



TECHNICAL OVERVIEW

Benefit from Dramatic Improvements with a Transition from the 4155/4156 Analyzer Series

Precision Current-Voltage Analyzer Series

Introduction

Since the 1990's the 4155/4156 analyzer series, provided by Hewlett Packard (HP) and Agilent Technologies (now Keysight Technologies, Inc.) has been the most popular standard semiconductor parametric analyzer on the market. Despite its fA class superior low current measurement performance and powerful analysis capabilities, having been on the market for more than 20 years, it now faces a number of challenges as follows:

1. Cumbersome file management with a FDD (Floppy Disk Drive) and no peripheral network support.
2. The 4155/4156 series does not support the latest device characterization requirements including advanced measurement capabilities, such as capacitance-voltage (CV) and ultra-fast pulsed measurements.
3. This demand for the more advanced measurement capabilities, in addition to the standard I/V measurement capabilities, has meant the need for complex system integration and programming with additional instruments, in order to achieve results.

4. The costs involved in setting up and performing a lab with instruments that are rarely utilized, along with the cost of storing these rarely used instruments.
5. The Standard Service Period for the 4155C/4156C series ended in 2016. Now, it has been its Extended Service Period and Keysight Technologies is only be able to offer a minimum level of support in terms of repair and calibration.

To replace the 4155/4156 analyzer series, Keysight offers its Precision Current Voltage Analyzer Series that provides a range of analyzers suitable to your specific measurement needs. All analyzers are incorporated with Windows and range from an economic model at entry level price range, to the most advanced analyzer capable of supporting cutting edge applications.

Windows platform	- No need to use floppy disks. - It enables more efficient file management using the latest technologies - HDD, Network Drive and USB peripherals.
Easy migration from the 4155/4156 series	- The new analyzer series has a similar operating mode to the 4155/4156 series - There is a tool available for the seamless migration of MES/DAT files.
EasyEXPERT group+ characterization software	- The GUI based software that is unified for multiple instruments and users. - Over 300 ready-to-use application tests covering the latest applications/materials. - Provides a portable and personal analyzer on a user's PC. - Accelerates the characterization tasks from manual and automated measurements to post-measurement analysis.
Advanced measurement capabilities, performance and expandability	- Low current measurement improved down to 0.1 fA. - Expandable advanced measurement capabilities of capacitance measurement (1 kHz to 5 MHz), high-speed pulsed/transient IV measurement (200 MSa/s), ultra high power (10 kV/1500 A) and much more.

4155/4156 series
(Legacy platform)



Precision Current-Voltage
Analyzers Series
(Windows platform)



Advanced Device Analyzer



Precision IV Analyzer



Economic IV Analyzer

Precision Current-Voltage Analyzer Series



Economic IV Analyzer

The entry IV analyzer is available for a range of IV characterizations



Precision IV Analyzer

The high performance IV analyzer with current measurement capability as low as 0.1 fA along with SMU scalability is available for advanced IV characterization.



Advanced Device Analyzer

The all in one analyzer supporting IV, CV, pulse/dynamic IV and more. Designed for all-round characterization from basic to cutting-edge applications.

Key Features and Specifications

		4155/4156 Series		Precision Current-Voltage Analyzer Series					
				Advanced Device Analyzers		Precision IV Analyzers	Economic IV Analyzers		
		4155	4156	B1500A	B1505A	E5270B	B2911B B2912B	B2901B B2902B	B2901BL B2910BL
IV measurement	Adequate low current to measurement	> 0.1 fA	> 0.1 fA	> 0.1 fA	> 10 fA	> 0.1 fA	> 10 fA	> 1 pA	> 10 pA > 100 fA
	Min. current measurement resolution	10 fA	1 fA	0.1 fA	10 fA	0.1 fA	10 fA	100 fA	1 pA 10 fA
	Max. voltage/current output	200 V/1 A	200 V/1 A	200 V/1 A	10kV/1500 A	200 V/1 A	210 V/3 A	210 V/3 A	21 V/1.5 A 210 V/1.5 A
	Number of SMUs	4 to 6	4 to 6	1 to 10	1 to 10	1 to 8	1 to 8*	1 to 8*	1 to 4*
	I/V Spot (DC, pulsed)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	I/V Sweep (DC, pulsed)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	I/V-t Sampling	Yes	Yes	Yes	Yes	–	Yes	Yes	Yes
Advanced measurement	Pulse Generator (PGU)	Yes	Yes	Yes	–	–	–	–	–
	Quasi-Static CV (QS-CV)	Yes (C model only)	Yes (C model only)	Yes	–	–	–	–	–
	Capacitance Measurement (CMU)	–	–	Yes	Yes	–	–	–	–
	Automated IV and CV switching (SCUU)	–	–	Yes	–	–	–	–	–
	Pulsed/Transient IV measurement (WGFMU)	–	–	Yes	–	–	–	–	–
	Voltage Source/Voltage Meter (VSU/VMU)	Yes	Yes	–	–	–	–	–	–
	Ultra high voltage/high current up to 10kV/1500A	–	–	–	Yes				
	Switching matrix control	–	–	Yes		Yes	Yes	Yes	Yes
	Semi-auto prober control	–	–	Yes	Yes	Yes	Yes	Yes	Yes
Software		–	–	EasyEXPERT group+ (Available on Windows PCs and B1500/B1505A built-in PC)					

* B2900B has one or two channels, B2900BL has one channel. Up to 4 units are supported. (1 primary unit and up to 3 secondary units)

The Most Up to Date Analyzers Move Away from Floppy Disk Based Operation and Enable Much More Efficient Characterization on Windows

One of the biggest issues of the 4155/4156 analyzer series is the floppy disk drive (FDD) based file management. It does not support any of the common portable file storage devices such as a USB, so data management can be time consuming. This type of file management system is not 'User Friendly' and has become out of date.

Keysight's Precision Current-Voltage Analyzer Series is much more efficiently operated with EasyEXPERT group+ software on Windows. You can therefore take full advantage of the Windows supporting peripherals such as a network drive, printer and USB storage, etc.

In addition, the EasyEXPERT group+ is the characterization software unified for the Keysight Precision Current-Voltage Analyzer Series. The portability of the setup file and measurement data enables you to quickly share and recall data among users and with a range of instruments. The EasyEXPERT group+ can be installed on multiple PCs at no additional cost, allowing every team member can have their own personal analyzer environment. It can be connected to the instrument via GPIB and ensures speed, accuracy, and efficiency. EasyEXPERT group+ also provides options to protect important data when sharing it with multiple users.

Floppy disk based limited environment

4155/4156 series



Floppy disk



Windows and EasyEXPERT based flexible environment

Office



Easy data sharing
between user's PCs



EasyEXPERT on user's PC

Improved data
portability between
PC and instruments



It is a personal analyzer that is
available either in the office or lab by
connecting instruments via GPIB.

Lab

Data is interoperable
among analyzers on the
EasyEXPERT



B1500A
B1505A

B2900B/BL
Series SMU



E5270B



EasyEXPERT group+ Software Accelerates the Characterization Tasks at Any Stage in the Process

A complete solution from measurement to analysis unified for instruments and users

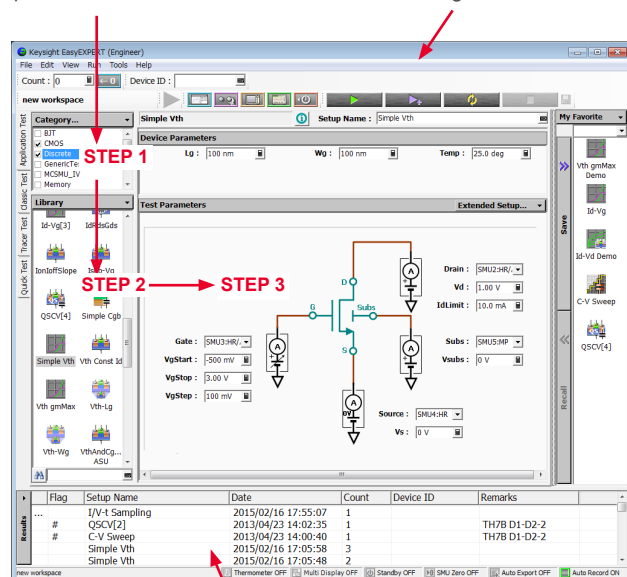
The EasyEXPERT group+ GUI based characterization software provides a range of integrated capabilities for accelerated device characterization using the Precision Current-Voltage Analyzer Series. The main operating area, called the “workspace”, provides easy to access measurement capabilities, parameter setup and execution panels and graphical analysis and data management tools. It quickly and easily facilitates characterization across the entire process, using its graphical intuitive user interface and mouse/keyboard operations.

The EasyEXPERT group+ software provides the unified characterization environment needed for multiple users and instruments.



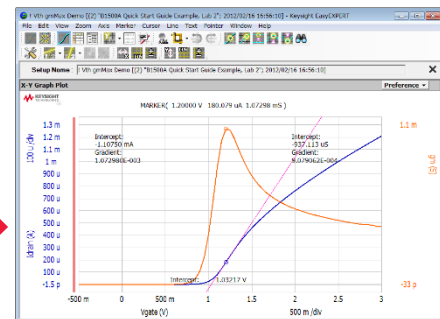
Application Test mode supports the measurement in three easy steps with extensive libraries of pre-defined tests.

The workspace provides quick access to EasyEXPERT's measurement capabilities, graphical analysis tools and data management tools.



The unique data management tool in the workspace. It allows automated storing of the measurement setup and data. The data can be quickly recalled for analysis or measurement reproduction at any time.

The data display window accelerates the analysis of the measurement results.



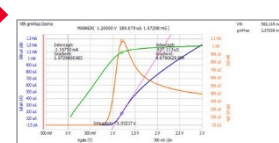
TXT/CSV



Excel



EasyEXPERT data



Image

Data can be quickly and easily exported in various formats.

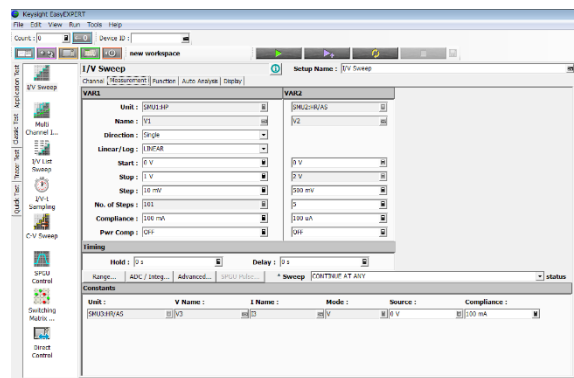
Classic Test Mode and Set Up File Conversion Capabilities Enable File Migration and Allow You to Facilitate Easy and Efficient Measurements

Classic test mode with a similar look and feel to the 4155/4156 series

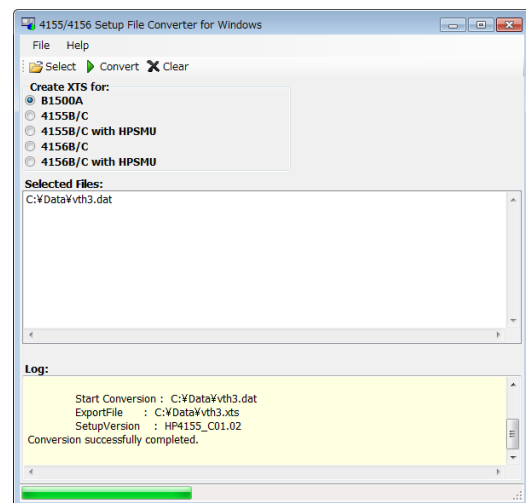
In addition to Application Test mode, EasyEXPERT supports the Classic Test mode. It has a similar look and feel to the front-panel interface of the 4155/56 parameter analyzer. Unlike the 4155/4156 series operating method, the Windows based interface enables you to quickly and easily set up, perform and analyze your measurement.

Existing 4155/4156 series set up files can be converted to EasyEXPERT files

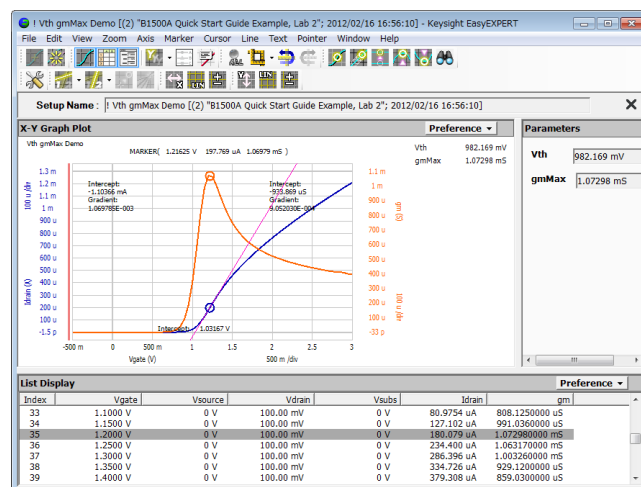
Classic test mode allows you to set up a new test as well allowing you to convert existing setup files (MES or DAT extensions) into Classic mode setups, using the setup file converter. This eliminates the need for floppy disk based file storage and allows 4155/4156 analyzer users to take advantage of the existing test setups.



Classic test mode



4155/4156 Setup File Converter

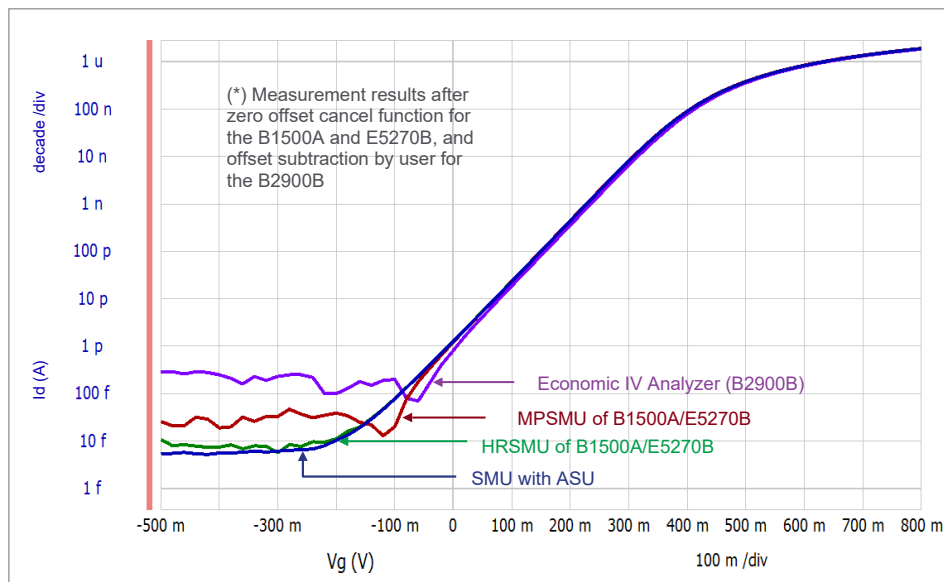


The Data Display provides the graphical analysis capabilities.

A Range of SMUs are Available, From Low-Cost to High-End, That Support 0.1 fA Low Current Measurements

The 4155/4156 series has provided the superior measurement performance down to 1 fA (HRSMU) or 10 fA (MPSMU) to satisfy the challenging low current measurement requirements for advanced semiconductor characterization. The Precision Current-Voltage Analyzer series further improves the measurement performance and the coverage for measurement requirements by offering a new range of SMUs. Current measurement capabilities as low as 0.1 fA are possible using the Atto-Sense Switch unit (ASU) which offers 10 times superior performance capabilities than the 4156's HRSMU. The ASU supports the HRSMU of the E5270B and the MPSMU/HRSMU of the B1500A.

The Precision Current-Voltage Analyzer series offers a range of SMUs, from low cost to high end, with a choice of model configurations to meet your measurement needs.



Atto-Sense Switch Unit (ASU)

On wafer MOS FET measurement example by different SMUs

A comparison of the maximum output and measurement resolutions of SMUs

		4155/4156 Series	Advanced Device Analyzer		Precision IV Analyzer	Economic IV Analyzer		
SMU type	Max. output	4155/4156	B1500A	B1505A	E5270B	B2911/12B	B2901/02B	B2901/10BL
HRSMU	100 V/100 mA	1 fA/2 μ V	1 fA/0.5 μ V	—	1 fA/0.5 μ V	—	—	—
MPSMU		10 fA/2 μ V	10 fA/0.5 μ V	10 fA/0.5 μ V	10 fA/0.5 μ V	—	—	—
HPSMU	200 V/1 A	10 fA/2 μ V	10 fA/2 μ V	10 fA/2 μ V	10 fA/2 μ V	—	—	—
B2900B	210 V/3 A	—	—	—	—	10 fA/0.1 μ V	100 fA/0.1 μ V	—
B2901BL	21 V/1.5 A	—	—	—	—	—	—	1 pA/0.1 μ V
B2910BL	210 V/1.5 A	—	—	—	—	—	—	10 fA/0.1 μ V
No. of SMUs		4 to 6	1 to 10	1 to 10	1 to 8	1 or 2**	1 or 2**	1**

* Minimum resolution can be expanded down to 0.1 fA by using optional ASU.

** B2900B has one or two channels, B2900BL has one channel. Up to 4 units are supported. (1 primary unit and up to 3 secondary units)

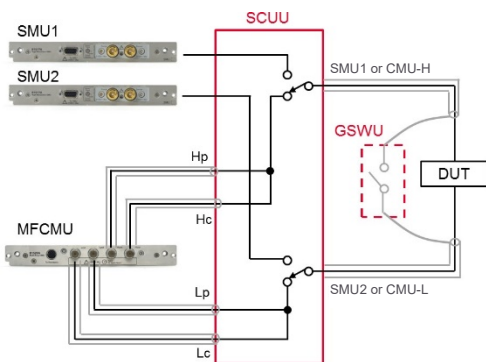
Offering Advanced Measurement Capabilities for Both CV Measurements and High-Speed Pulsed/Transient IV Measurements (B1500A)

An integrated IV, CV and QSCV measurement solution with automated switching capabilities

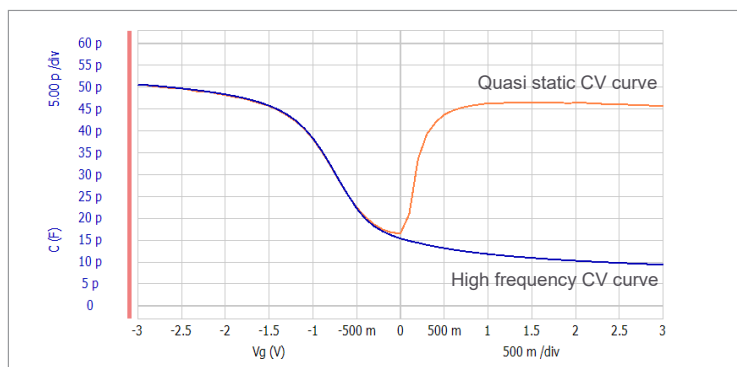
It is important to be able to perform a CV (Capacitance vs Voltage) measurement and a IV measurement at the same test station. In order to perform both measurements, an external LCR meter and switching matrix are needed for the 4155/4166 series.

In addition to the SMU, the B1500A/B1505A supports the CMU (Capacitance Measurement Unit) module that can perform CV, C-t and C-f measurements up to 5 MHz as easily as the SMU linked to EasyEXPERT.

For the B1500A, the optional SCUU (SMU CMU Unify Unit) and GSWU (Guard Switch Unit) are supported, which enables automated switching between SMU and CMU measurements. In combination with the SMU's QSCV measurement capability, the B1500A provides the complete solution for IV, CV and QS-CV measurements on a single instrument.



SCUU block diagram

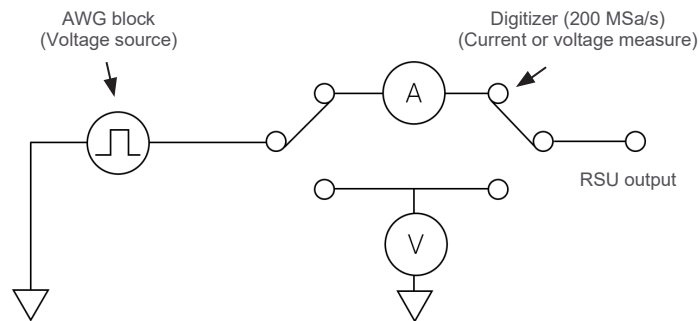


CV measurement example

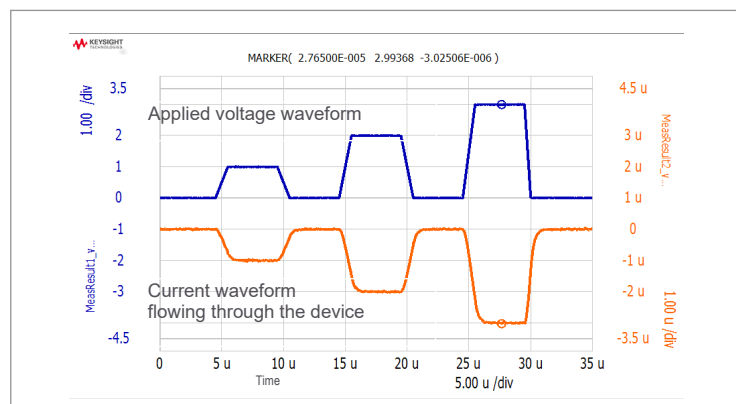
Pulsed/transient IV characteristics can be shown using the AWG and digitizing capabilities of WGFMU

There is an increasing demand for pulsed/transient IV measurements for the next generation of device characterization because these next generation device characteristics can be varied by a timing parameter (a timing dependency). Some example of next generation devices and applications include advanced non-volatile memory (NVM) such as ReRAM, PCRAM and FeRAM, organic and compound devices characterization, NBTI/PBTI reliability test, RTN (Random Telegraph Noise) measurement and so forth. For such fast measurements, a system configuring pulse generator, oscilloscope and shunt resistance are typically used but can be difficult to set up a system and perform a measurement accurately.

As a solution to these challenges, the B1500A supports the WGFMU (Waveform Generator/Fast Measurement unit). It is a unique module that integrates the precision digitizer (200 MSa/s) with the built-in AWG so that it can perform the high-speed current or voltage measurement on the generated pulse or arbitrary waveform at any point with min. 5 ns resolution up to 4M memory depth. In contrast to the conventional measurement method, using the WGFMU enables the broad range of I-t, V-t and I-V characterization varied by a timing parameter with incomparable accuracy and speed.



WGFMU block diagram



Pulsed IV measurement example

Unmatched Power Device Characterization Across a Wide Range of Operating Conditions (B1505A)

1500 A/10 kV IV measurement capabilities revolutionize power device evaluation

The HPSMU's coverage (200 V/1 A) is not sufficient to fully characterize a variety of power devices so a curve tracer or external high voltage or high current bench top SMU have been required when measuring a device exceeding the HPSMU's range. There is an increasing demand for new material-based wide band gap power devices such as GaN, SiC and Ga₂O₃, and it can be a challenge to find an analyzer with the appropriate measurement capabilities for such devices.

Keysight's B1505A power device analyzer/curve tracer resolves these challenges. It is an analyzer optimized for power device evaluation and analysis that allows you to accurately evaluate and characterize power devices from sub pA up to 10 kV and 1500 A.

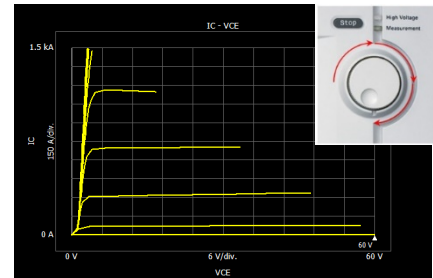
EasyEXPERT software supports the B1505A, allowing for efficient measurement and analysis. It also supports the tracer test mode so that you can operate the B1505A intuitively like a curve tracer.

Extensive device evaluation capabilities incomparable to conventional instruments

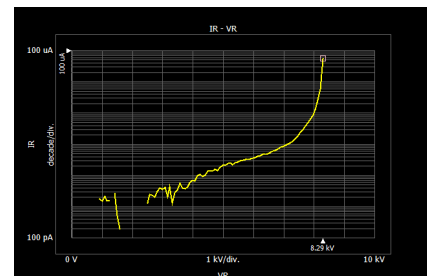
In addition to the IV measurement, the B1505A supports the following advanced measurements that can efficiently provide further insight into device characteristics.

- Fully automated Capacitance (Ciss, Coss, Crss, etc.) measurement at up to 3000 V DC bias
- Both packaged device and on-wafer IGBT/FET gate charge measurements
- High voltage/current fast switch option to characterize GaN current collapse effect
- Gate Charge (Qg) measurement at up to 3000 V and 1500 A
- Safe thermal testing from -50 °C to +250 °C via an interlock-equipped test fixture

These advanced measurement capabilities make the B1505A the best power device solution to meet your measurement needs.



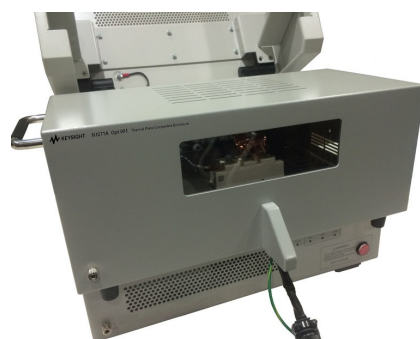
Example of IC-Vc up to 1500 A



Example of breakdown voltage up to 10 kV



N1272A Device Capacitance Selector and N1273A Capacitance Test Fixture



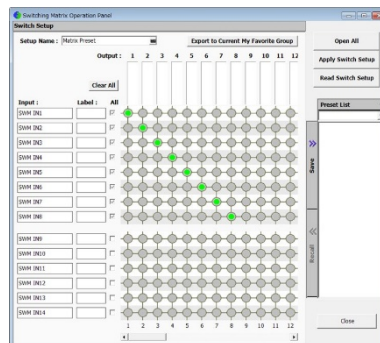
N1271A option 001 Thermal Plate Compatible Enclosure

Flexible Options for the Automated Test and User Programming Environment

EasyEXPERT group+ provides a convenient switching matrix and semi-auto prober control for automated testing

The EasyEXPERT group+ supports a switching matrix control. The switching matrix setup can be easily created using mouse point and click operations on the GUI.

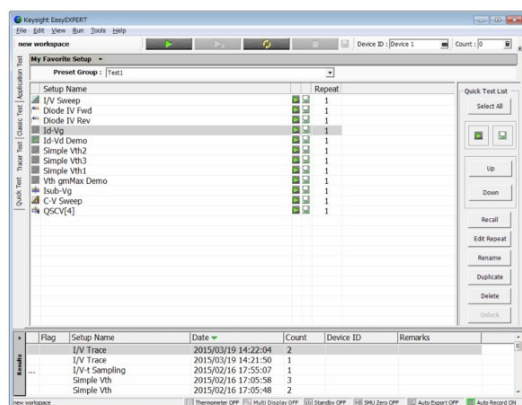
For automated testing, the EasyEXPERT group+ supports a GUI-based quick test mode. Quick test mode provides a convenient means to execute a sequence of tests created in EasyEXPERT, without the need for any programming. If you are using a switching matrix, you can automatically recall switching patterns created interactively. You can also combine semi-auto wafer prober control with quick test mode to perform multiple tests automatically across a wafer.



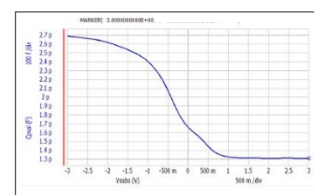
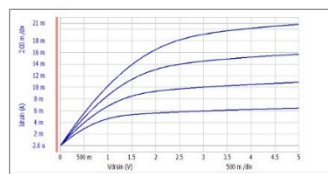
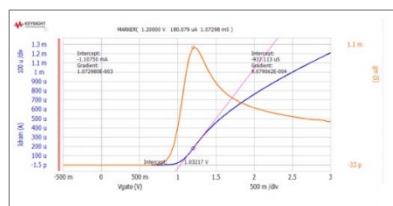
GUI based switching matrix



B2200/01A and E5250A Low Leakage Switch Matrix



Quick Test mode allows you to make a test sequence on GUI



The FLEX command set is supported with similar syntax to 4155/4156 FLEX

For user programming on VEE, LabView, VisualStudio, etc., the 4155/4156 series provided the FLEX command set (B and C model). For the B1500A, B1505A, and E5270B, the FLEX command set is supported for remote control with similar syntax to the 4155/4156 FLEX commands within the instrument's supported functions. Although there are minor differences, the same concept and similar syntax help to minimize the adjustments needed when moving from the 4155/4156 series' FLEX commands to the new analyzer's FLEX commands. Note that the B2900B/BL supports SCPI, but not FLEX command.

Software information

Features	FLEX Commands	4155/4156	E5270B	B1500A
Spot measurement	DI, DV	•	•	•
Staircase sweep measurement	WI, WV, WT, WM, WSI, WSV	•	•	•
1ch pulsed spot measurement	PI, PV, PT	•	•	•
Pulsed sweep measurement	PWI, PWV, PT, WM, WSI, WSV	•	•	•
Staircase sweep with pulsed bias measurement	WI, WV, WM, WSI, WSV, PI, PV, PT	•	•	•
Sampling measurement	MI, MV, MT, MSC, MCC	•	–	•
Stress force	POR, STI, STV, STP, STT, STM, STC	•	–	–
Linear search measurement	LSV, LSI, LGV, LGI, LSTM, LSSV, LSSI, LSVM, WM	•	•	•
Binary search measurement	BSV, BSI, BGV, BGI, BSM, BST, BSSV, BSSI, BSVM	•	•	•

For the details of the unsupported commands and the differences between each FLEX, consult with the Keysight application engineers when considering the program migration.

Comparison Table and Selection Guide

		The Precision Current-Voltage Analyzer Series						
		Economic IV Analyzer				Precision IV Analyzer	Advanced Device Analyzer	
Model number		B2901/02B	B2911/12B	B2901BL	B2910BL	E5270B	B1500A	B1505A
Max. output		210 V/3 A		21 V/1.5 A	210 V/1.5 A	200 V/1 A		10 kV/1500 A
Min. measurement resolution		100 fA/0.1 μV	10 fA/0.1 μV	1 pA/0.1 μV	10 fA/0.1 μV	0.1 fA/0.5 μV		10 fA/0.5 μV
No. of SMU channels		1 to 8*		1 to 4*		1 to 8	1 to 10	
SMU channel upgradability		Instrument stacking up to 4 units				Add SMU module to the mainframe		
Output connector type		Banana**				Active Guard Triaxial		
No. of Ground Unit (GNDU)		N/A				1		
Current-voltage measurement capability	Spot	Yes						
	Sweep	Yes						
	Time sampling	Yes				No	Yes	
Advanced measurement capability	Capacitance	No					Yes	
	Ultra-fast pulsed IV/ transient IV	No					Yes	No
Measurement setup and control	Mouse & keyboard operation	Yes						
	Classic test	Yes						
	Application test	Yes						
	Tracer test	Yes						
	Test sequence	Yes						
	Switch and prober control	Yes						
Data analysis and management	Data management by workspace	Yes						
	Graphical display with auto analysis	Yes						
	Automated data store	Yes (Measurement setup and result)						
	Automated data export	Yes (Excel dynamic data link, Excel files, CSV files, images, text, EasyEXPERT file)						
EasyEXPERT group+ and analyzer controller	Built-in PC	No					Yes (15 inch touch screen)	
	External PC	Yes						
Group usage support	Personal analyzer environment	Yes						
	Interoperability across the Keysight analyzer series	Yes						
	Data protection	Yes (Password protection and user level access control)						

* B2900B has one or two channels, B2900BL has one channel. Up to 4 units are supported. (1 primary unit and up to 3 secondary units)

** A Banana to Triaxial adapter is available.

Trading in Your Analyzer Model

After more than 20 years on the market, the 4155/4156 series has been out of date. Keysight offers its Precision Current Voltage Analyzer Series that provides a range of IV analyzers at competitive prices, suitable for your specific measurement needs and capable of supporting cutting edge applications.

To support the move to the new analyzer series, for a limited time, Keysight is offering money off the cost of a new analyzer when you trade in your old model. For further details about this promotion, visit [Keysight Trade-In web page](#).

Keysight Precision Current-Voltage Analyzer Series and Power Device Analyzer Series www.keysight.com/find/analyzer



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