



## STP60NH2LL

N-channel 24V - 0.010Ω - 40A TO-220  
STripFET™ Power MOSFET

### General features

Type	V <sub>DSS</sub> (@T <sub>jmax</sub> )	R <sub>DS(on)</sub>	I <sub>D</sub>
STP60NH2LL	24V	<0.011Ω	40A <sup>(1)</sup>

1. Value limited by wire bonding

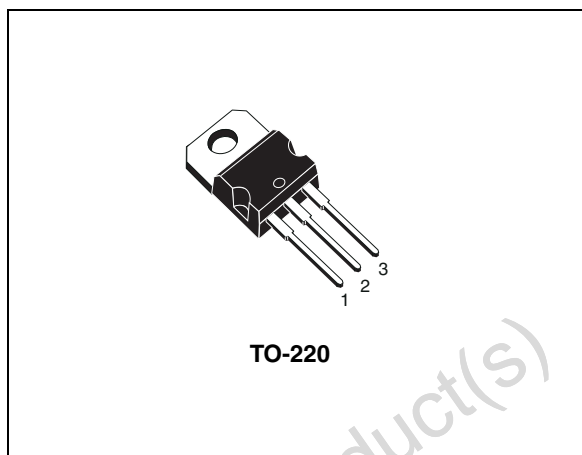
- R<sub>DS(ON)</sub> \* Qg industry's benchmark
- Conduction losses reduced
- Switching losses reduced
- Low threshold device

### Description

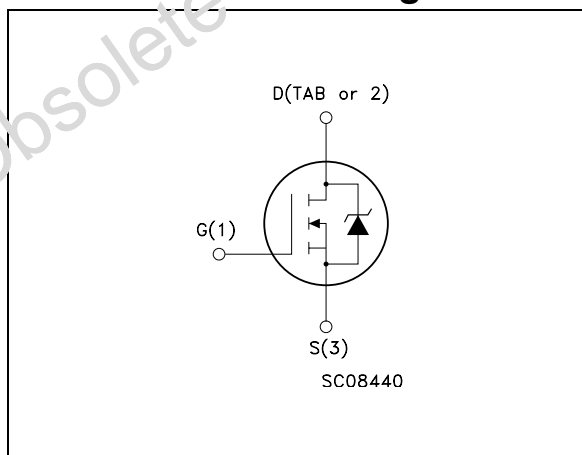
The STP60NH2LL utilizes the latest advanced design rules of ST's proprietary STripFET™ technology. This is suitable for the most demanding DC-DC converter application where high efficiency is to be achieved.

### Applications

- Switching application



### Internal schematic diagram



### Order codes

Part number	Marking	Package	Packaging
STP60NH2LL	P60NH2LL	TO-220	Tube

# Contents

<b>1</b>	<b>Electrical ratings</b> .....	<b>3</b>
<b>2</b>	<b>Electrical characteristics</b> .....	<b>4</b>
	2.1 Electrical characteristics (curves) .....	6
<b>3</b>	<b>Test circuit</b> .....	<b>8</b>
<b>4</b>	<b>Appendix A</b> .....	<b>9</b>
<b>5</b>	<b>Package mechanical data</b> .....	<b>11</b>
<b>6</b>	<b>Revision history</b> .....	<b>13</b>

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# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_{\text{spike}}^{(1)}$	Drain-source Voltage Rating	30	V
$V_{\text{DS}}$	Drain-source voltage ( $V_{\text{GS}} = 0$ )	24	V
$V_{\text{GS}}$	Gate-source voltage	$\pm 18$	V
$I_{\text{D}}$	Drain current (continuous) at $T_{\text{C}} = 25^{\circ}\text{C}$	40	A
$I_{\text{D}}$	Drain current (continuous) at $T_{\text{C}} = 100^{\circ}\text{C}$	28	A
$I_{\text{DM}}^{(2)}$	Drain current (pulsed)	160	A
$P_{\text{TOT}}$	Total dissipation at $T_{\text{C}} = 25^{\circ}\text{C}$	60	W
	Derating factor	0.4	W/ $^{\circ}\text{C}$
$E_{\text{AS}}^{(3)}$	Single pulse avalanche energy	600	mJ
$T_{\text{stg}}$	Storage temperature	-55 to 175	$^{\circ}\text{C}$
$T_{\text{j}}$	Max. operating junction temperature		

1. Guaranteed when external  $R_{\text{g}} = 4.7 \Omega$  and  $t_{\text{f}} < t_{\text{fmax}}$
2. Pulse width limited by safe operating area
3. Starting  $T_{\text{j}} = 25^{\circ}\text{C}$ ,  $I_{\text{D}} = 20\text{A}$ ,  $V_{\text{DD}} = 15\text{V}$

**Table 2. Thermal data**

$R_{\text{thj-case}}$	Thermal resistance junction-case Max	2.5	$^{\circ}\text{C}/\text{W}$
$R_{\text{thj-a}}$	Thermal resistance junction-ambient Max	100	$^{\circ}\text{C}/\text{W}$
$T_{\text{l}}$	Maximum lead temperature for soldering purpose	275	$^{\circ}\text{C}$

## 2 Electrical characteristics

( $T_{CASE}=25^{\circ}C$  unless otherwise specified)

**Table 3. On/off states**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	$I_D = 25 \text{ mA}, V_{GS} = 0$	24			V
$I_{DSS}$	Zero gate voltage drain current ( $V_{GS} = 0$ )	$V_{DS} = \text{Max rating},$ $V_{DS} = \text{Max rating}$ $T_C = 125^{\circ}C$			1 10	$\mu A$ $\mu A$
$I_{GSS}$	Gate body leakage current ( $V_{DS} = 0$ )	$V_{GS} = \pm 16V$			$\pm 100$	nA
$V_{GS(th)}$	Gate threshold voltage	$V_{DS} = V_{GS}, I_D = 250\mu A$	1			V
$R_{DS(on)}$	Static drain-source on resistance	$V_{GS} = 10V, I_D = 20A$ $V_{GS} = 4.5V, I_D = 20A$		0.010 0.012	0.011 0.0135	$\Omega$

**Table 4. Dynamic**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$g_{fs}^{(1)}$	Forward transconductance	$V_{DS} = 10V, I_D = 10A$		18		S
$C_{iss}$ $C_{oss}$ $C_{rss}$	Input capacitance Output capacitance Reverse transfer capacitance	$V_{DS} = 25V, f = 1 \text{ MHz},$ $V_{GS} = 0$		990 385 40		pF pF pF
$t_{d(on)}$ $t_r$ $t_{d(off)}$ $t_f$	Turn-on delay time rise time Turn-off delay time fall time	$V_{DD} = 10 \text{ V}, I_D = 20 \text{ A}$ $R_G = 4.7 \Omega, V_{GS} = 4.5 \text{ V}$ (see Figure 13)		5 56 13 10		ns ns ns ns
$Q_g$ $Q_{gs}$ $Q_{gd}$	Total gate charge Gate-source charge Gate-drain charge	$0.44 \leq V_{DD} = 10V, I_D = 40A$ $V_{GS} = 4.5V$		8.7 4.2 2.4	27	nC nC nC
$Q_{oss}^{(2)}$	Output charge	$V_{DS} = 16 \text{ V}, V_{GS} = 0 \text{ V}$		7.6		nC
$R_g$	Gate input resistance	$f = 1 \text{ MHz}$ Gate DC Bias = 0 test signal level = 20mV open drain		1.3		$\Omega$

1. Pulsed: pulse duration = 300 $\mu s$ , duty cycle 1.5%

2.  $Q_{oss} = C_{oss} \cdot \Delta V_{in}$ ,  $C_{oss} = C_{gd} + C_{ds}$ . See [Chapter 4: Appendix A](#)

**Table 5. Source drain diode**

Symbol	Parameter	Test conditions	Min.	Typ.	Max	Unit
$I_{SD}$	Source-drain current				40	A
$I_{SDM}$	Source-drain current (pulsed)				160	A
$V_{SD}^{(1)}$	Forward on voltage	$I_{SD}=20A, V_{GS}=0$			1.3	V
$t_{rr}$	Reverse recovery time	$I_{SD}=40A,$ $di/dt = 100A/\mu s,$ $V_{DD}=15V, T_j=150^\circ C$ (see Figure 15)		32.5		ns
$Q_{rr}$	Reverse recovery charge			28		$\mu C$
$I_{RRM}$	Reverse recovery current			1.7		A

1. Pulsed: pulse duration=300 $\mu s$ , duty cycle 1.5%

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## 2.1 Electrical characteristics (curves)

Figure 1. Safe operating area

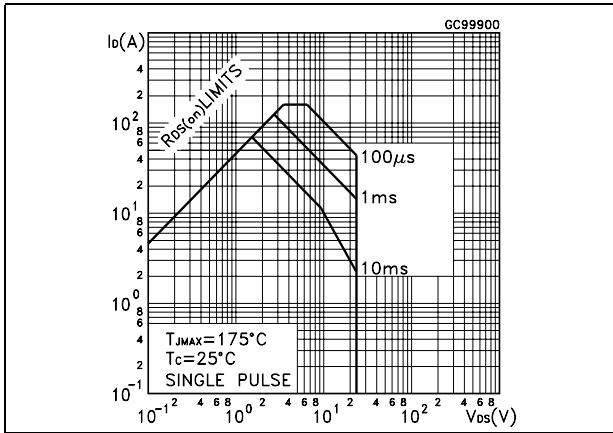


Figure 2. Thermal impedance

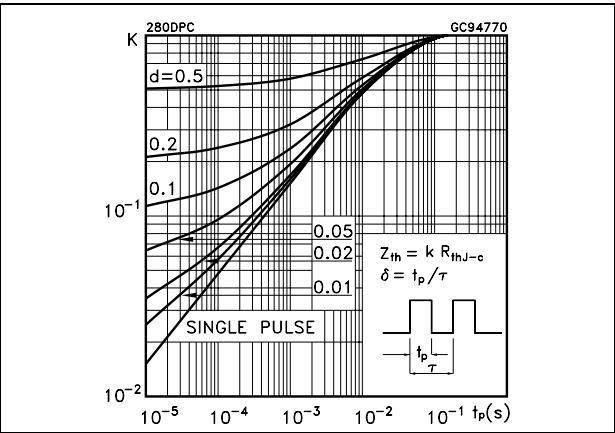


Figure 3. Output characteristics

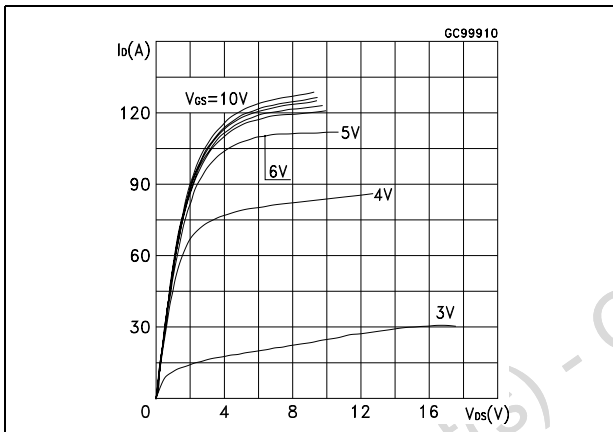


Figure 4. Transfer characteristics

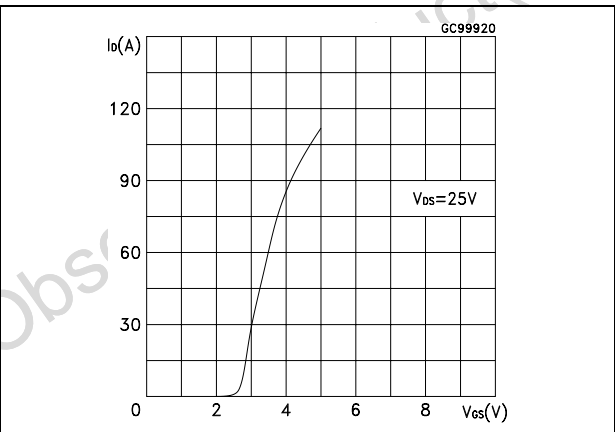


Figure 5. Transconductance

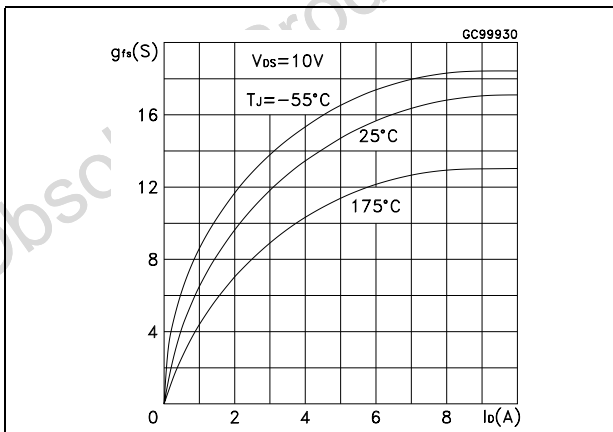


Figure 6. Static drain-source on resistance

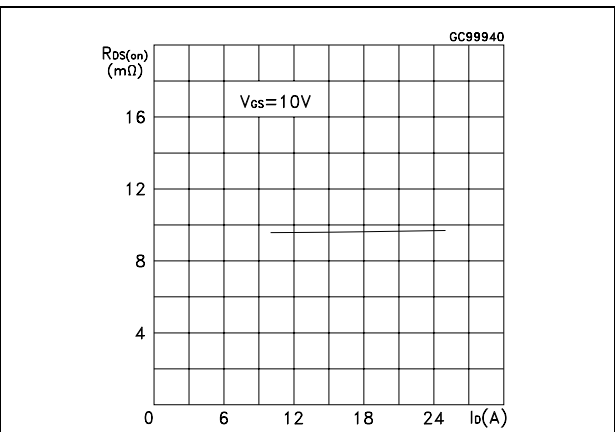


Figure 7. Gate charge vs. gate-source voltage Figure 8. Capacitance variations

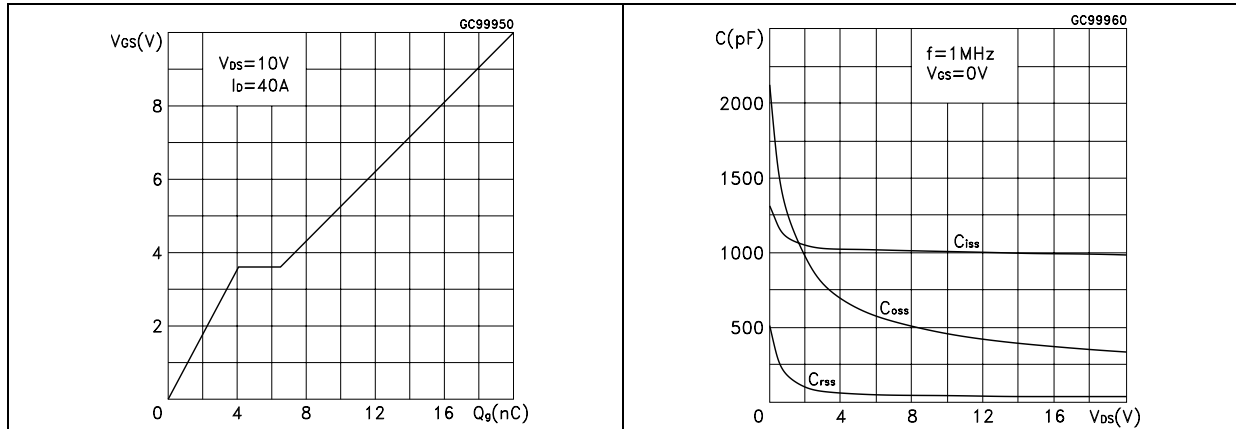


Figure 9. Normalized gate threshold voltage vs. temperature Figure 10. Normalized on resistance vs. temperature

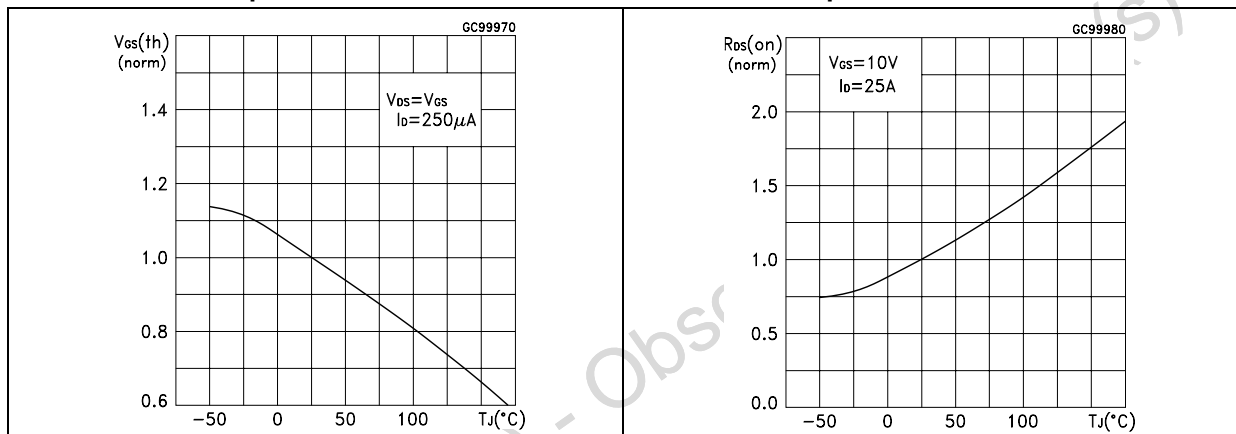
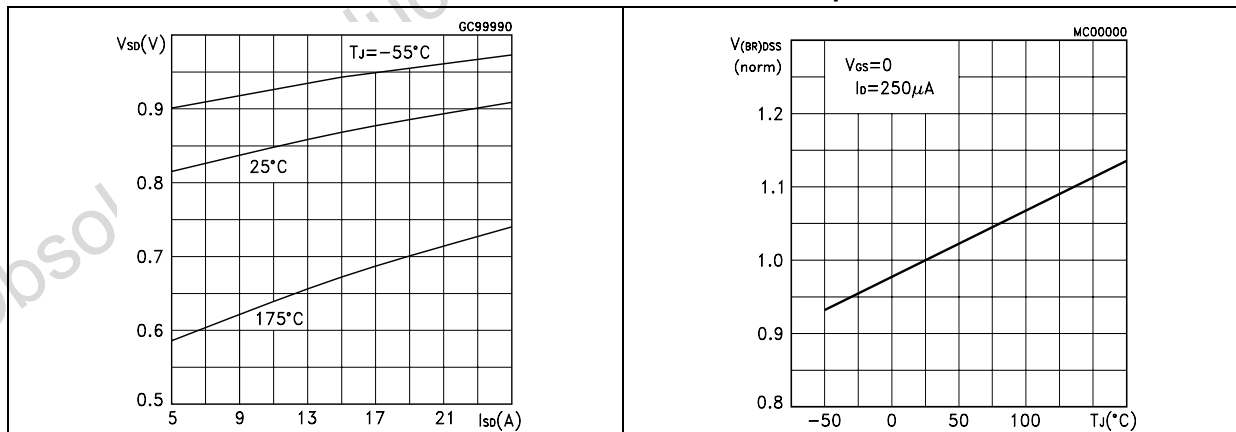


Figure 11. Source-drain diode forward characteristics Figure 12. Normalized Breakdown Voltage vs. Temperature



### 3 Test circuit

Figure 13. Switching times test circuit for resistive load

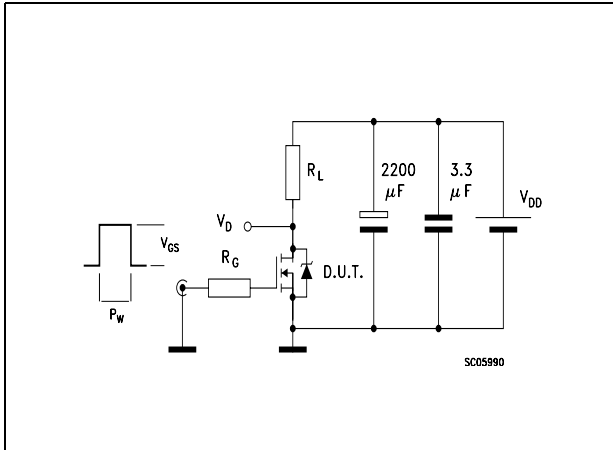


Figure 14. Gate charge test circuit

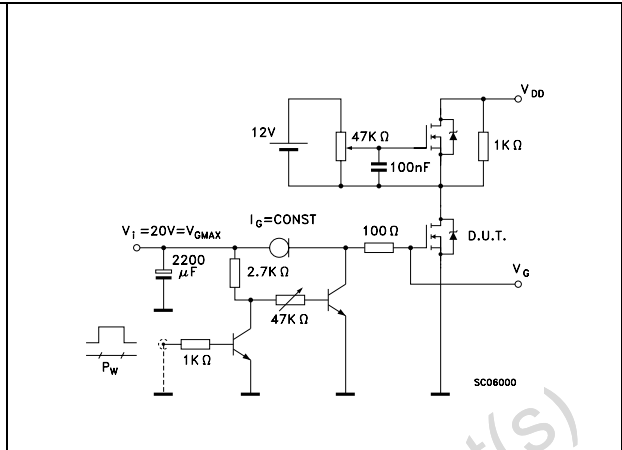


Figure 15. Test circuit for inductive load switching and diode recovery times

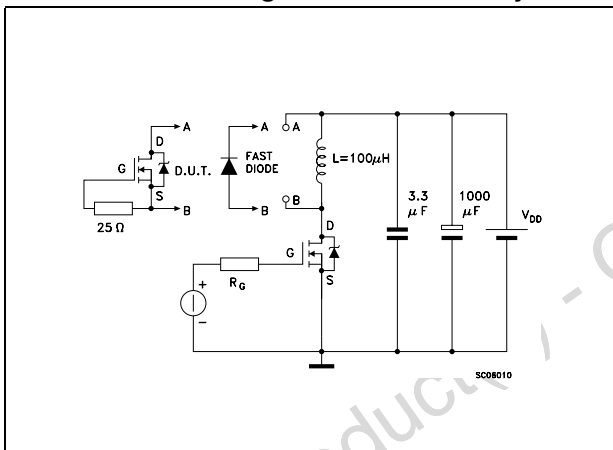


Figure 16. Unclamped Inductive load test circuit

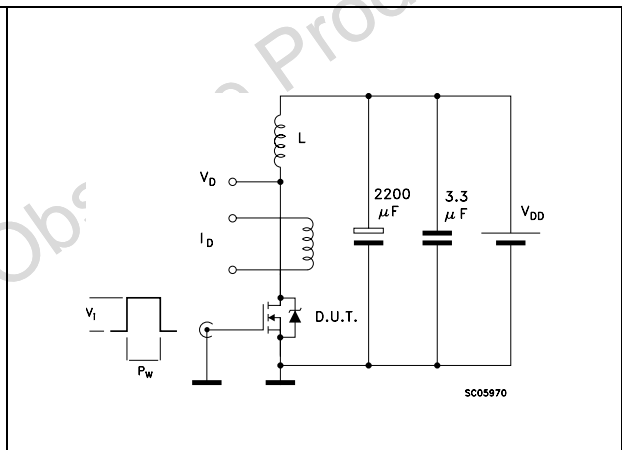


Figure 17. Unclamped inductive waveform

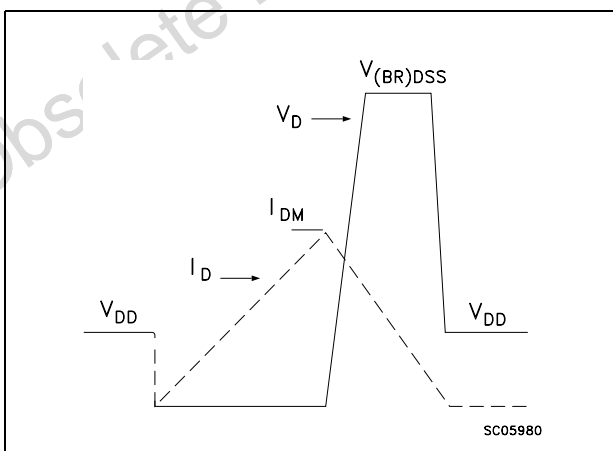
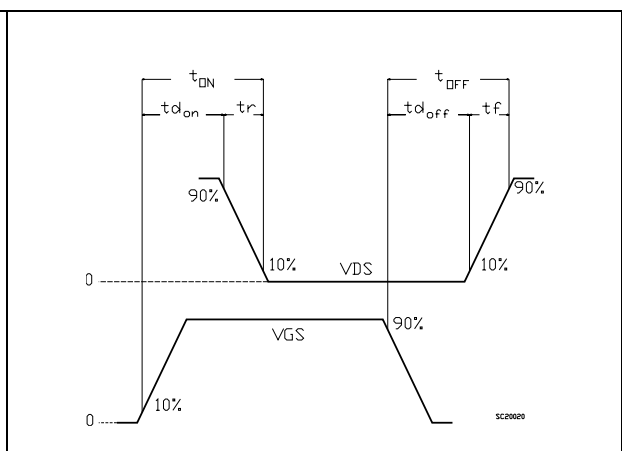


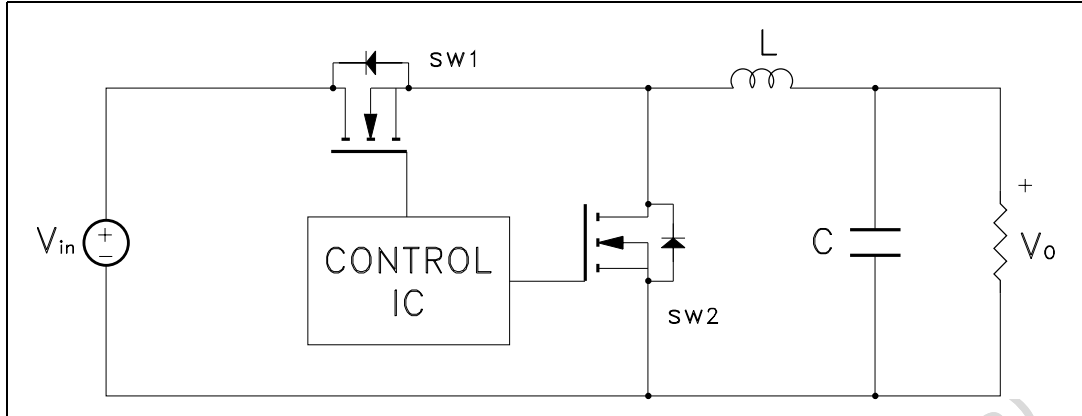
Figure 18. Switching time waveform





## 4 Appendix A

Figure 19. Buck converter: power losses estimation



The power losses associated with the FETs in a synchronous buck converter can be estimated using the equations shown in the table below. The formulas give a good approximation, for the sake of performance comparison, of how different pairs of devices affect the converter efficiency. However a very important parameter, the working temperature, is not considered. The real device behavior is really dependent on how the heat generated inside the devices is removed to allow for a safer working junction temperature.

- The low side (SW2) device requires:
  - Very low  $R_{DS(on)}$  to reduce conduction losses
  - Small  $Q_{gl}$  to reduce the gate charge losses
  - Small  $C_{oss}$  to reduce losses due to output capacitance
  - Small  $Q_{rr}$  to reduce losses on SW1 during its turn-on
  - The  $C_{gd}/C_{gs}$  ratio lower than  $V_{th}/V_{gg}$  ratio especially with low drain to source voltage to avoid the cross conduction phenomenon;
- The high side (SW1) device requires:
  - Small  $R_g$  and  $L_s$  to allow higher gate current peak and to limit the voltage feedback on the gate
  - Small  $Q_g$  to have a faster commutation and to reduce gate charge losses
  - Low  $R_{DS(on)}$  to reduce the conduction losses.

**Table 6. Power losses calculation**

		High side switching (SW1)	Low side switch (SW2)
Pconduction		$R_{DS(on)SW1} * I_L^2 * \delta$	$R_{DS(on)SW2} * I_L^2 * (1 - \delta)$
Pswitching		$V_{in} * (Q_{gsth(SW1)} + Q_{gd(SW1)}) * f * \frac{I_L}{I_g}$	Zero Voltage Switching
Pdiode	Recovery (1)	Not applicable	$V_{in} * Q_{rr(SW2)} * f$
	Conduction	Not applicable	$V_{f(SW2)} * I_L * t_{deadtime} * f$
Pgate(Q <sub>G</sub> )		$Q_{g(SW1)} * V_{gg} * f$	$Q_{gls(SW2)} * V_{gg} * f$
P <sub>Qoss</sub>		$\frac{V_{in} * Q_{oss(SW1)} * f}{2}$	$\frac{V_{in} * Q_{oss(SW2)} * f}{2}$

1. Dissipated by SW1 during turn-on

**Table 7. Parameters meaning**

Parameter	Meaning
d	Duty-cycle
Q <sub>gsth</sub>	Post threshold gate charge
Q <sub>gls</sub>	Third quadrant gate charge
Pconduction	On state losses
Pswitching	On-off transition losses
Pdiode	Conduction and reverse recovery diode losses
Pgate	Gate drive losses
P <sub>Qoss</sub>	Output capacitance losses

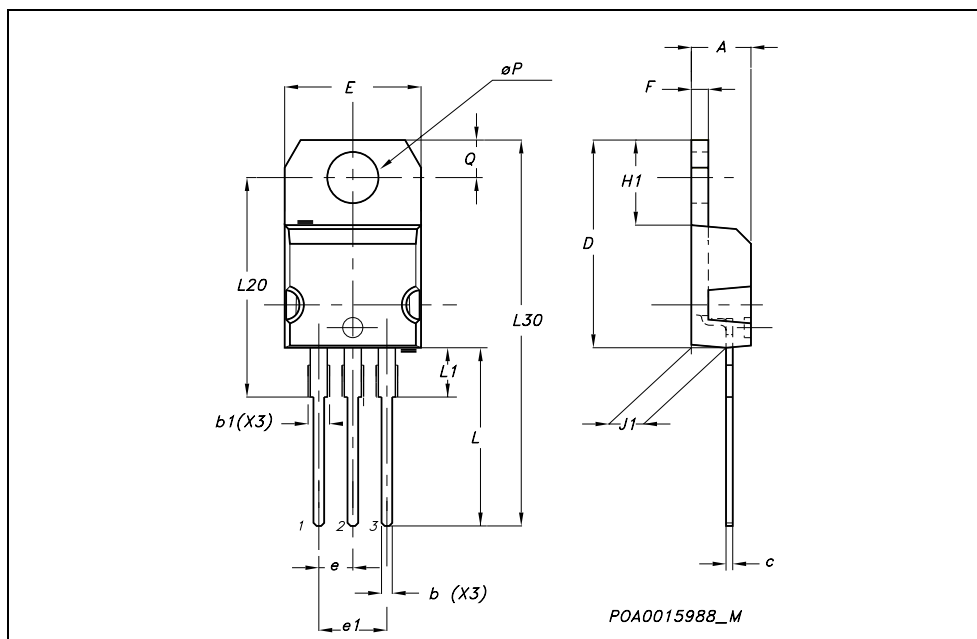
## 5 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com)

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**TO-220 MECHANICAL DATA**

DIM.	mm.			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.40		4.60	0.173		0.181
b	0.61		0.88	0.024		0.034
b1	1.15		1.70	0.045		0.066
c	0.49		0.70	0.019		0.027
D	15.25		15.75	0.60		0.620
E	10		10.40	0.393		0.409
e	2.40		2.70	0.094		0.106
e1	4.95		5.15	0.194		0.202
F	1.23		1.32	0.048		0.052
H1	6.20		6.60	0.244		0.256
J1	2.40		2.72	0.094		0.107
L	13		14	0.511		0.551
L1	3.50		3.93	0.137		0.154
L20		16.40			0.645	
L30		28.90			1.137	
øP	3.75		3.85	0.147		0.151
Q	2.65		2.95	0.104		0.116



Obsole

## 6 Revision history

**Table 8. Revision history**

Date	Revision	Changes
31-May-2005	1	First release.
06-Sep-2006	2	The document has been reformatted.
31-Jan-2007	3	Typo mistake on <a href="#">Table 1</a> .

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