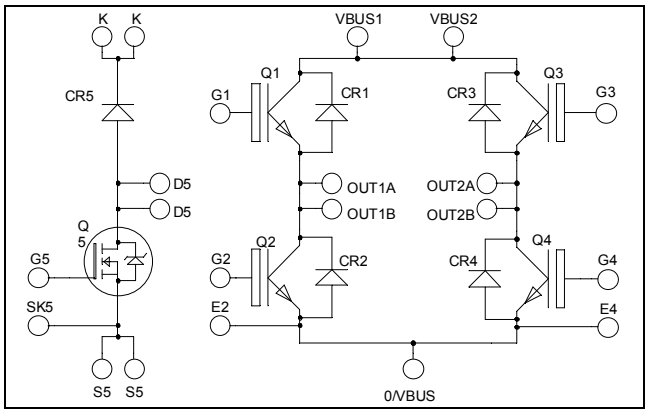
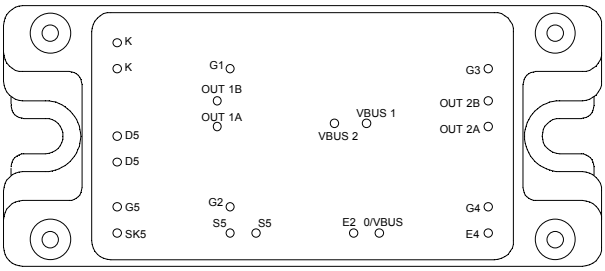
# APTGV50H60BG

***Boost chopper CoolMos™ + full bridge NPT & Trench + Field Stop IGBT Power module***




Full bridge top switches : Trench + Field Stop IGBT
Full bridge bottom switches : FAST NPT IGBT
Q5 boost chopper : CoolMOS™




All multiple inputs and outputs must be shorted together
OUT1A/OUT1B ; VBUS1/VBUS2 ; K/K ; …

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

**Fast NPT IGBT Q2, Q4:**
**$V_{CES}$ = 600V ; $I_C$ = 50A @ Tc = 80°C**

**CoolMOS™ Q5:**
**$V_{CES}$ = 600V ; $I_C$ = 49A @ Tc = 25°C**

**Application**

- Solar converter

**Features**

- ***Q2, Q4 (FAST Non Punch Through (NPT) IGBT)***
  - Switching frequency up to 100 kHz
  - RBSOA & SCSOA rated
  - Low tail current
- ***Q1, Q3 (Trench & Field Stop IGBT)***
  - Low voltage drop
  - Switching frequency up to 20 kHz
  - RBSOA & SCSOA rated
  - Low tail current

***Q5 (CoolMOS™)***
- Ultra low $R_{DSon}$
- Low Miller capacitance
- Ultra low gate charge
- Avalanche energy rated

- Kelvin emitter for easy drive
- Very low stray inductance
- 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

**CAUTION:** These Devices are sensitive to Electrostatic Discharge. Proper Handing Procedures Should Be Followed. See application note APT0502 on www.microsemi.com

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

## 1. Full bridge top switches

### 1.1 Top Trench + Field Stop IGBT® characteristics

**Absolute maximum ratings**

| *Symbol* | *Parameter* | | *Max ratings* | *Unit* |
|---|---|---|---|---|
| $V_{CES}$ | Collector - Emitter Breakdown Voltage | | 600 | V |
| $I_C$ | Continuous Collector Current | $T_C$ = 25°C | 80 | A |
| | | $T_C$ = 80°C | 50 | |
| $I_{CM}$ | Pulsed Collector Current | $T_C$ = 25°C | 100 | |
| $V_{GE}$ | Gate – Emitter Voltage | | ±20 | V |
| $P_D$ | Maximum Power Dissipation | $T_C$ = 25°C | 176 | W |
| RBSOA | Reverse Bias Safe Operating Area | $T_J$ = 150°C | 100A @ 550V | |

**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 | | |
| $T_{d(on)}$ | 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 | | |
| $E_{on}$ | Turn-on Switching Energy | $V_{GE}$ = ±15V<br>$V_{Bus}$ = 300V<br>$I_C$ = 50A<br>$R_G$ = 8.2Ω | $T_j$ = 25°C | | 0.3 | | mJ |
| | | | $T_j$ = 150°C | | 0.43 | | |
| $E_{off}$ | Turn-off Switching Energy | | $T_j$ = 25°C | | 1.35 | | mJ |
| | | | $T_j$ = 150°C | | 1.75 | | |
| $R_{thJC}$ | Junction to Case Thermal resistance | | | | | 0.85 | °C/W |

### 1.2 Top fast diode characteristics

| *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 | | 30 | | A |
| $V_F$ | Diode Forward Voltage | $I_F$ = 30A | | | 1.8 | 2.3 | V |
| | | $I_F$ = 60A | | | 2.1 | | |
| | | $I_F$ = 30A | $T_j$ = 125°C | | 1.5 | | |
| $t_{rr}$ | Reverse Recovery Time | $I_F$ = 30A<br>$V_R$ = 400V<br>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 | | |
| $R_{thJC}$ | Junction to Case Thermal resistance | | | | | 1.2 | °C/W |

## 2. Full bridge bottom switches

### 2.1 Bottom Fast NPT IGBT characteristics

**Absolute maximum ratings**

| *Symbol* | *Parameter* | | *Max ratings* | *Unit* |
|---|---|---|---|---|
| $V_{CES}$ | Collector - Emitter Breakdown Voltage | | 600 | V |
| $I_C$ | Continuous Collector Current | $T_C$ = 25°C | 65 | A |
| | | $T_C$ = 80°C | 50 | |
| $I_{CM}$ | Pulsed Collector Current | $T_C$ = 25°C | 230 | |
| $V_{GE}$ | Gate – Emitter Voltage | | ±20 | V |
| $P_D$ | Maximum Power Dissipation | $T_C$ = 25°C | 250 | W |
| RBSOA | Reverse Bias Safe Operating Area | $T_j$ = 125°C | 100A @ 500V | |

**Electrical Characteristics**

| *Symbol* | *Characteristic* | *Test Conditions* | | *Min* | *Typ* | *Max* | *Unit* |
|---|---|---|---|---|---|---|---|
| $I_{CES}$ | Zero Gate Voltage Collector Current | $V_{GE}$ = 0V<br>$V_{CE}$ = 600V | $T_j$ = 25°C | | | 250 | µA |
| | | | $T_j$ = 125°C | | | 500 | |
| $V_{CE(sat)}$ | Collector Emitter Saturation Voltage | $V_{GE}$ =15V<br>$I_C$ = 50A | $T_j$ = 25°C | 1.7 | 2.0 | 2.45 | V |
| | | | $T_j$ = 125°C | | 2.2 | | |
| $V_{GE(th)}$ | Gate Threshold Voltage | $V_{GE}$ = $V_{CE}$ , $I_C$ = 1mA | | 4 | | 6 | V |
| $I_{GES}$ | Gate – Emitter Leakage Current | $V_{GE}$ = 20V, $V_{CE}$ = 0V | | | | 400 | 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 | | | 2200 | | pF |
| $C_{oes}$ | Output Capacitance | | | | 323 | | |
| $C_{res}$ | Reverse Transfer Capacitance | | | | 200 | | |
| $Q_g$ | Total gate Charge | $V_{GE}$ = 15V<br>$V_{Bus}$ = 300V<br>$I_C$ = 50A | | | 166 | | nC |
| $Q_{ge}$ | Gate – Emitter Charge | | | | 20 | | |
| $Q_{gc}$ | Gate – Collector Charge | | | | 100 | | |
| $T_{d(on)}$ | Turn-on Delay Time | Inductive Switching (25°C)<br>$V_{GE}$ = 15V<br>$V_{Bus}$ = 400V<br>$I_C$ = 50A<br>$R_G$ = 2.7Ω | | | 40 | | ns |
| $T_r$ | Rise Time | | | | 9 | | |
| $T_{d(off)}$ | Turn-off Delay Time | | | | 120 | | |
| $T_f$ | Fall Time | | | | 12 | | |
| $T_{d(on)}$ | Turn-on Delay Time | Inductive Switching (125°C)<br>$V_{GE}$ = 15V<br>$V_{Bus}$ = 400V<br>$I_C$ = 50A<br>$R_G$ = 2.7Ω | | | 42 | | ns |
| $T_r$ | Rise Time | | | | 10 | | |
| $T_{d(off)}$ | Turn-off Delay Time | | | | 130 | | |
| $T_f$ | Fall Time | | | | 21 | | |
| $E_{on}$ | Turn-on Switching Energy | $V_{GE}$ = 15V<br>$V_{Bus}$ = 400V<br>$I_C$ = 50A<br>$R_G$ = 2.7Ω | $T_j$ = 125°C | | 0.5 | | mJ |
| $E_{off}$ | Turn-off Switching Energy | | $T_j$ = 125°C | | 1 | | |
| $R_{thJC}$ | Junction to Case Thermal resistance | | | | | 0.5 | °C/W |

### 2.2 Bottom diode characteristics

| 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 | | 30 | | A |
| $V_F$ | Diode Forward Voltage | $I_F$ = 30A | | | 1.8 | 2.3 | V |
| | | $I_F$ = 60A | | | 2.1 | | |
| | | $I_F$ = 30A | $T_j$ = 125°C | | 1.5 | | |
| $t_{rr}$ | Reverse Recovery Time | $I_F$ = 30A<br>$V_R$ = 400V<br>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 | | |
| $R_{thJC}$ | Junction to Case Thermal resistance | | | | | 1.2 | °C/W |

## 3. Boost chopper switch

### 3.1 CoolMOS™ characteristics

**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 | 290 | 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 | | | 0.29 | | |
| $Q_g$ | 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>$R_G$ = 4.7Ω | | 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 ; $R_G$ = 4.7Ω | | 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 ; $R_G$ = 4.7Ω | | 1100 | | µJ |
| $E_{off}$ | Turn-off Switching Energy | | | 635 | | |
| $R_{thJC}$ | Junction to Case Thermal resistance | | | | 0.5 | °C/W |

### 3.2 Chopper diode characteristics

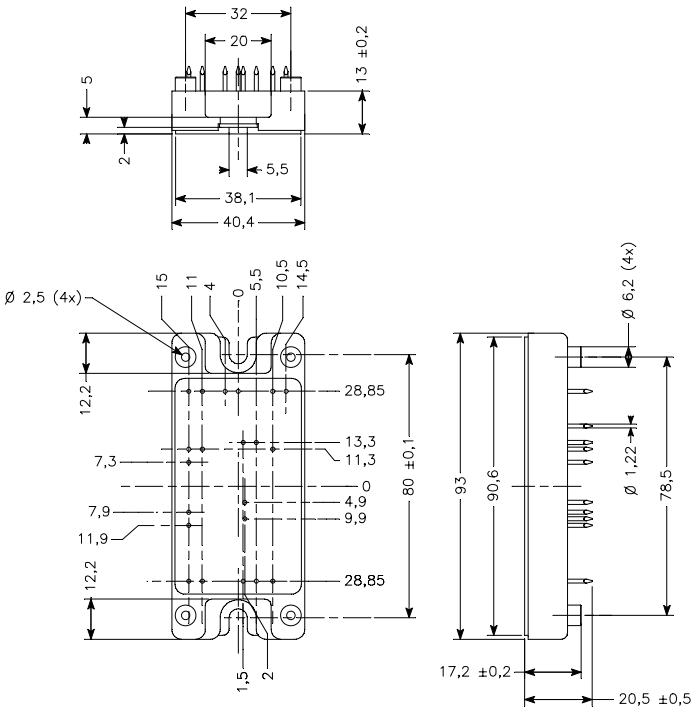
| Symbol | Characteristic | Test Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $V_{RRM}$ | Maximum Peak Repetitive Reverse Voltage | | | 600 | | | V |
| $I_{RM}$ | Maximum Reverse Leakage Current | $V_R$=600V | $T_j$ = 25°C | | | 25 | µA |
| | | | $T_j$ = 125°C | | | 500 | |
| $I_F$ | DC Forward Current | | Tc = 80°C | | 60 | | A |
| $V_F$ | Diode Forward Voltage | $I_F$ = 60A | | | 1.7 | 2.3 | V |
| | | $I_F$ = 120A | | | 2 | | |
| | | $I_F$ = 60A | $T_j$ = 125°C | | 1.4 | | |
| $t_{rr}$ | Reverse Recovery Time | $I_F$ = 60A<br>$V_R$ = 400V<br>di/dt =200A/µs | $T_j$ = 25°C | | 70 | | ns |
| | | | $T_j$ = 125°C | | 140 | | |
| $Q_{rr}$ | Reverse Recovery Charge | | $T_j$ = 25°C | | 100 | | nC |
| | | | $T_j$ = 125°C | | 690 | | |
| $R_{thJC}$ | Junction to Case Thermal resistance | | | | | 0.85 | °C/W |

### 4. Package characteristics

| Symbol | Characteristic | | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $V_{ISOL}$ | RMS Isolation Voltage, any terminal to case t =1 min, I isol<1mA, 50/60Hz | | | 2500 | | | V |
| $T_J$ | Operating junction temperature range | | | -40 | | 150* | °C |
| $T_{STG}$ | Storage Temperature Range | | | -40 | | 125 | |
| $T_C$ | Operating Case Temperature | | | -40 | | 100 | |
| Torque | Mounting torque | To heatsink | M5 | 2.5 | | 4.7 | N.m |
| Wt | Package Weight | | | | | 160 | g |

* Tj=175°C for Trench & Field Stop IGBT

### 5. SP4 Package outline (dimensions in mm)

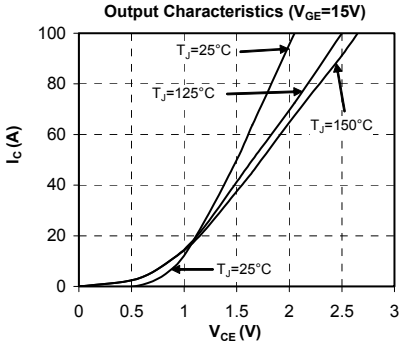



See application note APT0501 - Mounting Instructions for SP4 Power Modules on www.microsemi.com

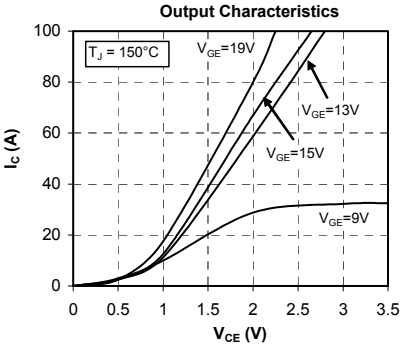
## 6. Full bridge top switches curves

### 6.1 Top Trench + Field Stop IGBT typical performance curves

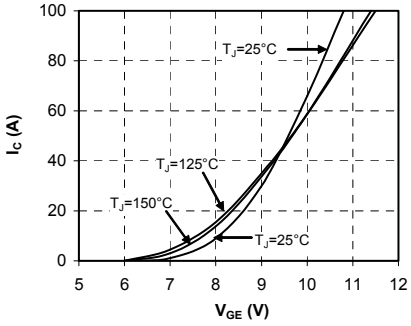
Output Characteristics ($V_{GE}$=15V)



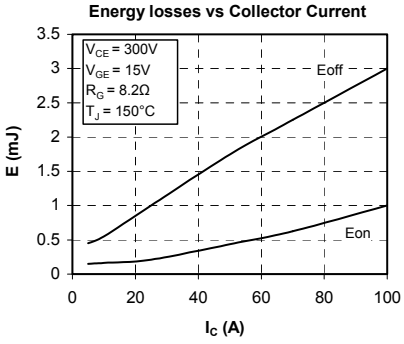

Output Characteristics



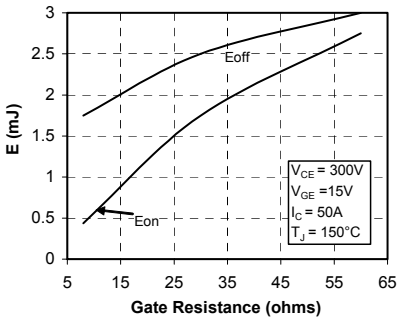

Transfert Characteristics



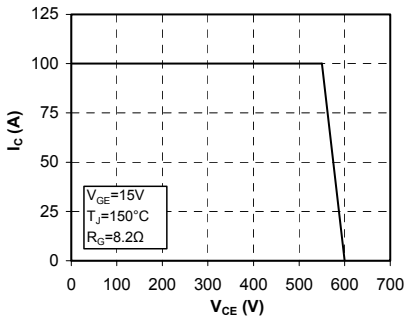

Energy losses vs Collector Current



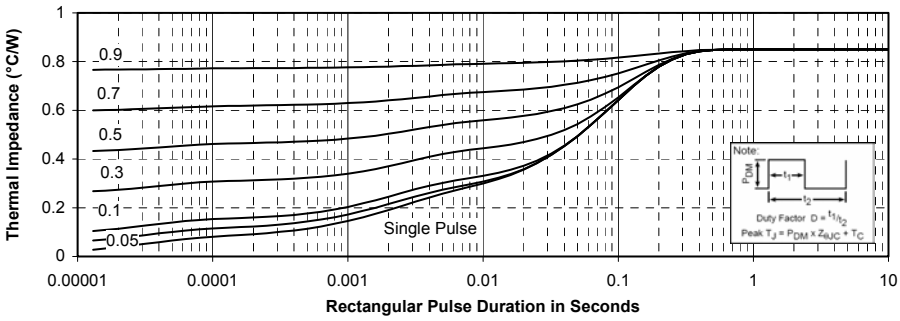

Switching Energy Losses vs Gate Resistance



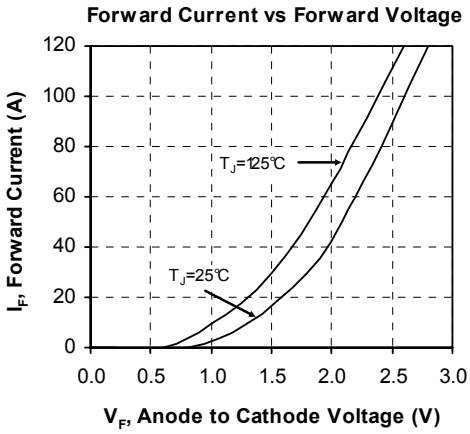

Reverse Bias Safe Operating Area

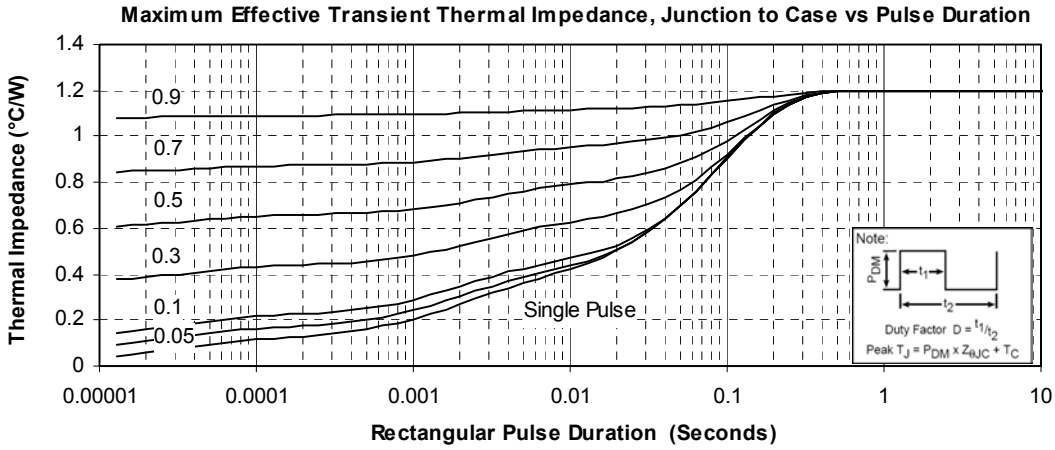



maximum Effective Transient Thermal Impedance, Junction to Case vs Pulse Duration



## 6.2 Top Fast diode typical performance curves

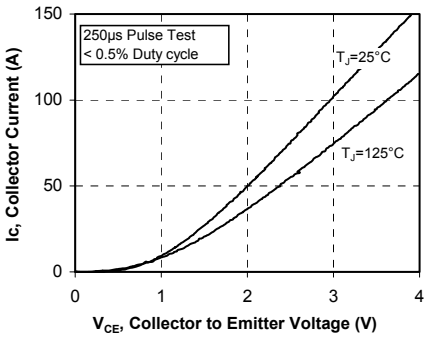


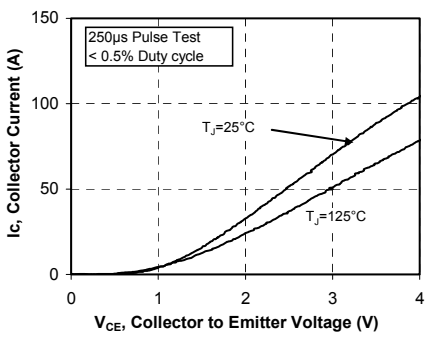
# 7. Full bridge bottom switches curves

## 7.1 Bottom fast NPT IGBT typical performance curves

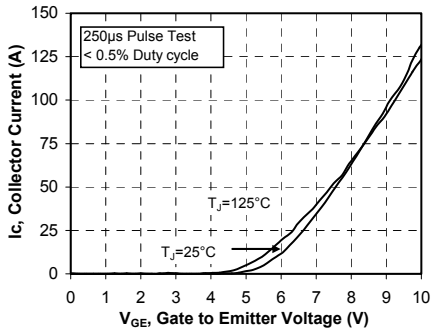
Output characteristics ($V_{GE}$=15V)



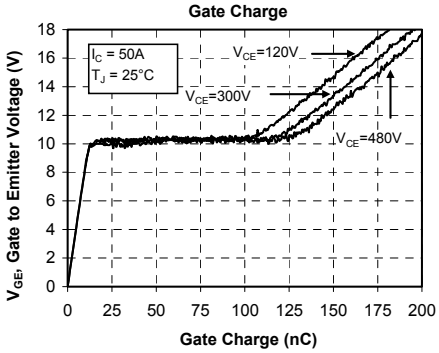

Output Characteristics ($V_{GE}$=10V)



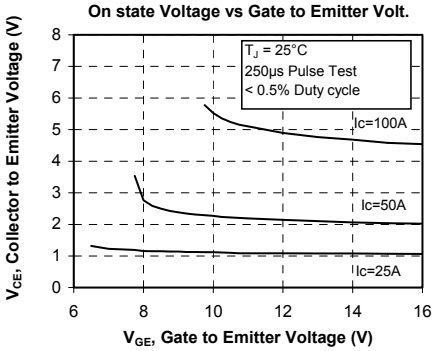

Transfer Characteristics



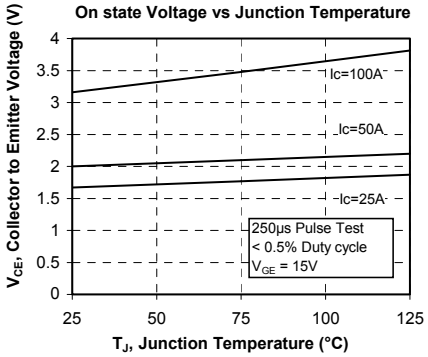

Gate Charge



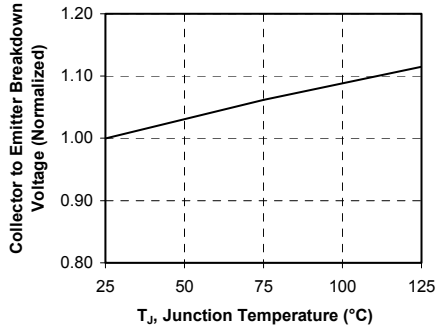

On state Voltage vs Gate to Emitter Volt.



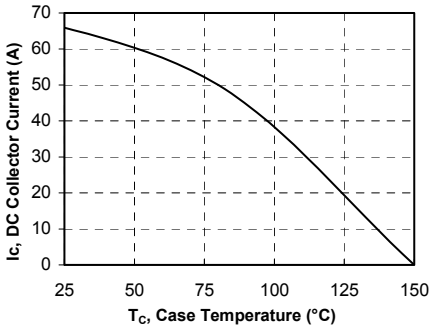

On state Voltage vs Junction Temperature



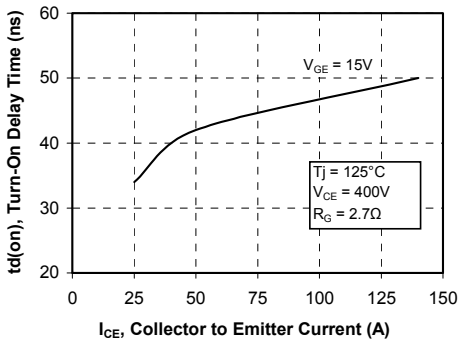

Breakdown Voltage vs Junction Temp.



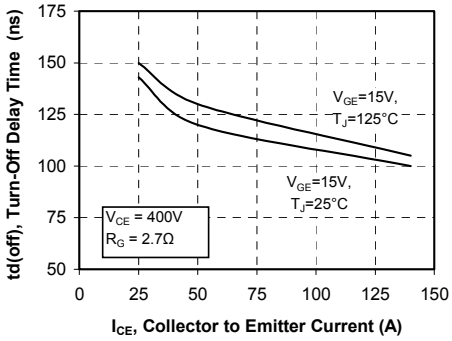

DC Collector Current vs Case Temperature



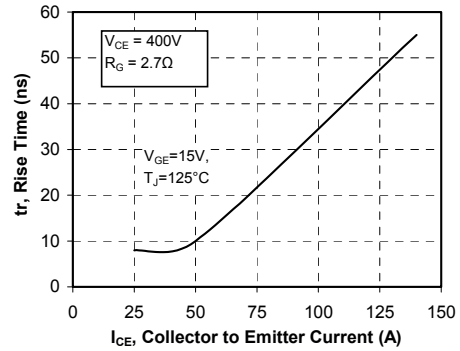
**Turn-On Delay Time vs Collector Current**



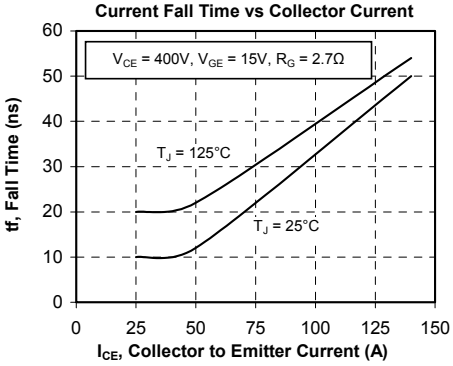

**Turn-Off Delay Time vs Collector Current**



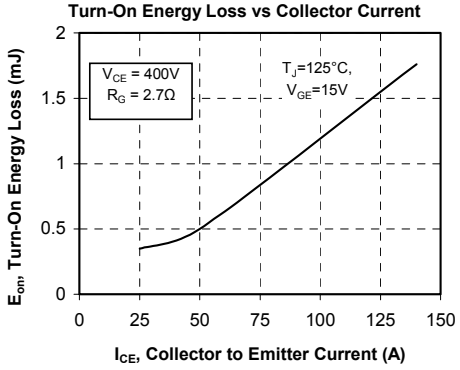

**Current Rise Time vs Collector Current**



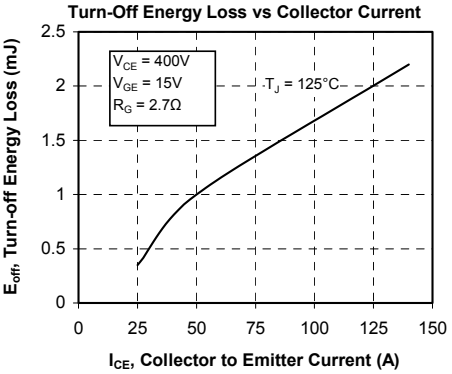

**Current Fall Time vs Collector Current**



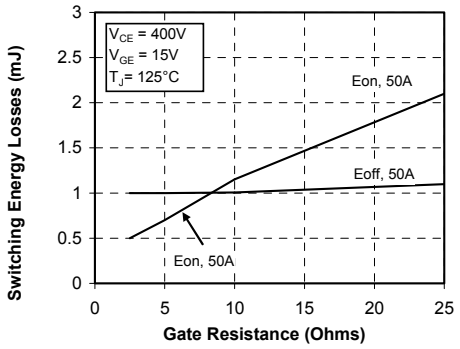

**Turn-On Energy Loss vs Collector Current**



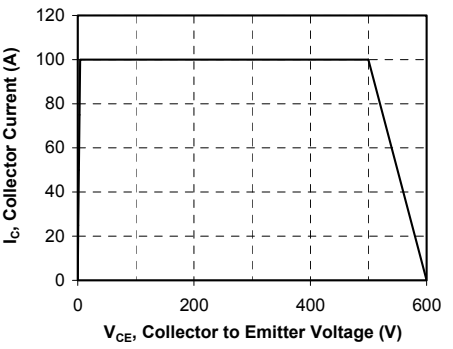

**Turn-Off Energy Loss vs Collector Current**

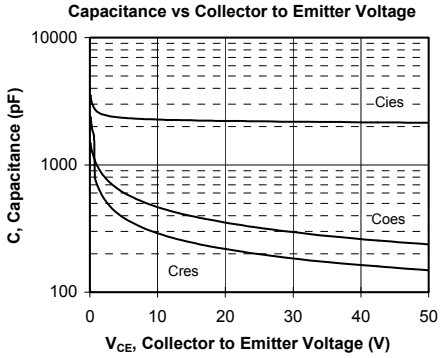


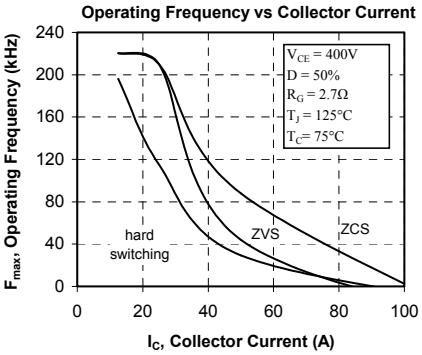

**Switching Energy Losses vs Gate Resistance**

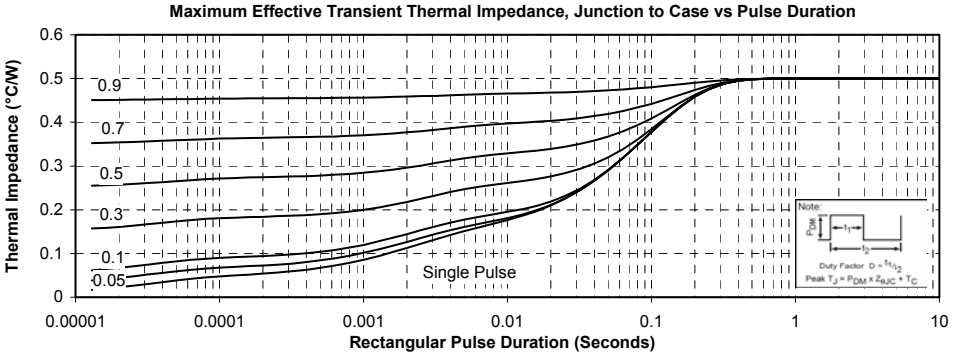



**Reverse Bias Safe Operating Area**

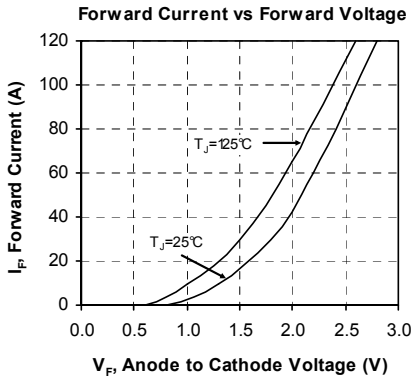


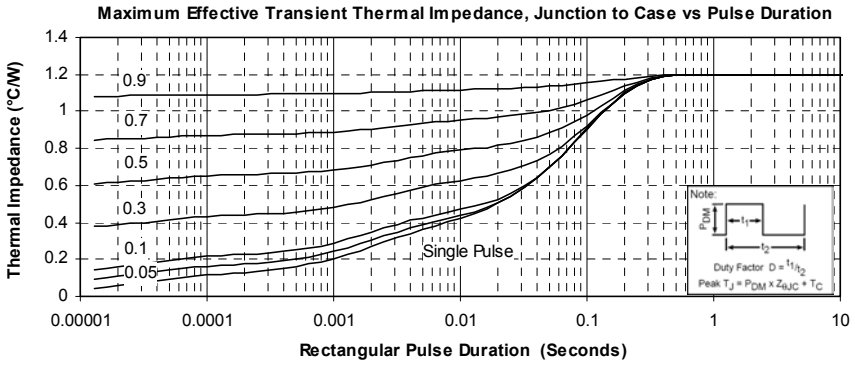


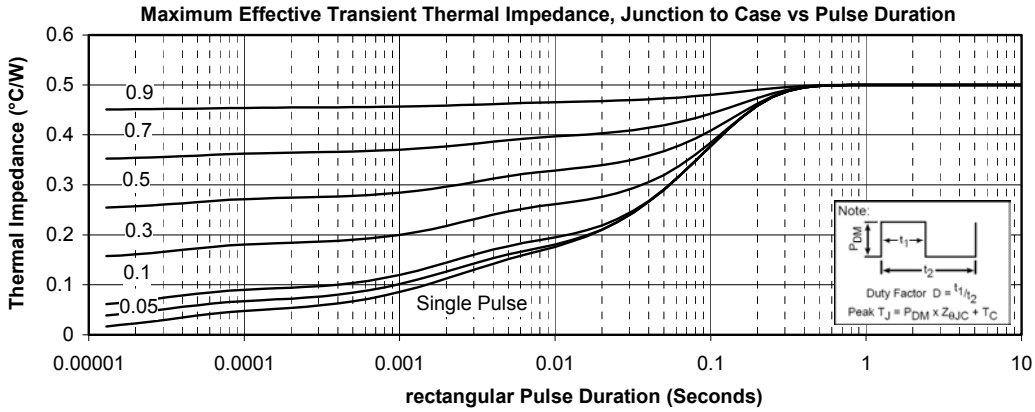

## 7.2 Bottom diode typical performance curves

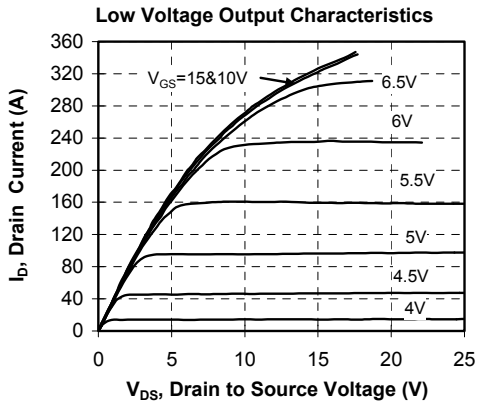


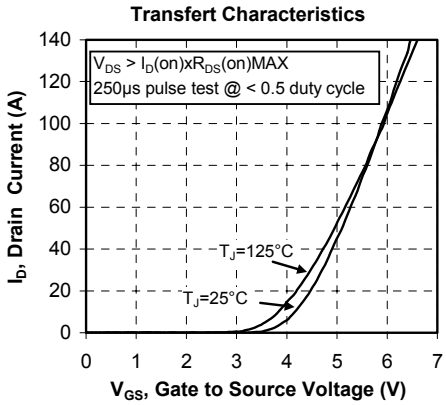



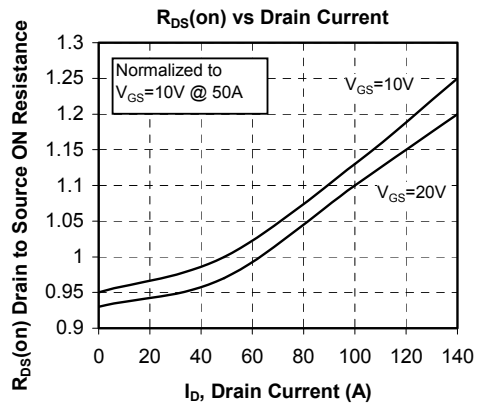
## 8. Boost chopper switch curves

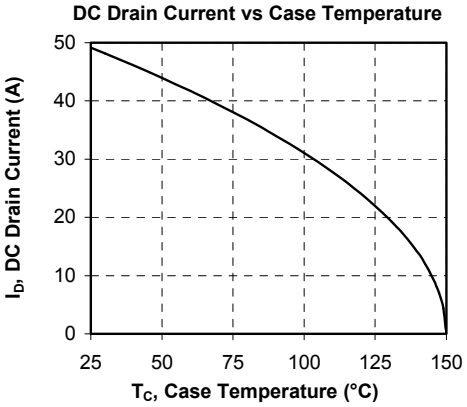
### 8.1 CoolMOS™ typical performance curves



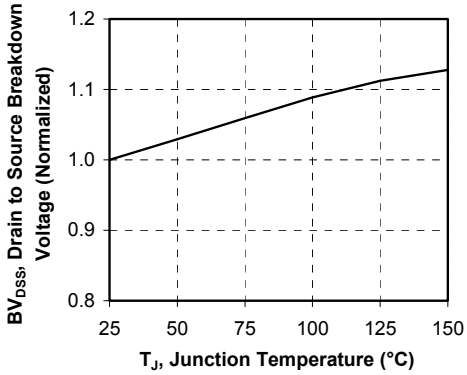



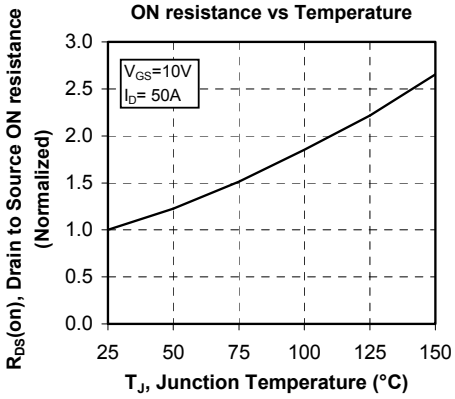



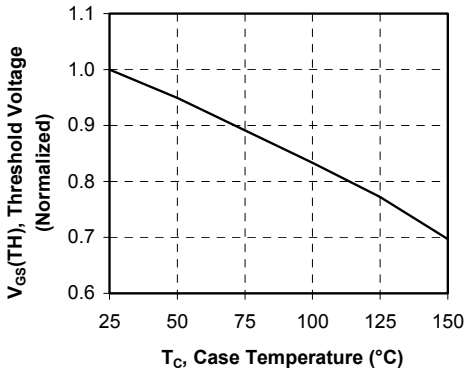
**Breakdown Voltage vs Temperature**



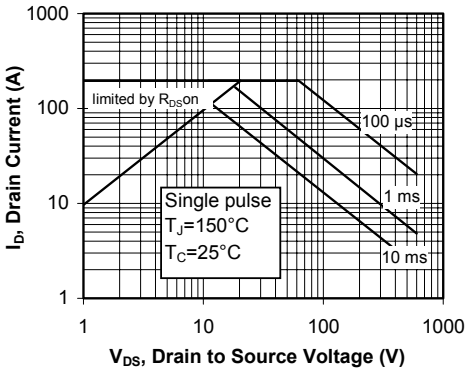

**ON resistance vs Temperature**



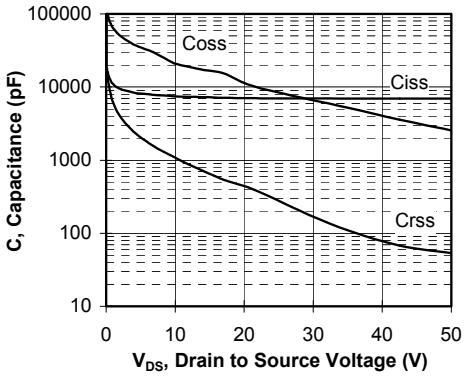

**Threshold Voltage vs Temperature**



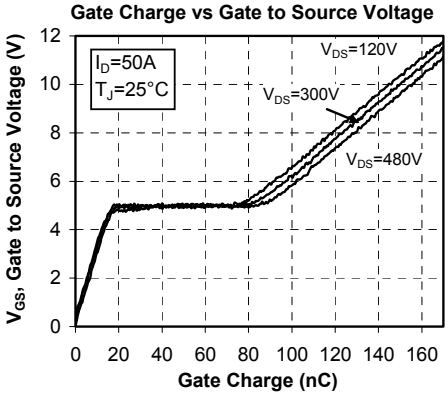

**Maximum Safe Operating Area**



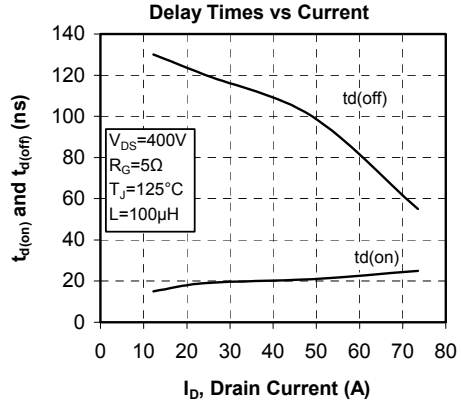

**Capacitance vs Drain to Source Voltage**



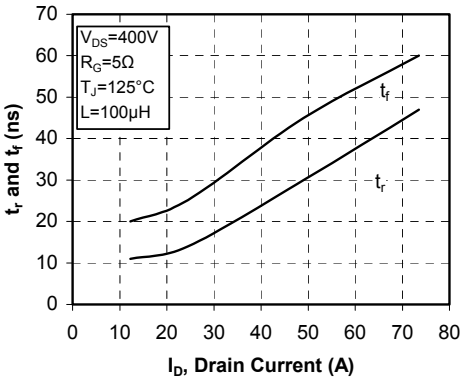

**Gate Charge vs Gate to Source Voltage**



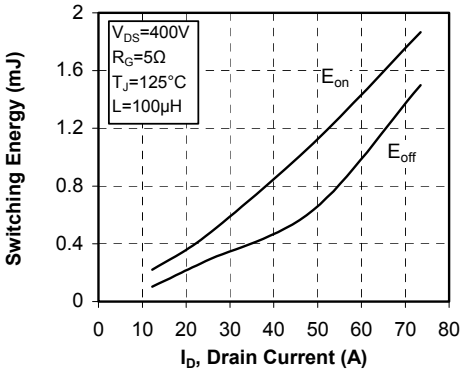
**Delay Times vs Current**



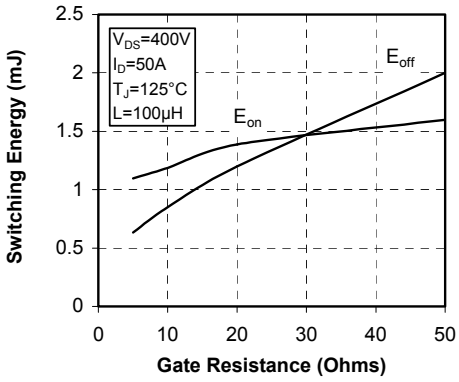

**Rise and Fall times vs Current**



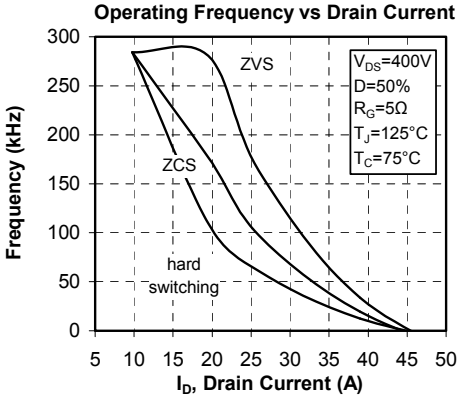

**Switching Energy vs Current**



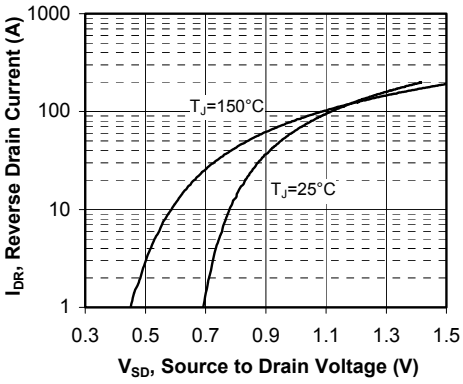

**Switching Energy vs Gate Resistance**




**Operating Frequency vs Drain Current**




**Source to Drain Diode Forward Voltage**



## 8.2 Chopper diode typical performance curves