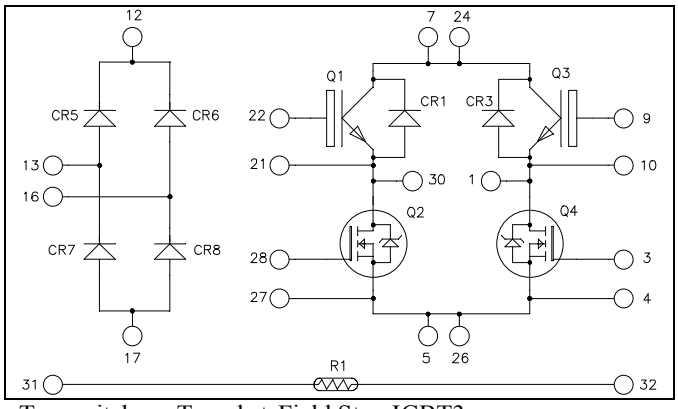
# APTCV60HM45RT3G

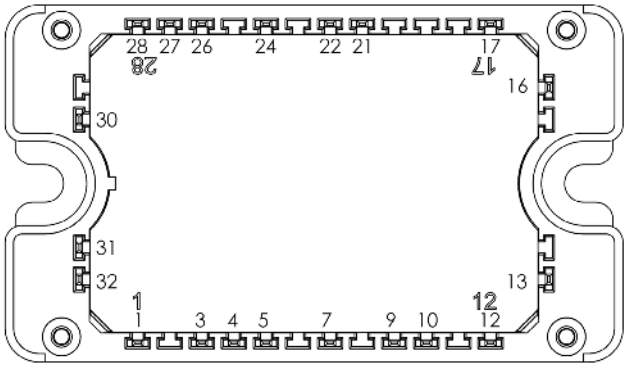
***Full bridge + rectifier bridge***
***CoolMOS & Trench + Field Stop IGBT3***
***Power Module***

**Trench & Field Stop IGBT3 Q1, Q3:**
**$V_{CES}$ = 600V ; $I_C$ = 50A @ Tc = 80°C**

**CoolMOS™ Q2, Q4:**
**$V_{DSS}$ = 600V**
**$R_{DSon}$ = 45mΩ max @ Tj = 25°C**




Top switches : Trench + Field Stop IGBT3
Bottom switches : CoolMOS™




All multiple inputs and outputs must be shorted together
7/24 ; 5/26

**Application**

- Solar converter

**Features**

- ***Q2, Q4 CoolMOS™***
  - Ultra low $R_{DSon}$
  - Low Miller capacitance
  - Ultra low gate charge
  - Avalanche energy rated
- ***Q1, Q3 Trench & Field Stop IGBT3***
  - Low voltage drop
  - Switching frequency up to 20 kHz
  - RBSOA & SCSOA rated
  - Low tail current
- Very low stray inductance
- Kelvin source for easy drive
- Internal thermistor for temperature monitoring
- High level of integration

**Benefits**

- Optimized conduction & switching losses
- Direct mounting to heatsink (isolated package)
- Low junction to case thermal resistance
- Solderable terminals both for power and signal for easy PCB mounting
- Low profile
- Easy paralleling due to positive $T_C$ of $V_{CEsat}$
- RoHS Compliant

**All ratings @ $T_j$ = 25°C unless otherwise specified**

# 1. Top switches

## 1.1 Top Trench + Field Stop IGBT3 characteristics (per IGBT)

### Electrical Characteristics

| *Symbol* | *Characteristic* | *Test Conditions* | | *Min* | *Typ* | *Max* | *Unit* |
|---|---|---|---|---|---|---|---|
| $I_{CES}$ | Zero Gate Voltage Collector Current | $V_{GE}$ = 0V, $V_{CE}$ = 600V | | | | 250 | µA |
| $V_{CE(sat)}$ | Collector Emitter Saturation Voltage | $V_{GE}$ =15V<br>$I_C$ = 50A | $T_j$ = 25°C | | 1.5 | 1.9 | V |
| | | | $T_j$ = 150°C | | 1.7 | | |
| $V_{GE(th)}$ | Gate Threshold Voltage | $V_{GE}$ = $V_{CE}$ , $I_C$ = 600µA | | 5.0 | 5.8 | 6.5 | V |
| $I_{GES}$ | Gate – Emitter Leakage Current | $V_{GE}$ = 20V, $V_{CE}$ = 0V | | | | 600 | nA |

### Dynamic Characteristics

| *Symbol* | *Characteristic* | *Test Conditions* | | *Min* | *Typ* | *Max* | *Unit* |
|---|---|---|---|---|---|---|---|
| $C_{ies}$ | Input Capacitance | $V_{GE}$ = 0V<br>$V_{CE}$ = 25V<br>f = 1MHz | | | 3150 | | pF |
| $C_{oes}$ | Output Capacitance | | | | 200 | | |
| $C_{res}$ | Reverse Transfer Capacitance | | | | 95 | | |
| $Q_G$ | Gate charge | $V_{GE}$=±15V, $I_C$=50A<br>$V_{CE}$=300V | | | 0.5 | | µC |
| $T_{d(on)}$ | Turn-on Delay Time | Inductive Switching (25°C)<br>$V_{GE}$ = ±15V<br>$V_{Bus}$ = 300V<br>$I_C$ = 50A<br>$R_G$ = 8.2Ω | | | 110 | | ns |
| $T_r$ | Rise Time | | | | 45 | | |
| $T_{d(off)}$ | Turn-off Delay Time | | | | 200 | | |
| $T_f$ | Fall Time | | | | 40 | | |
| $T_{d(on)}$ | Turn-on Delay Time | Inductive Switching (150°C)<br>$V_{GE}$ = ±15V<br>$V_{Bus}$ = 300V<br>$I_C$ = 50A<br>$R_G$ = 8.2Ω | | | 120 | | ns |
| $T_r$ | Rise Time | | | | 50 | | |
| $T_{d(off)}$ | Turn-off Delay Time | | | | 250 | | |
| $T_f$ | Fall Time | | | | 60 | | |
| $E_{off}$ | Turn-off Switching Energy | $V_{GE}$ = ±15V<br>$V_{Bus}$ = 300V<br>$I_C$ = 50A<br>$R_G$ = 8.2Ω | $T_j$ = 25°C | | 1.35 | | mJ |
| | | | $T_j$ = 150°C | | 1.75 | | |
| $I_{sc}$ | Short Circuit data | $V_{GE}$ ≤15V ; $V_{Bus}$ = 360V<br>$t_p$ ≤ 6µs ; $T_j$ = 150°C | | | 250 | | A |
| $R_{thJC}$ | Junction to Case Thermal resistance | | | | | 0.85 | °C/W |

### 1.2 Top diode characteristics (CR1, CR3) (per diode)

| Symbol | Characteristic | Test Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $V_{RRM}$ | Maximum Peak Repetitive Reverse Voltage | | | 600 | | | V |
| $I_{RM}$ | Maximum Reverse Leakage Current | $V_R$=600V | $T_j$ = 25°C | | | 25 | µA |
| | | | $T_j$ = 125°C | | | 500 | |
| $I_F$ | DC Forward Current | | Tc = 80°C | | 25 | | A |
| $V_F$ | Diode Forward Voltage | $I_F$ = 25A | | | 1.8 | 2.2 | V |
| | | $I_F$ = 50A | | | 2.2 | | |
| | | $I_F$ = 25A | $T_j$ = 125°C | | 1.6 | | |
| $t_{rr}$ | Reverse Recovery Time | $I_F$ = 25A<br>$V_R$ = 400V<br>di/dt =200A/µs | $T_j$ = 25°C | | 30 | | ns |
| | | | $T_j$ = 125°C | | 175 | | |
| $Q_{rr}$ | Reverse Recovery Charge | | $T_j$ = 25°C | | 55 | | nC |
| | | | $T_j$ = 125°C | | 485 | | |
| $R_{thJC}$ | Junction to Case Thermal resistance | | | | | 1.4 | °C/W |

## 2. Bottom switches

### 2.1 Bottom CoolMOS™ characteristics (Per CoolMOS™)

**Absolute maximum ratings**

| Symbol | Parameter | | Max ratings | Unit |
|---|---|---|---|---|
| $V_{DSS}$ | Drain - Source Breakdown Voltage | | 600 | V |
| $I_D$ | Continuous Drain Current | $T_c$ = 25°C | 49 | A |
| | | $T_c$ = 80°C | 38 | |
| $I_{DM}$ | Pulsed Drain current | | 130 | |
| $V_{GS}$ | Gate - Source Voltage | | ±20 | V |
| $R_{DSon}$ | Drain - Source ON Resistance | | 45 | mΩ |
| $P_D$ | Maximum Power Dissipation | $T_c$ = 25°C | 250 | W |
| $I_{AR}$ | Avalanche current (repetitive and non repetitive) | | 15 | A |
| $E_{AR}$ | Repetitive Avalanche Energy | | 3 | mJ |
| $E_{AS}$ | Single Pulse Avalanche Energy | | 1900 | |

**Electrical Characteristics**

| Symbol | Characteristic | Test Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $I_{DSS}$ | Zero Gate Voltage Drain Current | $V_{GS}$ = 0V,$V_{DS}$ = 600V | $T_j$ = 25°C | | | 250 | µA |
| | | $V_{GS}$ = 0V,$V_{DS}$ = 600V | $T_j$ = 125°C | | | 500 | |
| $R_{DS(on)}$ | Drain – Source on Resistance | $V_{GS}$ = 10V, $I_D$ = 24.5A | | | 40 | 45 | mΩ |
| $V_{GS(th)}$ | Gate Threshold Voltage | $V_{GS}$ = $V_{DS}$, $I_D$ = 3mA | | 2.1 | 3 | 3.9 | V |
| $I_{GSS}$ | Gate – Source Leakage Current | $V_{GS}$ = ±20 V, $V_{DS}$ = 0V | | | | 100 | nA |

## Dynamic Characteristics

| Symbol | Characteristic | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $C_{iss}$ | Input Capacitance | $V_{GS}$ = 0V ; $V_{DS}$ = 25V<br>f = 1MHz | | 7.2 | | nF |
| $C_{oss}$ | Output Capacitance | | | 8.5 | | |
| $Q_g$ | Total gate Charge | $V_{GS}$ = 10V<br>$V_{Bus}$ = 300V<br>$I_D$ = 49A | | 150 | | nC |
| $Q_{gs}$ | Gate – Source Charge | | | 34 | | |
| $Q_{gd}$ | Gate – Drain Charge | | | 51 | | |
| $T_{d(on)}$ | Turn-on Delay Time | **Inductive Switching (125°C)**<br>$V_{GS}$ = 10V<br>$V_{Bus}$ = 400V<br>$I_D$ = 49A<br>$R_G$ = 5Ω | | 21 | | ns |
| $T_r$ | Rise Time | | | 30 | | |
| $T_{d(off)}$ | Turn-off Delay Time | | | 100 | | |
| $T_f$ | Fall Time | | | 45 | | |
| $E_{on}$ | Turn-on Switching Energy | **Inductive switching @ 25°C**<br>$V_{GS}$ = 10V ; $V_{Bus}$ = 400V<br>$I_D$ = 49A ; $R_G$ = 5Ω | | 675 | | µJ |
| $E_{off}$ | Turn-off Switching Energy | | | 520 | | |
| $E_{on}$ | Turn-on Switching Energy | **Inductive switching @ 125°C**<br>$V_{GS}$ = 10V ; $V_{Bus}$ = 400V<br>$I_D$ = 49A ; $R_G$ = 5Ω | | 1096 | | µJ |
| $E_{off}$ | Turn-off Switching Energy | | | 635 | | |
| $R_{thJC}$ | Junction to Case Thermal resistance | | | | 0.5 | °C/W |

## Source - Drain diode ratings and characteristics

| Symbol | Characteristic | Test Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $I_S$ | Continuous Source current (Body diode) | | Tc = 25°C | | 49 | | A |
| | | | Tc = 80°C | | 38 | | |
| $V_{SD}$ | Diode Forward Voltage | $V_{GS}$ = 0V, $I_S$ = - 49A | | | | 1.2 | V |
| dv/dt | Peak Diode Recovery ❶ | | | | | 4 | V/ns |
| $t_{rr}$ | Reverse Recovery Time | $I_S$ = - 49A<br>$V_R$ = 350V<br>$di_S/dt$ = 100A/µs | $T_j$ = 25°C | | 600 | | ns |
| $Q_{rr}$ | Reverse Recovery Charge | | $T_j$ = 25°C | | 17 | | µC |

❶ dv/dt numbers reflect the limitations of the circuit rather than the device itself.
$I_S \le$ - 49A  di/dt ≤ 100A/µs  $V_R \le V_{DSS}$  $T_j \le$ 150°C

### 3. Rectifier bridge (per diode)

## Absolute maximum ratings

| Symbol | Parameter | | | Max ratings | Unit |
|---|---|---|---|---|---|
| $V_R$ | Maximum DC reverse Voltage | | | 600 | V |
| $V_{RRM}$ | Maximum Peak Repetitive Reverse Voltage | | | | |
| $I_{F(AV)}$ | Maximum Average Forward Current | Duty cycle = 50% | $T_C$ = 80°C | 40 | A |
| $I_{FSM}$ | Non-Repetitive Forward Surge Current | 8.3ms | $T_J$ = 45°C | 320 | |

## Electrical Characteristics

| Symbol | Characteristic | Test Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $V_F$ | Diode Forward Voltage | $I_F$ = 30A | | | 1.8 | 2.2 | V |
| | | $I_F$ = 60A | | | 2.2 | | |
| | | $I_F$ = 30A | $T_j$ = 125°C | | 1.5 | | |
| $I_{RM}$ | Maximum Reverse Leakage Current | $V_R$ = 600V | $T_j$ = 25°C | | | 250 | µA |
| | | | $T_j$ = 125°C | | | 500 | |

## Dynamic Characteristics

| Symbol | Characteristic | Test Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $t_{rr}$ | Reverse Recovery Time | $I_F$=1A,$V_R$=30V di/dt = 100A/µs | $T_j$ = 25°C | | 22 | | ns |
| $t_{rr}$ | Reverse Recovery Time | $I_F$ = 30A $V_R$ = 400V di/dt = 200A/µs | $T_j$ = 25°C | | 25 | | ns |
| | | | $T_j$ = 125°C | | 160 | | |
| $Q_{rr}$ | Reverse Recovery Charge | | $T_j$ = 25°C | | 35 | | nC |
| | | | $T_j$ = 125°C | | 480 | | |
| $I_{RRM}$ | Reverse Recovery Current | | $T_j$ = 25°C | | 3 | | A |
| | | | $T_j$ = 125°C | | 6 | | |
| $t_{rr}$ | Reverse Recovery Time | $I_F$ = 30A $V_R$ = 400V di/dt = 1000A/µs | $T_j$ = 125°C | | 85 | | ns |
| $Q_{rr}$ | Reverse Recovery Charge | | | | 920 | | µC |
| $I_{RRM}$ | Reverse Recovery Current | | | | 20 | | A |
| $R_{thJC}$ | Junction to Case Thermal Resistance | | | | | 1.2 | °C/W |

## 4. Thermal and package characteristics

### Temperature sensor NTC (see application note APT0406 on www.microsemi.com for more information).

| Symbol | Characteristic | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $R_{25}$ | Resistance @ 25°C | | | 50 | | kΩ |
| $\Delta R_{25}/R_{25}$ | | | | 5 | | % |
| $B_{25/85}$ | $T_{25}$ = 298.15 K | | | 3952 | | K |
| ΔB/B | | $T_C$=100°C | | 4 | | % |

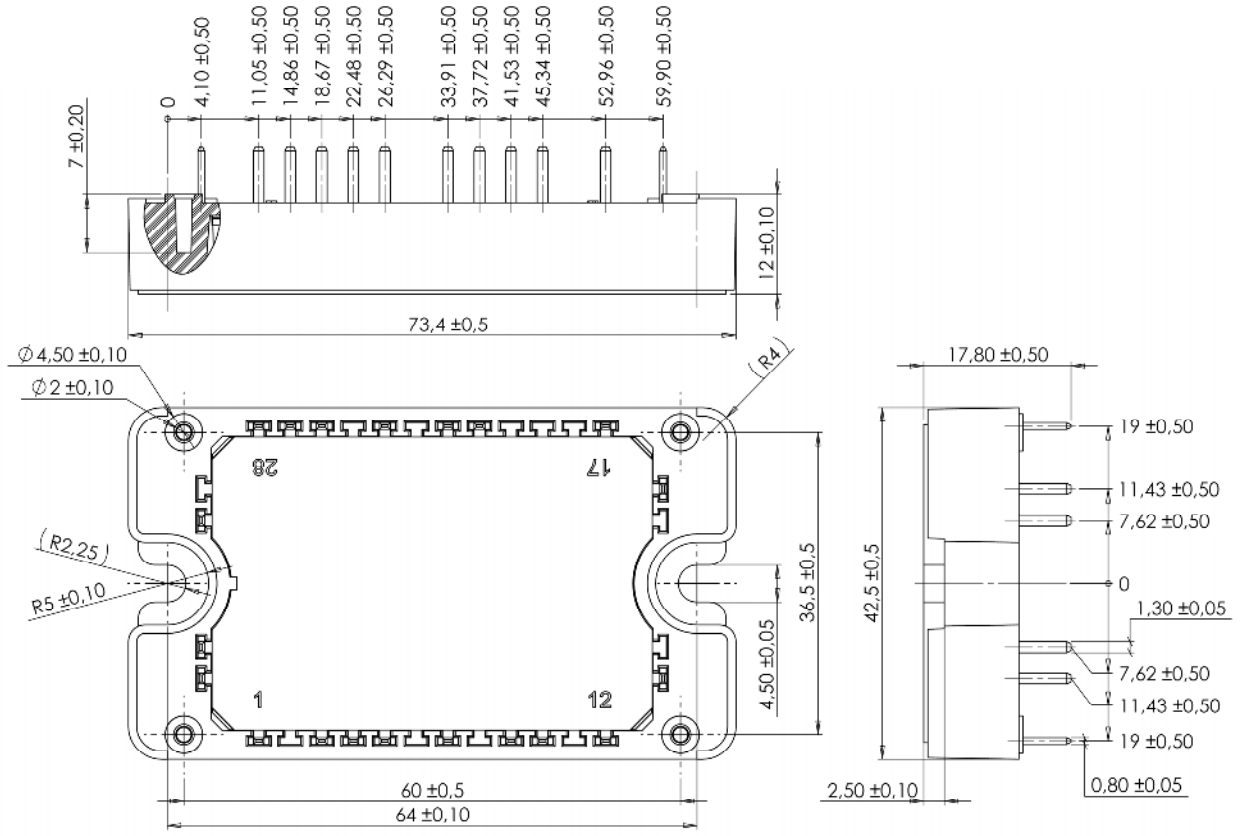
$$R_T = \frac{R_{25}}{\exp\left[B_{25/85}\left(\frac{1}{T_{25}} - \frac{1}{T}\right)\right]}$$

T: Thermistor temperature
$R_T$: Thermistor value at T

### Package characteristics

| Symbol | Characteristic | | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $V_{ISOL}$ | RMS Isolation Voltage, any terminal to case t =1 min, 50/60Hz | | | 4000 | | | V |
| $T_J$ | Operating junction temperature range | | | -40 | | 175 | °C |
| $T_{STG}$ | Storage Temperature Range | | | -40 | | 125 | |
| $T_C$ | Operating Case Temperature | | | -40 | | 100 | |
| Torque | Mounting torque | To heatsink | M4 | 2 | | 3 | N.m |
| Wt | Package Weight | | | | | 110 | g |

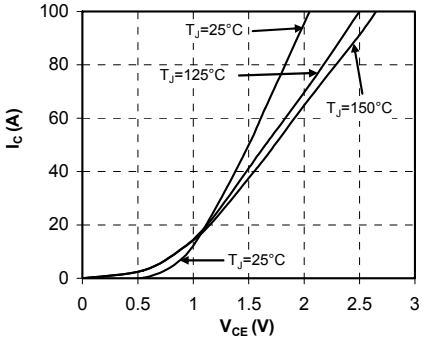
**SP3 Package outline** (dimensions in mm)



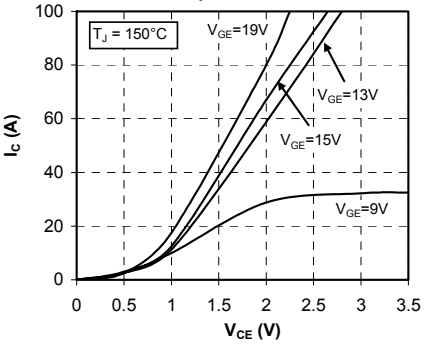
## 5. Top switches curves

### 5.1 Top Trench + Field Stop IGBT3 typical performance curves (per IGBT)

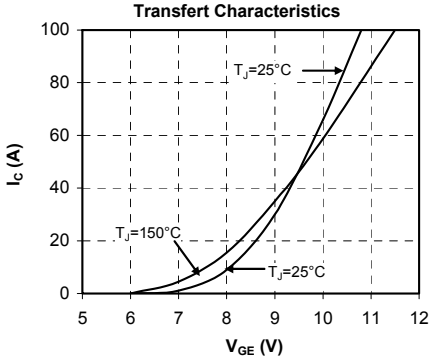
Output Characteristics ($V_{GE}$=15V)



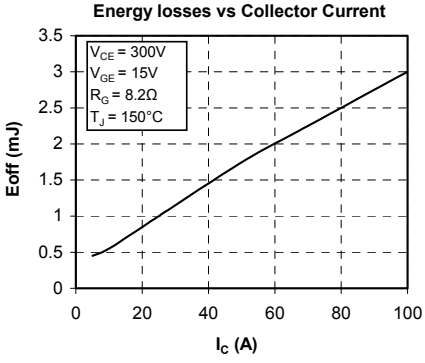

Output Characteristics



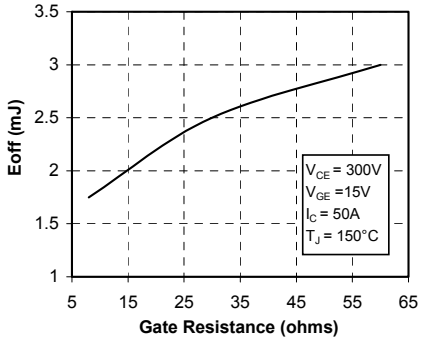

Transfert Characteristics



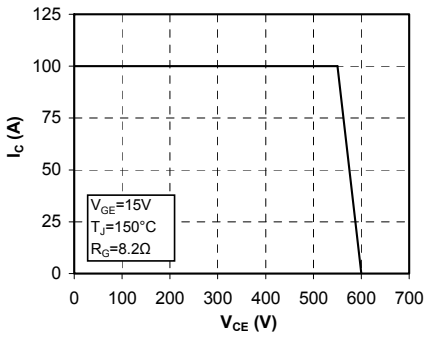

Energy losses vs Collector Current



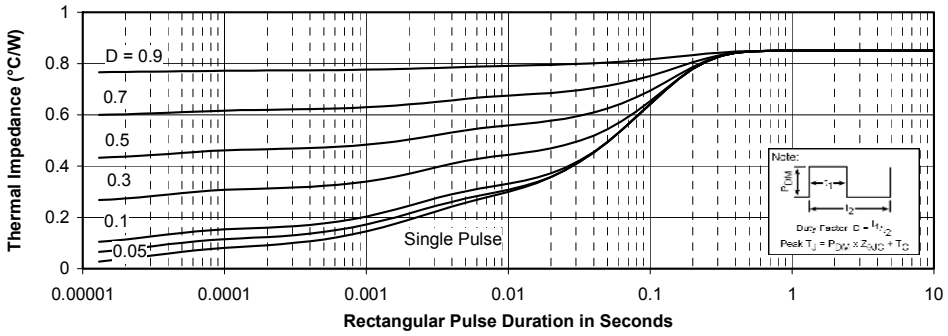

Switching Energy Losses vs Gate Resistance



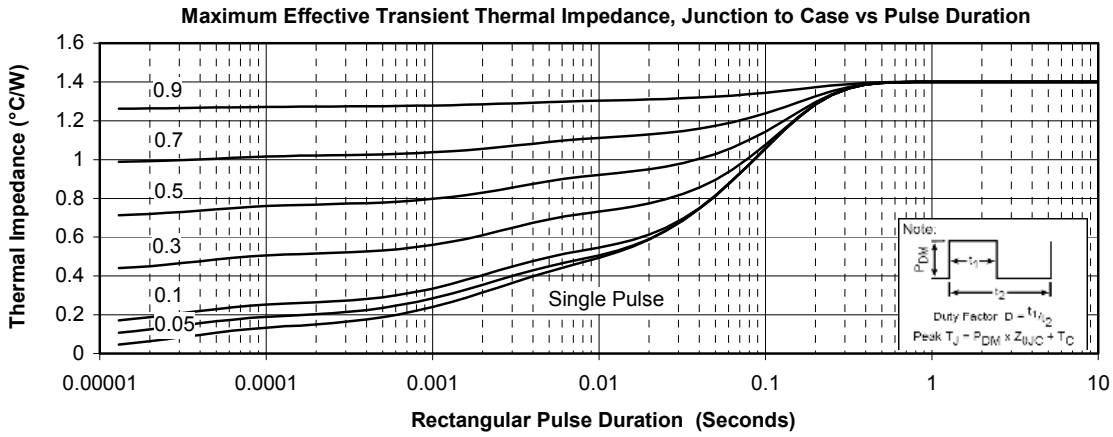

Reverse Bias Safe Operating Area

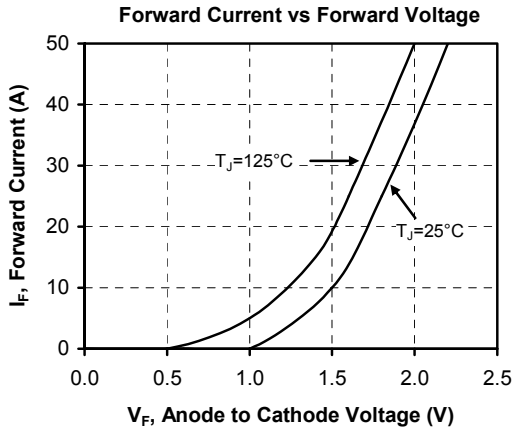



maximum Effective Transient Thermal Impedance, Junction to Case vs Pulse Duration

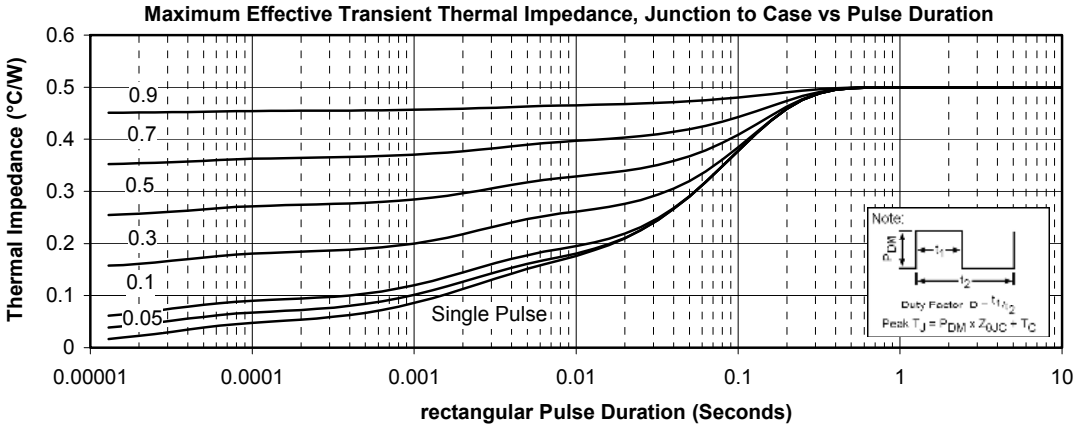


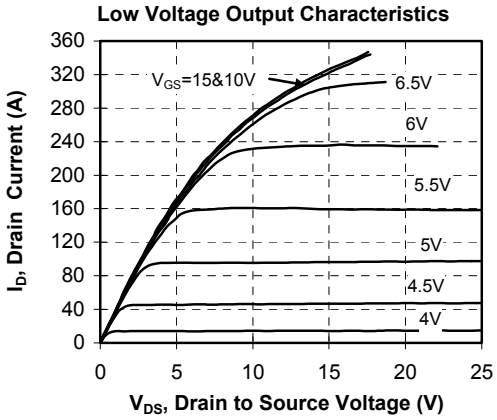
## 5.2 Top diode characteristics (per diode)

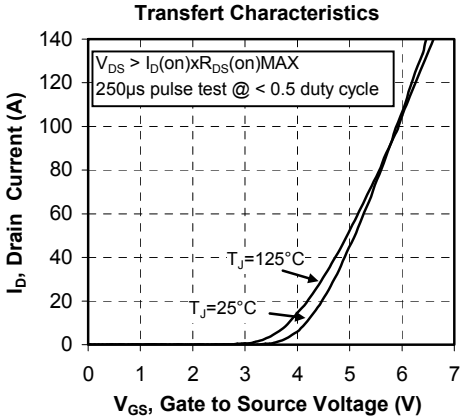


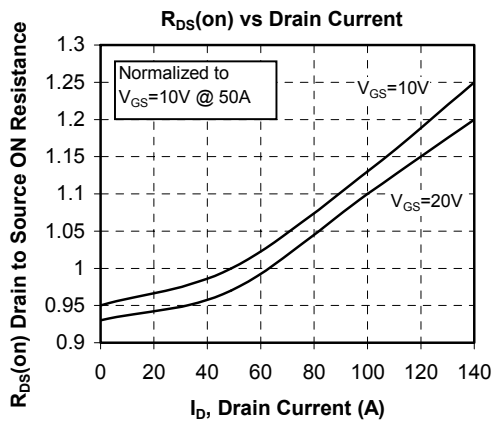



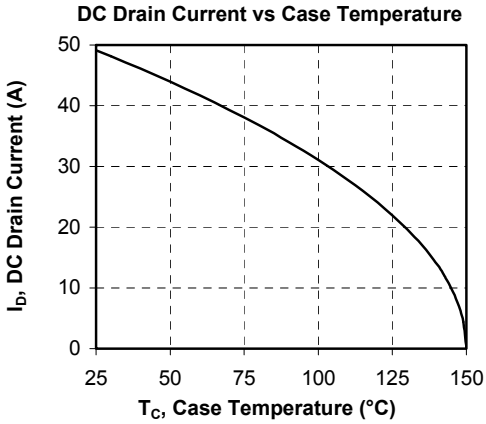
## 6. Bottom switches curves (per CoolMOS™)



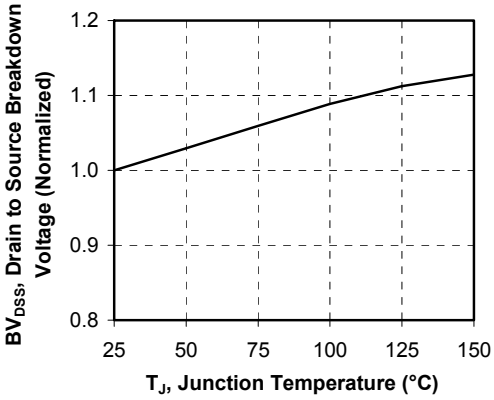



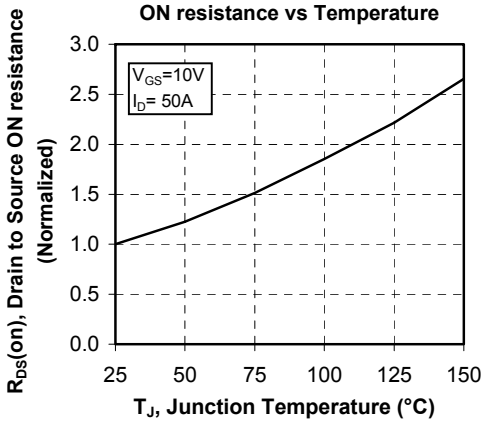



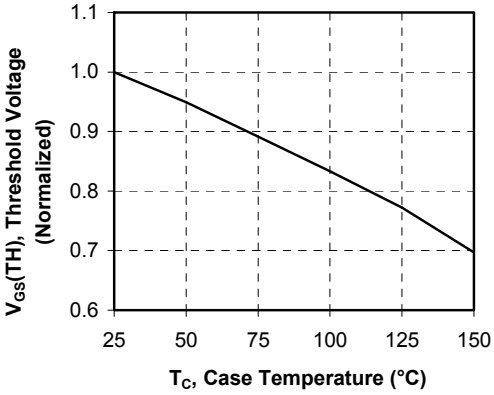
**Breakdown Voltage vs Temperature**



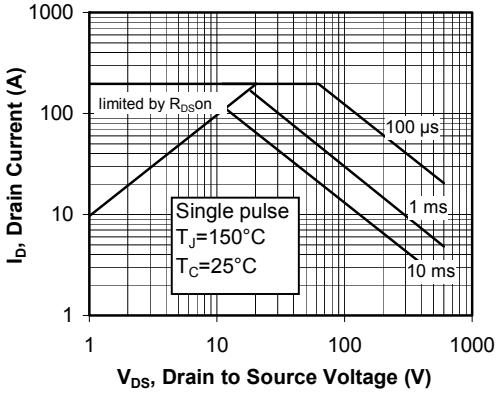

**ON resistance vs Temperature**



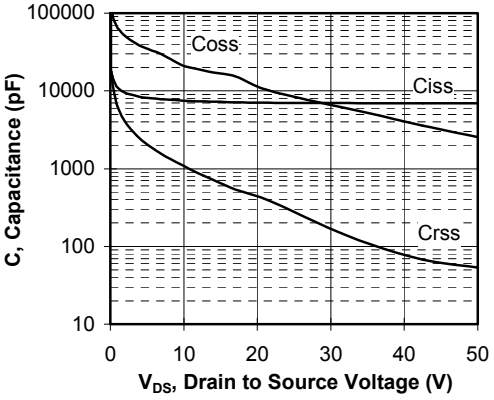

**Threshold Voltage vs Temperature**



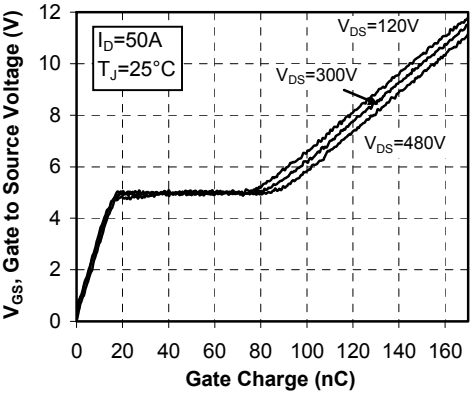

**Maximum Safe Operating Area**



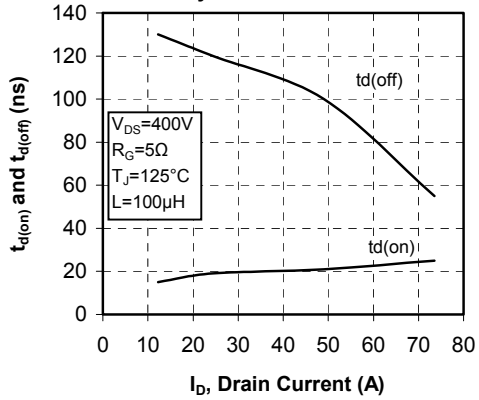

**Capacitance vs Drain to Source Voltage**



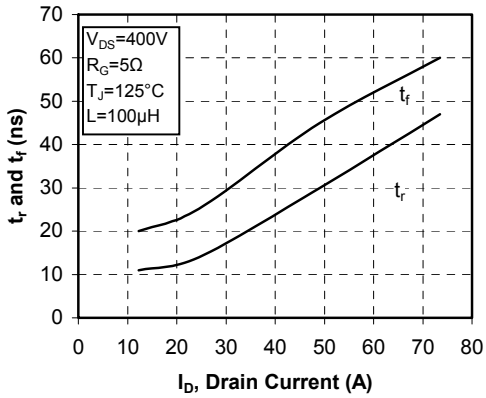

**Gate Charge vs Gate to Source Voltage**



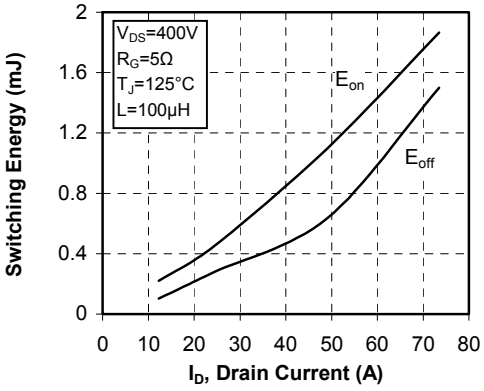
**Delay Times vs Current**



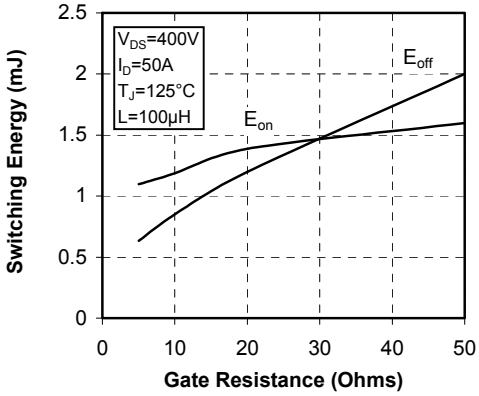

**Rise and Fall times vs Current**



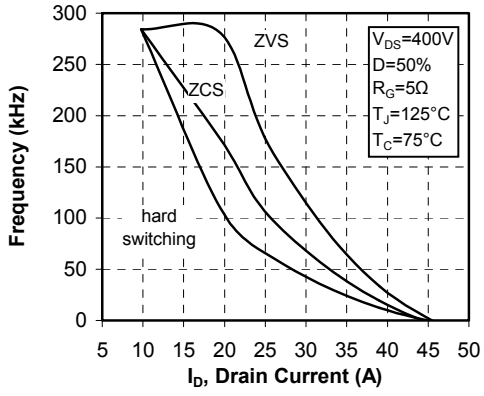

**Switching Energy vs Current**



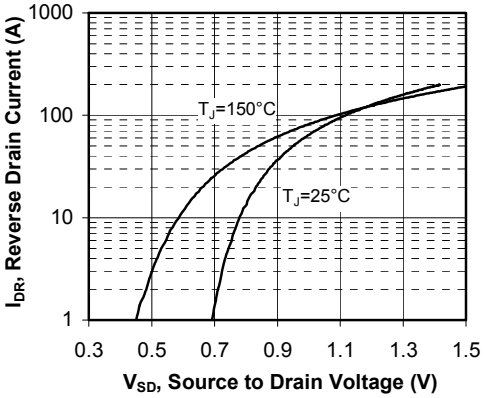

**Switching Energy vs Gate Resistance**



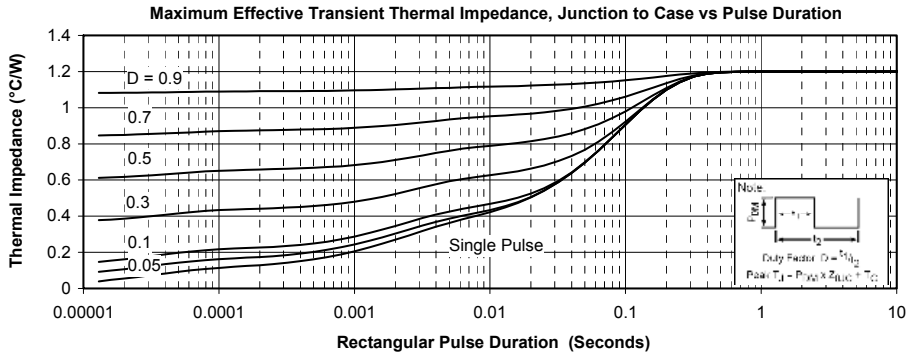

**Operating Frequency vs Drain Current**

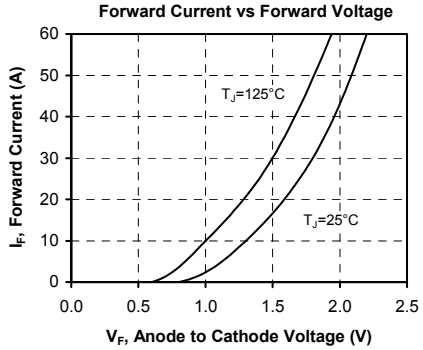


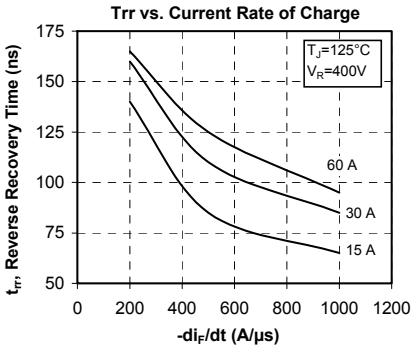

**Source to Drain Diode Forward Voltage**

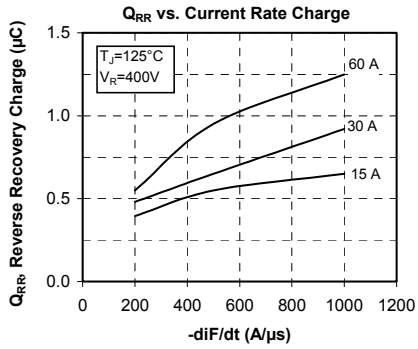


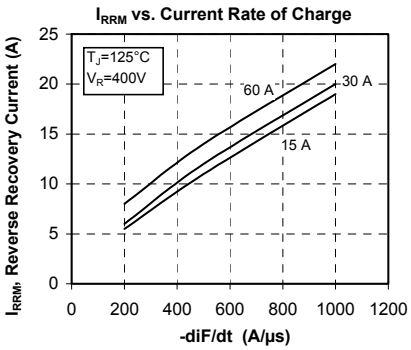
## 7. Typical rectifier bridge Performance Curve (per diode)

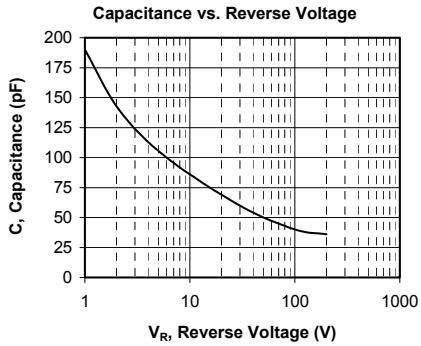
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