Keysight Technologies

Thyristor Characterization Using the Keysight B1505A Power Device Analyzer/Curve Tracer

Application Note

N1268A Ultra High Voltage Expander

N1265A Ultra High Current Expander/Fixture N1266A HVSMU Current Expander

B1505A Power Device Analyzer/Curve Tracer

Introduction

Thyristors, which behave like current-triggered diodes, have the unique current-voltage (IV) characteristics shown in Figure 1. This discontinuous behavior means that the characterization of a thyristor's DC parameters requires different methodologies than those used to characterize power devices such as IGBTs and high-power MOSFETs.

For example, before measuring thyristor holding current (IH) you must first turn on the thyristor. Similarly, characterizing latching current (IL) requires a looping test sequence of triggering and measurement.

This application note provides an overview of thyristor electrical characterization using the B1505A.

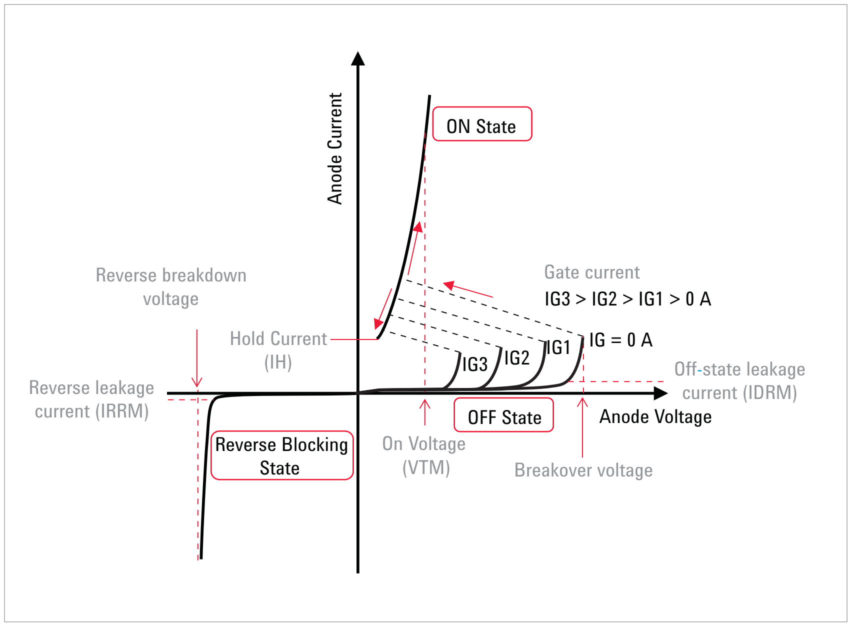

Figure 1. I-V characteristics of thyristor

Typical Thyristor Parameters

The static parameters listed in a typical thyristor data sheet are summarized in Table 1.
The right-most column indicates the B1505A's measurement range for each parameter.

Table 1. Typical DC parameters of thyristor and the compatibility of the B1505A

Typical Thyristor Parameter	Symbol	Unit	Measurement [1]	Typical Measurement Module	Typical Measurable Range by B1505A
Anode Characteristics	Ia	I	Ia-Vak	UHCU	–1500 A to 1500 A[2] (Minimum 500 µA resolution)
Max. peak off-state leakage current	IDRM	I	Ia-Vak	UHVU	–10 kV to 10 kV[3] (Minimum 10 mV resolution)
Max. peak reverse leakage current	IRRM	I	Ia-Vak	UHVU	–10 kV to 10 kV[3] (Minimum 10 mV resolution)
Max. on-state voltage	VTM	V	Ia-Vak	UHCU	–1500 A to 1500 A[2] (Minimum 500 µA resolution)
DC gate triggering voltage	VGT	V	Ia-Ig	MCSMU[4]	–30 V to 30 V (Minimum 0.2 µV resolution)
DC gate triggering current	IGT	A	Ia-Ig	MCSMU	–100 mA to 100 mA (Minimum 10 pA resolution)
DC gate voltage not to trigger	VGD	V	Ia-Ig	MCSMU	–30 V to 30 V (Minimum 0.2 µV resolution)
DC gate current not to trigger	IGD	A	Ia-Ig	MCSMU	–100 mA to 100 mA (Minimum 10 pA resolution)
DC (Maximum) holding current	IH	A	Va-Ia	HPSMU	–1 A to 1 A[5] (Minimum 50 fA resolution)
DC lathing current	IL	A	Va-Ia	HPSMU	–1 A to 1 A[5] (Minimum 50 fA resolution)
Gate diode characteristics	Ig	A	If-Vf	MCSMU	–1 A to 1 A[6] (Minimum 10 pA resolution)

1. Measurement used for extracting the parameter.
2. UHCU: Ultra High Current Unit 60 V/1500 A. HCSMU: High Current SMU 40 V/20 A, HPSMU: High Power SMU 200 V/1 A.
3. UHVU: Ultra High Voltage Unit 10 kV/20 mA. HVMCU: High Voltage Medium Current Unit 2.2 kV/2.5 A, HVSMU: High Voltage SMU 3 kV/8 mA.
4. MCSMU: Medium Current SMU 30 V/1 A
5. HPSMU: High Power SMU 200 V/1 A. HCSMU can be used. (Same maximum DC current range.)
6. Pulse mode. HCSMU: 20 A.

Thyristor Measurement Example

The following section describes an example thyristor measurement using the B1505A.

1. Ia-Vak characteristics

An Ia-Vak application test is available to perform Ia-Vak characterization on a thyristor.

Figure 2 shows the Ia-Vak application test's graphical user interface (GUI).

The intuitive GUI provides the following benefits:

- The circuit diagram provides an overview of the test, making iteasy to understand the connections between the thyristor and the measurement resources (SMUs). It also shows the SMU's operation mode (I force or V force mode). This visual overview helps to reduce measurement setup time.
- Series resistors are often needed when characterizing thyristors. An optional series resistor can be inserted using software commands.

Ia-Vak measurement example

Figure 3 shows the breakover voltage characteristic, which is one of the most important thyristor measurements. In this ex-ample, a gate current from 2.5 mA to 2.8 mA is applied in 50 μA steps while the anode is swept from 0 V to 1200 V. The HVMCU is connected to the thyristor anode through an internal 20 kΩ series resistor; however, the HVMCU sense line by-passes the 20 kΩ internal resistor and measures the voltage at the DUT.

Figure 3 shows how easy it is to obtain an accurate Ia-Vak curve using the B1505A.

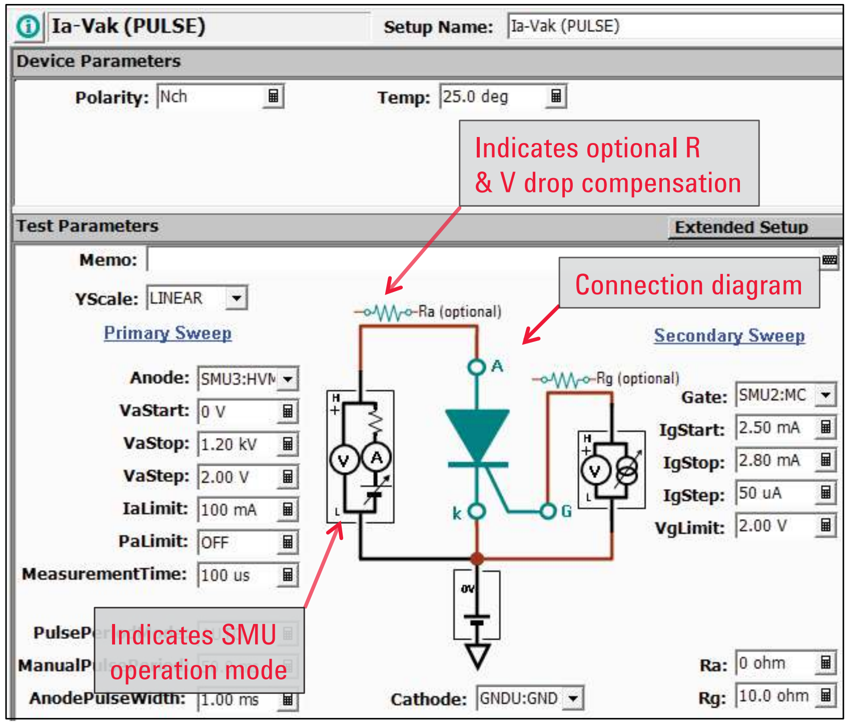

Figure 2. Ia-Vak Application Test GUI

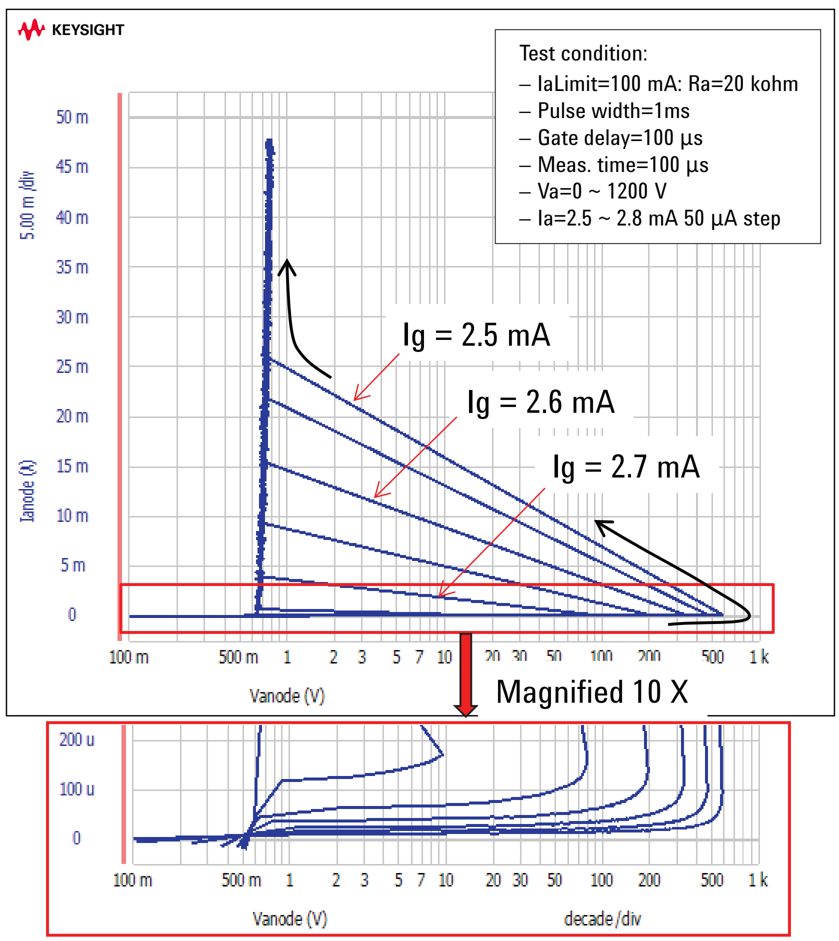

Figure 3. Breakover voltage characteristics

Thyristor Measurement Example

2. On-state voltage measurement (VTM)

VTM measurement can be performed using the B1505A's sweep measurement function.

Figure 4 shows an example of VTM on–state voltage measurement.

The software automatically positions the marker at the specified ITM current, and the voltage at the marker point is displayed as the VTM. In the Parameters Field it is easy to see the values for ITM and VTM (25 A and 1.17 V respectively).

3. Latching current (IL) measurement

Measuring latching current (IL) requires a looping trigger-measure cycle in order to determine the minimum anode current necessary to keep the thyristor turned on after the gate pulse is turned off.

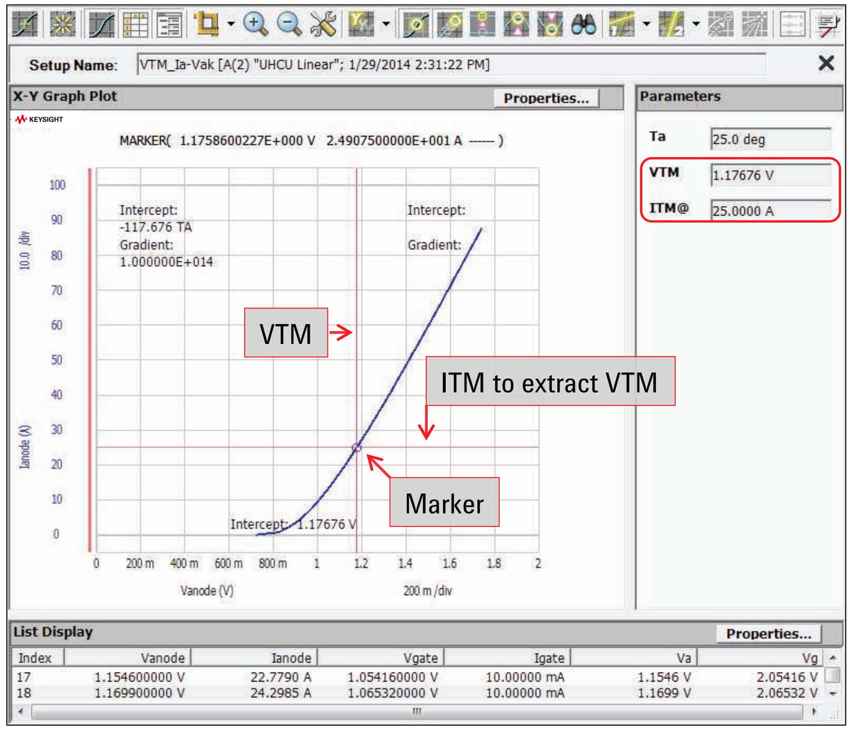

Figure 4. VTM test example

Figure 5 shows latching current test loop and the IL application test output.

The IL application test determines the latching current using the test sequence shown in Figures 5A and 5B. After each of these sequences the anode current is increased until the thyristor turns on.

The anode voltage and the anode current obtained using this procedure are plotted as shown in the right half of figure 5. Thus, using this application test the IL latching current can be determined automatically.

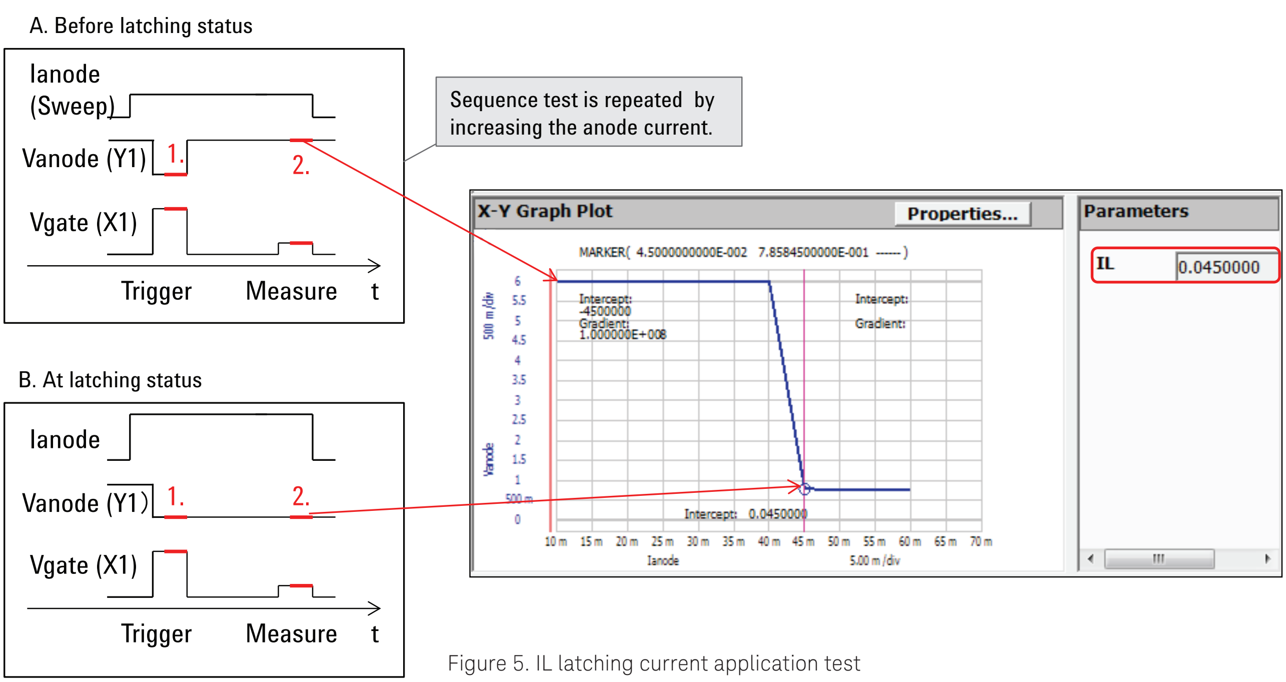

Figure 5. IL latching current application test

Thyristor Application Test Library

Table 2 shows sample thyristor application tests available for the B1505A.

These application tests run on EasyEXPERT, which is a GUI-based software resident on the B1505A.

You can download these sample application tests from the Keysight Technologies, Inc. website, **www.keysight.com/find/b1505a**.

Multiple Fixturing Options

The N1265A Ultra High Current Expander/Fixture supports various types of devices and modules.

It has a TO-220 compatible test socket module for measuring standard packaged devices.

The N1265A's 340 mm (W) x 170 mm (D) test area permits the measurement of relatively large devices and modules in a safe and secure test environment.

Note: A cable extension is also available to connect the N1265A to external test enclosures if the N1265A's test area cannot contain them.

Conclusion

Typical thyristor static electrical datasheet parameters can be measured using the Keysight B1505A Power Device Analyz-er/Curve Tracer. These measurements can be made up to the full 1500 A and 10 kV output capabilities of the instrument.

Even relatively complex thyristor parameters such as IH and IL, which require sequenced testing routines, can be automated using the sample application test library.

The B1505A can provide accurate and efficient thyristor characterization with minimal time investment in learning how to use the instrument.

Table 2. Thyristor application test library.

Application Test Name	Parameter	Description	Category
Ia-Vak, Ia-Vak (PULSE)	IA-VAK Curve	Measures Ia-Vak characteristics by stepping the gate current as a secondary sweep.	Thyristor
Off_Ia-Vak, Off_Ia-Vak (PULSE)	IDRM	Measures Ia-Vak characteristics of the off-state, and extracts the off-state current at the specified VDRM.	Thyristor
R_Ia-Vak, R_Ia-Vak (PULSE)	IRRM	Measures reverse Ia-Vak characteristics, and extracts reverse leakage current at the specified VPRM.	Thyristor
VTM_Ia-Vak	VTM	Measures Ia-Vak characteristics at the specified gate current, and extracts the on-state voltage at the specified on-state current.	Thyristor
IGT,VGT_Ia-Ig	IGT, VGT	Measures Ia-Ig characteristics, and detects the gate current and voltage to turn on the device.	Thyristor
"VGD,IGD_Ia-Vgk VGD,IGD_Ia-Vgk (PULSE)"	VGD, IGD	Measures Ia-Vgk characteristics at specified Va condition, and extracts the gate voltage or current just before the anode turns on.	Thyristor
IH_Ia-Vak, IH_Va-Iak	IH	Measures the holding current.	Thyristor
IL_Va-Iak	IL	Measures the latching current.	Thyristor
If-Vf	IF-VF Curve	Measures the I-V characteristics of the gate diode.	Thyristor

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Published in USA, August 4, 2014
5991-4491EN
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