

# Using WaferPro Express with B2200A Switch Matrix

Raj Sodhi  
Keysight EEsof EDA  
Device Modeling Product Marketing

# Different Types of Measurements

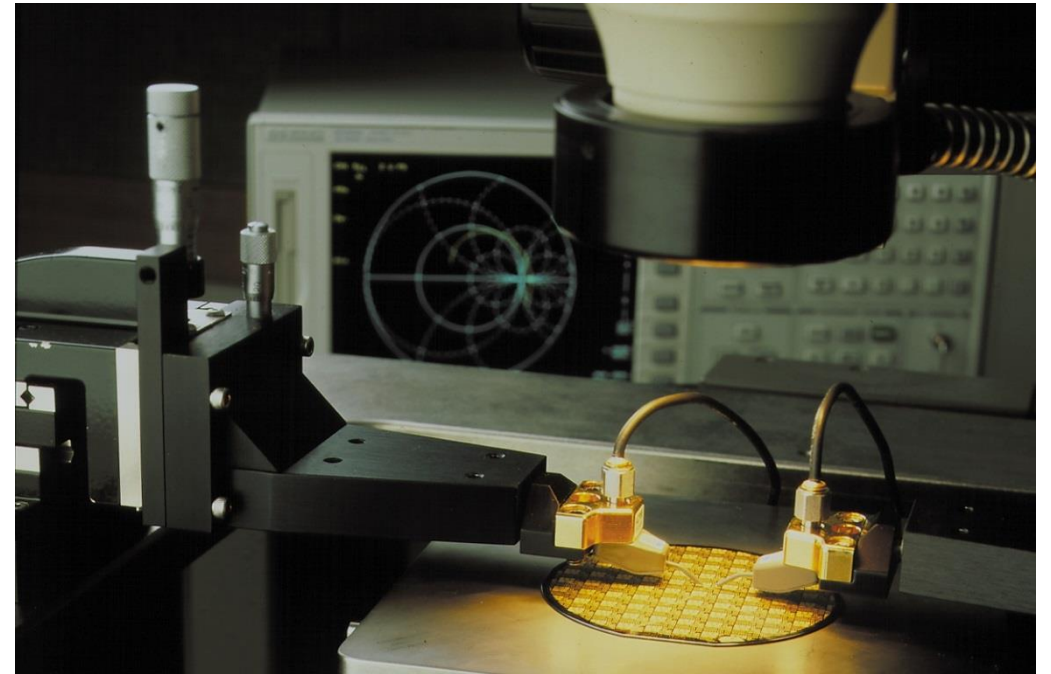
## DC IV or DC CV Measurements

- Majority of foundries use these measurements for baseband modeling
- Typically 4-5 systems in a lab



## DC IV + RF S-parameter Measurements

- For high-frequency modeling
- Typically 1 system in a silicon foundry lab
- For GaAs foundry, main application focus is RF





## E5270B Precision IV Analyzer / 8 Slot Precision Measurement Mainframe

Applying or measure current or voltage to devices under test



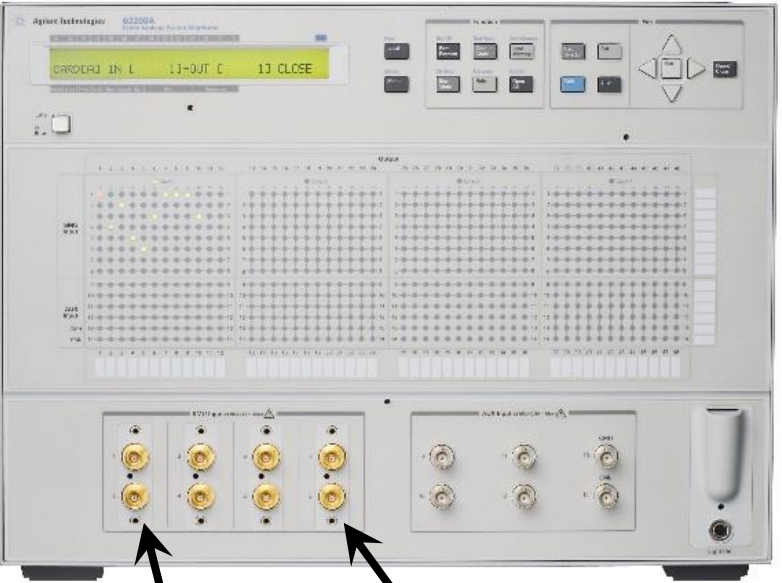
## B2200A fA Leakage Switch Mainframe

Reuse hardware to visit many sites

- in multi-pin package
- on probe card

# Switch matrix applications

Switch Matrix



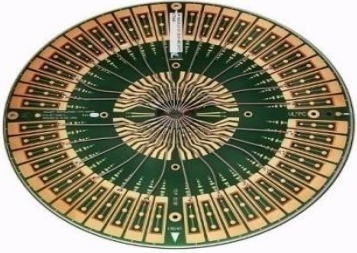
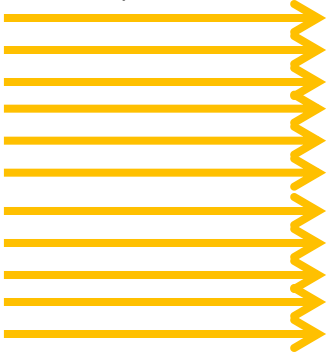
DC-IV



Capacitance

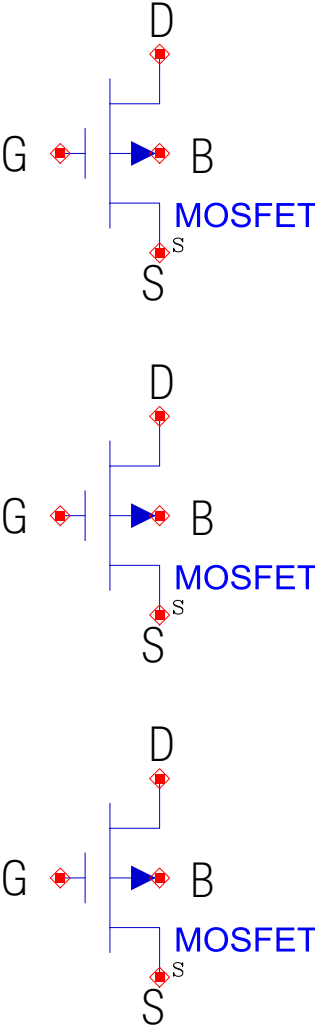
ports

pins



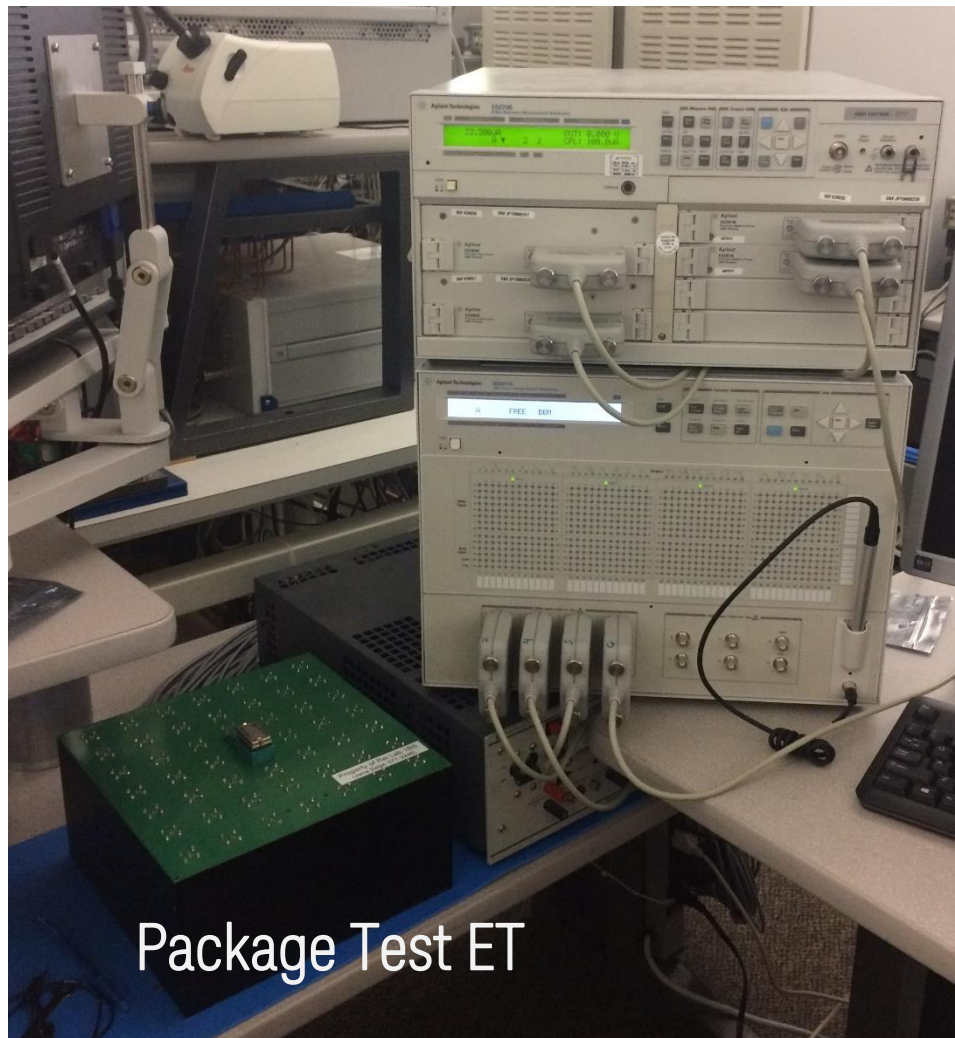
Probe Card  
or...

Packaged Group  
of Parts





# Hardware Setup



E5270B

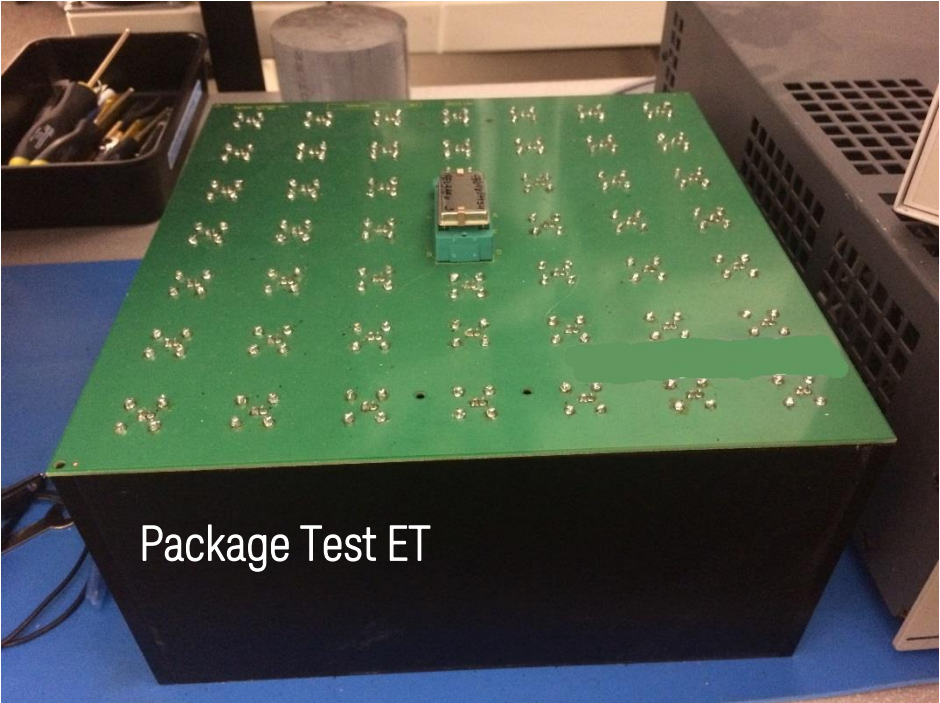
B2200A

Package Test ET



48 triax  
connections

# Package Test ET



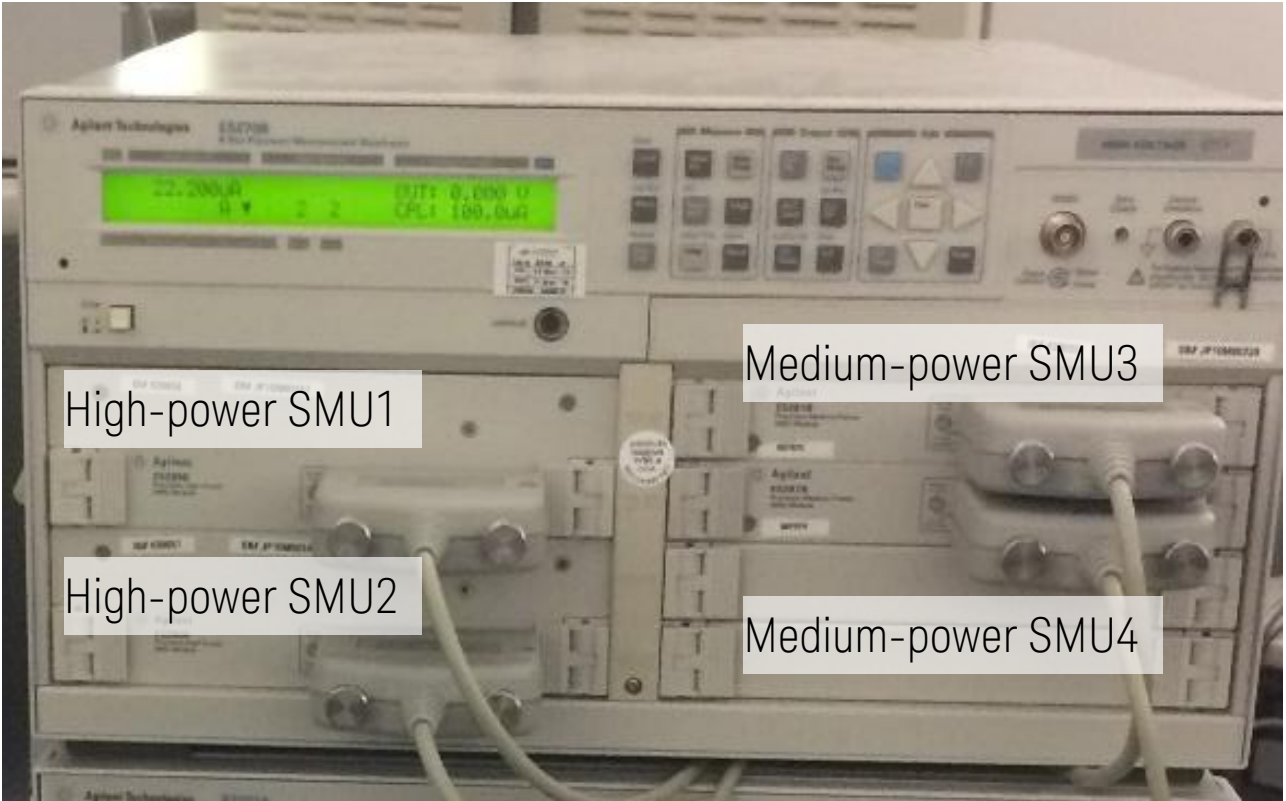
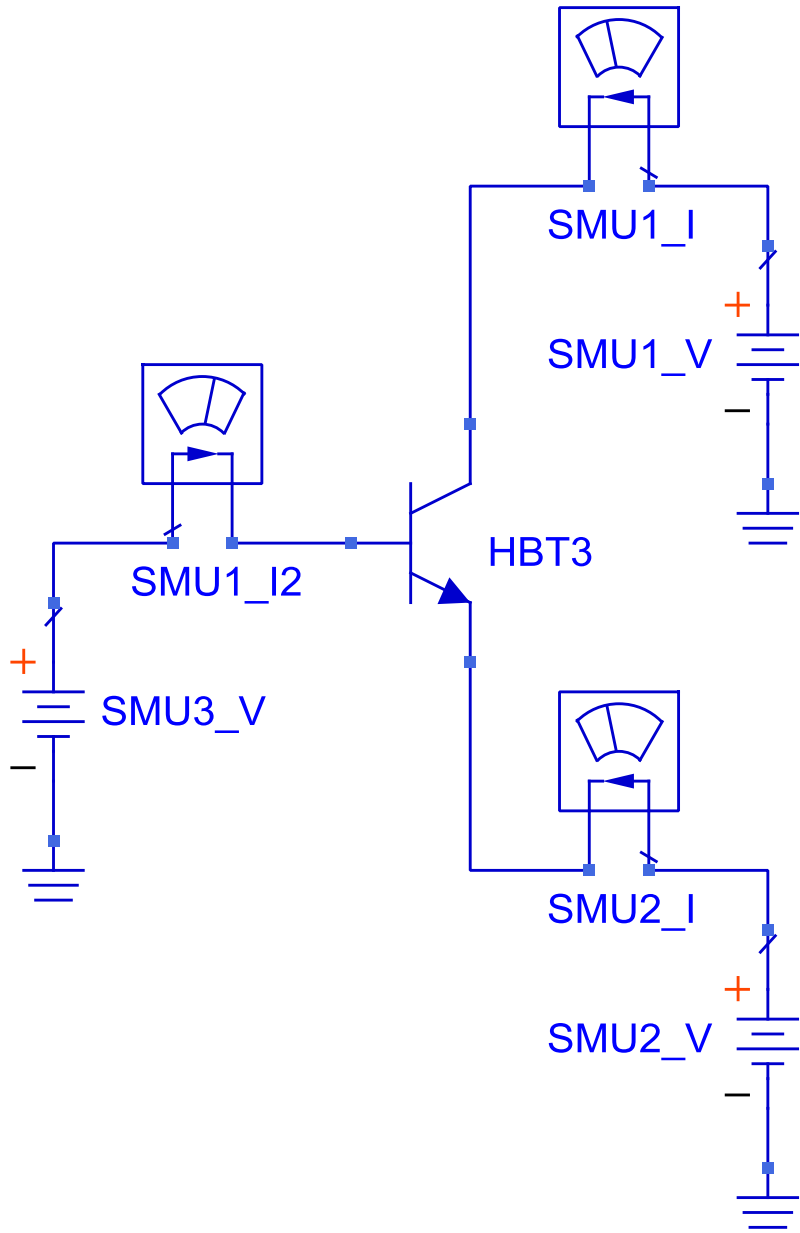
48 triax connector board mated to 24 pin socket

Force and sense connect just before socket

Guard = open







Instrument Settings

KeysightE5270

Interface: gpib0      Address: 1

Unit Table

Unit	Unit Alias
HPSMU2	SMU1
HPSMU4	SMU2
MPSMU5	SMU3
MPSMU6	SMU4

GPiB Connection

Test      Agilent Technologies,E5270B,0,B.01.01

# WaferPro Express GPIB Connections

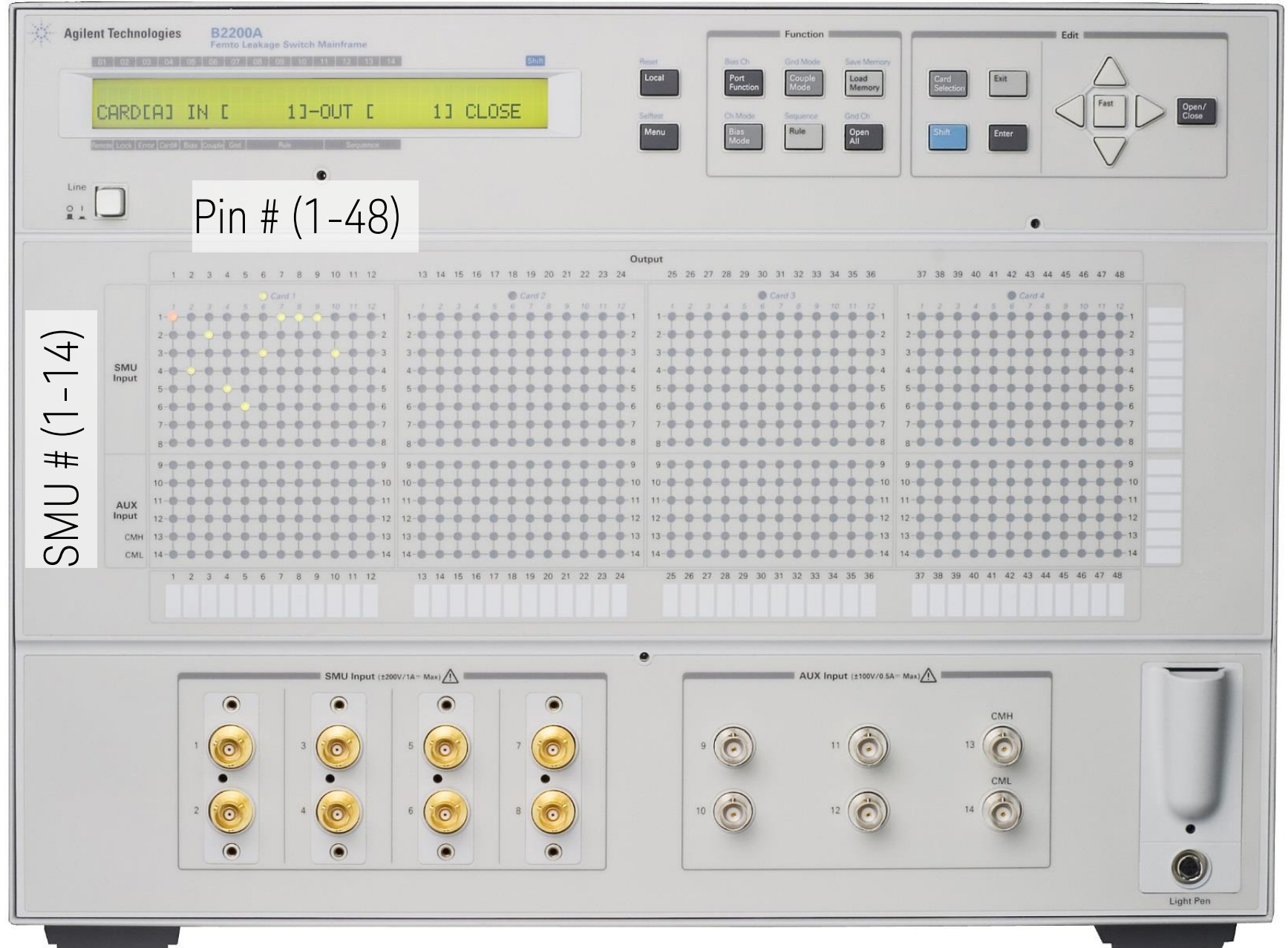
The screenshot shows the 'Hardware Connections' window with the following components:

- Hardware Connection:** A list containing 'gpi0' (callout 1).
- Active Instruments:** A list containing 'KeysightE5270 (gpi0, 1)' (callout 2).
- System Hardware:** A list containing 'Prober', 'Matrix', and 'Chuck', with 'Matrix' selected (callout 3).
- System Hardware Settings:** A section with a 'Matrix' dropdown set to 'B2200A\_02' (callout 4).
- Configuration Table:** A table with two tabs: 'Matrix Definition' and 'Probe Card Definition'. The 'Matrix Definition' tab is active, showing a table with columns 'Unit/Params' and 'Port/Value'.

Unit/Params	Port/Value
SMU1	1
SMU2	3
SMU3	5
SMU4	7
GROUND	0
CMHigh	13
CMLow	14
PinsCount	48
- Connection Test:** A section with 'Standard' selected, a 'Test' button, and a text field containing 'AGILENT,B2201A,0,A.01.04' (callout 5).







SMU # (1-14)

Pin # (1-48)



Force  
Sense

Configuration

Matrix Definition	Probe Card Definition
Unit/Params	Port/Value
SMU1	1
SMU2	3
SMU3	5
SMU4	7
GROUND	0
CMHigh	13
CMLow	14
PinsCount	48

{WPE\_Home}\hpeesof\waferpro\_2016\_04\instr\B2200A\_02.matrix

# Where to look at Switch Matrix drivers

... and define your own!

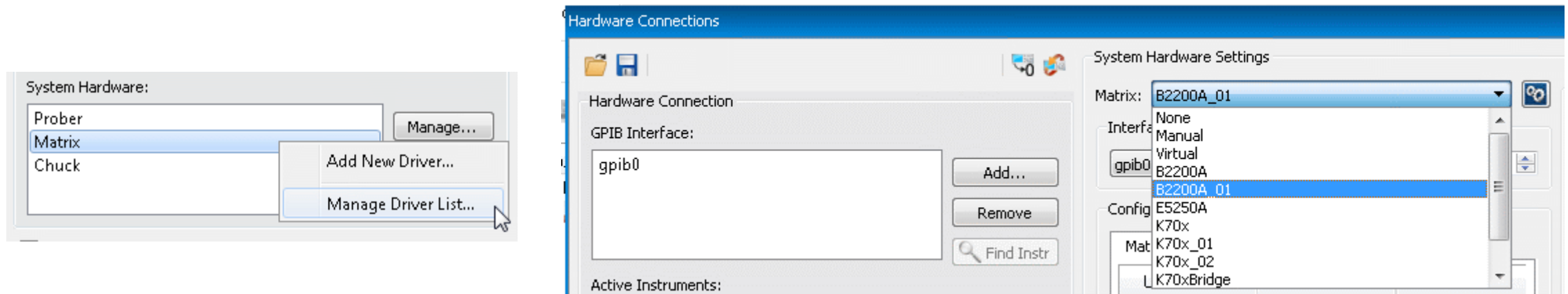
In C:\Keysight\WAFERPROXP\_2016\_04\_HF1\waferpro\config\DriverLibs

Driver~Matrix~B2200A.set

For set V only, standard approach

Driver~Matrix~B2200A\_01.set

For force and sense (Kelvin Connection)



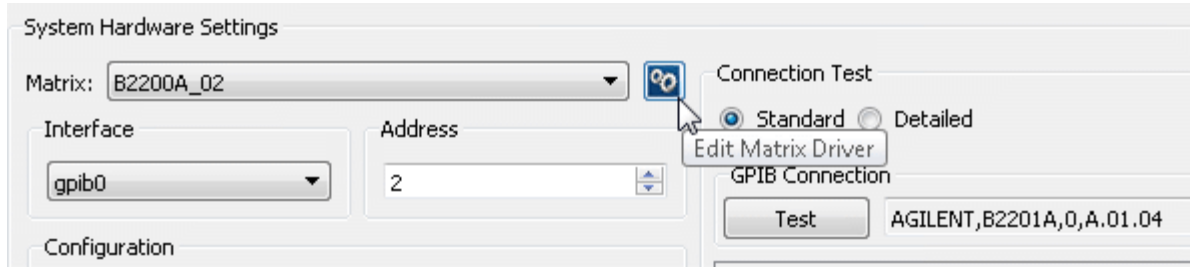
If you make a copy of this to edit it and call it B2200A\_02, it will be saved here:  
{WPE\_Home}\hpeesof\waferpro\_2016\_04\config\DriverLibs

Now it shows up here:





let's look at the switch matrix driver



Driver/Matrix/B2200A\_02:1

File Edit Help

Setup Variables Transforms

Execute  
Functions...  
New...  
Import Text...  
View...  
Rename...

Select Transform:  
README  
Init  
connect  
disconnect\_all  
ground\_all

Function Program Browse...

```
9 bRet = 1
10 errorMsg = ""
11
12 ! ---- Plug all pins to row iRow
13
14 UnitCol = VAL$(VAL(Unit), "%02.Of")
15 Pin = VAL(Pin)
16 PinInCard = Pin
17 Card = 0
18
19 PinLine = VAL$(PinInCard, "%02.Of")
20
21 hpib_cmd = ":ROUT:CLOS (@" & VAL$(Card) & UnitCol & VAL$(PinInCard, "%02.Of") &
22
23 Unit = val$(val(Unit)+1)
24 UnitCol = VAL$(VAL(Unit), "%02.Of")
25 Pin = val(Pin)+val(Offset)
26 PinInCard = Pin
27 PinLine = VAL$(PinInCard, "%02.Of")
28
29 hpib_cmd = val$(hpib_cmd) & ";;ROUT:CLOS (@" & VAL$(Card) & UnitCol & VAL$(Pin
30
31
32 ICCAP_FUNC("/Driver/Utilities/gpib/send_gpib_cmd", "Execute", VAL$(hpib_interface
33 IF /Driver/Utilities/gpib/send_gpib_cmd[0] == 0 THEN
34     bRet = 0
```

Driver/Matrix/B2200A\_02:1

File Edit Help

Setup Variables Transforms

System Variables... Variable Groups

Detach... All Variables

Print System Variables

User Variables

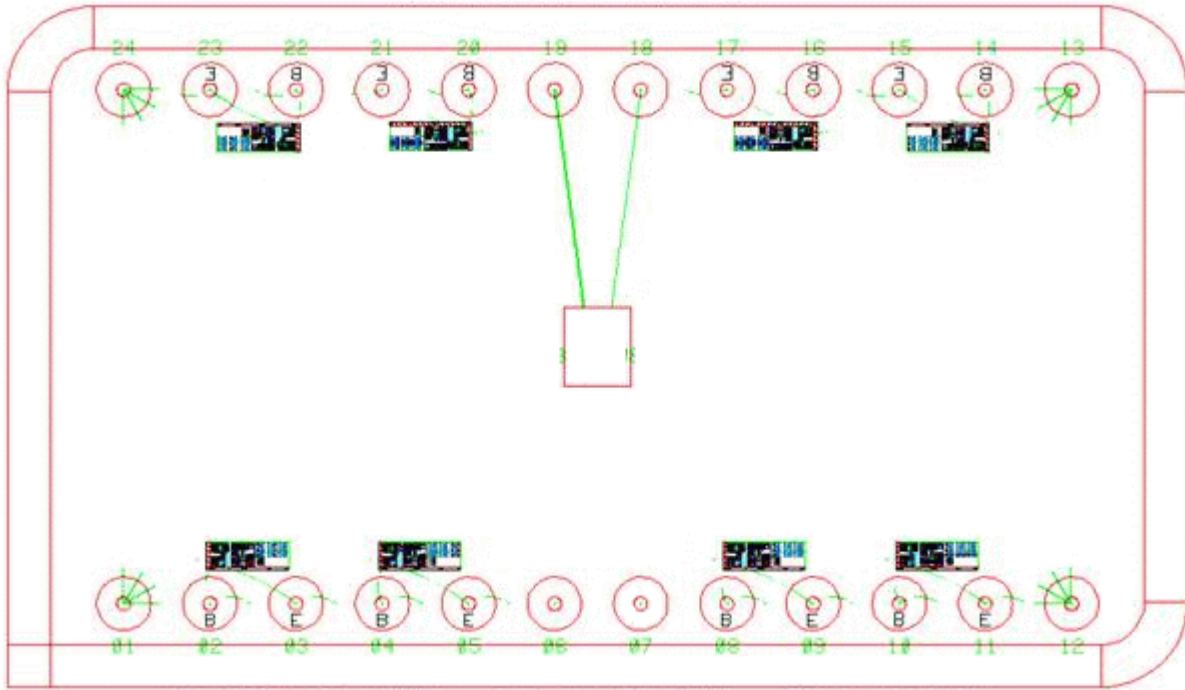
Variable Groupings

Search  Show All Refresh

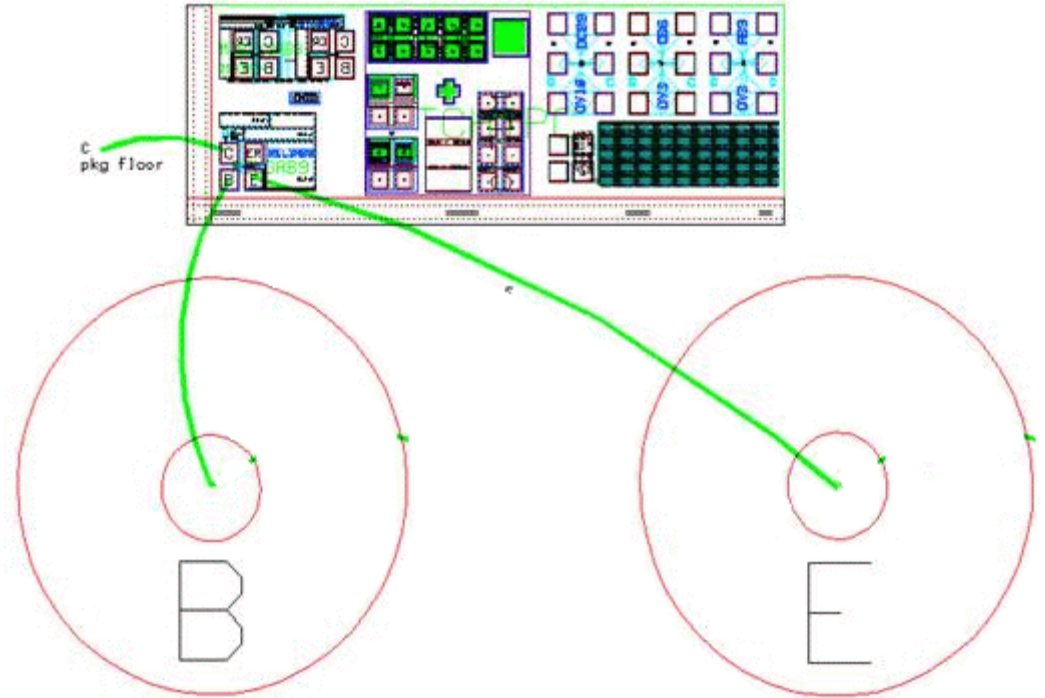
Name	Value	Comment
hpib_interface	gpib0	
hpib_addr	2	
hpib_suffix	\r	
bRet	1	
ErrorMsg		
ground_col	9	
pins_count	48	
hpib_cmd	:ROUT:CLOS (@00305);:ROUT:CLOS (@00406)	
PinTab[0]	48	
PinTab	ICCAP_ARRAY[1]	
Offset	1	

Sets the number of pins separation between force and sense



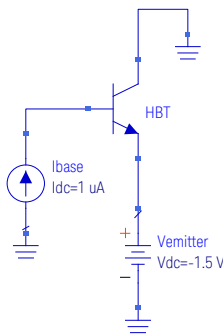
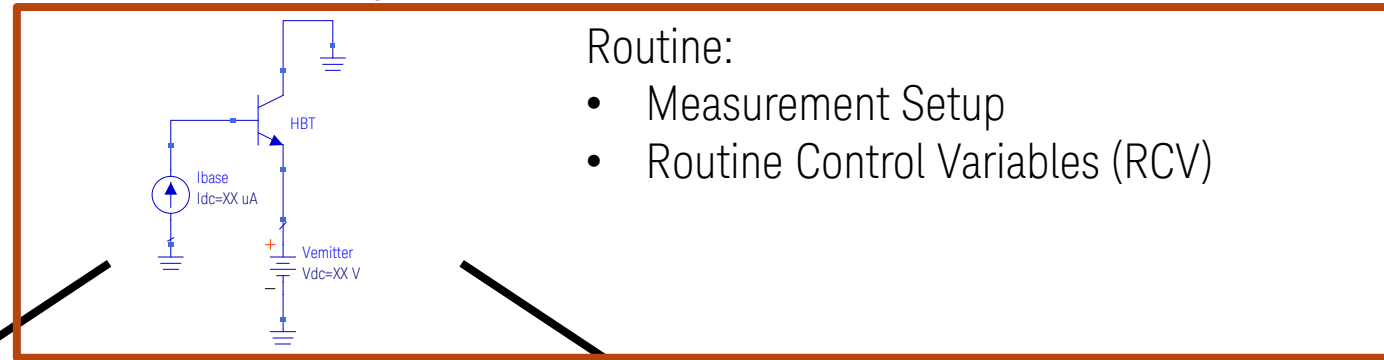


8 HBT devices bonded out to different pins

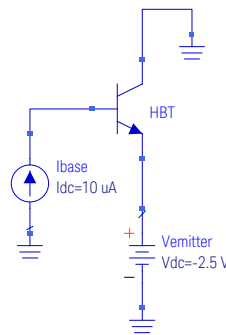


Collector = Package Ground  
 Base to pin  
 Emitter to pin  
 (no ESD wire)

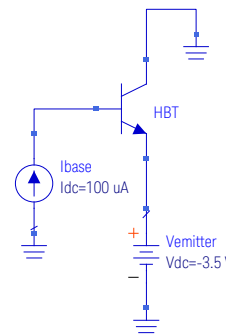
# Routine vs Measurement Group



Low Bias – small device



Medium Bias – medium device

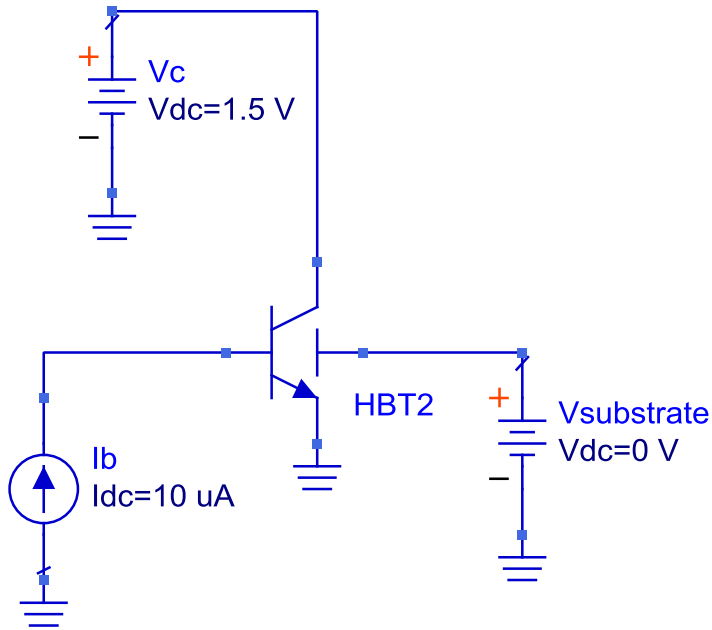


High Bias – big device

Measurement Groups:

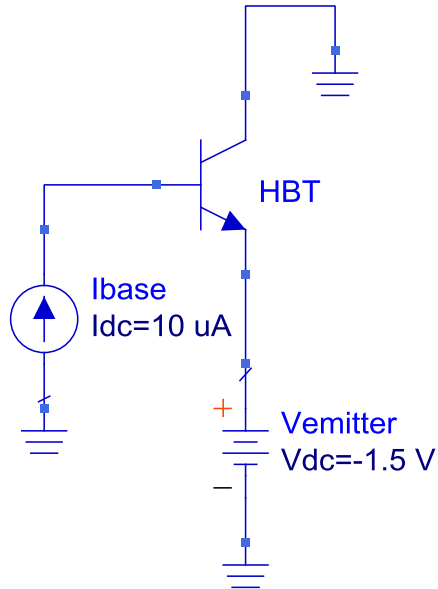
- Sets of RCV's

a measurement group instantiates your routine with particular bias conditions



Factory Provided Biasing Scheme  
BJT/DC/Wpro\_BJT\_DC/Output

Assumes 4 Terminals

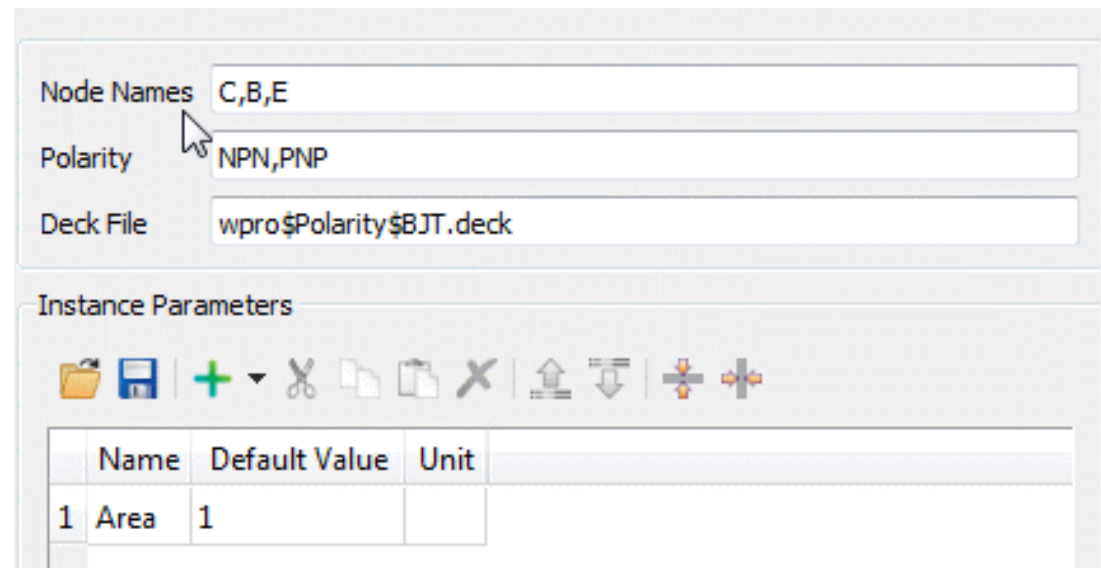
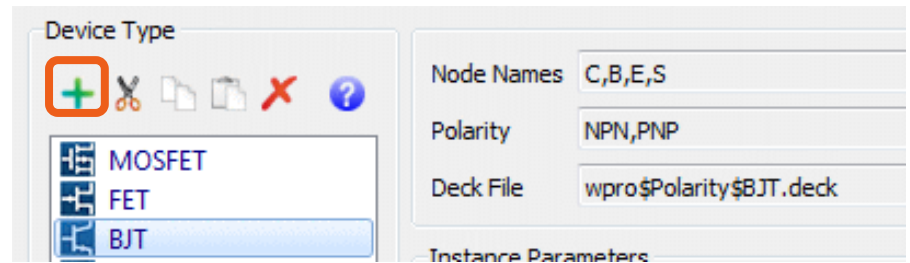
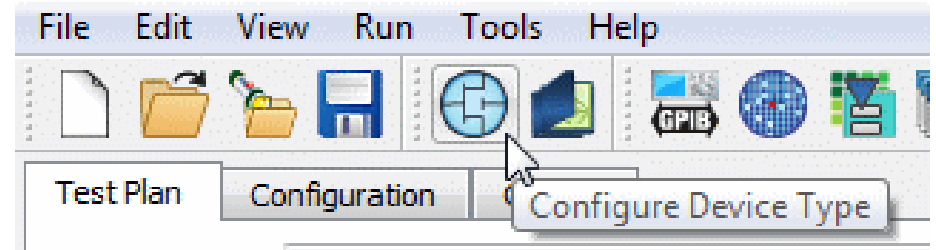


Desired Biasing Scheme

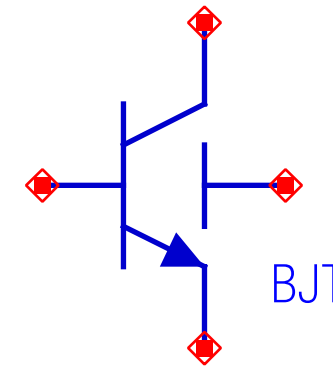
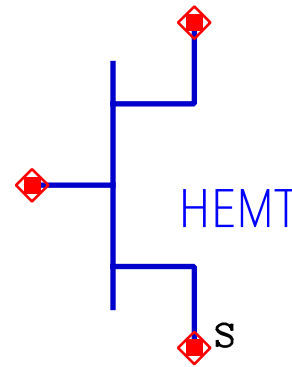
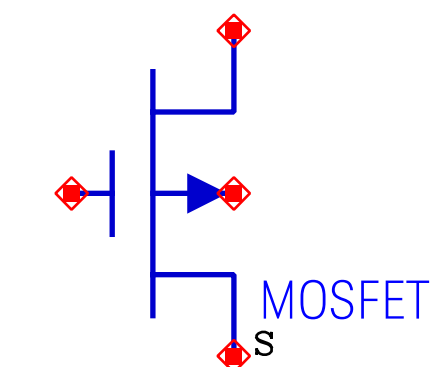
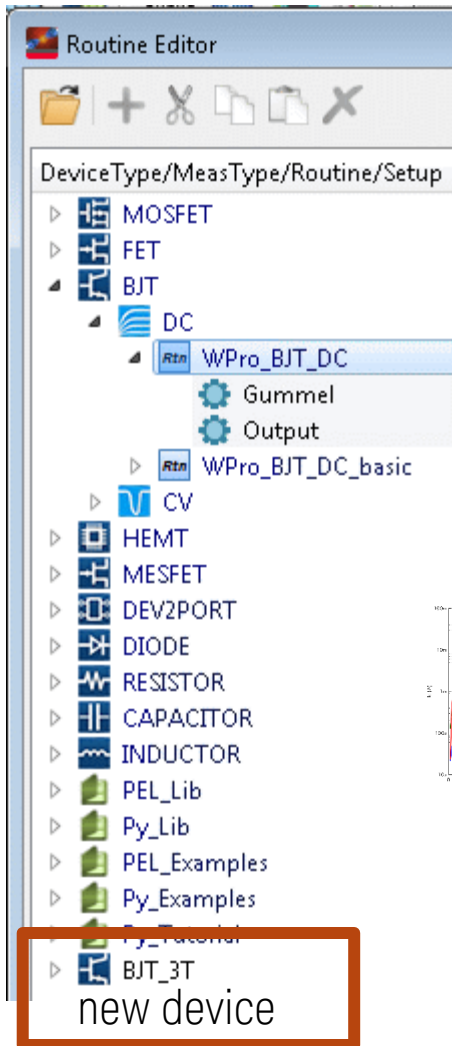
3 Terminals

Lets create a new  
type of device:

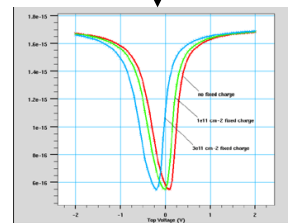
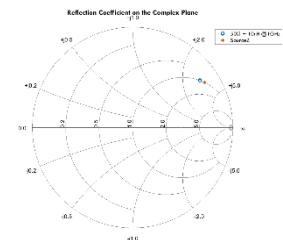
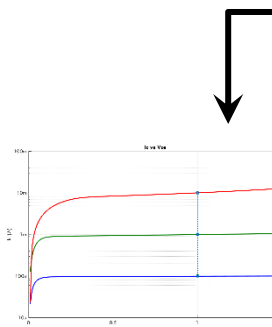
**BJT\_3T**







Device Type

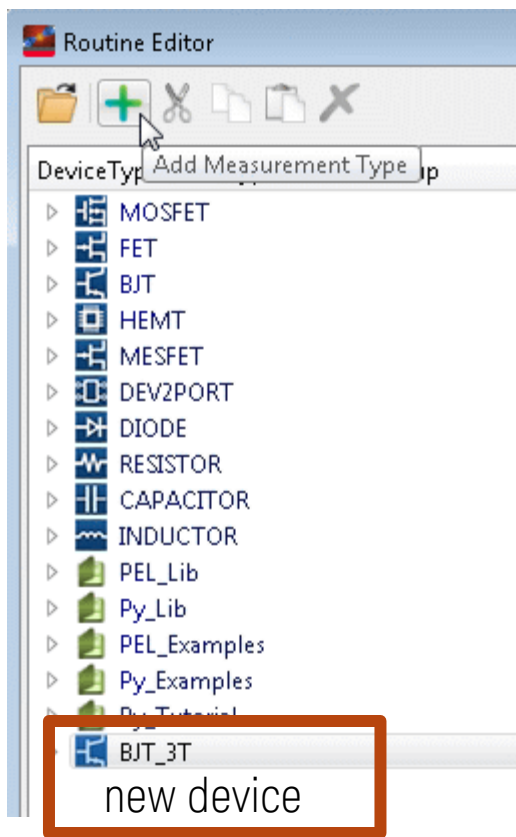


Measurement Type

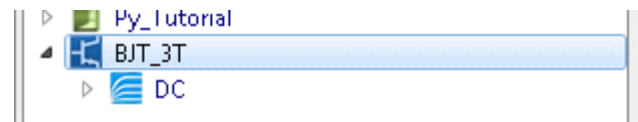
- WPro\_MOSFET\_DC
- WPro\_MOSFET\_DC\_basic
- WPro\_MOSFET\_DC\_basic2
- WPro\_MOSFET\_DC\_basic2\_py
- WPro\_MOSFET\_DC\_basic3
- WPro\_MOSFET\_DC\_basic\_py

Routines (Factory Defined)

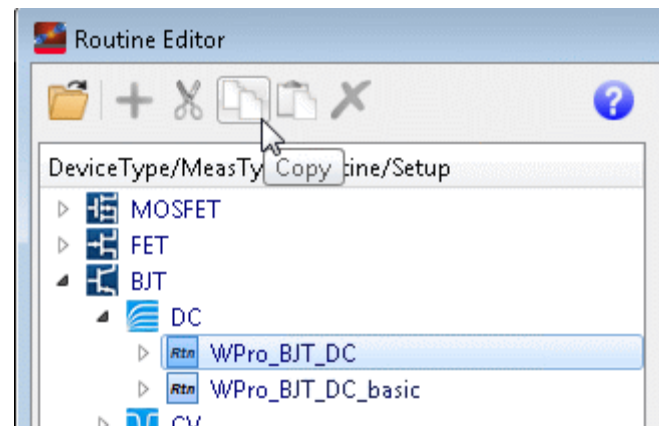
Let's create a routine for our new device that makes sense for a 3 port device



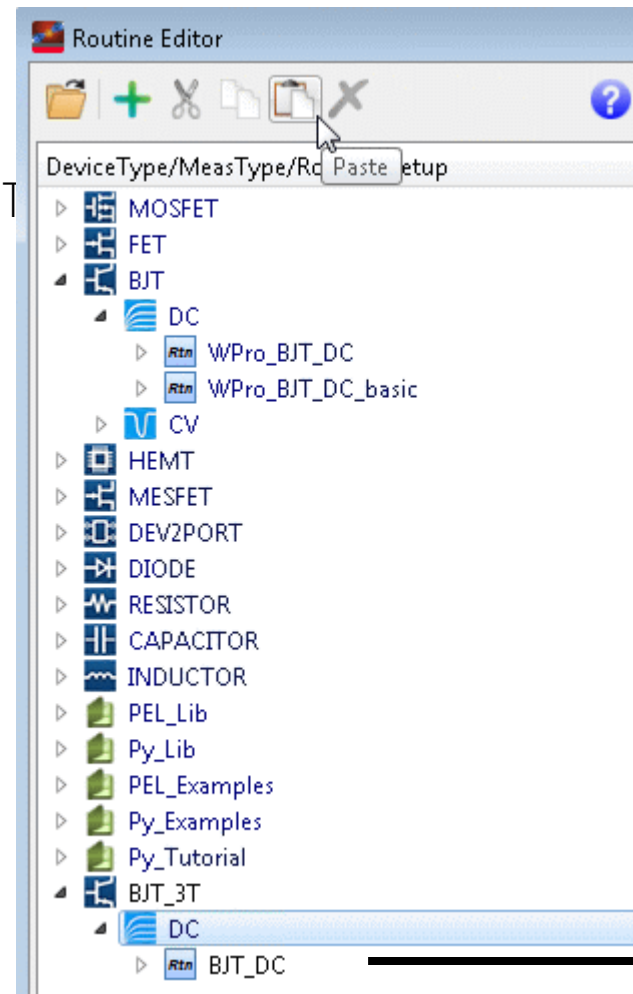
Add a new measurement type  
Choose "DC"



Copy a routine from factory provided BJT routines



paste it into BJT\_3T/DC

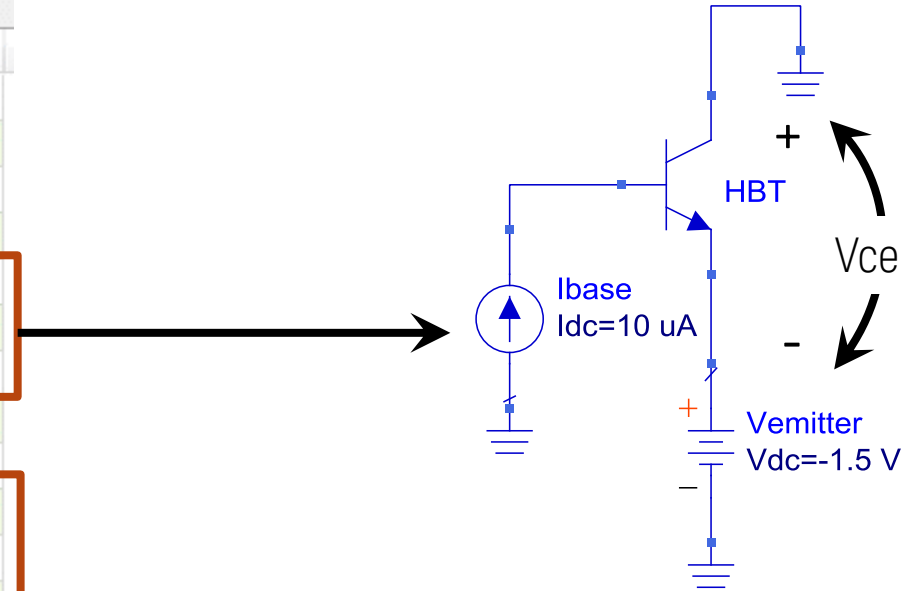


now customize  
this routine

# Routine Control Variables

Routine Control Variables (Measurement Condition Table Definition)

	Name	Default Value	Unit	Description
1	Name	(MC1)		Measurement Condition Name (used by the system)
2	Compl_I	5m	A	Current Compliance
3	Compl_V	1.5	V	Voltage Compliance
4	Gummel_MNL	C,E		[C,E] Measurement Node List for Gummel measurement
5	Ib_Start	0.1u	A	Base current bias start value
6	Ib_Stop	100u	A	Base current bias stop value
7	Ib_Step	10u	A	Base current bias step value
8	VCB	0	V	Collector to Base bias
9	Output_MNL	C,B,E		[C,B,E] Measurement Node List for Output Characteristics measurement
10	Vce_Nom	1.5	V	For Gummel plot
11	Vce_Start	0	V	Collector to Emitter bias start value
12	Vce_Stop	2	V	Collector to Emitter bias stop value
13	Vce_Step	0.05	V	Collector to Emitter bias step value



These are just variable names, with default values and descriptions.



# Set voltages, measure currents, etc.

The screenshot displays the Keysight ADS software interface for configuring a BJT model simulation. The left sidebar shows a project tree with folders like Py\_Lib, PEL\_Examples, Py\_Examples, Py\_Tutorial, and BJT\_3T, with a sub-folder BJT\_DC containing an 'Output' folder and two stimulus files: 'Ic\_vs\_Vbe\_Gum...' and 'Ic\_vs\_Ib\_Gummel'.

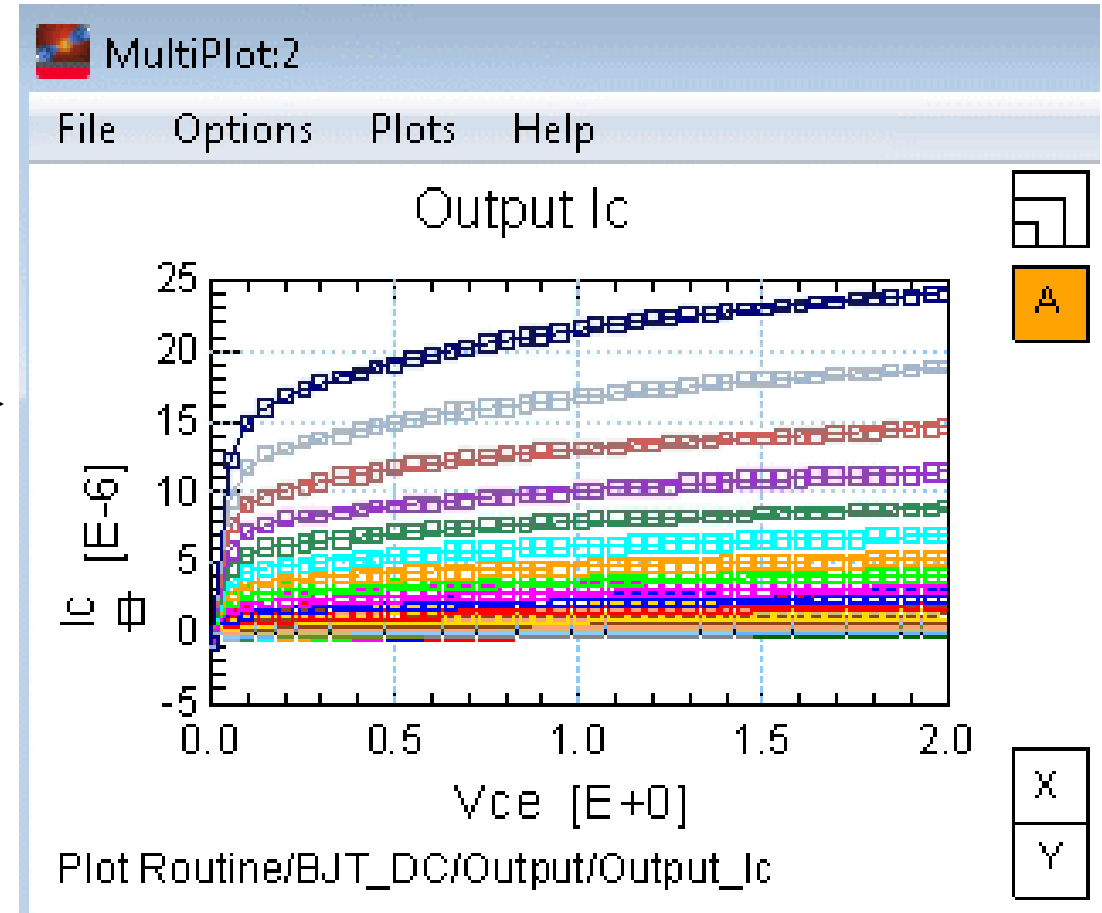
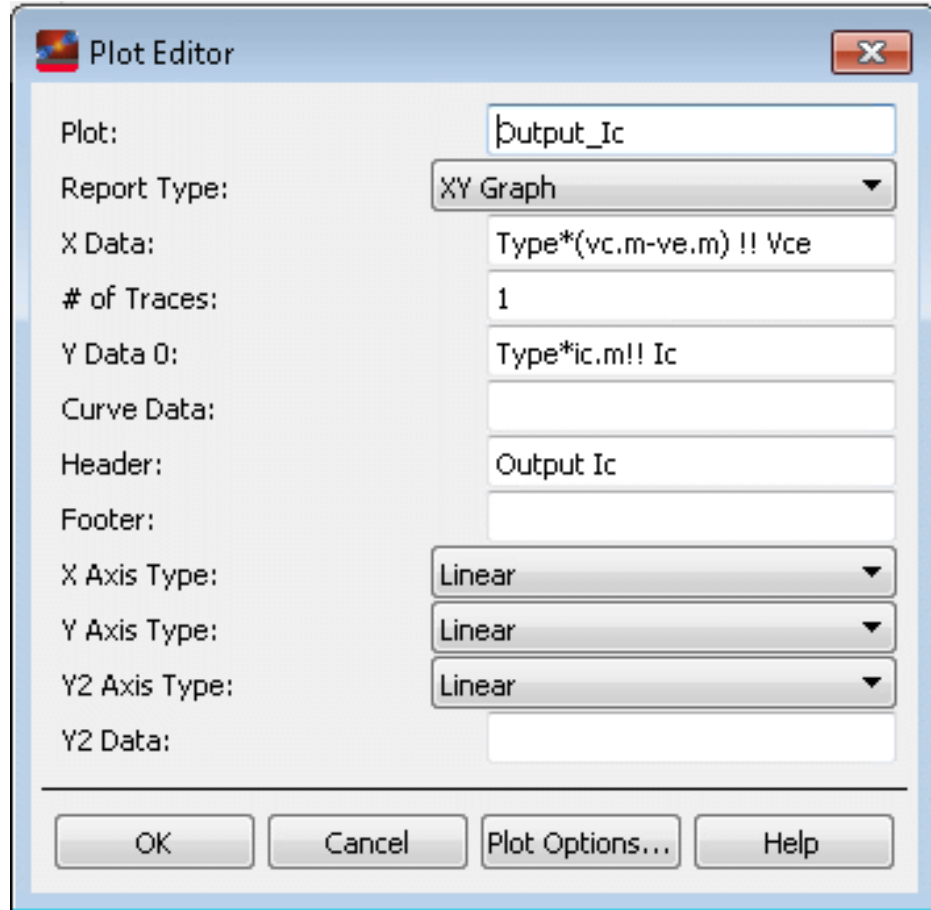
The main window is divided into several sections:

- Inputs (Stimulus):** A table defining the input signals. A text box asks, "What biases do we apply to each port?".

Name	Mode	Unit	Node1	Node2	SwpType	SwpOrder	Compliance	Values/SweepSetting					
vc	V	SMU1	C	GROUND	CON	-	Compl_I	Value	0.000				
ve	V	SMU2	E	GROUND	LIN	1	Compl_I	Start	-Type*Vce_Start	Stop	-Type*Vce_Stop	Npoints	Step -Type*Vce_Step
ib	I	SMU3	B	GROUND	LOG	2	Compl_V	Start	Ib_Start	Stop	Ib_Stop	Npoints	10 TotalPts
- Outputs (Response):** A table defining the output measurements. A text box asks, "What do we want to measure and at what port?".

Name	Mode	Unit	Node1/Port1	Node2/Port2
vb	V	SMU3	B	GROUND
ic	I	SMU1	C	GROUND
ie	I	SMU2	E	GROUND
- Plots:** A list of variables to be plotted: Output\_Ic, Output\_Ie, and Output\_Vbe. A text box asks, "What do we want to plot?".

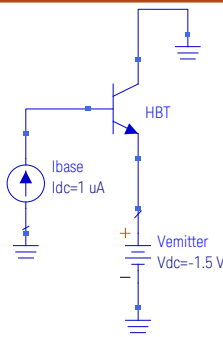
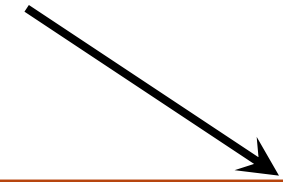
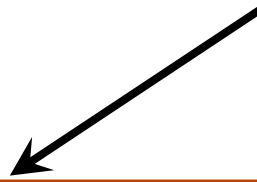
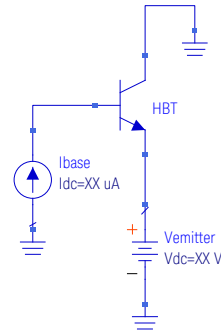
# What do we want to plot?



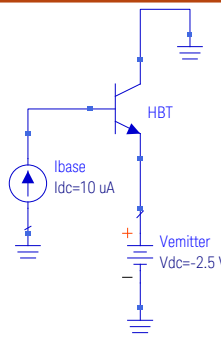
# Routine vs Measurement Group - Revisited

Routine:

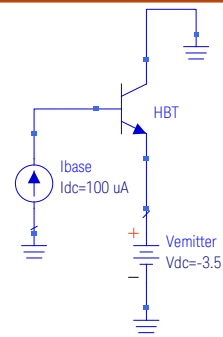
- Measurement Setup
- Routine Control Variables (RCV)



Low Bias – small device



Medium Bias – medium device



High Bias – big device

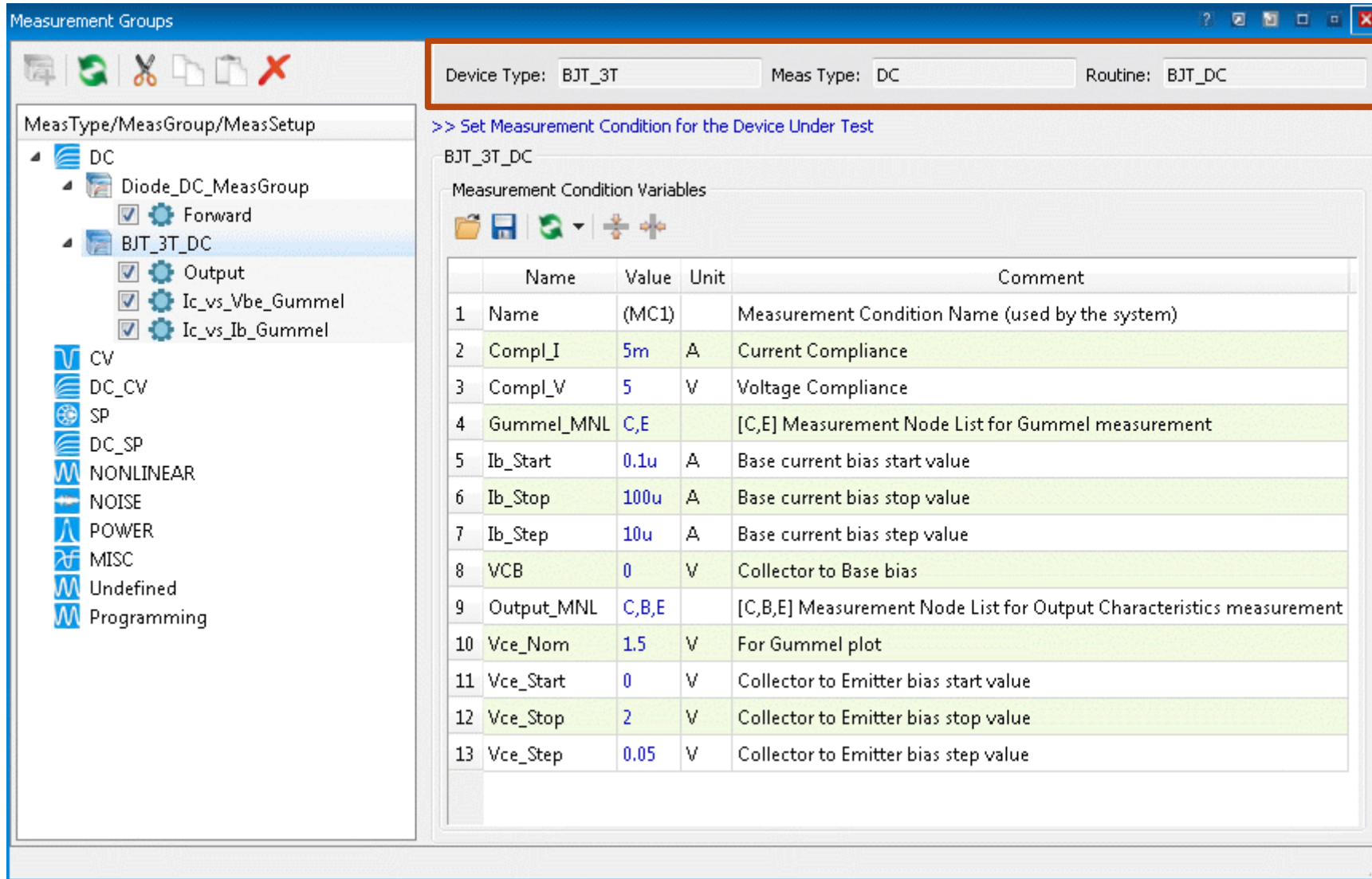
Measurement Groups:

- Sets of RCV's

a measurement group instantiates your routine with particular bias conditions

# Measurement Group

... instantiates a routine with specific variable settings



→ Only valid for Device "BJT\_3T"

Points to our newly created routine "BJT\_DC"

Measurement Group name = "BJT\_3T\_DC"

... will be called out in the test plan.



Packaged\_BJT\_Meas\_v1\* - WaferPro Express

File Edit View Run Tools Help

Project Location C:/Users/rsodhi01/Projects/WaferProExpress/Switch\_Matrix\_B2201A\_v1

Lot LotA

Measurement Device Table

New\_Sequence 27 Package\_1 Show Meas Group Summary

Test Plan View Device View

+ Add Measurement Device

	Device	Device Type	Polarity	Meas Group	Nodes	Parameters
1	HBT2B_1	BJT_3T	NPN	DC:BJT_3T_DC	C=1,B=3,E=5	Area=1
2	HBT2B_2	BJT_3T	NPN	DC:BJT_3T_DC	C=1,B=7,E=9	Area=1
3	HBT2B_3	BJT_3T	NPN	DC:BJT_3T_DC	C=23,B=15,E=17	Area=1
4	HBT2B_4	BJT_3T	NPN	DC:BJT_3T_DC	C=23,B=19,E=21	Area=1
5	HBT2B_5	BJT_3T	NPN	DC:BJT_3T_DC	C=25,B=27,E=29	Area=1
6	HBT2B_6	BJT_3T	NPN	DC:BJT_3T_DC	C=25,B=31,E=33	Area=1
7	HBT2B_7	BJT_3T	NPN	DC:BJT_3T_DC	C=47,B=39,E=41	Area=1
8	HBT2B_8	BJT_3T	NPN	DC:BJT_3T_DC	C=47,B=43,E=45	Area=1

View Option

Block  Subsite  Device Type  Polarity  Device Info

Seq(On/Off) / Temp / Wafer / Dies

- New\_Sequence
  - 27
    - Package\_1
      - X0-Y1

Driver: Prober=None,Matrix=None,Chuck=None Status:

Run Manual Measurement Start/Resume Test Plan

either run manual measurement on a single device or sequence the entire test plan.

WaferPro Express - Packaged\_BJT\_Meas\_v1\*

File Edit View Run Tools Help

Project Location: C:/Users/hftc\_etl/WPE\_Projects/Switch\_Matrix\_B2201A\_v1

Lot: LotA

Measurement Device Table

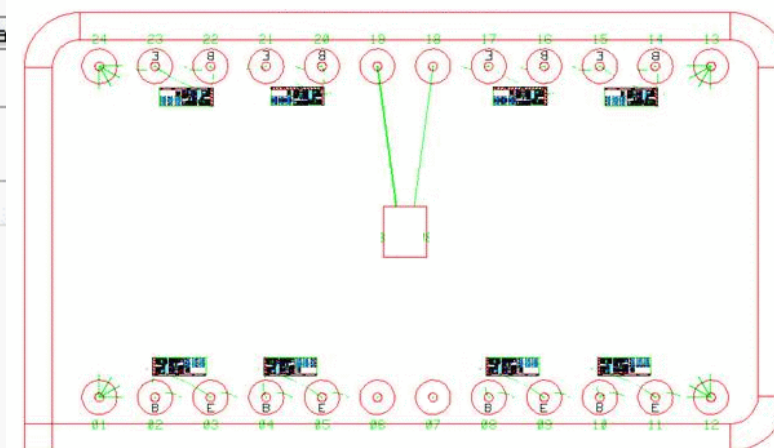
New\_Sequence: 27 Wafer\_1

Device Type: BJT\_3T

Block	Subsite	Device	Device Type	Polarity	Meas Group	C	B	E	Area	
1	WholeDie	Subsite_1	HBT2B_1	BJT_3T	NPN	DC:BJT_3T_DC	1	3	5	1
2	WholeDie	Subsite_1	HBT2B_2	BJT_3T	NPN	DC:BJT_3T_DC	1	7	9	1
3	WholeDie	Subsite_1	HBT2B_3	BJT_3T	NPN	DC:BJT_3T_DC	23	15	17	1
4	WholeDie	Subsite_1	HBT2B_4	BJT_3T	NPN	DC:BJT_3T_DC	23	19	21	1
5	WholeDie	Subsite_1	HBT2B_5	BJT_3T	NPN	DC:BJT_3T_DC	25	27	29	1
6	WholeDie	Subsite_1	HBT2B_6	BJT_3T	NPN	DC:BJT_3T_DC	25	31	33	1
7	WholeDie	Subsite_1	HBT2B_7	BJT_3T	NPN	DC:BJT_3T_DC	47	39	41	1
8	WholeDie	Subsite_1	HBT2B_8	BJT_3T	NPN	DC:BJT_3T_DC	47	43	45	1

Run Manual Measurement Start/Resume Test Plan

Driver: Prober=None,Matrix=B2200A\_02,Chuck=None Status:



$$\text{Force Pin} = 2 * \text{Package Pin} - 1$$

$$\text{Sense Pin} = \text{Force Pin} + \text{Offset}$$

(where Offset = 1)

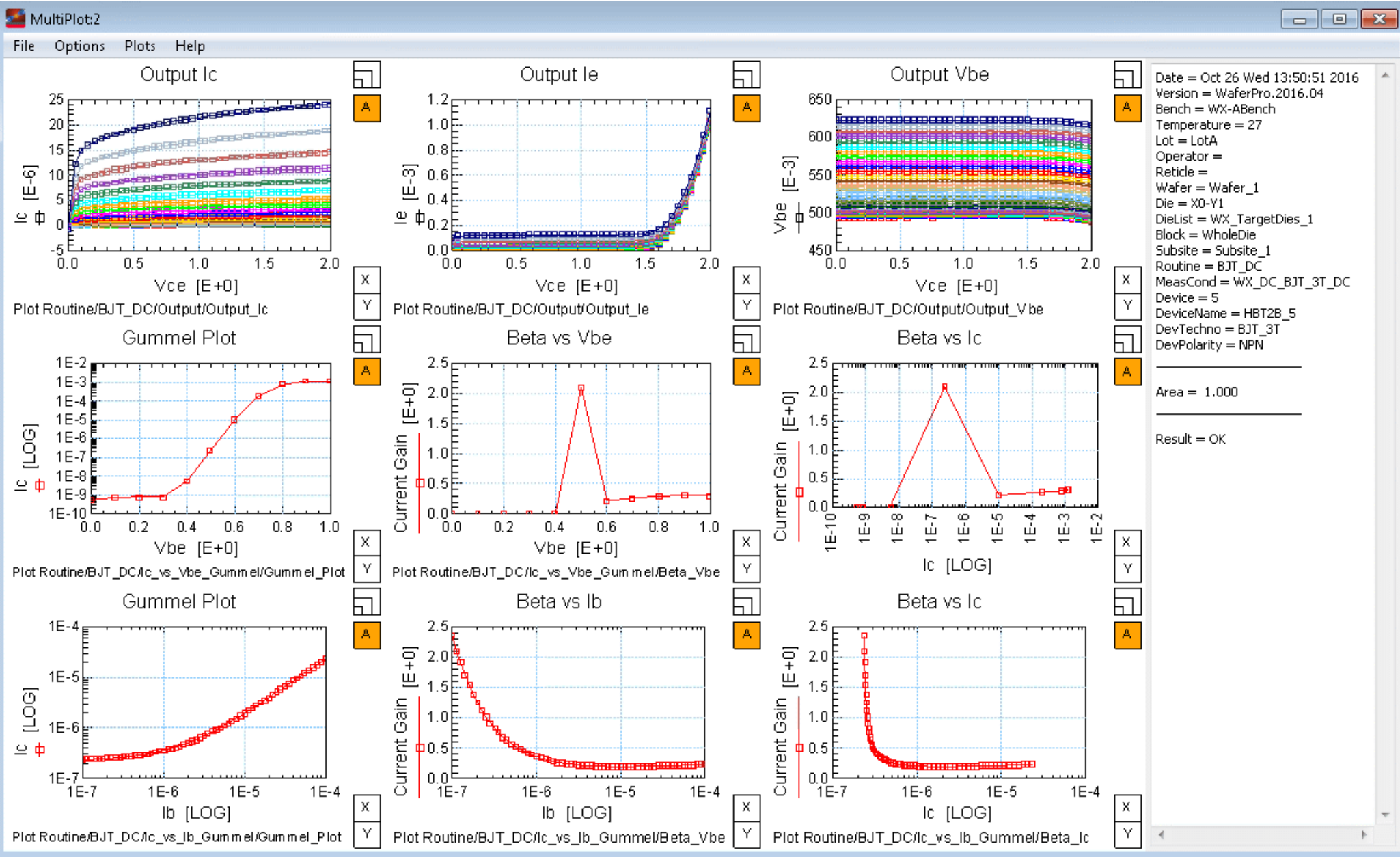
# Measurement Log

Measurement Result Log

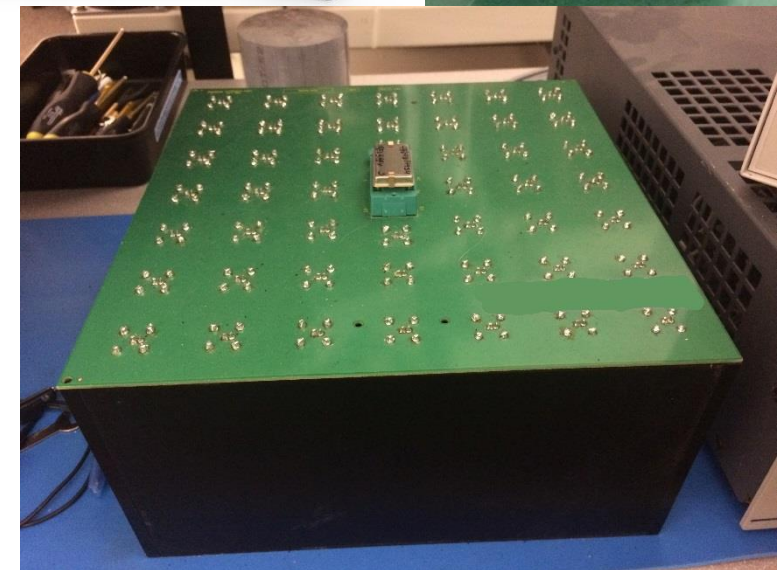
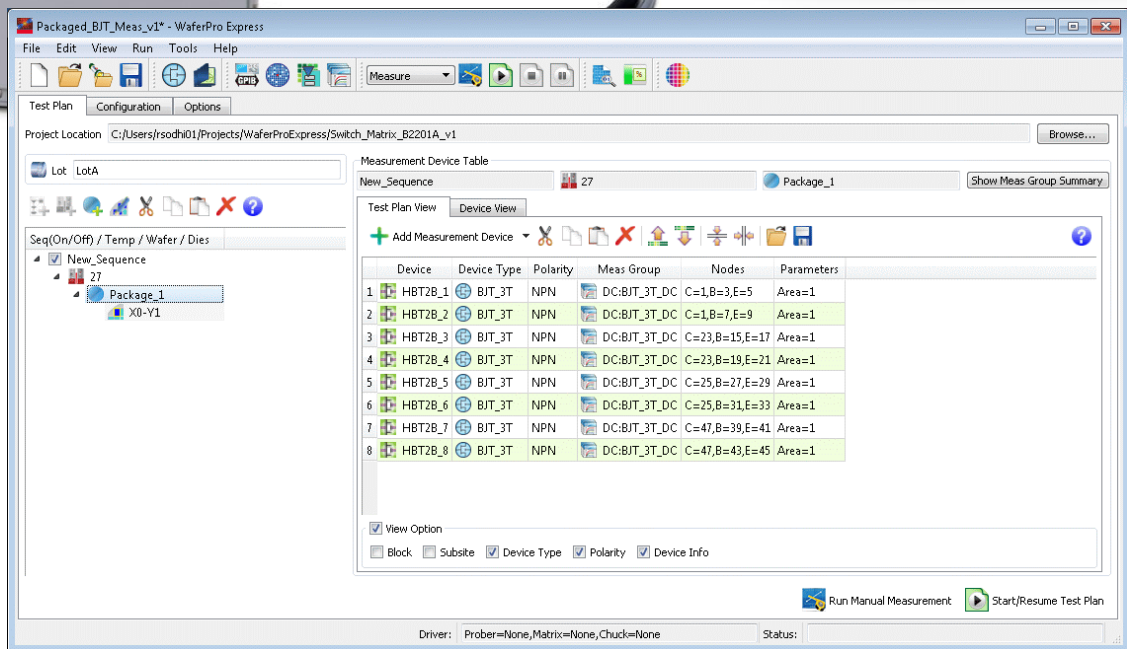
View Test Plan Progress During Execution

13:47:30> [START]  
13:47:30> Bench Temperature before sequence start: 27 degC  
13:47:32> Start Sequence Step: 1  
13:47:32> Current Wafer: Wafer\_1  
13:47:32> Target Wafer: Wafer\_1  
13:47:32> Loading wafer...  
13:47:32> Loaded wafer: [Wafer\_1] Next wafer: [Wafer\_2]  
13:47:32> Temperature change done[reached 27 degC].  
13:47:33> Moved to Die: X0-Y1, Block: WholeDie, Subsite: Subsite\_1  
13:48:32> (1/1|1/1|1/1|1/8|1/1) Measured Device HBT2B\_1, Routine BJT\_DC, MeasCond: WX\_DC\_BJT\_3T\_DC, Result OK Comment  
13:49:14> (1/1|1/1|1/1|2/8|1/1) Measured Device HBT2B\_2, Routine BJT\_DC, MeasCond: WX\_DC\_BJT\_3T\_DC, Result OK Comment  
13:49:46> (1/1|1/1|1/1|3/8|1/1) Measured Device HBT2B\_3, Routine BJT\_DC, MeasCond: WX\_DC\_BJT\_3T\_DC, Result OK Comment  
13:50:19> (1/1|1/1|1/1|4/8|1/1) Measured Device HBT2B\_4, Routine BJT\_DC, MeasCond: WX\_DC\_BJT\_3T\_DC, Result OK Comment  
13:50:51> (1/1|1/1|1/1|5/8|1/1) Measured Device HBT2B\_5, Routine BJT\_DC, MeasCond: WX\_DC\_BJT\_3T\_DC, Result OK Comment  
13:51:20> (1/1|1/1|1/1|6/8|1/1) Measured Device HBT2B\_6, Routine BJT\_DC, MeasCond: WX\_DC\_BJT\_3T\_DC, Result OK Comment  
13:51:50> (1/1|1/1|1/1|7/8|1/1) Measured Device HBT2B\_7, Routine BJT\_DC, MeasCond: WX\_DC\_BJT\_3T\_DC, Result OK Comment  
13:52:21> (1/1|1/1|1/1|8/8|1/1) Measured Device HBT2B\_8, Routine BJT\_DC, MeasCond: WX\_DC\_BJT\_3T\_DC, Result OK Comment  
13:52:22> Prober is in No Contact (Separate) state  
13:52:22> Prober moved to Home position  
13:52:22> Sequence finished  
13:52:22> [END]

→ double-click any one of these to get all of the plots for that device









# Where to Learn More

Keysight.com, Videos, Knowledge Center, etc.

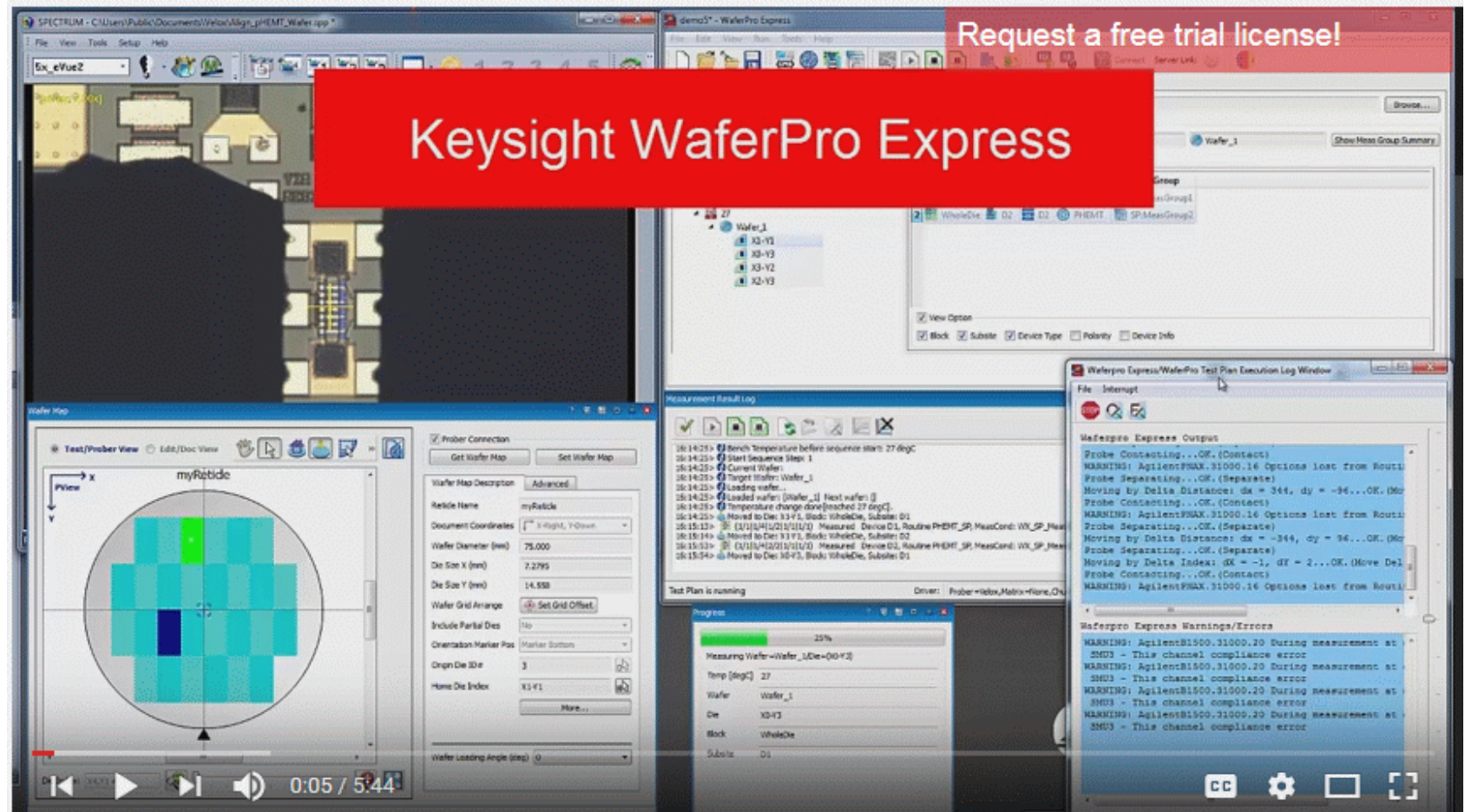
WaferPro Express

Knowledge Center

For questions, call:

Keysight Support

+1 800 829-4444



Keysight WaferPro Express

