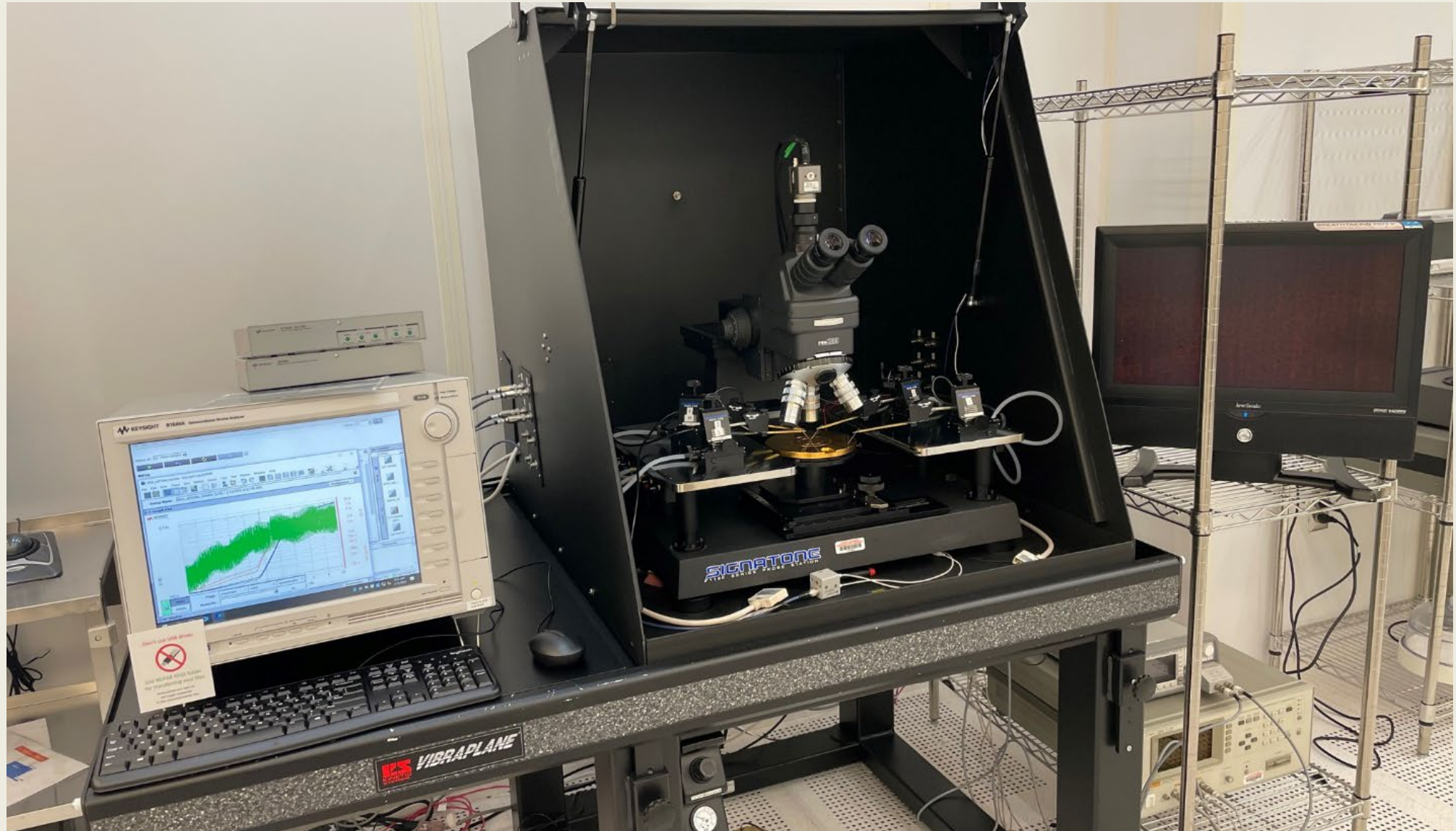


Advanced Electrical Test Using NUFAB Probe Station

Ying Jia

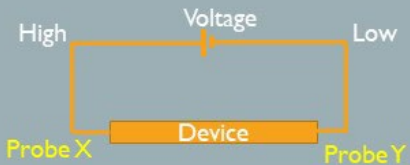
The Probe Station



The Four Basic Programs

2-point IV

- Quick connection check
- Diodes



High Voltage Low

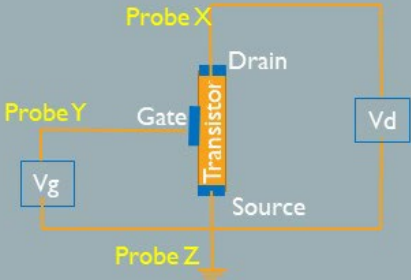
Probe X Device Probe Y

Import program Desktop/Test Setups/2point_IV
Edit channel units

Unit :	V Name :	I Name :	Mode :	Function :
SMU X	V4	I4	V	VAR1
SMU Y	V1	I1	COMMON	CONST

3 point IV

- Transistors



Probe X Drain

Probe Y Gate

Transistor

Vd

Vg

Source

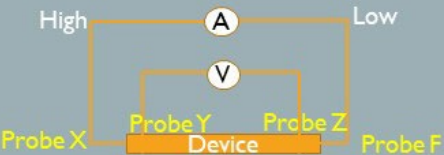
Probe Z

Import program Desktop/Test Setups/3point_transistor_*
Edit channel units

Unit :	V Name :	I Name :	Mode :
SMU Z	Vs	Is	COMMON
SMU X	Vd	Id	V
SMU Y	Vg	Ig	V

4-point IV

- Low resistors, e.g metal films/stripes, doped Si



High A Low


Probe X V Probe Y Probe Z Device Probe F

Import program Desktop/Test Setups/4point_IV
Edit channel units

Unit :	V Name :	I Name :	Mode :	Function :
SMU X	V1	I1	I	VAR1
SMU F	V2	I2	COMMON	CONST
SMU Y	V3	I3	I	CONST
SMU Z	V4	I4	I	CONST

CV

- Capacitors
- Dielectric materials



High Voltage Low

Probe 4 Capacitor Probe 3

Import program Desktop/Test Setups/CV_sweep
Edit channel units

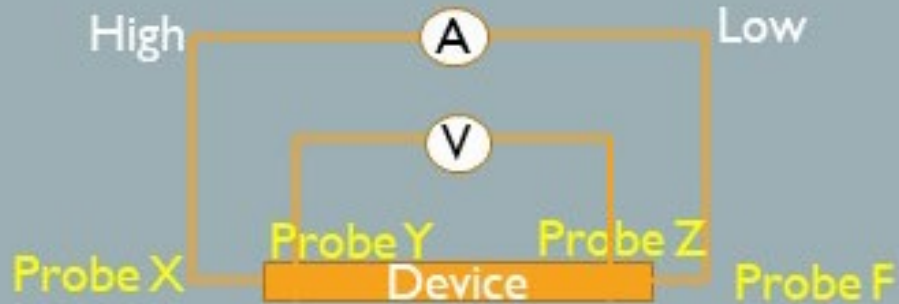
Unit :	V Name :	I Name :	Mode :	Function :
CMU124F/SC	VBas			VAR1

Outline

- Four-point IV
- Double-looped three-point transistor IV
- Pulsed two-point IV
- Arbitrary waveform and high-speed IV
- RF probes

The 4-point IV

4 point IV



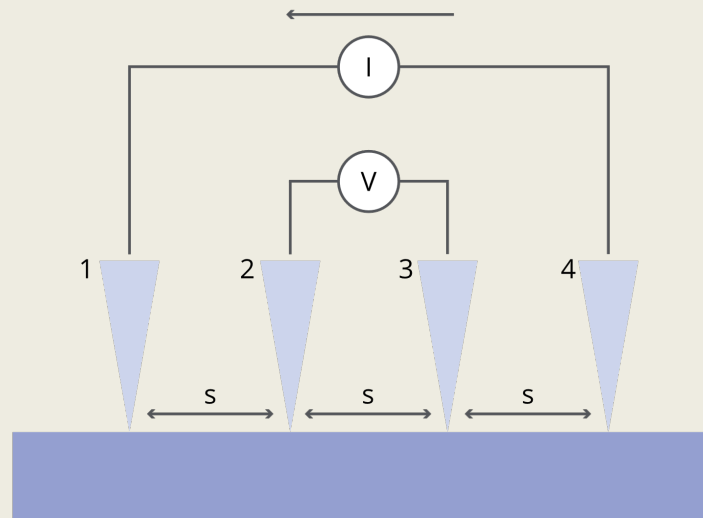
Import program Desktop/Test Setups/4point_IV
Edit channel units

Unit :	V Name :	I Name :	Mode :	Function :
SMU X	V1	I1	I	VAR1
SMU F	V2	I2	COMMON	CONST
SMU Y	V3	I3	I	CONST
SMU Z	V4	I4	I	CONST

Why use it?

- Eliminate contact and wire resistances from the measurement
- Sheet resistance

How to use it?



$$R_S = \frac{\pi}{\ln(2)} \frac{\Delta V}{I} = 4.53236 \frac{\Delta V}{I}$$

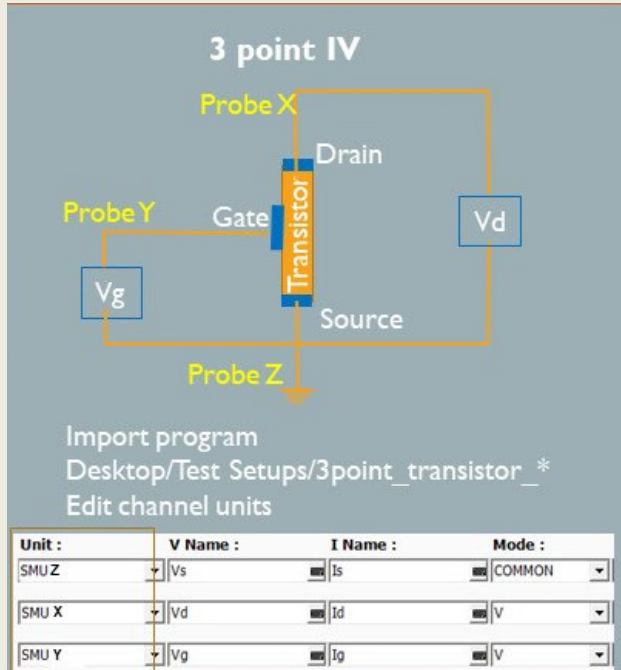
$$\rho = R_S \cdot t$$

Double-looped 3-point transistor IV

Why use it?

Automate 3-point IV

How to use it? Load existing program from application



NUFAB

Application Test

Category...

- Advanced NVM
- BIT
- CMOS
- Discrete
- GenericTest
- MCSMU_IV
- Memory

Library

- Id-Vd[3]
- Id-Vg pulse
- Id-Vg

Id-Vd[3] Setup Name : [Id-Vd[3]]

Device Parameters

Polarity : Nch Lg : 100 nm Wg : 10.0 um

Test Parameters

Primary Sweep

Drain : SMU3:MP

VdStart : 0 V

VdStop : 2.00 V

VdStep : 50 mV

Secondary Sweep

Gate : SMU1:HR

VgStart : 500 mV

VgStop : 2.00 V

VgStep : 500 mV

Source : SMU2:HR

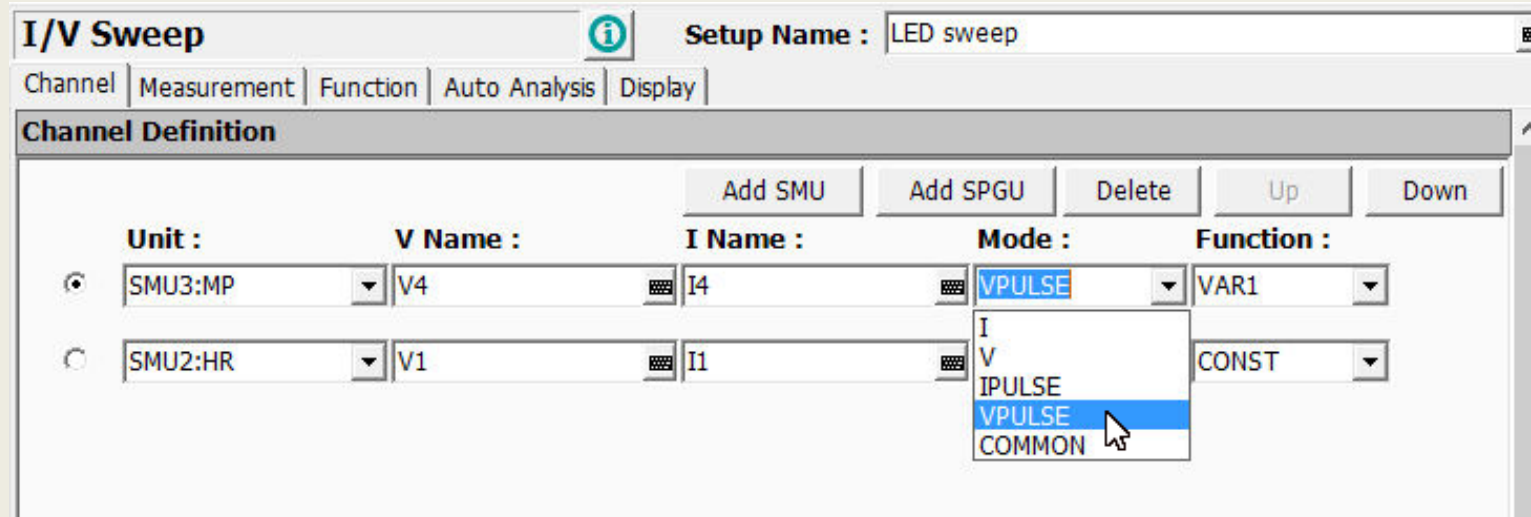
Pulsed 2-point IV

Why use it?

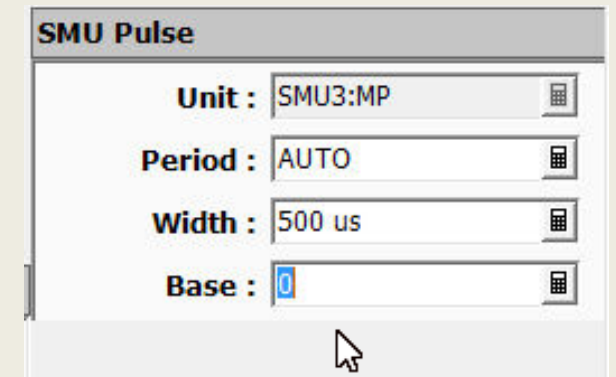
- Test devices operated by pulsed voltages
- Avoid self-heating
- Minimize trapped charges

How to use it?

- Modify the basic 2-point IV program



Pulse with basic 2-point IV
Minimum width: 0.5 ms



Too long? Semiconductor pulse generator unit SPGU

Semiconductor Pulse Generator Unit (SPGU)

I/V Sweep Setup Name : LED sweep

Channel | Measurement | Function | Auto Analysis | Display

Channel Definition

Add SMU Add SPGU Delete Up

Unit :	V Name :	I Name :	Mode :	Function :
SMU3:MP	V4	I4	V	VAR1
SMU2:HR	V1	I1	COMMON	CONST
SPGU1:HV	SPGUV1		VPULSE	

Application example: high power devices such as high electron mobility transistors (HEMTs)

Features

- Width down to 10 ns
- Leading and trailing time down to 10 ns
- Flexible settings
- Only output pulses
No measurement during pulses

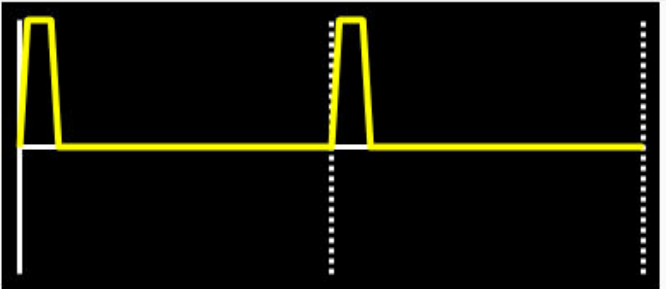
SPGU Pulse Setup

Global Settings	Operation
Period : 1.0	<input checked="" type="radio"/> Free Run <input type="radio"/> PULSE COUNT 1 <input type="radio"/> Duration 1 us

Pulse Settings

SPGU setup view order : Up Down

Unit :	Primary Pulse	Additional Pulse
SPGU1:HV	Base : 0 V	0 V
	Peak : 500 mV	500 mV
VName : SPGUV1	Delay : 0 s	0 s
	Width : 100 ns	100 ns
Type : 2-Level Pulse	Leading : 20 ns	20 ns
	Trailing : 20 ns	20 ns



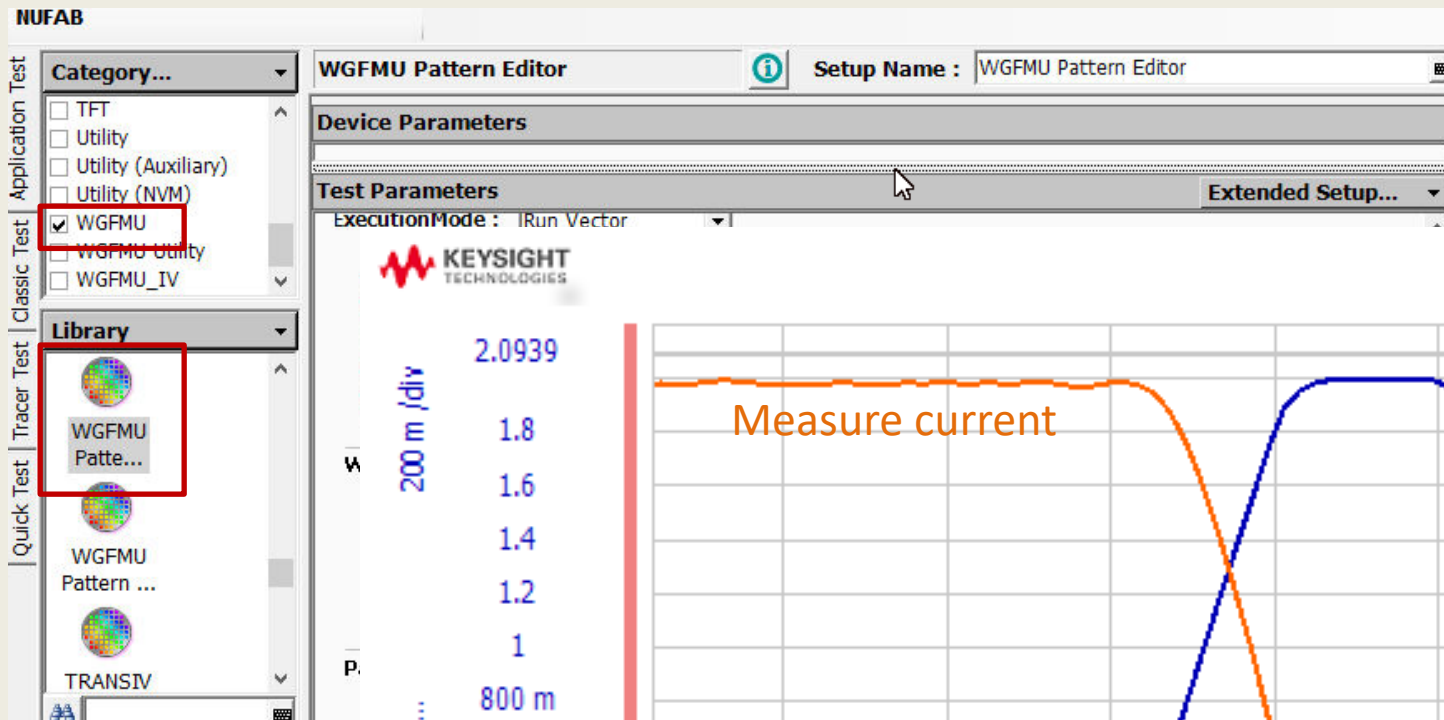
Arbitrary Linear Waveform Generator (ALWG)

Why use it? Simulate certain external conditions without the need of having the actual condition.

The image displays two software windows. The left window, titled "I/V Sweep", shows a "Channel Definition" table with two channels. The second channel is selected, and its "Function" dropdown menu is open, showing "ALWG" as the selected option. Below this, the "SPGU ALWG Setup" dialog is visible, showing "Free Run" selected and "Duration" set to "1 us". The right window, titled "Pattern Editor: Column No. 1", shows a graph of "Amplitude(V)" vs "Time(s)". The graph displays a waveform with four points: (0, 0), (0.0001, 1), (0.0002, 0), and (0.0003, -1). A tooltip shows the coordinates (3.000E-4, 0.000E0) for the point at 0.0003s. To the right of the graph is a table with the following data:

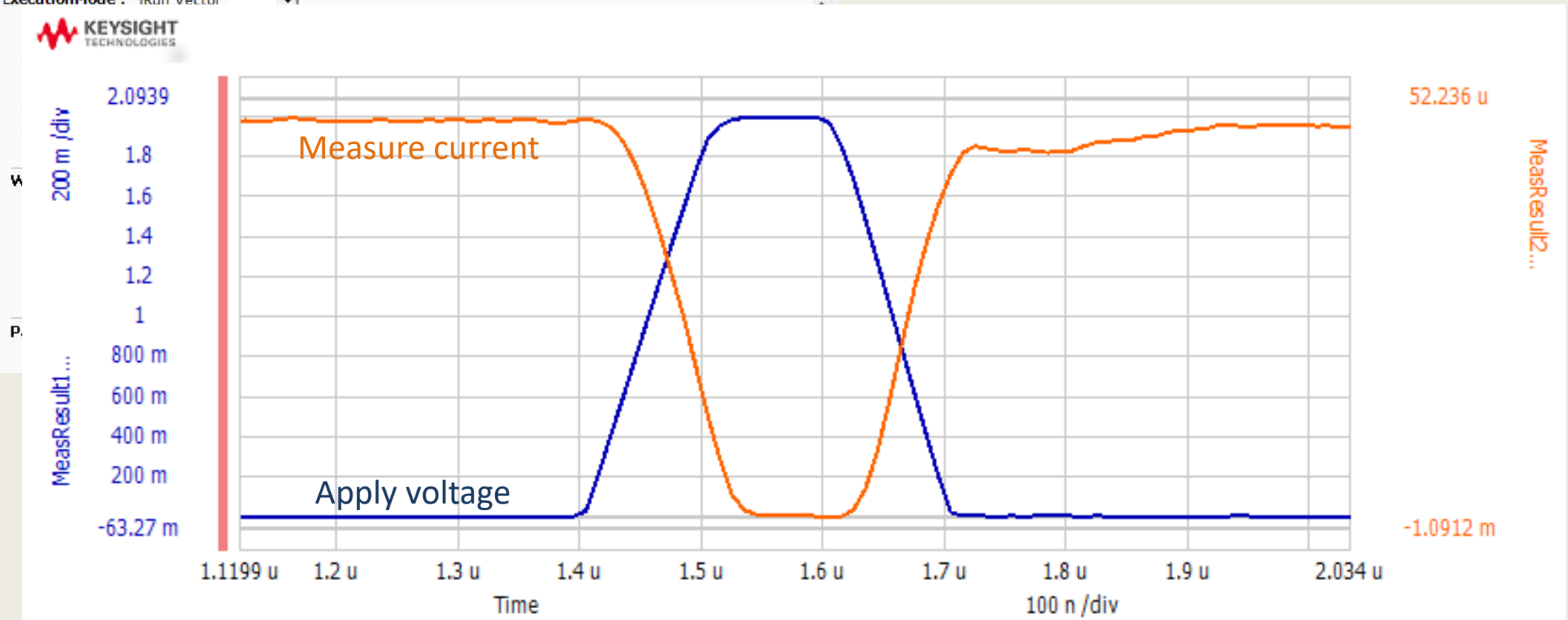
No	Time	Level	Switch
0	0.00000000E0	0.0000E0	1
1	1.00000000E-4	1.0000E0	1
2	2.00010000E-4	0.0000E0	1
3	3.00000000E-4	-1.0000E0	1
4	3.00010000E-4	0.0000E0	1

ALWG and fast measurement unit (WFGMU)



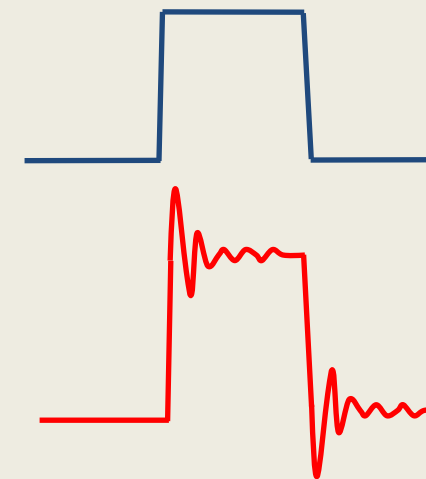
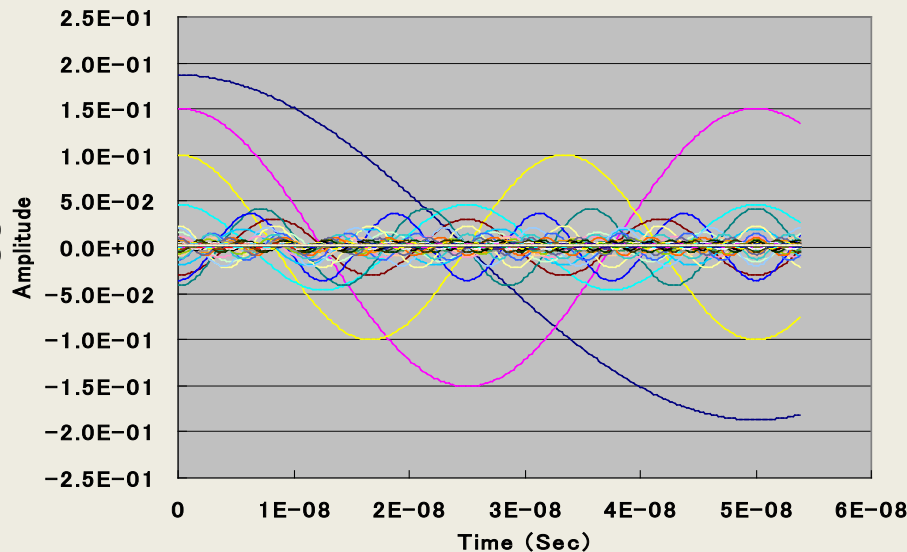
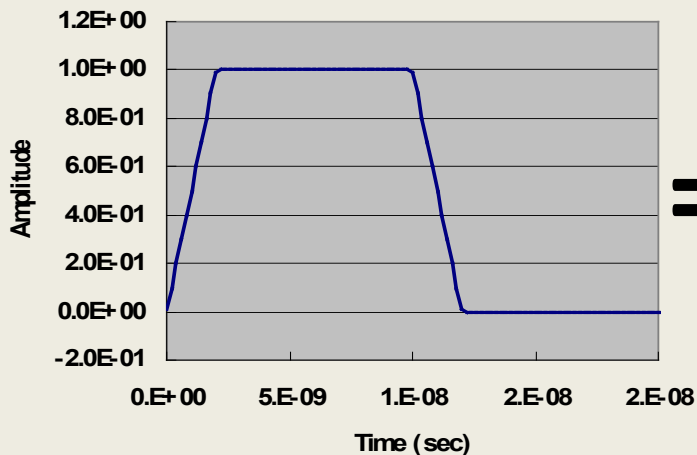
Why use it?

ALWG and high-speed measurement at the same time

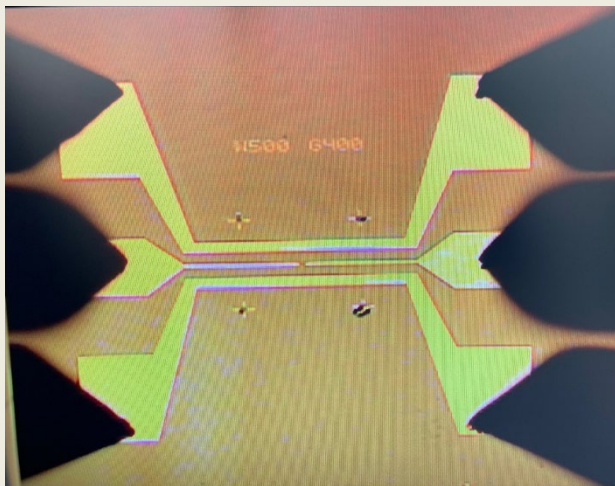
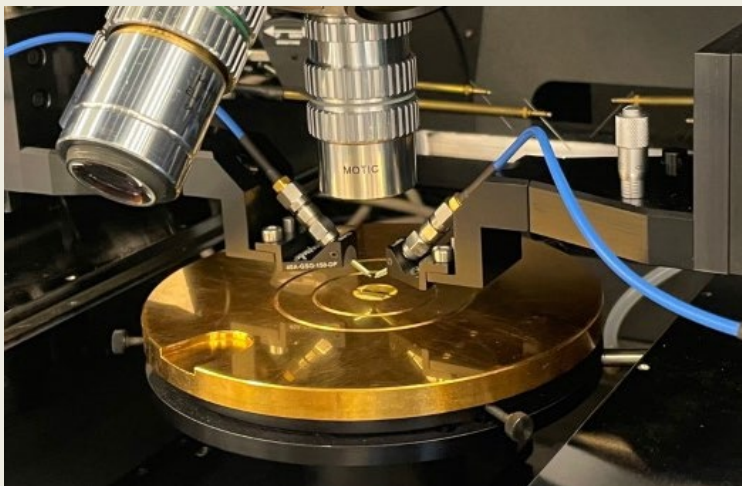


RF probes

Why use it?



How to use it?



- Special positioner, SMA cables
- GSG geometry, 150 μm pitch
- Pattern your device terminals accordingly

Summary

- Precise resistance measurement
- Automate 3-point IV
- Introduce pulses to IV measurement
- Short pulses and fast measurement
- Use RF probes

Contact me: ying.jia@northwestern.edu

General NUFAB contact: nufab@northwestern.edu

Upcoming workshop



RF Vector Network Analyzer Basics

April 23, 2024 – 9:00 AM–1:00 PM

**Technological Institute - Room #B211
Northwestern University, Evanston Campus**

SPGU and IV-t measurement

NUFAB

I/V-t Sampling Setup Name : I/V-t Sampling

Channel | Measurement | Function | Auto Analysis | Display

Channel Definition

Unit :	V Name :	I Name :	Mode :
<input type="radio"/> SMU3:MP	V3	I3	COMMON
<input type="radio"/> SPGU1:HV	SPGUV1		VPULSE

Buttons: Add SMU, Add SPGU, Delete, Up, Down

Left Sidebar (Quick Test): I/V-t Sampling (highlighted)

NUFAB

I/V-t Sampling Setup Name : I/V-t Sampling

Channel | Measurement | Function | Auto Analysis | Display

Sampling Parameter		Stop Condition	
Linear/Log :	LINEAR	Enable/Disable :	DISABLE
Interval :	50u	Enable Delay :	0 s
No. of Samples :	101		
Total Sampling Time :	50 ms		
Output Sequence :	SEQUENTIAL		
Hold Time :	0 s		
Base Hold Time :	0 s		

Message ID: 105071

Warning: Sampling interval for I/V-t sampling must be between 0.0001 s and 65.535 s.

OK

Left Sidebar (Quick Test): I/V-t Sampling