

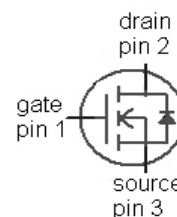
## OptiMOS<sup>®</sup> 2 Power-Transistor

### Features

- N-channel, normal level
- Excellent gate charge x  $R_{DS(on)}$  product (FOM)
- Very low on-resistance  $R_{DS(on)}$
- 175 °C operating temperature
- Pb-free lead plating; RoHS compliant
- Qualified according to JEDEC<sup>1)</sup> for target application
- Ideal for high-frequency switching and synchronous rectification

### Product Summary

|                          |     |    |
|--------------------------|-----|----|
| $V_{DS}$                 | 100 | V  |
| $R_{DS(on),max}$ (TO252) | 34  | mΩ |
| $I_D$                    | 27  | A  |



| Type    | IPB35CN10N G                                                                       | IPD33CN10N G                                                                       | IPI35CN10N G                                                                       | IPP35CN10N G                                                                        | IPU33CN10N G                                                                         |
|---------|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|         |  |  |  |  |  |
| Package | PG-TO263-3                                                                         | PG-TO252-3                                                                         | PG-TO262-3                                                                         | PG-TO220-3                                                                          | PG-TO251-3                                                                           |
| Marking | 35CN10N                                                                            | 33CN10N                                                                            | 35CN10N                                                                            | 35CN10N                                                                             | 33CN10N                                                                              |

**Maximum ratings**, at  $T_J=25\text{ °C}$ , unless otherwise specified

| Parameter                           | Symbol            | Conditions                                                                                           | Value       | Unit  |
|-------------------------------------|-------------------|------------------------------------------------------------------------------------------------------|-------------|-------|
| Continuous drain current            | $I_D$             | $T_C=25\text{ °C}$                                                                                   | 27          | A     |
|                                     |                   | $T_C=100\text{ °C}$                                                                                  | 20          |       |
| Pulsed drain current <sup>2)</sup>  | $I_{D,pulse}$     | $T_C=25\text{ °C}$                                                                                   | 108         |       |
| Avalanche energy, single pulse      | $E_{AS}$          | $I_D=27\text{ A}$ , $R_{GS}=25\text{ Ω}$                                                             | 47          | mJ    |
| Reverse diode $dv/dt$               | $dv/dt$           | $I_D=27\text{ A}$ , $V_{DS}=80\text{ V}$ ,<br>$di/dt=100\text{ A/μs}$ ,<br>$T_{j,max}=175\text{ °C}$ | 6           | kV/μs |
| Gate source voltage <sup>3)</sup>   | $V_{GS}$          |                                                                                                      | ±20         | V     |
| Power dissipation                   | $P_{tot}$         | $T_C=25\text{ °C}$                                                                                   | 58          | W     |
| Operating and storage temperature   | $T_j$ , $T_{stg}$ |                                                                                                      | -55 ... 175 | °C    |
| IEC climatic category; DIN IEC 68-1 |                   |                                                                                                      | 55/175/56   |       |

<sup>1)</sup> J-STD20 and JESD22

<sup>2)</sup> see figure 3

<sup>3)</sup>  $T_{j,max}=150\text{ °C}$  and duty cycle  $D=0.01$  for  $V_{GS}<-5\text{ V}$

| Parameter | Symbol | Conditions | Values |      |      | Unit |
|-----------|--------|------------|--------|------|------|------|
|           |        |            | min.   | typ. | max. |      |

### Thermal characteristics

|                                                              |            |                                  |   |   |     |     |
|--------------------------------------------------------------|------------|----------------------------------|---|---|-----|-----|
| Thermal resistance, junction - case                          | $R_{thJC}$ |                                  | - | - | 2.6 | K/W |
| Thermal resistance, junction - ambient (TO220, TO262, TO263) | $R_{thJA}$ | minimal footprint                | - | - | 62  |     |
|                                                              |            | 6 cm2 cooling area <sup>4)</sup> | - | - | 40  |     |
| Thermal resistance, junction - ambient (TO251, TO252)        |            | minimal footprint                | - | - | 75  |     |
|                                                              |            | 6 cm2 cooling area <sup>4)</sup> | - | - | 50  |     |

### Electrical characteristics, at $T_j=25\text{ }^{\circ}\text{C}$ , unless otherwise specified

#### Static characteristics

|                                  |               |                                                                          |     |     |     |               |
|----------------------------------|---------------|--------------------------------------------------------------------------|-----|-----|-----|---------------|
| Drain-source breakdown voltage   | $V_{(BR)DSS}$ | $V_{GS}=0\text{ V}, I_D=1\text{ mA}$                                     | 100 | -   | -   | V             |
| Gate threshold voltage           | $V_{GS(th)}$  | $V_{DS}=V_{GS}, I_D=29\text{ }\mu\text{A}$                               | 2   | 3   | 4   |               |
| Zero gate voltage drain current  | $I_{DSS}$     | $V_{DS}=80\text{ V}, V_{GS}=0\text{ V}, T_j=25\text{ }^{\circ}\text{C}$  | -   | 0.1 | 1   | $\mu\text{A}$ |
|                                  |               | $V_{DS}=80\text{ V}, V_{GS}=0\text{ V}, T_j=125\text{ }^{\circ}\text{C}$ | -   | 10  | 100 |               |
| Gate-source leakage current      | $I_{GSS}$     | $V_{GS}=20\text{ V}, V_{DS}=0\text{ V}$                                  | -   | 1   | 100 | nA            |
| Drain-source on-state resistance | $R_{DS(on)}$  | $V_{GS}=10\text{ V}, I_D=27\text{ A}, (TO252)$                           | -   | 25  | 33  | m $\Omega$    |
|                                  |               | $V_{GS}=10\text{ V}, I_D=27\text{ A}, (TO251)$                           | -   | 25  | 33  |               |
|                                  |               | $V_{GS}=10\text{ V}, I_D=27\text{ A}, (TO263)$                           | -   | 25  | 35  |               |
|                                  |               | $V_{GS}=10\text{ V}, I_D=27\text{ A}, (TO220, TO262)$                    | -   | 26  | 35  |               |
| Gate resistance                  | $R_G$         |                                                                          | -   | 1   | -   | $\Omega$      |
| Transconductance                 | $g_{fs}$      | $ V_{DS} >2 I_D R_{DS(on)max}, I_D=27\text{ A}$                          | 15  | 30  | -   | S             |

<sup>4)</sup> Device on 40 mm x 40 mm x 1.5 mm epoxy PCB FR4 with 6 cm<sup>2</sup> (one layer, 70  $\mu\text{m}$  thick) copper area for drain connection. PCB is vertical in still air.

| Parameter | Symbol | Conditions | Values |      |      | Unit |
|-----------|--------|------------|--------|------|------|------|
|           |        |            | min.   | typ. | max. |      |

### Dynamic characteristics

|                              |              |                                                                                 |   |      |      |    |
|------------------------------|--------------|---------------------------------------------------------------------------------|---|------|------|----|
| Input capacitance            | $C_{iss}$    | $V_{GS}=0\text{ V}, V_{DS}=50\text{ V},$<br>$f=1\text{ MHz}$                    | - | 1180 | 1570 | pF |
| Output capacitance           | $C_{oss}$    |                                                                                 | - | 175  | 233  |    |
| Reverse transfer capacitance | $C_{rss}$    |                                                                                 | - | 13   | 20   |    |
| Turn-on delay time           | $t_{d(on)}$  | $V_{DD}=50\text{ V}, V_{GS}=10\text{ V},$<br>$I_D=27\text{ A}, R_G=1.6\ \Omega$ | - | 11   | 17   | ns |
| Rise time                    | $t_r$        |                                                                                 | - | 21   | 31   |    |
| Turn-off delay time          | $t_{d(off)}$ |                                                                                 | - | 17   | 25   |    |
| Fall time                    | $t_f$        |                                                                                 | - | 4    | 6    |    |

### Gate Charge Characteristics<sup>5)</sup>

|                       |               |                                                                            |   |     |    |    |
|-----------------------|---------------|----------------------------------------------------------------------------|---|-----|----|----|
| Gate to source charge | $Q_{gs}$      | $V_{DD}=50\text{ V}, I_D=27\text{ A},$<br>$V_{GS}=0\text{ to }10\text{ V}$ | - | 7   | 9  | nC |
| Gate to drain charge  | $Q_{gd}$      |                                                                            | - | 4   | 6  |    |
| Switching charge      | $Q_{sw}$      |                                                                            | - | 7   | 11 |    |
| Gate charge total     | $Q_g$         |                                                                            | - | 18  | 24 |    |
| Gate plateau voltage  | $V_{plateau}$ |                                                                            | - | 5.6 | -  | V  |
| Output charge         | $Q_{oss}$     | $V_{DD}=50\text{ V}, V_{GS}=0\text{ V}$                                    | - | 18  | 24 | nC |

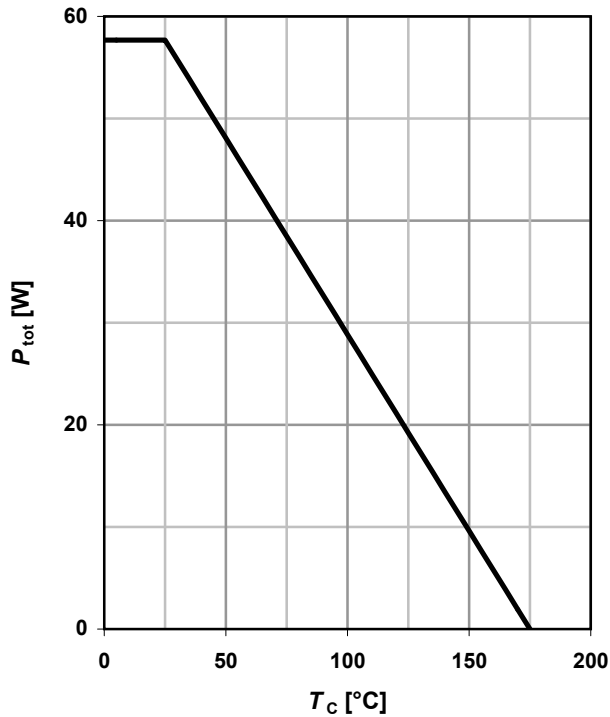
### Reverse Diode

|                                  |               |                                                                   |   |     |     |    |
|----------------------------------|---------------|-------------------------------------------------------------------|---|-----|-----|----|
| Diode continuous forward current | $I_S$         | $T_C=25\text{ °C}$                                                | - | -   | 27  | A  |
| Diode pulse current              | $I_{S,pulse}$ |                                                                   | - | -   | 108 |    |
| Diode forward voltage            | $V_{SD}$      | $V_{GS}=0\text{ V}, I_F=27\text{ A},$<br>$T_J=25\text{ °C}$       | - | 1   | 1.2 | V  |
| Reverse recovery time            | $t_{rr}$      | $V_R=50\text{ V}, I_F=I_S,$<br>$di_F/dt=100\text{ A}/\mu\text{s}$ | - | 77  |     | ns |
| Reverse recovery charge          | $Q_{rr}$      |                                                                   | - | 154 | -   | nC |

<sup>5)</sup> See figure 16 for gate charge parameter definition

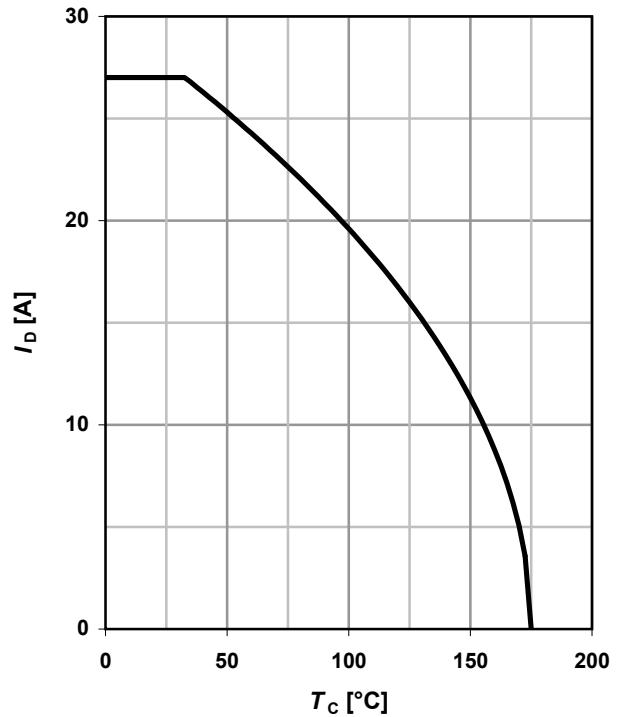
### 1 Power dissipation

$$P_{\text{tot}} = f(T_C)$$



### 2 Drain current

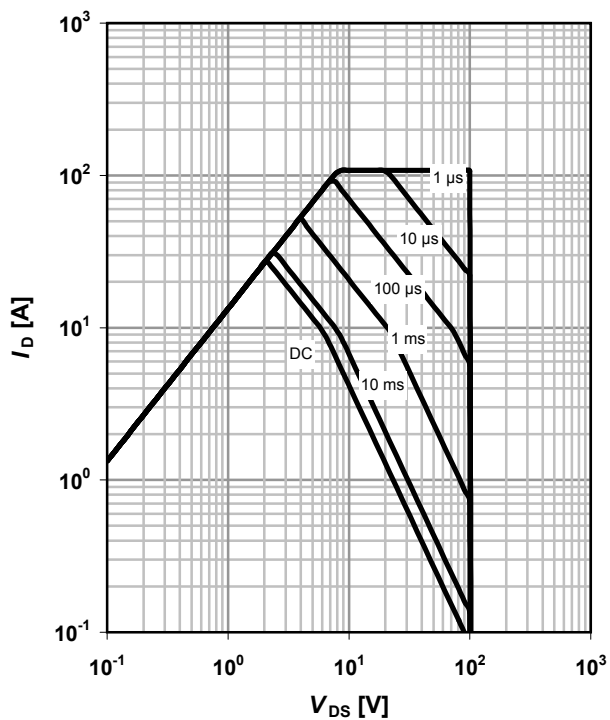
$$I_D = f(T_C); V_{GS} \geq 10 \text{ V}$$



### 3 Safe operating area

$$I_D = f(V_{DS}); T_C = 25^\circ\text{C}; D = 0$$

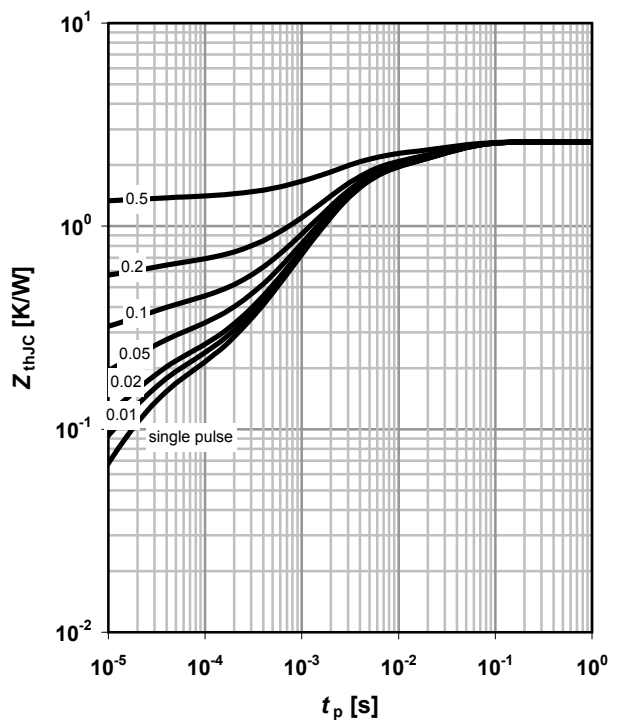
parameter:  $t_p$



### 4 Max. transient thermal impedance

$$Z_{\text{thJC}} = f(t_p)$$

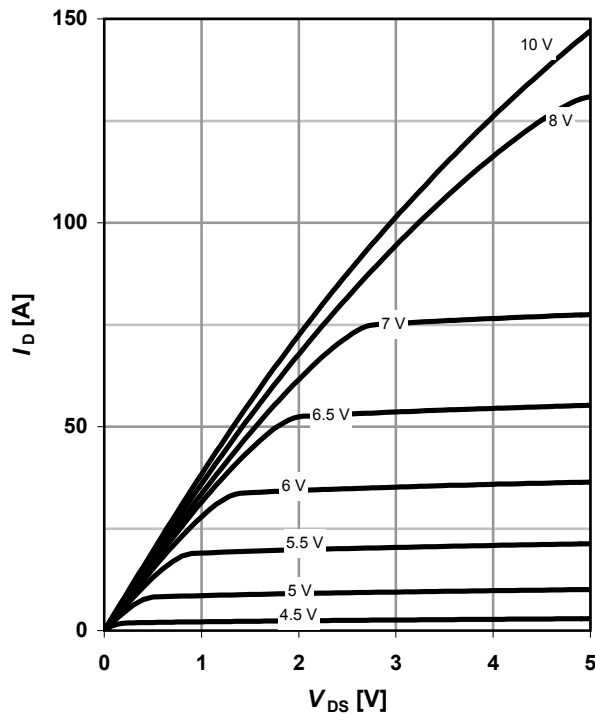
parameter:  $D = t_p / T$



### 5 Typ. output characteristics

$I_D = f(V_{DS}); T_j = 25^\circ\text{C}$

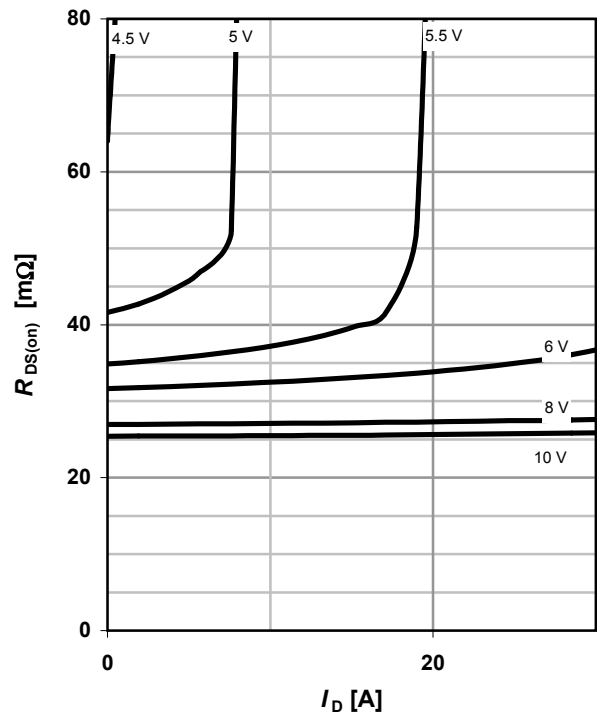
parameter:  $V_{GS}$



### 6 Typ. drain-source on resistance

$R_{DS(on)} = f(I_D); T_j = 25^\circ\text{C}$

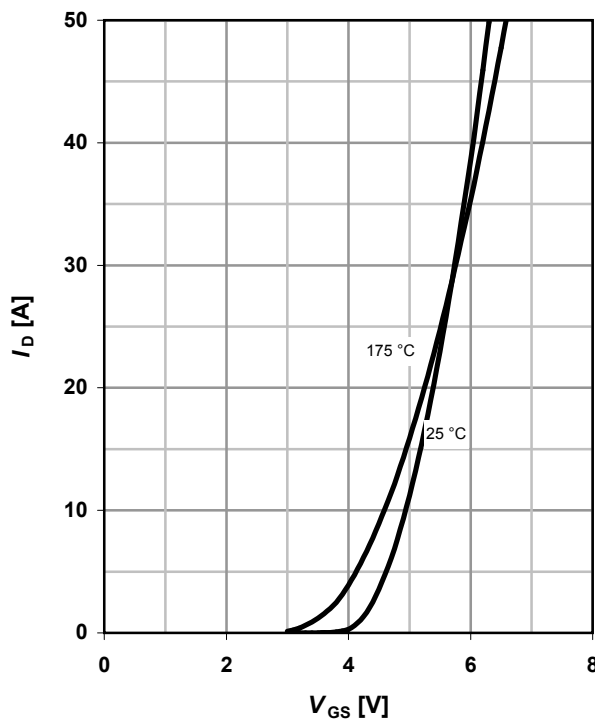
parameter:  $V_{GS}$



### 7 Typ. transfer characteristics

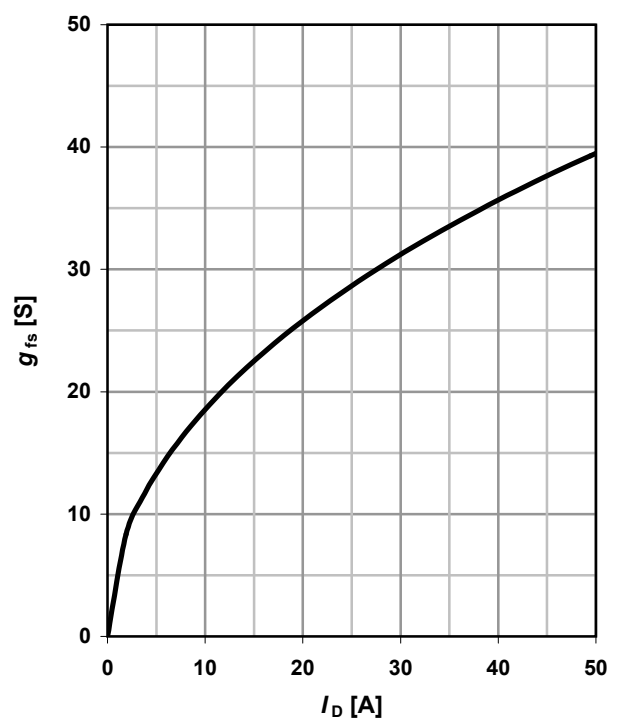
$I_D = f(V_{GS}); |V_{DS}| > 2|I_D|R_{DS(on)max}$

parameter:  $T_j$



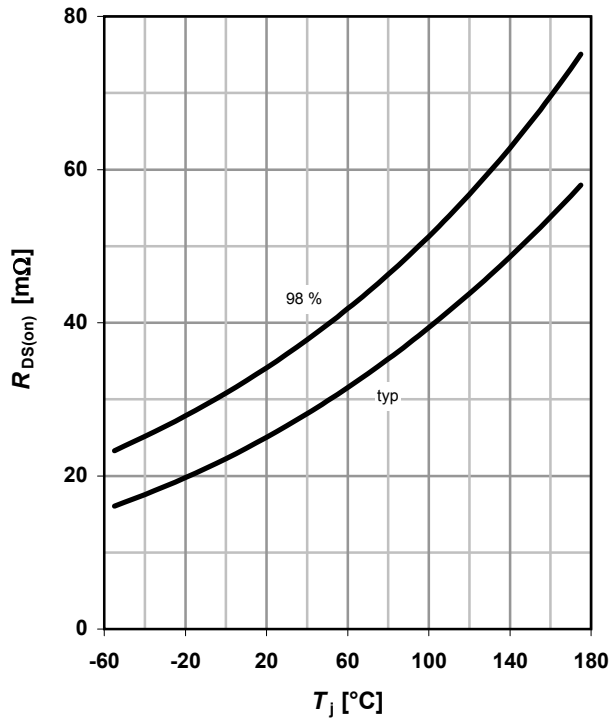
### 8 Typ. forward transconductance

$g_{fs} = f(I_D); T_j = 25^\circ\text{C}$



## 9 Drain-source on-state resistance

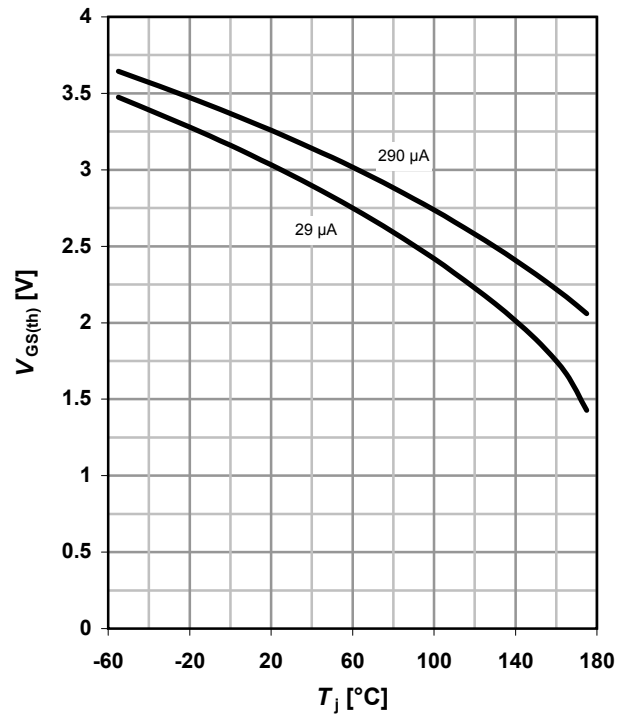
$R_{DS(on)} = f(T_j)$ ;  $I_D = 27 \text{ A}$ ;  $V_{GS} = 10 \text{ V}$



## 10 Typ. gate threshold voltage

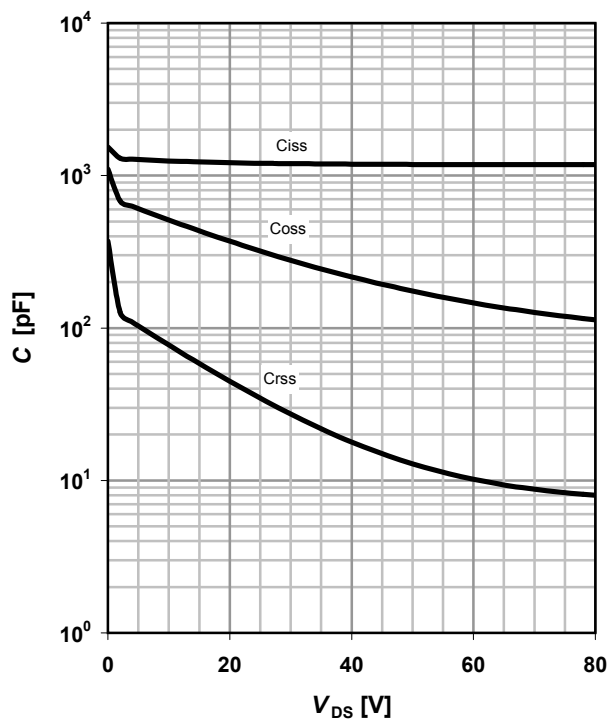
$V_{GS(th)} = f(T_j)$ ;  $V_{GS} = V_{DS}$

parameter:  $I_D$



## 11 Typ. capacitances

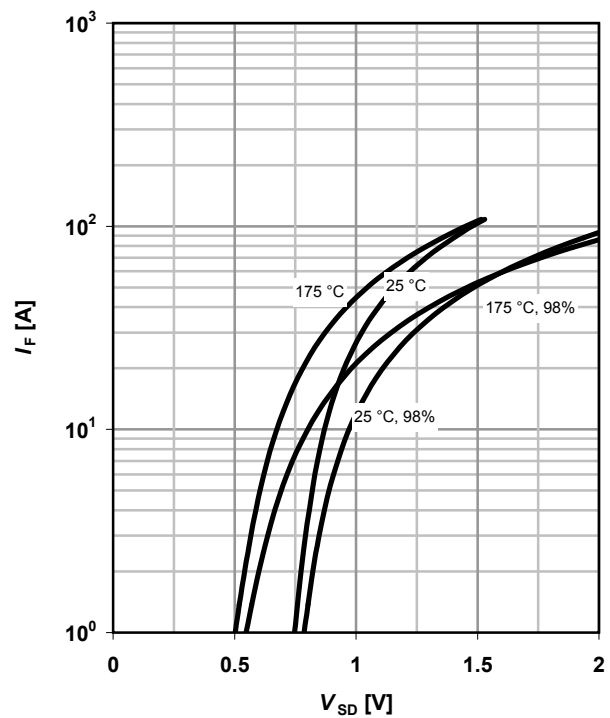
$C = f(V_{DS})$ ;  $V_{GS} = 0 \text{ V}$ ;  $f = 1 \text{ MHz}$



## 12 Forward characteristics of reverse diode

$I_F = f(V_{SD})$

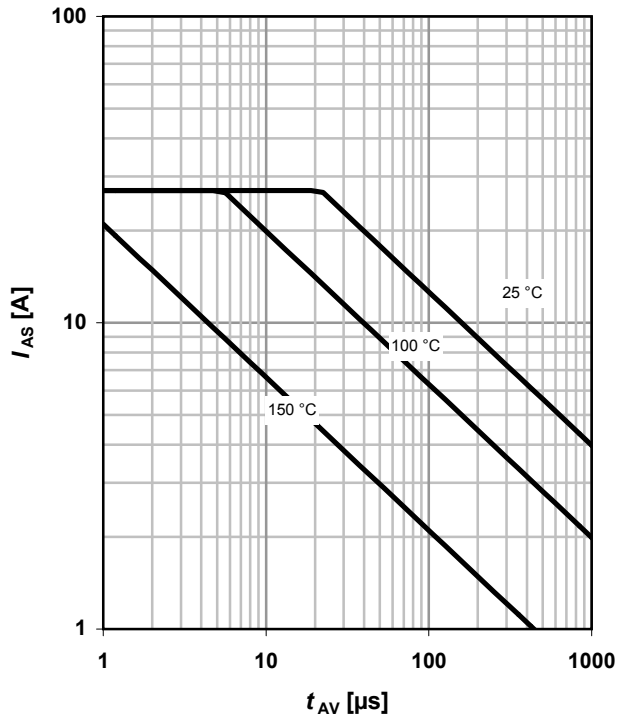
parameter:  $T_j$



### 13 Avalanche characteristics

$$I_{AS}=f(t_{AV}); R_{GS}=25\ \Omega$$

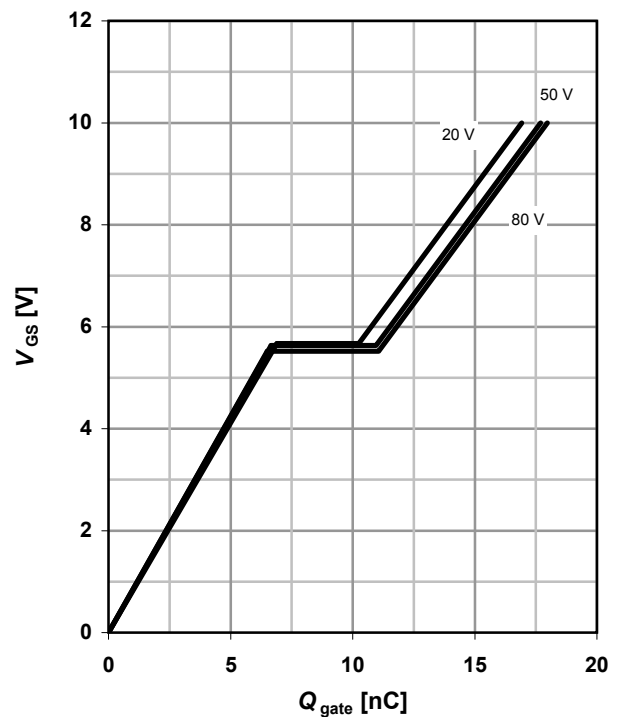
parameter:  $T_{j(\text{start})}$



### 14 Typ. gate charge

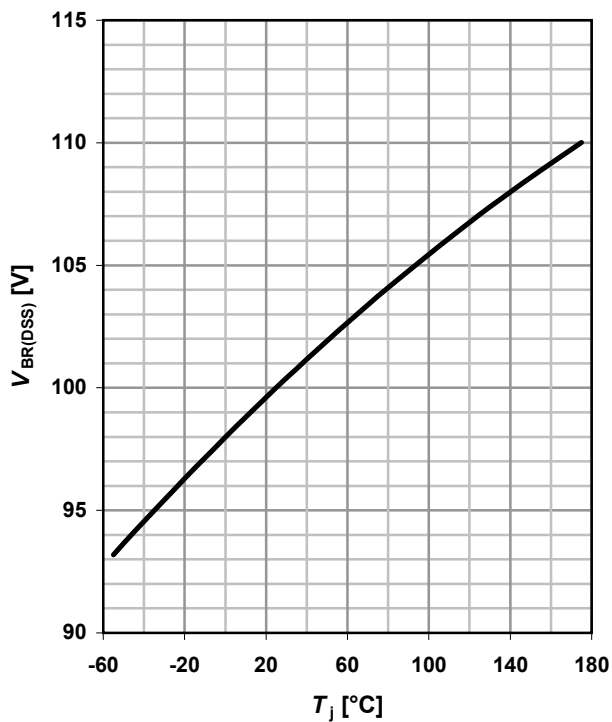
$$V_{GS}=f(Q_{\text{gate}}); I_D=27\ \text{A pulsed}$$

parameter:  $V_{DD}$

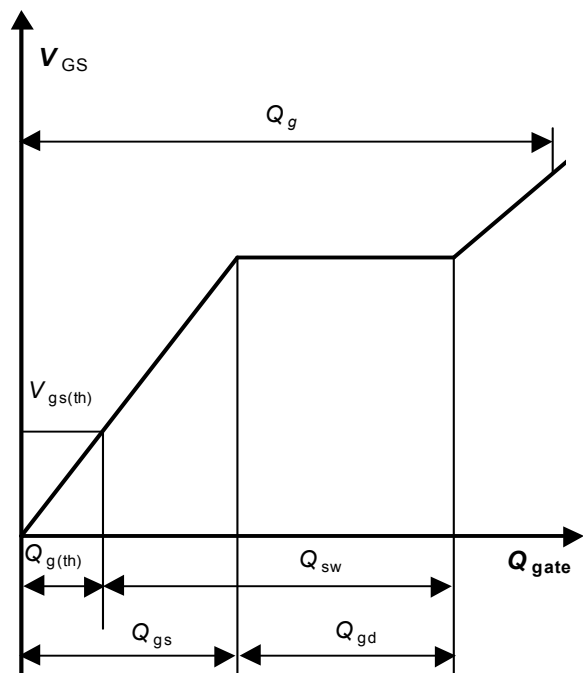


### 15 Drain-source breakdown voltage

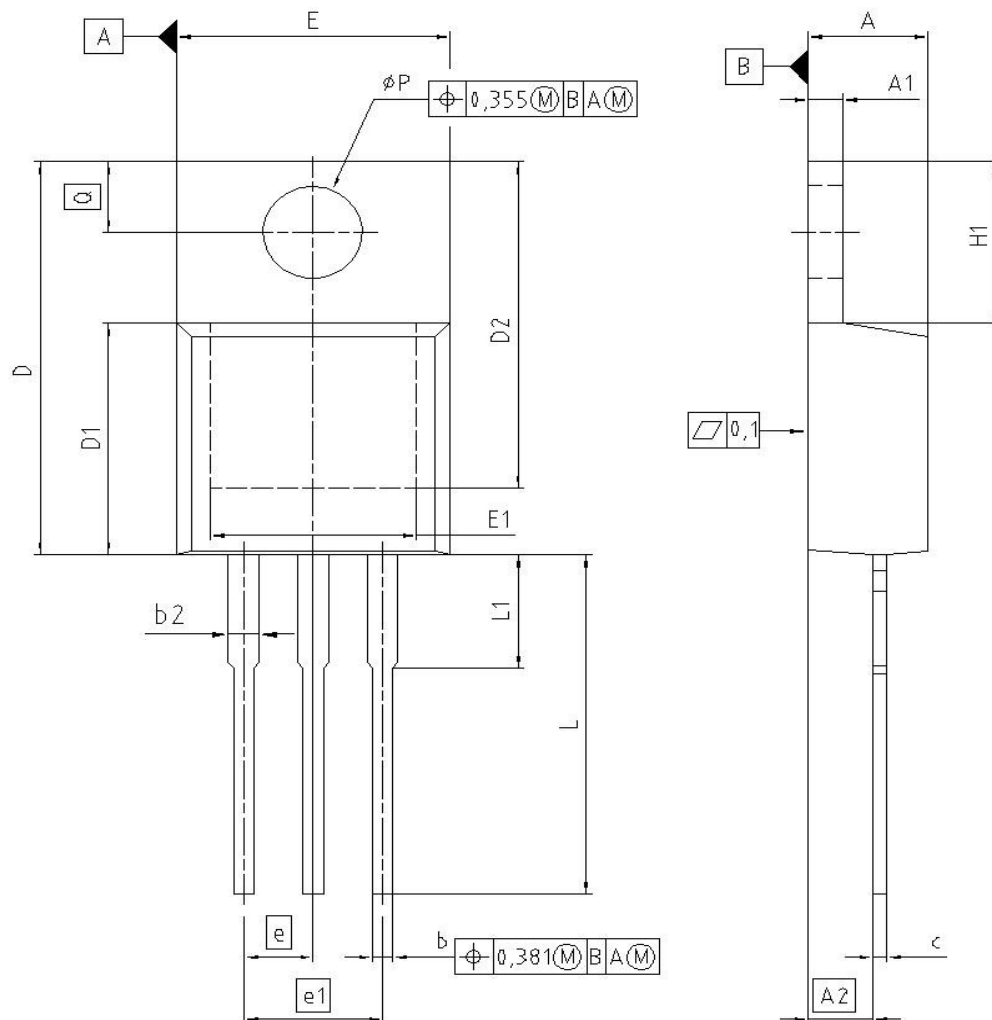
$$V_{BR(DSS)}=f(T_j); I_D=1\ \text{mA}$$



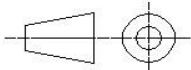
### 16 Gate charge waveforms



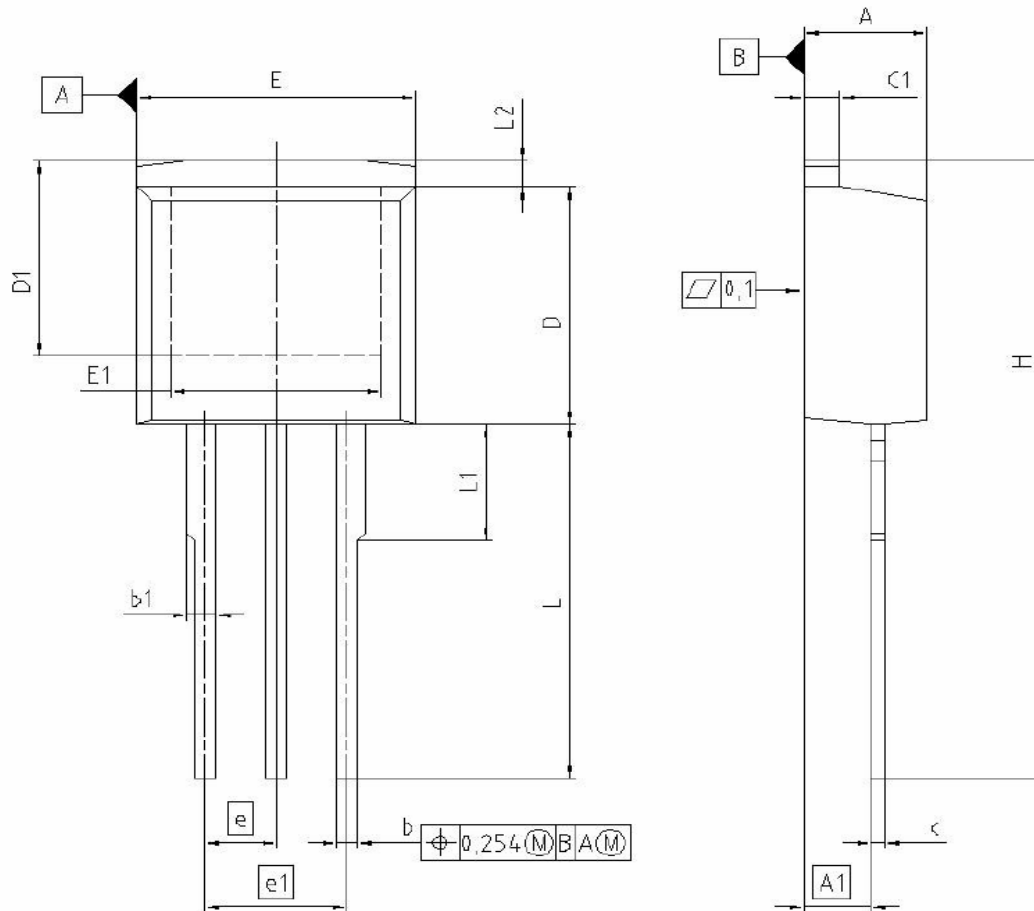
PG-TO220-3: Outline



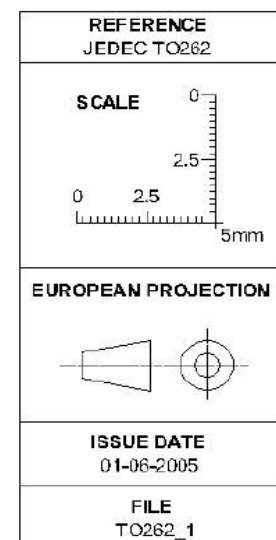
| DIM      | MILLIMETERS |        | INCHES |       |
|----------|-------------|--------|--------|-------|
|          | MIN         | MAX    | MIN    | MAX   |
| A        | 4.300       | 4.572  | 0.169  | 0.180 |
| A1       | 1.170       | 1.400  | 0.046  | 0.055 |
| A2       | 2.215       | 2.718  | 0.087  | 0.107 |
| b        | 0.650       | 0.864  | 0.026  | 0.034 |
| b2       | 0.635       | 1.778  | 0.025  | 0.070 |
| c        | 0.330       | 0.600  | 0.013  | 0.024 |
| D        | 14.808      | 15.950 | 0.583  | 0.628 |
| D1       | 8.509       | 9.450  | 0.335  | 0.372 |
| D2       | 12.850      | 13.100 | 0.506  | 0.516 |
| E        | 9.700       | 10.363 | 0.382  | 0.408 |
| E1       | 6.500       | 8.600  | 0.256  | 0.339 |
| e        | 2.540       |        | 0.100  |       |
| e1       | 5.080       |        | 0.200  |       |
| N        | 3           |        | 3      |       |
| H1       | 5.900       | 6.900  | 0.232  | 0.272 |
| L        | 13.000      | 14.000 | 0.512  | 0.551 |
| L1       | -           | 4.800  | -      | 0.189 |
| $\phi P$ | 3.700       | 3.886  | 0.146  | 0.153 |
| Q        | 2.600       | 3.000  | 0.102  | 0.118 |

|                                                                                                              |
|--------------------------------------------------------------------------------------------------------------|
| REFERENCE<br>JEDEC TO220                                                                                     |
| SCALE<br>0 2.5 5mm                                                                                           |
| EUROPEAN PROJECTION<br> |
| ISSUE DATE<br>01-06-2005                                                                                     |
| FILE<br>TO220_1                                                                                              |

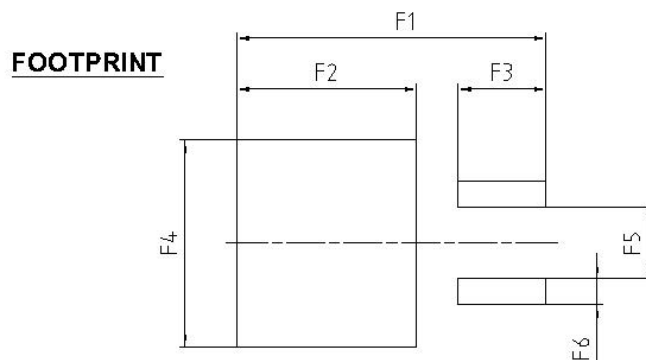
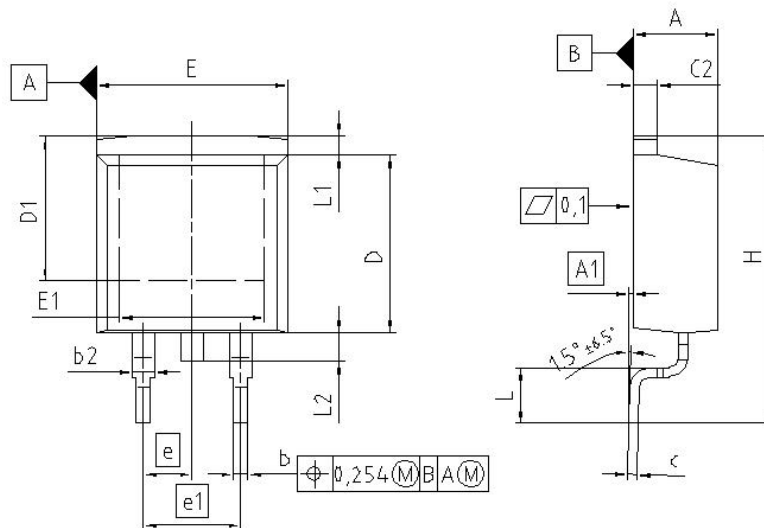
PG-TO-262-3-1 (I<sup>2</sup>-PAK)



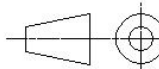
| DIM | MILLIMETERS |        | INCHES |       |
|-----|-------------|--------|--------|-------|
|     | MIN         | MAX    | MIN    | MAX   |
| A   | 4.300       | 4.500  | 0.169  | 0.177 |
| A1  | 2.150       | 2.650  | 0.085  | 0.104 |
| b   | 0.650       | 0.850  | 0.026  | 0.033 |
| b1  | 0.035       | 1.400  | 0.025  | 0.055 |
| c   | 0.400       | 0.600  | 0.016  | 0.024 |
| c1  | 1.170       | 1.370  | 0.046  | 0.054 |
| D   | 9.050       | 9.450  | 0.356  | 0.372 |
| D1  | 8.900       | 7.650  | 0.272  | 0.301 |
| E   | 9.800       | 10.200 | 0.386  | 0.402 |
| E1  | 7.250       | 8.600  | 0.285  | 0.339 |
| e   | 2.540       |        | 0.100  |       |
| e1  | 5.080       |        | 0.200  |       |
| N   | 3           |        | 3      |       |
| L   | 13.000      | 14.000 | 0.512  | 0.551 |
| L1  | 4.350       | 4.750  | 0.171  | 0.187 |
| L2  | 0.700       | 1.300  | 0.028  | 0.051 |



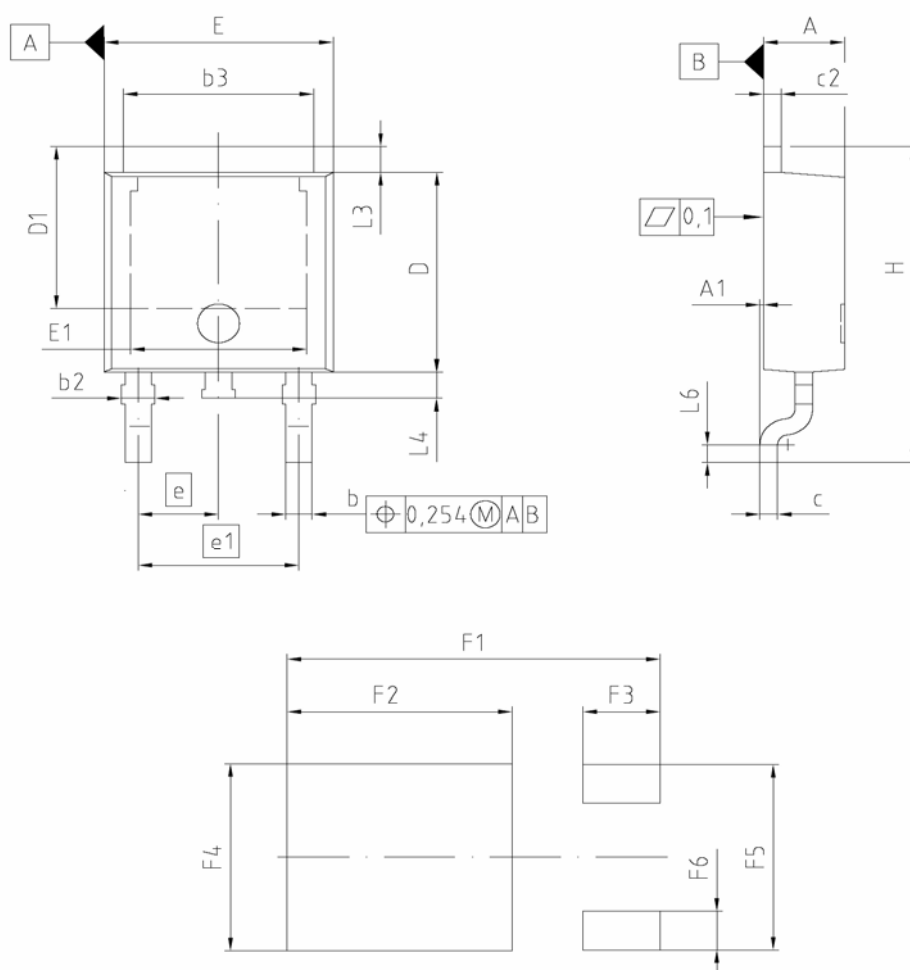
PG-TO-263 (D<sup>2</sup>-Pak)



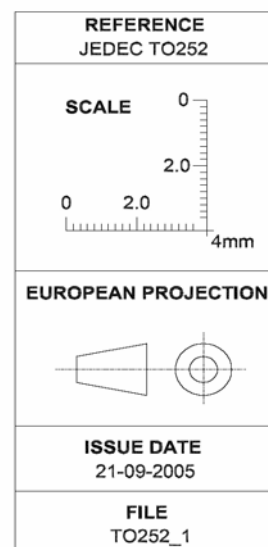
| DIM | MILLIMETERS |        | INCHES |       |
|-----|-------------|--------|--------|-------|
|     | MIN         | MAX    | MIN    | MAX   |
| A   | 4.300       | 4.572  | 0.169  | 0.180 |
| A1  | 0.000       | 0.254  | 0.000  | 0.010 |
| b   | 0.650       | 0.850  | 0.026  | 0.033 |
| b2  | 0.950       | 1.321  | 0.037  | 0.052 |
| c   | 0.330       | 0.650  | 0.013  | 0.026 |
| c2  | 0.170       | 1.400  | 0.046  | 0.055 |
| D   | 8.509       | 9.450  | 0.335  | 0.372 |
| D1  | 7.100       | -      | 0.280  | -     |
| E   | 9.800       | 10.312 | 0.386  | 0.406 |
| E1  | 6.500       | -      | 0.256  | -     |
| e   | 2.540       |        | 0.100  |       |
| e1  | 5.080       |        | 0.200  |       |
| N   | 2           |        | 2      |       |
| H   | 14.605      | 15.875 | 0.575  | 0.625 |
| L   | 2.200       | 3.000  | 0.087  | 0.118 |
| L1  | -           | 1.600  | -      | 0.063 |
| L2  | 1.000       | 1.778  | 0.039  | 0.070 |
| F1  | 16.050      | 16.250 | 0.632  | 0.640 |
| F2  | 9.300       | 9.500  | 0.366  | 0.374 |
| F3  | 4.500       | 4.700  | 0.177  | 0.185 |
| F4  | 10.700      | 10.900 | 0.421  | 0.429 |
| F5  | 3.630       | 3.830  | 0.143  | 0.151 |
| F6  | 1.100       | 1.300  | 0.043  | 0.051 |

|                                                                                                                     |
|---------------------------------------------------------------------------------------------------------------------|
| <b>REFERENCE</b><br>JEDEC TO263                                                                                     |
| <b>SCALE</b><br>0 5 5 7.5mm                                                                                         |
| <b>EUROPEAN PROJECTION</b><br> |
| <b>ISSUE DATE</b><br>12-02-2006                                                                                     |
| <b>FILE</b><br>TO263_2                                                                                              |

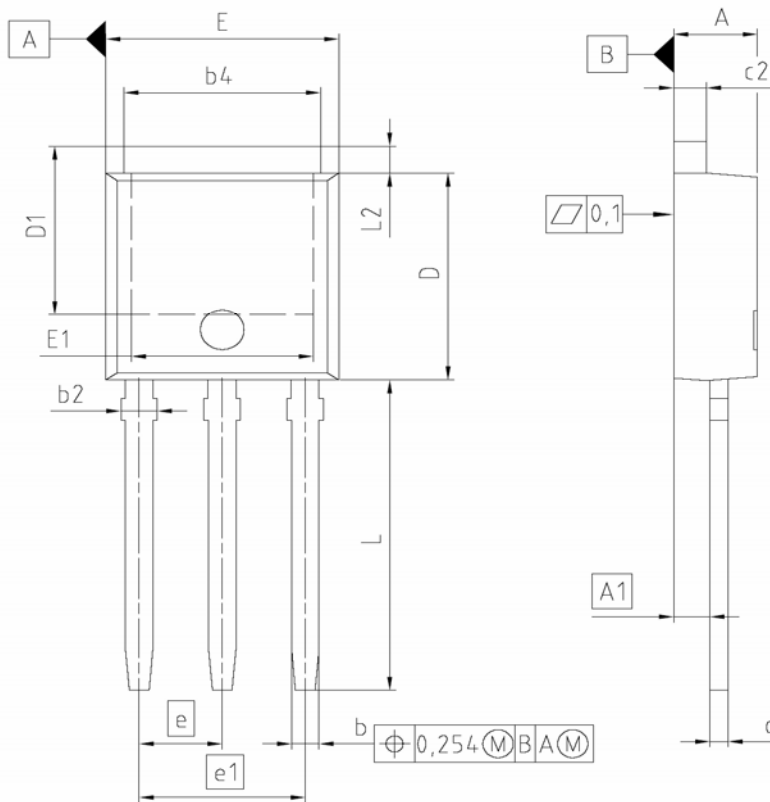
PG-TO252-3: Outline



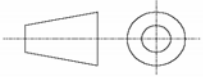
| DIM | MILLIMETERS |        | INCHES |       |
|-----|-------------|--------|--------|-------|
|     | MIN         | MAX    | MIN    | MAX   |
| A   | 2.159       | 2.413  | 0.085  | 0.095 |
| A1  | 0.000       | 0.150  | 0.000  | 0.006 |
| b   | 0.635       | 0.889  | 0.025  | 0.035 |
| b2  | 0.650       | 1.150  | 0.026  | 0.045 |
| b3  | 5.004       | 5.500  | 0.197  | 0.217 |
| c   | 0.457       | 0.580  | 0.018  | 0.023 |
| c2  | 0.460       | 0.980  | 0.018  | 0.039 |
| D   | 5.969       | 6.223  | 0.235  | 0.245 |
| D1  | 5.020       | 5.842  | 0.198  | 0.230 |
| E   | 6.400       | 6.731  | 0.252  | 0.265 |
| E1  | 4.850       | 5.207  | 0.191  | 0.205 |
| e   | 2.286       |        | 0.090  |       |
| e1  | 4.572       |        | 0.180  |       |
| N   | 3           |        | 3      |       |
| H   | 9.400       | 10.480 | 0.370  | 0.413 |
| L3  | 0.900       | 1.143  | 0.035  | 0.045 |
| L4  | 0.584       | 0.950  | 0.023  | 0.037 |
| L6  | 0.510       | 0.686  | 0.020  | 0.027 |
| F1  | 10.500      | 10.700 | 0.413  | 0.421 |
| F2  | 6.300       | 6.500  | 0.248  | 0.256 |
| F3  | 2.100       | 2.300  | 0.083  | 0.091 |
| F4  | 5.700       | 5.900  | 0.224  | 0.232 |
| F5  | 5.660       | 5.860  | 0.222  | 0.231 |
| F6  | 1.100       | 1.300  | 0.043  | 0.051 |



# PG-TO251-3: Outline



| DIM | MILLIMETERS |       | INCHES |       |
|-----|-------------|-------|--------|-------|
|     | MIN         | MAX   | MIN    | MAX   |
| A   | 2.159       | 2.413 | 0.085  | 0.095 |
| A1  | 0.900       | 1.118 | 0.035  | 0.044 |
| b   | 0.650       | 0.850 | 0.026  | 0.033 |
| b2  | 0.650       | 1.150 | 0.026  | 0.045 |
| b4  | 5.004       | 5.500 | 0.197  | 0.217 |
| c   | 0.457       | 0.580 | 0.018  | 0.023 |
| c2  | 0.737       | 0.980 | 0.029  | 0.039 |
| D   | 5.969       | 6.223 | 0.235  | 0.245 |
| D1  | 5.100       | 6.121 | 0.201  | 0.241 |
| E   | 6.400       | 6.731 | 0.252  | 0.265 |
| E1  | 4.850       | 5.207 | 0.191  | 0.205 |
| e   | 2.286       |       | 0.090  |       |
| e1  | 4.572       |       | 0.180  |       |
| N   | 3           |       | 3      |       |
| L   | 8.900       | 9.525 | 0.350  | 0.375 |
| L1  | 0.900       | 1.143 | 0.035  | 0.045 |

|                                                                                                              |
|--------------------------------------------------------------------------------------------------------------|
| REFERENCE<br>JEDEC TO251                                                                                     |
| SCALE<br>0 2.0 4mm                                                                                           |
| EUROPEAN PROJECTION<br> |
| ISSUE DATE<br>01-08-2005                                                                                     |
| FILE<br>TO251_1                                                                                              |

**Published by**  
Infineon Technologies AG  
81726 München, Germany  
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