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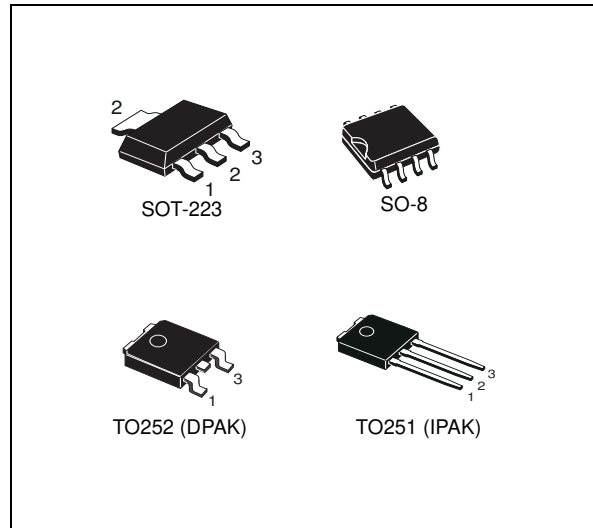
VNN7NV04, VNS7NV04 VND7NV04, VND7NV04-1

OMNIFET II
fully autoprotected Power MOSFET

Features

Type	$R_{DS(on)}$	I_{lim}	V_{clamp}
VNN7NV04 VNS7NV04 VND7NV04 VND7NV04-1	60 m Ω	6 A	40 V

- Linear current limitation
- Thermal shutdown
- Short circuit protection
- Integrated clamp
- Low current drawn from input pin
- Diagnostic feedback through input pin
- ESD protection
- Direct access to the gate of the Power MOSFET (analog driving)
- Compatible with standard Power MOSFET in compliance with the 2002/95/EC European Directive



Description

The VNN7NV04, VNS7NV04, VND7NV04, VND7NV04-1, are monolithic devices designed in STMicroelectronics VIPower M0-3 Technology, intended for replacement of standard Power MOSFETs from DC up to 50 kHz applications. Built in thermal shutdown, linear current limitation and overvoltage clamp protect the chip in harsh environments.

Fault feedback can be detected by monitoring the voltage at the input pin.

Table 1. Device summary

Package	Order codes			
	Tube	Tube (lead-free)	Tape and reel	Tape and reel (lead-free)
SOT-223	VNN7NV04	-	VNN7NV0413TR	-
SO-8	VNS7NV04	-	VNS7NV0413TR	-
TO-252	VND7NV04	VND7NV04-E	VND7NV0413TR	VND7NV04TR-E
TO-251	VND7NV04-1	VND7NV04-1-E	-	-

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1 Block diagram and pin description

Figure 1. Block diagram

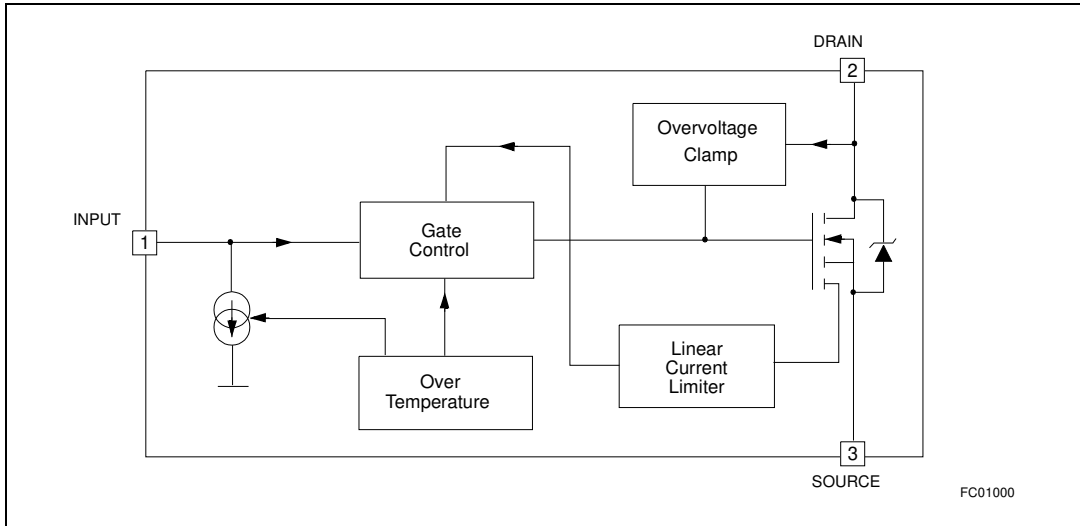
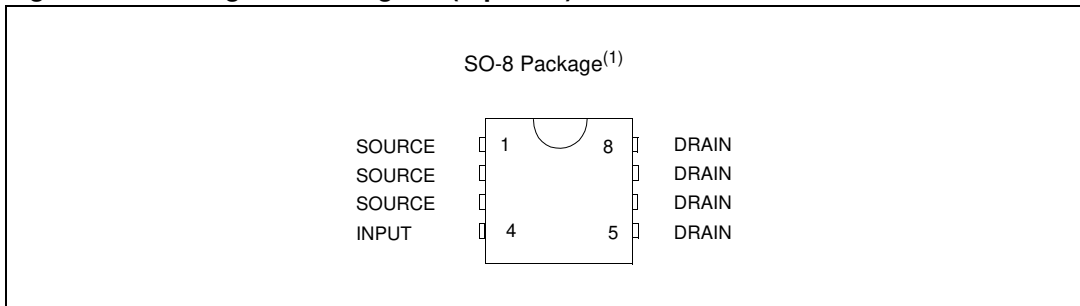


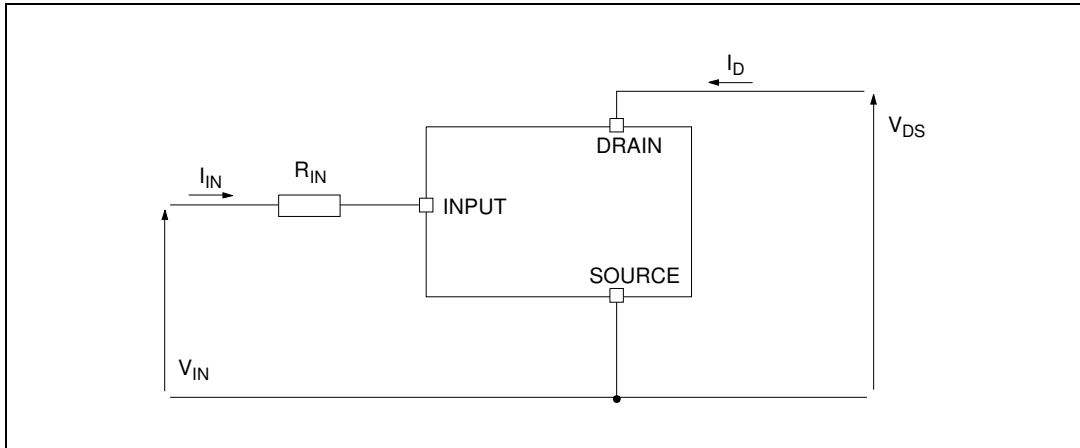
Figure 2. Configuration diagram (top view)



1. For the pins configuration related to SOT-223, DPAK, IPAK see outlines at page 1.

2 Electrical specifications

Figure 3. Current and voltage conventions



2.1 Absolute maximum ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Value			Unit
		SOT-223	SO-8	DPAK/IPAK	
V_{DS}	Drain-source voltage ($V_{IN}=0$ V)	Internally clamped			V
V_{IN}	Input voltage	Internally clamped			V
I_{IN}	Input current	+/-20			mA
$R_{IN\ MIN}$	Minimum input series impedance	150			Ω
I_D	Drain current	Internally limited			A
I_R	Reverse DC output current	-10.5			A
V_{ESD1}	Electrostatic discharge ($R=1.5$ K Ω , $C=100$ pF)	4000			V
V_{ESD2}	Electrostatic discharge on output pin only ($R=330$ Ω , $C=150$ pF)	16500			V
P_{tot}	Total dissipation at $T_c=25$ $^{\circ}C$	7	4.6	60	W
E_{MAX}	Maximum switching energy ($L=0.7$ mH; $R_L=0$ Ω ; $V_{bat}=13.5$ V; $T_{jstart}=150$ $^{\circ}C$; $I_L=9$ A)	40		40	mJ
E_{MAX}	Maximum switching energy ($L=0.6$ mH; $R_L=0$ Ω ; $V_{bat}=13.5$ V; $T_{jstart}=150$ $^{\circ}C$; $I_L=9$ A)		37		mJ
T_j	Operating junction temperature	Internally limited			$^{\circ}C$
T_c	Case operating temperature	Internally limited			$^{\circ}C$
T_{stg}	Storage temperature	-55 to 150			$^{\circ}C$

2.2 Thermal data

Table 3. Thermal data

Symbol	Parameter	Value				Unit
		SOT-223	SO-8	DKPAK	IPAK	
$R_{thj-case}$	Thermal resistance junction-case max	18		2.1	2.1	°C/W
$R_{thj-lead}$	Thermal resistance junction-lead max		27			°C/W
$R_{thj-amb}$	Thermal resistance junction-ambient max	96 ⁽¹⁾	90 ⁽¹⁾	65 ⁽¹⁾	102	°C/W

1. When mounted on a standard single-sided FR4 board with 0.5 mm² of Cu (at least 35 µm thick) connected to all DRAIN pins.

2.3 Electrical characteristics

-40 °C < T_j < 150 °C, unless otherwise specified.

Table 4. Electrical characteristics

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
Off						
V_{CLAMP}	Drain-source clamp voltage	$V_{IN}=0\text{ V}; I_D=3.5\text{ A}$	40	45	55	V
V_{CLTH}	Drain-source clamp threshold voltage	$V_{IN}=0\text{ V}; I_D=2\text{ mA}$	36			V
V_{INTH}	Input threshold voltage	$V_{DS}=V_{IN}; I_D=1\text{ mA}$	0.5		2.5	V
I_{ISS}	Supply current from input pin	$V_{DS}=0\text{ V}; V_{IN}=5\text{ V}$		100	150	µA
V_{INCL}	Input-source clamp voltage	$I_{IN}=1\text{ mA}$ $I_{IN}=-1\text{ mA}$	6 -1.0	6.8	8 -0.3	V
I_{DSS}	Zero input voltage drain current ($V_{IN}=0\text{ V}$)	$V_{DS}=13\text{ V}; V_{IN}=0\text{ V}; T_j=25\text{ °C}$ $V_{DS}=25\text{ V}; V_{IN}=0\text{ V}$			30 75	µA
On						
$R_{DS(on)}$	Static drain-source on resistance	$V_{IN}=5\text{ V}; I_D=3.5\text{ A}; T_j=25\text{ °C}$ $V_{IN}=5\text{ V}; I_D=3.5\text{ A}$			60 120	mΩ
Dynamic (T_j=25 °C, unless otherwise specified)						
$g_{fs}^{(1)}$	Forward transconductance	$V_{DD}=13\text{ V}; I_D=3.5\text{ A}$		9		S
C_{OSS}	Output capacitance	$V_{DS}=13\text{ V}; f=1\text{ MHz}; V_{IN}=0\text{ V}$		220		pF

Table 4. Electrical characteristics (continued)

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit	
Switching ($T_j=25\text{ }^\circ\text{C}$, unless otherwise specified)							
$t_{d(on)}$	Turn-on delay time	$V_{DD}=15\text{ V}; I_D=3.5\text{ A}$ $V_{gen}=5\text{ V}; R_{gen}=R_{IN\text{ MIN}}=150\ \Omega$ (see figure Figure 4.)		100	300	ns	
t_r	Rise time			470	1500	ns	
$t_{d(off)}$	Turn-off delay time			500	1500	ns	
t_f	Fall time			350	1000	ns	
$t_{d(on)}$	Turn-on delay time	$V_{DD}=15\text{ V}; I_D=3.5\text{ A}$ $V_{gen}=5\text{ V}; R_{gen}=2.2\text{ K}\Omega$ (see figure Figure 4.)		0.75	2.3	μs	
t_r	Rise time			4.6	14.0	μs	
$t_{d(off)}$	Turn-off delay time			5.4	16.0	μs	
t_f	Fall time			3.6	11.0	μs	
$(di/dt)_{on}$	Turn-on current slope	$V_{DD}=15\text{ V}; I_D=3.5\text{ A}$ $V_{gen}=5\text{ V}; R_{gen}=R_{IN\text{ MIN}}=150\ \Omega$		6.5		$\text{A}/\mu\text{s}$	
Q_i	Total input charge	$V_{DD}=12\text{ V}; I_D=3.5\text{ A}; V_{IN}=5\text{ V}$ $I_{gen}=2.13\text{ mA}$ (see figure Figure 7.)		18		nC	
Source drain diode ($T_j=25\text{ }^\circ\text{C}$, unless otherwise specified)							
$V_{SD}^{(1)}$	Forward on voltage	$I_{SD}=3.5\text{ A}; V_{IN}=0\text{ V}$		0.8		V	
t_{rr}	Reverse recovery time	$I_{SD}=3.5\text{ A}; di/dt=20\text{ A}/\mu\text{s}$ $V_{DD}=30\text{ V}; L=200\ \mu\text{H}$ (see test circuit, figure Figure 5.)		220		ns	
Q_{rr}	Reverse recovery charge				0.28		μC
I_{RRM}	Reverse recovery current				2.5		A
Protections ($-40\text{ }^\circ\text{C} < T_j < 150\text{ }^\circ\text{C}$, unless otherwise specified)							
I_{lim}	Drain current limit	$V_{IN}=5\text{ V}; V_{DS}=13\text{ V}$	6	9	12	A	
t_{dlim}	Step response current limit	$V_{IN}=5\text{ V}; V_{DS}=13\text{ V}$		4.0		μs	
T_{jsh}	Over temperature shutdown		150	175	200	$^\circ\text{C}$	
T_{jrs}	Over temperature reset		135			$^\circ\text{C}$	
I_{gf}	Fault sink current	$V_{IN}=5\text{ V}; V_{DS}=13\text{ V}; T_j=T_{jsh}$		15		mA	
E_{as}	Single pulse avalanche energy	starting $T_j=25\text{ }^\circ\text{C}; V_{DD}=24\text{ V}$ $V_{IN}=5\text{ V}; R_{gen}=R_{IN\text{ MIN}}=150\ \Omega; L=24\text{ mH}$ (see figures Figure 6. & Figure 8.)	200			mJ	

1. Pulsed: Pulse duration = 300 μs , duty cycle 1.5 %

3 Protection features

During normal operation, the input pin is electrically connected to the gate of the internal Power MOSFET through a low impedance path.

The device then behaves like a standard Power MOSFET and can be used as a switch from DC up to 50 kHz. The only difference from the user's standpoint is that a small DC current I_{SS} (typ. 100 μ A) flows into the input pin in order to supply the internal circuitry.

The device integrates:

- Overvoltage clamp protection: internally set at 45 V, along with the rugged avalanche characteristics of the Power MOSFET stage give this device unrivalled ruggedness and energy handling capability. This feature is mainly important when driving inductive loads.
- Linear current limiter circuit: limits the drain current I_D to I_{lim} whatever the input pin voltages. When the current limiter is active, the device operates in the linear region, so power dissipation may exceed the capability of the heatsink. Both case and junction temperatures increase, and if this phase lasts long enough, junction temperature may reach the over temperature threshold T_{jsh} .
- Over temperature and short circuit protection: these are based on sensing the chip temperature and are not dependent on the input voltage. The location of the sensing element on the chip in the power stage area ensures fast, accurate detection of the junction temperature. Over temperature cutout occurs in the range 150 to 190 °C, a typical value being 170 °C. The device is automatically restarted when the chip temperature falls of about 15 °C below shutdown temperature.
- Status feedback: in the case of an over temperature fault condition ($T_j > T_{jsh}$), the device tries to sink a diagnostic current I_{gf} through the input pin in order to indicate fault condition. If driven from a low impedance source, this current may be used in order to warn the control circuit of a device shutdown. If the drive impedance is high enough so that the input pin driver is not able to supply the current I_{gf} , the input pin will fall to 0 V. This will not however affect the device operation: no requirement is put on the current capability of the input pin driver except to be able to supply the normal operation drive current I_{SS} .

Additional features of this device are ESD protection according to the Human Body model and the ability to be driven from a TTL logic circuit.

Figure 4. Switching time test circuit for resistive load

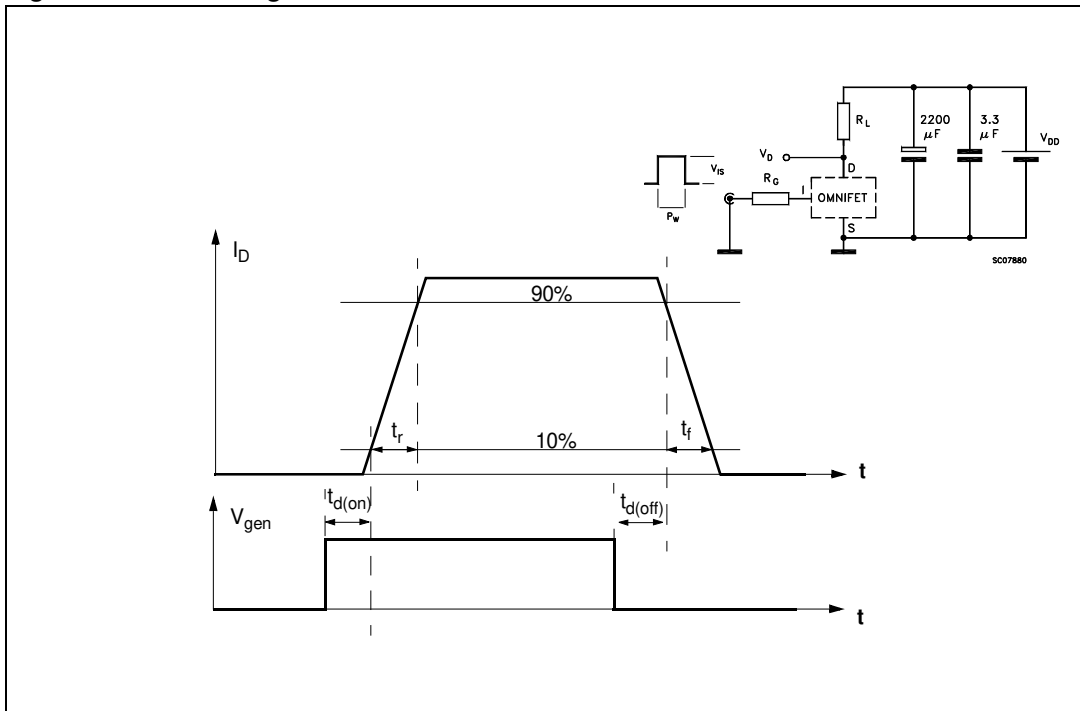


Figure 5. Test circuit for diode recovery times

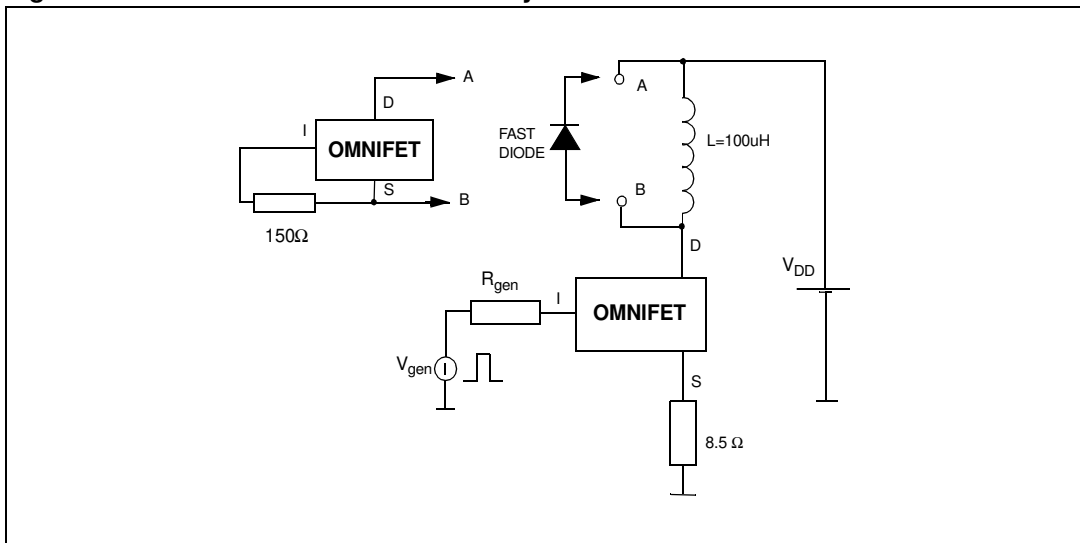


Figure 6. Unclamped inductive load test circuits

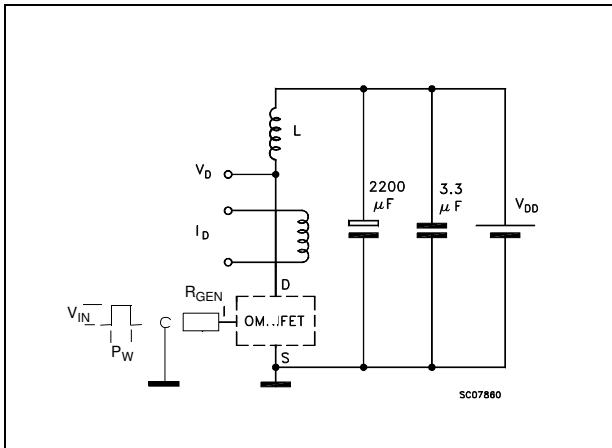


Figure 7. Input charge test circuit

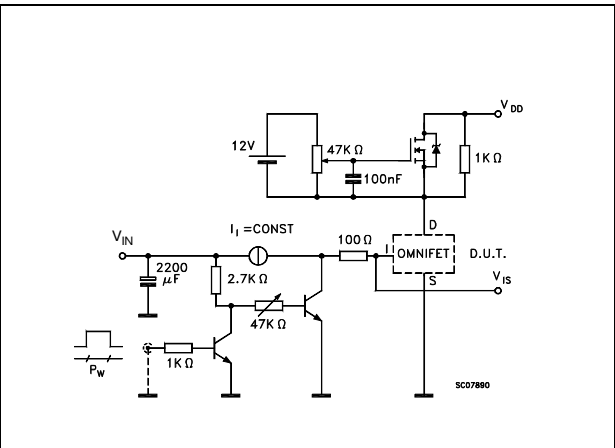
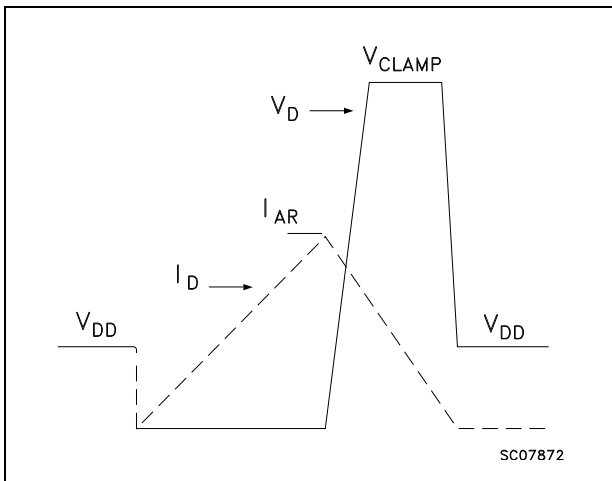


Figure 8. Unclamped inductive waveforms



3.1 Electrical characteristics curves

Figure 9. Derating curve

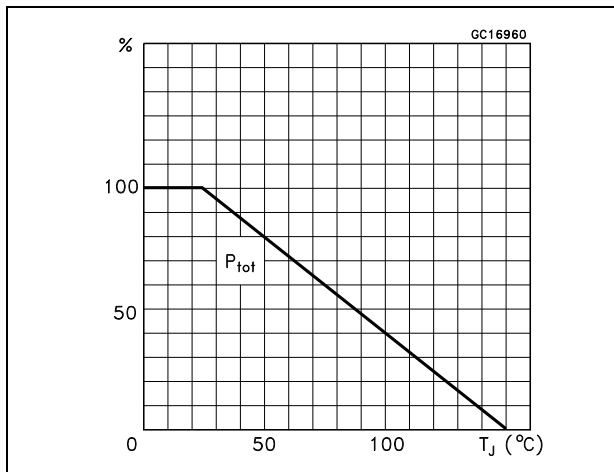


Figure 10. Transconductance

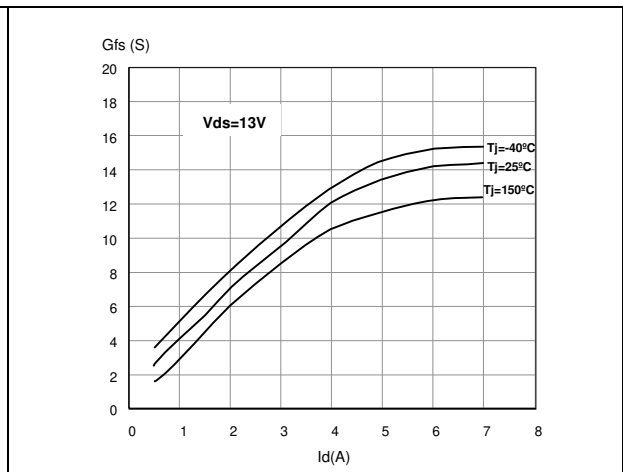


Figure 11. Static drain-source on resistance vs input voltage (part 1/2)

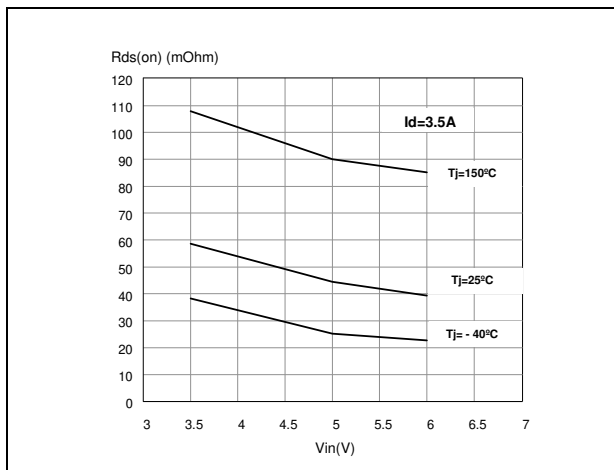


Figure 12. Static drain-source on resistance vs input voltage (part 2/2)

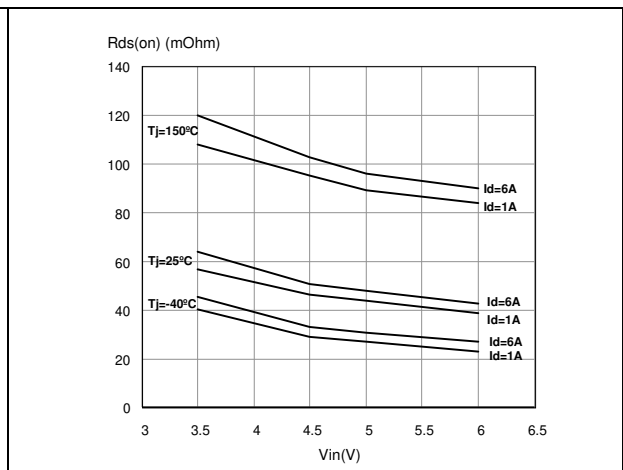


Figure 13. Source-drain diode forward characteristics

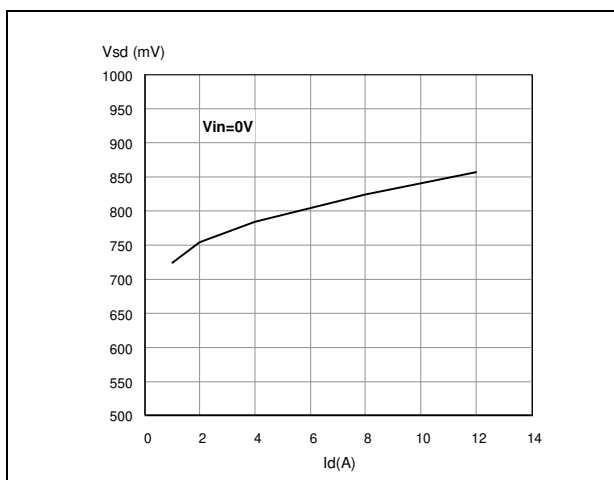


Figure 14. Static drain source on resistance

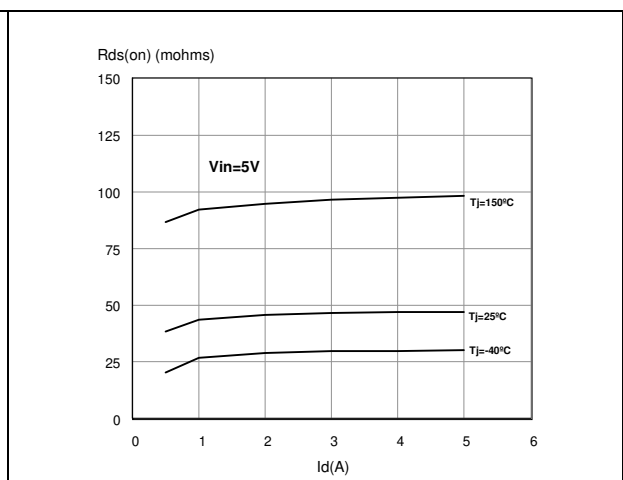


Figure 15. Turn-on current slope (part 1/2)

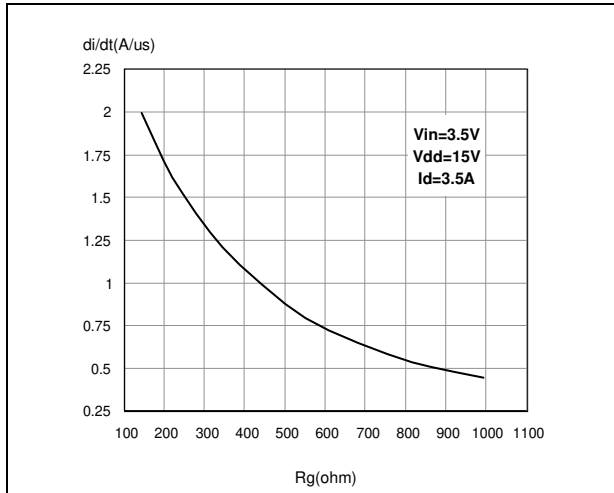


Figure 16. Turn-on current slope (part 2/2)

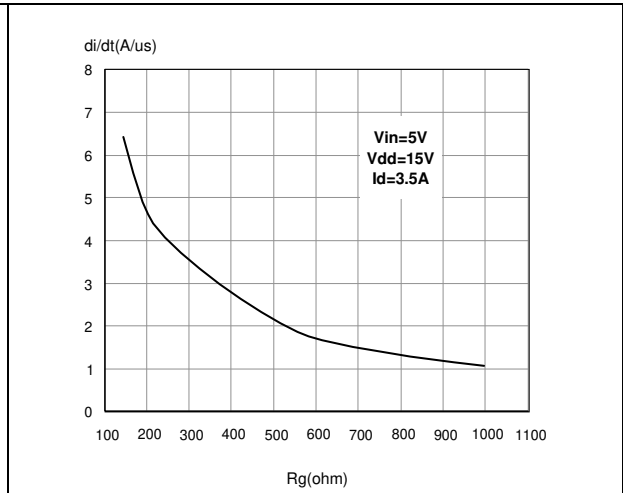


Figure 17. Transfer characteristics

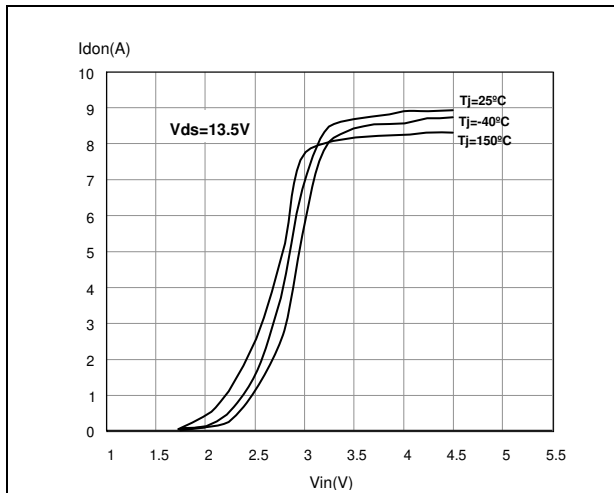


Figure 18. Static drain-source on resistance vs Id

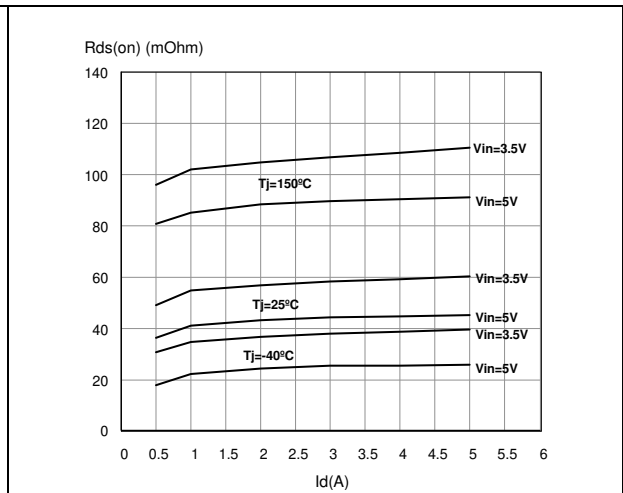


Figure 19. Input voltage vs input charge

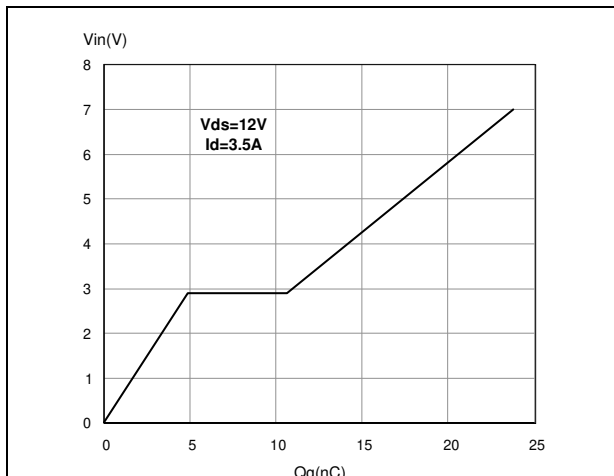


Figure 20. Turn-off drain source voltage slope (part 1/2)

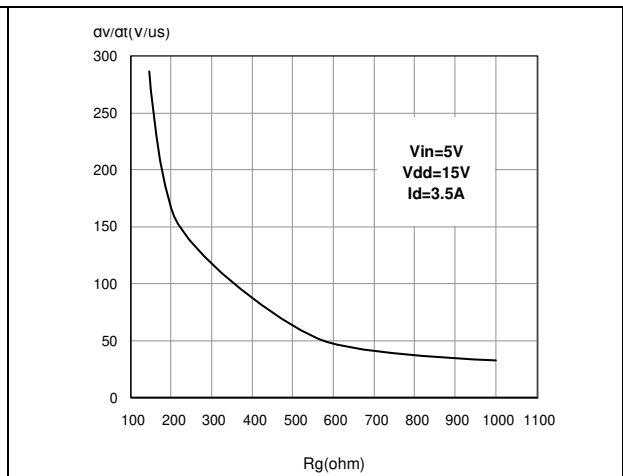


Figure 21. Turn-off drain source voltage slope **Figure 22. Capacitance variations**
(part 2/2)

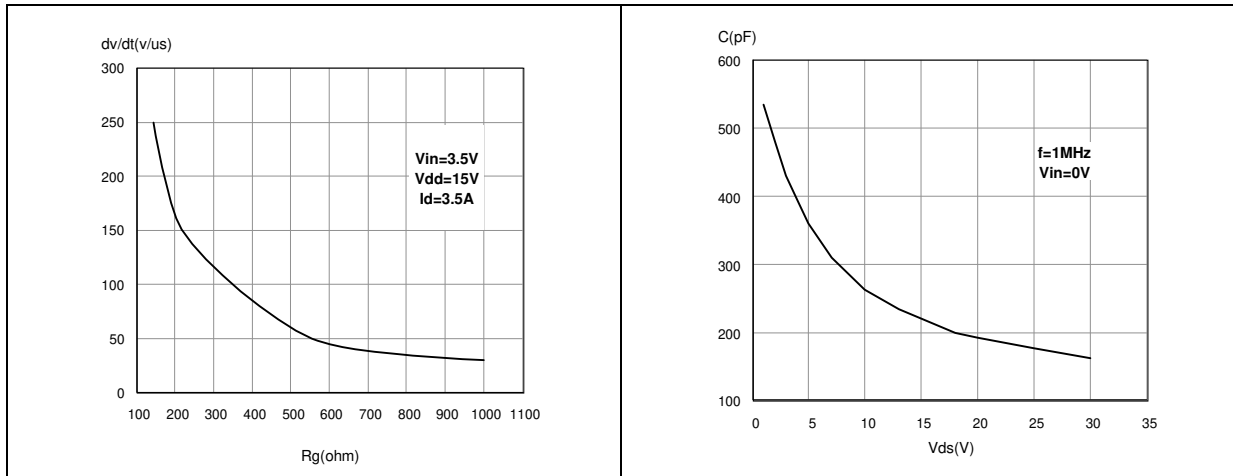


Figure 23. Output characteristics

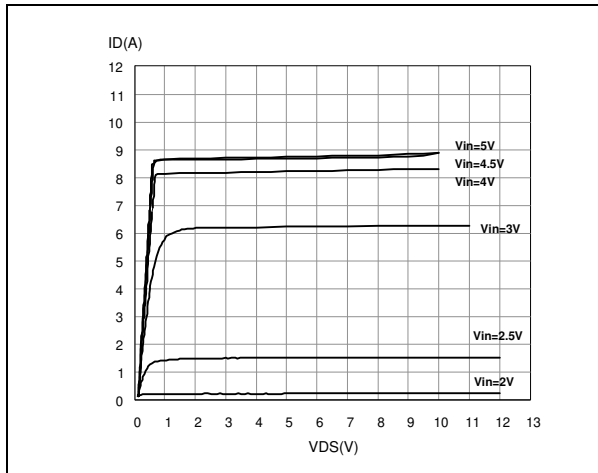


Figure 25. Switching time resistive load (part 1/2)

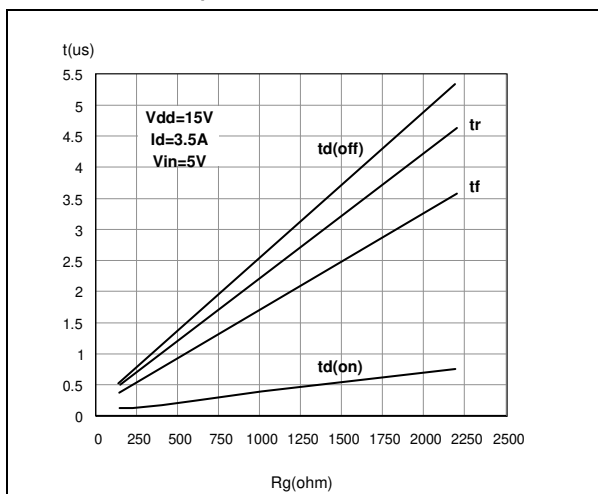


Figure 24. Normalized on resistance vs temperature

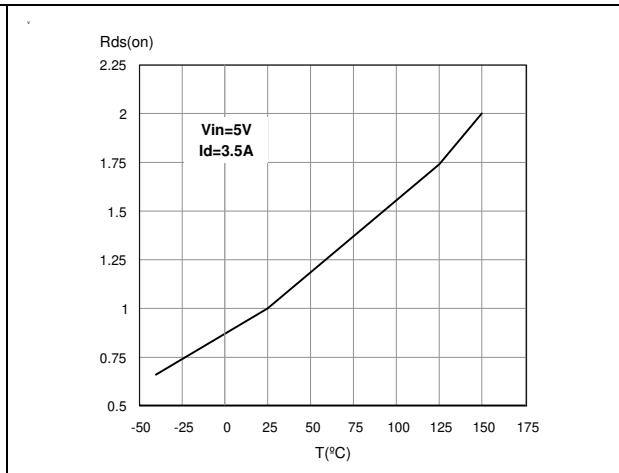


Figure 26. Switching time resistive load (part 2/2)

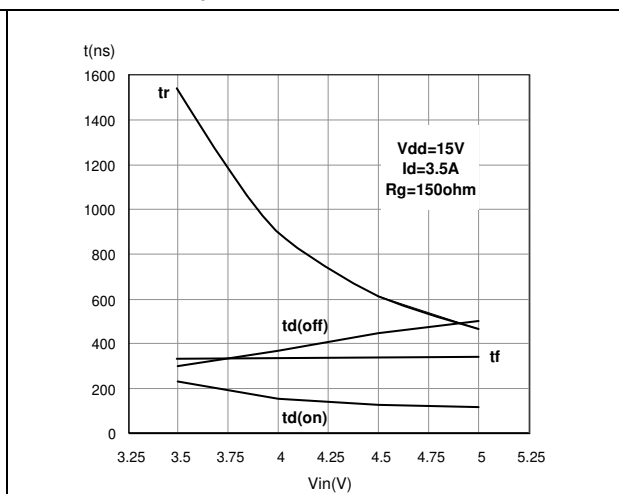


Figure 27. Normalized input threshold voltage vs temperature

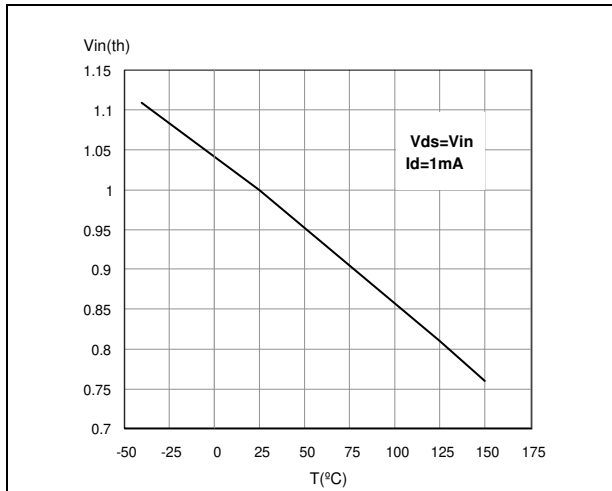


Figure 28. Normalized current limit vs junction temperature

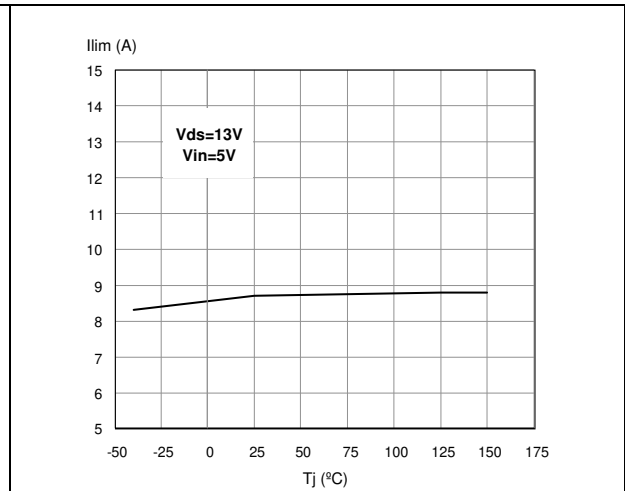
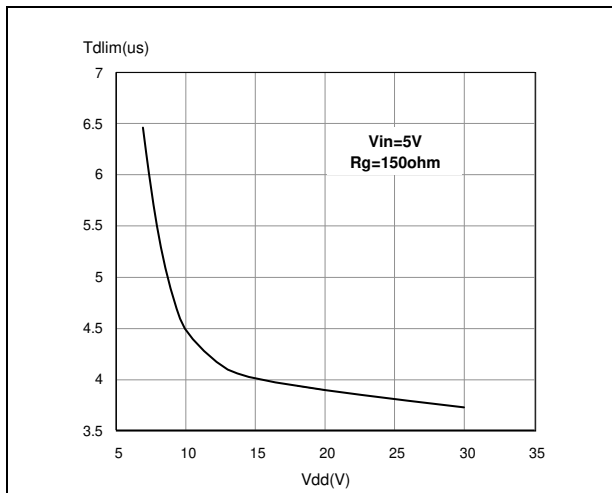
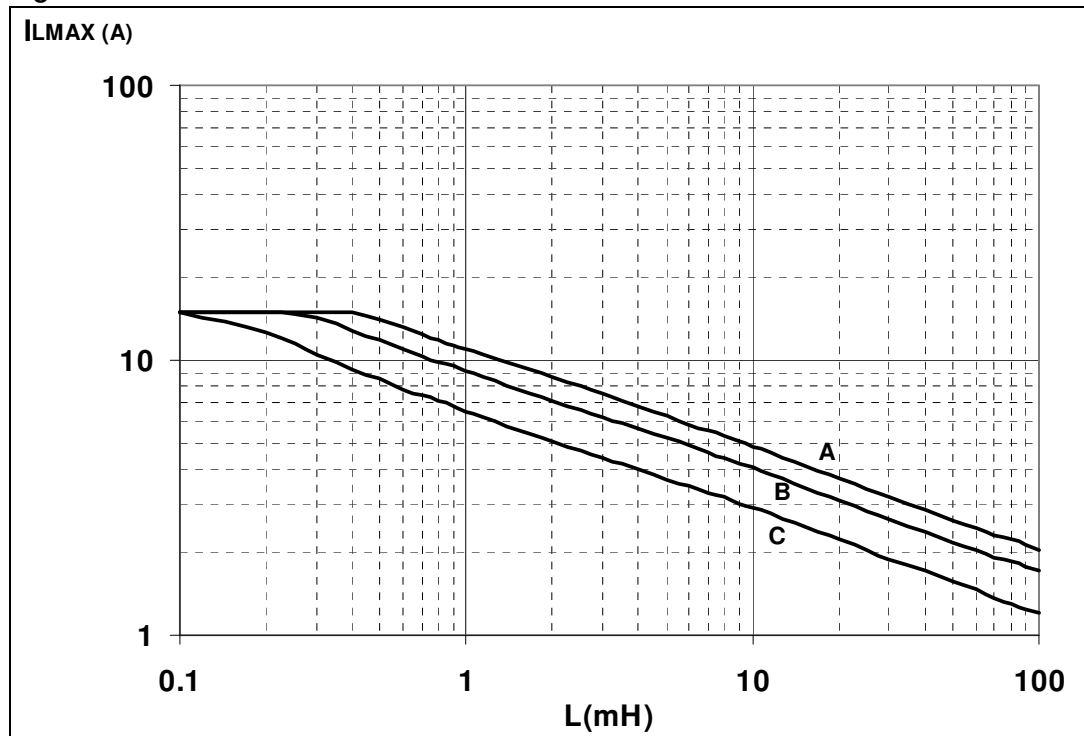


Figure 29. Step response current limit



3.2 SO-8 maximum demagnetization energy

Figure 30. SO-8 maximum turn-off current versus load inductance



Legend

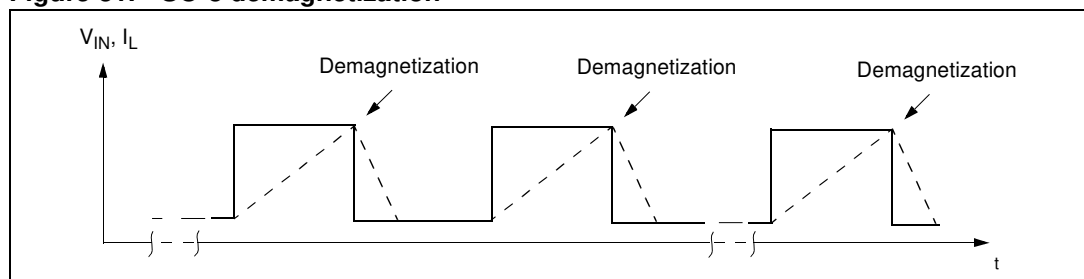
- A = Single Pulse at $T_{Jstart}=150\text{ }^{\circ}\text{C}$
- B = Repetitive pulse at $T_{Jstart}=100\text{ }^{\circ}\text{C}$
- C = Repetitive Pulse at $T_{Jstart}=125\text{ }^{\circ}\text{C}$

Conditions:

$V_{CC}=13.5\text{ V}$

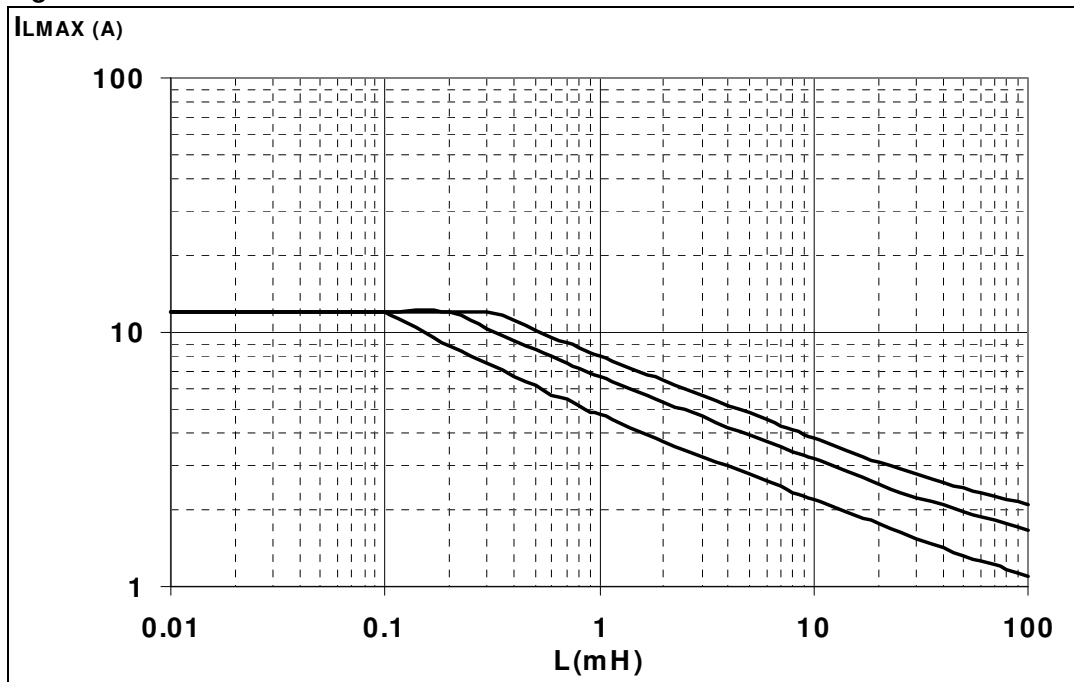
Values are generated with $R_L=0\text{ }\Omega$. In case of repetitive pulses, T_{Jstart} (at beginning of each demagnetization) of every pulse must not exceed the temperature specified above for curves B and C.

Figure 31. SO-8 demagnetization



3.3 DPAK maximum demagnetization energy

Figure 32. DPAK maximum turn-off current versus load inductance



Legend

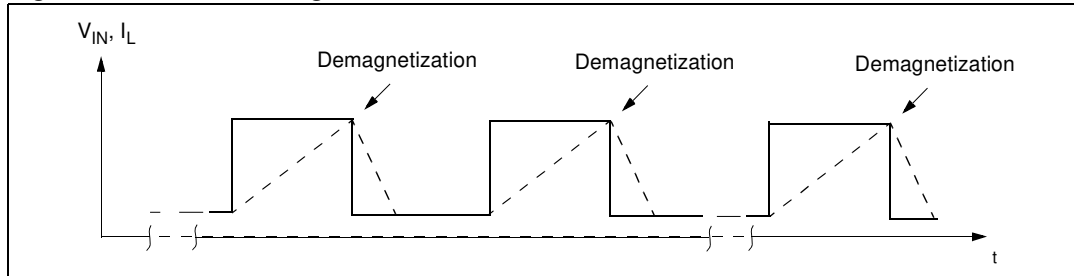
- A = Single Pulse at $T_{Jstart}=150\text{ °C}$
- B = Repetitive pulse at $T_{Jstart}=100\text{ °C}$
- C = Repetitive Pulse at $T_{Jstart}=125\text{ °C}$

Conditions:

$V_{CC}=13.5\text{ V}$

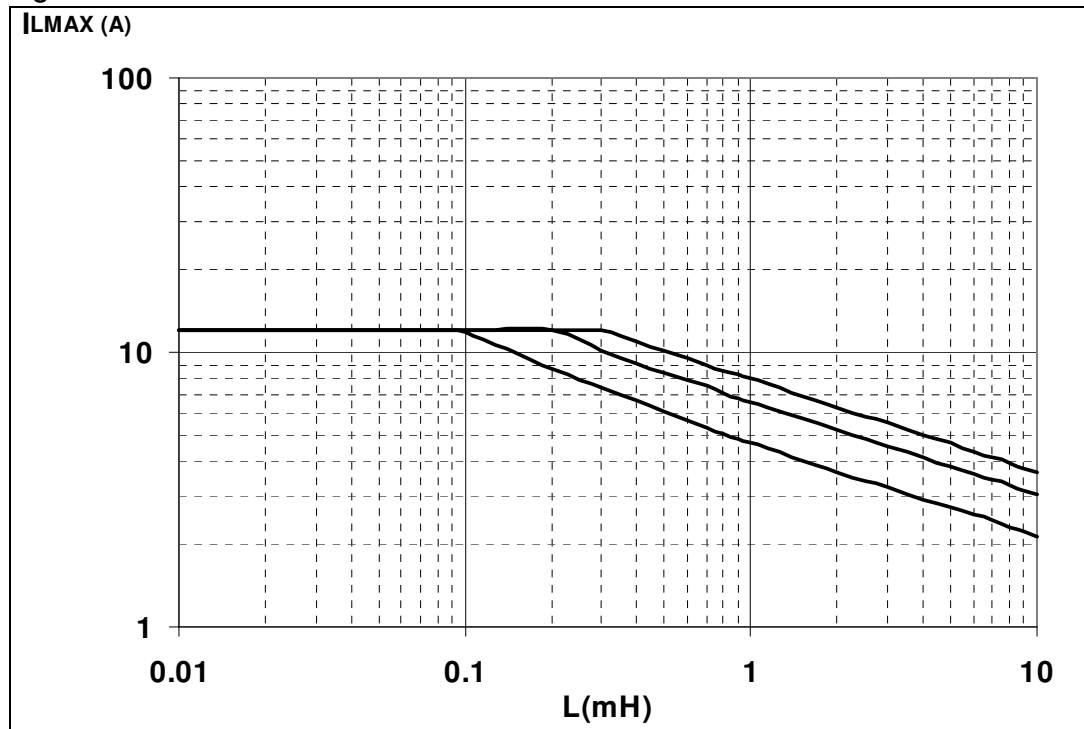
Values are generated with $R_L=0\ \Omega$. In case of repetitive pulses, T_{Jstart} (at beginning of each demagnetization) of every pulse must not exceed the temperature specified above for curves B and C.

Figure 33. DPAK demagnetization



3.4 SOT-223 maximum demagnetization energy

Figure 34. SOT-223 maximum turn-off current versus load inductance



Legend

A = Single Pulse at $T_{Jstart}=150\text{ }^{\circ}\text{C}$

B = Repetitive pulse at $T_{Jstart}=100\text{ }^{\circ}\text{C}$

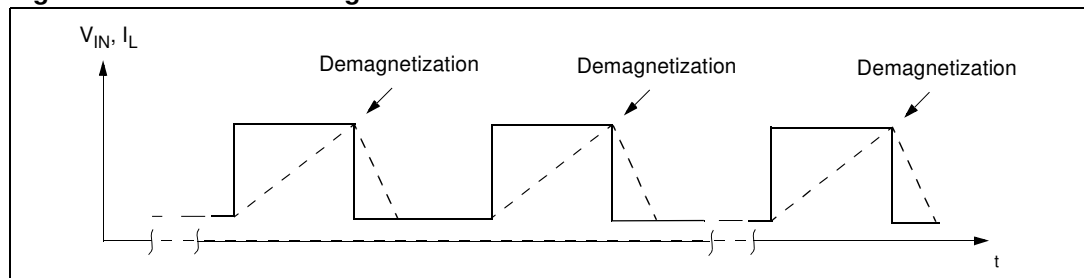
C = Repetitive Pulse at $T_{Jstart}=125\text{ }^{\circ}\text{C}$

Conditions:

$V_{CC}=13.5\text{ V}$

Values are generated with $R_L=0\text{ }\Omega$. In case of repetitive pulses, T_{Jstart} (at beginning of each demagnetization) of every pulse must not exceed the temperature specified above for curves B and C.

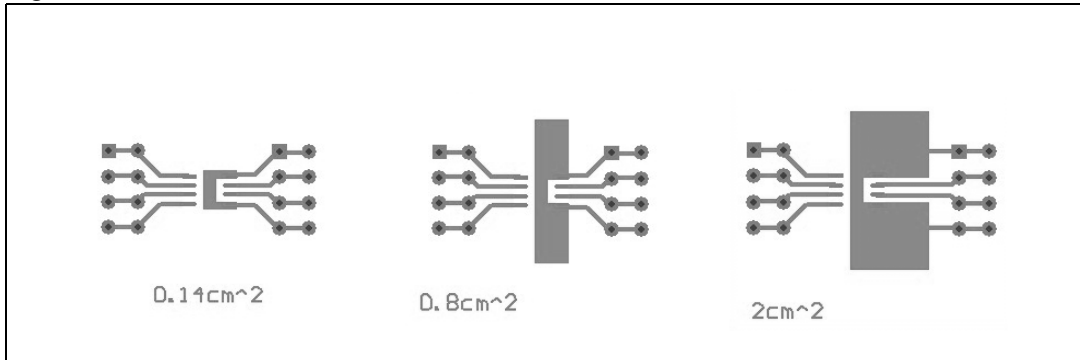
Figure 35. SOT-223 demagnetization



4 Package and PCB thermal data

4.1 SO-8 thermal data

Figure 36. SO-8 PC board



Note: Layout condition of R_{th} and Z_{th} measurements (PCB FR4 area=58 mm x 58 mm, PCB thickness=2 mm, Cu thickness=35 μm , Copper areas: 0.14 cm^2 , 0.8 cm^2 , 2 cm^2).

Figure 37. $R_{thj-amb}$ vs PCB copper area in open box free air condition

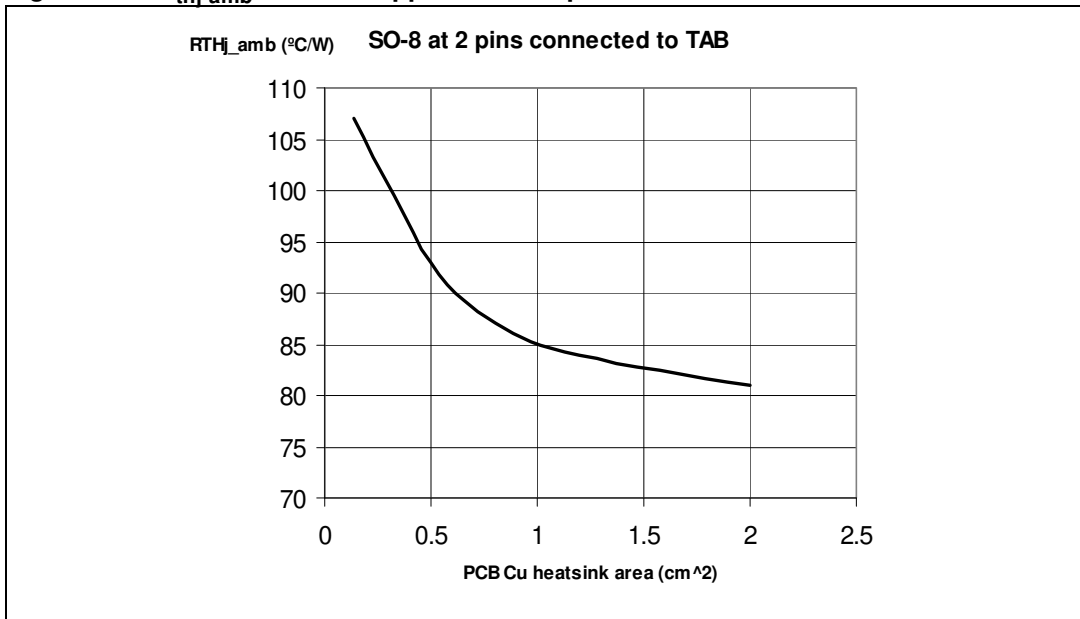


Figure 38. SO-8 thermal impedance junction ambient single pulse

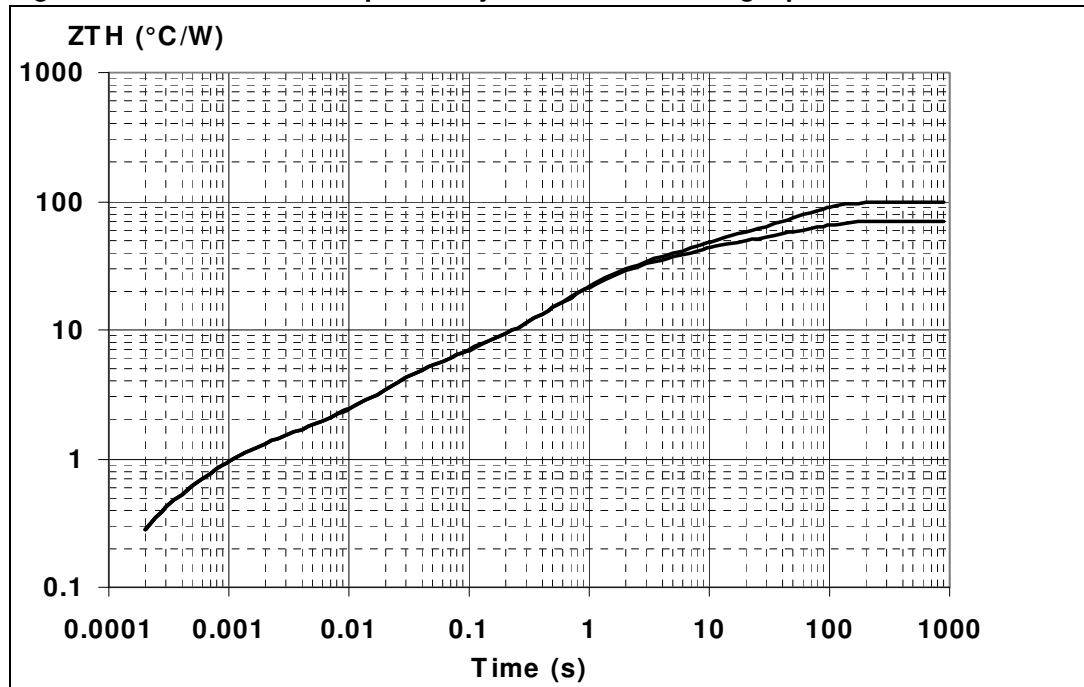
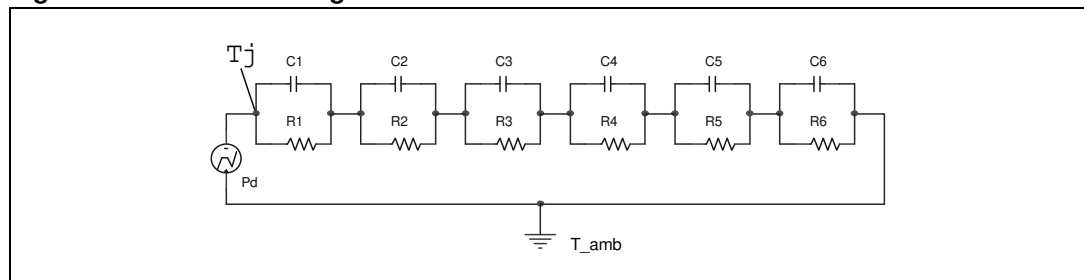


Figure 39. Thermal fitting model of an OMNIFET II in SO-8



Equation 1 Pulse calculation formula

$$Z_{TH\delta} = R_{TH} \cdot \delta + Z_{THtp}(1 - \delta)$$

where $\delta = t_p/T$

Table 5. SO-8 thermal parameter

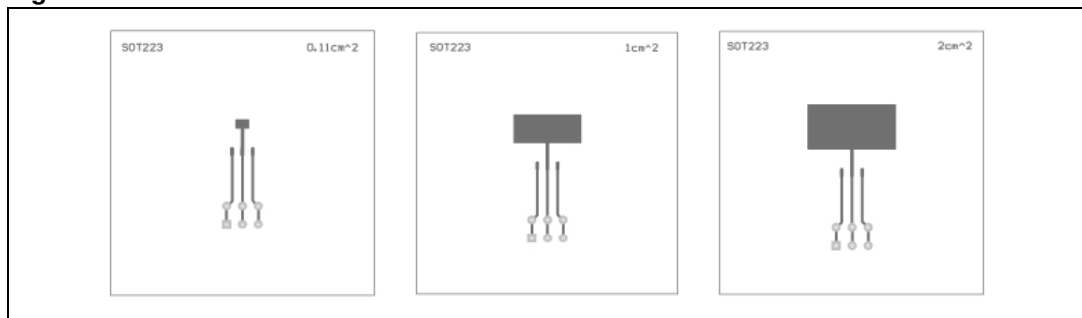
Area/island (cm ²)	Footprint	2
R1 (°C/W)	0.2	
R2 (°C/W)	0.9	
R3 (°C/W)	3.5	
R4 (°C/W)	21	
R5 (°C/W)	16	
R6 (°C/W)	58	28
C1 (W.s/°C)	3.00E-04	

Table 5. SO-8 thermal parameter (continued)

Area/island (cm ²)	Footprint	2
C2 (W.s/°C)	9.00E-04	
C3 (W.s/°C)	7.50E-03	
C4 (W.s/°C)	0.045	
C5 (W.s/°C)	0.35	
C6 (W.s/°C)	1.05	2

4.2 SOT-223 thermal data

Figure 40. SOT-223 PC board



Note: Layout condition of R_{th} and Z_{th} measurements (PCB FR4 area=58 mm x 58 mm, PCB thickness=2 mm, Cu thickness=35 μm, Copper areas: 0.11 cm², 1 cm², 2 cm²).

Figure 41. $R_{thj-amb}$ vs PCB copper area in open box free air condition

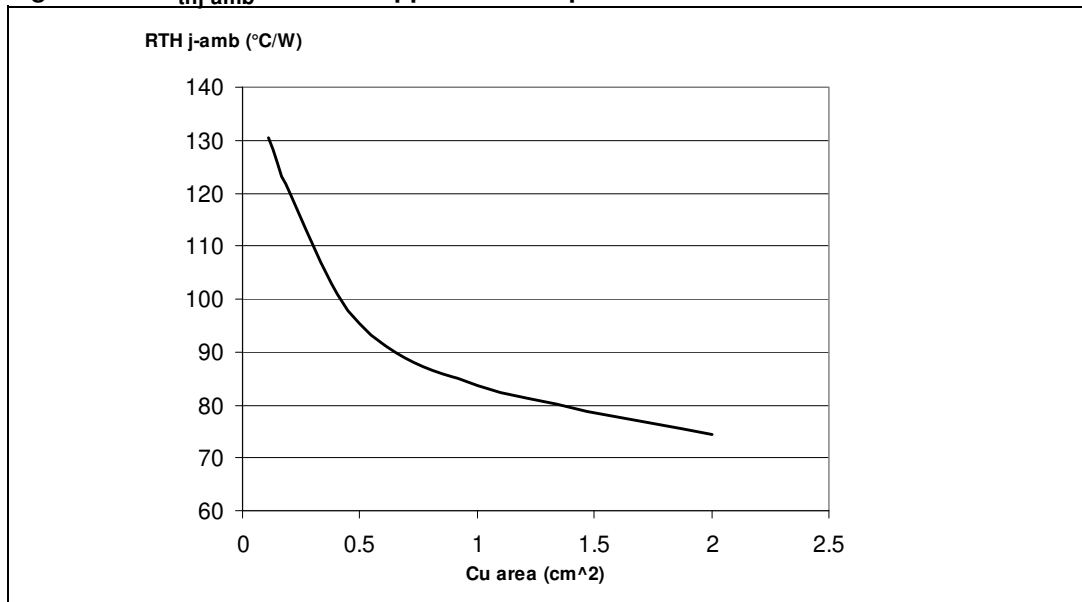


Figure 42. SOT-223 thermal impedance junction ambient single pulse

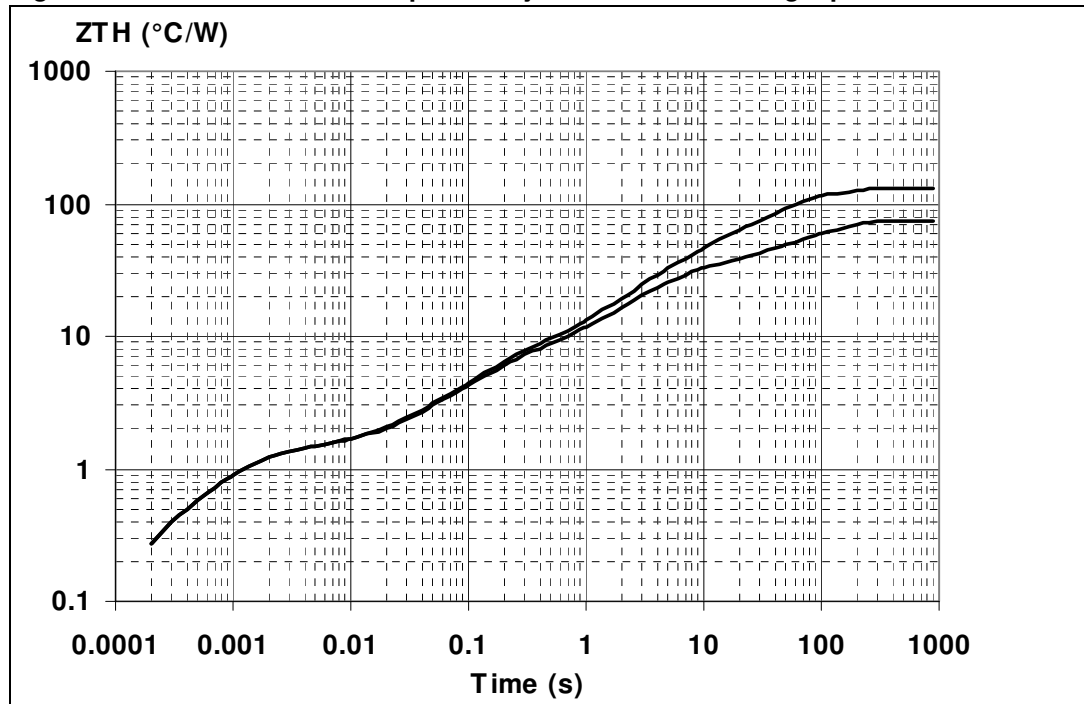
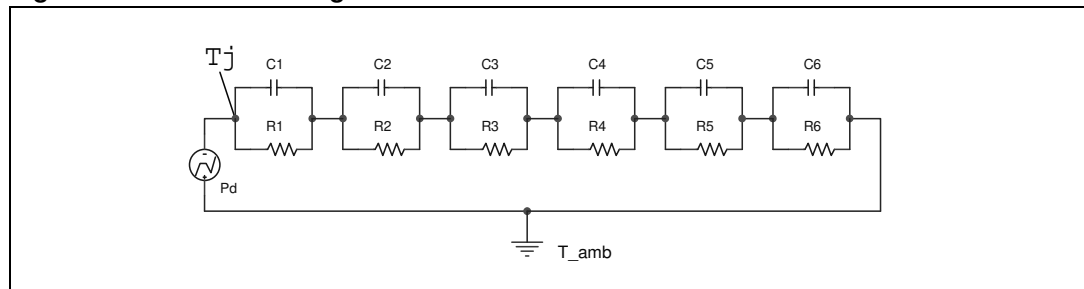


Figure 43. Thermal fitting model of an OMNIFET II in SOT-223



Equation 2 Pulse calculation formula

$$Z_{TH\delta} = R_{TH} \cdot \delta + Z_{THtp}(1 - \delta)$$

where $\delta = t_p/T$

Table 6. SOT-223 thermal parameter

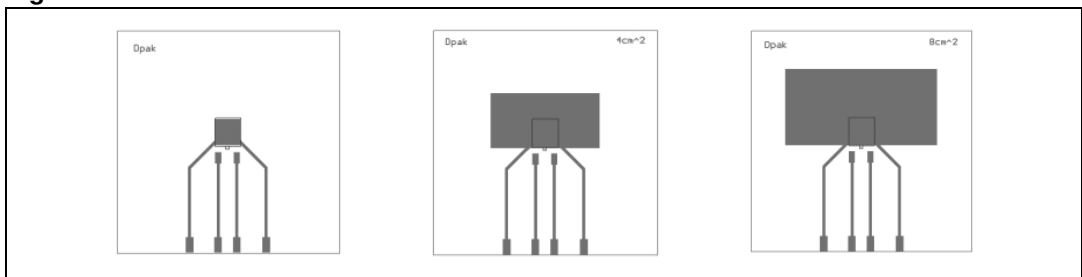
Area/island (cm ²)	Footprint	2
R1 (°C/W)	0.2	
R2 (°C/W)	1.1	
R3 (°C/W)	4.5	
R4 (°C/W)	24	
R5 (°C/W)	0.1	
R6 (°C/W)	100	45
C1 (W.s/°C)	3.00E-04	

Table 6. SOT-223 thermal parameter (continued)

Area/island (cm ²)	Footprint	2
C2 (W.s/°C)	9.00E-04	
C3 (W.s/°C)	3.00E-02	
C4 (W.s/°C)	0.16	
C5 (W.s/°C)	1000	
C6 (W.s/°C)	0.5	2

4.3 DPAK thermal data

Figure 44. DPAK PC board



Note: Layout condition of R_{th} and Z_{th} measurements (PCB FR4 area=60 mm x 60 mm, PCB thickness=2 mm, Cu thickness=35µm, Copper areas: from minimum pad lay-out to 8 cm2).

Figure 45. $R_{thj-amb}$ vs PCB copper area in open box free air condition

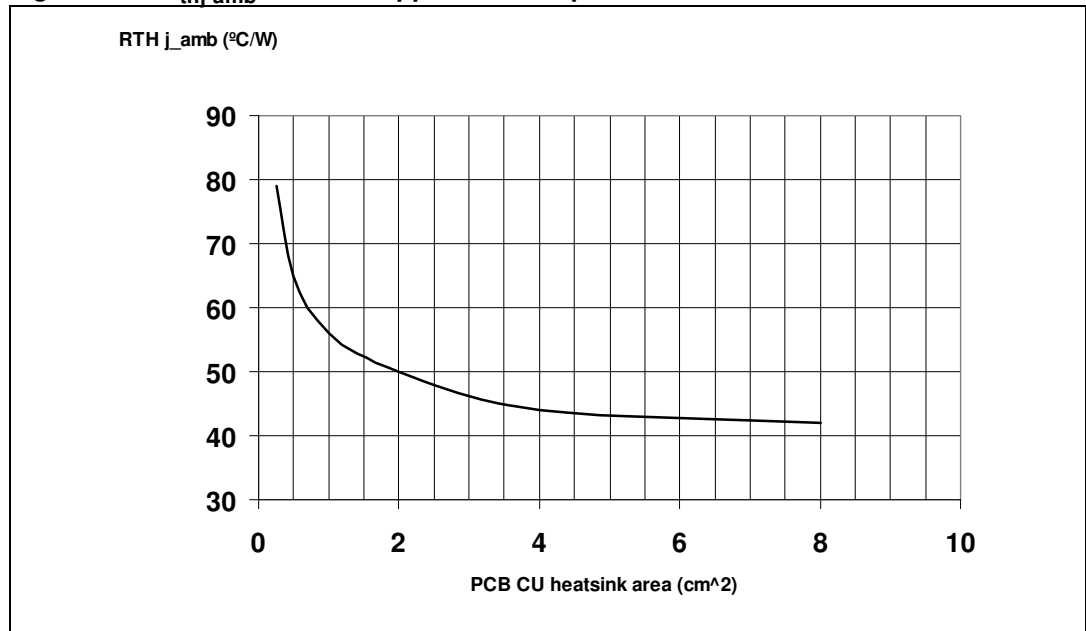


Figure 46. DPAK thermal impedance junction ambient single pulse

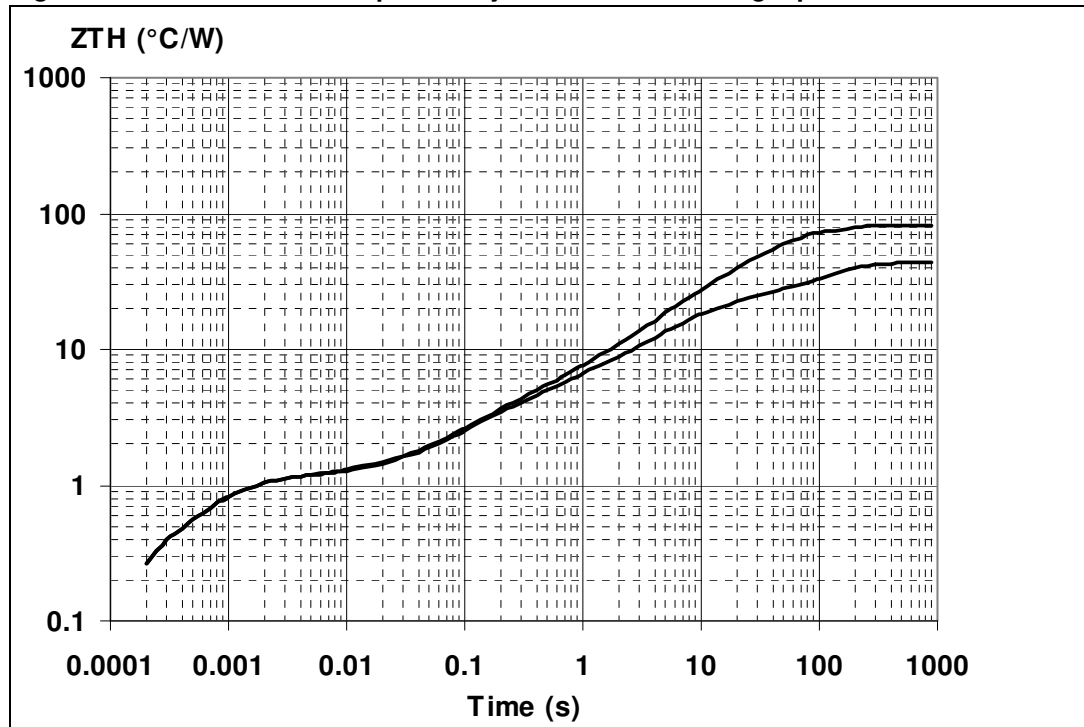
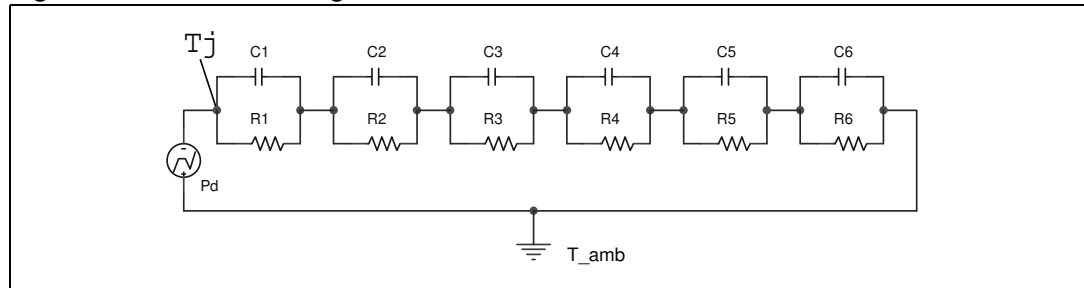


Figure 47. Thermal fitting model of an OMNIFET II in DPAK



Equation 3 Pulse calculation formula

$$Z_{TH\delta} = R_{TH} \cdot \delta + Z_{THtp}(1 - \delta)$$

where $\delta = t_p/T$

Table 7. DPAK thermal parameter

Area/island (cm ²)	Footprint	6
R1 (°C/W)	0.1	
R2 (°C/W)	0.35	
R3 (°C/W)	1.20	
R4 (°C/W)	2	
R5 (°C/W)	15	
R6 (°C/W)	61	24