JEDEC STANDARD

Test Method for Measurement of Reverse Recovery Time trr for Power MOSFET Drain-Source Diodes

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JEDEC SOLID STATE TECHNOLOGY ASSOCIATION

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TEST METHOD FOR MEASUREMENT OF REVERSE RECOVERY TIME t_{rr} FOR POWER MOSFET DRAIN-SOURCE DIODES

(From JEDEC Council ballot JCB-94-02, formulated under the cognizance of JC-25 Committee on Transistors)

1. Purpose

The purpose of this test is to determine the time required for the device under test (DUT) to switch off when a reverse bias is applied after the DUT has been forward biased and to determine the charge recovered under the same conditions.

2. Test conditions

2.1 Condition A, reverse recovered time (t_{rr})

Monitor diode current versus time. The gate lead must be shorted to the source lead. Use the following notes and precautions as a guide. Refer to figures 1 and 2 for clarification.

Figure 1 — t_{rr} test circuit

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Figure 2 — Generalized reverse recovery waveforms

2.1.1 Notes and precautions

— This method presumes that good engineering practice will be employed in the construction of the test circuit, e.g., short leads, good ground plane, minimum inductance of the measuring loop and minimum self-inductance (L1) of the current sampling resistor (R4). See figure 3 for suggested board layout.

— The measuring loop inductance (L_{loop}) represents the net effect of all inductive elements, whether lumped or distributed, e.g., bonding wires, test fixture, circuit board foil, inductance of energy storage capacitors, etc. The value of L_{loop} should be 100 nanohenries or less. The reason for controlling this circuit parameter is that it, combined with diode characteristics including capacitance, determines the value of t_b.

— The turn-off reverse-voltage overshoot shall not be allowed to exceed the device rated breakdown voltage. Ringing and overshoot may become a problem when $R_{loop}<2(L/C)^{1/2}$, where $L = L_{loop}$. That is another reason for minimizing L_{loop}.

— The reverse power supply voltage (V4) shall be specified.

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— The self-inductance of the current-sampling resistor R4 (see figure 1) must be kept low relative to the L1/R4 ratio because the observed values of t_a and I_{RM} increase with increasing self-inductance. Since the value of R4 is not specified, the recommended maximum inductance is expressed as a time constant (L1/R4) with a maximum value of t_a (min)/10, where t_a (min) is the lowest t_a value to be measured. This ratio is a practical compromise and would yield an observed t_a which is 10% high; (Δt_a=L1/R4). The I_{RM} error is a function of the L1/R4 time constant and di/dt. For a di/dt of 100A/μs the observed error would also be 10% high; ΔI_{RM}=(L1/R4)(di/dt).

— The di/dt of 100A/μs shall be measured from 0.5 of I_{FM} to 0.75 of I_{RM}. The di/dt of 100A/μs was chosen to avoid the larger I_{RM} errors caused by higher di/dt.

Bottom resistor current flow is in opposite direction of top resistor current flow, providing magnetic field cancellation. Sense lead to center conductor of probe jack exits at right angle to resistor axes and is located between the resistor layers; (5) on top layer and (5) on bottom layer.

Figure 3 — Suggested board layout for low L1/R4

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— The forward current value must be specified, otherwise the t_a and I_{RM} values have little useful meaning. The forward current generator consisting of Q1, Q2, R1, and R2 may be replaced with any functionally equivalent circuit. Likewise the current-ramp generator consisting of Q3, Q4, R3, and C1.

— The values of t_a and t_b are to be measured and recorded separately $t_{rr} = t_a + t_b$.

2.2 Condition B, reverse recovered charge (Q_{rr})

This method is direct reading and therefore does not require an oscilloscope. Use the following notes and precautions as a guide. Refer to figures 4 and 5 for clarification.

D1 provides forward current path to ground
D2 steers reverse signal current into integrating capacitor C2
V1 amplitude controls forward current (I_F)
V2 amplitude controls di/dt
$t_1 \geq 5\ t_a$ (max); t_a (max) is the highest t_a to be measured
$t_2 > t_{rr}$
$t_3 > 0$
D1 is a low-voltage Schottky rectifier
D2 must have a much lower recovered charge than the value being measured

$Q_{rr} = \frac{I_s}{PRR}$; where PRR is pulse repetition rate

di/dt = 100A/μs

Figure 4 — Q_{rr} test circuit

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Figure 5 — Typical t_{rr} waveform (for mnemonic reference only)

2.2.1 Notes and precautions

— This method presumes that good engineering practice will be employed in the construction of the test circuit, e.g., good ground plane, minimum inductance of the measuring loop and appropriate high speed generators and instruments.

— The measuring loop inductance (L_{loop}) represents the net DUT effect of all inductive elements in the loop, whether lumped or distributed, e.g., bonding wires, test fixture, circuit board foil, inductive component of energy storage capacitors, etc. The value of L_{loop} should be 100 nanohenries or less. See figure 4.

— The turn-off reverse-voltage overshoot shall not be allowed to exceed the device rated breakdown voltage. Ringing and overshoot may become a problem when $R_{loop}<2(L/C)^{1/2}$, where $L = L_{loop}$.

— -V4 shall be specified as a percentage of the rated breakdown voltage.

— The di/dt of 100A/μs was chosen as a compromise between having reasonably high signal levels for the faster devices and the need to keep the reverse voltage as low as possible. Higher di/dt requires a higher reverse voltage to overcome the drop across L_{loop}.

— The forward current used for this test must be specified.

— The capacitor C2 shall be large enough so that there is no appreciable voltage drop across it. Reducing its value by 50% shall not change than the reading by more than the required measurement accuracy. See figure 4.

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— The current meter across C2 should have as low a resistance as possible. Doubling the resistance shall not change the reading by more than the required measurement accuracy. A good compromise would be a digital ammeter with a full-scale drop of 0.2 volt. If the reverse bias supply is 30 volts, the maximum meter potential difference is then less than 1% of supply voltage.

— The recommended pulse repetition rate is 1 kilohertz.

— The forward-current-generator consisting of Q1, Q2, R1, and R2 may be replaced by any functionally equivalent circuit as may the reverse-current-ramp generator consisting of Q3, Q4, R3, and C1.

3. Summary

The following conditions shall be specified in the detail specification:

— Tc: case temperature if other than 25^{oC}

— Forward current = one half continuous rated circuit unless otherwise specified.

— di/dt: 100A/μs

— V4: Reverse-ramp power supply voltage

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