Fuji Electric **Innovating Energy Technology**

FML60N191S2FDHF

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FUJI POWER MOSFET

Super J MOS® S2 series

N-Channel enhancement mode power MOSFET

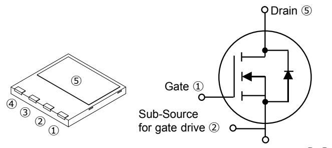
Features

- 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	22.7	A	T_C=25°C Note*1,2
		14.3	A	T_C=100°C Note*1,2
Pulsed Drain Current	I_{DP}	66.0	A	Note *2
Gate-Source Voltage	V_{GS}	±30	V	
Non-Repetitive Maximum Avalanche Current	I_{AS}	2.7	A	Note *3
Non-Repetitive Maximum Avalanche Energy	E_{AS}	391.1	mJ	Note *4
Maximum MOSFET d*v*/d*t*	dV_{DS}/d*t*	50	V/ns	V_{DS}≤ 600V
Continuous Diode Forward Current	I_{DR}	22.7	A	T_C=25°C Note*1,2
		14.3	A	T_C=100°C Note*1,2
Pulsed Diode Forward Current	I_{DRP}	66.0	A	Note *2
Peak Diode Recovery d*v*/d*t*	d*v*/d*t*	30	V/ns	Note *5
Peak Diode Recovery -di_{DR}/d*t*	-di_{DR}/d*t*	100	A/μs	Note *6
Maximum Power Dissipation	P_{tot}	127	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} = 1.7 A, L = 248 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} ≤ 17.9 A , -di_{DR}/d*t* ≤ 100 A/μs, $V_{DS\ peak}$ ≤ 600 V, T_{ch} ≤ 150 °C.
Note *6 : I_{DR} ≤ 17.9 A , d*v*/d*t* ≤ 30 V/ns, $V_{DS\ peak}$ ≤ 600 V, T_{ch} ≤ 150 °C.

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 I_D = 250 µA		600	-	-	V
Gate Threshold Voltage	$V_{GS(th)}$	V_{DS} = V_{GS} I_D = 2.7 mA		3.0	4.0	5.0	V
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS} = 600 V V_{GS} = 0 V	T_{ch} = 25 °C	-	-	25	µA
		V_{DS} = 480 V V_{GS} = 0 V	T_{ch} = 125 °C	-	-	250	
Gate-Source Leakage Current	I_{GSS}	V_{DS} = 0 V V_{GS} = ± 30 V		-	10	100	nA
Drain-Source On-State Resistance	$R_{DS(on)}$	V_{GS} = 10 V I_D = 4.5 A		-	0.171	0.191	Ω
Gate resistance	r_g	f = 1 MHz, open drain		-	9.8	-	Ω

• Dynamic characteristics

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Forward Transconductance	g_{fs}	V_{DS} = 25 V I_D = 9.0 A	3.2	13	-	S
Input Capacitance	C_{iss}	V_{DS} = 400 V V_{GS} = 0 V f = 250 kHz	-	940	-	pF
Output Capacitance	C_{oss}		-	34	-	
Reverse Transfer Capacitance	C_{rss}		-	5.2	-	
Effective output capacitance, energy related (Note *7)	$C_{o(er)}$	V_{DS} = 0…400 V V_{GS} = 0 V	-	83	-	
Effective output capacitance, time related (Note *8)	$C_{o(tr)}$	V_{DS} = 0…400 V V_{GS} = 0 V I_D = constant	-	321	-	
Turn-On Time	$t_{d(on)}$	V_{DD} = 400 V, V_{GS} = 10 V I_D = 9.0 A, R_G = 36 Ω See Figure 3 and 4	-	31	-	ns
	t_r		-	23	-	
Turn-Off Time	$t_{d(off)}$		-	184	-	
	t_f		-	19	-	
Total Gate Charge	Q_G	V_{DD} = 400 V, V_{GS} = 10 V I_D = 17.9 A See Figure 5	-	48	-	nC
Gate-Source Charge	Q_{GS}		-	20	-	
Gate-Drain Charge	Q_{GD}		-	26	-	

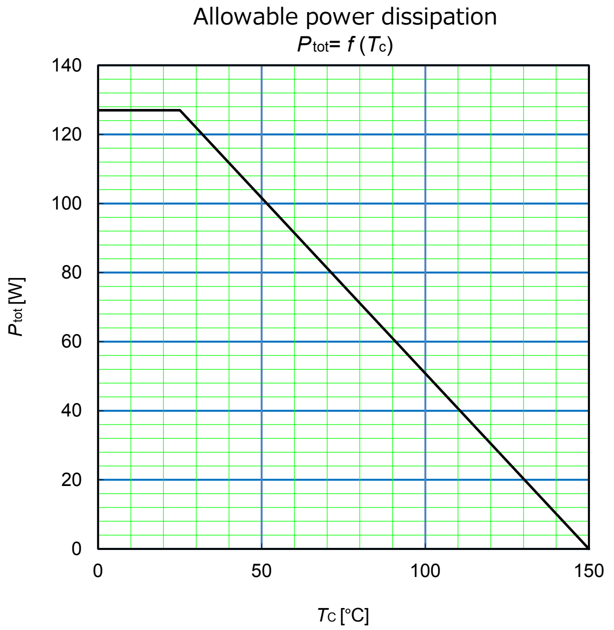
Note *7 : $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as C_{oss} while V_{DS} is rising from 0 to 400 V.
Note *8 : $C_{o(tr)}$ is a fixed capacitance that gives the same charging times as C_{oss} while V_{DS} is rising from 0 to 400 V.

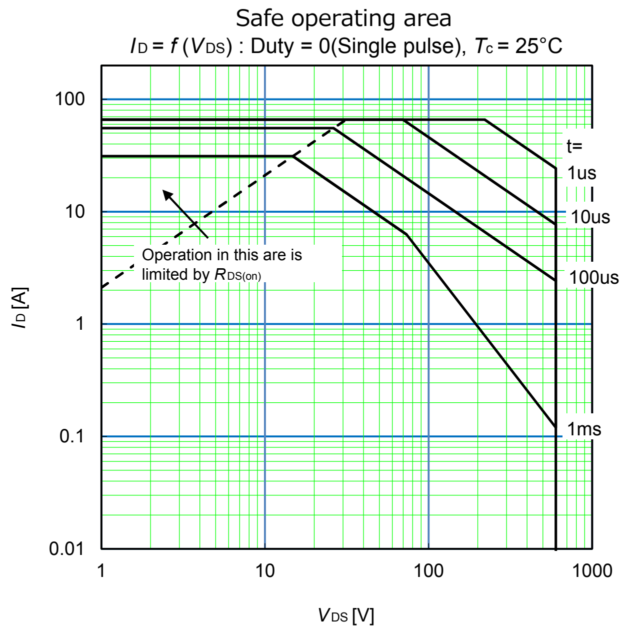
• Reverse diode characteristics

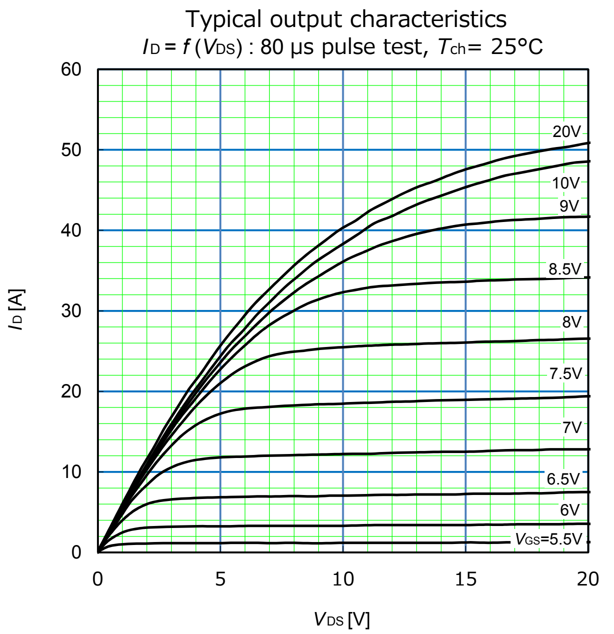
Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Diode Forward On-Voltage	V_{DSR}	I_{DR} = 17.9 A, V_{GS} = 0 V T_{ch} = 25 °C	-	1.00	1.35	V
Reverse Recovery Time	t_{rr}	V_{DD} = 400 V I_{DR} = 17.9 A V_{GS} = 0 V -di_{DR}/dt = 100 A/µs T_{ch} = 25 °C See Figure 6 and 7	-	150	-	ns
Reverse Recovery Charge	Q_{rr}		-	1	-	µC
Peak Reverse Recovery Current	I_{rrm}		-	12.9	-	A

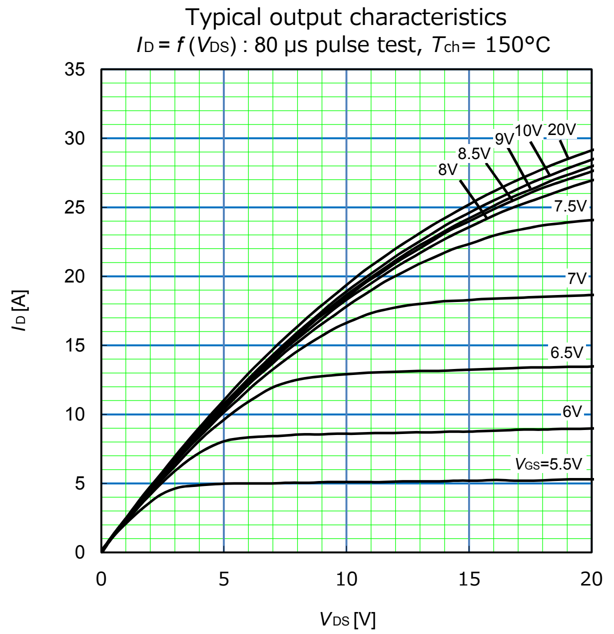
Thermal Resistance

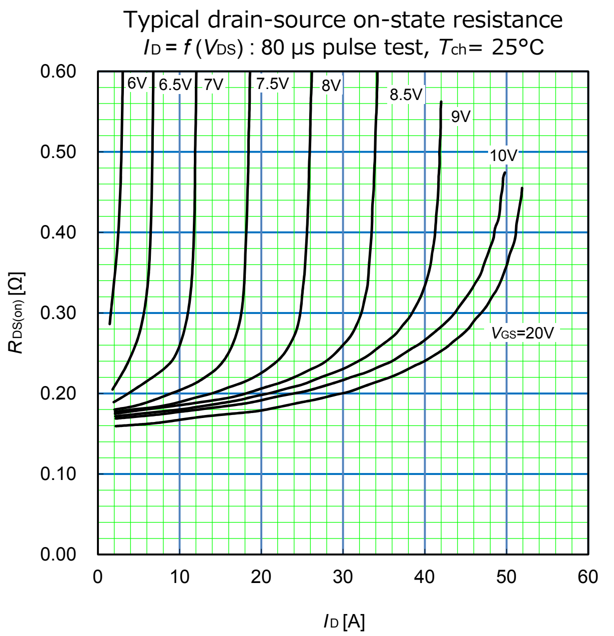
Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Thermal Resistance, Channel – Ambient	$R_{th(ch-a)}$	Device mounted on PCB (FR4) Size: 40mm*40mm*1.5mm with 6cm² copper area (one layer, 70µm thickness) for drain connection and cooling.	-	-	45	°C/W
Thermal Resistance, Channel – Case	$R_{th(ch-c)}$		-	-	0.984	°C/W

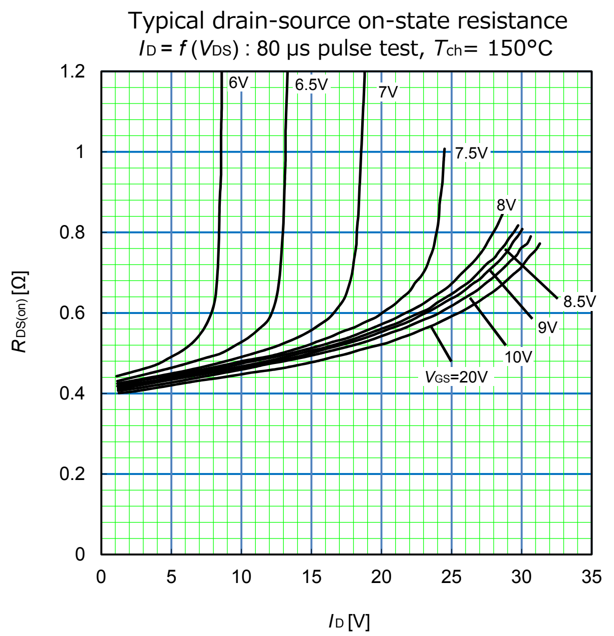

Allowable power dissipation
Ptot= f (Tc)
Ptot [W]
Tc [°C]
140
120
100
80
60
40
20
0
0
50
100
150


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


Typical output characteristics
ID = f (VDS) : 80 μs pulse test, Tch= 25°C
20V
10V
9V
8.5V
8V
7.5V
7V
6.5V
6V
VGS=5.5V
ID [A]
VDS [V]
60
50
40
30
20
10
0
0
5
10
15
20

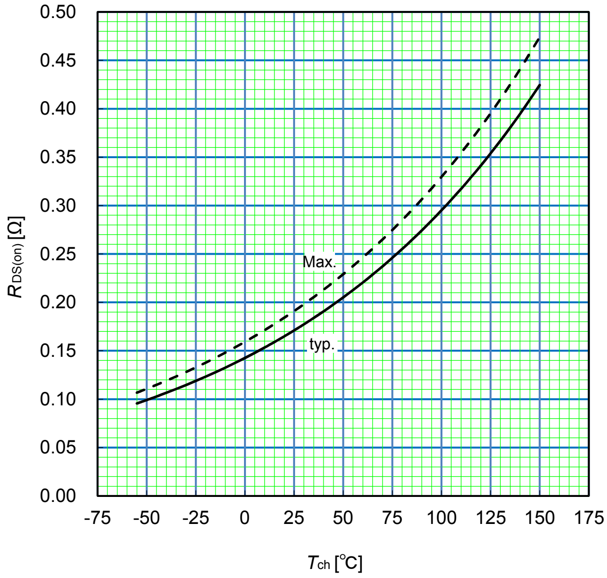

Typical output characteristics
ID = f (VDS) : 80 μs pulse test, Tch= 150°C
9V
10V
20V
8.5V
8V
7.5V
7V
6.5V
6V
VGS=5.5V
ID [A]
VDS [V]
35
30
25
20
15
10
5
0
0
5
10
15
20


Typical drain-source on-state resistance
ID = f (VDS) : 80 μs pulse test, Tch= 25°C
6V
6.5V
7V
7.5V
8V
8.5V
9V
10V
VGS=20V
RDS(on) [Ω]
ID [A]
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
10
20
30
40
50
60


Typical drain-source on-state resistance
ID = f (VDS) : 80 μs pulse test, Tch= 150°C
6V
6.5V
7V
7.5V
8V
8.5V
9V
10V
VGS=20V
RDS(on) [Ω]
ID [V]
1.2
1
0.8
0.6
0.4
0.2
0
0
5
10
15
20
25
30
35

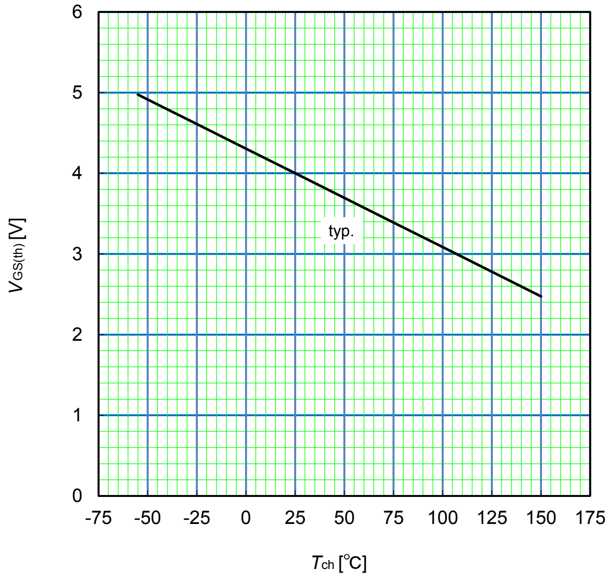
Drain-source on-state resistance

$R_{DS(on)} = f(T_{ch})$: I_D = 4.5 A, V_{GS} = 10 V



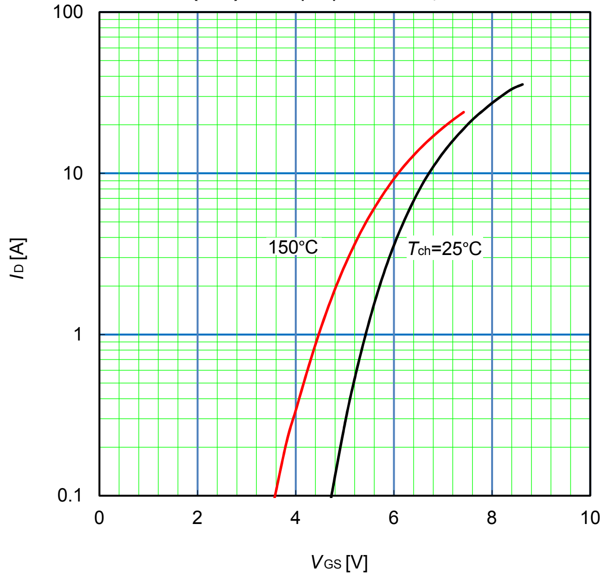
Gate threshold voltage

$V_{GS(th)} = f(T_{ch})$: $V_{DS} = V_{GS}$, I_D = 2.7 mA



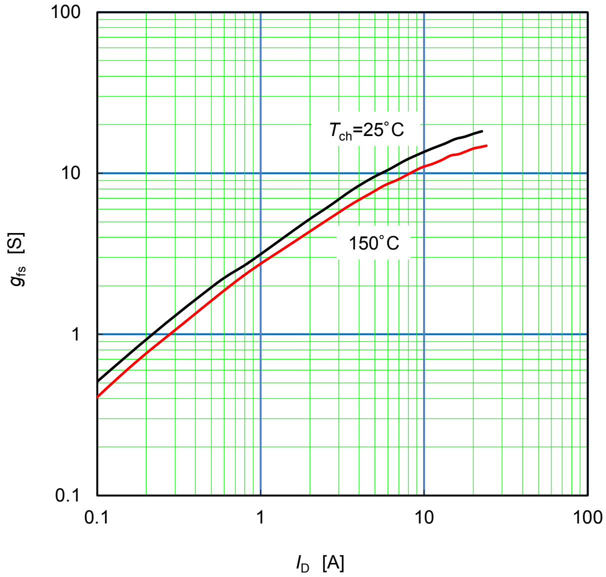
Typical transfer characteristic

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



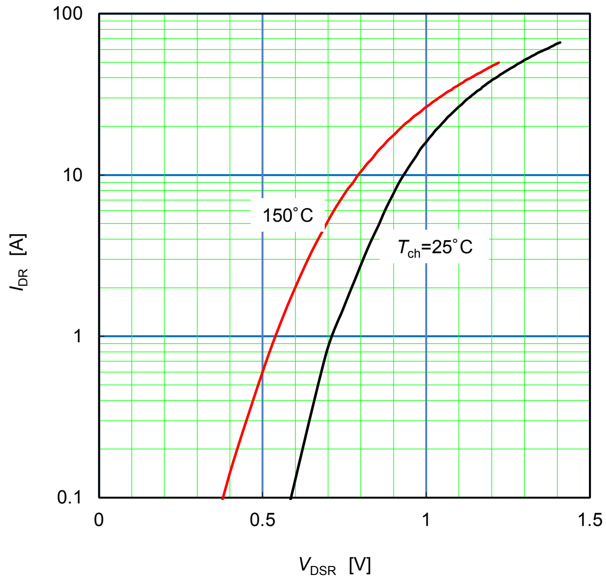
Typical transconductance

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



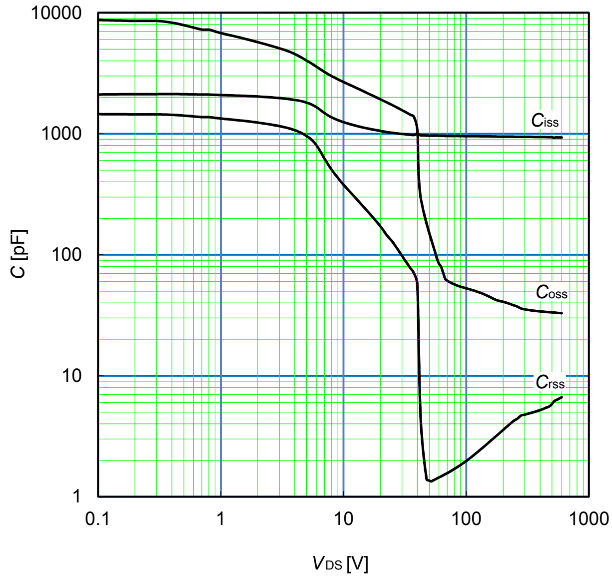
Typical forward characteristics of reverse diode

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

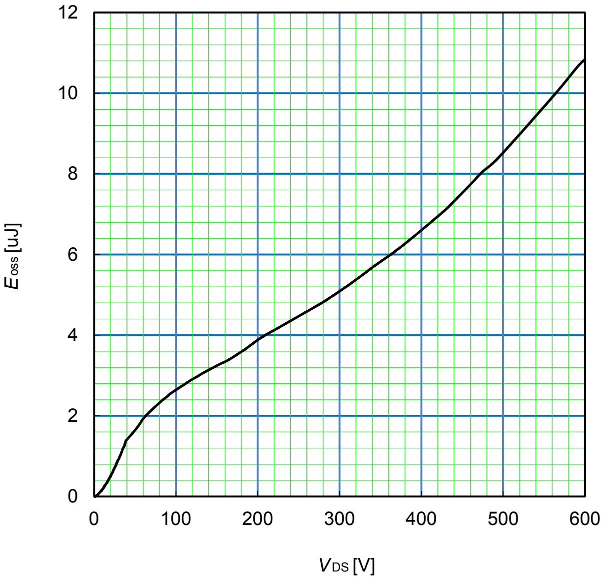


Typical capacitance

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

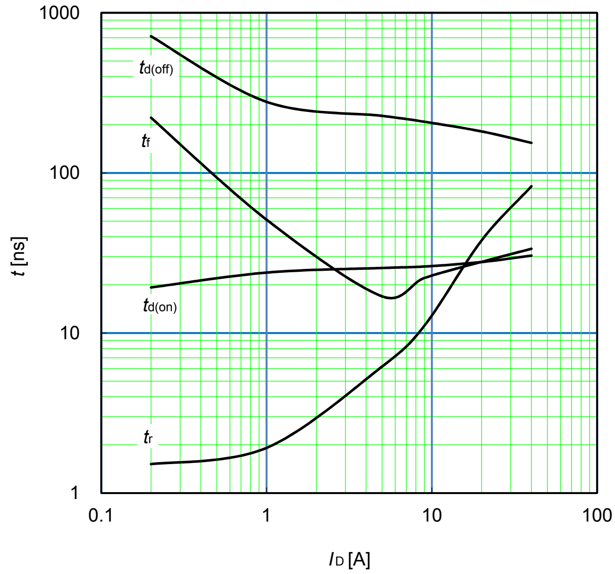


Typical C_{oss} stored energy



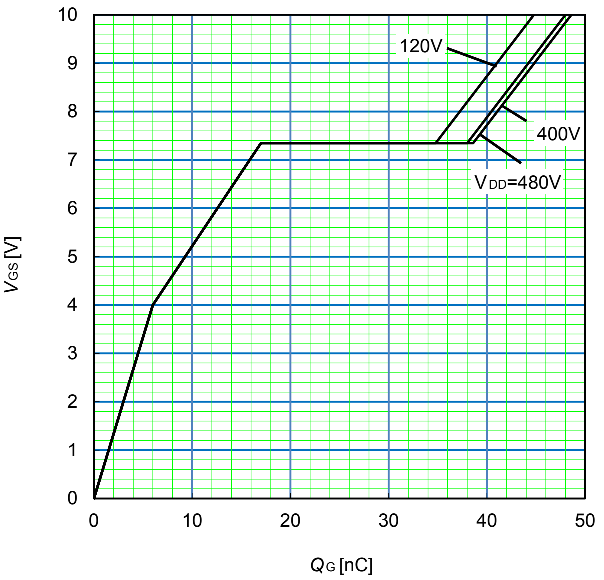
Typical switching times vs. I_D

$t = f(I_D)$: V_{DD}= 400 V, V_{GS}= 10 V/0 V, R_G= 36 Ω, T_{ch}= 25°C



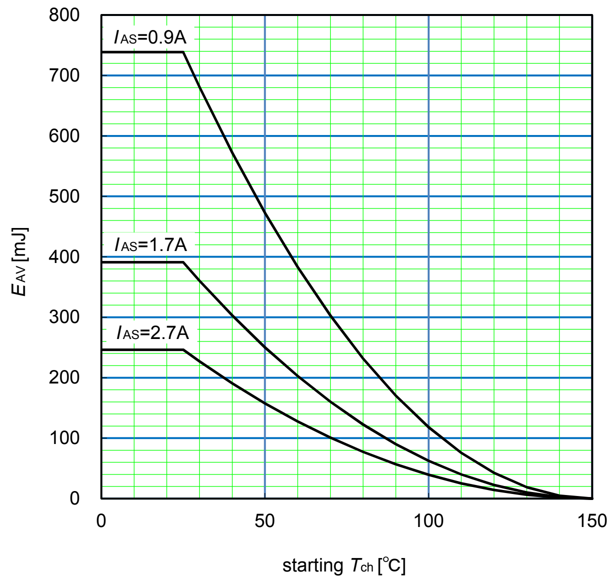
Typical gate charge

$V_{GS} = f(Q_G)$: I_D= 17.9 A, T_{ch}= 25°C



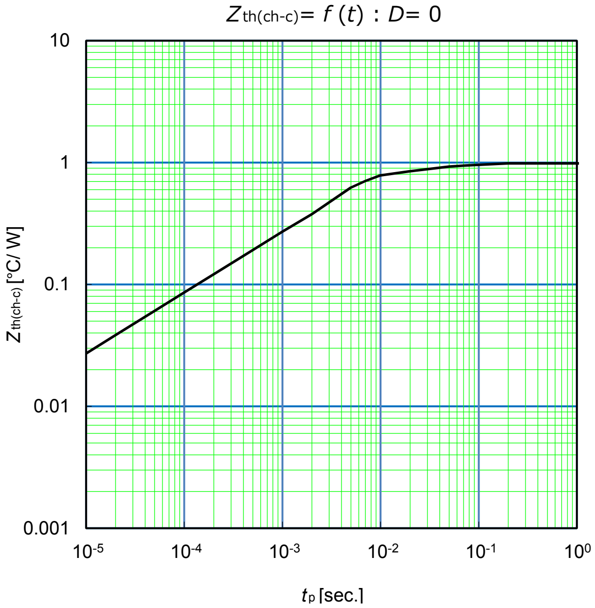
Maximum Avalanche Energy

$E_{AV} = f$(starting T_{ch}) : V_{DD}= 60 V, I_{AV}≤2.7 A



Transient Thermal Impedance

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



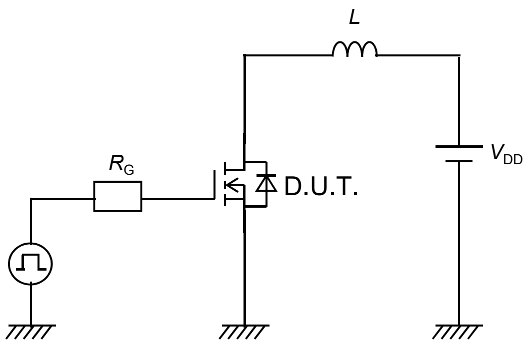


Figure 1. Unclamped inductive load test circuit

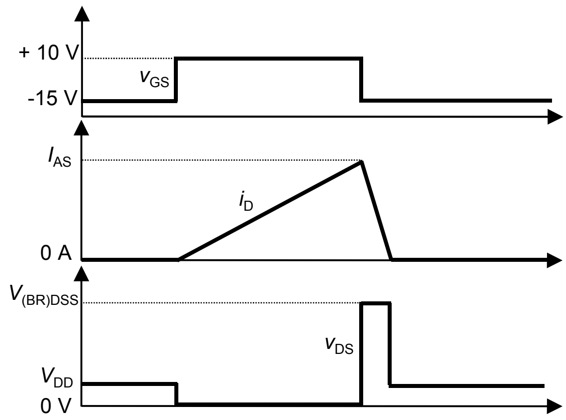


Figure 2. Unclamped inductive waveform

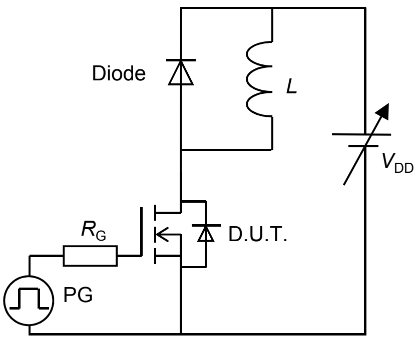


Figure 3. Switching test circuit

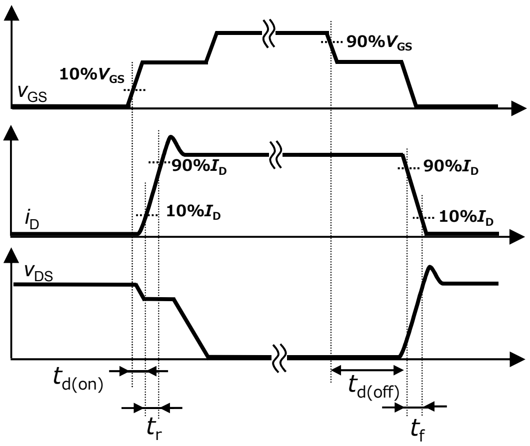


Figure 4. Switching times waveform

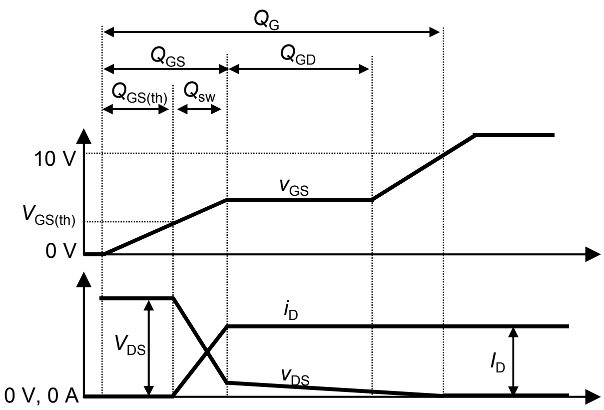


Figure 5. Gate charge waveform

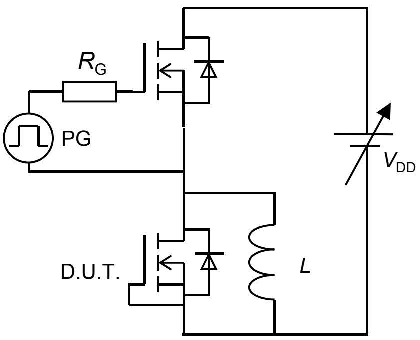


Figure 6. Diode reverse recovery test circuit

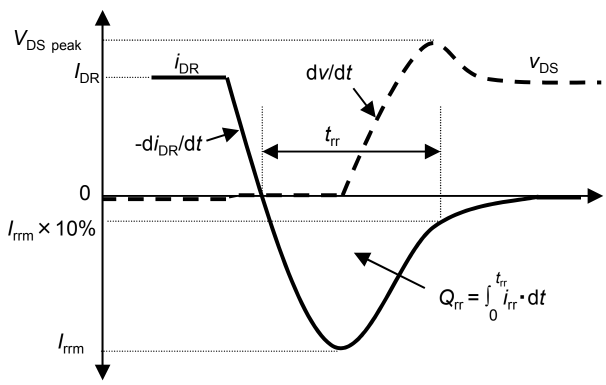
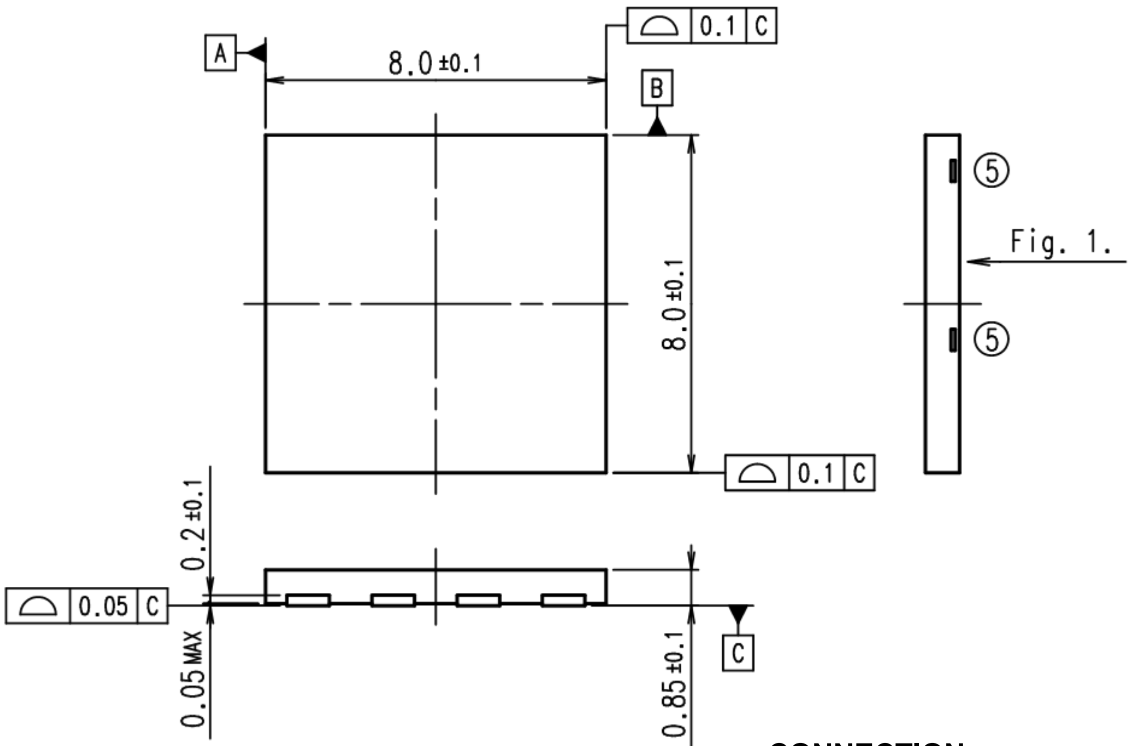
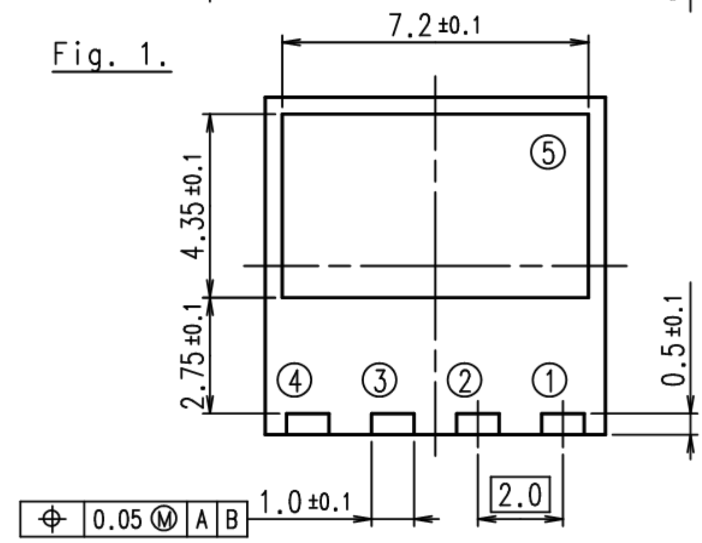


Figure 7. Diode reverse recovery waveform

Package Dimensions : DFN8x8 Package

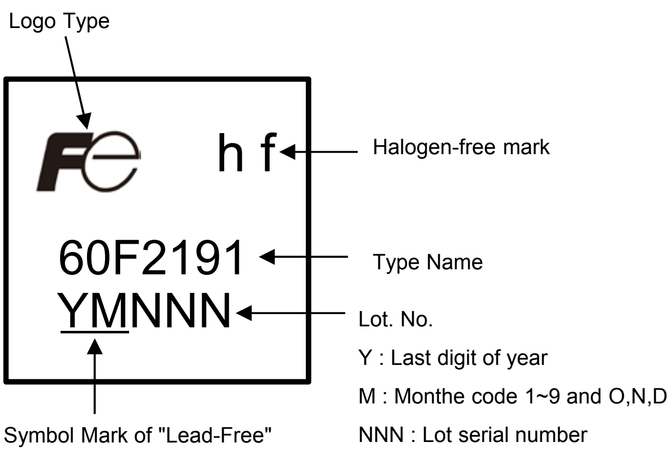




CONNECTION
① Gate
② Sub-Source for Gate Drive
③,④ Source
⑤ Drain

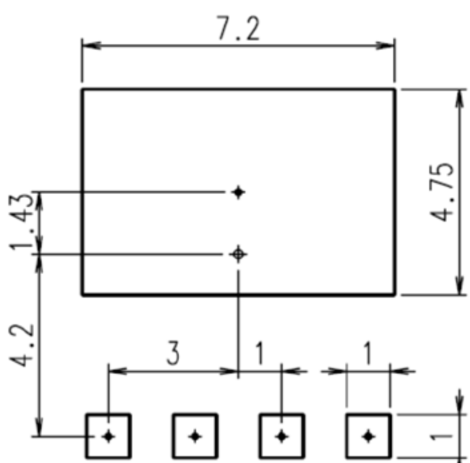
Notes
The metal part is covered with the solder plating, part of cutting is without the solder plating.

Marking



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

Recommended footprint



DIMENSIONS ARE IN MILLIMETERS

WARNING

1. This Catalog contains the product specifications, characteristics, data, materials, and structures as of September 2021. The contents are subject to change without notice for specification changes or other reasons. When using a product listed in this Catalog, be sure 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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