

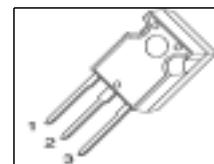
## Cool MOS™ Power Transistor

### Feature

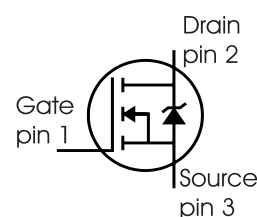
- New revolutionary high voltage technology
- Worldwide best  $R_{DS(on)}$  in TO 247
- Ultra low gate charge
- Periodic avalanche rated
- Extreme  $dv/dt$  rated
- Ultra low effective capacitances
- Pb-free lead plating; RoHS compliant
- Qualified according to JEDEC<sup>(0)</sup> for target applications

|                     |      |          |
|---------------------|------|----------|
| $V_{DS} @ T_{jmax}$ | 650  | V        |
| $R_{DS(on)}$        | 0.07 | $\Omega$ |
| $I_D$               | 47   | A        |

PG-TO247



| Type       | Package  | Ordering Code | Marking |
|------------|----------|---------------|---------|
| SPW47N60C3 | PG-TO247 | Q67040-S4491  | 47N60C3 |



### Maximum Ratings

| Parameter                                                                                                                | Symbol              | Value       | Unit |
|--------------------------------------------------------------------------------------------------------------------------|---------------------|-------------|------|
| Continuous drain current<br>$T_C = 25\text{ °C}$<br>$T_C = 100\text{ °C}$                                                | $I_D$               | 47<br>30    | A    |
| Pulsed drain current, $t_p$ limited by $T_{jmax}$                                                                        | $I_{D\text{ puls}}$ | 141         |      |
| Avalanche energy, single pulse<br>$I_D = 10\text{ A}$ , $V_{DD} = 50\text{ V}$                                           | $E_{AS}$            | 1800        | mJ   |
| Avalanche energy, repetitive $t_{AR}$ limited by $T_{jmax}$ <sup>1</sup><br>$I_D = 20\text{ A}$ , $V_{DD} = 50\text{ V}$ | $E_{AR}$            | 1           |      |
| Avalanche current, repetitive $t_{AR}$ limited by $T_{jmax}$                                                             | $I_{AR}$            | 20          | A    |
| Gate source voltage static                                                                                               | $V_{GS}$            | $\pm 20$    | V    |
| Gate source voltage AC ( $f > 1\text{ Hz}$ )                                                                             | $V_{GS}$            | $\pm 30$    |      |
| Power dissipation, $T_C = 25\text{ °C}$                                                                                  | $P_{tot}$           | 415         | W    |
| Operating and storage temperature                                                                                        | $T_j, T_{stg}$      | -55... +150 | °C   |
| Reverse diode $dv/dt$ <sup>4)</sup>                                                                                      | $dv/dt$             | 15          | V/ns |

**Maximum Ratings**

| Parameter                                                                                                          | Symbol  | Value | Unit |
|--------------------------------------------------------------------------------------------------------------------|---------|-------|------|
| Drain Source voltage slope<br>$V_{DS} = 480 \text{ V}$ , $I_D = 47 \text{ A}$ , $T_j = 125 \text{ }^\circ\text{C}$ | $dv/dt$ | 50    | V/ns |

**Thermal Characteristics**

| Parameter                                                                    | Symbol     | Values |      |      | Unit             |
|------------------------------------------------------------------------------|------------|--------|------|------|------------------|
|                                                                              |            | min.   | typ. | max. |                  |
| Thermal resistance, junction - case                                          | $R_{thJC}$ | -      | -    | 0.3  | K/W              |
| Thermal resistance, junction - ambient, leaded                               | $R_{thJA}$ | -      | -    | 62   |                  |
| Soldering temperature, wavesoldering<br>1.6 mm (0.063 in.) from case for 10s | $T_{sold}$ | -      | -    | 260  | $^\circ\text{C}$ |

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

| Parameter                                   | Symbol        | Conditions                                                                                         | Values |      |      | Unit          |
|---------------------------------------------|---------------|----------------------------------------------------------------------------------------------------|--------|------|------|---------------|
|                                             |               |                                                                                                    | min.   | typ. | max. |               |
| Drain-source breakdown voltage              | $V_{(BR)DSS}$ | $V_{GS}=0\text{V}$ , $I_D=0.25\text{mA}$                                                           | 600    | -    | -    | V             |
| Drain-Source avalanche<br>breakdown voltage | $V_{(BR)DS}$  | $V_{GS}=0\text{V}$ , $I_D=20\text{A}$                                                              | -      | 700  | -    |               |
| Gate threshold voltage                      | $V_{GS(th)}$  | $I_D=2700\mu\text{A}$ , $V_{GS}=V_{DS}$                                                            | 2.1    | 3    | 3.9  |               |
| Zero gate voltage drain current             | $I_{DSS}$     | $V_{DS}=600\text{V}$ , $V_{GS}=0\text{V}$ ,<br>$T_j=25^\circ\text{C}$ ,<br>$T_j=150^\circ\text{C}$ | -      | 0.5  | 25   | $\mu\text{A}$ |
|                                             |               |                                                                                                    | -      | -    | 250  |               |
| Gate-source leakage current                 | $I_{GSS}$     | $V_{GS}=30\text{V}$ , $V_{DS}=0\text{V}$                                                           | -      | -    | 100  | nA            |
| Drain-source on-state resistance            | $R_{DS(on)}$  | $V_{GS}=10\text{V}$ , $I_D=30\text{A}$ ,<br>$T_j=25^\circ\text{C}$<br>$T_j=150^\circ\text{C}$      | -      | 0.06 | 0.07 | $\Omega$      |
|                                             |               |                                                                                                    | -      | 0.16 | -    |               |
| Gate input resistance                       | $R_G$         | $f=1\text{MHz}$ , open Drain                                                                       | -      | 0.62 | -    |               |

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

| Parameter                                                     | Symbol       | Conditions                                                                                                    | Values |      |      | Unit |
|---------------------------------------------------------------|--------------|---------------------------------------------------------------------------------------------------------------|--------|------|------|------|
|                                                               |              |                                                                                                               | min.   | typ. | max. |      |
| Transconductance                                              | $g_{fs}$     | $V_{DS} \geq 2 \cdot I_D \cdot R_{DS(on)max}$ ,<br>$I_D = 30\text{A}$                                         | -      | 40   | -    | S    |
| Input capacitance                                             | $C_{iss}$    | $V_{GS} = 0\text{V}$ , $V_{DS} = 25\text{V}$ ,<br>$f = 1\text{MHz}$                                           | -      | 6800 | -    | pF   |
| Output capacitance                                            | $C_{oss}$    |                                                                                                               | -      | 2200 | -    |      |
| Reverse transfer capacitance                                  | $C_{rss}$    |                                                                                                               | -      | 145  | -    |      |
| Effective output capacitance, <sup>2)</sup><br>energy related | $C_{o(er)}$  | $V_{GS} = 0\text{V}$ ,<br>$V_{DS} = 0\text{V to } 480\text{V}$                                                | -      | 193  | -    | pF   |
| Effective output capacitance, <sup>3)</sup><br>time related   | $C_{o(tr)}$  |                                                                                                               | -      | 412  | -    |      |
| Turn-on delay time                                            | $t_{d(on)}$  | $V_{DD} = 380\text{V}$ , $V_{GS} = 0/13\text{V}$ ,<br>$I_D = 47\text{A}$ , $R_G = 1.8\Omega$ ,<br>$T_j = 125$ | -      | 18   | -    | ns   |
| Rise time                                                     | $t_r$        |                                                                                                               | -      | 27   | -    |      |
| Turn-off delay time                                           | $t_{d(off)}$ |                                                                                                               | -      | 111  | 165  |      |
| Fall time                                                     | $t_f$        |                                                                                                               | -      | 8    | 12   |      |

**Gate Charge Characteristics**

|                       |                 |                                                                                      |   |     |     |    |
|-----------------------|-----------------|--------------------------------------------------------------------------------------|---|-----|-----|----|
| Gate to source charge | $Q_{gs}$        | $V_{DD} = 350\text{V}$ , $I_D = 47\text{A}$                                          | - | 24  | -   | nC |
| Gate to drain charge  | $Q_{gd}$        |                                                                                      | - | 121 | -   |    |
| Gate charge total     | $Q_g$           | $V_{DD} = 350\text{V}$ , $I_D = 47\text{A}$ ,<br>$V_{GS} = 0 \text{ to } 10\text{V}$ | - | 252 | 320 |    |
| Gate plateau voltage  | $V_{(plateau)}$ | $V_{DD} = 350\text{V}$ , $I_D = 47\text{A}$                                          | - | 5.5 | -   | V  |

<sup>0</sup> J-STD20 and JESD22

<sup>1</sup> Repetitive avalanche causes additional power losses that can be calculated as  $P_{AV} = E_{AR} \cdot f$ .

<sup>2</sup>  $C_{o(er)}$  is a fixed capacitance that gives the same stored energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

<sup>3</sup>  $C_{o(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80%  $V_{DSS}$ .

<sup>4</sup>  $I_{SD} \leq I_D$ ,  $di/dt \leq 200\text{A}/\mu\text{s}$ ,  $V_{DClink} = 400\text{V}$ ,  $V_{peak} < V_{BR, DSS}$ ,  $T_j < T_{j,max}$ .

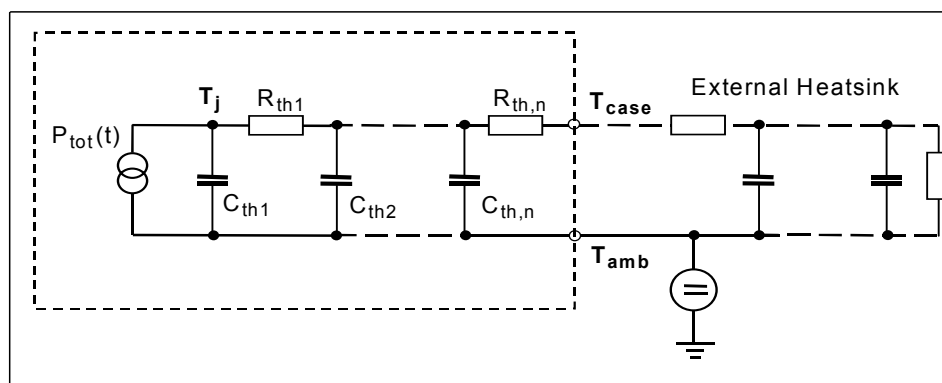
Identical low-side and high-side switch.

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

| Parameter                                     | Symbol       | Conditions                              | Values |      |      | Unit      |
|-----------------------------------------------|--------------|-----------------------------------------|--------|------|------|-----------|
|                                               |              |                                         | min.   | typ. | max. |           |
| Inverse diode continuous forward current      | $I_S$        | $T_C=25^{\circ}C$                       | -      | -    | 47   | A         |
| Inverse diode direct current, pulsed          | $I_{SM}$     |                                         | -      | -    | 141  |           |
| Inverse diode forward voltage                 | $V_{SD}$     | $V_{GS}=0V, I_F=I_S$                    | -      | 1    | 1.2  | V         |
| Reverse recovery time                         | $t_{rr}$     | $V_R=350V, I_F=I_S, di_F/dt=100A/\mu s$ | -      | 580  | -    | ns        |
| Reverse recovery charge                       | $Q_{rr}$     |                                         | -      | 23   | -    | $\mu C$   |
| Peak reverse recovery current                 | $I_{rrm}$    |                                         | -      | 73   | -    | A         |
| Peak rate of fall of reverse recovery current | $di_{rr}/dt$ |                                         | -      | 900  | -    | $A/\mu s$ |

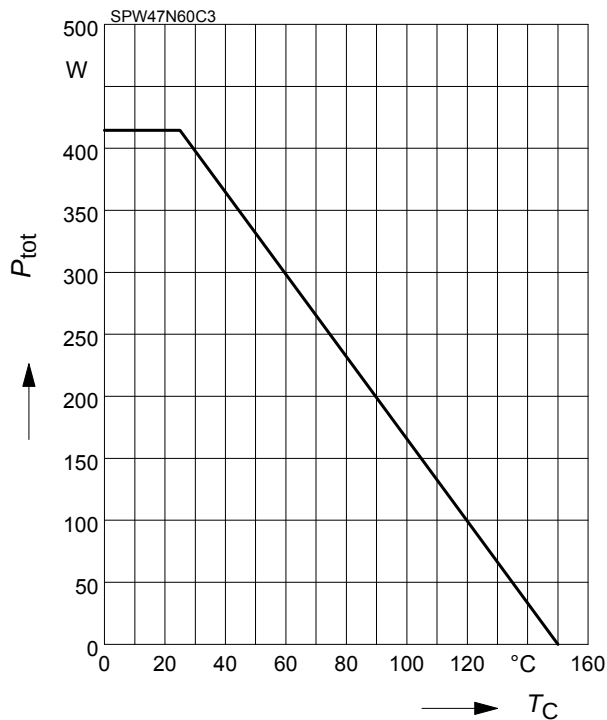
## Typical Transient Thermal Characteristics

| Symbol             | Value    | Unit | Symbol              | Value    | Unit |
|--------------------|----------|------|---------------------|----------|------|
|                    | typ.     |      |                     | typ.     |      |
| Thermal resistance |          |      | Thermal capacitance |          |      |
| $R_{th1}$          | 0.002689 | K/W  | $C_{th1}$           | 0.001081 | Ws/K |
| $R_{th2}$          | 0.005407 |      | $C_{th2}$           | 0.004021 |      |
| $R_{th3}$          | 0.011    |      | $C_{th3}$           | 0.005415 |      |
| $R_{th4}$          | 0.054    |      | $C_{th4}$           | 0.014    |      |
| $R_{th5}$          | 0.071    |      | $C_{th5}$           | 0.025    |      |
| $R_{th6}$          | 0.036    |      | $C_{th6}$           | 0.158    |      |



### 1 Power dissipation

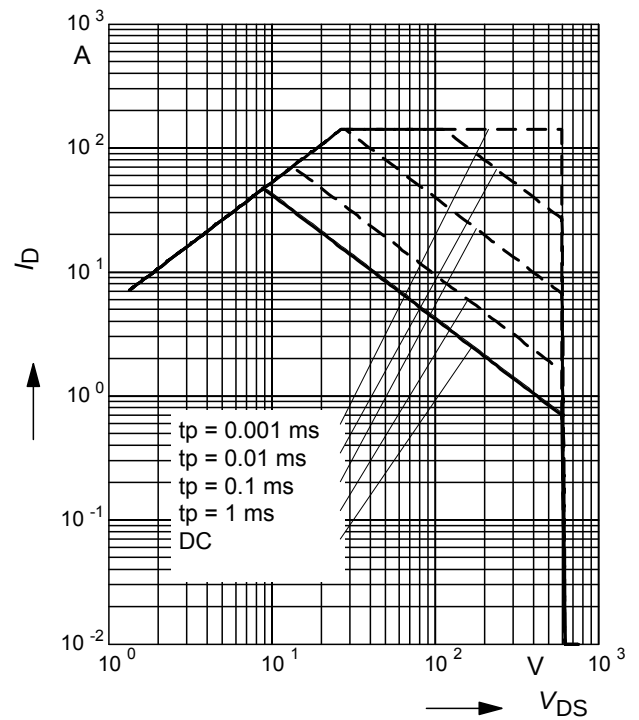
$$P_{\text{tot}} = f(T_C)$$



### 2 Safe operating area

$$I_D = f(V_{DS})$$

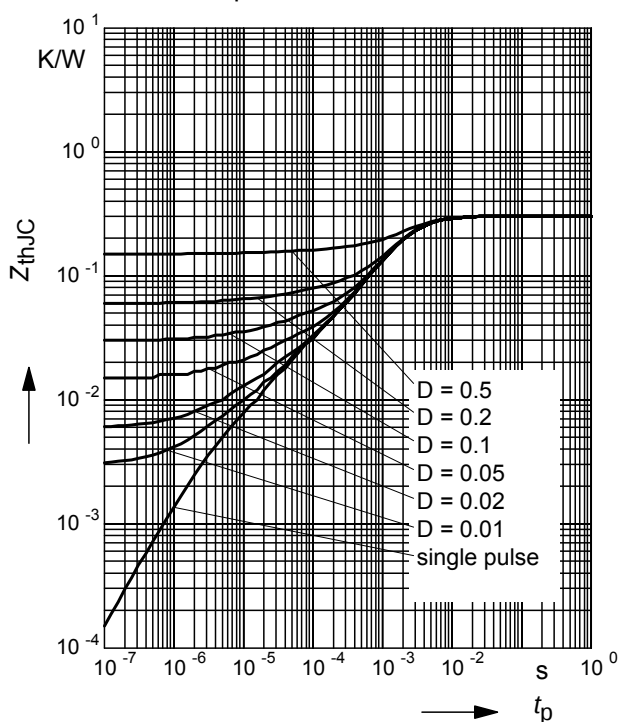
parameter :  $D = 0$  ,  $T_C = 25^\circ\text{C}$



### 3 Transient thermal impedance

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

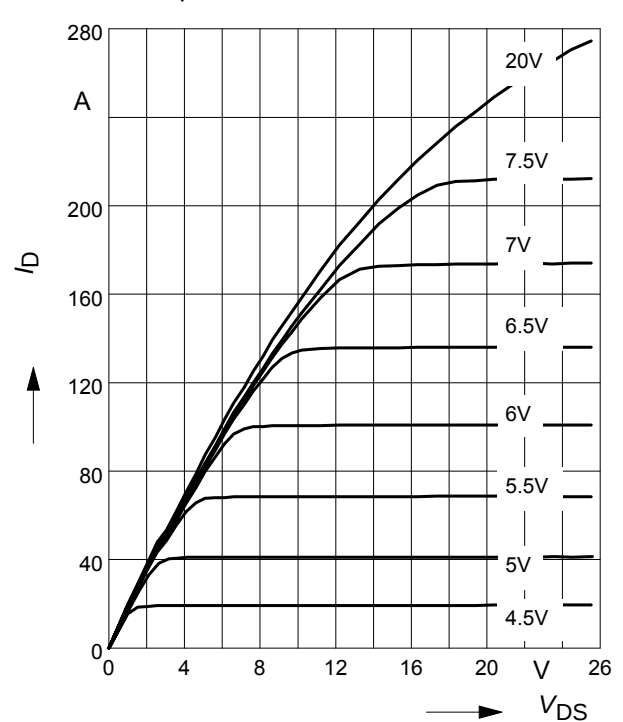
parameter:  $D = t_p/T$



### 4 Typ. output characteristic

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

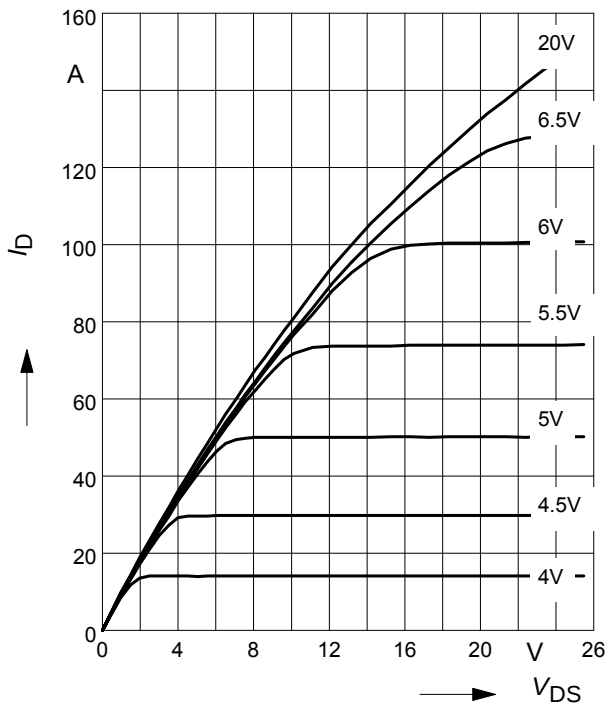
parameter:  $t_p = 10 \mu\text{s}$ ,  $V_{GS}$



**5 Typ. output characteristic**

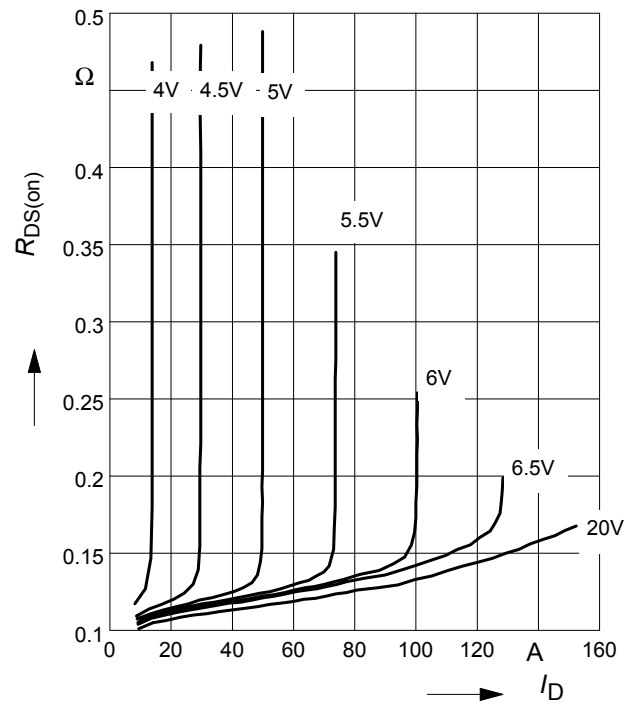
$$I_D = f(V_{DS}); T_j = 150^\circ\text{C}$$

parameter:  $t_p = 10\ \mu\text{s}$ ,  $V_{GS}$


**6 Typ. drain-source on resistance**

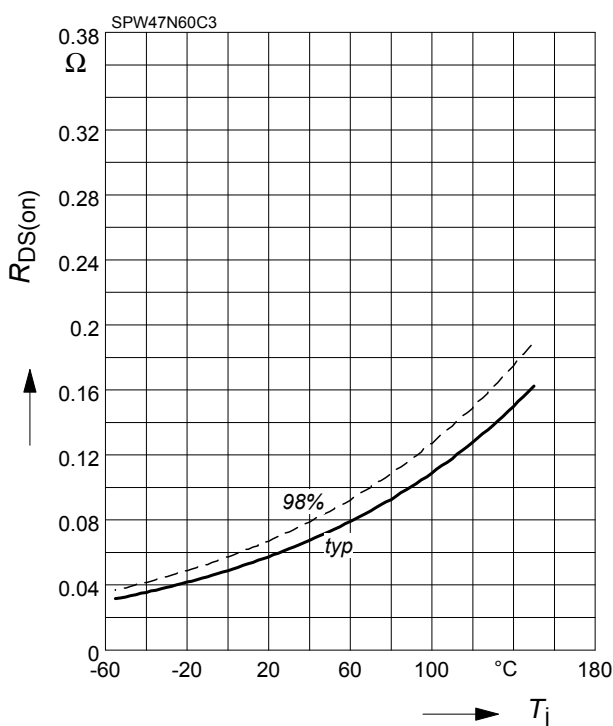
$$R_{DS(on)} = f(I_D)$$

parameter:  $T_j = 150^\circ\text{C}$ ,  $V_{GS}$


**7 Drain-source on-state resistance**

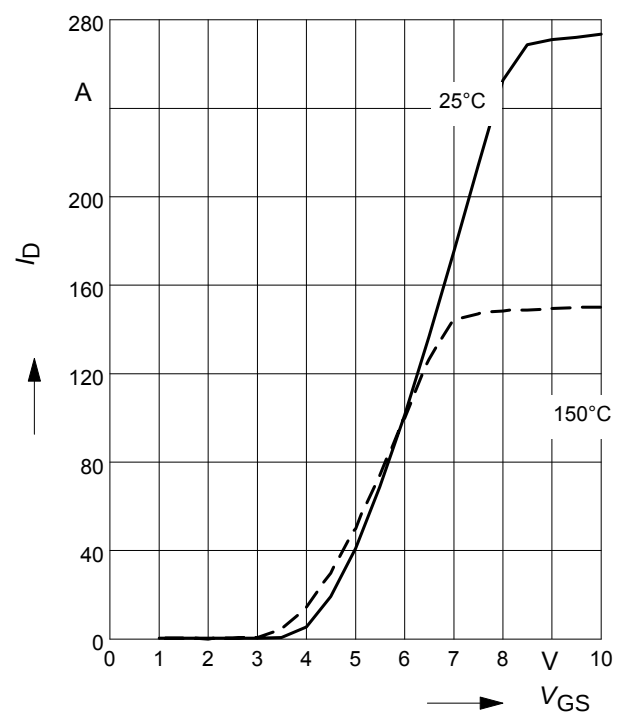
$$R_{DS(on)} = f(T_j)$$

parameter:  $I_D = 47\ \text{A}$ ,  $V_{GS} = 10\ \text{V}$


**8 Typ. transfer characteristics**

$$I_D = f(V_{GS}); V_{DS} \geq 2 \times I_D \times R_{DS(on)\text{max}}$$

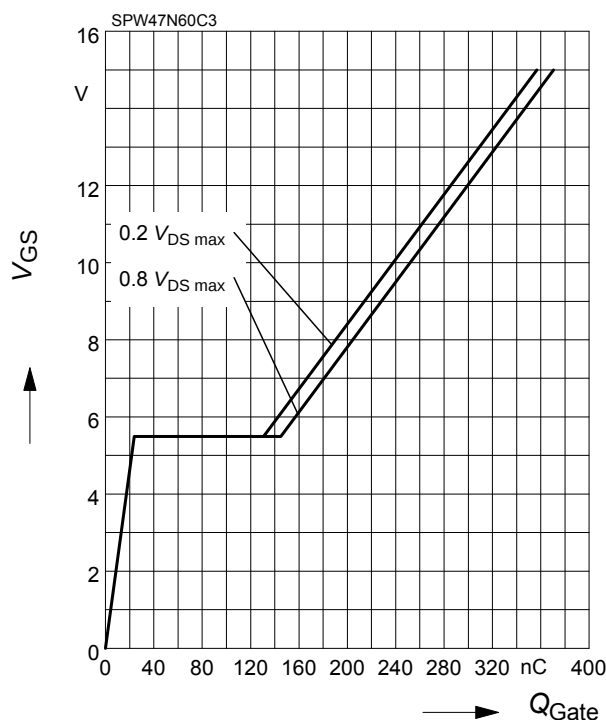
parameter:  $t_p = 10\ \mu\text{s}$



### 9 Typ. gate charge

$$V_{GS} = f(Q_{Gate})$$

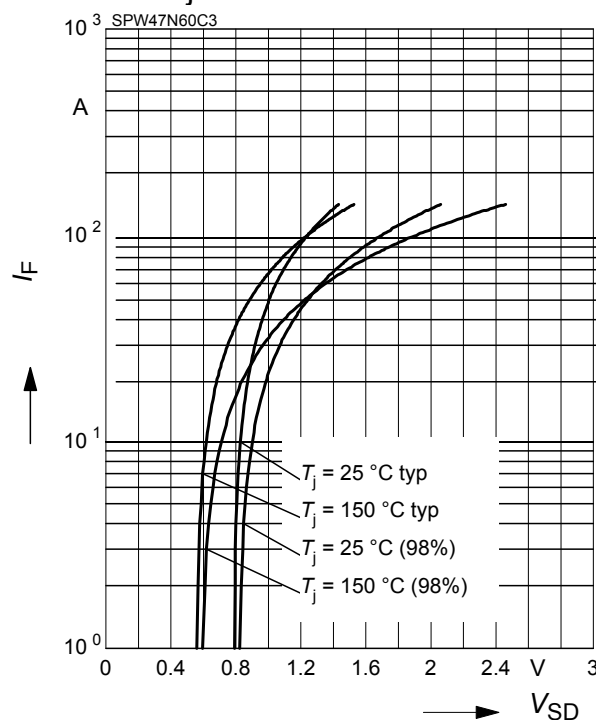
parameter:  $I_D = 47\text{ A}$  pulsed



### 10 Forward characteristics of body diode

$$I_F = f(V_{SD})$$

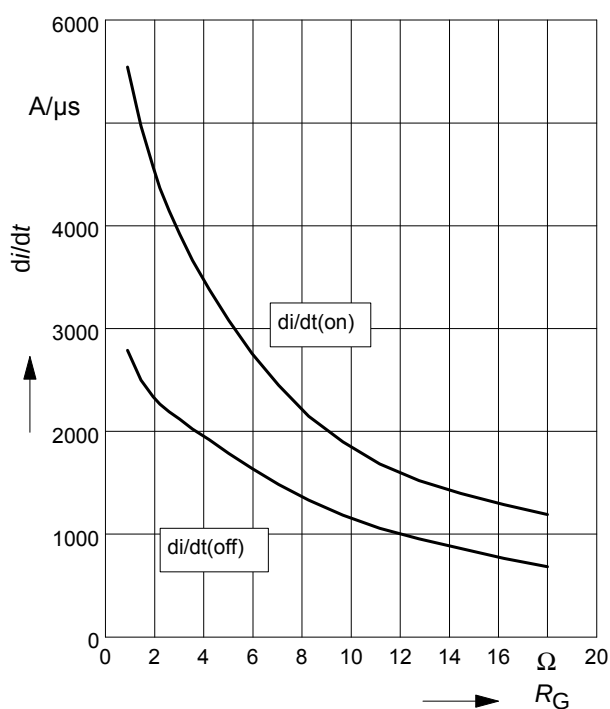
parameter:  $T_j$ ,  $t_p = 10\text{ }\mu\text{s}$



### 11 Typ. drain current slope

$$di/dt = f(R_G), \text{ inductive load, } T_j = 125^\circ\text{C}$$

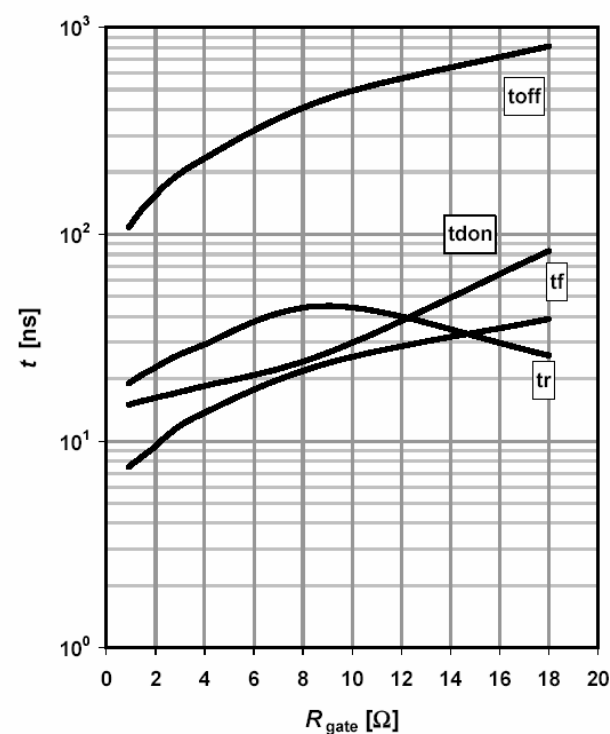
par.:  $V_{DS}=380\text{V}$ ,  $V_{GS}=0/+13\text{V}$ ,  $I_D=47\text{A}$



### 12 Typ. switching time

$$t = f(R_G), \text{ inductive load, } T_j=125^\circ\text{C}$$

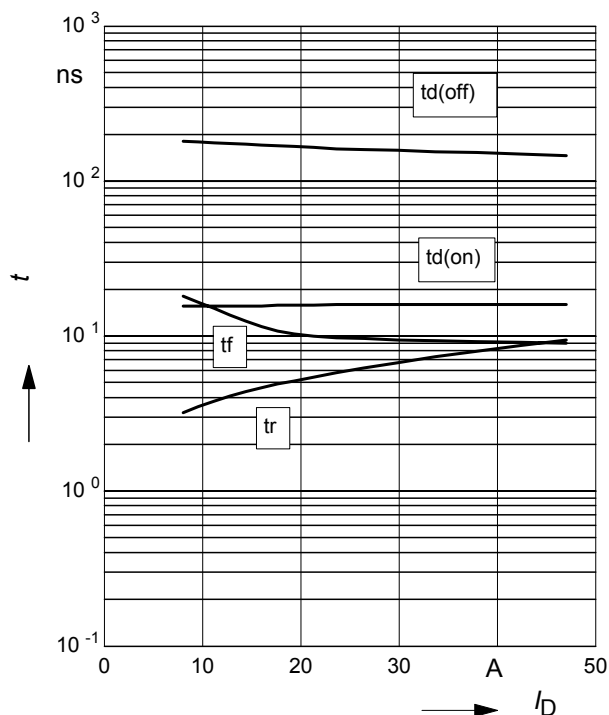
par.:  $V_{DS}=380\text{V}$ ,  $V_{GS}=0/+13\text{V}$ ,  $I_D=47\text{ A}$



### 13 Typ. switching time

$t = f(I_D)$ , inductive load,  $T_j = 125^\circ\text{C}$

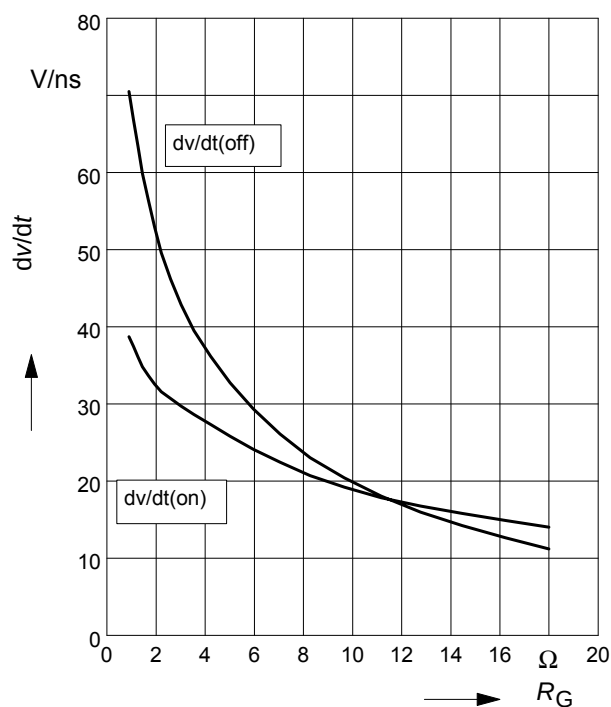
par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $R_G = 1.8\Omega$



### 14 Typ. drain source voltage slope

$dv/dt = f(R_G)$ , inductive load,  $T_j = 125^\circ\text{C}$

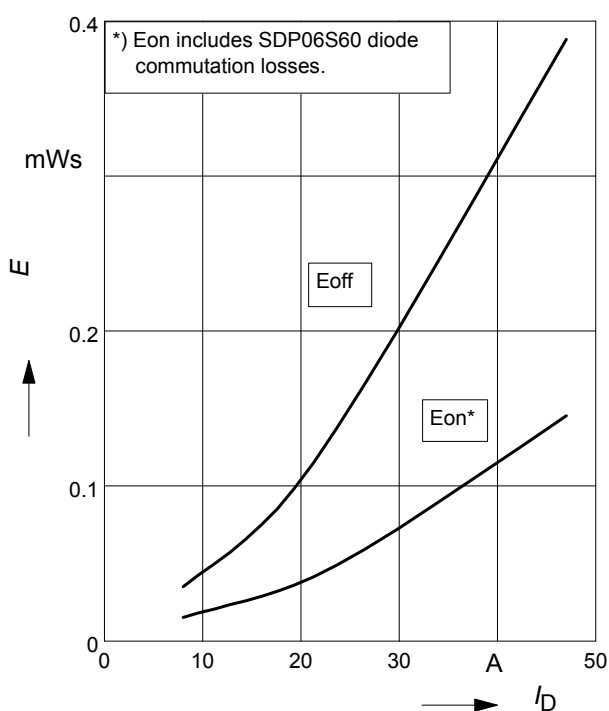
par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $I_D = 47\text{A}$



### 15 Typ. switching losses

$E = f(I_D)$ , inductive load,  $T_j = 125^\circ\text{C}$

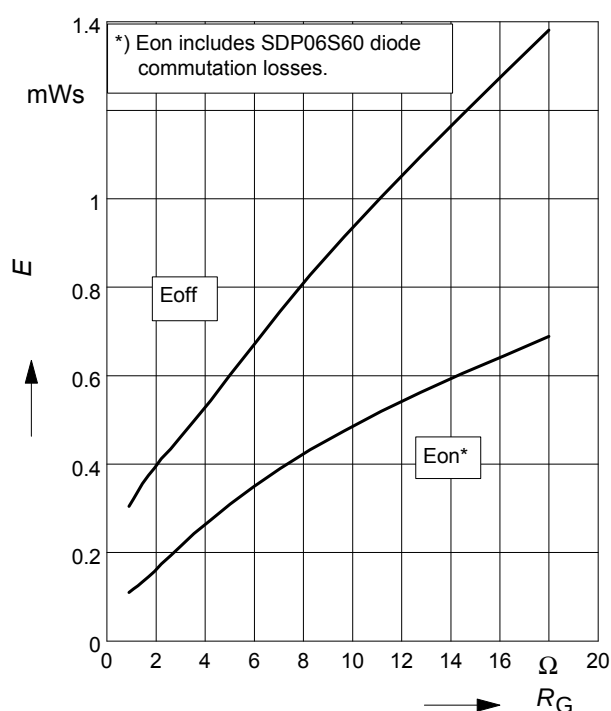
par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $R_G = 1.8\Omega$



### 16 Typ. switching losses

$E = f(R_G)$ , inductive load,  $T_j = 125^\circ\text{C}$

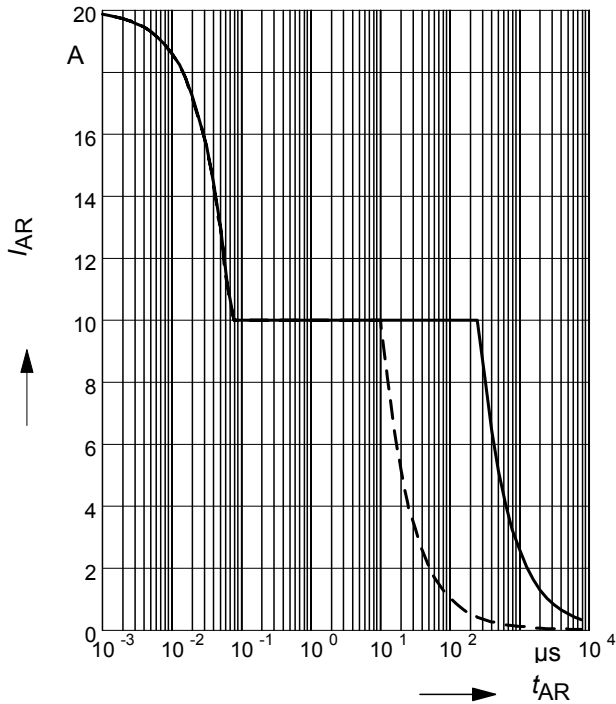
par.:  $V_{DS} = 380\text{V}$ ,  $V_{GS} = 0/+13\text{V}$ ,  $I_D = 47\text{A}$



### 17 Avalanche SOA

$$I_{AR} = f(t_{AR})$$

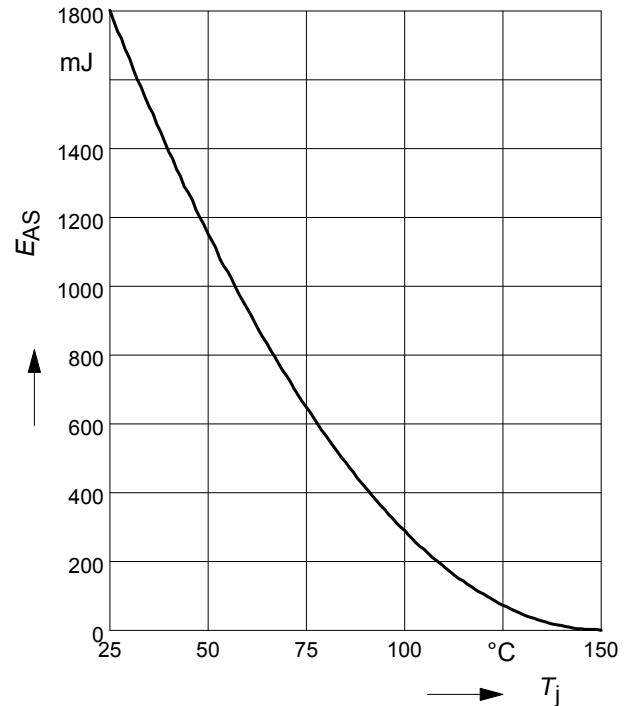
par.:  $T_j \leq 150^\circ\text{C}$



### 18 Avalanche energy

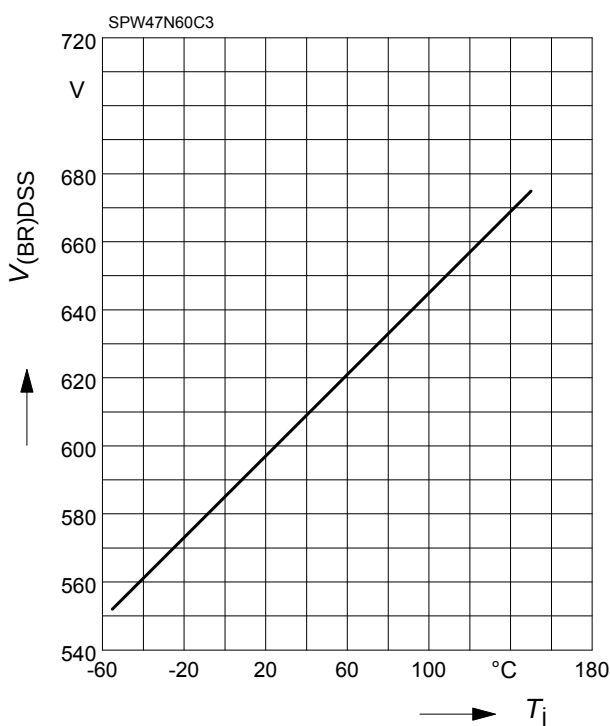
$$E_{AS} = f(T_j)$$

par.:  $I_D = 10\text{ A}$ ,  $V_{DD} = 50\text{ V}$



### 19 Drain-source breakdown voltage

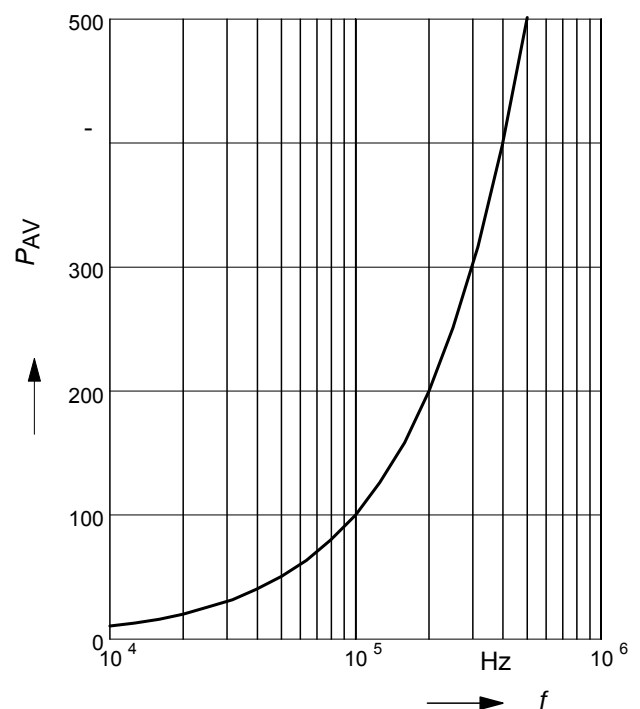
$$V_{(BR)DSS} = f(T_j)$$



### 20 Avalanche power losses

$$P_{AR} = f(f)$$

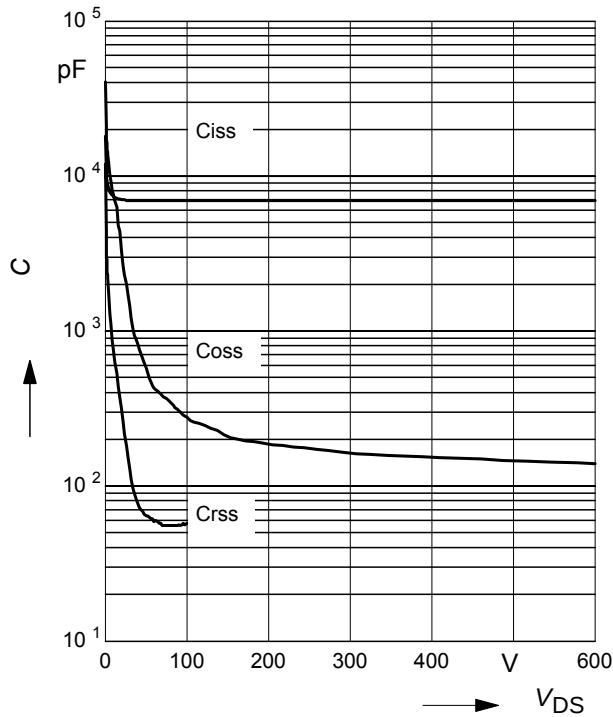
parameter:  $E_{AR}=1\text{ mJ}$



### 21 Typ. capacitances

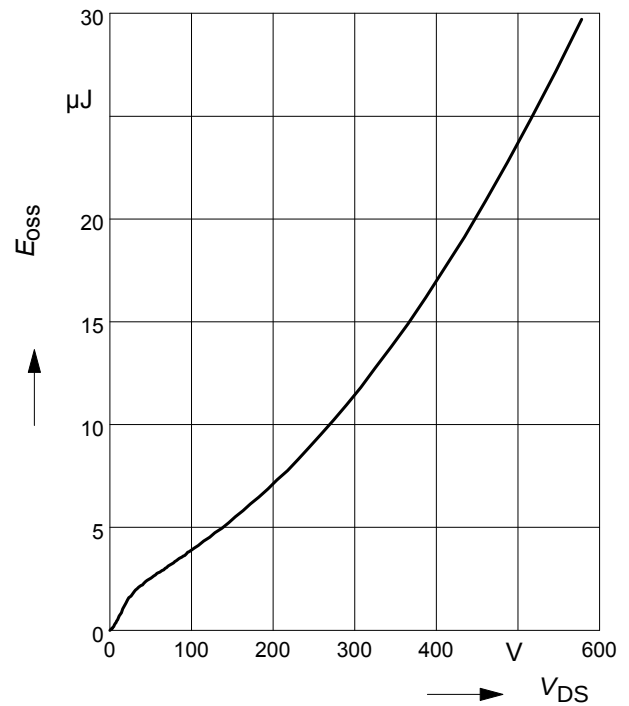
$$C = f(V_{DS})$$

parameter:  $V_{GS}=0V$ ,  $f=1\text{ MHz}$



### 22 Typ. $C_{oss}$ stored energy

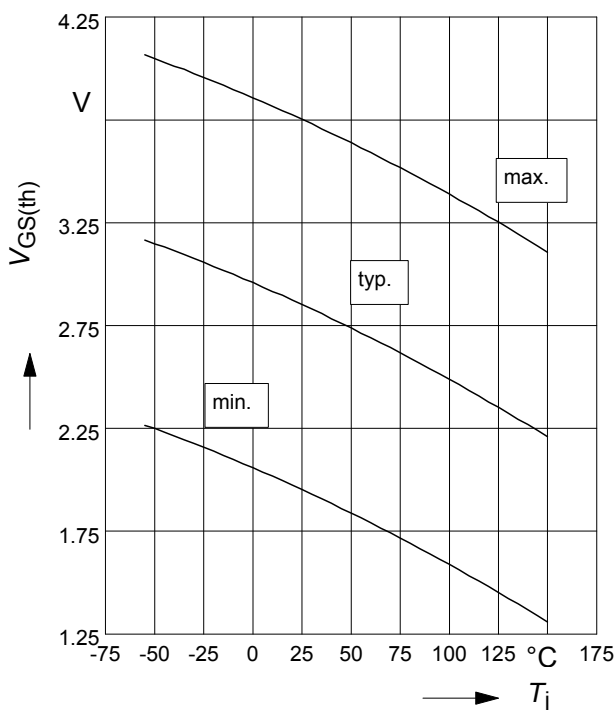
$$E_{oss}=f(V_{DS})$$



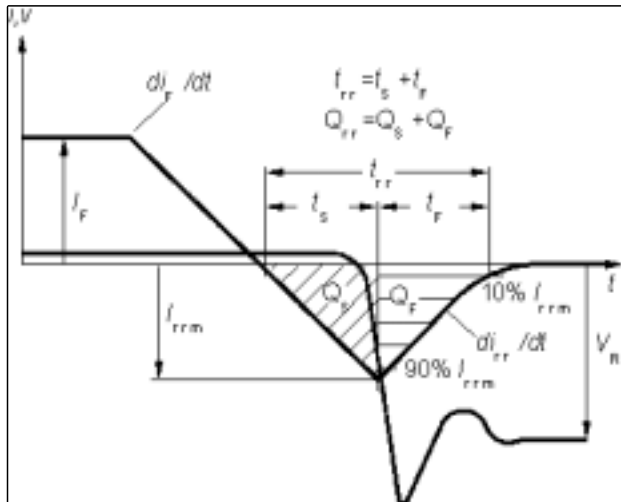
### 23 Typ. gate threshold voltage

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

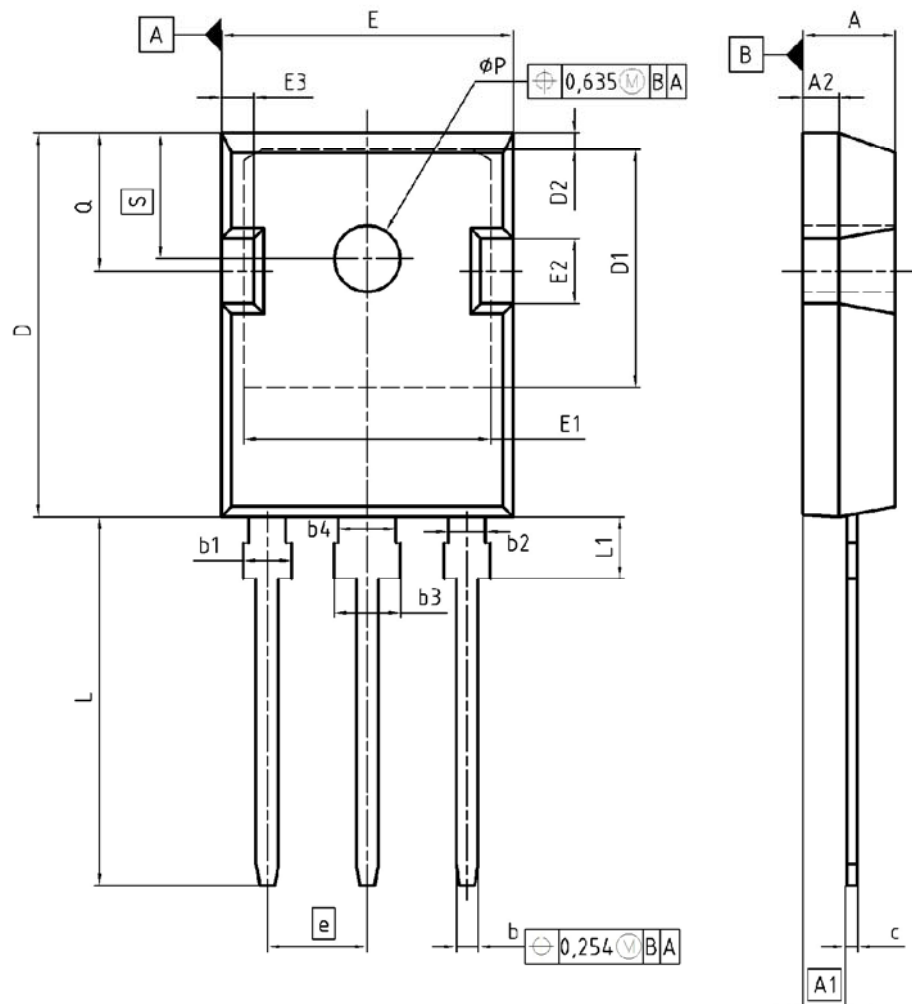
parameter:  $V_{GS} = V_{DS}$ ;  $I_D = 2.7\text{ mA}$



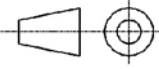
## Definition of diodes switching characteristics



PG-TO-247-3-1



| DIM      | MILLIMETERS |       | INCHES |       |
|----------|-------------|-------|--------|-------|
|          | MIN         | MAX   | MIN    | MAX   |
| A        | 4.90        | 5.16  | 0.193  | 0.203 |
| A1       | 2.27        | 2.53  | 0.089  | 0.099 |
| A2       | 1.85        | 2.11  | 0.073  | 0.083 |
| b        | 1.07        | 1.33  | 0.042  | 0.052 |
| b1       | 1.90        | 2.41  | 0.075  | 0.095 |
| b2       | 1.90        | 2.16  | 0.075  | 0.085 |
| b3       | 2.87        | 3.38  | 0.113  | 0.133 |
| b4       | 2.87        | 3.13  | 0.113  | 0.123 |
| c        | 0.55        | 0.68  | 0.022  | 0.027 |
| D        | 20.82       | 21.10 | 0.820  | 0.831 |
| D1       | 16.25       | 17.65 | 0.640  | 0.695 |
| D2       | 1.05        | 1.35  | 0.041  | 0.053 |
| E        | 15.70       | 16.03 | 0.618  | 0.631 |
| E1       | 13.10       | 14.15 | 0.516  | 0.557 |
| E2       | 3.68        | 5.10  | 0.145  | 0.201 |
| E3       | 1.68        | 2.60  | 0.066  | 0.102 |
| e        | 5.44        |       | 0.214  |       |
| N        | 3           |       | 3      |       |
| L        | 19.80       | 20.31 | 0.780  | 0.799 |
| L1       | 4.17        | 4.47  | 0.164  | 0.176 |
| $\phi P$ | 3.50        | 3.70  | 0.138  | 0.146 |
| Q        | 5.49        | 6.00  | 0.216  | 0.236 |
| S        | 6.04        | 6.30  | 0.238  | 0.248 |

|                                                                                                              |
|--------------------------------------------------------------------------------------------------------------|
| DOCUMENT NO.<br>Z8B00003327                                                                                  |
| SCALE<br>0 5 5 7.5mm                                                                                         |
| EUROPEAN PROJECTION<br> |
| ISSUE DATE<br>17-12-2007                                                                                     |
| REVISION<br>03                                                                                               |

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#### **Warnings**

Due to technical requirements, components may contain dangerous substances. For information on the types in question, please contact the nearest Infineon Technologies Office. Infineon Technologies components may be used in life-support devices or systems only with the express written approval of Infineon Technologies, if a failure of such components can reasonably be expected to cause the failure of that life-support device or system or to affect the safety or effectiveness of that device or system. Life support devices or systems are intended to be implanted in the human body or to support and/or maintain and sustain and/or protect human life. If they fail, it is reasonable to assume that the health of the user or other persons may be endangered.

## 1 New package outlines TO-247

Assembly capacity extension for CoolMOSTM technology products assembled in lead-free package  
PG-TO247-3 at subcontractor ASE (Weihai) Inc., China (Changes are marked in blue.)

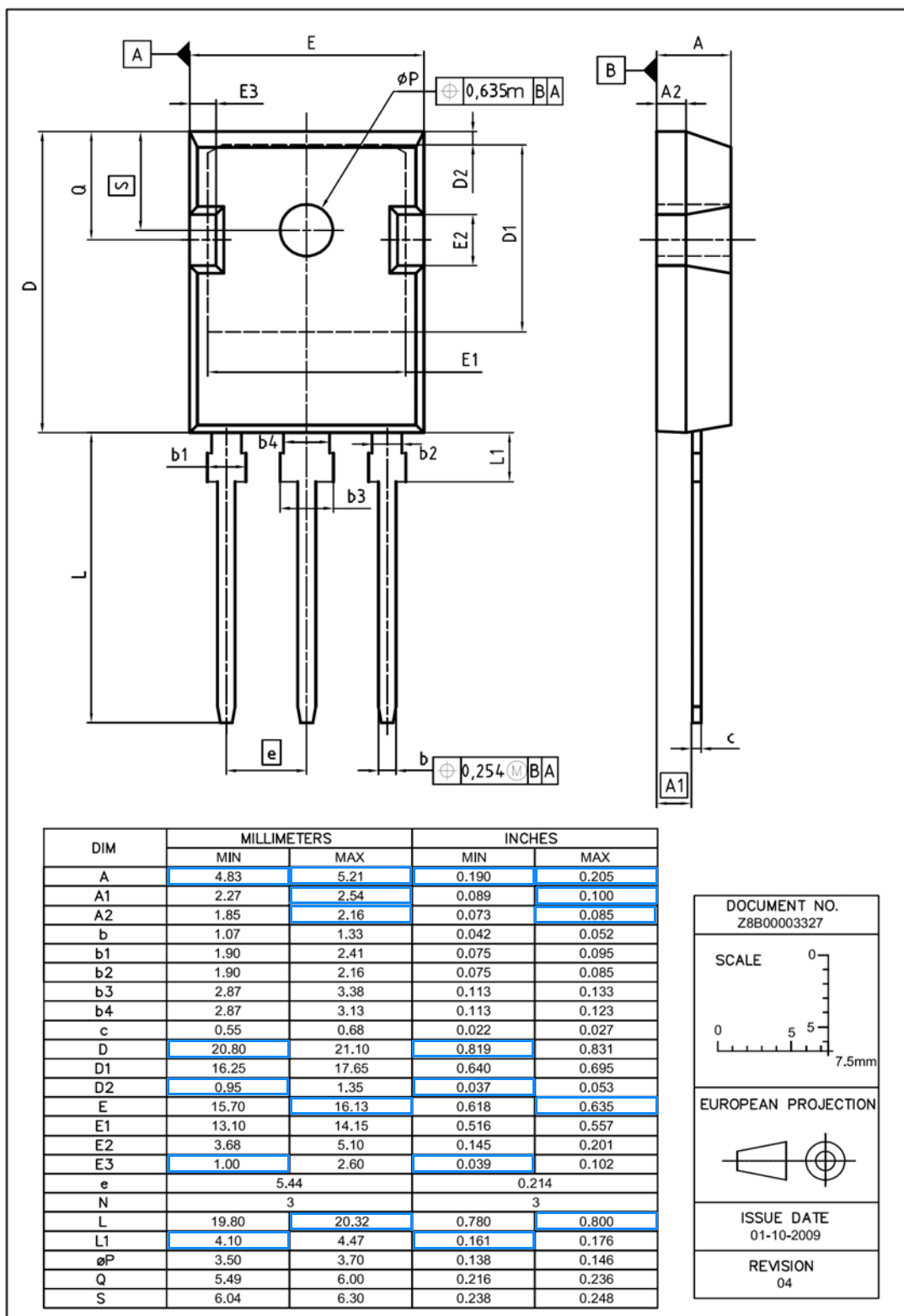


Figure 1 Outlines TO-247, dimensions in mm/inches