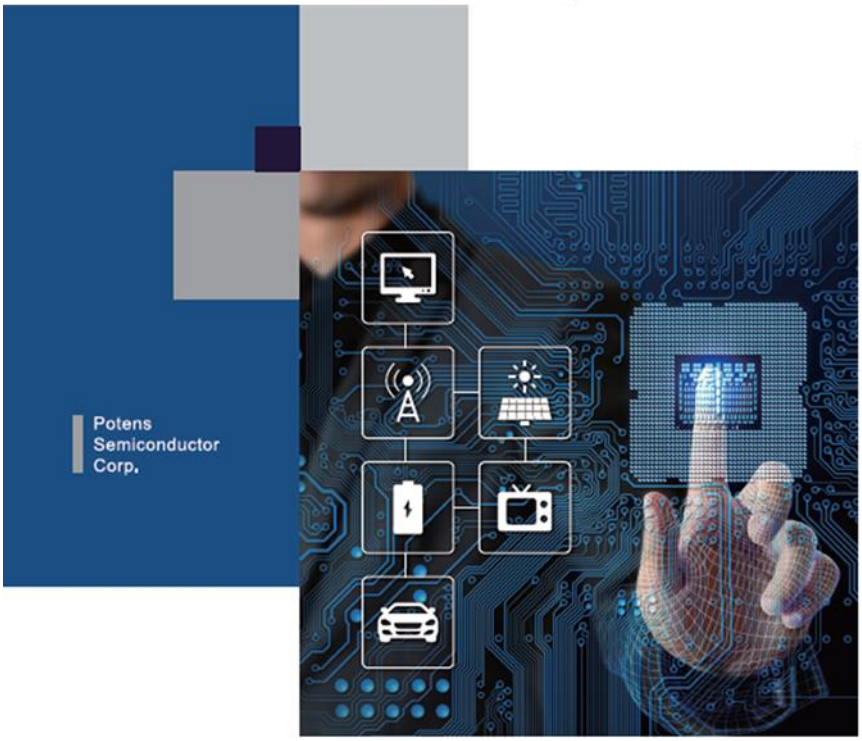
Application Information

SOA Test Fixture



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1. Introduction

This document provides the fundamentals, operations, circuit design, equipment setup procedures and test example of SOA test fixture to depict the SOA diagram of MOSFET mainly in linear mode region. This SOA test fixture can replace the traditional thermal transient tester and it also can show the secondary breakdown limitation of MOSFET in the Spirito effect region

1.1 Circuit Diagram and Function

Fig. 1 shows the circuit diagram of SOA test fixture. It is also called constant current circuit which controlled by an operational amplifier (OPA). The main circuit is including input capacitor (C_2), OPA (U_1), current sense shunt (R_{shunt}), and device under test (MOSFET, Q_1). For this test fixture, the input DC voltage (V_{DC}) is the setting value of drain-source voltage, the input pulse is for the setting values of drain current and its time duration, the output current (I_D) is drain current of MOSFET, and the OPA is used in the circuit for keeping a constant current flow through current sense shunt. The drain current is controlled by changing the V_{GS} (Gate-Source voltage) of the MOSFET. The power supply for this circuit is taken from the power supply under test. In other words, the current flowing from the power supply makes the MOSFET to act as variable resistor in the linear mode region. Therefore, we can draw points with different voltage, current and period onto the SOA diagram

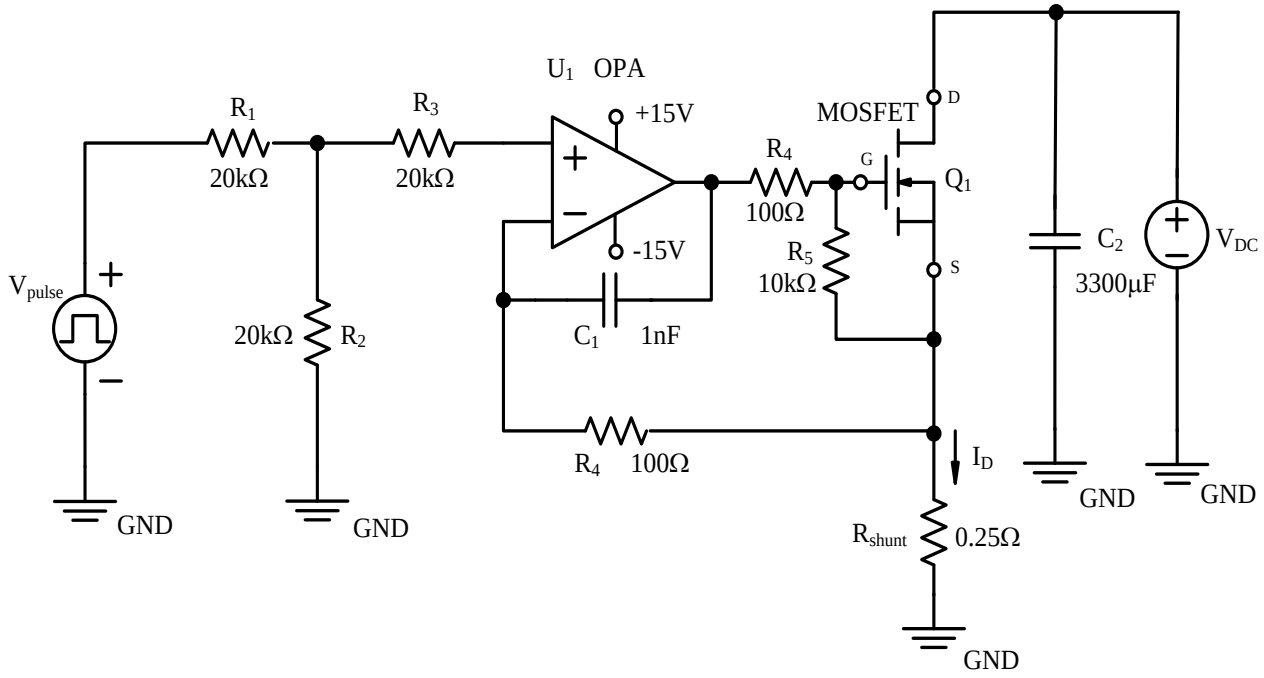

Fig. 1 The circuit diagram of SOA test fixture

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1.2 Design and Application Concept

Fig. 1 shows the basic diagram of the constant current circuit using an OPA. The drain current can flow when a positive gate-source voltage is applied to the MOSFET. The voltage of the shunt resistor (R_{shunt}) while the drain current flows through is shown as:

$$V_{shunt} = I_D \times R_{shunt} \tag{1}$$

where I_D is drain current and R_{shunt} is shunt resistor. The voltage of the non-inverting input terminal (+) is derived as:

$$V_+ = V_{pulse} \times \frac{R_2}{R_1+R_2} \tag{2}$$

where V_{pulse} is the voltage of the pulse waveform, R_1. and R_2 are resistors for voltage divider. From ideal OPA circuit theory, the OPA amplifier has an imaginary short circuit operation. Therefore, the voltage of inverting input terminal (-) is the same as the voltage of the non-inverting input terminal (+). So, the following equation can be derived:

$$V_{shunt} = V_+ \tag{3}$$

From above equation, the setting value of I_D drain current can be easily obtained:

$$I_D = \frac{V_{pulse} \times \frac{R_2}{R_1+R_2}}{R_{shunt}} \tag{4}$$

1.3 Schematics

Fig. 2 is the schematics of SOA test fixture. It is considering the three input capacitors for current supply capability, the four shunt resistors for power rating and current setting, the two OPA for voltage rating and different type of package, and the MOSFET socket for the test fixture PCB of different package MOSFET.

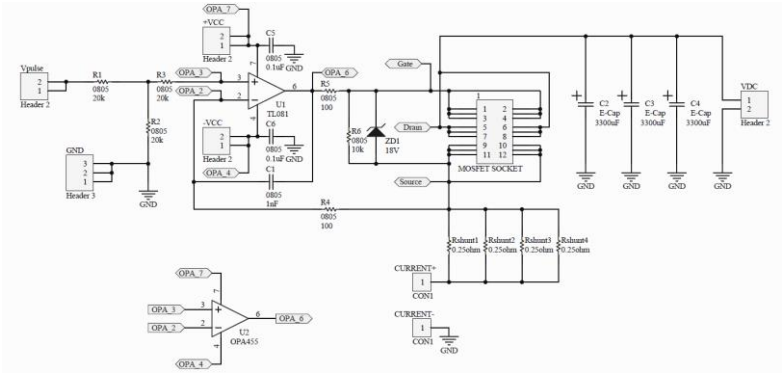

Fig. 2 The schematic of SOA test fixture

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1.4 Printed Circuit Board

Figure 3 shows the top view of the SOA test fixture. It includes the input DC voltage, input capacitors, MOSFET/socket, current sense shunts, OPA, OPA power supply pins, input pulse pins and GND pins.

2. Evaluation Results

The test setup, the test equipment and evaluation results of the SOA test fixture are shown as following subsection.

2.1 Test setup

Figure 4 shows the test setup of the SOA test fixture. (a) Function generator, Auxiliary DC power supply and DC power supply. (b) Oscilloscope, current probe and SOA test fixture.

2.2 Test Equipment

The table 1 shows the test equipment of the SOA test fixture.

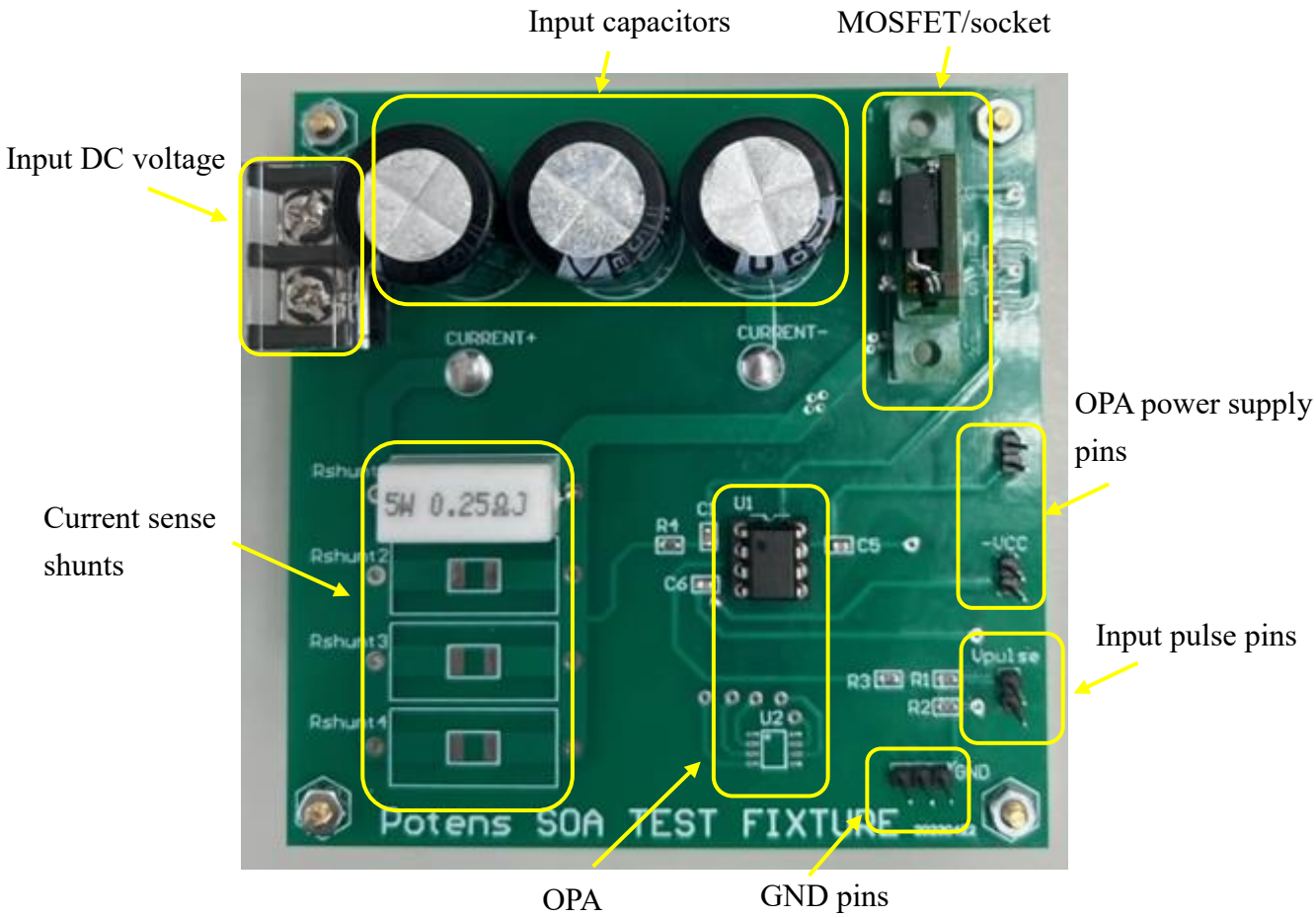

Figure 3 shows the top view of the SOA test fixture.

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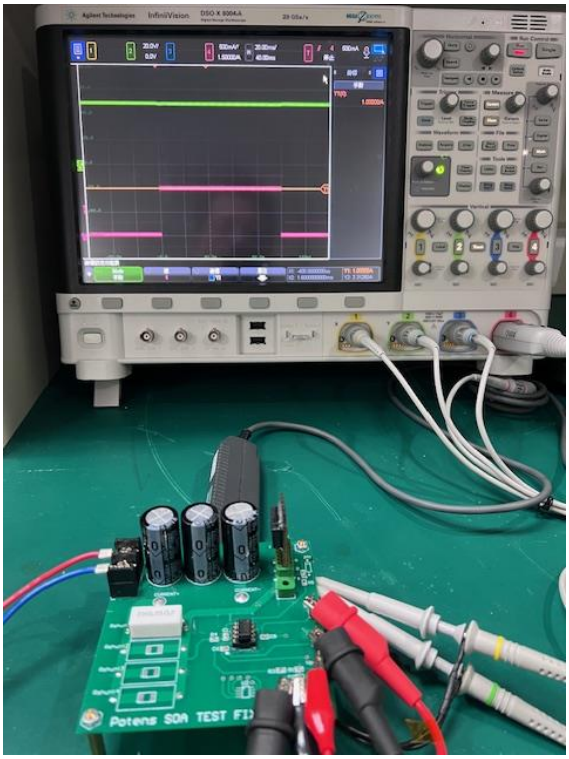
(a)



(b)

Figure 4 shows the test setup of the SOA test fixture. (a) Function generator, Auxiliary DC power supply and DC power supply. (b) Oscilloscope, current probe and SOA test fixture.

Table 1. List of the test equipment

Test equipment	Model
Function generator	KEYSIGHT 33500B
Auxiliary DC Power supply	GWINSTEK GPD-3303D
DC Power supply	AMP SP600VDC2000W
Oscilloscope	Angilent DSO-X 6004A
Current probe	CYBERTEK CP8150A

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2.3 Test Procedure

The test procedure of SOA test fixture is as follows:

Step 1. Input DC voltage connector connects to DC power supply (for example: voltage setting is 50Vdc).

Step 2. Input pulse connector connects to function generator (for example: the pulse width setting is 10ms and the pulse high level is 500mV).

Step 3. OPA power supply connector connects to auxiliary DC power supply (for example: supply voltage is ±15V).

Step 4. Power on DC source and auxiliary DC source. Then trigger the function generator.

Step 5. Measure and check V_{DS} and I_D waveforms to confirm whether MOSFET is broken or not. Increase the drain current setting and test if MOSFET is not broken and repeat step 1 to step 5. Change the DC voltage and pulse width for next voltage condition.

2.4 Simulation

Fig. 5 is the simulation model of the SOA test fixture and Fig. 6 is the simulation result. The result of V_{DS}, I_D and time duration are 50V, 1A and 100ms.

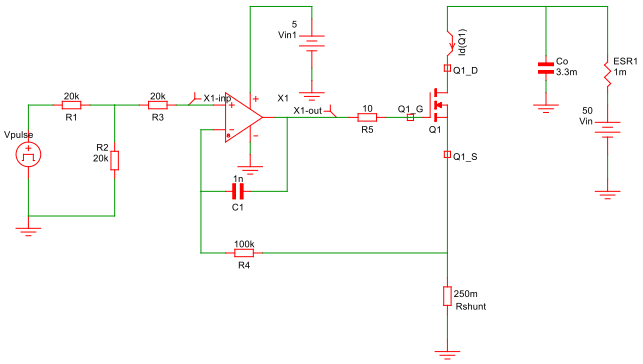

Fig. 5 The simulation model of the SOA test fixture.

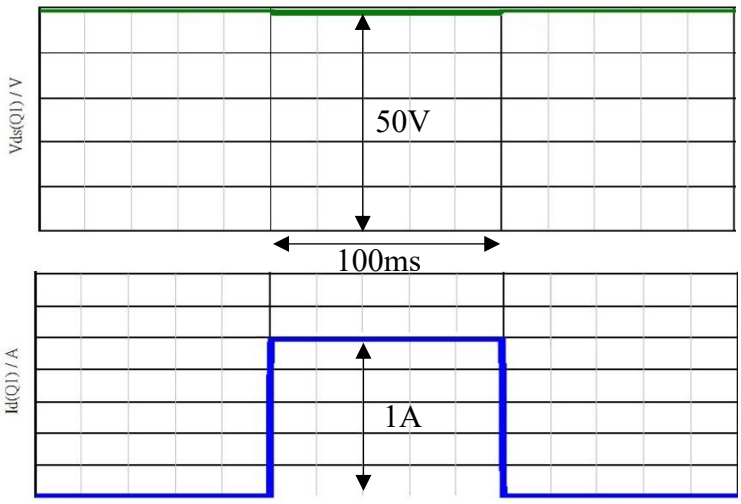

Fig. 6 The simulation result of the SOA test fixture.

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2.5 Example

Fig. 6 shows the test waveforms by SOA test fixture. The setting values and results of V_{DS}, I_D and time duration are 50V, 1A and 100ms. Channel 2 is Vds of MOSFET and Channel 4 is I_D drain current.

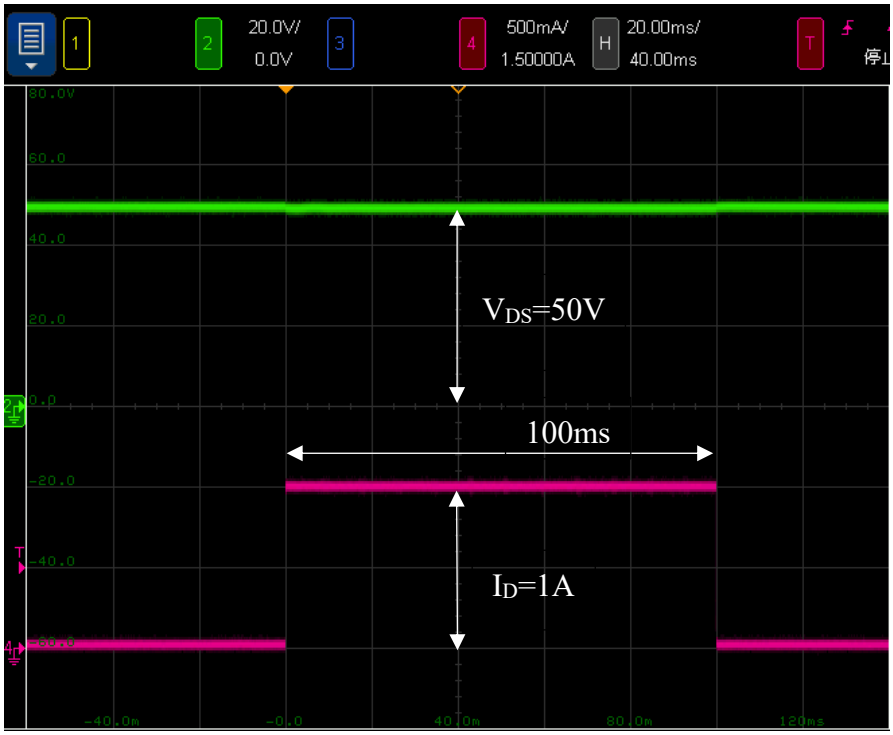

Fig. 6 The test waveforms by SOA test fixture.

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