

# MOSFET

Metal Oxide Semiconductor Field Effect Transistor

## CoolMOS E6

600V CoolMOS™ E6 Power Transistor  
IPx60R520E6

## Data Sheet

Rev. 2.0, 2010-04-09  
Final

Industrial & Multimarket

## 600V CoolMOS™ E6 Power Transistor

## IPP60R520E6, IPA60R520E6

### 1 Description

CoolMOS™ is a revolutionary technology for high voltage power MOSFETs, designed according to the superjunction (SJ) principle and pioneered by Infineon Technologies. CoolMOS™ E6 series combines the experience of the leading SJ MOSFET supplier with high class innovation. The offered devices provide all benefits of a fast switching SJ MOSFET while not sacrificing ease of use. Extremely low switching and conduction losses make switching applications even more efficient, more compact, lighter, and cooler.

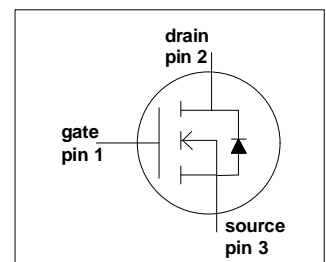
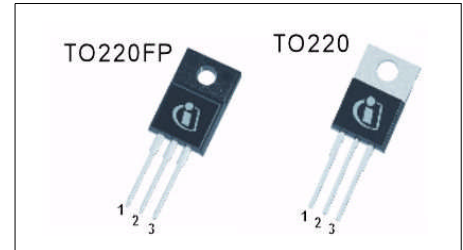
#### Features

- Extremely low losses due to very low FOM  $R_{DS(on)} \cdot Q_g$  and  $E_{oss}$
- Very high commutation ruggedness
- Easy to use/drive
- JEDEC<sup>1)</sup> qualified, Pb-free plating, halogen free

#### Applications

PFC stages, hard switching PWM stages and resonant switching PWM stages for e.g. PC Silverbox, Adapter, LCD & PDP TV, Lighting, Server, Telecom and UPS.

Please note: For MOSFET paralleling the use of ferrite beads on the gate or separate totem poles is generally recommended.



**Table 1 Key Performance Parameters**

| Parameter            | Value | Unit       |
|----------------------|-------|------------|
| $V_{DS} @ T_{j,max}$ | 650   | V          |
| $R_{DS(on),max}$     | 0.52  | $\Omega$   |
| $Q_{g,typ}$          | 23.4  | nC         |
| $I_{D,pulse}$        | 22    | A          |
| $E_{oss} @ 400V$     | 2.1   | $\mu J$    |
| Body diode $di/dt$   | 500   | A/ $\mu s$ |

| Type / Ordering Code | Package          | Marking | Related Links   |
|----------------------|------------------|---------|---|
| IPA60R520E6          | PG-TO220 FullPAK | 6R520E6 | <a href="#">IFX CoolMOS Webpage</a><br><a href="#">IFX Design tools</a> |
| IPP60R520E6          | PG-TO220         |         |   |

1) J-STD20 and JESD22



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## 2 Maximum ratings

at  $T_j = 25\text{ °C}$ , unless otherwise specified.

**Table 2 Maximum ratings**

| Parameter                                     | Symbol         | Values |      |      | Unit | Note / Test Condition   |
|---|----------------|--------|------|------|------|---|
|   |                | Min.   | Typ. | Max. |      |   |
| Continuous drain current <sup>1)</sup>        | $I_D$          | -      | -    | 8.1  | A    | $T_C = 25\text{ °C}$  |
|   |                |        |      | 5.1  |      | $T_C = 100\text{ °C}$   |
| Pulsed drain current <sup>2)</sup>            | $I_{D,pulse}$  | -      | -    | 22   | A    | $T_C = 25\text{ °C}$  |
| Avalanche energy, single pulse                | $E_{AS}$       | -      | -    | 153  | mJ   | $I_D = 1.4\text{ A}, V_{DD} = 50\text{ V}$<br>(see table 21)              |
| Avalanche energy, repetitive                  | $E_{AR}$       | -      | -    | 0.23 |      | $I_D = 1.3\text{ A}, V_{DD} = 50\text{ V}$                                |
| Avalanche current, repetitive                 | $I_{AR}$       | -      | -    | 1.4  | A    |   |
| MOSFET dv/dt ruggedness                       | dv/dt          | -      | -    | 50   | V/ns | $V_{DS} = 0 \dots 480\text{ V}$   |
| Gate source voltage                           | $V_{GS}$       | -20    | -    | 20   | V    | static  |
|   |                | -30    |      | 30   |      | AC ( $f > 1\text{ Hz}$ )  |
| Power dissipation for TO-220                  | $P_{tot}$      | -      | -    | 66   | W    | $T_C = 25\text{ °C}$  |
| Power dissipation for TO-220 FullPAK          | $P_{tot}$      | -      | -    | 29   | W    | $T_C = 25\text{ °C}$  |
| Operating and storage temperature             | $T_j, T_{stg}$ | -55    | -    | 150  | °C   |   |
| Mounting torque TO-220                        |                | -      | -    | 60   | Ncm  | M3 and M3.5 screws  |
| Mounting torque TO-220 FullPAK                |                |        |      | 50   |      | M2.5 screws   |
| Continuous diode forward current              | $I_S$          | -      | -    | 7    | A    | $T_C = 25\text{ °C}$  |
| Diode pulse current <sup>2)</sup>             | $I_{S,pulse}$  | -      | -    | 22   | A    | $T_C = 25\text{ °C}$  |
| Reverse diode dv/dt <sup>3)</sup>             | dv/dt          | -      | -    | 15   | V/ns | $V_{DS} = 0 \dots 400\text{ V}, I_{SD} \leq I_D,$<br>$T_j = 25\text{ °C}$ |
| Maximum diode commutation speed <sup>3)</sup> | di/dt          |        |      | 500  | A/μs | (see table 22)  |

1) Limited by  $T_{j,max}$ . Maximum duty cycle  $D = 0.75$

2) Pulse width  $t_p$  limited by  $T_{j,max}$

3) Identical low side and high side switch with identical  $R_G$

### 3 Thermal characteristics

**Table 3 Thermal characteristics TO-220 (IPP60R520E6)**

| Parameter  | Symbol     | Values |      |      | Unit | Note / Test Condition                 |
|--|------------|--------|------|------|------|---------------------------------------|
|  |            | Min.   | Typ. | Max. |      |                                       |
| Thermal resistance, junction - case                        | $R_{thJC}$ | -      | -    | 1.9  | °C/W | leaded                                |
| Thermal resistance, junction - ambient                     | $R_{thJA}$ | -      | -    | 62   |      |                                       |
| Soldering temperature, wavesoldering only allowed at leads | $T_{sold}$ | -      | -    | 260  | °C   | 1.6 mm (0.063 in.) from case for 10 s |

**Table 4 Thermal characteristics TO-220FullPAK (IPA60R520E6)**

| Parameter  | Symbol     | Values |      |      | Unit | Note / Test Condition                 |
|--|------------|--------|------|------|------|---------------------------------------|
|  |            | Min.   | Typ. | Max. |      |                                       |
| Thermal resistance, junction - case                        | $R_{thJC}$ | -      | -    | 4.3  | °C/W | leaded                                |
| Thermal resistance, junction - ambient                     | $R_{thJA}$ | -      | -    | 80   |      |                                       |
| Soldering temperature, wavesoldering only allowed at leads | $T_{sold}$ | -      | -    | 260  | °C   | 1.6 mm (0.063 in.) from case for 10 s |

## 4 Electrical characteristics

Electrical characteristics, at  $T_J=25\text{ °C}$ , unless otherwise specified.

**Table 5 Static characteristics**

| Parameter                        | Symbol        | Values |      |      | Unit          | Note / Test Condition  |
|----------------------------------|---------------|--------|------|------|---------------|--|
|                                  |               | Min.   | Typ. | Max. |               |  |
| Drain-source breakdown voltage   | $V_{(BR)DSS}$ | 600    | -    | -    | V             | $V_{GS}=0\text{ V}$ , $I_D=0.25\text{ mA}$                           |
| Gate threshold voltage           | $V_{GS(th)}$  | 2.5    | 3    | 3.5  |               | $V_{DS}=V_{GS}$ , $I_D=0.23\text{ mA}$                               |
| Zero gate voltage drain current  | $I_{DSS}$     | -      | -    | 1    | $\mu\text{A}$ | $V_{DS}=600\text{ V}$ , $V_{GS}=0\text{ V}$ ,<br>$T_J=25\text{ °C}$  |
|                                  |               | -      | 10   | -    |               | $V_{DS}=600\text{ V}$ , $V_{GS}=0\text{ V}$ ,<br>$T_J=150\text{ °C}$ |
| Gate-source leakage current      | $I_{GSS}$     | -      | -    | 100  | nA            | $V_{GS}=20\text{ V}$ , $V_{DS}=0\text{ V}$                           |
| Drain-source on-state resistance | $R_{DS(on)}$  | -      | 0.47 | 0.52 | $\Omega$      | $V_{GS}=10\text{ V}$ , $I_D=2.8\text{ A}$ ,<br>$T_J=25\text{ °C}$    |
|                                  |               | -      | 1.22 | -    |               | $V_{GS}=10\text{ V}$ , $I_D=2.8\text{ A}$ ,<br>$T_J=150\text{ °C}$   |
| Gate resistance                  | $R_G$         | -      | 9    | -    | $\Omega$      | $f=1\text{ MHz}$ , open drain  |

**Table 6 Dynamic characteristics**

| Parameter  | Symbol       | Values |      |      | Unit | Note / Test Condition   |
|--|--------------|--------|------|------|------|---|
|  |              | Min.   | Typ. | Max. |      |   |
| Input capacitance  | $C_{iss}$    | -      | 512  | -    | pF   | $V_{GS}=0\text{ V}$ , $V_{DS}=100\text{ V}$ ,<br>$f=1\text{ MHz}$   |
| Output capacitance   | $C_{oss}$    | -      | 35   | -    |      |   |
| Effective output capacitance, energy related <sup>1)</sup> | $C_{o(er)}$  | -      | 23   | -    |      |   |
| Effective output capacitance, time related <sup>2)</sup>   | $C_{o(tr)}$  | -      | 100  | -    |      | $I_D=\text{constant}$ , $V_{GS}=0\text{ V}$<br>$V_{DS}=0\dots480\text{ V}$  |
| Turn-on delay time   | $t_{d(on)}$  | -      | 12   | -    | ns   | $V_{DD}=400\text{ V}$ ,<br>$V_{GS}=13\text{ V}$ , $I_D=3.5\text{ A}$ ,<br>$R_G=6.8\text{ }\Omega$<br>(see table 20) |
| Rise time  | $t_r$        | -      | 10   | -    |      |   |
| Turn-off delay time  | $t_{d(off)}$ | -      | 75   | -    |      |   |
| Fall time  | $t_f$        | -      | 9    | -    |      |   |

1)  $C_{o(er)}$  is a fixed capacitance that gives the same stored energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{(BR)DSS}$

2)  $C_{o(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{(BR)DSS}$

**Table 7 Gate charge characteristics**

| Parameter             | Symbol        | Values |      |      | Unit | Note / Test Condition  |
|-----------------------|---------------|--------|------|------|------|--|
|                       |               | Min.   | Typ. | Max. |      |  |
| Gate to source charge | $Q_{gs}$      | -      | 2.8  | -    | nC   | $V_{DD}=480\text{ V}$ , $I_D=3.5\text{ A}$ ,<br>$V_{GS}=0\text{ to }10\text{ V}$ |
| Gate to drain charge  | $Q_{gd}$      | -      | 12   | -    |      |  |
| Gate charge total     | $Q_g$         | -      | 23.4 | -    |      |  |
| Gate plateau voltage  | $V_{plateau}$ | -      | 5.4  | -    | V    |  |

**Table 8 Reverse diode characteristics**

| Parameter                     | Symbol    | Values |      |      | Unit          | Note / Test Condition   |
|-------------------------------|-----------|--------|------|------|---------------|---|
|                               |           | Min.   | Typ. | Max. |               |   |
| Diode forward voltage         | $V_{SD}$  | -      | 0.9  | -    | V             | $V_{GS}=0\text{ V}$ , $I_F=3.5\text{ A}$ ,<br>$T_j=25\text{ °C}$                                  |
| Reverse recovery time         | $t_{rr}$  | -      | 260  | -    | ns            | $V_R=400\text{ V}$ , $I_F=3.5\text{ A}$ ,<br>$di_F/dt=100\text{ A}/\mu\text{s}$<br>(see table 22) |
| Reverse recovery charge       | $Q_{rr}$  | -      | 2.5  | -    | $\mu\text{C}$ |   |
| Peak reverse recovery current | $I_{rrm}$ | -      | 18   | -    | A             |   |

## 5 Electrical characteristics diagrams

Table 9

| Power dissipation<br>TO-220 | Power dissipation<br>TO-220 FullPAK |
|-----------------------------|-------------------------------------|
|                             |                                     |
| $P_{tot} = f(T_C)$          | $P_{tot} = f(T_C)$                  |

Table 10

| Max. transient thermal impedance<br>TO-220       | Max. transient thermal impedance<br>TO-220 FullPAK |
|--|--|
|  |  |
| $Z_{(thJC)} = f(t_p)$ ; parameter: $D = t_p / T$ | $Z_{(thJC)} = f(t_p)$ ; parameter: $D = t_p / T$   |



Table 11

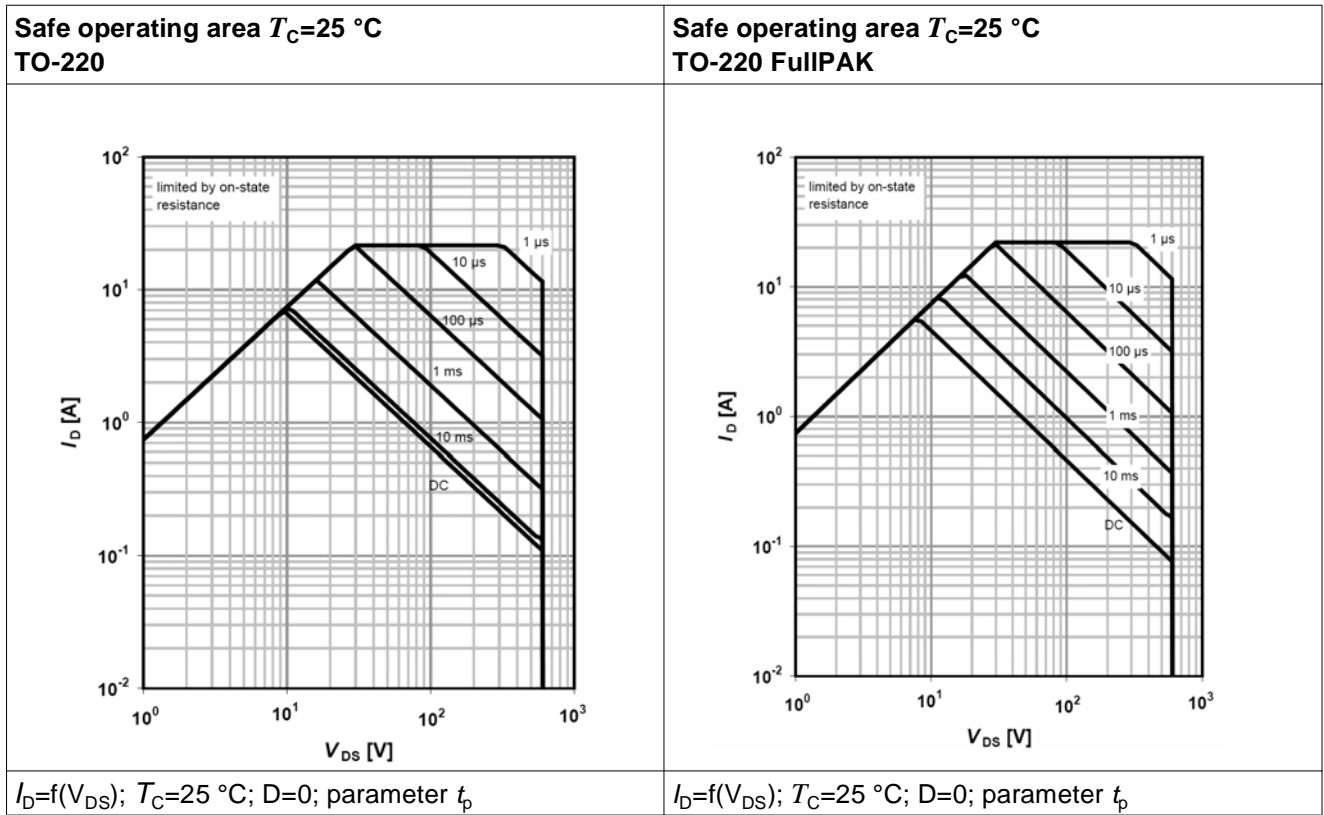


Table 12

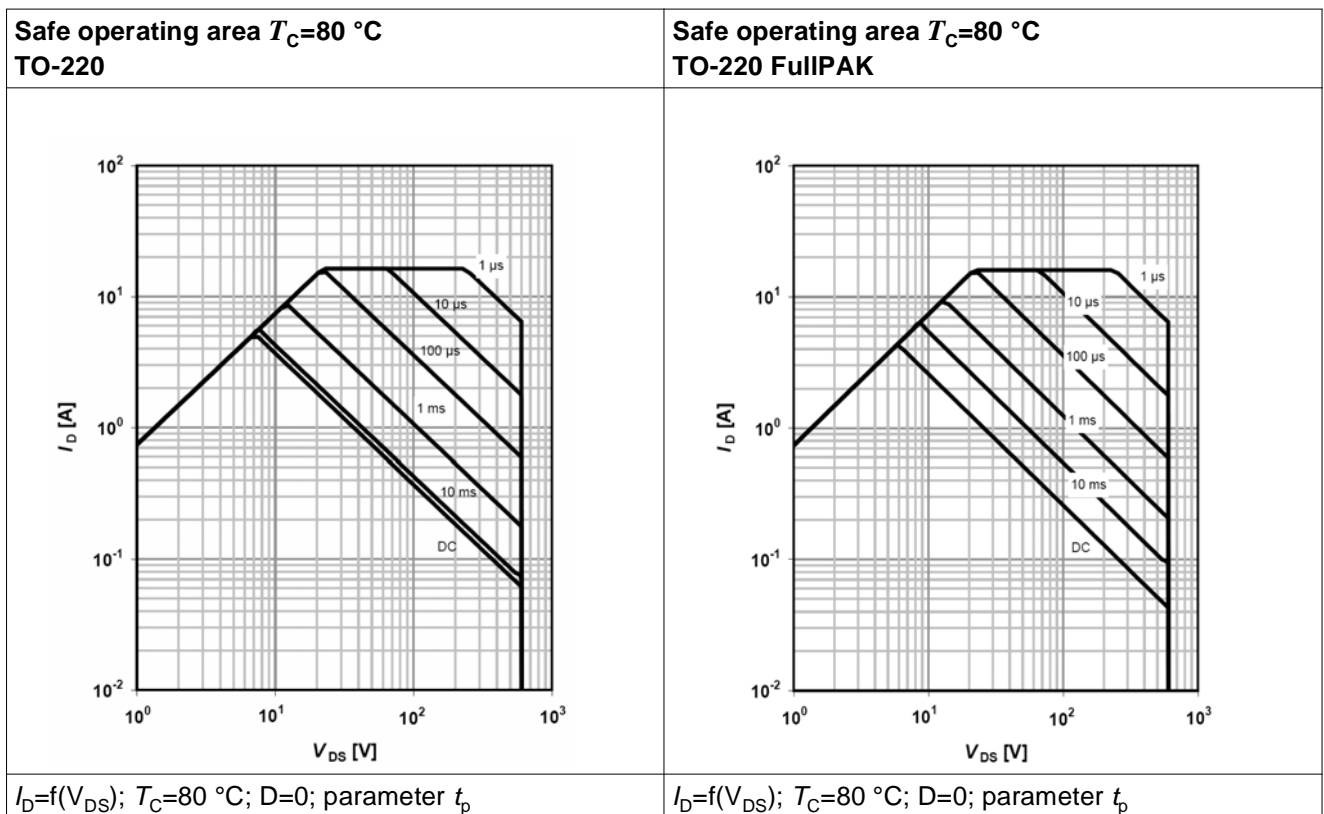


Table 13

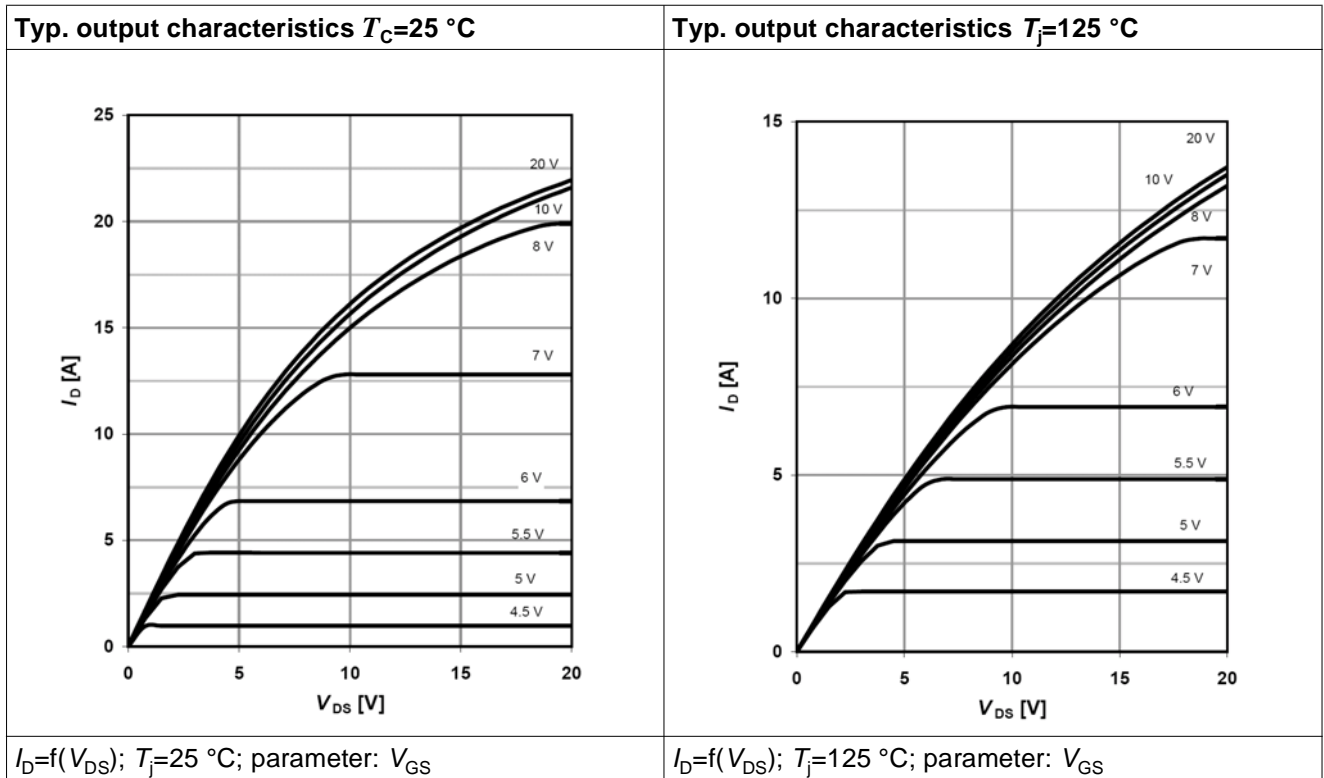


Table 14

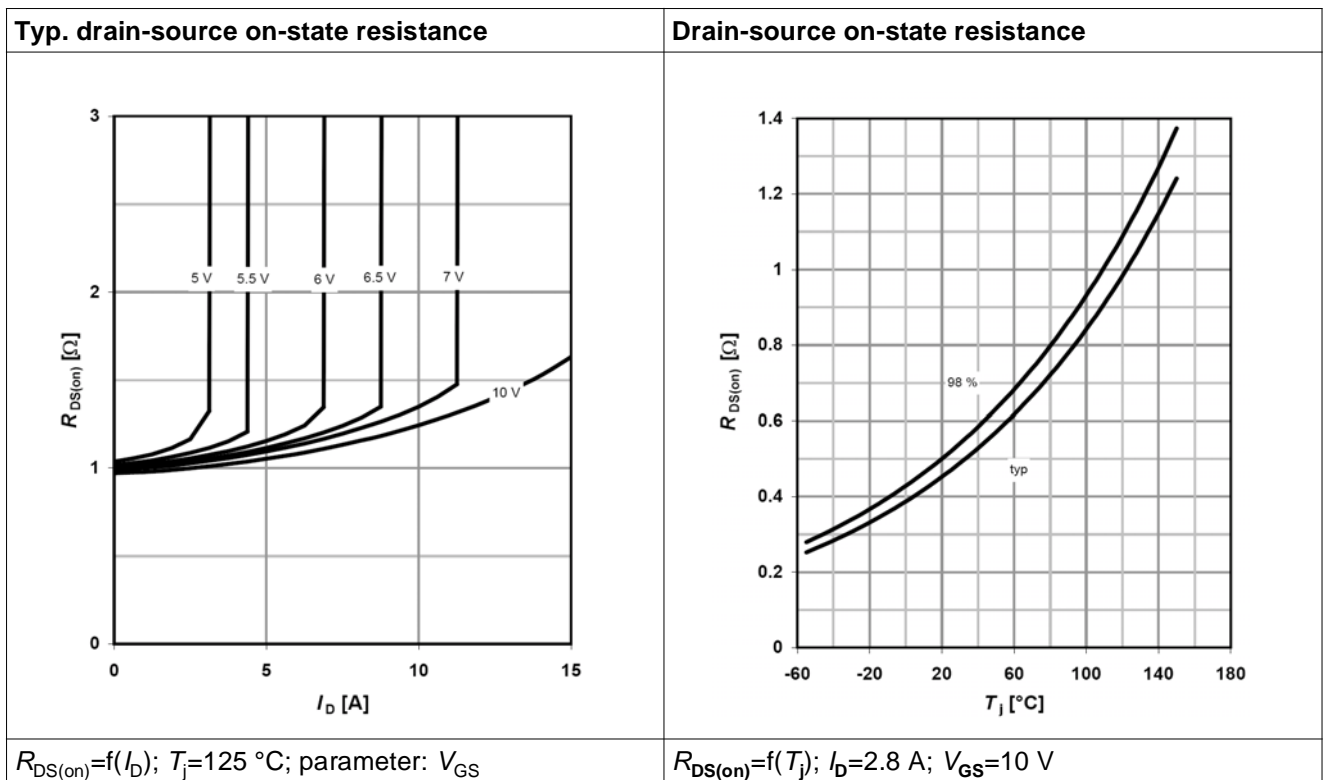


Table 15

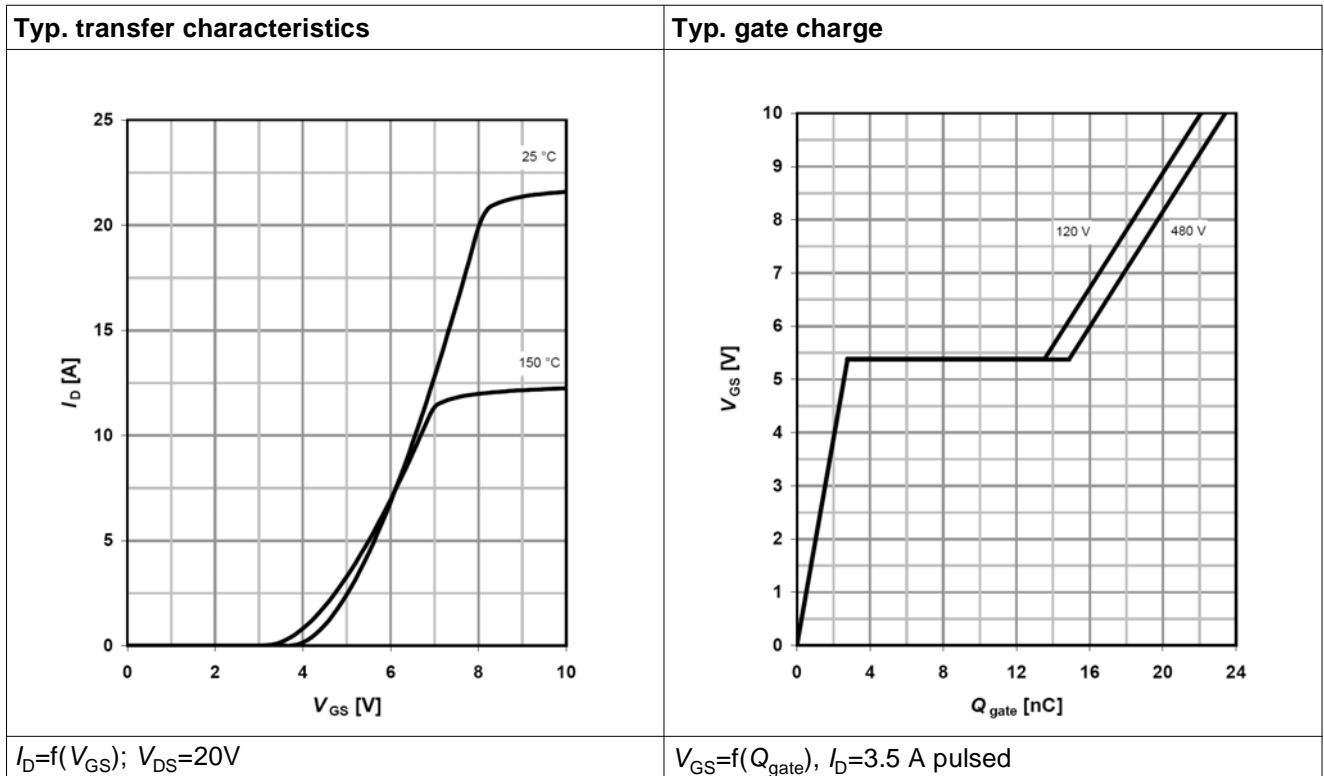


Table 16

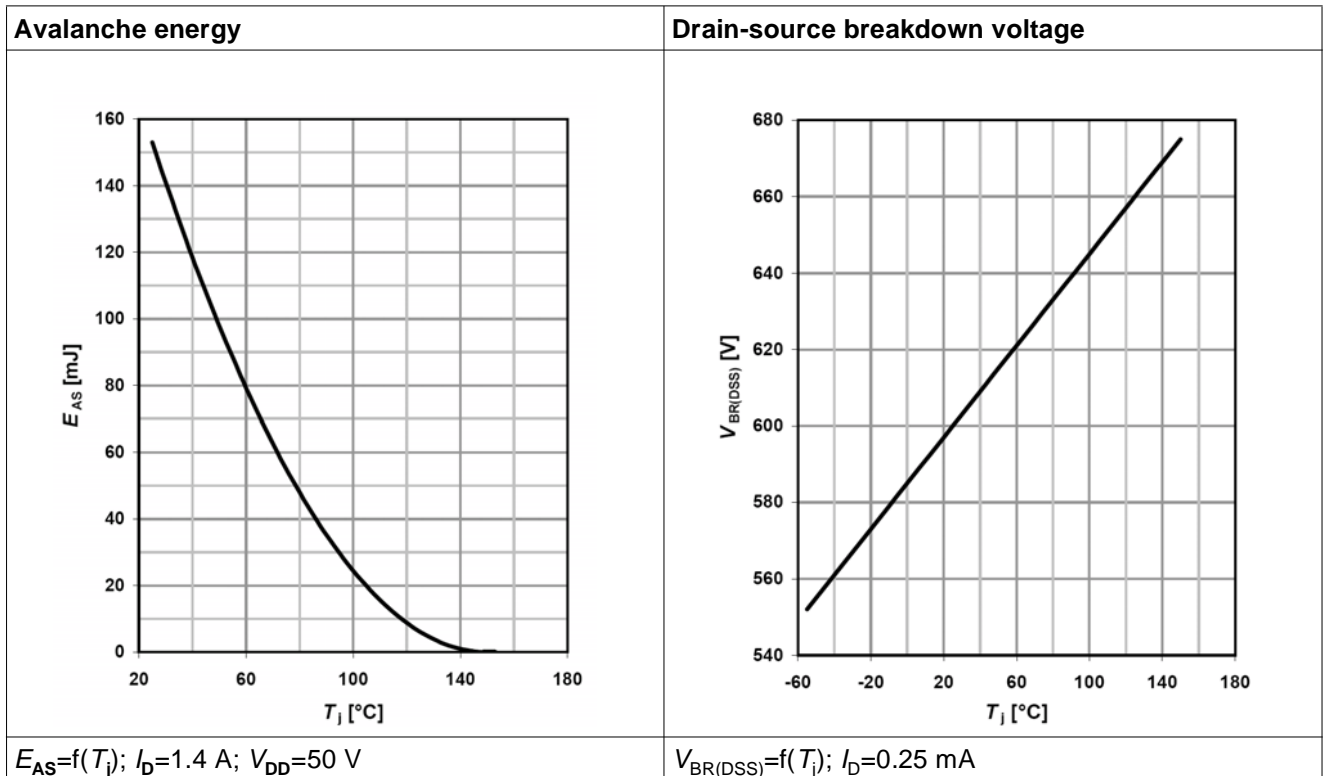


Table 17

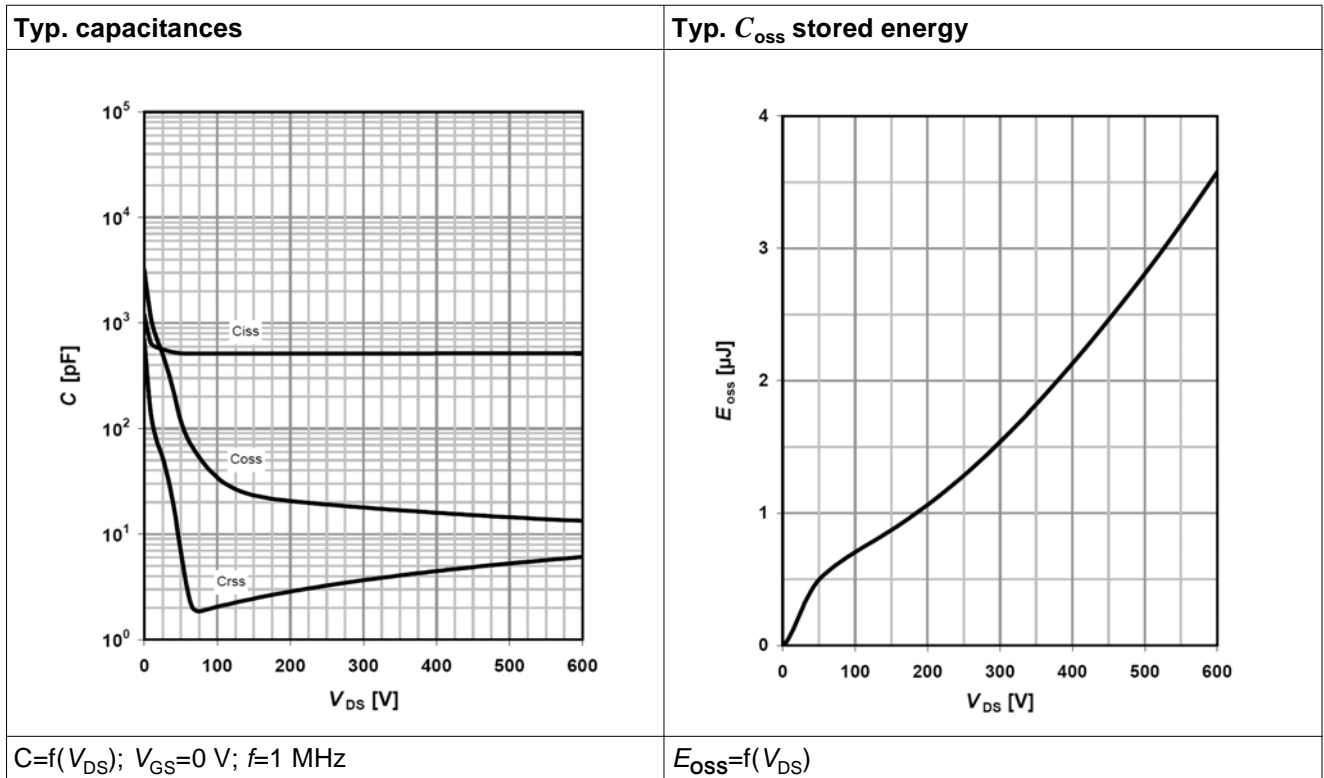
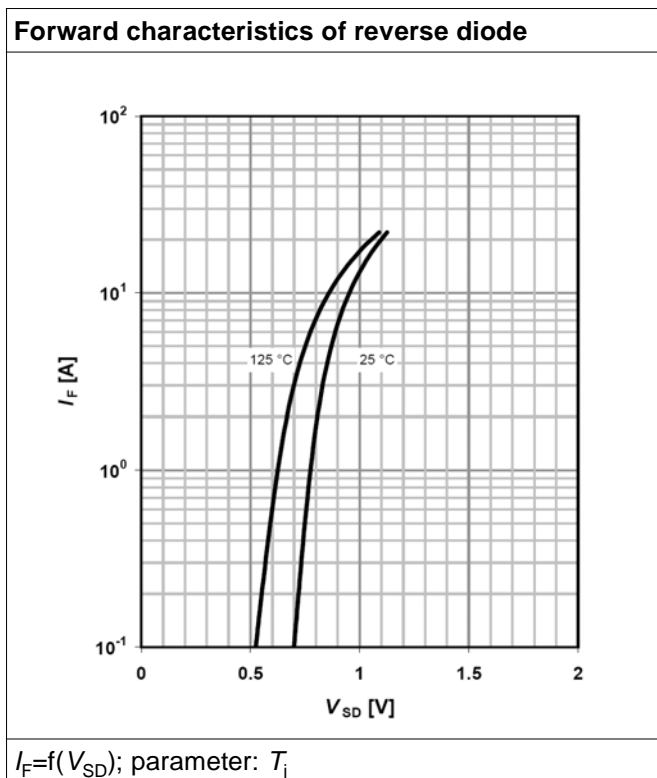


Table 18



## 6 Test circuits

Table 19 Switching times test circuit and waveform for inductive load

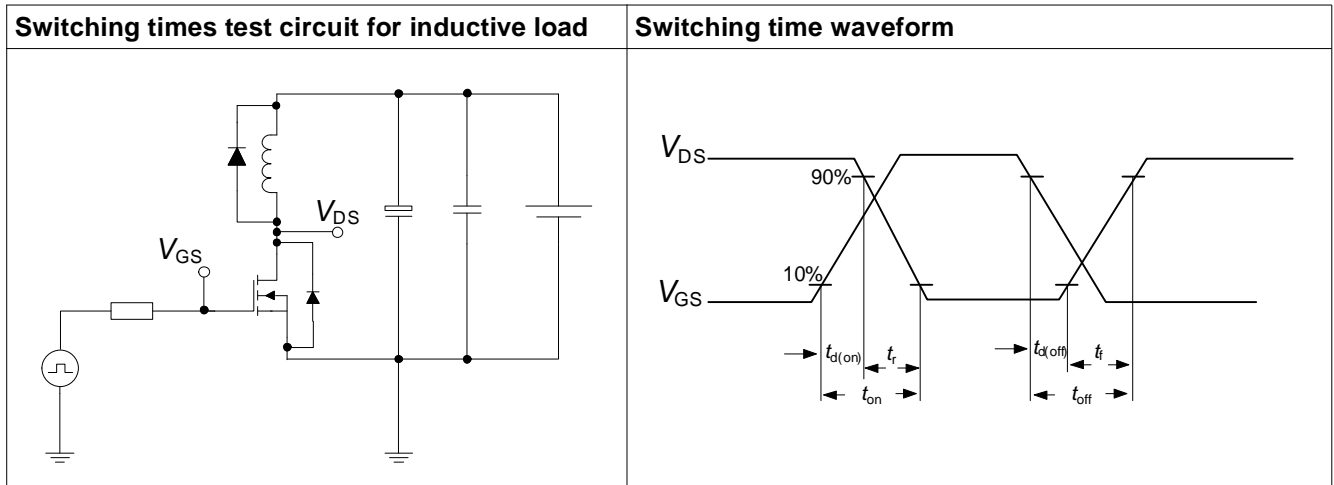


Table 20 Unclamped inductive load test circuit and waveform

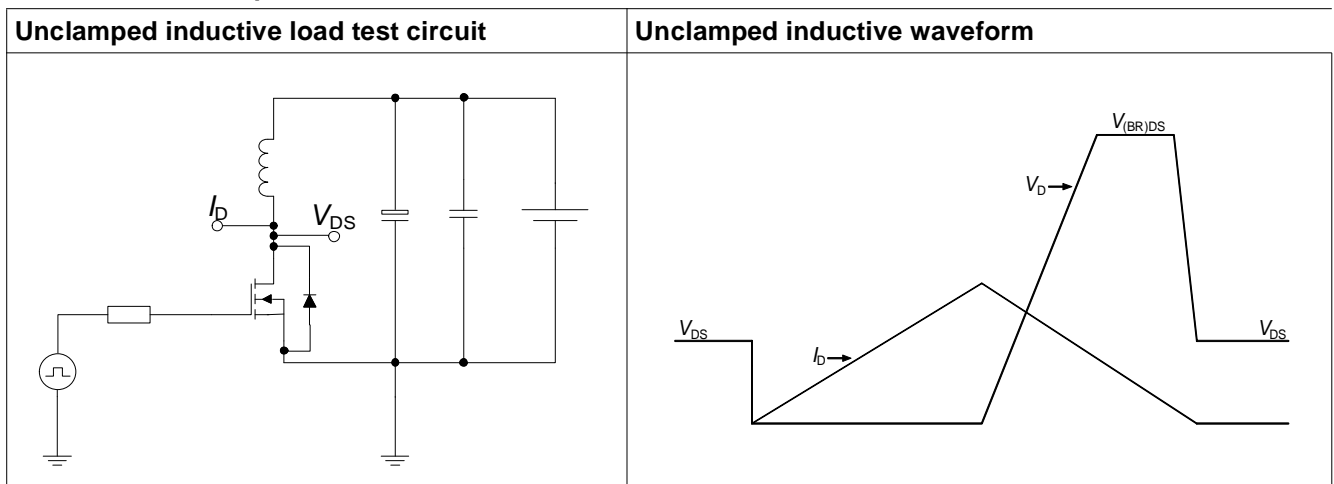
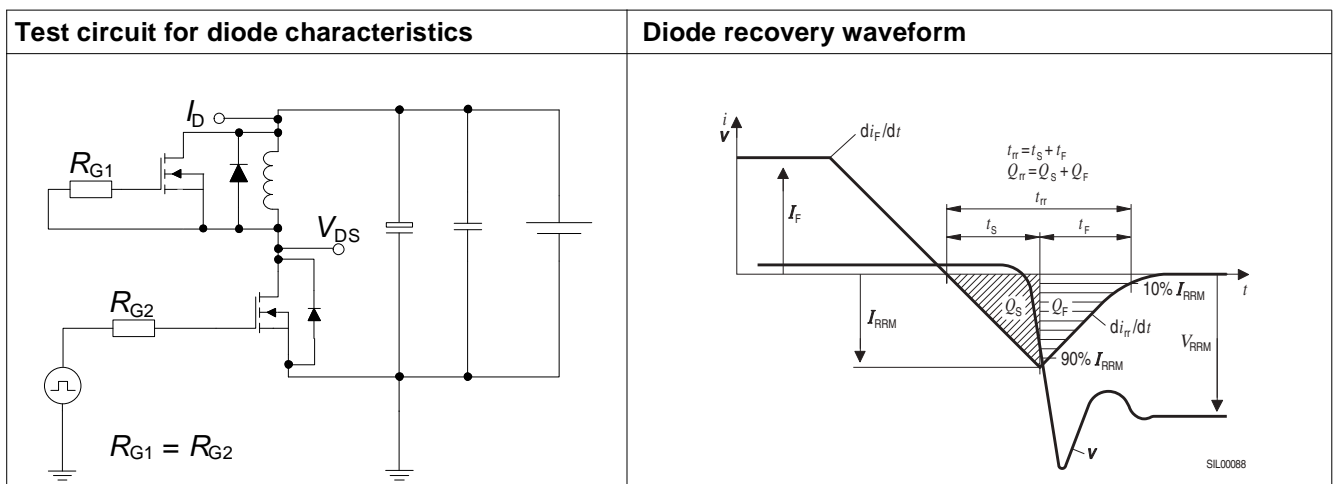
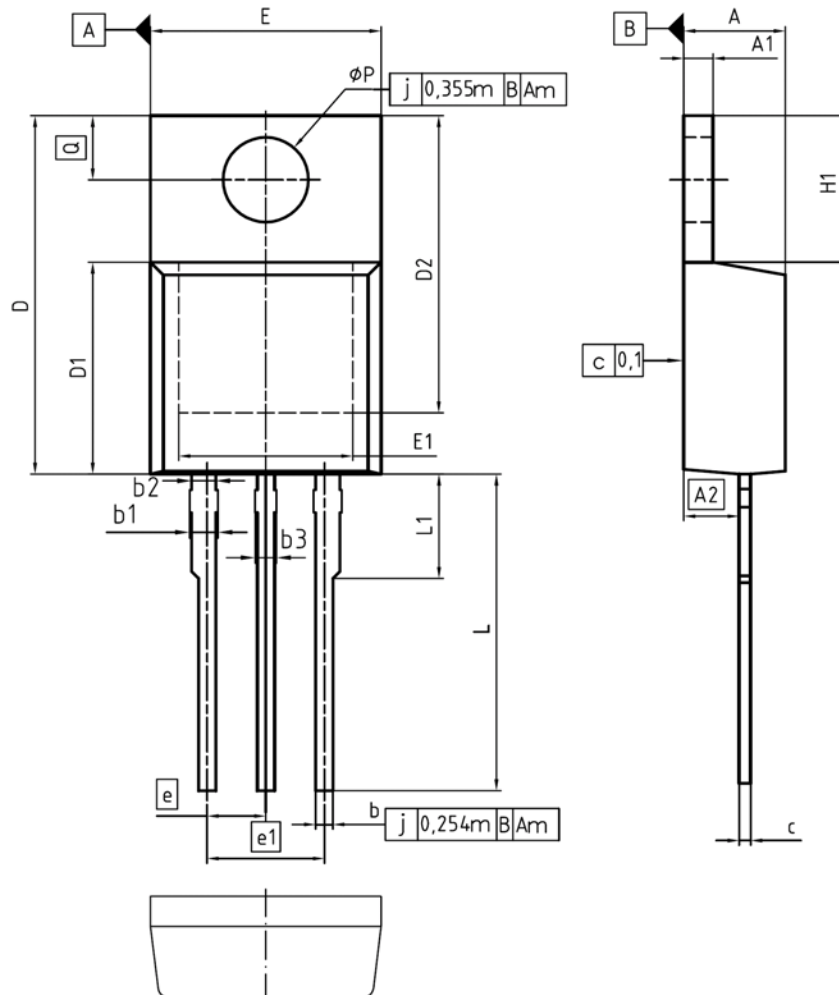


Table 21 Test circuit and waveform for diode characteristics



7 Package outlines



| DIM | MILLIMETERS |       | INCHES |       |
|-----|-------------|-------|--------|-------|
|     | MIN         | MAX   | MIN    | MAX   |
| A   | 4.30        | 4.57  | 0.169  | 0.180 |
| A1  | 1.17        | 1.40  | 0.046  | 0.055 |
| A2  | 2.15        | 2.72  | 0.085  | 0.107 |
| b   | 0.65        | 0.86  | 0.026  | 0.034 |
| b1  | 0.95        | 1.40  | 0.037  | 0.055 |
| b2  | 0.95        | 1.15  | 0.037  | 0.045 |
| b3  | 0.65        | 1.15  | 0.026  | 0.045 |
| c   | 0.33        | 0.60  | 0.013  | 0.024 |
| D   | 14.81       | 15.95 | 0.583  | 0.628 |
| D1  | 8.51        | 9.45  | 0.335  | 0.372 |
| D2  | 12.19       | 13.10 | 0.480  | 0.516 |
| E   | 9.70        | 10.36 | 0.382  | 0.408 |
| E1  | 6.50        | 8.60  | 0.256  | 0.339 |
| e   | 2.54        |       | 0.100  |       |
| e1  | 5.08        |       | 0.200  |       |
| N   | 3           |       | 3      |       |
| H1  | 5.90        | 6.90  | 0.232  | 0.272 |
| L   | 13.00       | 14.00 | 0.512  | 0.551 |
| L1  | -           | 4.80  | -      | 0.189 |
| øP  | 3.60        | 3.89  | 0.142  | 0.153 |
| Q   | 2.60        | 3.00  | 0.102  | 0.118 |

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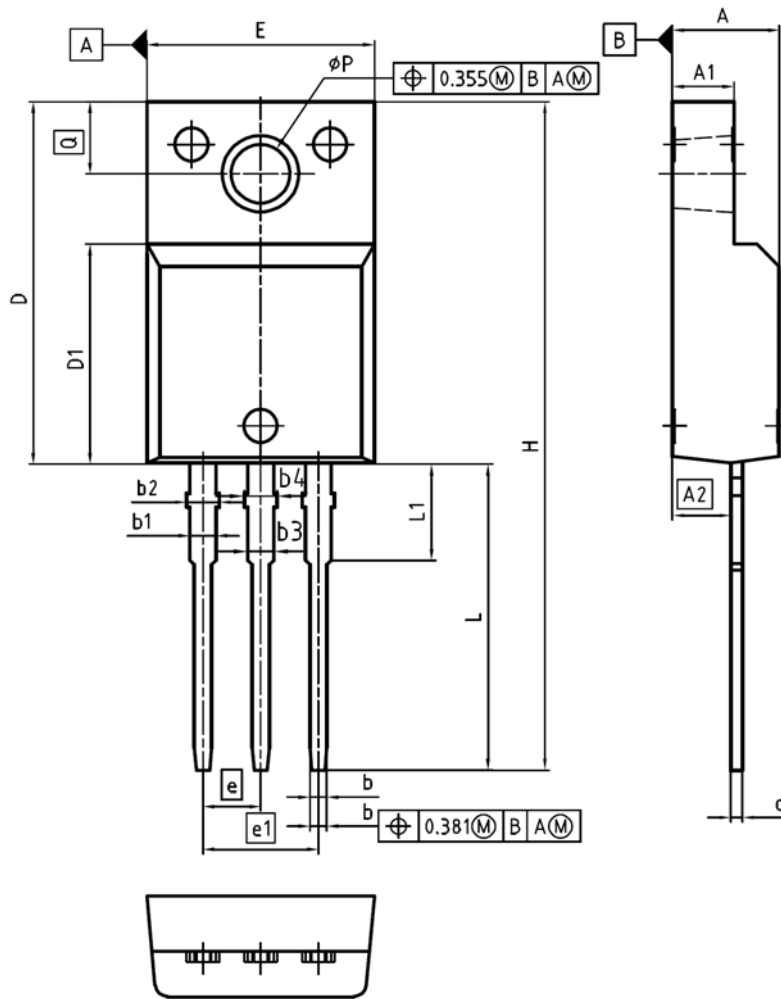
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ISSUE DATE  
23-08-2007

REVISION  
05

Figure 1 Outlines TO-220, dimensions in mm/inches



| DIM   | MILLIMETERS |       | INCHES |       |
|-------|-------------|-------|--------|-------|
|       | MIN         | MAX   | MIN    | MAX   |
| A     | 4.55        | 4.85  | 0.179  | 0.191 |
| A1    | 2.55        | 2.85  | 0.100  | 0.112 |
| A2    | 2.42        | 2.72  | 0.095  | 0.107 |
| b     | 0.65        | 0.85  | 0.026  | 0.033 |
| b1    | 0.95        | 1.33  | 0.037  | 0.052 |
| b2    | 0.95        | 1.51  | 0.037  | 0.059 |
| b3    | 0.65        | 1.33  | 0.026  | 0.052 |
| b4    | 0.65        | 1.51  | 0.026  | 0.059 |
| c     | 0.40        | 0.63  | 0.016  | 0.025 |
| D     | 15.85       | 16.15 | 0.624  | 0.636 |
| D1    | 9.53        | 9.83  | 0.375  | 0.387 |
| E     | 10.35       | 10.65 | 0.407  | 0.419 |
| e     | 2.54        |       | 0.100  |       |
| e1    | 5.08        |       | 0.200  |       |
| N     | 3           |       | 3      |       |
| H     | 29.45       | 29.75 | 1.159  | 1.171 |
| L     | 13.45       | 13.75 | 0.530  | 0.541 |
| L1    | 3.15        | 3.45  | 0.124  | 0.136 |
| phi P | 2.95        | 3.20  | 0.116  | 0.126 |
| Q     | 3.15        | 3.50  | 0.124  | 0.138 |

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03

Figure 2 Outlines TO-220 FullPAK, dimensions in mm/inches

## 8 Revision History

### CoolMOS E6 600V CoolMOS™ E6 Power Transistor

Revision History: 2010-04-09, Rev. 2.0

**Previous Revision:**

| Revision | Subjects (major changes since last revision) |
|----------|--|
| 2.0      | Release of final data sheet                  |
|          |  |
|          |  |

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