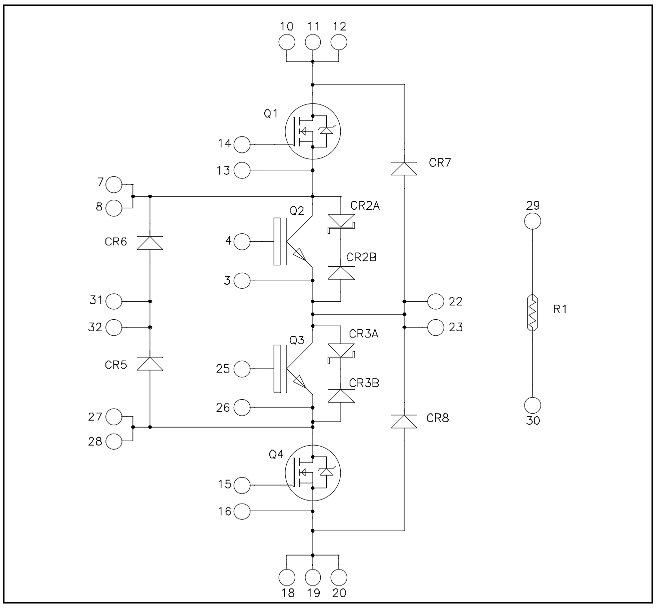
Three level inverter Power Module

Trench & Field Stop IGBT3 Q2, Q3:
V_{CES} = 600V ; I_C = 50A @ Tc = 80°C

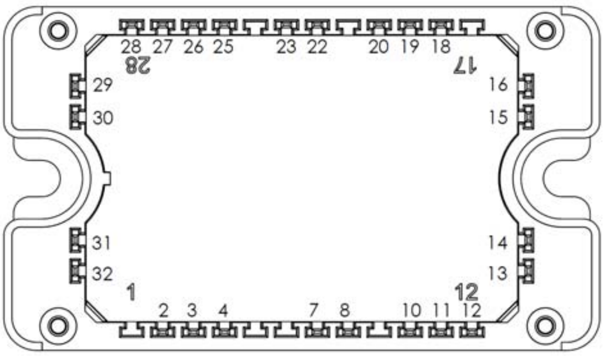
Super junction MOSFET Q1, Q4:
V_{DSS} = 600V ; I_D = 29A @ Tc = 80°C



Application
- Solar converter
- Uninterruptible Power Supplies

Features
- ***Q2, Q3 Trench + Field Stop IGBT3***
  - Low voltage drop
  - Low tail current
  - Switching frequency up to 20 kHz
  - Low leakage current
  - RBSOA and SCSOA rated
- ***Q1, Q4 Super junction MOSFET***
  - Ultra low R_{DSon}
  - Low Miller capacitance
  - Ultra low gate charge
  - Avalanche energy rated
  - Very rugged
- Kelvin emitter for easy drive
- Very low stray inductance
- High level of integration
- Internal thermistor for temperature monitoring

Benefits
- Stable temperature behavior
- Very rugged
- Direct mounting to heatsink (isolated package)
- Low junction to case thermal resistance
- Low profile
- RoHS Compliant



All multiple inputs and outputs must be shorted together
Example: 10/11/12 ; 7/8 …

All ratings @ T_j = 25°C unless otherwise specified

CAUTION: These Devices are sensitive to Electrostatic Discharge. Proper Handling Procedures Should Be Followed.

Q1 & Q4 Absolute maximum ratings (per Super junction MOSFET)

Symbol	Parameter		Max ratings	Unit
V_{DSS}	Drain - Source Voltage		600	V
I_D	Continuous Drain Current	$T_c = 25°C$	39	A
		$T_c = 80°C$	29	
I_{DM}	Pulsed Drain current		160	
V_{GS}	Gate - Source Voltage		±20	V
R_{DSon}	Drain - Source ON Resistance		70	mΩ
P_D	Power Dissipation	$T_c = 25°C$	250	W
I_{AR}	Avalanche current (repetitive and non repetitive)		20	A
E_{AR}	Repetitive Avalanche Energy		1	mJ
E_{AS}	Single Pulse Avalanche Energy		1800	

Q1 & Q4 Electrical Characteristics (per Super junction MOSFET)

Symbol	Characteristic	Test Conditions	Min	Typ	Max	Unit
I_{DSS}	Zero Gate Voltage Drain Current	$V_{GS} = 0V, V_{DS} = 600V$			25	µA
$R_{DS(on)}$	Drain – Source on Resistance	$V_{GS} = 10V$, $I_D = 39A$			70	mΩ
$V_{GS(th)}$	Gate Threshold Voltage	$V_{GS} = V_{DS}$, $I_D = 2.7mA$	2.1	3	3.9	V
I_{GSS}	Gate – Source Leakage Current	$V_{GS} = ±20$ V, $V_{DS} = 0V$			±100	nA

Q1 & Q4 Dynamic Characteristics (per Super junction MOSFET)

Symbol	Characteristic	Test Conditions	Min	Typ	Max	Unit
C_{iss}	Input Capacitance	$V_{GS} = 0V$ $V_{DS} = 25V$ f = 1MHz		7		nF
C_{oss}	Output Capacitance			2.56		
C_{rss}	Reverse Transfer Capacitance			0.21		
Q_g	Total gate Charge	$V_{GS} = 10V$ $V_{Bus} = 300V$ $I_D = 39A$		259		nC
Q_{gs}	Gate – Source Charge			29		
Q_{gd}	Gate – Drain Charge			111		
$T_{d(on)}$	Turn-on Delay Time	**Inductive Switching @ 125°C** $V_{GS} = 15V$ $V_{Bus} = 400V$ $I_D = 39A$ $R_G = 5Ω$		21		ns
T_r	Rise Time			30		
$T_{d(off)}$	Turn-off Delay Time			283		
T_f	Fall Time			84		
E_{on}	Turn-on Switching Energy	**Inductive switching @ 25°C** $V_{GS} = 15V$, $V_{Bus} = 400V$ $I_D = 39A$, $R_G = 5Ω$		670		µJ
E_{off}	Turn-off Switching Energy			980		
E_{on}	Turn-on Switching Energy	**Inductive switching @ 125°C** $V_{GS} = 15V$, $V_{Bus} = 400V$ $I_D = 39A$, $R_G = 5Ω$		1096		µJ
E_{off}	Turn-off Switching Energy			1206		
R_{thJC}	Junction to Case Thermal Resistance				0.5	°C/W

Q2 & Q3 Absolute maximum ratings (per IGBT)

Symbol	Parameter		Max ratings	Unit
V_{CES}	Collector - Emitter 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	Power Dissipation	$T_C = 25°C$	176	W
RBSOA	Reverse Bias Safe Operating Area	$T_J = 150°C$	100A @ 550V	

Q2 & Q3 Electrical Characteristics (per IGBT)

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	$V_{GE} = 15V$ $I_C = 50A$	$T_j = 25°C$		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

Q2 & Q3 Dynamic Characteristics (per IGBT)

Symbol	Characteristic	Test Conditions		Min	Typ	Max	Unit
C_{ies}	Input Capacitance	$V_{GE} = 0V$ $V_{CE} = 25V$ f = 1MHz			3150		pF
C_{oes}	Output Capacitance				200		
C_{res}	Reverse Transfer Capacitance				95		
Q_G	Gate charge	$V_{GE} = ±15V$, $I_C = 50A$ $V_{CE} = 300V$			0.5		µC
$T_{d(on)}$	Turn-on Delay Time	Inductive Switching (25°C) $V_{GE} = ±15V$ $V_{Bus} = 300V$ $I_C = 50A$ $R_G = 8.2Ω$			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) $V_{GE} = ±15V$ $V_{Bus} = 300V$ $I_C = 50A$ $R_G = 8.2Ω$			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	$V_{GE} = ±15V$ $V_{Bus} = 300V$ $I_C = 50A$ $R_G = 8.2Ω$	$T_j = 25°C$		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		
I_{sc}	Short Circuit data	$V_{GE} \le 15V$; $V_{Bus} = 360V$ $t_p \le 6µs$; $T_j = 150°C$			250		A
R_{thJC}	Junction to Case Thermal Resistance					0.85	°C/W

CR2 & CR3 diode ratings and characteristics (per device)

Symbol	Characteristic	Test Conditions	Min	Typ	Max	Unit
V_F	Diode + tranzorb Forward Voltage	I_F = 10A		10		V
R_{thJC}	Junction to Case Thermal Resistance				8	°C/W

CR5 & CR6 diode ratings and characteristics (per diode)

Symbol	Characteristic	Test Conditions		Min	Typ	Max	Unit
V_{RRM}	Peak Repetitive Reverse Voltage					600	V
I_{RM}	Reverse Leakage Current	V_R=600V				25	µA
I_F	DC Forward Current		Tc = 80°C		30		A
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		
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		
E_{rr}	Reverse Recovery Energy	I_F = 30A V_R = 400V di/dt =1000A/µs	T_j = 125°C		0.6		mJ
R_{thJC}	Junction to Case Thermal Resistance					1.2	°C/W

CR7 & CR8 diode ratings and characteristics (per diode)

Symbol	Characteristic	Test Conditions		Min	Typ	Max	Unit
V_{RRM}	Peak Repetitive Reverse Voltage					1200	V
I_{RM}	Reverse Leakage Current	V_R=1200V				100	µA
I_F	DC Forward Current		Tc = 80°C		30		A
V_F	Diode Forward Voltage	I_F = 30A			2.6	3.1	V
		I_F = 60A			3.2		
		I_F = 30A	T_j = 125°C		1.8		
t_{rr}	Reverse Recovery Time	I_F = 30A V_R = 800V di/dt =200A/µs	T_j = 25°C		300		ns
			T_j = 125°C		380		
Q_{rr}	Reverse Recovery Charge		T_j = 25°C		360		nC
			T_j = 125°C		1700		
E_{rr}	Reverse Recovery Energy	I_F = 30A V_R = 800V di/dt =1000A/µs	T_j = 125°C		1.6		mJ
R_{thJC}	Junction to Case Thermal Resistance					1.2	°C/W

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		%

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

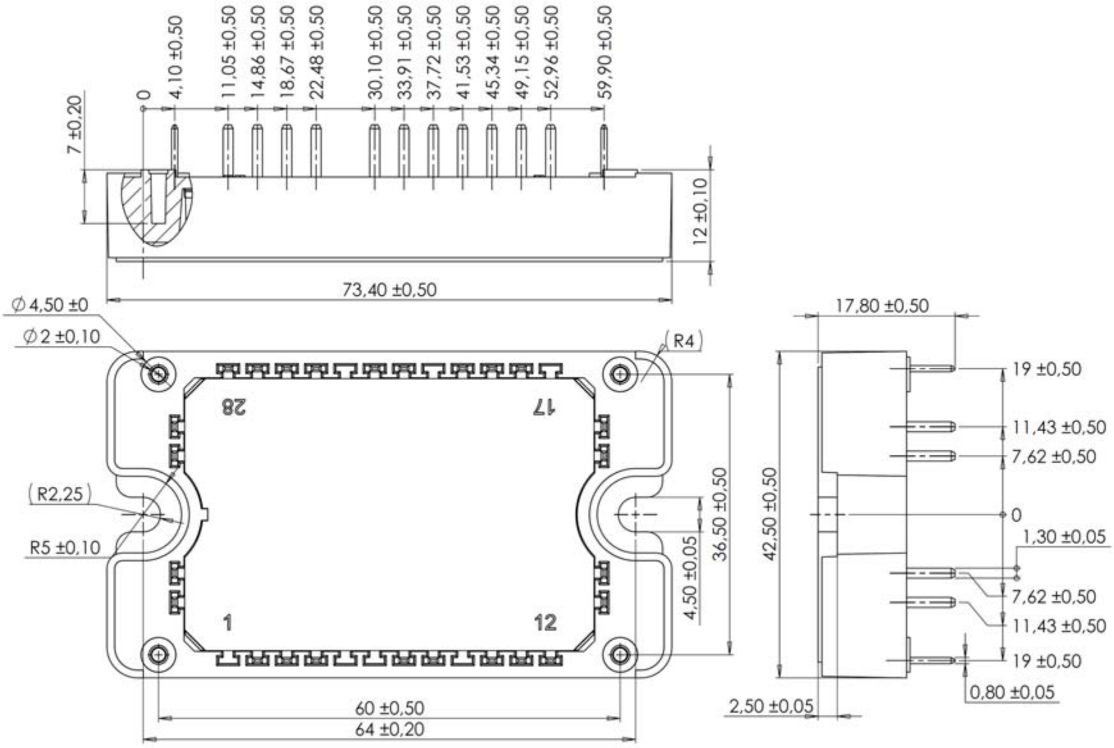
T: Thermistor temperature
R_T: Thermistor value at T

Thermal and package characteristics

Symbol	Characteristic			Min	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_{JOP}	Recommended junction temperature under switching conditions			-40	$T_J$max -25	°C
T_{STG}	Storage Temperature Range			-40	125	°C
T_C	Operating Case Temperature			-40	125	°C
Torque	Mounting torque	To heatsink	M4	2	3	N.m
Wt	Package Weight				110	g

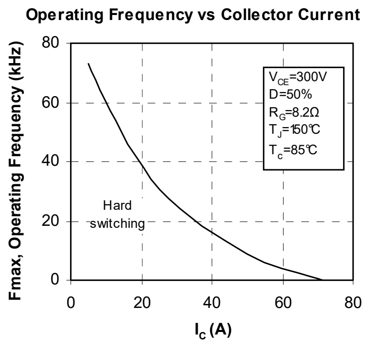
*Tjmax = 150°C for Q1 & Q4

Package outline (dimensions in mm)

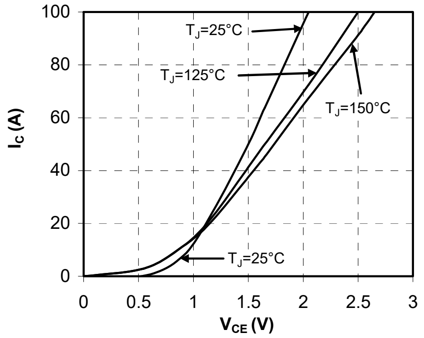


See application note 1906 - Mounting Instructions for SP3F Power Modules on www.microsemi.com

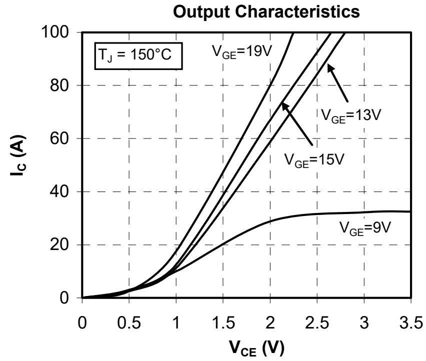
Q2 & Q3 Typical performance curve



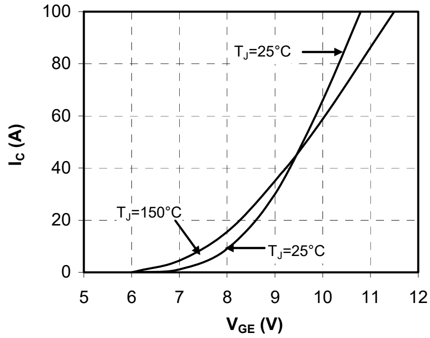
Output Characteristics (V_{GE}=15V)



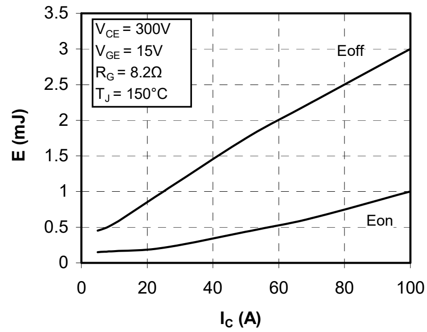
Output Characteristics



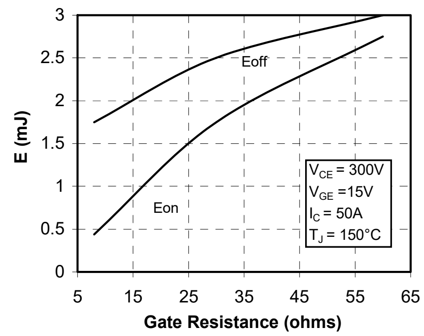
Transfert Characteristics



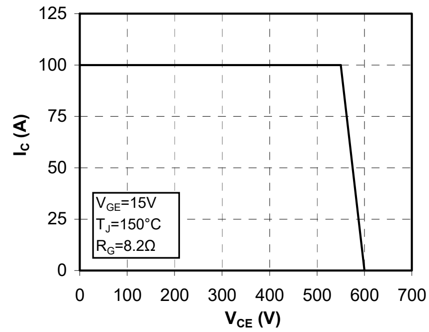
Energy losses vs Collector Current



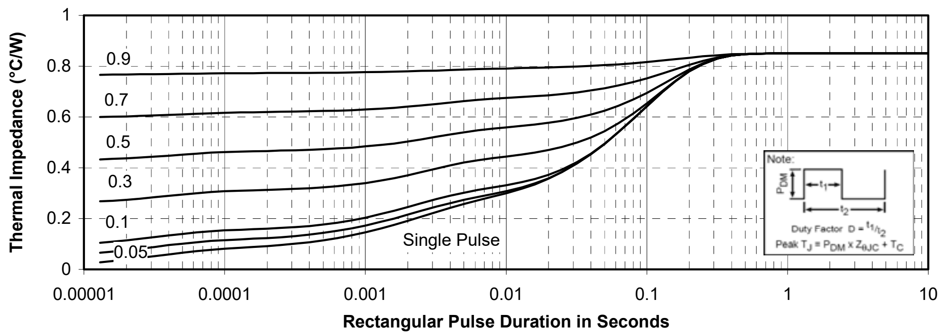
Switching Energy Losses vs Gate Resistance



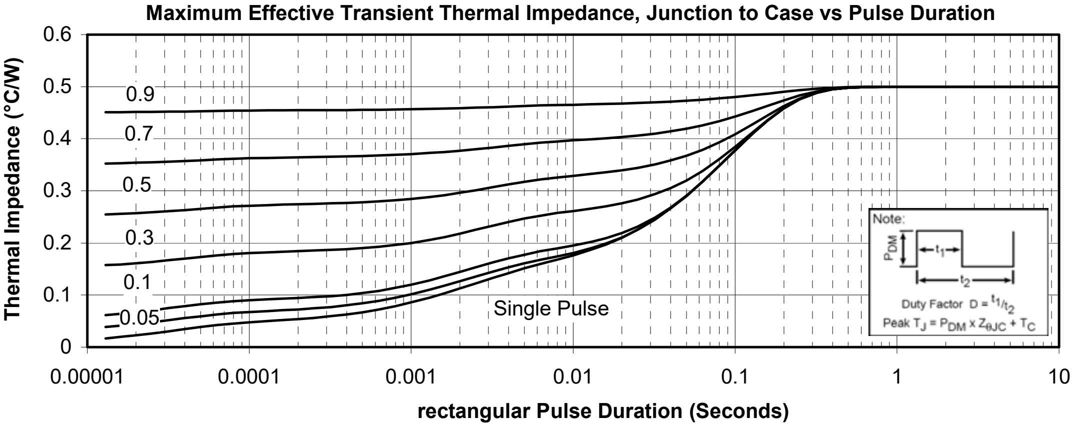
Reverse Bias Safe Operating Area

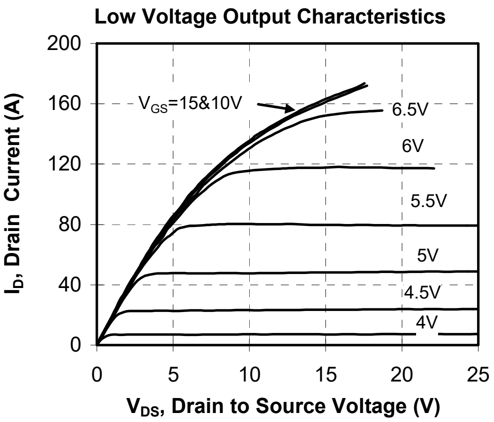


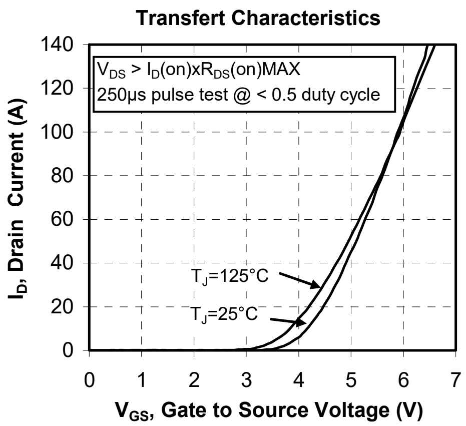
maximum Effective Transient Thermal Impedance, Junction to Case vs Pulse Duration

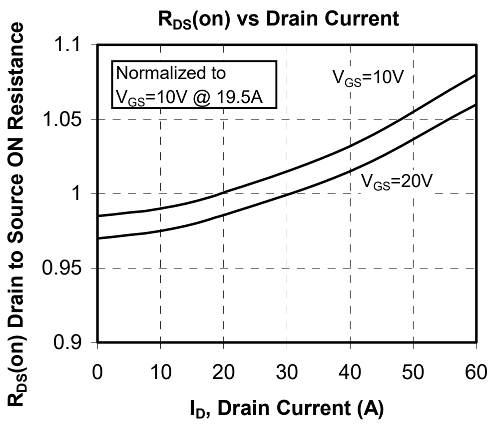


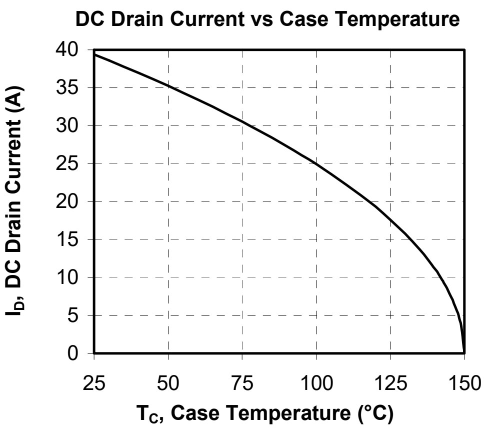
Q1 & Q4 Typical performance curve

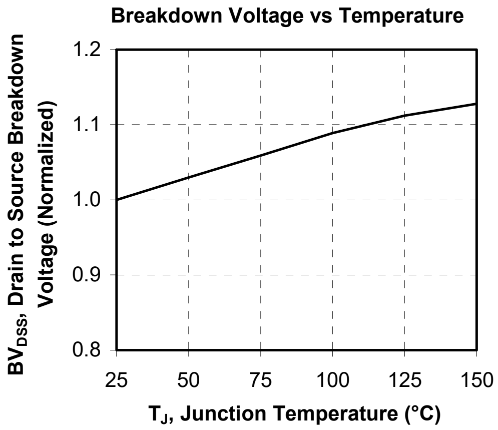


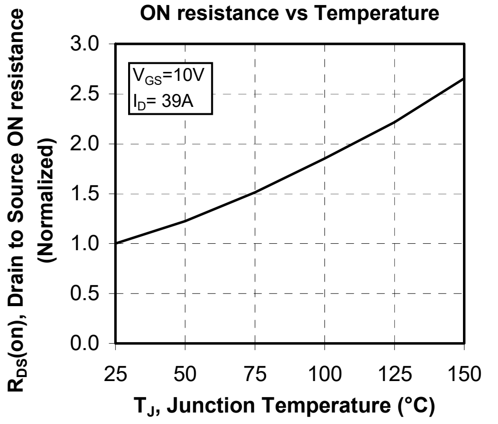


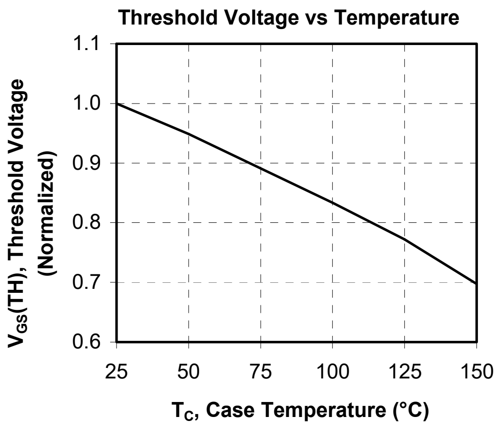


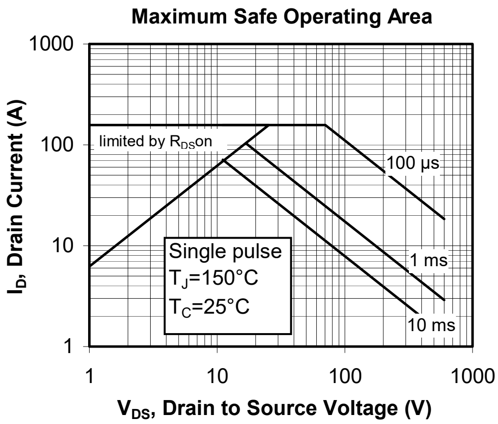


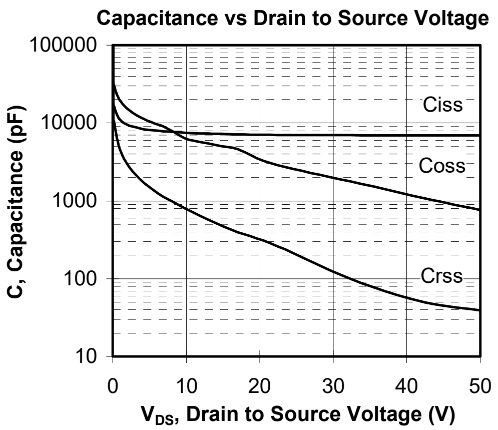


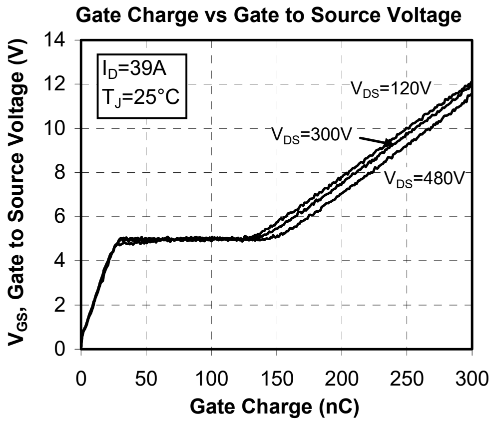

Breakdown Voltage vs Temperature
BVDSS, Drain to Source Breakdown Voltage (Normalized)
TJ, Junction Temperature (°C)
1.2
1.1
1.0
0.9
0.8
25
50
75
100
125
150

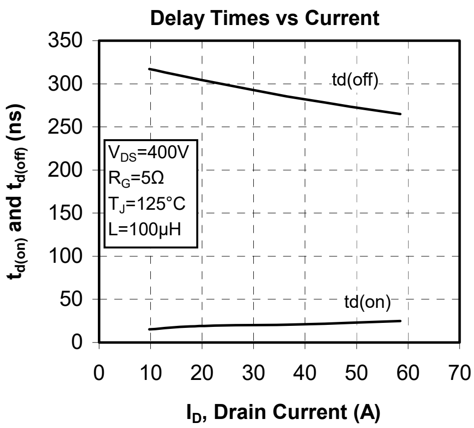

ON resistance vs Temperature
RDS(on), Drain to Source ON resistance (Normalized)
TJ, Junction Temperature (°C)
VGS=10V
ID= 39A
3.0
2.5
2.0
1.5
1.0
0.5
0.0
25
50
75
100
125
150

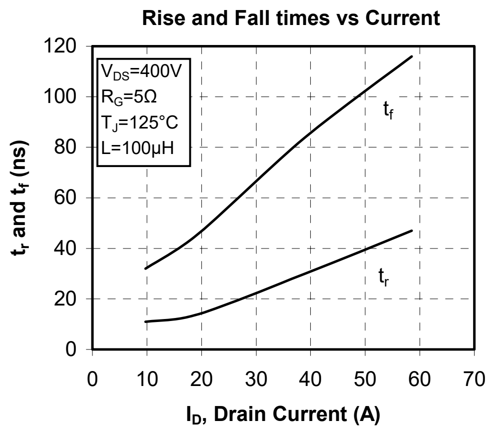

Threshold Voltage vs Temperature
VGS(TH), Threshold Voltage (Normalized)
TC, Case Temperature (°C)
1.1
1.0
0.9
0.8
0.7
0.6
25
50
75
100
125
150

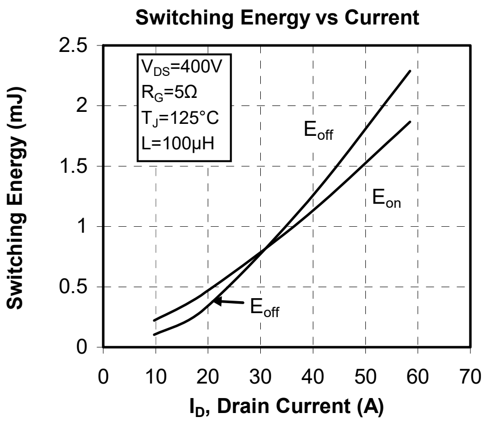

Maximum Safe Operating Area
ID, Drain Current (A)
VDS, Drain to Source Voltage (V)
limited by RDSon
100 µs
1 ms
10 ms
Single pulse
TJ=150°C
TC=25°C
1000
100
10
1
1
10
100
1000

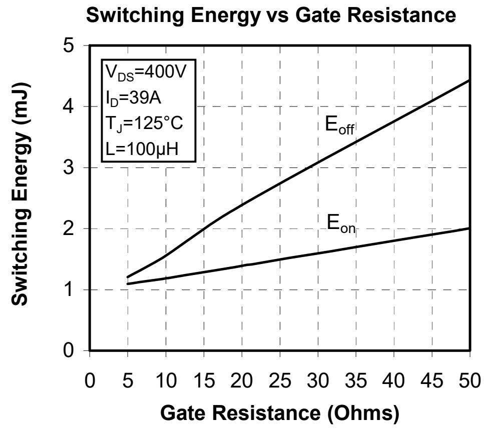

Capacitance vs Drain to Source Voltage
C, Capacitance (pF)
VDS, Drain to Source Voltage (V)
Ciss
Coss
Crss
100000
10000
1000
100
10
0
10
20
30
40
50

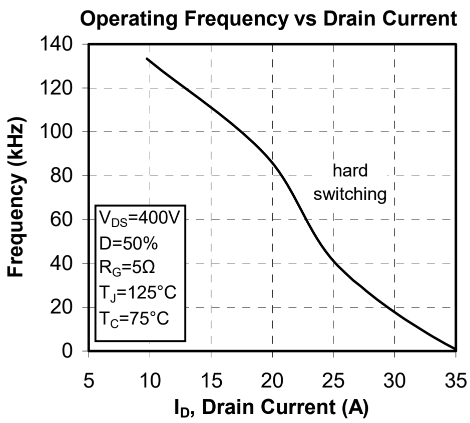

Gate Charge vs Gate to Source Voltage
VGS, Gate to Source Voltage (V)
Gate Charge (nC)
ID=39A
TJ=25°C
VDS=120V
VDS=300V
VDS=480V
14
12
10
8
6
4
2
0
0
50
100
150
200
250
300

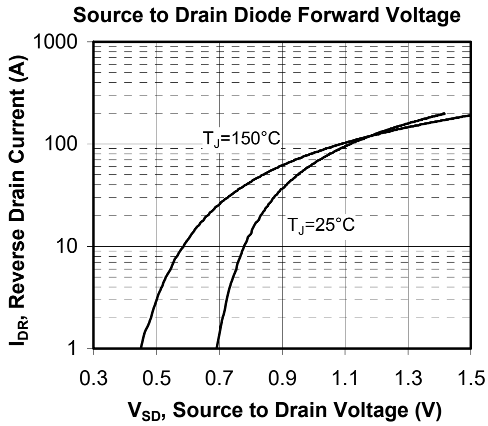

Delay Times vs Current
td(off)
td(on)
VDS=400V
RG=5Ω
TJ=125°C
L=100µH
td(on) and td(off) (ns)
ID, Drain Current (A)


Rise and Fall times vs Current
VDS=400V
RG=5Ω
TJ=125°C
L=100µH
tf
tr
tr and tf (ns)
ID, Drain Current (A)

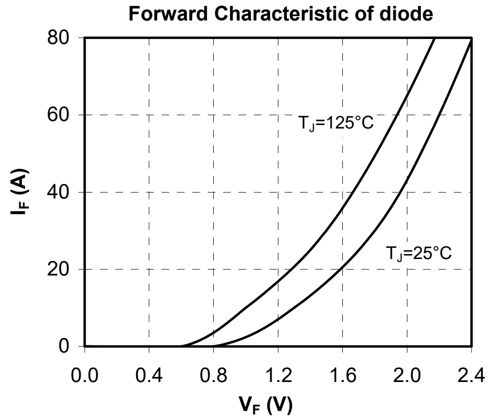

Switching Energy vs Current
VDS=400V
RG=5Ω
TJ=125°C
L=100µH
Eoff
Eon
Eoff
Switching Energy (mJ)
ID, Drain Current (A)

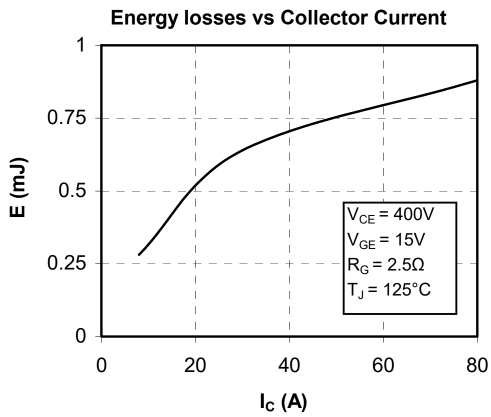

Switching Energy vs Gate Resistance
VDS=400V
ID=39A
TJ=125°C
L=100µH
Eoff
Eon
Switching Energy (mJ)
Gate Resistance (Ohms)

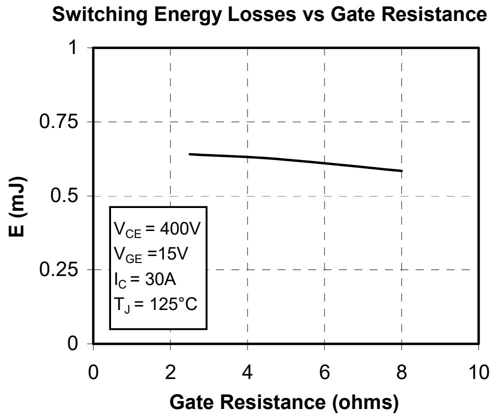

Operating Frequency vs Drain Current
hard
switching
VDS=400V
D=50%
RG=5Ω
TJ=125°C
TC=75°C
Frequency (kHz)
ID, Drain Current (A)

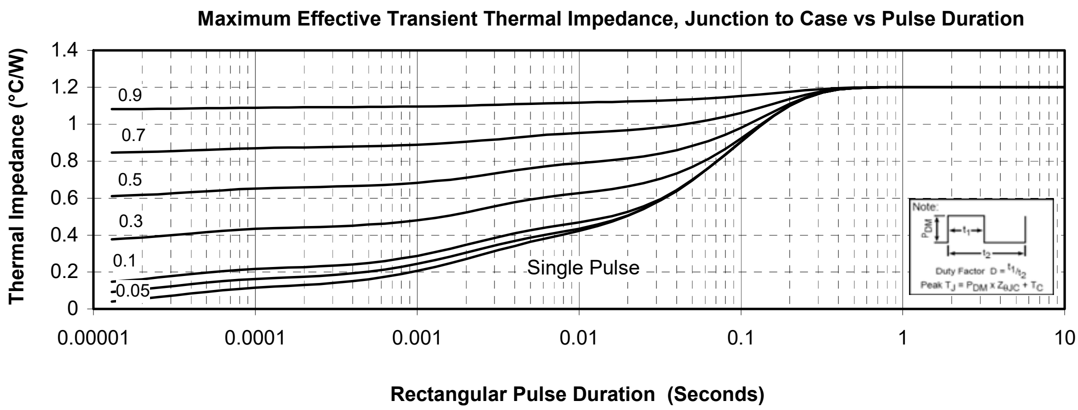

Source to Drain Diode Forward Voltage
TJ=150°C
TJ=25°C
IDR, Reverse Drain Current (A)
VSD, Source to Drain Voltage (V)

CR5 & CR6 Typical performance curve

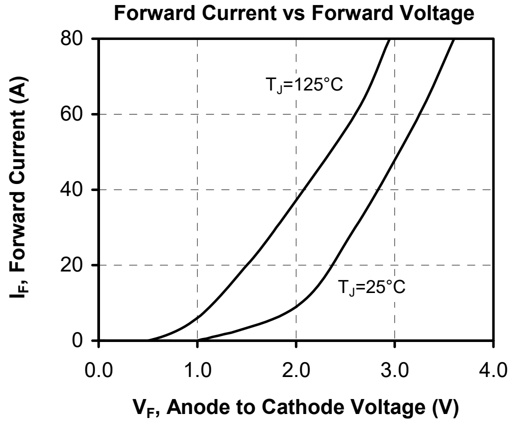


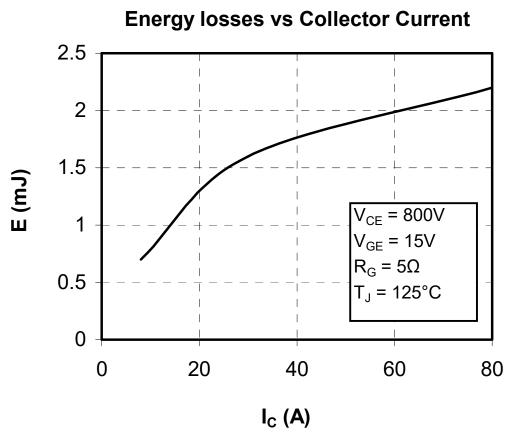


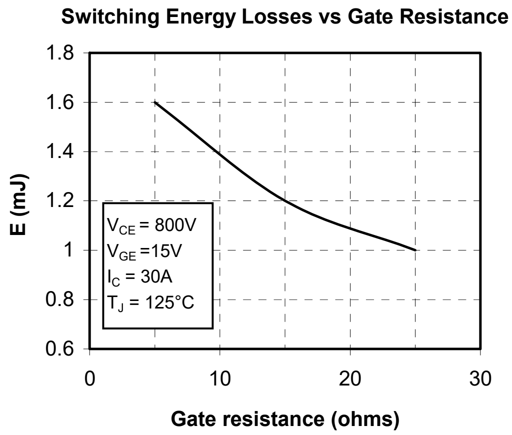


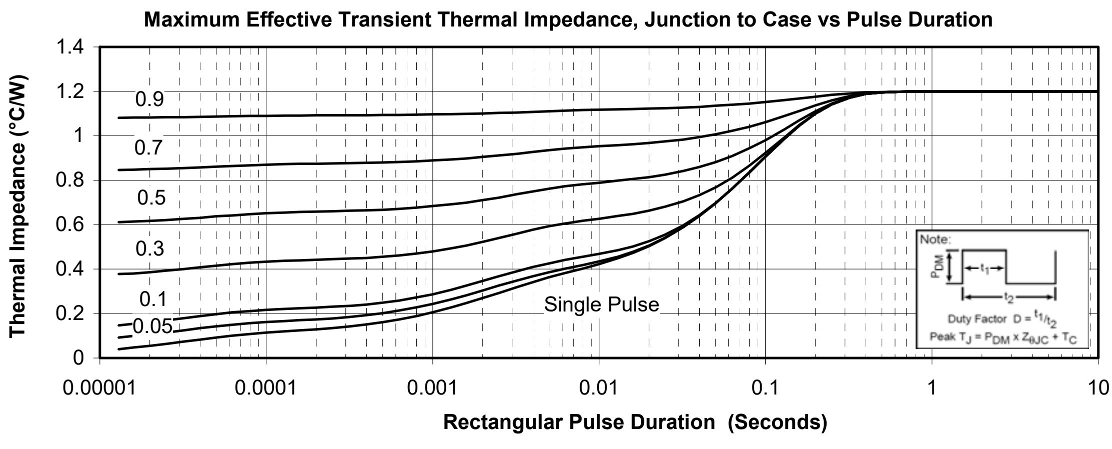


CR7 & CR8 Typical performance curve









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