



Features

- High Speed Switching with Low Capacitances
- High Blocking Voltage with Low $R_{DS(on)}$
- Easy to parallel
- Simple to drive
- RoHS Compliant

Benefits

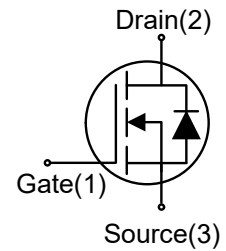
- Increased Power Density
- Faster Operating Frequency
- Reduction of Heat Sink Requirements
- Higher Efficiency
- Reduced EMI

Applications

- Power Factor Correction Modules
- Switch Mode Power Supplies
- DC-AC Inverters
- High Voltage DC/DC Converters



TO-220F



Ordering Part Number	Package	Brand
WML13N65EM	TO-220F	HXY MOSFET

Maximum Ratings (T_c = 25 °C unless otherwise specified)

Symbol	Parameter	Value	Unit	Test Conditions	Note
V _{DSmax}	Drain - Source Voltage	650	V	V _{GS} = 0 V, I _D = 100 μ A	
V _{GSmx}	Gate - Source Voltage (dynamic)	-8/+22	V	AC (f > 1 Hz)	Note 1
V _{GSop}	Gate - Source Voltage (static)	-4/+18	V	Static	Note 2
I _D	Continuous Drain Current	12	A	T _C = 25°C	Fig. 19 Note 3
		8		T _C = 100°C	
I _{D(pulse)}	Pulsed Drain Current	24	A	Pulse width t _p limited by T _{Jmax}	
P _D	Power Dissipation	48	W	T _C = 25°C	Fig. 20
		24		T _C = 100°C	
T _J , T _{stg}	Operating Junction and Storage Temperature	-40 to +175	°C		



Electrical Characteristics ($T_C = 25^\circ\text{C}$ unless other wise specified)

Static Characteristics

Symbol	Parameter	Test conditions	Value			Unit
			Min.	Typ.	Max.	
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	$I_D=100\mu\text{A}$, $V_{GS}=0\text{V}$	650			V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS}=650\text{V}$, $V_{GS}=0\text{V}$		1		μA
I_{GSS}	Gate-Source Leakage Current	$V_{DS}=0\text{V}$, $V_{GS}=18\text{V}$			250	nA
$V_{GS(th)}$	Gate Threshold Voltage	$V_{DS}=V_{GS}$, $I_D=1.33\text{mA}$ $T_J=25^\circ\text{C}$ $T_J=175^\circ\text{C}$	2	3.1 2.3	4	V
$R_{DS(on)}$	Drain-Source On-State Resistance	$V_{GS}=18\text{V}$, $I_D=4.5\text{A}$ $T_J=25^\circ\text{C}$ $T_J=175^\circ\text{C}$		270		m Ω

Thermal Characteristics

Symbol	Parameter	Value			Unit
		Min.	Typ.	Max.	
$R_{th(j-c)}$	Thermal Resistance from Junction to Case		3.12		$^\circ\text{C/W}$

Dynamic Characteristics

Symbol	Parameter	Test conditions	Value			Unit
			Min.	Typ.	Max.	
C_{iss}	Input Capacitance	$V_{DS}=600\text{V}$, $f=1\text{MHz}$, $V_{GS}=0\text{V}$		203		pF
C_{oss}	Output Capacitance			26		pF
C_{rss}	Reverse Transfer Capacitance			3.5		pF
$R_{G(int)}$	Internal Gate Resistance	$f=1\text{MHz}$		3.6		Ω
Q_g	Total Gate Charge	$V_{DS}=400\text{V}$, $I_D=4.5\text{A}$, $V_{GS}=-4/18\text{V}$		11.2		nC
Q_{gs}	Gate to Source Charge			2		nC
Q_{gd}	Gate to Drain Charge			5.2		nC



Switching Characteristics

Symbol	Parameter	Test conditions	Value			Unit
			Min.	Typ.	Max.	
$t_{d(on)}$	Turn-On Delay Time	$V_{DD}=400V$, $I_D=4.5A$, $V_{GS}=-4V/18V$, $R_G=2.5\Omega$, $L=200\mu H$		5		ns
t_r	Rise Time			23		ns
$t_{d(off)}$	Turn-Off Delay Time			6		ns
t_f	Fall Time			8		ns
E_{on}	Turn-On Energy			34		μJ
E_{off}	Turn-Off Energy			4		μJ

Reverse Diode Characteristics

Symbol	Parameter	Test conditions	Value			Unit
			Min.	Typ.	Max.	
V_{SD}	Diode Forward Voltage	$V_{GS}=-4V$, $I_{SD}=2.5A$ $T_j=25^\circ C$ $T_j=175^\circ C$ $V_{GS}=-4V$, $I_{SD}=4.5A$ $T_j=25^\circ C$ $T_j=175^\circ C$		4.0 3.6 4.5 4.0		V
I_S	Continuous Diode Forward Current	$V_{GS}=-4V$ $T_c=25^\circ C$ $T_c=100^\circ C$		13 5.5		A
t_{rr}	Reverse Recovery Time	$V_{GS}=-4V$, $I_{SD}=4.5A$, $V_R=400V$, $di/dt=1000A/\mu s$		22		ns
Q_{rr}	Reverse Recovery Charge			68		nC
I_{rrm}	Peak Reverse Recovery Current			4		A



Typical Performance

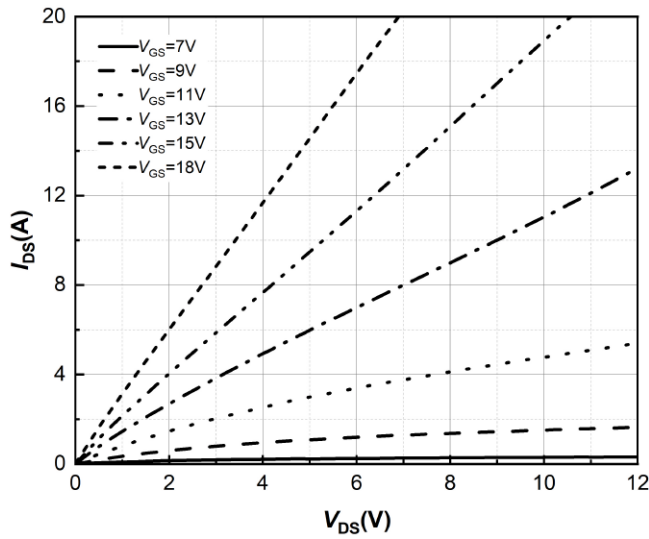


Figure 1. Output Characteristics
 $T_j = -40^\circ\text{C}$

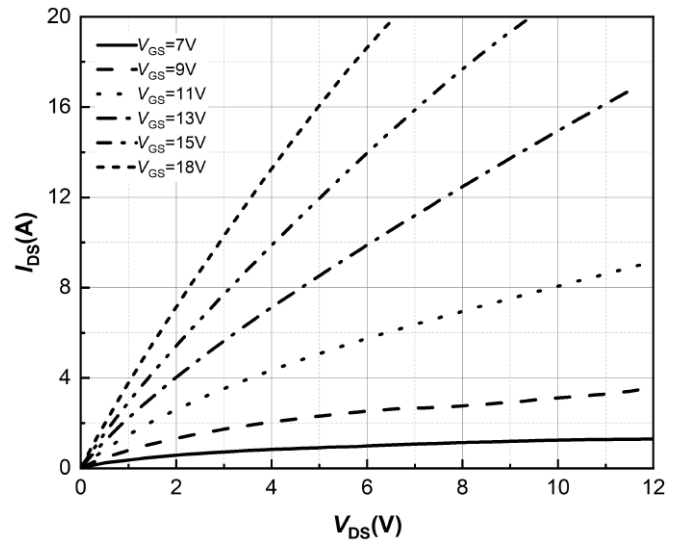


Figure 2 Output Characteristics

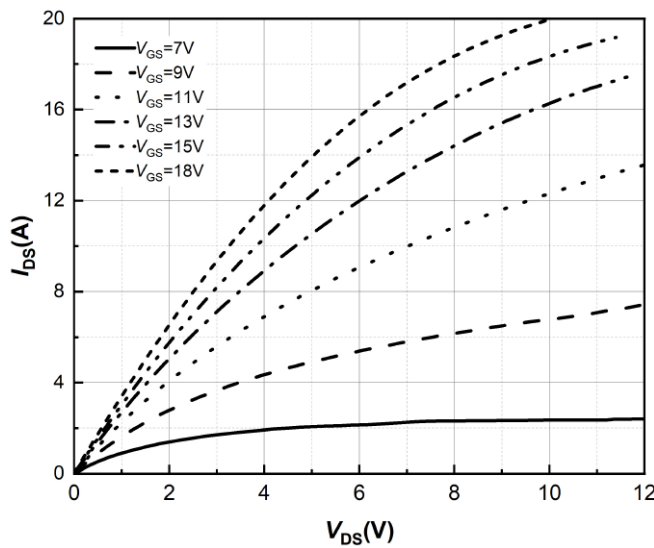


Figure 3. Output Characteristics
 $T_j = 175^\circ\text{C}$

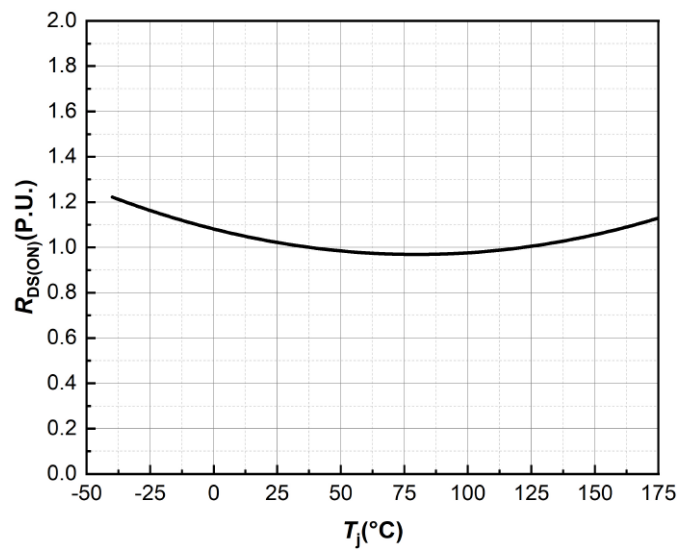


Figure 4. Normalized On-Resistance vs.
Temperature

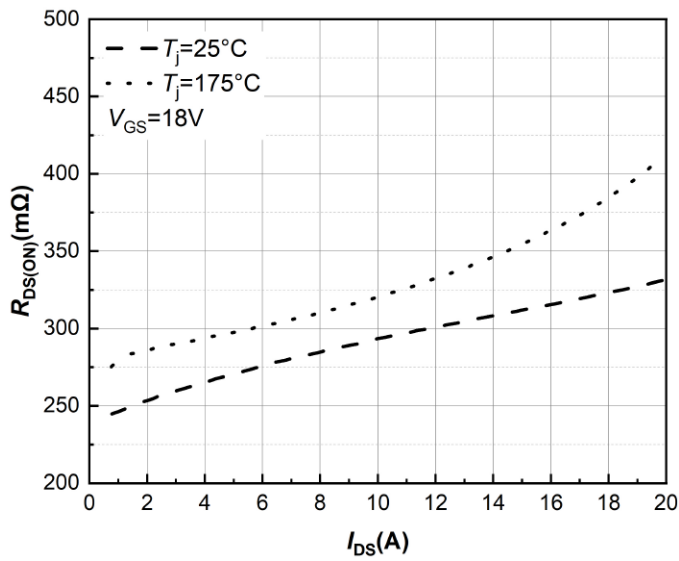


Figure 5. On-Resistance vs. Drain Current
For Various Temperatures

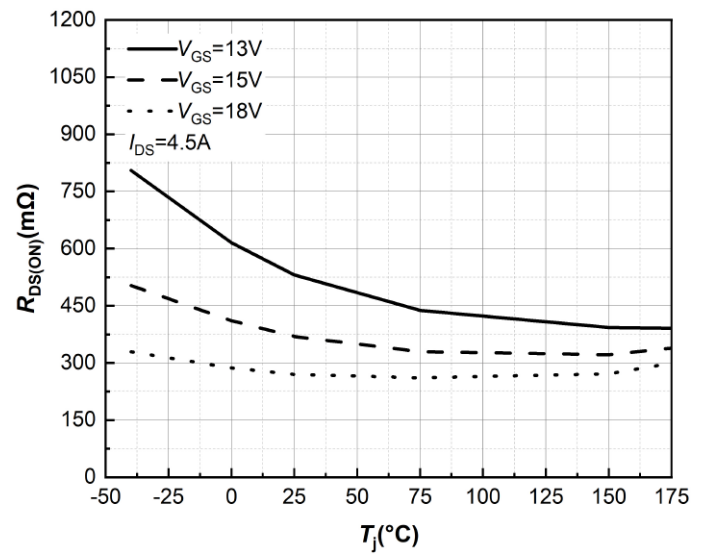


Figure 6. On-Resistance vs. Temperature
For Various Gate Voltage

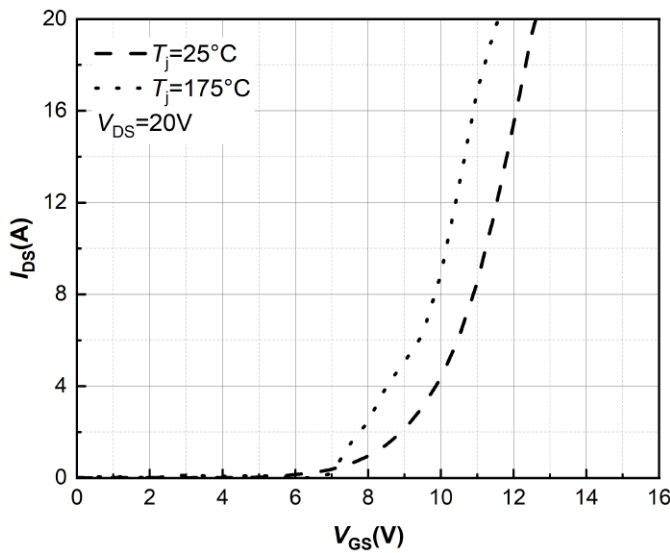


Figure 7. Transfer Characteristic for
Various Junction Temperatures

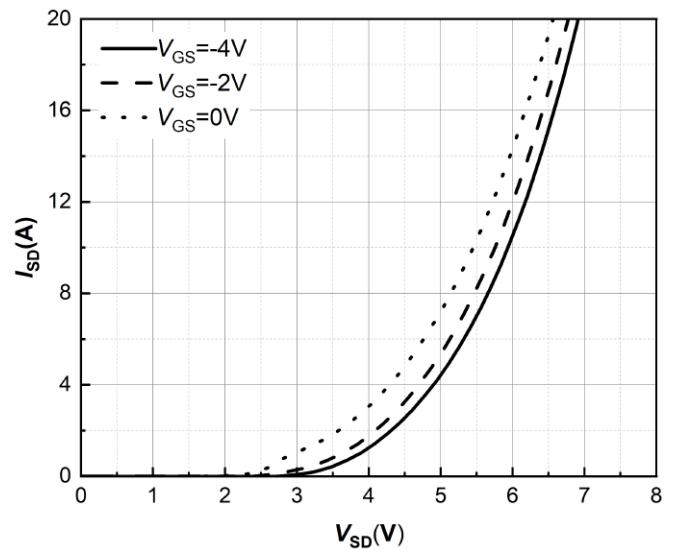


Figure 8. Body Diode Characteristic
 $T_J = -40^\circ C$

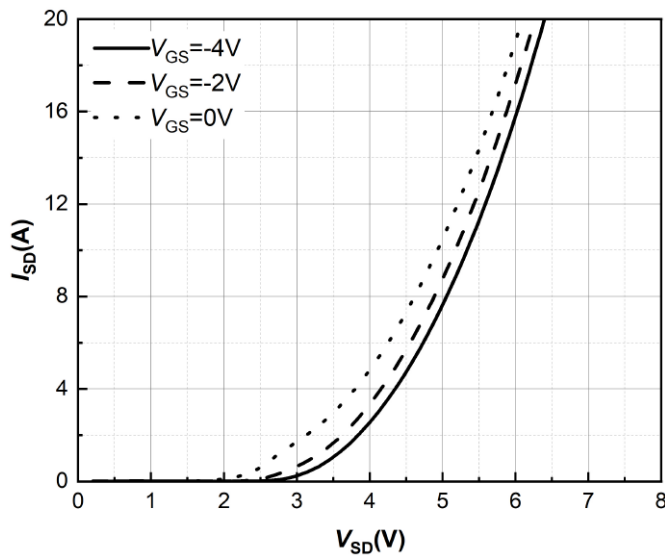


Figure 9. Body Diode Characteristic
 $T_j = 25^\circ\text{C}$

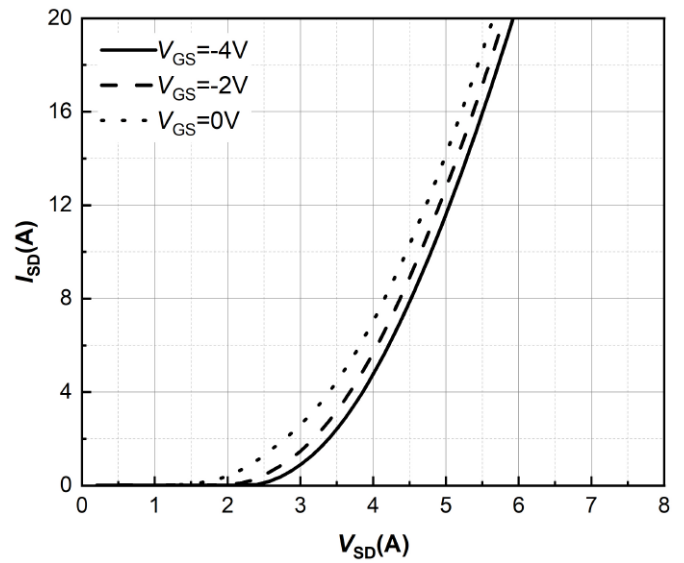


Figure 10. Body Diode Characteristic
 $T_j = 175^\circ\text{C}$

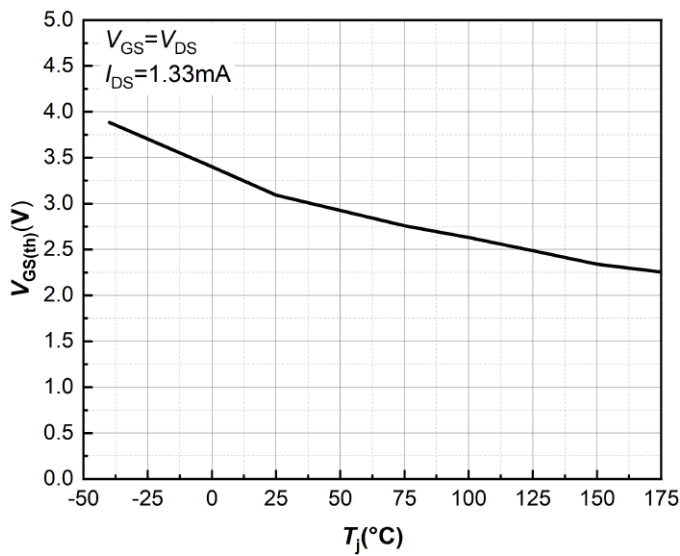


Figure 11. Threshold Voltage vs.
Temperature

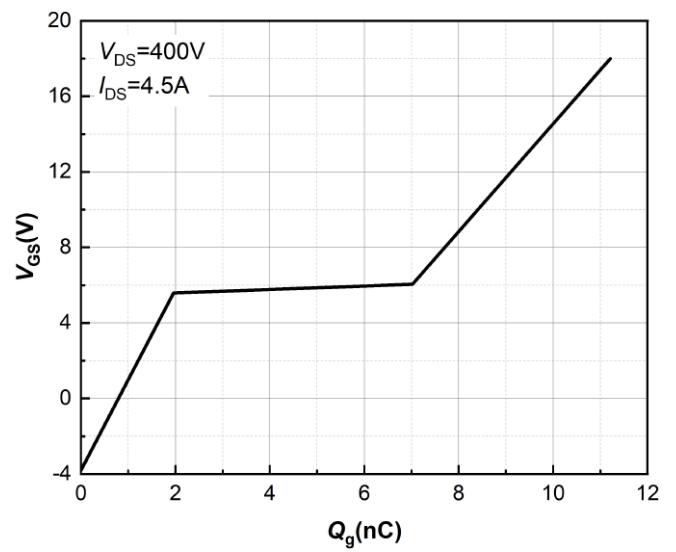


Figure 12. Gate Charge Characteristics

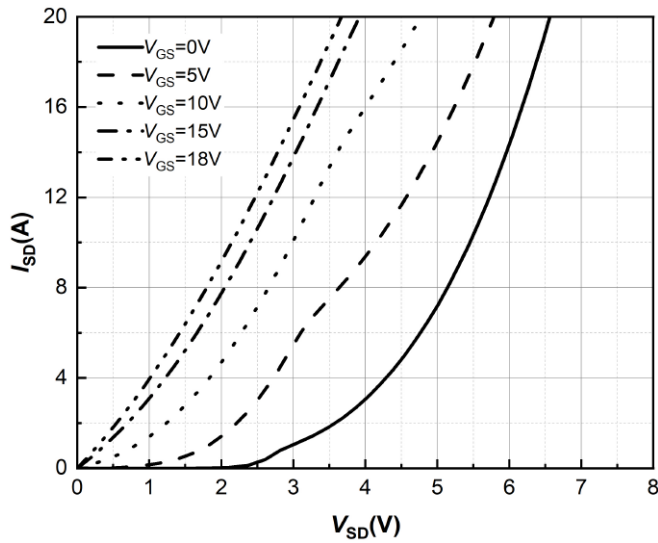


Figure 13. 3rd Quadrant Characteristic
 $T_j = -40^\circ\text{C}$

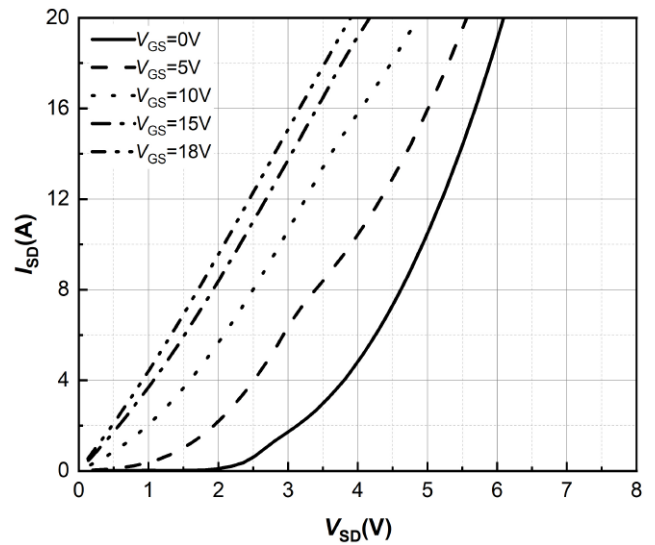


Figure 14. 3rd Quadrant Characteristic
 $T_j = 25^\circ\text{C}$

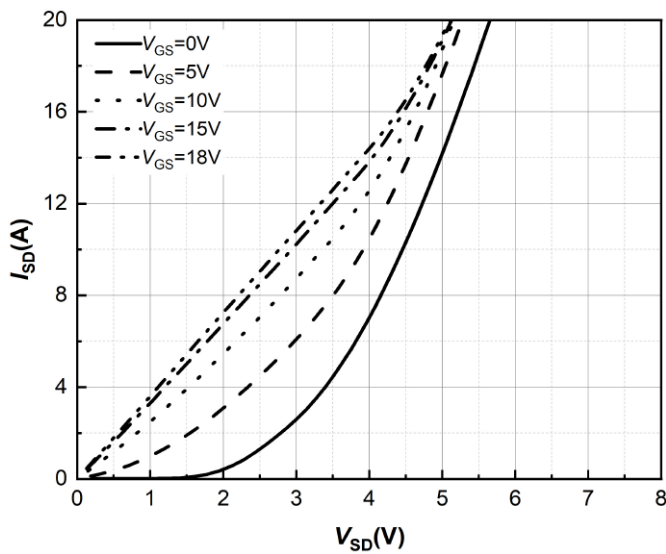


Figure 15. 3rd Quadrant Characteristic
 $T_j = 175^\circ\text{C}$

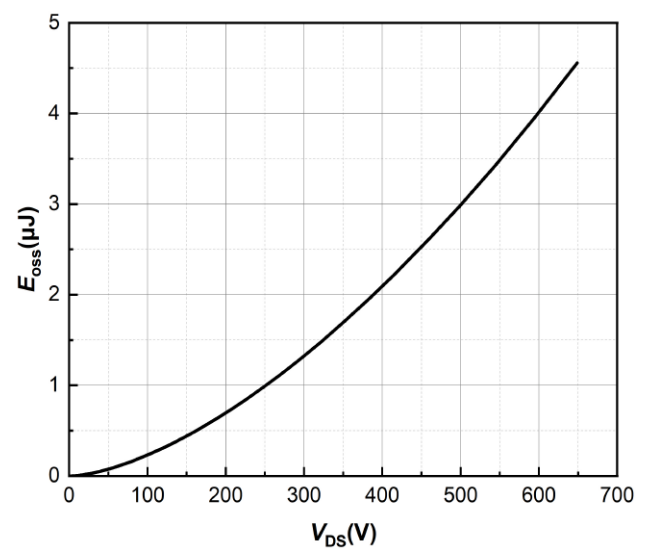


Figure 16. Output Capacitor Stored Energy

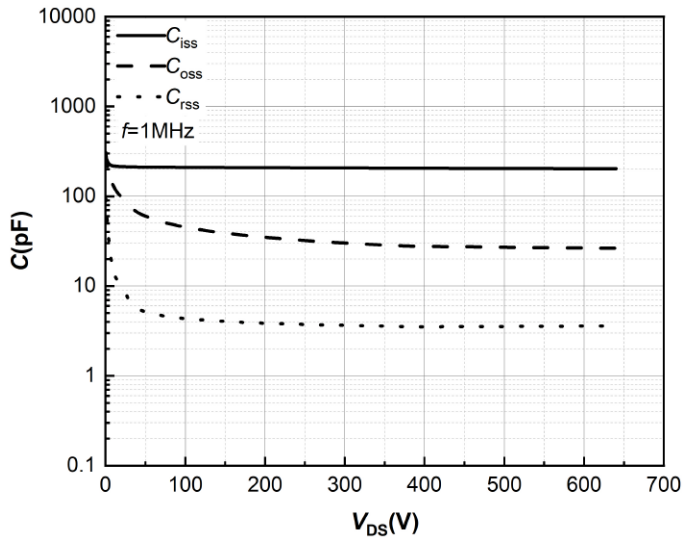


Figure 17. Capacitances vs. Drain-Source

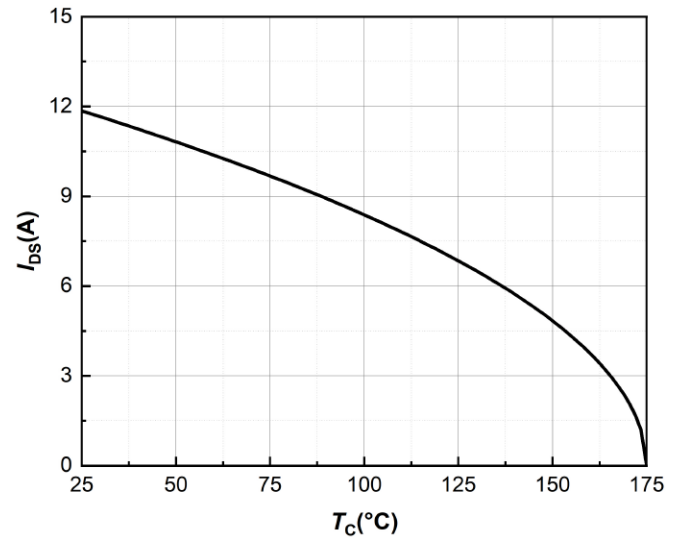


Figure 18. Continuous Drain Current Derating vs. Case Temperature

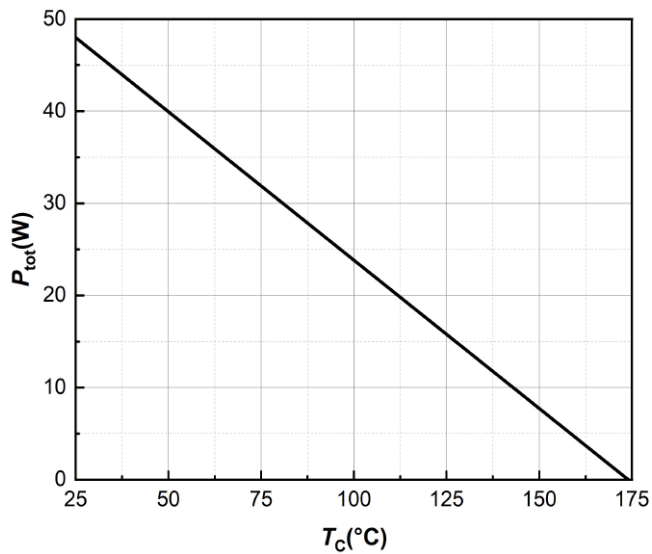


Figure 19. Maximum Power Dissipation Derating vs. Case Temperature

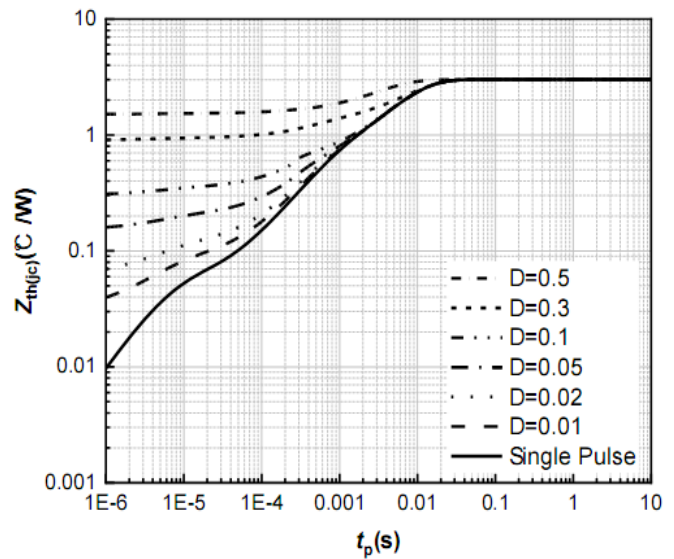


Figure 20. Transient Thermal Impedance

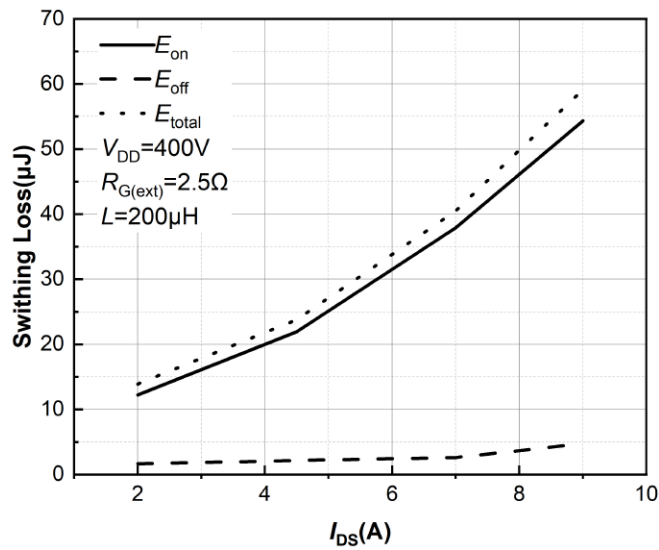


Figure 21. Clamped Inductive Switching Energy vs. Drain Current

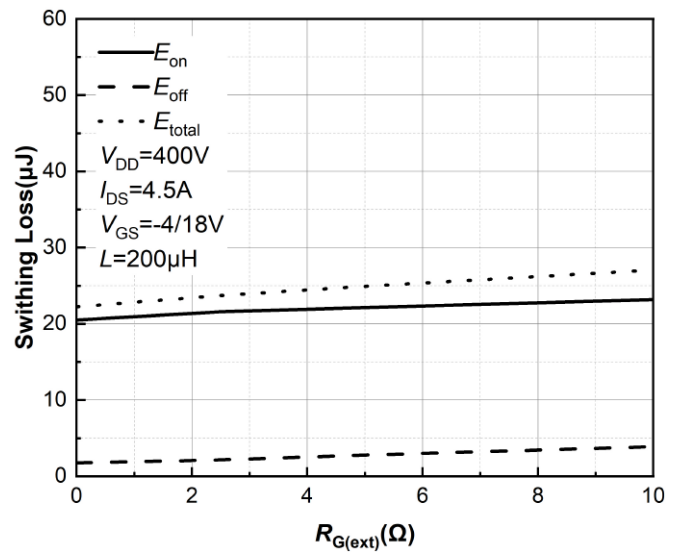


Figure 22. Clamped Inductive Switching Energy vs. R_G

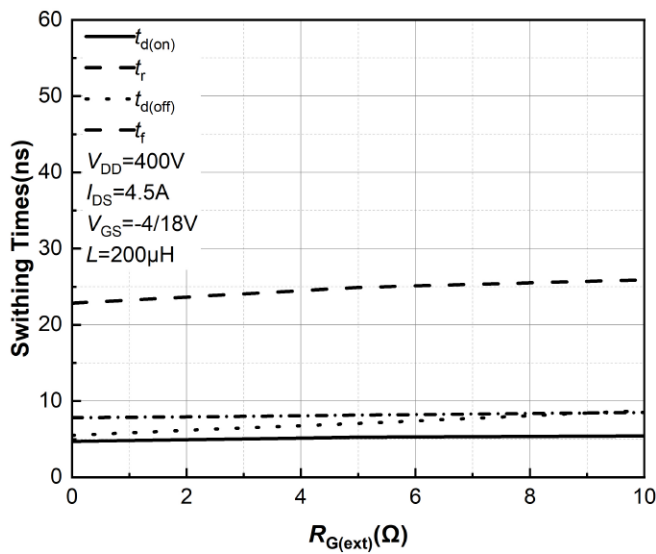


Figure 23. Switching Times vs. R_G

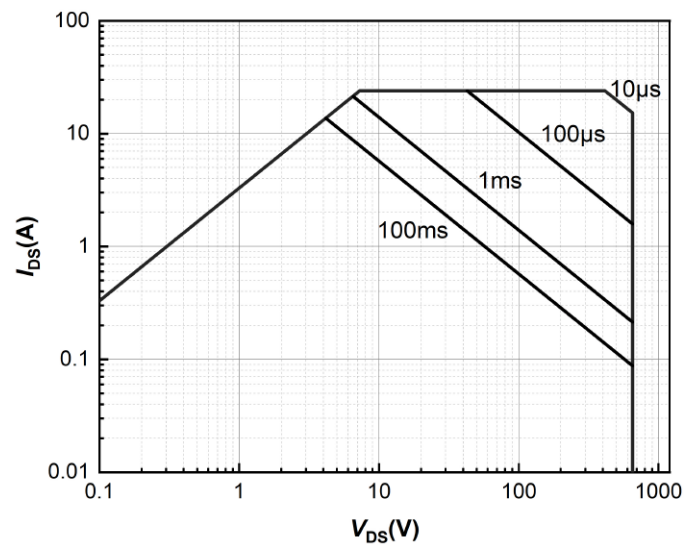
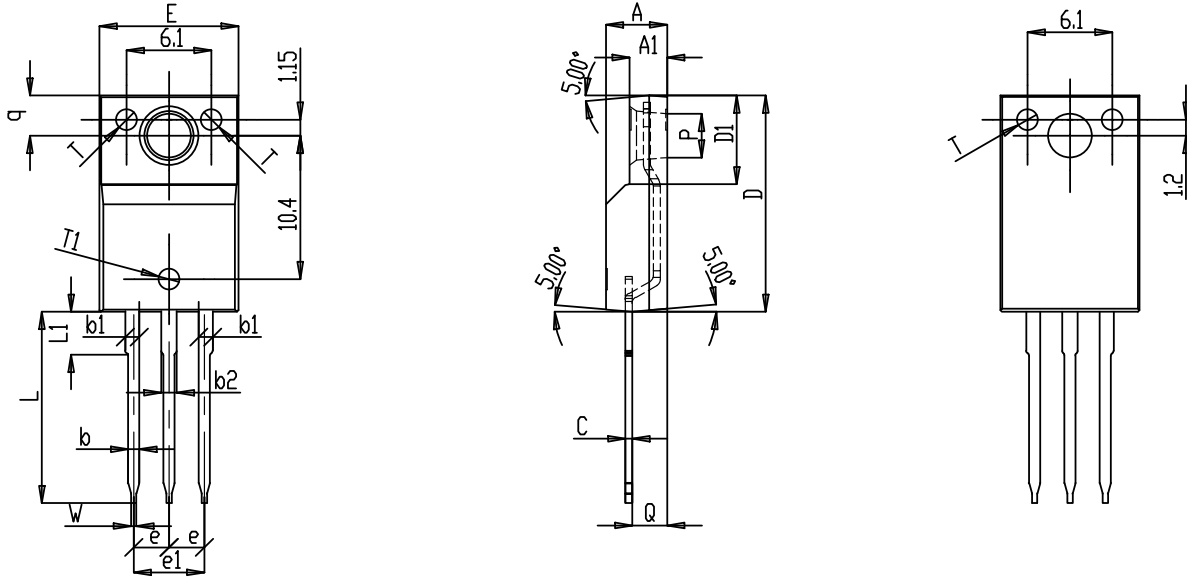


Figure 24. Safe Operating Area



Package Dimensions

Package TO-220F



SYMBOL	MILLIMETERS			NOTES	SYMBOL	MILLIMETERS			NOTES
	Normal	MIN.	MAX.			Normal	MIN.	MAX.	
A	4.4	4.2	4.6		e1	5.08	5	5.12	
A1	2.7	2.5	2.9		L	13.90	13.5	14.4	
b	0.8	0.7	0.9		L1	3.12	2.8	3.3	
b1	1.07	0.9	1.3		P	3.14	3.00	3.20	
b2	1.17	1	1.4		Q	2.44	2.3	2.6	
C	0.5	0.4	0.6		q	2.87	2.6	3	
D	15.63	15.4	15.8		W	0.37	0.3	0.5	
D1	6.22	6	6.4		T	1.52	1.3	1.7	
E	10.06	9.7	10.3		T1	1.20	1.1	1.3	
e	2.54	2.5	2.58						



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