Fuji Electric

*Innovating Energy Technology*

# FML60N104S2FDHF

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FUJI POWER MOSFET

## Super J MOS® S2 series

**N-Channel enhancement mode power MOSFET**

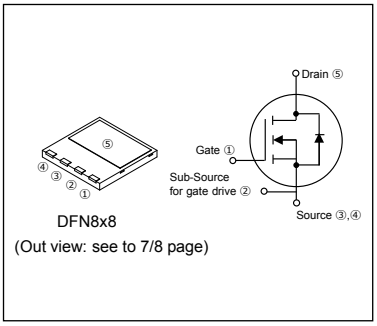
### Features

Pb-free lead terminal
RoHS compliant
Halogen-free molding compound
MSL:1, Reflow available

### Applications

For switching

### Package and Internal circuit chart




DFN8x8

(Out view: see to 7/8 page)

### Absolute Maximum Ratings at $T_C$=25°C (unless otherwise specified)

| Parameter | Symbol | Characteristics | Unit | Remarks |
|---|---|---|---|---|
| Drain-Source Voltage | $V_{DS}$ | 600 | V | |
| | $V_{DSX}$ | 600 | V | $V_{GS}$=-30V |
| Continuous Drain Current | $I_D$ | 41.3 | A | $T_C$=25°C Note*1,2 |
| | | 26.1 | A | $T_C$=100°C Note*1,2 |
| Pulsed Drain Current | $I_{DP}$ | 120.4 | A | Note *2 |
| Gate-Source Voltage | $V_{GS}$ | ±30 | V | |
| Non-Repetitive Maximum Avalanche Current | $I_{AS}$ | 4.9 | A | Note *3 |
| Non-Repetitive Maximum Avalanche Energy | $E_{AS}$ | 809.3 | mJ | Note *4 |
| Maximum MOSFET d$v$/d$t$ | d$v_{DS}$/d$t$ | 50 | V/ns | $V_{DS}$≤ 600V |
| Continuous Diode Forward Current | $I_{DR}$ | 41.3 | A | $T_C$=25°C Note*1,2 |
| | | 26.1 | A | $T_C$=100°C Note*1,2 |
| Pulsed Diode Forward Current | $I_{DRP}$ | 120.4 | A | Note *2 |
| Peak Diode Recovery d$v$/d$t$ | d$v$/d$t$ | 30 | V/ns | Note *5 |
| Peak Diode Recovery -d$i_{DR}$/d$t$ | -d$i_{DR}$/d$t$ | 100 | A/μs | Note *6 |
| Maximum Power Dissipation | $P_{tot}$ | 232 | W | $T_C$=25°C |
| | | 2.78 | W | $T_a$=25°C |
| Operating Channel Temperature | $T_{ch}$ | 150 | °C | |
| Storage Temperature | $T_{stg}$ | -55 to +150 | °C | |

Note *1 : Maximum duty cycle D=0.53
Note *2 : Limited by maximum channel temperature.
Note *3 : $T_{ch}$ ≤ 150 °C, See Figure 1 and 2.
Note *4 : Starting $T_{ch}$ = 25 °C, $I_{AS}$ = 3 A, L = 165 mH, $V_{DD}$ = 60 V, $R_G$ = 50 Ω, See Figure 1 and 2.
$E_{AS}$ limited by maximum channel temperature and avalanche current.
Note *5 : $I_{DR}$ ≤32.8 A , -d$i_{DR}$/d$t$ ≤ 100 A/μs, $V_{DS\ peak}$ ≤ 600 V, $T_{ch}$ ≤ 150 °C.
Note *6 : $I_{DR}$ ≤32.8 A , d$v$/d$t$ ≤ 30 V/ns, $V_{DS\ peak}$ ≤ 600 V, $T_{ch}$ ≤ 150 °C.



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## Electrical Characteristics at $T_c$=25°C (unless otherwise specified)

### • Static characteristics

| Parameter | Symbol | Conditions | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| Drain-Source Breakdown Voltage | $V_{(BR)DSS}$ | $V_{GS}$ = 0 V<br>$I_D$ = 250 µA | | 600 | - | - | V |
| Gate Threshold Voltage | $V_{GS(th)}$ | $V_{DS}$ = $V_{GS}$<br>$I_D$ = 4.9 mA | | 3.0 | 4.0 | 5.0 | V |
| Zero Gate Voltage Drain Current | $I_{DSS}$ | $V_{DS}$ = 600 V<br>$V_{GS}$ = 0 V | $T_{ch}$ = 25 °C | - | - | 25 | µA |
| | | $V_{DS}$ = 480 V<br>$V_{GS}$ = 0 V | $T_{ch}$ = 125 °C | - | - | 250 | |
| Gate-Source Leakage Current | $I_{GSS}$ | $V_{DS}$ = 0 V<br>$V_{GS}$ = ± 30 V | | - | 10 | 100 | nA |
| Drain-Source On-State Resistance | $R_{DS(on)}$ | $V_{GS}$ = 10 V<br>$I_D$ = 8.2 A | | - | 0.093 | 0.104 | Ω |
| Gate resistance | $r_g$ | $f$ = 1 MHz, open drain | | - | 7.5 | - | Ω |

### • Dynamic characteristics

| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Forward Transconductance | $g_{fs}$ | $V_{DS}$ = 25 V<br>$I_D$ = 16.4 A | 6 | 24 | - | S |
| Input Capacitance | $C_{iss}$ | $V_{DS}$ = 400 V<br>$V_{GS}$ = 0 V<br>$f$ = 250 kHz | - | 1720 | - | pF |
| Output Capacitance | $C_{oss}$ | | - | 60 | - | |
| Reverse Transfer Capacitance | $C_{rss}$ | | - | 7.9 | - | |
| Effective output capacitance, energy related (Note *7) | $C_{o(er)}$ | $V_{DS}$ = 0…400 V<br>$V_{GS}$ = 0 V | - | 139 | - | |
| Effective output capacitance, time related (Note *8) | $C_{o(tr)}$ | $V_{DS}$ = 0…400 V<br>$V_{GS}$ = 0 V<br>$I_D$ = constant | - | 569 | - | |
| Turn-On Time | $t_{d(on)}$ | $V_{DD}$ = 400 V, $V_{GS}$ = 10 V<br>$I_D$ = 16.4 A,<br>$R_G$ = 20 Ω<br>See Figure 3 and 4 | - | 36 | - | ns |
| | $t_r$ | | - | 33 | - | |
| Turn-Off Time | $t_{d(off)}$ | | - | 207 | - | |
| | $t_f$ | | - | 21 | - | |
| Total Gate Charge | $Q_G$ | $V_{DD}$ = 400 V, $V_{GS}$ = 10 V<br>$I_D$ = 32.8 A<br>See Figure 5 | - | 83 | - | nC |
| Gate-Source Charge | $Q_{GS}$ | | - | 27 | - | |
| Gate-Drain Charge | $Q_{GD}$ | | - | 47 | - | |

Note *7 : $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as $C_{oss}$ while $V_{DS}$ is rising from 0 to 400V.
Note *8 : $C_{o(tr)}$ is a fixed capacitance that gives the same charging times as $C_{oss}$ while $V_{DS}$ is rising from 0 to 400V.

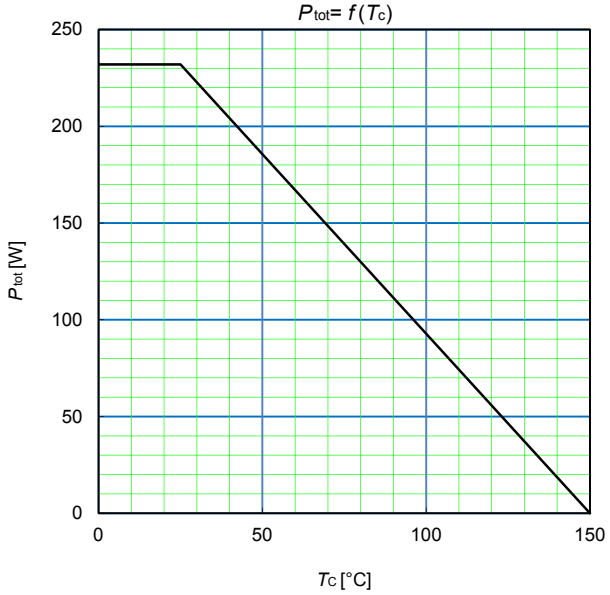
### • Reverse diode characteristics

| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Diode Forward On-Voltage | $V_{DSR}$ | $I_{DR}$ = 32.8 A, $V_{GS}$ = 0 V<br>$T_{ch}$ = 25 °C | - | 1.00 | 1.35 | V |
| Reverse Recovery Time | $t_{rr}$ | $V_{DD}$ = 400 V<br>$I_{DR}$ = 32.8 A<br>$V_{GS}$ = 0 V<br>-d$i_{DR}$/d$t$ = 100 A/µs<br>$T_{ch}$ = 25 °C<br>See Figure 6 and 7 | - | 185 | - | ns |
| Reverse Recovery Charge | $Q_{rr}$ | | - | 1.6 | - | µC |
| Peak Reverse Recovery Current | $I_{rrm}$ | | - | 15.8 | - | A |

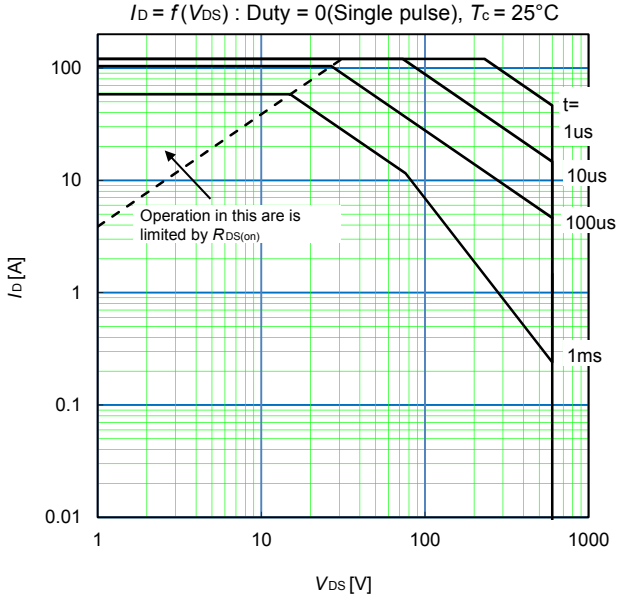
## Thermal Resistance

| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Thermal Resistance, Channel – Ambient | $R_{th(ch-a)}$ | Device mounted on PCB (FR4)<br>Size: 40mm*40mm*1.5mm<br>with 6cm² copper area<br>(one layer, 70µm thickness)<br>for drain connection and cooling. | - | - | 45 | °C/W |
| Thermal Resistance, Channel – Case | $R_{th(ch-c)}$ | | - | - | 0.539 | °C/W |

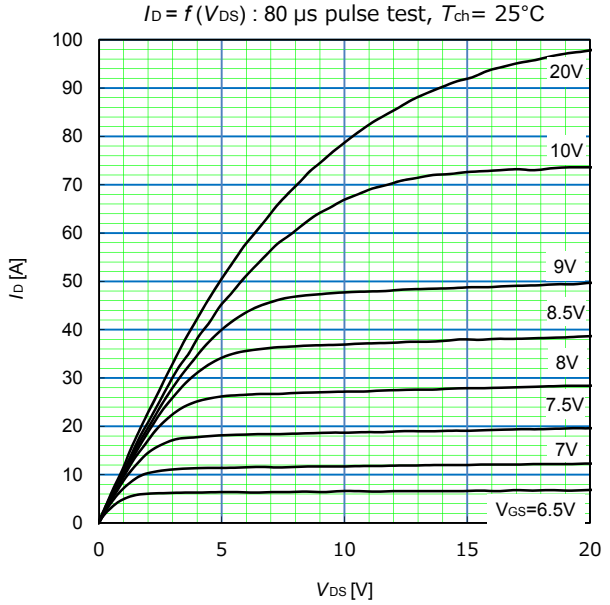
Allowable power dissipation
$P_{tot} = f(T_c)$



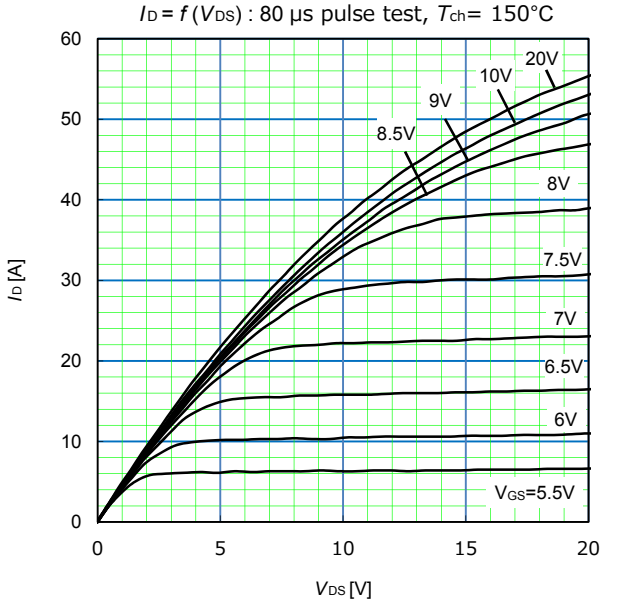

Safe operating area
$I_D = f(V_{DS})$ : Duty = 0(Single pulse), $T_c$ = 25°C



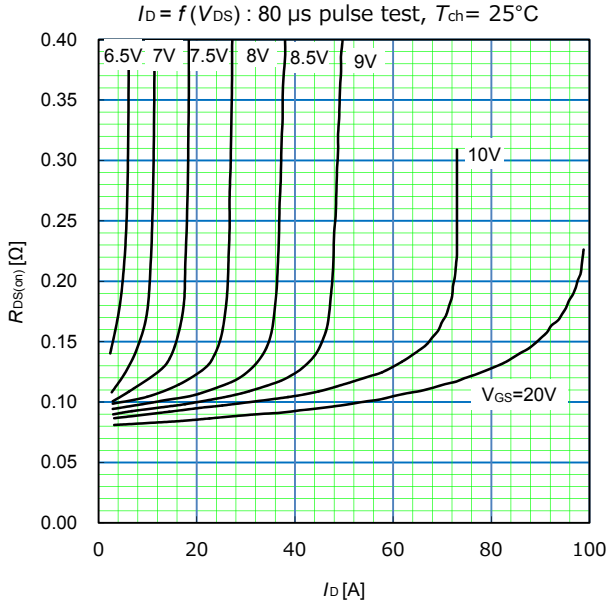

Typical output characteristics
$I_D = f(V_{DS})$ : 80 µs pulse test, $T_{ch}$= 25°C



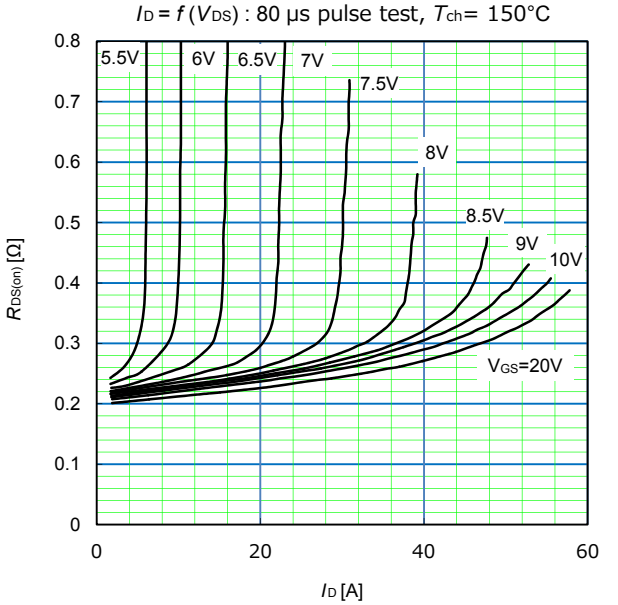

Typical output characteristics
$I_D = f(V_{DS})$ : 80 µs pulse test, $T_{ch}$= 150°C



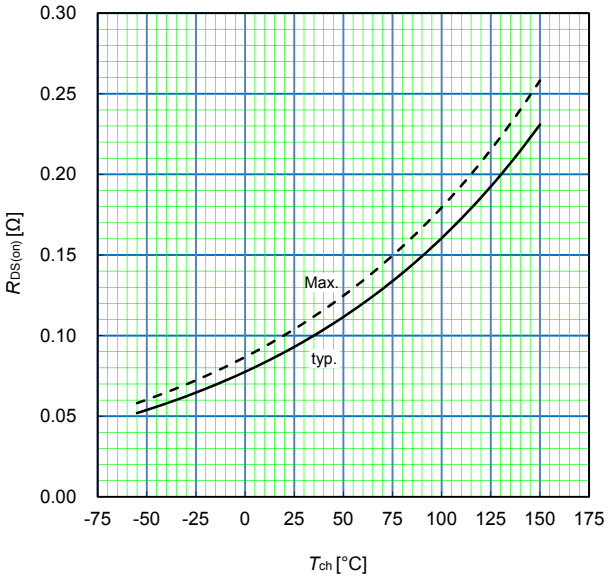

Typical drain-source on-state resistance
$I_D = f(V_{DS})$ : 80 µs pulse test, $T_{ch}$= 25°C



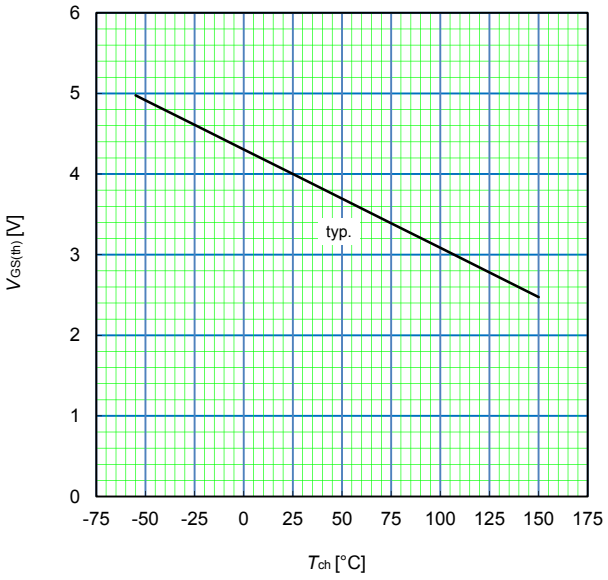

Typical drain-source on-state resistance
$I_D = f(V_{DS})$ : 80 µs pulse test, $T_{ch}$= 150°C



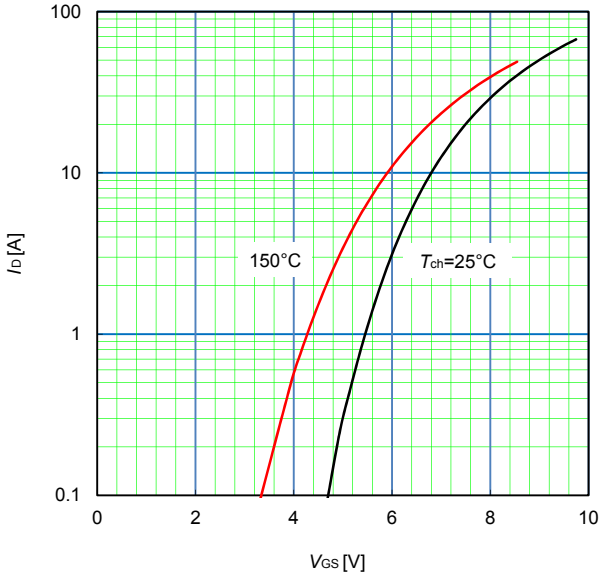
Drain-source on-state resistance
$R_{DS(on)}$= $f$ ($T_{ch}$) : $I_D$= 16.4 A, $V_{GS}$= 10 V



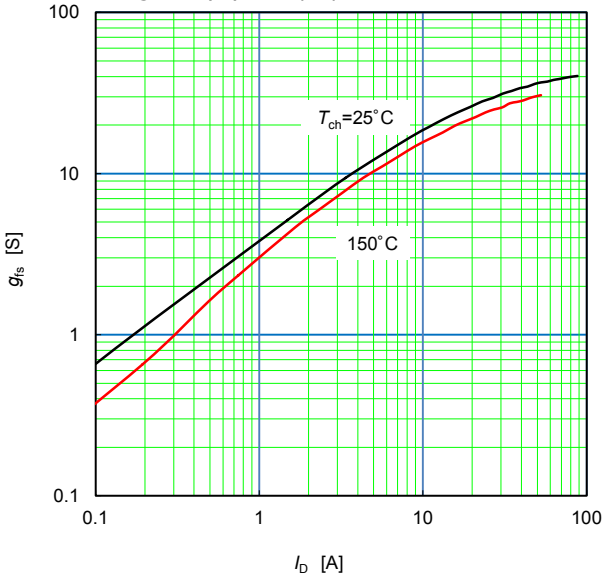

Gate threshold voltage
$V_{GS(th)}$= $f$ ($T_{ch}$) : $V_{DS}$= $V_{GS}$, $I_D$= 4.9 mA



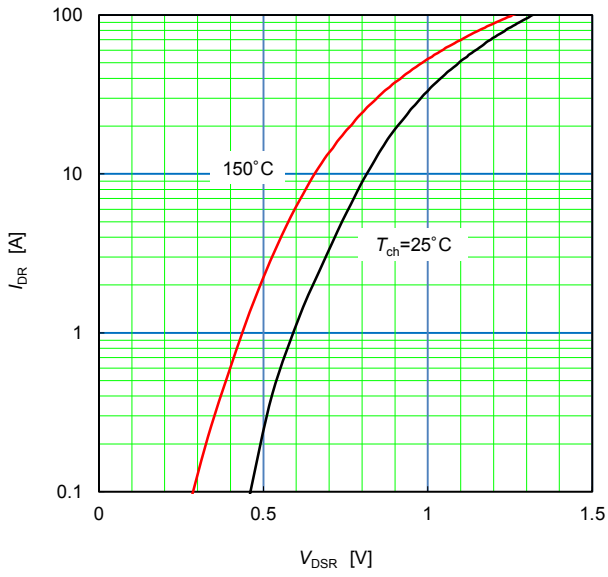

Typical transfer characteristic
$I_D$= $f$ ($V_{GS}$) : 80 µs pulse test, $V_{DS}$= 25 V



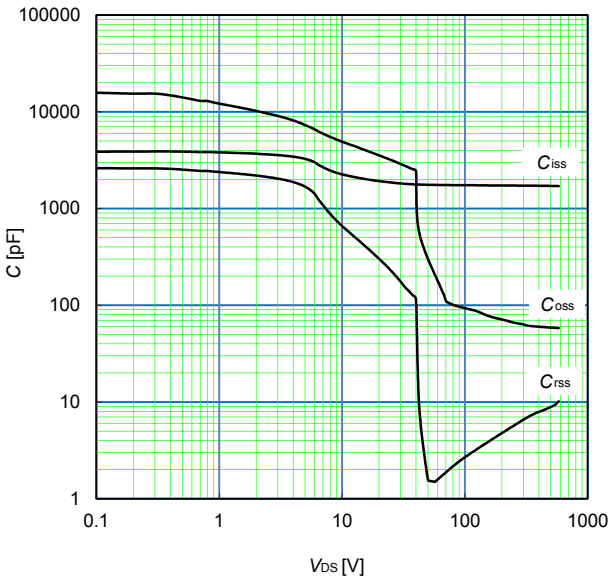

Typical transconductance
$g_{fs}$= $f$ ($I_D$) : 80 µs pulse test, $V_{DS}$= 25 V



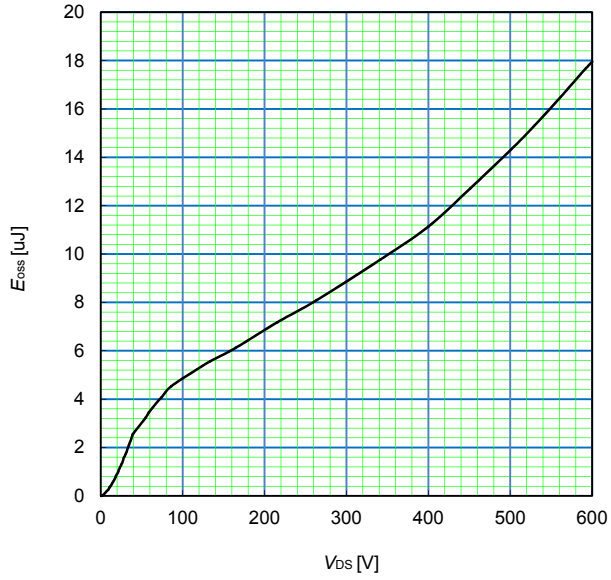

Typical forward characteristics of reverse diode
$I_{DR}$= $f$ ($V_{DSR}$) : 80 µs pulse test




Typical capacitance
$C$= $f$ ($V_{DS}$) : $V_{GS}$= 0 V, $f$= 250 kHz

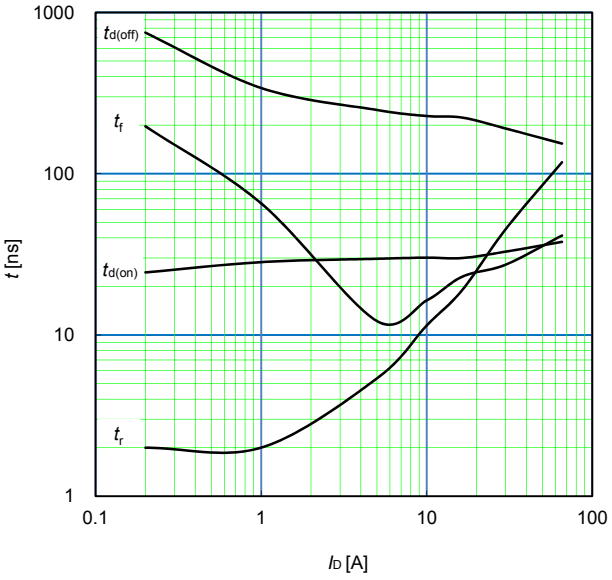


Typical $C_{oss}$ stored energy



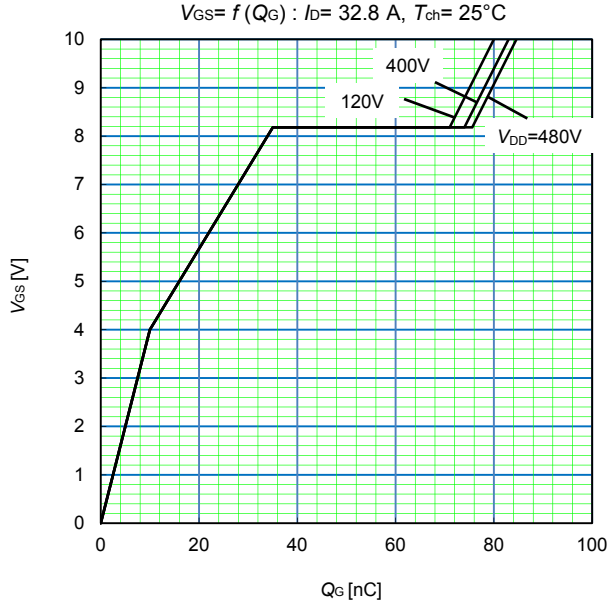

Typical switching times vs. $I_D$

$t = f(I_D)$ : $V_{DD}$= 400 V, $V_{GS}$= 10 V/0 V, $R_G$= 20 Ω, $T_{ch}$= 25°C



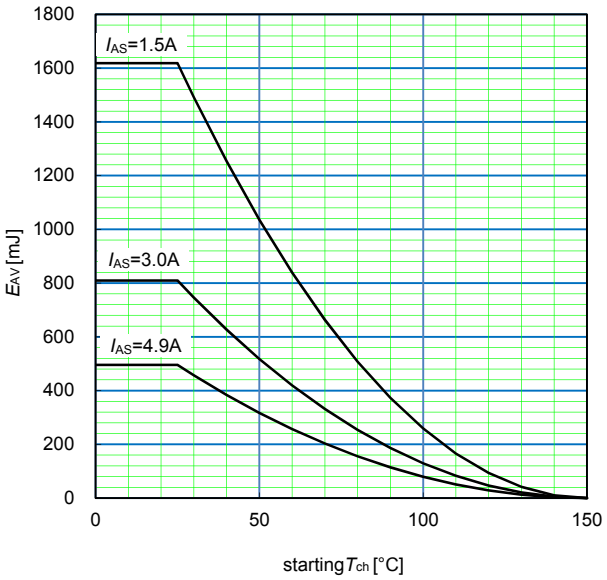

Typical gate charge

$V_{GS} = f(Q_G)$ : $I_D$= 32.8 A, $T_{ch}$= 25°C



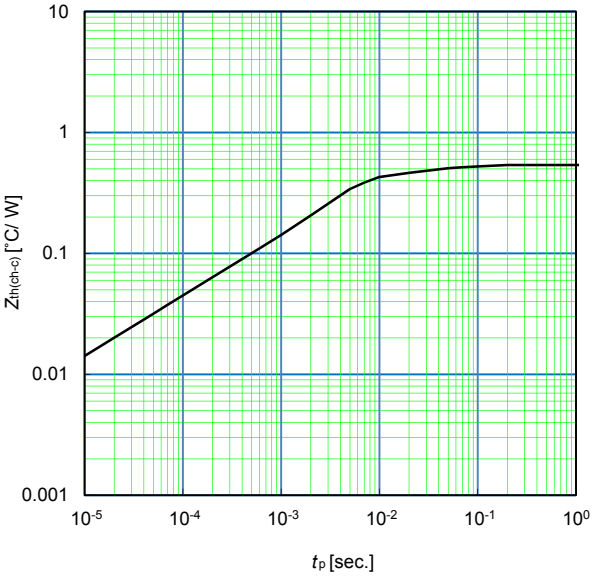

Maximum Avalanche Energy

$E_{AV} = f$ (starting $T_{ch}$) : $V_{DD}$= 60 V, $I_{AV} \leq$ 4.9 A




Transient Thermal Impedance

$Z_{th(ch-c)} = f(t)$ : $D$= 0



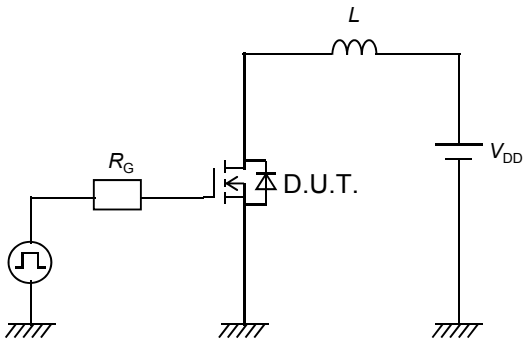



Figure 1. Unclamped inductive load test circuit

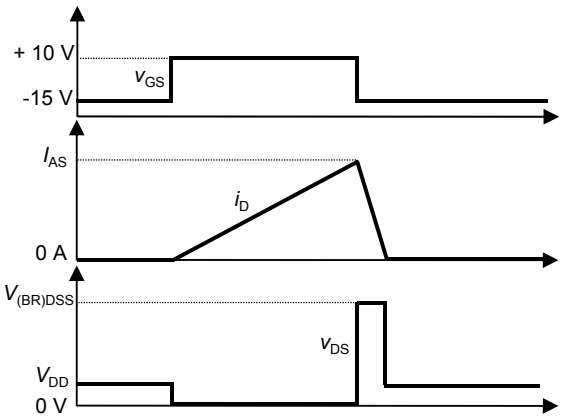



Figure 2. Unclamped inductive waveform

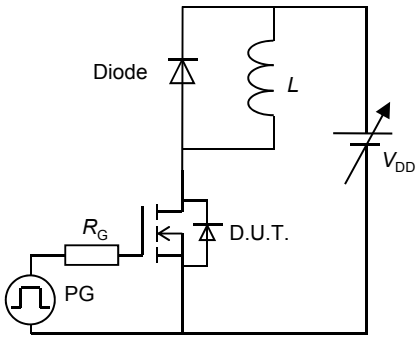



Figure 3. Switching test circuit

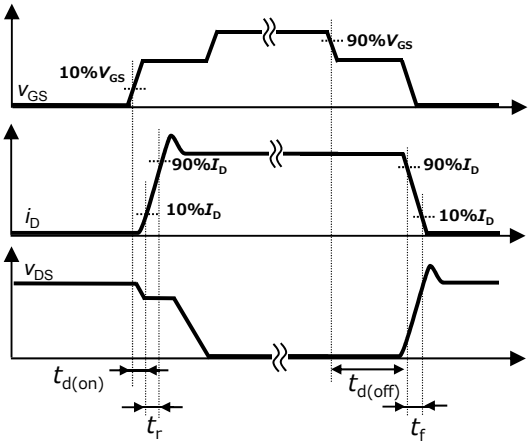



Figure 4. Switching times waveform

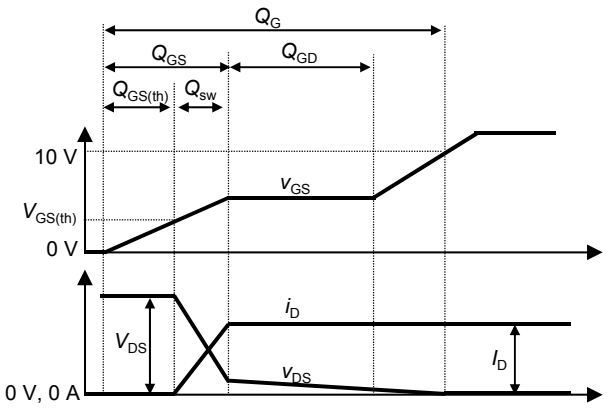



Figure 5. Gate charge waveform

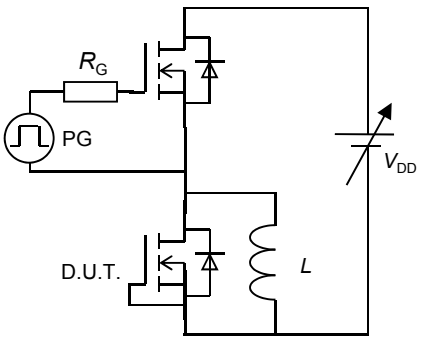



Figure 6. Diode reverse recovery test circuit

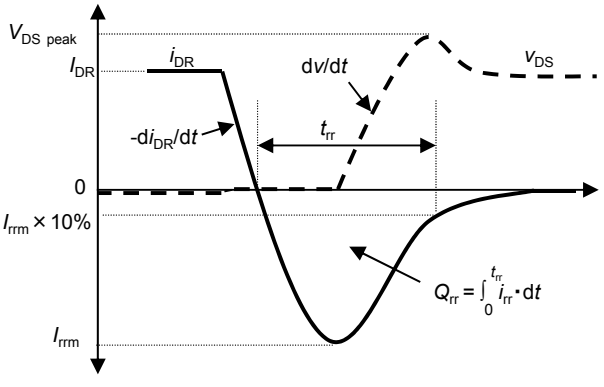



Figure 7. Diode reverse recovery waveform

## Package Dimensions : DFN8x8 Package

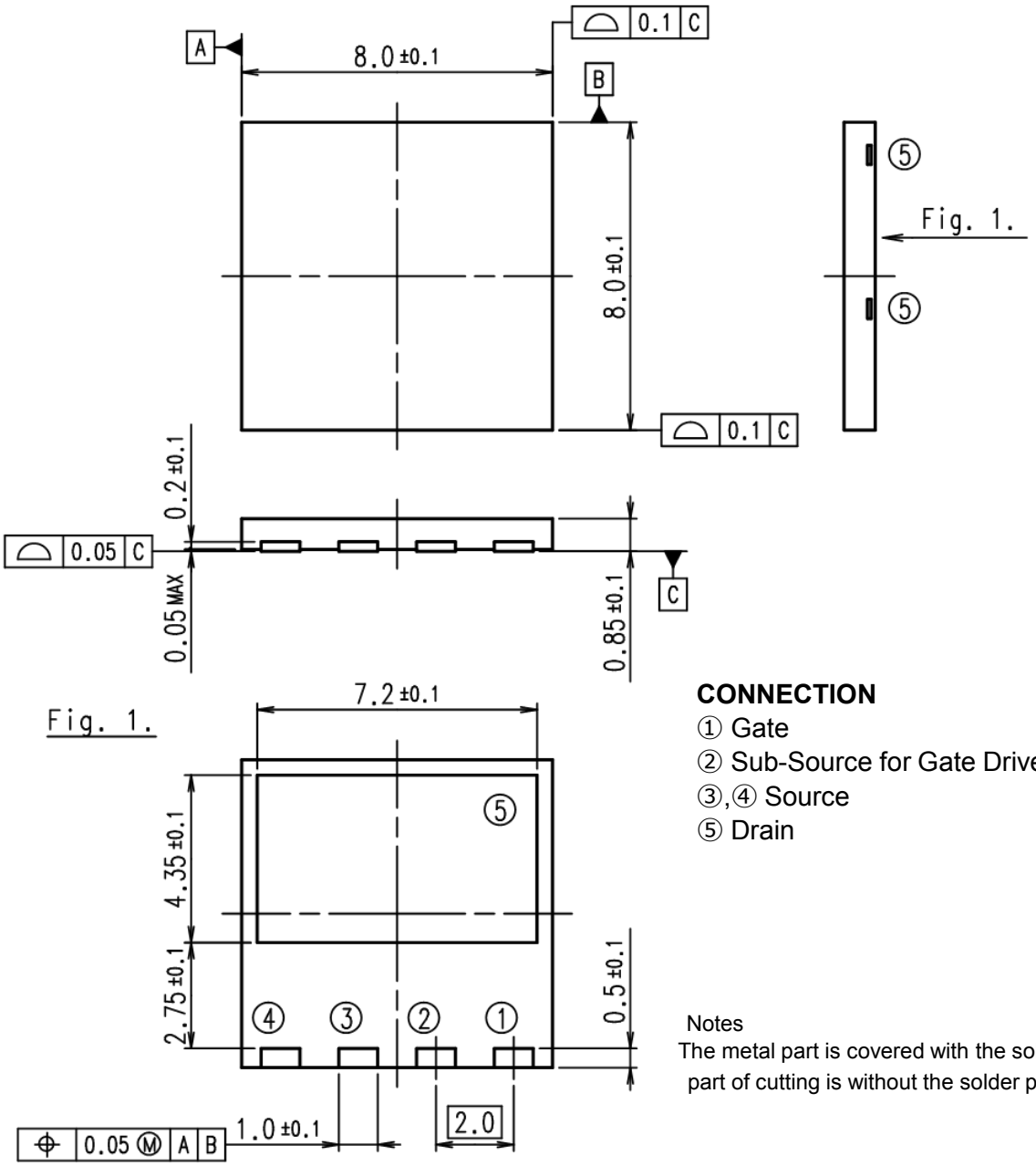



Fig. 1.

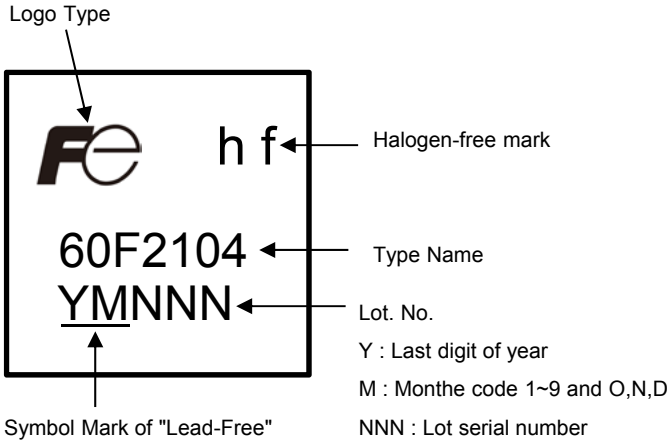



**CONNECTION**

① Gate
② Sub-Source for Gate Drive
③,④ Source
⑤ Drain

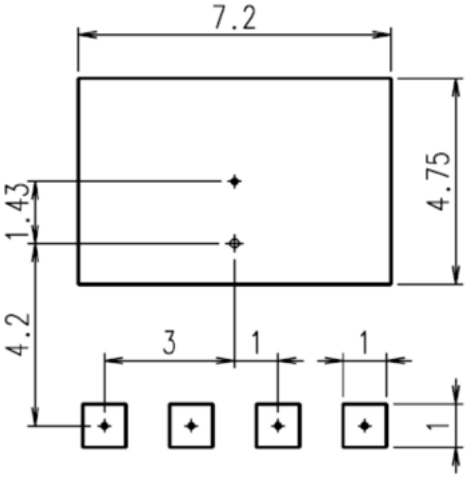
Notes
The metal part is covered with the solder plating, part of cutting is without the solder plating.

## Marking




* The font (font type,size) and the trademark-size might be actually different.

## Recommended footprint




DIMENSIONS ARE IN MILLIMETERS

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• Machine tools • Audiovisual equipment • Electrical home appliances • Personal equipment • Industrial robots etc.

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• Trunk communications equipment
• Traffic-signal control equipment
• Gas leakage detectors with an auto-shut-off feature
• Emergency equipment for responding to disasters and anti-burglary devices
• Safety devices
• Medical equipment

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• Submarine repeater equipment



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