

V_{DSS}	600V
$R_{DS(on)}$ (Max.)	0.51 Ω
I_D	12A
P_D	50W

●Features

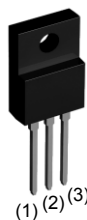
- 1) Fast reverse recovery time (t_{rr}).
- 2) Low on-resistance.
- 3) Fast switching speed.
- 4) Gate-source voltage (V_{GSS}) guaranteed to be $\pm 30V$.
- 5) Drive circuits can be simple.
- 6) Parallel use is easy.
- 7) Pb-free lead plating ; RoHS compliant

●Application

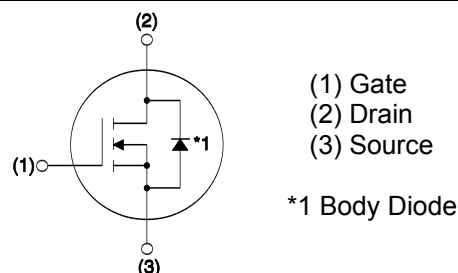
Switching Power Supply

●Outline

TO-220FM



●Inner circuit



●Packaging specifications

Type	Packaging	Bulk
	Reel size (mm)	-
	Tape width (mm)	-
	Basic ordering unit (pcs)	500
	Taping code	-
	Marking	R6012FNX

●Absolute maximum ratings($T_a = 25^\circ C$)

Parameter		Symbol	Value	Unit
Drain - Source voltage		V_{DSS}	600	V
Continuous drain current	$T_c = 25^\circ C$	I_D^{*1}	± 12	A
	$T_c = 100^\circ C$	I_D^{*1}	± 6	A
Pulsed drain current		$I_{D,pulse}^{*2}$	± 48	A
Gate - Source voltage		V_{GSS}	± 30	V
Avalanche energy, single pulse		E_{AS}^{*3}	9.6	mJ
Avalanche energy, repetitive		E_{AR}^{*4}	3.5	mJ
Avalanche current		I_{AR}^{*3}	6	A
Power dissipation ($T_c = 25^\circ C$)		P_D	50	W
Junction temperature		T_j	150	$^\circ C$
Range of storage temperature		T_{stg}	-55 to +150	$^\circ C$
Reverse diode dv/dt		dv/dt ^{*5}	15	V/ns

●Absolute maximum ratings

Parameter	Symbol	Conditions	Values	Unit
Drain - Source voltage slope	dv/dt	$V_{DS} = 480V, I_D = 12A$ $T_j = 125^\circ C$	50	V/ns

●Thermal resistance

Parameter	Symbol	Values			Unit
		Min.	Typ.	Max.	
Thermal resistance, junction - case	R_{thJC}	-	-	2.5	$^\circ C/W$
Thermal resistance, junction - ambient	R_{thJA}	-	-	70	$^\circ C/W$
Soldering temperature, wavesoldering for 10s	T_{sold}	-	-	265	$^\circ C$

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

Parameter	Symbol	Conditions	Values			Unit
			Min.	Typ.	Max.	
Drain - Source breakdown voltage	$V_{(BR)DSS}$	$V_{GS} = 0V, I_D = 1mA$	600	-	-	V
Drain - Source avalanche breakdown voltage	$V_{(BR)DS}$	$V_{GS} = 0V, I_D = 12A$	-	700	-	V
Zero gate voltage drain current	I_{DSS}	$V_{DS} = 600V, V_{GS} = 0V$ $T_j = 25^\circ C$	-	1	100	μA
		$T_j = 125^\circ C$	-	-	10	mA
Gate - Source leakage current	I_{GSS}	$V_{GS} = \pm 30V, V_{DS} = 0V$	-	-	± 100	nA
Gate threshold voltage	$V_{GS(th)}$	$V_{DS} = 10V, I_D = 1mA$	3	-	5	V
Static drain - source on - state resistance	$R_{DS(on)}^{*6}$	$V_{GS} = 10V, I_D = 6A$ $T_j = 25^\circ C$	-	0.39	0.51	Ω
		$T_j = 125^\circ C$	-	0.75	-	
Gate input resistance	R_G	$f = 1MHz, \text{open drain}$	-	8.0	-	Ω

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

Parameter	Symbol	Conditions	Values			Unit
			Min.	Typ.	Max.	
Transconductance	g_{fs}^{*6}	$V_{DS} = 10\text{V}, I_D = 6.0\text{A}$	3.5	8	-	S
Input capacitance	C_{iss}	$V_{GS} = 0\text{V}$	-	1300	-	pF
Output capacitance	C_{oss}	$V_{DS} = 25\text{V}$	-	890	-	
Reverse transfer capacitance	C_{rss}	$f = 1\text{MHz}$	-	45	-	
Effective output capacitance, energy related	$C_{o(er)}$	$V_{GS} = 0\text{V}$ $V_{DS} = 0\text{V to } 480\text{V}$	-	56.7	-	pF
Effective output capacitance, time related	$C_{o(tr)}$		-	57.3	-	
Turn - on delay time	$t_{d(on)}^{*6}$	$V_{DD} \approx 300\text{V}, V_{GS} = 10\text{V}$	-	30	-	ns
Rise time	t_r^{*6}	$I_D = 6\text{A}$	-	37	-	
Turn - off delay time	$t_{d(off)}^{*6}$	$R_L = 50\Omega$	-	77	154	
Fall time	t_f^{*6}	$R_G = 10\Omega$	-	20	40	

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

Parameter	Symbol	Conditions	Values			Unit
			Min.	Typ.	Max.	
Total gate charge	Q_g^{*6}	$V_{DD} \approx 300\text{V}$	-	35	-	nC
Gate - Source charge	Q_{gs}^{*6}	$I_D = 12\text{A}$	-	10	-	
Gate - Drain charge	Q_{gd}^{*6}	$V_{GS} = 10\text{V}$	-	15	-	
Gate plateau voltage	$V_{(plateau)}$	$V_{DD} \approx 300\text{V}, I_D = 12\text{A}$	-	6.6	-	V

*1 Limited only by maximum temperature allowed.

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

*3 $L \approx 500\mu\text{H}$, $V_{DD} = 50\text{V}$, $R_G = 25\Omega$, starting $T_j = 25^\circ\text{C}$

*4 $L \approx 500\mu\text{H}$, $V_{DD} = 50\text{V}$, $R_G = 25\Omega$, starting $T_j = 25^\circ\text{C}$, $f = 10\text{kHz}$

*5 Reference measurement circuits Fig.5-1.

*6 Pulsed

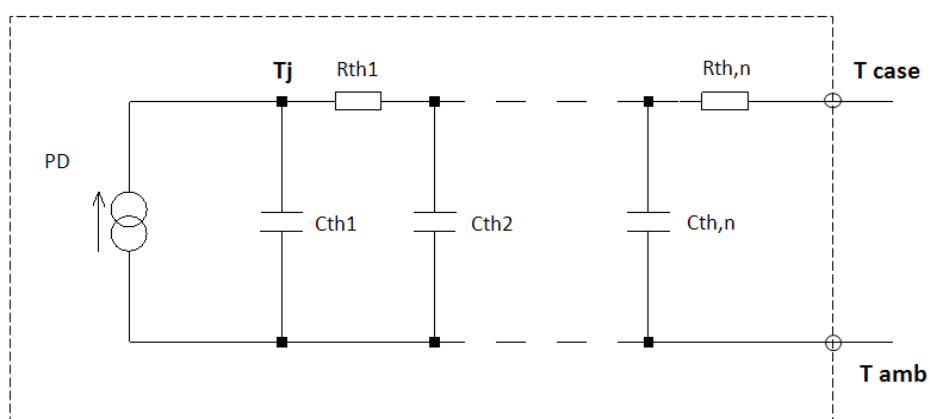
●Body diode electrical characteristics (Source-Drain)($T_a = 25^\circ\text{C}$)

Parameter	Symbol	Conditions	Values			Unit
			Min.	Typ.	Max.	
Inverse diode continuous, forward current	I_S^{*1}	$T_c = 25^\circ\text{C}$	-	-	12	A
Inverse diode direct current, pulsed	I_{SM}^{*2}		-	-	48	A
Forward voltage	V_{SD}^{*6}	$V_{GS} = 0\text{V}, I_S = 12\text{A}$	-	-	1.5	V
Reverse recovery time	t_{rr}^{*6}	$I_S = 12\text{A}$ $di/dt = 100\text{A}/\mu\text{s}$	45	75	105	ns
Reverse recovery charge	Q_{rr}^{*6}		-	0.26	-	μC
Peak reverse recovery current	I_{rrm}^{*6}		-	6.9	-	A
Peak rate of fall of reverse recovery current	di_{rr}/dt	$T_j = 25^\circ\text{C}$	-	740	-	$\text{A}/\mu\text{s}$

●Typical Transient Thermal Characteristics

Symbol	Value	Unit
R_{th1}	0.158	K/W
R_{th2}	0.75	
R_{th3}	2.15	

Symbol	Value	Unit
C_{th1}	0.00247	Ws/K
C_{th2}	0.0317	
C_{th3}	0.485	



●Electrical characteristic curves

Fig.1 Power Dissipation Derating Curve

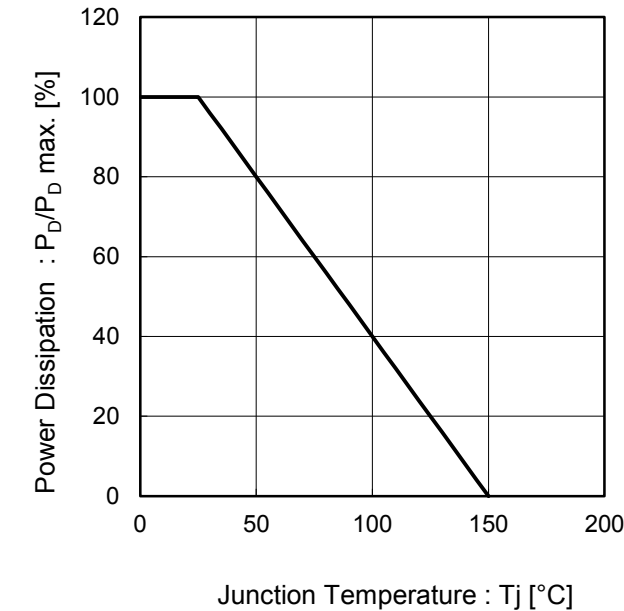


Fig.2 Maximum Safe Operating Area

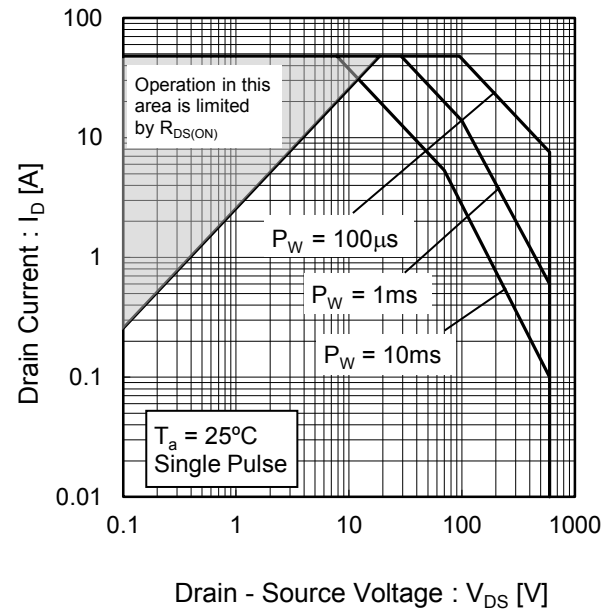
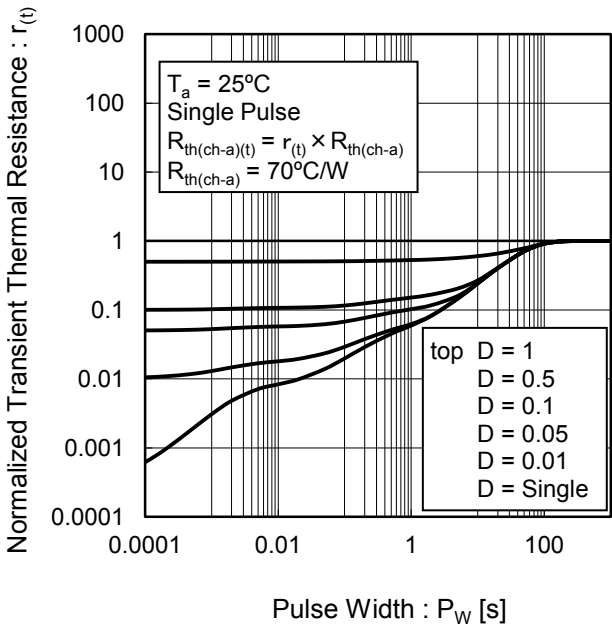


Fig.3 Normalized Transient Thermal Resistance vs. Pulse Width



●Electrical characteristic curves

Fig.4 Avalanche Current vs Inductive Load

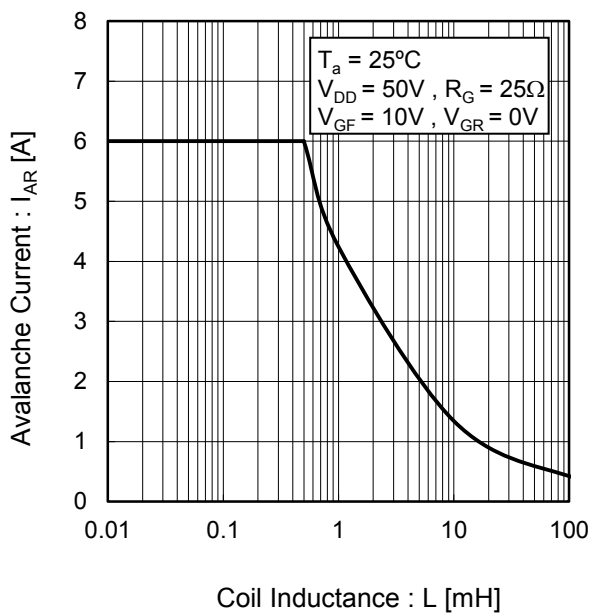


Fig.5 Avalanche Power Losses

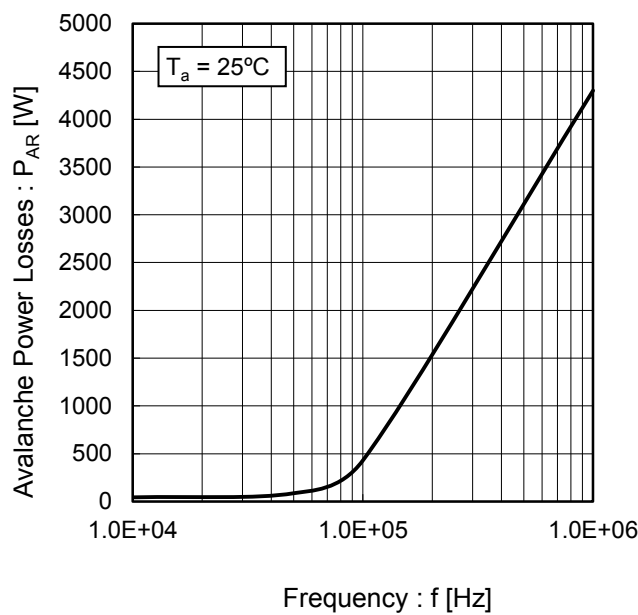
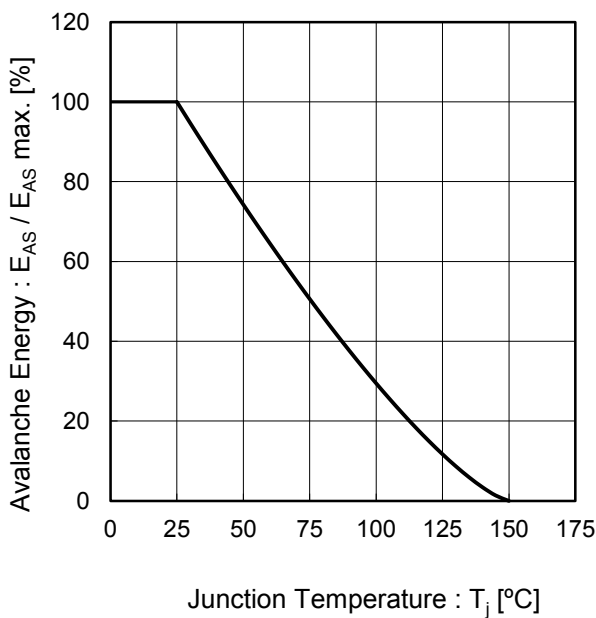


Fig.6 Avalanche Energy Derating Curve vs Junction Temperature



●Electrical characteristic curves

Fig.7 Typical Output Characteristics(I)

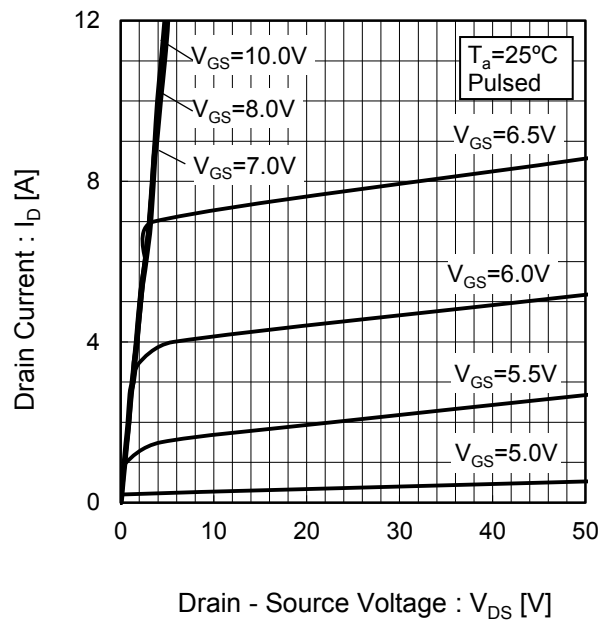


Fig.8 Typical Output Characteristics(II)

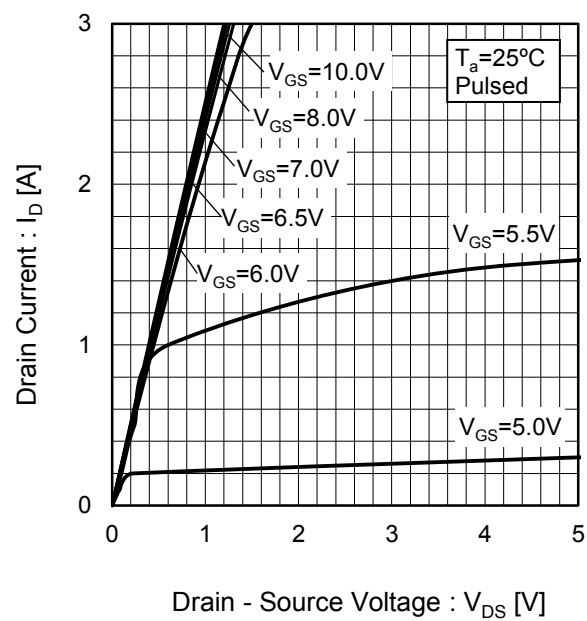


Fig.9 $T_j = 150^\circ\text{C}$ Typical Output Characteristics(I)

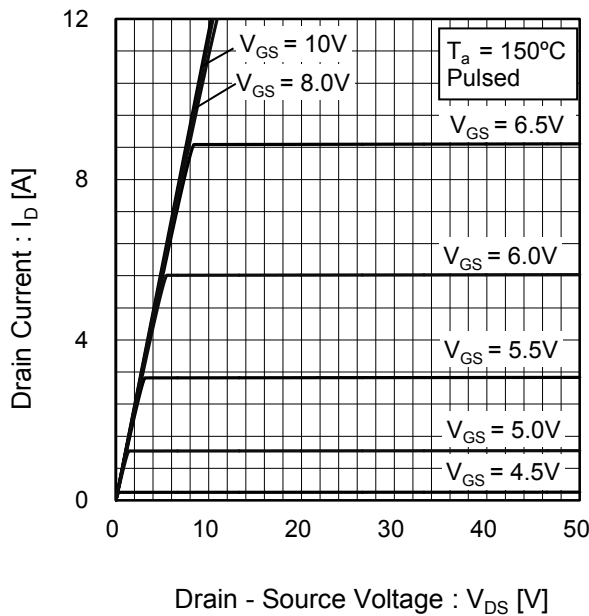
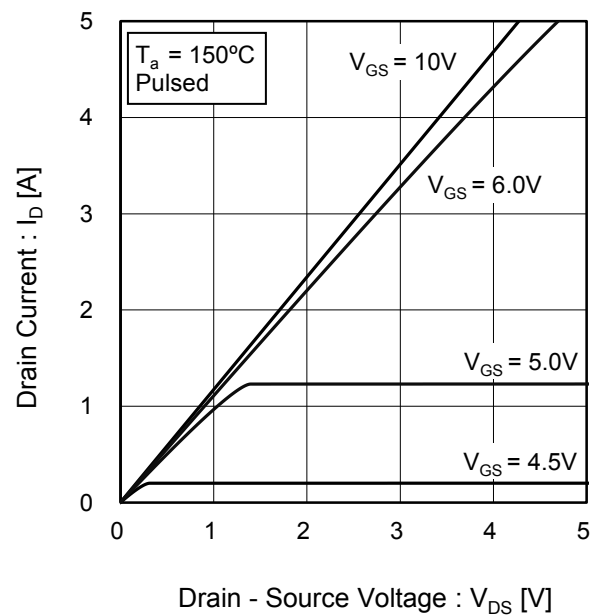


Fig.10 $T_j = 150^\circ\text{C}$ Typical Output Characteristics(II)



●Electrical characteristic curves

Fig.11 Breakdown Voltage
vs. Junction Temperature

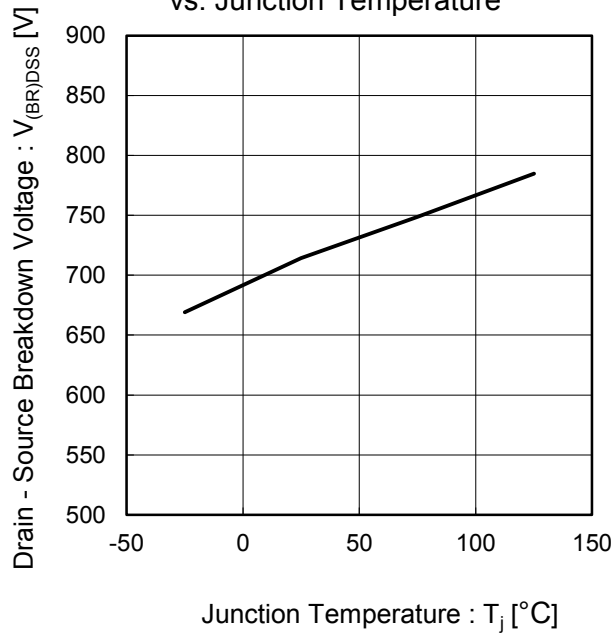


Fig.12 Typical Transfer Characteristics

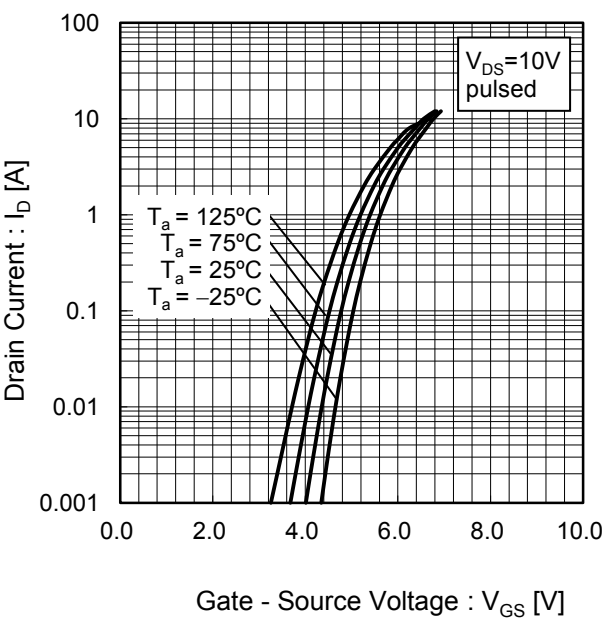


Fig.13 Gate Threshold Voltage
vs. Junction Temperature

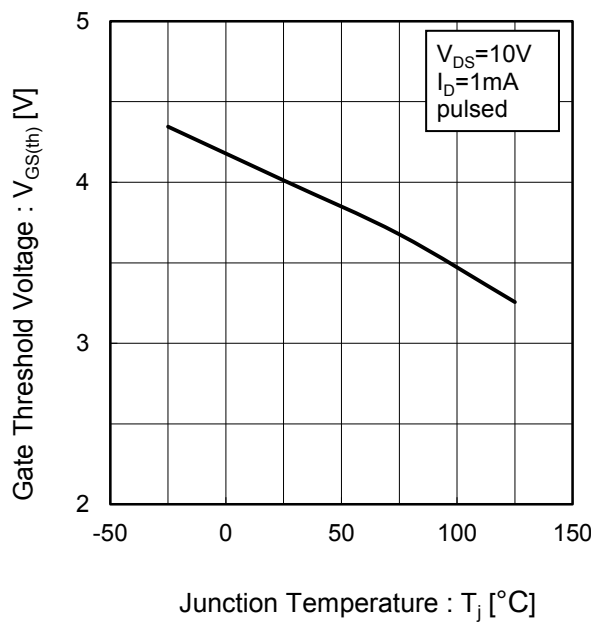
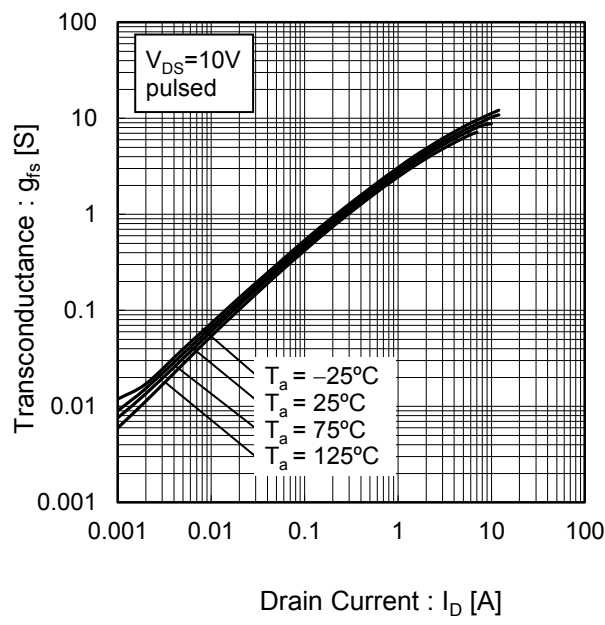


Fig.14 Transconductance vs. Drain Current



●Electrical characteristic curves

Fig.15 Static Drain - Source On - State Resistance vs. Gate Source Voltage

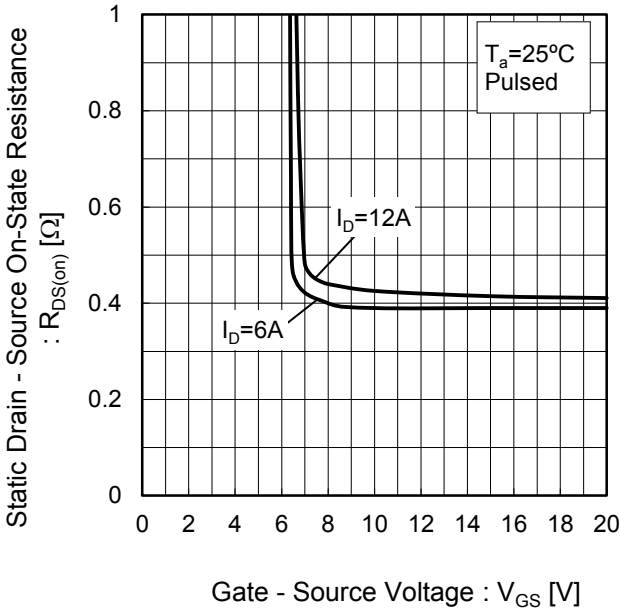


Fig.16 Static Drain - Source On - State Resistance vs. Junction Temperature

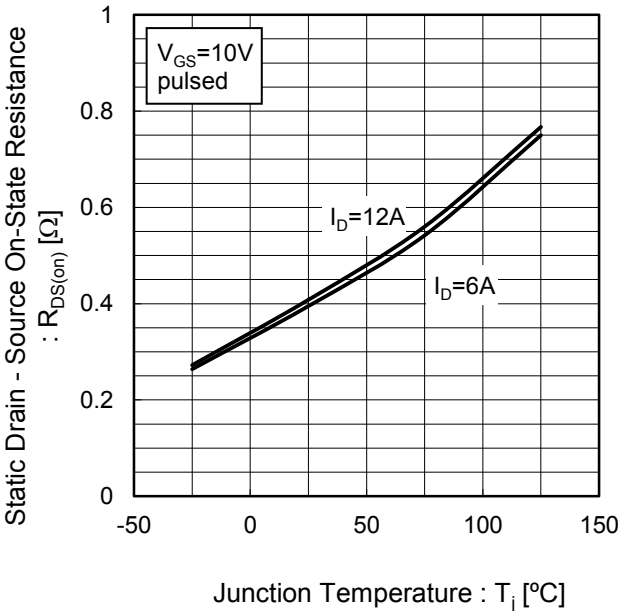
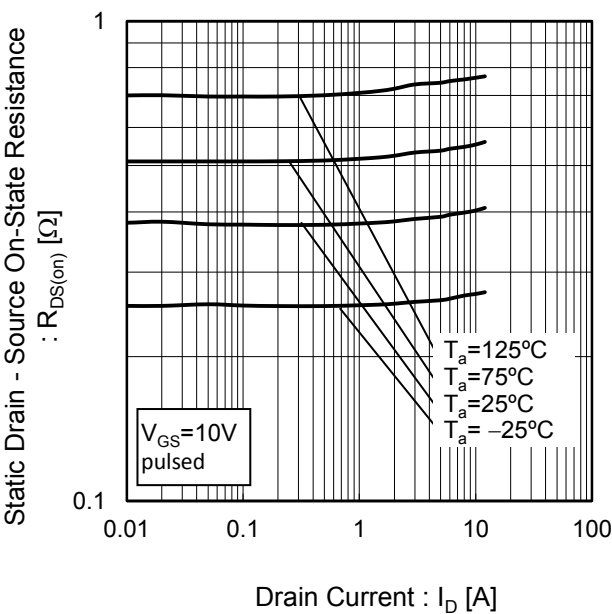


Fig.17 Static Drain - Source On - State Resistance vs. Drain Current



●Electrical characteristic curves

Fig.18 Typical Capacitance vs. Drain - Source Voltage

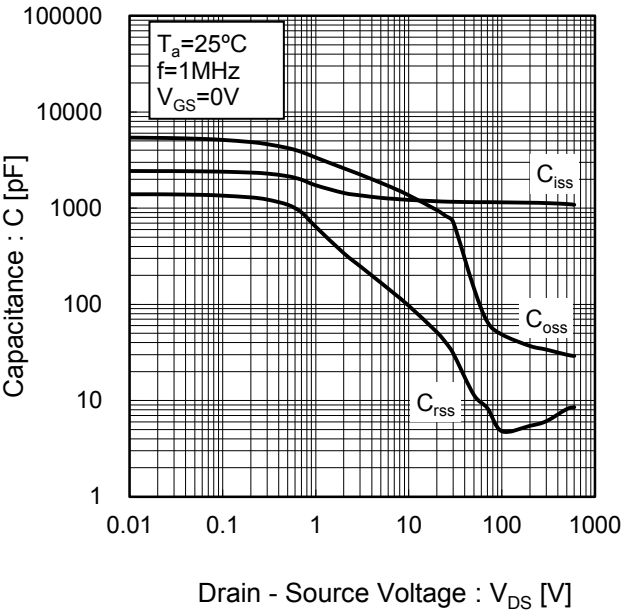


Fig.19 Coss Stored Energy

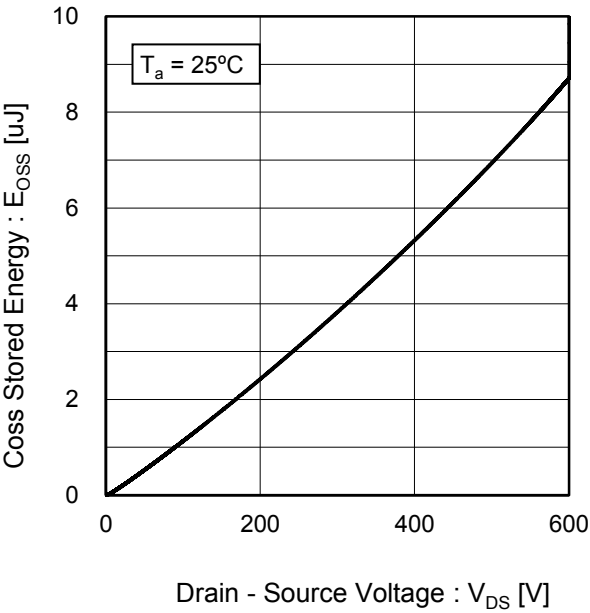


Fig.20 Switching Characteristics

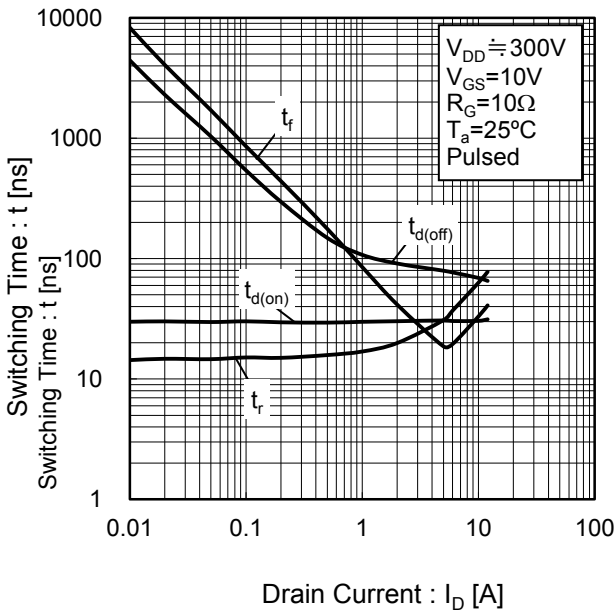
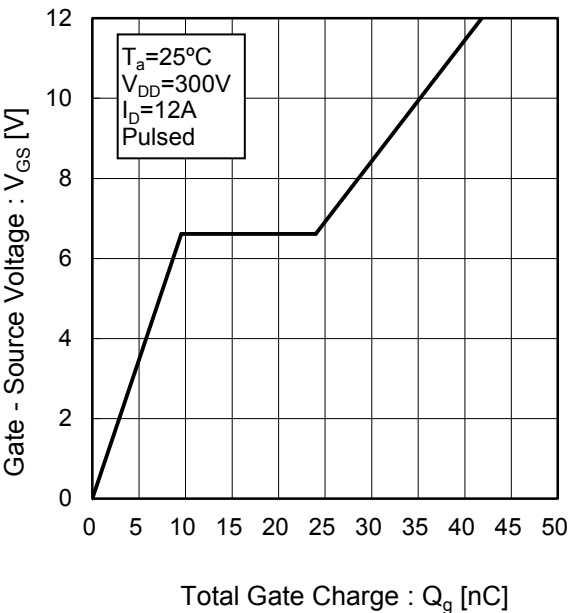


Fig.21 Dynamic Input Characteristics



●Electrical characteristic curves

Fig.22 Inverse Diode Forward Current vs. Source - Drain Voltage

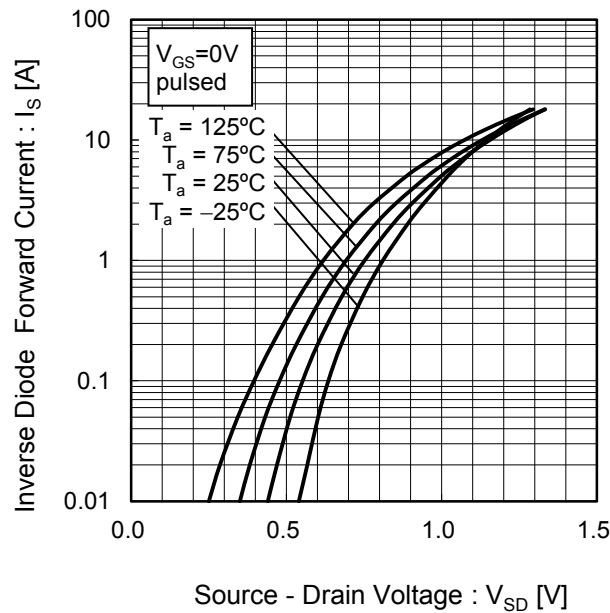
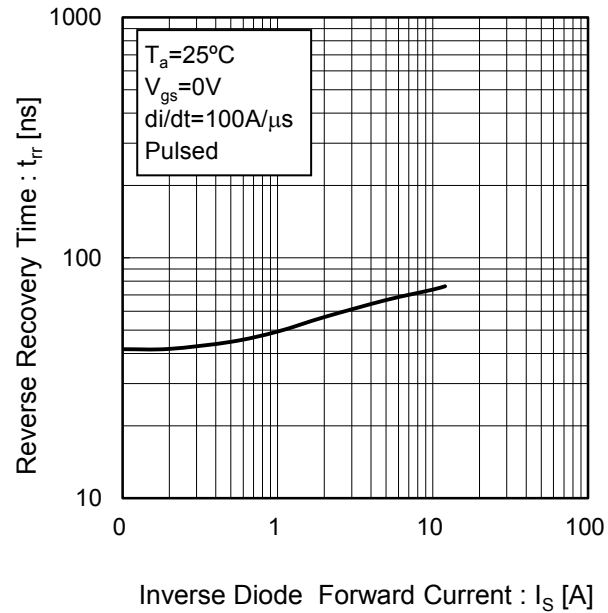


Fig.23 Reverse Recovery Time vs. Inverse Diode Forward Current



●Measurement circuits

Fig.1-1 Switching Time Measurement Circuit

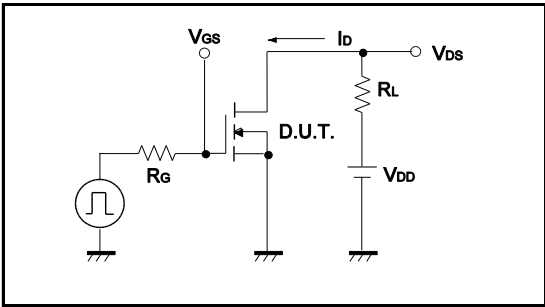


Fig.1-2 Switching Waveforms

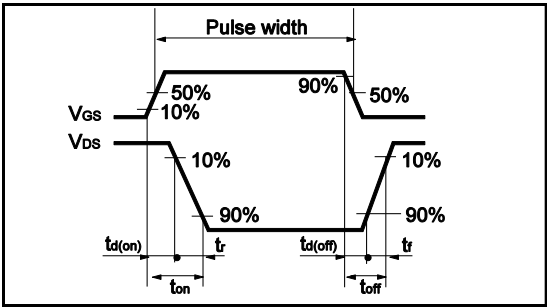


Fig.2-1 Gate Charge Measurement Circuit

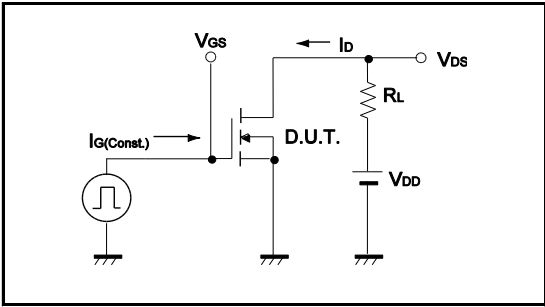


Fig.2-2 Gate Charge Waveform

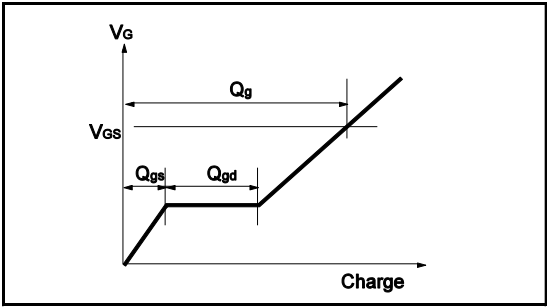


Fig.3-1 Avalanche Measurement Circuit

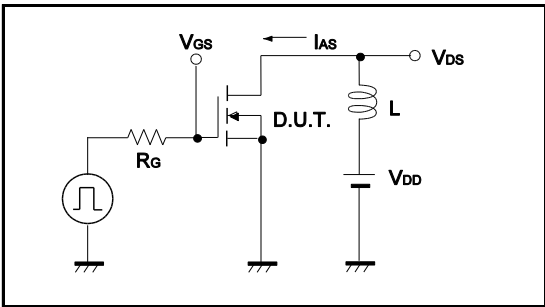


Fig.3-2 Avalanche Waveform

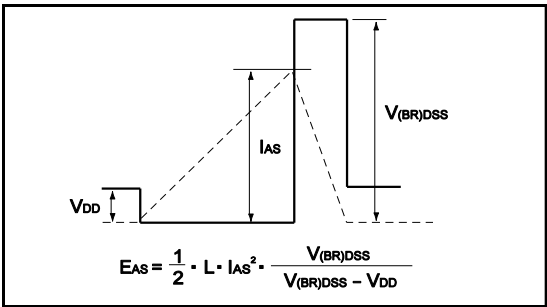


Fig.4-1 dv/dt Measurement Circuit

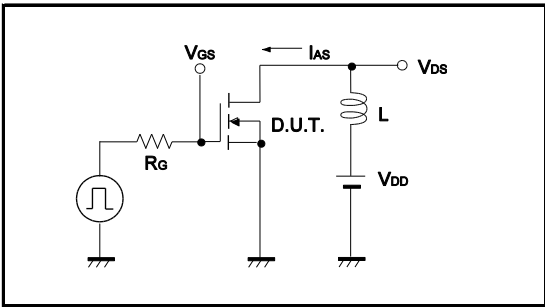


Fig.4-2 dv/dt Waveform

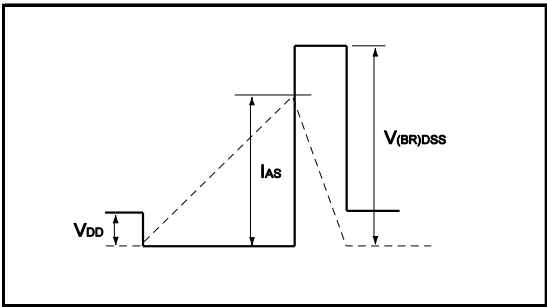


Fig.5-1 di/dt Measurement Circuit

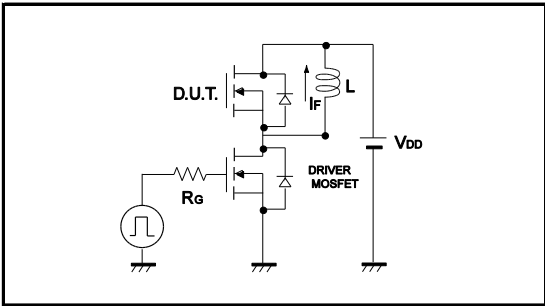
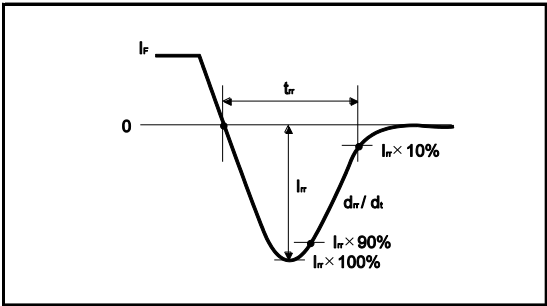
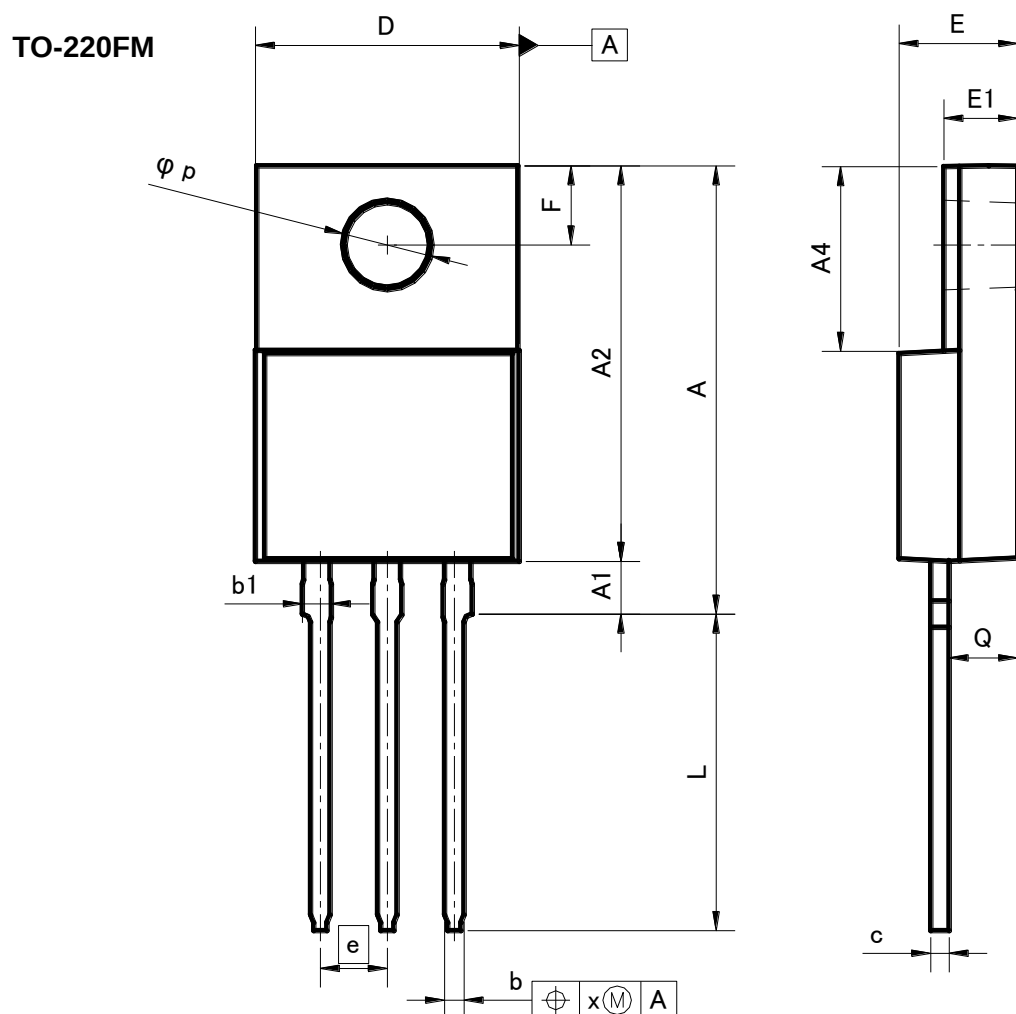


Fig.5-2 di/dt Waveform



●Dimensions (Unit : mm)



DIM	MILIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.60	17.60	0.654	0.693
A1	1.80	2.20	0.071	0.087
A2	14.80	15.40	0.583	0.606
A4	6.80	7.20	0.268	0.283
b	0.70	0.85	0.028	0.033
b1	1.10	1.50	0.043	0.059
c	0.70	0.85	0.028	0.033
D	9.90	10.30	0.390	0.406
E	4.40	4.80	0.173	0.189
e	2.54		0.100	
E1	2.70	3.00	0.106	0.118
F	2.80	3.20	0.110	0.126
L	11.50	12.50	0.453	0.492
p	3.00	3.40	0.118	0.134
Q	2.10	3.10	0.083	0.122
x	—	0.38	—	0.015

Dimension in mm / inches

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