

Research on Interval Pulse IV Test Method for Power Semiconductor Devices

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Abstract. This paper did carefully research on the principle of point test method for semiconductor devices testing, and pulse step current source and voltage source was developed. Verification system of the interval pulse IV test method was developed to identify the relationship of the pulse width and interval time of Interval pulse IV test method. The specification of this system is vivificated through evaluating the uncertainties of the system. Then standard protocol of the interval pulse IV test method for power semiconductor devices is fulfilled.

Introduction

Semiconductor discrete devices are widely used in various electronic equipments. With the development of semiconductor devices, the application of power semiconductor devices is increasing. The quality of power semiconductor device is determined by its performance parameters which are measured by using special equipments. There are three methods used to test its performance parameters, include Point test method, Continuous step IV test method and Interval pulse IV test method.

For Interval pulse IV test method, its principle is to apply interval point test conditions. If the devices heat in the test process, the test results of the parameters will not be stable. The bias condition applied on the devices, such as pulse width and interval time, are the main factor of heating.

It is urgent to develop a verification system to verify the details of the Interval pulse IV test method and standard protocol for Interval pulse IV test method for power semiconductor devices needs to be compiled.

Test methods for electric parameters

The so-called point test method is to use the corresponding calculation formula to calculate the relevant parameters based on the fixed bias conditions, input conditions and measured output parameters. There are a lot of semiconductor test instruments that used the point test method to test electric parameters, include power semiconductor device test system, power diode test system, single parameter semiconductor testing instrument, etc. The main problem of this kind of equipment is not to be able to see the change trend of the device parameters in its full operating range.

But when we test the pulsed IV characteristics of the power semiconductor devices, the step current signal that applied on the base of the transistor, or the step voltage signal that applied on the gate of the MOSFET devices, is given in continuous form, and there is no interval time between adjacent steps (or DIVs). This test method is called continuous step IV method.

When we change the input and bias conditions in a certain period of time, which we can get a series of increasing conditions as input and bias conditions, by measuring the dynamic output parameters, the full range characteristic curve can be pointed out. This test method can be called Interval pulse IV test method.

With the requirement of full parameters test for power semiconductor devices, point test method cannot meet the demands. With the increasing power of semiconductor devices, continuous step IV method also cannot meet the demands.

Using the interval pulse IV test method, this can strongly make up the deficiency of the point test method, to test the semiconductor devices. Firstly, we can directly see the characteristic curves of the devices' parameters. Secondly we can also get every test data through all the test data of curve points, through these data all kinds of test useful graphs can be pointed out to different applications.

Interval pulse IV test method is widely used in equipments like power semiconductor curve tracers, power semiconductor IV characteristic analyzer and semiconductor devices test equipments, and so on.

Details needed to verify for Interval pulse IV test method

As we know, power semiconductor curve tracers are the main equipments that using Interval pulse IV test method. Its main design principle is similar to that of the traditional semiconductor curve tracers, and the main engine block diagram for typical model BJ4822 is shown in Figure 1.

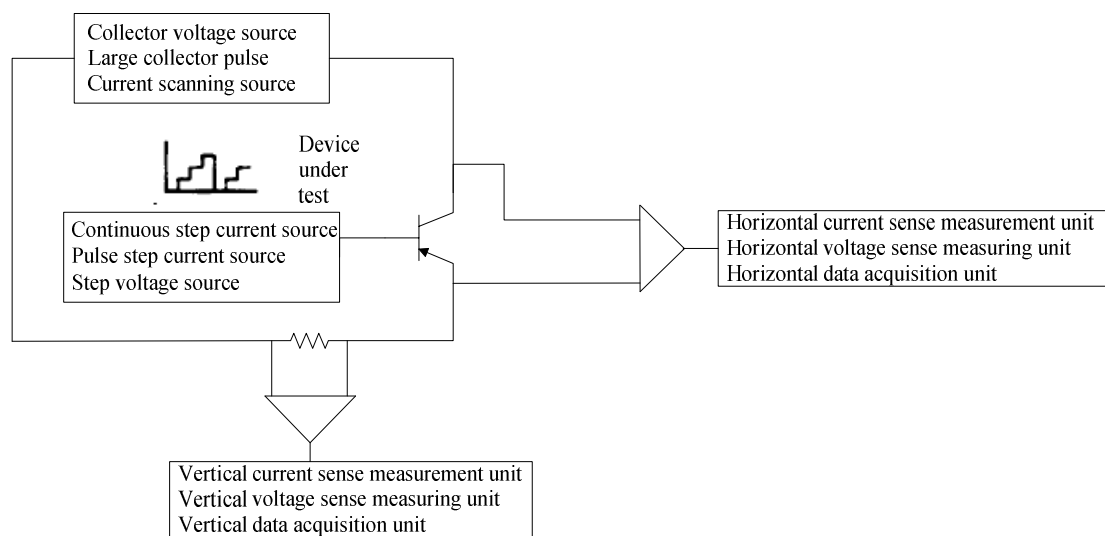


Figure 1 block diagram of the main engine for typical model BJ4822

From the above figure, we can see that the system is composed of Power supply, Continuous step current source, Pulse step current source, Step voltage source, Collector voltage source, Large collector pulse current scanning source, Vertical current sense measurement unit, Vertical voltage sense measuring unit, Vertical data acquisition unit, Horizontal current sense measurement unit, Horizontal voltage sense measuring unit, Horizontal data acquisition unit, sequence control unit, I/O bus interface unit, computer control system, and so on. The horizontal and the vertical collecting signals are converted into RAM through the AD chips. Computer transfers the signals to the computer via the control bus, and points them on the computer screen through the operation software.

There are two operation mode in power semiconductor curve tracers, high voltage mode and high current mode. Under high voltage mode, the peak amplitude of the voltage is up to 3kV. Under high current mode, the peak current pulse current amplitude of collector (or drain) is 400A, and the step generator can generate the current step wave. There are two types of current sources can generate the current step waves, continuous step current source, and the interval pulse IV step current source, as shown in Figure 2.

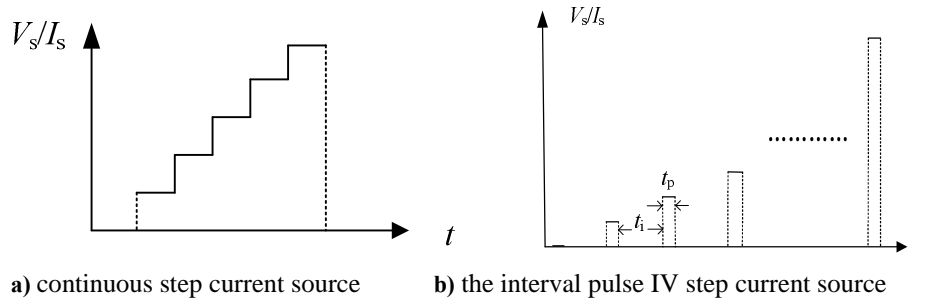


Figure 2 two types of current step sources

The interval pulse IV step current source is mainly applied in the area of pulse peak amplitude above 10A, and the pulse width of the pulse current is generally 300 micro seconds. In order to meet the requirements of the development of the semiconductor power devices, the advanced research about the relationship between pulse width and interval time of the step sources should be put on the agenda. In this paper, based on the existing research foundation, Verification system of the test method of interval pulse IV test method is developed out and setup. Based on a set of experiments, the relationship between the pulse width and the interval time of high power step current source is presented.

Development of Verification system of the interval pulse IV test method

Verification system of the test method of interval pulse IV test method is developed out based on the modular design. In our design, The system includes power modules, system motherboard, step voltage source, step current source, main pole current source, main pole voltage source, primary current source, Force Voltage Measure Current source, synchronization acquisition unit, matrix conversion array, test fixture, and so on. The power modules provided voltage or current sources for all the other modules. Based on these modules, Pulse IV test Verifying software has been developed in the enviroment of Visual C++ 6.0, the key technologies such as the electromagnetic interference rejection , the pulse step large current generation technology, circuit protection, and so on have been overcome. The verification system is composed of a block diagram shown in Figure 3.

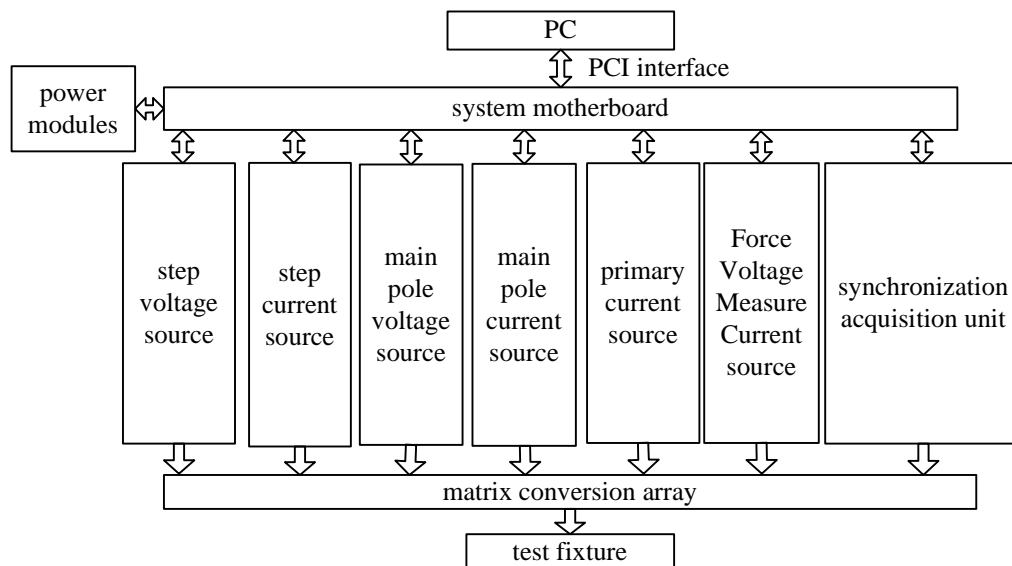


Figure 3 block diagram of the verification system

The verification device is shown in Figure 4.



Figure 4 block diagram of the verification system

Verification device and test graph

Three same bipolar transistor devices with the type MJ11028 are chosen to test the verification. The parameter h_{FE} is chosen do this experiment. Its test condition I_C is 25 amperes, and test condition V_{CE} is 5 volts, the qualified range of the parameter h_{FE} is from 1000 to 18000, typical test result as below Figure 5.

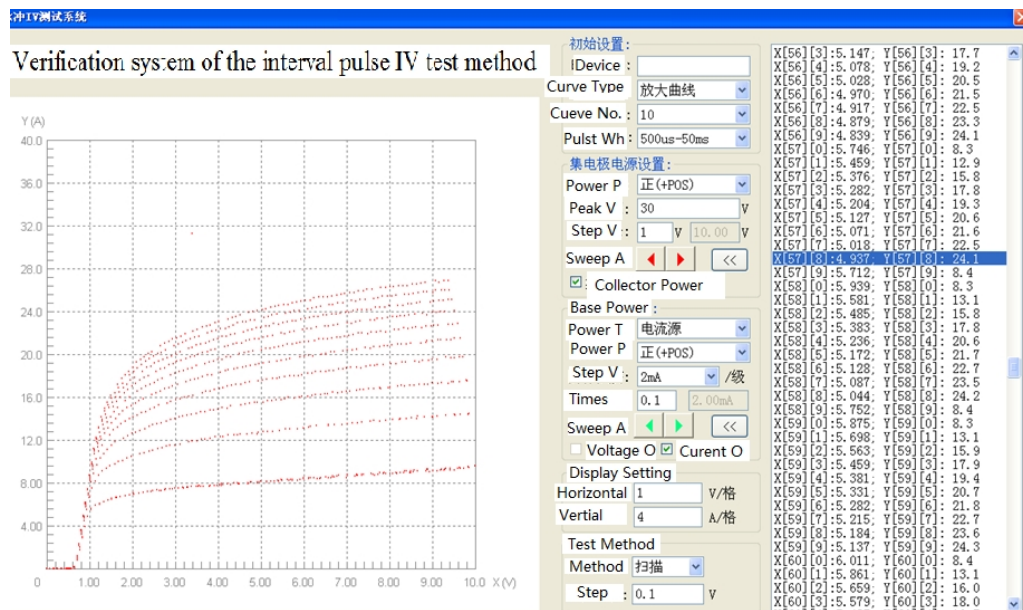


Figure 5 typical test result

Conclusions

Based on the verification result, step voltage signal or step current signal waveform is recommended as below Figure 5.

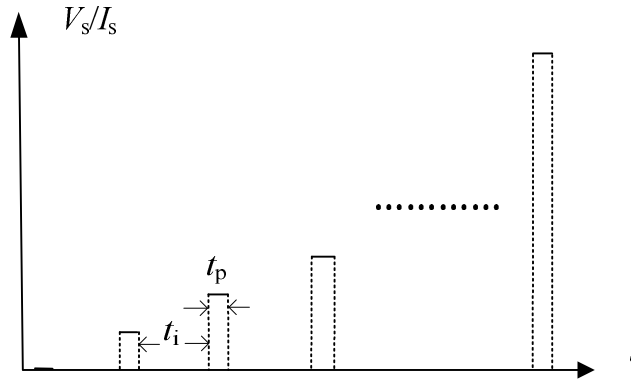


Figure 6 step voltage signal or step current signal waveform

Following are the graphic descriptions and technical requirements:

- 1) V_s is the applied voltage step signal that applied to test the parameters of the power field effect transistor.
- 2) I_s is the applied current step signal that applied to test the parameters of the power transistor.
The step pulse signal's steps (or DIVs) are recommended as ten, that is ten steps or ten DIVs, and the amplitude of the first step (or DIV) is recommended as zero.
- 3) The pulse width of a single step pulse expressed as t_p is recommended as the range from 100 micro seconds to 1 milli second, and the typical value is 300 micro seconds.
- 4) When the pulse width of a single step pulse expressed as t_p is designed to the typical value 300 micro seconds, the rise time and fall time of the single step pulse must less than 100 micro seconds, and the acquisition rate of the hardware must be designed to no less than 50kS/s.
- 5) When the pulse width of a single step pulse expressed as t_p is designed to more than 300 micro seconds, the rise time and fall time of the single step pulse must less than 1/3 of the pulse interval time, and the acquisition rate of the hardware must be designed to no less than 50kS/s.
- 6) When the pulse width of a single step pulse expressed as t_p is designed to the typical value 300 micro seconds, the pulse interval time expressed as t_i must be designed to 30 milli seconds.
- 7) In order to avoid the effect of the device heating to the pulse IV characteristics of the scanning waveform, the pulse interval time expressed as t_i is designed to 50 to 1000 times of the pulse width of a single step pulse expressed as t_p .

Summary

This paper developed the Verification system of the test method of interval pulse IV test, overcome a lot of technical difficulties, and proposed the test method of interval pulse IV test.

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