PowerMOS transistor
Logic level TOPFET

BUK112-50GL

DESCRIPTION

Monolithic temperature and overload protected logic level power MOSFET in a 5 pin plastic envelope, intended as a low side switch for automotive applications.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	MAX.	UNIT
V_{DS}	Continuous drain source voltage	50	V
I_D	Continuous drain current	12	A
T_j	Continuous junction temperature	150	˚C
$R_{DS(ON)}$	Drain-source on-state resistance	93	mΩ
SYMBOL	**PARAMETER**	**NOM.**	**UNIT**
V_{PS}	Protection supply voltage	5	V

FEATURES

- Vertical power DMOS output stage
- Low on-state resistance
- Low operating supply current
- Overtemperature protection
- Overload protection against short circuit load with drain current limiting
- Latched overload protection reset by protection supply
- Protection circuit condition indicated by flag pin
- Off-state detection of open circuit load indicated by flag pin
- 5 V logic compatible input level
- Integral input resistors.
- ESD protection on all pins
- Over voltage clamping

FUNCTIONAL BLOCK DIAGRAM

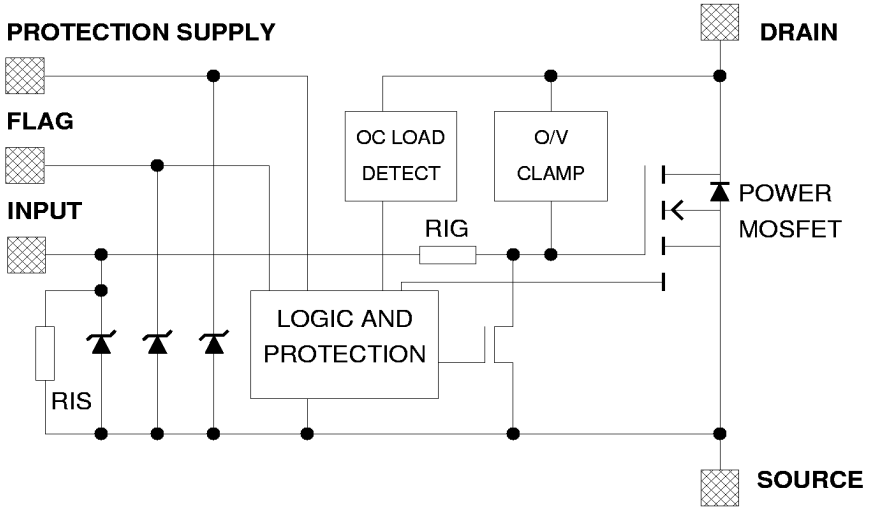


Fig.1. Elements of the TOPFET.

PINNING - SOT263

PIN	DESCRIPTION
1	input
2	flag
3	drain
4	protection supply
5	source
tab	drain

PIN CONFIGURATION

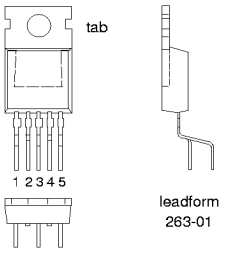


Fig. 2.

SYMBOL

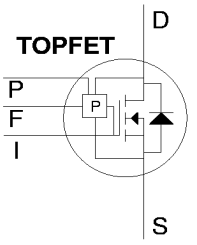


Fig. 3.

LIMITING VALUES

Limiting values in accordance with the Absolute Maximum Rating System (IEC 134)

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
	Continuous voltage				
V_{DS}	Drain source voltage[1]	V_{IS} = 0 V	-	50	V
	Continuous currents				
I_D	Drain current	V_{PS} = 5 V; T_{mb} = 25 ˚C	-	self - limited	A
		V_{PS} = 0 V; T_{mb} = 94 ˚C	-	12	A
I_I	Input current	-	-5	5	mA
I_F	Flag current	-	-5	5	mA
I_P	Protection supply current	-	-5	5	mA
	Thermal				
P_{tot}	Total power dissipation	T_{mb} = 25 ˚C	-	52	W
T_{stg}	Storage temperature	-	-55	175	˚C
T_j	Junction temperature[2]	continuous	-	150	˚C
T_{sold}	Lead temperature	during soldering	-	260	˚C

ESD LIMITING VALUES

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
	Electrostatic discharge capacitor voltages	Human body model; C = 100 pF; R = 1.5 kΩ			
V_{C1}	Drain to source		-	4.5	kV
V_{C2}	Input, flag or protection to source		-	2	kV

OVERLOAD PROTECTION LIMITING VALUE

With the protection supply connected, TOPFET can protect itself from two types of overload - short circuit load and overtemperature.

For overload conditions an n-MOS transistor turns on between the gate and source to quickly discharge the power MOSFET gate capacitance.

The drain current is limited to reduce dissipation in case of short circuit load. Refer to OVERLOAD CHARACTERISTICS.

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{PSP}	Protection supply voltage[3]	for valid protection	4.5	-	V

OVERVOLTAGE CLAMPING LIMITING VALUES

At a drain source voltage above 50 V the power MOSFET is actively turned on to clamp overvoltage transients.

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
E_{DSM}	Non-repetitive clamping energy	I_{DM} = 6 A; T_{mb} = 25˚C	-	200	mJ
E_{DRM}	Repetitive clamping energy	I_{DM} = 3.1 A; $V_{DD} \leq$ 20 V; $T_{mb} \leq$ 120˚C; f = 250 Hz	-	20	mJ

1 Prior to the onset of overvoltage clamping. For voltages above this value, safe operation is limited by the overvoltage clamping energy.

2 A higher T_j is allowed as an overload condition but at the threshold $T_{j(TO)}$ the over temperature trip operates to protect the switch.

3 The minimum supply voltage required for correct operation of the overload protection circuits.

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
	Thermal resistance					
$R_{th\ j\text{-}mb}$	Junction to mounting base	-	-	-	2.38	K/W
$R_{th\ j\text{-}a}$	Junction to ambient	in free air	-	60	-	K/W

OUTPUT CHARACTERISTICS

T_{mb} = 25 ˚C; V_{PS} = 0 V unless otherwise specified

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
	Off-state					
$V_{(CL)DSS}$	Drain-source clamping voltage	I_D = 10 mA; -40˚C ≤ T_{mb} ≤ 150˚C	50	-	70	V
		I_{DM} = 0.75 A; t_p ≤ 300 μs; δ ≤ 0.01	50	60	70	V
I_{DSS}	Drain-source leakage current[1]	V_{IS} = 0 V; V_{DS} = 13 V	-	0.5	10	μA
		V_{DS} = 50 V	-	1	20	μA
		T_{mb} = 125 ˚C; V_{DS} = 40 V	-	10	100	μA
	On-state	t_p ≤ 300 μs; δ ≤ 0.01				
$R_{DS(ON)}$	Drain-source on-resistance	I_{DM} = 6 A; V_{IS} = 4.4 V; V_{PS} = 4.5 V	-	70	93	mΩ
		T_{mb} = 150 ˚C	-	135	165	mΩ

INPUT CHARACTERISTICS

T_{mb} = 25 ˚C unless otherwise specified

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
	Normal operation					
$V_{IS(TO)}$	Input threshold voltage	V_{DS} = 13 V; V_{PS} = 0 V; I_D = 1 mA	1	1.5	2	V
		-40˚C ≤ T_{mb} ≤ 150˚C	0.5	-	2.5	V
I_{IS}	Input current	V_{IS} = 5 V -40˚C ≤ T_{mb} ≤ 150˚C	200	350	500	μA
$V_{(CL)IS}$	Input clamping voltage	I_I = 1.5 mA	6	7.1	-	V
R_{IG}	Internal series resistance	to gate of power MOSFET	-	1.5	-	kΩ
	Overload protection latched					
I_{ISL}	Input current	V_{PS} = 5 V; V_{IS} = 5 V	1.5	3.2	4	mA

REVERSE CHARACTERISTICS

T_{mb} = 25 ˚C

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$-V_{DS}$	Reverse drain voltage[2]	$-I_D$ = 6 A	-	0.8	-	V
$-V_{IS}$	Reverse input voltage	$-I_I$ = 5 mA	-	0.7	-	V
$-V_{PS}$	Reverse protection pin voltage	$-I_P$ = 5 mA	-	0.7	-	V
$-V_{FS}$	Reverse flag voltage	$-I_F$ = 5 mA	-	0.7	-	V

1 The drain current required for open circuit load detection is switched off when there is no protection supply, in order to ensure a low off-state quiescent current. Refer to OPEN CIRCUIT LOAD DETECTION CHARACTERISTICS.

2 Protection functions are disabled during reverse conduction.

PROTECTION SUPPLY CHARACTERISTICS

T_{mb} = 25 ˚C unless otherwise specified

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
	Normal operation or protection latched					
I_{PS}, I_{PSL}	Supply current	V_{PS} = 4.5 V	-	330	400	µA
		-40˚C ≤ T_{mb} ≤ 150˚C	-	-	450	µA
$V_{(CL)PS}$	Clamping voltage	I_P = 1.5 mA	6	7.1	-	V
	Overload protection latched					
V_{PSR}	Reset voltage		-	2.1	-	V
		-40˚C ≤ T_{mb} ≤ 150˚C	1.5	-	3	V
t_{pr}	Reset time	V_{PS} = 0 V	-	25	-	µs
		-40˚C ≤ T_{mb} ≤ 150˚C	-	-	150	µs

OPEN CIRCUIT LOAD DETECTION CHARACTERISTICS

An open circuit load condition can be detected while the TOPFET is in the off-state.
-40˚C ≤ T_{mb} ≤ 150˚C; V_{PS} = 5 V; V_{DS} = 13 V unless otherwise specified

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
I_{DSP}	Off-state drain current[1]	V_{IS} = 0 V	0.5	1.4	2	mA
I_{DSF}	Off-state drain threshold current	V_{IS} = 0 V; I_F = 100 µA	0.4	1.1	-	mA
V_{ISF}	Input threshold voltage[2]	I_F = 100 µA; I_D = 100 µA; T_{mb} = 25 ˚C	-	1.2	-	V

TRUTH TABLE

For normal, open-circuit load and overload conditions or inadequate protection supply voltage.

CONDITION	PROTECTION	INPUT	FLAG	OUTPUT
Normal on-state	1	1	0	1
Normal off-state	1	0	0	0
Open circuit load	1	1	0	1
Open circuit load	1	0	1	0
Short circuit load	1	1	1	0
Over temperature	1	X	1	0
Low protection supply voltage	0	1	1	1
Low protection supply voltage	0	0	1	0

For protection '0' equals low, '1' equals high.
For input '0' equals low, '1' equals high, 'X' equals don't care.
For flag '0' equals low, '1' equals open or high.
For output switch '0' equals off, '1' equals on.

1 The drain source current which flows when the protection supply is high and the input is low.

2 For open circuit load indication, V_{IS} must be less than V_{ISF}.

OVERLOAD CHARACTERISTICS

T_{mb} = 25 ˚C; V_{PS} = 5 V unless otherwise specified

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
	Short circuit load protection	V_{IS} = 5 V				
I_D	Drain current limiting	V_{DS} = 13 V -40˚C ≤ T_{mb} ≤ 150˚C	12	24	36	A
$P_{D(TO)}$	Overload power threshold[1]	for protection to operate	-	100	-	W
E_{DSC}	Characteristic energy	which determines trip time[2]	-	200	-	mJ
I_{DM}	Peak drain current[3]	V_{DD} = 13 V; R_L ≤ 10 mΩ	-	45	-	A
	Overtemperature protection					
$T_{j(TO)}$	Threshold temperature	I_D ≥ 1 A	150	185	215	˚C

FLAG CHARACTERISTICS

The flag is an open drain transistor which requires an external pull-up circuit.
T_{mb} = 25 ˚C unless otherwise specified

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
	Flag 'low'	normal operation; V_{PS} = 5 V				
V_{FSF}	Flag voltage	I_F = 100 µA	-	0.7	-	V
		-40˚C ≤ T_{mb} ≤ 150˚C	-	-	0.9	V
I_{FSF}	Flag saturation current	V_{FS} = 5 V	-	10	-	mA
	Flag 'high'	overload or fault				
I_{FSO}	Flag leakage current	V_{FS} = 5 V	-	0.1	1	µA
		T_{mb} = 150˚C	-	1	10	µA
$V_{(CL)FS}$	Flag clamping voltage	I_F = 100 µA	6	6.9	-	V
V_{PSF}	Protection supply threshold voltage[4]	I_F = 100 µA; V_{DS} = 5 V	2.5	3	4	V
		-40˚C ≤ T_{mb} ≤ 150˚C	2	-	4	V
	Application information					
R_F	Suitable external pull-up resistance	V_{FF} = 5 V	-	50	-	kΩ

1 Refer to figure 15.

2 Trip time $t_{d\,sc} \approx E_{DSC} / [P_D - P_{D(TO)}]$. Refer also to figure 15.

3 For short circuit load connected after turn-on.

4 When V_{PS} is less than V_{PSF} the flag pin indicates low protection supply voltage. Refer to TRUTH TABLE.

SWITCHING CHARACTERISTICS

T_{mb} = 25 ˚C

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
	Resistive load	R_L = 4 Ω; I_D = 3 A				
$t_{d\ on}$	Turn-on delay time	V_{IS}: 0 V ⇒ 5 V	-	0.6	-	µs
t_r	Rise time		-	2.8	-	µs
$t_{d\ off}$	Turn-off delay time	V_{IS}: 5 V ⇒ 0 V	-	3.5	-	µs
t_f	Fall time		-	3.2	-	µs
	Inductive load	I_D = 3 A; V_{DD} = 13 V; with freewheel diode				
$t_{d\ on}$	Turn-on delay time	V_{IS}: 0 V ⇒ 5 V	-	0.9	-	µs
t_r	Rise time		-	1.2	-	µs
$t_{d\ off}$	Turn-off delay time	V_{IS}: 5 V ⇒ 0 V	-	6.7	-	µs
t_f	Fall time		-	0.6	-	µs

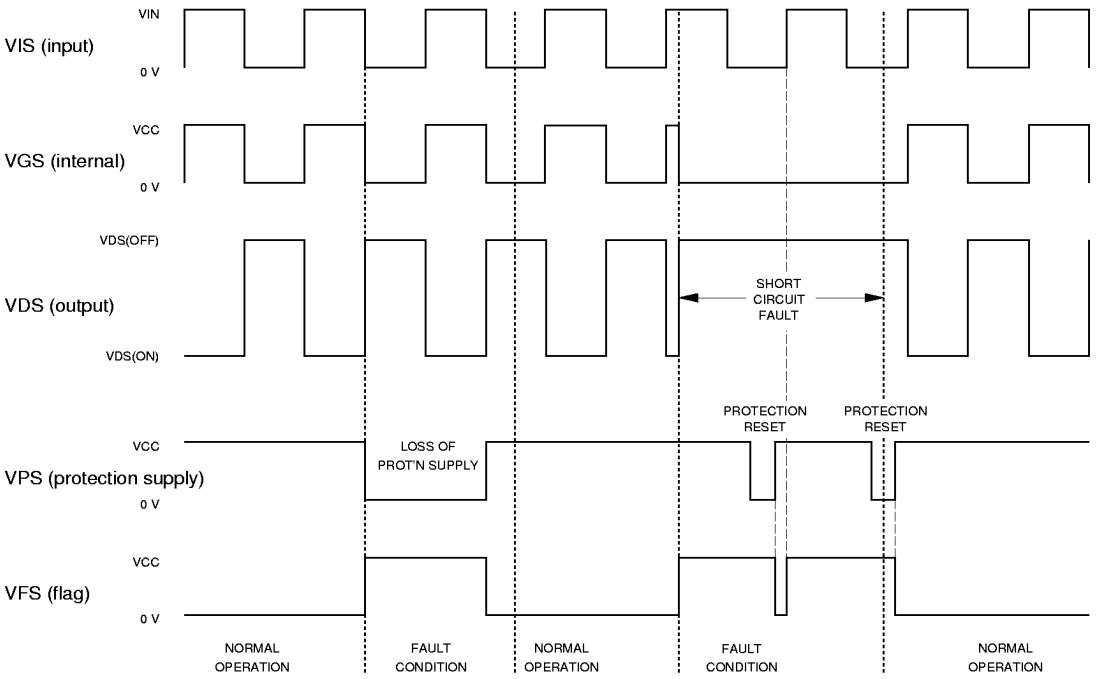


Fig. 4. Waveforms for normal and fault conditions.

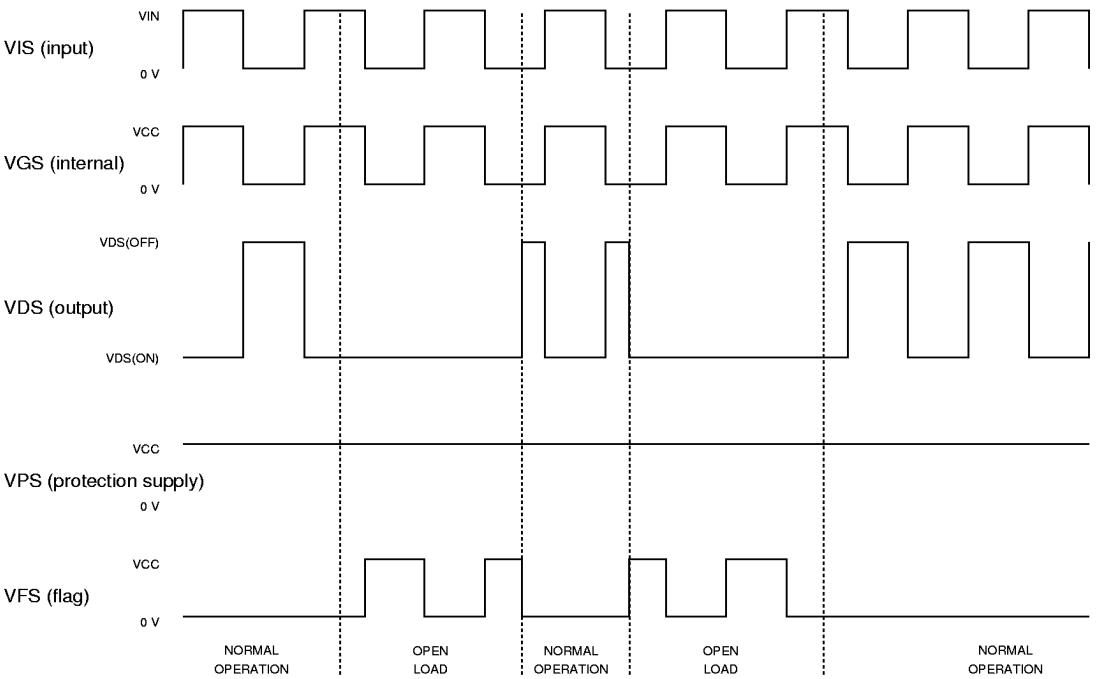


Fig. 5. Waveforms for normal and open circuit load.

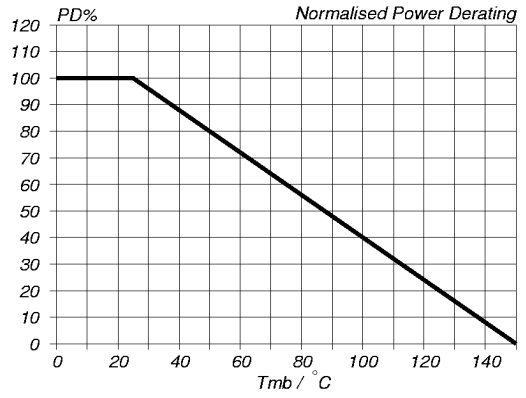


Fig.6. Normalised limiting power dissipation.
$P_D\% = 100 \cdot P_D/P_D(25^\circ C) = f(T_{mb})$

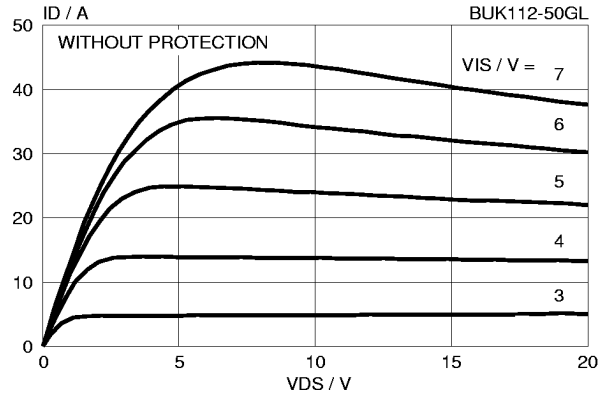


Fig.9. Typical output characteristics, $T_j = 25^\circ C$.
$I_D = f(V_{DS})$; $t_p = 250\ \mu s$; $V_{PS} = 0$ V; parameter V_{IS}

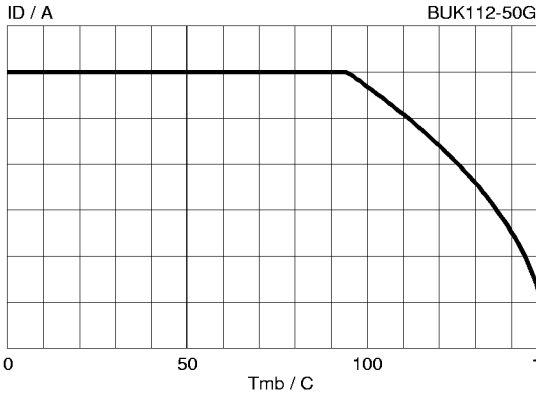


Fig.7. Continuous limiting drain current.
$I_D = f(T_{mb})$; conditions: $V_{IS} = 5$ V; $V_{PS} = 5$ V

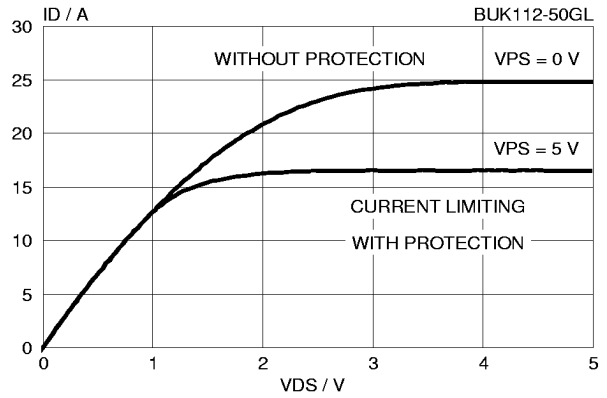


Fig.10. Typical on-state characteristics, $T_j = 25^\circ C$.
$I_D = f(V_{DS})$; $V_{IS} = 5$ V; $t_p = 250\ \mu s$; parameter V_{PS}

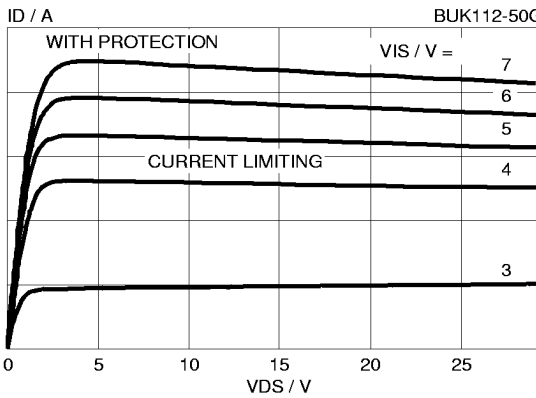


Fig.8. Typical output characteristics, $T_j = 25^\circ C$.
$I_D = f(V_{DS})$; $t_p = 250\ \mu s$; $V_{PS} = 5$ V; parameter V_{IS}

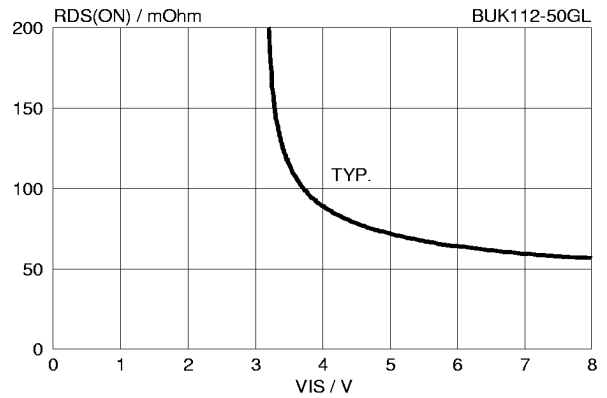


Fig.11. Typical on-state resistance, $T_j = 25^\circ C$.
$R_{DS(ON)} = f(V_{IS})$; $t_p = 250\ \mu s$; parameter V_{IS}

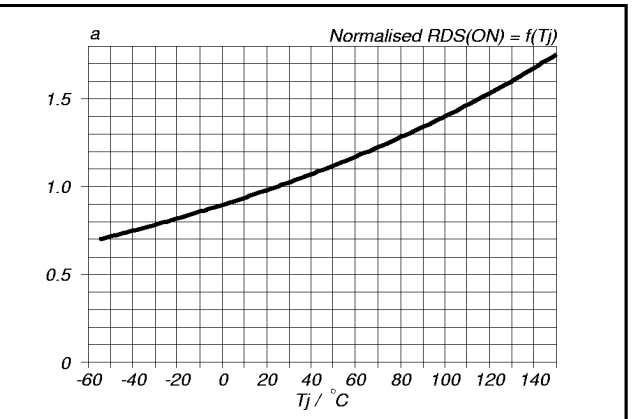


Fig.12. Normalised drain-source on-state resistance. $a = R_{DS(ON)}/R_{DS(ON)}25^{\circ}C = f(T_j)$; I_D = 6 A; $V_{IS} \geq 4.4$ V

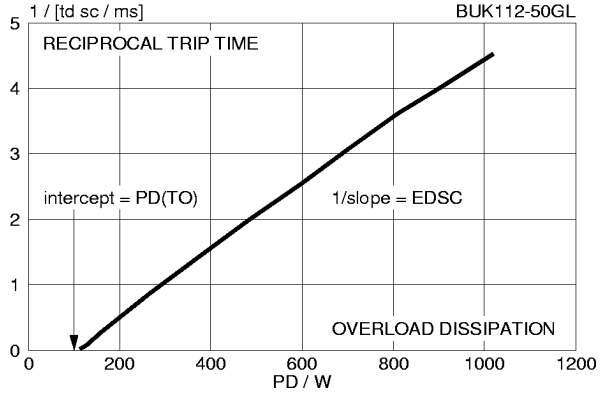


Fig.15. Typical reciprocal overload trip time. $1/t_{d\,sc} = f(P_D)$; conditions: V_{PS} = 5 V, $T_{mb} = 25^{\circ}C$

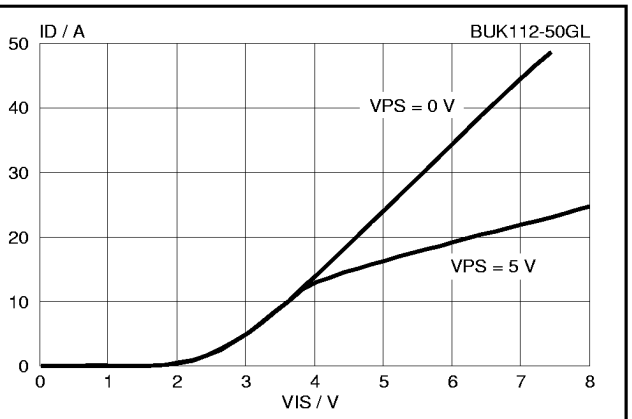


Fig.13. Typical transfer characteristics, $T_j = 25^{\circ}C$. $I_D = f(V_{IS})$; conditions: V_{DS} = 10 V; t_p = 250 µs

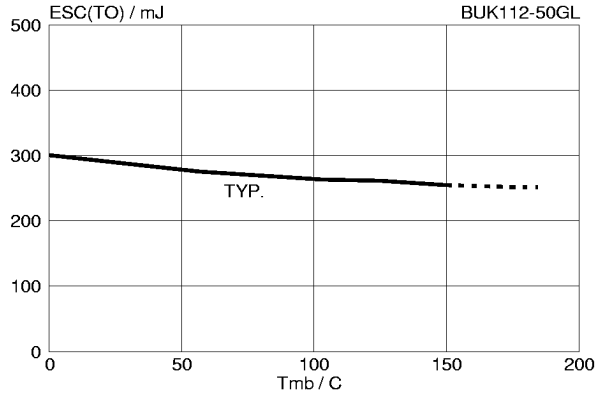


Fig.16. Typical overload protection energy. $E_{SC(TO)} = f(T_{mb})$; V_{DD} = 13 V; V_{PS} = 5 V, V_{IS} = 5 V

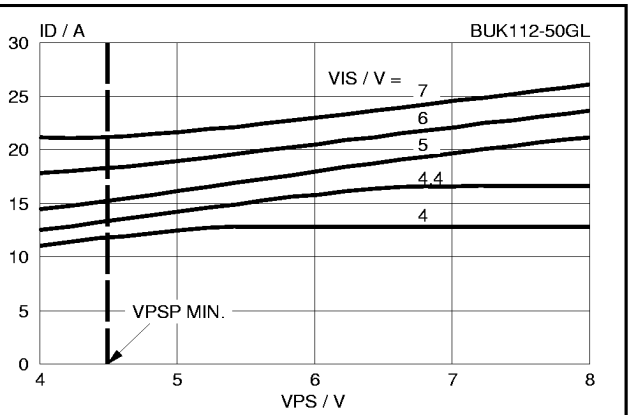


Fig.14. Typical output current limiting, $T_j = 25^{\circ}C$. $I_D = f(V_{PS})$; t_p = 250 µs; V_{DS} = 10 V; parameter V_{IS}

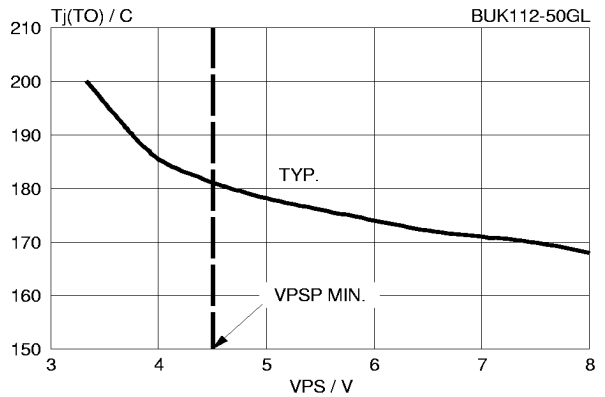


Fig.17. Typical overtemperature protection threshold. $T_{j(TO)} = f(V_{PS})$; V_{IS} = 5 V; $I_D \geq 1$ A

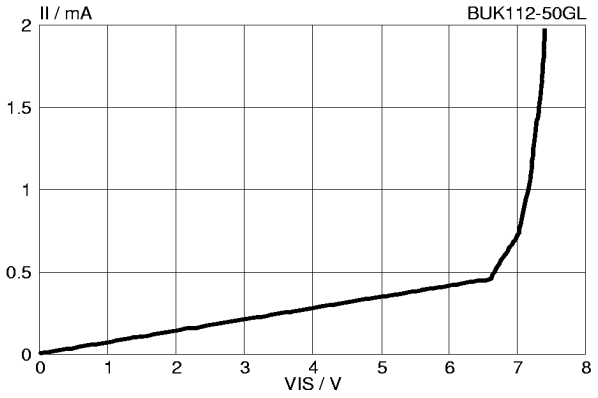


Fig.18. Typical DC input characteristic.
$I_I = f(V_{IS})$ normal operation; $T_j = 25˚C$

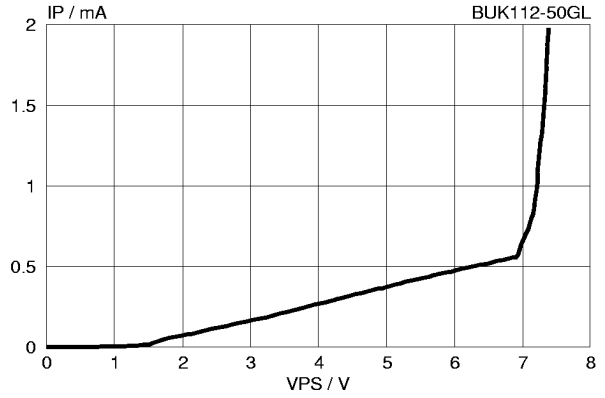


Fig.21. Typical protection supply characteristics.
$I_P = f(V_{PS})$; normal or overload operation; $T_j = 25˚C$

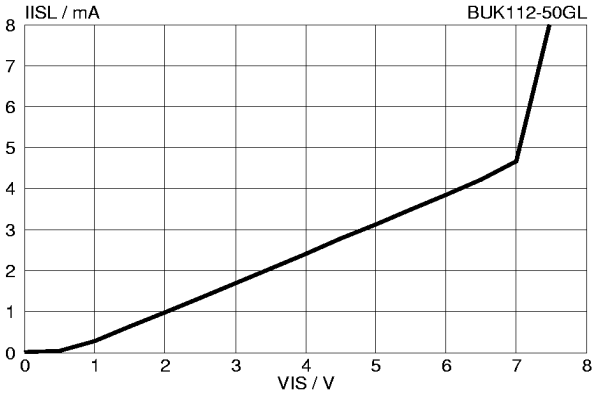


Fig.19. Typical DC input characteristic, $T_j = 25˚C$.
$I_{ISL} = f(V_{IS})$ overload protection latched; $V_{PS} = 5$ V

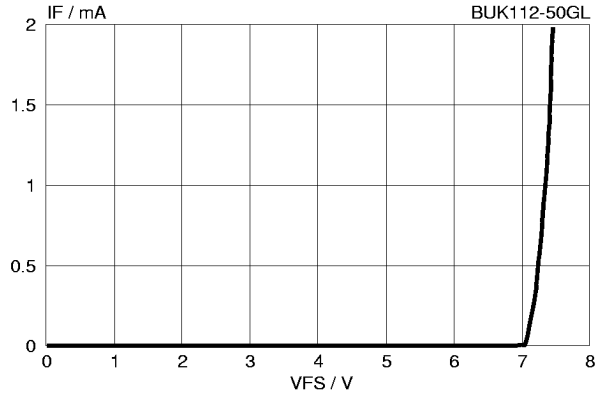


Fig.22. Typical flag high characteristic, $T_j = 25˚C$.
$I_F = f(V_{FS})$; refer to TRUTH TABLE

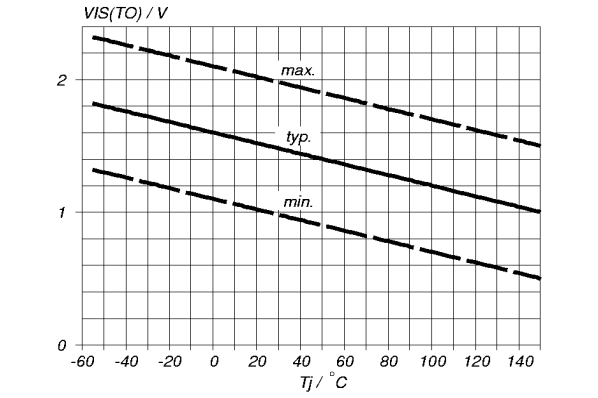


Fig.20. Input threshold voltage.
$V_{IS(TO)} = f(T_j)$; conditions: $I_D = 1$ mA; $V_{DS} = 5$ V

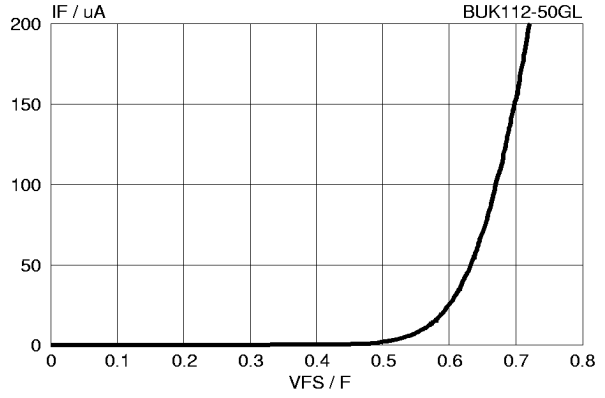


Fig.23. Typical flag low characteristic, $T_j = 25˚C$.
$I_F = f(V_{FS})$; $V_{PS} = 5$ V; refer to TRUTH TABLE

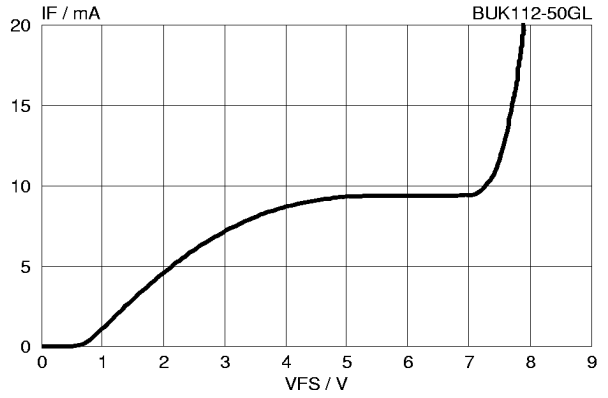


Fig.24. Typical flag saturation current, T_j = 25˚C. $I_F = f(V_{FS})$; flag 'low'; external R_F = 0 kΩ; V_{PS} = 5 V

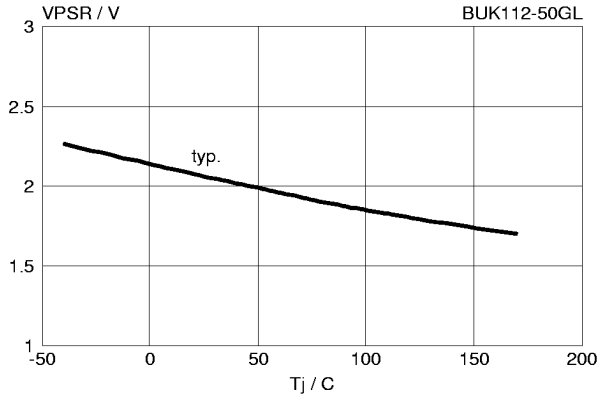


Fig.27. Protection supply reset voltage. $V_{PSR} = f(T_j)$

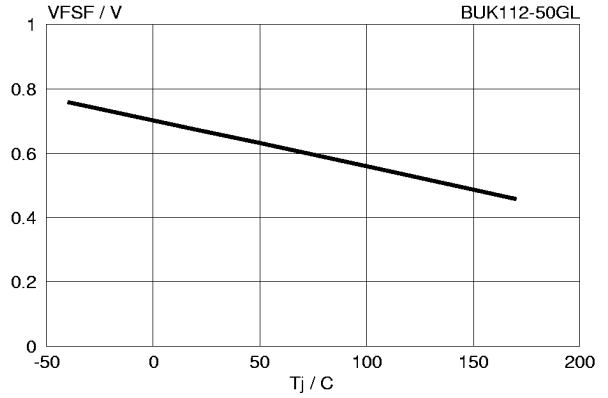


Fig.25. Typical flag low voltage. $V_{FSF} = f(T_j)$; V_{PS} = 5 V; V_{IS} = 5 V; V_{DS} = 0 V

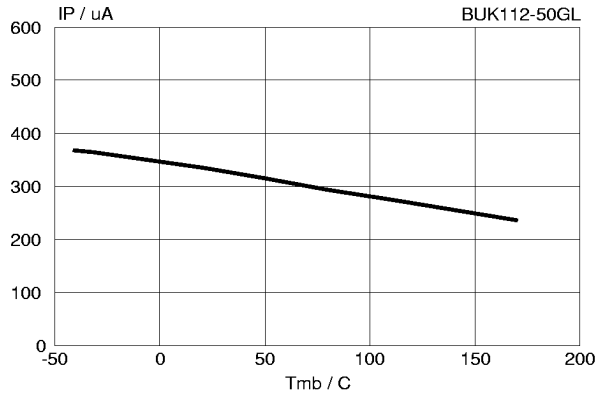


Fig.28. Typical protection supply current. $I_P = f(T_j)$; V_{PS} = 4.5 V

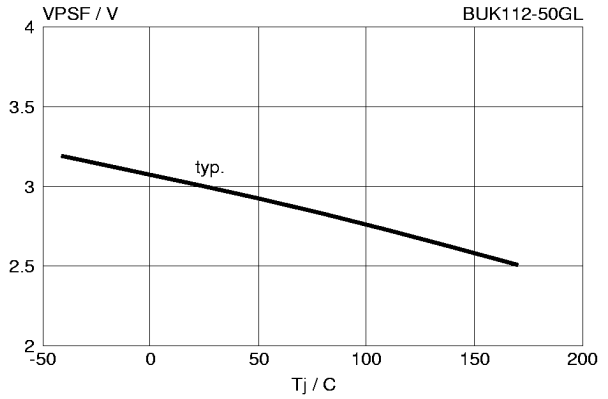


Fig.26. Protection supply threshold voltage. $V_{PSF} = f(T_j)$; condition: V_{DS} = 5 V

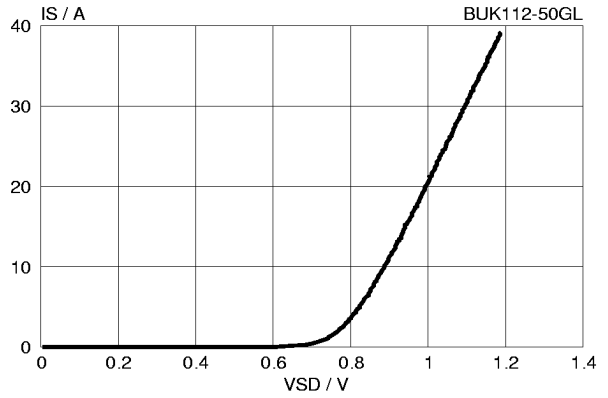


Fig.29. Typical reverse diode current, T_j = 25˚C. $I_S = f(V_{SD})$; conditions: V_{IS} = 0 V; t_p = 250 μs

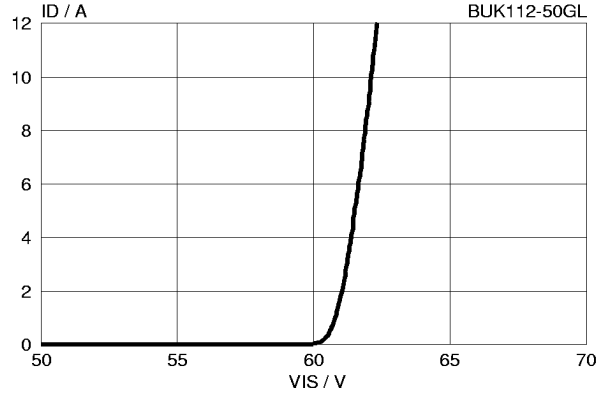


Fig.30. Typical clamping characteristics, 25˚C. $I_D = f(V_{DS})$; conditions: $V_{IS} = 0$ V; $t_p \leq 50$ µs

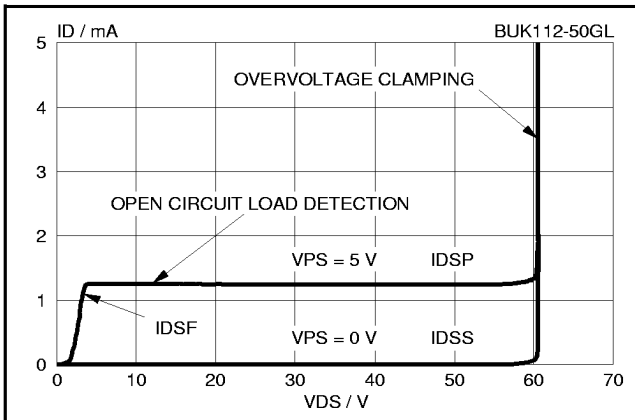


Fig.33. Typical off-state characteristics, $T_j = 25$˚C. $I_D = f(V_{DS})$; $V_{IS} = 0$ V; parameter V_{PS}

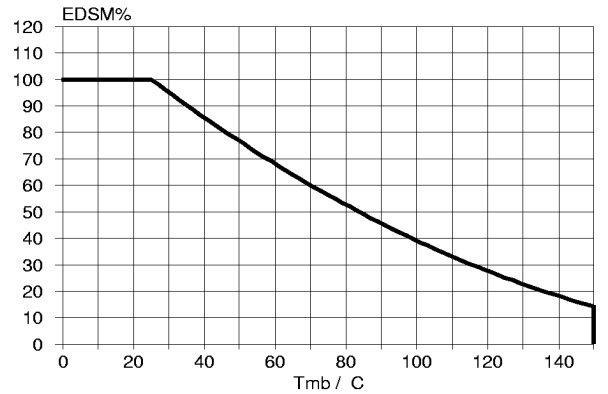


Fig.31. Normalised limiting clamping energy. $E_{DSM}\% = f(T_{mb})$; conditions: $I_D = 6$ A

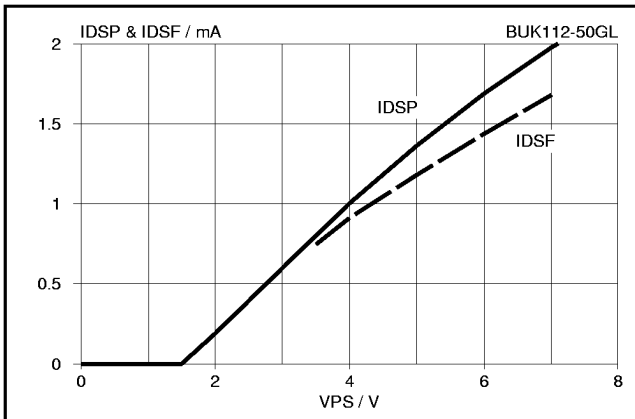


Fig.34. Typical open circuit load detect currents. I_{DSP} & $I_{DSF} = f(V_{PS})$; $V_{IS} = 0$ V; $V_{DS} \geq 5$ V; $T_j = 25$˚C

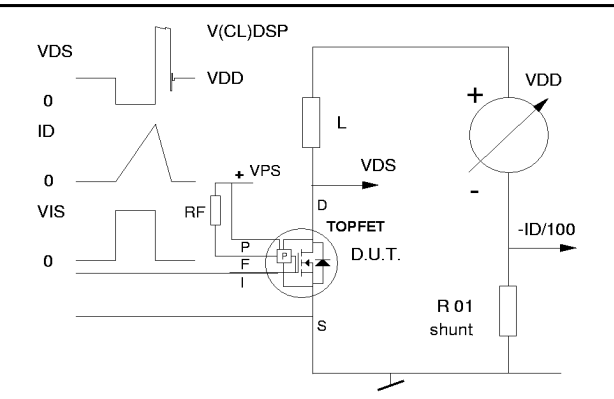


Fig.32. Clamping energy test circuit.
$$E_{DSM} = 0.5 \cdot LI_D^2 \cdot V_{(CL)DSS}/(V_{(CL)DSS} - V_{DD})$$

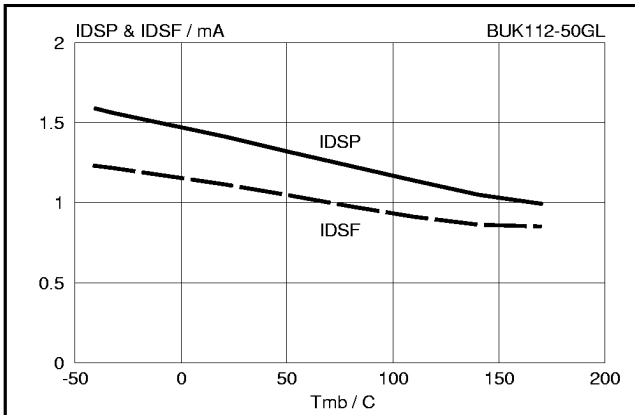


Fig.35. Typical open circuit load detect currents. I_{DSP} & $I_{DSF} = f(T_j)$; $V_{PS} = 5$ V; $V_{IS} = 0$ V

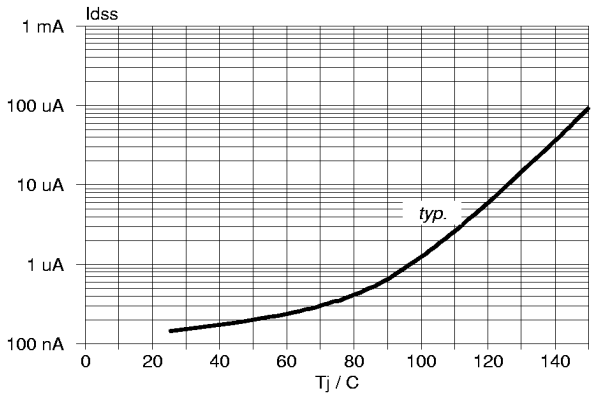


Fig.36. Typical off-state leakage current.
I_{DSS} = f(T_j); Conditions: V_{DS} = 40 V; V_{IS} = 0 V.

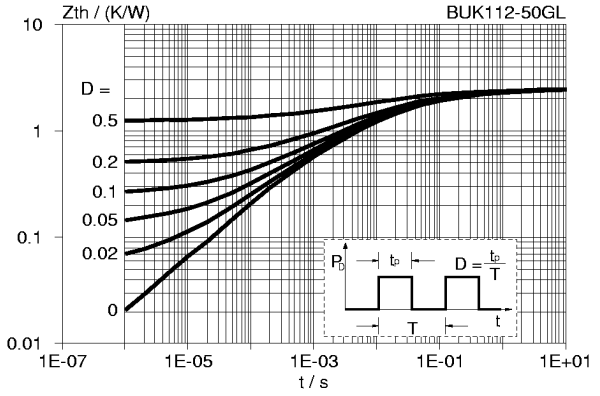


Fig.38. Transient thermal impedance.
$Z_{th\ j\text{-}mb}$ = f(t); parameter D = t_p/T

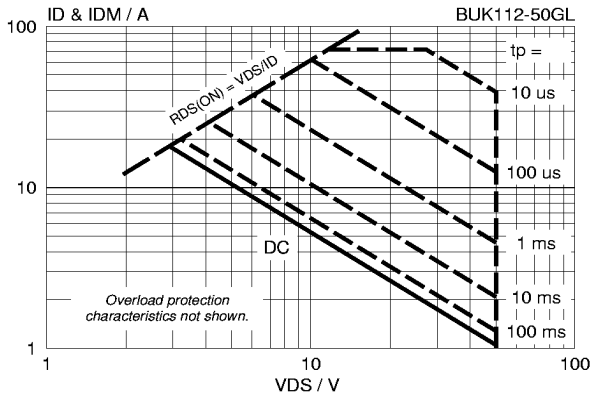


Fig.37. Safe operating area, V_{PS} = 0 V, T_{mb} = 25˚C.
I_D & I_{DM} = f(V_{DS}); I_{DM} single pulse; parameter t_p

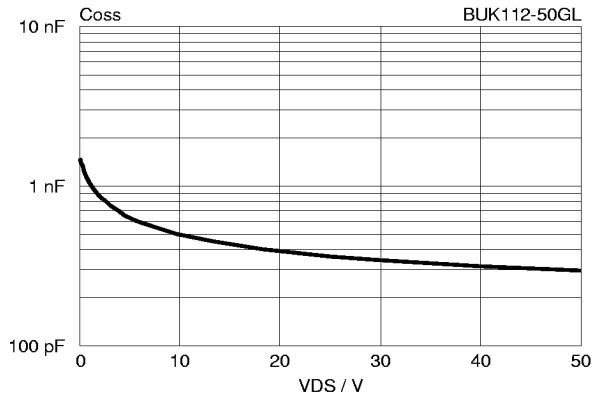


Fig.39. Typical output capacitance.
C_{oss} = f(V_{DS}); conditions: V_{IS} = 0 V; f = 1 MHz

APPLICATION INFORMATION

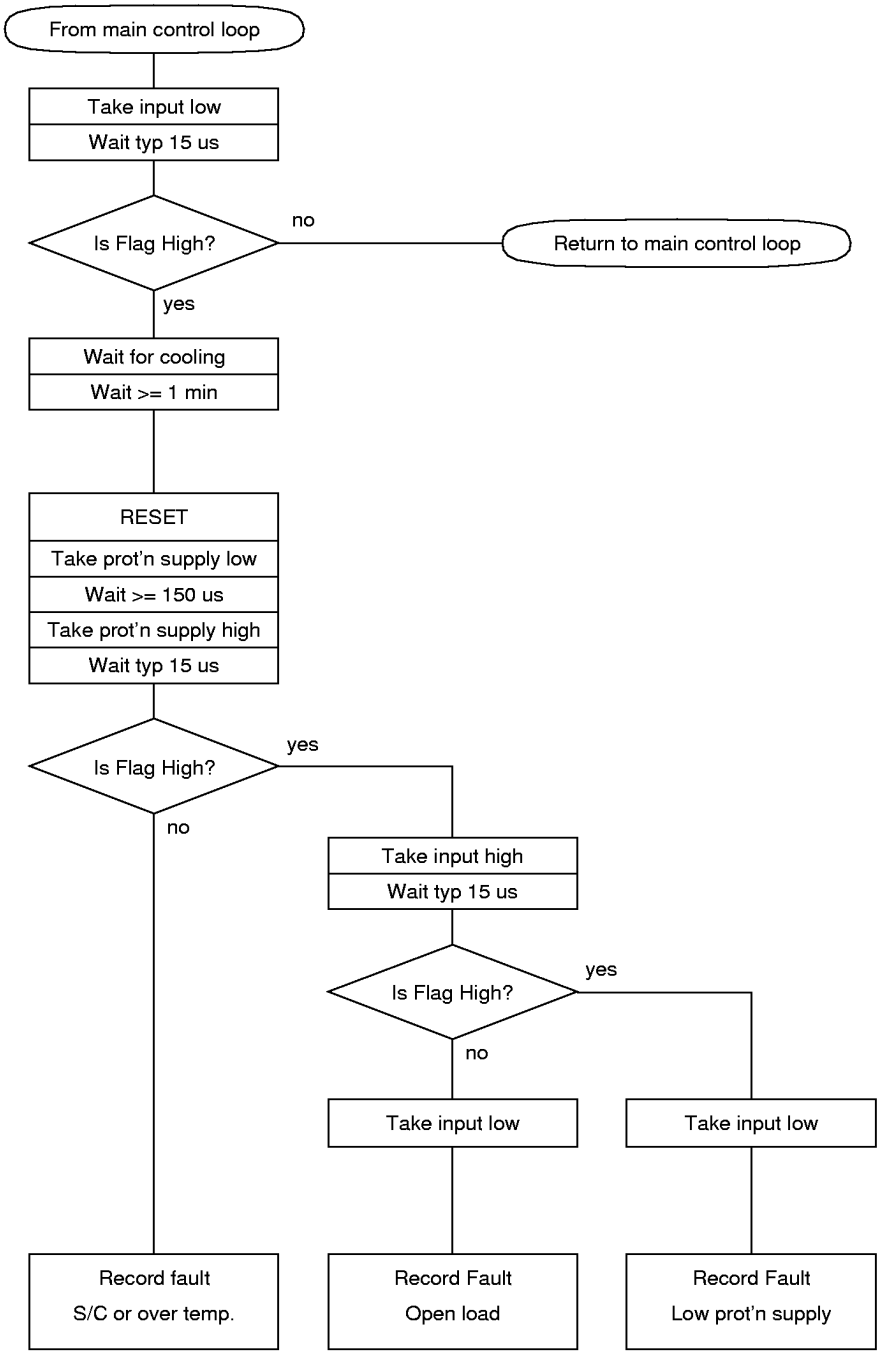
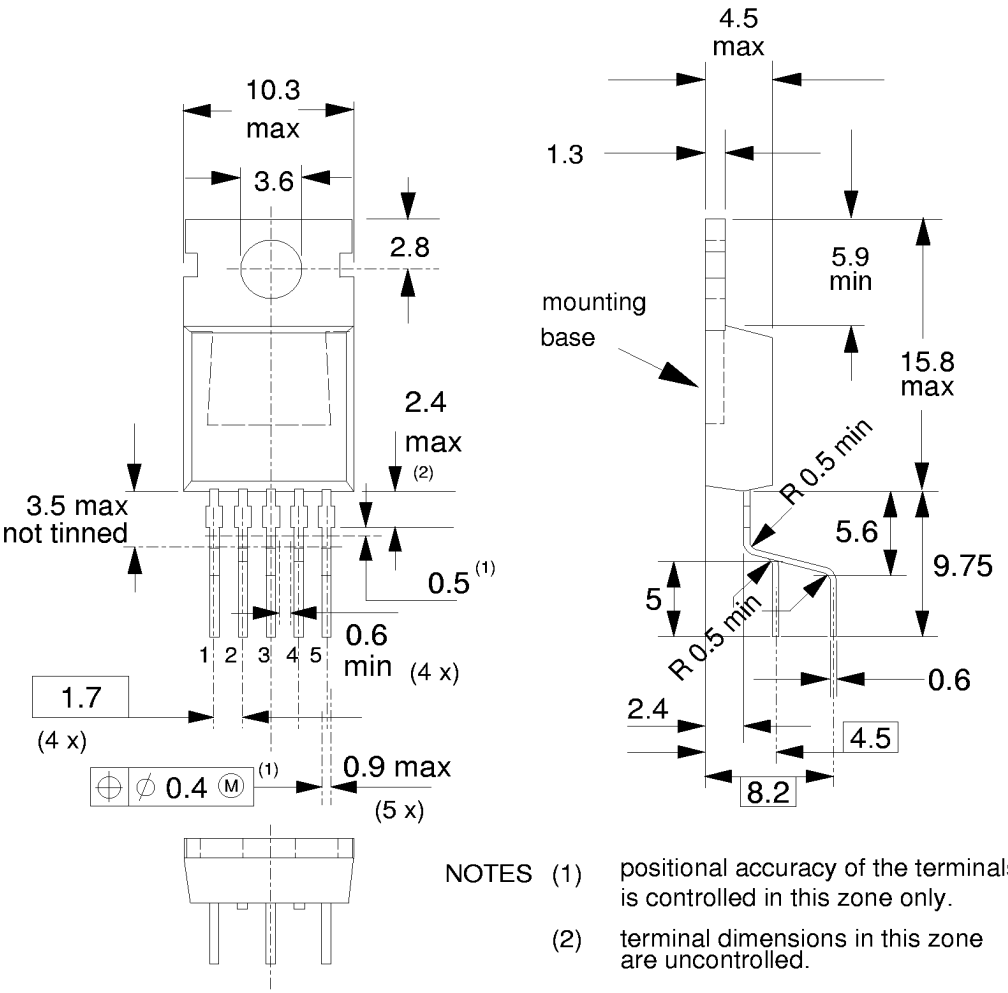


Fig. 40. Possible fault diagnosis procedure.

MECHANICAL DATA

Dimensions in mm

Net Mass: 2 g



NOTES (1) positional accuracy of the terminals is controlled in this zone only.

(2) terminal dimensions in this zone are uncontrolled.

Fig.41. SOT263 leadform 263-01;

pin 3 connected to mounting base.

Note
1. Refer to mounting instructions for TO220 envelopes.
2. Epoxy meets UL94 V0 at 1/8".