Fuji Electric

*Innovating Energy Technology*

# FML60N103S2HF

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FUJI POWER MOSFET

## Super J MOS® S2 series

**N-Channel enhancement mode power MOSFET**

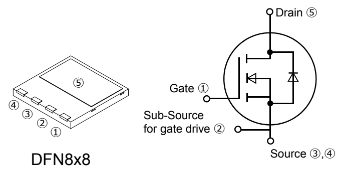
### Features

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 dv/dt** | $dV_{DS}/dt$ | 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 dv/dt** | dv/dt | 15 | V/ns | Note *5 |
| **Peak Diode Recovery -di$_{DR}$/dt** | $-di_{DR}/dt$ | 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 , $-di_{DR}/dt$ ≤ 100 A/μs, $V_{DS\ peak}$ ≤ 600 V, $T_{ch}$ ≤ 150 °C.
Note *6 : $I_{DR}$ ≤ 32.8 A , dv/dt ≤ 15 V/ns, $V_{DS\ peak}$ ≤ 600 V, $T_{ch}$ ≤ 150 °C.



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NOVEMBER 2017

## 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>$I_D$ = 1.74 mA | | 3.5 | 4.0 | 4.5 | 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 | | - | 0.092 | 0.103 | Ω |
| Gate resistance | $r_g$ | $f$ = 1 MHz, open drain | | - | 1.2 | - | Ω |

### • Dynamic characteristics

| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Forward Transconductance | $g_{fs}$ | $V_{DS}$ = 25 V<br>$I_D$ = 16.4 A | 5.7 | 23 | - | S |
| Input Capacitance | $C_{iss}$ | $V_{DS}$ = 400 V<br>$V_{GS}$ = 0 V<br>$f$ = 250 kHz | - | 1830 | - | pF |
| Output Capacitance | $C_{oss}$ | | - | 59 | - | |
| Reverse Transfer Capacitance | $C_{rss}$ | | - | 7.5 | - | |
| Effective output capacitance, energy related (Note *7) | $C_{o(er)}$ | $V_{DS}$ = 0…400 V<br>$V_{GS}$ = 0 V | - | 138 | - | |
| Effective output capacitance, time related (Note *8) | $C_{o(tr)}$ | $V_{DS}$ = 0…400 V<br>$V_{GS}$ = 0 V<br>$I_D$ = constant | - | 546 | - | |
| Turn-On Time | $t_{d(on)}$ | $V_{DD}$ = 400 V, $V_{GS}$ = 10 V<br>$I_D$ = 16.4 A,<br>$R_G$ = 30 Ω<br>See Figure 3 and 4 | - | 33 | - | ns |
| | $t_r$ | | - | 26 | - | |
| Turn-Off Time | $t_{d(off)}$ | | - | 204 | - | |
| | $t_f$ | | - | 24 | - | |
| Total Gate Charge | $Q_G$ | $V_{DD}$ = 400 V, $V_{GS}$ = 10 V<br>$I_D$ = 32.8 A<br>See Figure 5 | - | 72 | - | nC |
| Gate-Source Charge | $Q_{GS}$ | | - | 30 | - | |
| Gate-Drain Charge | $Q_{GD}$ | | - | 29 | - | |

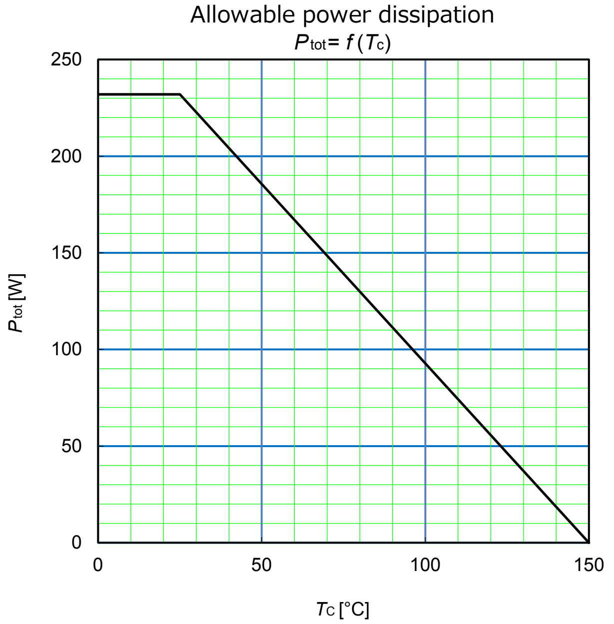
Note *7 : $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as $C_{oss}$ while $V_{DS}$ is rising from 0 to 400 V.
Note *8 : $C_{o(tr)}$ is a fixed capacitance that gives the same charging times as $C_{oss}$ while $V_{DS}$ is rising from 0 to 400 V.

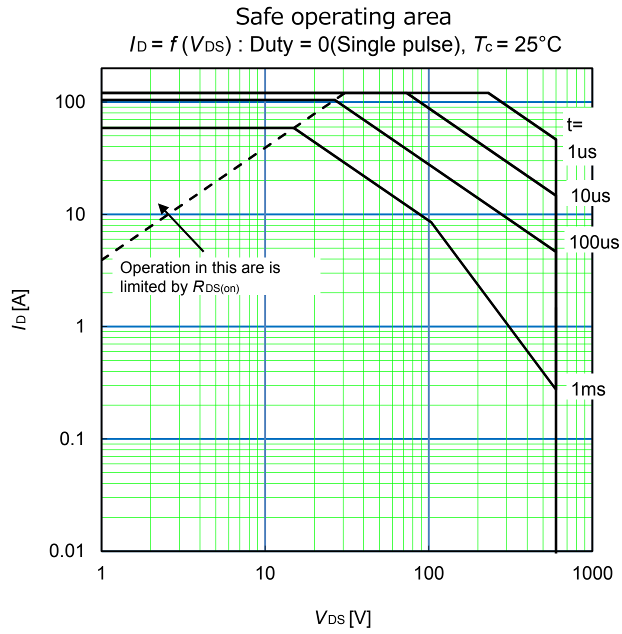
### • Reverse diode characteristics

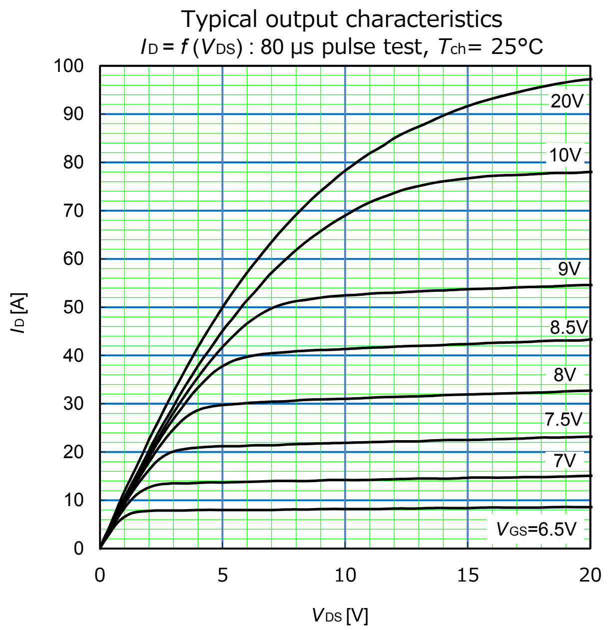
| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Diode Forward On-Voltage | $V_{DSR}$ | $I_{DR}$ = 32.8 A, $V_{GS}$ = 0 V<br>$T_{ch}$ = 25 °C | - | 1.00 | 1.35 | V |
| Reverse Recovery Time | $t_{rr}$ | $V_{DD}$ = 400 V<br>$I_{DR}$ = 32.8 A<br>$V_{GS}$ = 0 V<br>-d$i_{DR}$/d$t$ = 100 A/μs<br>$T_{ch}$ = 25 °C<br>See Figure 6 and 7 | - | 370 | - | ns |
| Reverse Recovery Charge | $Q_{rr}$ | | - | 6.5 | - | μC |
| Peak Reverse Recovery Current | $I_{rrm}$ | | - | 33 | - | A |

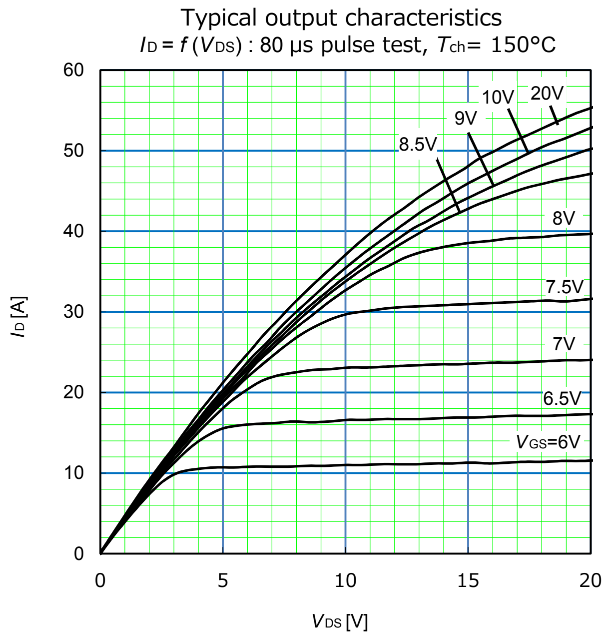
## Thermal Resistance

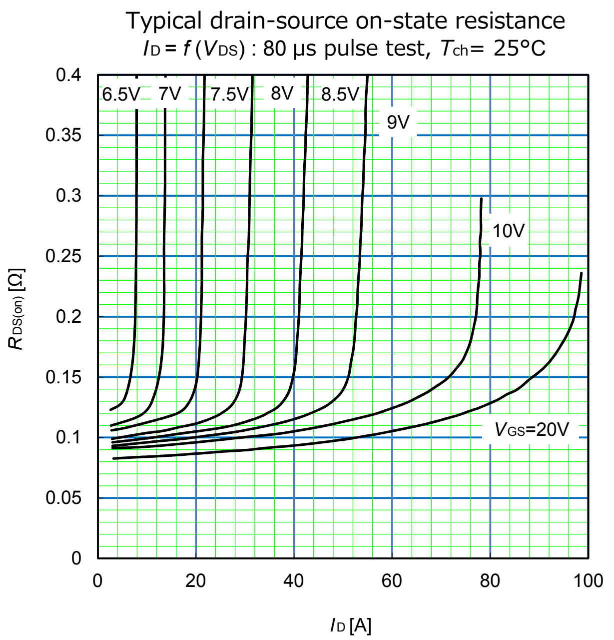
| Parameter | Symbol | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Thermal Resistance, Channel – Ambient | $R_{th(ch-a)}$ | Device mounted on PCB (FR4)<br>Size: 40mm*40mm*1.5mm<br>with 6cm² copper area<br>(one layer, 70μm thickness)<br>for drain connection and cooling. |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

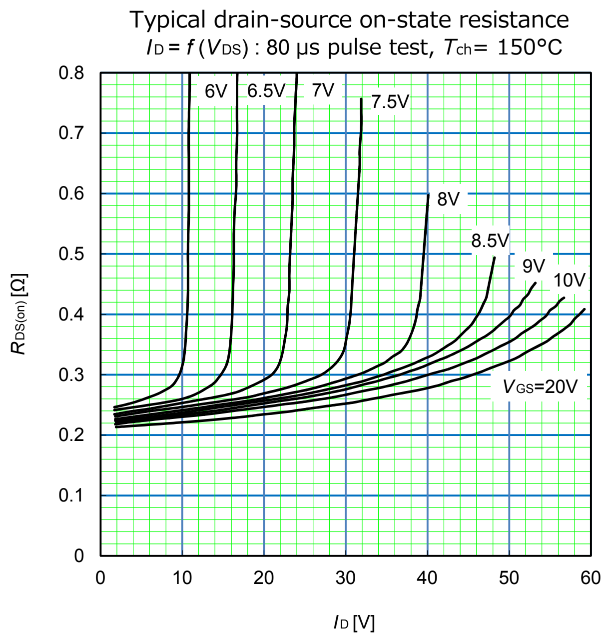

Allowable power dissipation
Ptot= f (Tc)
Ptot [W]
Tc [°C]
250
200
150
100
50
0
0
50
100
150


Safe operating area
ID = f (VDS) : Duty = 0(Single pulse), Tc = 25°C
ID [A]
VDS [V]
t=
1us
10us
100us
1ms
Operation in this are is
limited by RDS(on)
100
10
1
0.1
0.01
1
10
100
1000


Typical output characteristics
ID = f (VDS) : 80 μs pulse test, Tch= 25°C
ID [A]
VDS [V]
20V
10V
9V
8.5V
8V
7.5V
7V
VGS=6.5V
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20

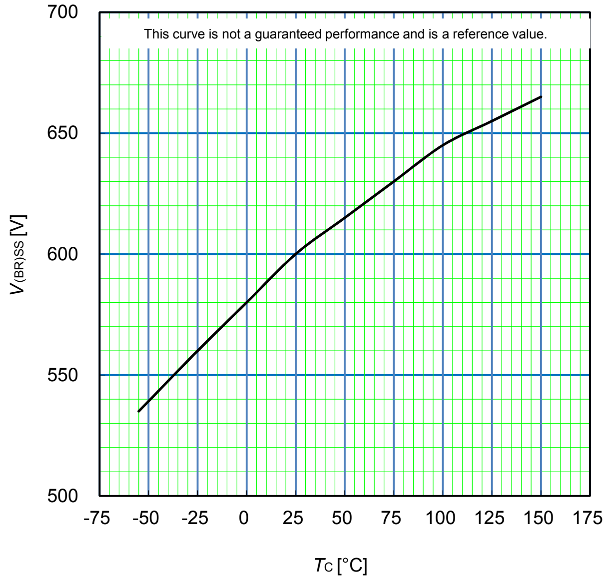

Typical output characteristics
ID = f (VDS) : 80 μs pulse test, Tch= 150°C
ID [A]
VDS [V]
10V
20V
9V
8.5V
8V
7.5V
7V
6.5V
VGS=6V
60
50
40
30
20
10
0
0
5
10
15
20


Typical drain-source on-state resistance
ID = f (VDS) : 80 μs pulse test, Tch= 25°C
RDS(on) [Ω]
ID [A]
6.5V
7V
7.5V
8V
8.5V
9V
10V
VGS=20V
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
20
40
60
80
100


Typical drain-source on-state resistance
ID = f (VDS) : 80 μs pulse test, Tch= 150°C
RDS(on) [Ω]
ID [V]
6V
6.5V
7V
7.5V
8V
8.5V
9V
10V
VGS=20V
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60

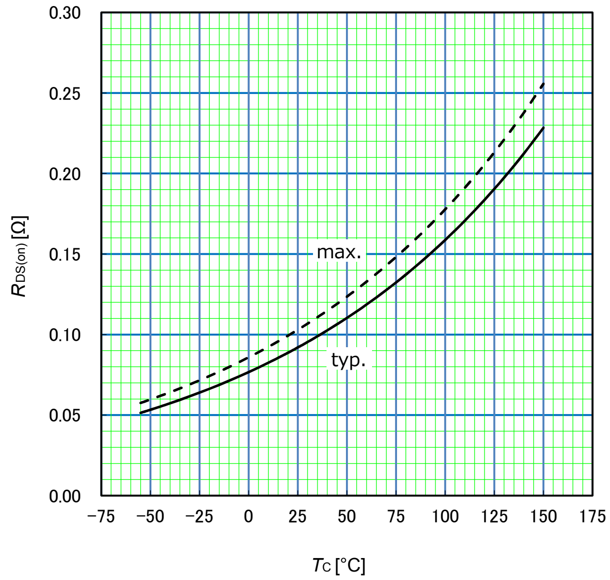
Drain-source breakdown voltage

$V_{(BR)DSS} = f(T_{ch})$ : $I_D$ = 10 mA, $V_{GS}$ = 0 V



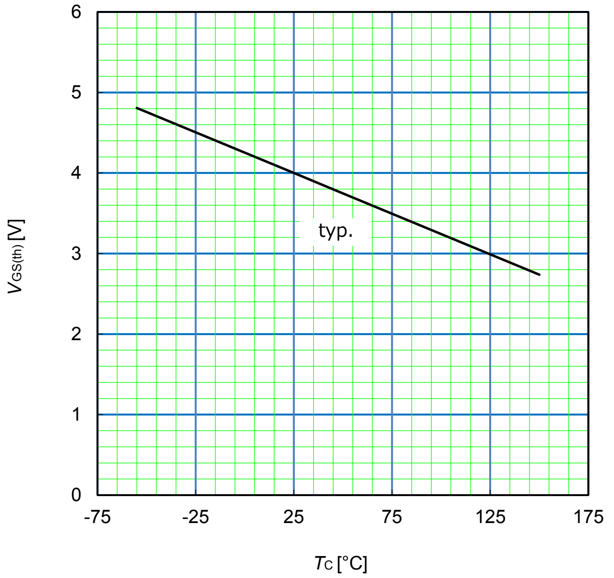

Drain-source on-state resistance

$R_{DS(on)} = f(T_{ch})$ : $I_D$ = 9.3 A, $V_{GS}$ = 10 V



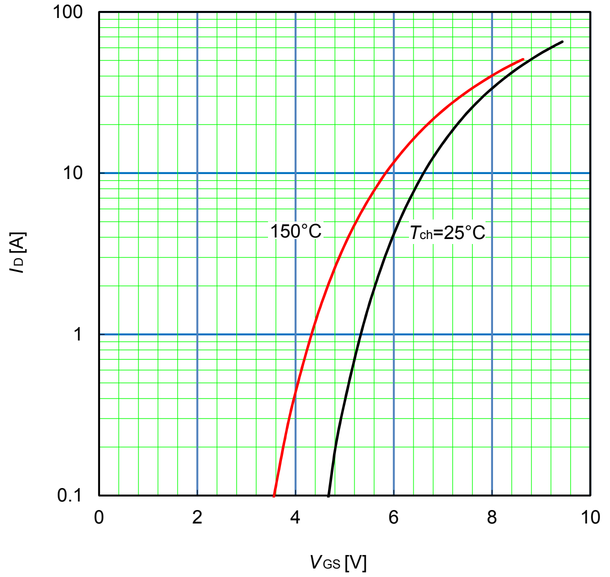

Gate threshold voltage

$V_{GS(th)} = f(T_{ch})$ : $V_{DS} = V_{GS}$, $I_D$ = 1.95 mA



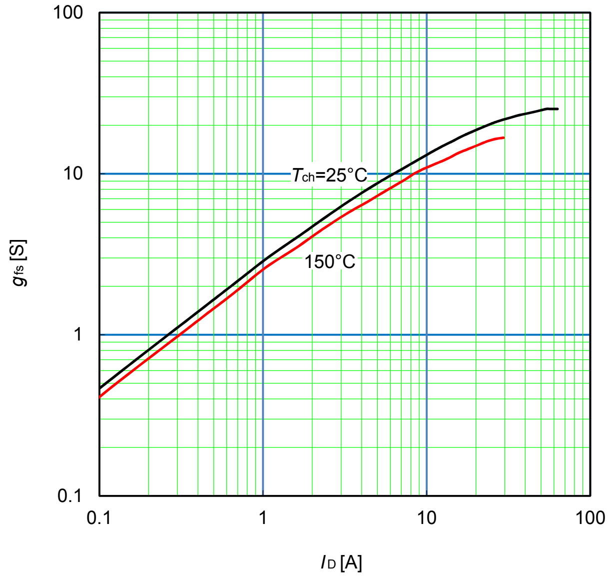

Typical transfer characteristic

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



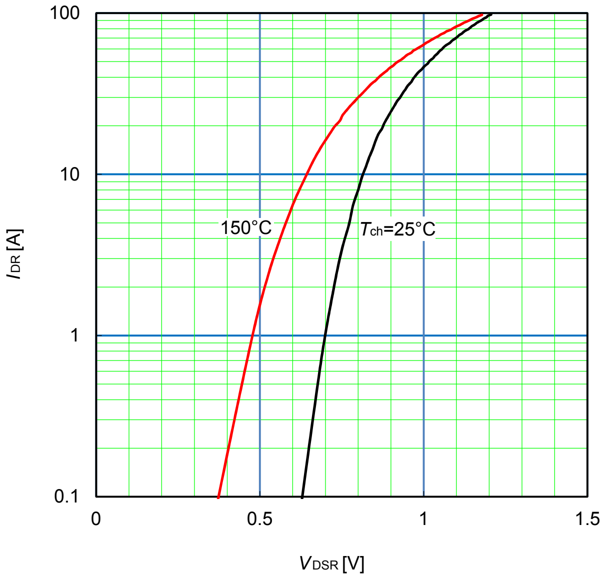

Typical transconductance

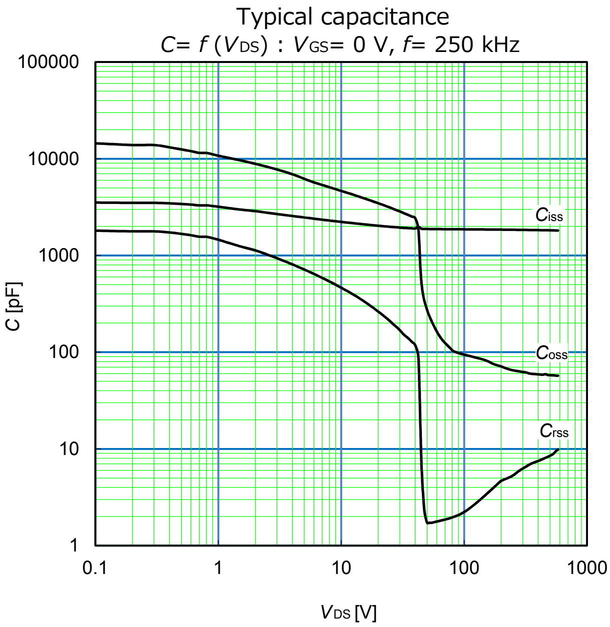
$g_{fs} = f(I_D)$ : 80 μs pulse test, $V_{DS}$ = 25 V

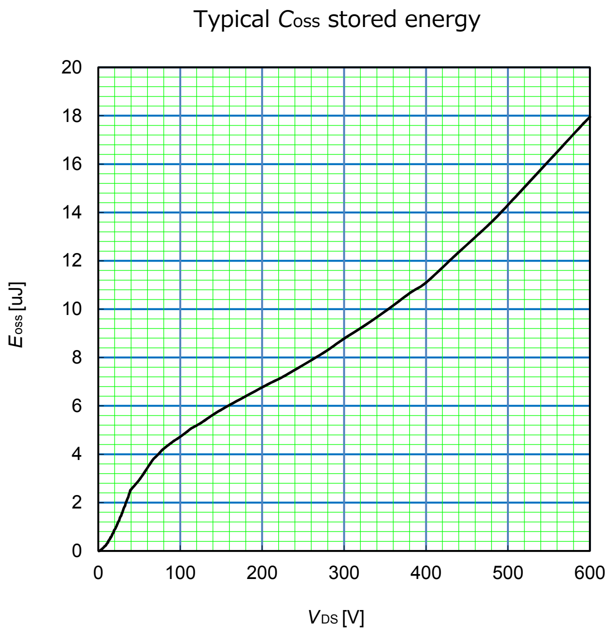


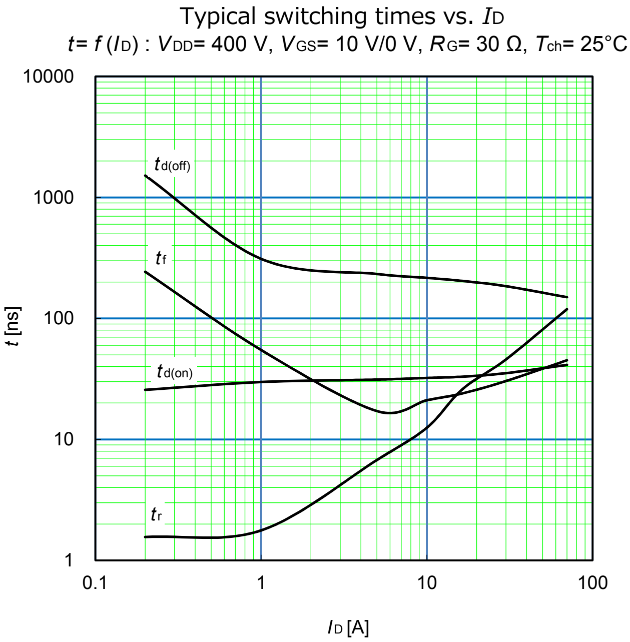

Typical forward characteristics of reverse diode

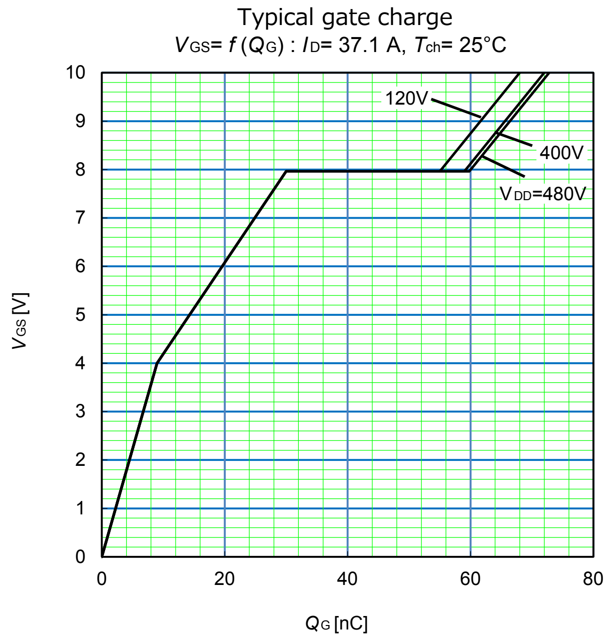
$I_{DR} = f(V_{DSR})$ : 80 μs pulse test

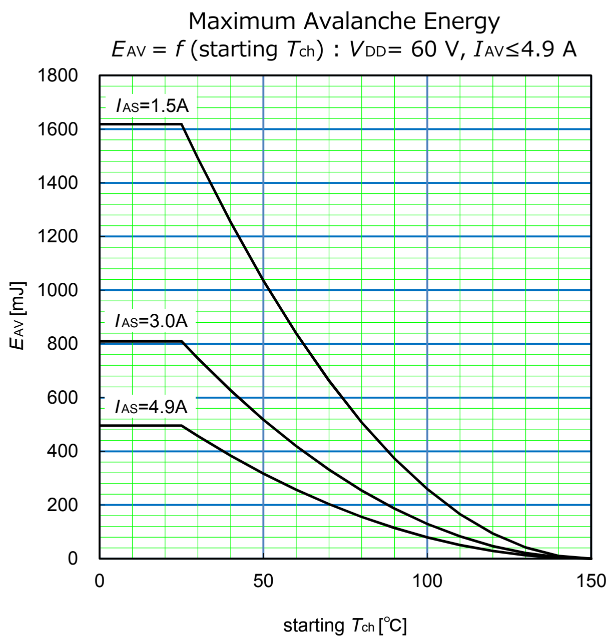


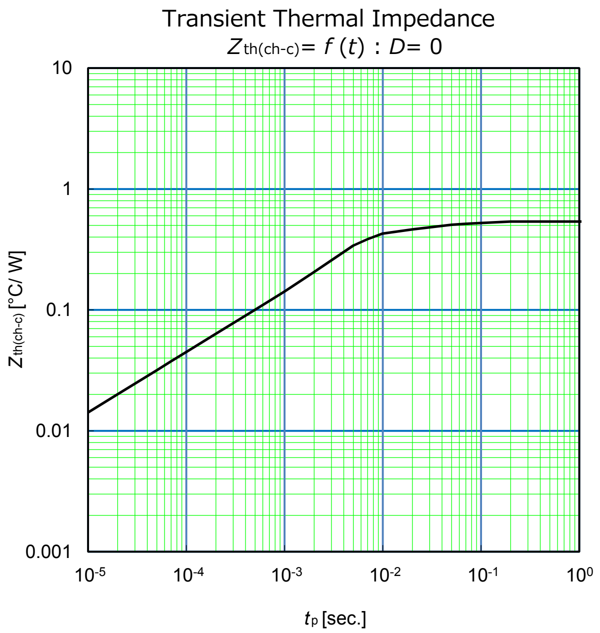

Typical capacitance
C= f (VDS) : VGS= 0 V, f= 250 kHz
100000
10000
1000
100
10
1
0.1
1
10
100
1000
C [pF]
VDS [V]
Ciss
Coss
Crss


Typical Coss stored energy
20
18
16
14
12
10
8
6
4
2
0
0
100
200
300
400
500
600
Eoss [uJ]
VDS [V]


Typical switching times vs. ID
t= f (ID) : VDD= 400 V, VGS= 10 V/0 V, RG= 30 Ω, Tch= 25°C
10000
1000
100
10
1
0.1
1
10
100
t [ns]
ID [A]
td(off)
tf
td(on)
tr


Typical gate charge
VGS= f (QG) : ID= 37.1 A, Tch= 25°C
10
9
8
7
6
5
4
3
2
1
0
0
20
40
60
80
VGS [V]
QG [nC]
120V
400V
VDD=480V


Maximum Avalanche Energy
EAV = f (starting Tch) : VDD= 60 V, IAV≤4.9 A
1800
1600
1400
1200
1000
800
600
400
200
0
0
50
100
150
EAV [mJ]
starting Tch [°C]
IAS=1.5A
IAS=3.0A
IAS=4.9A


Transient Thermal Impedance
Zth(ch-c)= f (t) : D= 0
10
1
0.1
0.01
0.001
10-5
10-4
10-3
10-2
10-1
100
Zth(ch-c) [°C/ W]
tp [sec.]

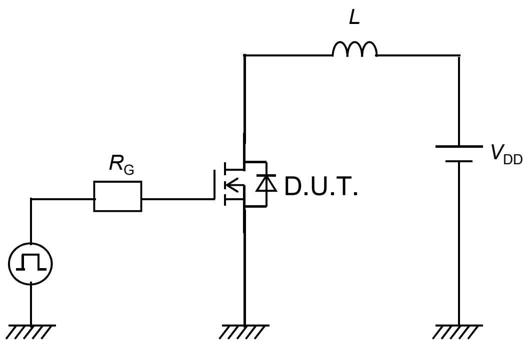



Figure 1. Unclamped inductive load test circuit

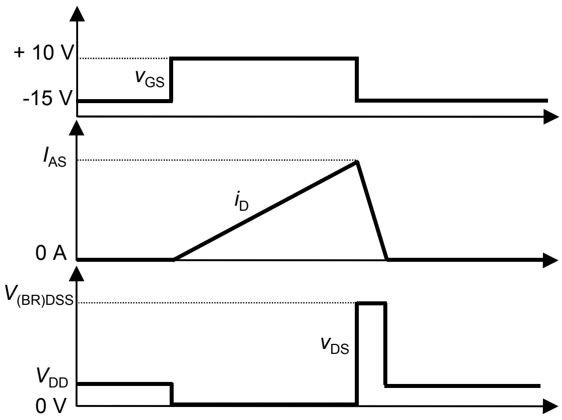



Figure 2. Unclamped inductive waveform

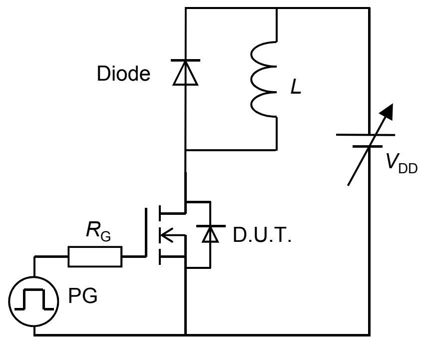



Figure 3. Switching test circuit

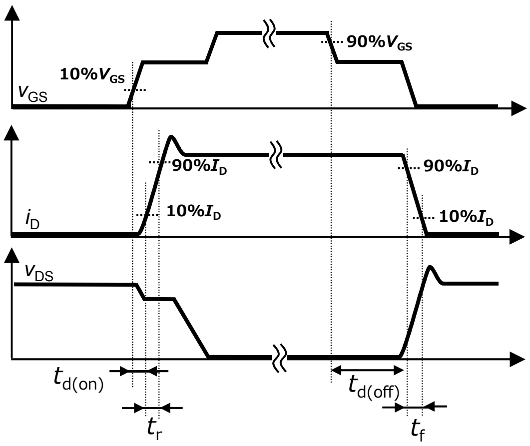



Figure 4. Switching times waveform

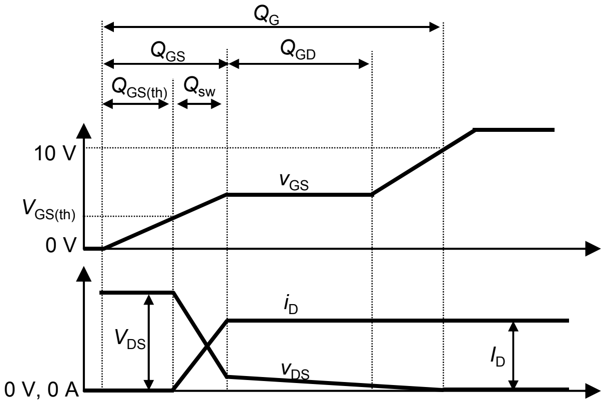



Figure 5. Gate charge waveform

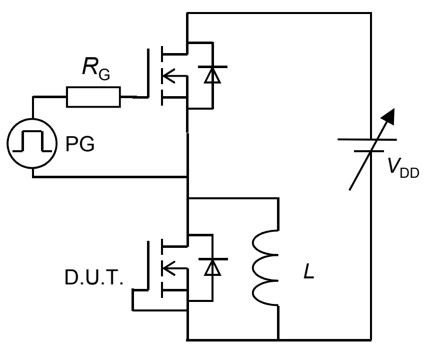



Figure 6. Diode reverse recovery test circuit

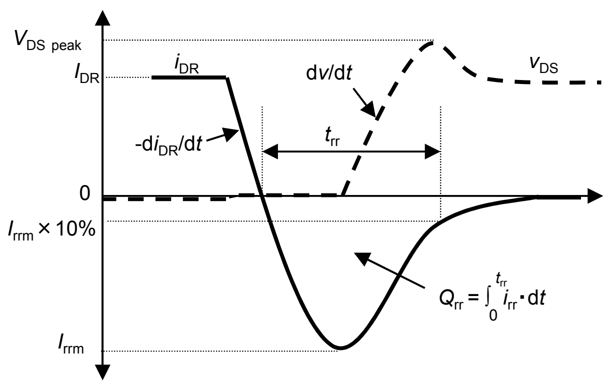
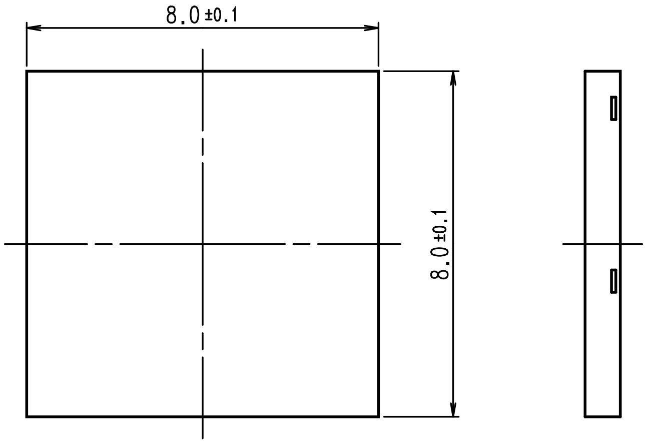
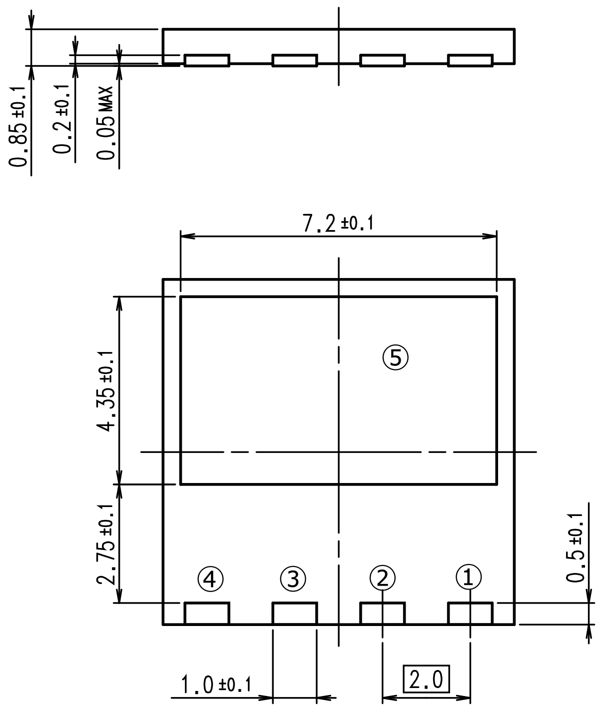



Figure 7. Diode reverse recovery waveform

## Package Dimensions : DFN8x8 Package




**CONNECTION**

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

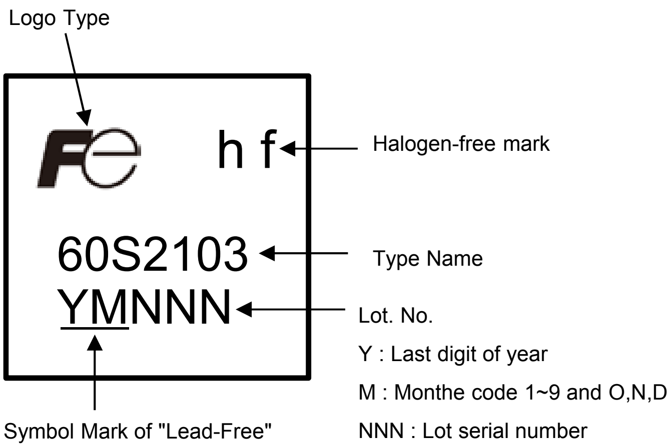
DIMENSIONS ARE IN MILLIMETERS

Notes

1.( ) : Reference dimensions.

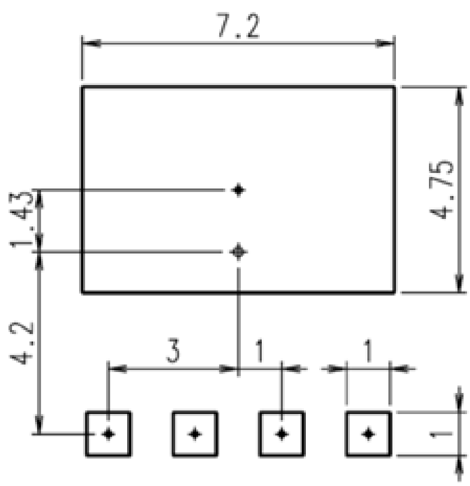
2. The metal part is covered with the solder plating, part of cutting is without the solder plating.

## Marking




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

## Recommended footprint



## WARNING

1. This Catalog contains the product specifications, characteristics, data, materials, and structures as of November 2017.
The contents are subject to change without notice for specification changes or other reasons. When using a product listed in this Catalog, be sur to obtain the latest specifications.

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4. The products introduced in this Catalog are intended for use in the following electronic and electrical equipment which has normal reliability requirements.
   - Computers
   - OA equipment
   - Communications equipment (terminal devices)
   - Measurement equipment
   - Machine tools
   - Audiovisual equipment
   - Electrical home appliances
   - Personal equipment
   - Industrial robots etc.

5. If you need to use a product in this Catalog for equipment requiring higher reliability than normal, such as for the equipment listed below, it is imperative to contact Fuji Electric Co., Ltd. to obtain prior approval. When using these products for such equipment, take adequate measures such as a backup system to prevent the equipment from malfunctioning even if a Fuji's product incorporated in the equipment becomes faulty.
   - Transportation equipment (mounted on cars and ships)
   - 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

6. Do not use products in this Catalog for the equipment requiring strict reliability such as the following and equivalents to strategic equipment (without limitation).
   - Space equipment
   - Aeronautic equipment
   - Nuclear control equipment
   - Submarine repeater equipment



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