI (double): The current range for Collector current measure. For pulse mode, auto range is not allowed.
PLC (double): PLC for SMU on Collector terminal.
pulse_width (double): Duration of the output ON time.
pulse_delay (double): Duration of the output OFF time.
Vg_start (double): Start voltage of sweep on Gate terminal.

IdVd_BiasVg_any_SMU**Description:**

Use this module to test Drain current at Drain voltage sweep and specified Gate voltage with measurement at a Drain terminal that is in pulse mode using the Keithley Instruments Model 265xA SourceMeter. For details, refer to IdVd_BiasVg in [Mixed SMUs in pulse mode](#) (on page 2-339).

IdON_any_SMU

Description: Use this module to determine the on-state Drain current. To measure current on Drain, apply a voltage sweep to Drain-Source. Use a specific Gate voltage to turn on the device to the Id current value given in the data sheet.

Module Type: PTM

Instrument: Keithley Instruments Series 2650A, Series 2600A, Series 2400, and Series 4200-SMU

INPUTS:

DSMU:	Model 2651A SMU connected to Drain terminal.
GSMU:	SMU connected to Gate terminal.
vd_start:	Start pulse voltage of Drain.
vd_stop:	Stop pulse voltage of Drain.
base_level:	Base level of pulse in volts.
points:	The number of points for Drain sweep.
Compliancei_DSMU:	Compliance (limit) value for Drain voltage force.
Meas_Rangei:	The current range for Drain current measure. For pulse mode, auto range is not allowed.
PLC:	PLC for SMU on Drain terminal.
pulse_width:	Duration of the output ON time.
pulse_delay:	Duration of the output OFF time.
Vg:	Voltage applied on Gate terminal.
Compliancei_GSMU:	Compliance value for Gate voltage force.
G2D_delay:	Gate to Drain delay; the time between Gate Step and the output of the first pulse in the Drain Sweep.
Sense_mode4GSMU:	Sense mode for SMU on Gate terminal.
Sense_mode4DSMU:	Sense mode for SMU on Drain terminal.
Start_Ramp_Flag:	Enable or disable Soft-Ramp function at the start of bias.
End_Ramp_Flag:	Enable or disable Soft-Ramp function at the end of bias.
Start_Ramp_Delay:	Time delay at each step of start ramp.
End_Ramp_Delay:	Time delay at each step of end ramp.
Start_Ramp_Steps:	The number of steps at the start of Soft-Ramp.
End_Ramp_Steps:	The number of steps at the end of Soft-Ramp.

OUTPUT:

Vd:	Drain voltage measured.
Id:	Drain current measured at the specified Gate bias current.
Return Values:	
0	OK
-100	SMU configuration error
-200	Initialize error occurred.
-300	Pulse Configuration error occurred.
-400	Reading error occurred.
-10100	(INVAL_PARAM) Invalid parameter entered.

GUI related:

Figure 271: IdON_any_SMU GUI

The screenshot shows the IdON GUI interface. On the left, there is an 'Input' table with parameters like DSMU, GSMU, vd_start, vd_stop, base_level, points, Compliance_DSMU, Meas_RangeI, PLC, PulseOff, PulseWidth, Vg, and Compliance_GSMU. On the right, there is an 'Output' table with Vd and Id. Below these is a circuit diagram showing a MOSFET with terminals D, G, and S. Two SMU units are connected: one to the Gate (G) and another to the Drain (D). A current source symbol is also present. To the right of the diagram is a 'Description' section with detailed information about the module name, instrument, DUT, function, results, and various input/output parameters.

Input	
DSMU	SMU3
GSMU	SMU1
vd_start	0
vd_stop	10
base_level	0
points	101
Compliance_DSMU	20
Meas_RangeI	5
PLC	0.005
PulseOff	0.03
PulseWidth	0.0003
Vg	10
Compliance_GSMU	0.001

Output	
Vd	Vd
Id	Id

Description

Module name: IdON
Instrument: Keithley 2651A, 260xA, 240x and 420x-SMU
DUT: Power MOSFET
Function: This module is used to determine the on-state Drain current. Measure current on Drain by applying voltage sweep to Drain-Source with specific Gate voltage to turn on the device to certain Id current value given in datasheet.
Results: Get measured Drain current at Gate specified voltage.
INPUTS:
DSMU (str): Model 2651A SMU connected to Drain terminal.
GSMU (str): SMU connected to Gate terminal.
vd_start (double): Start pulse voltage of Drain.
vd_stop (double): Stop pulse voltage of Drain.
base_level (double): Base level of pulse in volts.
points (int): The number of points for Drain sweep.
Compliance_DSMU (double): Compliance value for Drain voltage force.
Meas_RangeI (double): The current range for Drain current measurement. For pulse mode, auto range is not allowed.
PLC (double): PLC for SMU on Drain terminal.
pulse_width (double): Duration of the output ON time.

IdVg_24xx

Description:

Use this test to test the Drain current at a specified Drain voltage and Gate voltage sweep. For details, refer to IdVg in [Mixed SMUs in pulse mode](#) (on page 2-339).

IdVd_StepVg_any_SMU

Description:

Use this module test Drain current at Drain voltage sweep and specified Gate voltage with measurement at Drain terminal that is in pulse mode using the Keithley Instruments Series 265xA SourceMeter. For details, refer to IdVd_StepVg in [Mixed SMUs in pulse mode](#) (on page 2-339).

Idvd_24xx

Description: Tests the Drain current at a specified Gate voltage and Drain voltage sweep.

Module Type: PTM

Instrument: Keithley Model 2400 SourceMeter.

DUT: MOSFET, Source and bulk to be grounded.

Pin 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):	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.
hold_time (double):	Sweep first point hold time.
delay_time (double):	Sweep delay time.

OUTPUT:

Vd	Drain voltage programmed.
Id1	Drain current measured at the 1st Gate bias voltage.
Id2	Drain current measured at the 2nd Gate bias voltage.
Id3	Drain current measured at the 3rd Gate bias voltage.
Id4	Drain current measured at the 4th Gate bias voltage.
...	
Error:	Error value
0	OK
-1	24xx not found on GPIB
-200	Initialize error occurred.
-400	Reading error occurred.
-10000	(INVAL_INST_ID) The specified instrument ID does not exist.
-10090	(GPIB_ERROR_OCCUR) A GPIB communications error occurred.
-10091	(GPIB_TIMEOUT) A timeout occurred during communications.
-10100	(INVAL_PARAM) Invalid parameter entered.

GUI related:

Figure 272: IdVd_24xx GUI

The screenshot shows the 'User Module' window for 'IdVd'. It features an 'Input' table, an 'Output' field, and a 'Description' section. Below the input table is a circuit diagram of a MOSFET test setup. The circuit includes a MOSFET with its gate connected to a 24XX SMU (Source Measure Unit) and its drain connected to another 24XX SMU. A current source (A) is connected to the drain. A graph in the top left of the diagram shows Id vs Vd curves. The 'Description' section provides details about the module name, instrument, DUT, function, pin connections, results, and input parameters.

Input	
drain_addr	24
gate_addr	25
vd_start	0
vd_stop	2
points	51
limit	0.1
range	0
plc	1
vg_start	0.5
vg_stop	2.5
vg_step	0.5
hold_time	0.01
delay_time	0.001

Output

Description

Module name: IdVd
 Instrument: Keithley 24xx.
 DUT: MOSFET, source and bulk to be grounded
 Function: This module is used to test drain current at specified gate voltage and drain voltage sweep.
 Pin Connection: Drain swept, Gate biased. Bulk and Source connected to ground if not applied voltage.
 Results: Get measured Drain current at Drain voltage sweep and 10 Gate bias voltages at most.

INPUTS:

- drain_addr (int) : drain terminal 24xx 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.
- limit (double) Compliance value for drain voltage force. The valid input is from -10A to 10A.
- range (double) The current range for drain current measure. For pulse mode, auto range is not allowed. Valid input: -10~10
- plc (double) Number of Power Line Cycles for integration time. For pulse mode, valid input

IdVd_Pulse_24xx

Description:

This module tests Drain current at specified Gate voltage and Drain voltage sweep, with measurement at Drain terminal in sweep pulse mode using the Keithley 2430 SourceMeter controlled over the GPIB bus only.

Module Type: PTM

Instrument: Keithley Model 2400 SourceMeter, at least one Model 2430 SourceMeter.

INPUTS:

Drain_addr (int):	Drain terminal 2430 GPIB address.
Gate_addr (int):	Gate terminal 24xx GPIB address.
vd_start (double):	Start pulse voltage of Drain.
vd_stop (double):	Stop pulse voltage of Drain.
points (int):	The number of points for Drain sweep.
limiti (double):	Compliance value for Drain voltage force. The valid input is from -10A to 10A.
rangei (double):	The current range for Drain current measure. For pulse mode, 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 0.15 ms to 5 ms.
pulst_delay (double):	Duration of the output OFF time. The valid value is from 0 s to 9999.999 s.

OUTPUT:

Vd	(D_ARRAY_T) Drain voltage programmed.
Idi	(D_ARRAY_T) Drain current measured at the first Gate bias voltage.
Error:	Error value
0	OK
-1	24xx not found on GPIB
-2	2430 not found on GPIB
-200	Initialize error occurred.
-300	Configuration error occurred.
-400	Reading error occurred.
-10000	(INVAL_INST_ID) The specified instrument ID does not exist.
-10090	(GPIB_ERROR_OCCUR) A GPIB communications error occurred.
-10091	(GPIB_TIMEOUT) A timeout occurred during communications.
-10100	(INVAL_PARAM) Invalid parameter entered.

GUI related:

Figure 273: IdVd_Pulse_24xx

User Module IdVd_Pulse

Input		
drain_addr	24	
gate_addr	25	
vd_start	0	
vd_stop	3	
points	51	
limit	0.1	
rangei	0.1	
pic	0.01	
vg_start	0.5	
vg_stop	2	
vg_step	0.5	
pulse_width	0.001	
pulse_delay	0.1	

Description

Module name: IdVd_Pulse
 Instrument: Keithley 24xx, at least one 2430
 DUT: MOSFET, source and bulk to be grounded
 Function: This module is used to test drain current at specified Gate voltage and Drain voltage sweep, with measurement at Drain term is in sweep pulse mode using the Keithley 2430 SourceMeter controlled over the GPIB bus only.
 Pin Connection: Drain swept, Gate biased. Bulk and Source connected to ground if not applied voltage.
 Results: Get measured Drain current in sweep pulse mode at 10 Gate bias voltages at most

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.
- limit (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

IdVg_BiasVd_any_SMU

Description: Use this module to test Drain current at Gate voltage sweep and specified Drain voltage. The measurement at the Drain terminal is in pulse mode.

Module Type: PTM

Instrument: Keithley Instruments Series 2650A, Series 2600A, Series 2400, and Series 4200-SMU

INPUTS:

DSMU:	Model 2651A SMU connected to Drain terminal.
GSMU:	SMU connected to Gate terminal.
vd_pulse:	Pulse level in volts on Drain terminal.
vd_base:	Base level in volts on Drain terminal.
Compliancei_DSMU:	Compliance (limit) value for Drain voltage force.
Meas_Rangei:	The current range for Drain current measure. For pulse mode, auto range is not allowed.
PLC:	PLC for SMU on Drain terminal.
pulse_width:	Duration of the output ON time.
pulse_delay:	Duration of the output OFF time.
Vg_start:	Start voltage of sweep on Gate terminal.
Vg_stop:	Stop voltage of sweep on Gate terminal.
Compliancei_GSMU:	Compliance (limit) value for Gate voltage force.
G2D_delay:	Gate to Drain delay; the time between Gate Step and the output of the first pulse in the Drain pulse.
Sense_mode4GSMU:	Sense mode for SMU on Gate terminal.
Sense_mode4DSMU:	Sense mode for SMU on Drain terminal.
Start_Ramp_Flag:	Enable or disable Soft-Ramp function at the start of bias.
End_Ramp_Flag:	Enable or disable Soft-Ramp function at the end of bias.
Start_Ramp_Delay:	Time delay at each step of start ramp.
End_Ramp_Delay:	Time delay at each step of end ramp.
Start_Ramp_Steps:	The number of steps at the start of Soft-Ramp.
End_Ramp_Steps:	The number of steps at the end of Soft-Ramp.

OUTPUT:

Vg:	Gate voltage programmed.
Id:	Drain current measured at the specified Gate bias current.
Vd:	Drain voltage measured.
Return Values:	
0	OK
-100	SMU configuration error
-200	Initialize error occurred.
-300	Pulse Configuration error occurred.
-400	Reading error occurred.
-10100	(INVAL_PARAM) Invalid parameter entered.

GUI related:**Figure 274: IdVg_BiasVd_any_SMU GUI**

The screenshot displays the GUI for the 'IdVg_BiasVd' module. It is divided into several sections:

- User Module:** IdVg_BiasVd
- Input Parameters:**

DSMU	SMU3
GSMU	SMU1
vd_pulse	17.5
vd_base	0
Compliance_DSMU	50
Meas_RangeI	5
PLC	0.005
PulseOff	0.03
PulseWidth	0.0003
Vg_start	0
Vg_stop	10
Compliance_GSMU	0.001
points_sweep	101
- Output Parameters:**

Vg	Vg
Id	Id
Vd	Vd
- Description:**

Module name: IdVg_BiasVd
Instrument: Keithley 2651A, 26xxxA, 24xx and 42xx-SMU
DUT: Power MOSFET
Function: This module is used to test Drain current at Gate voltage sweep and specified Drain voltage, with measurement at Drain terminal in pulse mode.
Results: Get measured Drain current at Gate sweep voltage.
INPUTS:
DSMU (str): Model 2651A SMU connected to Drain terminal.
GSMU (str): SMU connected to Gate terminal.
vd_pulse (double): Pulse level in volts on Drain terminal.
vd_base (double): Base level in volts on Drain terminal.
Compliance_DSMU (double): Compliance value for Drain voltage force.
Meas_RangeI (double): The current range for Drain current measure. For pulse mode, auto range is not allowed.
PLC (double): PLC for SMU on Drain terminal.
pulse_width (double): Duration of the output ON time.
pulse_delay (double): Duration of the output OFF time.
Vg_start (double): Start voltage of sweep on Gate terminal.
Vg_stop (double): Stop voltage of sweep on Gate
- Circuit Diagram:** A schematic diagram showing a MOSFET with its Gate terminal connected to an SMU (SMU1) and its Drain terminal connected to another SMU (SMU3). A current source symbol is shown at the Drain terminal, and a current measurement symbol (A) is connected in series with the Drain terminal.

IdVg_Pulse_24xx

Description:

Tests the Drain current at the Gate voltage sweep and a specified Drain voltage, with measurements at the Drain terminal in pulse mode using the Keithley Model 2430 SourceMeter that is controlled through a GPIB bus only.

Module Type: PTM

Instrument: Keithley Model 2400 SourceMeter (at least one Model 2430 SourceMeter).

Pin 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 V_{tx} and V_{t0}

INPUTS:

<code>Drain_addr (int):</code>	Drain terminal 2430 GPIB address.
<code>Gate_addr (int):</code>	Gate terminal 24xx GPIB address.
<code>vg_start (double):</code>	Start voltage of Gate. The valid input is from -200 V to 200 V.
<code>vg_stop (double):</code>	Stop voltage of Gate. The valid input is from -200 V to 200 V.
<code>points (int):</code>	The number of points for Gate sweep.
<code>vd (double):</code>	Drain bias voltage.
<code>hold_time (double):</code>	Hold time in seconds before Gate sweep. The valid value is from 0 s to 9999.999 s.
<code>delay_time (double):</code>	Delay time in seconds between each Gate sweep point. The valid value is from 0 s to 9999.999 s.
<code>limiti (double):</code>	Compliance (limit) value for Drain voltage force. The valid input is from -10 A to 10 A.
<code>rangei (double):</code>	The current range for Drain current measure. For pulse mode, auto range is not allowed. Valid input: -10 A through 10 A.
<code>plc (double):</code>	Number of power line cycles for integration time. For pulse mode, valid input 0.004 to 0.1.
<code>pulse_width (double):</code>	Output on time of the pulse for Drain voltage force. The valid input is from 150 μ s to 5 ms

NOTE

Pulse width should be longer than 200 μ s 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.

<code>pulse_delay (double):</code>	Output off of the pulse for Drain voltage force. The valid input is from 0 to 9999.999.
------------------------------------	---

OUTPUT:

Id	(D_ARRAY_T) Drain current measured at Gate sweep voltage.
Vg	(D_ARRAY_T) Gate voltage programmed.
Gm	(D_ARRAY_T) $G_m = dI_d/dV_g$
Vtx	(double*) $V_{tx} = V_{t0} - V_s/2$
Vt0	(double*) Calculate $G_m = dI_d/dV_g$. Find G_{mmax} and extrapolate back to $I_{ds} = 0$ to find V_{t0}
Error:	Error value
0	OK
-1	24xx not found on GPIB
-2	2430 not found on GPIB
-200	Initialize error occurred.
-300	Configuration error occurred.
-400	Reading error occurred.
-10000	(INVAL_INST_ID) The specified instrument ID does not exist.
-10090	(GPIB_ERROR_OCCUR) A GPIB communications error occurred.
-10091	(GPIB_TIMEOUT) A timeout occurred during communications.
-10100	(INVAL_PARAM) Invalid parameter entered.

GUI related:**Figure 275: IdVg_Pulse_24xx GUI**

The screenshot displays the 'User Module' interface for 'IdVg_Pulse'. It features an 'Input' table with parameters such as drain_addr (24), gate_addr (25), vg_start (0), vg_stop (3), points (51), vd (0.1), hold_time (0.1), delay_time (0.001), limit (0.1), range1 (0.1), plc (0.01), pulse_width (0.001), and pulse_delay (0.1). An 'Output' field is currently empty. A central circuit diagram shows a MOSFET with a 24XX SML current source and a 2430 current source connected to its drain and gate. A small graph in the top left shows current (I) versus voltage (V). The 'Description' panel on the right provides details about the module name, instrument requirements, function (drain current measurement at gate voltage sweep), pin connections, and a list of results and inputs.

Input Parameters:

Parameter	Value
drain_addr	24
gate_addr	25
vg_start	0
vg_stop	3
points	51
vd	0.1
hold_time	0.1
delay_time	0.001
limit	0.1
range1	0.1
plc	0.01
pulse_width	0.001
pulse_delay	0.1

Description:

Module name: IdVg_Pulse
Instrument: Keithley 24xx, at least one 2430.
DUT: MOSFET, source and bulk to be grounded
Function: This module is used to test drain current at Gate voltage sweep and specified Drain voltage, with measurement at Drain term is in pulse mode using the Keithley 2430 SourceMeter controlled by over the GPIB bus only.
Pin Connection: Gate sweep, Drain bias. Bulk and Source connected to ground if not applied voltage.
Results:
1) get measured Drain current at Gate voltage sweep and Drain in pulse mode
2) get results 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)

RdsOn_any_SMU

Description:

Use this module to test drain current at Drain voltage sweep and specified Gate voltage with measurement at Drain terminal that is in pulse mode using the Keithley Instruments Series 265xA SourceMeter. For details, refer to Rdson in [Mixed SMUs in pulse mode](#) (on page 2-339).

SweepCurr_23x

Description:

Sweeps current and take I/V/Time readings for the Model 236, 237, or 238.

Instrument: Keithley Models 236, 237, and 238 source measure units.

NOTE

These instruments cannot be automatically scanned by ACS Basic. You must configure them as a general purpose instruments. Refer to "Connect to external instruments" in the *ACS Basic Reference Manual* for information.

INPUTS:

instAddr:	GPIB address, 0 through 30, default is 17, change the address according to instrument setting.
SweepMode:	Sweep Mode. 0: fixed bias, sampling measurement 1: Linear sweep; 2: Log sweep.
StartI:	Start current of the sweep. If in sampling mode, this is the output Source value. Value differs by model of the meter.
StopI:	Stop current of the sweep. Value differs by model of the meter.
NumofPoints:	Number of sweep points. Valid input 1 to 1000 for fixed bias mode and linear mode. For log sweep mode, valid input is: 0: 5 points per decade sweep 1: 10 points per decade sweep 2: 25 points per decade sweep 3: 50 points per decade sweep
ComplianceV:	Voltage compliance of the sweep. Value differs by model of the meter.
SourceRange:	Source range. 0: 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 0 s to 9999.999 s.
SweepDelay:	Delay time between each sweep point. Valid input 0 s to 9999.999 s.
Integration:	A/D integration speed: 0: fast 1: medium 2: long, 1 PLC (60 Hz) 3: long, 1 PLC (50 Hz)

OUTPUT:

output_V:	Measured voltage
output_I:	Measured current
output_time:	Timestamp at each point
output_error:	Error value
0	OK
-10090	(GPIB_ERROR_OCCUR) A GPIB communications error occurred.
-10100	(INVAL_PARAM) Invalid parameter entered.

GUI related:**Figure 276: SweepCurr_23x GUI**

The screenshot shows the SweepCurr_23x GUI interface. It features a 'User Module' dropdown set to 'SweepCurr_23x'. The interface is divided into three main sections: Input parameters, Output parameters, and a Description. Below these is a circuit diagram and a 'Sweep' control icon.

Input	
InstAddr	1
SweepMode	2
StartI	0.0001
StopI	0.001
NumofPoints	0
ComplianceV	10
SourceRange	0
MeasureRange	0
HoldTime	1
SweepDelay	0.1
Integration	3

Output	
output_V	V
output_I	I
output_time	time
output_error	error

Description

This module is used to sweep current and take I/V/Time readings for 236/237/238. ---InstAddr: GPIB address, 0~30, 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 differs by different model of the meter. Please refer to the user manual for correct limit
 ---StopI: Stop current of the sweep. Value differs by different model of the meter. Please refer to the user manual for correct limit
 ---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 different model of the meter. Please refer to the user manual for correct

The circuit diagram shows a current source labeled 'K123X' connected in series with a resistor (represented by a yellow box with a zigzag line). The circuit is connected to a ground symbol. A red circular icon with a white sawtooth wave and the word 'Sweep' is positioned below the circuit.

SweepI_MeasV_24xx

Description:

Sweep the current signal and make I/V/Time readings for the Model 2400, 2410, 2420, 2425, or 2430 SourceMeter.

Module name: SweepI_MeasV

Instrument: Keithley Models 2400, 2410, 2420, 2425, or 2430 SourceMeter.

These instruments cannot be hardware-scanned by ACS Basic. They must be added as a General Purpose Instruments through KI System Configuration. See the *ACS Basic Reference Manual* for instruction.

INPUTS:

<code>gpi_b_addr (int):</code>	Instrument GPIB address. Valid input: 1 through 30.
<code>start_i (double):</code>	Start signal level of the sweep. Value differs by model of the SourceMeter.
<code>stop_i (double):</code>	Stop signal level of the sweep. Value differs by model of the SourceMeter.
<code>points (int):</code>	Number of sweep points. Valid input 1 to 2500.
<code>limit_v (double):</code>	Compliance (limit) of the sweep. Value differs by model of the SourceMeter.
<code>srange_i (double):</code>	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 SourceMeter.
<code>mrange_v (double):</code>	Measurement range for voltage. 0: Auto range. Otherwise, the range is the smallest that can accommodate the input value. The source range limit differs by model of the SourceMeter.
<code>holdtime (double):</code>	Time sitting at the first point of sweep. Valid input 0 s to 9999.999 s.
<code>delay_time (double):</code>	Delay time between each sweep point. Valid input 0 s to 9999.999 s.
<code>plc (double)</code>	A/D integration time in terms of power line cycles (PLCs). Valid input 0.01 to 10.

OUTPUT:

<code>I</code>	
<code>V</code>	
<code>time</code>	
<code>Error:</code>	Error value
<code>0</code>	OK
<code>-200</code>	Instrument initialize error.
<code>-300</code>	Configuration error occurred.
<code>-400</code>	Reading error occurred.
<code>-10000</code>	(<code>INVAL_INST_ID</code>) The specified instrument ID does not exist.
<code>-10090</code>	(<code>GPIB_ERROR_OCCUR</code>) A GPIB communications error occurred.
<code>-10091</code>	(<code>GPIB_TIMEOUT</code>) A timeout occurred during communications.

GUI related:

Figure 277: SweepI_MeasV_24xx GUI

User Module SweepI_MeasV

Input	Output	Description
gpib_addr	24	<p>MODULE: SweepI_MeasV</p> <p>Function: This module is used to sweep 1 signal and take I/V/Time readings for 2400/2410/2420/2425/2430.</p> <p>INPUTS:</p> <p>gpib_addr(nt): Instrument GPIB address. valid input: 1~30</p> <p>start(double): Start signal level of the sweep. Value differs by different model of the meter. Please refer to the user manual for correct limits.</p> <p>stop(double): Stop signal level of the sweep. Value differs by different model of the meter. Please refer to the user manual for correct limit.</p> <p>points(nt): number of sweep points. Valid input 1 to 2500</p> <p>limitv(double): compliance of the sweep. Value differs by different model of the meter. Please refer to the user manual for correct compliance limit.</p> <p>srange(double): Source range. 0: Auto range. Otherwise, the range is the smallest that can accommodate the input value. The source range limit differs by different module</p>
start	0.0001	
stop	0.001	
points	51	
limitv	1	
srange	0	
mrangev	0	
hold_time	0.01	
delay_time	0.001	
plc	1	

SweepVolt_23x

Description:

Sweeps voltage and takes I/V/Time readings for the Model 236, 237, or 238.

Instrument: Keithley Models 236, 237, and 238 Source measure units.

NOTE

These instruments cannot be automatically scanned by ACS Basic. You must configure them as a general purpose instruments. Refer to "Connect to external instruments" in the *ACS Basic Reference Manual* for information.

INPUTS:

instAddr:	GPIB address, 0 through 30, default is 17, change the address according to instrument setting.
SweepMode:	Sweep Mode. 0: fixed bias, sampling measurement 1: Linear sweep; 2: Log sweep.
StartV:	Start voltage of the sweep. If in sampling mode, this is the output bias value.
StopV:	Stop voltage of the sweep. The limit of the value differs by the model of the meter.
NumofPoints:	Number of sweep points. Valid input 1 to 1000 for fixed bias mode and linear mode. For log sweep mode, valid input is: 0: 5 points per decade sweep 1: 10 points per decade sweep 2: 25 points per decade sweep 3: 50 points per decade sweep
ComplianceI:	Current compliance of the sweep. Value differs by model of the meter.
SourceRange:	Source range. 0: 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 0 s to 9999.999 s.
SweepDelay:	Delay time between each sweep point. Valid input 0 s to 9999.999 s.
Integration:	A/D integration speed: 0: fast 1: medium 2: long, 1 PLC (60 Hz) 3: long, 1 PLC (50 Hz)

OUTPUTS:

output_V:	Measured voltage
output_I:	Measured current
output_time:	Timestamp at each point
output_error:	Error value
0	OK
-1	23x not found on GPIB
-10000	(INVAL_INST_ID) The specified instrument ID does not exist.
-10090	(GPIB_ERROR_OCCUR) A GPIB communications error occurred.
-10091	(GPIB_TIMEOUT) A timeout occurred during communications.
-10100	(INVAL_PARAM) Invalid parameter entered.

GUI related:

User Module: SweepVolt_23x

Input		Output	
instAddr	1	output_V	V
SweepMode	1	output_I	I
StartV	0	output_time	time
StopV	2	output_error	error
NumofPoints	21		
ComplianceI	0.1		
SourceRange	0		
MeasureRange	0		
HoldTime	0		
SweepDelay	0.1		
Integration	3		

Description

This module is used to sweep voltage and take I/V/Time readings for 236/237/238. Run config23x prior to this Module.

---instAddr:GPIB address, 0~30, 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. Please refer to the user manual for correct voltage limit

---StopV:Stop Voltage of the sweep. Limit of value differs by model of the meter. Please refer to the user manual for correct voltage limit

---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. Please refer to theuser manual for correct

SweepV_MeasI_24XX

Description:

Sweeps the voltage signal and takes I/V/Time readings for the Model 2400, 2410, 2420, 2425, or 2430 SourceMeter.

Module name: SweepV_MeasI

Instrument: Keithley Models Model 2400, 2410, 2420, 2425, or 2430 SourceMeter.

INPUTS:

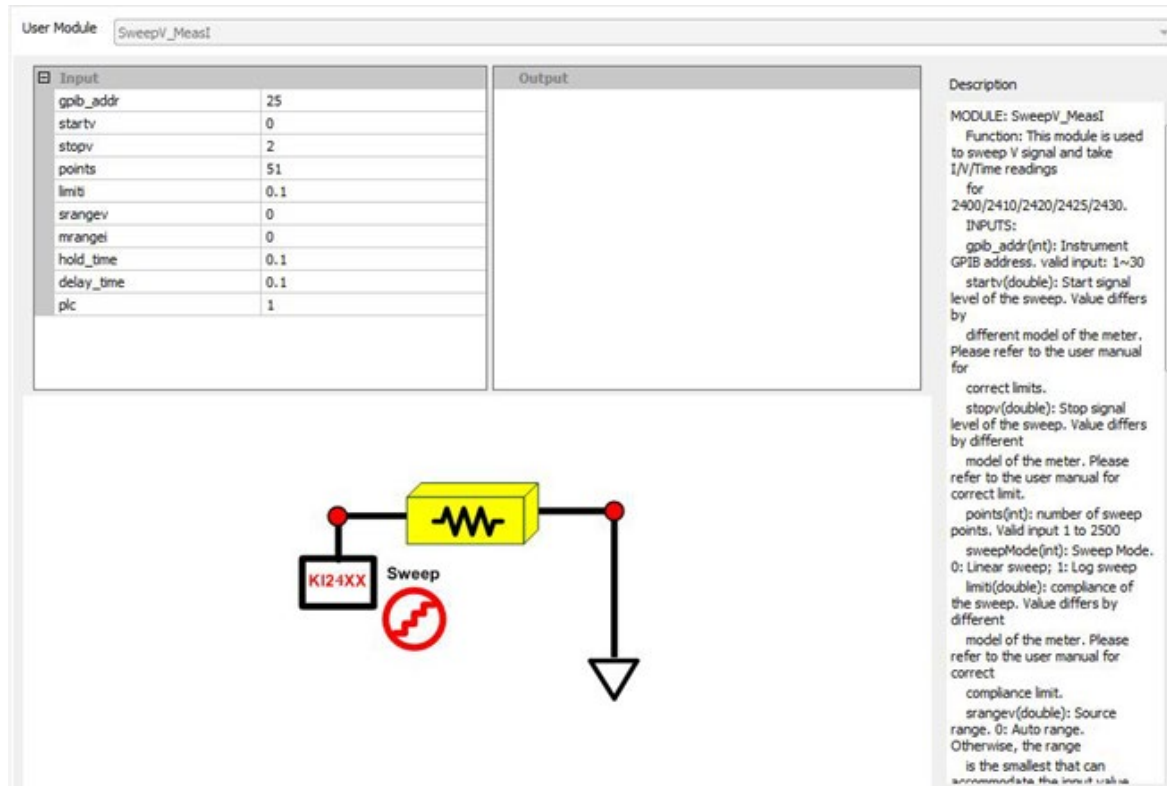
<code>gpib_addr (int):</code>	Instrument GPIB address. Valid input: 1 through 30.
<code>startv (double):</code>	Start signal level of the sweep. Value differs by model of the SourceMeter.
<code>stopv (double):</code>	Stop signal level of the sweep. Value differs by model of the SourceMeter.
<code>points (int):</code>	Number of sweep points. Valid input 1 to 2500.
<code>sweepMode (int):</code>	Sweep Mode. 0: Linear sweep; 1: Log sweep.
<code>limiti (double):</code>	Compliance (limit) of the sweep. Value differs by model of the SourceMeter.
<code>srangev (double):</code>	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 SourceMeter.
<code>mrangei (double):</code>	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 SourceMeter.
<code>holdtime (double):</code>	Time sitting at the first point of sweep. Valid input 0 s to 9999.999 s.
<code>delay_time (double):</code>	Delay time between each sweep point. Valid input 0 s to 9999.999 s.
<code>plc (double)</code>	A/D integration time in terms of power line cycles (PLCs). Valid input 0.01 to 10.

OUTPUTS:

<code>I</code>	
<code>V</code>	
<code>time</code>	
<code>Error:</code>	Error value
<code>0</code>	OK
<code>-200</code>	Instrument initialize error.
<code>-300</code>	Configuration error occurred.
<code>-400</code>	Reading error occurred.
<code>-10000</code>	(INVAL_INST_ID) The specified instrument ID does not exist.
<code>-10090</code>	(GPIB_ERROR_OCCUR) A GPIB communications error occurred.
<code>-10091</code>	(GPIB_TIMEOUT) A timeout occurred during communications.

GUI related:

Figure 278: SweepV_Meas1 GUI



Vcesat_bjt_any_SMU

Description:

Use this test module to measure the Collector-Emitter saturation voltage. A current sweep occurs at the Collector terminal with a fixed current applied from Base to Emitter terminals. For details, refer to Vcesat_bjt in [Mixed SMUs in pulse mode](#) (on page 2-339).

Vcesat_IGBT_any_SMU

Description:

Use this test module to measure the Collector-Emitter saturation voltage. A current sweep occurs at the Collector terminal with a fixed voltage applied on the Gate terminal. For details, refer to Vcesat_IGBT in [Mixed SMUs in pulse mode](#) (on page 2-339).

VdsId_237

Description:

High voltage measurement of the current Id at the same time forcing Vd and stepping Vg.

Instrument: Keithley Model 236, 237, or 238 source measure unit; Model 4200-SCS.

NOTE

These instruments cannot be automatically scanned by ACS Basic. You must configure them as a general purpose instruments. Refer to "Connect to external instruments" in the *ACS Basic Reference Manual* for information.

Device connection:

Drain: KI237

Gate, sub, well: Each corresponds with a SMU (for example, SMU1, SMU2, or SMU8 in the Model 4200).

INPUTS:

instAddr:	GPIO address of the Model 237. Valid from 0 through 30.
GateSMU:	The system terminal is attached to the Gate of the MOSFET. If 'GNDU' is chosen, the terminal should be connected to GND manually.
SourceSMU:	The system terminal is attached to the Source of the MOSFET. If 'GNDU' is chosen, the terminal should be connected to GND manually.
SubSMU:	The system terminal is attached to the sub of the MOSFET. If 'GNDU' is chosen, the terminal should be connected to GND manually.
WellSMU:	The system terminal is attached to the well of the MOSFET. If 'GNDU' is chosen, the terminal should be connected to GND manually; if there is no well terminal, choose 'NONE'.
VgStart:	Start voltages of Gate in volts.
VgStop:	End voltages of Gate in volts.
VgPoint:	Number of intervals of forced Vg.
VdStart:	Start voltages of Drain in volts.
VdStop:	End voltages of Drain in volts.
VdPoint:	Number of intervals of forced Vd.
IdLimit:	Current limits on measured sites in amperes.
Integration:	A/D integration speed: 0: fast 1: medium 2: long, 1 PLC (60 Hz) 3: long, 1 PLC (50 Hz)
DelayTime:	Delay time of one measurement in seconds.
VscForce:	Voltage bias force to Source.
VsbForce:	Voltage bias force to Sub.
VwForce:	Voltage bias force to Well.
VgMsrFlag:	Flag for determining if Vg is measured.
IgMsrFlag:	Flag for determining if Ig is measured.
VscMsrFlag:	Flag for determining if Vsc is measured.
IscMsrFlag:	Flag for determining if Isc is measured.
VsbMsrFlag:	Flag for determining if Vsb is measured.
IsbMsrFlag:	Flag for determining if Isb is measured.
VwMsrFlag:	Flag for determining if Vw is measured.

IwMsrFlag: Flag for determining if Iw is measured.

OUTPUTS:

output_error: Error value

0 OK

-1 23x not found on GPIB

-10000 (INVAL_INST_ID) The specified instrument ID does not exist.

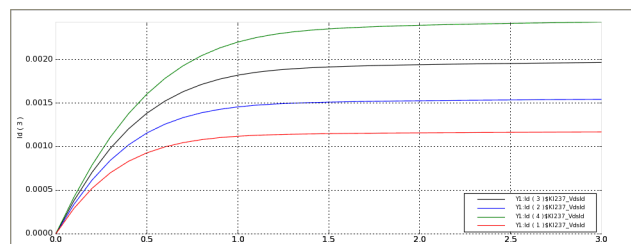
-10090 (GPIB_ERROR_OCCUR) A GPIB communications error occurred.

-10091 (GPIB_TIMEOUT) A timeout occurred during communications.

-10100 (INVAL_PARAM) Invalid parameter entered.

GUI related:

Figure 279: Vdstd_237 test result



VgsON_any_SMU

Description: Use this module to test the Gate to Source on-state voltage. Measure the current on Drain by applying a voltage sweep to the Gate-Source. Use a specific Drain to Source voltage to turn the device on to certain Id current value.

Module Type: PTM

Instrument: Keithley Instruments Series 2650A, Series 2600A, Series 2400, and Series 4200-SMU

INPUTS:

DSMU:	Model 2651A SMU connected to Drain terminal.
GSMU:	SMU connected to Gate terminal.
vd_pulse:	Pulse level in volts on Drain terminal.
vd_base:	Base level in volts on Drain terminal.
Compliancei_DSMU:	Compliance (limit) value for Drain voltage force.
Meas_Rangei:	The current range for Drain current measure. For pulse mode, auto range is not allowed.
PLC:	PLC for SMU on Drain terminal.
pulse_width:	Duration of the output ON time.
pulse_delay:	Duration of the output OFF time.
Vg_start:	Start voltage of sweep on Gate terminal.
Vg_stop:	Stop voltage of sweep on Gate terminal.
Compliancei_GSMU:	Compliance (limit) value for Gate voltage force.
points_sweep:	The number of points for Gate sweep.
G2D_delay:	Gate to Drain delay; the time between Gate step and the output of the Drain pulse.
Sense_mode4GSMU:	Sense mode for SMU on Gate terminal.
Sense_mode4DSMU:	Sense mode for SMU on Drain terminal.
Start_Ramp_Flag:	Enable or disable Soft-Ramp function at the start of bias.
End_Ramp_Flag:	Enable or disable Soft-Ramp function at the end of bias.
Start_Ramp_Delay:	Time delay at each step of start ramp.
End_Ramp_Delay:	Time delay at each step of end ramp.
Start_Ramp_Steps:	The number of steps at the start of Soft-Ramp.
End_Ramp_Steps:	The number of steps at the end of Soft-Ramp.

OUTPUTS:

Vg:	Gate voltage programmed.
Id:	Drain current measured at the specified Gate bias current.
Vd:	Drain voltage measured.
Return Values:	
0	OK
-100	SMU configuration error
-200	Initialize error occurred.
-300	Pulse Configuration error occurred.
-400	Reading error occurred.
-10100	(INVAL_PARAM) Invalid parameter entered.

GUI related:

Figure 280: VgsON_any_SMU GUI

The screenshot displays the VgsON GUI interface. It features a 'User Module' dropdown set to 'VgsON'. The interface is divided into several sections:

- Input Parameters:** A table listing various input settings:

DSMU	SMU3
GSMU	SMU1
vd_pulse	8
vd_base	0
Compliance_DSMU	50
Meas_RangeI	5
PLC	0.005
PulseOff	0.03
PulseWidth	0.0003
Vg_start	0
Vg_stop	12
Compliance_GSMU	0.01
points_sweep	121
- Output Parameters:** A table listing output variables:

Vg	Vg
Id	Id
Vd	Vd
- Description:** A text block providing details about the module:

Module name: VgsON
 Instrument: Keithley 2651A, 26xxA, 24xx and 42xx-SMU
 DUT: Power MOSFET
 Function: This module is used to get the Gate to Source on-state voltage. Measure current on Drain by applying voltage sweep to Gate-Source with specific Drain to Source voltage to turn on the device to certain Id current value.
 Results: Get measured Drain current at Gate sweep voltage and Gate to Source on-state voltage.
- Inputs:** A list of input variables:
 - DSMU (str): Model 2651A SMU connected to Drain terminal.
 - GSMU (str): SMU connected to Gate terminal.
 - vd_pulse (double): Pulse level in volts on Drain terminal.
 - vd_base (double): Base level in volts on Drain terminal.
 - Compliance_DSMU (double): Compliance value for Drain voltage force.
 - Meas_RangeI (double): The current range for Drain current measure. For pulse mode, auto range is not allowed.
 - PLC (double): PLC for SMU on Drain terminal.
 - pulse_width (double): Duration of the output ON time.
 - pulse_delay (double): Duration of the output OFF time.
- Circuit Diagram:** A schematic showing a MOSFET with terminals G (Gate), D (Drain), and S (Source). A source terminal is connected to ground. The Gate terminal is connected to an SMU (represented by a yellow circle with an 'A' and a red 'Sweep' icon). The Drain terminal is connected to another SMU (represented by a yellow circle with an 'A' and a red 'SMU' label).

Common other library

Common other library overview

The ACS Basic common library includes matrix control, power supply, and scope control tests. All test modules in the common other library can be added to any device. You can also build a common other library to import and use.

Common other library

KI37XX_DMM_Switch

Description:

Supports two types of cards: 6x16, High Density, Matrix Card (3730) and Dual 1x30 Multiplexer Card (3720).

Module Type: PTM

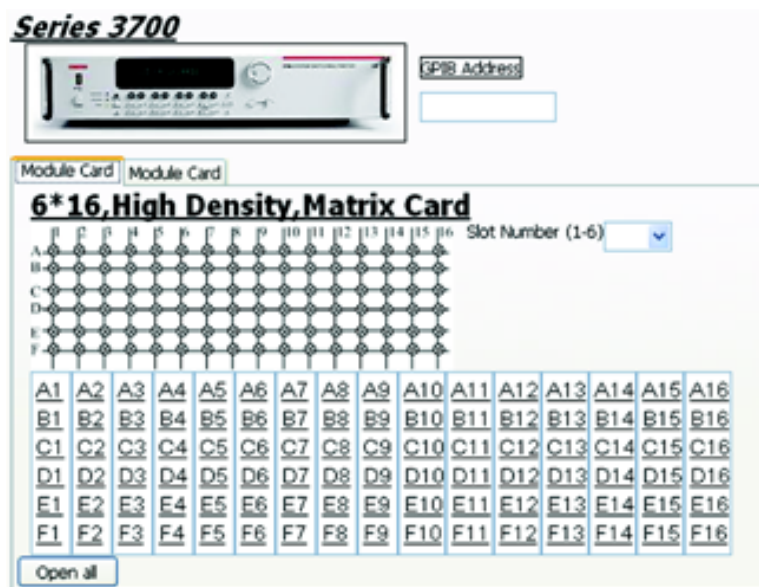
Module Name: Series 3700 Switch control

Instrument: Keithley Series 3700 System Switch/Multimeter and plug-in cards.

Pin connections: For 4-wire measurement, if you are using a multiplexer card, use a channel pair. Channels 1 through 30 are used as the INPUT terminals and channel 31 through 60 are used as the SENSE terminals.

GUI related:

Figure 281: KI37XX_DMM_Switch GUI

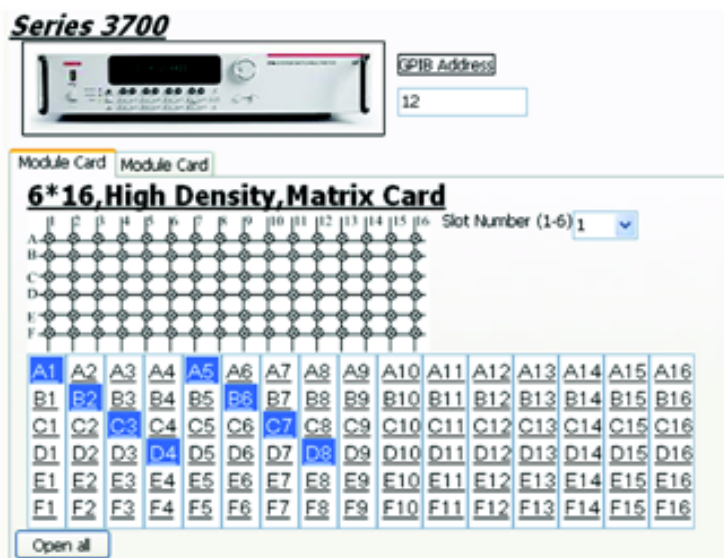


Control the 3700 matrix in the GUI (see previous figure):

- 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 282: Matrix control setting example

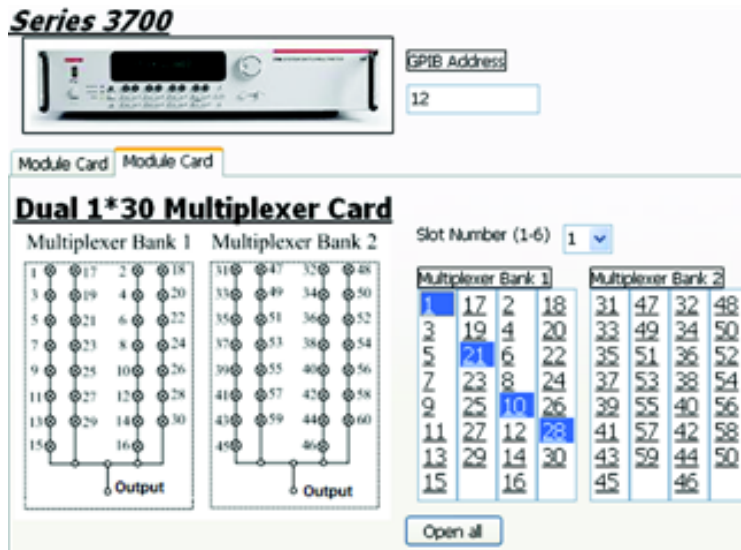


Control the multiplexer card in the GUI:

- 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 283: Multiplexer control setting example



power_supply

Description:

You can use this module to make simple leakage current measurements on two-terminal and three-terminal devices using a high-voltage power supply and a SMU. This module can support the following SMUs for measuring the current through the device: Models 2611/12 A/B, Models 2635/6 A/B, Model 4200-SMU, Model 4210-SMU. These models will be supported with the Model 2290-PM-200 Protection Module.

Module Name: power_supply

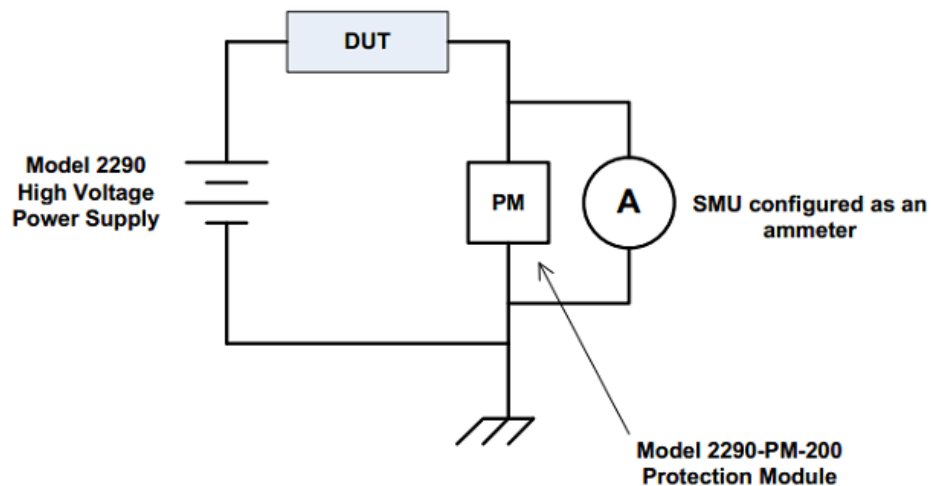
Instrument: Model 2290 power supply.

NOTE

The Model 2290 cannot be automatically scanned by ACS Basic. You must configure it as a general purpose instrument. Refer to "Connect to external instruments" in the *ACS Basic Reference Manual* for information.

Test connections:

Figure 284: power_supply test connections



INPUTS:

HV Power Supply Settings

- Global Name: GPI1, GPI2, ..., GPI n .
- Device Connection: List of pins to connect.

Test Mode Settings

- Mode: Allows you to select test mode (Bias or Sweeping) from a list.
- Bias V: Force value for the bias.
- Number of Points: The number of points for sweep.
- Sweep start V: Initial force value for the sweep.
- Sweep stop V: Final force value for the sweep.

Other Power Supply Settings

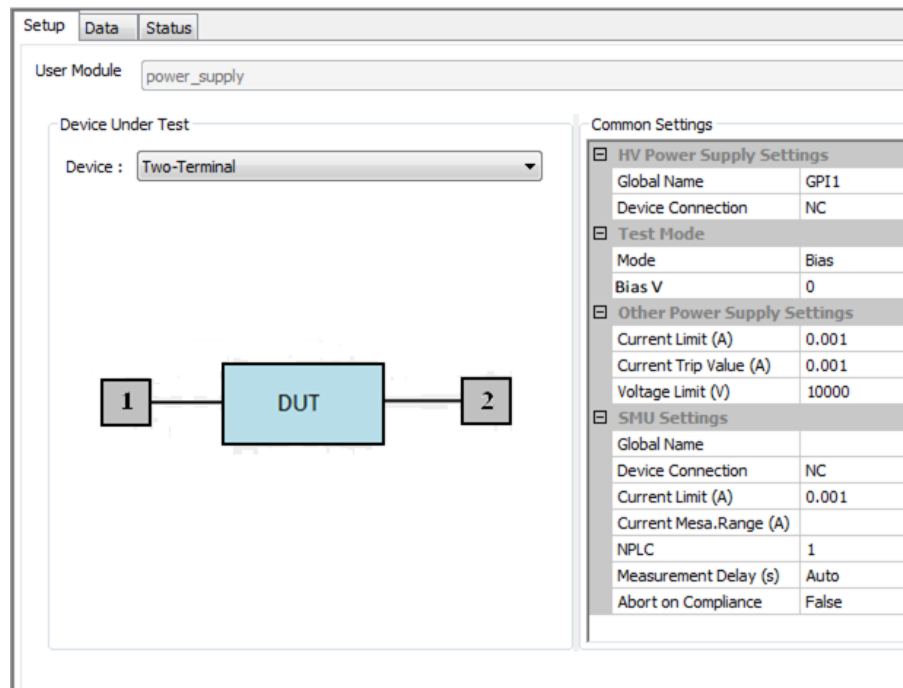
- Current Limit: Current limiting varies the output voltage to limit the output current to less than or equal to the programmed current limit value. The default value is 1 mA.
- Current Trip Value: The current trip shuts off the high voltage when the output current exceeds the trip value. The default value is 1 mA.
- Voltage Limit: The voltage limit is a protection feature to prevent the output voltage from being set too high or overshooting because of dramatic load changes. The output voltage cannot be set higher than the voltage limit. The default value is the max of power supply.

SMU Settings

- Global Name: SMU1, SMU2, ..., SMU n
- Device Connection: List of pins to connect.
- Current Limit: Current Limitation on measured sites in Ampere. The default value is 1 mA; the minimum and maximum depend on the SMU used.
- Current Meas.Range: Specifies the SMU current measure range used. Auto option commands the SMU to automatically optimize the measurement range. This option provides the best resolution. Numerical range options allow you to manually select a fixed measurement range to suit your needs. The default is Auto.
- NPLC: Number of power line cycles for integration. The default value is 1.
- Measurement Delay: The measure delay is a specific delay applied before each measurement is taken. You can either change the delay to a specific value or to auto. If the measure delay is set to auto, a range-dependent delay is applied each time the instrument performs a current measurement, or after changing current ranges during an autoranged measurement. The default measurement delay varies by model. The Auto setting only can be applied to 26XX SMU. When 42XX SMU is used, please input a specific value. If use Auto for 42XX SMU, this delay will be disabled by default (measurements are taken immediately).
- Abort on Compliance: Determines if the test aborts if it reaches the compliance (limit) value. If you do not want to abort the test on compliance, select False. To abort the test on compliance, select True.

GUI related:

Figure 285: power_supply GUI



switchctrl_6cards_70x

The switchctrl_6cards_70x test module connects specified matrix row terminals and column pins, as specified by the user. This module is only applicable to the Keithley Instrument Models 707A and 708A. Directly send corresponding commands without HV SMU check.

The single-test model of this test module is in CommonLib_other. You can import a multi-test version from the directory:

```
C:\ACS_BASIC\library\pyLibrary\PTMLib\switchctrl1.py
```

For details, refer to [Switch control PTM](#) (on page 2-366).

switchctrl_6cards_3706

The switchctrl_6cards_3706 test module connects specified matrix row terminals and column pins, as specified by the user.

The single-test model of this test module is in CommonLib_other. You can import a multi-test version from the directory:

```
C:\ACS_BASIC\library\pyLibrary\PTMLib\switchctrl1.py
```

For details, refer to [Switch control PTM](#) (on page 2-366).

TEKSCOPE_ReadWave

Description:

Reads the waveform on the scope. It reads data one channel at a time. Some modification is needed to enable it to read data from more channels simultaneously.

Known issues: Returns 2 bytes of binary data.

Instrument: TEKSCOPE

NOTE

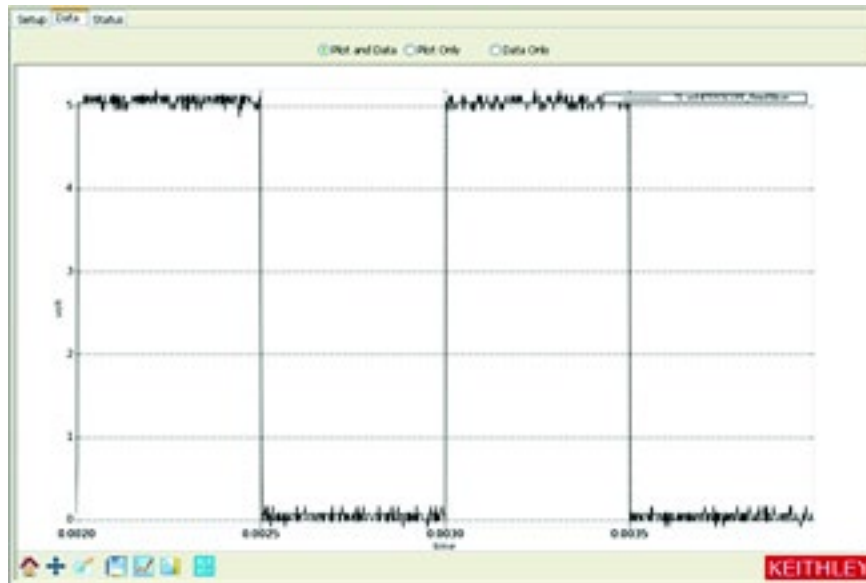
This instrument cannot be automatically scanned by ACS Basic. You must configure it as a general purpose instrument. Refer to "Connect to external instruments" in the *ACS Basic Reference Manual* for information.

GUI related:

Figure 286: Waveform reading GUI



Figure 287: Waveform reading data



High-voltage capacitance-voltage PTM

Generic high-voltage capacitance-voltage PTM overview

You can make capacitance-voltage (CV) measurements using this PTM module.

The following are supported SMUs:

- 4200 SMU
- 2600 SMU
- 2657 SMU

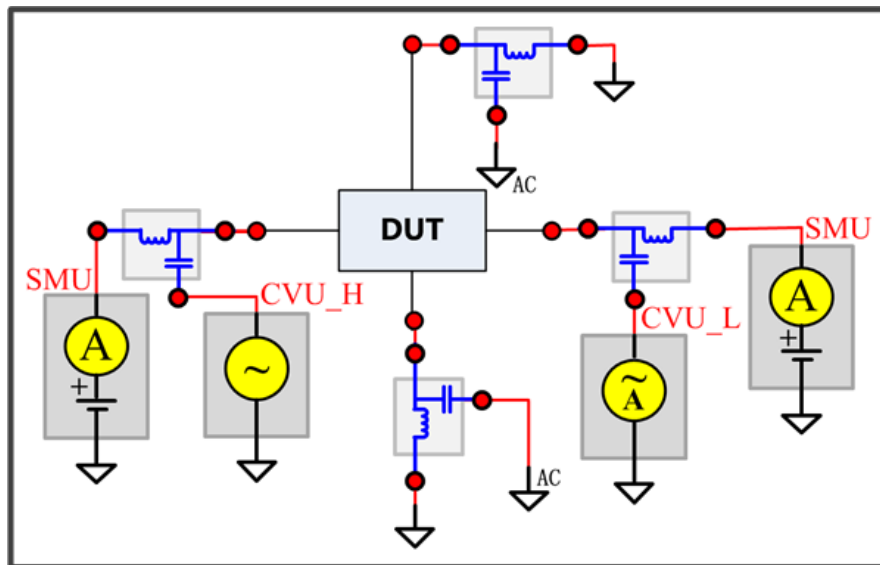
The configuration of this PTM module requires the following setup:

- Model 4200-CVU (to supply AC voltage).
- Model 4205-RBTs (200 V remote bias tee) or 3 kV remote bias tee (up to four bias tees can be used in the configuration).
- Model 8010 Test Fixture or Model 8020 Test Fixture

For supplies of ± 200 V or 400 V differential DC bias or sweep voltage, either the 4200 SMU or the 2600 SMU can be used. The 4205-RBTs are connected to the device under test (DUT) through the Model 8010 test fixture.

For supplies of 3 kV DC bias or sweep voltage, the 2657A SMU is needed. The 3 kV remote bias tees are connected to the DUT through the Model 8020 test fixture.

Figure 288: HV_CV measurement hardware connections



NOTE

In the previous graphic, a four-terminal device is shown. You can also use this test for two-terminal and three-terminal devices.

Generic high-voltage capacitance-voltage functions

The generic high-voltage high-current PTM library module is in the following directory:

C:\ACS_BASIC\library\pyLibrary\PTMLib\GenericHVCVlib.py

To open the module, import the .py file to your test.

You can use this module to switch between three functions: C vs. V, C vs. t and C vs. f. The details of these three functions are indicated in the following figure. Descriptions follow the figure.

Figure 289: High-voltage capacitance-voltage PTM module GUI

The GUI for the GenericHVCVlib module includes the following components:

- Function Selection:** Radio buttons for C vs. V (selected), C vs. t, and C vs. f.
- CVU Connection Compensation:** A section for compensation data with a dropdown for 2TComp, a text field for the last saved file, and checkboxes for Cable Length <1.5M>, Open, and Short.
- Timing:** A button labeled 'Timing'.
- Connection Diagram:** A central DUT (Device Under Test) with four pads. Pad 1 is connected to SMU1 (DC) and CVU_H (AC). Pad 2 is connected to SMU3 (DC) and NONE (AC). Pad 3 is connected to SMU2 (DC) and CVU_L (AC). Pad 4 is connected to SMU4 (DC) and NONE (AC). A 'device map field' label points to the diagram.
- SMU Settings Table:** A table with columns: Pad, SMU, Pad Name, Function, Source, Measure, Compliance, Meas.Range, and Advanced.

Pad	SMU	Pad Name	Function	Source	Measure	Compliance	Meas.Range	Advanced
1	SMU1	Pad1	Sweep V	[0, 0, 40, 41]	V	0.001		...
2	SMU3	Pad2	Bias V	[0, 0]	None	0.001		...
3	SMU2	Pad3	Bias V	[0, 0]	None	0.001		...
4	SMU4	Pad4	Bias V	[0, 0]	None	0.001		...
- CVU Settings Table:** A table with columns: Pad #, CVU, Pad Name, Function, Frequency, ACV, Model, and Advanced.

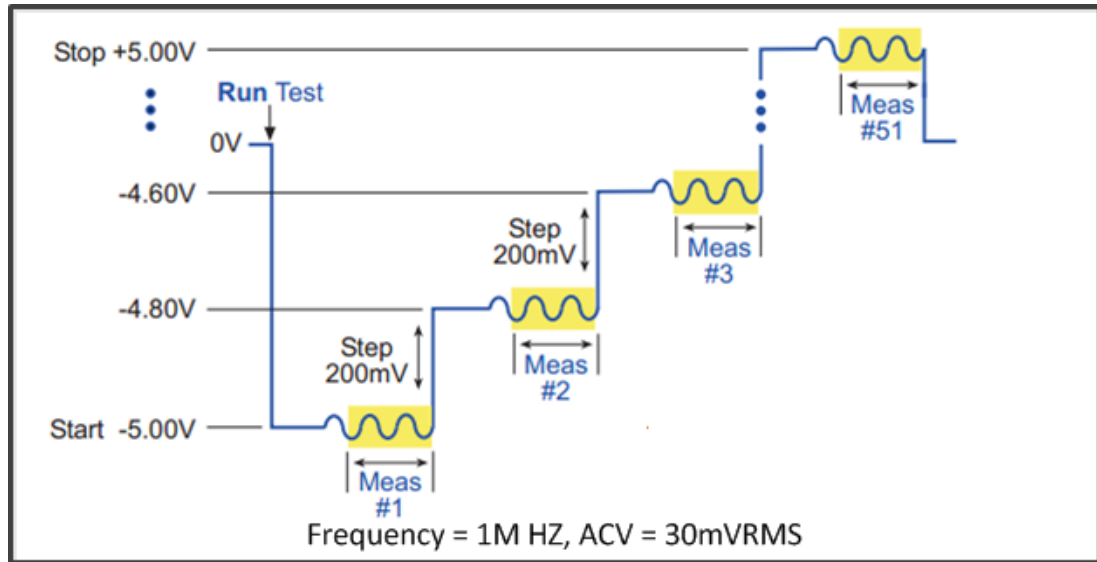
Pad #	CVU	Pad Name	Function	Frequency	ACV	Model	Advanced
1,3	CVU_H_L	Pad1_Pad3	C vs. V	100k Hz	30mVRMs	Gp-Gp-D	...

Generic high-voltage capacitance-voltage GUI descriptions

Function:

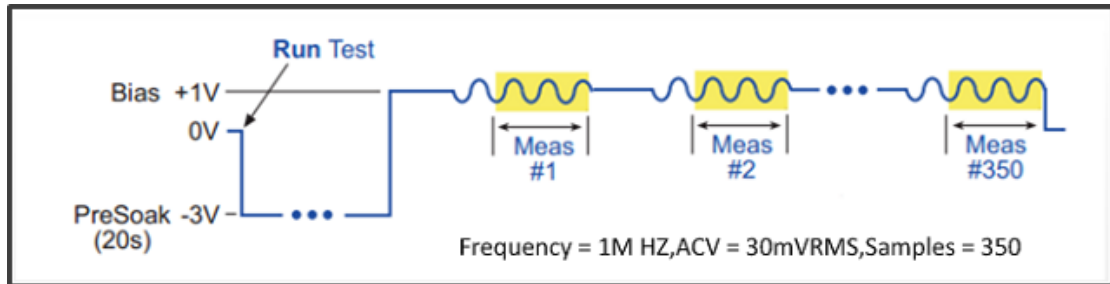
C vs. V: Using a voltage sweep, capacitance is measured at every step of the sweep to generate a Capacitance versus Voltage graph. An example is shown in the following figure.

Figure 290: C vs. V waveform example



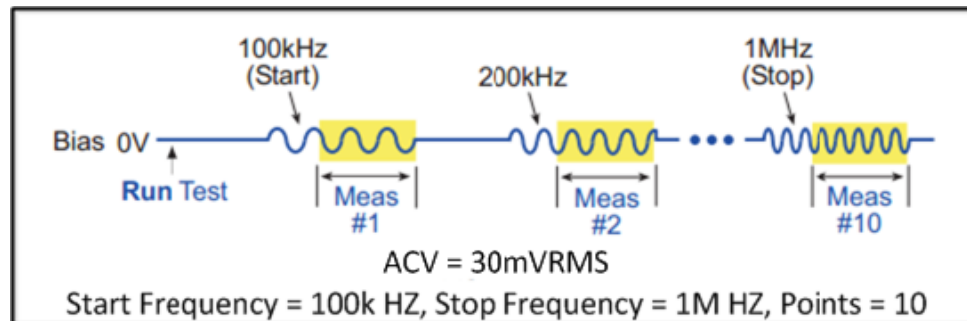
C vs. t: Performs a specified number of capacitance measurements (Sample Count) at a specified time interval (Measurement Delay) with voltage and frequency held constant. The capacitance versus time measurements is then plotted on a graph. An example is shown in the following figure.

Figure 291: C vs. t waveform example



C vs. f: Using a frequency sweep, capacitance is measured at every frequency point to generate a Capacitance versus Frequency graph. An example is shown in the following figure.

Figure 292: C vs. f waveform example.png

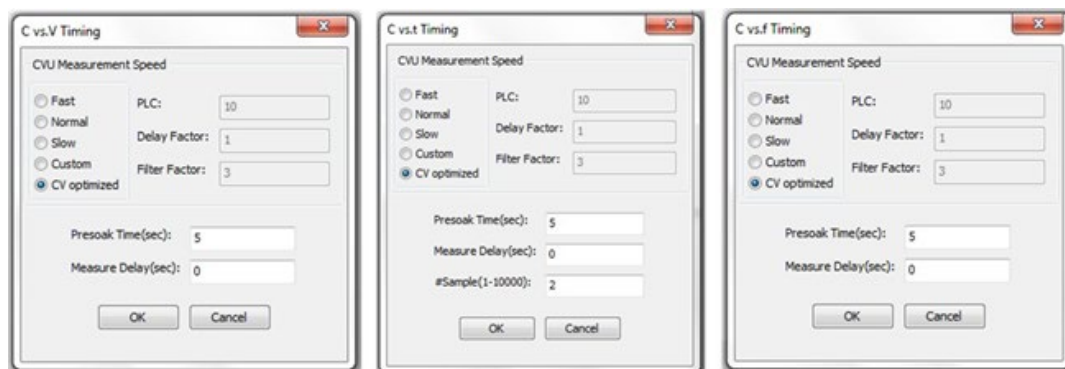


CVU connection compensation:

- Compensation data file: Select compensation data file to be used. For more information about how to generate a compensation file, refer to the Generate connection compensation data topic.
- Open: Enable or disable open compensation for CVU
- Short: Enable or disable short compensation for CVU

Double-click the cell to display the Timing dialog box for the selected function.

Figure 293: C vs. V, C vs. t, and C vs. f Timing dialog boxes



Measurement Speed: Selects the SMU and CVU measure speed.

- Fast: Optimizes speed at the expense of noise performance. It is a good choice for fast measurements where noise and settling time are not concerns.
- Normal: The most commonly used setting. It provides a good combination of speed and low noise, and is the best setting for most cases.
- Slow: Optimizes the low-noise measurements at the expense of speed. If speed is not a critical consideration, it is a good choice when you need the lowest noise and most accurate measurements.

- Custom: Allows you to fine-tune the timing parameters to meet a particular need. With Custom, you can configure the integration time and the number of readings to produce a composite setting. The entries in the PLC edit fields control the A/D (analog-to-digital) converter integration time used to measure a signal. A short integration time for each A/D conversion results in a relatively fast measurement speed, at the expense of noise. A long integration time results in a relatively low noise reading, at the expense of speed. The integration time setting is based on the number of power line cycles (NPLCs):
 - For 60 Hz line power, 1.0 PLC = 16.67 msec (1/60 of a second).
 - For 50 Hz line power, 1.0 PLC = 20 msec (1/50 of a second).
- CV optimized: This option allows you to select a setting that gives an accurate CV measurement.
- PLC: If you selected the Custom measurement Speed mode, you can enter any value between 0.001 and 25 NPLC. If you selected the **Fast, Normal, Slow** or **CV optimized** measurement Speed mode, ACS Basic sets the A/D Integration Time correspondingly. The next table summarizes the allowed A/D Integration Time settings for various measurement Speed modes.

Measurement speed	PLC
Fast	0.01
Normal	1
Slow	10
Custom	0.001 to 25
CV optimized	10

- Delay Factor: After applying a forced voltage or current, an SMU waits for a delay time before making a measurement. The delay time allows for source settling. The default delay time is pre-programmed and range-dependent to allow for the very long settling times needed at very low current ranges. The applied delay time is a multiple of the default delay time and the value in the Delay Factor edit box specifies this multiple.

Applied delay time = (Default delay time) x (Delay Factor)

For example, if the default delay time is 1 ms and the Delay Factor is 0.7, the applied delay time is 0.7 ms (1 ms x 0.7).

If you select the Custom measurement speed mode, you can enter a custom Delay Factor of 0 to 100. If you select the **Fast, Normal, Slow** or **CV optimized** measurement speed mode, the SMU sets an appropriate fixed Delay Factor.

Measurement speed	Delay Factor
Fast	0.7
Normal	1.0
Slow	1.3
Custom	0 to 100
CV optimized	1

- **Filter Factor:** To reduce measurement noise, an SMU applies filtering, which may include averaging of multiple readings to make one measurement. The value entered in the Filter Factor edit box specifies a multiple of this preprogrammed filtering.

If you select the Custom measurement speed mode, you can enter a Filter Factor value of 0 to 100. If you select the **Fast**, **Normal**, **Slow** or **CV optimized** measurement speed mode, the SMU sets an appropriate fixed Filter Factor.

Measurement speed	Filter Factor
Fast	0.2
Normal	1
Slow	3
Custom	0 to 100
CV optimized	3

Presoak Time (sec): Time in seconds to apply soak voltage.

Measurement Delay (sec): Delay time in seconds before measurement. The delay time allows for source settling.

#Sample (1-10000): Specifies the number of data points to be acquired during the test.

SMU settings:

Pad: Cannot be changed here. Pads are fixed and referenced to the diagram in the device map field.

SMU: Cannot be changed here. It can only be assigned in the device map field based on the hardware connection.

Pad Name: The header for the data related to the hardware connection.

Function: The function type for force. Double-click to select one of the following options from the drop-down list:

- C vs. V: Bias V/Sweep V/List V/GND/Open can be selected, but only one SMU can be set to Sweep V or List V
- C vs. t: Only Bias V/GND/Open can be selected
- C vs. f: Only Bias V/GND/Open can be selected

Source: The source value of SMU. Double-click the Source cell to display a Settings dialog box.

Options for Bias V:

- **Presoak V:** When the test is started and before measurement sequence, the device is stressed at a specified voltage (Presoak V) for a specified period of time (Presoak Time), as shown in the following figure.
- **Bias Level:** Defines a constant and valid voltage at the terminal.

Figure 294: Bias V settings

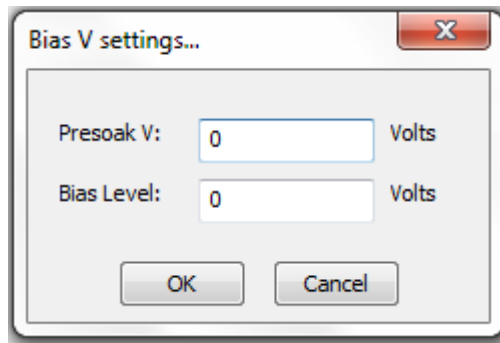
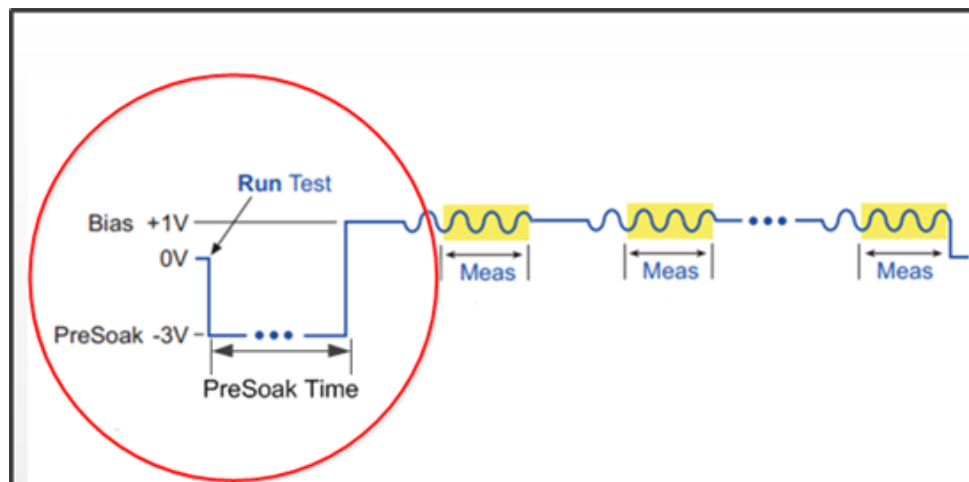


Figure 295: Presoak V and Presoak time



Options for Sweep V:

- Dual Sweep: You can set the SMUs in a test to perform a dual sweep. When enabled, the SMU will sweep from Start to Stop, and then continue to sweep from Stop back to Start. When it is disabled, the SMU will only sweep from Start to Stop.

Figure 296: Sweep V settings

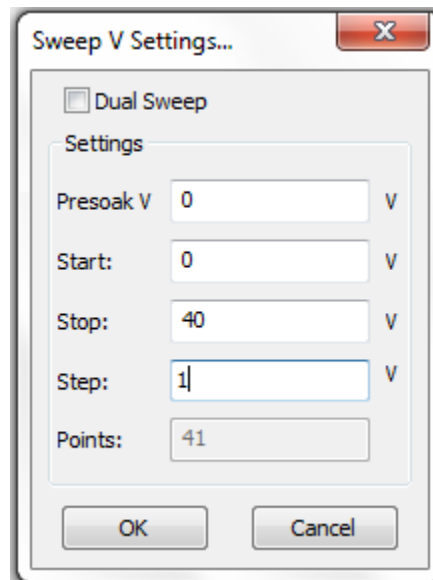
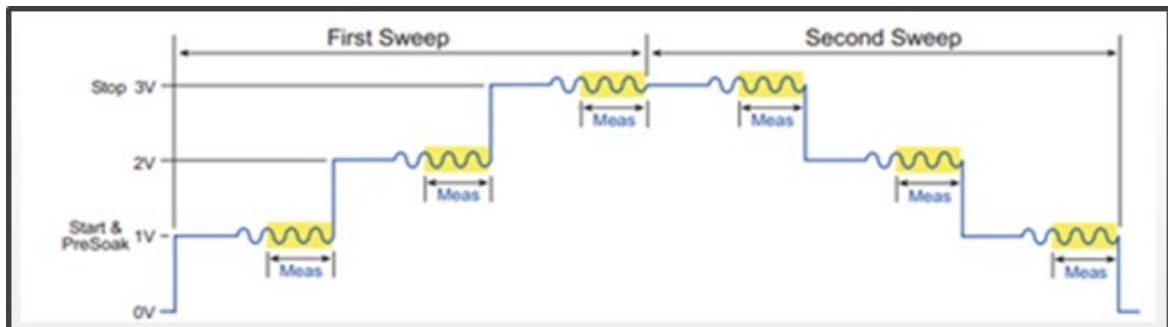


Figure 297: Dual voltage sweep example



- Presoak V: When the test is started and before measurement sequence, the device is stressed at a specified voltage (Presoak V) for a specified period of time (Presoak Time).
- Start: The Start edit box specifies the voltage forced for the first data point of the sweep.
- Stop: The Stop edit box specifies the voltage forced for the last data point of the sweep.
- Step: The Step edit box specifies the size of the voltage increments and determines the calculated Points value $\{Points = \text{integer value of } [1 + (Stop - Start)/(Step)]\}$
- Points: Shows the number of data points that are input when a sweep is executed.

Options for **List V**:






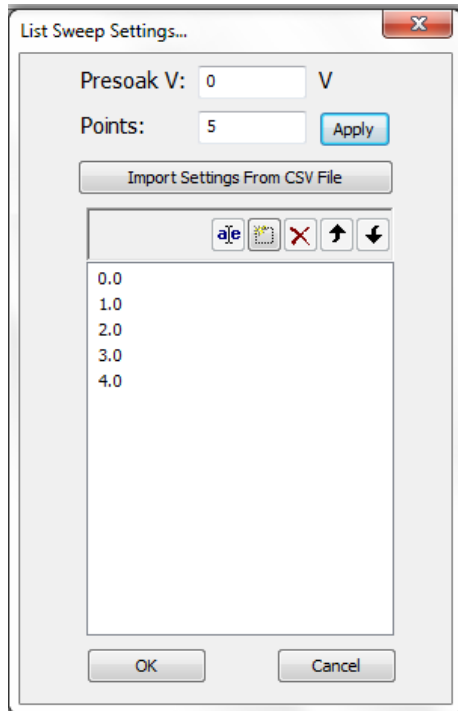
- Presoak V: When the test is started and before measurement sequence, the device is stressed at a specified voltage (Presoak V) for a specified period of time (Presoak Time).
- Points: The number of points for the forcing values.
- Import Settings From CSV File: Allows you to import and then save a .csv file.
- Edit item : Change the number.
- New item : Adds a new item.
- Delete item : Delete the selected item.
- Move up : Move the selected item up.
- Move down : Move the selected item down.

Figure 298: List Sweep Settings

Measure: Measures the voltage unit in volts.

Compliance: Enables the test to abort and turn off the SMU output when it reaches the compliance (limit) value. The value is limited by the specifications of the SMU.

Meas.Range: This item is disabled.

Advanced: Double-click the Advanced cell to open a dialog box that allows you to set advanced features for this SMU.

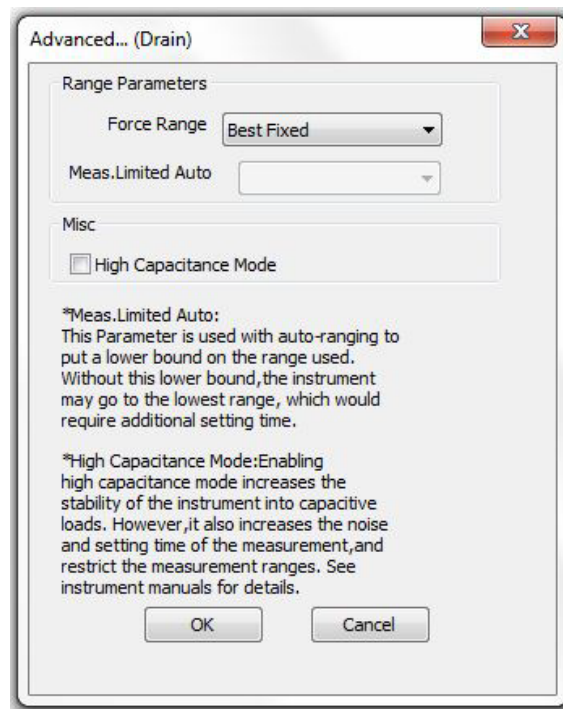
Range Parameters:

- Force Range: Specifies the SMU force range used to force voltage, including Best Fixed and numerical range options.
- Meas. Limited Auto: This item is disabled.

Misc:

- High Capacitance Mode: Sets the SMU to high capacitance mode.

Figure 299: SMU Advanced settings dialog box



CVU settings:

Pad #: Changed with AC settings in the device map field accordingly.

CVU: Cannot be changed here. It can only be assigned in the device map field.

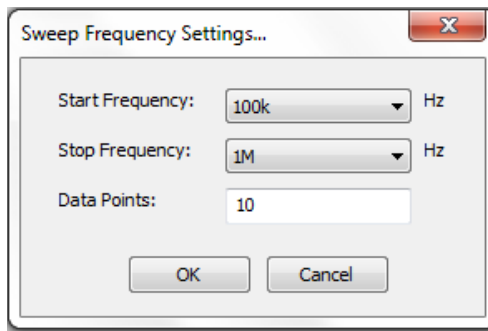
Pad Name: Changed with AC settings in the device map field accordingly.

Function: Changed with the function selected.

Frequency: Test frequency (Hz). A variable that selects the measurement frequency to use.

- In C vs. V and C vs. t, the frequency is biased (10 KHz to 2 MHz)
- In C vs. f, the frequency sweeps up or down

Figure 300: Sweep Frequency Settings



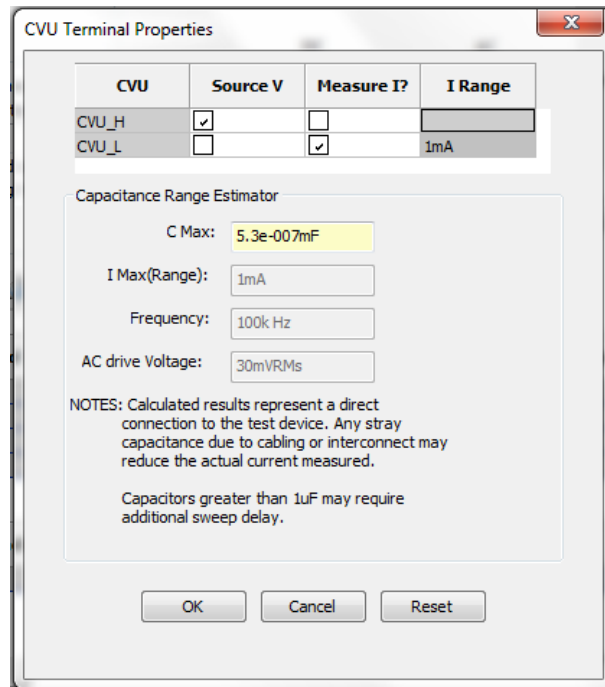
ACV: AC test voltage of CVU (10 mV to 100 mV RMS).

Model: The parameters that can be measured by 4200-CVU:

- Cp-Gp-D: Parallel Capacitance and Conductance and Dissipation Factor.
- R+jX: Resistance and Reactance.
- Z,Theta: Impedance and Phase Angle.
- Cs-Rs-D: Series Capacitance and Conductance and Dissipation Factor.

Advanced

Figure 301: CVU Terminal Properties dialog box



- I Range: Fixed 1 mA
- Capacitance Range Estimator: The capacitance is calculated from the capacitive impedance

The test frequency range is calculated using the following formula:

$$C_{\max} \approx \frac{I_{\max}}{2\pi f V_{ac}}$$

- C Max: The calculated capacitance
- I Max(Range): Fixed 1 mA
- Frequency: Test frequency, the value changed with the setting in CVU settings GUI accordingly
- AC drive Voltage: Measured AC voltage, the value changed with the setting in CVU settings GUI accordingly

Device specific high-voltage capacitance-voltage PTM

The device specific high-voltage capacitance-voltage PTM libraries are located in the following computer directory: ACS_BASIC\library\pyLibrary\PTMLib. They include the following test libraries specific to different devices:

- Specific_IGBT.py
- Specific_nMOSFET.py
- Specific_npnBJT.py
- Specific_pMOSFET.py
- Specific_pnpBJT.py
- Specific_nPowerMOSFET.py
- Specific_pPowerMOSFET.py
- Specific_npnPowerBJT.py
- Specific_pnpPowerBJT.py

Import the .py file you need for your test and the device module opens.

Discharge test

The discharge test PTM library module is located in the following computer directory: ACS_BASIC\library\pyLibrary\PTMLib\ Discharge_Test.py.

This module is optional and is used to safely discharge the bias tee capacitance, especially once each CV test ends in which there is DC bias applied by the Model 2657A. You can import the .py file and insert in the test sequence. This module can discharge bias tees by programming all SMUs to zero volts with 1 mA compliance and turning their outputs on for 1 second then turning off.

This module can be used for both Generic _HVCV_Test and device specific PTMs in MultiMode.

Mixed SMUs in pulse mode

The mixed model of SMUs in pulse mode is an explanation of the mixed use-case for the Series 2650A SMU with the Series 2600 SMU, Series 2400 SMU, and Model 4200-SMU. In these tests the Series 2650A SMUs are in pulse mode, while other SMUs are in DC mode.

Mixed SMUs overview

To open the Mixed_SMUs_pulselib PTM:


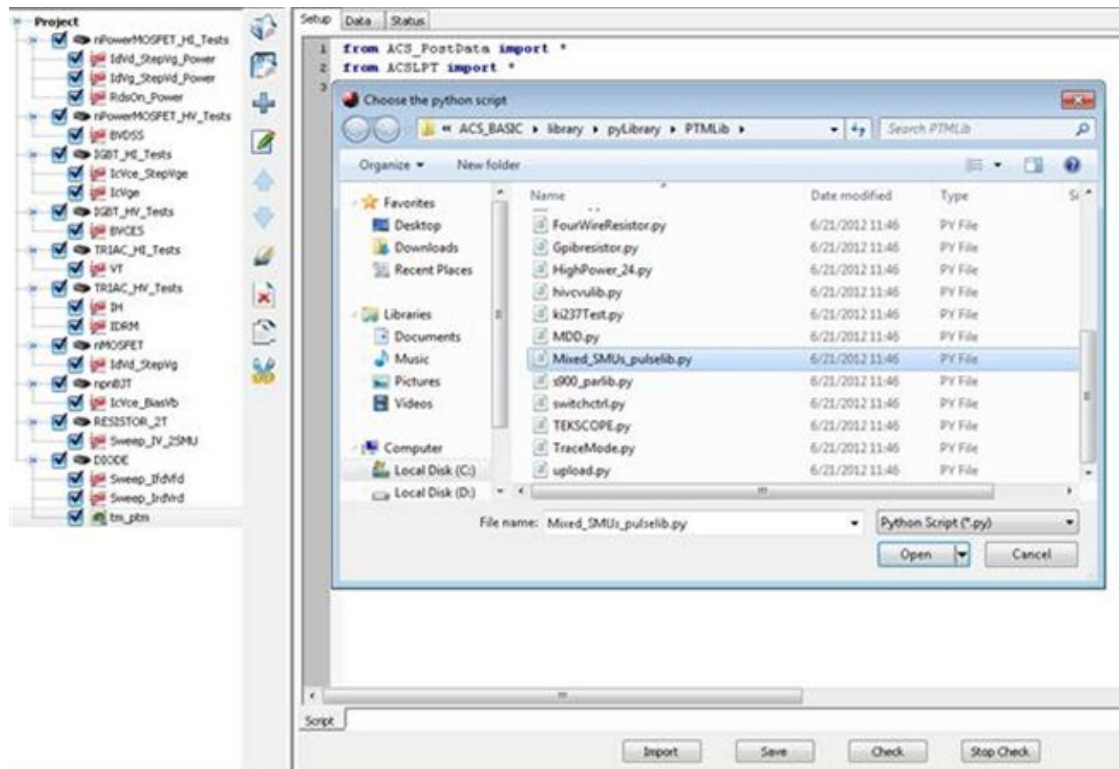
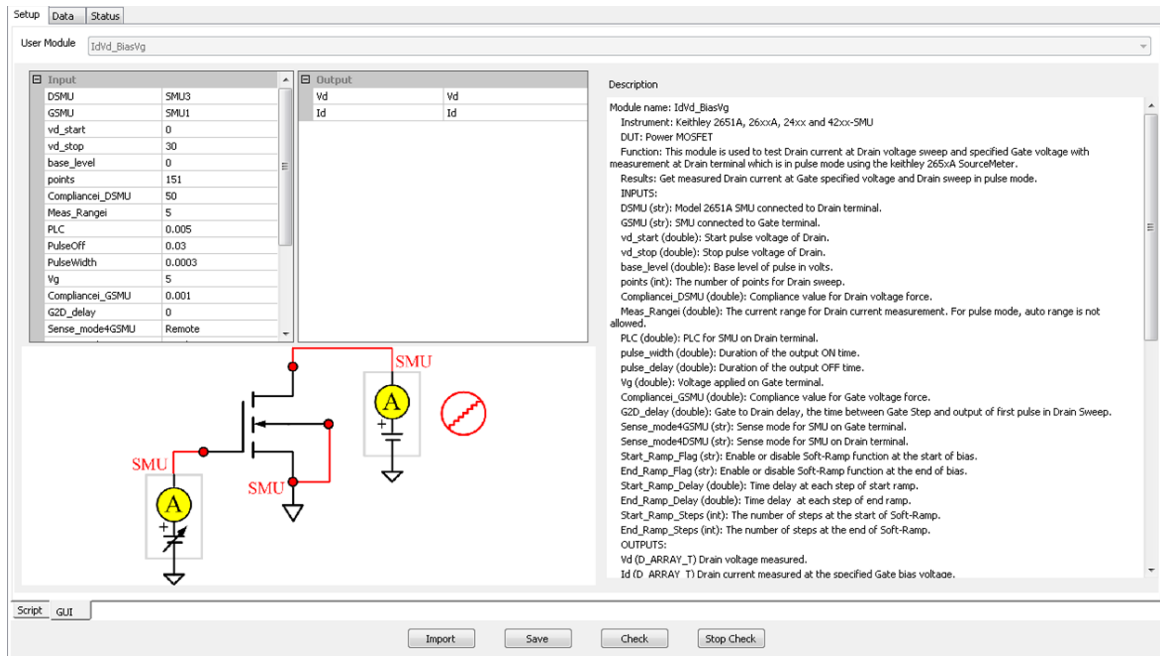
1. Select a test type in the project configuration navigator.
2. Click .
3. Select **PTM (Python Language Test Module)** to add a new PTM to the project configuration navigator.
4. Click the **Import** button.
5. Select the **Mixed_SMUs_pulselib.py** script (see next figure).

Figure 302: Import the Mixed_SMUs_pulselib PTM



The Mixed_SMUs_pulselib PTM GUI opens (see next figure).

Figure 303: Mixed_SMUs_pulselib PTM GUI



Test modules of Mixed_SMUs_pulselib PTM

Mixed_SMUs_pulselib PTM includes the following modules:

- IdVd_BiasVg
- IdVd_StepVg
- IdVg_BiasVd
- IcVce_stepVbe
- IcVce_stepIb
- Vcesat_bjt
- Vcesat_IGBT
- IcVce_StepVge
- RdsOn
- BVdsv
- BVcei
- BVcev
- IcVge
- hFE_BJT
- VgsON
- IdON

For all of these tests, the high-power SMU is used in pulse mode and other SMUs are used in DC mode.

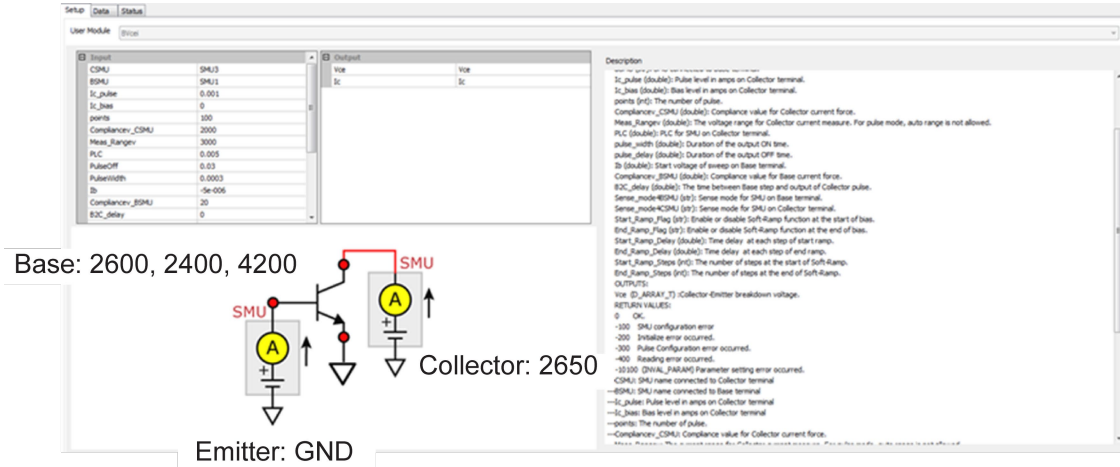
Mixed SMUs library

BVcei

Description:

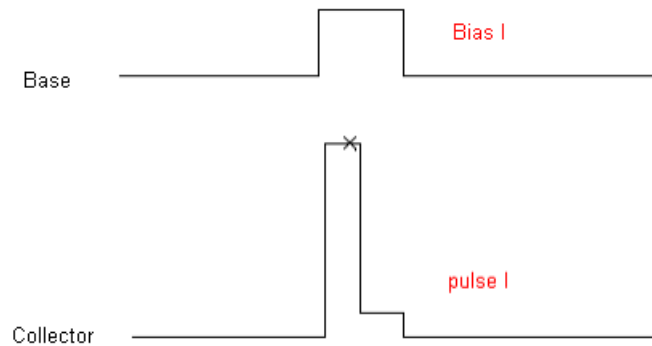
Tests the Collector-Emitter breakdown voltage of a BJT with the Base forcing current (see next figure).

Figure 304: BVcei



Test pulse sequence: Base bias I, Collector pulse I (see next figure).

Figure 305: 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:

V_{ce}: 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.

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

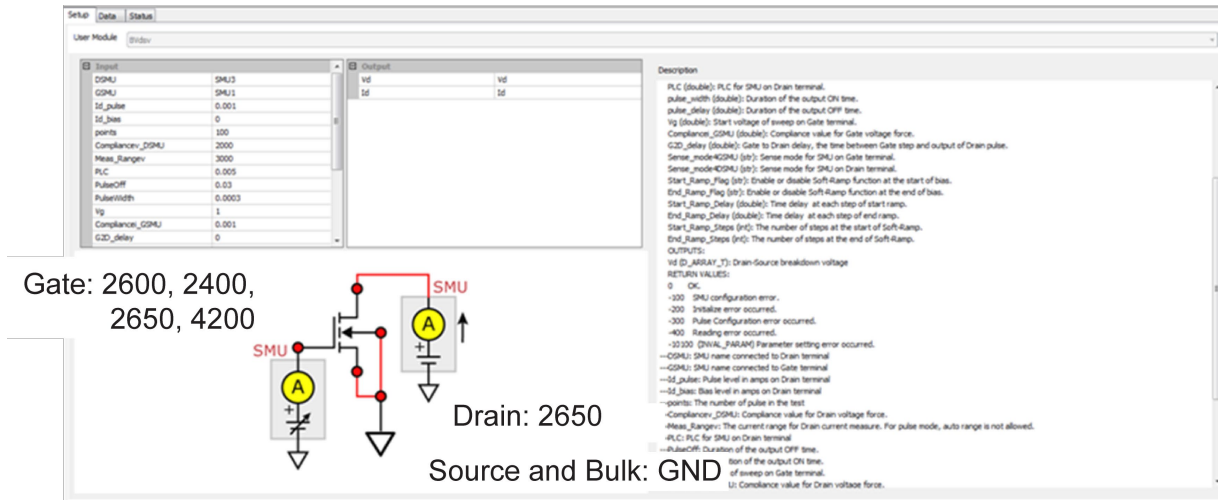
If the Base terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the Collector terminal.

BVdsv

Description:

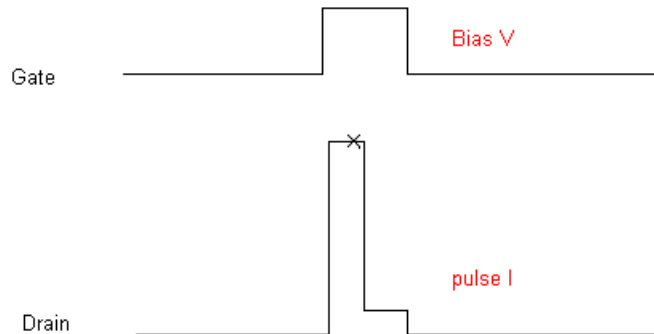
Tests the Drain-Source breakdown voltage of a MOSFET with the Gate biasing voltage (see next figure).

Figure 308: BVdsv



Test pulse sequence: Gate bias V, Drain pulse I (see next figure).

Figure 309: 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

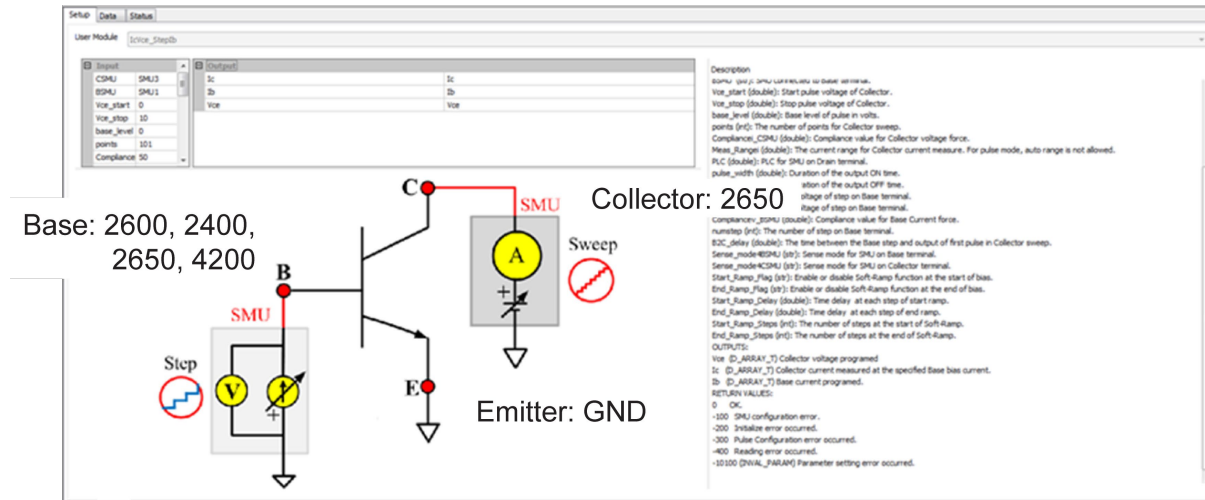
If the Gate terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the Drain terminal.

IcVce_StepIb

Description:

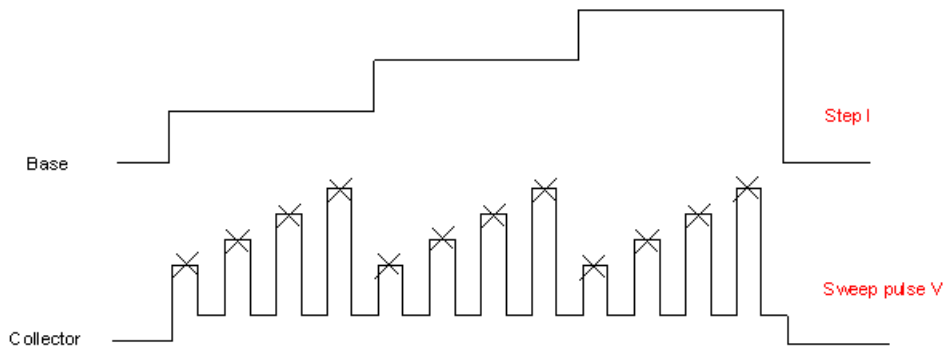
Measures the voltage and current at the Collector terminal while sweeping the Collector voltage for each voltage step at the Base terminal (see next figure).

Figure 310: IcVce_StepIb



Test pulse sequence: Collector sweep pulse V, Base step I (see next figure).

Figure 311: 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

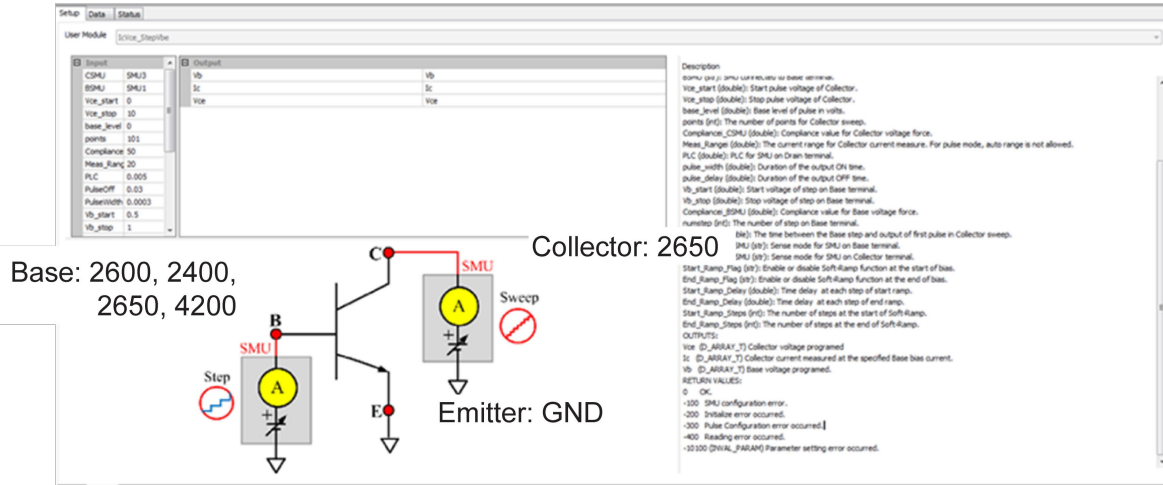
If the Base terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the Collector terminal.

IcVce_StepVbe

Description:

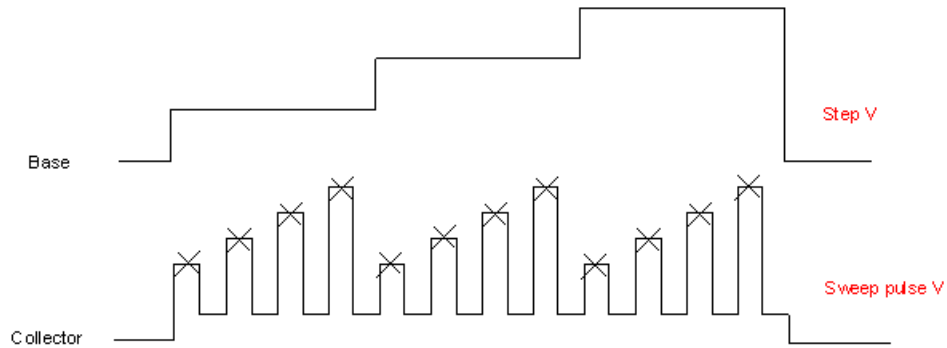
Measures the voltage and current at the Collector-terminal while sweeping the Collector voltage for each voltage step at the Base terminal (see next figure).

Figure 312: IcVce_StepVbe



Test pulse sequence: Collector sweep pulse V, Base step V (see next figure).

Figure 313: IcVce_StepVbe test pulse sequence



INPUTS:

CSMU:	Model 265xA SMU connected to Collector terminal.
BSMU:	SMU connected to Base terminal.
Vce_start:	Start pulse voltage of Collector.
Vce_stop:	Stop pulse voltage of Collector.
Base_level:	Base level of pulse in volts.
points:	The number of points for Collector sweep.
Compliancei:	Compliance value for Collector voltage force.
Meas_Rangei:	The current range for Collector current measure. For pulse mode, 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

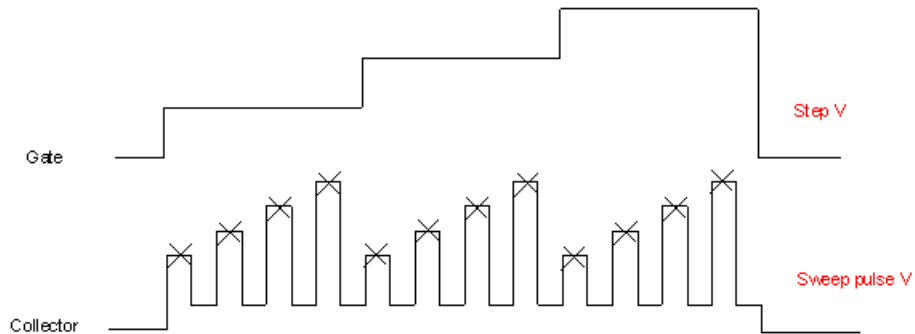
Description:

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 314: IcVce_StepVge

Test pulse sequence: Collector sweep pulse V, Gate step V (see next figure).

Figure 315: 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 Series 2650A SMU, make sure it is the same type as the Series 2650A SMU that is connected to the Collector terminal.

IdVd_BiasVg

Description:

Tests the current over a Drain voltage sweep at a specified Gate voltage, with measurements at the Drain terminal, which is in pulse mode using the Keithley Series 2650A SourceMeter (see next figure).

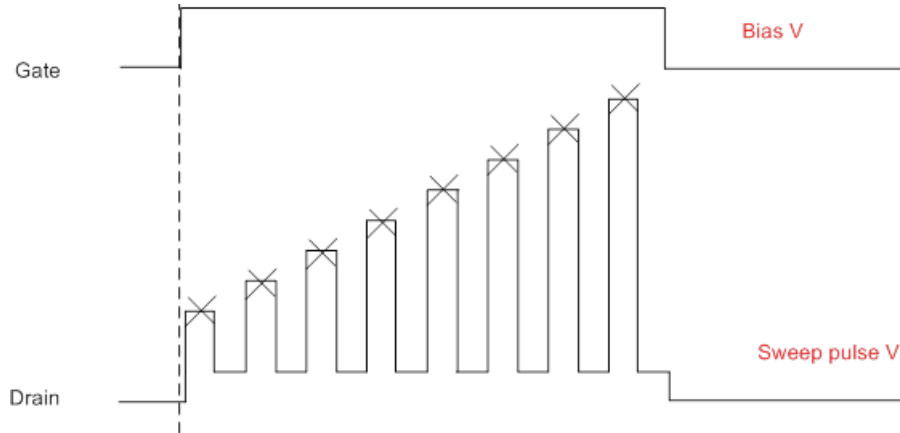
Figure 316: IdVd_BiasVg

The screenshot displays the configuration interface for the IdVd_BiasVg module. It is divided into several sections:

- Input Parameters:** A list of parameters including DSMU (SMU1), GDSMU (SMU2), vd_start (0), vd_stop (30), base_level (0), points (301), Compliance_DSMTU (1), Meas_Range (1), PLC (0.01), PulseOff (0.0225), PulseWidth (0.005), Vg (1), and Compliance_GDSMU (0.001).
- Output Parameters:** A list showing Vd and Id.
- Pin and Connection:** A schematic diagram showing the connection of two SMUs to a MOSFET circuit.
- Description:** A detailed text block explaining the module's purpose: "This module is used to test Drain current at Drain voltage sweep and specified Gate voltage with measurement at Drain terminal which is in pulse mode using the Keithley 2650A SourceMeter." It lists various parameters like G2D_delay, Sense_mode, Start_Ramp_Flag, and Start_Ramp_Delay.

Test pulse sequence: Gate bias V, Drain sweep pulse V (see next figure).

Figure 317: 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

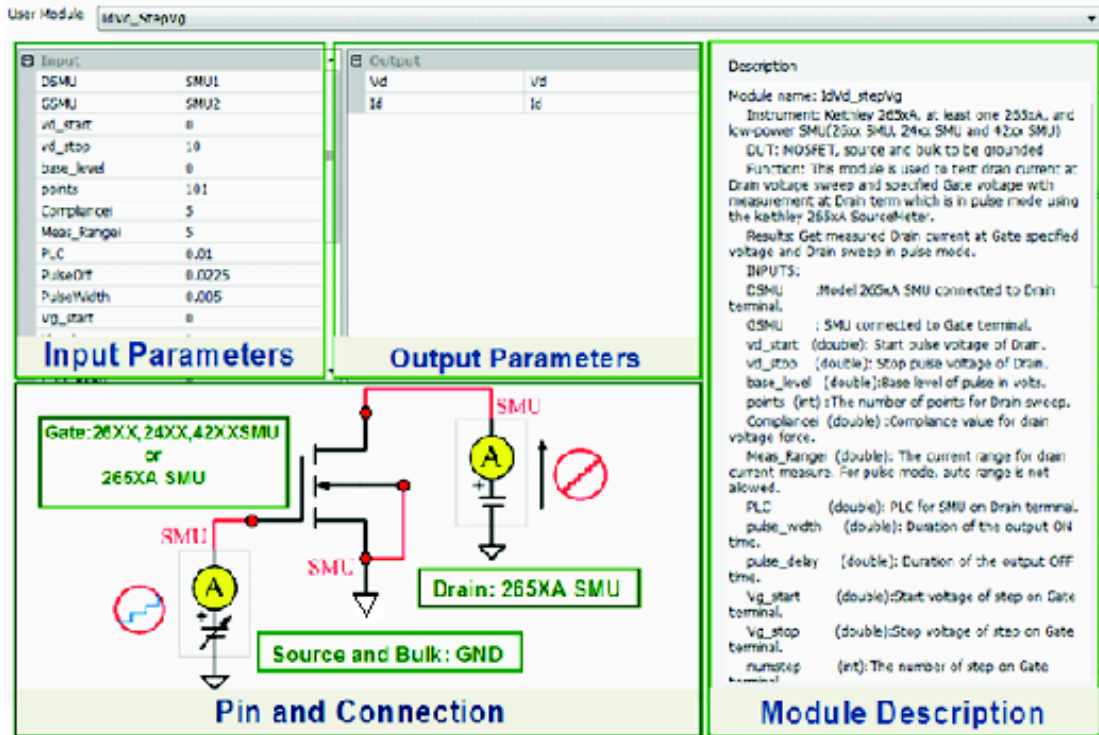
If the Gate terminal is connected to a Model 265XA SMU, make sure it is the same type as the Model 265XA SMU that is connected to the Drain terminal.

IdVd_StepVg

Description:

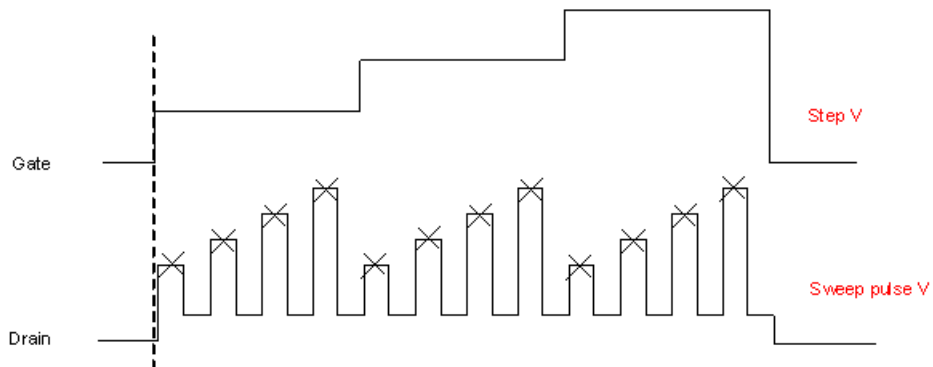
Tests the Drain current at the Drain voltage sweep and the specified Gate voltage, with measurements at the Drain terminal, which is in pulse mode using the Keithley Series 2650A SourceMeter (see next figure).

Figure 318: IdVd_StepVg



Test pulse sequence: Gate step V, Drain sweep pulse V (see next figure).

Figure 319: 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_BiasVd

Description:

Tests the Drain current at the Gate voltage sweep and the specified Drain voltage, with measurements at the Drain terminal, which is in pulse mode (see next figure).

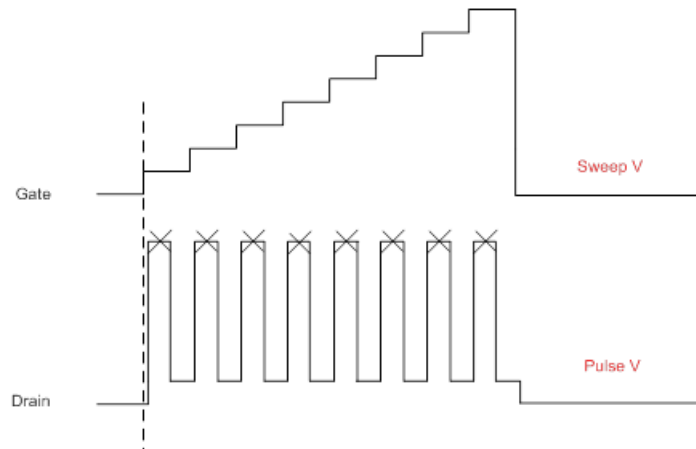
Figure 320: Idvg_BiasVd

The screenshot displays the configuration interface for the `Idvg_BiasVd` module. It is divided into several sections:

- Input Parameters:** A table listing parameters such as `DGMU` (SMU1), `GGMU` (SMU2), `vd_pulse` (1), `vd_base` (0), `Compliance_DGMU` (5), `Meas_RangeI` (5), `PLC` (0.01), `PulseOff` (0.0225), `PulseWidth` (0.005), `Vg_start` (0), `Vg_stop` (1), `Compliance_GGMU` (0.001), and `points_sweep` (5).
- Output Parameters:** A table listing `Vg`, `Id`, and `Vd`.
- Pin and Connection:** A schematic diagram showing a MOSFET with `SMU1` connected to the Gate terminal and `SMU2` connected to the Drain terminal. An ammeter symbol is shown on the Drain terminal.
- Module Description:** Text describing the module name (`Idvg_BiasVd`), instrument (Keithley 2655A, 2600A, 2400, and 400-SMU), and function. It lists results and provides a detailed list of parameters including `Compliance_DGMU`, `Meas_RangeI`, `PLC`, `PulseWidth`, `Vg_start`, `Vg_stop`, `Compliance_GGMU`, `points_sweep`, `G2D_delay`, `Sense_nodeGGMU`, `Sense_nodeDGMU`, `Start_Ramp_Flag`, and `Start_Ramp_Delay`.

Test pulse sequence: Gate sweep V, Drain pulse V (see next figure).

Figure 321: 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).

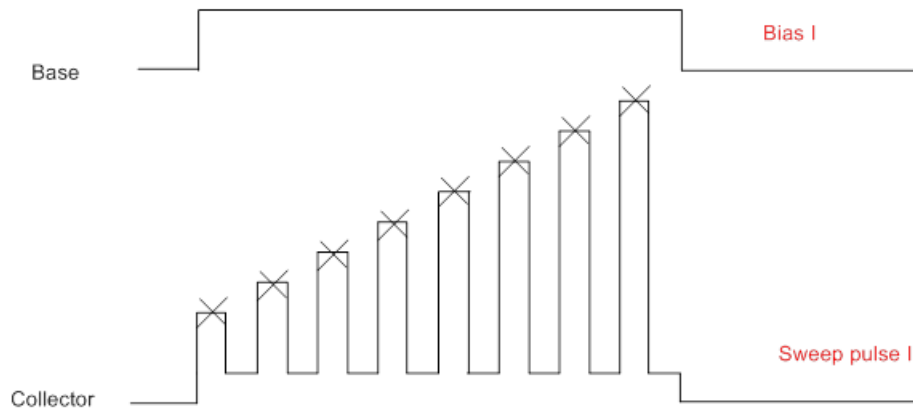
Figure 322: Vcesat_bjt

The screenshot shows the 'User Module' window for 'Vcesat_bjt'. It is divided into three main sections:

- Input Parameters:** A table listing various parameters such as CSMU, BSMU, I_{c_start}, I_{c_stop}, base_level, points, Compliance_{v_CSMU}, Meas_Range_v, PLC, PulseOff, PulseWidth, Ib, and Compliance_{v_BSMU}.
- Output Parameters:** A table with two columns: 'Vce' and 'Ic', each with a corresponding 'Vce' and 'Ic' value.
- Pin and Connection:** A schematic diagram of a BJT transistor with an SMU connected to the Collector terminal and another SMU connected to the Base terminal.
- Module Description:** A text block providing details about the module name, instrument, function, results, and a list of inputs and their descriptions.

Test pulse sequence: Collector sweep pulse I, Base bias I (see next figure).

Figure 323: 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).

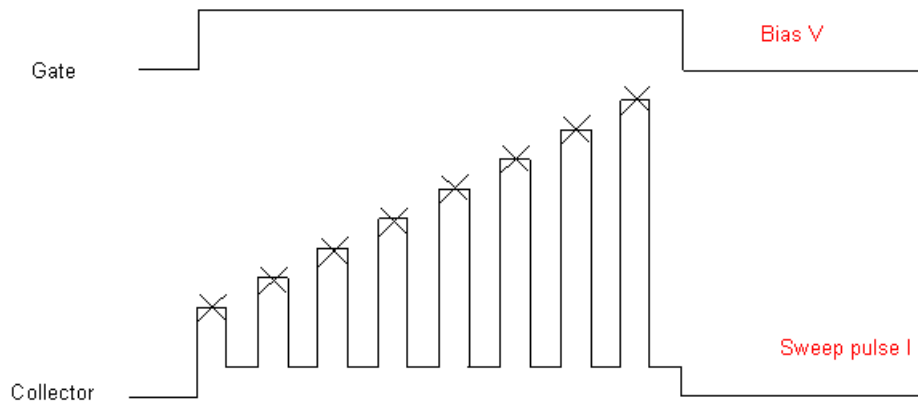
Figure 324: Vcesat_IGBT

The screenshot displays the 'User Module' window for 'Vcesat_IGBT'. It is divided into several sections:

- Input Parameters:** A table listing various parameters such as CSMU, GSMU, Ic_start, base_level, points, Compliance_CSMU, Meas_Rangev, PLC, PulseOff, PulseWidth, Vg, and Compliance_GSMU.
- Output Parameters:** A table showing Vce and Ic.
- Pin and Connection:** A schematic diagram of an IGBT with terminals G (Gate), C (Collector), and E (Emitter). It shows an SMU connected to the Collector terminal (measuring current Ic) and another SMU connected to the Gate terminal (measuring voltage Vg).
- Description:** A detailed text block explaining the module's purpose: 'Measures the Collector-Emitter saturation voltage. A current sweep occurs at the Collector terminal with a fixed voltage applied on the Gate terminal.' It lists numerous input and output parameters with their units and functions.

Test pulse sequence: Collector sweep pulse I, Gate bias V (see next figure).

Figure 325: 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

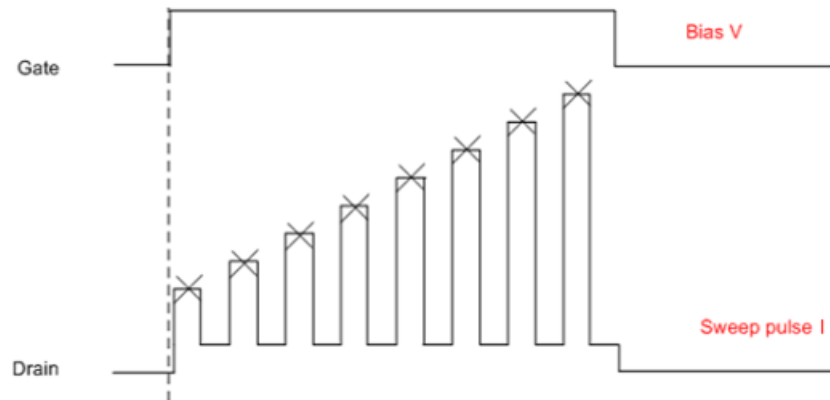
Description:

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 326: RdsOn

Test pulse sequence: Gate bias V, Drain sweep pulse I (see next figure).

Figure 327: 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.

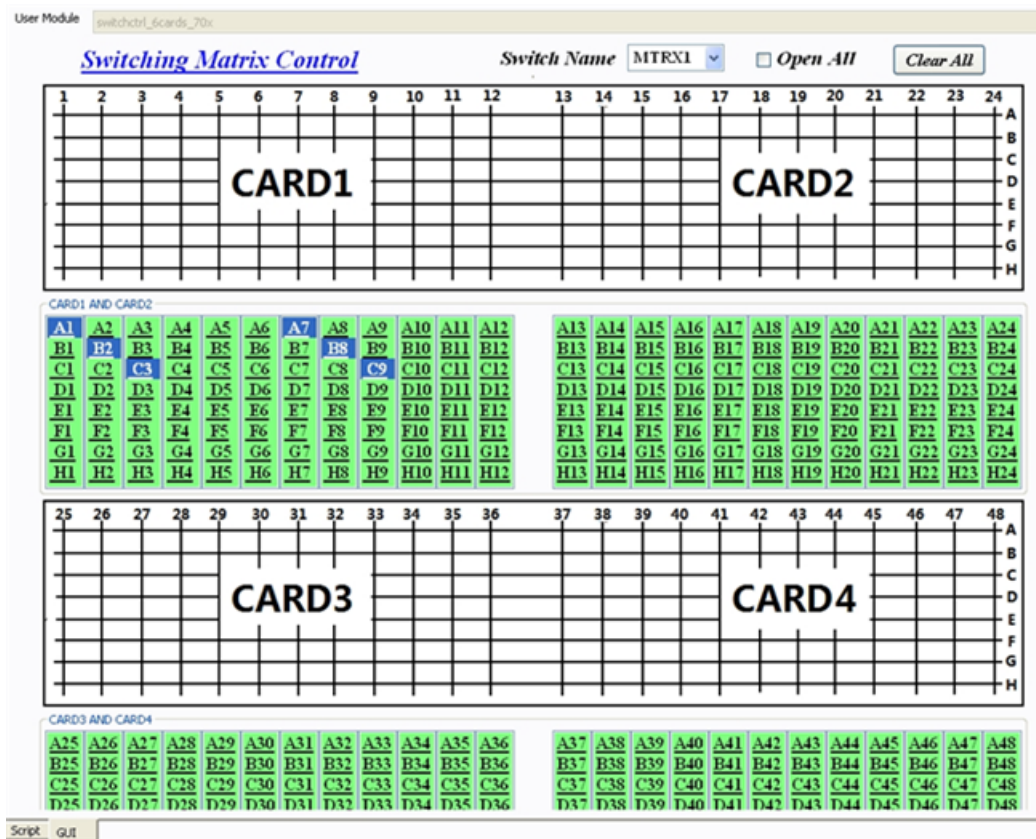
Switch control PTM

You can use this PTM module 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 is 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_other, or it can be imported in multi-test mode from the following directory:

```
C:\ACS_BASIC\library\pyLibrary\PTMLib\switchctrl.py
```

Figure 328: 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 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.

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