

650V N-Channel Silicon Carbide Power MOSFET



1. Applications

- Asymmetrical Bridge Converter
- Inverter
- Single Switch Forward Flyback

2. Features

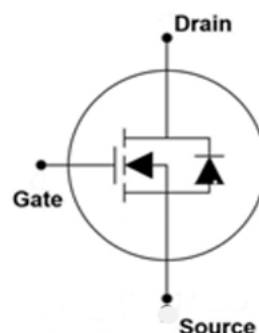
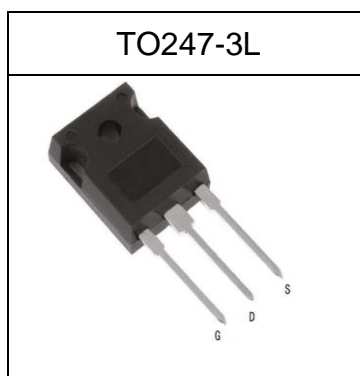
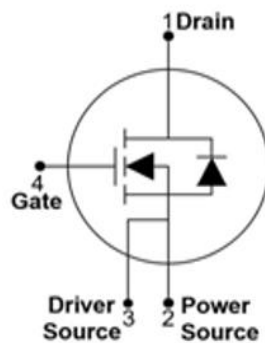
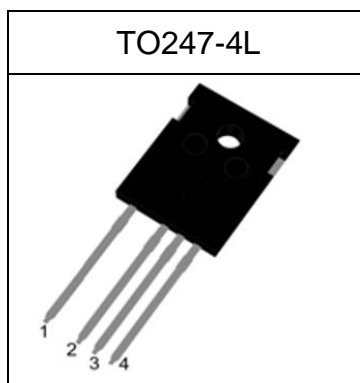
- Low drain-source on-resistance:  $R_{DS(ON)} = 30m\Omega$  (typ.)
- Easy to control Gate switching
- Enhancement mode:  $V_{th} = 2.2$  to  $5V$

Table 1 Key Performance Parameters

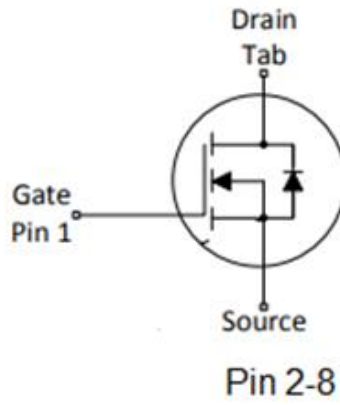
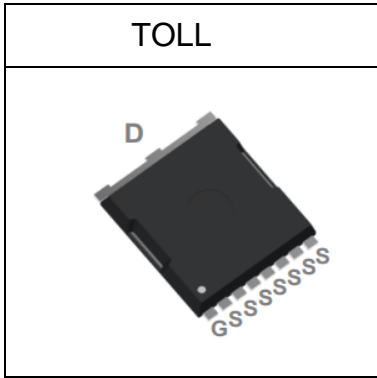
Parameter	Value	Unit
$V_{DS} @ T_{j,max}$	650	V
$R_{DS(on),max}$	42	$m\Omega$
$Q_{g,typ}$	97.6	nC
$I_{D,pulse}$	250	A

3. Packaging and Internal Circuit

Part Name	Package	Marking
ADQ065N028AH	TO-247-4L	ADQ065N028AH
ADW065N028AH	TO-247-3L	ADW065N028AH
ADR065N028AH	TOLL	ADR065N028AH



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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 <sup>1)</sup>	$I_D$	-	-	80	A	$T_C=25^\circ\text{C}$
		-	-	58	A	$T_C=100^\circ\text{C}$
Avalanche energy, single pulse	$E_{AS}$	-	-	605	mJ	$T_C=25^\circ\text{C}, V_{DD}=50\text{V}, L=10\text{mH}, R_G=25\Omega$
Gate source voltage (dynamic)	$V_{GS}$	-5	-	20	V	Absolute maximum values
Gate source voltage (static)	$V_{GS}$	-4	-	18	V	Recommended operational values
Power dissipation	$P_{tot}$	-	-	294	W	$T_C=25^\circ\text{C}$
Storage temperature	$T_{stg}$	-55	-	175	$^\circ\text{C}$	
Operating junction temperature	$T_j$	-55	-	175	$^\circ\text{C}$	
Soldering Temperature Distance of 1.6mm from case for 10s	$T_L$			260	$^\circ\text{C}$	
Transconductance	GFS		20.9	-	S	$V_{DS}=20\text{V } I_{DS}=33.5\text{A}$
			21.6			$V_{DS}=20\text{V } I_{DS}=33.5\text{A}, T_j=175^\circ\text{C}$

<sup>1)</sup>Limited by  $T_{j,max}$ . Maximum Duty Cycle  $D = 0.50$

<sup>2)</sup>Pulse width  $t_p$  limited by  $T_{j,max}$

<sup>3)</sup>Identical low side and high side switch with identical  $R_G$

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## 2 Thermal characteristics

Table 3 Thermal characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Thermal resistance, junction - case	$R_{thJC}$	-	0.51	0.7	°C/W	-
Thermal resistance, junction - ambient	$R_{thJA}$	-	-	62	°C/W	device on PCB, minimal footprint

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### 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	$V_{GS}=0V, I_D=100\mu A$
Gate threshold voltage	$V_{(GS)th}$	2.2	2.8	5.0	V	$V_{DS}=V_{GS}, I_D=5mA$
Zero gate voltage drain current	$I_{DSS}$	-	-	100	$\mu A$	$V_{DS}=650V, V_{GS}=0V$
Gate-source leakage current	$I_{GSS+}$	-	-	250	nA	$V_{GS}=20V, V_{DS}=0V$
Gate-source leakage current	$I_{GSS-}$	-	-	-100	nA	$V_{GS}=-5V, V_{DS}=0V$
Drain-source on-state resistance	$R_{DS(on)}$	-	30	45	$m\Omega$	$V_{GS}=18V, I_D=30A, T_j=25^\circ\text{C}$
			33			$V_{GS}=18V, I_D=30A, T_j=150^\circ\text{C}$
Gate resistance (Intrinsic)	$R_G$	-	5.1	-	$\Omega$	$f=1MHz, \text{open drain}$

**Table 5 Dynamic characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Input capacitance	$C_{iss}$	-	2333	-	pF	$V_{GS}=0V, V_{DS}=400V, f=1MHz$
Output capacitance	$C_{oss}$	-	226.7	-	pF	
Reverse transfer capacitance	$C_{rss}$	-	12.9	-	pF	
Turn-on delay time	$t_{d(on)}$	-	11.5	-	ns	$V_{DD}=400V, I_D=33.5A, R_G=2.5\Omega; T_j=25^\circ\text{C}$ $V_{GS}=-4/18V, L=59\mu H$
Rise time	$t_r$	-	17.5	-	ns	
Turn-off delay time	$t_{d(off)}$	-	32.5	-	ns	
Fall time	$t_f$	-	8.6	-	ns	
Turn-on Switching Energy	$E_{on}$		71.2		$\mu J$	
Turn-off Switching Energy	$E_{off}$		83.9		$\mu J$	

**Table 6 Gate charge characteristics**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Gate to source charge	$Q_{gs}$	-	28.2	-	nC	$V_{DD}=400V, I_D=33.5A, V_{GS}=-4/18V$
Gate to drain charge	$Q_{gd}$	-	26.1	-	nC	
Gate charge total	$Q_g$	-	97.6	-	nC	

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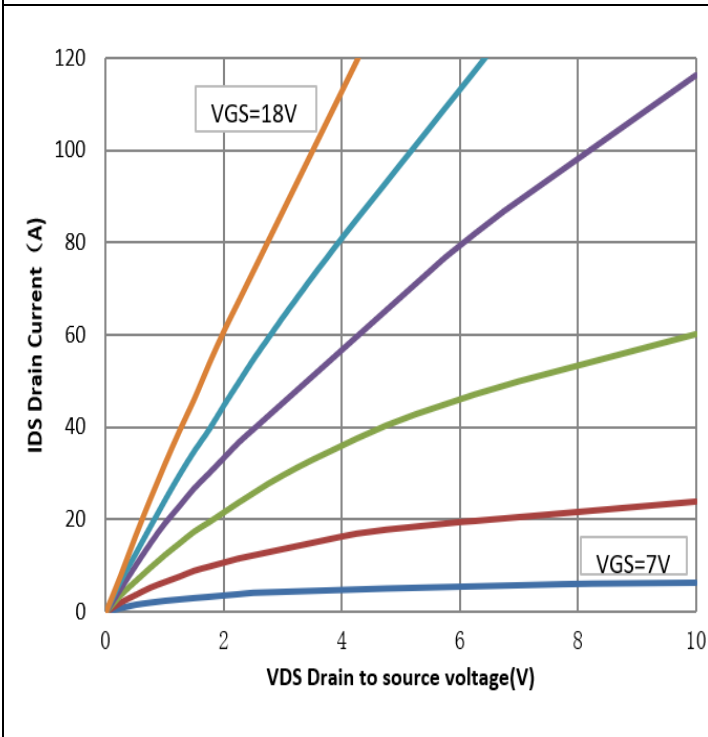
Table 7 Reverse diode characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Continuous Source Current	$I_{SD}$	-	-	80	A	
Diode forward voltage	$V_{SD}$	-	3.75	-	V	$I_S=20A, V_{GS}=-4V, T_j=25^\circ C$
Reverse recovery time	$t_{rr}$	-	19.52	-	ns	$V_{GS}=-4V, I_{SD}=33.5A, V_R=400V$ $dif/dt = 1630A/\mu s, T_j=25^\circ C$
Reverse recovery charge	$Q_{rr}$	-	230	-	nC	
Peak reverse recovery current	$I_{rrm}$	-	20.44	-	A	
Reverse recovery time	$t_{rr}$	-	15.04	-	ns	$V_{GS}=-4V, I_{SD}=33.5A, V_R=400V$ $dif/dt = 5665A/\mu s, T_j=25^\circ C$
Reverse recovery charge	$Q_{rr}$	-	400	-	nC	
Peak reverse recovery current	$I_{rrm}$	-	46.46	-	A	

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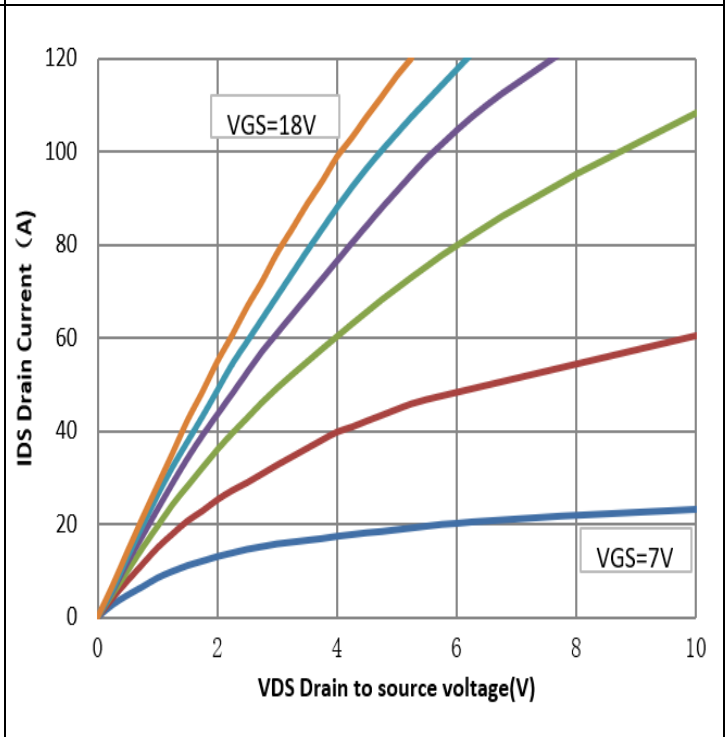
### 4 Electrical characteristics diagram

Diagram 1: Typ. output characteristics



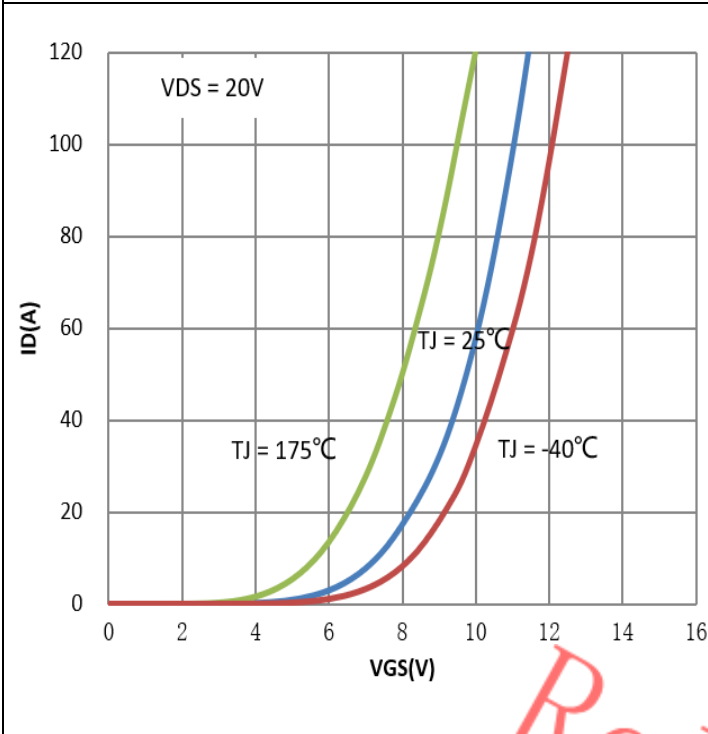
$I_D = f(V_{DS})$ ;  $T_j = 25^\circ\text{C}$ ; parameter:  $V_{GS}$ ;  $V_{GS} = 7, 9, 11, 13, 15, 18\text{V}$

Diagram 2: Typ. output characteristics



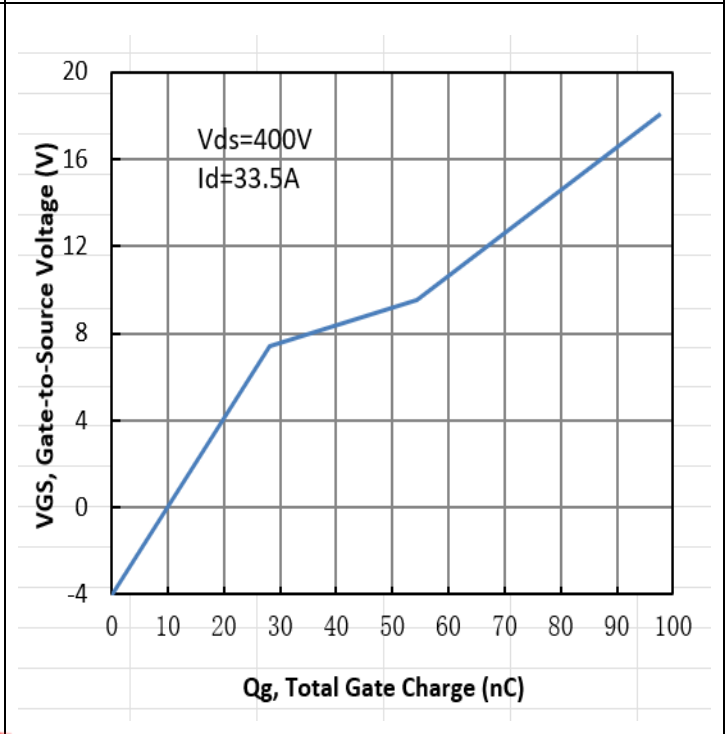
$I_D = f(V_{DS})$ ;  $T_j = 175^\circ\text{C}$ ; parameter:  $V_{GS}$ ;  $V_{GS} = 7, 9, 11, 13, 15, 18\text{V}$

Diagram 3: Typ. transfer characteristics



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

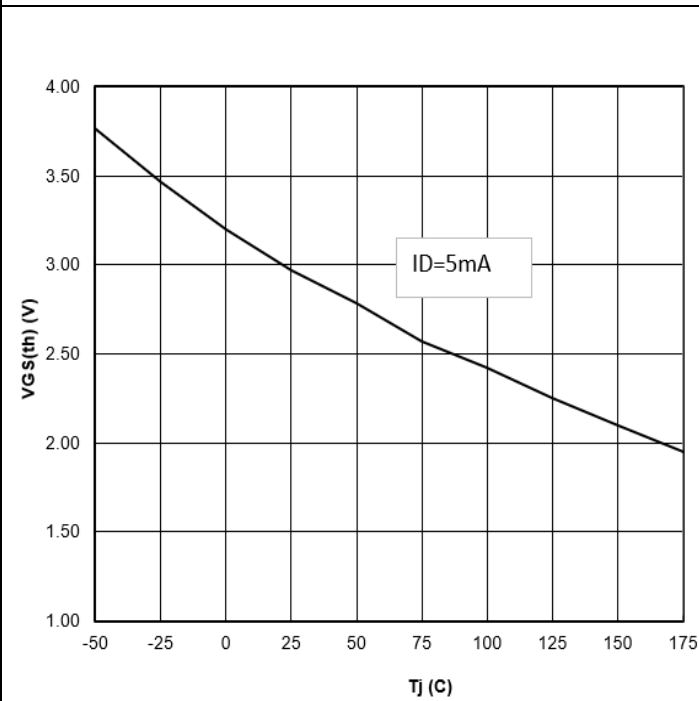
Diagram 4: Typ. gate charge



$V_{GS} = f(Q_{gate})$ ;  $I_D = 33.5\text{A}$ ;  $V_{DS} = 400\text{V}$ ; turn-on pulse

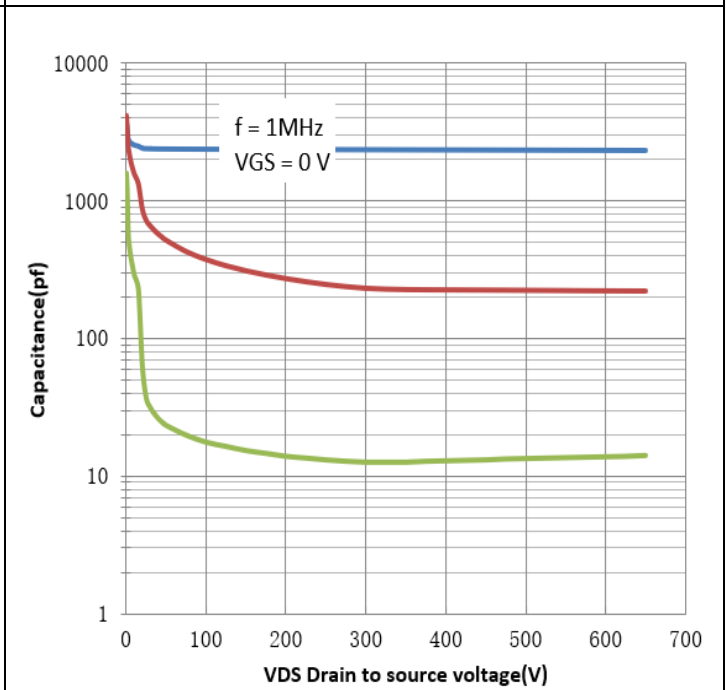
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Diagram 5: Typical gate-source threshold voltage as a function of junction temperature



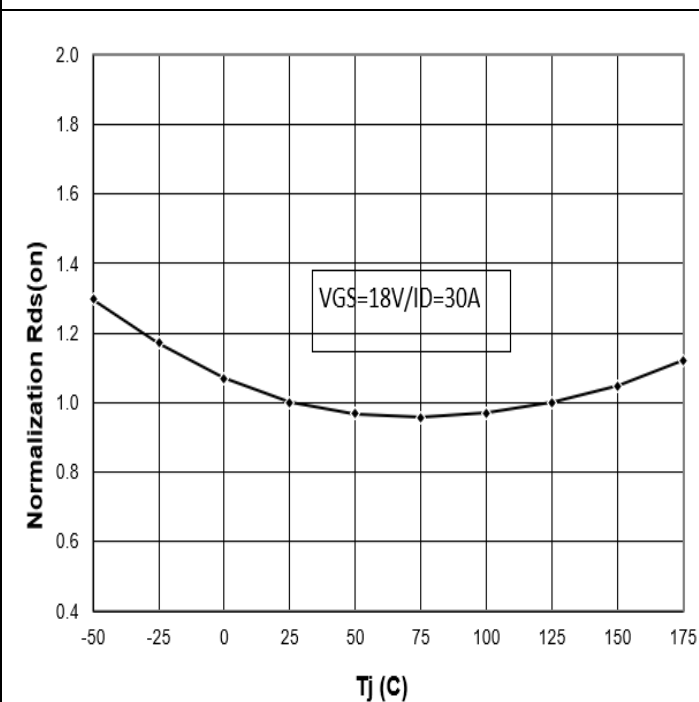
$V_{GS(th)} = f(T_J); I_{DS} = 5mA; V_{GS} = V_{DS}$

Diagram 6: Typ. Capacitance as a function of drain-source voltage



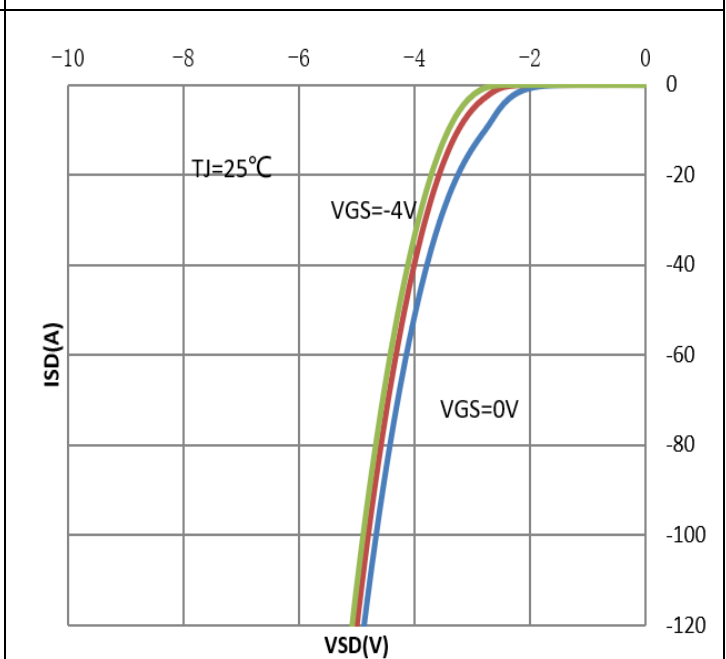
$C = f(V_{DS}); V_{GS} = 0V; f = 1MHz$

Diagram 7: Normalized on-resistance vs. junction temperature



$R_{DS(ON)} = f(T_J); I_{DS} = 30A$

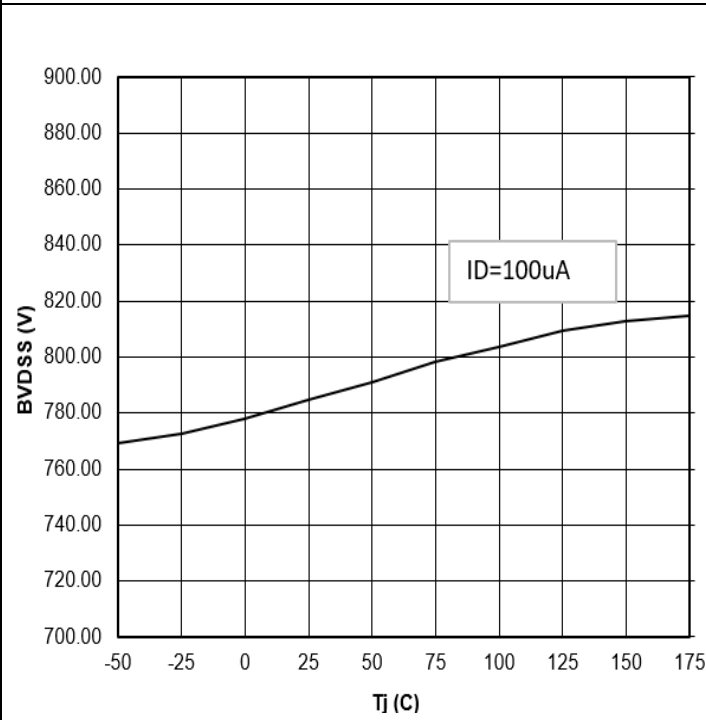
Diagram 8: Typical body diodes Characteristics at 25C



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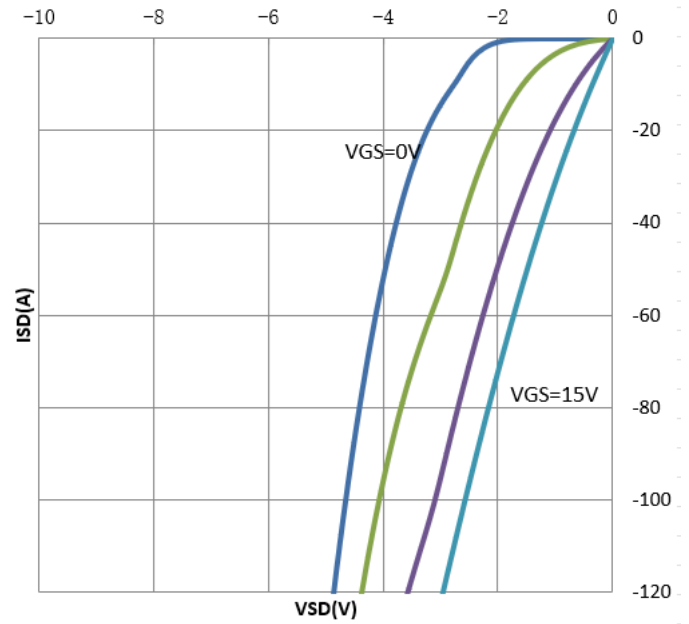


Diagram 9: BVDSS VS junction temperature



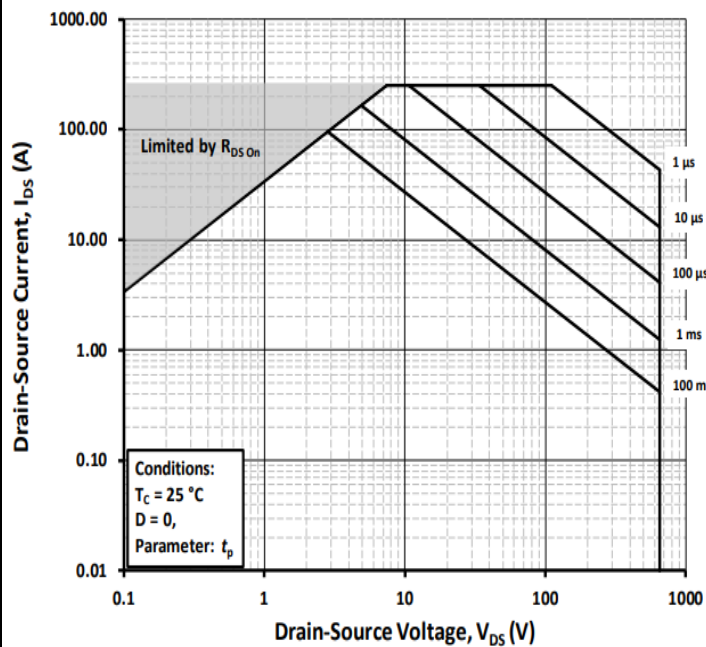
$Bvdss=f(T_j)$

Diagram 10: 3rd Quadrant Characteristic at 25 °C



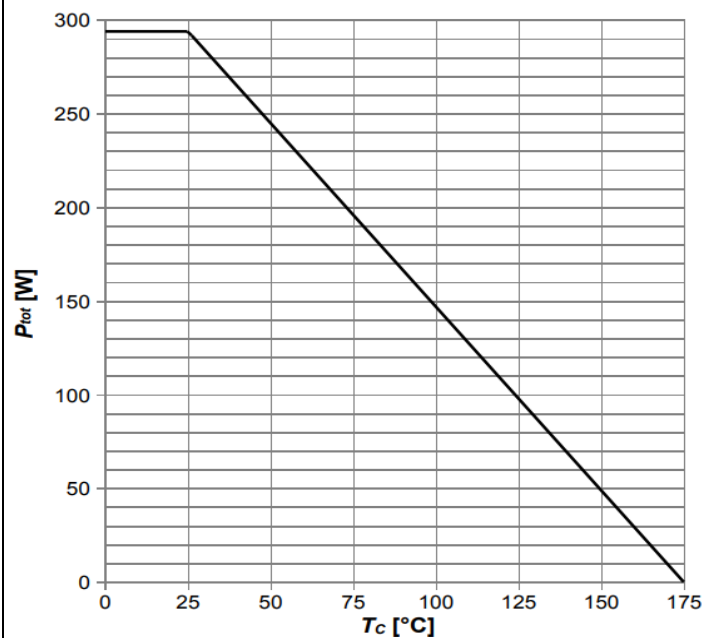
$I_{SD}=f(V_{SD})$

Diagram 11: Safe operating area(SOA)



$V_{GS}=0/18V; T_c=25\text{ }^\circ\text{C}; T_j<175\text{ }^\circ\text{C}$

Diagram 12: Power dissipation as a function of case temperature limited by bond wire



$P_{tot}=f(T_c)$

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Diagram 13: Clamped Inductive Switching Energy vs. Drain Current (VDD = 400V)

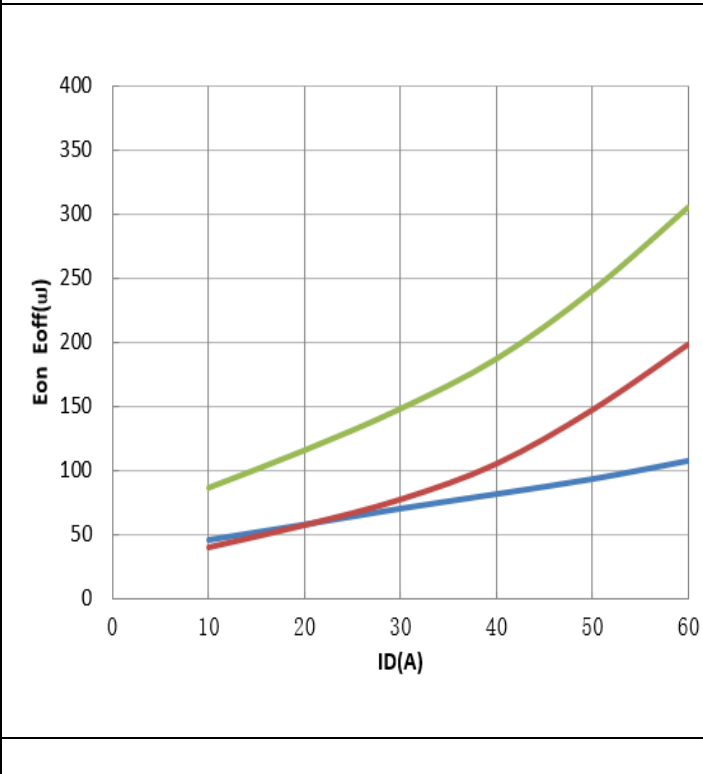


Diagram 14: Clamped Inductive Switching Energy vs. RG(ext)

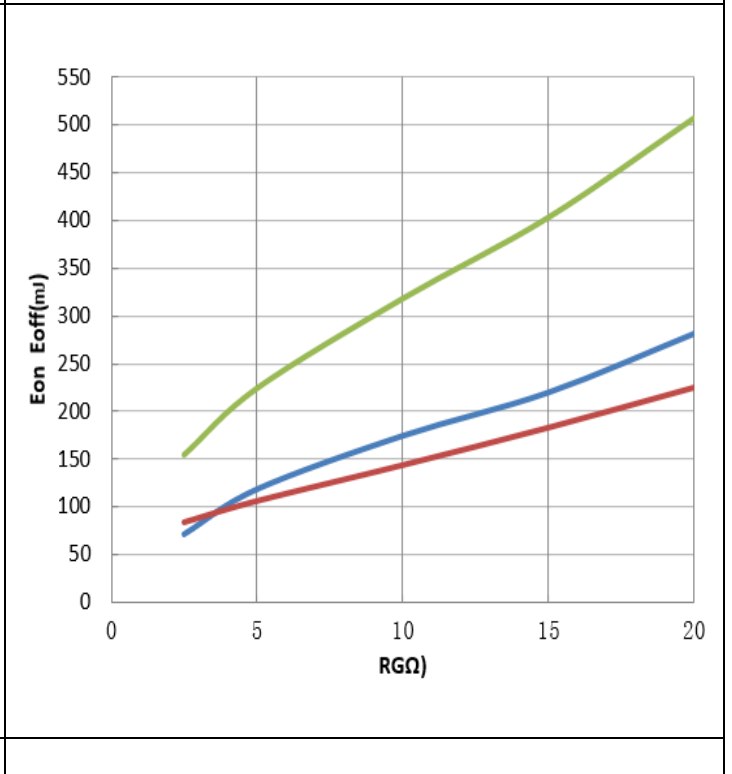


Diagram 15: Clamped Inductive Switching Energy vs. Temperature

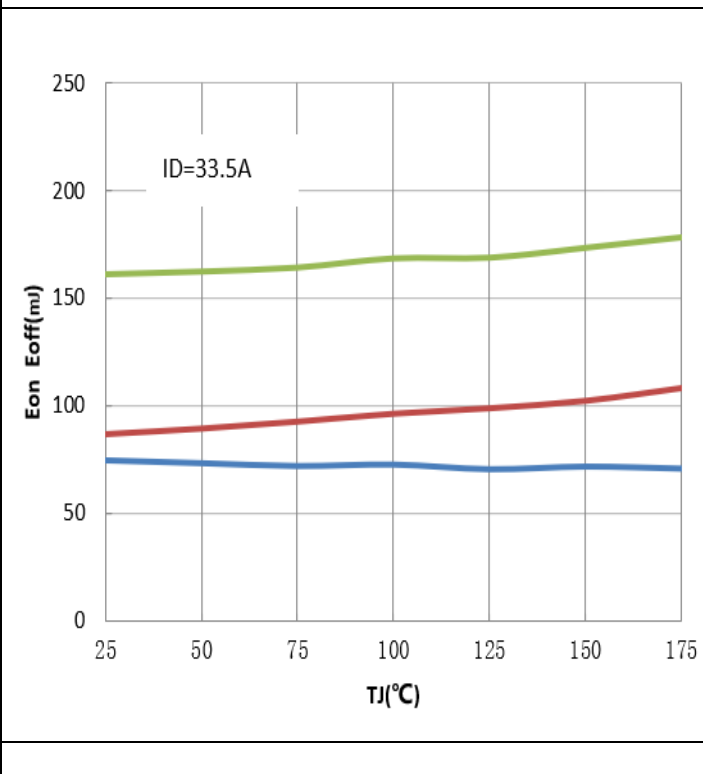


Diagram 16: Switching Times vs. RG(ext)

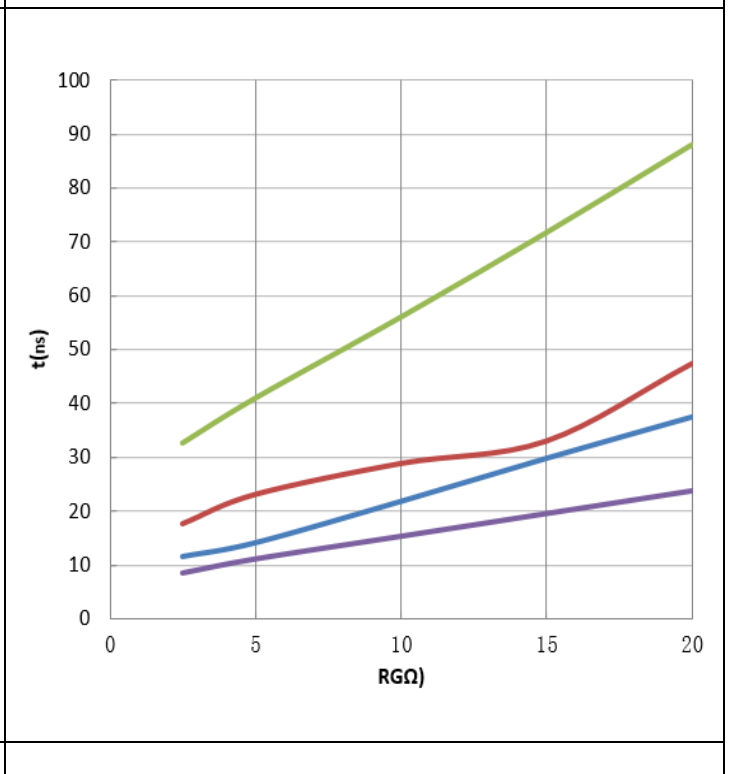
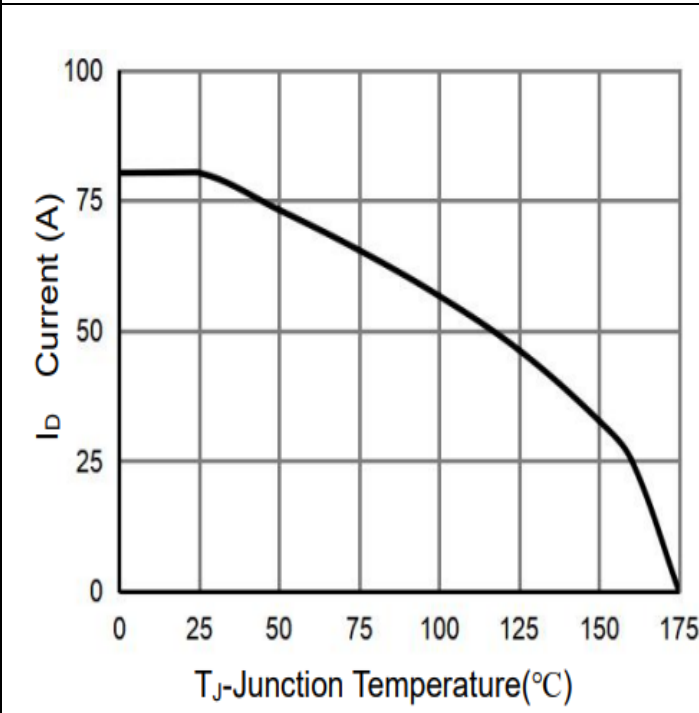
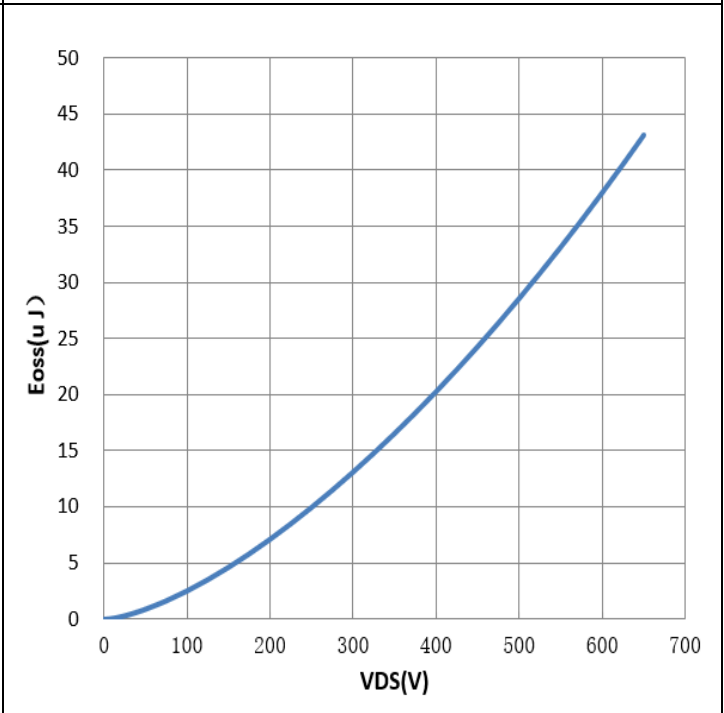


Diagram 17: Continuous Drian Current Derating vs. Case Temperature



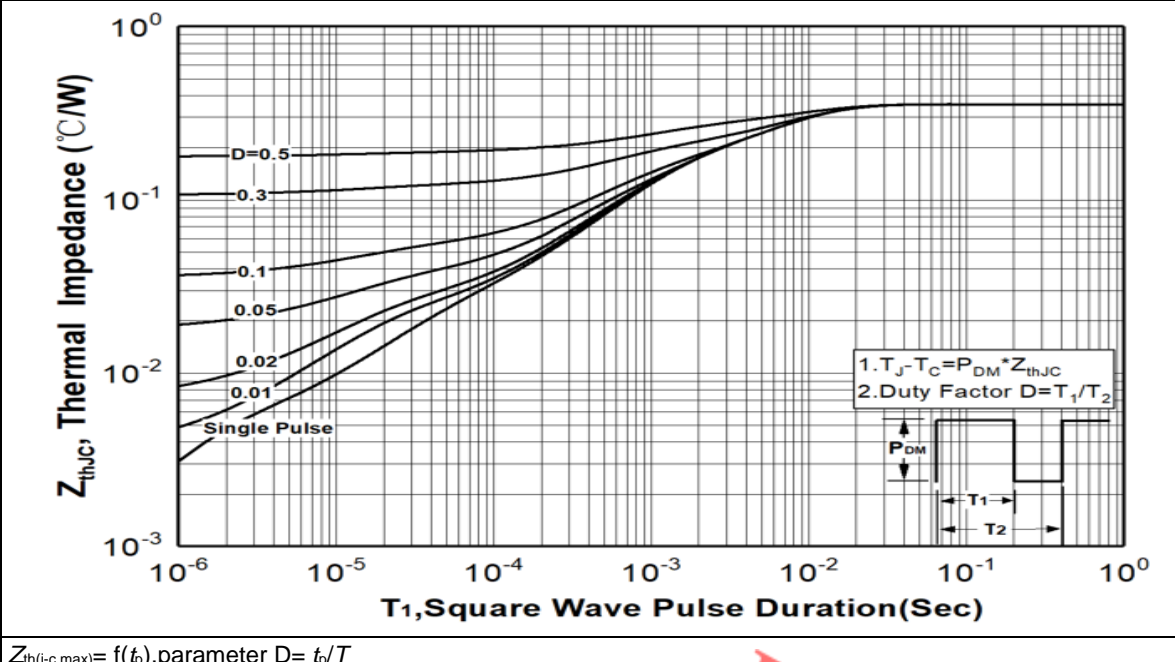
$I_{DS} = f(T_C)$

Diagram 18: Output Capacitor Stored Energy



$E_{oss} = f(V_{DS})$

Diagram 19: Max. transient thermal resistance(MOSFET/diodes)

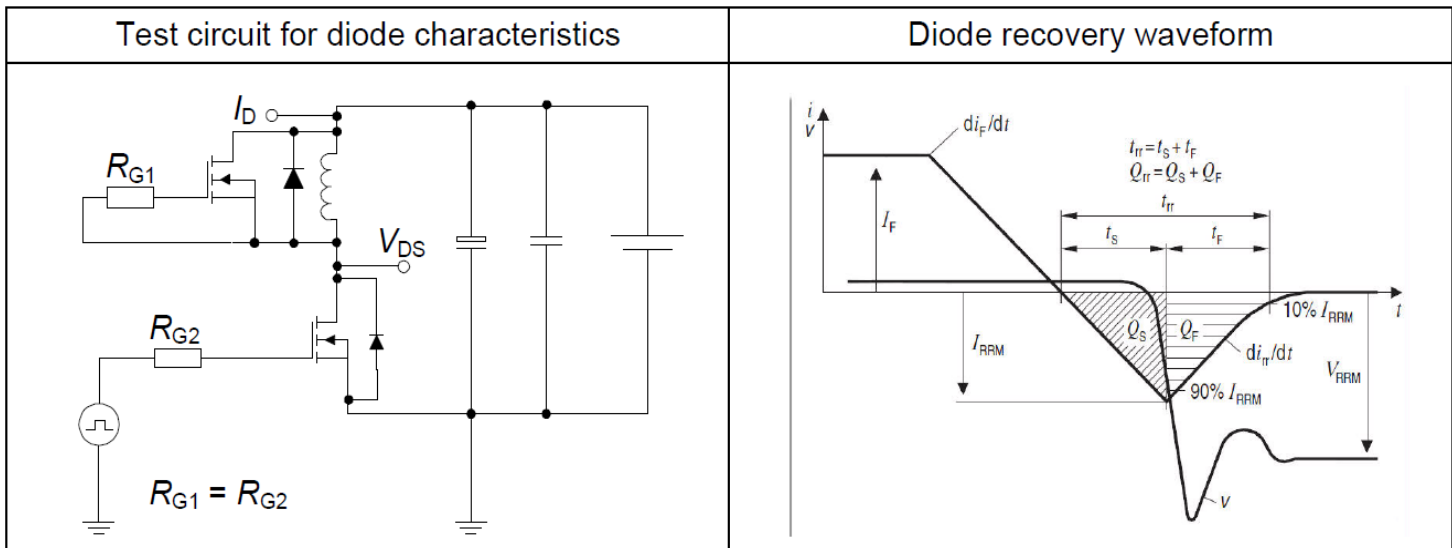


$Z_{th(j-c,max)} = f(t_p)$ , parameter  $D = t_p/T$

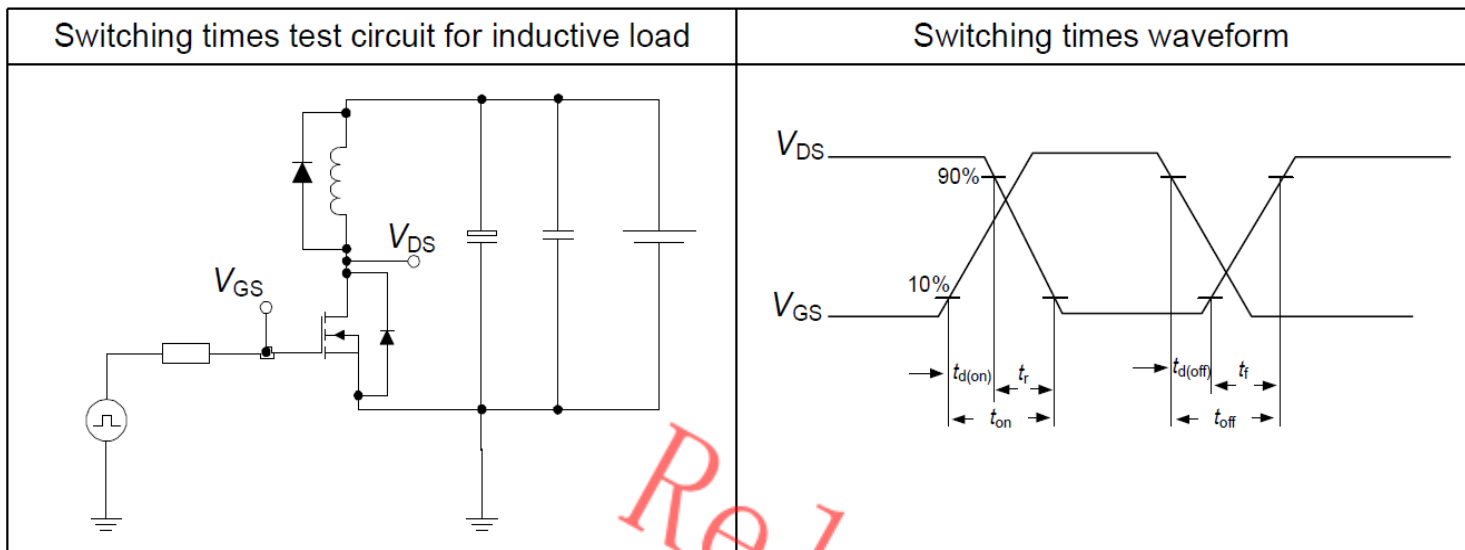
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## 5 Test Circuits

**Table 8 Diode characteristics**



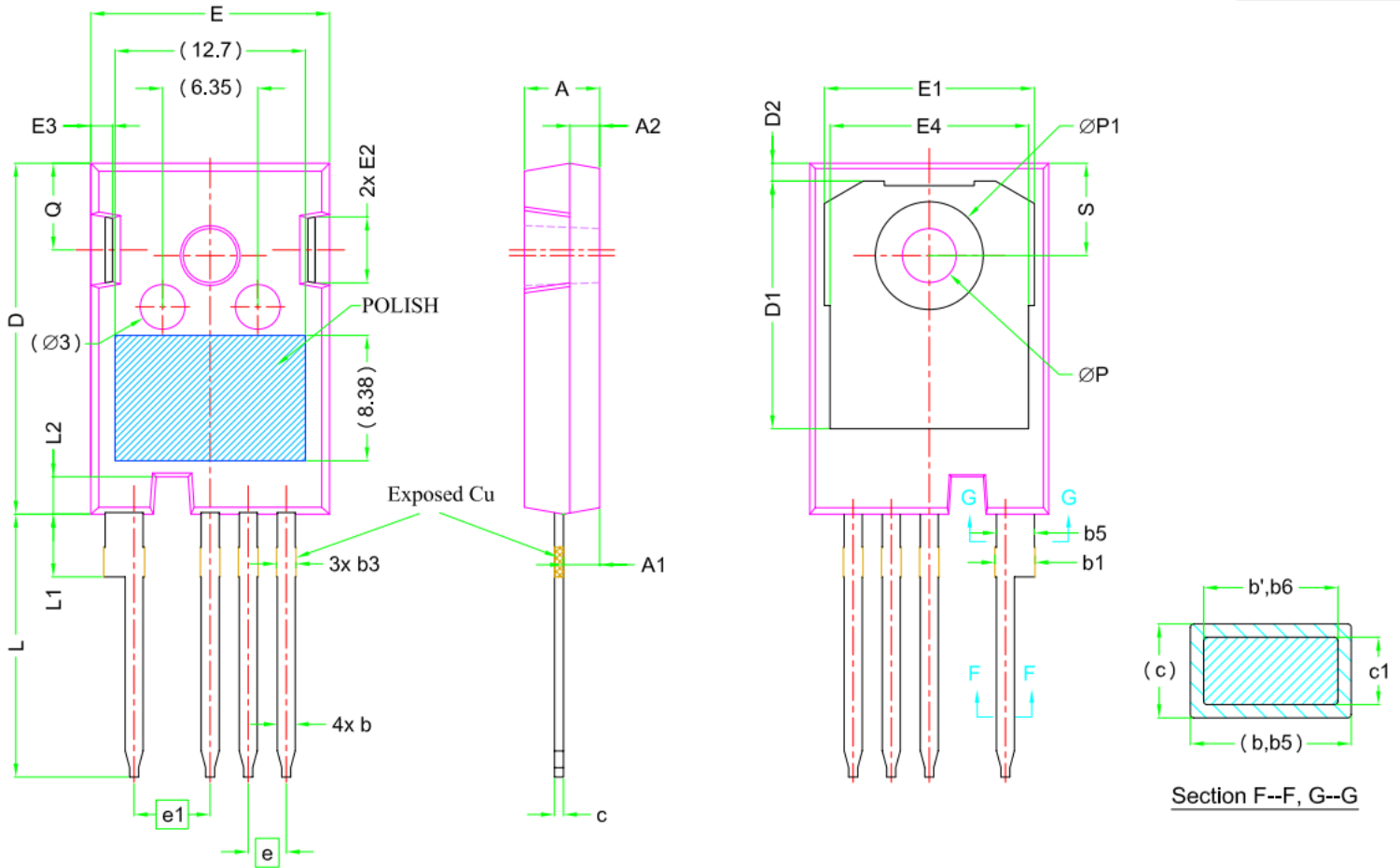
**Table 9 Switching times**



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## 6 Package Outlines

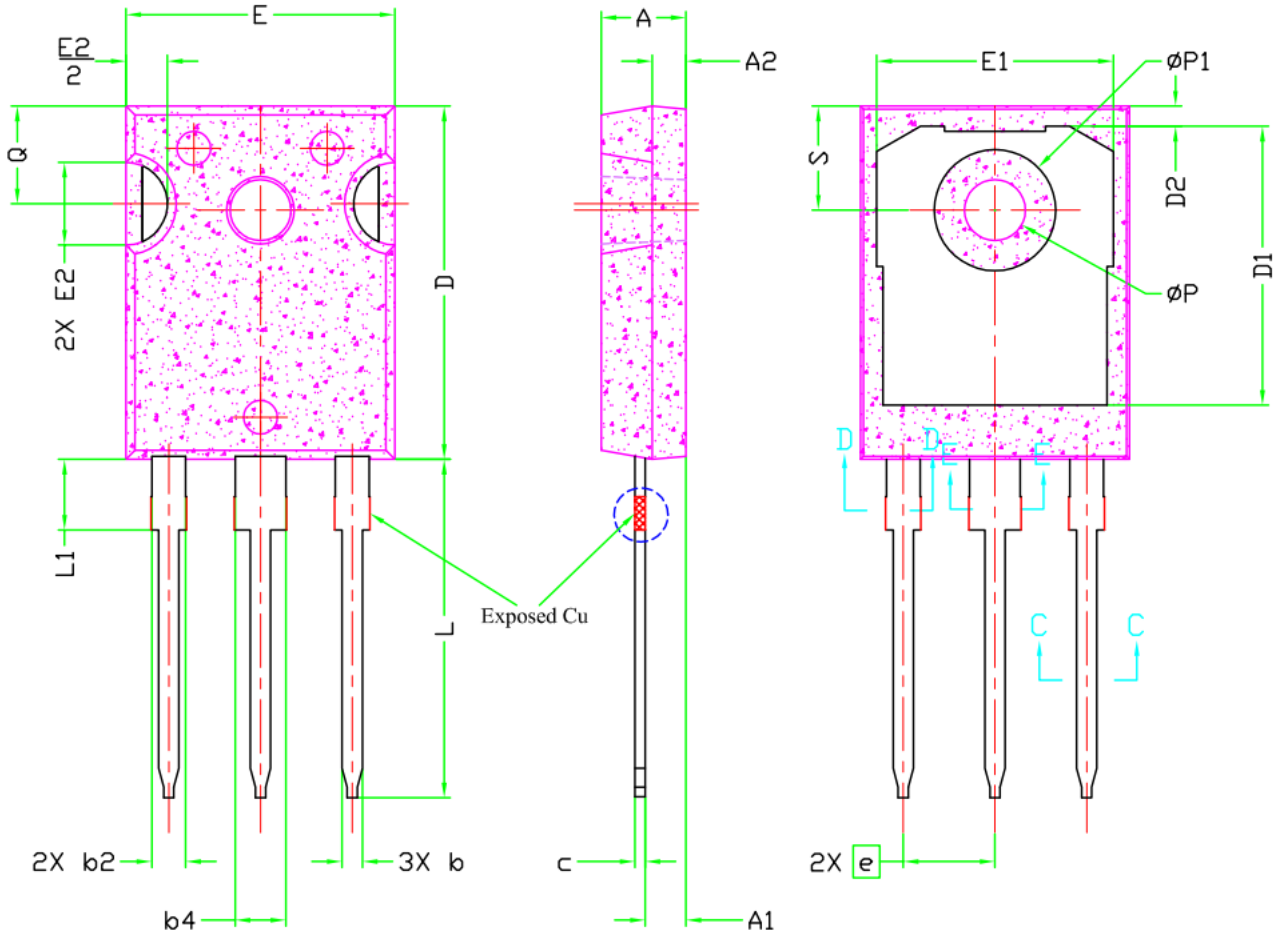
TO-247-4L



SYMBOL	DIMENSIONS		
	MIN.	NOM.	MAX.
A	4.83	5.02	5.21
A1	2.29	2.41	2.54
A2	1.91	2.00	2.16
b'	1.07	1.20	1.28
b	1.07	1.20	1.33
b1	2.39	2.67	2.94
b3	1.07	1.30	1.60
b5	2.39	2.53	2.69
b6	2.39	2.53	2.64
c	0.55	0.60	0.68
c1	0.55	0.60	0.65
D	23.30	23.45	23.60
D1	16.25	16.55	17.65
D2	0.95	1.19	1.25
E	15.75	15.94	16.13
E1	13.10	14.02	14.15
E2	3.68	4.40	5.10
E3	1.00	1.45	1.90
E4	12.38	13.26	13.43
e	2.54 BSC		
e1	5.08 BSC		
L	17.31	17.57	17.82
L1	3.97	4.19	4.37
L2	2.35	2.50	2.65
ØP	3.51	3.61	3.65
ØP1	7.19 REF.		
Q	5.49	5.79	6.00
S	6.04	6.17	6.30

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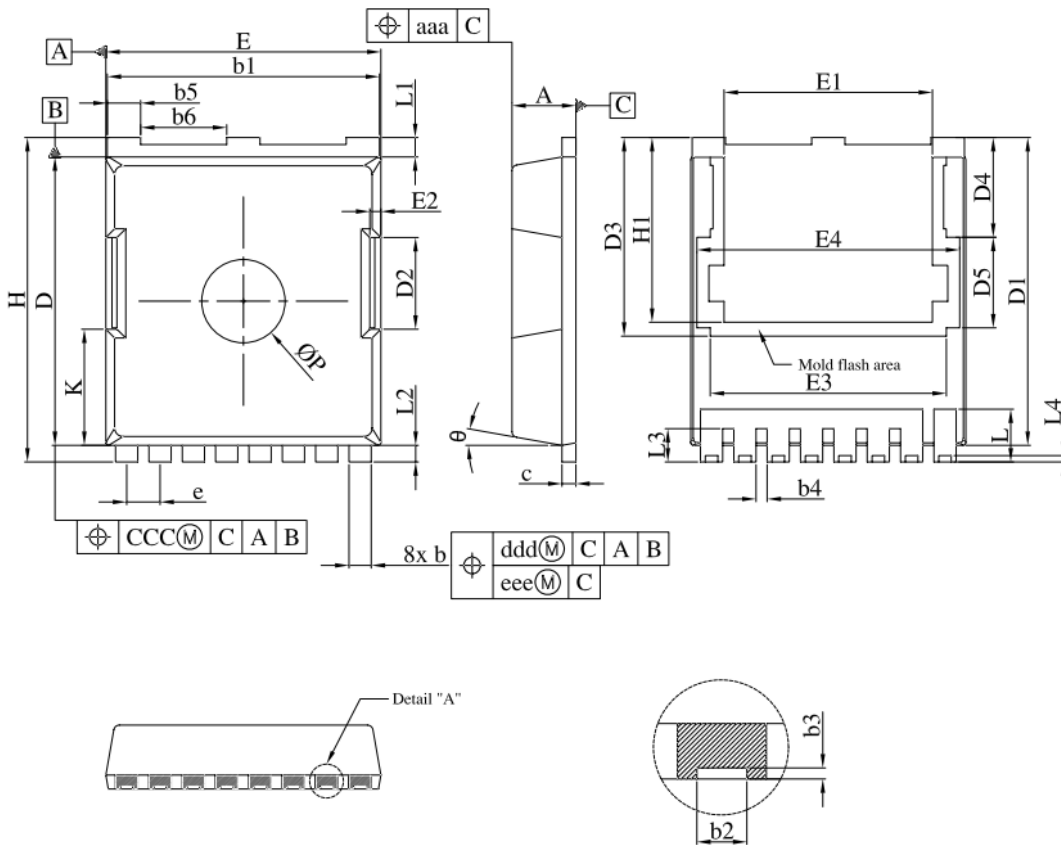
TO-247-3L



SYMBOL	DIMENSIONS			NOTES
	MIN.	NOM.	MAX.	
A	4.83	5.02	5.21	
A1	2.29	2.41	2.55	
A2	1.50	2.00	2.49	
b	1.12	1.20	1.33	
b1	1.12	1.20	1.28	
b2	1.91	2.00	2.39	6
b3	1.91	2.00	2.34	
b4	2.87	3.00	3.22	6, 8
b5	2.87	3.00	3.18	
c	0.55	0.60	0.69	6
c1	0.55	0.60	0.65	
D	20.80	20.95	21.10	4
D1	16.25	16.55	17.65	5
D2	0.51	1.19	1.35	
E	15.75	15.94	16.13	4
E1	13.46	14.02	14.16	5
E2	4.32	4.91	5.49	3
e	5.44BSC			
L	19.81	20.07	20.32	
L1	4.10	4.19	4.40	6
∅P	3.56	3.61	3.65	7
∅P1	7.19REF.			
Q	5.39	5.79	6.20	
S	6.04	6.17	6.30	

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TOLL



SYMBOL	COMMON		
	MILLIMETER		
	MIN.	NOMINAL	MAX.
A	2.20	2.30	2.40
b	0.70	0.80	0.90
b1	9.70	9.80	9.90
b2	0.36	0.45	0.55
b3	0.05	0.100	/
b4	0.30	0.40	0.50
b5	1.10	1.20	1.30
b6	3.00	3.10	3.20
c	0.40	0.50	0.60
D	10.28	10.38	10.55
D1	10.98	11.08	11.18
D2	3.20	3.30	3.40
D3	7.15		
D4	3.59		
D5	3.26		
e	1.10	1.20	1.30
E	9.80	9.90	10.00
E1	7.40	7.50	7.60
E2	0.30	0.40	0.50
E3	8.50		
E4	9.46		
H	11.50	11.68	11.85
H1	6.55	6.65	6.75
K	4.08	4.18	4.28
L	1.60	1.90	2.10
L1	0.50	0.70	0.90
L2	0.50	0.60	0.70
L3	1.00	1.20	1.30
L4	0.13	0.23	0.33
P	2.85	3.00	3.15
θ	10° REF		
aaa	0.20		
ccc	0.20		
ddd	0.25		
eee	0.20		

Outline PG-TOLL(JQ)

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**Revision History**

Revision	Date	Subjects (major changes since last revision)
1.0	2024-03-12	Preliminary version
1.1	2024-04-22	Added TOLL package

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[GC2M0080120D](#) [SP50N120CTF](#) [SP35N120CTF](#) [SP25N120CTF](#) [IV2Q171R0D7](#) [IV1Q06040L1](#) [IV1Q06060T3G](#) [IV1Q12160T4](#)  
[IV1B12013HA1L](#) [IV1Q12160T3](#) [IV1Q07015T4G](#) [IV1Q12750O3](#) [IV1Q06040T3](#) [IV1Q12050T4Z](#) [IV1Q12030T4G](#)