



# STF2NK60Z - STQ2NK60ZR-AP STP2NK60Z - STD2NK60Z-1

N-CHANNEL 600V - 7.2Ω - 1.4A TO-220/TO-220FP/TO-92/IPAK  
Zener-Protected SuperMESH™ MOSFET

**Table 1: General Features**

| TYPE          | V <sub>DSS</sub> | R <sub>DS(on)</sub> | I <sub>D</sub> | P <sub>W</sub> |
|---------------|------------------|---------------------|----------------|----------------|
| STF2NK60Z     | 600 V            | < 8 Ω               | 1.4 A          | 20             |
| STQ2NK60ZR-AP | 600 V            | < 8 Ω               | 0.4 A          | 3 W            |
| STP2NK60Z     | 600 V            | < 8 Ω               | 1.4 A          | 45 W           |
| STD2NK60Z-1   | 600 V            | < 8 Ω               | 1.4 A          | 45 W           |

- TYPICAL R<sub>DS(on)</sub> = 7.2 Ω
- EXTREMELY HIGH dv/dt CAPABILITY
- ESD IMPROVED CAPABILITY
- 100% AVALANCHE TESTED
- NEW HIGH VOLTAGE BENCHMARK
- GATE CHARGE MINIMIZED

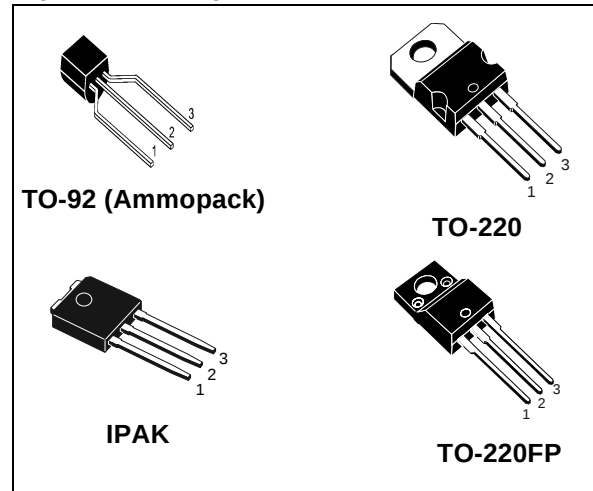
## DESCRIPTION

The SuperMESH™ series is obtained through an extreme optimization of ST's well established strip-based PowerMESH™ layout. In addition to pushing on-resistance significantly down, special care is taken to ensure a very good dv/dt capability for the most demanding applications. Such series complements ST full range of high voltage MOSFETs including revolutionary MDmesh™ products.

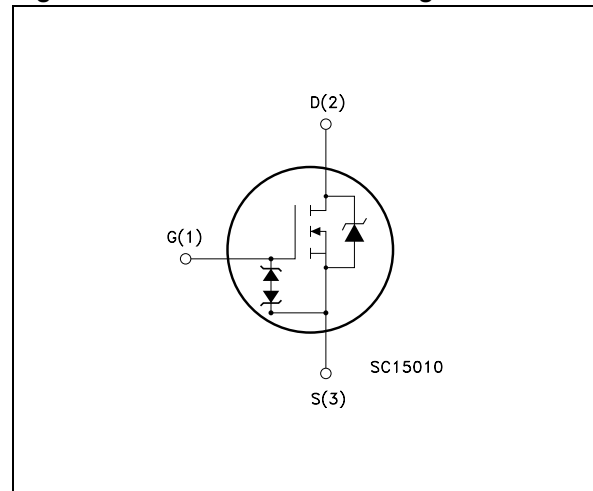
## APPLICATIONS

- LOW POWER BATTERY CHARGERS
- SWITCH MODE LOW POWER SUPPLIES(SMPS)
- LOW POWER, BALLAST, CFL (COMPACT FLUORESCENT LAMPS)

**Figure 1: Package**



**Figure 2: Internal Schematic Diagram**



**Table 2: Order Codes**

| Part Number   | Marking  | Package  | Packaging |
|---------------|----------|----------|-----------|
| STQ2NK60ZR-AP | Q2NK60ZR | TO-92    | AMMOPAK   |
| STP2NK60Z     | P2NK60Z  | TO-220   | TUBE      |
| STD2NK60Z-1   | D2NK60Z  | IPAK     | TUBE      |
| STF2NK60Z     | F2NK60Z  | TO-220FP | TUBE      |

Rev. 5

**STQ2NK60ZR-AP - STP2NK60Z - STF2NK60Z - STD2NK60Z-1**
**Table 3: Absolute Maximum ratings**

| Symbol             | Parameter                                               | Value         |       |          | Unit                |
|--------------------|---------------------------------------------------------|---------------|-------|----------|---------------------|
|                    |                                                         | TO-220 / IPAK | TO-92 | TO-220FP |                     |
| $V_{DS}$           | 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 $T_C = 25^\circ\text{C}$  | 1.4           | 0.4   | 1.4 (*)  | A                   |
| $I_D$              | Drain Current (continuous) at $T_C = 100^\circ\text{C}$ | 0.77          | 0.25  | 0.77 (*) | A                   |
| $I_{DM}(\bullet)$  | Drain Current (pulsed)                                  | 5.6           | 1.6   | 5.6 (*)  | A                   |
| $P_{TOT}$          | Total Dissipation at $T_C = 25^\circ\text{C}$           | 45            | 3     | 20       | W                   |
|                    | Derating Factor                                         | 0.36          | 0.025 | 0.16     | W/ $^\circ\text{C}$ |
| $V_{ESD}(G-S)$     | Gate source ESD (HBM-C= 100pF, R=1.5k $\Omega$ )        | 1500          |       |          | V                   |
| $V_{ISO}$          | Insulation Withstand Voltage (DC)                       |               |       | 2500     | V                   |
| dv/dt (1)          | Peak Diode Recovery voltage slope                       | 4.5           |       |          | V/ns                |
| $T_j$<br>$T_{stg}$ | Operating Junction Temperature<br>Storage Temperature   | -55 to 150    |       |          | $^\circ\text{C}$    |

(●) Pulse width limited by safe operating area

(1)  $I_{SD} \leq 1.4\text{A}$ ,  $di/dt \leq 200\text{A}/\mu\text{s}$ ,  $V_{DD} \leq V_{(BR)DSS}$ ,  $T_j \leq T_{JMAX}$ .

(\*) Limited only by maximum temperature allowed

**Table 4: Thermal Data**

|           |                                                | TO-220/IPAK | TO-220FP | TO-92 | Unit                      |
|-----------|------------------------------------------------|-------------|----------|-------|---------------------------|
| Rthj-case | Thermal Resistance Junction-case Max           | 2.77        | 6.25     | --    | $^\circ\text{C}/\text{W}$ |
| Rthj-amb  | Thermal Resistance Junction-ambient Max        | 100         | 100      | 120   | $^\circ\text{C}/\text{W}$ |
| Rthj-lead | Thermal Resistance Junction-lead Max           | --          | --       | 40    | $^\circ\text{C}/\text{W}$ |
| $T_l$     | Maximum Lead Temperature For Soldering Purpose | 300         |          | 260   | $^\circ\text{C}$          |

**Table 5: Avalanche Characteristics**

| Symbol   | Parameter                                                                                                    | Max Value | Unit |
|----------|--------------------------------------------------------------------------------------------------------------|-----------|------|
| $I_{AR}$ | Avalanche Current, Repetitive or Not-Repetitive (pulse width limited by $T_j$ max)                           | 1.4       | A    |
| $E_{AS}$ | Single Pulse Avalanche Energy (starting $T_j = 25^\circ\text{C}$ , $I_D = I_{AR}$ , $V_{DD} = 50\text{ V}$ ) | 90        | mJ   |

**Table 6: Gate-Source Zener Diode**

| Symbol     | Parameter                     | Test Conditions                         | Min. | Typ. | Max. | Unit |
|------------|-------------------------------|-----------------------------------------|------|------|------|------|
| $BV_{GSO}$ | Gate source Breakdown Voltage | $I_{GS} = \pm 1\text{ mA}$ (Open Drain) | 30   |      |      | V    |

**PROTECTION FEATURES OF GATE-TO-SOURCE ZENER DIODES**

The built-in back-to-back Zener diodes have specifically been designed to enhance not only the device's ESD capability, but also to make them safely absorb possible voltage transients that may occasionally be applied from gate to source. In this respect the Zener voltage is appropriate to achieve an efficient and cost-effective intervention to protect the device's integrity. These integrated Zener diodes thus avoid the usage of external components.

**STQ2NK60ZR-AP - STP2NK60Z - STF2NK60Z - STD2NK60Z-1**
**ELECTRICAL CHARACTERISTICS** ( $T_{CASE} = 25^{\circ}\text{C}$  UNLESS OTHERWISE SPECIFIED)

**Table 7: On/Off**

| Symbol        | Parameter                                        | Test Conditions                                                                            | Min. | Typ. | Max.     | Unit                           |
|---------------|--------------------------------------------------|--------------------------------------------------------------------------------------------|------|------|----------|--------------------------------|
| $V_{(BR)DSS}$ | Drain-source Breakdown Voltage                   | $I_D = 1\text{mA}$ , $V_{GS} = 0$                                                          | 600  |      |          | V                              |
| $I_{DSS}$     | Zero Gate Voltage Drain Current ( $V_{GS} = 0$ ) | $V_{DS} = \text{Max Rating}$<br>$V_{DS} = \text{Max Rating}$ , $T_C = 125^{\circ}\text{C}$ |      |      | 1<br>50  | $\mu\text{A}$<br>$\mu\text{A}$ |
| $I_{GSS}$     | Gate-body Leakage Current ( $V_{DS} = 0$ )       | $V_{GS} = \pm 20\text{V}$                                                                  |      |      | $\pm 10$ | $\mu\text{A}$                  |
| $V_{GS(th)}$  | Gate Threshold Voltage                           | $V_{DS} = V_{GS}$ , $I_D = 50\ \mu\text{A}$                                                | 3    | 3.75 | 4.5      | V                              |
| $R_{DS(on)}$  | Static Drain-source On Resistance                | $V_{GS} = 10\text{V}$ , $I_D = 0.7\ \text{A}$                                              |      | 7.2  | 8        | $\Omega$                       |

**Table 8: Dynamic**

| Symbol                                        | Parameter                                                               | Test Conditions                                                                                                                         | Min. | Typ.                | Max. | Unit                 |
|-----------------------------------------------|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|------|---------------------|------|----------------------|
| $g_{fs}$ (1)                                  | Forward Transconductance                                                | $V_{DS} = 15\ \text{V}$ , $I_D = 0.7\ \text{A}$                                                                                         |      | 1                   |      | S                    |
| $C_{iss}$<br>$C_{oss}$<br>$C_{rss}$           | Input Capacitance<br>Output Capacitance<br>Reverse Transfer Capacitance | $V_{DS} = 25\text{V}$ , $f = 1\ \text{MHz}$ , $V_{GS} = 0$                                                                              |      | 170<br>27<br>5      |      | pF<br>pF<br>pF       |
| $C_{oss\ eq. (3)}$                            | Equivalent Output Capacitance                                           | $V_{GS} = 0\text{V}$ , $V_{DS} = 0\text{V to } 480\text{V}$                                                                             |      | 30                  |      | pF                   |
| $t_{d(on)}$<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     | $V_{DD} = 300\ \text{V}$ , $I_D = 0.65\ \text{A}$ ,<br>$R_G = 4.7\ \Omega$ , $V_{GS} = 10\ \text{V}$<br>(Resistive Load see, Figure 22) |      | 8<br>30<br>22<br>55 |      | 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            | $V_{DD} = 480\text{V}$ , $I_D = 1.5\ \text{A}$ ,<br>$V_{GS} = 10\text{V}$<br>(see, Figure 24)                                           |      | 7.7<br>1.7<br>4     | 10   | nC<br>nC<br>nC       |

**Table 9: Source Drain Diode**

| Symbol                            | Parameter                                                                    | Test Conditions                                                                                                                                        | Min. | Typ.              | Max.     | Unit                     |
|-----------------------------------|------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------------------|----------|--------------------------|
| $I_{SD}$<br>$I_{SDM}$ (2)         | Source-drain Current<br>Source-drain Current (pulsed)                        |                                                                                                                                                        |      |                   | 1.5<br>6 | A<br>A                   |
| $V_{SD}$ (1)                      | Forward On Voltage                                                           | $I_{SD} = 1.5\ \text{A}$ , $V_{GS} = 0$                                                                                                                |      |                   | 1.6      | V                        |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{RRM}$ | Reverse Recovery Time<br>Reverse Recovery Charge<br>Reverse Recovery Current | $I_{SD} = 1.3\ \text{A}$ , $di/dt = 100\ \text{A}/\mu\text{s}$<br>$V_{DD} = 25\text{V}$ , $T_j = 25^{\circ}\text{C}$<br>(see test circuit, Figure 23)  |      | 250<br>550<br>4.4 |          | ns<br>$\mu\text{C}$<br>A |
| $t_{rr}$<br>$Q_{rr}$<br>$I_{RRM}$ | Reverse Recovery Time<br>Reverse Recovery Charge<br>Reverse Recovery Current | $I_{SD} = 1.3\ \text{A}$ , $di/dt = 100\ \text{A}/\mu\text{s}$<br>$V_{DD} = 25\text{V}$ , $T_j = 150^{\circ}\text{C}$<br>(see test circuit, Figure 23) |      | 300<br>690<br>4.6 |          | ns<br>$\mu\text{C}$<br>A |

(1) Pulsed: Pulse duration = 300  $\mu\text{s}$ , duty cycle 1.5 %.

(2) Pulse width limited by safe operating area.

(3)  $C_{oss\ eq.}$  is defined as a constant equivalent capacitance giving the same charging time as  $C_{oss}$  when  $V_{DS}$  increases from 0 to 80%  $V_{DSS}$

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Figure 3: Safe Operating Area For TO-220

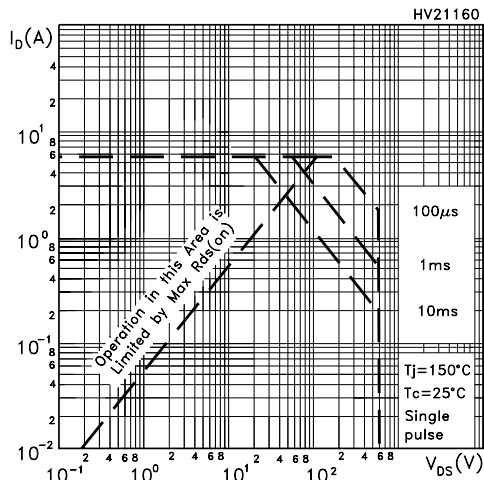


Figure 4: Safe Operating Area For IPAK

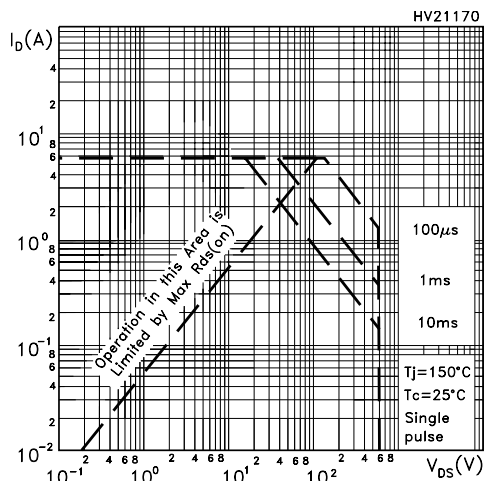


Figure 5: Safe Operating Area For TO-92

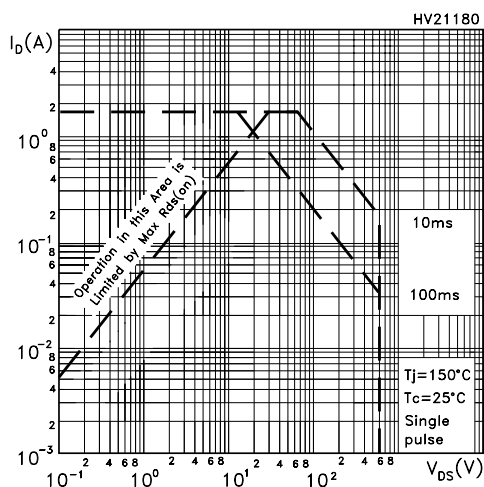


Figure 6: Thermal Impedance For TO-220

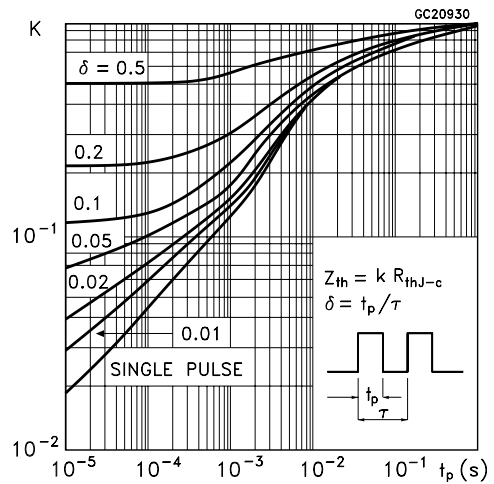


Figure 7: Thermal Impedance For IPAK

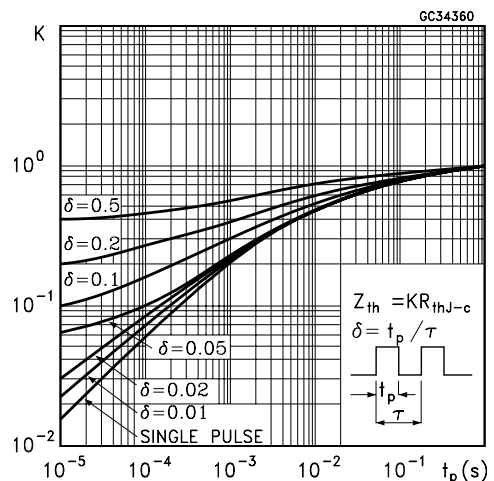
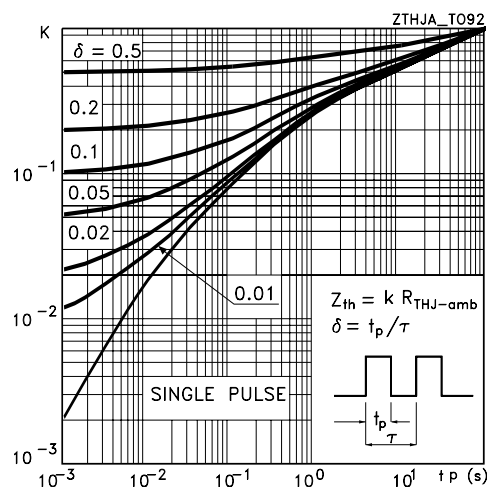


Figure 8: Thermal Impedance For TO-92



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Figure 9: Safe Operating Area For TO-220FP

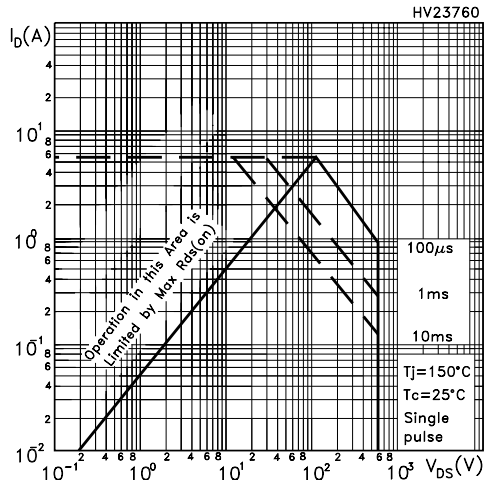


Figure 10: Output Characteristics

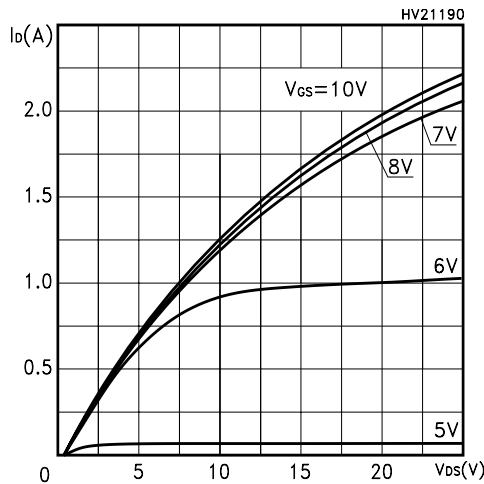


Figure 11: Transconductance

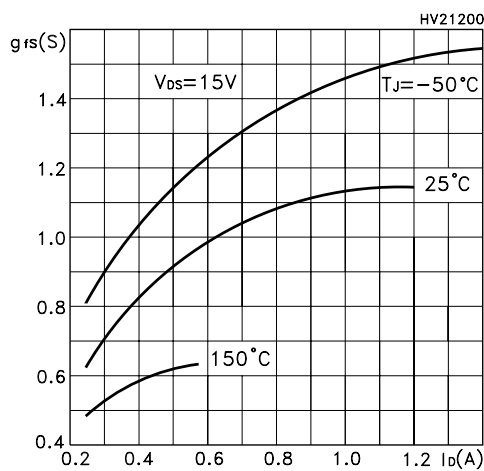


Figure 12: Thermal Impedance For TO-220FP

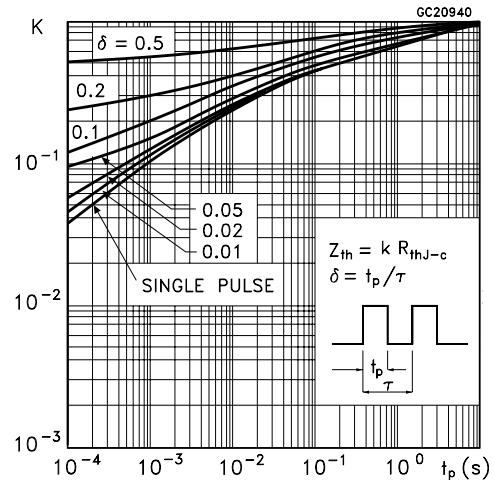


Figure 13: Transfer Characteristics

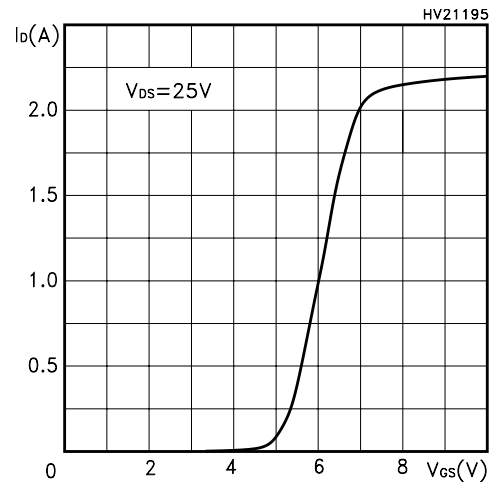
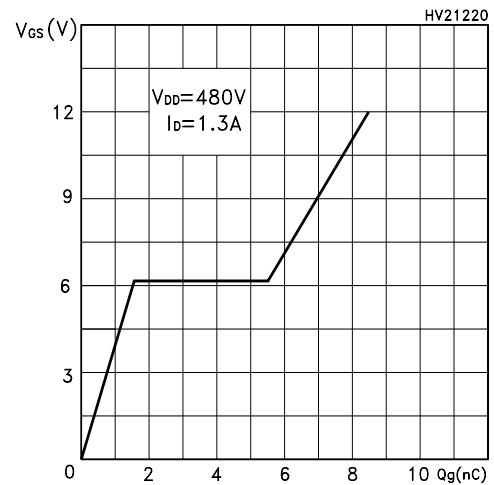


Figure 14: Gate Charge vs Gate-source Voltage



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Figure 15: Static Drain-source On Resistance

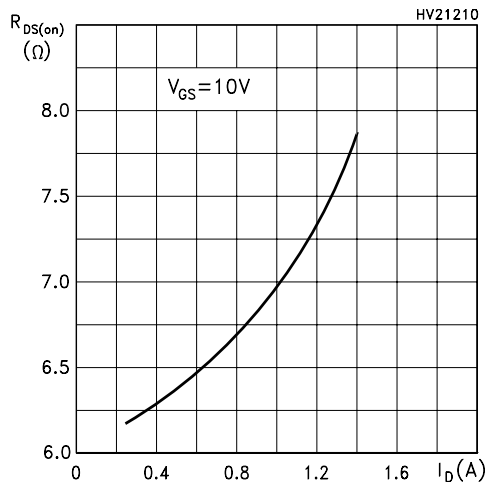


Figure 16: Capacitance Variations

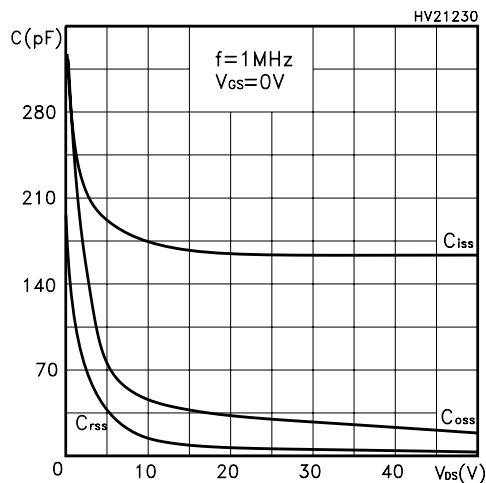


Figure 17: Normalized Gate Threshold Voltage vs Temperature

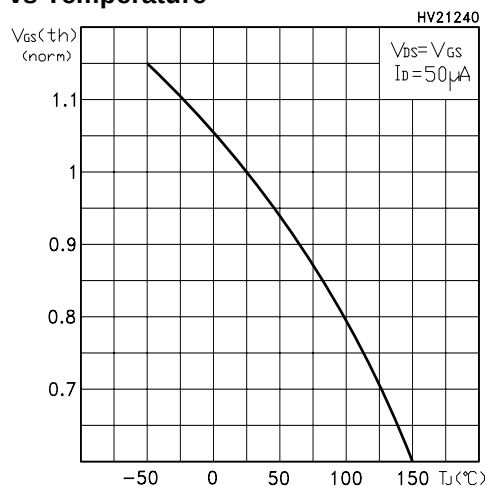


Figure 18: Source-Drain Forward Characteristics

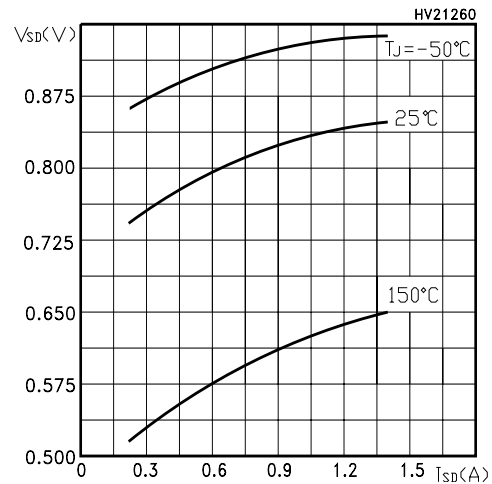


Figure 19: Maximum Avalanche Energy vs Temperature

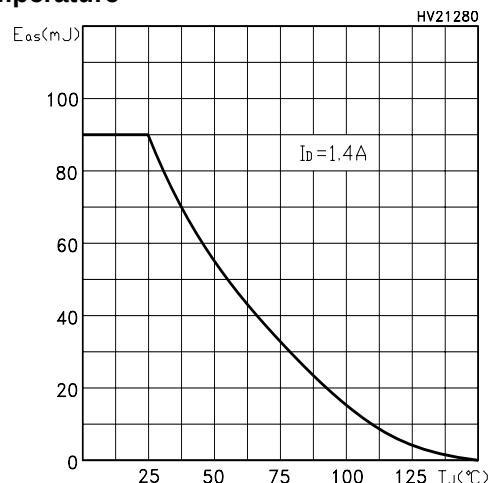
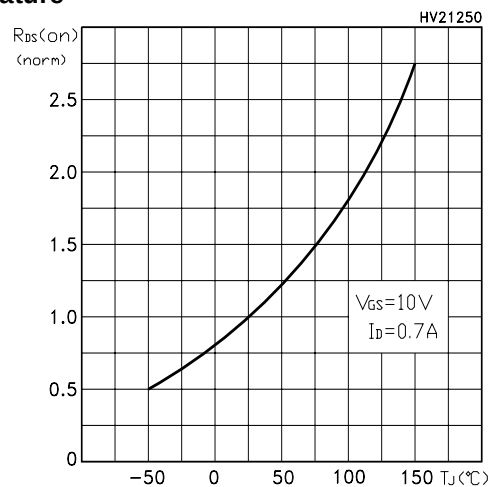
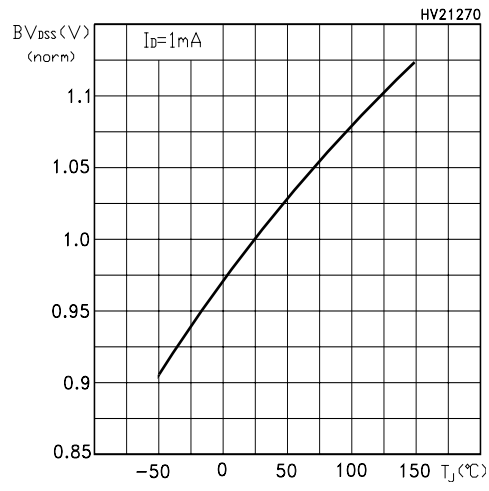


Figure 20: Normalized On Resistance vs Temperature



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Figure 21: Normalized  $BV_{DSS}$  vs Temperature



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Figure 22: Switching Times Test Circuit For Resistive Load

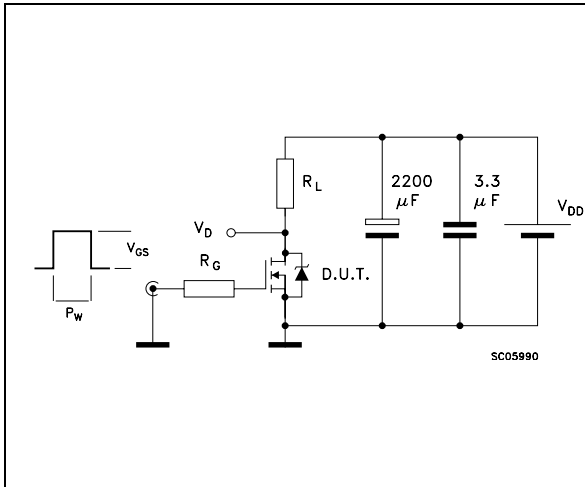


Figure 23: Test Circuit For Inductive Load Switching and Diode Recovery Times

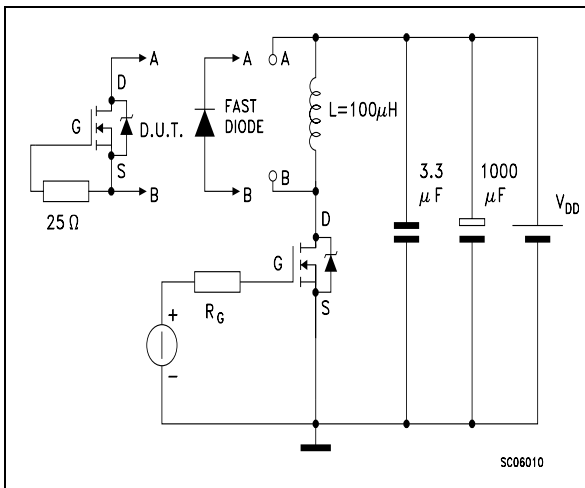
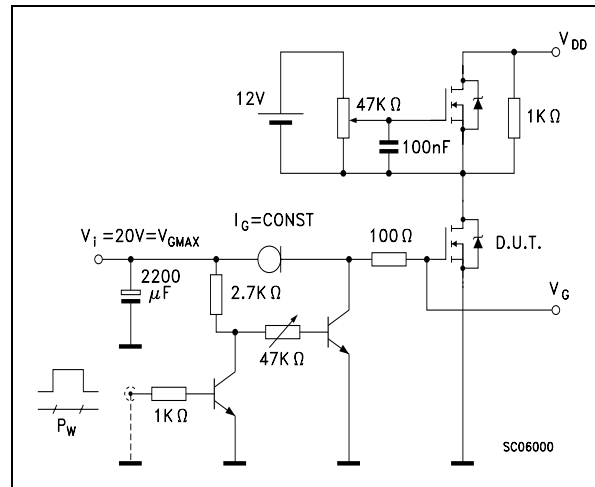


Figure 24: Gate Charge Test Circuit



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**STQ2NK60ZR-AP - STP2NK60Z - STF2NK60Z - STD2NK60Z-1**

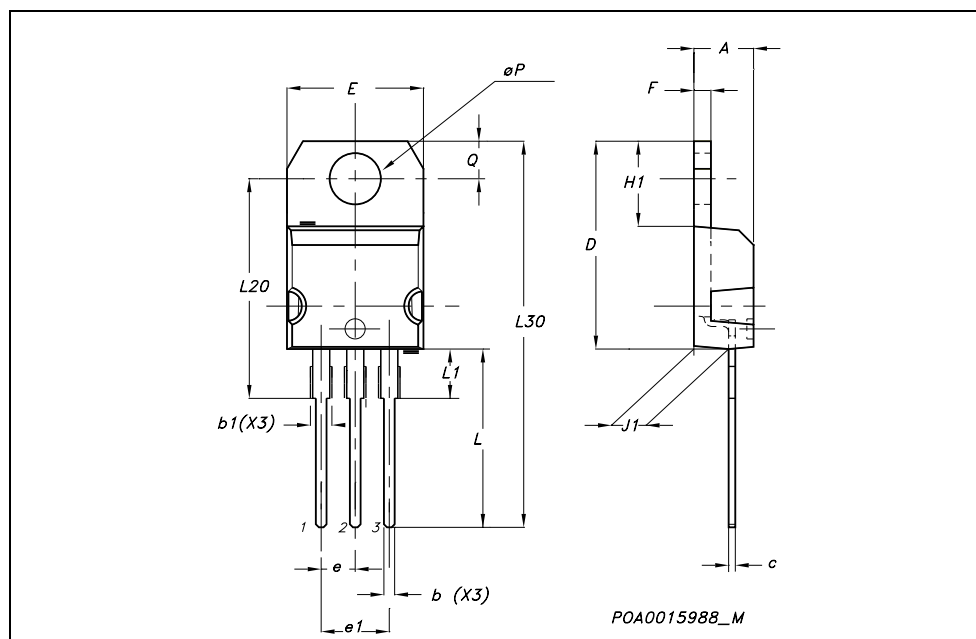
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In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect . The category of second level interconnect is marked on the package and on the inner box label, in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

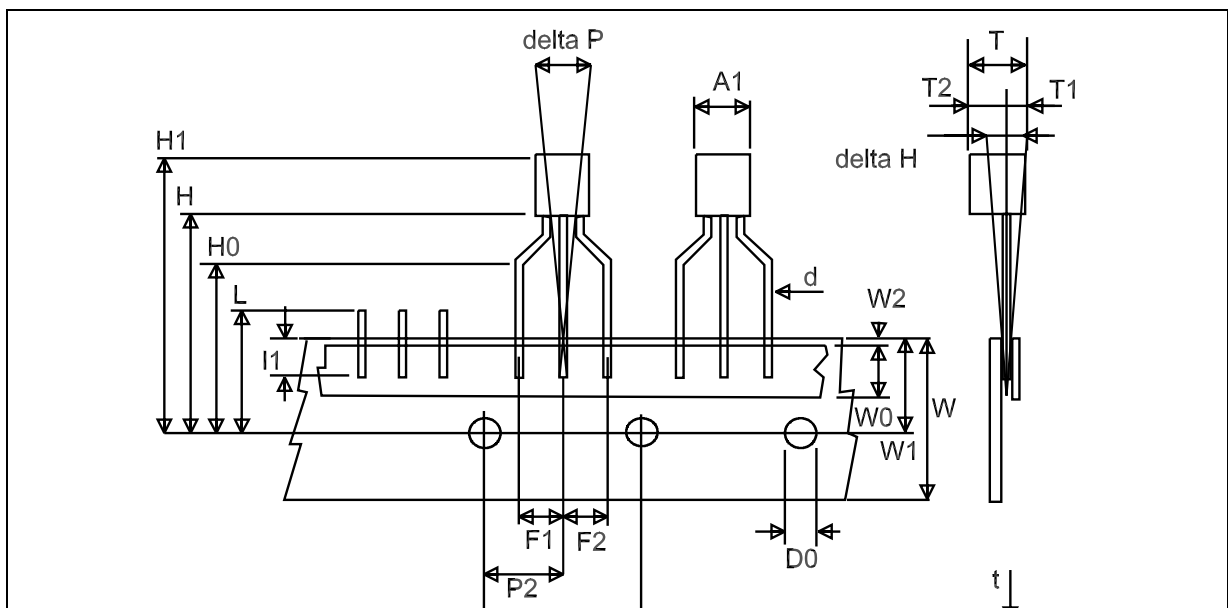
| DIM. | mm.   |       |       | inch  |       |       |
|------|-------|-------|-------|-------|-------|-------|
|      | MIN.  | TYP   | MAX.  | MIN.  | TYP.  | MAX.  |
| A    | 4.40  |       | 4.60  | 0.173 |       | 0.181 |
| b    | 0.61  |       | 0.88  | 0.024 |       | 0.034 |
| b1   | 1.15  |       | 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 |



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TO-92 AMMOPACK

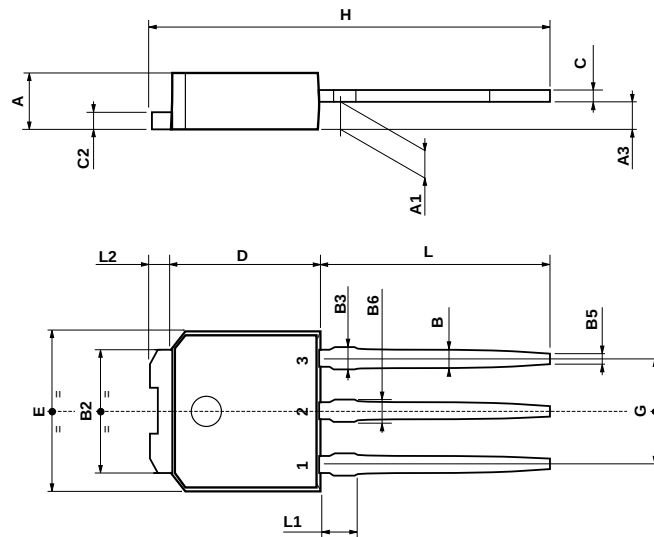
| DIM.    | mm.  |      |      | inch  |       |       |
|---------|------|------|------|-------|-------|-------|
|         | MIN. | TYP  | MAX. | MIN.  | TYP.  | MAX.  |
| A1      | 4.45 |      | 4.95 | 0.170 |       | 0.194 |
| T       | 3.30 |      | 3.94 | 0.130 |       | 0.155 |
| T1      |      |      | 1.6  |       |       | 0.06  |
| T2      |      |      | 2.3  |       |       | 0.09  |
| d       | 0.41 |      | 0.56 | 0.016 |       | 0.022 |
| P0      | 12.5 | 12.7 | 12.9 | 0.49  | 0.5   | 0.51  |
| P2      | 5.65 | 6.35 | 7.05 | 0.22  | 0.25  | 0.27  |
| F1, F2  | 2.44 | 2.54 | 2.94 | 0.09  | 0.1   | 0.11  |
| delta H | -2   |      | 2    | -0.08 |       | 0.08  |
| W       | 17.5 | 18   | 19   | 0.69  | 0.71  | 0.74  |
| W0      | 5.7  | 6    | 6.3  | 0.22  | 0.23  | 0.24  |
| W1      | 8.5  | 9    | 9.25 | 0.33  | 0.35  | 0.36  |
| W2      |      |      | 0.5  |       |       | 0.02  |
| H       | 18.5 |      | 20.5 | 0.72  |       | 0.80  |
| H0      | 15.5 | 16   | 16.5 | 0.61  | 0.63  | 0.65  |
| H1      |      |      | 25   |       |       | 0.98  |
| D0      | 3.8  | 4    | 4.2  | 0.15  | 0.157 | 0.16  |
| t       |      |      | 0.9  |       |       | 0.035 |
| L       |      |      | 11   |       |       | 0.43  |
| l1      | 3    |      |      | 0.11  |       |       |
| delta P | -1   |      | 1    | -0.04 |       | 0.04  |



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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 |

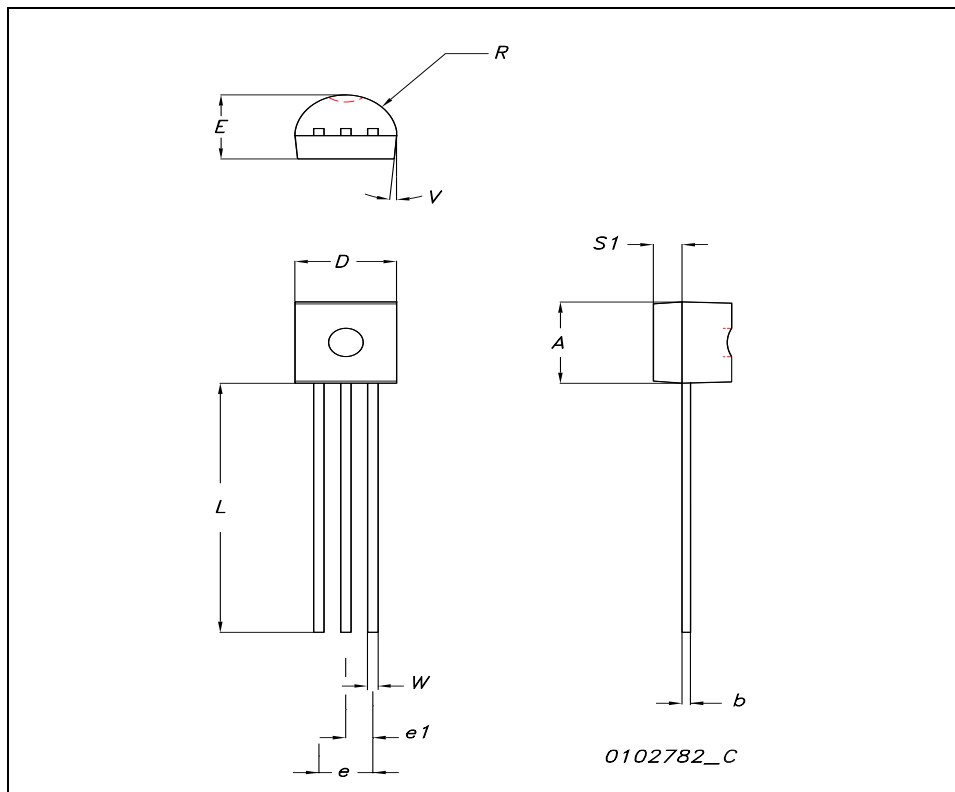


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STQ2NK60ZR-AP - STP2NK60Z - STF2NK60Z - STD2NK60Z-1

TO-92 MECHANICAL DATA

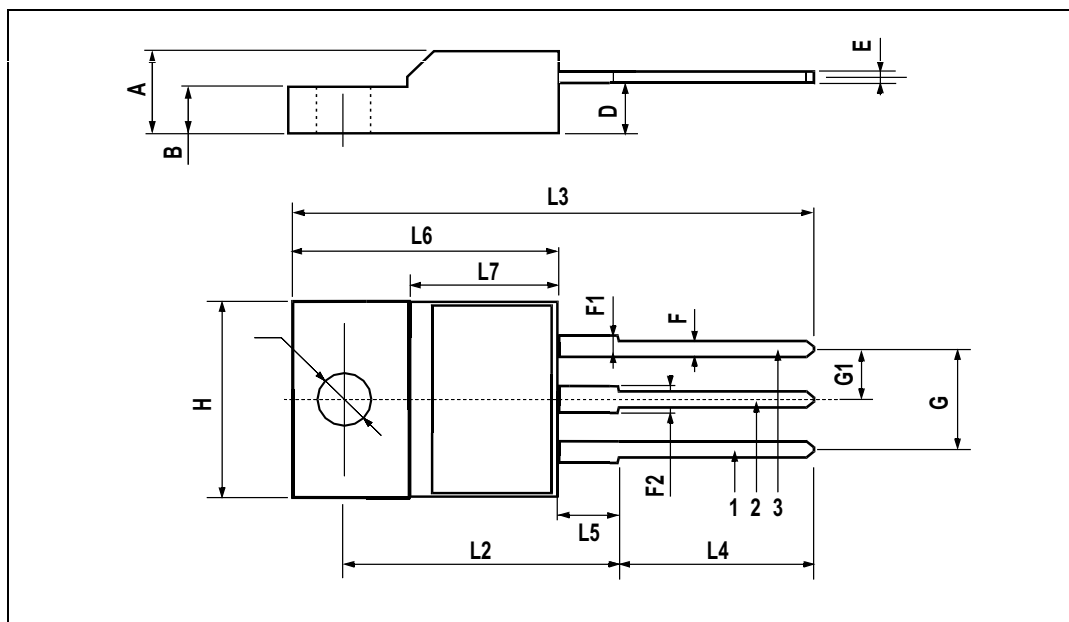
| DIM. | mm.   |      |       | inch  |      |       |
|------|-------|------|-------|-------|------|-------|
|      | MIN.  | TYP. | MAX.  | MIN.  | TYP. | MAX.  |
| A    | 4.32  |      | 4.95  | 0.170 |      | 0.194 |
| b    | 0.36  |      | 0.51  | 0.014 |      | 0.020 |
| D    | 4.45  |      | 4.95  | 0.175 |      | 0.194 |
| E    | 3.30  |      | 3.94  | 0.130 |      | 0.155 |
| e    | 2.41  |      | 2.67  | 0.094 |      | 0.105 |
| e1   | 1.14  |      | 1.40  | 0.044 |      | 0.055 |
| L    | 12.70 |      | 15.49 | 0.50  |      | 0.610 |
| R    | 2.16  |      | 2.41  | 0.085 |      | 0.094 |
| S1   | 0.92  |      | 1.52  | 0.036 |      | 0.060 |
| W    | 0.41  |      | 0.56  | 0.016 |      | 0.022 |
| V    |       | 5°   |       |       | 5°   |       |



STQ2NK60ZR-AP - STP2NK60Z - STF2NK60Z - STD2NK60Z-1

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 |



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**STQ2NK60ZR-AP - STP2NK60Z - STF2NK60Z - STD2NK60Z-1**

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**Table 10: Revision History**

| Date        | Revision | Description of Changes                                            |
|-------------|----------|-------------------------------------------------------------------|
| 07-Jul-2004 | 3        | The document change from "TARGET" to "COMPLETE"<br>New stylesheet |
| 11/Nov/2004 | 4        | Added TO-220FP                                                    |
| 05-Sep-2005 | 5        | Inserted Ecopack indication                                       |

**STQ2NK60ZR-AP - STP2NK60Z - STF2NK60Z - STD2NK60Z-1**

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