



# STF20NM60D - STP20NM60FD STW20NM60FD

N-channel 600V - 0.26Ω - 20A - TO-220 - TO-220FP - TO-247  
FDmesh™ Power MOSFET (with fast diode)

## General features

| Type        | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> | P <sub>w</sub> |
|-------------|------------------|---------------------|----------------|----------------|
| STF20NM60D  | 600V             | <0.29Ω              | 20A            | 192W           |
| STP20NM60FD | 600V             | <0.29Ω              | 20A            | 45W            |
| STW20NM60FD | 600V             | <0.29Ω              | 20A            | 214W           |

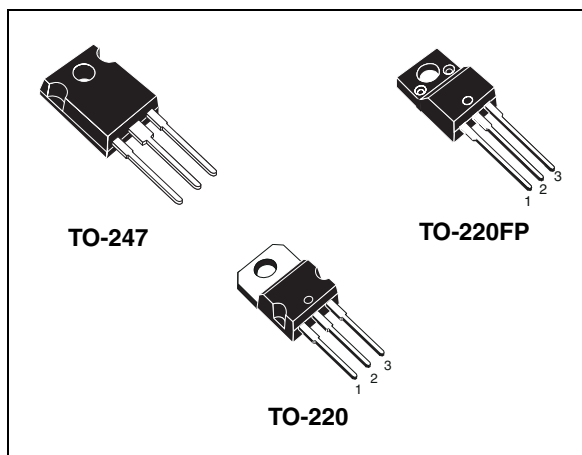
- High dv/dt and avalanche capabilities
- 100% Avalanche tested
- Low input capacitance and gate charge
- Low gate input resistance
- Tight process control and high manufacturing yields

## Description

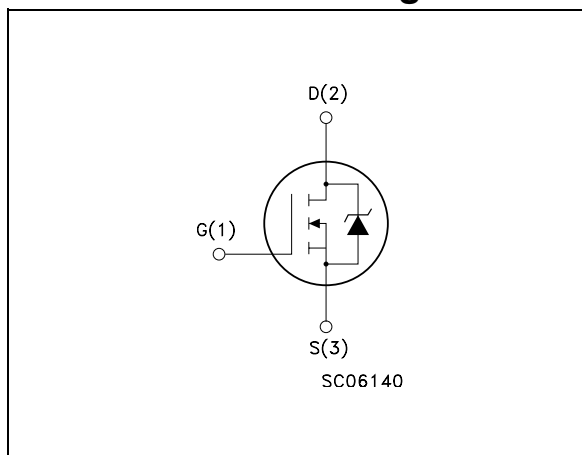
The FDmesh™ associates all advantages of reduced on-resistance and fast switching with an intrinsic fast-recovery body diode. It is therefore strongly recommended for bridge topologies, in particular ZVS phase-shift converters.

## Applications

- Switching application



## Internal schematic diagram



## Order codes

| Part number | Marking   | Package  | Packaging |
|-------------|-----------|----------|-----------|
| STF20NM60D  | F20NM60D  | TO-220FP | Tube      |
| STP20NM60FD | P20NM60FD | TO-220   | Tube      |
| STW20NM60FD | W20NM60FD | TO-247   | Tube      |

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# 1 Electrical ratings

**Table 1. Absolute maximum ratings**

| Symbol             | Parameter                                               | Value       |                     |        | Unit                                 |
|--------------------|---------------------------------------------------------|-------------|---------------------|--------|--------------------------------------|
|                    |                                                         | TO-220      | TO-220FP            | TO-247 |                                      |
| $V_{DS}$           | Drain-source voltage ( $V_{GS} = 0$ )                   | 600         |                     |        | V                                    |
| $V_{DGR}$          | Drain-gate voltage ( $R_{GS} = 20\text{ k}\Omega$ )     | 600         |                     |        | V                                    |
| $V_{GS}$           | Gate- source voltage                                    | $\pm 30$    |                     |        | V                                    |
| $I_D$              | Drain current (continuous) at $T_C = 25^\circ\text{C}$  | 20          | 20 <sup>(1)</sup>   | 20     | A                                    |
| $I_D$              | Drain current (continuous) at $T_C = 100^\circ\text{C}$ | 12.6        | 12.6 <sup>(1)</sup> | 12.6   | A                                    |
| $I_{DM}^{(2)}$     | Drain current (pulsed)                                  | 80          | 80 <sup>(1)</sup>   | 80     | A                                    |
| $P_{TOT}$          | Total dissipation at $T_C = 25^\circ\text{C}$           | 192         | 45                  | 214    | W                                    |
|                    | Derating factor                                         | 1.20        | 0.36                | 1.42   | W/ $^\circ\text{C}$                  |
| $dv/dt^{(3)}$      | Peak diode recovery voltage slope                       | 20          |                     |        | V/ns                                 |
| $V_{ISO}$          | Insulation withstand voltage (DC)                       | -           | 2500                | -      | V                                    |
| $T_j$<br>$T_{stg}$ | Operating junction temperature<br>Storage temperature   | - 65 to 150 |                     |        | $^\circ\text{C}$<br>$^\circ\text{C}$ |

1. Limited only by maximum temperature allowed
2. Pulse width limited by safe operating area
3.  $I_{SD} \leq 20\text{A}$ ,  $di/dt \leq 400\text{A}/\mu\text{s}$ ,  $V_{DD} = 80\%V_{(BR)DSS}$

**Table 2. Thermal resistance**

| Symbol         | Parameter                                      | Value  |          |        | Unit                      |
|----------------|------------------------------------------------|--------|----------|--------|---------------------------|
|                |                                                | TO-220 | TO-220FP | TO-247 |                           |
| $R_{thj-case}$ | Thermal resistance junction-case Max           | 0.65   | 2.8      | 0.585  | $^\circ\text{C}/\text{W}$ |
| $R_{thj-amb}$  | Thermal resistance junction-ambient Max        | 62.5   |          | 30     | $^\circ\text{C}/\text{W}$ |
| $T_I$          | Maximum lead temperature for soldering purpose | 300    |          |        | $^\circ\text{C}$          |

**Table 3. Avalanche data**

| Symbol   | Parameter                                                                                                    | Value | Unit |
|----------|--------------------------------------------------------------------------------------------------------------|-------|------|
| $I_{AR}$ | Avalanche current, repetitive or not-repetitive (pulse width limited by $T_j$ max)                           | 10    | A    |
| $E_{AS}$ | Single pulse avalanche energy (starting $T_j = 25^\circ\text{C}$ , $I_D = I_{AR}$ , $V_{DD} = 35\text{ V}$ ) | 700   | mJ   |

## 2 Electrical characteristics

(T<sub>CASE</sub>=25°C unless otherwise specified)

**Table 4. On/off states**

| Symbol               | Parameter                                             | Test conditions                                                                       | Min | Typ  | Max      | Unit     |
|----------------------|-------------------------------------------------------|---------------------------------------------------------------------------------------|-----|------|----------|----------|
| V <sub>(BR)DSS</sub> | Drain-source breakdown voltage                        | I <sub>D</sub> = 250μA, V <sub>GS</sub> = 0                                           | 600 |      |          | V        |
| I <sub>DSS</sub>     | Zero gate voltage drain current (V <sub>GS</sub> = 0) | V <sub>DS</sub> = Max rating<br>V <sub>DS</sub> = Max rating, T <sub>C</sub> = 125 °C |     |      | 1<br>10  | μA<br>μA |
| I <sub>GSS</sub>     | Gate-body leakage current (V <sub>DS</sub> = 0)       | V <sub>GS</sub> = ±30V                                                                |     |      | ±10<br>0 | μA       |
| V <sub>GS(th)</sub>  | Gate threshold voltage                                | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250μA                            | 3   | 4    | 5        | V        |
| R <sub>DS(on)</sub>  | Static drain-source on resistance                     | V <sub>GS</sub> = 10V, I <sub>D</sub> = 10A                                           |     | 0.26 | 0.29     | Ω        |

**Table 5. Dynamic**

| Symbol                                                   | Parameter                                                               | Test conditions                                                                           | Min | Typ               | Max | Unit           |
|----------------------------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|-----|-------------------|-----|----------------|
| g <sub>fs</sub> <sup>(1)</sup>                           | Forward transconductance                                                | V <sub>DS</sub> > I <sub>D(on)</sub> × R <sub>DS(on)max</sub> ,<br>I <sub>D</sub> = 10A   |     | 9                 |     | S              |
| C <sub>iss</sub><br>C <sub>oss</sub><br>C <sub>rss</sub> | Input capacitance<br>Output capacitance<br>Reverse transfer capacitance | V <sub>DS</sub> = 25V, f = 1 MHz, V <sub>GS</sub> = 0                                     |     | 1300<br>500<br>35 |     | pF<br>pF<br>pF |
| C <sub>oss eq.</sub> <sup>(2)</sup>                      | Equivalent output capacitance                                           | V <sub>GS</sub> = 0V, V <sub>DS</sub> = 0V to 480V                                        |     | 190               |     | pF             |
| R <sub>G</sub>                                           | Gate input resistance                                                   | f=1 MHz Gate DC Bias = 0<br>Test signal level = 20mV<br>open drain                        |     | 2.7               |     | Ω              |
| Q <sub>g</sub><br>Q <sub>gs</sub><br>Q <sub>gd</sub>     | Total gate charge<br>Gate-source charge<br>Gate-drain charge            | V <sub>DD</sub> = 480V, I <sub>D</sub> = 20A,<br>V <sub>GS</sub> = 10V<br>(see Figure 17) |     | 37<br>10<br>17    | 52  | nC<br>nC<br>nC |

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

2. C<sub>oss eq.</sub> is defined as a constant equivalent capacitance giving the same charging time as C<sub>oss</sub> when V<sub>DS</sub> increases from 0 to 80%

**Table 6. Switching times**

| Symbol        | Parameter             | Test conditions                                    | Min. | Typ. | Max. | Unit |
|---------------|-----------------------|----------------------------------------------------|------|------|------|------|
| $t_{d(on)}$   | Turn-on delay time    | $V_{DD} = 300V, I_D = 10A$                         |      | 25   |      | ns   |
| $t_r$         | Rise time             | $R_G = 4.7\Omega, V_{GS} = 10V$<br>(see Figure 16) |      | 12   |      | ns   |
| $t_{r(Voff)}$ | Off-voltage rise time | $V_{DD} = 480V, I_D = 20A,$                        |      | 8    |      | ns   |
| $t_f$         | Fall time             | $R_G = 4.7\Omega, V_{GS} = 10V$                    |      | 22   |      | ns   |
| $t_c$         | Cross-over time       | (see Figure 16)                                    |      | 30   |      | ns   |

**Table 7. Source drain diode**

| Symbol          | Parameter                     | Test conditions                    | Min | Typ. | Max | Unit |
|-----------------|-------------------------------|------------------------------------|-----|------|-----|------|
| $I_{SD}$        | Source-drain current          |                                    |     |      | 20  | A    |
| $I_{SDM}^{(1)}$ | Source-drain current (pulsed) |                                    |     |      | 80  | A    |
| $V_{SD}^{(2)}$  | Forward on voltage            | $I_{SD} = 20A, V_{GS} = 0$         |     |      | 1.5 | V    |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 20A, T_j = 25^\circ C$   |     | 240  |     | ns   |
| $Q_{rr}$        | Reverse recovery charge       | $di/dt = 100A/\mu s, V_{DD} = 60V$ |     | 1800 |     | nC   |
| $I_{RRM}$       | Reverse recovery current      | (see Figure 21)                    |     | 16   |     | A    |
| $t_{rr}$        | Reverse recovery time         | $I_{SD} = 20A, T_j = 150^\circ C$  |     | 396  |     | ns   |
| $Q_{rr}$        | Reverse recovery charge       | $di/dt = 100A/\mu s, V_{DD} = 60V$ |     | 2960 |     | nC   |
| $I_{RRM}$       | Reverse recovery current      | (see Figure 21)                    |     | 20   |     | 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 for TO-220

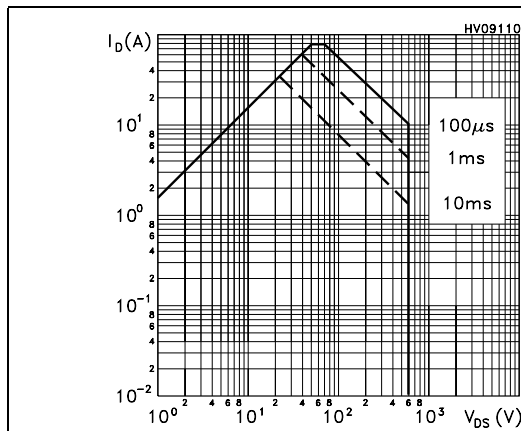


Figure 2. Thermal impedance for TO-220

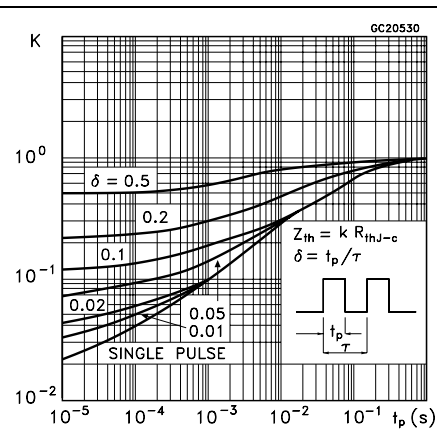


Figure 3. Safe operating area for TO-220FP

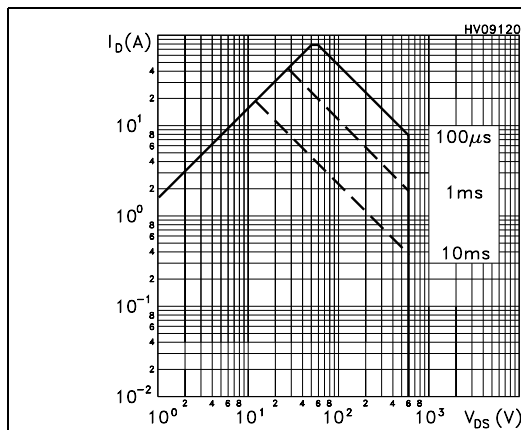


Figure 4. Thermal impedance for TO-220FP

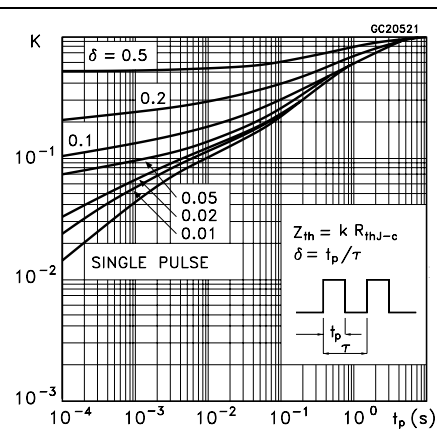


Figure 5. Safe operating area for TO-247

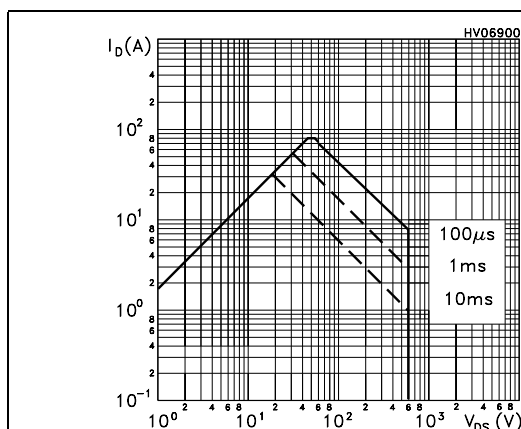


Figure 6. Thermal impedance for TO-247

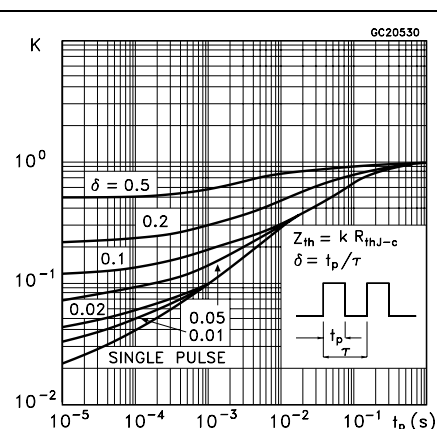


Figure 7. Output characteristics

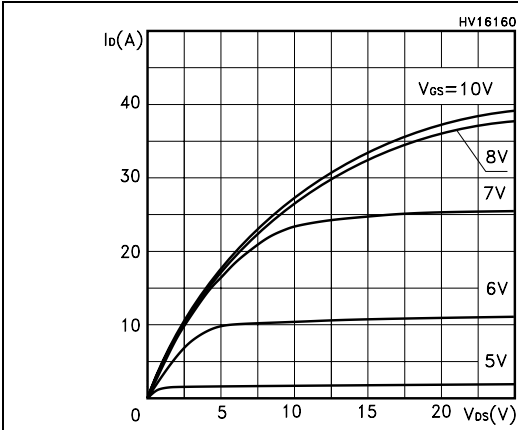


Figure 8. Transfer characteristics

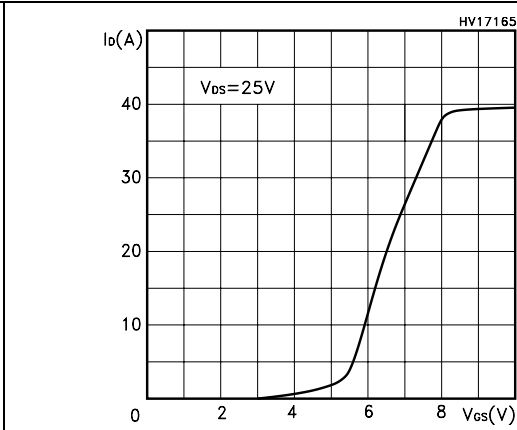


Figure 9. Transconductance

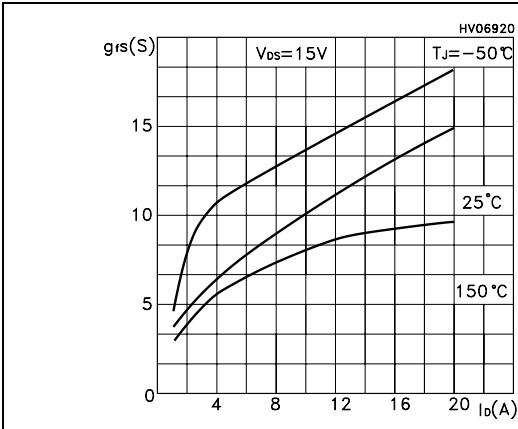


Figure 10. Static drain-source on resistance

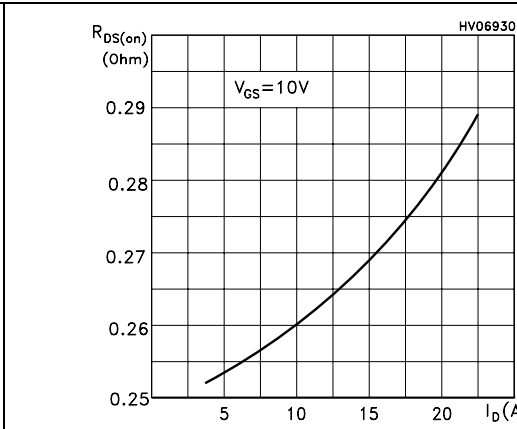


Figure 11. Gate charge vs gate-source voltage

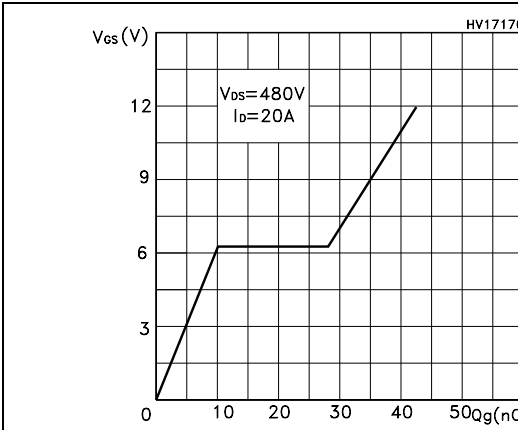


Figure 12. Capacitance variations

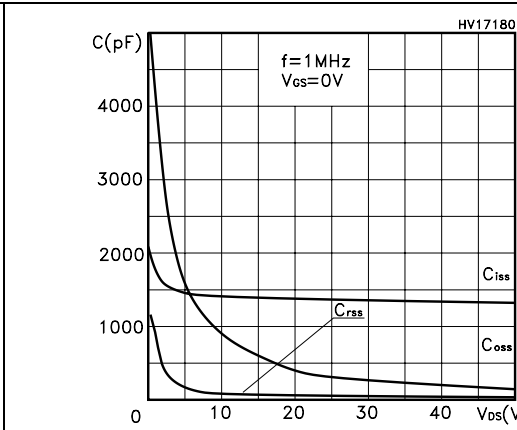


Figure 13. Normalized gate threshold voltage vs temperature

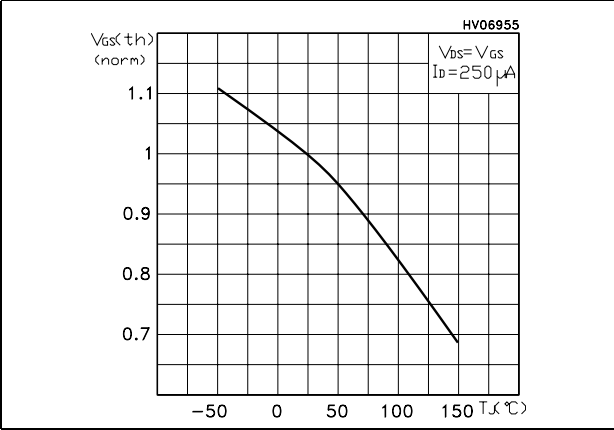


Figure 14. Normalized on resistance vs temperature

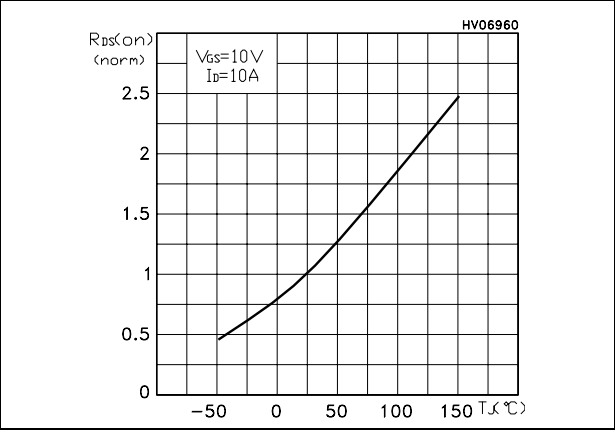
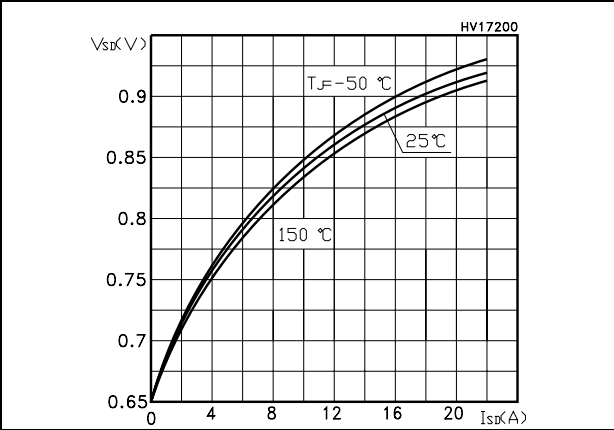


Figure 15. Source-drain diode forward characteristics





### 3 Test circuit

Figure 16. Switching times test circuit for resistive load

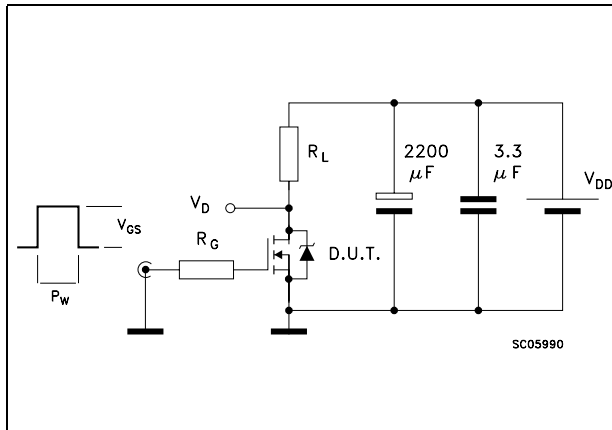


Figure 17. Gate charge test circuit

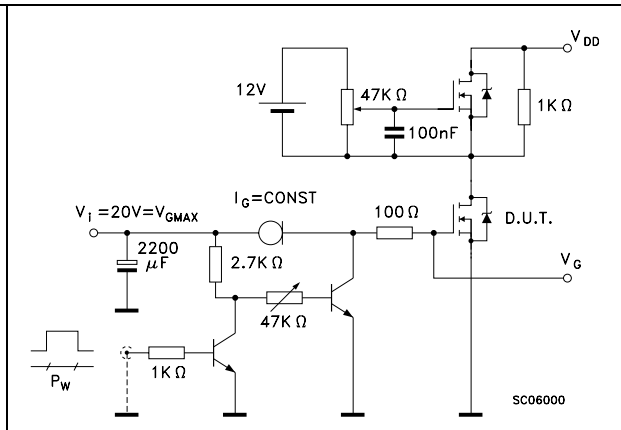


Figure 18. Test circuit for inductive load switching and diode recovery times

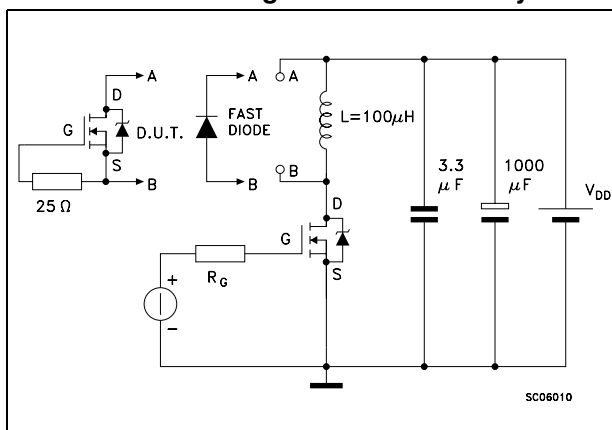


Figure 19. Unclamped inductive load test circuit

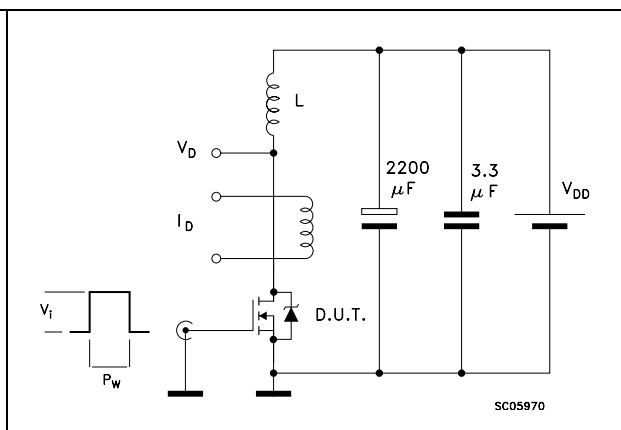


Figure 20. Unclamped inductive waveform

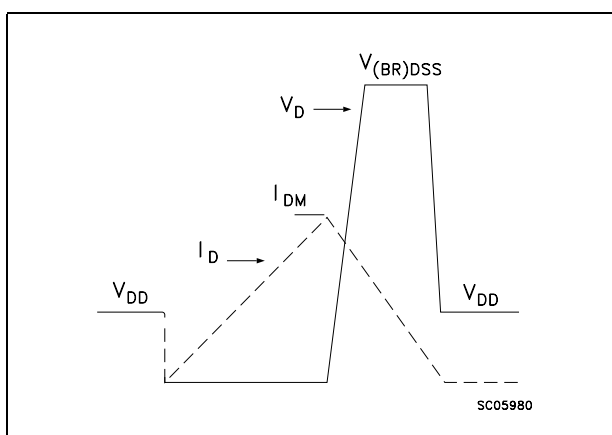
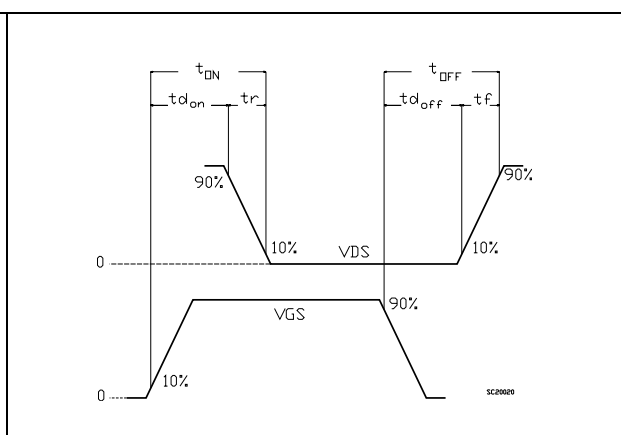


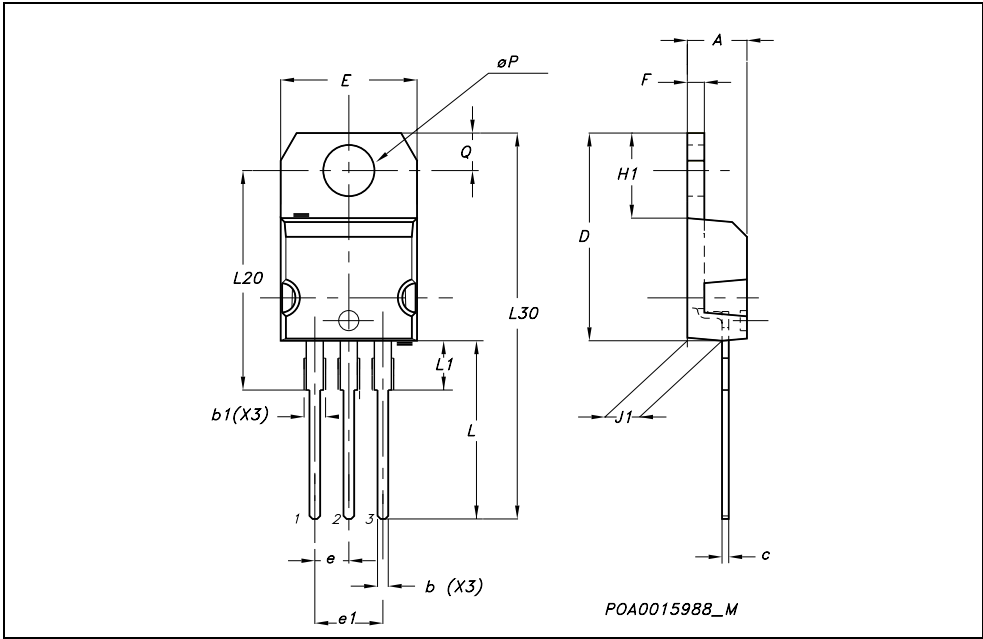
Figure 21. Switching time waveform



## 4 Package mechanical data

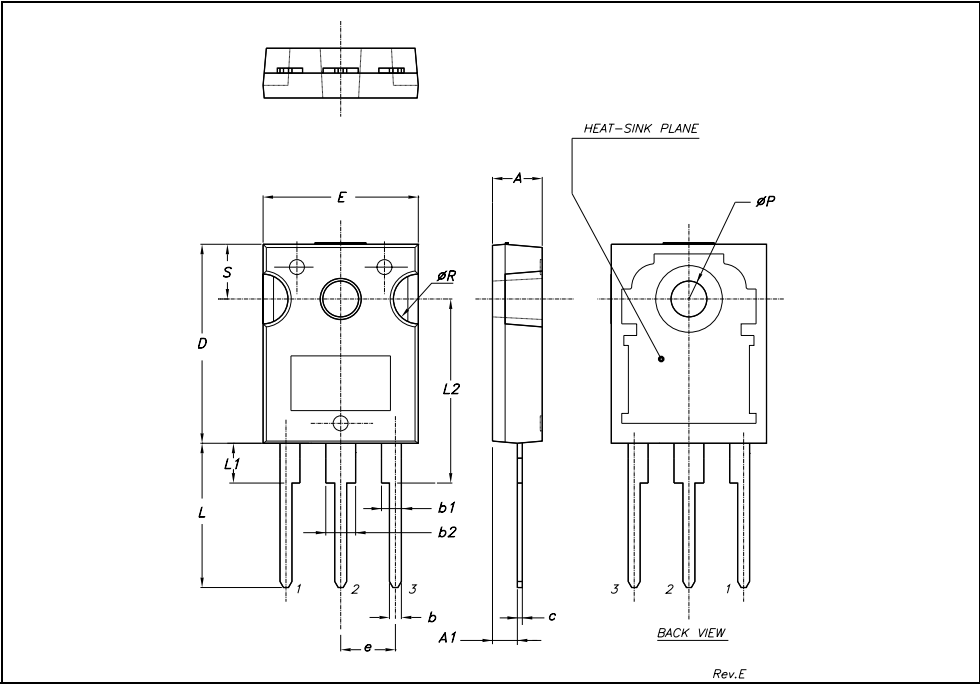
In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect . The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings 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-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 |



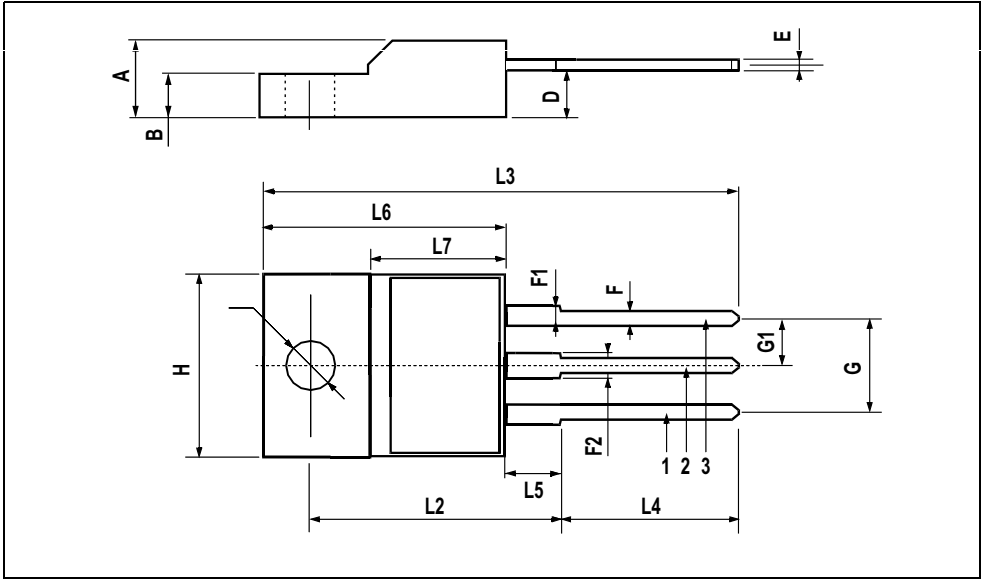
TO-247 MECHANICAL DATA

| DIM. | mm.   |       |       | inch  |       |       |
|------|-------|-------|-------|-------|-------|-------|
|      | MIN.  | TYP   | MAX.  | MIN.  | TYP.  | MAX.  |
| A    | 4.85  |       | 5.15  | 0.19  |       | 0.20  |
| A1   | 2.20  |       | 2.60  | 0.086 |       | 0.102 |
| b    | 1.0   |       | 1.40  | 0.039 |       | 0.055 |
| b1   | 2.0   |       | 2.40  | 0.079 |       | 0.094 |
| b2   | 3.0   |       | 3.40  | 0.118 |       | 0.134 |
| c    | 0.40  |       | 0.80  | 0.015 |       | 0.03  |
| D    | 19.85 |       | 20.15 | 0.781 |       | 0.793 |
| E    | 15.45 |       | 15.75 | 0.608 |       | 0.620 |
| e    |       | 5.45  |       |       | 0.214 |       |
| L    | 14.20 |       | 14.80 | 0.560 |       | 0.582 |
| L1   | 3.70  |       | 4.30  | 0.14  |       | 0.17  |
| L2   |       | 18.50 |       |       | 0.728 |       |
| øP   | 3.55  |       | 3.65  | 0.140 |       | 0.143 |
| øR   | 4.50  |       | 5.50  | 0.177 |       | 0.216 |
| S    |       | 5.50  |       |       | 0.216 |       |



TO-220FP MECHANICAL DATA

| DIM. | mm.  |     |      | inch  |       |       |
|------|------|-----|------|-------|-------|-------|
|      | MIN. | TYP | MAX. | MIN.  | TYP.  | MAX.  |
| A    | 4.4  |     | 4.6  | 0.173 |       | 0.181 |
| B    | 2.5  |     | 2.7  | 0.098 |       | 0.106 |
| D    | 2.5  |     | 2.75 | 0.098 |       | 0.108 |
| E    | 0.45 |     | 0.7  | 0.017 |       | 0.027 |
| F    | 0.75 |     | 1    | 0.030 |       | 0.039 |
| F1   | 1.15 |     | 1.7  | 0.045 |       | 0.067 |
| F2   | 1.15 |     | 1.7  | 0.045 |       | 0.067 |
| G    | 4.95 |     | 5.2  | 0.195 |       | 0.204 |
| G1   | 2.4  |     | 2.7  | 0.094 |       | 0.106 |
| H    | 10   |     | 10.4 | 0.393 |       | 0.409 |
| L2   |      | 16  |      |       | 0.630 |       |
| L3   | 28.6 |     | 30.6 | 1.126 |       | 1.204 |
| L4   | 9.8  |     | 10.6 | .0385 |       | 0.417 |
| L5   | 2.9  |     | 3.6  | 0.114 |       | 0.141 |
| L6   | 15.9 |     | 16.4 | 0.626 |       | 0.645 |
| L7   | 9    |     | 9.3  | 0.354 |       | 0.366 |
| Ø    | 3    |     | 3.2  | 0.118 |       | 0.126 |



## 5 Revision history

**Table 8.** Revision history

| Date        | Revision | Changes                                             |
|-------------|----------|-----------------------------------------------------|
| 09-Sep-2004 | 1        | First release                                       |
| 21-Apr-2006 | 2        | New template                                        |
| 25-Jul-2006 | 3        | Modified part number                                |
| 01-Aug-2006 | 4        | Corrected unit on <a href="#">Table 5.: Dynamic</a> |

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