SPECIFICATION

Device Name	:	Power MOSFET
Type Name	:	2SK4006-01L,S,SJ
Spec. No.	:	MS5F6095
Date	:	*Apr.-11-2005*

Fuji Electric Device Technology Co.,Ltd.
Matsumoto Factory

	DATE	NAME	APPROVED
DRAWN	*Apr.-11-'05*	T.Kuboyama	
CHECKED	*Apr.-11-'05*	T.HOSEN	
CHECKED	*Apr.-11-'05*	T.Kokawa	

Fuji Electric Device Technology Co.,Ltd.

DWG.NO. MS5F6095 1/21

Revised Records

Date	Classification	Index	Content	Drawn	Checked	Checked	Approved
Apr.-11 2005	enactment	—	———————	T.Kidoguchi	T.HOSEN	T.Kobayashi	J. Sakai

1.Scope This specifies Fuji Power MOSFET 2SK4006-01L,S,SJ

2.Construction N-Channel enhancement mode power MOSFET

3.Applications for Switching

4.Outview T-Pack L Outview See to 8/21 page

T-Pack S Outview See to 9/21 page

T-Pack SJ Outview See to 10/21 page

5.Absolute Maximum Ratings at Tc=25°C (unless otherwise specified)

Description	Symbol	Characteristics	Unit	Remarks
Drain-Source Voltage	V_{DS}	900	V	
	V_{DSX}	900	V	VGS=-30V
Continuous Drain Current	I_D	9	A	
Pulsed Drain Current	I_{DP}	± 36	A	
Gate-Source Voltage	V_{GS}	± 30	V	
Repetitive and Non-repetitive Maximum Avalanche Current	I_{AR}	9	A	Note *1
Non-Repetitive Maximum Avalanche Energy	E_{AS}	719.1	mJ	Note *2
Repetitive Maximum Avalanche Energy	E_{AR}	27.0	mJ	Note *3
Maximum Drain-Source dV/dt	dV_{DS}/dt	40	kV/μs	VDS≤900V
Peak Diode Recovery dV/dt	dV/dt	5	kV/μs	Note *4
Maximum Power Dissipation	P_D	270	W	Tc=25°C
		1.67		Ta=25°C
Operating and Storage	T_{ch}	150	°C	
Temperature range	T_{stg}	-55 to +150	°C	

6.Electrical Characteristics at Tc=25°C (unless otherwise specified)

Static Ratings

Description	Symbol	Conditions		min.	typ.	max.	Unit
Drain-Source Breakdown Voltage	BV_{DSS}	I_D=250μA V_{GS}=0V		900	-	-	V
Gate Threshold Voltage	V_{GS}(th)	I_D=250μA V_{DS}=V_{GS}		3.0	-	5.0	V
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS}=900V V_{GS}=0V	T_{ch}=25°C	-	-	25	μA
		V_{DS}=720V V_{GS}=0V	T_{ch}=125°C	-	-	250	
Gate-Source Leakage Current	I_{GSS}	V_{GS}= ± 30V V_{DS}=0V		-	10	100	nA
Drain-Source On-State Resistance	R_{DS}(on)	I_D=4.5A V_{GS}=10V		-	1.22	1.58	Ω

Dynamic Ratings

Description	Symbol	Conditions	min.	typ.	max.	Unit
Forward Transconductance	g_{fs}	I_D=4.5A V_{DS}=25V	5.0	10	-	S
Input Capacitance	Ciss	V_{DS}=25V	-	1100	1650	pF
Output Capacitance	Coss	V_{GS}=0V	-	140	210	pF
Reverse Transfer Capacitance	Crss	f=1MHz	-	8.0	12	pF
Turn-On Time	td(on)	V_{cc}=600V	-	25	38	ns
	tr	V_{GS}=10V	-	12	18	ns
Turn-Off Time	td(off)	I_D=4.5A	-	50	75	ns
	tf	R_{GS}=10Ω	-	12	18	ns
Total Gate Charge	Q_G	V_{cc}=450V	-	31.0	46.5	nC
Gate-Source Charge	Q_{GS}	I_D=9A	-	4.5	8.0	nC
Gate-Drain Charge	Q_{GD}	V_{GS}=10V	-	11.0	16.5	nC

Reverse Diode

Description	Symbol	Conditions	min.	typ.	max.	Unit
Diode Forward On-Voltage	V_{SD}	I_F=9A V_{GS}=0V T_{ch}=25°C	-	0.90	1.50	V
Reverse Recovery Time	trr	I_F=9A V_{GS}=0V	-	3.2	-	μs
Reverse Recovery Charge	Qrr	-di/dt=100A/μs T_{ch}=25°C	-	15.5	-	μC

7.Thermal Resistance

Description	Symbol	min.	typ.	max.	Unit
Channel to Case	Rth(ch-c)			0.463	°C/W
Channel to Ambient	Rth(ch-a)			75	°C/W

Note *1 : Tch≤150°C, See Fig.1 and Fig.2

Note *2 : Starting Tch=25°C,I_{AS}=3.6A,L=102mH,Vcc=90V,R_G=50Ω,See Fig.1 and Fig.2
E_{AS} limited by maximum channel temperature and avalanche current.
See to the 'Avalanche Energy' graph of page 20/21.

Note *3 : Repetitive rating : Pulse width limited by maximum channel temperature.
See to the 'Maximum Transient Thermal impedance' graph of page 21/21.

Note *4 : I_F≤-I_D,-di/dt=50A/μs,Vcc≤BV_{DSS},Tch≤150°C

Fig.1 Test circuit

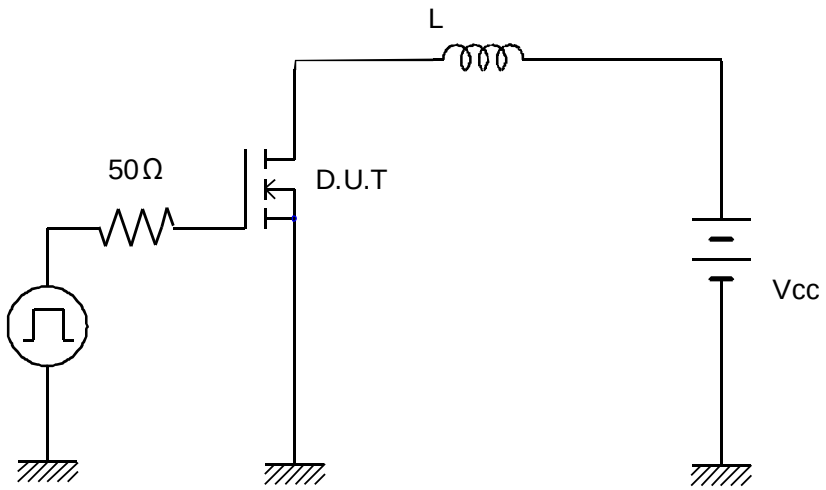
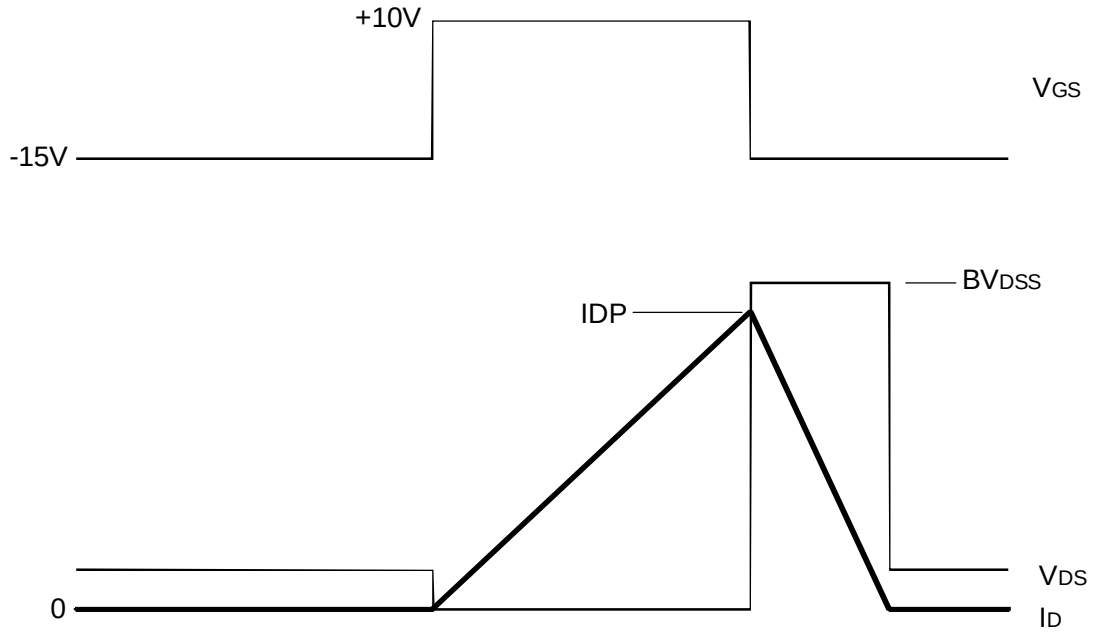


Fig.2 Operating waveforms



8.Reliability test items

All guaranteed values are under the categories of reliability per non-assembled(only MOSFETs). Each categories under the guaranteed reliability conform to EIAJ ED4701/100 method104 standards.

Test items required without fail.
Humidification treatment (85±2°C,65±5%RH,168±24hr)
Heat treatment of soldering
Through Hole Package (Solder Dipping,260±5°C(265°Cmax.),10±1sec,2 times)
SMD Package(IR-ray Reflow ,255±5°C(260°Cmax.),10±1sec,2 times)

	Test No.	Test Items	Testing methods and Conditions	Reference Standard	Sampling number	Acceptance number
Mechanical test methods	1	Terminal Strength (Tensile) (Through Hole)	Pull force TO-220,TO-220F : 10N TO-3P,TO-3PF,TO-247 : 25N TO-3PL : 45N T-Pack,K-Pack : 10N Force maintaining duration :30±5sec	EIAJ ED4701/400 method 401	15	(0:1)
	2	Terminal Strength (Bending) (Through Hole)	Load force TO-220,TO-220F : 5N TO-3P,TO-3PF,TO-247 : 10N TO-3PL : 15N T-Pack,K-Pack : 5N Number of times :2times(90deg./time)	EIAJ ED4701/400 method 401	15	
	3	Mounting Strength (Through Hole)	Screwing torque value: (M3) TO-220,TO-220F : 40±10N･cm TO-3P,TO-3PF,TO-247 : 50±10N･cm TO-3PL : 70±10N･cm	EIAJ ED4701/400 method 402	15	
	4	Vibration	frequency : 100Hz to 2kHz Acceleration : 200m/s^2 Sweeping time : 4min. 48min. for each X,Y&Z directions.	EIAJ ED4701/400 method 403	15	
	5	Shock	Peak amplitude: 15km/s^2 Duration time : 0.5ms 3times for each X,Y&Z directions.	EIAJ ED4701/400 method 404	15	
	6	Solderability	Solder temp. : 245±5°C Immersion time : 5±0.5sec About Through Hole Package type, each terminal shall be immersed in the solder bath within 1 to 1.5mm from the body.	-----	15	
	7	Resistance to Soldering Heat (Through Hole)	Solder temp. : 260±5°C Immersion time : 10±1sec Number of times : 1times	EIAJ ED4701/300 method 302	15	
		Resistance to Soldering Heat (SMD Type)	Solder temp. : 255±5°C Immersion time : 10±1sec Number of times : 2times IR-ray Reflowing	EIAJ ED4701/400 method 301	15	

	Test No.	Test Items	Testing methods and Conditions	Reference Standard	Sampling number	Acceptance number
Climatic test methods	1	High Temp. Storage	Temperature : 150+0/-5°C Test duration : 1000hr	EIAJ ED4701/200 method 201	22	(0:1)
	2	Low Temp. Storage	Temperature : -55+5/-0°C Test duration : 1000hr	EIAJ ED4701/200 method 202	22	
	3	Temperature Humidity Storage	Temperature : 85±2°C Relative humidity : 85±5% Test duration : 1000hr	EIAJ ED4701/100 method 103	22	
	4	Temperature Humidity BIAS	Temperature : 85±2°C Relative humidity : 85±5% Bias Voltage : V_{DS}(max) * 0.8 Test duration : 1000hr	EIAJ ED4701/100 method 103	22	
	5	Unsaturated Pressurized Vapor	Temperature : 130±2°C Relative humidity : 85±5% Vapor pressure : 230kPa Test duration : 48hr	EIAJ ED4701/100 method 103	22	
	6	Temperature Cycle	High temp.side : 150±5°C/30min. Low temp.side : -55±5°C/30min. RT : 5°C ～ 35°C/5min. Number of cycles : 100cycles	EIAJ ED4701/100 method 105	22	
	7	Thermal Shock	Fluid : pure water(running water) High temp.side : 100+0/-5°C Low temp.side : 0+5/-0°C Duration time : HT 5min,LT 5min Number of cycles : 100cycles	EIAJ ED4701/300 method 307	22	
Endurance test methods	8	Intermittent Operating Life	ΔTc=90degree Tch≦Tch(max.) Test duration : 3000 cycle	EIAJ ED4701/100 method 106	22	(0:1)
	9	HTRB (Gate-source)	Temperature : Tch=150+0/-5°C Bias Voltage : +V_{GS}(max) Test duration : 1000hr	EIAJ ED4701/100 method 101	22	
	10	HTRB (Drain-Source)	Temperature : Tch=150+0/-5°C Bias Voltage : V_{DS}(max)*0.8 Test duration : 1000hr	EIAJ ED4701/100 method 101	22	

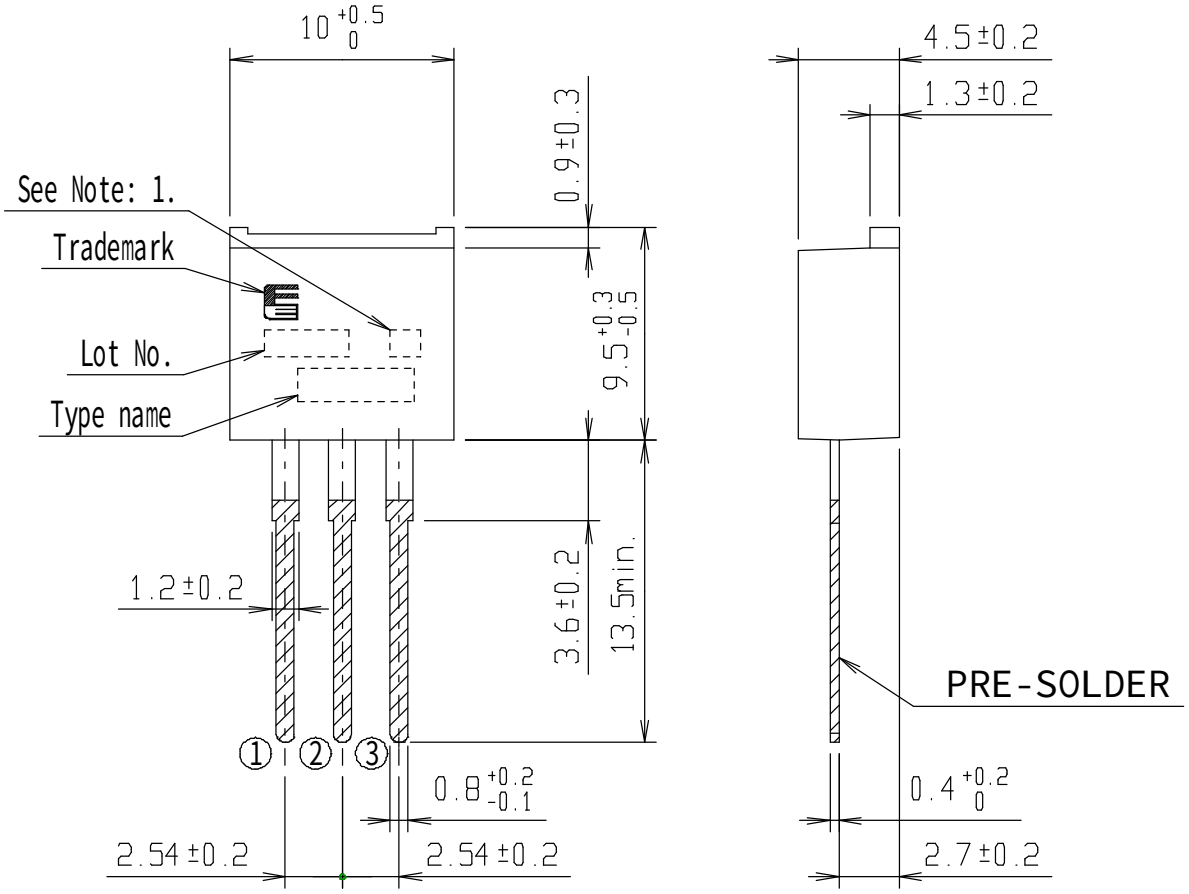
Failure Criteria

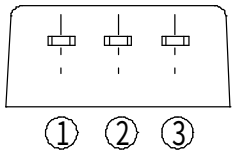
Item		Symbols	Failure Criteria		Unit
			Lower Limit	Upper Limit	
Electrical Characteristics	Breakdown Voltage	BVDSS	LSL	-----	V
	Zero gate Voltage Drain-Source Current	IDSS	-----	USL	A
	Gate-Source Leakage Current	IGSS	-----	USL	A
	Gate Threshold Voltage	VGS(th)	LSL	USL	V
	Drain-Source on-state Resistance	RDS(on)	-----	USL	Ω
	Forward Transconductance	gfs	LSL	-----	S
	Diode forward on-Voltage	VSD	-----	USL	V
Outview	Marking Soldering and other damages	-----	With eyes or Microscope		-----

* LSL : Lower Specification Limit　　* USL : Upper Specification Limit

* Before any of electrical characteristics measure, all testing related to the humidity have conducted after drying the package surface for more than an hour at 150°C.

FUJI POWER MOS FET





CONNECTION

① GATE
② DRAIN
③ SOURCE

JEDEC : TO-220AB

Note: 1. Guaranteed mark of avalanche ruggedness.

DIMENSIONS ARE IN MILLIMETERS.

FUJI POWER MOS FET

OUT VIEW

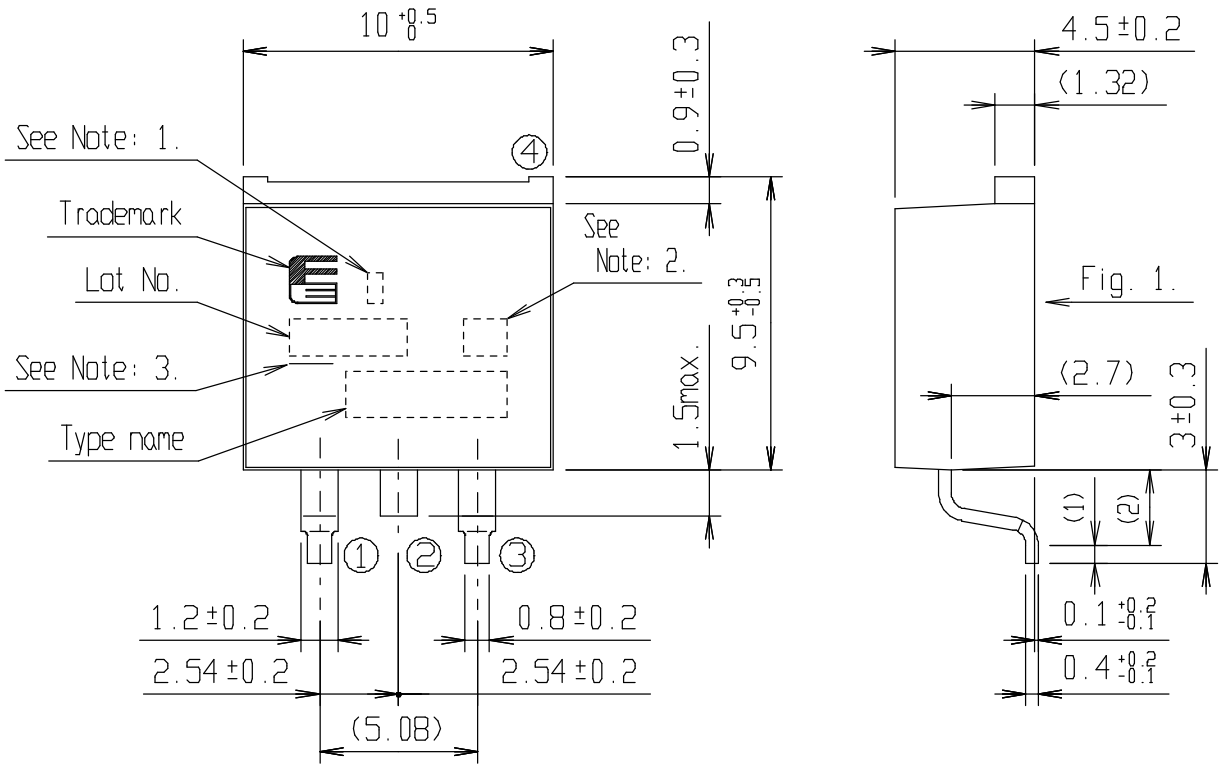
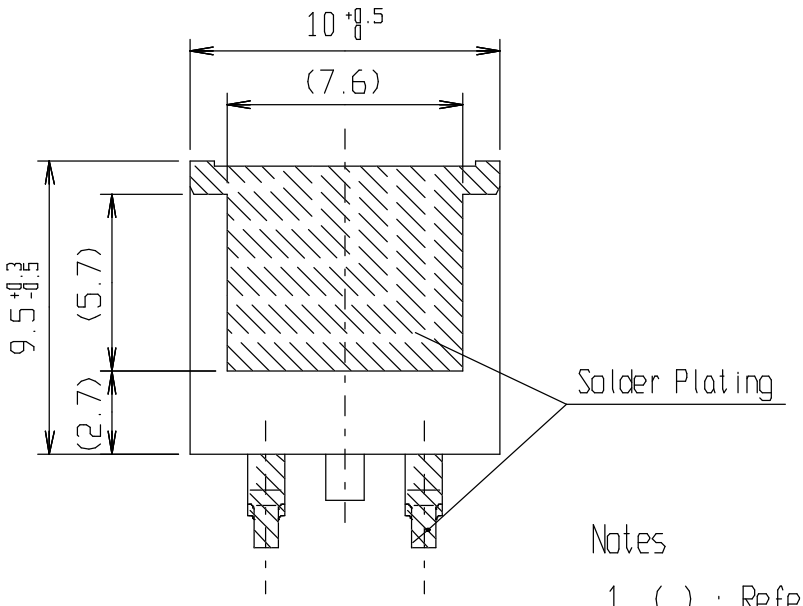


Fig. 1.



CONNECTION

① GATE
④ ② DRAIN
③ SOURCE

Note: 1. Country of origin mark.
- No mark is Made in JAPAN.
- "P" is Made in Philippines.

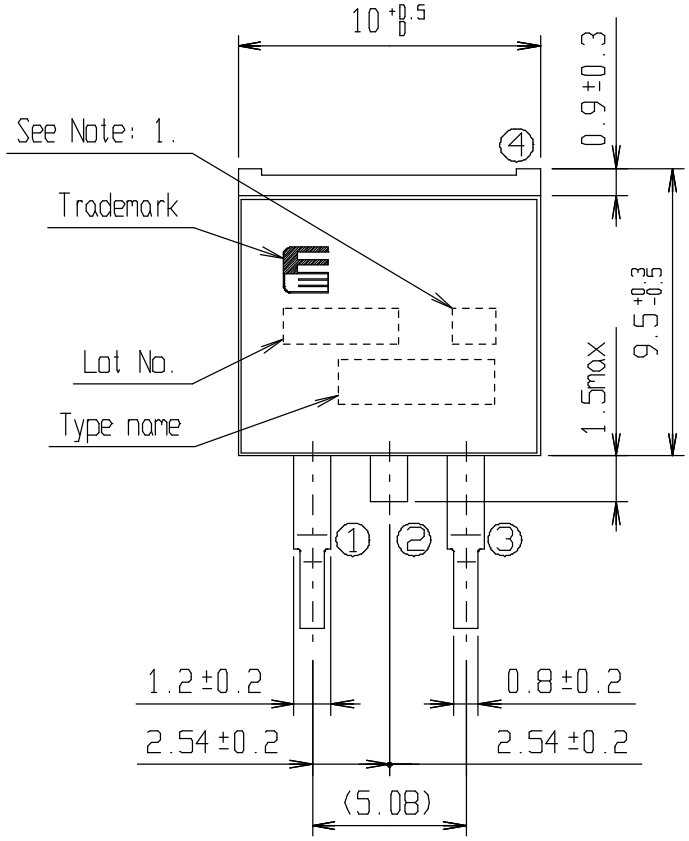
2. Guaranteed mark of avalanche ruggedness.
3. Mark of Lead-Free Solder. (①-④terminals)

Notes

1. ( ) : Reference dimensions.
2. The metal part is covered with the solder plating, part of cutting is without the solder plating.

DIMENSIONS ARE IN MILLIMETERS.

OUT VIEW



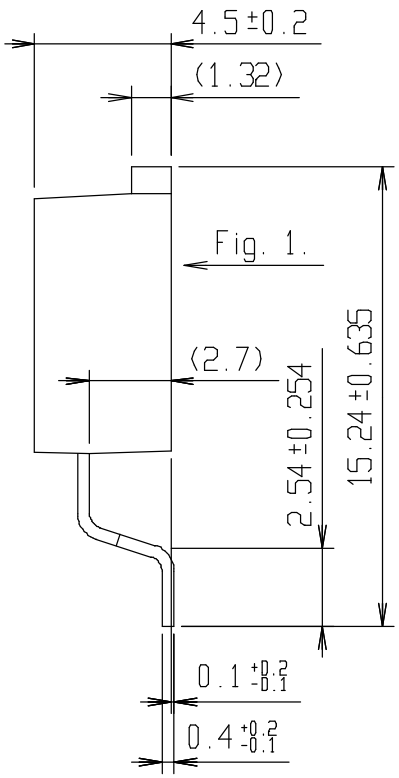
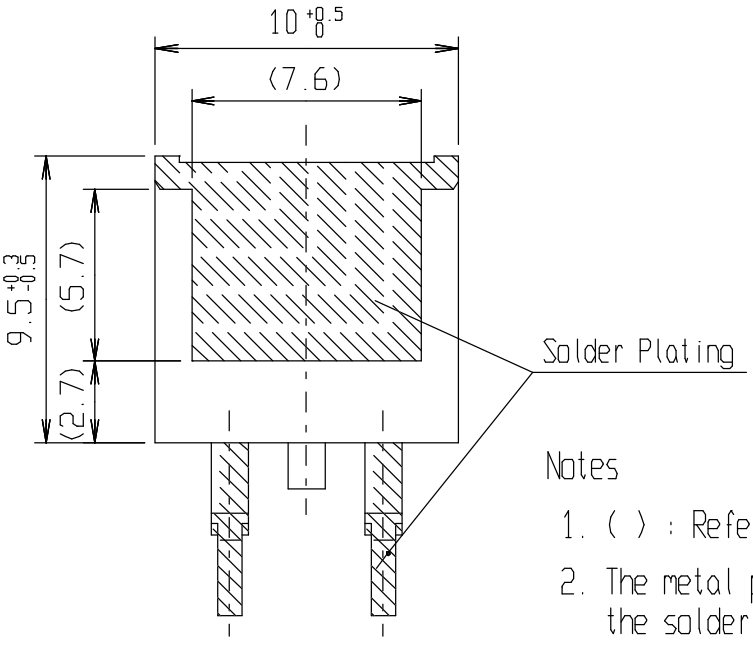


Fig. 1.



Note: 1. Guaranteed mark of avalanche ruggedness.

CONNECTION

① GATE
④ ② DRAIN
③ SOURCE

Notes

1. ( ) : Reference dimensions.
2. The metal part is covered with the solder plating, part of cutting is without the solder plating.

DIMENSIONS ARE IN MILLIMETERS.

9. Cautions

・Although Fuji Electric Device Technology is continually improving product quality and reliability, a small percentage of semiconductor products may become faulty. When using Fuji Electric Device Technology semiconductor products in your equipment, you are requested to take adequate safety measures to prevent the equipment from causing physical injury, fire, or other problem in case any of the products fail. It is recommended to make your design fail-safe, flame retardant, and free of malfunction.

・The products described in this Specification are intended for use in the following electronic and electrical equipment which has normal reliability requirements.

・Computers	・OA equipment	・Communications equipment (Terminal devices)
・Machine tools	・AV equipment	・Measurement equipment
・Personal equipment	・Industrial robots	・Electrical home appliances etc.

・The products described in this Specification are not designed or manufactured to be used in equipment or systems used under life-threatening situations. If you are considering using these products in the equipment listed below, first check the system construction and required reliability, and take adequate safety measures such as a backup system to prevent the equipment from malfunctioning.

・Backbone network equipment	・Transportation equipment (automobiles, trains, ships, etc.)
・Traffic-signal control equipment	・Gas alarms, leakage gas auto breakers
・Submarine repeater equipment	・Burglar alarms, fire alarms, emergency equipment
・Medical equipment	・Nuclear control equipment etc.

・Do not use the products in this Specification for equipment requiring strict reliability such as(but not limited to):

・Aerospace equipment	・Aeronautical equipment

10. Warnings

・The MOSFETs should be used in products within their absolute maximum rating(voltage, current, temperature, etc.).
・The MOSFETs may be destroyed if used beyond the rating.
・We only guarantee the non-repetitive Avalanche capability and not for the continuous Avalanche capability which can be assumed as abnormal condition .Please note the device may be destructed from the Avalanche over the specified maximum rating.
・The equipment containing MOSFETs should have adequate fuses or circuit breakers to prevent the equipment from causing secondary destruction (fire, explosion etc...).
・Use the MOSFETs within their reliability and lifetime under certain environments or conditions. The MOSFETs may fail before the target lifetime of your products if used under certain reliability conditions.

・Be careful when handling MOSFETs for ESD damage. (It is an important consideration)
・When handling MOSFETs, hold them by the case (package) and don't touch the leads and terminals.
・It is recommended that any handling of MOSFETs is done on grounded electrically conductive floor or tablemats.

・Before touching a MOSFET terminal, discharge any static electricity from your body and clothes by grounding out through a high impedance resistor (about 1MΩ)
・When soldering, in order to protect the MOSFETs from static electricity, ground the soldering iron or soldering bath through a low impedance resistor.
・You must design the MOSFETs to be operated within the specified maximum ratings(voltage, current, temperature, etc.) to prevent possible failure or destruction of devices.
・Consider the possible temperature rise not only for the channel and case, but also for the outer leads.
・Do not directly touch the leads or package of the MOSFETs while power is supplied or during operation in order to avoid electric shock and burns.
・The MOSFETs are made of incombustible material. However, if a MOSFET fails, it may emit smoke or flame. MOSFETs become hotter during operation. Hence, operating the MOSFETs near any flammable place or material is unadvisable. Design the arrangement to prevent the spread of fire.
・The MOSFETs should not used in an environment in the presence of acid, organic matter, or corrosive gas(hydrogen sulfide, sulfurous acid gas etc.)
・The MOSFETs should not used in an irradiated environment since they are not radiation-proof.

Installation / Through-Hole Package

・Soldering involves temperatures which exceed the device storage temperature rating. To avoid device damage and to ensure reliability, observe the following guidelines from the quality assurance standard.

Soldering temperature and duration (through-hole package)

Solder temperature	Immersion time
260±5 °C	10±1 seconds
350±10 °C	3.5±0.5 seconds

・The immersion depth of the lead should basically be up to the lead stopper and the distance should be a maximum of 1.5mm from the device.
・When flow-soldering, be careful to avoid immersing the package in the solder bath.

Soldering methods (through-hole package)

	Methods				
Packages	Wave Soldering (Full dipping)	Wave Soldering (Only terminal)	Infrared Reflow	Air Reflow	Soldering iron (Re-work)
TO-3PL	×	◎	×	×	○
TO-3P	×	◎	×	×	○
TO-247	×	◎	×	×	○
TO-3PF	×	◎	×	×	○
TO-220	×	◎	×	×	○
TO-220F	×	◎	×	×	○
T-Pack(L)	×	◎	×	×	○
TO-3PL-7	×	◎	×	×	○

◎：Possible ○：Limited to 1 time ×：Unable

・Refer to the following torque reference when mounting the device on a heat sink. Excess torque applied to the mounting screw causes damage to the device and weak torque will increase the thermal resistance, both of which conditions may destroy the device.

Table 1: Recommended tightening torques.

Package style	Screw	Tightening torques	Note
TO-220 TO-220F	M3	30 – 50 Ncm	flatness : < ±30μm roughness : <10μm Plane off the edges : C<1.0mm
TO-3P TO-3PF TO-247	M3	40 – 60 Ncm	
TO-3PL	M3	60 –80 Ncm	

・The heat sink should have a flatness within±30μm and roughness within 10μm. Also, keep the tightening torque within the limits of this specification.

・Improper handling may cause isolation breakdown leading to a critical accident.
ex.) Over plane off the edges of screw hole. (Recommended plane off the edge is C<1.0mm)

・We recommend the use of thermal compound to optimize the efficiency of heat radiation. It is important to evenly apply the compound and to eliminate any air voids.

Installation / SMD Package

・Soldering involves temperatures which exceed the device storage temperature rating. To avoid device damage and to ensure reliability, observe the following guidelines from the quality assurance standard.

Soldering temperature and duration (SMD Package)

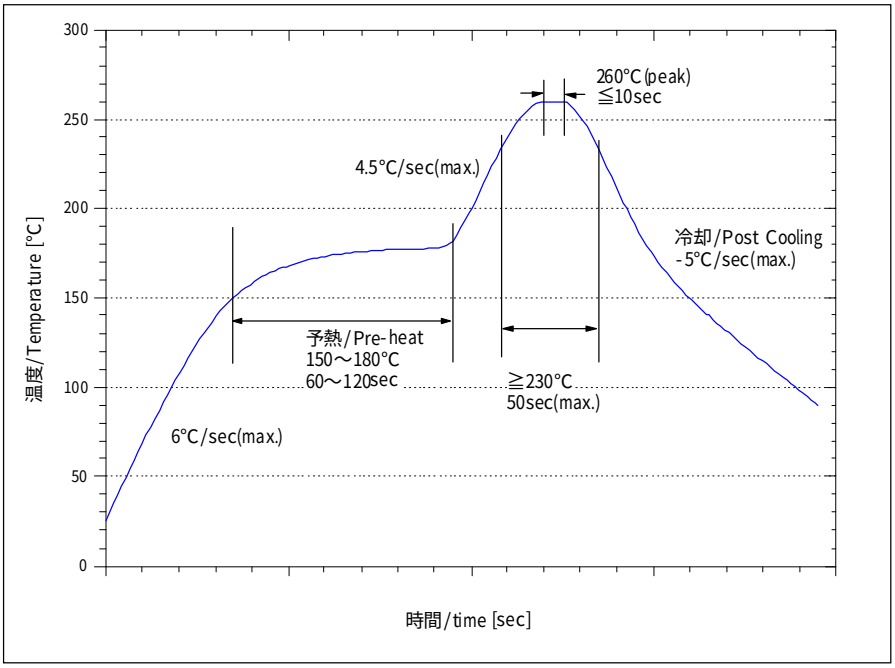
	Reflow-Soldering
Number of times	Twice
Soldering Temp. & Time	≥230℃, ≤50sec
Package surface Peak Temp. & Time	≤260℃, ≤10sec

Soldering methods (SMD Package)

	Methods				
Packages	Wave Soldering (Full dipping)	Wave Soldering (Only terminal)	Infrared Reflow	Air Reflow	Soldering iron (Re-work)
T-Pack(S)	×	×	◎	◎	×
T-Pack(SJ)	×	×	◎	◎	×
K-Pack(S)	×	×	◎	◎	×
TFP	×	×	◎	◎	×

◎：Possible ○：Limited to 1 time ×：Unable

Recommended Reflow profile



Storage

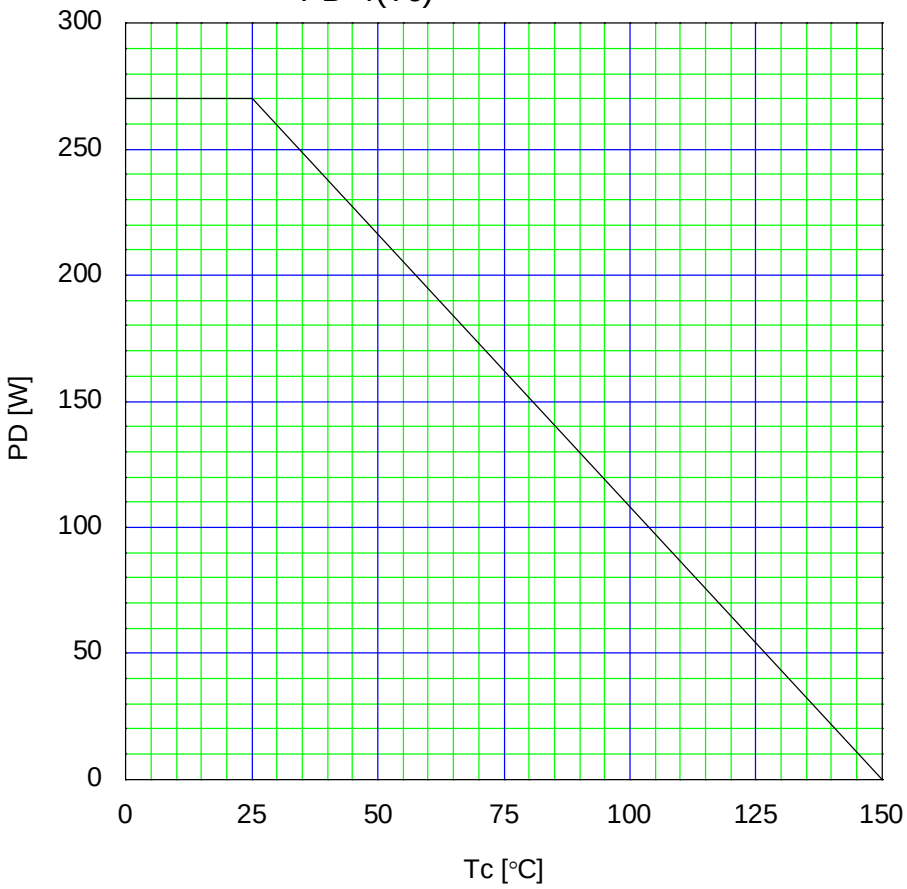
- The MOSFETs must be stored at a standard temperature of 5 to 35°C and relative humidity of 45 to 75%.
- If the storage area is very dry, a humidifier may be required. In such a case, use only deionized water or boiled water, since the chlorine in tap water may corrode the leads.
- The MOSFETs should not be subjected to rapid changes in temperature to avoid condensation on the surface of the MOSFETs. Therefore store the MOSFETs in a place where the temperature is steady.
- The MOSFETs should not be stored on top of each other, since this may cause excessive external force on the case.
- The MOSFETs should be stored with the lead terminals remaining unprocessed. Rust may cause presoldered connections to fail during later processing.
- The MOSFETs should be stored in antistatic containers or shipping bags.

11.Appendix

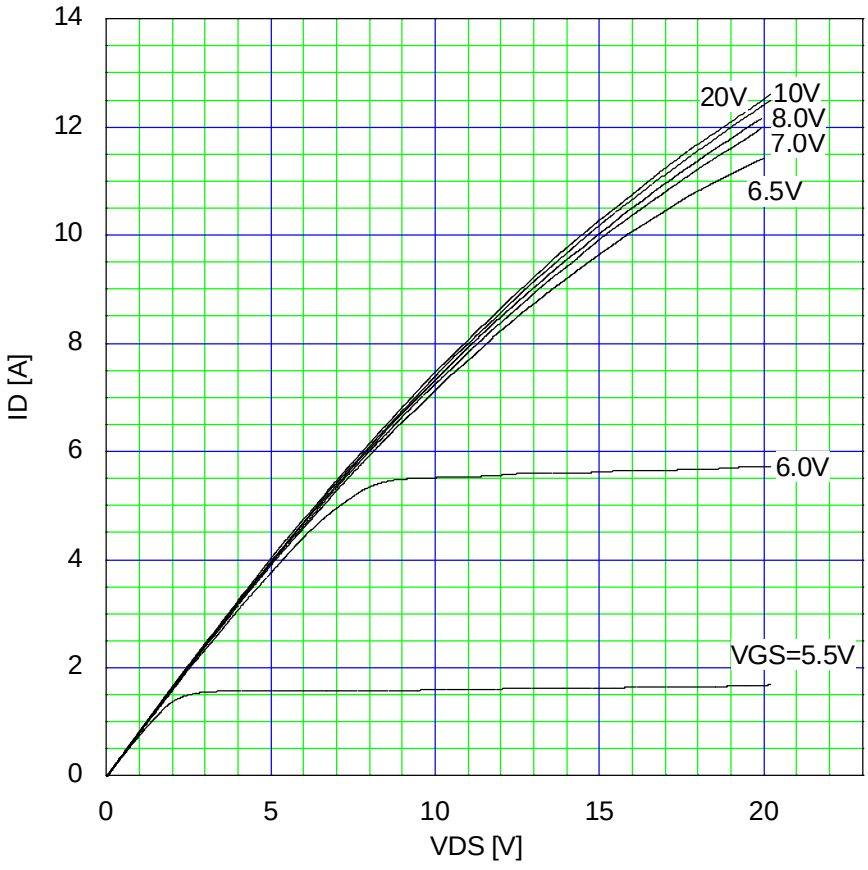
- This product does not contain PBBs(Polybrominated Biphenyl), PBDEs(Polybrominated Diphenyl Ether) , Mercury Compounds, Cadmium Compounds, Hexavalent Chromium Conpounds, Lead Compounds(but inner solder), substances.
- This product does not contain Class- Ⅰ and Class- Ⅱ ODS substances set force by Clean Air Act of US' law.

- If you have any questions about any part of this Spesification, please contact Fuji Electric Device Technology or its sales agent before using the product.
- Neither Fuji nor its agents shall be held liable for any injury caused by using the products not in accordance with the instructions.
- The application examples described in this specification are merely typical uses of Fuji Electric Device Technology products.

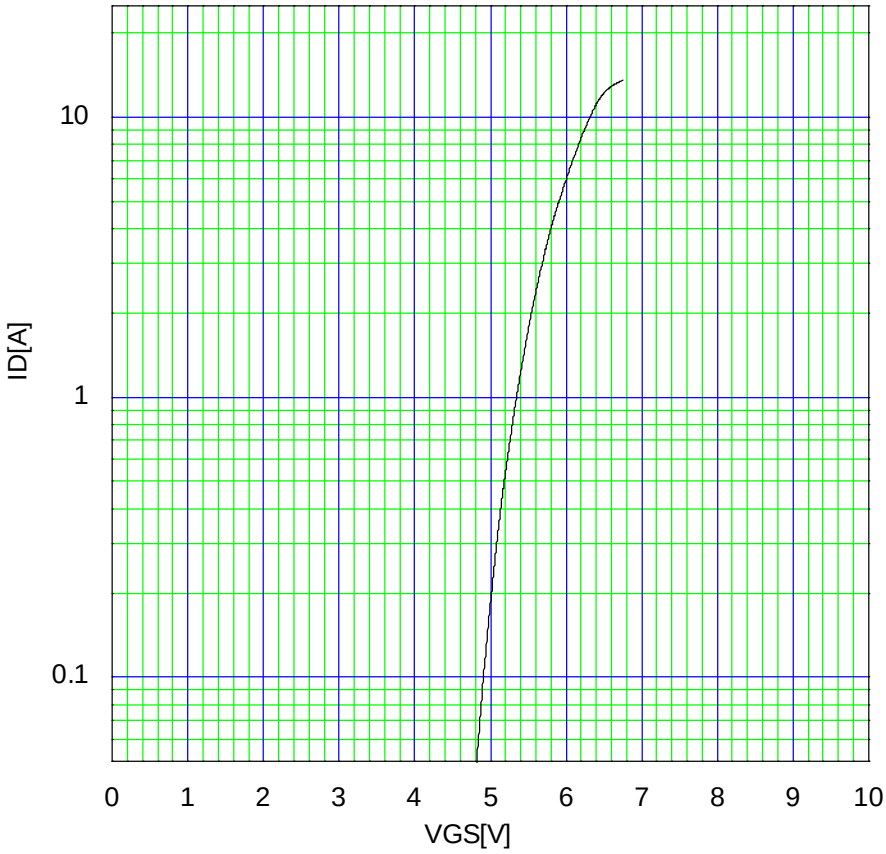
Allowable Power Dissipation
PD=f(Tc)



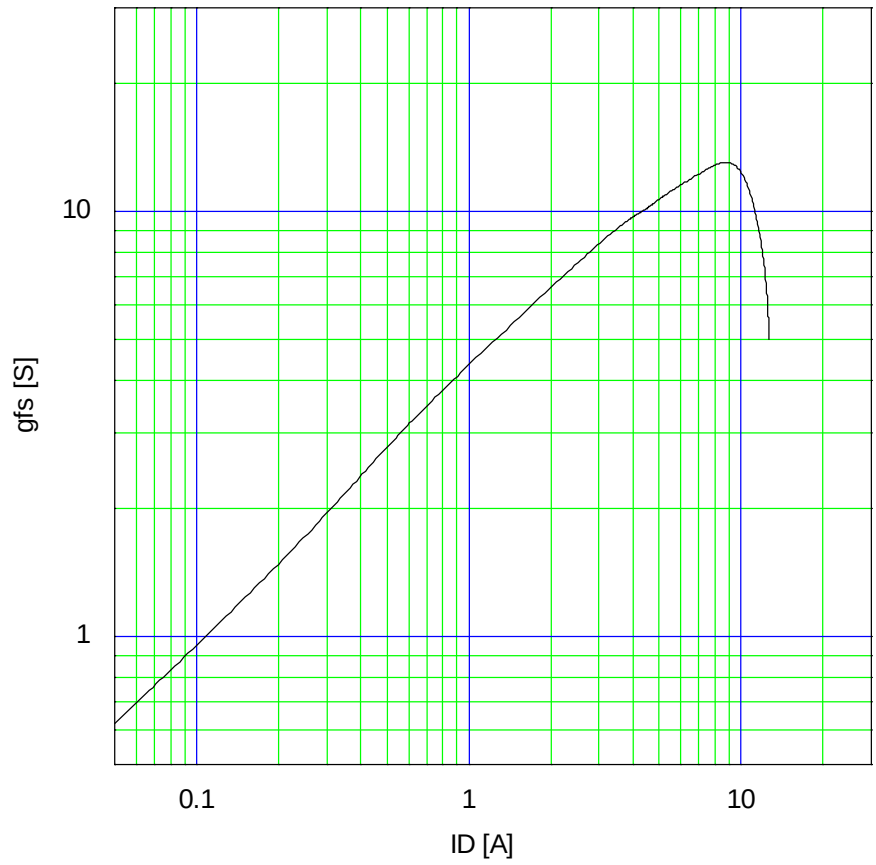
Typical Output Characteristics
ID=f(VDS):80 μs pulse test,Tch=25°C



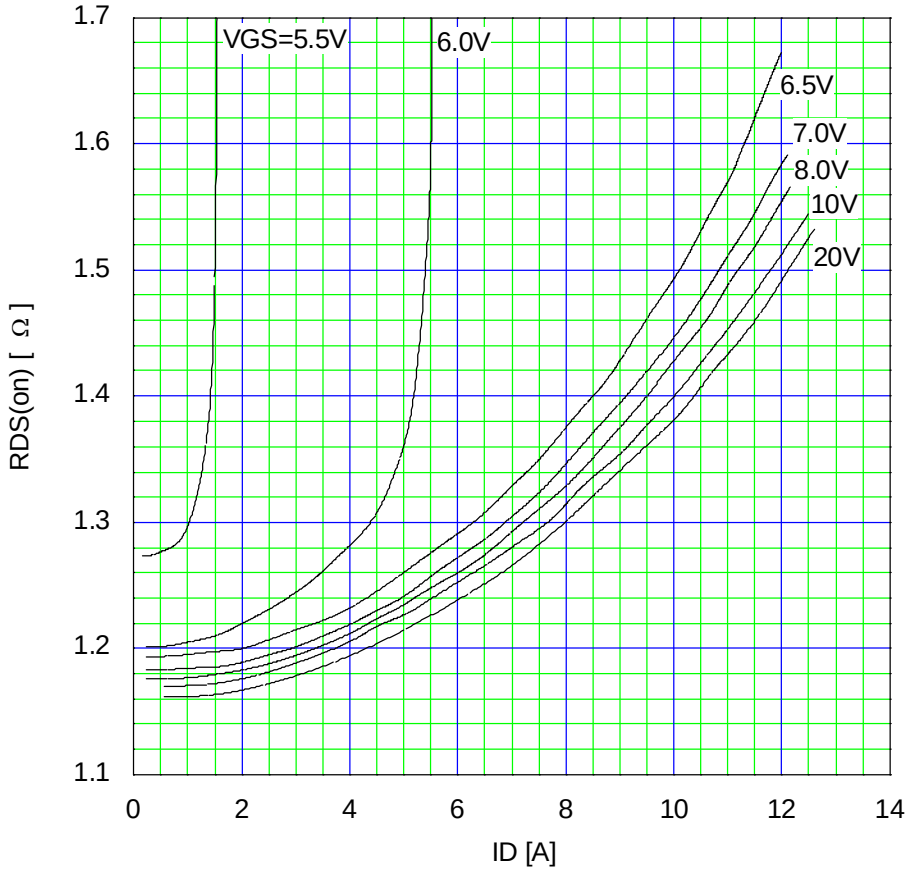
Typical Transfer Characteristic
ID=f(VGS):80 μs pulse test,VDS=25V,Tch=25°C



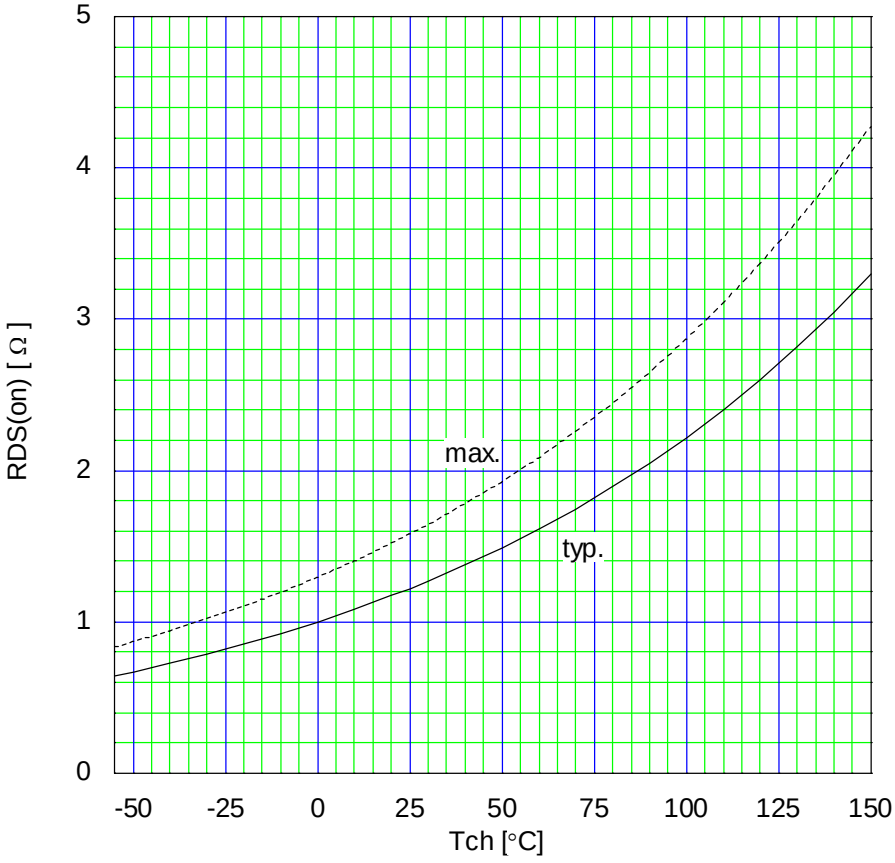
Typical Transconductance
gfs=f(ID):80 μs pulse test,VDS=25V,Tch=25°C



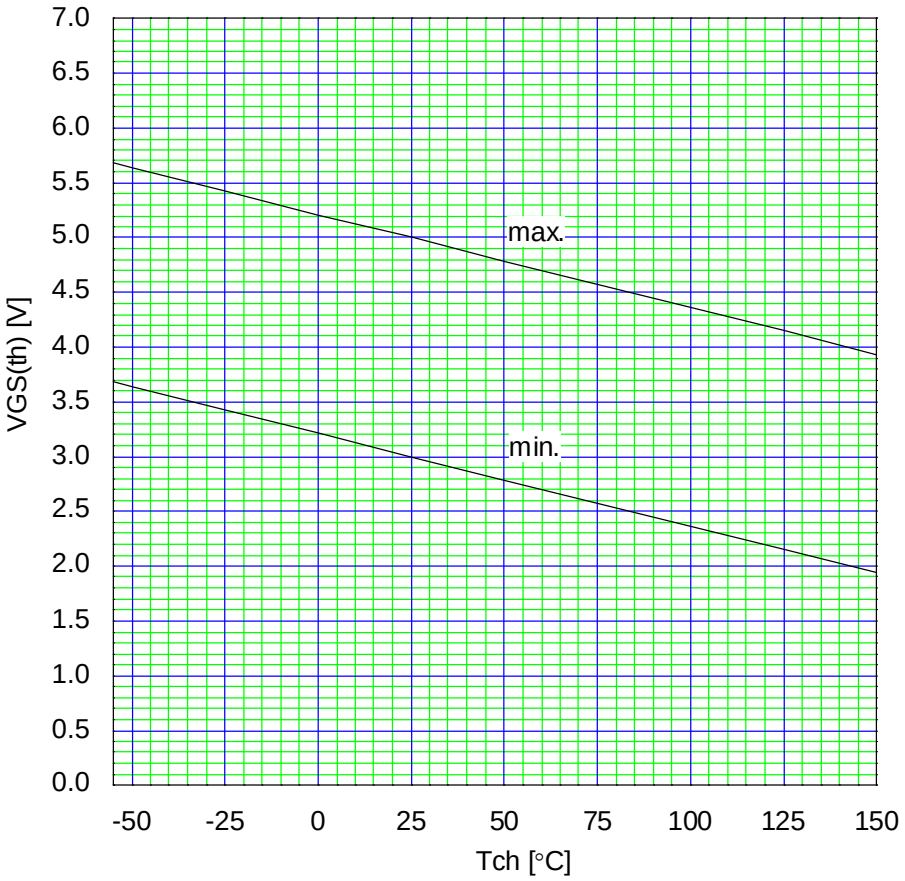
Typical Drain-Source on-state Resistance
RDS(on)=f(ID):80 μs pulse test,Tch=25°C



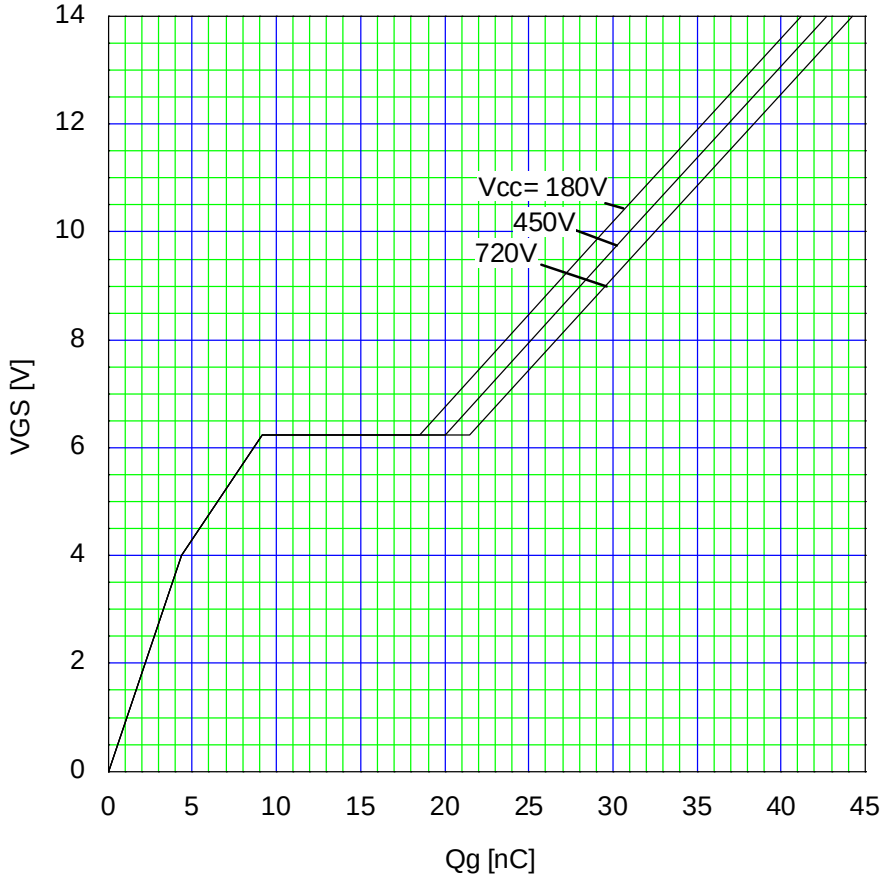
Drain-Source On-state Resistance
RDS(on)=f(Tch):ID=4.5A,VGS=10V



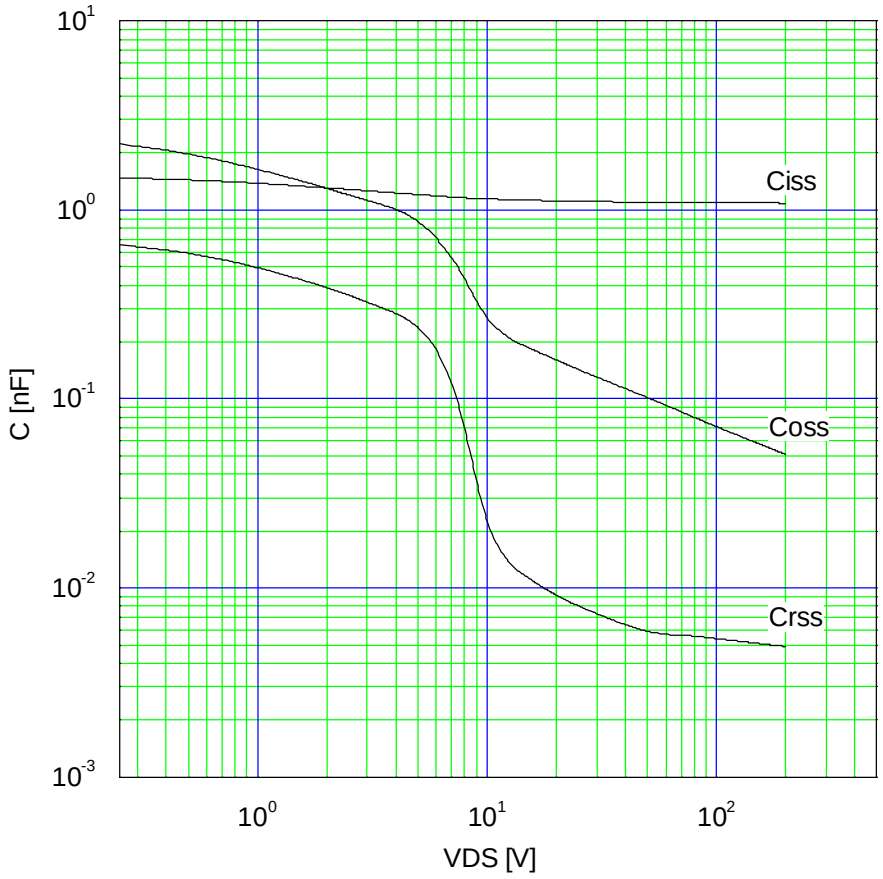
Gate Threshold Voltage vs. Tch
VGS(th)=f(Tch):VDS=VGS,ID=250μA



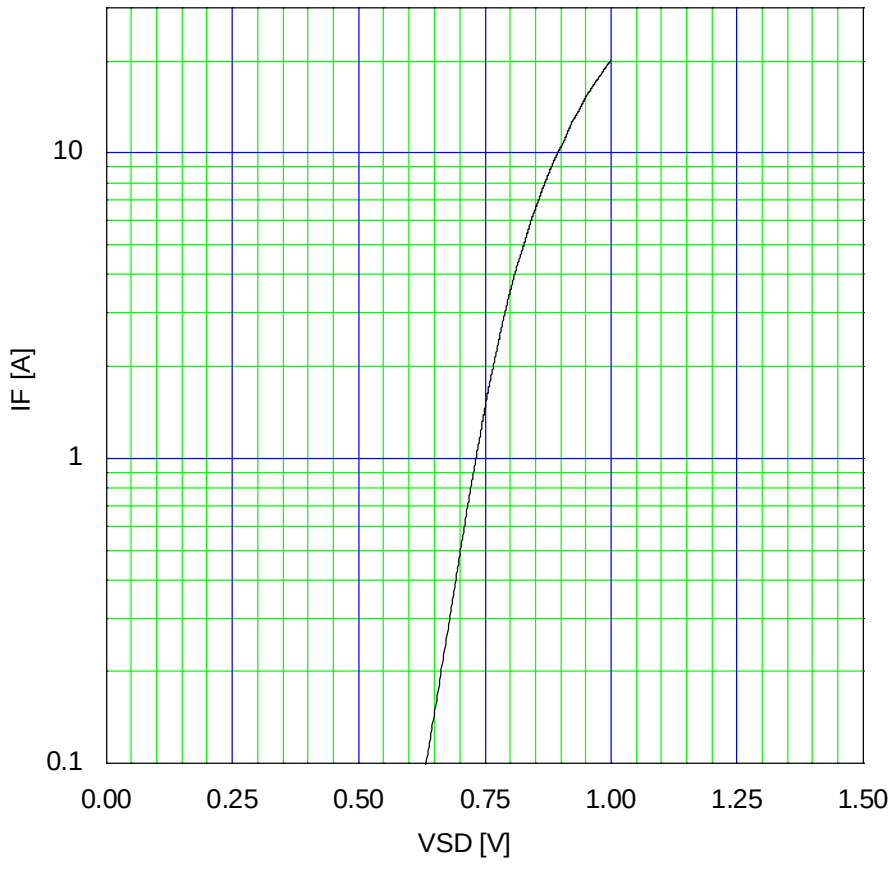
Typical Gate Charge Characteristics
VGS=f(Qg):ID=9A,Tch=25°C



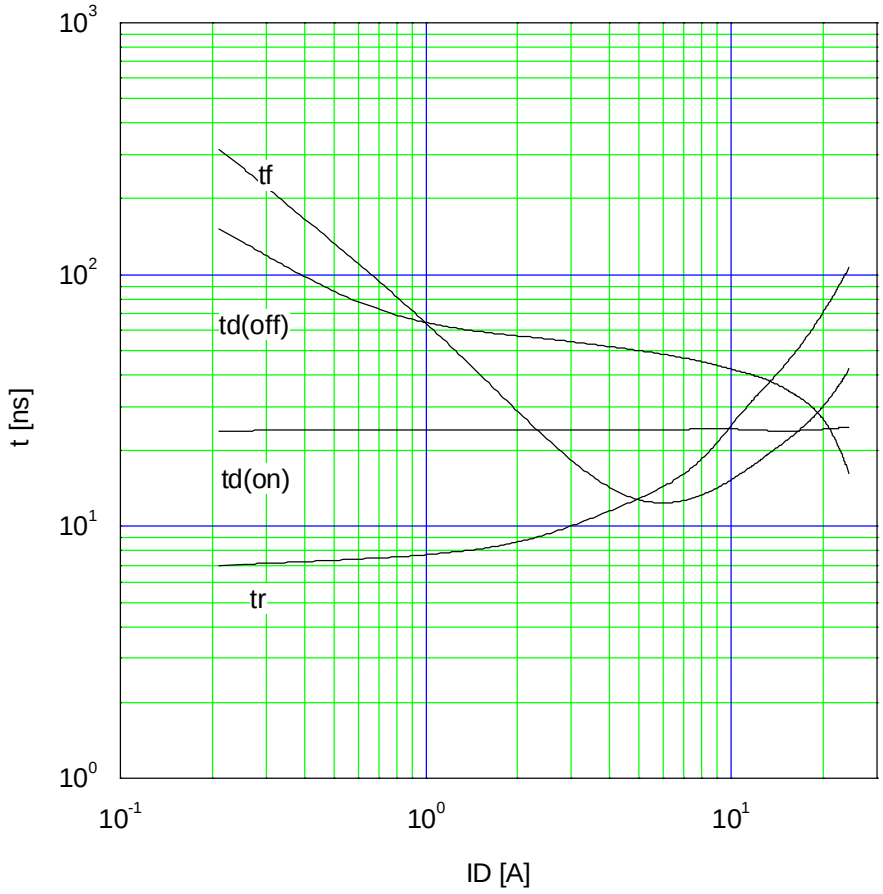
Typical Capacitance
C=f(VDS):VGS=0V,f=1MHz



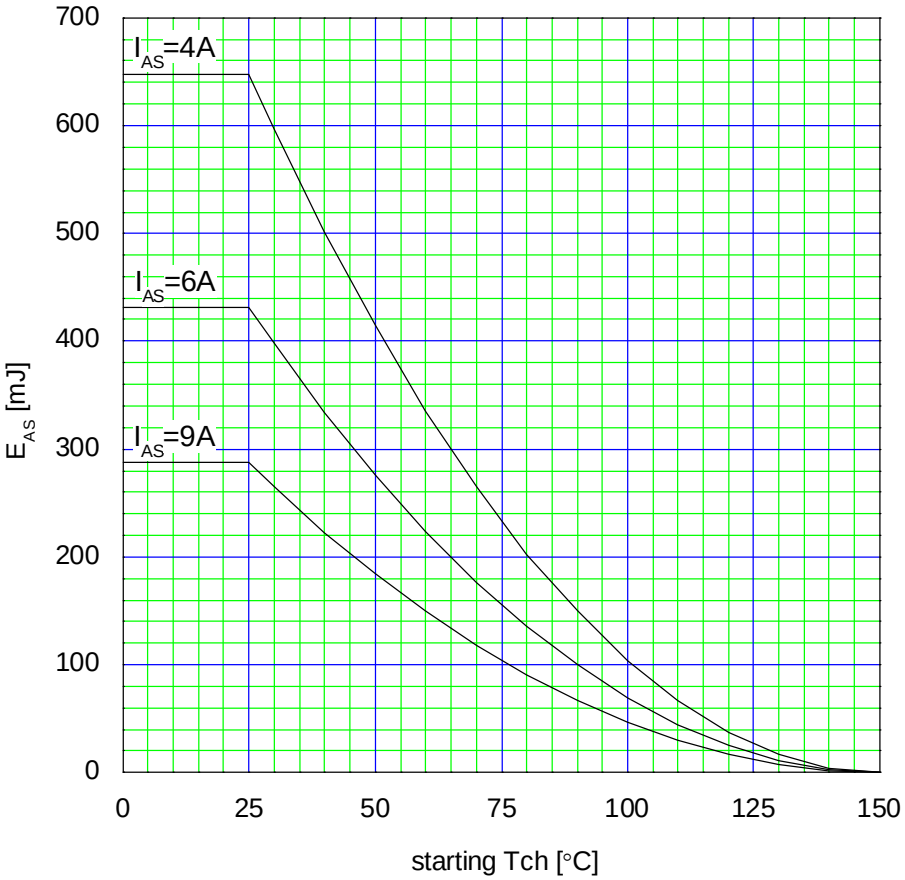
Typical Forward Characteristics of Reverse Diode
IF=f(VSD):80 μs pulse test,Tch=25°C



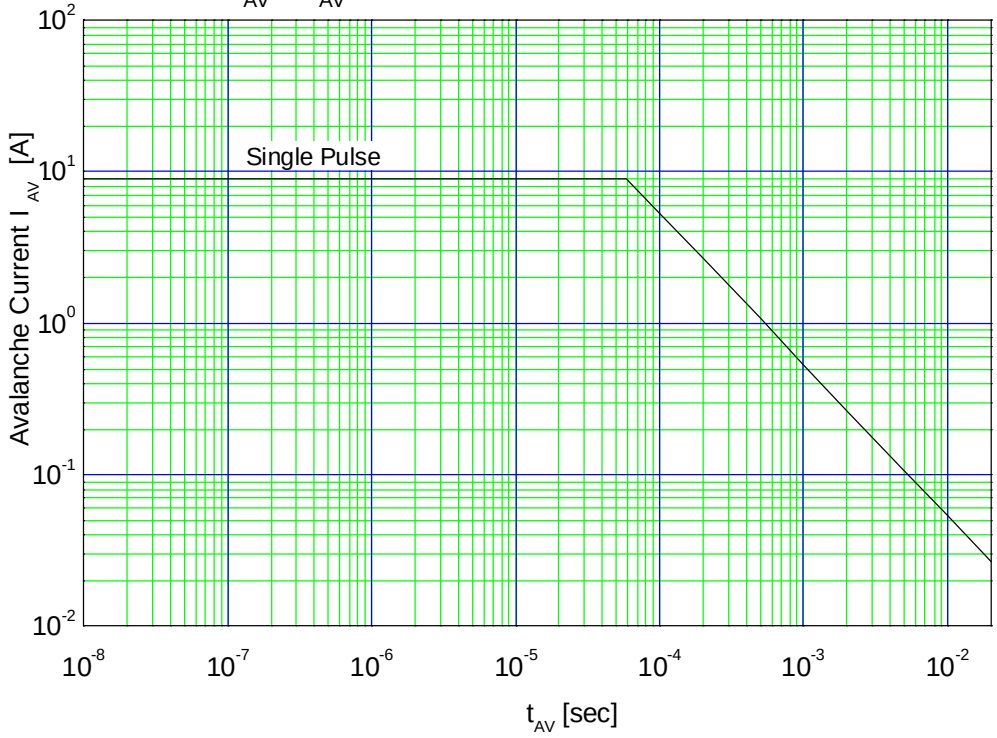
Typical Switching Characteristics vs. ID
t=f(ID):Vcc=600V,VGS=10V,RG=10 Ω



Maximum Avalanche Energy vs. starting Tch
E(AS)=f(starting Tch):Vcc=90V



Maximum Avalanche Current Pulsewidth
$I_{AV}=f(t_{AV})$:starting Tch=25°C,Vcc=90V



Maximum Transient Thermal Impedance
Zth(ch-c)=f(t):D=0