

MOSFET

650V 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 series combines the experience of the leading SJ MOSFET supplier with high class innovation. The resulting devices provide all benefits of a fast switching Superjunction 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 Eoss
- Very high commutation ruggedness
- Easy to use/drive
- JEDEC qualified, 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.



PG-TO 220 FP

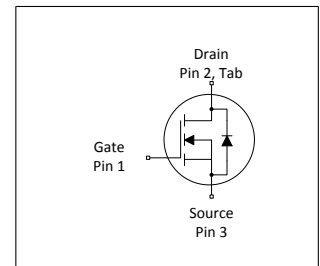


Table 1 Key Performance Parameters

| Parameter | Value | Unit |
|----------------------|-------|-----------|
| $V_{DS} @ T_{j,max}$ | 700 | V |
| $R_{DS(on),max}$ | 400 | $m\Omega$ |
| I_D | 15.1 | A |
| $Q_{g,typ}$ | 39 | nC |
| $I_{D,pulse}$ | 30 | A |
| $E_{oss@400V}$ | 2.8 | μJ |

| Type / Ordering Code | Package | Marking | Related Links |
|----------------------|-------------------|----------|----------------|
| IPA65R400CE | PG-TO 220 FullPAK | 65S400CE | 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 | - | - | 15.1 9.5 | A | $T_C=25^\circ\text{C}$ $T_C=100^\circ\text{C}$ |
| Pulsed drain current ²⁾ | $I_{D,pulse}$ | - | - | 30 | A | $T_C=25^\circ\text{C}$ |
| Avalanche energy, single pulse | E_{AS} | - | - | 215 | mJ | $I_D=1.8\text{A}$; $V_{DD}=50\text{V}$; see table 10 |
| Avalanche energy, repetitive | E_{AR} | - | - | 0.32 | mJ | $I_D=1.8\text{A}$; $V_{DD}=50\text{V}$; see table 10 |
| Avalanche current, repetitive | I_{AR} | - | - | 1.8 | 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 (Non FullPAK) TO-252, TO-251 | P_{tot} | - | - | 118 | W | $T_C=25^\circ\text{C}$ |
| Power dissipation (FullPAK) TO-220FP | P_{tot} | - | - | 31 | W | $T_C=25^\circ\text{C}$ |
| Storage temperature | T_{stg} | -55 | - | 150 | $^\circ\text{C}$ | - |
| Operating junction temperature | T_j | -55 | - | 150 | $^\circ\text{C}$ | - |
| Continuous diode forward current | I_S | - | - | 10.6 | A | $T_C=25^\circ\text{C}$ |
| Diode pulse current ²⁾ | $I_{S,pulse}$ | - | - | 30 | 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 8 |
| 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 8 |
| Mounting torque (FullPAK) TO-220FP | - | - | - | 50 | Ncm | M2.5 screws |
| Insulation withstand voltage for TO-220FP | V_{ISO} | - | - | 2500 | V | V_{rms} , $T_C=25^\circ\text{C}$, $t=1\text{min}$ |

¹⁾ Limited by $T_{j,max}$. TO251 equivalent, Maximum duty cycle $D=0.5$

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

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

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} | - | - | 4 | °C/W | - |
| Thermal resistance, junction - ambient | R_{thJA} | - | - | 80 | °C/W | leaded |
| Soldering temperature, wavesoldering only allowed at leads | T_{sold} | - | - | 260 | °C | 1.6mm (0.063 in.) from case for 10s |

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 | $V_{(BR)DSS}$ | 650 | - | - | V | $V_{GS}=0V, I_D=1mA$ |
| Gate threshold voltage | $V_{(GS)th}$ | 2.5 | 3.0 | 3.5 | V | $V_{DS}=V_{GS}, I_D=0.32mA$ |
| Zero gate voltage drain current | I_{DSS} | - | - | 1 | μA | $V_{DS}=650, V_{GS}=0V, T_j=25^\circ\text{C}$ $V_{DS}=650, V_{GS}=0V, T_j=150^\circ\text{C}$ |
| Gate-source leakage current | I_{GSS} | - | - | 100 | nA | $V_{GS}=20V, V_{DS}=0V$ |
| Drain-source on-state resistance | $R_{DS(on)}$ | - | 0.36 0.94 | 0.40 - | Ω | $V_{GS}=10V, I_D=3.2435A, T_j=25^\circ\text{C}$ $V_{GS}=10V, I_D=3.2435A, T_j=150^\circ\text{C}$ |
| Gate resistance | R_G | - | 17 | - | 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} | - | 710 | - | pF | $V_{GS}=0V, V_{DS}=100V, f=1\text{MHz}$ |
| Output capacitance | C_{oss} | - | 41 | - | pF | $V_{GS}=0V, V_{DS}=100V, f=1\text{MHz}$ |
| Effective output capacitance, energy related ¹⁾ | $C_{o(er)}$ | - | 32 | - | pF | $V_{GS}=0V, V_{DS}=0\dots480V$ |
| Effective output capacitance, time related ²⁾ | $C_{o(tr)}$ | - | 140 | - | pF | $I_D=\text{constant}, V_{GS}=0V, V_{DS}=0\dots480V$ |
| Turn-on delay time | $t_{d(on)}$ | - | 12 | - | ns | $V_{DD}=400V, V_{GS}=13V, I_D=4.86525A, R_G=4.9\Omega$; see table 9 |
| Rise time | t_r | - | 12 | - | ns | $V_{DD}=400V, V_{GS}=13V, I_D=4.86525A, R_G=4.9\Omega$; see table 9 |
| Turn-off delay time | $t_{d(off)}$ | - | 110 | - | ns | $V_{DD}=400V, V_{GS}=13V, I_D=4.86525A, R_G=4.9\Omega$; see table 9 |
| Fall time | t_f | - | 11 | - | ns | $V_{DD}=400V, V_{GS}=13V, I_D=4.86525A, R_G=4.9\Omega$; see table 9 |

Table 6 Gate charge characteristics

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|-----------------------|---------------|--------|------|------|------|--|
| | | Min. | Typ. | Max. | | |
| Gate to source charge | Q_{gs} | - | 4 | - | nC | $V_{DD}=480V, I_D=4.86525A, V_{GS}=0$ to 10V |
| Gate to drain charge | Q_{gd} | - | 20 | - | nC | $V_{DD}=480V, I_D=4.86525A, V_{GS}=0$ to 10V |
| Gate charge total | Q_g | - | 39 | - | nC | $V_{DD}=480V, I_D=4.86525A, V_{GS}=0$ to 10V |
| Gate plateau voltage | $V_{plateau}$ | - | 5.5 | - | V | $V_{DD}=480V, I_D=4.86525A, V_{GS}=0$ 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 480V

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 480V

Table 7 Reverse diode characteristics

| Parameter | Symbol | Values | | | Unit | Note / Test Condition |
|-------------------------------|-----------|--------|------|------|---------|--|
| | | Min. | Typ. | Max. | | |
| Diode forward voltage | V_{SD} | - | 0.9 | - | V | $V_{GS}=0V, I_F=4.9A, T_j=25^\circ C$ |
| Reverse recovery time | t_{rr} | - | 280 | - | ns | $V_R=400V, I_F=4.9A, di_F/dt=100A/\mu s$; see table 19 |
| Reverse recovery charge | Q_{rr} | - | 2.8 | - | μC | $V_R=400V, I_F=4.9A, di_F/dt=100A/\mu s$; see table 19 |
| Peak reverse recovery current | I_{rrm} | - | 17 | - | A | $V_R=400V, I_F=4.9A, di_F/dt=100A/\mu s$; see table 19 |

4 Electrical characteristics diagrams

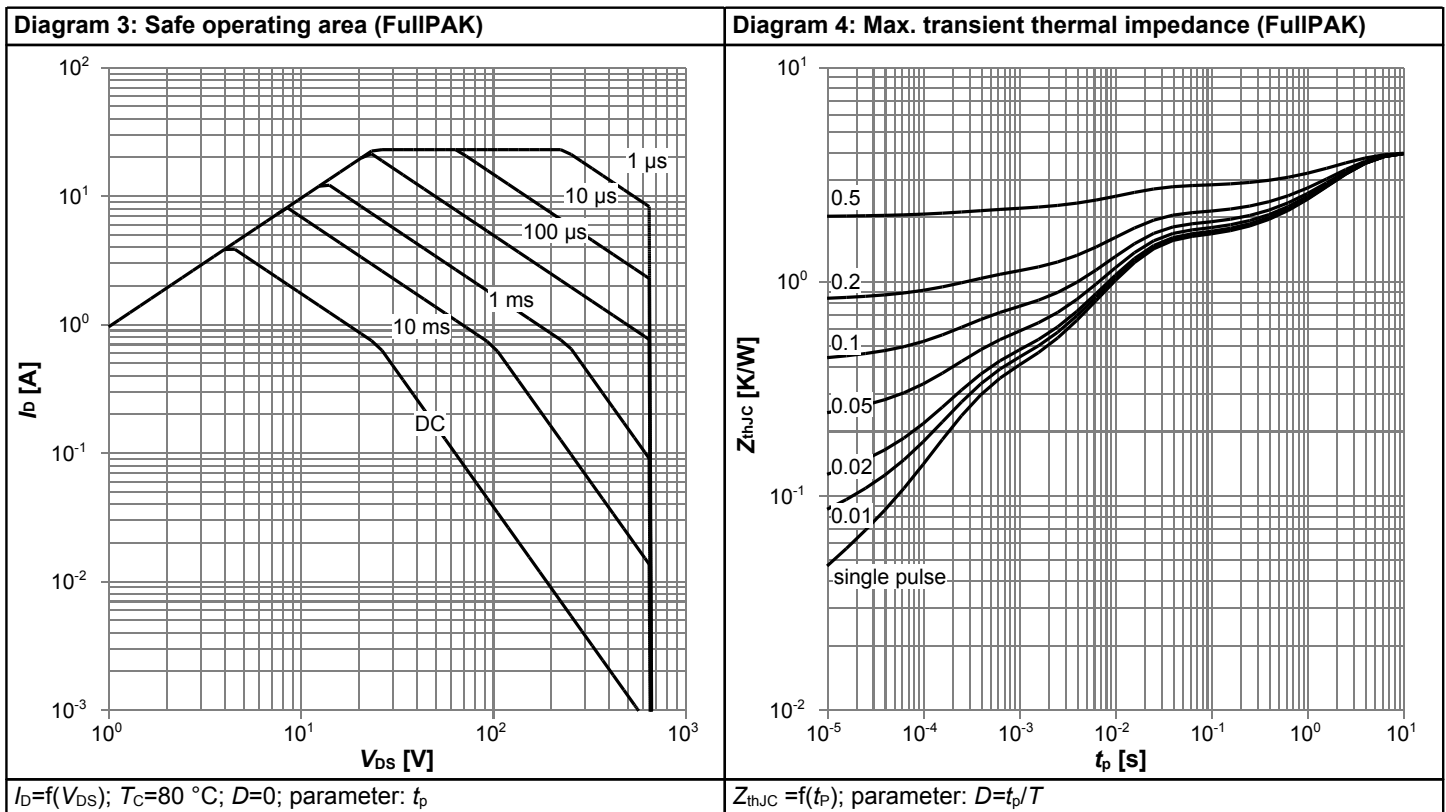
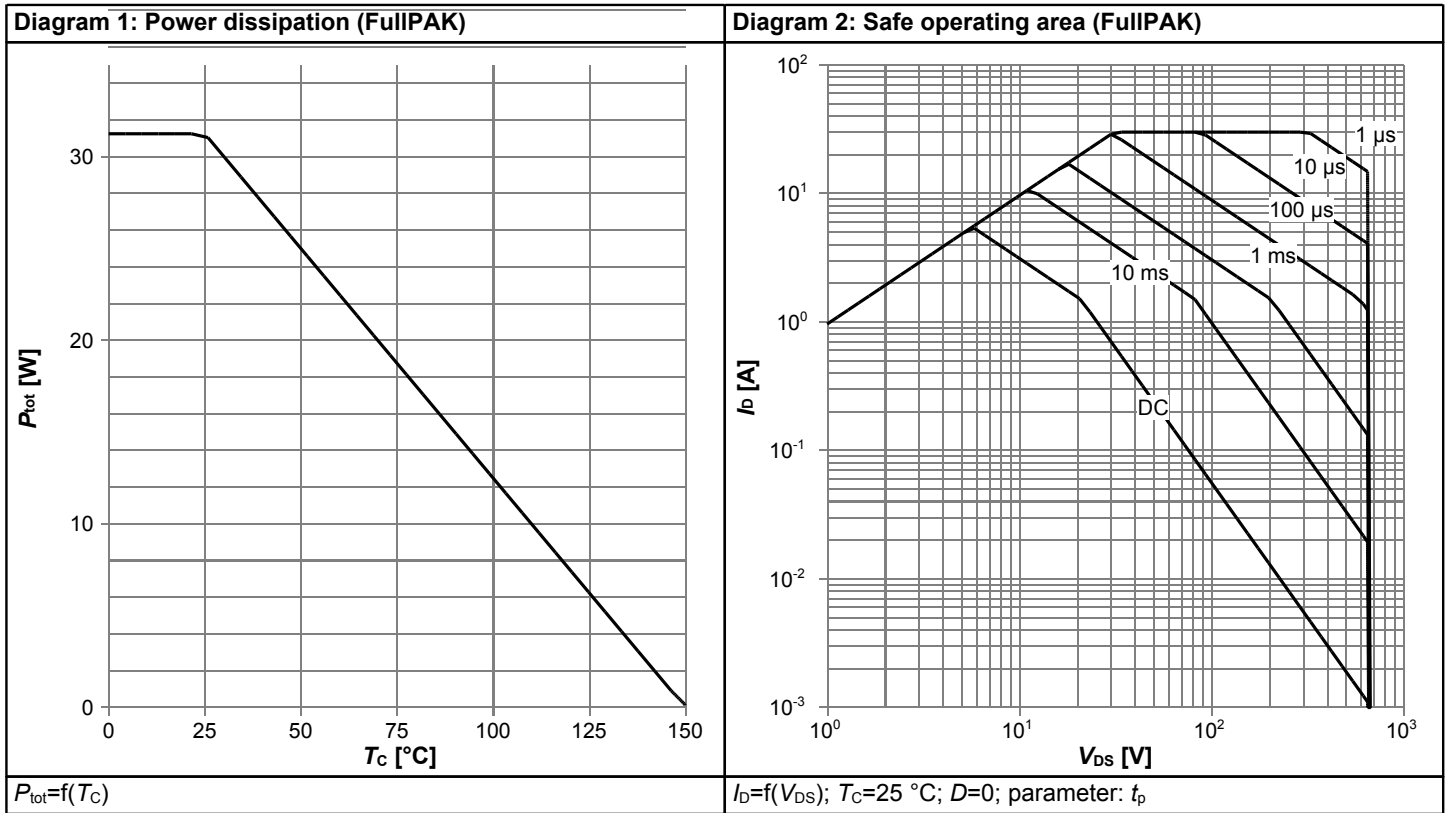
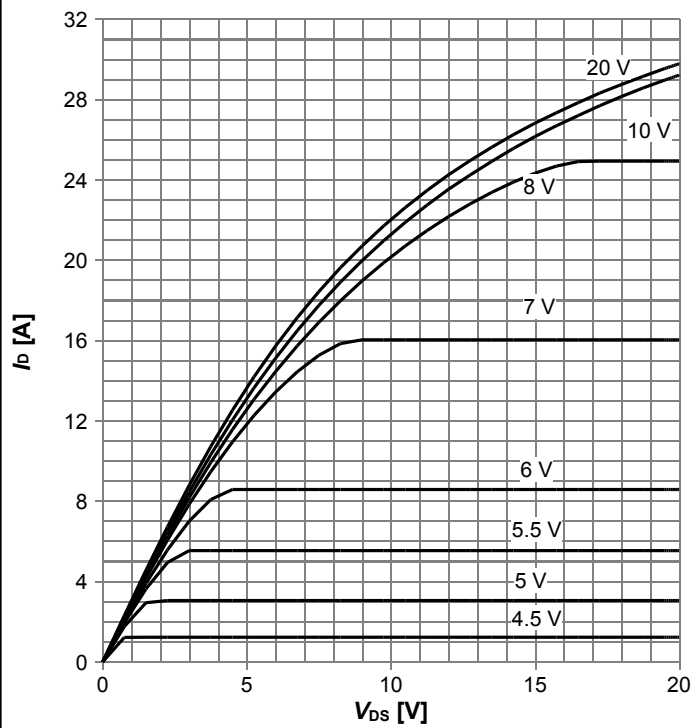
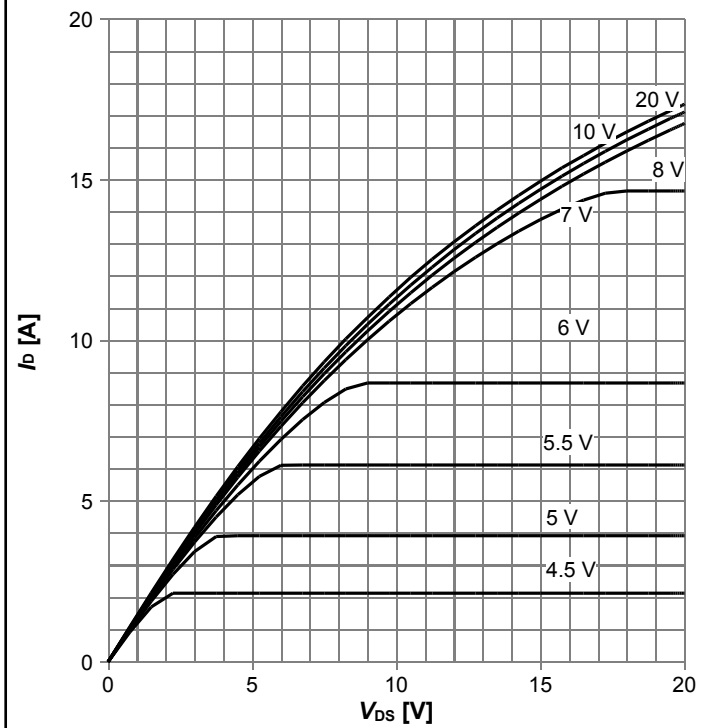


Diagram 5: Typ. output characteristics



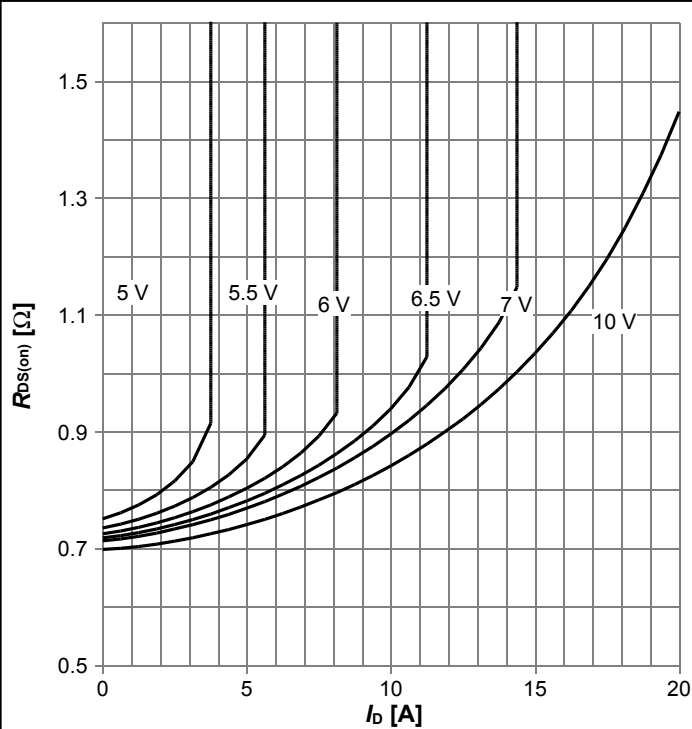
$I_D=f(V_{DS}); T_j=25\text{ °C};$ parameter: V_{GS}

Diagram 6: Typ. output characteristics



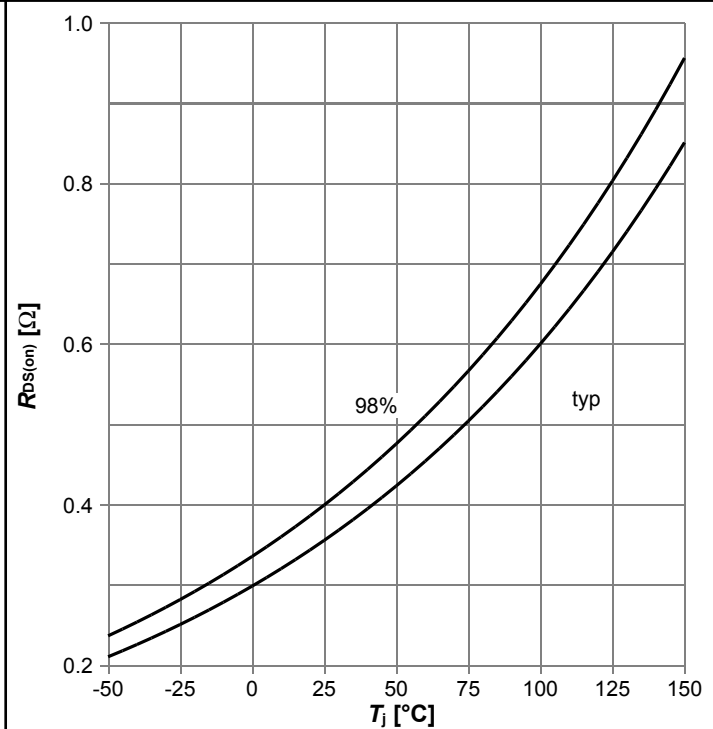
$I_D=f(V_{DS}); T_j=125\text{ °C};$ parameter: V_{GS}

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



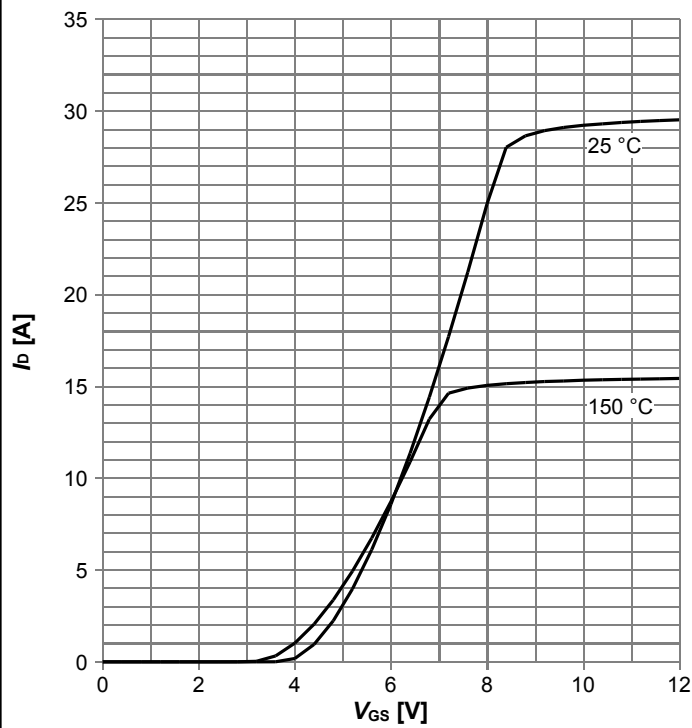
$R_{DS(on)}=f(I_D); T_j=125\text{ °C};$ parameter: V_{GS}

Diagram 8: Drain-source on-state resistance



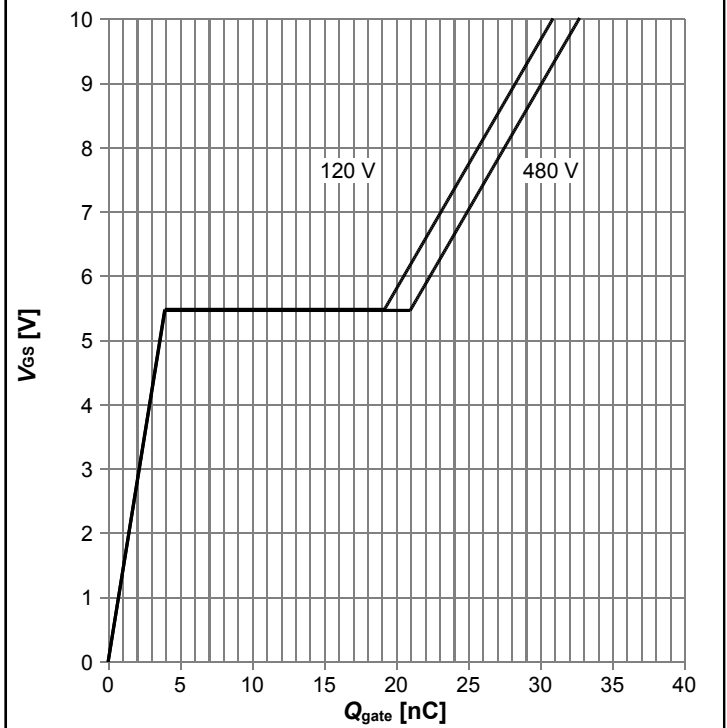
$R_{DS(on)}=f(T_j); I_D=3.2\text{A}; V_{GS}=10\text{V}$

Diagram 9: Typ. transfer characteristics



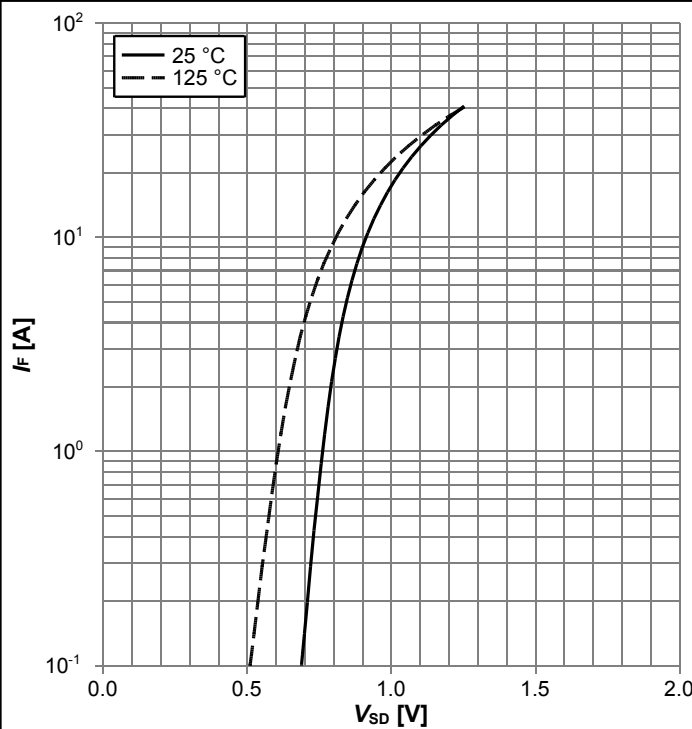
$I_D = f(V_{GS})$; $V_{DS} = 20V$; parameter: T_j

Diagram 10: Typ. gate charge



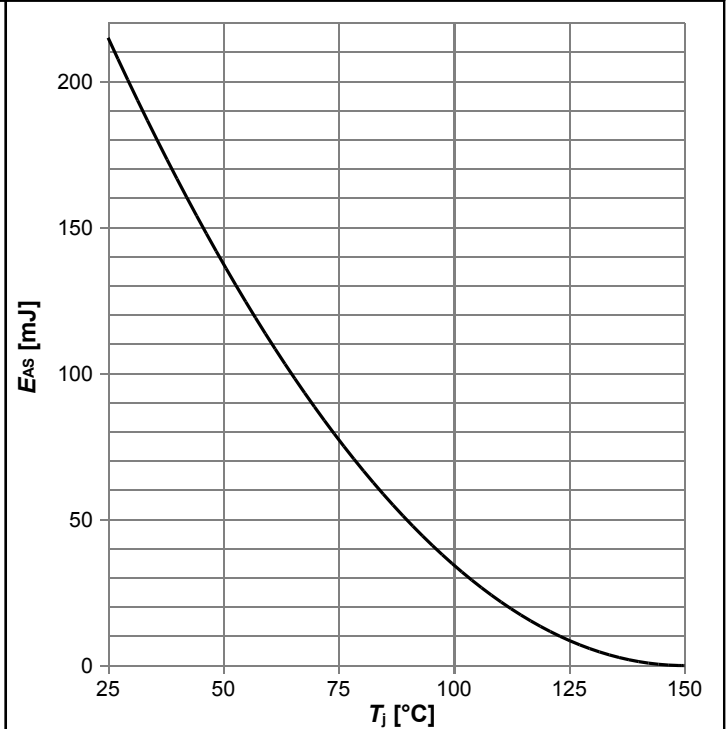
$V_{GS} = f(Q_{gate})$; $I_D = 4.9 A$ pulsed; parameter: V_{DD}

Diagram 11: Forward characteristics of reverse diode



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

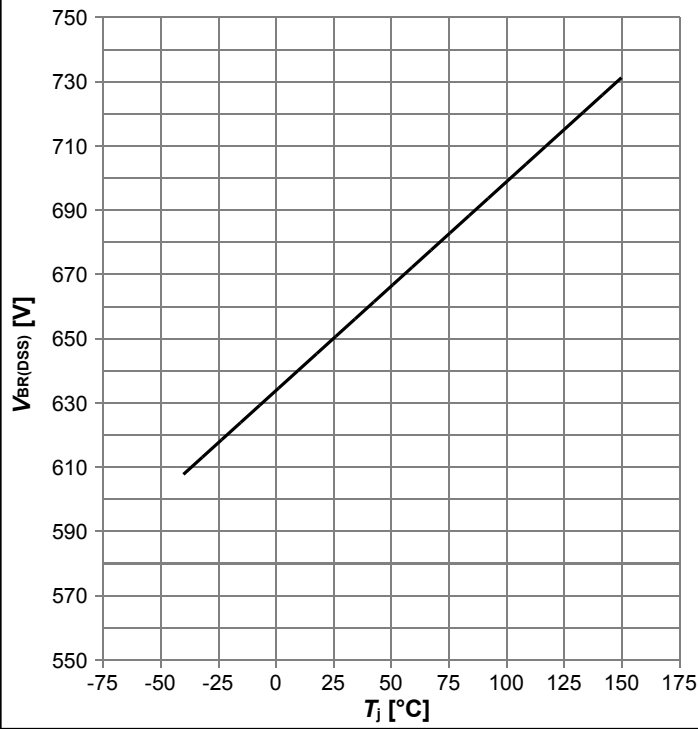
Diagram 12: Avalanche energy



$E_{AS} = f(T_j)$; $I_D = 1.8 A$; $V_{DD} = 50 V$

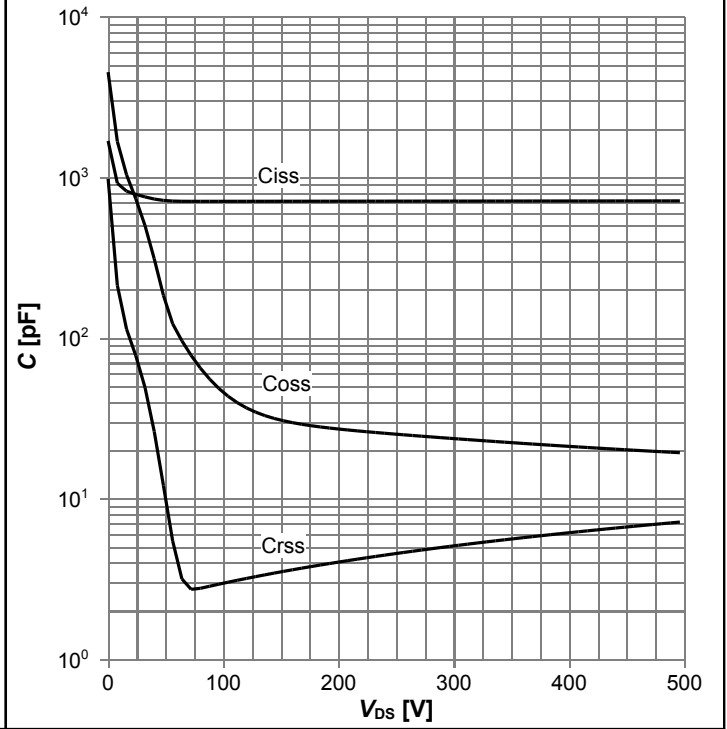
650V CoolMOS™ CE Power Transistor
IPA65R400CE

Diagram 13: Drain-source breakdown voltage



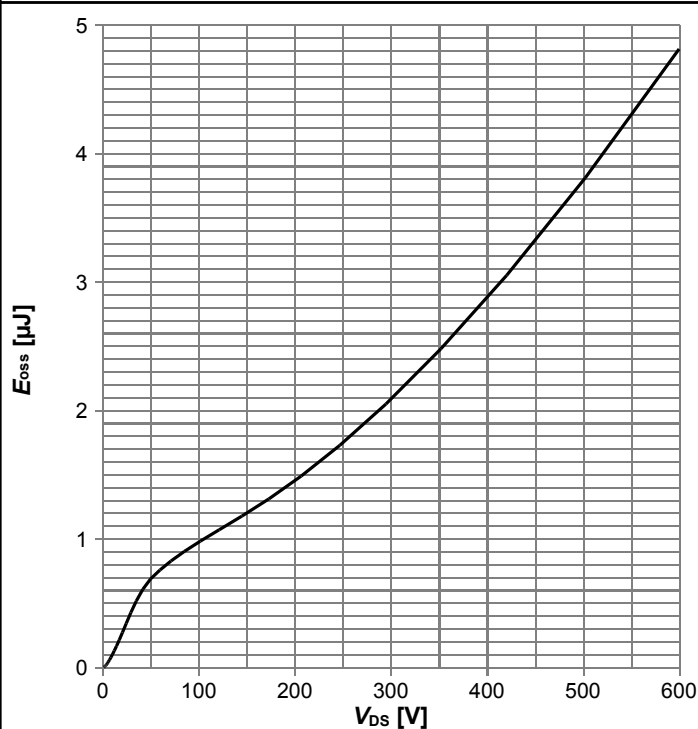
$V_{BR(DSS)}=f(T_j); I_D=1.0 \text{ mA}$

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

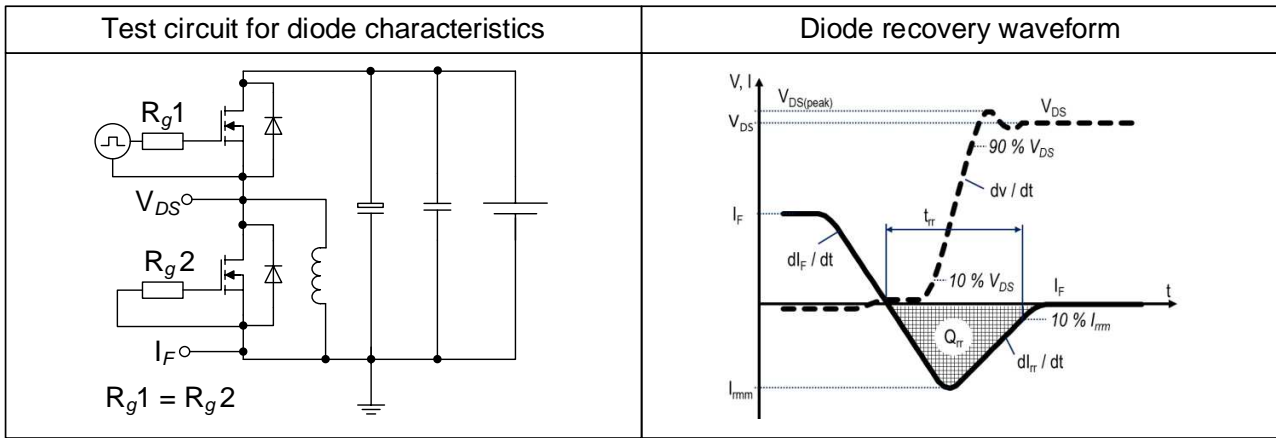


Table 9 Switching times

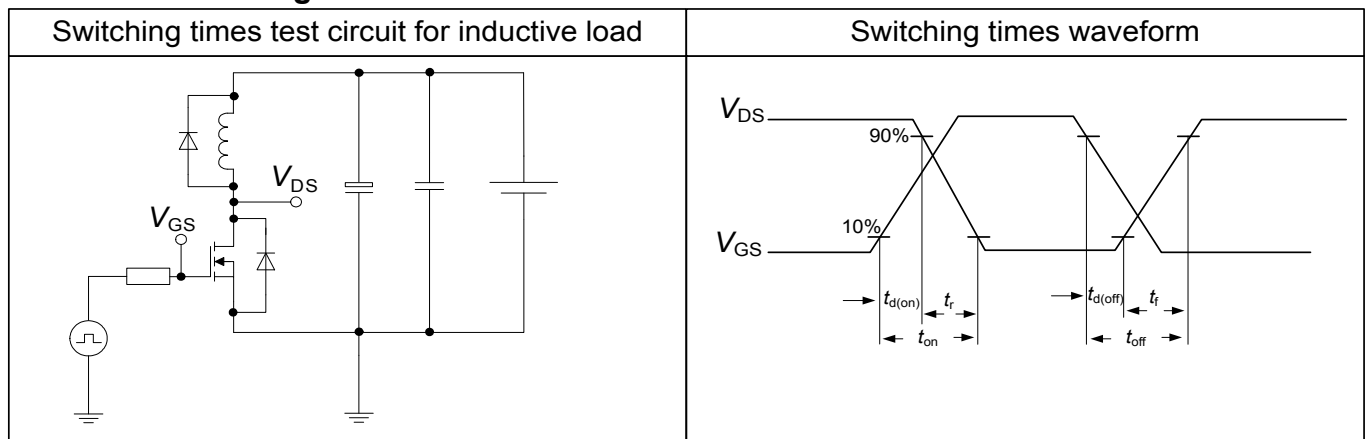
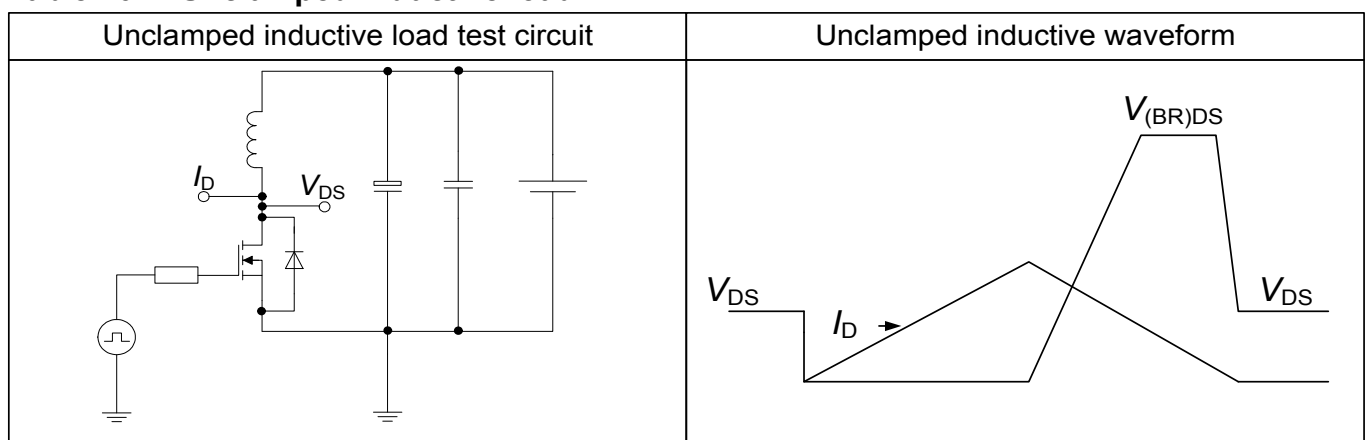
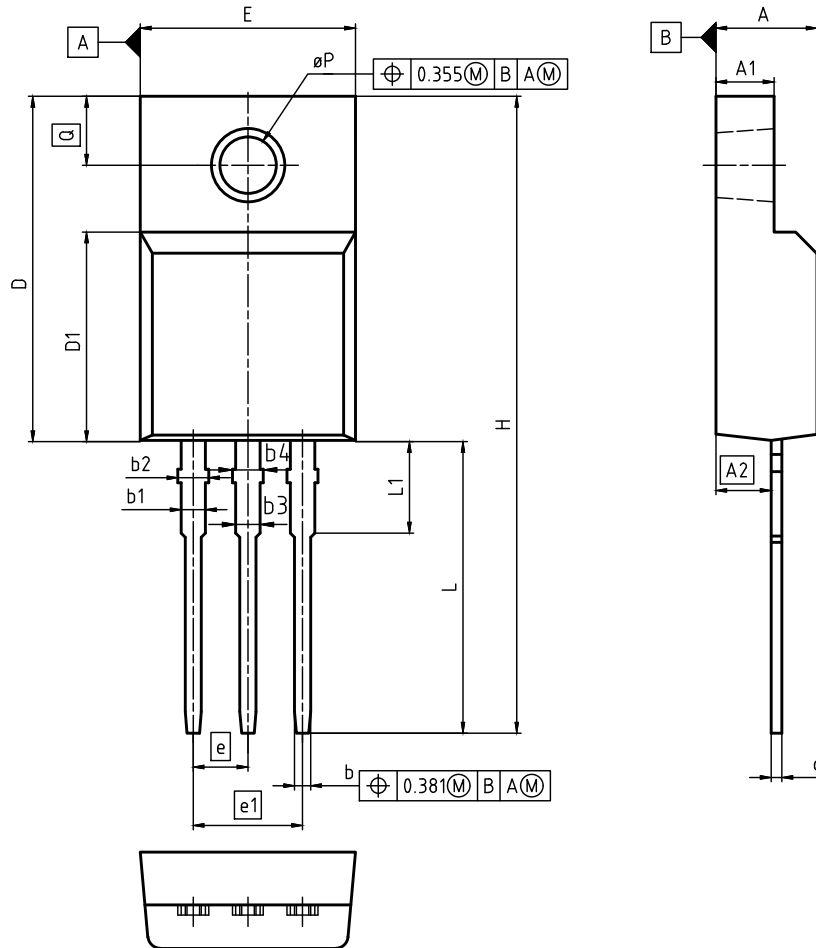


Table 10 Unclamped inductive load



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

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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

IPA65R400CE

Revision: 2017-04-19, Rev. 2.1

Previous Revision

| Revision | Date | Subjects (major changes since last revision) |
|----------|------------|--|
| 2.0 | 2016-02-24 | Release of final version |
| 2.1 | 2017-04-19 | Modified Rg value in Table 6 and timing value in Table 7 |

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