

MOSFET

600V CoolMOS™ CE Power Transistor

CoolMOS™ is a revolutionary technology for high voltage power MOSFETs, designed according to the superjunction (SJ) principle and pioneered by Infineon Technologies. CoolMOS™ CE is a price-performance optimized platform enabling to target cost sensitive applications in Consumer and Lighting markets by still meeting highest efficiency standards. The new series provides all benefits of a fast switching Superjunction MOSFET while not sacrificing ease of use and offering the best cost down performance ratio available on the market.

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
- Pb-free plating, Halogen free mold compound
- Qualified for standard grade applications

Applications

PFC stages, hard switching PWM stages and resonant switching stages for e.g. PC Silverbox, Adapter, LCD & PDP TV and indoor lighting.

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

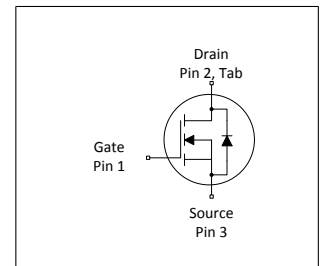


Table 1 Key Performance Parameters

| Parameter | Value | Unit |
|----------------------|-------|-----------|
| $V_{DS} @ T_{j,max}$ | 650 | V |
| $R_{DS(on),max}$ | 1500 | $m\Omega$ |
| I_d | 5 | A |
| $Q_{g,typ}$ | 9.4 | nC |
| $I_{D,pulse}$ | 8 | A |
| $E_{oss@400V}$ | 1 | μJ |

| Type / Ordering Code | Package | Marking | Related Links |
|----------------------|-------------------|----------|----------------|
| IPA60R1K5CE | PG-TO 220 FullPAK | 60S1K5CE | see Appendix A |

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1 Maximum ratings

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

Table 2 Maximum ratings

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|--|---------------|--------|------|----------|------------------|---|
| | | Min. | Typ. | Max. | | |
| Continuous drain current ¹⁾ | I_D | - | - | 5 3.2 | A | $T_C=25^\circ\text{C}$ $T_C=100^\circ\text{C}$ |
| Pulsed drain current ²⁾ | $I_{D,pulse}$ | - | - | 8 | A | $T_C=25^\circ\text{C}$ |
| Avalanche energy, single pulse | E_{AS} | - | - | 26 | mJ | $I_D=0.6\text{A}$; $V_{DD}=50\text{V}$; see table 11 |
| Avalanche energy, repetitive | E_{AR} | - | - | 0.09 | mJ | $I_D=0.6\text{A}$; $V_{DD}=50\text{V}$; see table 11 |
| Avalanche current, repetitive | I_{AR} | - | - | 0.6 | A | - |
| MOSFET dv/dt ruggedness | dv/dt | - | - | 50 | V/ns | $V_{DS}=0\dots480\text{V}$ |
| Gate source voltage (static) | V_{GS} | -20 | - | 20 | V | static; |
| Gate source voltage (dynamic) | V_{GS} | -30 | - | 30 | V | AC ($f>1\text{ Hz}$) |
| Power dissipation (FullPAK) TO-220FP | P_{tot} | - | - | 20 | W | $T_C=25^\circ\text{C}$ |
| Storage temperature | T_{stg} | -40 | - | 150 | $^\circ\text{C}$ | - |
| Operating junction temperature | T_j | -40 | - | 150 | $^\circ\text{C}$ | - |
| Mounting torque (FullPAK) TO-220FP | - | - | - | 50 | Ncm | M2.5 screws |
| Continuous diode forward current | I_S | - | - | 3.5 | A | $T_C=25^\circ\text{C}$ |
| Diode pulse current ²⁾ | $I_{S,pulse}$ | - | - | 8 | A | $T_C=25^\circ\text{C}$ |
| Reverse diode dv/dt ³⁾ | dv/dt | - | - | 15 | V/ns | $V_{DS}=0\dots400\text{V}$, $I_{SD}\leq I_S$, $T_j=25^\circ\text{C}$ see table 9 |
| Maximum diode commutation speed | di/dt | - | - | 500 | A/ μs | $V_{DS}=0\dots400\text{V}$, $I_{SD}\leq I_S$, $T_j=25^\circ\text{C}$ see table 9 |
| Insulation withstand voltage for TO-220FP | V_{ISO} | - | - | 2500 | V | V_{rms} , $T_C=25^\circ\text{C}$, $t=1\text{min}$ |
| Power dissipation TO-252 | P_{tot} | - | - | 49 | W | $T_C=25^\circ\text{C}$ |

2 Thermal characteristics

Table 3 Thermal characteristics (FullPAK) TO-220FP

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|---|------------|--------|------|------|--------------------|-------------------------------------|
| | | Min. | Typ. | Max. | | |
| Thermal resistance, junction - case | R_{thJC} | - | - | 6.4 | $^\circ\text{C/W}$ | - |
| Thermal resistance, junction - ambient | R_{thJA} | - | - | 80 | $^\circ\text{C/W}$ | leaded |
| Soldering temperature, wavesoldering only allowed at leads | T_{sold} | - | - | 260 | $^\circ\text{C}$ | 1.6mm (0.063 in.) from case for 10s |

¹⁾ Limited by $T_{j,max}$, TO252 equivalent, Maximum duty cycle $D=0.50$

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

³⁾ Identical low side and high side switch with identical R_θ

3 Electrical characteristics

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

Table 4 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 | 3.0 | 3.5 | V | $V_{DS}=V_{GS}$, $I_D=0.09\text{mA}$ |
| Zero gate voltage drain current | I_{DSS} | - | - | 1 | μA | $V_{DS}=600$, $V_{GS}=0\text{V}$, $T_j=25^\circ\text{C}$ $V_{DS}=600$, $V_{GS}=0\text{V}$, $T_j=150^\circ\text{C}$ |
| Gate-source leakage current | I_{GSS} | - | - | 100 | nA | $V_{GS}=20\text{V}$, $V_{DS}=0\text{V}$ |
| Drain-source on-state resistance | $R_{DS(on)}$ | - | 1.26 3.28 | 1.50 | Ω | $V_{GS}=10\text{V}$, $I_D=1.1\text{A}$, $T_j=25^\circ\text{C}$ $V_{GS}=10\text{V}$, $I_D=1.1\text{A}$, $T_j=150^\circ\text{C}$ |
| Gate resistance | R_G | - | 14 | - | Ω | $f=1\text{MHz}$, open drain |

Table 5 Dynamic characteristics

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|--|--------------|--------|------|------|------|---|
| | | Min. | Typ. | Max. | | |
| Input capacitance | C_{iss} | - | 200 | - | pF | $V_{GS}=0\text{V}$, $V_{DS}=100\text{V}$, $f=1\text{MHz}$ |
| Output capacitance | C_{oss} | - | 16 | - | pF | $V_{GS}=0\text{V}$, $V_{DS}=100\text{V}$, $f=1\text{MHz}$ |
| Effective output capacitance, energy related ¹⁾ | $C_{o(er)}$ | - | 11 | - | pF | $V_{GS}=0\text{V}$, $V_{DS}=0\dots480\text{V}$ |
| Effective output capacitance, time related ²⁾ | $C_{o(tr)}$ | - | 41.3 | - | pF | $I_D=\text{constant}$, $V_{GS}=0\text{V}$, $V_{DS}=0\dots480\text{V}$ |
| Turn-on delay time | $t_{d(on)}$ | - | 8 | - | ns | $V_{DD}=400\text{V}$, $V_{GS}=13\text{V}$, $I_D=1.4\text{A}$, $R_G=12.2\Omega$; see table 10 |
| Rise time | t_r | - | 7 | - | ns | $V_{DD}=400\text{V}$, $V_{GS}=13\text{V}$, $I_D=1.4\text{A}$, $R_G=12.2\Omega$; see table 10 |
| Turn-off delay time | $t_{d(off)}$ | - | 40 | - | ns | $V_{DD}=400\text{V}$, $V_{GS}=13\text{V}$, $I_D=1.4\text{A}$, $R_G=12.2\Omega$; see table 10 |
| Fall time | t_f | - | 20 | - | ns | $V_{DD}=400\text{V}$, $V_{GS}=13\text{V}$, $I_D=1.4\text{A}$, $R_G=12.2\Omega$; see table 10 |

Table 6 Gate charge characteristics

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|-----------------------|----------------------|--------|------|------|------|---|
| | | Min. | Typ. | Max. | | |
| Gate to source charge | Q_{GS} | - | 1.1 | - | nC | $V_{DD}=480\text{V}$, $I_D=1.4\text{A}$, $V_{GS}=0$ to 10V |
| Gate to drain charge | Q_{gd} | - | 5 | - | nC | $V_{DD}=480\text{V}$, $I_D=1.4\text{A}$, $V_{GS}=0$ to 10V |
| Gate charge total | Q_g | - | 9.4 | - | nC | $V_{DD}=480\text{V}$, $I_D=1.4\text{A}$, $V_{GS}=0$ to 10V |
| Gate plateau voltage | V_{plateau} | - | 5.4 | - | V | $V_{DD}=480\text{V}$, $I_D=1.4\text{A}$, $V_{GS}=0$ to 10V |

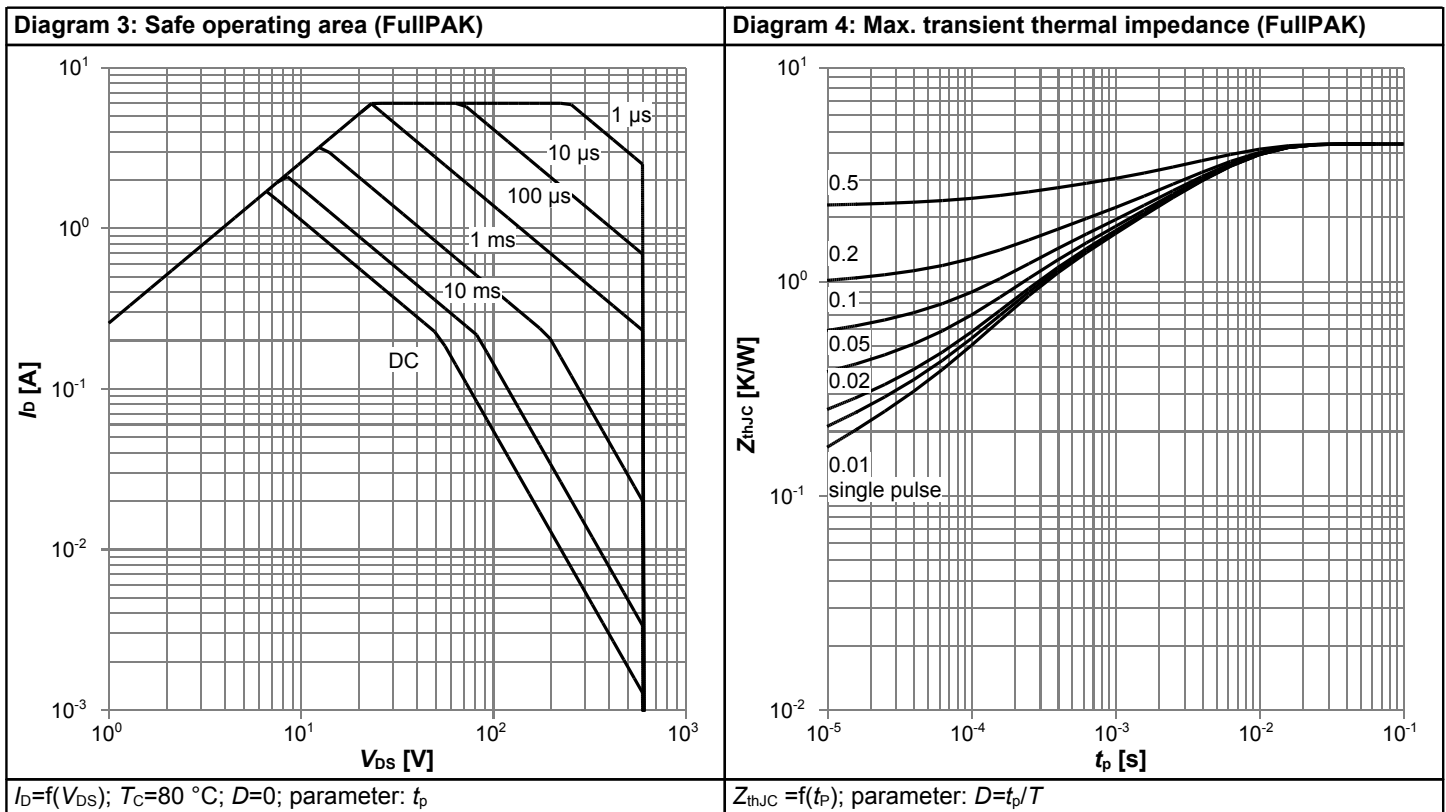
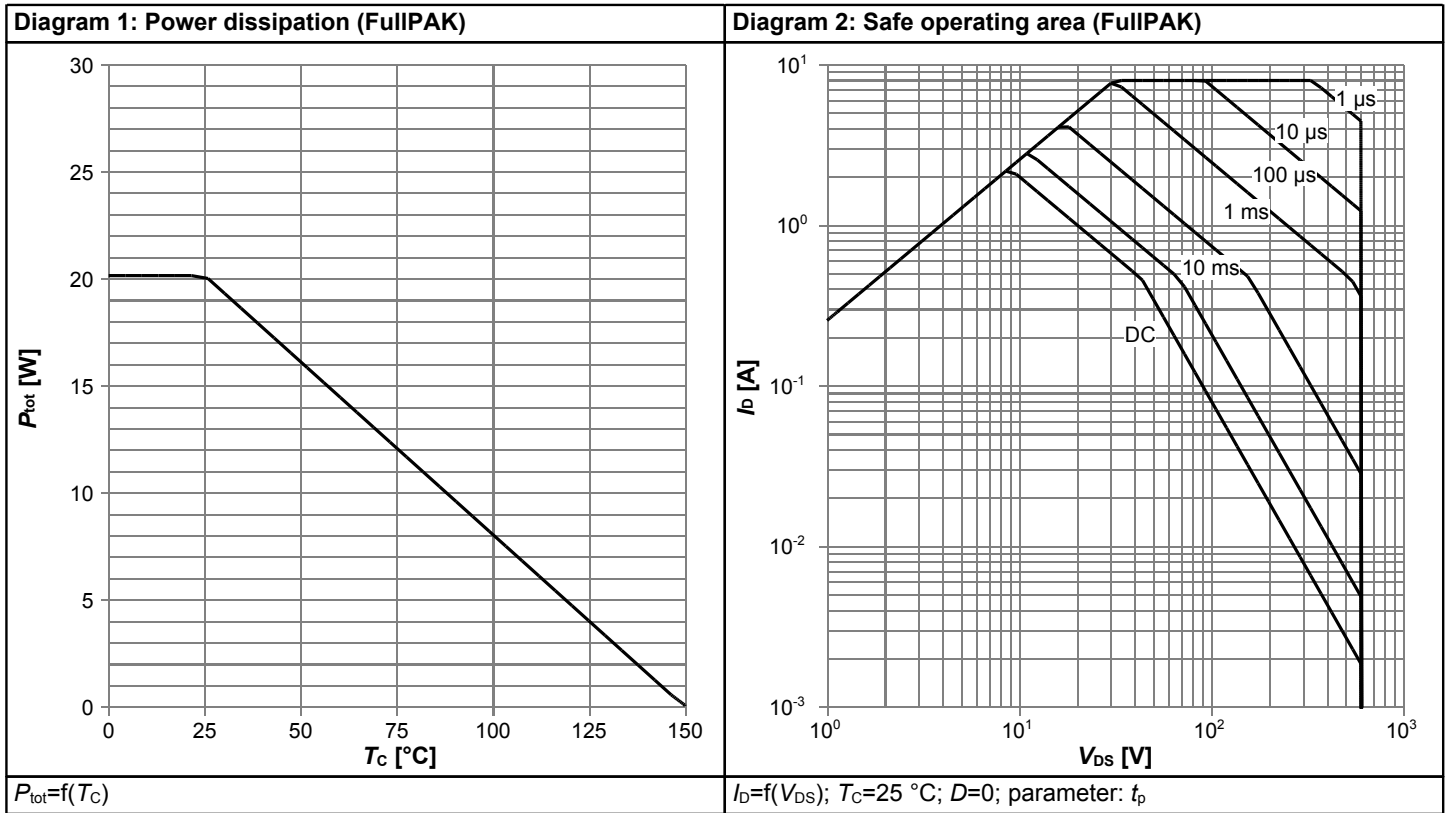
¹⁾ $C_{o(er)}$ is a fixed capacitance that gives the same stored energy as C_{oss} while V_{DS} is rising from 0 to 80% $V_{o(BR)DSS}$

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

Table 7 Reverse diode characteristics

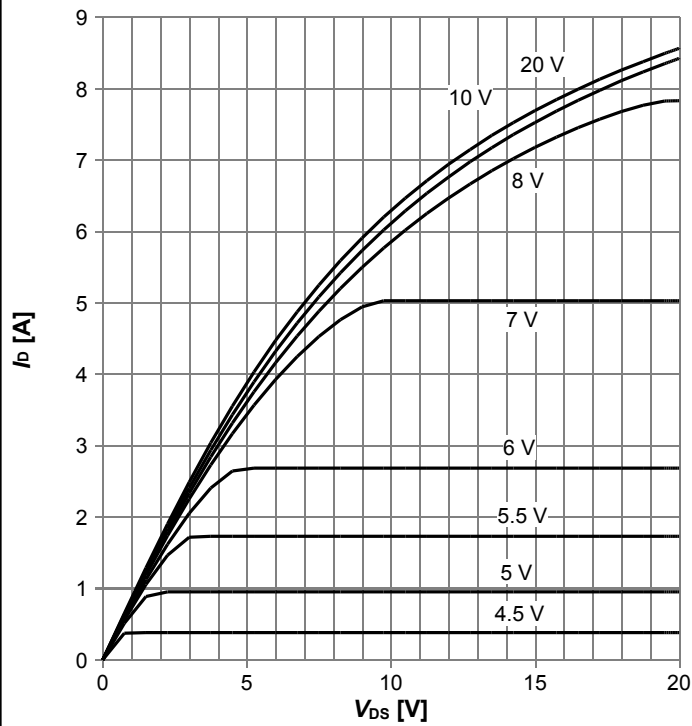
| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|-------------------------------|-----------|--------|------|------|---------|---|
| | | Min. | Typ. | Max. | | |
| Diode forward voltage | V_{SD} | - | 0.9 | - | V | $V_{GS}=0V, I_F=1.4A, T_j=25^{\circ}C$ |
| Reverse recovery time | t_{rr} | - | 230 | - | ns | $V_R=400V, I_F=1.4A, di_F/dt=100A/\mu s$; see table 9 |
| Reverse recovery charge | Q_{rr} | - | 1.1 | - | μC | $V_R=400V, I_F=1.4A, di_F/dt=100A/\mu s$; see table 9 |
| Peak reverse recovery current | I_{rrm} | - | 9.8 | - | A | $V_R=400V, I_F=1.4A, di_F/dt=100A/\mu s$; see table 9 |

4 Electrical characteristics diagrams



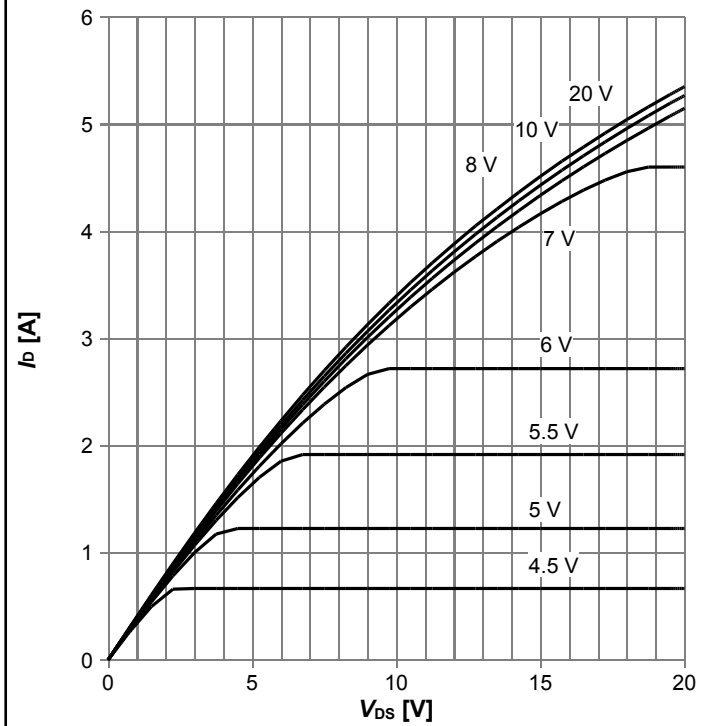
600V CoolMOS™ CE Power Transistor IPA60R1K5CE

Diagram 5: Typ. output characteristics



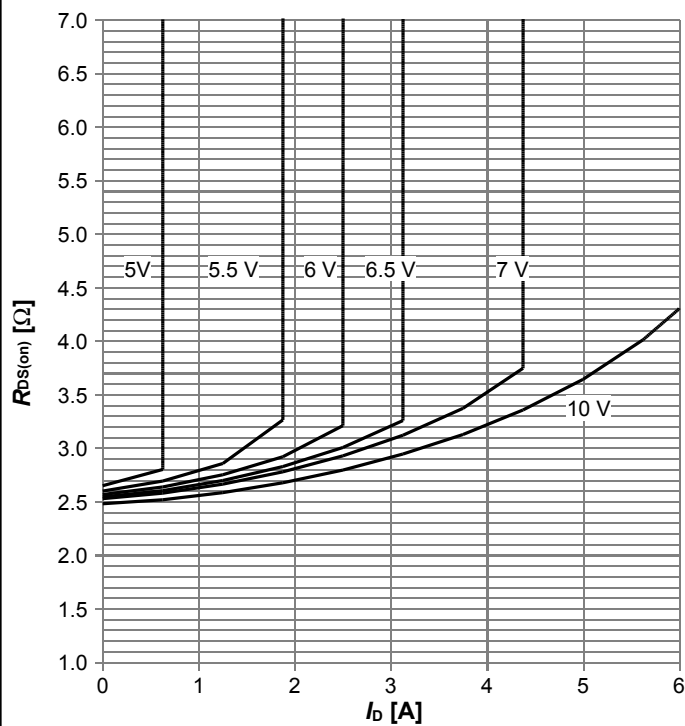
$I_D=f(V_{DS}); T_j=25\text{ }^\circ\text{C};$ parameter: V_{GS}

Diagram 6: Typ. output characteristics



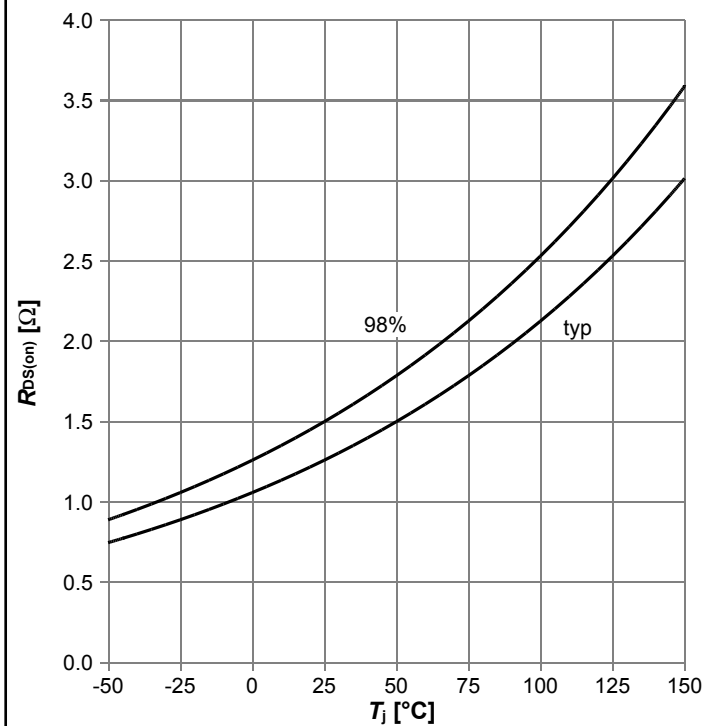
$I_D=f(V_{DS}); T_j=125\text{ }^\circ\text{C};$ parameter: V_{GS}

Diagram 7: Typ. drain-source on-state resistance



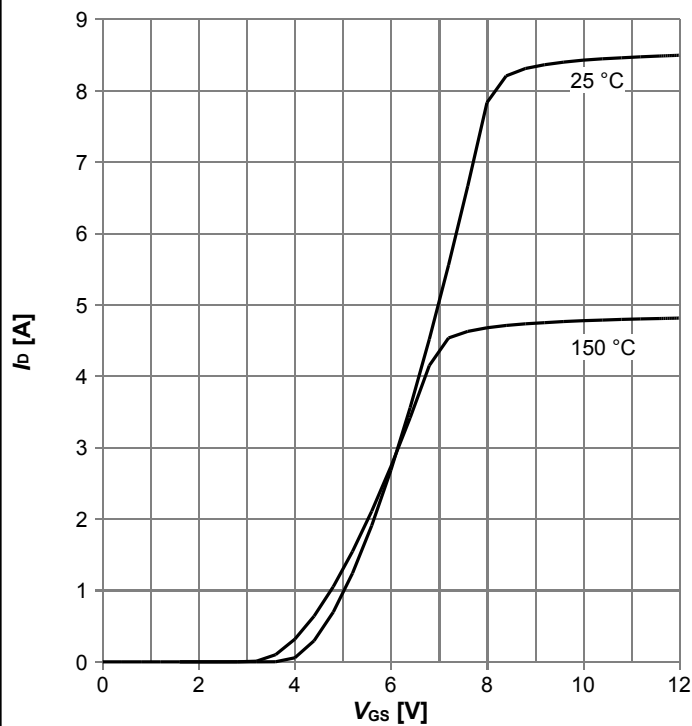
$R_{DS(on)}=f(I_D); T_j=125\text{ }^\circ\text{C};$ parameter: V_{GS}

Diagram 8: Drain-source on-state resistance



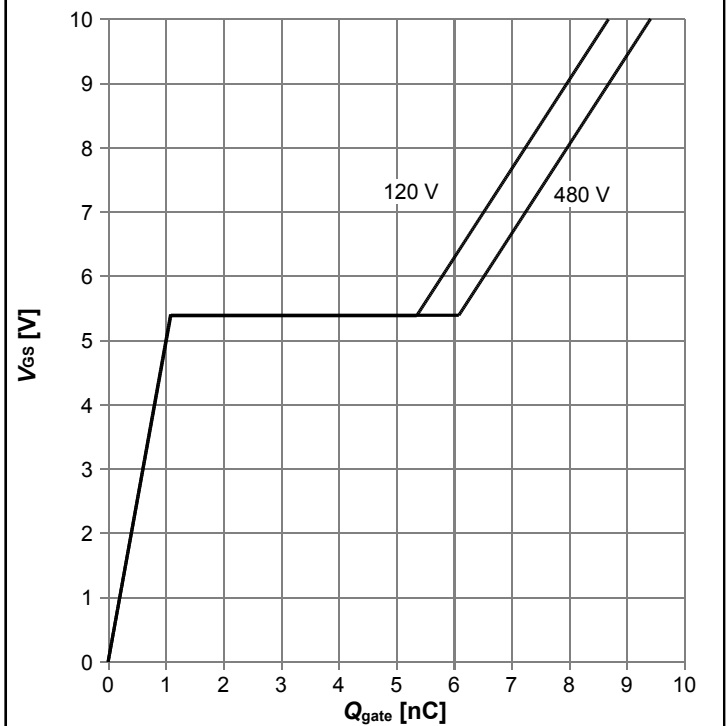
$R_{DS(on)}=f(T_j); I_D=1.1\text{ A}; V_{GS}=10\text{ V}$

Diagram 9: Typ. transfer characteristics



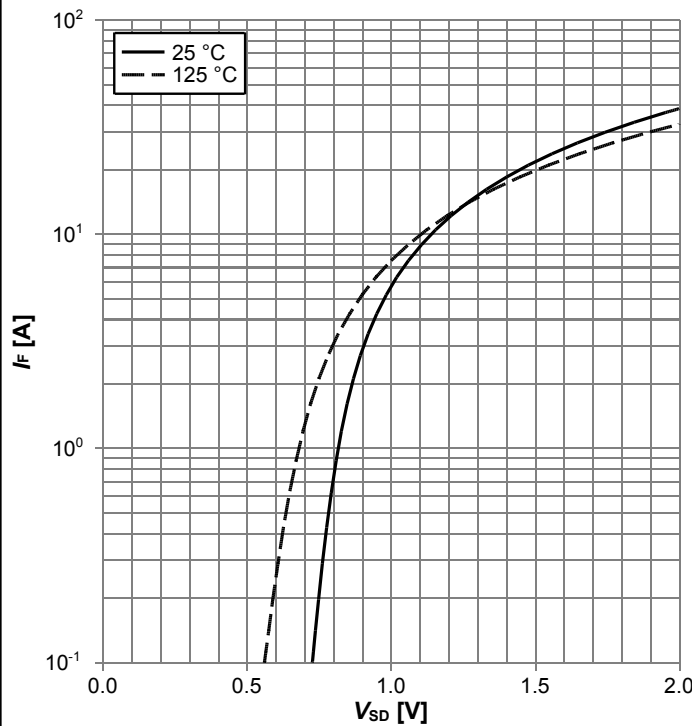
$I_D = f(V_{GS}); V_{DS} = 20V; \text{parameter: } T_j$

Diagram 10: Typ. gate charge



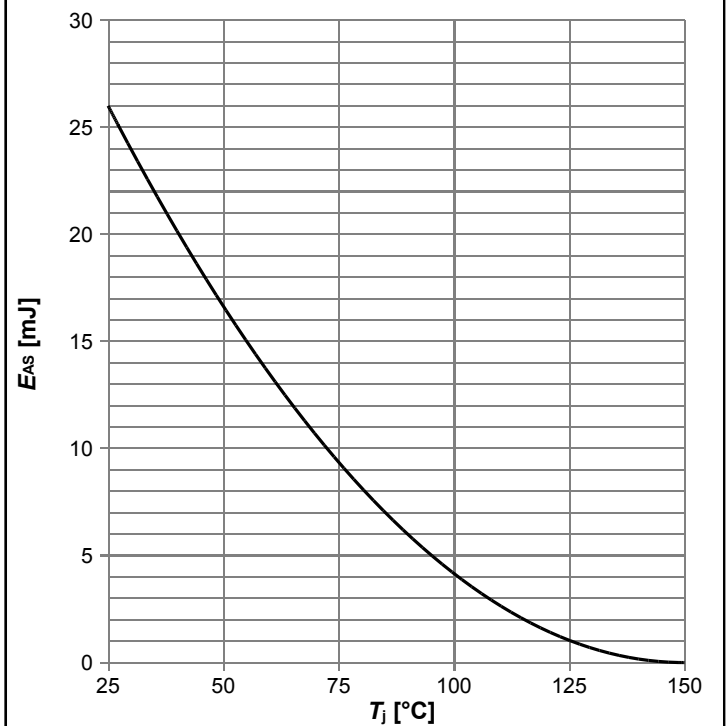
$V_{GS} = f(Q_{gate}); I_D = 1.4 \text{ A pulsed}; \text{parameter: } V_{DD}$

Diagram 11: Forward characteristics of reverse diode



$I_F = f(V_{SD}); \text{parameter: } T_j$

Diagram 12: Avalanche energy

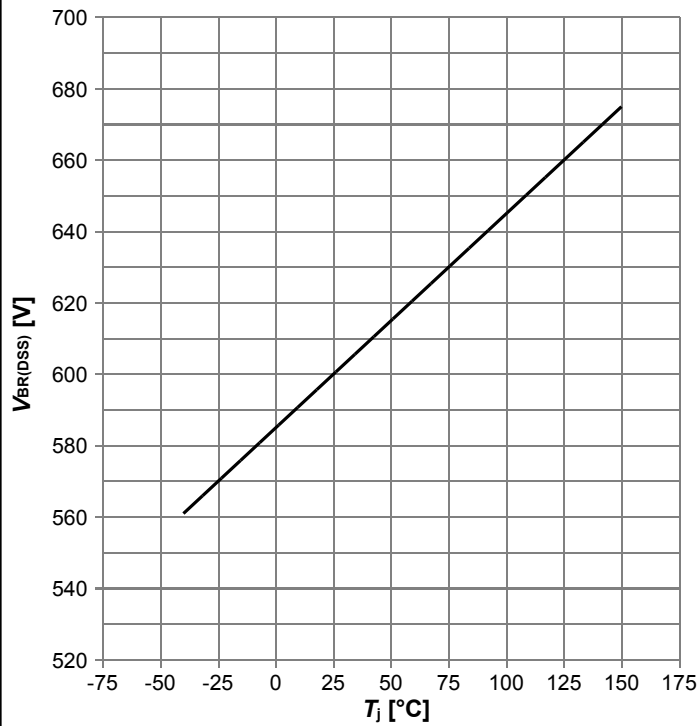


$E_{AS} = f(T_j); I_D = 0.6 \text{ A}; V_{DD} = 50 \text{ V}$

600V CoolMOS™ CE Power Transistor

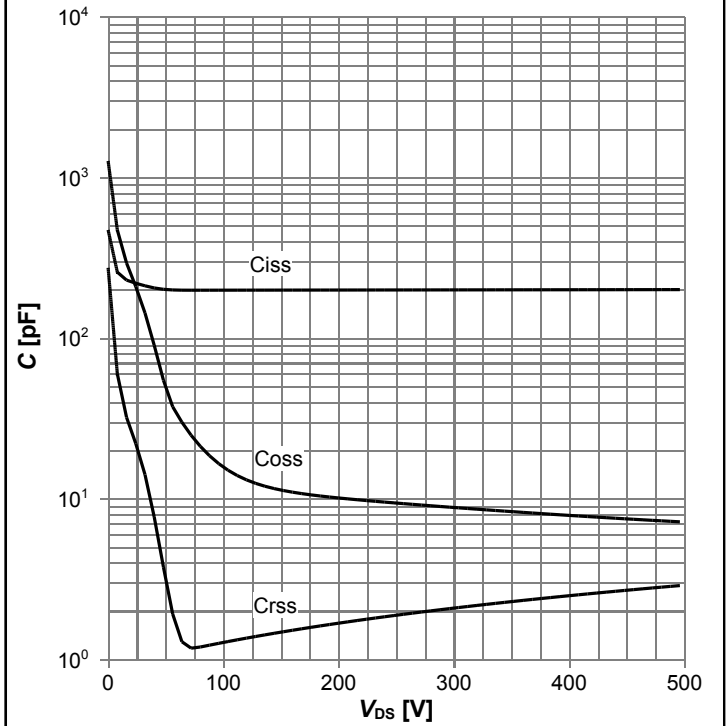
IPA60R1K5CE

Diagram 13: Drain-source breakdown voltage



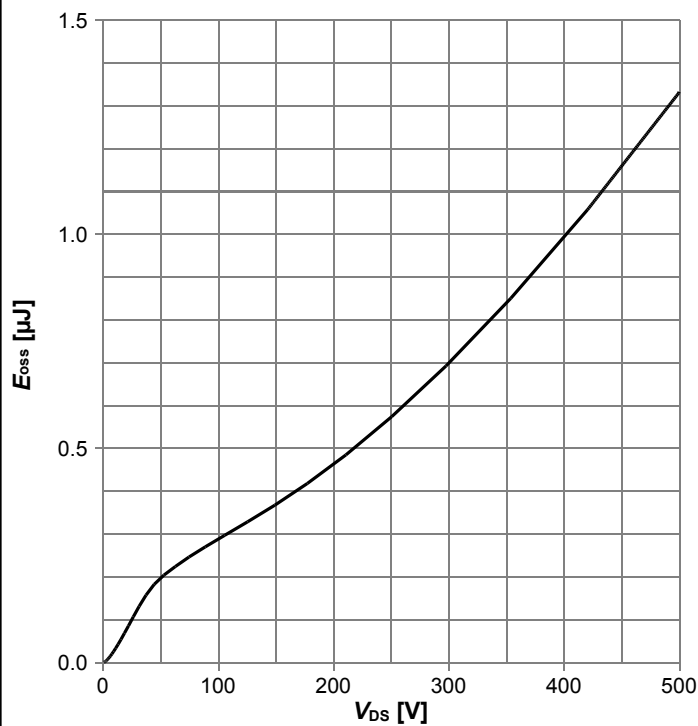
$V_{BR(DSS)} = f(T_j); I_D = 0.25 \text{ mA}$

Diagram 14: Typ. capacitances



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

Diagram 15: Typ. Coss stored energy



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

5 Test Circuits

Table 8 Diode characteristics

| Test circuit for diode characteristics | Diode recovery waveform |
|--|---|
| <p>$R_{g1} = R_{g2}$</p> | <p>$t_{tr} = t_F + t_S$ $Q_{rr} = Q_F + Q_S$</p> |

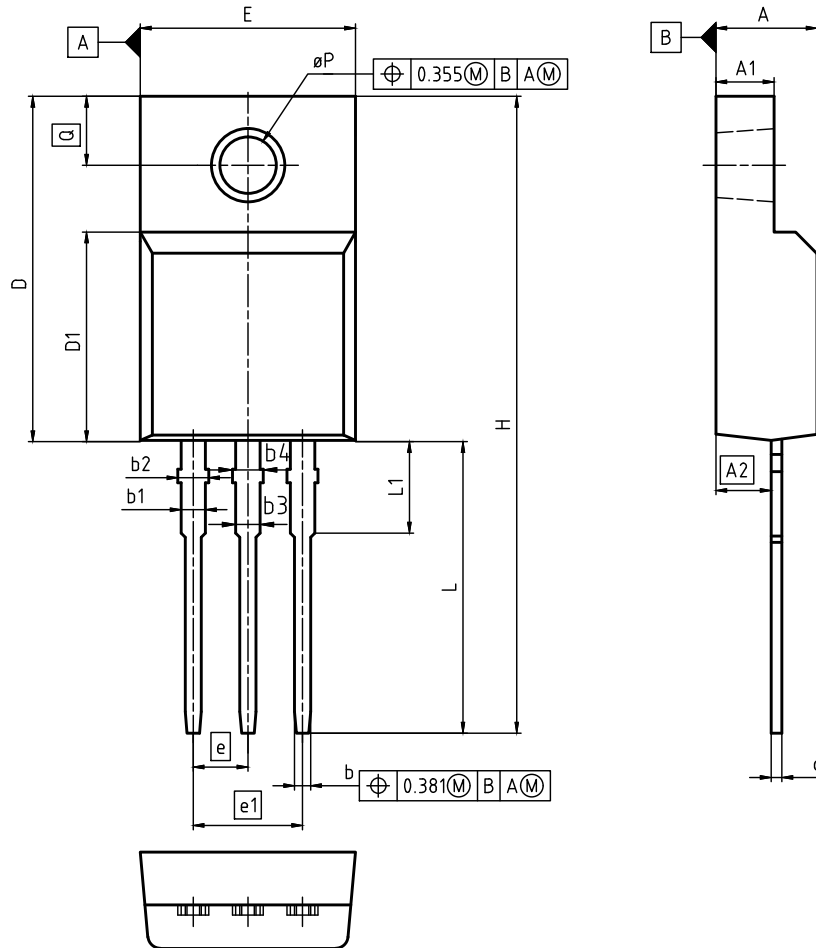
Table 9 Switching times

| Switching times test circuit for inductive load | Switching times waveform |
|---|--------------------------|
| | |

Table 10 Unclamped inductive load

| Unclamped inductive load test circuit | Unclamped inductive waveform |
|---------------------------------------|--------------------------------|
| | <p>$V_{(BR)DS}$</p> |

6 Package Outlines



| DIM | MILLIMETERS | | INCHES | |
|-----------------|-------------|-------|-------------|-------|
| | MIN | MAX | MIN | MAX |
| A | 4.50 | 4.90 | 0.177 | 0.193 |
| A1 | 2.34 | 2.85 | 0.092 | 0.112 |
| A2 | 2.42 | 2.86 | 0.095 | 0.113 |
| b | 0.65 | 0.90 | 0.026 | 0.035 |
| b1 | 0.95 | 1.38 | 0.037 | 0.054 |
| b2 | 0.95 | 1.51 | 0.037 | 0.059 |
| b3 | 0.65 | 1.38 | 0.026 | 0.054 |
| b4 | 0.65 | 1.51 | 0.026 | 0.059 |
| c | 0.40 | 0.63 | 0.016 | 0.025 |
| D | 15.67 | 16.15 | 0.617 | 0.636 |
| D1 | 8.97 | 9.83 | 0.353 | 0.387 |
| E | 10.00 | 10.65 | 0.394 | 0.419 |
| e | 2.54 (BSC) | | 0.100 (BSC) | |
| e1 | 5.08 | | 0.200 | |
| N | 3 | | 3 | |
| H | 28.70 | 29.75 | 1.130 | 1.171 |
| L | 12.78 | 13.75 | 0.503 | 0.541 |
| L1 | 2.83 | 3.45 | 0.111 | 0.136 |
| $\varnothing P$ | 2.95 | 3.38 | 0.116 | 0.133 |
| Q | 3.15 | 3.50 | 0.124 | 0.138 |

Dimensions do not include mold flash, protrusions or gate burrs

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SCALE

EUROPEAN PROJECTION

ISSUE DATE
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REVISION
04

Figure 1 Outline PG-TO 220 FullPAK, dimensions in mm/inches

7 Appendix A

Table 11 Related Links

- IFX CoolMOS™ CE Webpage: www.infineon.com
- IFX CoolMOS™ CE application note: www.infineon.com
- IFX CoolMOS™ CE simulation model: www.infineon.com
- IFX Design tools: www.infineon.com

Revision History

IPA60R1K5CE

Revision: 2016-02-26, Rev. 2.0

Previous Revision

| Revision | Date | Subjects (major changes since last revision) |
|----------|------------|--|
| 2.0 | 2016-02-26 | Release of final version |

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