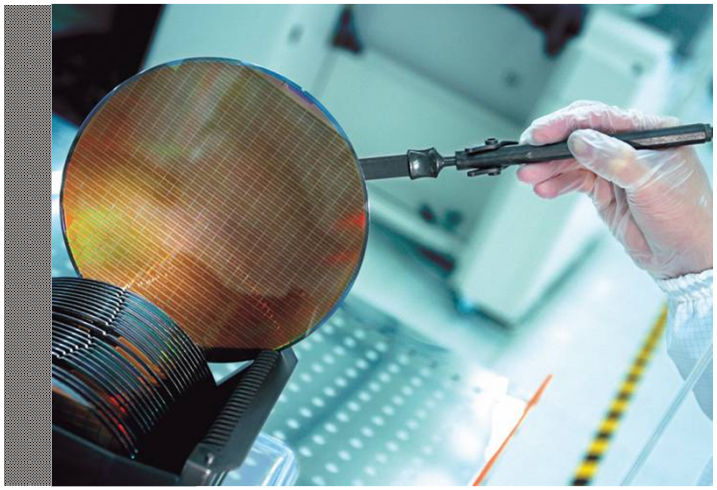
Keithley Parametric Curve Tracer (PCT)

- For Power Device Characterization, Analysis and IQC

Keithley Instrument
Date: April 2013



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Agenda

1. Keithley instrument introduction
2. Power device market drivers
3. Overview of Keithley's semiconductor test offerings & PCT
4. Parametric Curve Tracer (PCT) configuration details
5. Discussion & Conclusion

Keithley Instrument Intro.

Keithley and Tektronix: Where We Are Headed

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Combined, Tektronix and Keithley are very strong

- Complementary products – the widest range in T&M
- Customers rank combined brand superior
- Starting to leverage distribution channels
- Increased investment in new products
- Guided by ingenuity, precision, and simplicity

Tektronix and Keithley – From Nanovolts to Gigahertz.

吉時利儀器簡介

- 專精於高階電性量測儀器，擁有超過60年以上的研發經驗
  - 為全球專業的電子製造商提供高準確度用於產品測試、過程監控、產品發展和研究的各種測量解決方案。
  - 針對各產業特性開發解決方案。例如: 半導體、光電、平面顯示器、通訊、電腦週邊、汽車 …
- 總部位於美國Ohio州Cleveland市，全球有超過100個銷售服務據點
  - 台灣、日本、韓國、中國大陸、新加坡、美國、英國、德國 …
  - 各地分公司擁有完整維修與技術諮詢能力
- 不斷創新與突破
  - 多次諾貝爾獎得主，使用Keithley儀器量測發表研究成果而獲將獎

Supplier Excellence Award 2006

Texas Instruments

VLSI RESEARCH INC 10 BEST SUPPLIERS OF 2008 Customer Satisfaction

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產品範圍

DC/AC儀器和系統

- 專業儀器和系統
- 靈敏性量測
- 波形產生器
- 電流源
- 電壓源
- 數位多功能電錶
- 音頻分析儀
- 電源-電壓源(I-V)和量測(SMU)儀器
- 高速電源供應器

半導體測試系統和軟體

- 半導體參數分析儀
- 半導體開關系統
- 半導體電源量測單元(SMU)
- 半導體特性分析軟體
- 半導體可靠性測試方案
- 自動整合測試系統
- 半導體參數測試系統

配件

- IEEE-488/GPIB界面
- KPCI/KUSB
- 接頭/轉接器/工具
- 靜電計軟體
- 測試治具
- 測試導線和探針
- 觸發鏈結附件
- 觸發器附件
- 數據擷取器(DAQ)的DIN導軌固定套件
- 購物車
- 适配器，电缆和稳定工具箱
- 電腦配件
- 遠程前置放大器底座配件
- 手提儀器箱
- 掃描和開關選項
- 測試台套件
- 功率分配器
- 纜線
- 機架、機架安裝套件和機殼

數據擷取

- 多功能
- 類比輸出
- 數位I/O
- 計數器/定時器
- 數據記錄儀

開關系統

- 半導體/低漏電流
- 射頻/微波
- 多功能
- 整合式數位多功能電錶/開關

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DC/AC儀器和系統
- 數位多功能電錶

高性能

七位半或八位半量測解析度

28位元A/D轉換器

其中一個檔位可量測1μV 到20V

靈敏度是所選檔位的1%

支援T/C或RTD的溫度測量

特定應用

六位半解析度

聲音頻帶品質量測（2015/16）

諧波量測和分析（2015/16）

THD、THD+雜訊和SINAD量測（2015/16）

安全氣囊測試系統（2790）

廣泛用途

高精度六位半數位多功能電錶

量測電壓、電流和電阻

內建數學和量測函數

掃描卡選項（2000）

測試台和系統應用

數位多功能電錶/開關

整合數位多功能電錶、開關系統和/或數據記錄

六位半或七位半量測解析度

開關卡系列

高達200或576個通道

LXI、乙太網路、GPIB、USB和/或數位I/O界面

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Tektronix®

DC/AC儀器和系統
- 電源量測儀器 (SMU)

通用/中等功率

高穩定DC電源加上五位半多功能電錶

範圍包括1pA到10A、1μV 到200V

用於快速PASS/FAIL測試的內建比較器

可選的接觸檢查功能

特性分析和生產測試應用

低電流

量測靈敏度達10aA、1μV

可選的脈衝功能

四至六位半解析度

電壓量測的輸入電阻達10^14/10^16歐姆

遠程前置放大器(6430)將線纜雜訊減至最小

測試粒子束、SET和超高電阻

高電流

最大電流範圍達5.25A

可選的每通道10A脈衝模式

30 至 1100W 功率輸出

精確時序和同步

並聯測試功能（2600系列)

測試高功率元件和IDDQ

高電壓

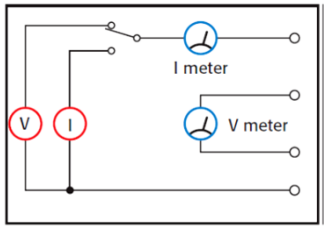
最大電壓檔位1100V

浮動輸出電壓高達±250V

四到五位半解析度

客戶自定掃描程序

測試電壓係數和高電壓元件



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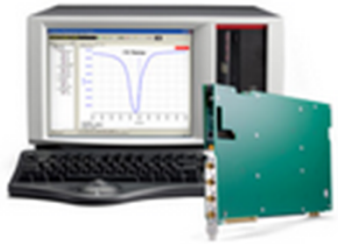
半導體測試系統和軟體
- 半導體參數分析儀

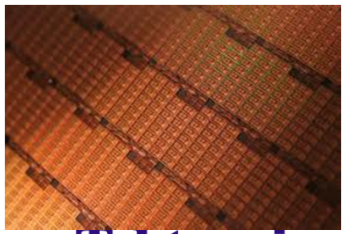
ACS基本版

- 半導體元件特性分析
- 失效分析
- 易於適應新技術應用
- 上百個標準元件測試庫
- 支援吉時利全系列數位電源電錶和更多設備

4200-SCS半導體參數分析儀



- 直覺式Windows人機使用界面
- 單儀器方案
- 具有I-V、C-V、脈衝產生功能以及脈衝I-V測試功能
- 包含支援各種技術的應用庫



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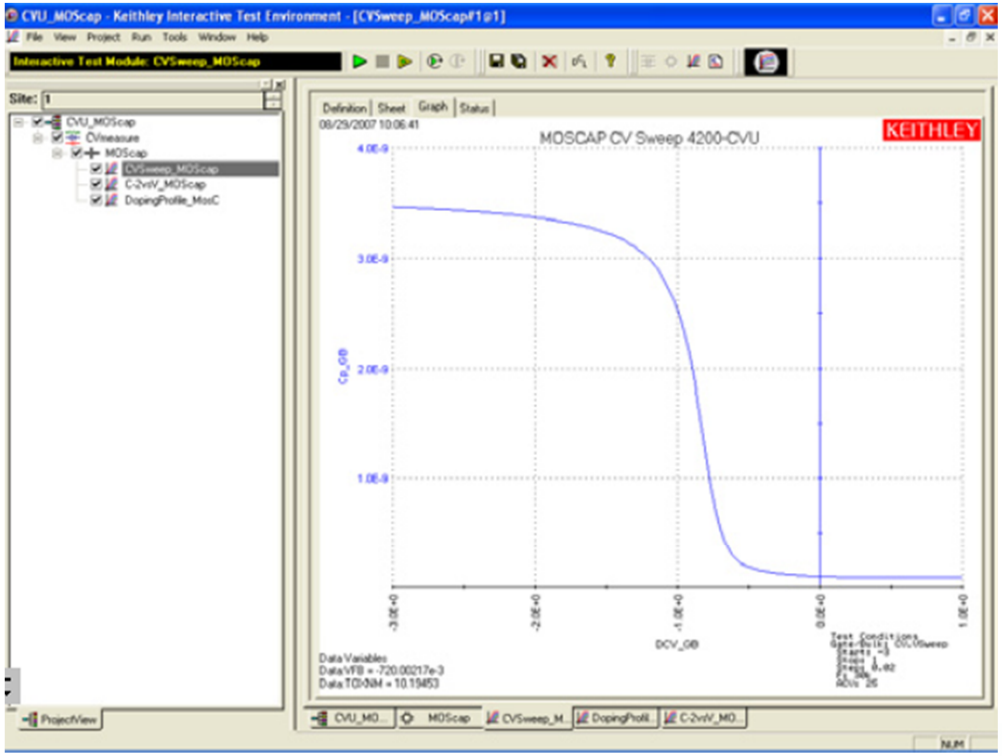
半導體參數分析儀 (K4200)
- Capacitance Voltage Unit (CVU)



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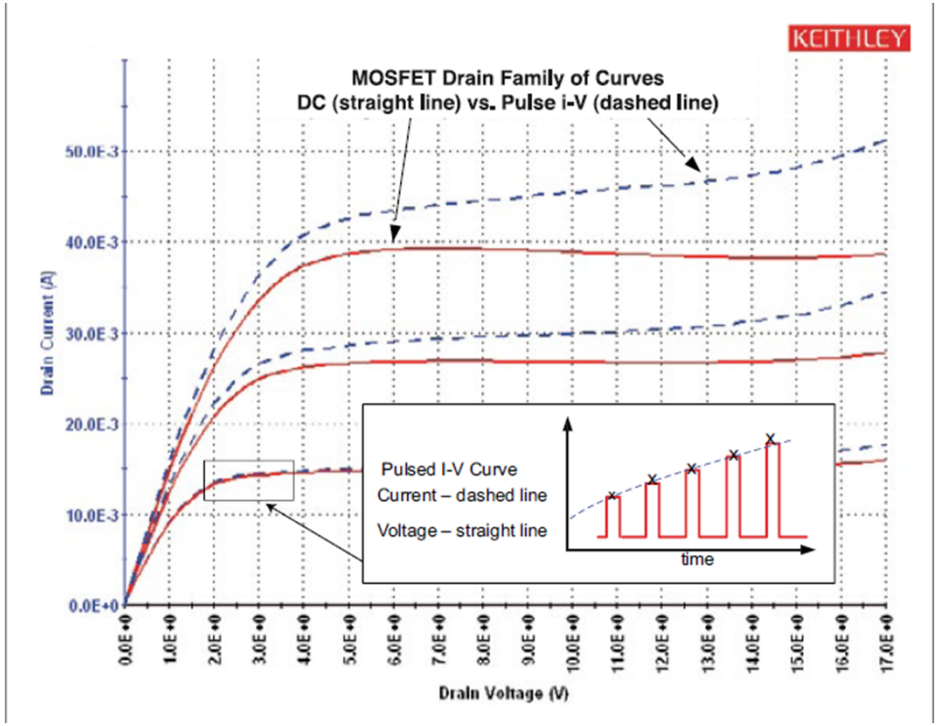
半導體參數分析儀 (K4200)
- Ultra High Speed Pulse Measure Unit (PMU; ns Level)



Self-heating effects on MOSFET

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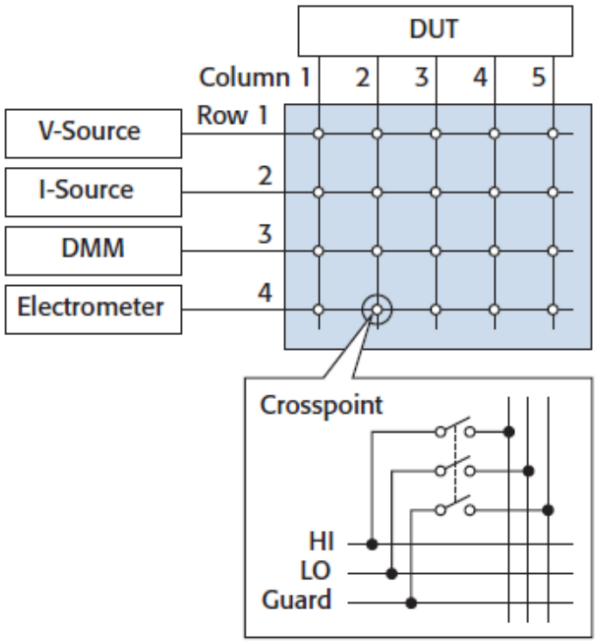
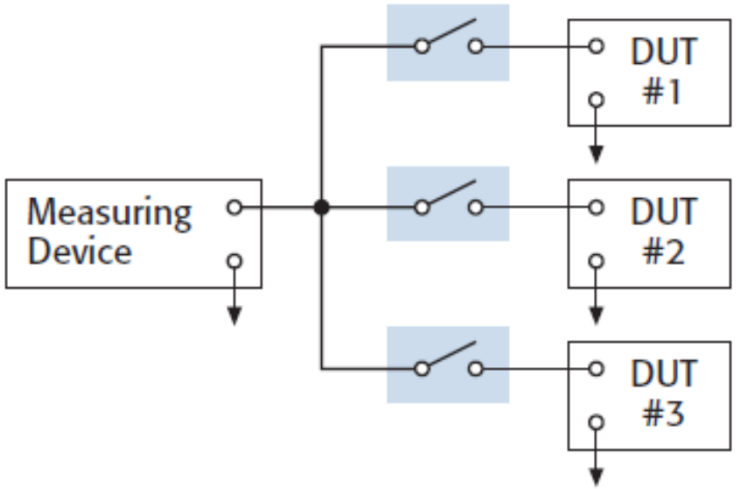
半導體測試系統和軟體
- 半導體開關系統 (K2700, K3706A, K707B)



Matrix System



Mux System

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半導體測試系統和軟體
- 半導體參數測試系統

S530基礎

業界最高成本效益的自動參數測試儀

相容於常見的全自動探針系統

外部配線使探針界面的靈活性最大化

支援5英寸探針卡庫

成熟的儀器技術確保高量測精度和可重復性

S530低電流特性

pA電流量測功能

低漏電流量測完整性

20W SMU最高可提供1A電流和200V電壓

可配置多達8個SMU和60個接腳

可選的轉接器擴展探針具有漏電流抑制能力

相容於常見的全自動探針系統

C-V量測高達1MHz

S530高電壓特性

最高可提供10mA下1000V的電壓源

支援高壓漏電流和崩潰測試

低漏電流量測完整性

具有pA電流量測功能

20W SMU最高可提供1A電流和200V電壓

可配置最多7個SMU和32個接腳

可選的轉接器擴展探針具有漏電流抑制能力

相容於常見的全自動探針系統

C-V量測高達1MHz

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半導體測試系統和軟體
- 半導體參數測試系統 (Cont')

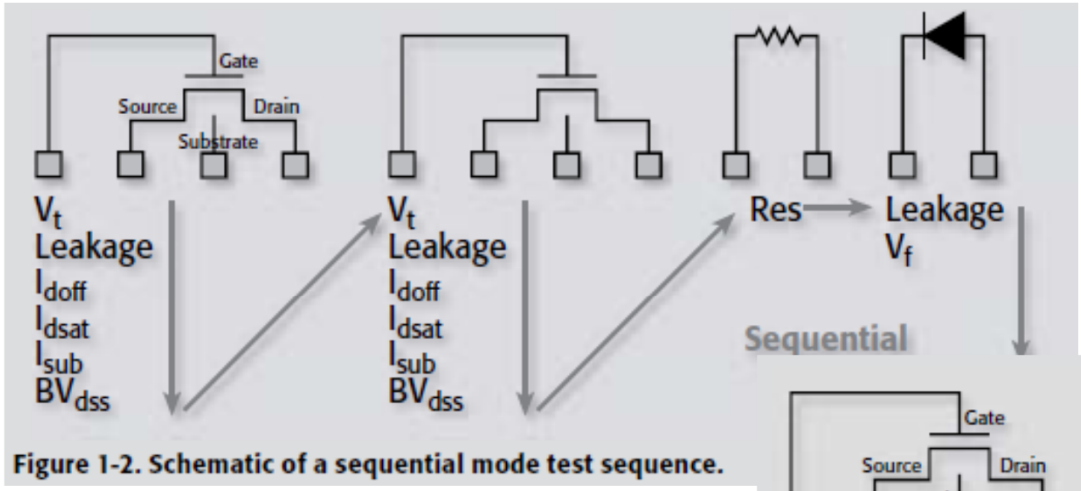


Figure 1-2. Schematic of a sequential mode test sequence.

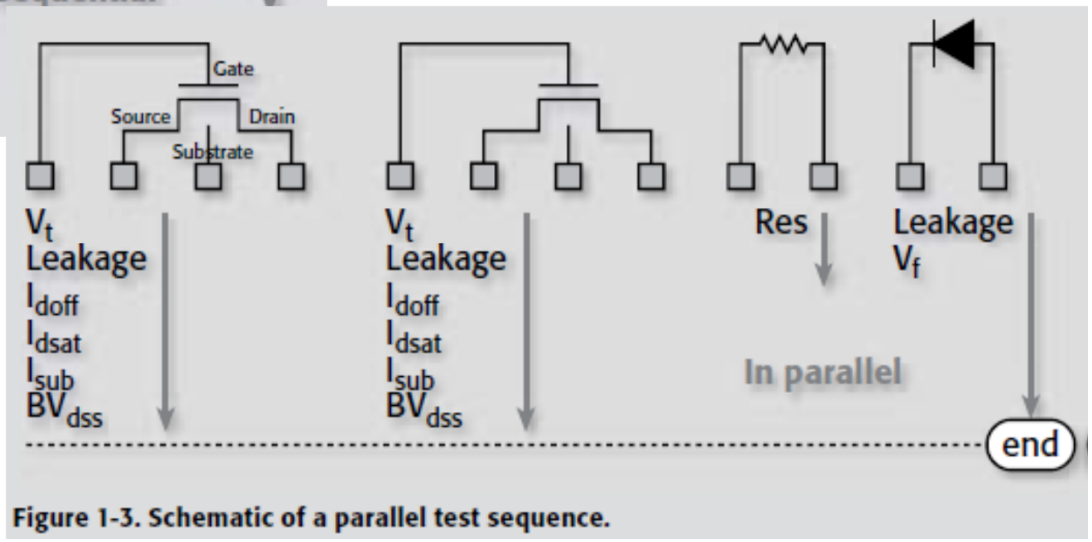
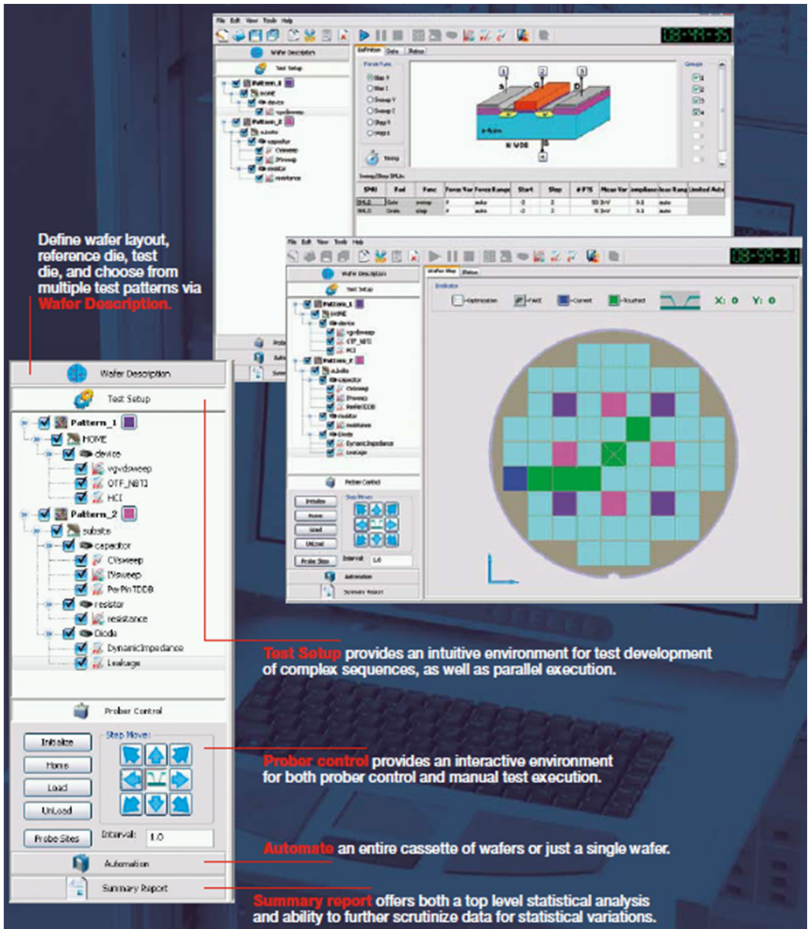


Figure 1-3. Schematic of a parallel test sequence.

半導體測試系統和軟體
- 半導體參數測試系統 (Cont')

ACS BASIC



Automated Characterization Suite (ACS)

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常用配件
- IEEE-488/GPIB界面

PCI

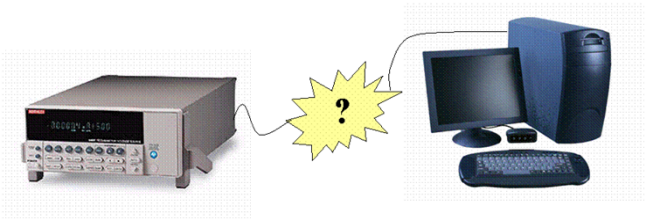
GPIB到PCI界面
33位元/33MHz
最高可控制14台設備
支援3.3V和5V
長達2m的連接長度

IEEE纜線和轉接器

單層屏障線
雙層屏障線
屏蔽轉接器
印表機轉接器

USB

GPIB到USB界面
1.8MB/s 速度
最高可控制14台設備
支援3.3V和5V
無需外接電源



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Market Drivers

Market Drivers

- Green movement
  - Improved energy efficiency
    - Motor drivers, power supplies, lighting (LEDs), IT (servers)
  - Energy generation and management
    - Alternate sources of energy such as solar and wind turbines
  - Energy regulation policies
    - Energy efficiency standards (voluntary and mandatory), Power Factor Correction (PFC) policies
- Increasing use of electronics in transportation industry
  - Power control elements in all vehicles
  - Critical for HEV/EV

Power semiconductor devices are critical to all of the above!

So how does this relate to semiconductor devices?

- Opportunities for energy efficiency improvement exist in products we interact with daily.
- One of the most common products is the switchmode power supply (SMPS).
- SMPS are more efficient and lighter weight than linear power supplies
  - Still, the SMPS accounts for >10% total system weight of PC. Making a more efficient SMPS will produce a lighter end product.
  - Still, lots of power is wasted in SMPS. Average desktop PC is only 50% efficient.

Diagram from On Semiconductor "Overview of Energy Efficient Solutions"

Background on Power Semiconductor Devices



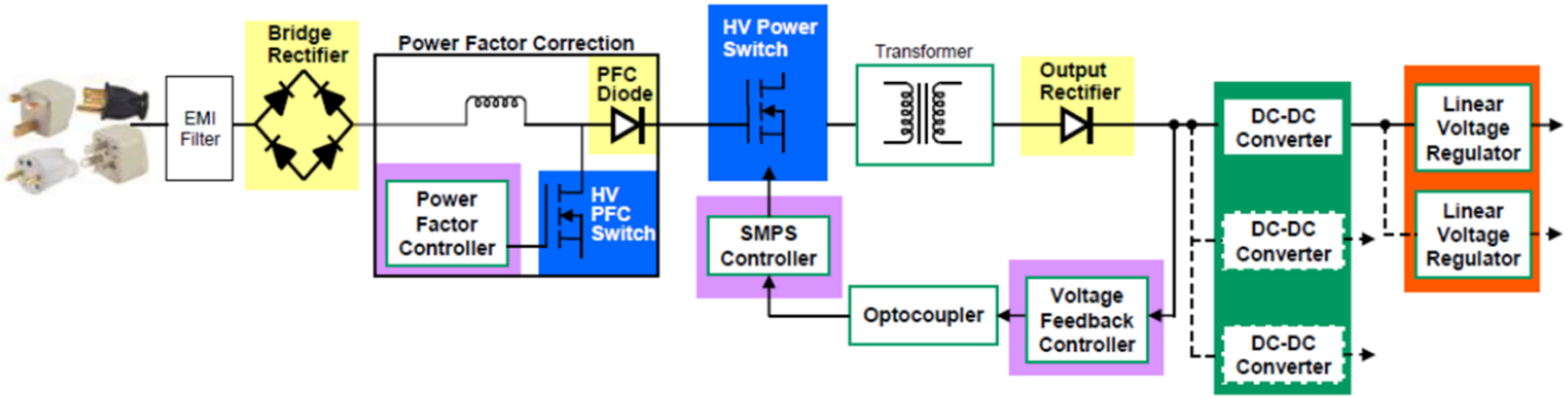

Power semiconductor devices are in all areas of energy modification

- AC to DC conversion (rectification)
  - Happens almost every time an electrical device is plugged into a wall
- DC to AC conversion (inversion)
  - Motor control, transporting bulk power (DC from solar panel to supply AC power within a company or residence)
- DC to DC
  - Used for voltage regulation. Used often in mobile devices
- AC to AC
  - Changing voltage or frequency → light dimmer circuit

High Power Device - Overview

- The driving factors for lots of interest in power semiconductor performance improvements
- Role of semiconductor components in the switching power supply
  - **Diode**
  - **BJT**
  - **MOSFET**
  - **IGBT**
- Role of advanced materials in improving power semiconductor device performance

Example: The role of power semiconductor devices in the switching power supply

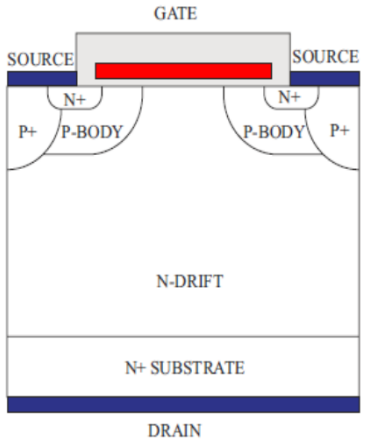


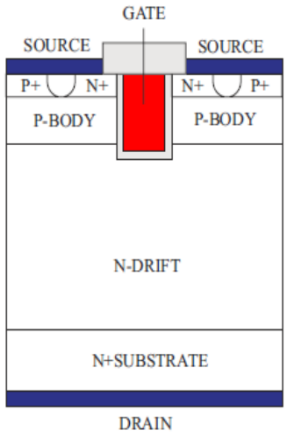
- Semiconductor switches (e.g. MOSFETs) and diodes are largest determinants of switching power supply efficiency
  - Fuels increased interest in design and test of power semi devices
- Power supply designers evaluate components for their designs

Diagram from On Semiconductor "Overview of Energy Efficient Solutions"

Next Generation Material for Power Device
→ Silicon Carbide (SiC) Power FET

- 碳化矽(SiC)、矽(Si)和氮化鎵(GaN)的熱傳導能力分別為1.5, 5以及2　Watts/ cm K；故SiC比Si和GaN擁有**更優異的熱傳導力**，使SiC在此特性上，很適合於高功率領域之應用。
- 由於SiC比Si有更高的操作溫度，故其元件**可以在更高接面溫度下作業**；同時可以在超過正常操作溫度下，維持低的導通電阻(R_{DSon})和元件的漏電電流。
- **目前SiC的製程較GaN-on-Si困難**，主要是因為GaN在發光二極體(LED)與射頻(RF)元件的應用已行之有年，產業鏈與相關技術較為完整。

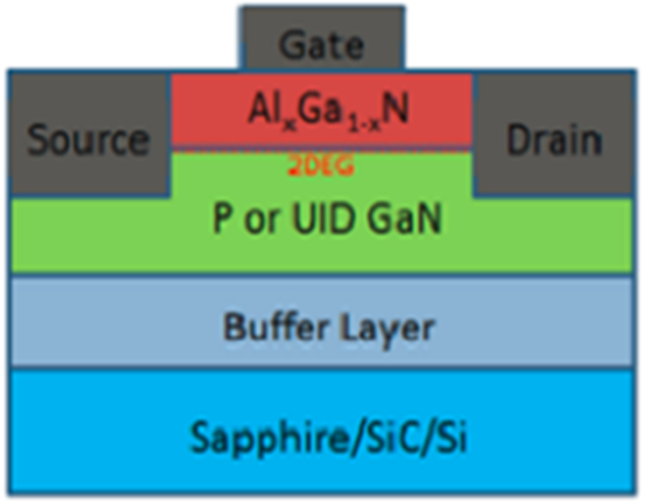




Diagrams from "High Temperature Electronics in Europe" report, Chapter 7 "High Voltage SiC Devices" by T. Paul Chow. Downloaded from http://itri2.org .

Next Generation Material for Power Device
→ Gallium Nitride (GaN) Power FET

- 氮化鎵(GaN)比Si和SiC有**更高的電子遷移能力，此特性具有更低的導通電阻，故可以最小化功率元件使用時之傳導損失(conduction loss)**。另外GaN可以在多種的基板上製作 。
- GaN為側向結構元件，有更快的開關切換速度，故十分適合於RF方面的應用；但側向元件先天上的崩潰電壓和元件製造的密度會較垂直型元件差一些。
- **2DEG (Two-Dimensional Electron Gas)為二維電子氣，具有更高速的電子遷移能力**，故非常亦適合高速功率元件驅動之應用。



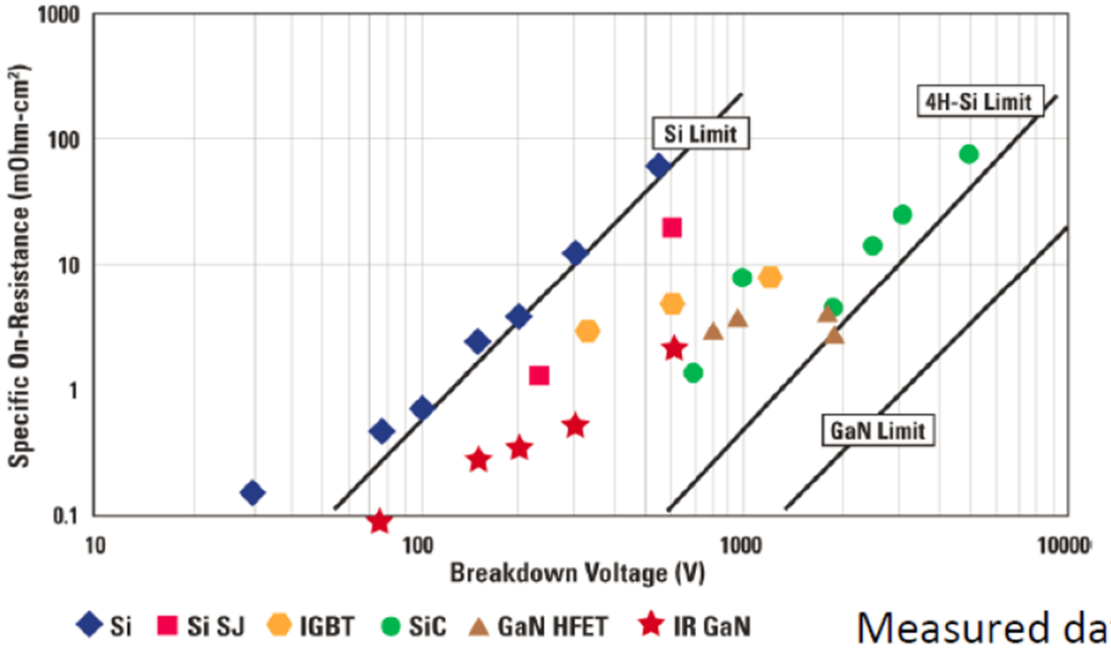
GaN HEMT structure

Diagram from "GaN Based FETS for Power Switching Apps" by Thomas Marron of Renesselaer Polytechnic Institute. Downloaded from http://homepages.rpi.edu/~sawyes/ .

SiC vs. GaN vs. Si Comparison

Materials Property	Si	SiC-4H	GaN
Band Gap (eV)	1.1	3.2	3.4
Critical Field 10^6 V/cm	.3	3	3.5
Electron Mobility (cm^2/V-sec)	1450	900	2000
Electron Saturation Velocity (10^6 cm/sec)	10	22	25
Thermal Conductivity (Watts/cm^2 K)	1.5	5	1.3

Comparison of R_{on} for Si, SiC, and GaN



Measured data

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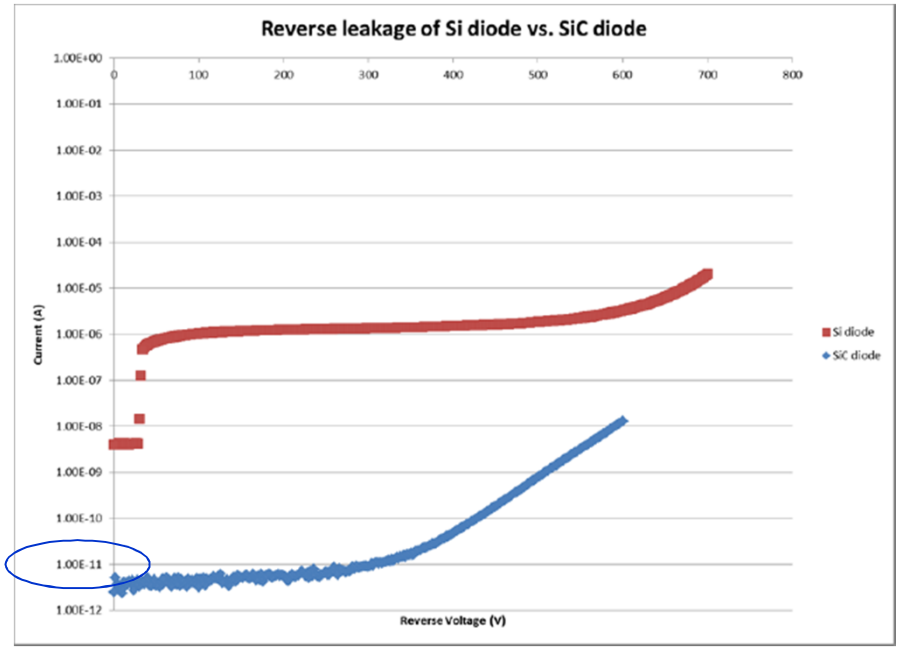
Si Diode vs. Wide Band Gap Device (SiC Diode) Comparison: Off-State Characterization

- Commonly performed at DC to achieve high accuracy leakage measurements
- Very low leakage measurement capability required for new wide bandgap technologies (GaN, SiC)
- Test equipment must be capable of generating high voltages and measuring low currents
- Variety of tests dictates both voltage and current source control



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Overview of Keithley's semiconductor test offerings

Semiconductor Test at Keithley

4200-SCS

Semiconductor characterization system, single box solution with integrated test software

Parametric Curve Tracer

High power and highly flexible parametric curve tracer configurations with test software

S530, S500 & ACS

Automated semiconductor device characterization and parametric test systems and software

Keithley Semiconductor Characterization Solutions

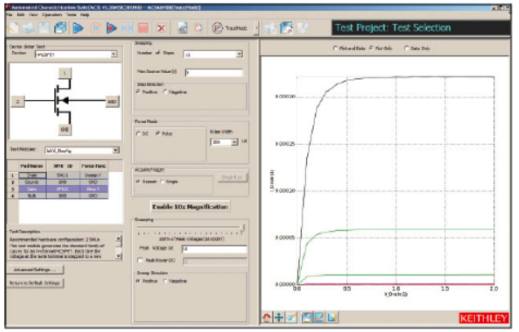
	Model	Range	Device	Application
Traditional Semiconductor Characterization System Pgs. 61-63	**4200-SCS**	< 200 V, 1 A	MOSFETs, CMOS, BJT's, diodes, capacitors, resistors, memory devices, MEMS, III-V devices, Thin-film Transistors (TFT), solar cells, nanoscale devices & structures, optoelectronics, etc.	Consumer electronics (iPads, cell phones, laptop computers, etc), automotive electronics, communications and other electronics
High Power Parametric Curve Tracer Pgs. 64-66	**Parametric Curve Tracer**	< 3 kV, 100 A	IGBTs, MOSFETs, BJTs, Triacs/SCRs, diodes and other power control devices, etc.	Energy conversion (AC-DC, DC-DC), energy generation (solar cells, etc.), industrial controls (motor and machine controls), appliances (stoves, etc.), lighting, and automotive controls
Ultra High Power Parameter Analyzer	**Contact Keithley Applications Engineer**	> 3 kV, 100 A	IGBTs, Triacs/SCRs, and diodes, etc.	Large scale energy management (power plants), traction motors (trains and ships), and other electric vehicles (HEV/EV)

From p.60 of Keithley Sales Guide, September 2012 Edition

Parametric Curve Tracer (PCT) Overview

Keithley PCT
- What is a Parametric Curve Tracer?

A configurable benchtop system for characterizing power devices



- Comprehensive solution including instruments, cables, test fixture, software, test libraries, and sample devices
- World Class measurements to **3KV** and **100A**
- Cost-effective
- Easy field upgrades, scalable and re-configurable
- Supports both *Parametric* and *Trace* test modes

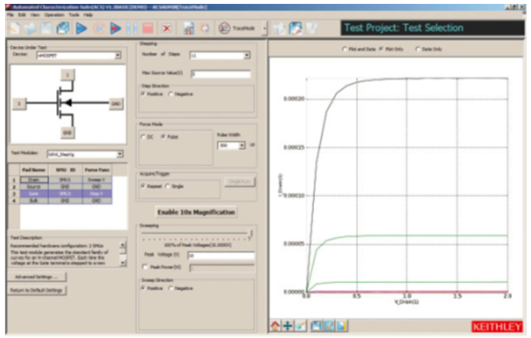
Keithley PCT
- What is Trace Test Mode?

- Generates rapid visual results of device characteristics

- Requires real-time operator control based upon visual inspection of test results (graph, plot)
  - The “knob” for the Tektronix curve tracer
  - The slider for the Keithley Parametric Curve Tracer

- Used to determine condition of device (bad or good) or boundaries of device (breakdown voltage)

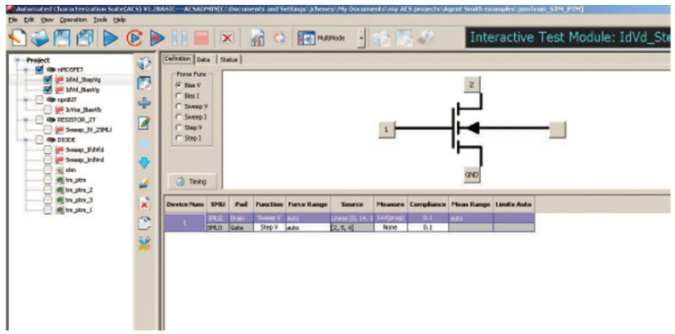
- Common in
  - Device development
  - Failure analysis



Curve Tracer Test

Keithley PCT
- What is Parametric Test Mode?

- Each test has clearly defined variables (e.g. start, stop, and step levels of sweep)
- Outputs precise digital data, which is necessary for parameter extraction (e.g. hfe, RdsON, gm)
- Operator controls test programmatically. Tests can run automatically without operator intervention.
- Common in
  - Device qualification
  - Process monitoring
  - Data sheet generation

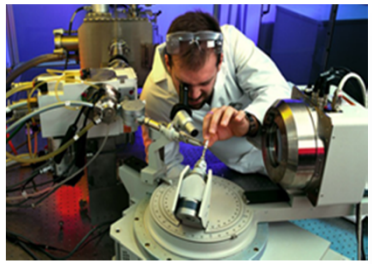
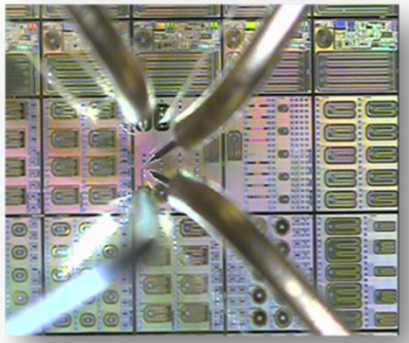
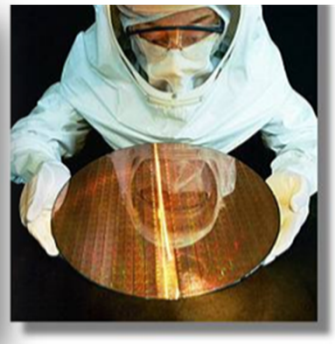
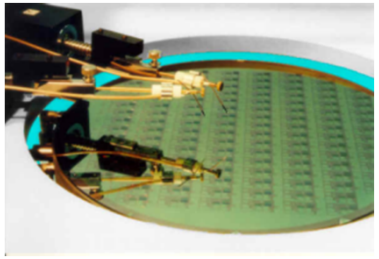


Parametric Test

Keithley PCT
- Why parametric curve tracer configurations?

- Tektronix curve tracer was the primary test instrument for power devices
  - Combined high power with interactive control
- Increased interest in power devices requires parametric analysis
- However, power device engineers also want the familiar, interactive control of the Tektronix curve tracer
- The Keithley parametric curve tracer configurations combine precise device parameter measurements with the interactive and visualization benefits of a curve tracer
  - In many cases, these configurations are a suitable alternative for the Tektronix Curve Tracer for characterizing power devices

Semiconductor Test and the Parametric Curve Trace configurations


Companies involved in:

Research & Education Facilities

Integrated Circuits
Discrete & Power Components
Flat Panel Displays

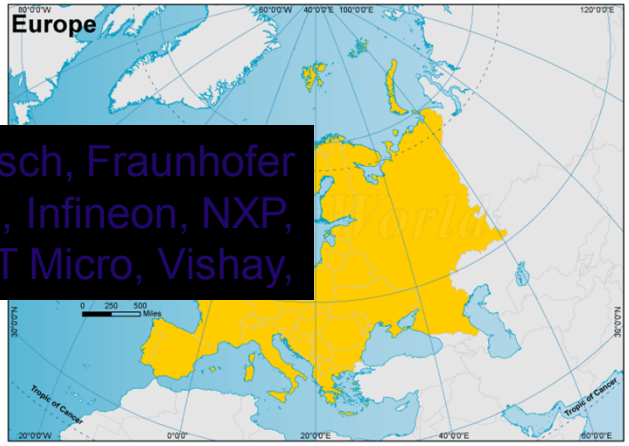
Electronic Systems Manufacturers. Consumers of discrete & power components)

Materials & Novel Device Research	Device Development & Charac-terization	Reliability Analysis	Process Control Monitoring (PCM)	Functional (Die Sort) Test	Failure Analysis	Incoming Inspection

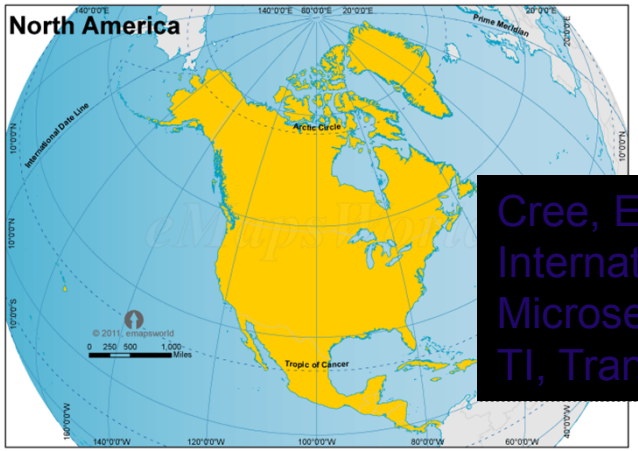
Target Customers & Apps for Parametric Curve Tracer

Example of Parametric Curve Tracer Customers

AIST, Denso, Fuji Electric, Hitachi, Mitsubishi Electric, Renesas, Rohm, Toshiba, Toyota



ABB, Azzurro, Bosch, Fraunhofer Institute, IMEC, Infineon, NXP, Semikron, ST Micro, Vishay,



Cree, EPC, Fairchild, GE Global Research, GeneSiC, International Rectifier (IRF), IXYS, Linear Technology, Microsemi, National Semi, OnSemi, RFMD, SemiSouth, TI, Transphorm, numerous universities and national labs

Parametric Curve Tracer Detail

Keithley Parametric Curve Tracer Configurations

Model 2600-PCT-4

Model 4200-PCT-4 on K420 Cart

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Keithley Parametric Curve Tracer Configurations

Model		2600-PCT-1	2600-PCT-2	2600-PCT-3	2600-PCT-4	4200-PCT-2	4200-PCT-3	4200-PCT-4
		Entry Level	**High Current**	**High Voltage**	**High Current and Voltage**	**High Current + C-V**	**High Voltage + C-V**	**High Current and Voltage + C-V**
Collector/ Drain Supply	**High Voltage Mode**	200V/10A	200V/10A	3KV/120mA	3KV/120mA	200V/1A	3KV/120mA	3KV/120mA
	High Current Mode	200V/10A	40V/50A	200V/10A	40V/50A	40V/50A	200V/1A	200V/1A
Step Generator (Base/Gate supply)		200V/10A	200V/10A	200V/10A	200V/10A	200V/1A	200V/1A	200V/1A
Typical Applications		Incoming Inspection, FA, QA, Reliability, Design Qual, Product Dev.	Incoming Inspection, FA, QA, Reliability, Design Qual, Product Dev.	Incoming Inspection, FA, QA, Reliability, Design Qual, Product Dev.	Incoming Inspection, FA, QA, Reliability, Design Qual, Product Dev.	Data Sheet Generation, Modeling, General Characterization	Data Sheet Generation, Modeling, General Characterization	Data Sheet Generation, Modeling, General Characterization
Software		ACS Basic Edition with Trace Mode and Parametric Mode, single and sequenced tests, sample power device libraries						
Text Fixture		Model 8010 High Power Device Test Fixture supports 3KV/100A Includes TO-220, TO-247, Axial, Custom sockets,. sample demo parts (BJT, MOSFET, diode, etc.)						

From p.64 of Keithley Sales Guide, September 2012 Edition

What is included in each Parametric Curve Tracer configuration?

Models	2600-PCT-1	2600-PCT-2	2600-PCT-3	2600-PCT-4	4200-PCT-2	4200-PCT-3	4200-PCT-4
Capability	(200V/10A)	(200V/50A)	(3KV/10A)	(3KV/50A)	(200V/50A/ 400V-CV)	(3KV/1A/ 400V-CV)	(3KV/50A/ 400V-CV)
2636B	✓	✓	✓	✓			
2651A		✓		✓	✓		✓
2657A			✓	✓		✓	✓
4200-SCS					✓	✓	✓
8010 Test Fixture	✓	✓	✓	✓	✓	✓	✓
All Cables and adaptors	✓	✓	✓	✓	✓	✓	✓
ACS-Basic 2.0	✓	✓	✓	✓	✓	✓	✓
Misc Sample Parts	✓	✓	✓	✓	✓	✓	✓

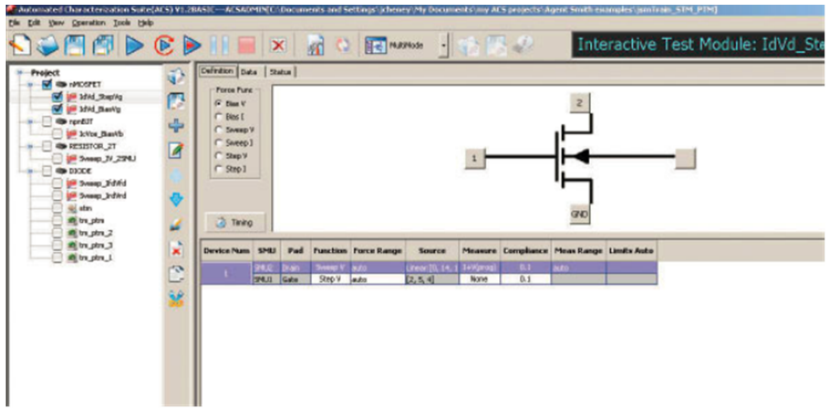
From p.66 of Keithley Sales Guide, September 2012 Edition

Additional Notes

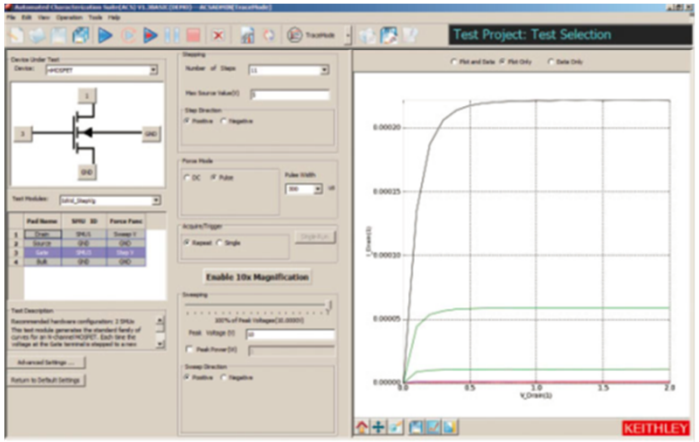
- Parametric Curve Tracer configuration are fixed
- Customer supplies PC with Model 2600-PCT-*. Keithley includes PC with Model 4200-PCT-*.

Parametric Curve Tracer software: ACS-Basic 2.0

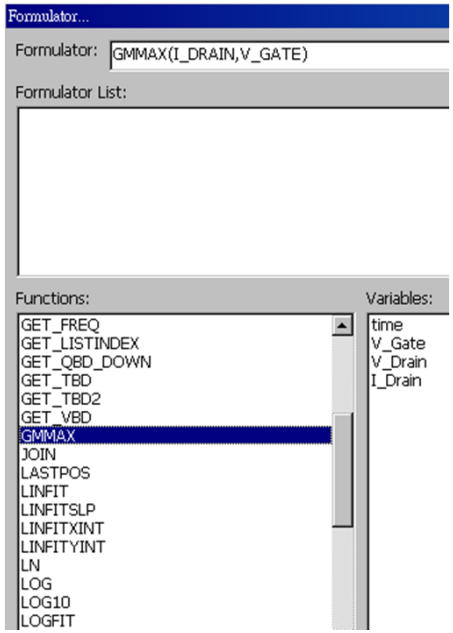
For fast and simple single device testing!



Parametric Test



Curve Tracer Test



Parameter Extract

Typical Power Transistor Parameters

Parameter	Symbol	Test Method [1]	Maximum Range	Typical Best Resolution	Typical Accuracy
Breakdown Voltage	Bvdss, Bvceo	Id–Vd or Id (pulse)	±3000 V [2]	100 μV, 10 fA	0.05% rdg + 0.05% rng
On-State Current (DC)	Vdson, Vcesat, Vf	Id–Vd	±20 A [4], Optional: ±40 A [4]	100 nA, 1 μV	0.05% rdg + 0.05% rng
On-State Current (Pulse)	Vdson, Vcesat, Vf	Id–Vd	±50 A [4], Optional: ±100 A [4]	100 μA, 1 μV	0.05% rdg + 0.05% rng
Drain/Collector Leakage Current	Idss, Ir/Icbo, Iceo	Id–Vd	±20 mA @ 3000 [2, 5]	10 fA, 1 μV	0.2% rdg + 1% rng
Gate/Base Leakage Current	Igss, Ib	Ig–Vg	±1 A or, ±10 A Pulsed [3]	10 fA, 1 μV	0.2% rdg + 1% rng
On-State Threshold Voltage or Cutoff Voltage	Vth, Vf, Vbeon, Vcesat	Id–Vg	±200 V [3]	10 fA, 1 μV	0.2% rdg + 0.5% rng
Forward Transfer Admittance or Forward Transconductance	|yfs| Gfs, Hfe, gain	Vd–Id @ Vds	1 ms ~ 1000 s [6]	1 pA, 1 μV	1%
On-State Resistance	RDS(on), Vcesat	Vd–Vg @ Id	<100 μΩ [7]	10 μΩ, 1 μV	1%
Input Capacitance	Ciss	C–V 100 kHz	10 nF [8] ±200 V	10 fF, 10 μV	Better than 1% at C<10 nF
Output Capacitance	Coss	C–V 100 kHz	10 nF [8] ±200 V	10 fF, 10 μV	Better than 1% at C<10 nF
Reverse Transfer Capacitance	Crss	C–V 100 kHz	10 nF [8] ±200 V	10 fF, 10 μV	Better than 1% at C<10 nF

1. Test method used for extracting the parameter. Only typical MOSFET listed, but similar method for other devices.
2. Model 2657A High Power System SourceMeter® SMU Instrument.
3. Model 2636A SourceMeter SMU Instrument or Model 4210-SMU.
4. Model 2651A High Power System SourceMeter SMU Instrument or optional dual Model 2651A High Power System SourceMeter SMU Instruments.
5. Maximum 20mA at 3000V, 120mA at 1500V.
6. Typical extracted capability (Example: 1mA/1V ~ 1A/1mV).
7. Typical extracted capability (Example: 1mV/10A).
8. Max. ±200VDC (±400VDC differential) bias with 4210-CVU and 4200-CVU-PWR.

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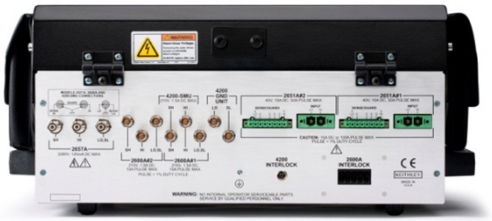
Keithley Parametric Curve Tracer Demonstration

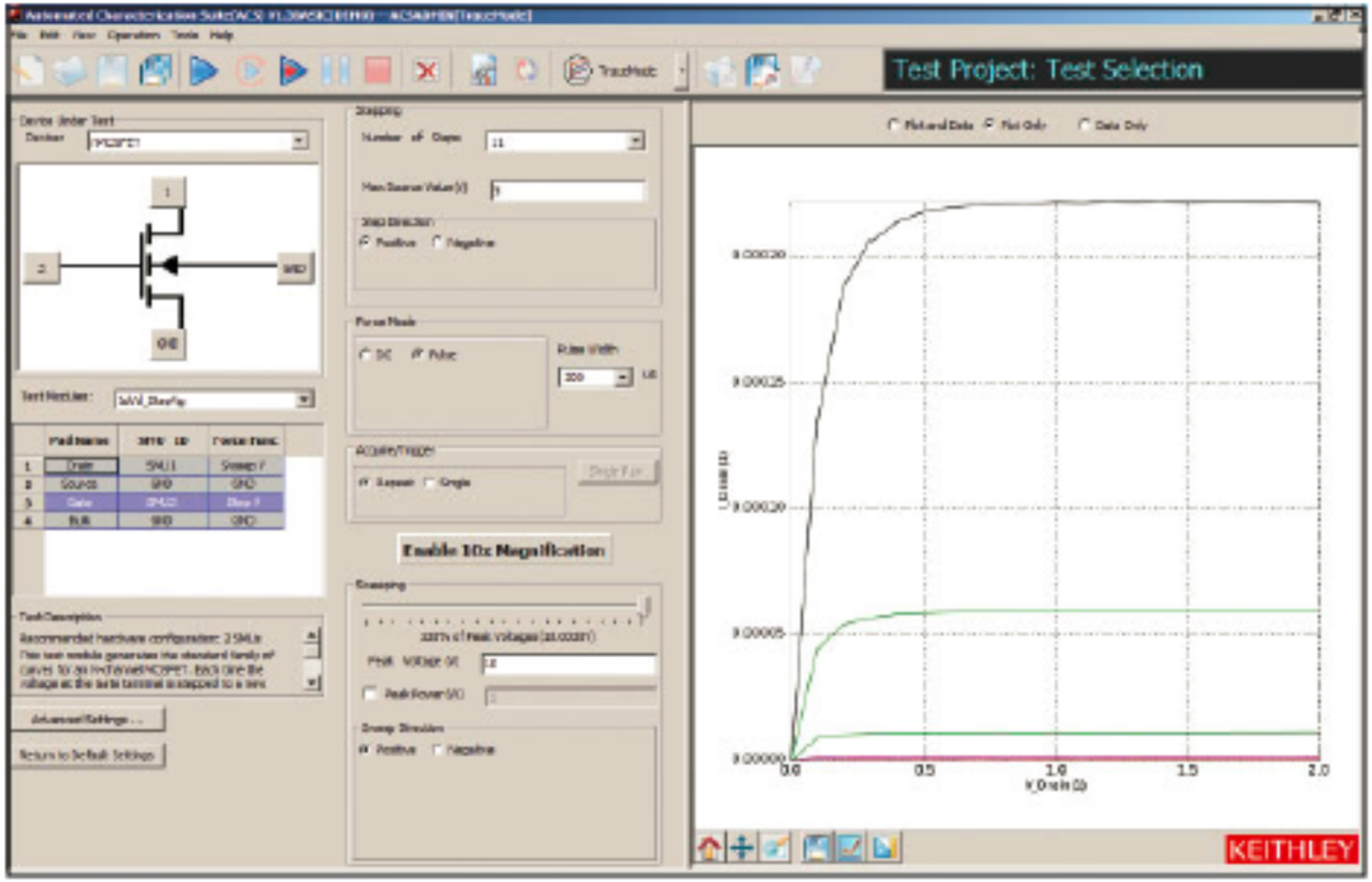


- Connect instruments to the test fixture
- Start ACS-Basic

- Install device in test fixture

- Select the test mode: parametric or curve tracer
- Select a device and a test
- Run

Keithley Parametric Curve Tracer Demonstration - Trace Mode



Series 2600B and 2650A SMUs

Model 2636B SMU

- Two independent SMU channels
- Up to 200V
- Up to 10A pulsed
- 0.1fA measurement resolution

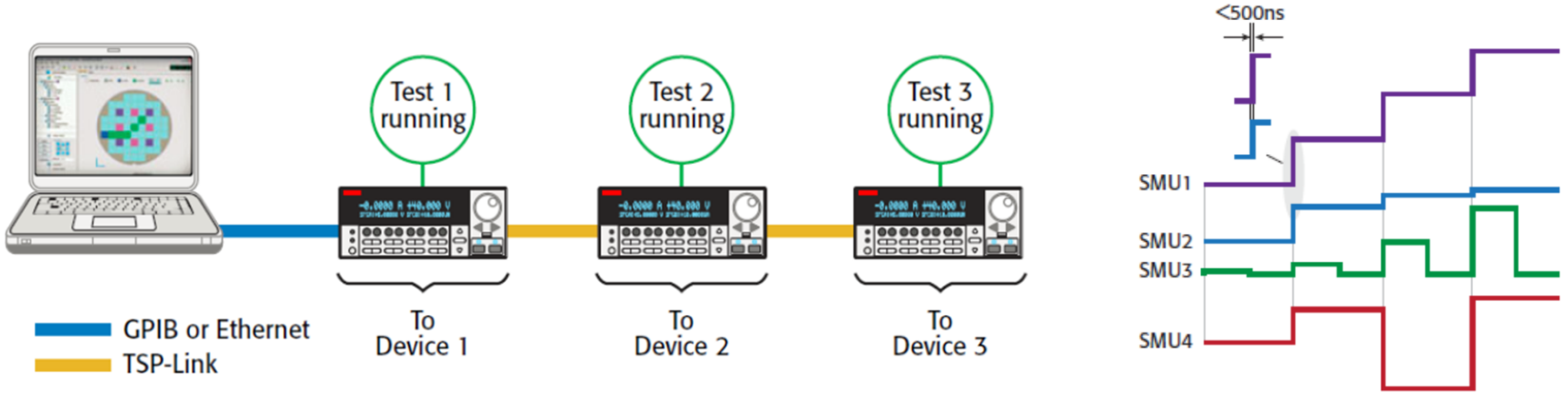
Model 2651A SMU

- Up to 50A pulsed (up to 100A with 2 units)
- Up to 2000W pulse / 200 W DC power
- Pulse widths from 100us to DC
- High speed and integrating ADCs

Model 2657A SMU

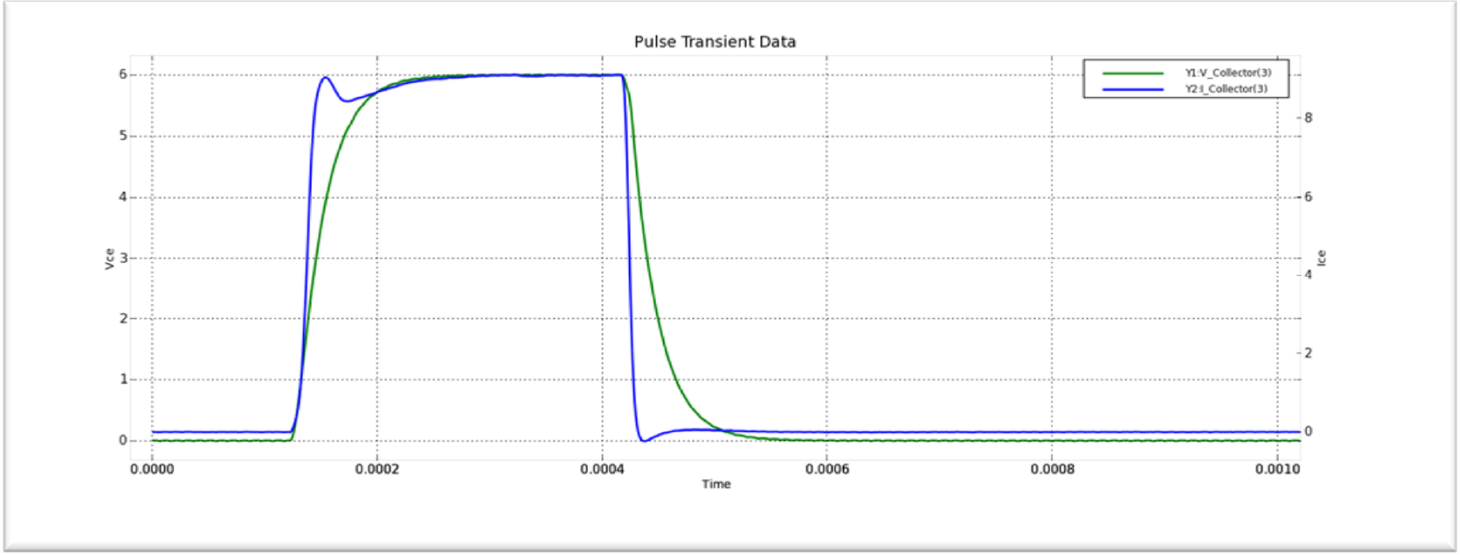
- Up to 3000V, Up to 180W of power
- 4-Quadrant operation (source and sink power)
- 1fA measurement resolution
- High speed and integrating ADCs

Series 2600B and 2650A SMUs – Flexibility and Speed



- Each SMU is a completely independent instrument
  - Can be used alone or as a component of a larger system
- Virtual backplane (TSP-Link) includes enhanced communication and triggering features
  - Nearly simultaneous synchronization between instruments on the backplane

Series 2650A ADCs



Integrating ADC

- 24-bit resolution
- Maximum reading rate = 20kHz
- Simultaneous voltage and current measurements ensured by dual ADCs
- Useful for high accuracy measurements

Fast ADC

- 18-bit resolution
- Maximum sample rate = 1 MHz
- Provide high speed measurements without external instruments
- Useful for transient characterization, especially pulse integrity inspection

Series 2650A accessories for optimal performance

- High Current, Low Inductance, Low Resistance Cable
  - Custom design
  - Critical for achieving 100us pulses at 100A
  - Supplied with Parametric Curve Tracer

- High Voltage Low Noise Triaxial Cable
  - Custom design
  - Critical for achieving guarded pA-level current measurements at 3kV
  - Supplied with Parametric Curve Tracer

Model 4200-SCS Semiconductor Characterization System

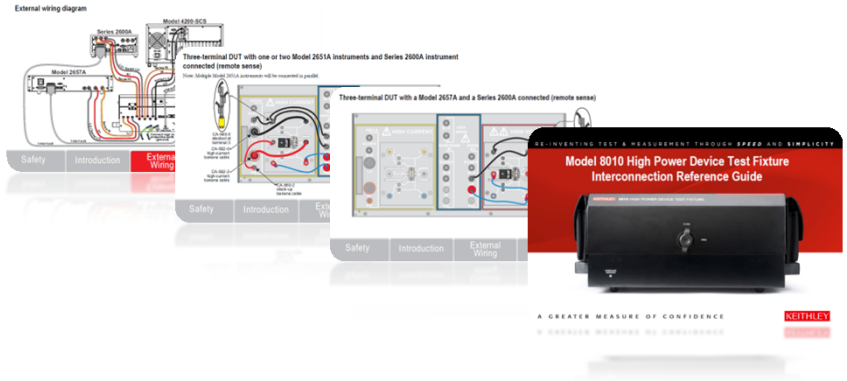
- A an integrated semiconductor parameter analyzer that contains
  - Source-Measure Units (SMUs) – 200V, 1A
  - **Capacitance meters**
  - Ultra-Fast I-V and Pulse cards

This is the only reason to have 4200 in a parametric curve tracer

- Includes PC and Window-based, point-and-click GUI that enables the user to quickly and simply set up and run tests, and analyze data

- For more details on Keithley Model 4200, refer to KI201

Model 8010 Test Fixture



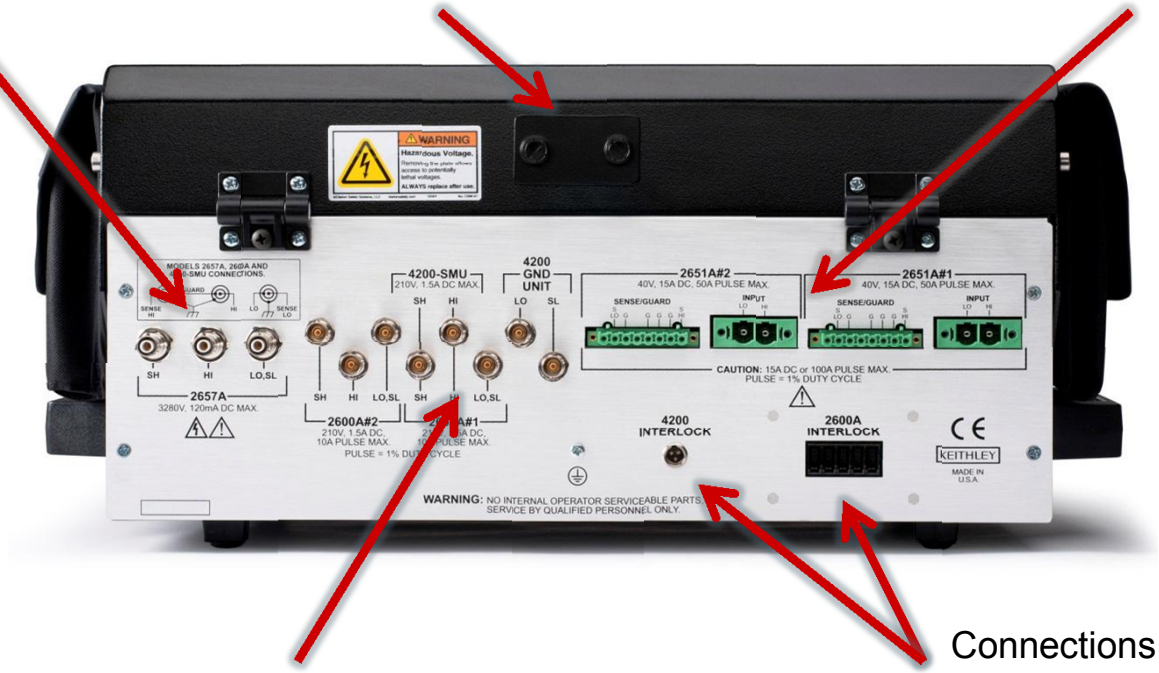
- Provides safe environment for testing at 3kV and at 100A
- Includes test sockets for TO-220 and TO-247 packages and custom devices.
- Easy to use banana connections
- Includes laminated, full-color connection guide

Connections to the Model 8010 Test Fixture

Connect one Model 2657A for 3kV and low current (pA) testing

Access port for routing external instrumentation (scope probes, thermocouples)

Connect two Model 2651As in parallel for 100A pulsed testing



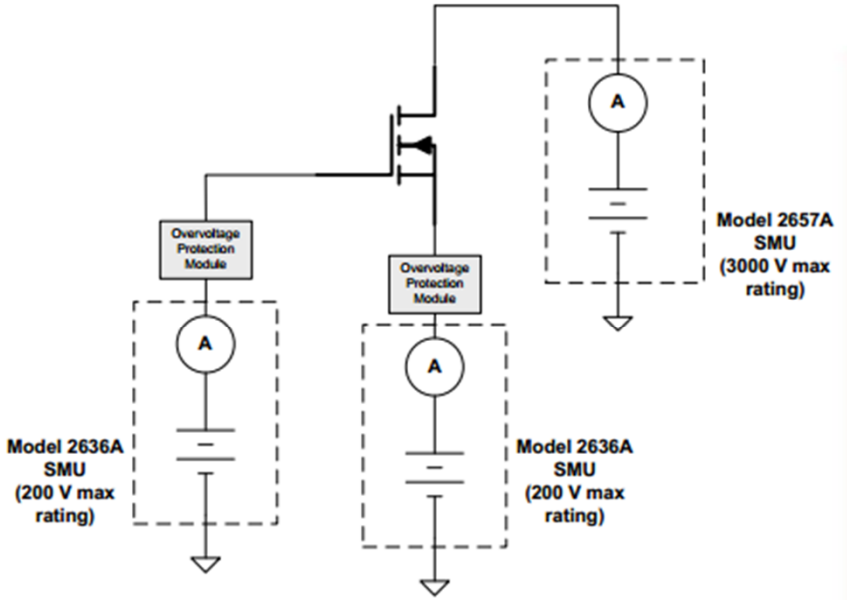
Connect up to two Model 2636Bs or Model 4200 SMUs for 200V and low current (pA) testing

Connections to SMU interlocks. Disables high voltage outputs of SMUs when test fixture is opened.

Protect your instrument if device is failed

Overvoltage protection modules ensure that the lower voltage instrument is protected if device failure results

Model 2657A-PM-200 Protection Module



Note: K8010 test fixture is built in the protection module.

Keithley Parametric Curve Tracer Demonstration
- Parametric Mode (Toshiba TK12A60U)

Electrical Characteristics (Ta = 25°C)

Characteristics	Symbol	Test Condition	Min	Typ.	Max	Unit
Gate leakage current	I_{GSS}	V_{GS} = ±30 V, V_{DS} = 0 V	—	—	±1	μA
Drain cut-off current	I_{DSS}	V_{DS} = 600 V, V_{GS} = 0 V	—	—	100	μA
Drain-source breakdown voltage	$V_{(BR)\ DSS}$	I_D = 10 mA, V_{GS} = 0 V	600	—	—	V
Gate threshold voltage	V_{th}	V_{DS} = 10 V, I_D = 1 mA	3.0	—	5.0	V
Drain-source ON-resistance	$R_{DS\ (ON)}$	V_{GS} = 10 V, I_D = 6 A	—	0.36	0.4	Ω
Forward transfer admittance	$\|Y_{fs}\|$	V_{DS} = 10 V, I_D = 6 A	2.0	7.0	—	S

Characteristics		Symbol	Rating	Unit
Drain-source voltage		V_{DSS}	600	V
Gate-source voltage		V_{GSS}	±30	V
Drain current	DC (Note 1)	I_D	12	A
	Pulse (Note 1)	I_{DP}	24	

D: K2657A (Hi V; 3KV)

D: K2651A (Hi I; 50A Pulse)

G: K2635A (Hi P)

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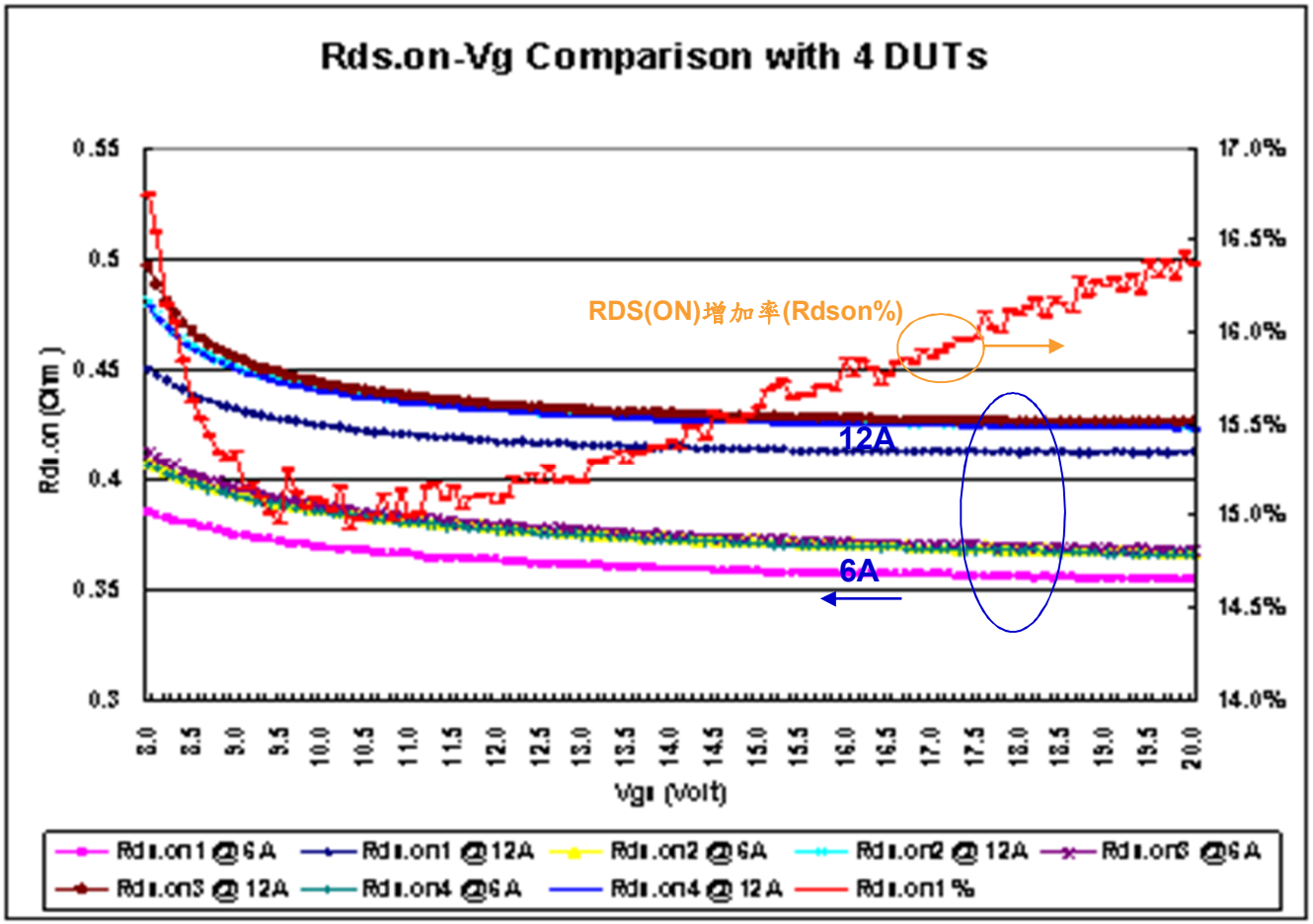
Keithley Parametric Curve Tracer Demonstration
- Parametric Mode (Ex. R_{dson}, Toshiba TK12A60U)



Drain-source ON-resistance	$R_{DS\ (ON)}$	V_{GS} = 10 V, I_D = 6 A	—	0.36	0.4	Ω

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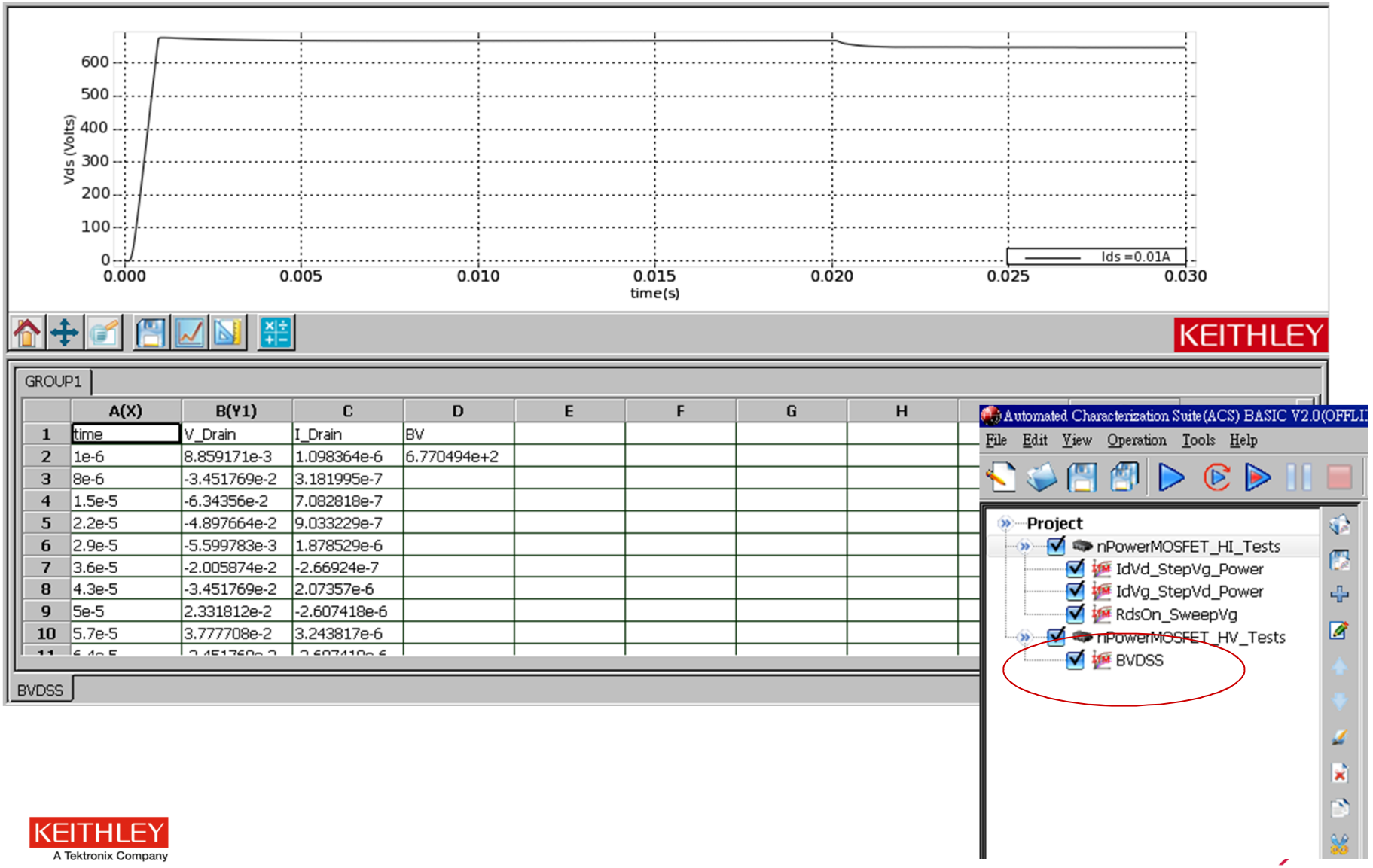
Keithley Parametric Curve Tracer Demonstration
- Parametric Mode (Ex. V_{BRDSS}, Toshiba TK12A60U)



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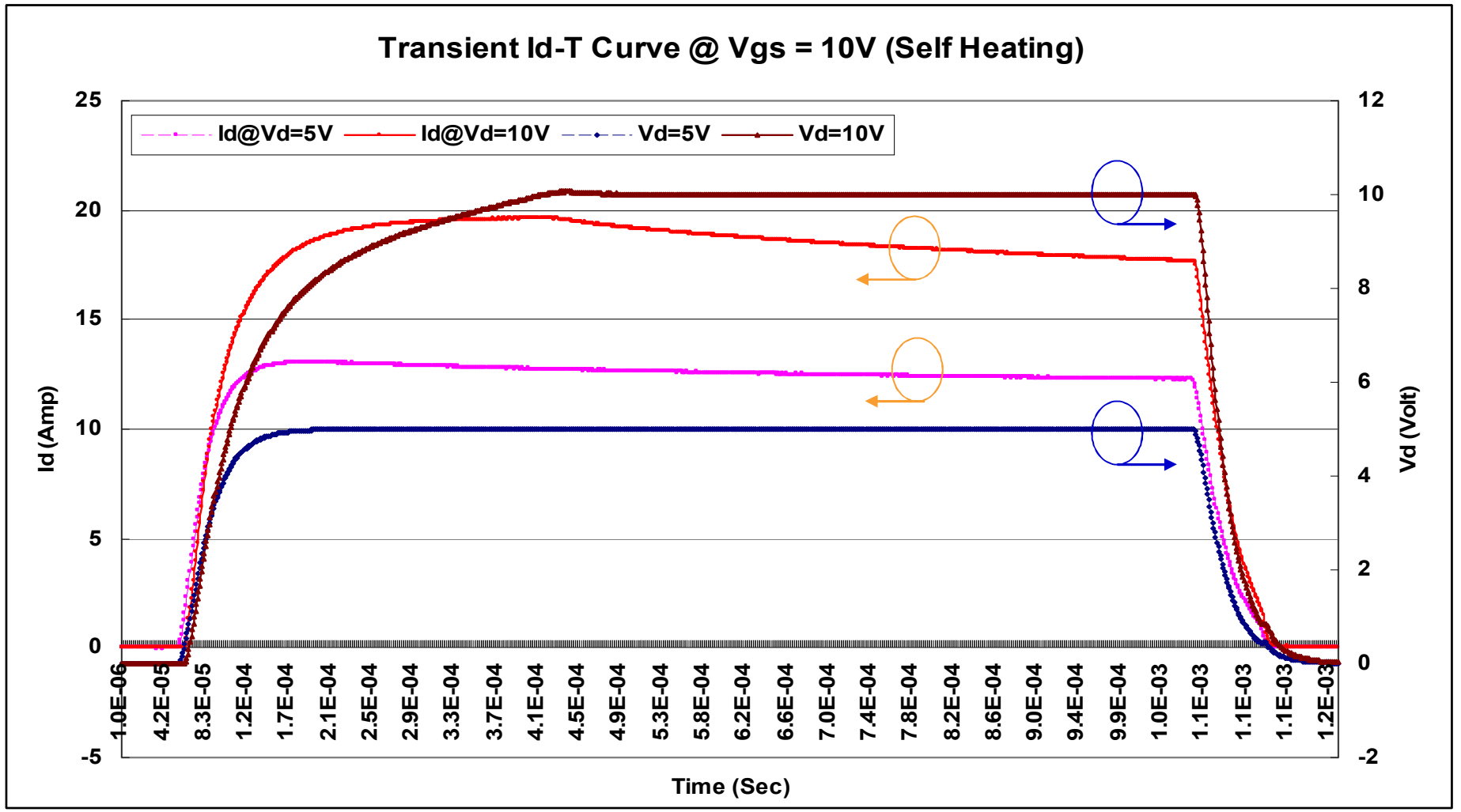
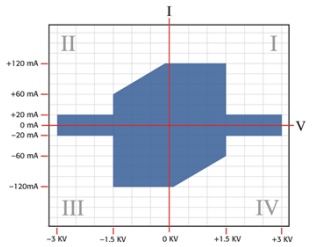
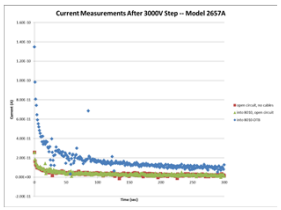
Keithley Parametric Curve Tracer Demonstration
→ Transient IV (1us / point synchronous measure)

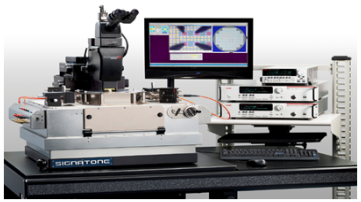


Conclusion

1. Keithley high power parametric curve tracer provides the most flexible, economical, upgradable and accurate for high power device characterization (Si, SiC, GaN, etc).
2. The max voltage up to 3KV @ 20mA and the max current up to 100A @ 40V with parallel connection.
3. Superior low current ability which can achieve pA level measurement under high voltage.
4. Available accessories are ready for further customized prober or test fixture integration.







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Thanks for your time ~