

| | |
|-----------------------------------|--------|
| $V_{DSS}(@T_j \text{ max.})^{*5}$ | 650V |
| $R_{DS(on)}(\text{Max.})$ | 0.300Ω |
| I_{DP}^{*2} | ±39A |
| P_D | 54W |

●Features

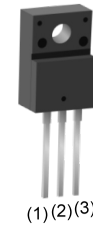
- 1) Fast reverse recovery time (trr)
- 2) Low on-resistance
- 3) Fast switching speed
- 4) Drive circuits can be simple
- 5) Pb-free plating ; RoHS compliant
- 6) Halogen free mold compound

●Application

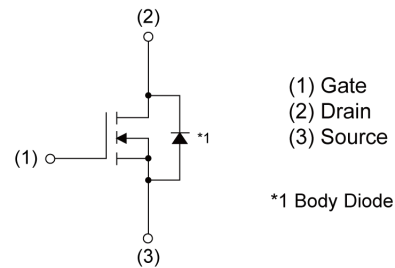
Switching applications

●Outline

TO-220FM



●Inner circuit



| | |
|---------|----------|
| Marking | R6013VNX |
|---------|----------|

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

| Parameter | Symbol | Value | Unit |
|---|---------------|-------------|------|
| Drain - Source voltage | V_{DSS} | 600 | V |
| Continuous drain current ($T_c = 25^\circ\text{C}$) | I_D^{*1} | ±8 | A |
| Pulsed drain current | I_{DP}^{*2} | ±39 | A |
| Gate - Source voltage | V_{GSS} | ±30 | V |
| Avalanche current, single pulse | I_{AS}^{*3} | 1 | A |
| Avalanche energy, single pulse | E_{AS}^{*3} | 55 | mJ |
| MOSFET dv/dt | dv/dt^{*4} | 120 | V/ns |
| Power dissipation ($T_c = 25^\circ\text{C}$) | P_D | 54 | W |
| Junction temperature | T_j | 150 | °C |
| Operating junction and storage temperature range | T_{stg} | -55 to +150 | °C |

● Thermal resistance

| Parameter | Symbol | Values | | | Unit |
|--|------------|--------|------|------|------|
| | | Min. | Typ. | Max. | |
| Thermal resistance, junction - case | R_{thJC} | - | - | 2.30 | °C/W |
| Thermal resistance, junction - ambient | R_{thJA} | - | - | 62.5 | °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} | $V_{DS} = 600V, V_{GS} = 0V$ | - | - | 100 | μA |
| Gate - Source leakage current | I_{GSS} | $V_{GS} = \pm 30V, V_{DS} = 0V$ | - | - | ± 100 | nA |
| Gate threshold voltage | $V_{GS(th)}$ | $V_{DS} = V_{GS}, I_D = 0.5mA$ | 4.5 | 5.5 | 6.5 | V |
| Static drain - source on - state resistance | $R_{DS(on)}^{*5}$ | $V_{GS} = 15V, I_D = 3A$ | - | 0.250 | 0.300 | Ω |
| | | $V_{GS} = 10V, I_D = 3A$ | - | 0.275 | 0.330 | Ω |
| Gate resistance | R_G | $f = 1MHz, \text{open drain}$ | - | 1.6 | - | Ω |

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

| Parameter | Symbol | Conditions | Values | | | Unit |
|---|-------------------|-------------------------------------|--------|------|------|------|
| | | | Min. | Typ. | Max. | |
| Input capacitance | C_{iss} | $V_{GS} = 0V, V_{DS} = 100V$ | - | 900 | - | pF |
| Output capacitance | C_{oss} | $f = 100\text{kHz}$ | - | 45 | - | |
| Effective output capacitance energy related | $C_{o(er)}^{*6}$ | $V_{GS} = 0V$ | - | 29 | - | |
| Effective output capacitance time related | $C_{o(tr)}^{*7}$ | $V_{DS} = 0V \text{ to } 480V$ | - | 188 | - | |
| Turn - on delay time | $t_{d(on)}^{*5}$ | $V_{DD} \approx 300V, V_{GS} = 15V$ | - | 18 | - | ns |
| Rise time | t_r^{*5} | $I_D = 3A$ | - | 10 | - | |
| Turn - off delay time | $t_{d(off)}^{*5}$ | $R_L \approx 100\Omega$ | - | 46 | - | |
| Fall time | t_f^{*5} | $R_G = 10\Omega$ | - | 25 | - | |

● Gate charge characteristics ($T_a = 25^\circ\text{C}$)

| Parameter | Symbol | Conditions | Values | | | Unit |
|----------------------|-----------------|---------------------------------|--------|------|------|------|
| | | | Min. | Typ. | Max. | |
| Total gate charge | Q_g^{*5} | $V_{DD} \approx 300V$ | - | 21 | - | nC |
| Gate - Source charge | Q_{gs}^{*5} | $I_D = 3A$ | - | 7 | - | |
| Gate - Drain charge | Q_{gd}^{*5} | $V_{GS} = 10V$ | - | 10 | - | |
| Gate plateau voltage | $V_{(plateau)}$ | $V_{DD} \approx 300V, I_D = 3A$ | - | 7.1 | - | V |

●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} | $T_C = 25^\circ\text{C}$ | - | - | 8 | A |
| Pulsed source current | I_{SP}^{*2} | | - | - | 39 | A |
| Source-Drain voltage | V_{SD}^{*5} | $V_{GS} = 0\text{V}, I_S = 3\text{A}$ | - | - | 1.5 | V |
| Reverse recovery time | t_{rr}^{*5} | $V_{DD} \approx 400\text{V}$ $I_S = 3\text{A}$ $di/dt = 100\text{A}/\mu\text{s}$ | - | 65 | - | ns |
| Reverse recovery charge | Q_{rr}^{*5} | | - | 190 | - | nC |
| Peak reverse recovery current | I_{rr}^{*5} | | - | 6 | - | A |

*1 Limited only by maximum temperature allowed.

*2 $P_w \leq 10\mu\text{s}$, Duty cycle $\leq 1\%$

*3 $L \approx 100\text{mH}$, $V_{DD} = 50\text{V}$, $R_G = 25\Omega$, starting $T_j = 25^\circ\text{C}$

*4 $V_{DS} = 0$ to 400V

*5 Pulsed

*6 $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

*7 $C_{o(tr)}$ is a fixed capacitance that gives the same charging time as C_{oss} while V_{DS} is rising from 0 to 80% V_{DSS} .

● Electrical characteristic curves

Fig.1 Power Dissipation Derating Curve

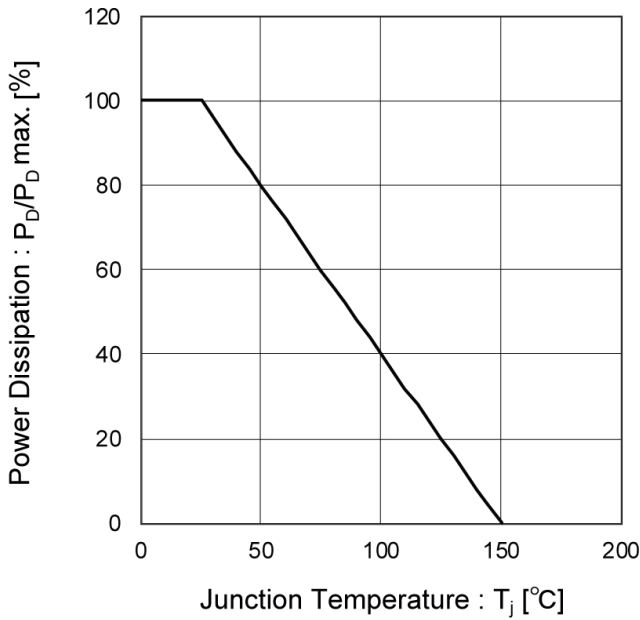


Fig.2 Drain Current Derating Curve

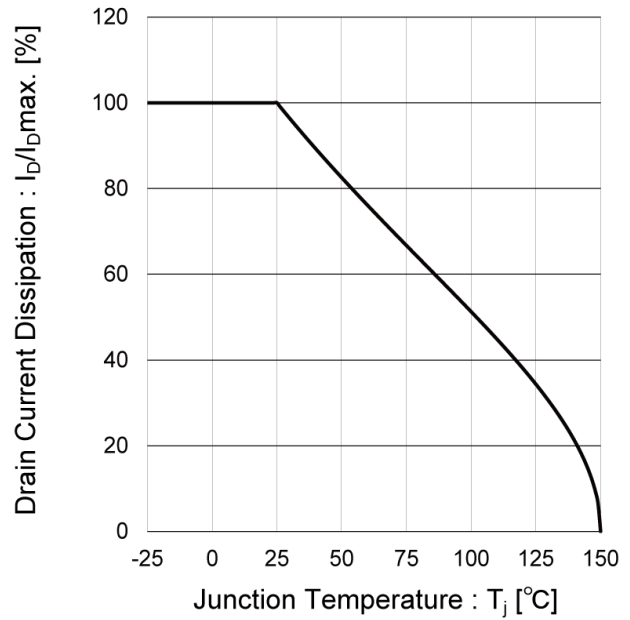


Fig.3 Normalized Transient Thermal Resistance vs. Pulse Width

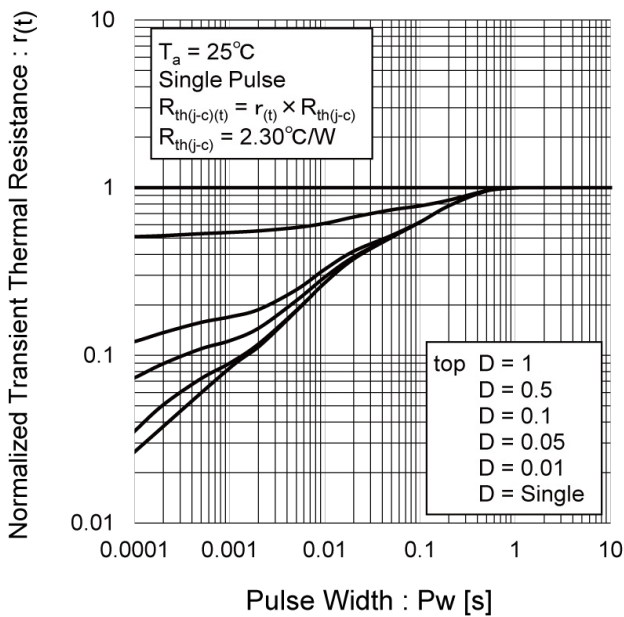
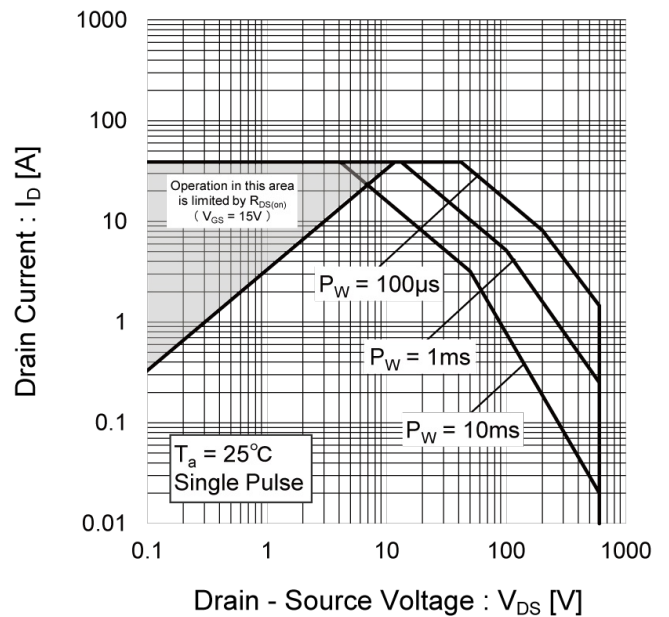


Fig.4 Maximum Safe Operating Area



● Electrical characteristic curves

Fig.5 Avalanche Energy Derating Curve



Fig.6 Normalized Breakdown Voltage vs. Junction Temperature

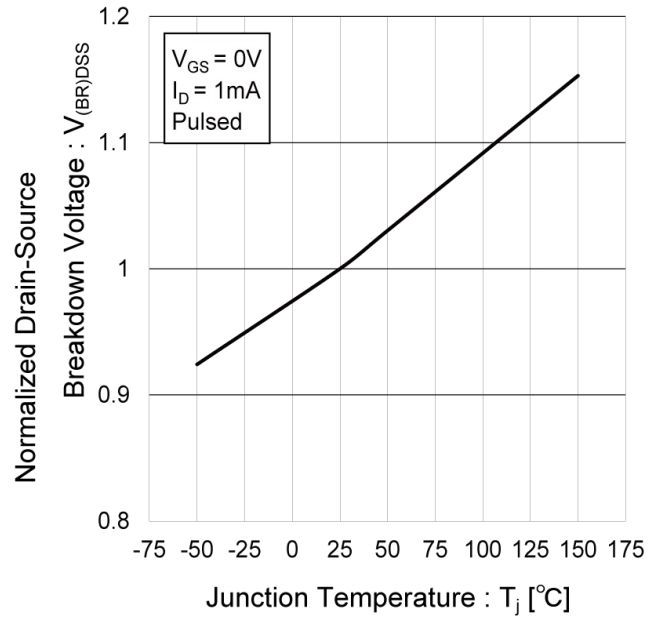


Fig.7 Output Characteristics(I)

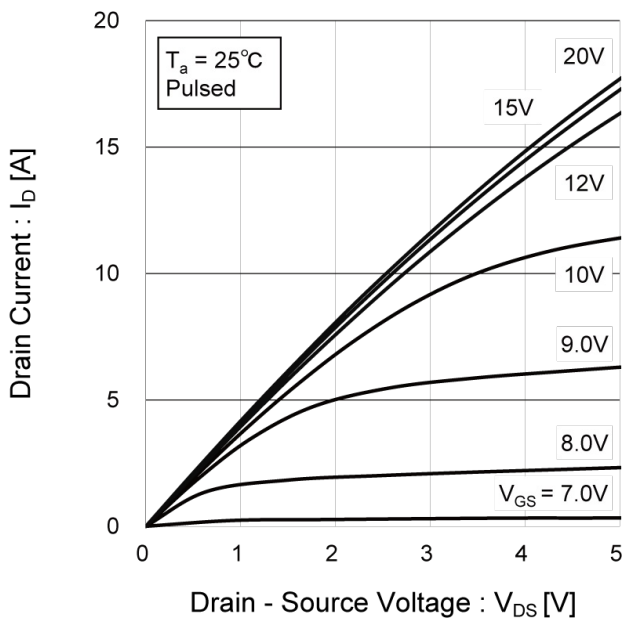
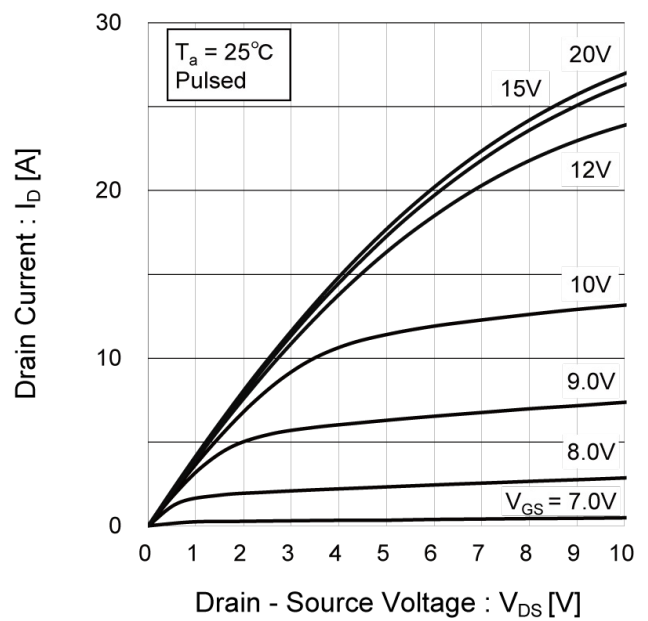


Fig.8 Output Characteristics(II)



● Electrical characteristic curves

Fig.9 Gate Threshold Voltage vs. Drain current

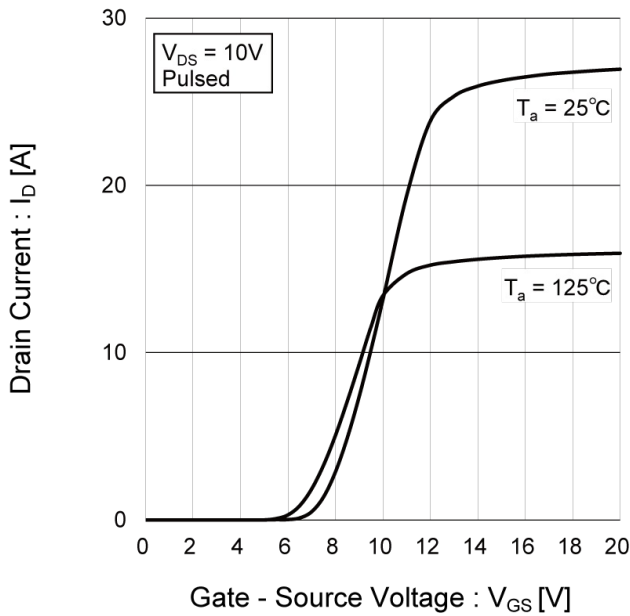


Fig.10 Normalized Gate Threshold Voltage vs Junction Temperature

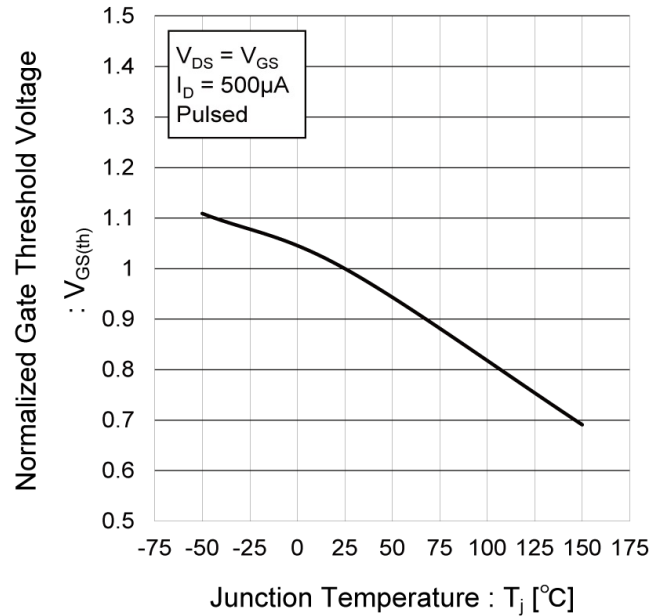


Fig.11 Static Drain - Source On - State Resistance vs. Gate Source Voltage

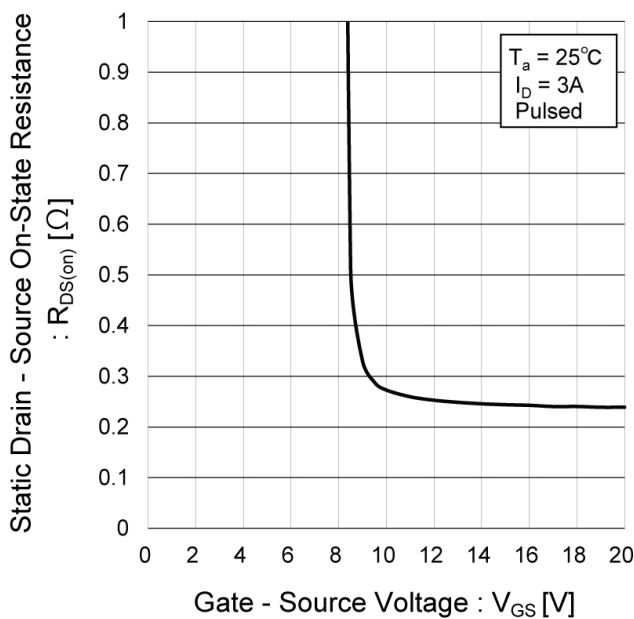
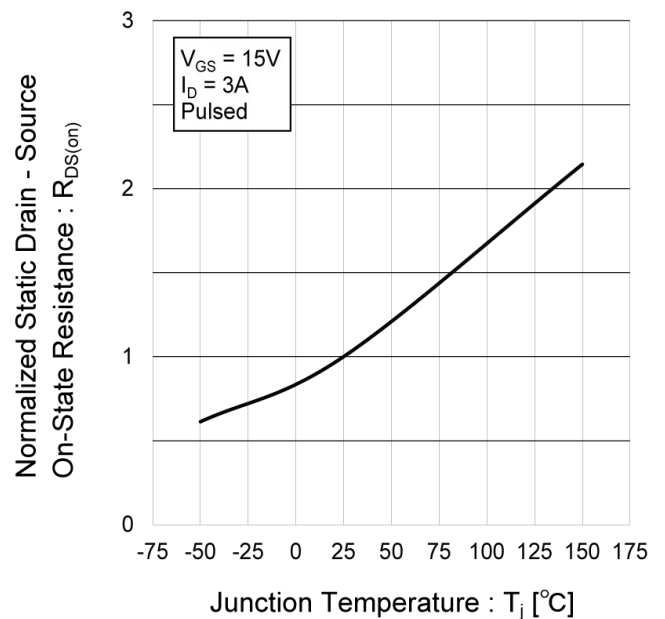


Fig.12 Normalized Static Drain - Source On - State Resistance vs. Junction Temperature



● Electrical characteristic curves

Fig.13 Static Drain - Source On - State Resistance vs. Drain Current

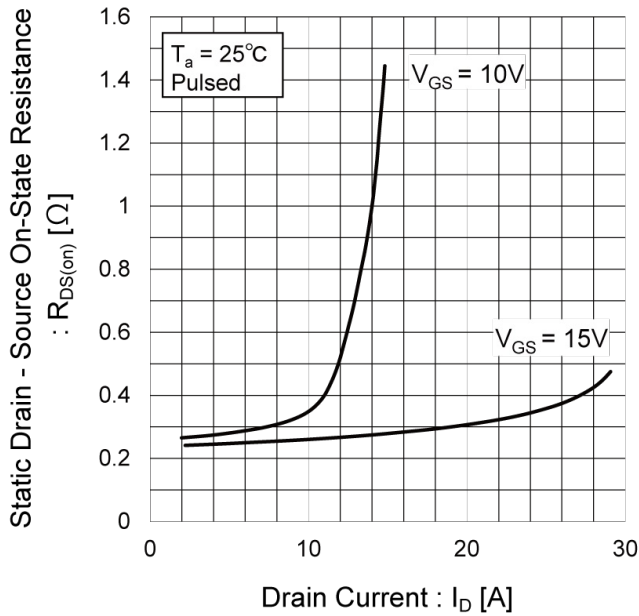


Fig.14 Capacitances

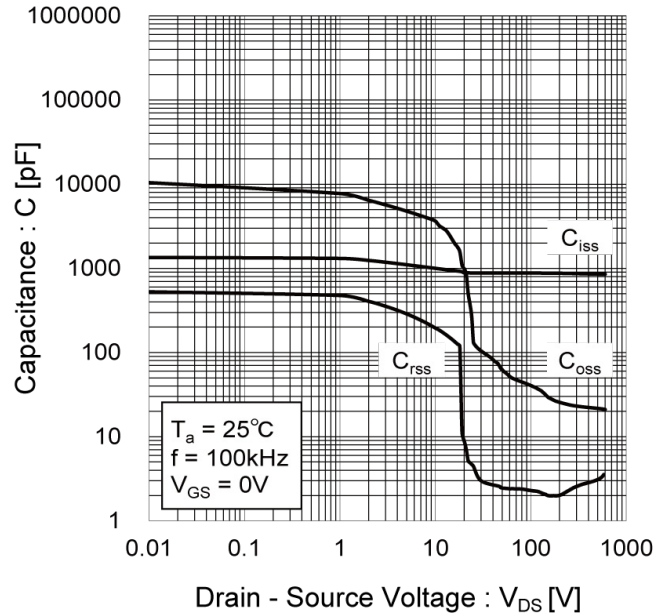


Fig.15 Coss Stored Energy

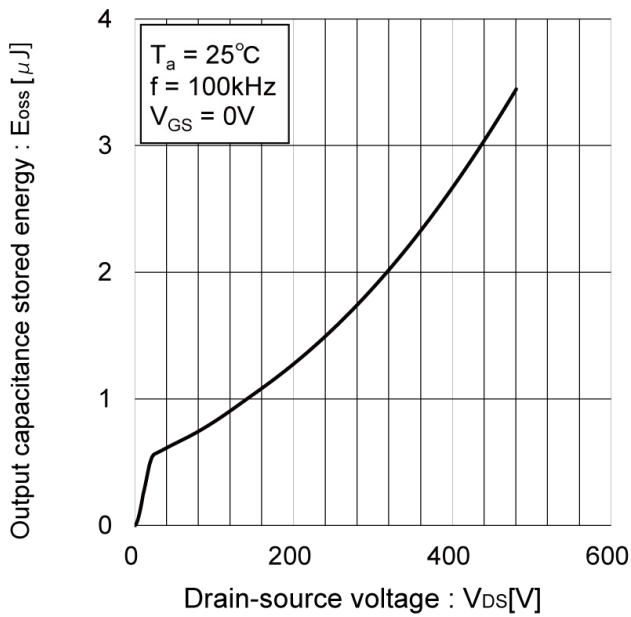
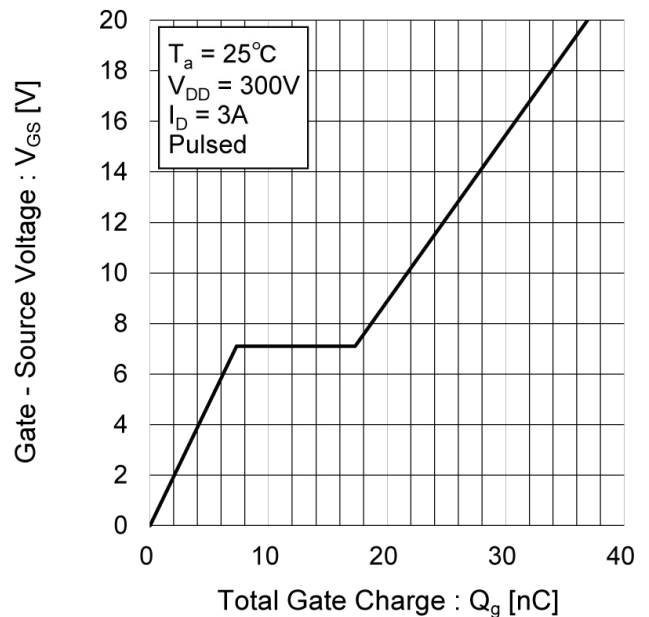


Fig.16 Gate Charge



● Electrical characteristic curves

Fig.17 Source Current vs. Source - Drain Voltage

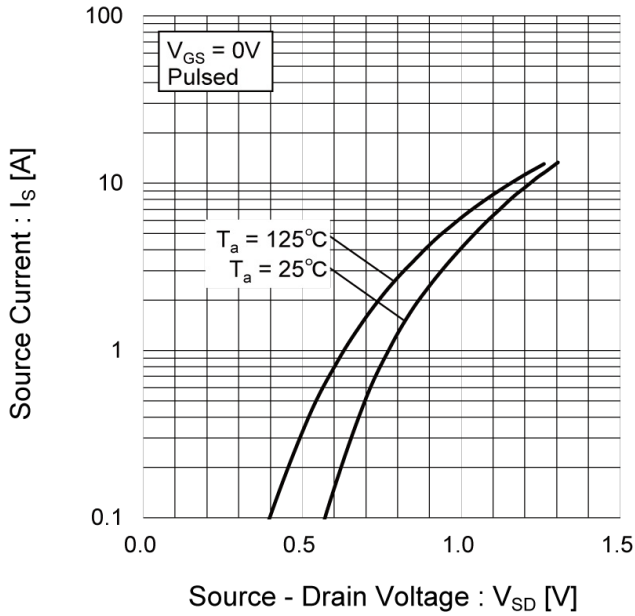
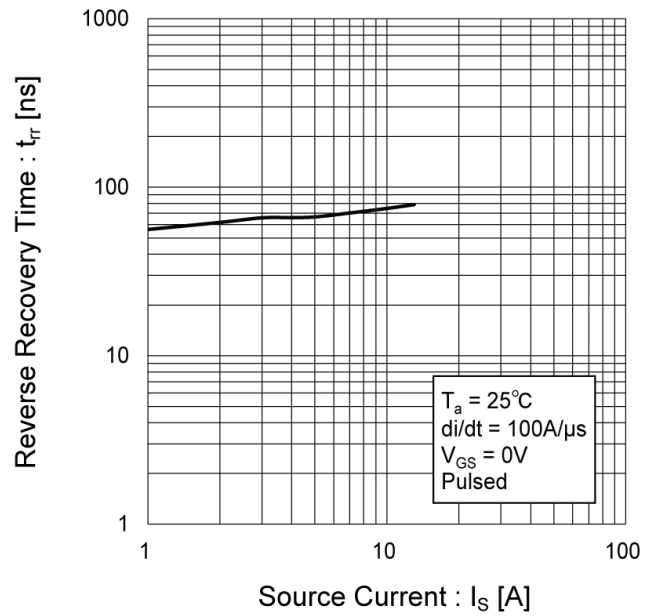


Fig.18 Reverse Recovery Time vs. Source Current



● Measurement circuits

Fig.1-1 Switching Time Measurement Circuit



Fig.1-2 Switching Waveforms

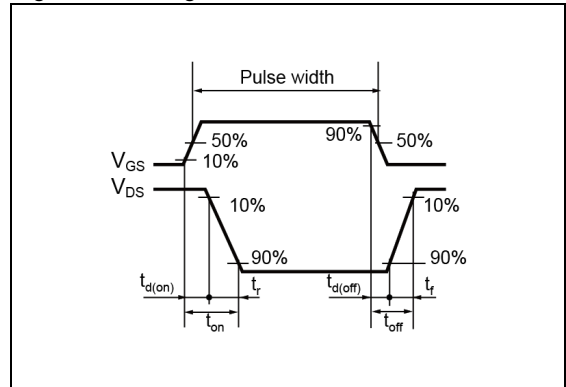


Fig.2-1 Gate Charge Measurement Circuit

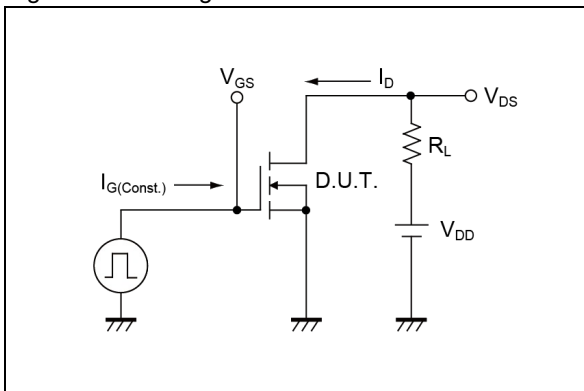


Fig.2-2 Gate Charge Waveform

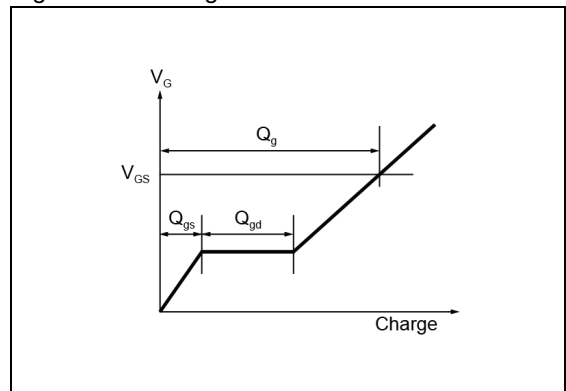


Fig.3-1 Avalanche Measurement Circuit



Fig.3-2 Avalanche Waveform



Fig.4-1 Diode Recovery Measurement Circuit

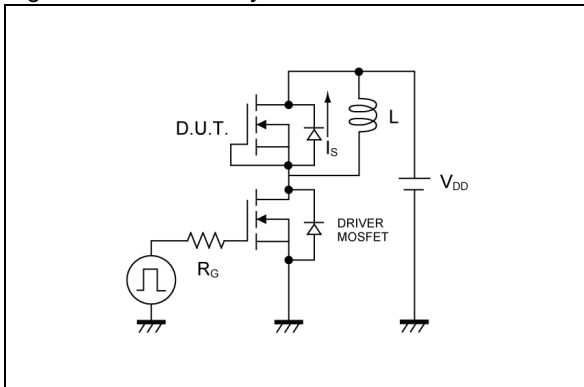
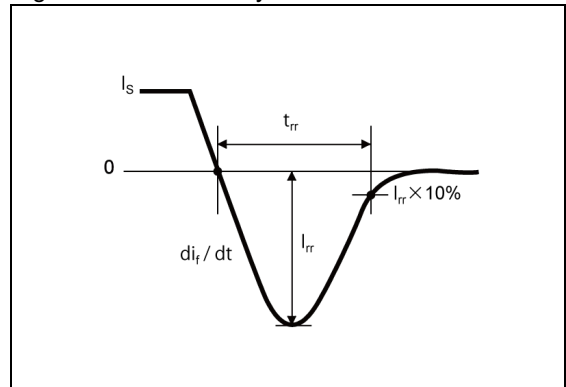
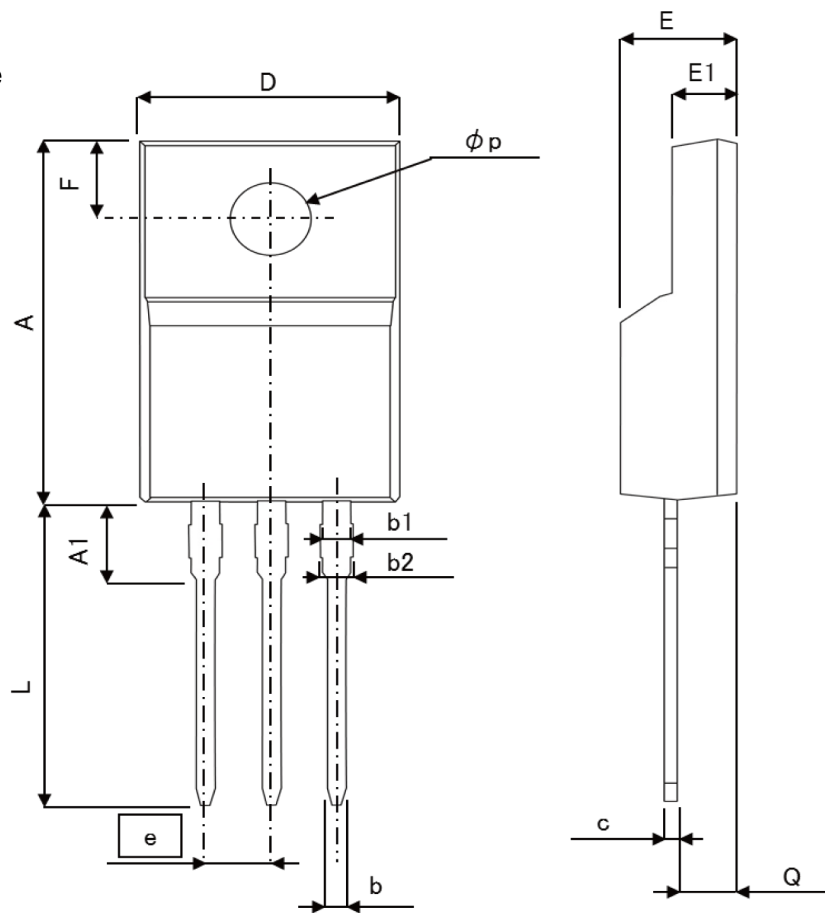


Fig.4-2 Diode Recovery Waveform



●Dimensions

TO-220FM
 Packing code
 C7 G



| DIM | MILIMETERS | | INCHES | |
|-----|------------|-------|--------|-------|
| | MIN | MAX | MIN | MAX |
| A | 15.67 | 16.27 | 0.617 | 0.641 |
| A1 | 3.03 | 3.43 | 0.119 | 0.135 |
| b | 0.70 | 0.95 | 0.028 | 0.037 |
| b1 | 1.00 | 1.40 | 0.039 | 0.055 |
| b2 | 1.10 | 1.50 | 0.043 | 0.059 |
| c | 0.45 | 0.65 | 0.018 | 0.026 |
| D | 9.90 | 10.30 | 0.390 | 0.406 |
| E | 4.60 | 5.00 | 0.181 | 0.197 |
| E1 | 2.44 | 2.74 | 0.096 | 0.108 |
| e | 2.54 | | 0.100 | |
| F | 3.10 | 3.50 | 0.122 | 0.138 |
| L | 12.6 | 13.6 | 0.946 | 0.535 |
| p | 2.98 | 3.38 | 0.117 | 0.133 |
| Q | 2.25 | 3.25 | 0.089 | 0.128 |

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 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 (Exclude cases where no-clean type fluxes is used. However, recommend sufficiently about the residue.) ; 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.

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- 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.

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 - [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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