

## Automotive-grade N-channel 650 V, 0.024 $\Omega$ typ., 69 A, MDmesh™ V Power MOSFET in a TO-247 package

Datasheet - production data

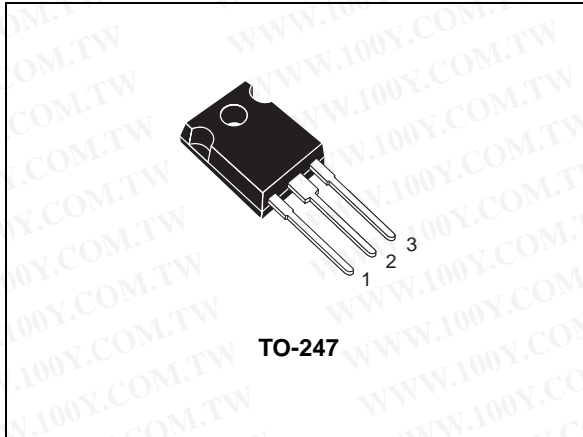
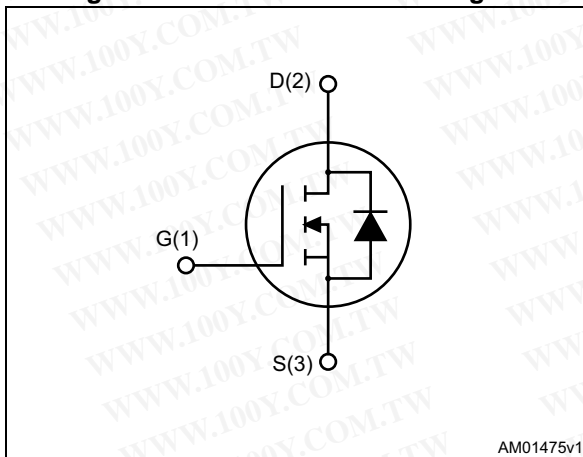


Figure 1. Internal schematic diagram



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Table 1. Device summary

Order code	Marking	Package	Packaging
STW78N65M5	78N65M5	TO-247	Tube

### Features

Order code	$V_{DS} @ T_{jmax.}$	$R_{DS(on) max.}$	$I_D$
STW78N65M5	710 V	0.032 $\Omega$	69 A

- Designed for automotive applications and AEC-Q101 qualified
- Higher  $V_{DS}$  rating
- Higher dv/dt capability
- Excellent switching performance
- Easy to drive
- 100% avalanche tested

### Applications

- Switching applications

### Description

This device is an N-channel MDmesh™ V Power MOSFET based on an innovative proprietary vertical process technology, which is combined with STMicroelectronics' well-known PowerMESH™ horizontal layout structure. The resulting product has extremely low on-resistance, which is unmatched among silicon-based Power MOSFETs, making it especially suitable for applications which require superior power density and outstanding efficiency.

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# 1 Electrical ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{GS}$	Gate- source voltage	$\pm 25$	V
$I_D$	Drain current (continuous) at $T_C = 25\text{ }^\circ\text{C}$	69	A
$I_D$	Drain current (continuous) at $T_C = 100\text{ }^\circ\text{C}$	41.5	A
$I_{DM}^{(1)}$	Drain current (pulsed)	276	A
$P_{TOT}$	Total dissipation at $T_C = 25\text{ }^\circ\text{C}$	450	W
$dv/dt^{(2)}$	Peak diode recovery voltage slope	15	V/ns
$dv/dt^{(3)}$	MOSFET $dv/dt$ ruggedness	50	V/ns
$T_{stg}$	Storage temperature	- 55 to 150	$^\circ\text{C}$
$T_j$	Max. operating junction temperature	150	$^\circ\text{C}$

1. Pulse width limited by safe operating area
2.  $I_{SD} \leq 69\text{ A}$ ,  $di/dt = 400\text{ A}/\mu\text{s}$ ,  $V_{DS\text{ peak}} < V_{(BR)DSS}$ ,  $V_{DD} = 400\text{ V}$
3.  $V_{DS} \leq 520\text{ V}$

**Table 3. Thermal data**

Symbol	Parameter	Value	Unit
$R_{thj-case}$	Thermal resistance junction-case max	0.28	$^\circ\text{C}/\text{W}$
$R_{thj-amb}$	Thermal resistance junction-ambient max	50	$^\circ\text{C}/\text{W}$

**Table 4. Avalanche characteristics**

Symbol	Parameter	Value	Unit
$I_{AR}$	Max current during repetitive or single pulse avalanche (pulse width limited by $T_{JMAX}$ )	15	A
$E_{AS}$	Single pulse avalanche energy (starting $T_j = 25\text{ }^\circ\text{C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ )	2000	mJ

## 2 Electrical characteristics

( $T_C = 25\text{ °C}$  unless otherwise specified)

**Table 5. On /off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage ( $V_{GS} = 0$ )	$I_D = 1\text{ mA}$	650			V
$I_{DSS}$	Zero gate voltage drain current ( $V_{GS} = 0$ )	$V_{DS} = 650\text{ V}$ $V_{DS} = 650\text{ V}, T_C = 125\text{ °C}$			1 100	$\mu\text{A}$ $\mu\text{A}$
$I_{GSS}$	Gate-body leakage current ( $V_{DS} = 0$ )	$V_{GS} = \pm 25\text{ V}$			$\pm 100$	nA
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$	3	4	5	V
$R_{DS(on)}$	Static drain-source on-resistance	$V_{GS} = 10\text{ V}, I_D = 34.5\text{ A}$		0.024	0.032	$\Omega$

**Table 6. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$C_{iss}$	Input capacitance	$V_{DS} = 100\text{ V}, f = 1\text{ MHz},$ $V_{GS} = 0$	-	9000	-	pF
$C_{oss}$	Output capacitance		-	210	-	pF
$C_{rss}$	Reverse transfer capacitance		-	9	-	pF
$C_{o(tr)}^{(1)}$	Equivalent capacitance time related	$V_{GS} = 0, V_{DS} = 0\text{ to }520\text{ V}$	-	768	-	pF
$C_{o(er)}^{(2)}$	Equivalent capacitance energy related	$V_{GS} = 0, V_{DS} = 0\text{ to }520\text{ V}$	-	205	-	pF
$R_G$	Intrinsic gate resistance	$f = 1\text{ MHz open drain}$	-	1.5	-	$\Omega$
$Q_g$	Total gate charge	$V_{DD} = 520\text{ V}, I_D = 34.5\text{ A},$ $V_{GS} = 10\text{ V}$ (see <a href="#">Figure 16</a> )	-	203	-	nC
$Q_{gs}$	Gate-source charge		-	50	-	nC
$Q_{gd}$	Gate-drain charge		-	84	-	nC

- $C_{o(tr)}$  is a constant capacitance value that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .
- $C_{o(er)}$  is a constant capacitance value that gives the same stored energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

Table 7. Switching times

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(V)}$	Voltage delay time	$V_{DD} = 400\text{ V}$ , $I_D = 40\text{ A}$ , $R_G = 4.7\ \Omega$ , $V_{GS} = 10\text{ V}$ (see <a href="#">Figure 17</a> ) (see <a href="#">Figure 20</a> )	-	163	-	ns
$t_{r(V)}$	Voltage rise time		-	14	-	ns
$t_{f(i)}$	Current fall time		-	14	-	ns
$t_{c(off)}$	Crossing time		-	26	-	ns

Table 8. Source drain diode

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{SD}$	Source-drain current		-		69	A
$I_{SDM}^{(1)}$	Source-drain current (pulsed)		-		276	A
$V_{SD}^{(2)}$	Forward on voltage	$I_{SD} = 69\text{ A}$ , $V_{GS} = 0$	-		1.5	V
$t_{rr}$	Reverse recovery time	$I_{SD} = 69\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 100\text{ V}$ (see <a href="#">Figure 17</a> )	-	504		ns
$Q_{rr}$	Reverse recovery charge		-	13		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current	$I_{SD} = 69\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ $V_{DD} = 100\text{ V}$ , $T_j = 150\text{ }^\circ\text{C}$ (see <a href="#">Figure 17</a> )	-	49		A
$t_{rr}$	Reverse recovery time		-	635		ns
$Q_{rr}$	Reverse recovery charge		-	19		$\mu\text{C}$
$I_{RRM}$	Reverse recovery current		-	59		A

1. Pulse width limited by safe operating area

2. Pulsed: pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5%

## 2.1 Electrical characteristics (curves)

Figure 2. Safe operating area

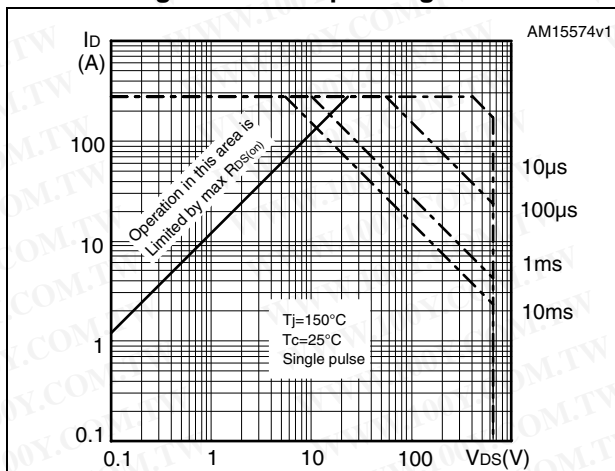


Figure 3. Thermal impedance

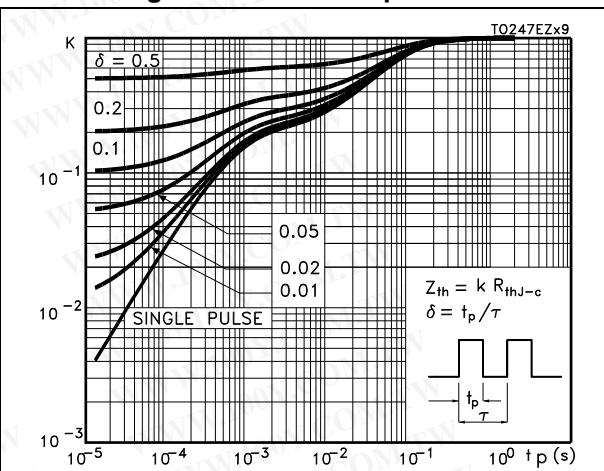


Figure 4. Output characteristics

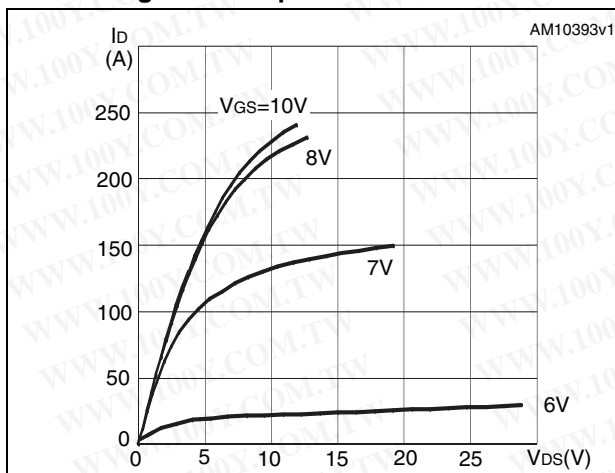


Figure 5. Transfer characteristics

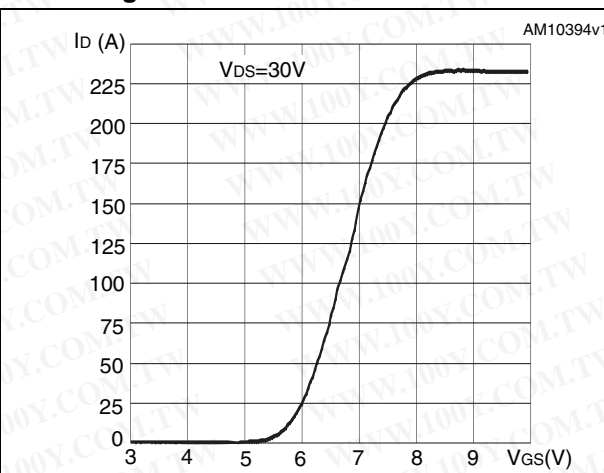


Figure 6. Gate charge vs gate-source voltage

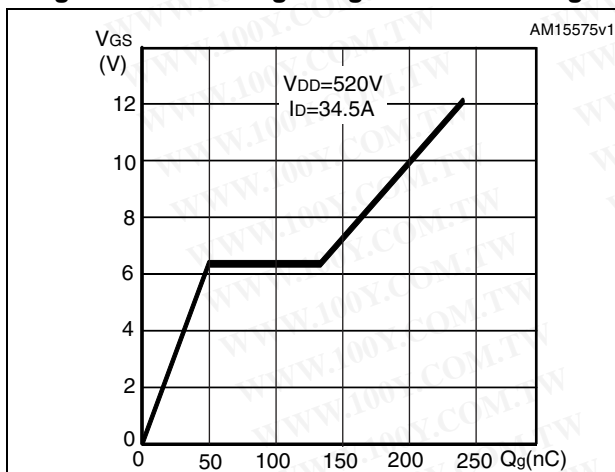


Figure 7. Static drain-source on-resistance

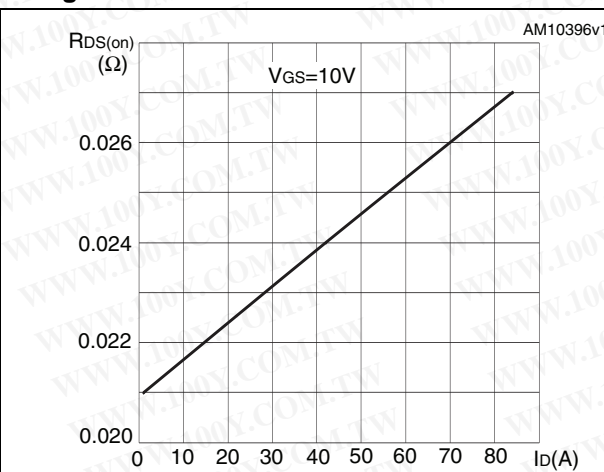


Figure 8. Capacitance variations

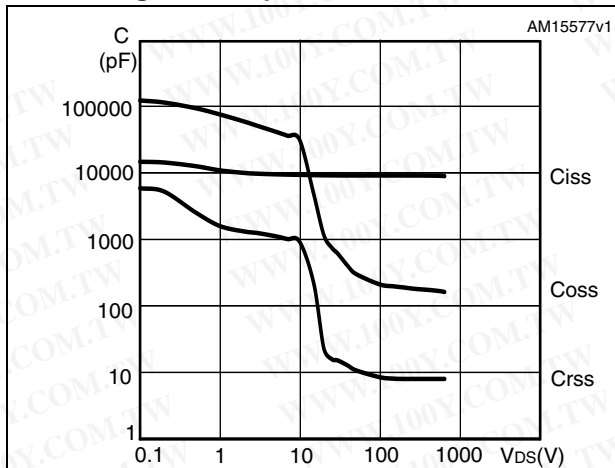


Figure 9. Output capacitance stored energy

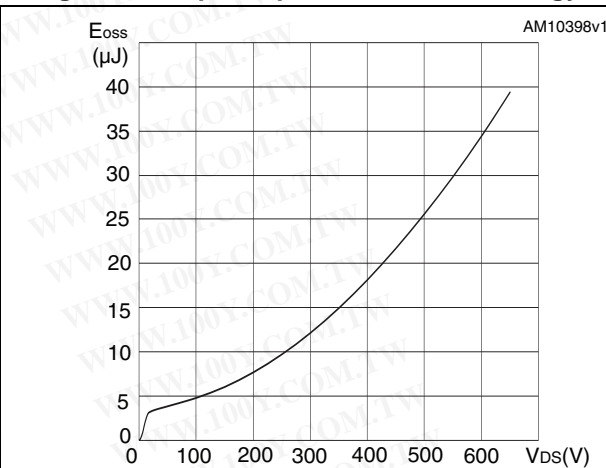


Figure 10. Normalized gate threshold voltage vs temperature

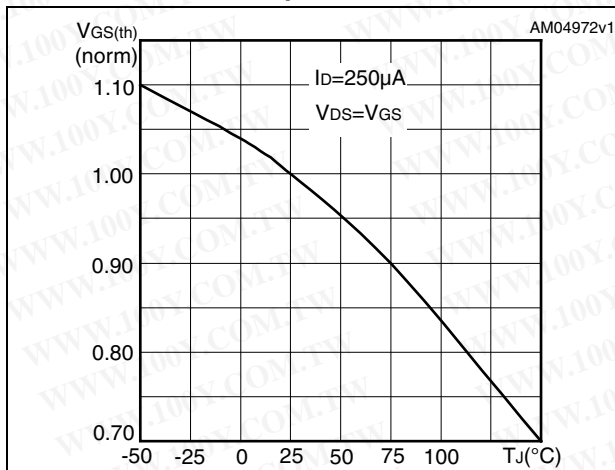


Figure 11. Normalized on-resistance vs temperature

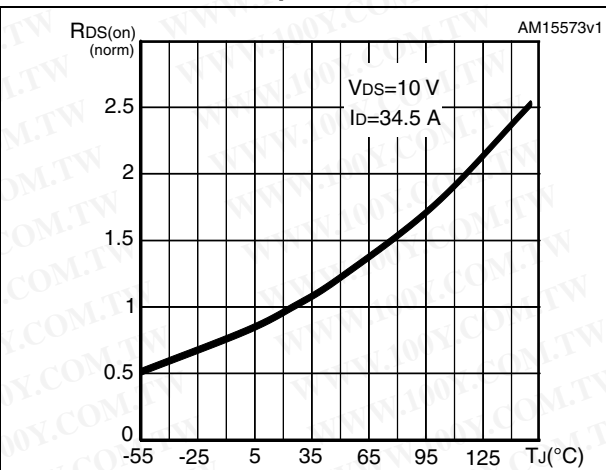


Figure 12. Source-drain diode forward characteristics

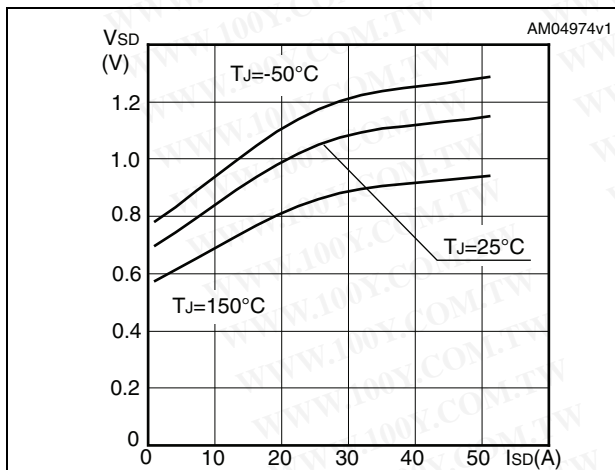


Figure 13. Normalized VDS vs temperature

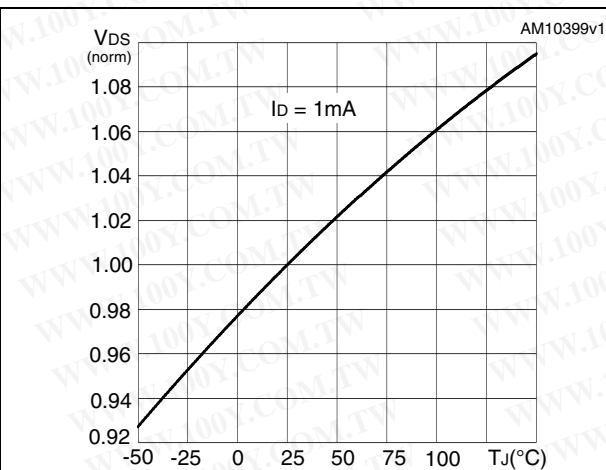
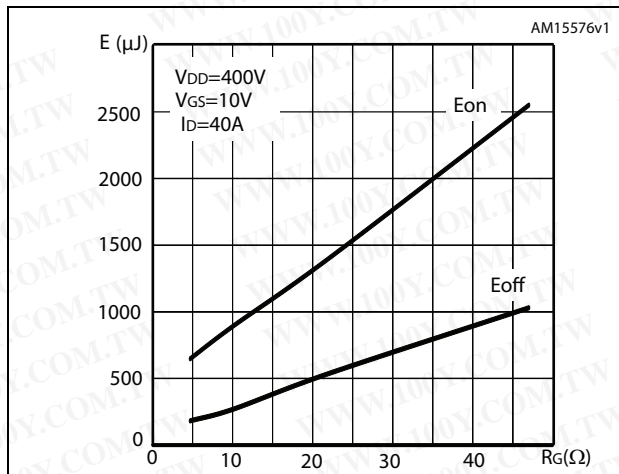


Figure 14. Switching losses vs gate resistance (1)



1.  $E_{on}$  including reverse recovery of a SiC diode



### 3 Test circuits

Figure 15. Switching times test circuit for resistive load

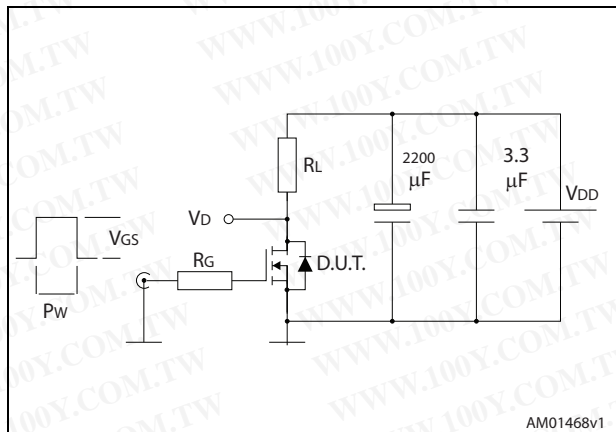


Figure 16. Gate charge test circuit

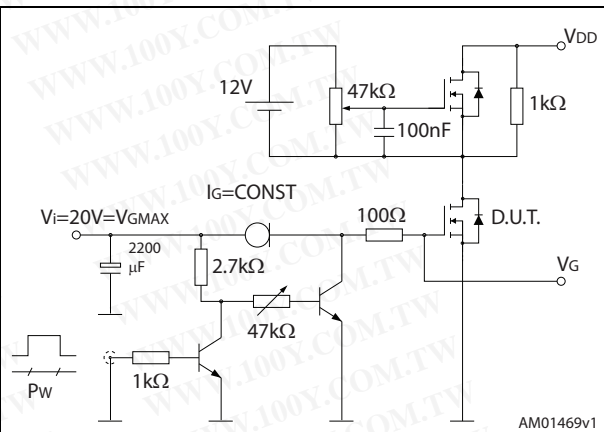


Figure 17. Test circuit for inductive load switching and diode recovery times

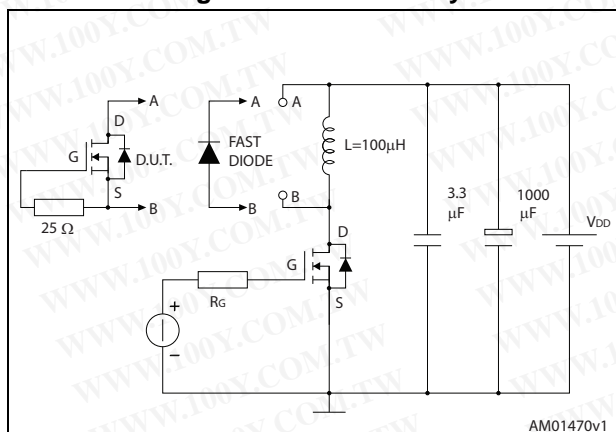


Figure 18. Unclamped inductive load test circuit

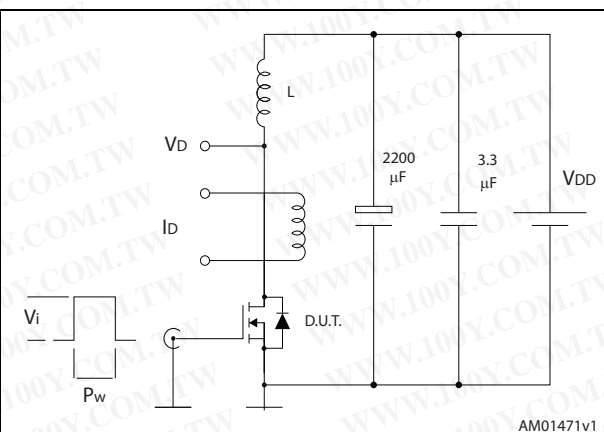


Figure 19. Unclamped inductive waveform

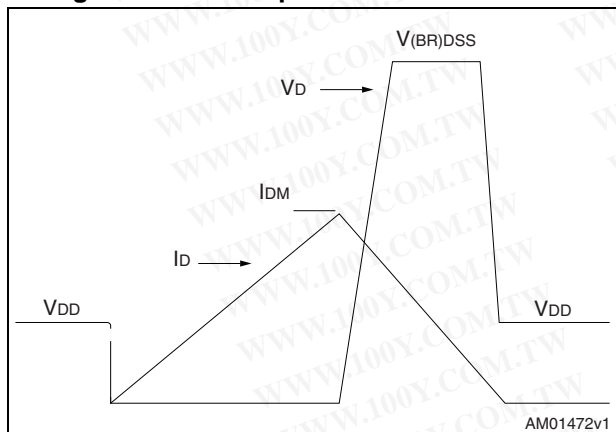
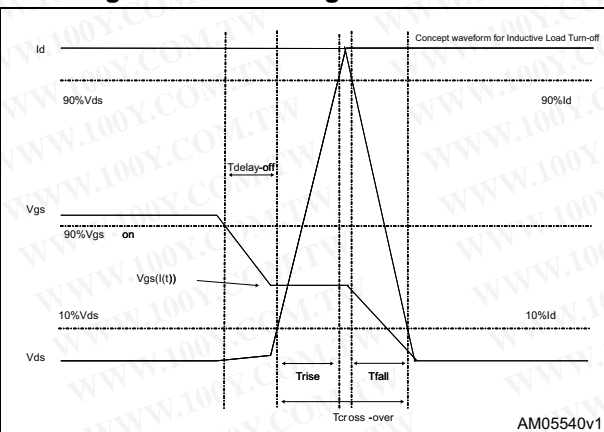


Figure 20. Switching time waveform



## 4 Package mechanical data

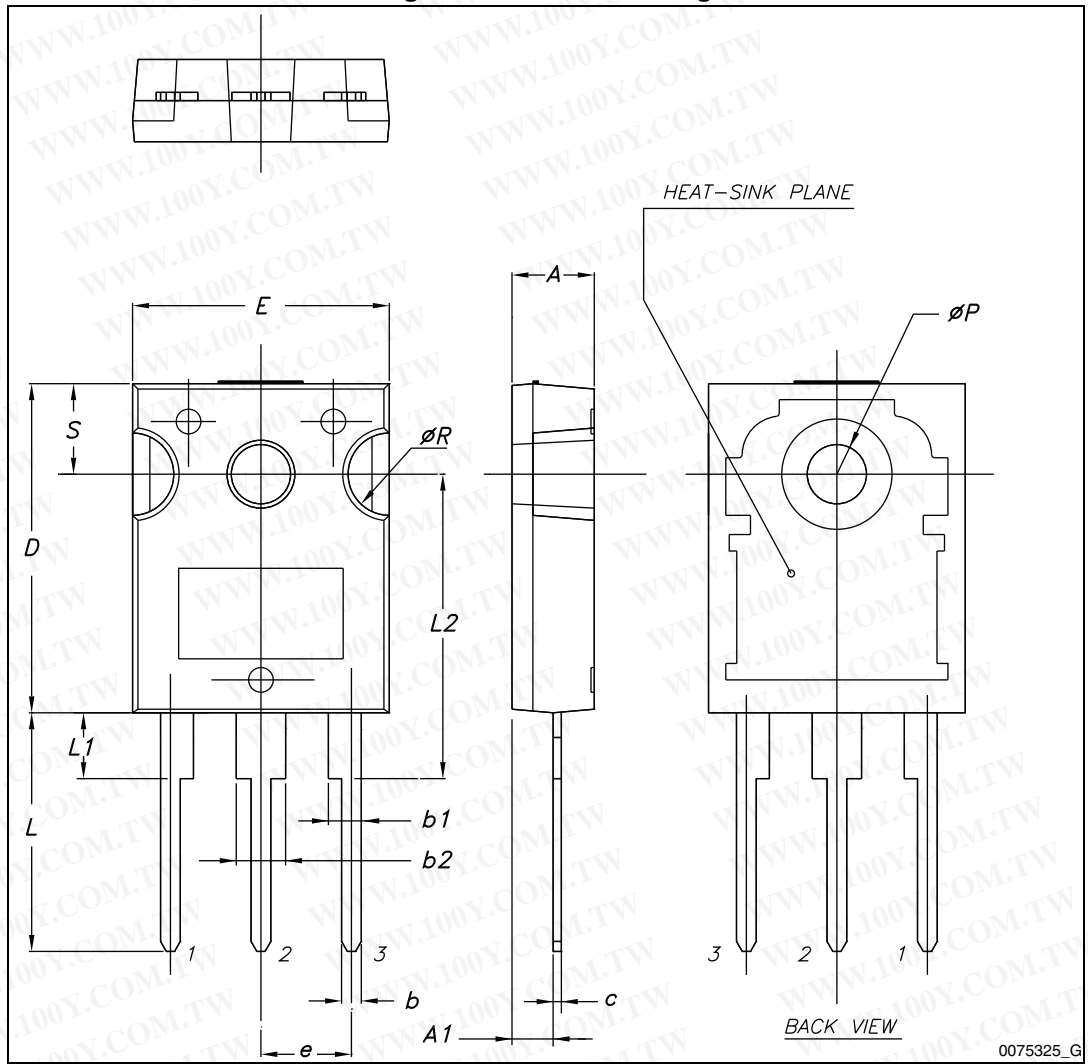
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Table 9. TO-247 mechanical data

Dim.	mm.		
	Min.	Typ.	Max.
A	4.85		5.15
A1	2.20		2.60
b	1.0		1.40
b1	2.0		2.40
b2	3.0		3.40
c	0.40		0.80
D	19.85		20.15
E	15.45		15.75
e	5.30	5.45	5.60
L	14.20		14.80
L1	3.70		4.30
L2		18.50	
ØP	3.55		3.65
ØR	4.50		5.50
S	5.30	5.50	5.70

Figure 21. TO-247 drawing



## 5 Revision history

**Table 10. Document revision history**

Date	Revision	Changes
16-Jul-2012	1	First release.
22-Jan-2013	2	Modified: $R_{DS(on)}$ on first page, $I_D$ , $I_{DM}$ on <a href="#">Table 2</a> , note 2 on <a href="#">Table 2</a> , typical values on <a href="#">Table 6</a> , <a href="#">7</a> , max and typical values on <a href="#">Table 8</a> , <a href="#">Figure 2</a> , <a href="#">6</a> , <a href="#">8</a> , <a href="#">9</a> , <a href="#">11</a> and <a href="#">14</a>
07-Aug-2013	3	<ul style="list-style-type: none"> <li>– Minor text changes</li> <li>– Modified: <a href="#">Applications</a> in first page</li> <li>– Added: MOSFET dv/dt ruggedness parameter in <a href="#">Table 2</a></li> <li>– Added: <a href="#">Table 4: Avalanche characteristics</a></li> <li>– Modified: <a href="#">Figure 15</a>, <a href="#">16</a>, <a href="#">17</a> and <a href="#">18</a></li> </ul>
08-Aug-2013	4	<ul style="list-style-type: none"> <li>– Minor text changes</li> <li>– Modified: <a href="#">Figure 14</a></li> </ul>

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