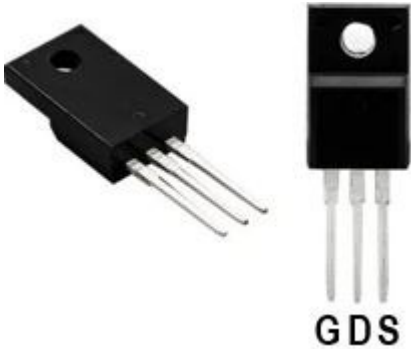


Key Electrical Characteristics		
Parameter / Symbol	Value / Description	Unit
$BV_{DSS \min.}$	650	V
$R_{DS(ON) \text{ Typ. @10V}}$	293	m Ω
I_D	11.0	A
$V_{TH \text{ Typ.}}$	3.5	V
$C_{iss \text{ Typ.}}$	882	pF
$Q_g \text{ 10V}$	19.9	nC
ESD (HBM)	≥ 2	KV

Package Outline
TO-220F


General Description

These devices are N-channel power MOSFET developed using Super Junction structure technology. There is high speed switching capacity, low $R_{DS(on)}$ parameter, excellent quality, and characteristics for these devices. Moreover, it is a good choose in improved efficiency of circuit and raise power density are required. These features combine to be an advantage design for use in wide variety of application including switch mode power design.

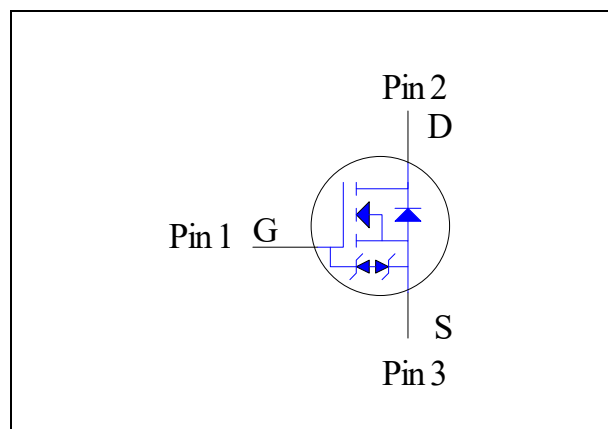
Features

- ✧ Fast Switching
- ✧ Low $R_{DS(on)}$ Resistance
- ✧ Low Switching Loss
- ✧ Integrated ESD protection diode
- ✧ Insulated package available
- ✧ 100% Single Pulse Avalanche Energy Test
- ✧ Pb-free lead plating and RoHS compliant

Potential Applications

- ◆ AC to DC converter
- ◆ Electronic ballasts and LED lighting power
- ◆ Consumer electronics adaptor or charger
- ◆ Network equipment and display power supply unit
- ◆ Switch Mode Power Supply

Symbol and Pin assignment



Ordering Information

N.o	Item	Description
01	Orderable P/N	SJ650N360F2
02	Part Number	SJ650N360F2
03	Package Type	TO-220F
04	Package Code	F
05	Packing Type	Tube
06	Quantity/pcs	50
07	RoHS Status	Halogen-Free

Content

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2.	Thermal Resistance Ratings -----	3
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1. Absolute Maximum Ratings ($T_J=25^{\circ}\text{C}$ unless otherwise noted)

Parameter		Symbol	Values			Unit
			Min.	Typ.	Max.	
Drain-Source Voltage		V_{DS}	-	-	650	V
Gate-Source Voltage		V_{GS}	-	-	± 30	V
Drain Current-Continuous ^{Note 1}	$T_C=25^{\circ}\text{C}$	I_D	-	-	11.0	A
	$T_C=100^{\circ}\text{C}$		-	-	7.0	A
Drain Current-Pulsed ^{Note 2}	$T_C=25^{\circ}\text{C}$	I_{DM}	-	-	24	A
Avalanche Current		I_{AS}	-	-	3.7	A
Single Pulse Avalanche Energy ^{Note 3}		E_{AS}	-	-	68	mJ
Maximum Power Dissipation	$T_C=25^{\circ}\text{C}$	P_D	-	-	72.2	W
	$T_C=100^{\circ}\text{C}$		-	-	28.9	W
	Derate Factor Above $T_C=25^{\circ}\text{C}$		-	-	0.57	W/ $^{\circ}\text{C}$
Body Diode dv/dt ^{Note 4}	$T_C=25^{\circ}\text{C}$, $V_{DD}=0\sim 400\text{V}$	dv/dt	-	-	10.1	V/nS
Max. Operating Junction Temperature		T_J	-	-	150	$^{\circ}\text{C}$
Storage Temperature Range		T_{STG}	-55	-	150	$^{\circ}\text{C}$

2. Thermal Resistance Ratings

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Thermal resistance, Junction-Case ^{Note 5}	$R_{\theta JC}$	Steady State	-	-	1.73	$^{\circ}\text{C/W}$
Thermal resistance, Junction-Ambient ^{Note 5}	$R_{\theta JA}$	Steady State	-	-	39.79	$^{\circ}\text{C/W}$

Notes:

- Limited by silicon chip capability and $R_{\theta JC}$ junction-to-case thermal resistance.
- Must be ensure junction temperature does not exceed 150-degree C. (Pulse Width $\leq 380\mu\text{s}$, Duty $\leq 2\%$)
- Limited by T_{Jmax} , starting $T_J=25^{\circ}\text{C}$, $L=10\text{ mH}$, $R_g=25\Omega$, $I_{AS}=3.7\text{A}$, $V_{GS}=10\text{V}$.
- $V_{DD} = 0\sim 400\text{ V}$, $I_{SD}=I_S \leq 6\text{ A}$ starting $T_C = 25^{\circ}\text{C}$
- The value of thermal resistance is measured with the single device put on cooling plate under a still air environment temperature is 25 degree C based on JEDEC standard JESD51-14 and JESD51-2a. Thermal resistance obtained depends on the user's specific board design and given application.
- $C_{o(er)}$ is fixed capacitance that gives same stored energy as C_{OSS} while V_{DS} rising to 400V from 0V.
- $C_{o(tr)}$ is fixed capacitance that gives same charging time as C_{OSS} while V_{DS} rising to 400V from 0V.

3. Electrical Characteristics (T_J=25°C unless otherwise noted)

STATIC CHARACTERISTICS						
Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Drain-Source Breakdown Voltage	BV _{DSS}	V _{GS} =0V, I _{DS} =250μA	650	-	-	V
Zero Gate Voltage Drain Current	I _{DSS}	V _{DS} =650V, V _{GS} =0V	-	-	1	μA
		V _{DS} =650V, V _{GS} =0V, T _J =125°C	-	-	10	μA
Gate-Body Leakage Current	I _{GSS}	V _{GS} =±20V, V _{DS} =0V	-	-	±1	μA

STATIC CHARACTERISTICS						
Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Gate Threshold Voltage	V _{GS(TH)}	V _{DS} =V _{GS} , I _{DS} =250μA	3.0	3.5	4.0	V
Drain-Source On-State Resistance	R _{DS(ON)}	V _{GS} =10V, I _{DS} =7.0A	-	293	360	mΩ
Gate Resistance	R _G	V _{GS} =0V, V _{DS} =0V, f=1MHz	-	3.7	-	Ω
Forward Transconductance	g _{fs}	V _{DS} =10V, I _{DS} =7.0A	-	8.5	-	S

DYNAMIC CHARACTERISTICS						
Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Input Capacitance	C _{iss}	V _{DD} =650V, V _{DS} =325V, V _{GS} =0V, F=500KHz	-	882	-	pF
Output Capacitance	C _{oss}	V _{DD} =650V, V _{DS} =325V, V _{GS} =0V, F=500KHz	-	27.5	-	pF
Reverse Transfer Capacitance	C _{rss}	V _{DD} =650V, V _{DS} =325V, V _{GS} =0V, F=500KHz	-	5.8	-	pF
Effective output capacitance-energy	C _{o(er)}	V _{DD} =400V, V _G =10V, energy related ^{Note 6}	-	94.2	-	pF
Effective output capacitance-time	C _{o(tr)}	V _{DD} =400V, V _G =10V, time related ^{Note 7}	-	350	-	pF
Turn-On Delay Time	T _{d(on)}	V _{DS} =400V, V _{GS} =10V, I _{DS} =6.0A, R _{GEN} =10Ω	-	17.5	-	nS
Rise Time	t _r	V _{DS} =400V, V _{GS} =10V, I _{DS} =6.0A, R _{GEN} =10Ω	-	31.4	-	nS
Turn-Off Delay Time	T _{d(off)}	V _{DS} =400V, V _{GS} =10V, I _{DS} =6.0A, R _{GEN} =10Ω	-	41.7	-	nS
Fall Time	t _f	V _{DS} =400V, V _{GS} =10V, I _{DS} =6.0A, R _{GEN} =10Ω	-	40.8	-	nS

GATE CHARGE CHARACTERISTICS						
Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Gate charge total	Q _{g 10V}	V _{DD} =100V, I _D =6.0A, V _{GS} =0 to 10V	-	19.9	-	nC
Gate to Source Gate Charge	Q _{gs}	V _{DD} =100V, I _D =6.0A, V _{GS} =0 to 10V	-	6.2	-	nC
Gate to Drain Charge	Q _{gd}	V _{DD} =100V, I _D =6.0A, V _{GS} =0 to 10V	-	6.4	-	nC
Gate plateau voltage	V _{plateau}	V _{DD} =100V, I _D =6.0A, V _{GS} =0 to 10V	-	5.9	-	V

BODY DIODE CHARACTERISTICS AND MAXIMUM RATINGS						
Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Diode continuous forward current	I _S	T _C =25°C	-	-	11.0	A
Diode pulsed forward current	I _{SM}	T _C =25°C	-	-	24	A
Diode forward Voltage	V _{SD}	T _C =25°C, V _{GS} =0V, I _S = 7A	-	0.84	1.0	V
Diode reverse Recovery Time	t _{rr}	V _{DD} =100V, I _{SD} =6.0A, T _C =25°C, di/dt=50A/μs	-	337	-	nS
Diode reverse Recovery Charge	Q _{rr}	V _{DD} =100V, I _{SD} =6.0A, T _C =25°C, di/dt=50A/μs	-	2997	-	nC
Diode peak reverse recovery current	I _{rm}	V _{DD} =100V, I _{SD} =6.0A, T _C =25°C, di/dt=50A/μs	-	17.3	-	A

4. Typical Operating Characteristics diagrams

Fig. 1: Output Characteristics

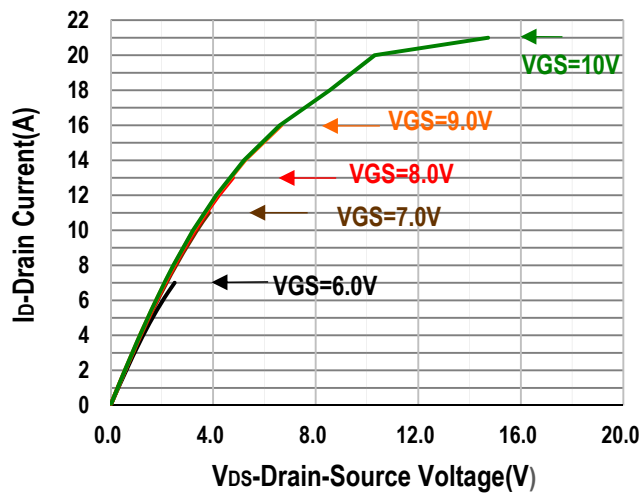


Fig. 2: Normalized $V_{(TH)GS}$ Voltage Vs. T_A

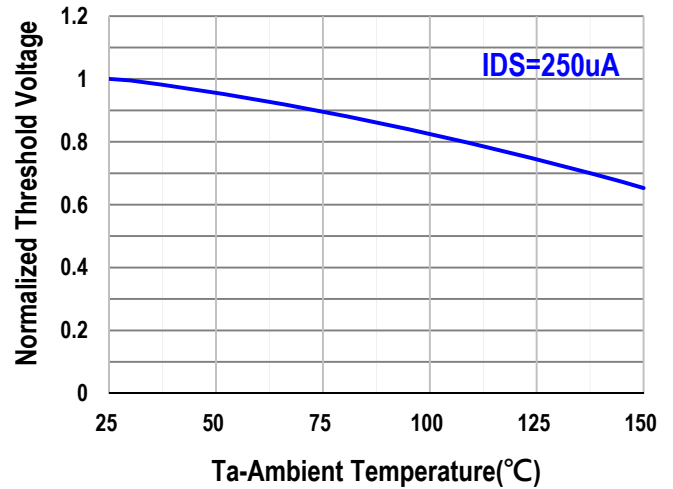


Fig. 3: Drain-Source On Resistance Vs V_{GS}

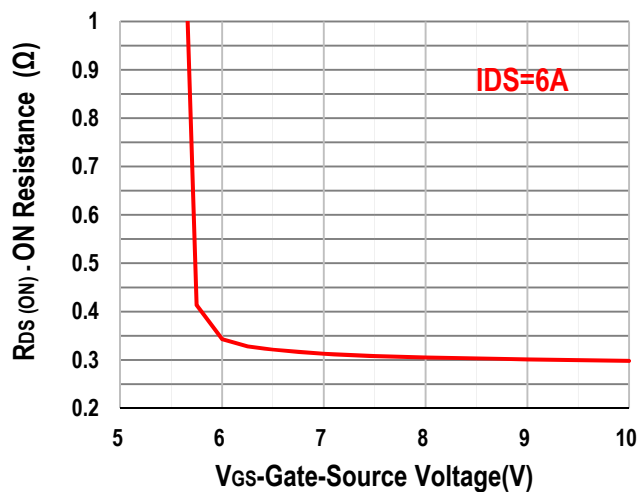


Fig. 4: Normalized $R_{DS(ON)}$ Resistance Vs. T_A

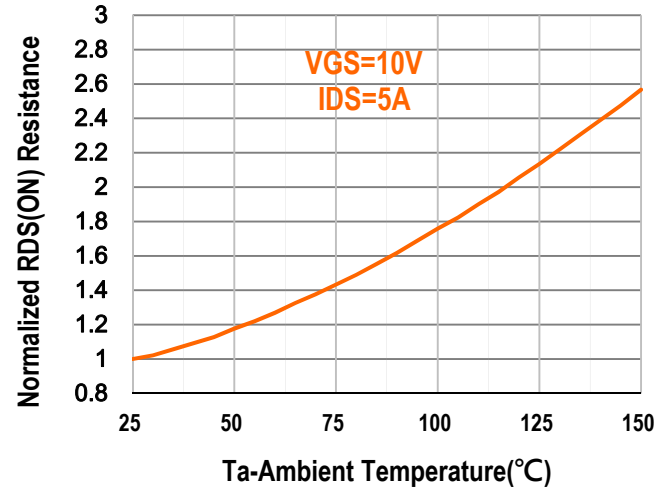


Fig. 5: Drain-Source On Resistance Vs I_D

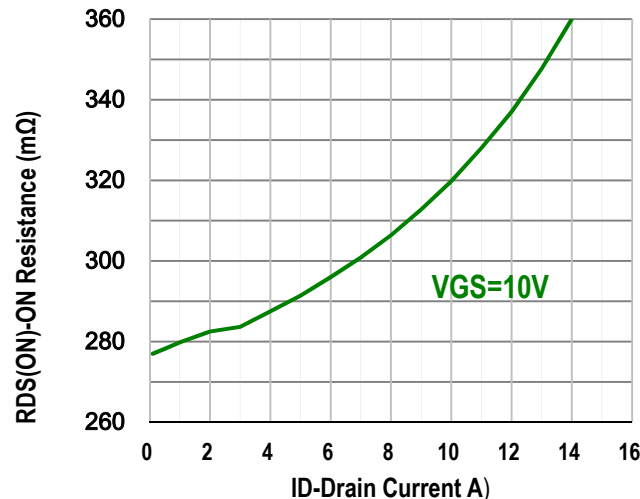
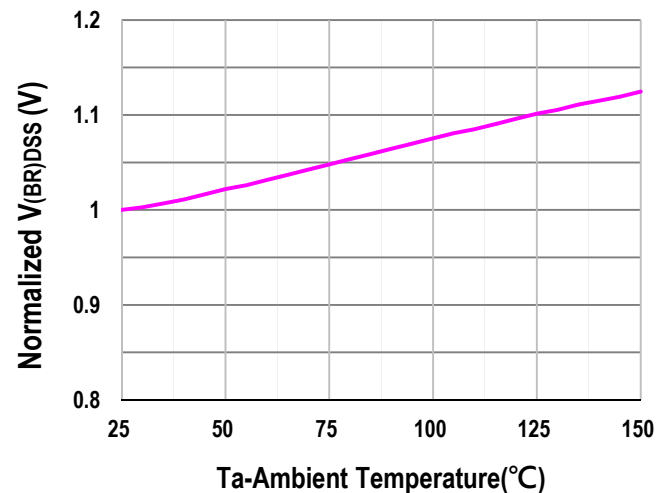


Fig. 6: Normalized BV_{DSS} Voltage Vs T_A



4. Typical Operating Characteristics diagrams

Fig. 7: Typical Capacitance Variation Vs V_{DS}

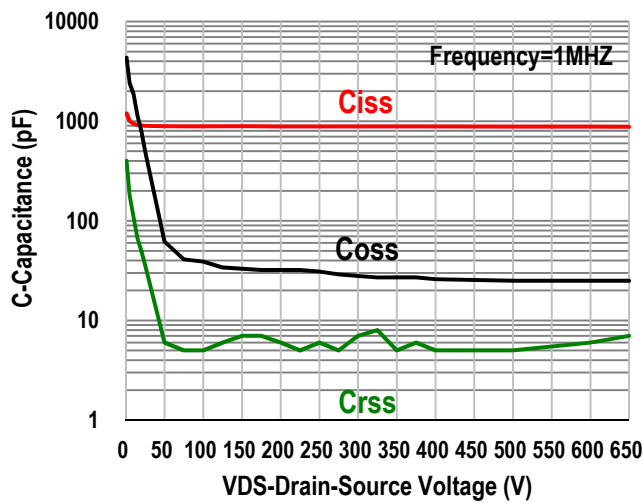


Fig. 8: Gate Charge Vs V_{GS}

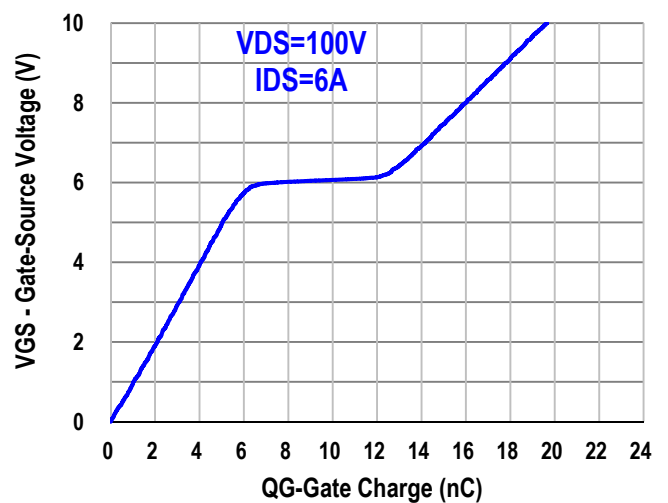


Fig. 9: Power Dissipation Vs. T_c

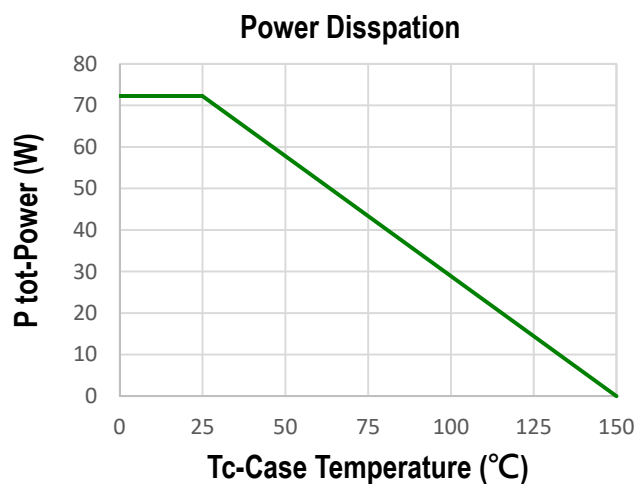


Fig. 10: Drain Current Vs. T_c

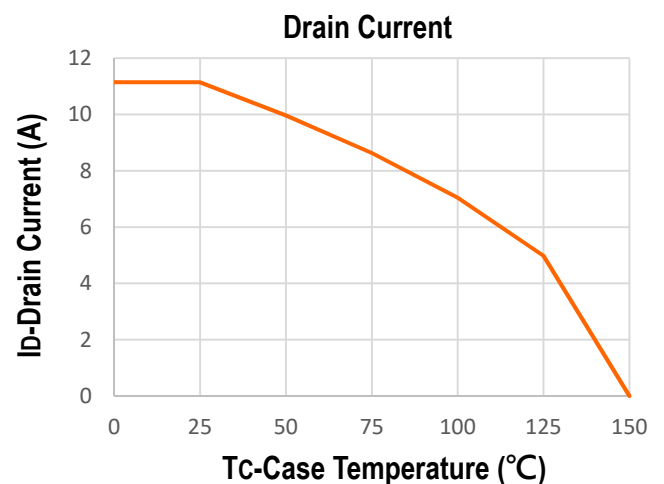


Fig. 11: Body Diode Forward Voltage Vs. I_s

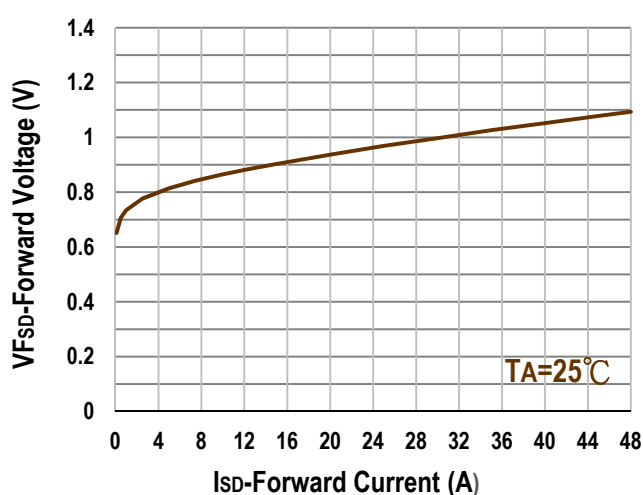
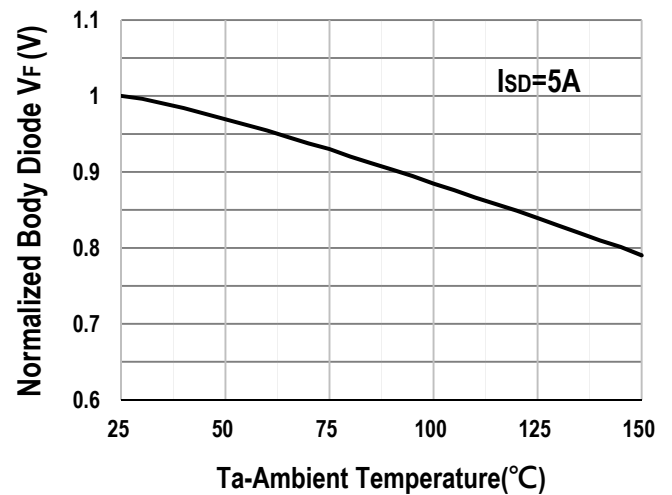


Fig. 12: Body Diode Forward Voltage Vs. T_A



4. Typical Operating Characteristics diagrams

Fig. 13: Safe Operation Area

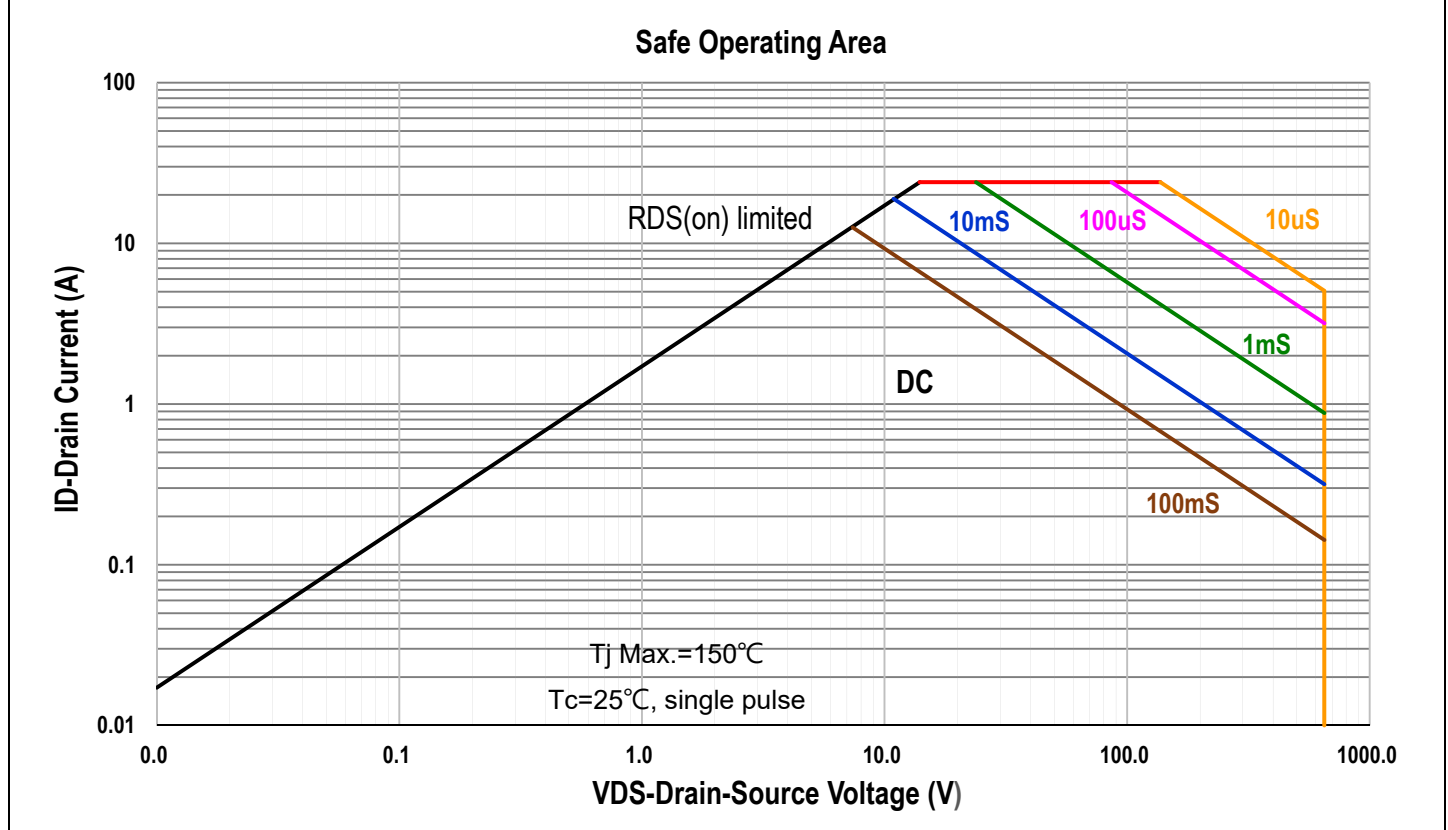
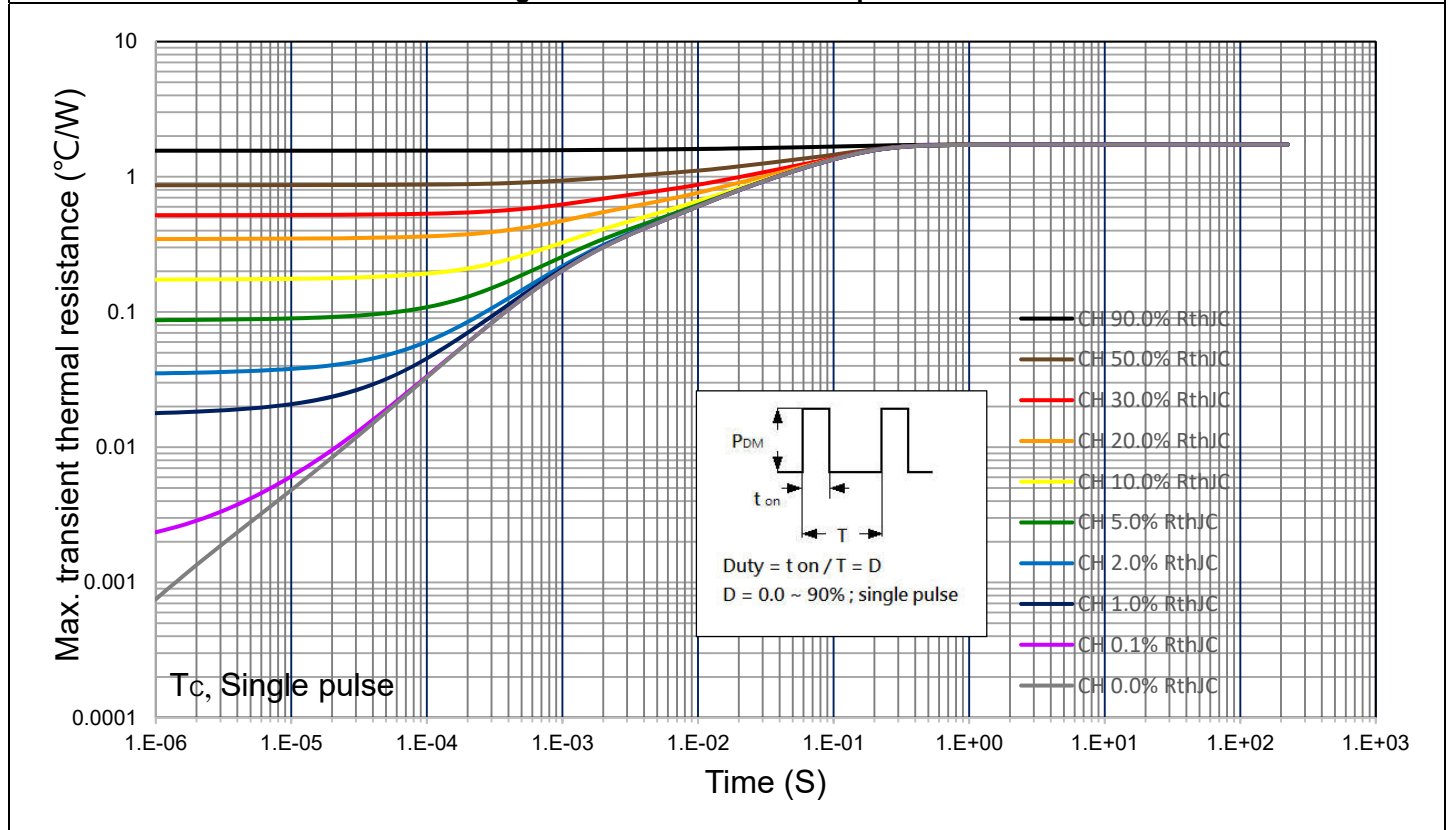


Fig. 14: Transient Thermal Impedance



5. Measurement Schematic

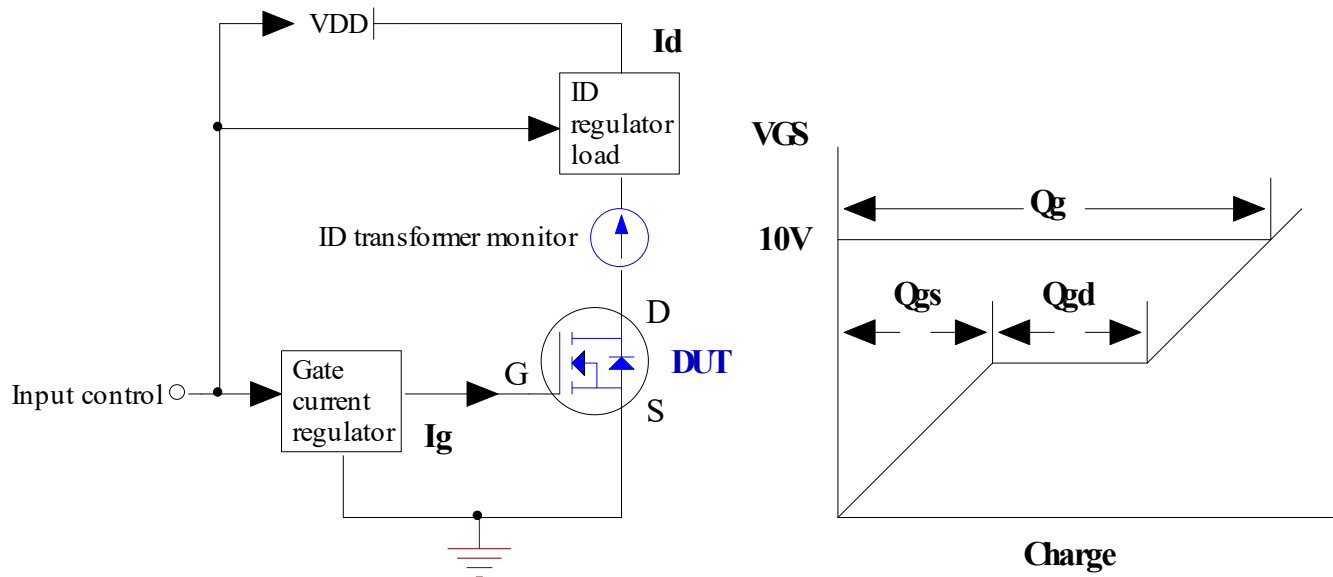


Diagram 5.1 Gate Charge Measurement Circuit and Waveforms

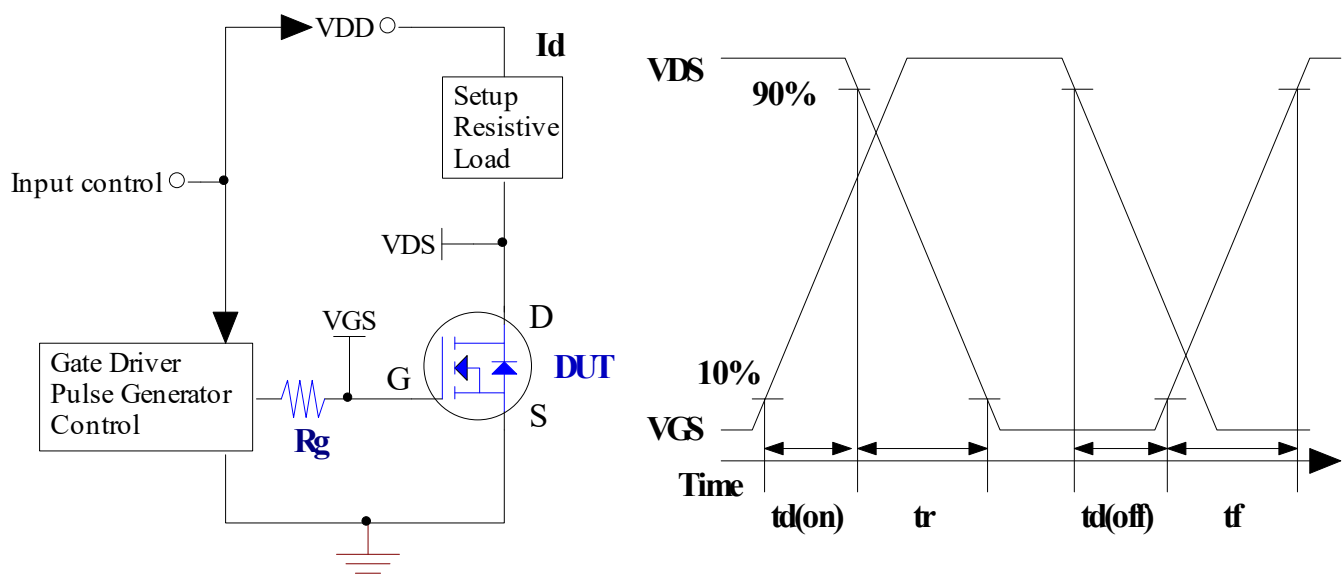


Diagram 5.2 Resistive Switching Measurement Circuit and Waveforms

5. Measurement Schematic

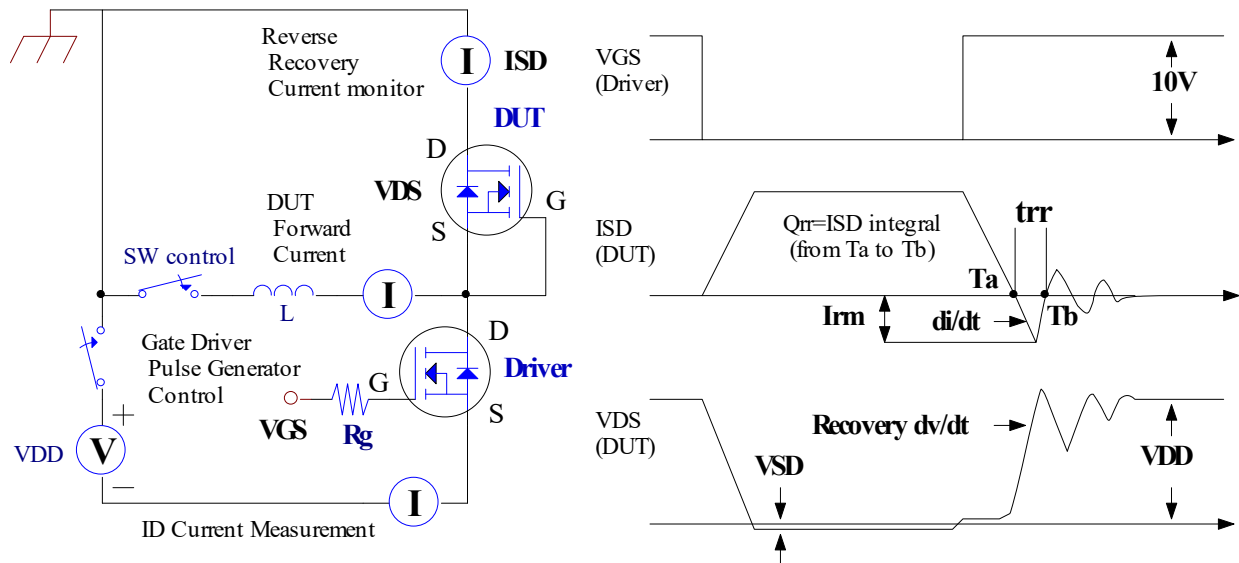


Diagram 5.3 Body Diode Recovery Characteristics Measurement Circuit and Waveforms

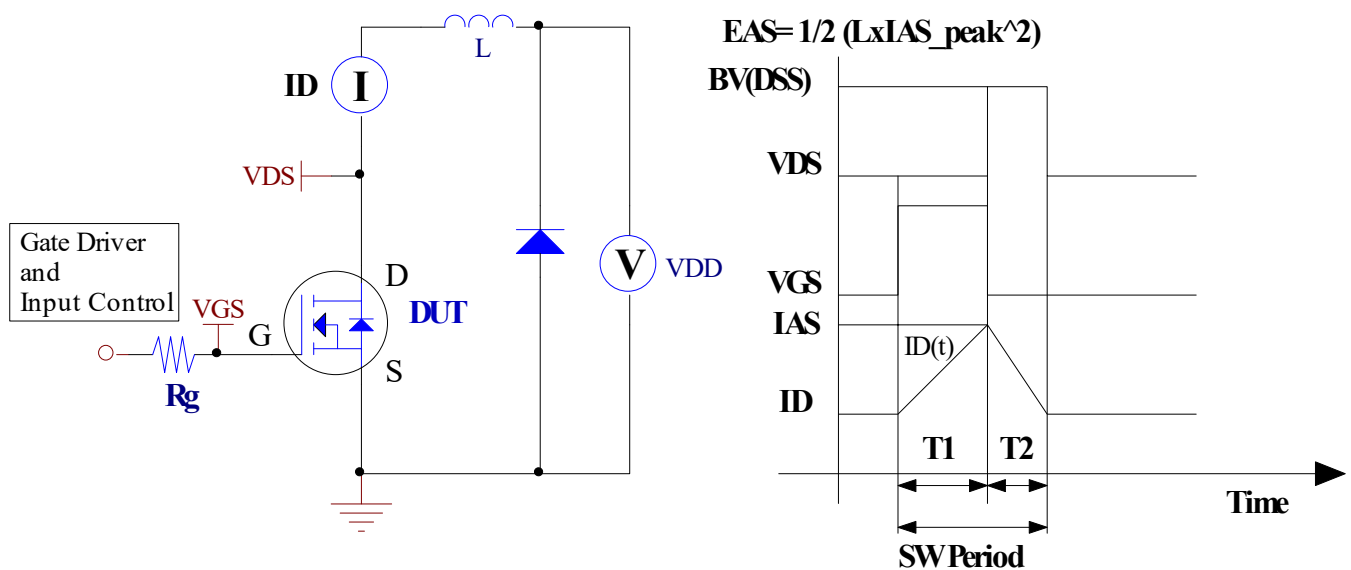
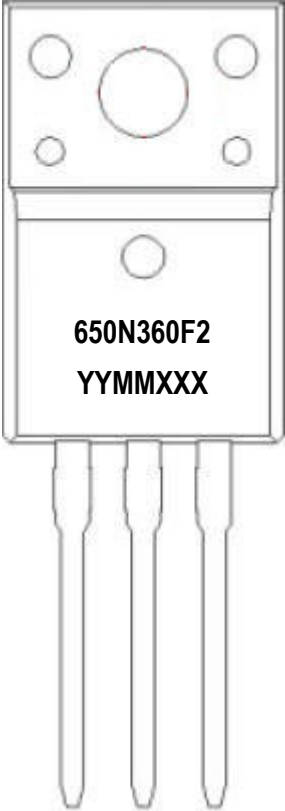


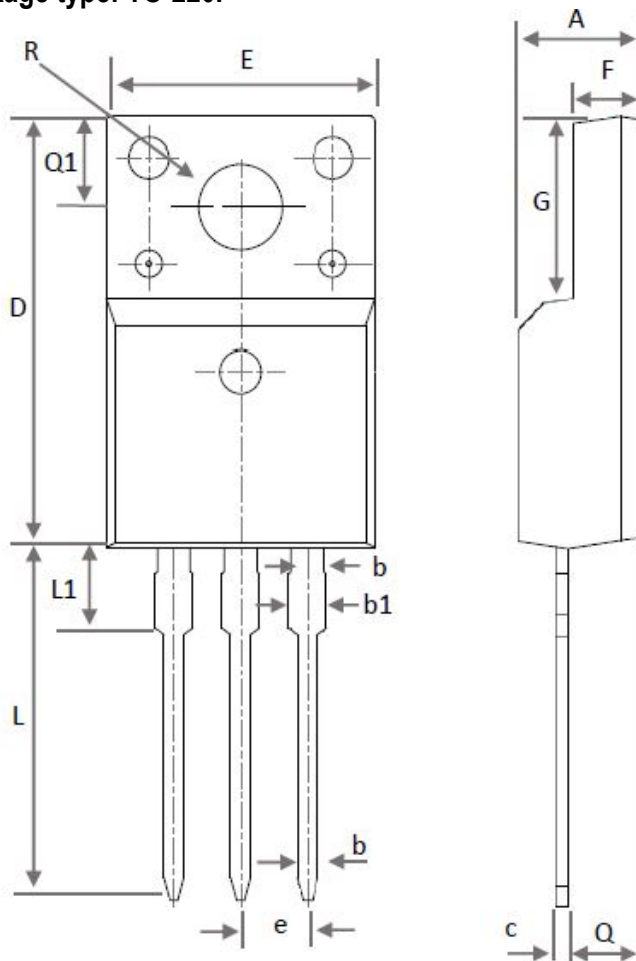
Diagram 5.4 Unclamped Inductive Switching Measurement Circuit and Waveforms

6. Marking Information

TO-220F (F)	Marking Rule
Laser Marking 	<u>Line 1</u> : Device 650N360F2 <u>Line 2</u> : Date Code YYMMXXX YY : Year Code MM : Month Code XXX : Serial Number

7. Package of Dimension

Package type: TO-220F



Symbol	Min	Nor	Max
A	4.50	4.67	4.83
b	0.70	0.81	0.91
b1	1.20	1.34	1.47
b2	1.10	1.24	1.38
C	0.40	0.52	0.63
D	15.67	15.87	16.07
e	2.54 BSC		
E	9.96	10.16	10.36
F	2.34	2.54	2.74
G	6.48	6.69	6.90
L	12.68	12.99	13.30
L1	3.13	3.32	3.50
Q	2.54	2.74	2.93
Q1	3.20	3.30	3.40
R	3.08	3.18	3.28

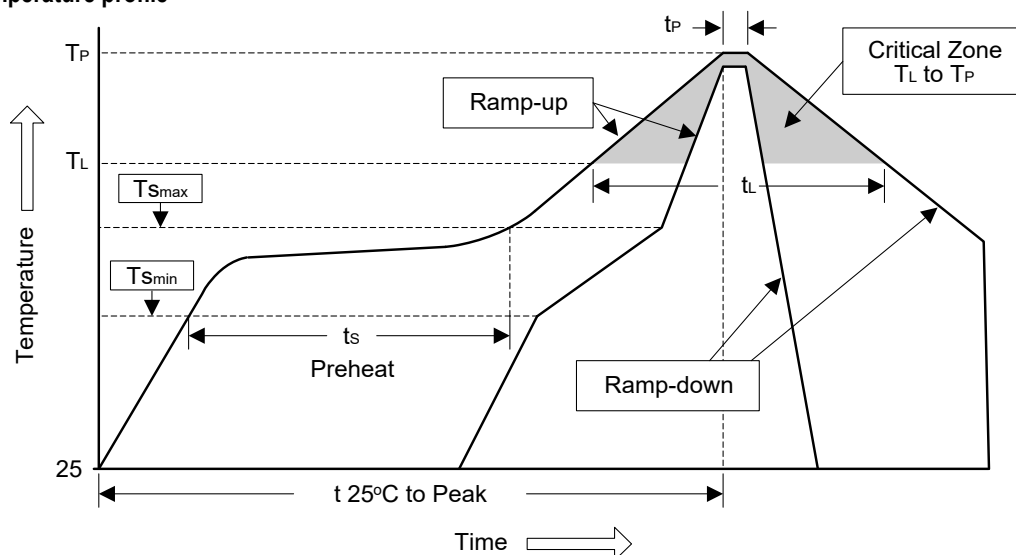
8. Appendix

Appendix-A

Soldering Methods for Silicongear's Products (Just for SMD type of device)

1. Storage environment: Temperature=10°C to 35°C Humidity=65%±15%
2. Reflow soldering of surface-mount devices

Figure 1: Temperature profile



Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Average ramp-up rate (T_L to T_P)	<3°C/sec	<3°C/sec
Preheat		
- Temperature Min (T_{Smin})	100°C	150°C
- Temperature Max (T_{Smax})	150°C	200°C
- Time (min to max) (t_s)	60 to 120 sec	60 to 180 sec
T_{Smax} to T_L		
- Ramp-up Rate	<3°C/sec	<3°C/sec
Time maintained above:		
- Temperature (T_L)	183°C	217°C
- Time (t_L)	60 to 150 sec	60 to 150 sec
Peak Temperature (T_P)	240°C +0/-5°C	260°C +0/-5°C
Time within 5°C of actual Peak Temperature (t_P)	10 to 30 sec	20 to 40 sec
Ramp-down Rate	<6°C/sec	<6°C/sec
Time 25°C to Peak Temperature	<6 minutes	<8 minutes

3. Flow (wave) soldering (solder dipping)

Products	Peak Temperature	Dipping Time
Pb devices.	245°C ±5°C	5sec ±1sec
Pb-Free devices.	260°C +0/-5°C	5sec ±1sec

8. Appendix**Appendix-B****Important Notice****© Silicongear Corporation**

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