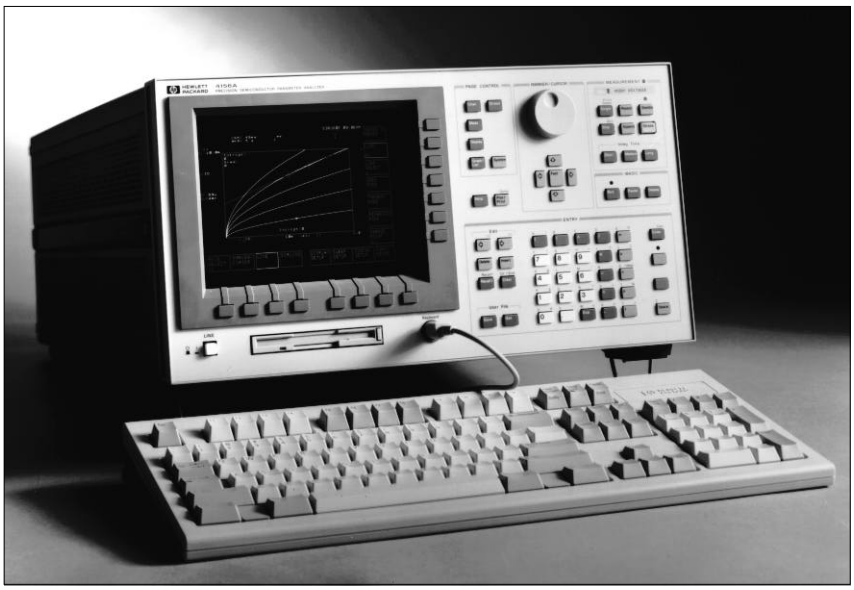
H

Measurement of Power Devices Using External DC Power Supply

Application Note 4156-5

HP 4155A/4156A Semiconductor Parameter Analyzer

Expansion of measurement range to cover several amperes easily achieved using external DC power supply



Introduction

If used in combination with an external DC power supply, the HP 4155A/4156A semiconductor parameter analyzer can easily evaluate the DC characteristics of a power device that requires a current of several amperes. This application note describes how to connect the highly cost-effective HP E3615A DC power supply to the HP 4155A and to use the HP 4155A's automatic analysis functions to automatically calculate threshold voltage (Vth).

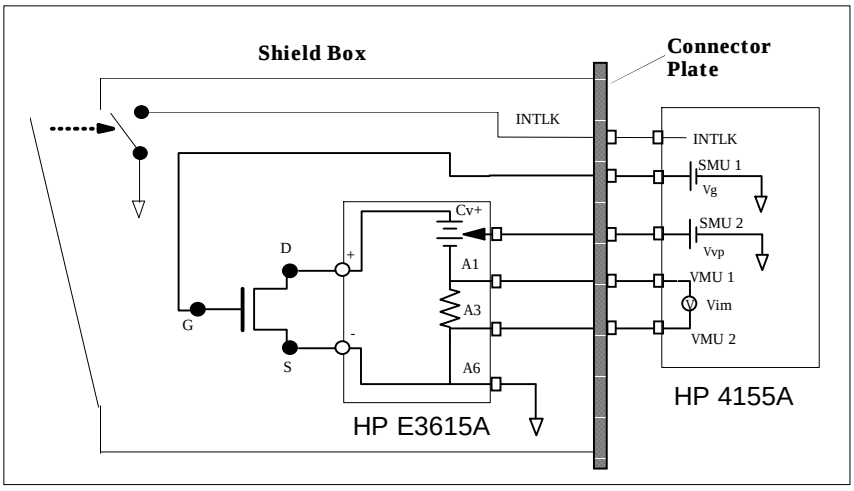


Figure 1. Diagram of Connections for Power Transistor Measurement

Power transistor measurement

Curve tracers are widely used for power transistor measurement, but have few analysis functions and have difficulty in extracting transistor parameters. They also have the disadvantage of being difficult to automate in order to improve productivity.

The HP 4155A/4156A offers a wide range of analysis functions including log sweep measurement functions, tangent line, regression line, and marker Min/Max. It also has built-in HP Instrument BASIC, which allows the control and automation of all measurements without any external controller, and offers major improvements in productivity from device development and design to incoming inspection. The dedicated expander (HP 41501A) gives a measurement range of up to 1A/200V, and using an external DC power supply that can be remotely controlled allows further expansion of the measurement range.

The HP E3615A can be remotely controlled by applying a voltage to its control terminal, and current can be monitored remotely via its sense resistor. This paper describes how this function can be used to increase the output power and expand the current

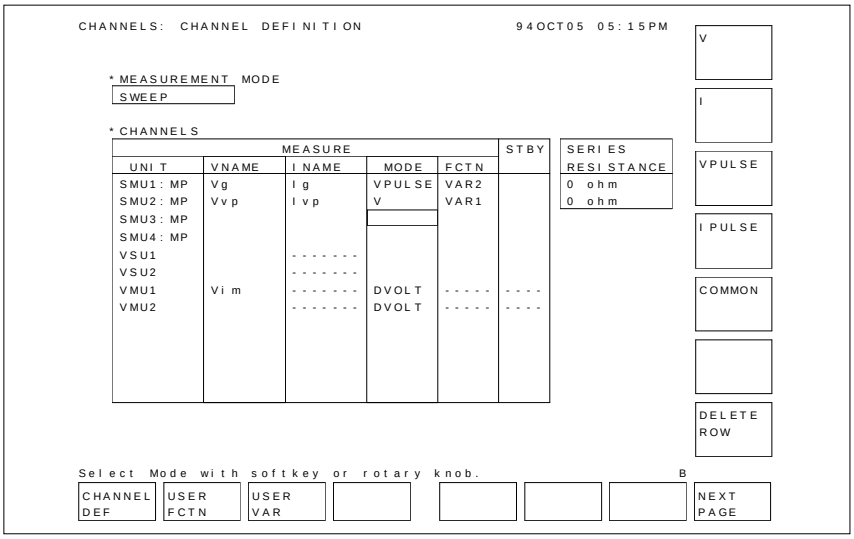


Figure 2. CHANNEL DEFINITION Page

measurement range of the HP 4155A. Our example uses the HP E3615A, which provides a maximum of 60W and 3A/20V, but the HP E3614A (6A/8V) or the HP E3617A (1A/60V) are also suitable.

Connections

The HP 4155A and HP E3615A are connected as shown in Figure 1. SMU2 is connected to the control terminal Cv+ to control output voltage, and the voltage measurement units (VMU1 and VMU2) are connected to sense resistor terminals A1 and A3 to monitor output current. To give the HP E3615A a circuit common potential, terminal A6 is connected to the common terminal which is the outer shield of SMU2. These connections are made using the connector plate supplied with the HP 4155A[*1].

HP 4155A settings and results of measurements

Figures 2 to 4 show the HP 4155A setup screens for the drain characteristic measurements. On the CHANNEL DEFINITION page (Figure 2), SMU1, which is connected to the gate, is set to pulse output. Driving the gate using a pulse voltage reduces the average output current, so thermal drift is

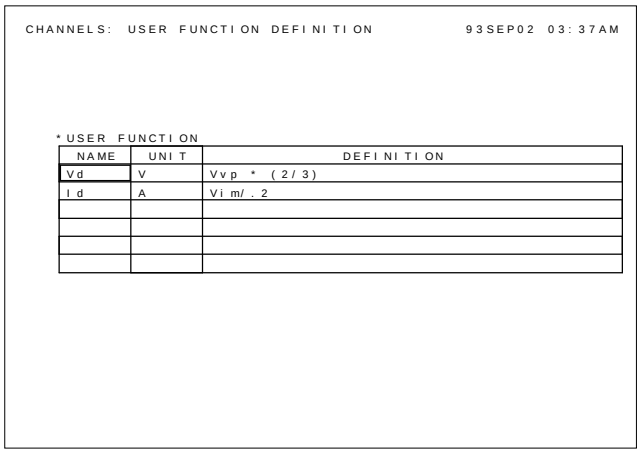


Figure 3. USER FUNCTION DEFINITION Page

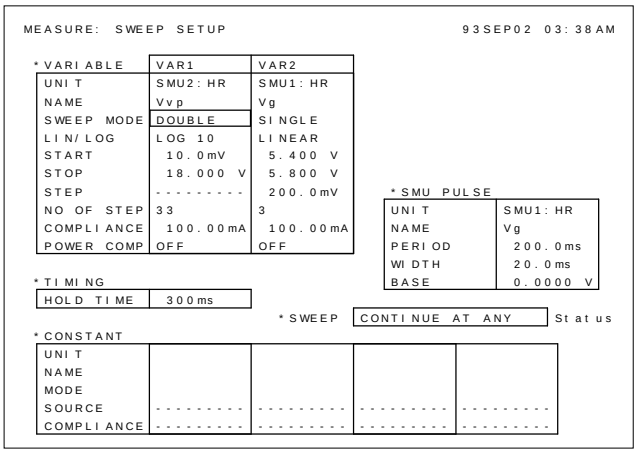


Figure 4. SWEEP SETUP Page

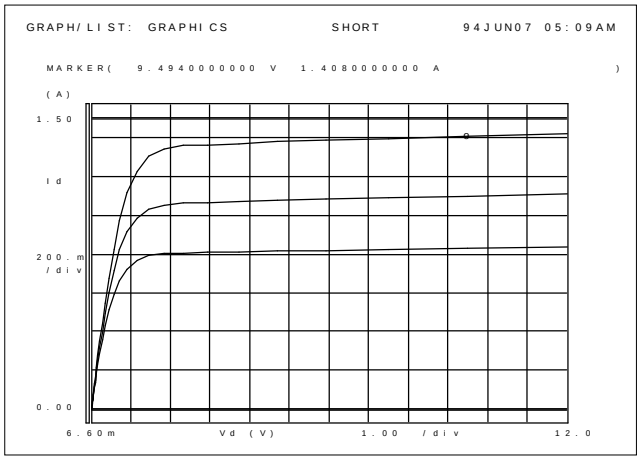


Figure 5. Example of Drain Characteristic Measurements

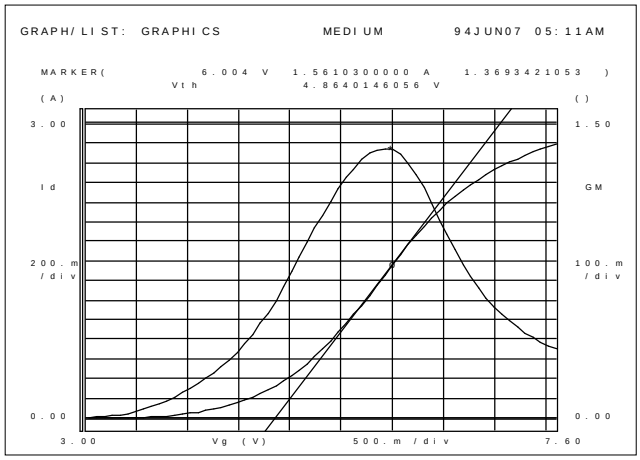


Figure 6. Drain Current versus Gate Voltage Characteristics to Obtain Vth

reduced. VMU1 and VMU2 are set to differential mode and the potential difference (Vim) is measured.

The USER FUNCTION DEFINITION page (Figure 3) is used to calculate the Vd and Id variables. Vd is the SMU2 output voltage (Vvp) multiplied by a factor depending on the DC power supply (2/3 for the HP E3615A). The sense resistance is 0.2 Ω for the HP E3615A, so Id = Vim/0.2. So, you set the user functions as follows:

Vd = Vvp * (2/3)

Id = Vim / 0.2

For other DC power supplies, see *2 at end of this note.

The SWEEP SETUP page (Figure 4) is used to set the sweep conditions for SMU1 and SMU2, and the pulse output for SMU1. In this example, to reduce the number of measurements in the high voltage range and prevent heating, SMU2 is set to log sweep. Pulse width and pulse period are set so that pulse of SMU1 has a duty cycle of 10 %. The measurement results of drain characteristics are shown in Figure 5.

Automatic extraction of transistor parameters

The HP 4155A/4156A can automatically extract parameters after measurements[*3]. Figure 6 shows the automatic extraction of threshold voltage from the "drain current versus the gate voltage" characteristics graph. Before measurement, you set up the ANALYSIS SETUP page to extract desired parameters. After measurement, HP 4155A/4156A automatically extracts the parameters.

In this example, the HP 4155A finds maximum Gm, then draws tangent to Id curve of this point. The x-intercept of this tangent line is Vth, which is automatically displayed. Measurement productivity, repeatability, and speed are all significantly improved.

Tips on maximizing measurement accuracy

To obtain the highest possible accuracy of measurement, you should observe the following points:

- Instead of calculating Vd by user functions, directly connect one SMU to drain and one SMU to source, and subtract voltage difference between the drain and the source. This will eliminate the error caused by remote programming and the voltage loss caused by the cables.
- To minimize voltage loss in cables that carry a high current, use cables that are as short and thick as possible.
- After a sweep, when the drain voltage returns abruptly to zero, the HP E3615A may generate a spike. To eliminate this spike, use the double-staircase sweep mode.
- As much as possible, you should use a heat sink.

Conclusion

This application note described one example of how the HP 4155A can be used with the highly cost-effective HP E3615A DC power supply to extract power transistor parameters, which are difficult to extract using the conventional curve tracer method.
The HP 4155A/4156A's automatic analysis functions and built-in HP Instrument BASIC environment also allow HP 4155A/4156A to become an automatic test station.

Notes:

*1 Please observe following safety precautions when using the HP 4155A.
- Make sure that the wiring used with the connector plate and shield box has adequate capacity. The maximum output voltage and current of each external DC power supply are as follows:

Model No.	Max.output voltage	Max.output current
HP E3614A	8V	6A
HP E3615A	20V	3A
HP E3616A	35V	1.7A
HP E3617A	60V	1A

- To protect yourself against electrical shocks when replacing the DUT, be sure to fit an INTLK switch and install the measurement system, including external DC power supply in a shield box.

*2 For other external DC power supplies, use the following user functions:
HP E3614A:
Vd = Vvp * (4/9), Id = Vim / 0.1
HP E3616A:
Vd = Vvp * (7/9), Id = Vim / 0.6
HP E3617A:
Vd = Vvp * (6/7), Id = Vim / 0.89

*3 For a detailed explanation of automatic analytical functions, see "Application Note 4156-2, Automated Extraction of Semiconductor Parameters Using the HP 4155A/4156A" (HP part number 5963-1249E).

For more information, call your local HP sales office listed in your telephone directory or an HP regional office listed below for the location of your nearest sales office.

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