



# STD38NH02L STD38NH02L-1

N-channel 24V - 0.011 $\Omega$  - 38A - DPAK/IPAK  
STripFET™ III Power MOSFET

## General features

| Type         | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> |
|--------------|------------------|---------------------|----------------|
| STD38NH02L-1 | 24V              | <0.0135 $\Omega$    | 38A            |
| STD38NH02L   | 24V              | <0.0135 $\Omega$    | 38A            |

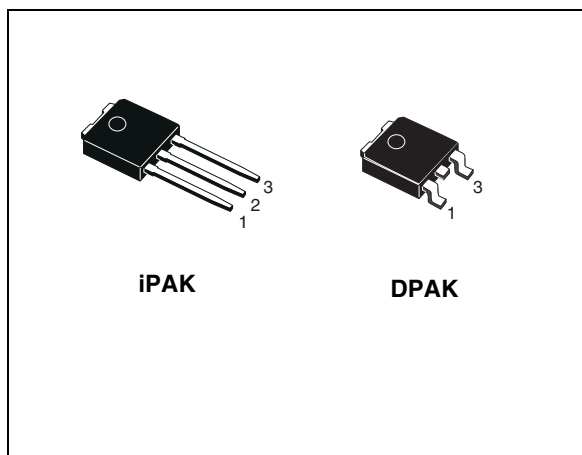
- Logic level device
- R<sub>DS(ON)</sub> \* Q<sub>G</sub> Industry's benchmark
- Conduction losses reduced
- Switching losses reduced
- Low threshold drive

## Description

This device 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

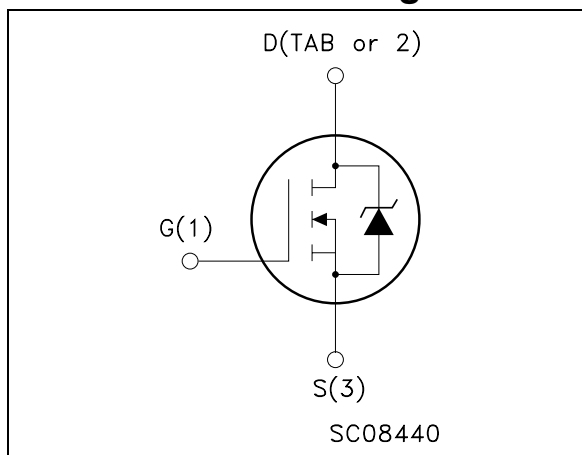
- Switching application



## Order codes

| Part number  | Marking  | Package | Packaging   |
|--------------|----------|---------|-------------|
| STD38NH02L-1 | D38NH02L | IPAK    | Tube        |
| STD38NH02LT4 | D38NH02L | DPAK    | Tape & reel |

## Internal schematic diagram



# Contents

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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                     |
| $V_{\text{DGR}}$         | Drain-gate voltage ( $R_{\text{GS}} = 20 \text{ k}\Omega$ )        | 24         | V                     |
| $V_{\text{GS}}$          | Gate- source voltage   | $\pm 20$   | V                     |
| $I_{\text{D}}$           | Drain current (continuous) at $T_{\text{C}} = 25^{\circ}\text{C}$  | 38         | A                     |
| $I_{\text{D}}$           | Drain current (continuous) at $T_{\text{C}} = 100^{\circ}\text{C}$ | 27         | A                     |
| $I_{\text{DM}}^{(2)}$    | Drain current (pulsed)   | 152        | A                     |
| $P_{\text{tot}}$         | Total dissipation at $T_{\text{C}} = 25^{\circ}\text{C}$           | 40         | W                     |
|                          | Derating Factor  | 0.27       | W/ $^{\circ}\text{C}$ |
| $E_{\text{AS}}^{(3)}$    | Single pulse avalanche energy                                      | 250        | 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  $T_{\text{j}} = 25^{\circ}\text{C}$ ,  $I_{\text{D}} = 19\text{A}$ ,  $V_{\text{DD}} = 18\text{V}$

**Table 2. Thermal data**

|                       |  |      |                             |
|-----------------------|--|------|-----------------------------|
| $R_{\text{thj-case}}$ | Thermal resistance junction-case max           | 3.75 | $^{\circ}\text{C}/\text{W}$ |
| $R_{\text{thj-amb}}$  | Thermal resistance junction-ambient max        | 100  | $^{\circ}\text{C}/\text{W}$ |
| $T_{\text{j}}$        | 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                   | $I_D = 25mA, V_{GS} = 0$                               | 24   |                |                 | V                    |
| $I_{DSS}$     | Zero gate voltage drain current ( $V_{GS} = 0$ ) | $V_{DS} = 20V$<br>$V_{DS} = 20V, T_C = 125^{\circ}C$   |      |                | 1<br>10         | $\mu A$<br>$\mu A$   |
| $I_{GSS}$     | Gate-body leakage current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20V$                                     |      |                | $\pm 100$       | nA                   |
| $V_{GS(th)}$  | Gate threshold voltage                           | $V_{DS} = V_{GS}, I_D = 250\mu A$                      | 1    | 1.8            | 2.5             | V                    |
| $R_{DS(on)}$  | Static drain-source on resistance                | $V_{GS} = 10V, I_D = 19A$<br>$V_{GS} = 5V, I_D = 9.5A$ |      | 0.011<br>0.015 | 0.0135<br>0.025 | $\Omega$<br>$\Omega$ |

**Table 4. Dynamic**

| Symbol  | Parameter   | Test conditions  | Min. | Typ.                | Max. | Unit                 |
|---|---|--|------|---------------------|------|----------------------|
| $g_{fs}^{(1)}$                                | Forward transconductance  | $V_{DS} = 10V, I_D = 19A$  |      | 19                  |      | S                    |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$           | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | $V_{DS} = 25V, f = 1MHz,$<br>$V_{GS} = 0$  |      | 1070<br>305<br>45   |      | pF<br>pF<br>pF       |
| $R_G$   | Gate Input Resistance   | $f = 1 MHz$ Gate<br>DC Bias = 0 Test Signal<br>Level = 20 mV Open<br>Drain   |      | 1                   |      | $\Omega$             |
| $t_{d(on)}$<br>$t_r$<br>$t_{d(off)}$<br>$t_f$ | Turn-on delay time<br>Rise time<br>Turn-off delay time<br>Fall time     | $V_{DD} = 10V, I_D = 19A$<br>$R_G = 4.7\Omega, V_{GS} = 10V$<br>(see <a href="#">Figure 13</a> )                     |      | 7<br>62<br>25<br>12 |      | ns<br>ns<br>ns<br>ns |
| $Q_g$<br>$Q_{gs}$<br>$Q_{gd}$                 | Total gate charge<br>Gate-source charge<br>Gate-drain charge            | $0.44V \leq V_{DD} \leq 10V,$<br>$I_D = 38A,$<br>$V_{GS} = 10V, R_G = 4.7\Omega$<br>(see <a href="#">Figure 14</a> ) |      | 18<br>4<br>2.5      | 24   | nC<br>nC<br>nC       |
| $Q_{oss}^{(2)}$                               | Output charge   | $V_{DS} = 16 V, V_{GS} = 0 V$  |      | 6.5                 |      | nC                   |

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          |
|-----------------------------------|--|--|------|-----------------|-----------|---------------|
| $I_{SD}$<br>$I_{SDM}^{(1)}$       | Source-drain current<br>Source-drain current<br>(pulsed)                     |  |      |                 | 38<br>152 | A<br>A        |
| $V_{SD}^{(2)}$                    | Forward on voltage   | $I_{SD} = 19A, V_{GS} = 0$   |      |                 | 1.3       | V             |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{RRM}$ | Reverse recovery time<br>Reverse recovery charge<br>Reverse recovery current | $I_{SD} = 38A, di/dt = 100A/\mu s,$<br>$V_{DD} = 18V, T_j = 150^\circ C$<br>(see <a href="#">Figure 15</a> ) |      | 27<br>22<br>1.6 |           | ns<br>nC<br>A |

1. Pulse width limited by safe operating area.
2. Pulsed: Pulse duration = 300  $\mu s$ , duty cycle 1.5 %

## 2.1 Electrical characteristics (curves)

Figure 1. Safe operating area

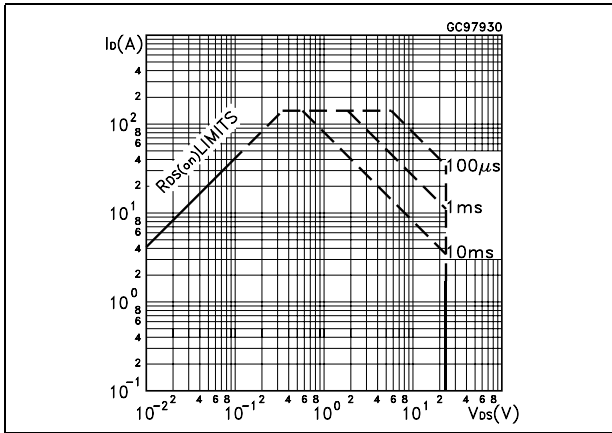


Figure 2. Thermal impedance

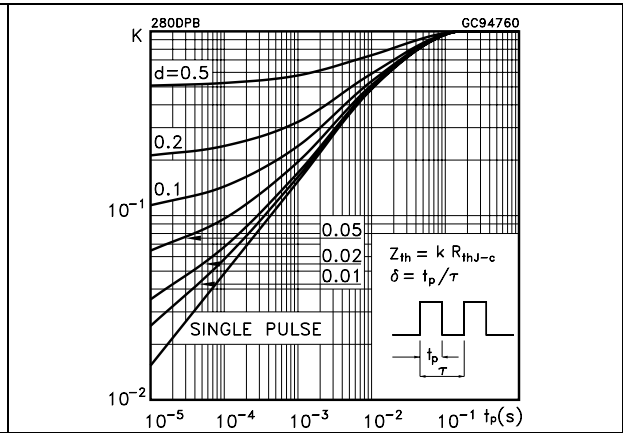


Figure 3. Output characteristics

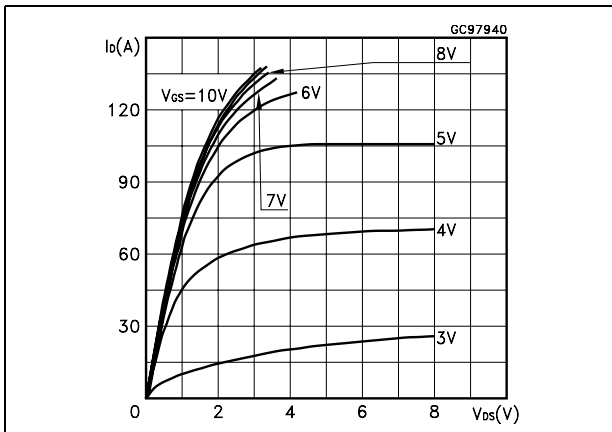


Figure 4. Transfer characteristics

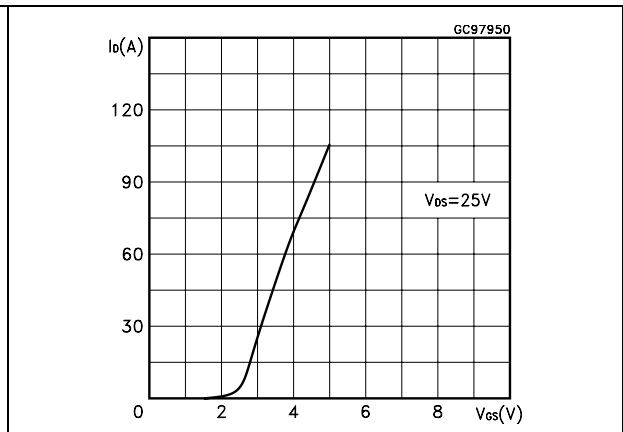


Figure 5. Transconductance

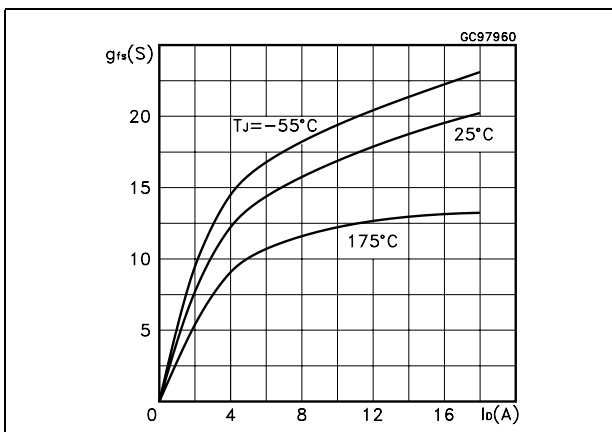


Figure 6. Static drain-source on resistance

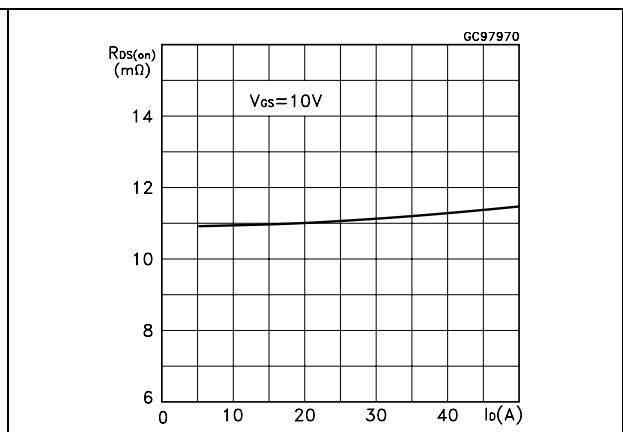


Figure 7. Gate charge vs gate-source voltage Figure 8. Capacitance variations

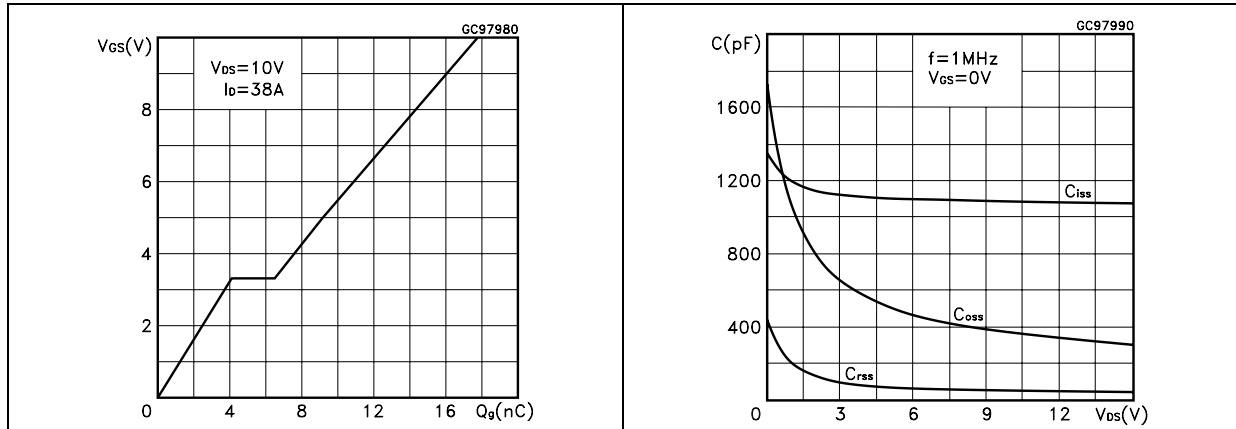


Figure 9. Normalized gate threshold voltage vs temperature Figure 10. Normalized on resistance vs temperature

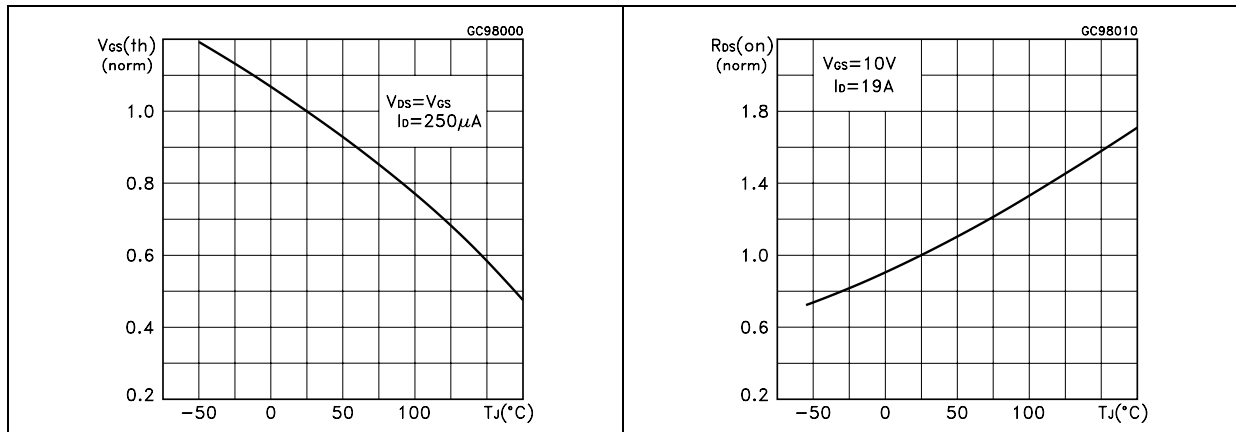
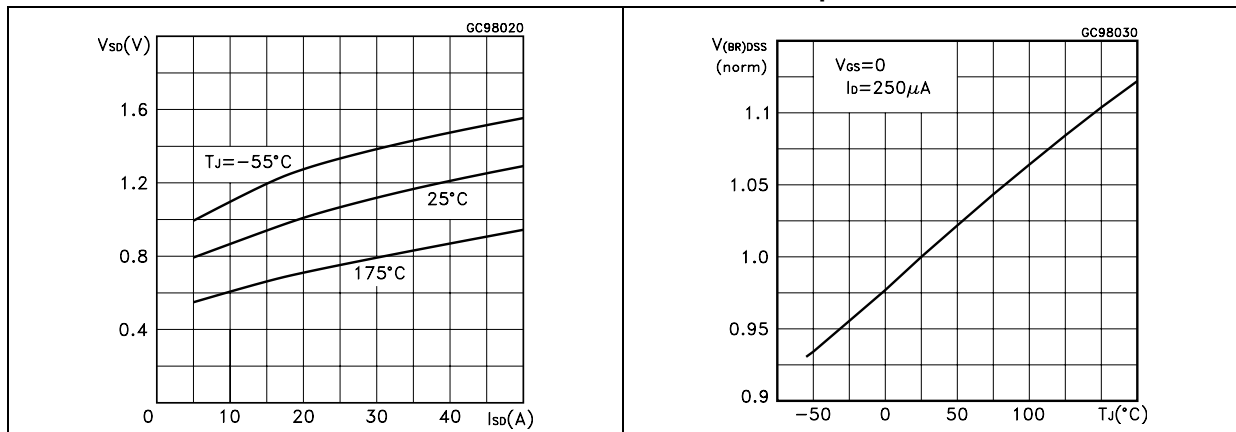


Figure 11. Source-drain diode forward characteristics Figure 12. Normalized breakdown voltage vs temperature



### 3 Test circuit

Figure 13. Switching times test circuit for resistive load

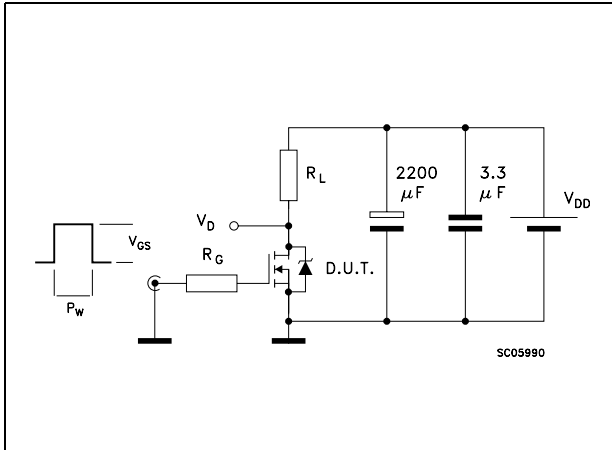


Figure 14. Gate charge test circuit

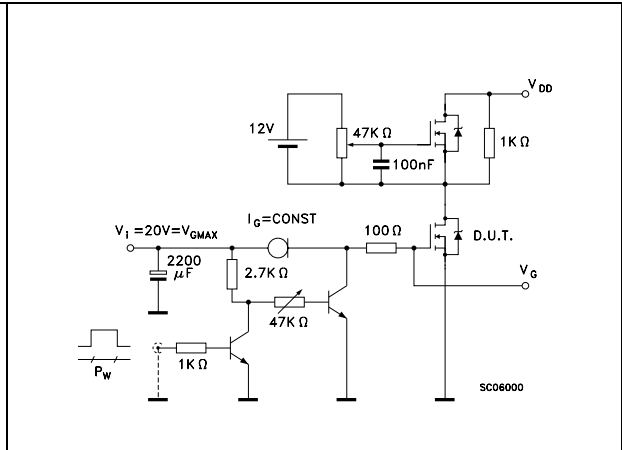


Figure 15. Test circuit for inductive load switching and diode recovery times

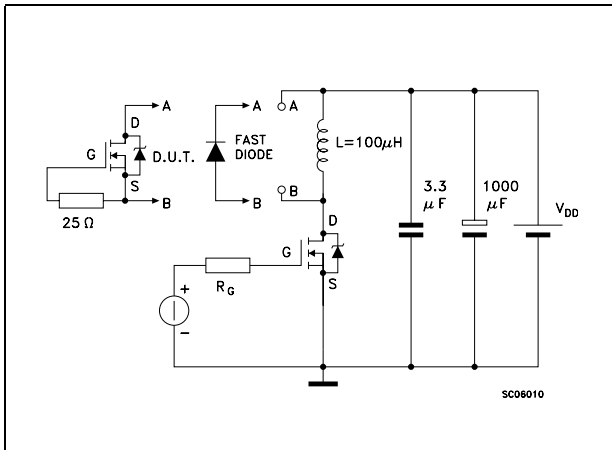


Figure 16. Unclamped Inductive load test circuit

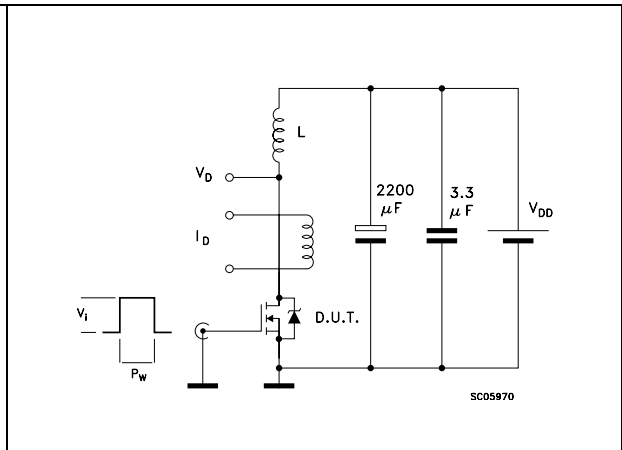


Figure 17. Unclamped inductive waveform

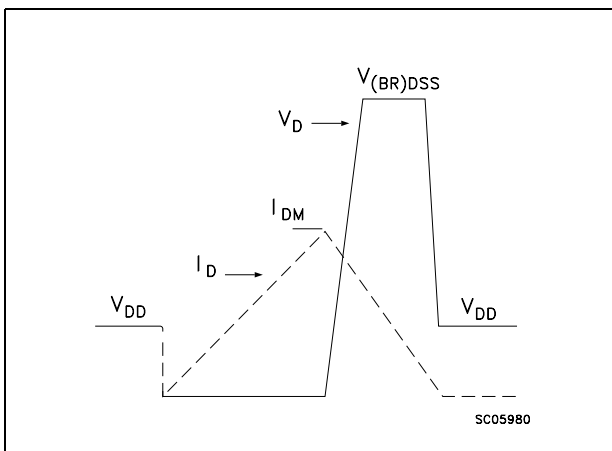
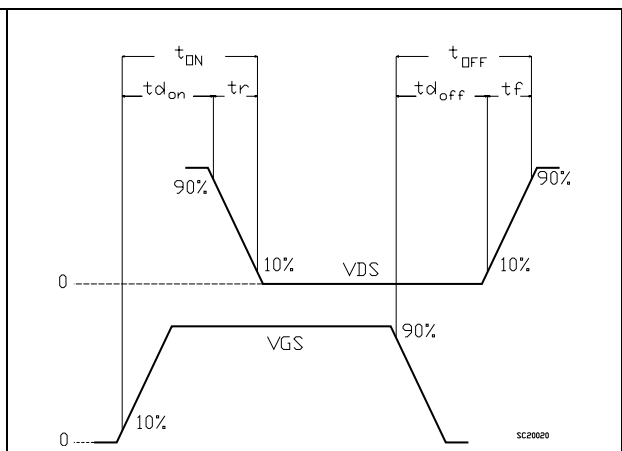


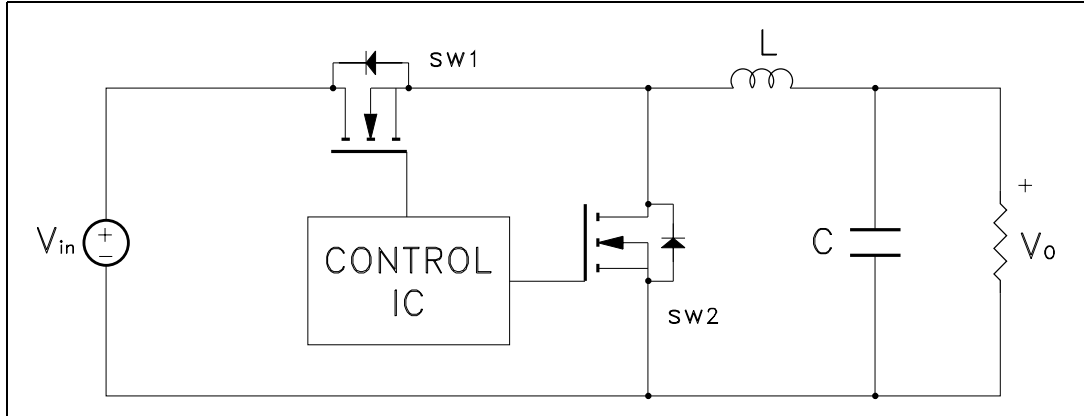
Figure 18. Switching time waveform





## 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. Paramiters meaning**

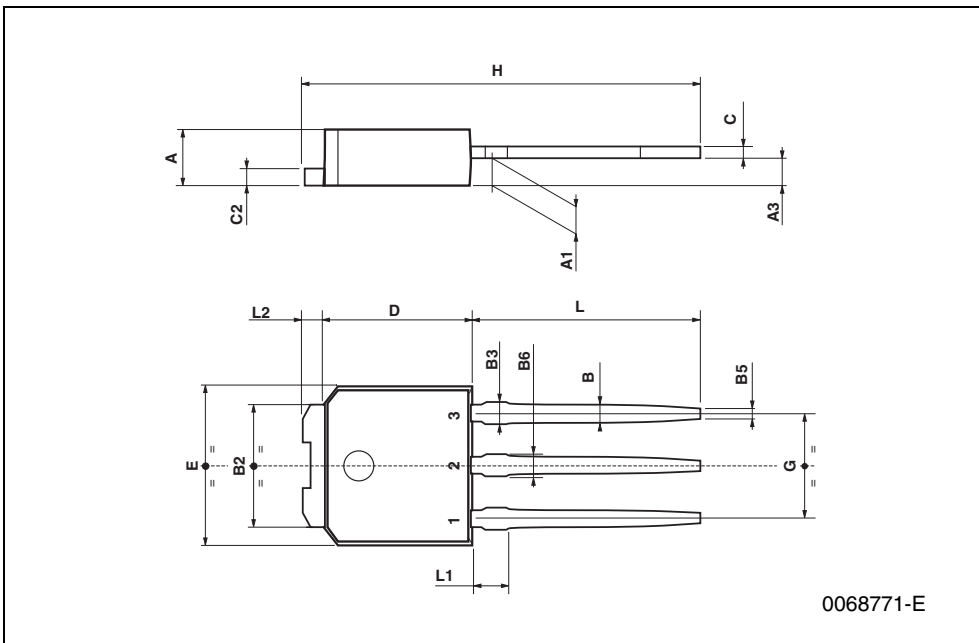
| Parameter         | Meaning                                      |
|-------------------|--|
| d                 | Duty-cycle                                   |
| Q <sub>gsth</sub> | Post threshold gate charge                   |
| Q <sub>gls</sub>  | Third quadrant gate charge                   |
| 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)

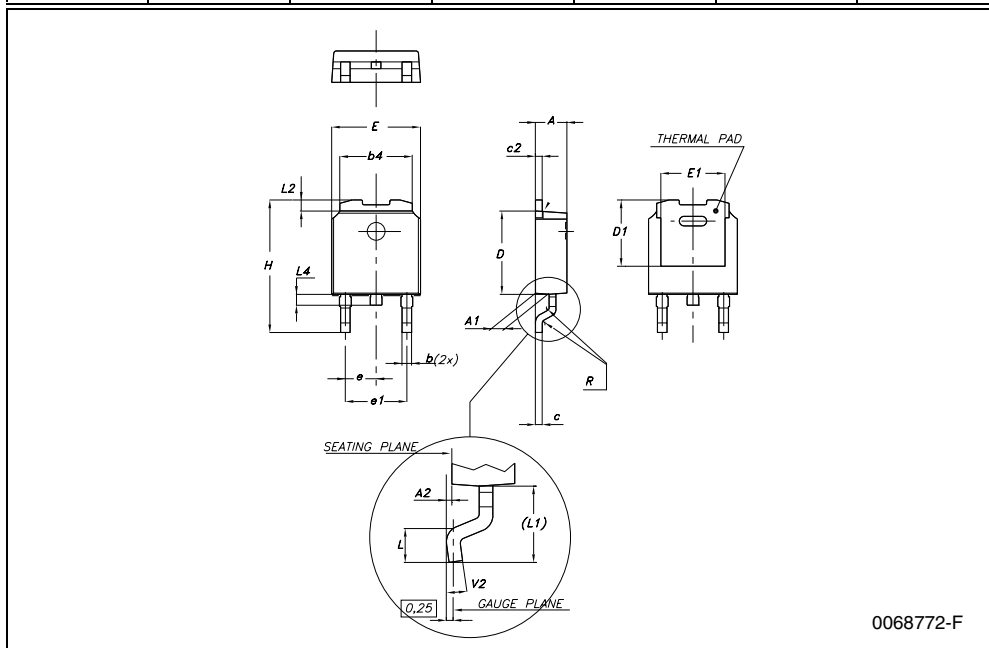
**TO-251 (IPAK) MECHANICAL DATA**

| DIM. | mm   |      |      | inch  |       |       |
|------|------|------|------|-------|-------|-------|
|      | MIN. | TYP. | MAX. | MIN.  | TYP.  | MAX.  |
| A    | 2.2  |      | 2.4  | 0.086 |       | 0.094 |
| A1   | 0.9  |      | 1.1  | 0.035 |       | 0.043 |
| A3   | 0.7  |      | 1.3  | 0.027 |       | 0.051 |
| B    | 0.64 |      | 0.9  | 0.025 |       | 0.031 |
| B2   | 5.2  |      | 5.4  | 0.204 |       | 0.212 |
| B3   |      |      | 0.85 |       |       | 0.033 |
| B5   |      | 0.3  |      |       | 0.012 |       |
| B6   |      |      | 0.95 |       |       | 0.037 |
| C    | 0.45 |      | 0.6  | 0.017 |       | 0.023 |
| C2   | 0.48 |      | 0.6  | 0.019 |       | 0.023 |
| D    | 6    |      | 6.2  | 0.236 |       | 0.244 |
| E    | 6.4  |      | 6.6  | 0.252 |       | 0.260 |
| G    | 4.4  |      | 4.6  | 0.173 |       | 0.181 |
| H    | 15.9 |      | 16.3 | 0.626 |       | 0.641 |
| L    | 9    |      | 9.4  | 0.354 |       | 0.370 |
| L1   | 0.8  |      | 1.2  | 0.031 |       | 0.047 |
| L2   |      | 0.8  | 1    |       | 0.031 | 0.039 |



**DPAK MECHANICAL DATA**

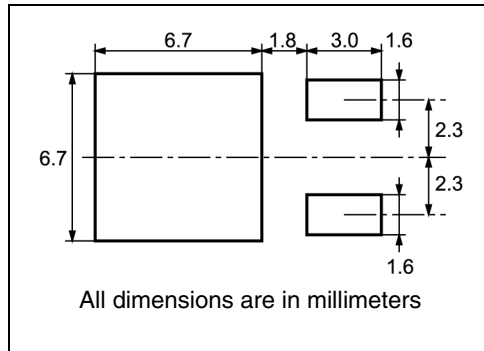
| DIM. | mm.  |      |      | inch  |       |       |
|------|------|------|------|-------|-------|-------|
|      | MIN. | TYP. | MAX. | MIN.  | TYP.  | MAX.  |
| A    | 2.2  |      | 2.4  | 0.086 |       | 0.094 |
| A1   | 0.9  |      | 1.1  | 0.035 |       | 0.043 |
| A2   | 0.03 |      | 0.23 | 0.001 |       | 0.009 |
| B    | 0.64 |      | 0.9  | 0.025 |       | 0.035 |
| b4   | 5.2  |      | 5.4  | 0.204 |       | 0.212 |
| C    | 0.45 |      | 0.6  | 0.017 |       | 0.023 |
| C2   | 0.48 |      | 0.6  | 0.019 |       | 0.023 |
| D    | 6    |      | 6.2  | 0.236 |       | 0.244 |
| D1   |      | 5.1  |      |       | 0.200 |       |
| E    | 6.4  |      | 6.6  | 0.252 |       | 0.260 |
| E1   |      | 4.7  |      |       | 0.185 |       |
| e    |      | 2.28 |      |       | 0.090 |       |
| e1   | 4.4  |      | 4.6  | 0.173 |       | 0.181 |
| H    | 9.35 |      | 10.1 | 0.368 |       | 0.397 |
| L    | 1    |      |      | 0.039 |       |       |
| (L1) |      | 2.8  |      |       | 0.110 |       |
| L2   |      | 0.8  |      |       | 0.031 |       |
| L4   | 0.6  |      | 1    | 0.023 |       | 0.039 |
| R    |      | 0.2  |      |       | 0.008 |       |
| V2   | 0°   |      | 8°   | 0°    |       | 8°    |



0068772-F

# 6 Packing mechanical data

## DPAK FOOTPRINT



## TAPE AND REEL SHIPMENT

40 mm min. Access hole at slot location

Full radius

Tape slot in core for tape start 2.5mm min. width

G measured at hub

### REEL MECHANICAL DATA

| DIM. | mm   |      | inch  |        |
|------|------|------|-------|--------|
|      | MIN. | MAX. | MIN.  | MAX.   |
| A    |      | 330  |       | 12.992 |
| B    | 1.5  |      | 0.059 |        |
| C    | 12.8 | 13.2 | 0.504 | 0.520  |
| D    | 20.2 |      | 0.795 |        |
| G    | 16.4 | 18.4 | 0.645 | 0.724  |
| N    | 50   |      | 1.968 |        |
| T    |      | 22.4 |       | 0.881  |

### TAPE MECHANICAL DATA

| DIM. | mm   |      | inch  |       |
|------|------|------|-------|-------|
|      | MIN. | MAX. | MIN.  | MAX.  |
| A0   | 6.8  | 7    | 0.267 | 0.275 |
| B0   | 10.4 | 10.6 | 0.409 | 0.417 |
| B1   |      | 12.1 |       | 0.476 |
| D    | 1.5  | 1.6  | 0.059 | 0.063 |
| D1   | 1.5  |      | 0.059 |       |
| E    | 1.65 | 1.85 | 0.065 | 0.073 |
| F    | 7.4  | 7.6  | 0.291 | 0.299 |
| K0   | 2.55 | 2.75 | 0.100 | 0.108 |
| P0   | 3.9  | 4.1  | 0.153 | 0.161 |
| P1   | 7.9  | 8.1  | 0.311 | 0.319 |
| P2   | 1.9  | 2.1  | 0.075 | 0.082 |
| R    | 40   |      | 1.574 |       |
| W    | 15.7 | 16.3 | 0.618 | 0.641 |

10 pitches cumulative tolerance on tape +/- 0.2 mm

Center line of cavity

User Direction of Feed

TRL

FEED DIRECTION

Bending radius R min.

For machine ref. only including draft and radii concentric around B0

## 7 Revision history

**Table 8. Revision history**

| <b>Date</b> | <b>Revision</b> | <b>Changes</b>                  |
|-------------|-----------------|---------------------------------|
| 21-Jun-2004 | 7               | Preliminary version             |
| 11-Jul-2006 | 8               | New template, no content change |

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