

$V_{DSS}$	600V
$R_{DS(on)}(Max.)$	0.98 $\Omega$
$I_D$	$\pm 4.0A$
$P_D$	59W

### ●Features

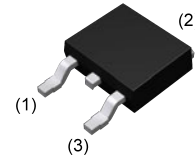
- 1) Low on-resistance
- 2) Low radiation noise
- 3) Fast switching
- 4) Parallel use is easy
- 5) Pb-free plating ; RoHS compliant

### ●Application

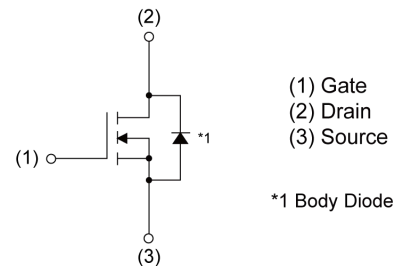
Switching applications

### ●Outline

TO-252



### ●Inner circuit



### ●Packaging specifications

Packing	Embossed Tape
Packing code	TL1
Marking	R6004E
Basic ordering unit (pcs)	2500

### ●Absolute maximum ratings ( $T_a = 25^\circ C$ , unless otherwise specified)

Parameter	Symbol	Value	Unit
Drain - Source voltage	$V_{DSS}$	600	V
Continuous drain current ( $T_c = 25^\circ C$ )	$I_D^{*1}$	$\pm 4.0$	A
Pulsed drain current	$I_{DP}^{*2}$	$\pm 8.0$	A
Gate - Source voltage	$V_{GSS}$	Static	$\pm 20$
		AC( $f > 1Hz$ )	$\pm 30$
Avalanche current, single pulse	$I_{AS}^{*3}$	0.8	A
Avalanche energy, single pulse	$E_{AS}^{*3}$	46	mJ
Power dissipation ( $T_c = 25^\circ C$ )	$P_D$	59	W
Junction temperature	$T_j$	150	$^\circ C$
Operating junction and storage temperature range	$T_{stg}$	-55 to +150	$^\circ C$

### ● Thermal resistance

Parameter	Symbol	Values			Unit
		Min.	Typ.	Max.	
Thermal resistance, junction - case	$R_{thJC}^{*4}$	-	-	2.1	°C/W
Thermal resistance, junction - ambient	$R_{thJA}^{*5}$	-	-	147	°C/W
Soldering temperature, wavesoldering for 10s	$T_{sold}$	-	-	265	°C

### ● Electrical characteristics ( $T_a = 25^\circ\text{C}$ )

Parameter	Symbol	Conditions	Values			Unit
			Min.	Typ.	Max.	
Drain - Source breakdown voltage	$V_{(BR)DSS}$	$V_{GS} = 0V, I_D = 1mA$	600	-	-	V
Zero gate voltage drain current	$I_{DSS}$	$V_{DS} = 600V, V_{GS} = 0V$ $T_j = 25^\circ\text{C}$	-	-	100	$\mu\text{A}$
		$T_j = 125^\circ\text{C}$	-	-	1000	
Gate - Source leakage current	$I_{GSS}$	$V_{GS} = \pm 20V, V_{DS} = 0V$	-	-	$\pm 100$	nA
Gate threshold voltage	$V_{GS(th)}$	$V_{DS} = 10V, I_D = 1mA$	2	-	4	V
Static drain - source on - state resistance	$R_{DS(on)}^{*6}$	$V_{GS} = 10V, I_D = 1.5A$ $T_j = 25^\circ\text{C}$	-	0.9	0.98	$\Omega$
		$T_j = 125^\circ\text{C}$	-	1.36	-	
Gate resistance	$R_G$	$f = 1MHz, \text{open drain}$	-	16.7	-	$\Omega$

**●Electrical characteristics (T<sub>a</sub> = 25°C)**

Parameter	Symbol	Conditions	Values			Unit
			Min.	Typ.	Max.	
Forward Transfer Admittance	$ Y_{fs} ^{*6}$	V <sub>DS</sub> = 10V, I <sub>D</sub> = 2A	1.5	3.0	-	S
Input capacitance	C <sub>iss</sub>	V <sub>GS</sub> = 0V	-	250	-	pF
Output capacitance	C <sub>oss</sub>	V <sub>DS</sub> = 25V	-	250	-	
Reverse transfer capacitance	C <sub>rss</sub>	f = 1MHz	-	30	-	
Turn - on delay time	t <sub>d(on)</sub> <sup>*6</sup>	V <sub>DD</sub> ≈ 300V, V <sub>GS</sub> = 10V	-	22	-	ns
Rise time	t <sub>r</sub> <sup>*6</sup>	I <sub>D</sub> = 2A	-	22	-	
Turn - off delay time	t <sub>d(off)</sub> <sup>*6</sup>	R <sub>L</sub> ≈ 150Ω	-	55	-	
Fall time	t <sub>f</sub> <sup>*6</sup>	R <sub>G</sub> = 10Ω	-	40	-	

**●Gate charge characteristics (T<sub>a</sub> = 25°C)**

Parameter	Symbol	Conditions	Values			Unit
			Min.	Typ.	Max.	
Total gate charge	Q <sub>g</sub> <sup>*6</sup>	V <sub>DD</sub> ≈ 300V	-	15	-	nC
Gate - Source charge	Q <sub>gs</sub> <sup>*6</sup>	I <sub>D</sub> = 4A	-	2.5	-	
Gate - Drain charge	Q <sub>gd</sub> <sup>*6</sup>	V <sub>GS</sub> = 10V	-	10	-	
Gate plateau voltage	V <sub>(plateau)</sub>	V <sub>DD</sub> ≈ 300V, I <sub>D</sub> = 4A	-	6.5	-	V

\*1 Limited only by maximum channel temperature allowed.

\*2 Pw ≤ 10μs, Duty cycle ≤ 1%

\*3 L ≐ 100mH, V<sub>DD</sub>=50V, R<sub>G</sub>=25Ω, STARTING T<sub>j</sub>=25°C

\*4 T<sub>C</sub>=25°C

\*5 Mounted on an epoxy PCB FR4 (20mm x 20mm x 0.8mm)

\*6 Pulsed

**●Body diode electrical characteristics (Source-Drain) ( $T_a = 25^\circ\text{C}$ )**

Parameter	Symbol	Conditions	Values			Unit
			Min.	Typ.	Max.	
Source current	$I_S^{*1}$	$T_C = 25^\circ\text{C}$	-	-	4.0	A
Pulsed source current	$I_{SP}^{*2}$		-	-	8.0	A
Source-Drain voltage	$V_{SD}^{*6}$	$V_{GS} = 0\text{V}, I_S = 4\text{A}$	-	-	1.5	V
Reverse recovery time	$t_{rr}^{*6}$	$I_S = 4\text{A}$ $di/dt = 100\text{A}/\mu\text{s}$	-	320	-	ns
Reverse recovery charge	$Q_{rr}^{*6}$		-	2.4	-	$\mu\text{C}$
Peak reverse recovery current	$I_{rr}^{*6}$		-	15	-	A

● Electrical characteristic curves

Fig.1 Power Dissipation Derating Curve

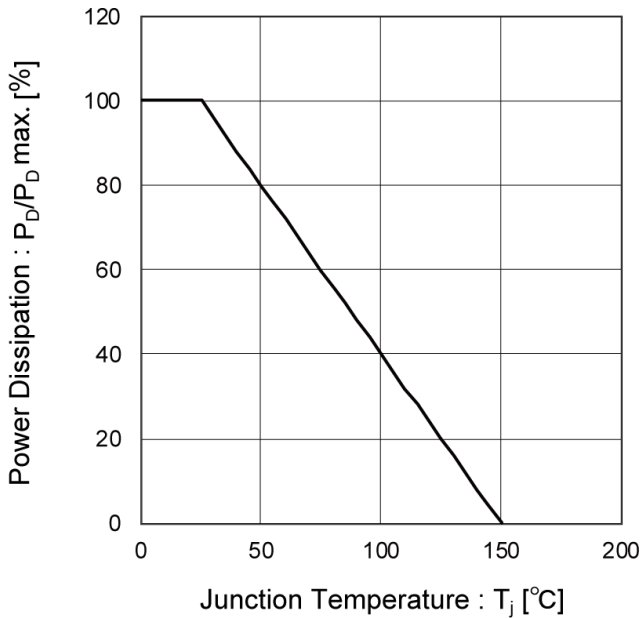


Fig.2 Drain Current Derating Curve

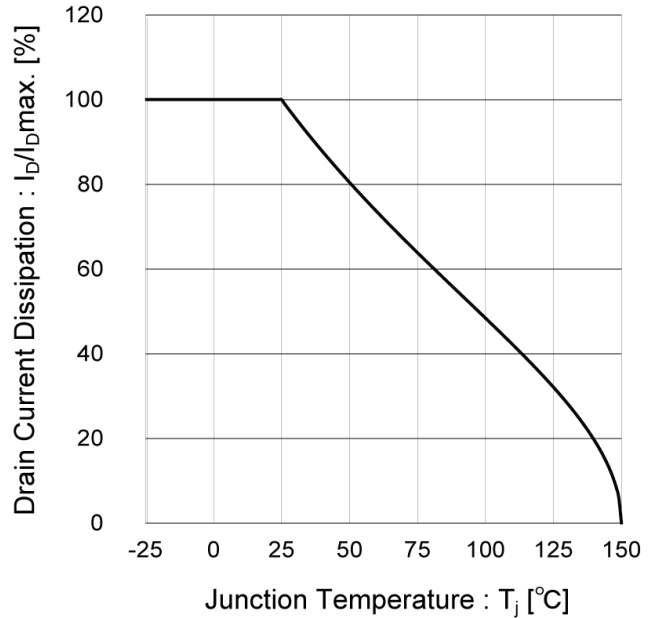


Fig.3 Transient Thermal Resistance vs. Pulse Width

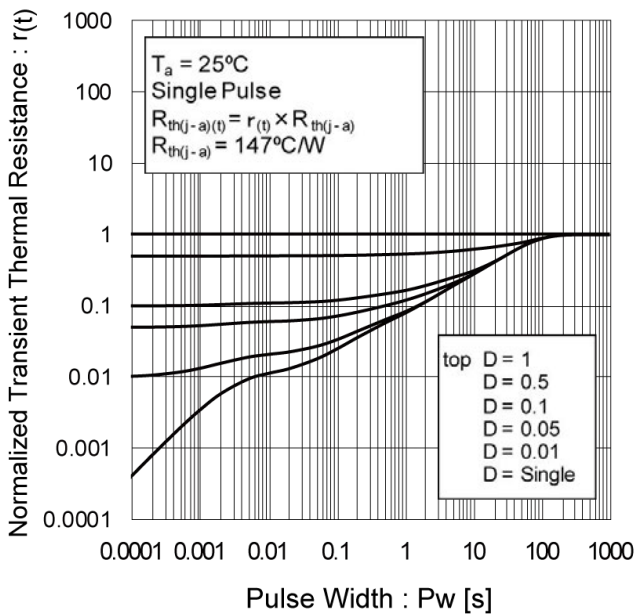
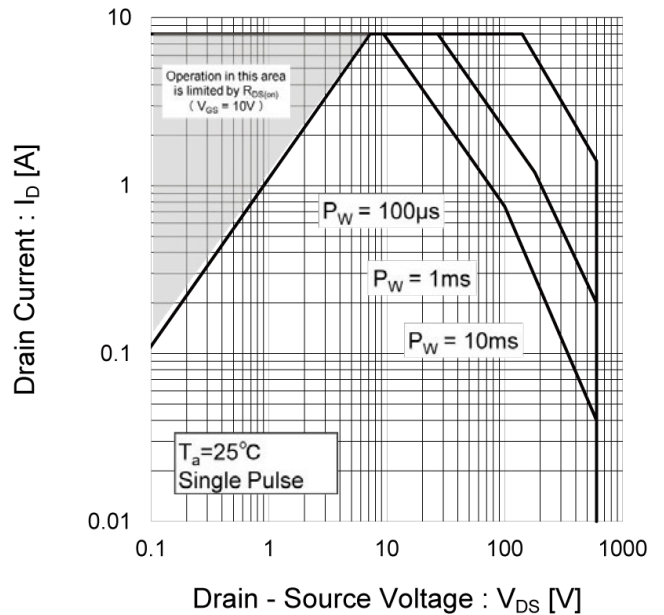


Fig.4 Maximum Safe Operating Area



● Electrical characteristic curves

Fig.5 Avalanche Energy Derating Curve

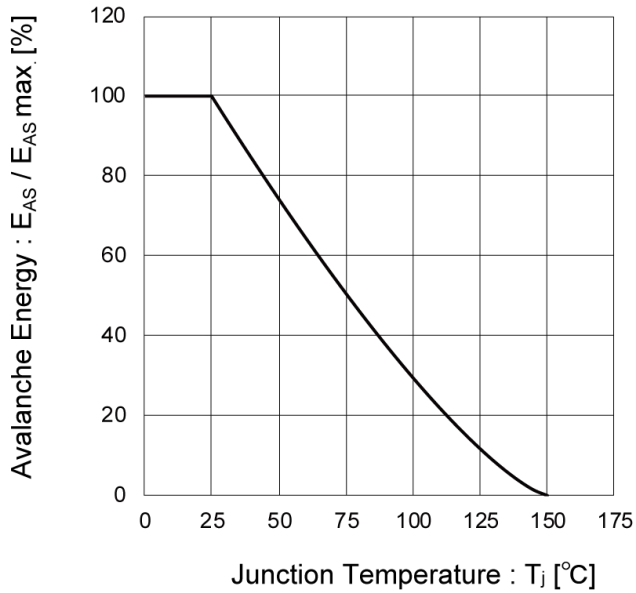


Fig.6 Breakdown Voltage vs. Junction Temperature

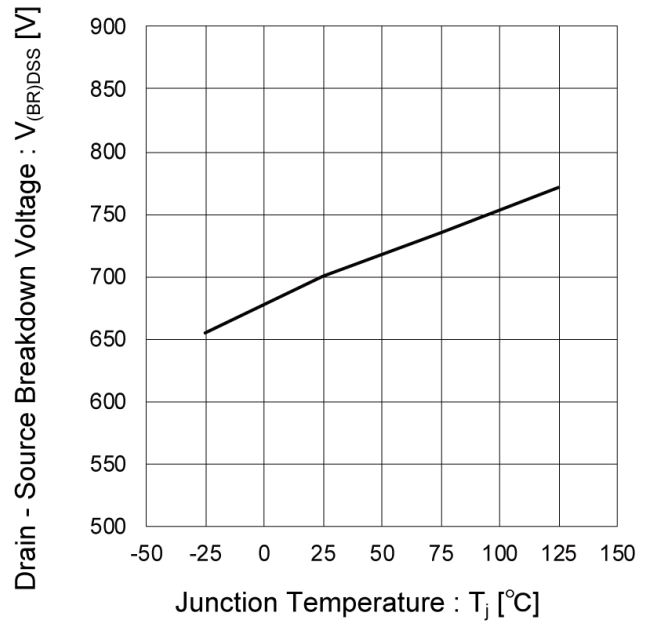


Fig.7 Typical Output Characteristics(I)

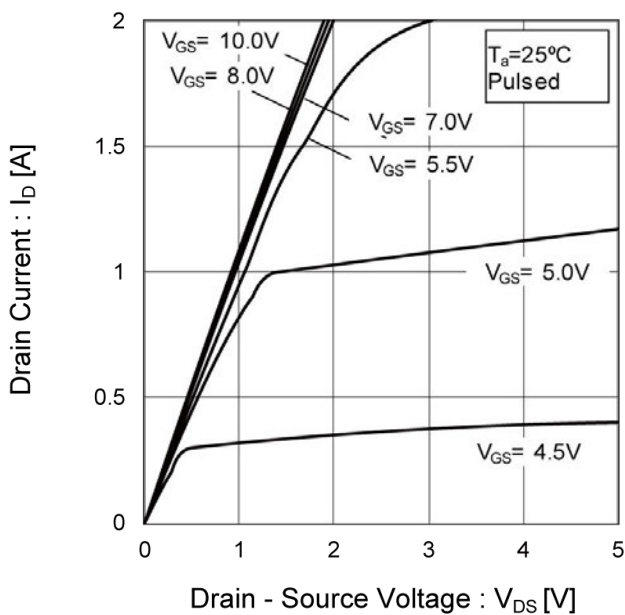
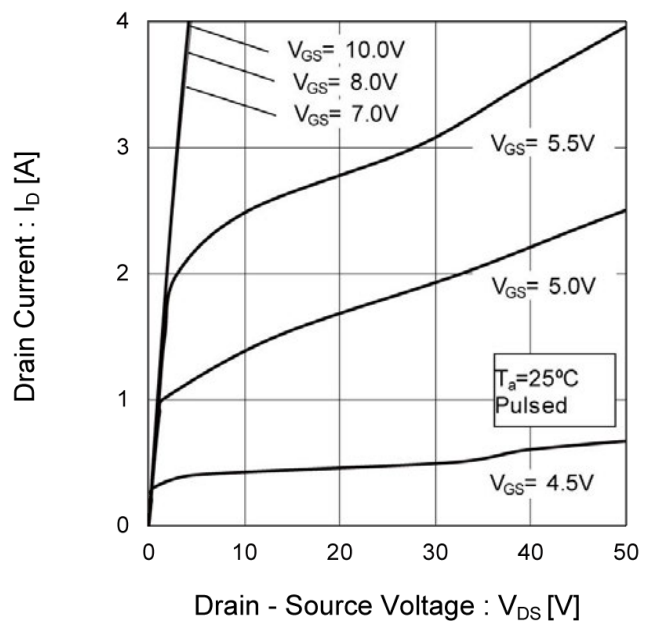


Fig.8 Typical Output Characteristics(II)



● Electrical characteristic curves

Fig.9 Gate Threshold Voltage vs. Drain Current

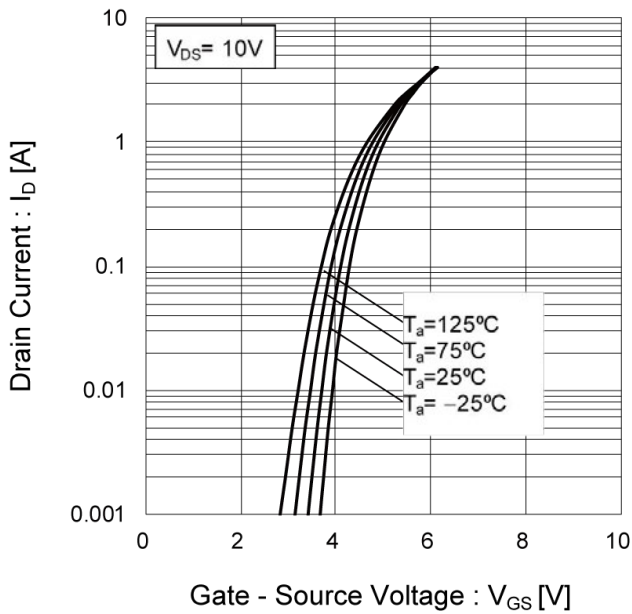


Fig.10 Gate Threshold Voltage vs. Junction Temperature

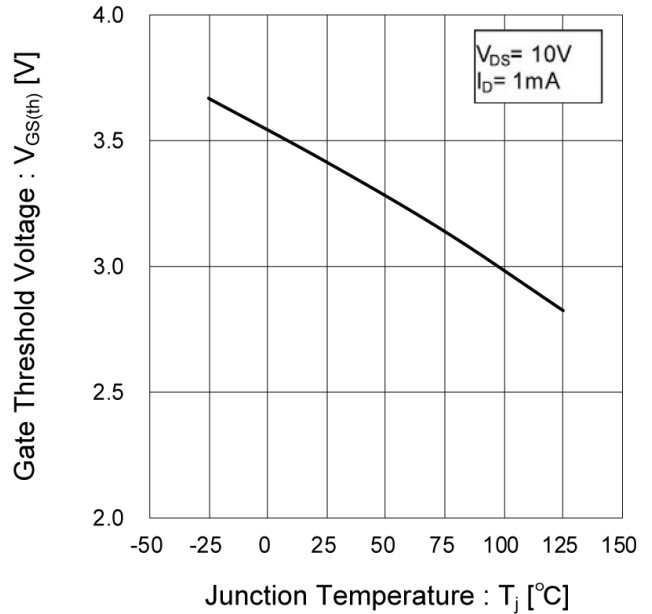
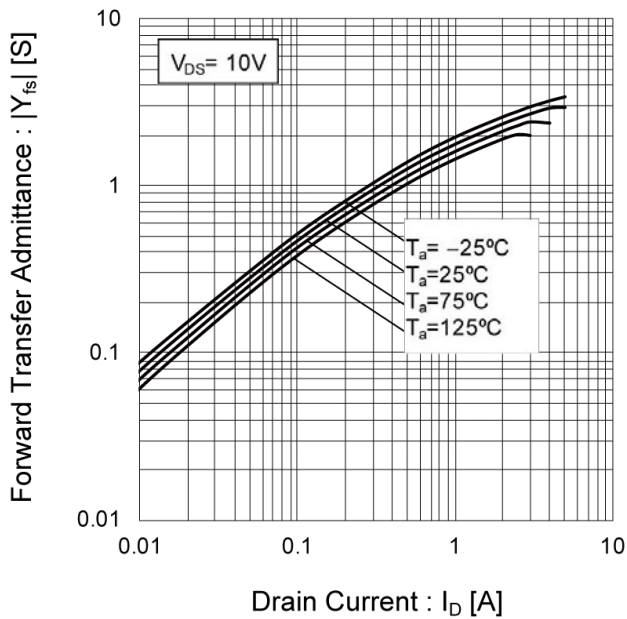


Fig.11 Forward Transfer Admittance vs. Drain Current



● Electrical characteristic curves

Fig.12 Static Drain - Source On - State Resistance vs. Drain Current

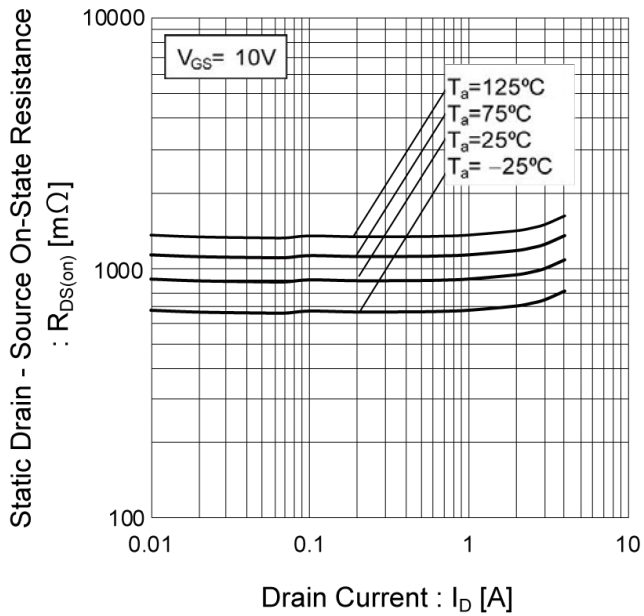


Fig.13 Static Drain - Source On - State Resistance vs. Gate Source Voltage

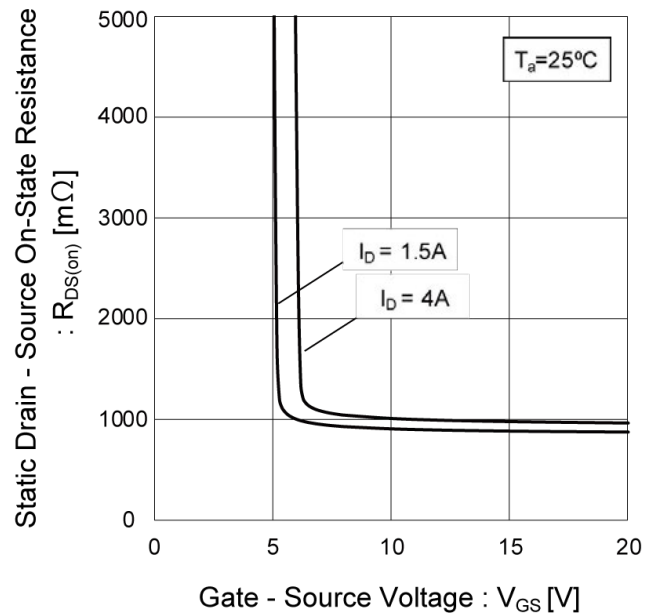
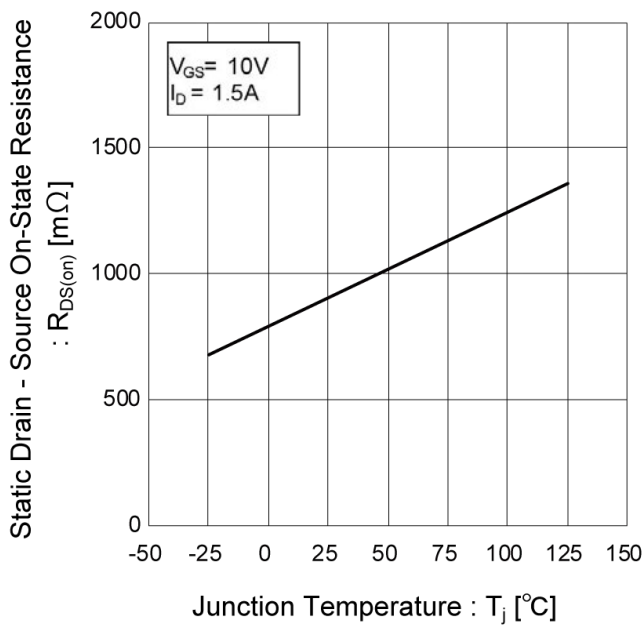


Fig.14 Static Drain - Source On - State Resistance vs. Junction Temperature





● Electrical characteristic curves

Fig.15 Typical Capacitance vs. Drain - Source Voltage

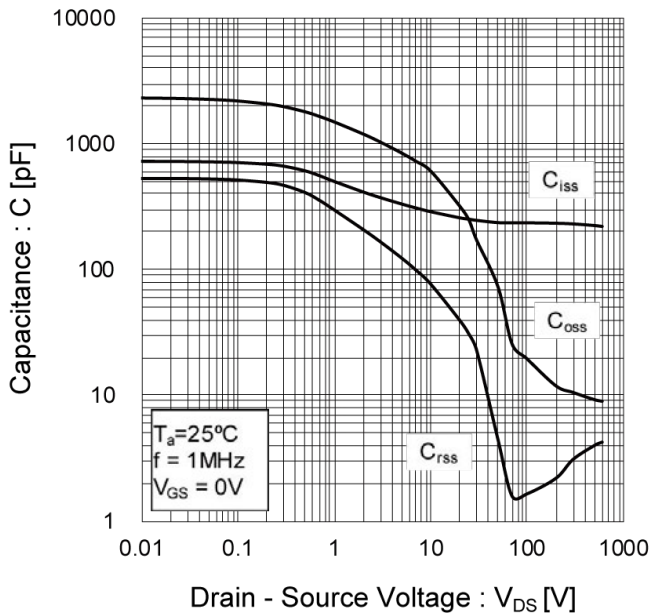


Fig.16 Switching Characteristics

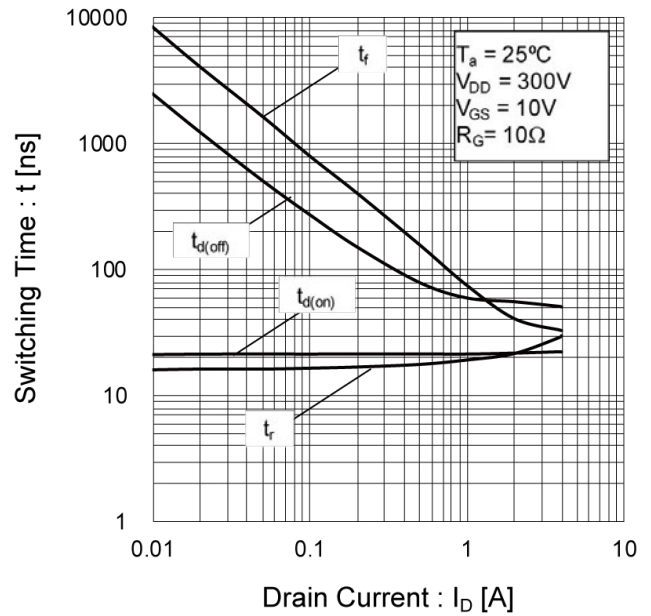
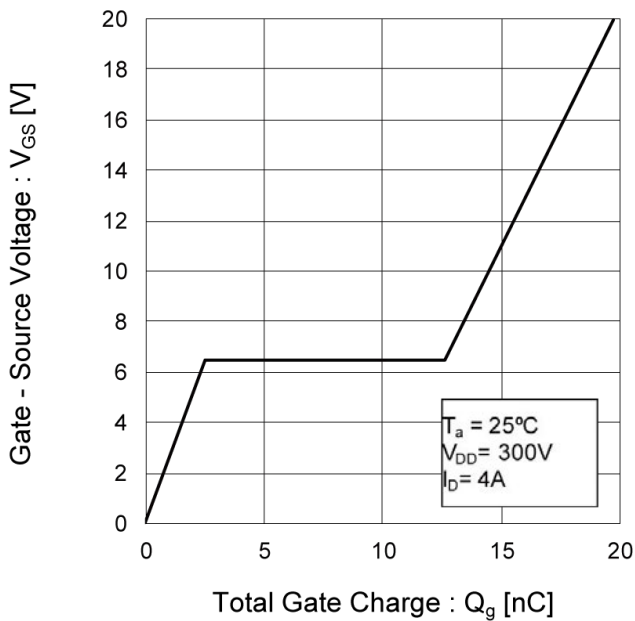


Fig.17 Typical Gate Charge



●Electrical characteristic curves

Fig.18 Source Current vs. Source - Drain Voltage

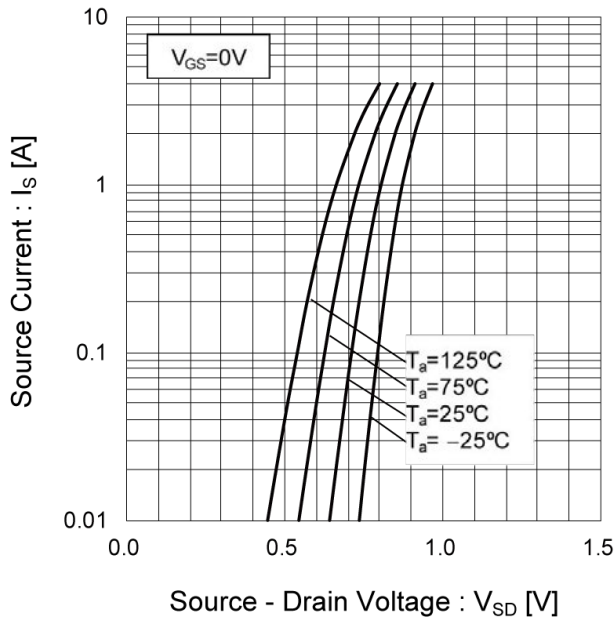
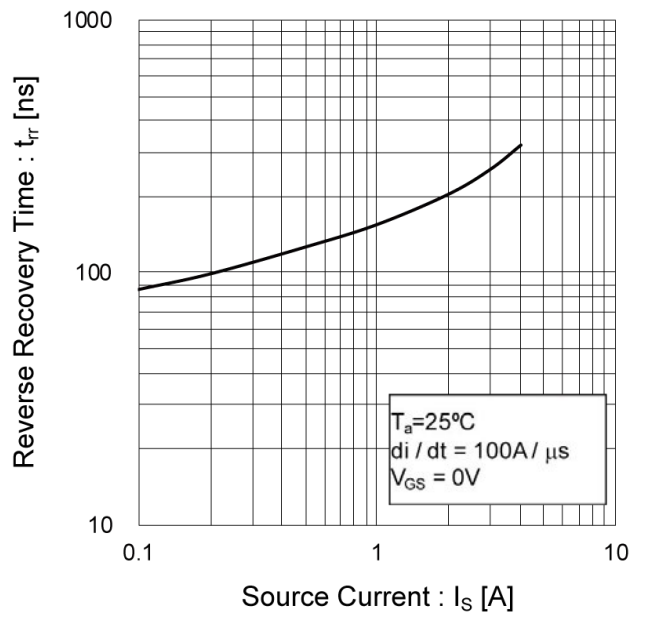


Fig.19 Reverse Recovery Time vs. Source Current



● Measurement circuits

Fig.1-1 Switching Time Measurement Circuit

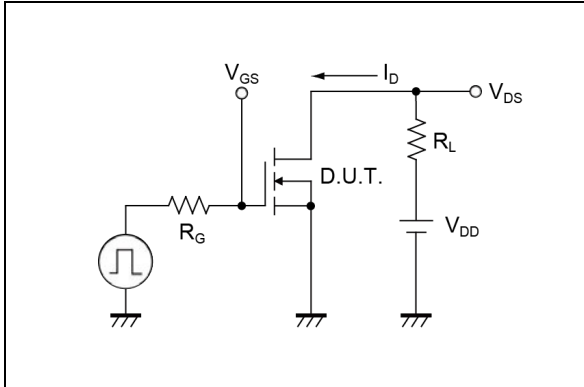


Fig.1-2 Switching Waveforms

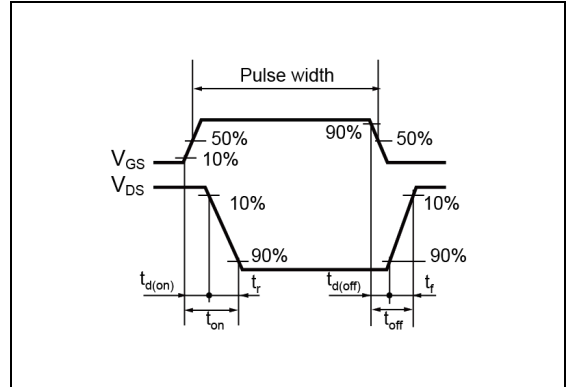


Fig.2-1 Gate Charge Measurement Circuit

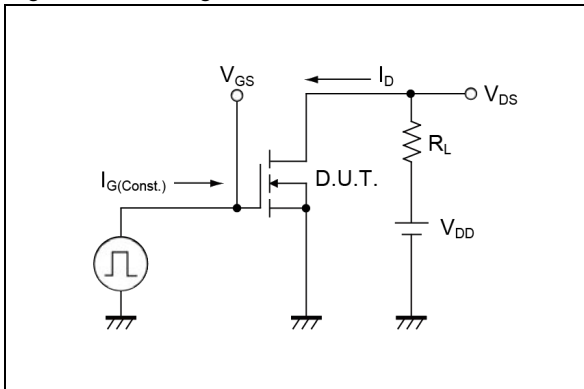


Fig.2-2 Gate Charge Waveform

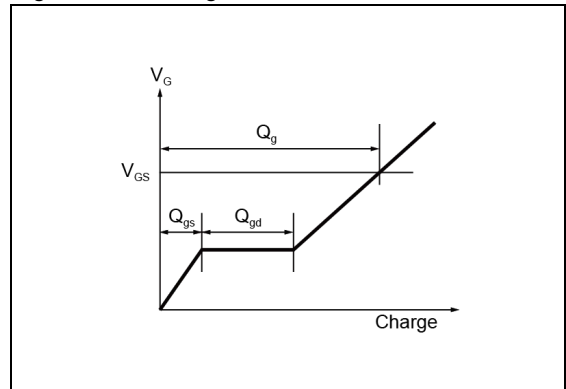


Fig.3-1 Avalanche Measurement Circuit

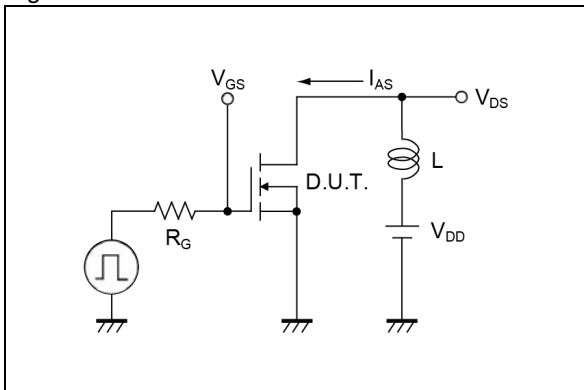


Fig.3-2 Avalanche Waveform

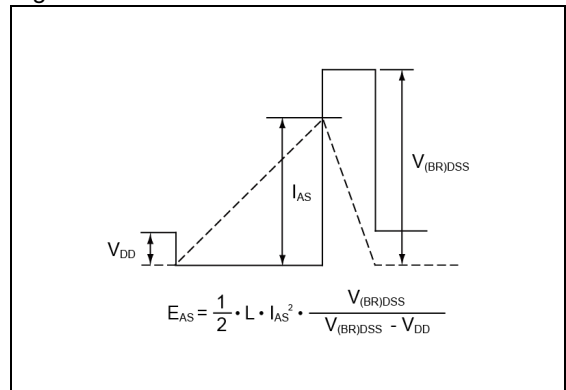


Fig.4-1 trr Measurement Circuit

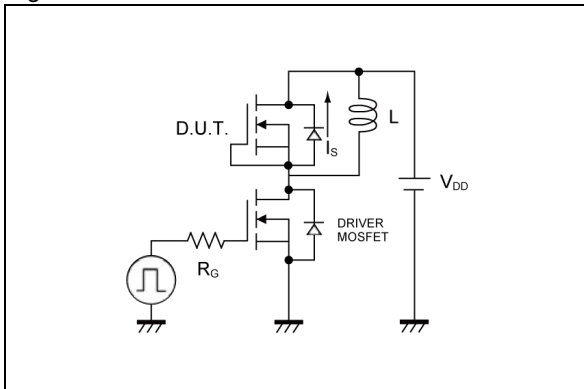
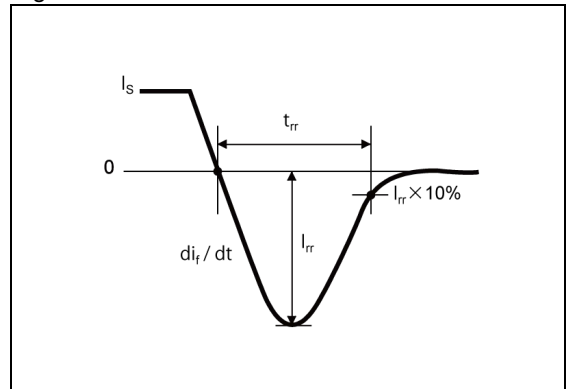
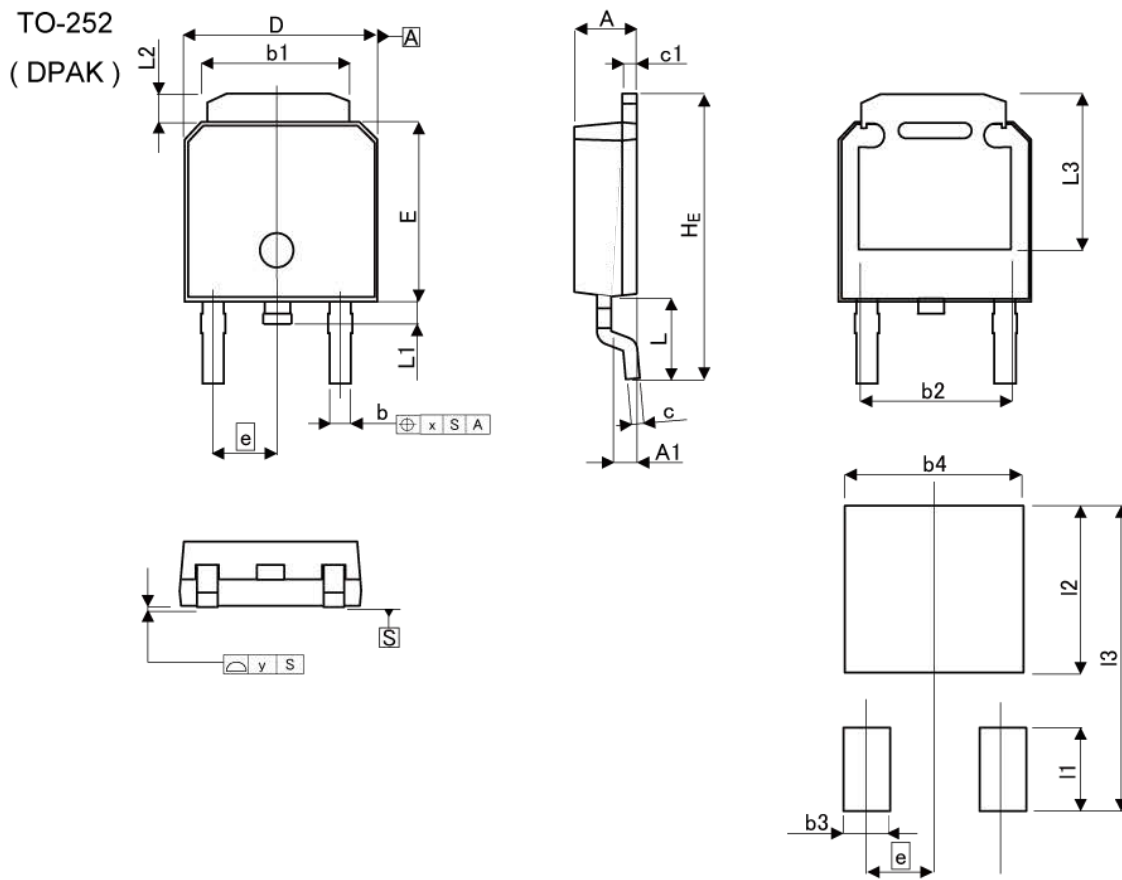


Fig.4-2 trr Waveform



●Dimensions



Pattern of terminal position areas  
[Not a recommended pattern of soldering pads]

DIM	MILIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.20	2.40	0.087	0.094
A1	0.70	1.10	0.028	0.043
b	0.60	0.90	0.024	0.035
b1	5.20	5.50	0.205	0.217
b2	4.80		0.189	
c	0.40	0.60	0.016	0.024
c1	0.40	0.60	0.016	0.024
D	6.40	6.80	0.252	0.268
e	2.30		0.091	
E	6.00	6.40	0.236	0.252
He	9.40	10.40	0.370	0.409
L	2.90		0.114	
L1	0.60	1.00	0.024	0.039
L2	0.70	1.30	0.028	0.051
L3	5.30		0.209	
x	-	0.25	-	0.010
y	-	0.10	-	0.004

DIM	MILIMETERS		INCHES	
	MIN	MAX	MIN	MAX
b3	-	1.15	-	0.045
b4	-	5.55	-	0.219
l1	-	2.77	-	0.109
l2	-	5.50	-	0.217
l3	-	10.40	-	0.409

Dimension in mm/inches

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JAPAN	USA	EU	CHINA
CLASS III	CLASS III	CLASS II b	CLASS III
CLASS IV		CLASS III	

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  - Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
  - Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
  - Sealing or coating our Products with resin or other coating materials
  - Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
  - Use of the Products in places subject to dew condensation
- The Products are not subject to radiation-proof design.
- Please verify and confirm characteristics of the final or mounted products in using the Products.
- In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse. is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.
- De-rate Power Dissipation depending on ambient temperature. When used in sealed area, confirm that it is the use in the range that does not exceed the maximum junction temperature.
- Confirm that operation temperature is within the specified range described in the product specification.
- ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

## Precaution for Mounting / Circuit board design

- When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.
- In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

### Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.
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### Precaution for Electrostatic

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of ionizer, friction prevention and temperature / humidity control).

### Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
  - [a] the Products are exposed to sea winds or corrosive gases, including Cl<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - [b] the temperature or humidity exceeds those recommended by ROHM
  - [c] the Products are exposed to direct sunshine or condensation
  - [d] the Products are exposed to high Electrostatic
2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.
3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.
4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

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