VNB14N04 - VNK14N04FM VNV14N04

"OMNIFET"
fully autoprotected Power MOSFET

Features

Type	V_{clamp}	$R_{DS(on)}$	I_{lim}
VNB14N04	42 V	0.07 Ω	14 A
VNK14N04FM	42 V	0.07 Ω	14 A
VNV14N04	42 V	0.07 Ω	14 A

- 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

D2PAK
TO-263

SOT82-FM

PowerSO-10
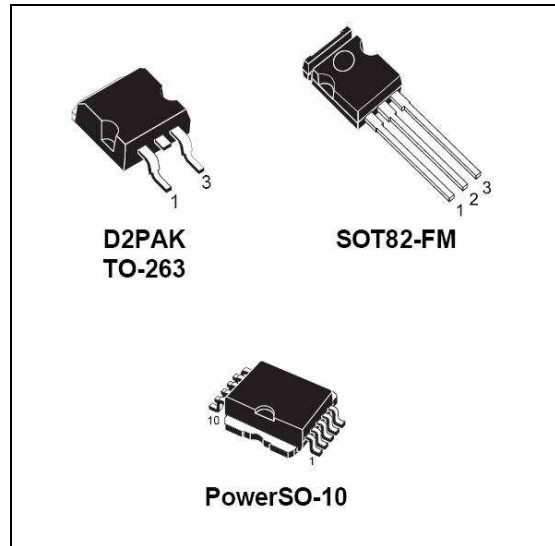
Description

The VNB14N04, VNK14N04FM and VNV14N04 are monolithic devices made using STMicroeletronics VIPower M0 Technology, intended for replacement of standard power MOSFETS in DC to 50 kHz applications. Built-in thermal shutdown, linear current limitation and overvoltage clamp protect the chip in harsh environment.

Fault feedback can be detected by monitoring the voltage at the input pin.
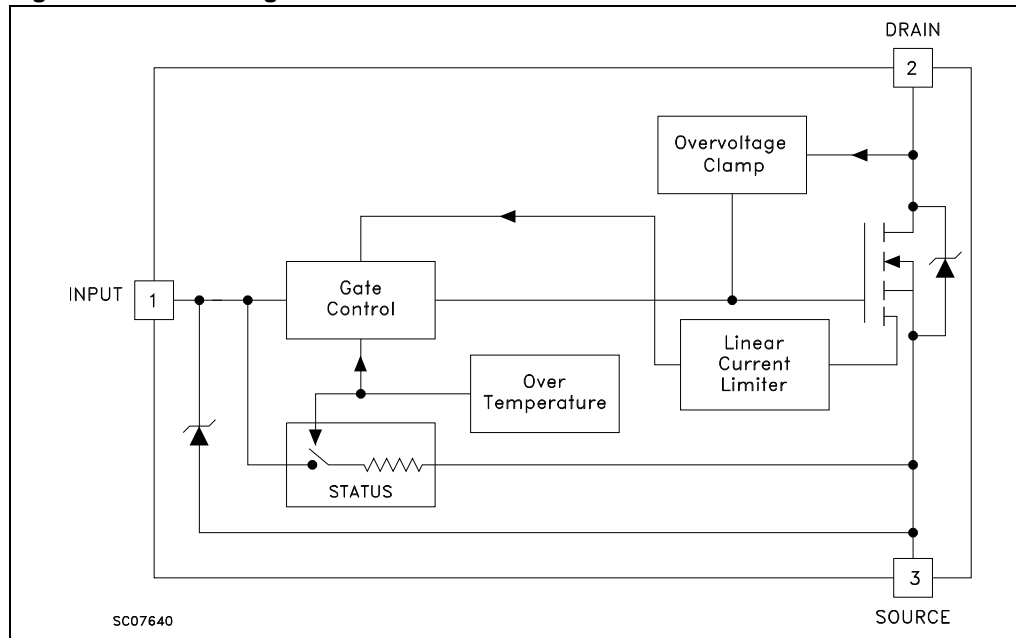
Table 1. Device summary

Part number	Order code
VNB14N04	VNB14N04, VNB14N04-E, VNB14N0413TR, VNB14N04TR-E
VNK14N04FM	VNK14N04FM
VNV14N04	VNV14N04, VNV14N04-E

Contents

1   Block diagram

Figure 1.   Block diagram

1.   PowerSO-10 pin configuration : INPUT = 6,7,8,9,10; SOURCE = 1,2,4,5; DRAIN = TAB

2 Electrical specification

2.1 Absolute maximum rating

Table 2.   Absolute maximum rating

Symbol	Parameter	Value		Unit
		PowerSO-10 D2PAK	**SOT-82FM**	
V_{DS}	Drain-source voltage (V_{in} = 0)	Internally clamped		V
V_{in}	Input voltage	18		V
I_D	Drain current	Internally limited		A
I_R	Reverse DC output current	-14		A
V_{esd}	Electrostatic discharge (C = 100 pF, R=1.5 KΩ)	2000		V
P_{tot}	Total dissipation at T_c = 25 °C	50	9.5	W
T_j	Operating junction temperature	Internally limited		°C
T_c	Case operating temperature	Internally limited		°C
T_{stg}	Storage temperature	-55 to 150		°C

2.2 Thermal data

Table 3.   Thermal data

Symbol	Parameter	PowerSO-10	SOT82-FM	D2PAK	Unit
$R_{thj-case}$	Thermal resistance junction-case max	2.5	13	2.5	°C/W
$R_{thj-amb}$	Thermal resistance junction-ambient max	50	100	62.5	°C/W

2.3 Electrical characteristics

T_{case} =25 °C unless otherwise specified.

Table 4.   Electrical characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
Off						
V_{CLAMP}	Drain-source clamp voltage	I_D = 200 mA V_{in} = 0	36	42	48	V
V_{CLTH}	Drain-source clamp threshold voltage	I_D = 2 mA V_{in} = 0	35			V
V_{INCL}	Input-source reverse clamp voltage	I_{in} = -1 mA	-1		-0.3	V

Table 4.   Electrical characteristics (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{DSS}	Zero input voltage drain current (V_{in} = 0)	V_{DS} = 13 V V_{in} = 0 V_{DS} = 25 V V_{in} = 0			50 200	µA µA
I_{ISS}	Supply current from input pin	V_{DS} = 0 V V_{in} = 10 V		250	500	µA
On[1]						
$V_{IN(th)}$	Input threshold voltage	V_{DS} = V_{in} I_D + I_{in} = 1 mA	0.8		3	V
$R_{DS(on)}$	Static drain-source on resistance	V_{in} = 10 V I_D = 7 A V_{in} = 5 V I_D = 7 A			0.7 0.1	Ω Ω
Dynamic						
g_{fs} [1]	Forward transconductance	V_{DS} = 13 V I_D = 7 A	8	10		S
C_{oss}	Output capacitance	V_{DS} = 13 V f = 1 MHz V_{in} = 0		400	500	pF
Switching[2]						
$t_{d(on)}$ t_r $t_{d(off)}$ t_f	Turn-on delay time Rise time Turn-off delay time Fall time	V_{DD} = 15 V I_d = 7 A V_{gen} = 10 V R_{gen} = 10 Ω (see *Figure 26*)		60 160 250 100	120 300 400 200	ns ns ns ns
$t_{d(on)}$ t_r $t_{d(off)}$ t_f	Turn-on delay time Rise time Turn-off delay time Fall time	V_{DD} = 15 V I_d = 7 A V_{gen} = 10 V R_{gen} = 1000 Ω (see *Figure 26*)		300 1.5 5.5 1.8	500 2.2 7.5 2.5	ns µs µs µs
$(di/dt)_{on}$	Turn-on current slope	V_{DD} = 15 V I_D = 7 A V_{in} = 10 V R_{gen} = 10 Ω		120		A/µs
Q_i	Total input charge	V_{DD} = 12 V I_D = 7 A V_{in} = 10 V		30		nC
Source drain diode						
V_{SD} [1]	Forward on voltage	I_{SD} = 7 A V_{in} = 0			1.6	V
t_{rr} [2] Q_{rr} [2] I_{RRM} [2]	Reverse recovery time Reverse recovery charge Reverse recovery current	I_{SD} = 7 A di/dt = 100 A/µs V_{DD} = 30 V T_j = 25 ℃ (see test circuit, *Figure 28*)		110 0.34 6.1		ns µC A
Protection						
I_{lim}	Drain current limit	V_{in} = 10 V V_{DS} = 13 V V_{in} = 5 V V_{DS} = 13 V	10 10	14 14	20 20	A A
t_{dlim} [2]	Step response Current limit	V_{in} = 10 V V_{in} = 5 V		30 80	60 150	µs µs
T_{jsh} [2]	Overtemperature shutdown		150			℃
T_{jrs} [2]	Overtemperature reset		135			°C

Table 4.   Electrical characteristics (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{gf} [2]	Fault sink current	V_{in} = 10 V V_{DS} = 13 V V_{in} = 5 V V_{DS} = 13 V		50 20		mA mA
E_{as} [2]	Single pulse avalanche energy	starting T_j = 25°C V_{DD} = 20 V V_{in} = 10 V R_{gen} = 1 KΩ L = 10 mH	0.65			J

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

2.   Parameters guaranteed by design/characterization

3   Protection features

During normal operation, the Input pin is electrically connected to the gate of the internal power MOSFET. The device then behaves like a standard power MOSFET and can be used as a switch from DC to 50 kHz. The only difference from the user's standpoint is that a small DC current (I_{iss}) flows into the Input pin in order to supply the internal circuitry.

The device integrates:

●   Overvoltage clamp protection: internally set at 42 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 Id to Ilim whatever the Input pin voltage. 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 overtemperature threshold T_{jsh}.

●   Overtemperature 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. Overtemperature cutout occurs at minimum 150 °C. The device is automatically restarted when the chip temperature falls below 135 °C.

●   Status feedback: in the case of an overtemperature fault condition, a Status Feedback is provided through the Input pin. The internal protection circuit disconnects the input from the gate and connects it instead to ground via an equivalent resistance of 100 Ω. The failure can be detected by monitoring the voltage at the Input pin, which will be close to ground potential.

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 (with a small increase in $R_{DS(on)}$).

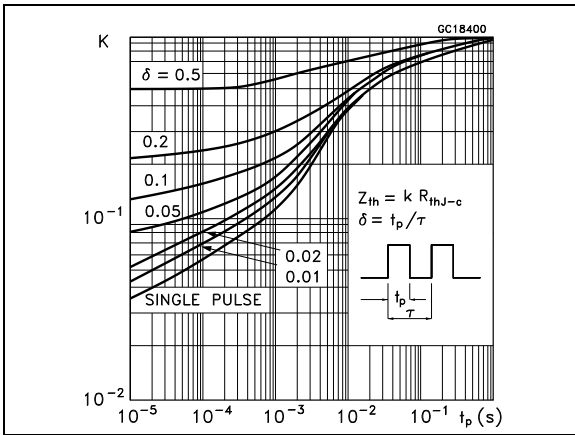**Figure 2.   Thermal impedance for D2PAK/PowerSO-10**
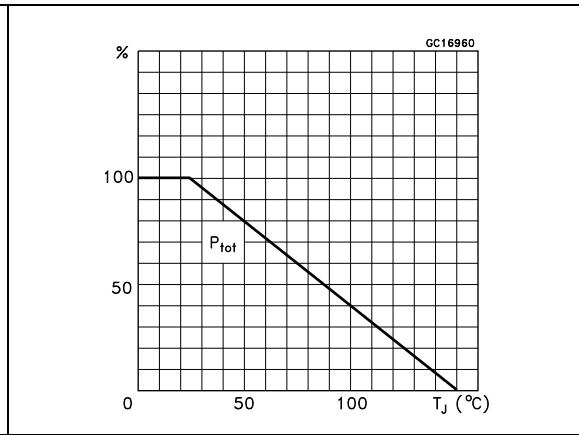

Figure 3.   Derating curve

Figure 4.   Output characteristics
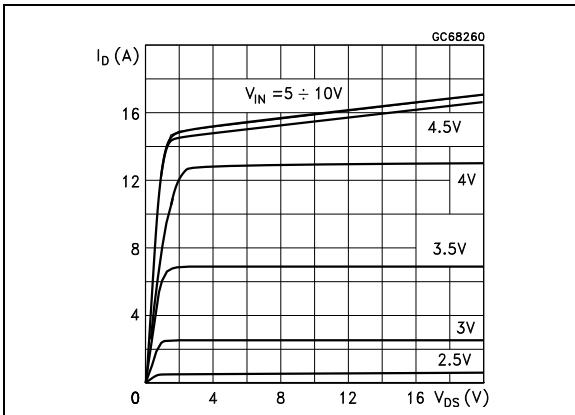

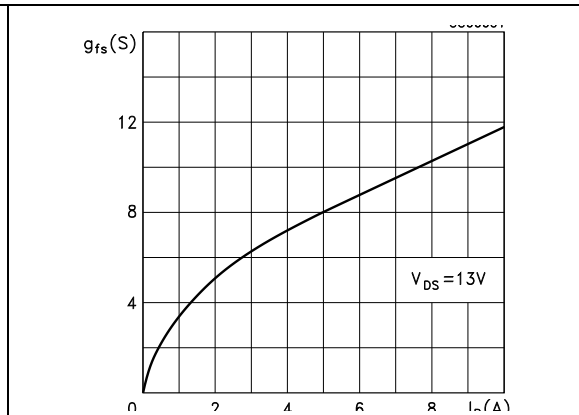**Figure 5.   Transconductance**

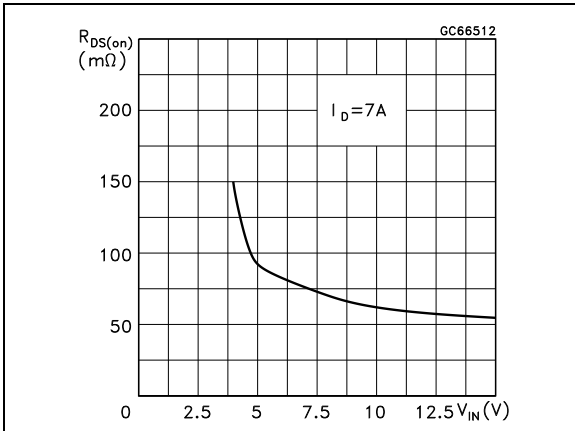**Figure 6.   Static drain-source on resistance vs input voltage**

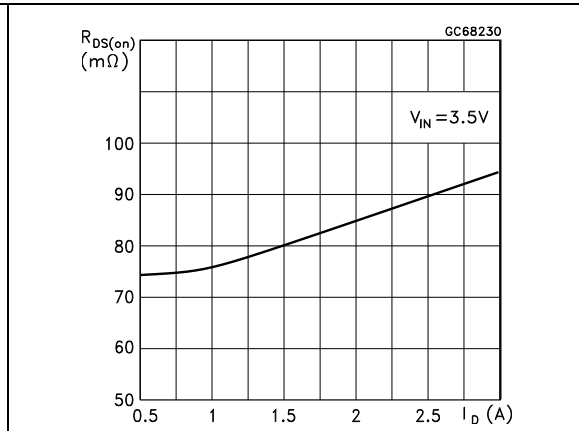**Figure 7.   Static drain-source on resistance (part 1/2)**

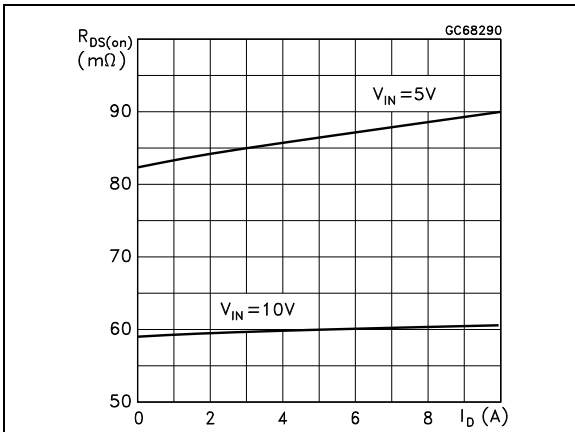**Figure 8.   Static drain-source on resistance (part 2/2)**
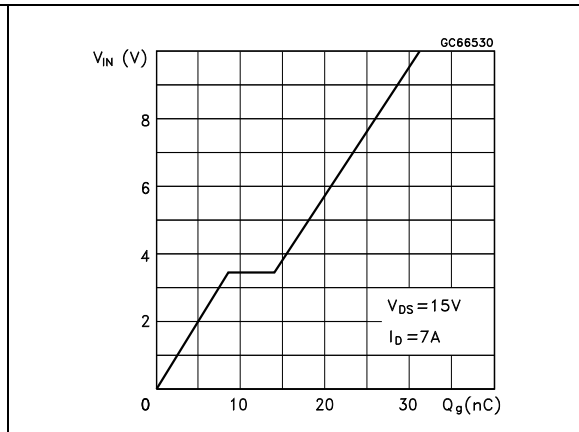

Figure 9.   Input charge vs input voltage
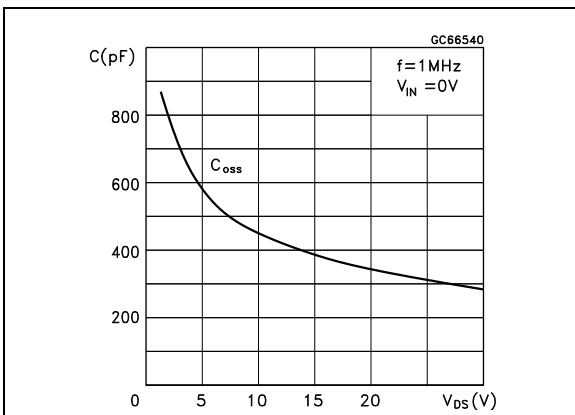

Figure 10.   Capacitance variations

Figure 11.   Normalized input threshold voltage vs temperature
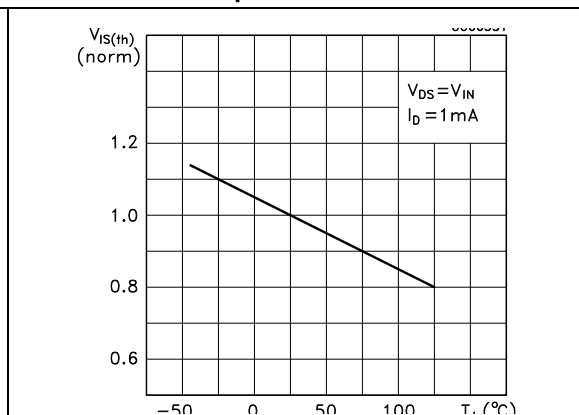
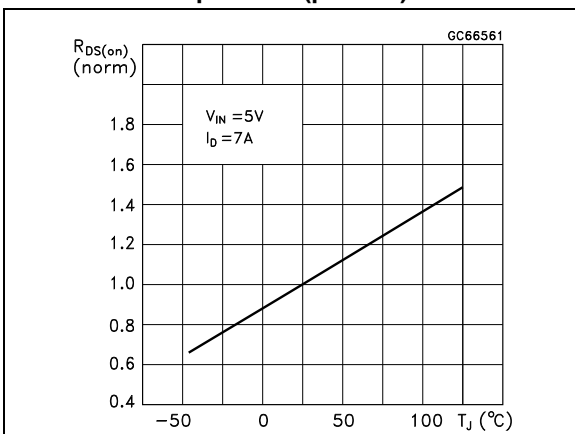**Figure 12.   Normalized on resistance vs temperature (part 1/2)**

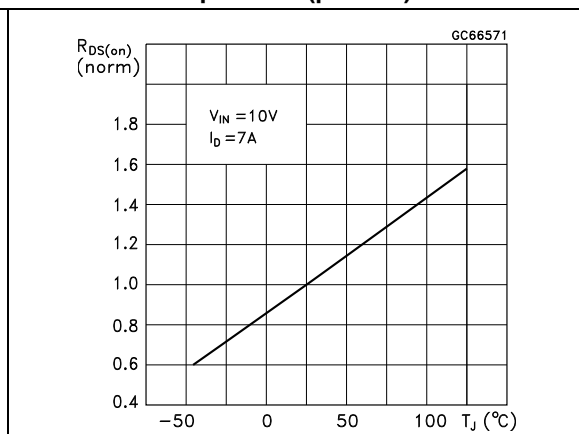**Figure 13.   Normalized on resistance vs temperature (part 2/2)**

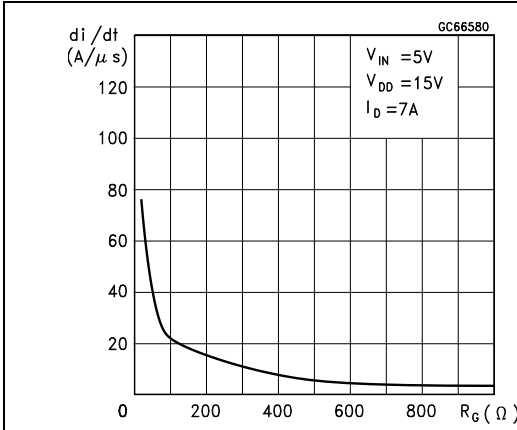**Figure 14. Turn-on current slope(part 1/2)**

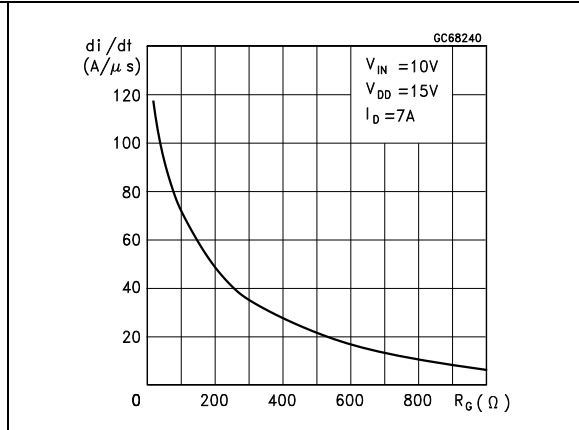**Figure 15. Turn-on current slope (part 2/2)**

Figure 16. Turn-off drain-source voltage slope (part 1/2)
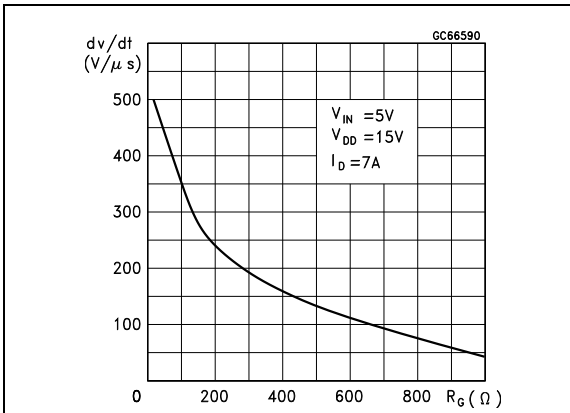

Figure 17. Turn-off drain-source voltage slope (part 2/2)
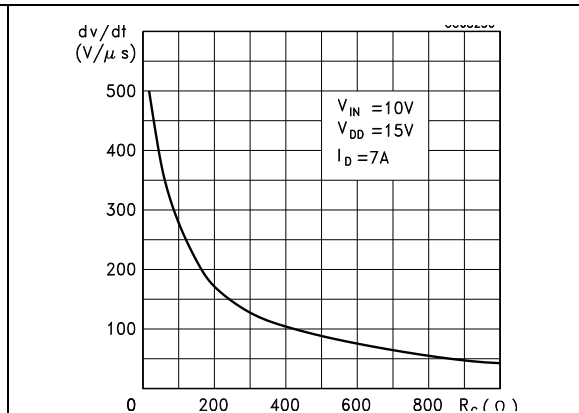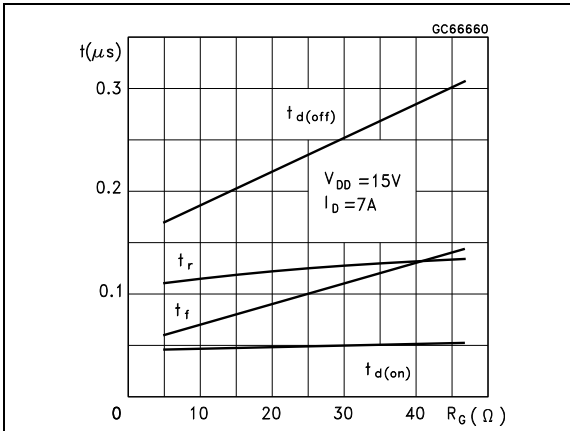

Figure 18. Switching time resistive load (part 1/3)
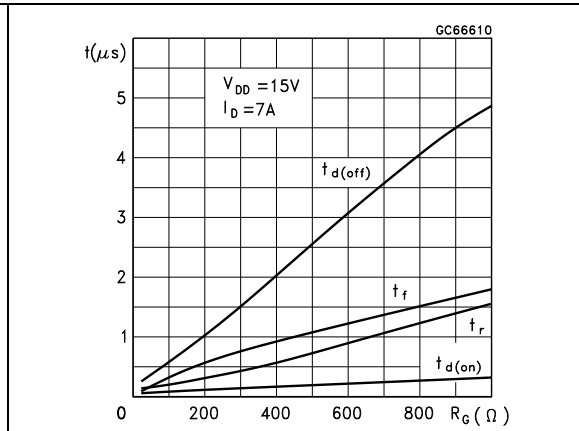

Figure 19. Switching time resistive load (part 2/3)

Figure 20.   Switching time resistive load (part 3/3)

GC66620

$V_{DD} = 15V$
$I_D = 7A$
$R_g = 4.7\Omega$

Figure 21.   Current limit vs junction temperature

GC66630

$V_{IN} = 10V$
$V_{DD} = 13V$
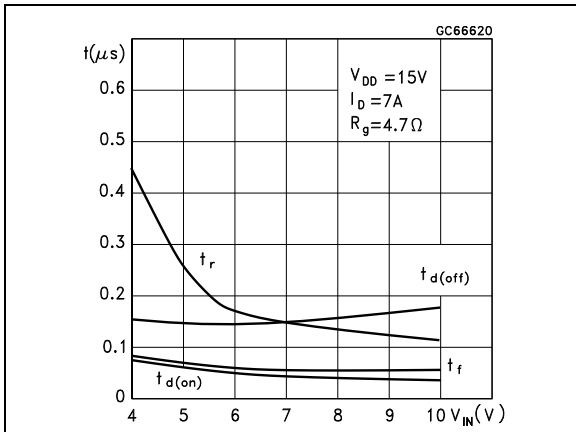
Figure 22.   Step response current limit

GC66640

$V_{IN} = 10V$
$R_G = 10\,\Omega$
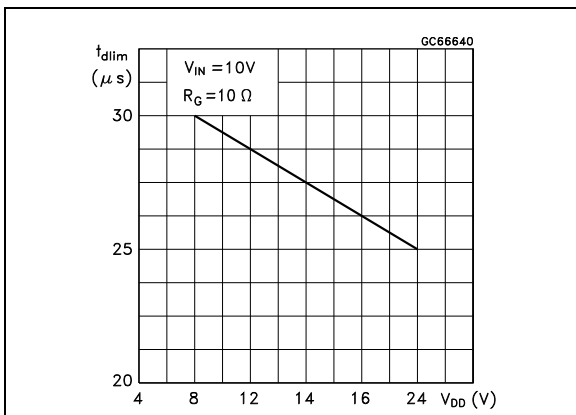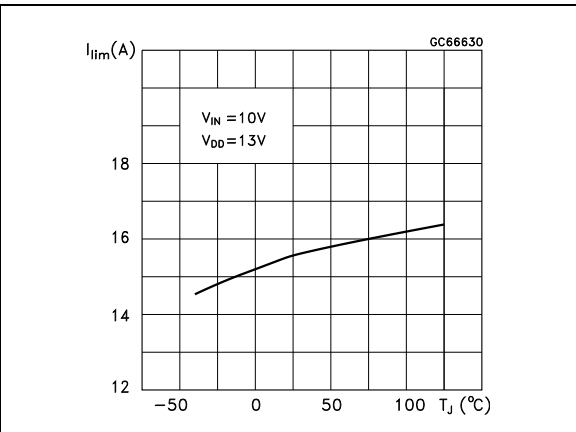
Figure 23.   Source drain diode forward characteristics

$V_{IN} = 0V$

Figure 24. Unclamped inductive load test circuits

Figure 25. Unclamped inductive waveforms

Figure 26. Switching times test circuits for resistive load

Figure 27. Input charge test circuit
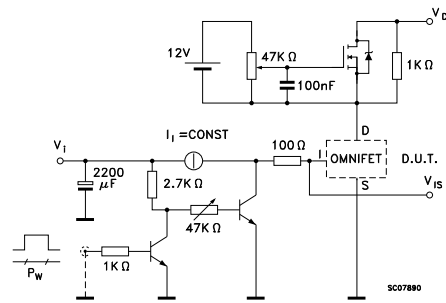
Figure 28. Test circuit for inductive load switching and diode recovery times
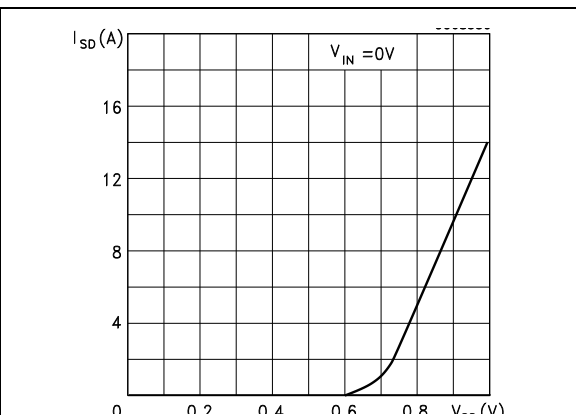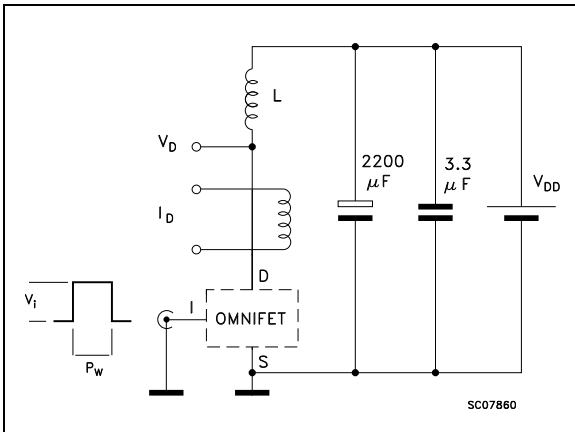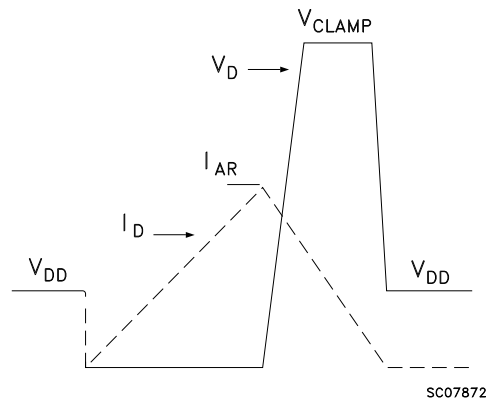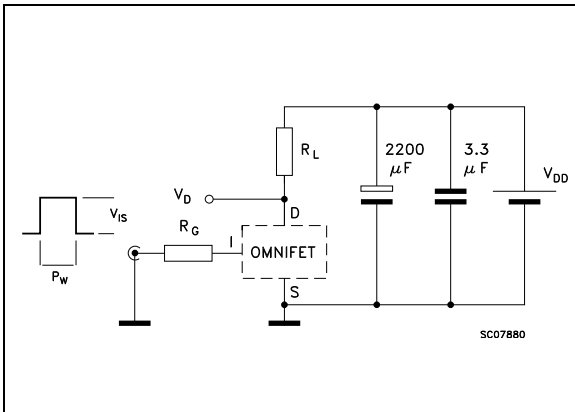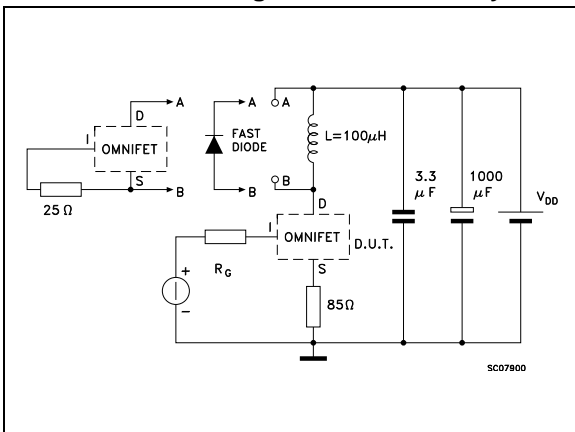

Figure 29. Waveforms
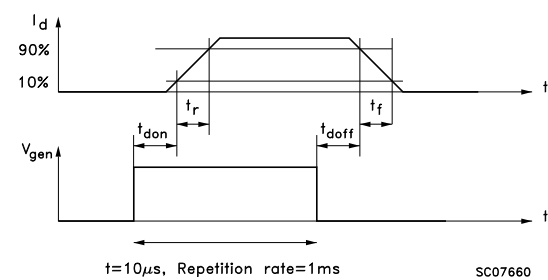
4   Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: *www.st.com*.

ECOPACK® is an ST trademark.

Figure 30.   TO-263 (D2PAK) mechanical data

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.3		4.6	0.169		0.181
A1	2.49		2.69	0.098		0.106
B	0.7		0.93	0.027		0.036
B2	1.25		1.4	0.049		0.055
C	0.45		0.6	0.017		0.023
C2	1.21		1.36	0.047		0.053
D	8.95		9.35	0.352		0.368
E	10		10.28	0.393		0.404
G	4.88		5.28	0.192		0.208
L	15		15.85	0.590		0.624
L2	1.27		1.4	0.050		0.055
L3	1.4		1.75	0.055		0.068

P011P6/C
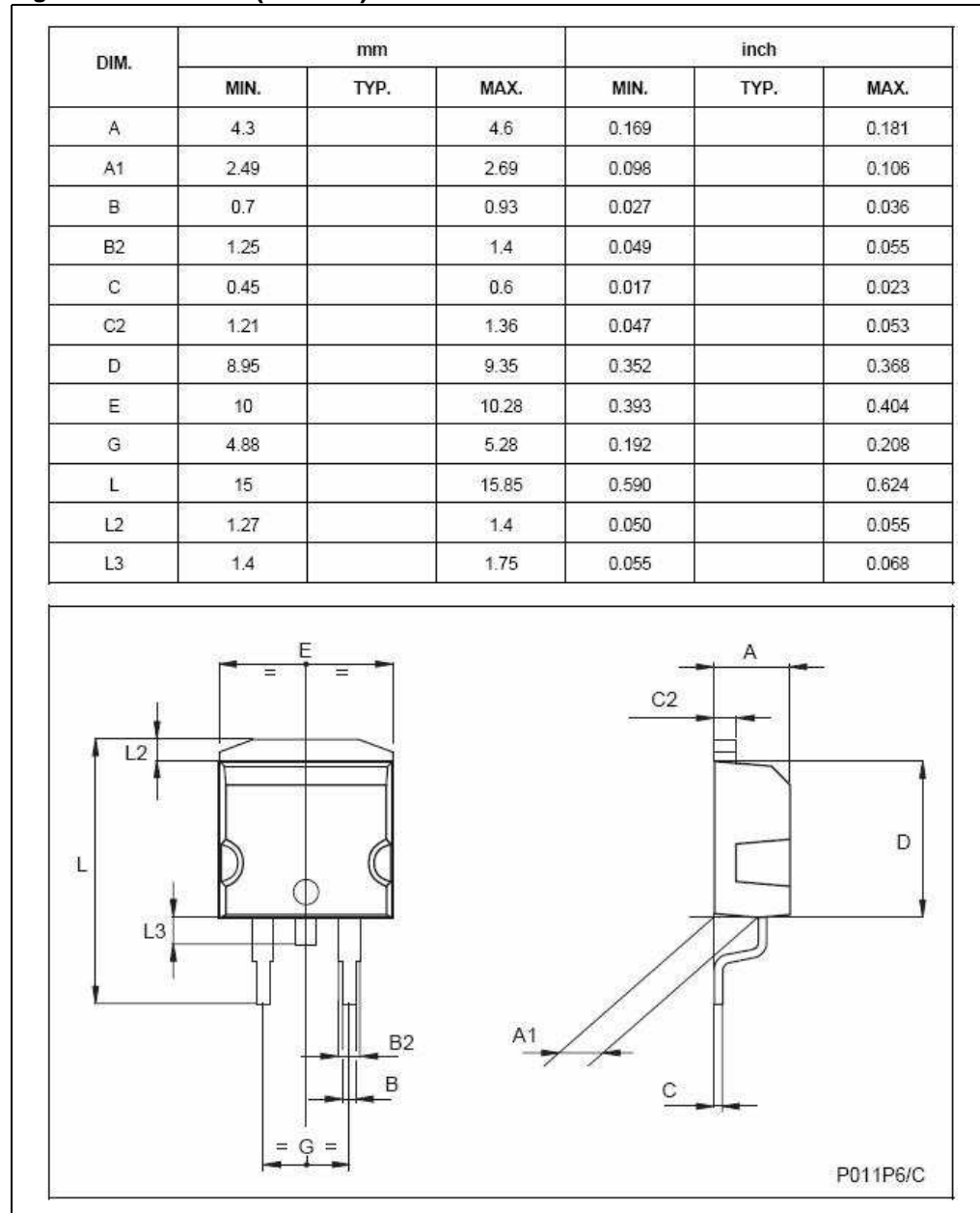
Figure 31.   SOT82-FM mechanical data

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	2.85		3.05	1.122		1.200
A1	1.47		1.67	0.578		0.657
b	0.40		0.60	0.157		0.236
b1	1.4		1.6	0.551		0.630
b2	1.3		1.5	0.511		0.590
c	0.45		0.6	0.177		0.236
D	10.5		10.9	4.133		4.291
e	2.2		2.8	0.866		1.102
E	7.45		7.75	2.933		3.051
L	15.5		15.9	6.102		6.260
L1	1.95		2.35	0.767		0.925

14/17
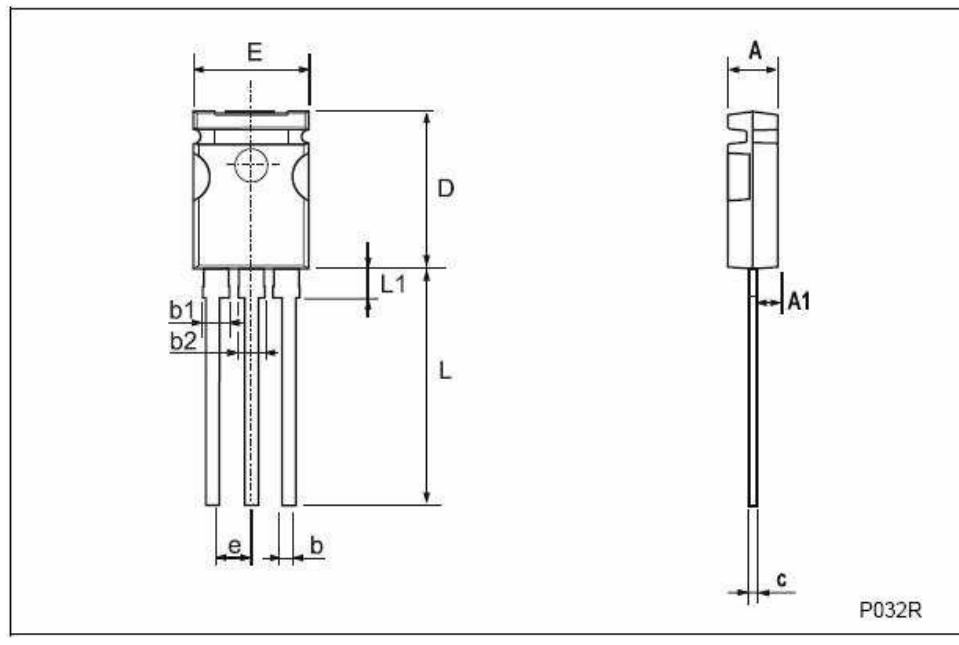
Figure 32.   PowerSO-10 mechanical data

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	3.35		3.65	0.132		0.144
A1	0.00		0.10	0.000		0.004
B	0.40		0.60	0.016		0.024
c	0.35		0.55	0.013		0.022
D	9.40		9.60	0.370		0.378
D1	7.40		7.60	0.291		0.300
E	9.30		9.50	0.366		0.374
E1	7.20		7.40	0.283		0.291
E2	7.20		7.60	0.283		0.300
E3	6.10		6.35	0.240		0.250
E4	5.90		6.10	0.232		0.240
e		1.27			0.050	
F	1.25		1.35	0.049		0.053
H	13.80		14.40	0.543		0.567
h		0.50			0.002	
L	1.20		1.80	0.047		0.071
q		1.70			0.067	
α	0°		8°			

0068039-C
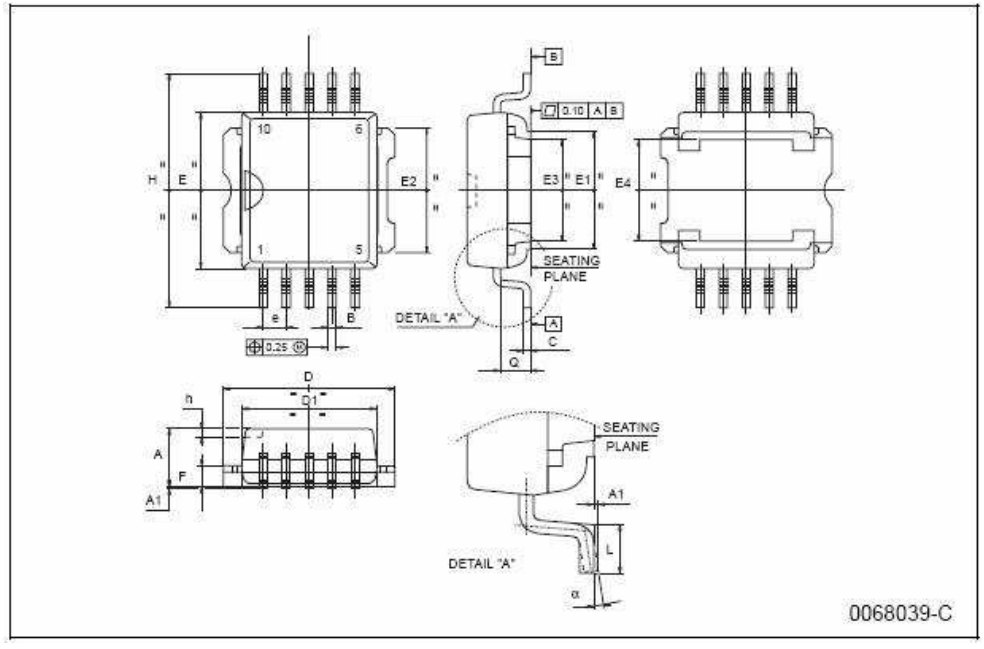
5 Revision history

Table 5. Document revision history

Date	Revision	Changes
20-Jan-1998	1	Initial release.
21-Jun-2004	5	Update.
08-Apr-2009	6	Document reformatted. Added *Table 1: Device summary on page 1*. Updated *Section 4: Package information on page 13*

Please Read Carefully:

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST's terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

UNLESS OTHERWISE SET FORTH IN ST'S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

UNLESS EXPRESSLY APPROVED IN WRITING BY AN AUTHORIZED ST REPRESENTATIVE, ST PRODUCTS ARE NOT RECOMMENDED, AUTHORIZED OR WARRANTED FOR USE IN MILITARY, AIR CRAFT, SPACE, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS, NOR IN PRODUCTS OR SYSTEMS WHERE FAILURE OR MALFUNCTION MAY RESULT IN PERSONAL INJURY, DEATH, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE. ST PRODUCTS WHICH ARE NOT SPECIFIED AS "AUTOMOTIVE GRADE" MAY ONLY BE USED IN AUTOMOTIVE APPLICATIONS AT USER'S OWN RISK.

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

www.st.com