650V N-Channel Silicon Carbide Power MOSFET

1. Applications

Asymmetrical Bridge
Converter
Inverter
Single Switch Forward
Flyback

2. Features

Low drain-source on-resistance: RDS(ON) = 30mΩ (typ.)
Easy to control Gate switching
Enhancement mode: Vth = 2.2 to 5V

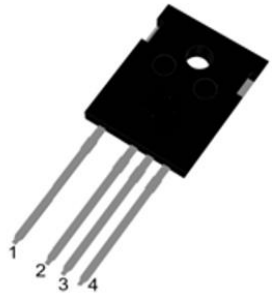
Table 1 Key Performance Parameters

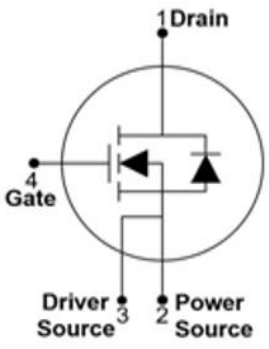
Parameter	Value	Unit
V_{DS} @ $T_{j,max}$	650	V
$R_{DS(on),max}$	42	mΩ
$Q_{g,typ}$	97.6	nC
$I_{D,pulse}$	250	A

3. Packaging and Internal Circuit

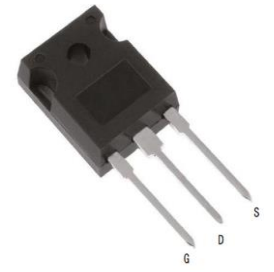
Part Name	Package	Marking
ADQ065N028AH	TO-247-4L	ADQ065N028AH
ADW065N028AH	TO-247-3L	ADW065N028AH
ADR065N028AH	TOLL	ADR065N028AH

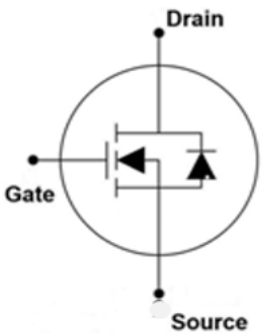
TO247-4L





TO247-3L





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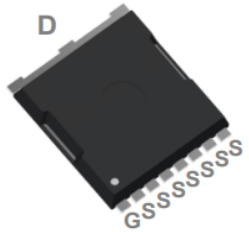
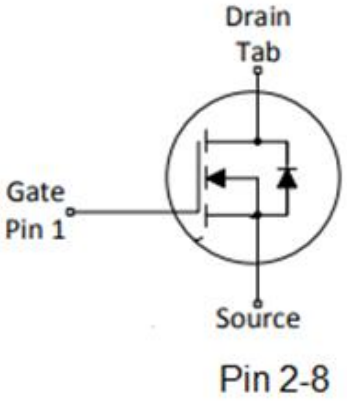




Pin 2-8

1 Maximum ratings

at T_j = 25°C, unless otherwise specified

Table 2 Maximum ratings

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Continuous drain current[1)]	I_D	-	-	80	A	TC=25°C
		-	-	58	A	TC=100°C
Avalanche energy, single pulse	E_{AS}	-	-	605	mJ	Tc=25℃,VDD=50V,L=10mH, RG=25Ω
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	TC=25°C
Storage temperature	T_{stg}	-55	-	175	°C	
Operating junction temperature	T_j	-55	-	175	°C	
Soldering Temperature Distance of 1.6mm from case for 10s	T_L			260	°C	
Transconductance	GFS	-	20.9	-	S	VDS=20V IDS=33.5A
			21.6			VDS=20V IDS=33.5A, Tj=175°C

[1)] Limited by $T_{j,max}$. Maximum Duty Cycle D = 0.50
[2)] Pulse width t_p limited by $T_{j,max}$
[3)] Identical low side and high side switch with identical R_G

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

3 Electrical characteristics

at T_j=25°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=100uA
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	uA	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	mΩ	V_{GS}=18V, I_D=30A, T_j=25°C
			33			V_{GS}=18V, I_D=30A, T_j=150°C
Gate resistance (Intrinsic)	R_G	-	5.1	-	Ω	f=1MHz, open drain

Table 5 Dynamic characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Input capacitance	C_{iss}	-	2333	-	pF	*VGS=0V, VDS=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=2.5Ω; T_J =25°C *VGS=-4/18V L=59uH*
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	*Eon*		71.2		uJ	
Turn-off Switching Energy	*Eoff*		83.9		uJ	

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	

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°C
Reverse recovery time	t_{rr}	-	19.52	-	ns	VGS=-4V, ISD=33.5A, VR=400 V dif/dt =1630A/μs, TJ=25 °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	VGS=-4V, ISD=33.5A, VR=400 V dif/dt =5665A/μs, TJ=25 °C
Reverse recovery charge	Q_{rr}	-	400	-	nC	
Peak reverse recovery current	I_{rrm}	-	46.46	-	A	

4 Electrical characteristics diagram

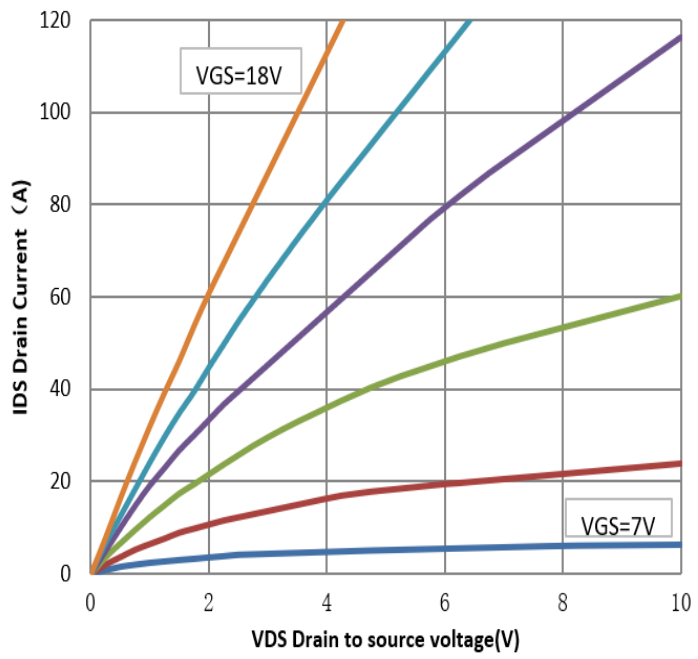
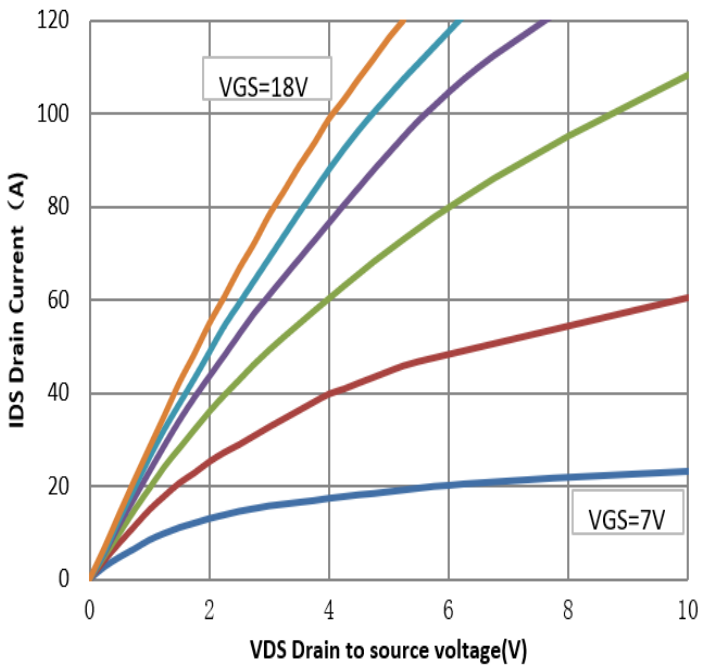
Diagram 1: Typ. output characteristics	Diagram 2: Typ. output characteristics
	
I_D=f(V_{DS});T_j=25 °C; parameter: $V_{GS;}$ VGS=7,9,11,13,15,18V	I_D=f(V_{DS});T_j=175 °C; parameter: $V_{GS;}$ VGS=7,9,11,13,15,18V

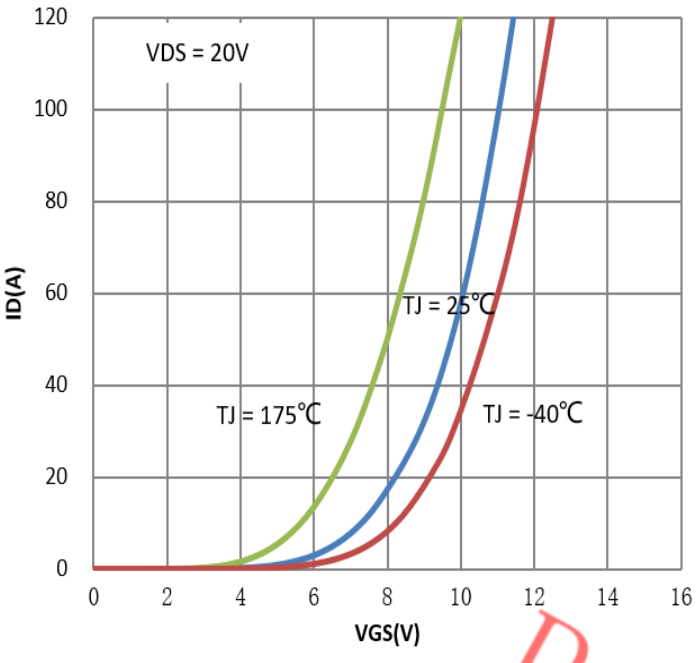
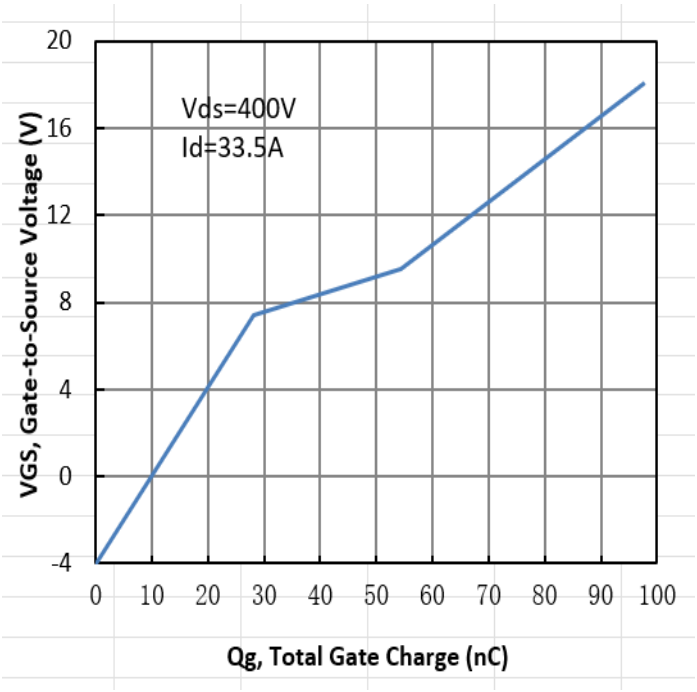
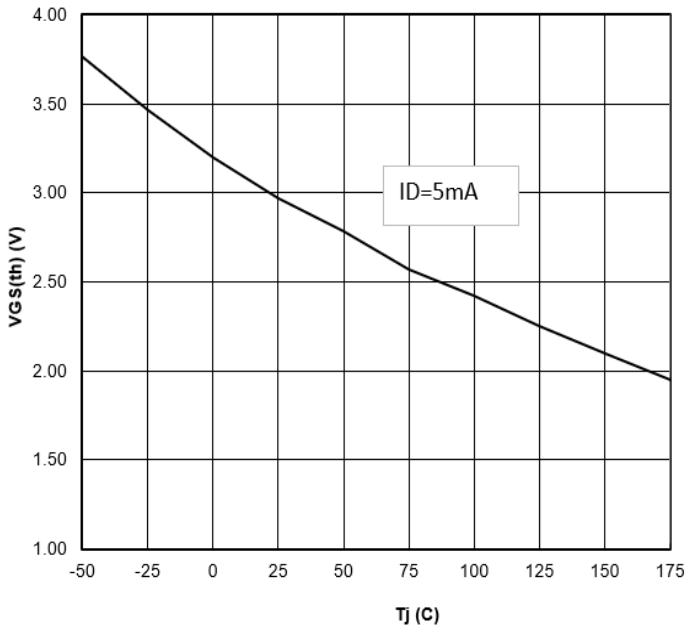
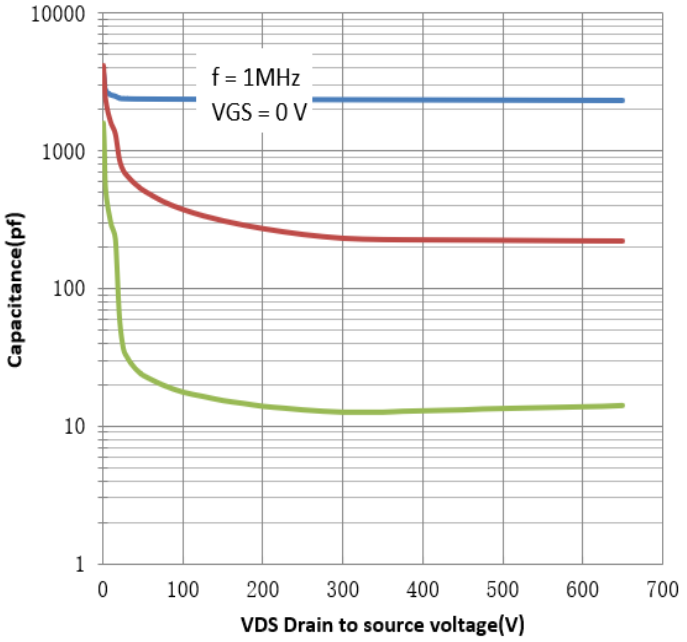
Diagram 3: Typ. transfer characteristics	Diagram 4: Typ. gate charge
	
I_D=f(V_{GS}); V_{DS} =20V; parameter: T_j	V_{GS}=f(Q_{gate});I_D=33.5A ; V_{DS} =400V; turn-on pulse

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



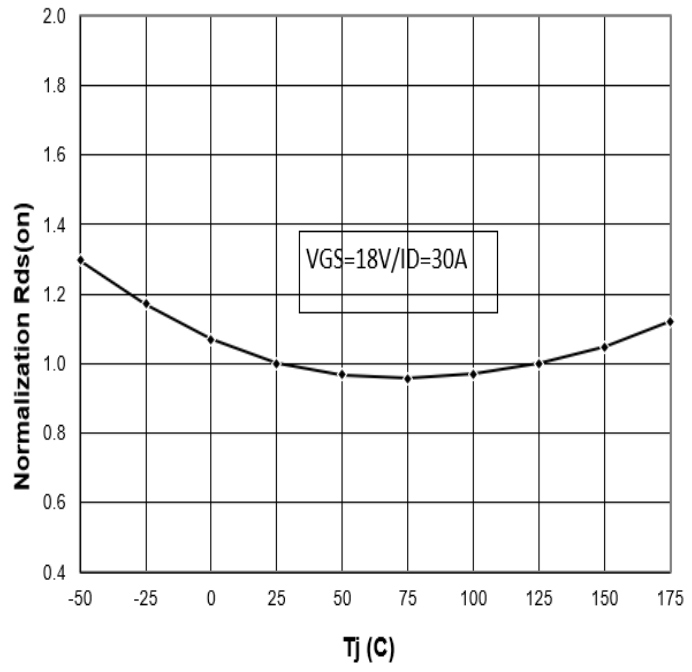
$V_{GS(th)}$=f(T_j); I_{DS}=5mA; V_{GS}=V_{DS}

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

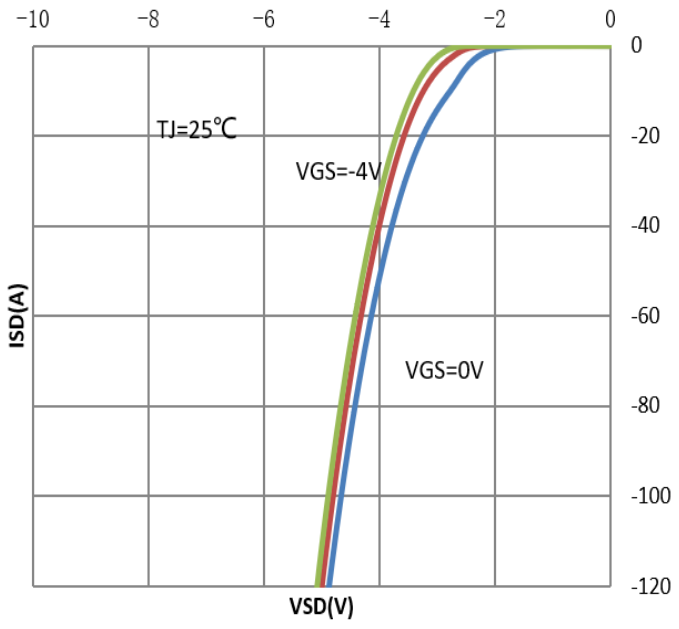
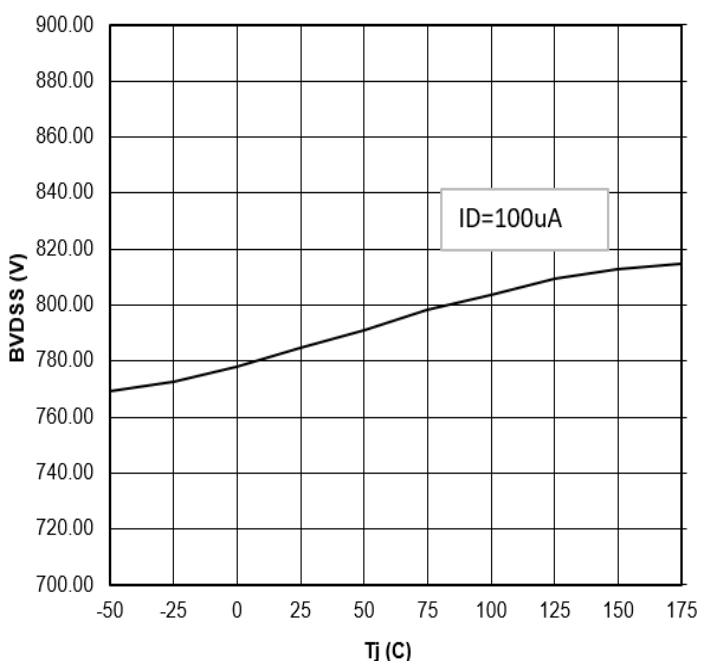
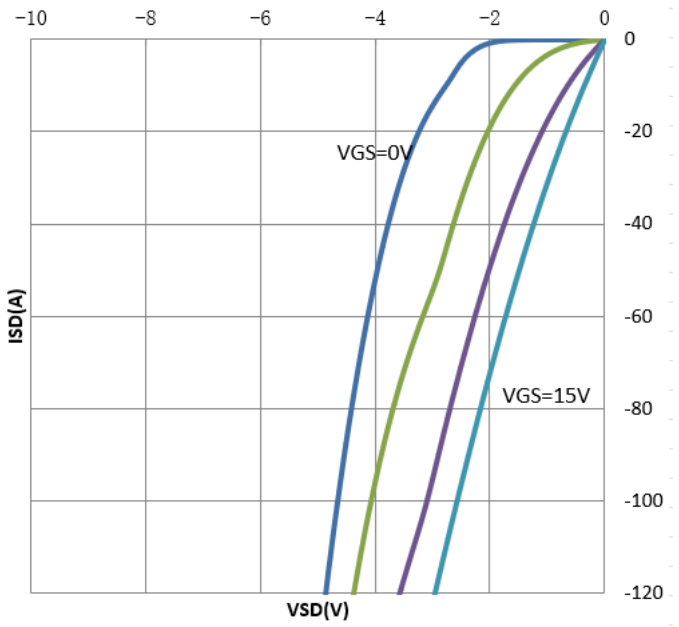


Diagram 9: BVDSS VS junction temperature



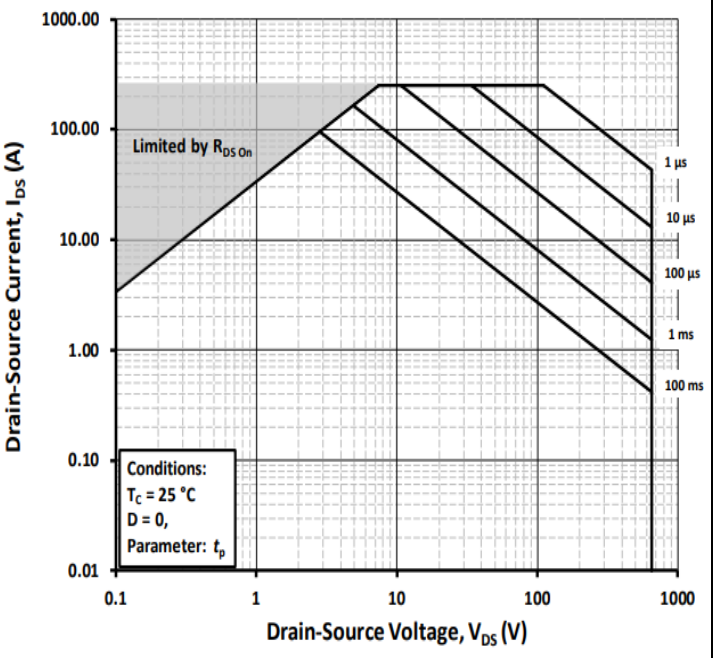
Bvdss=f(T_j)

Diagram 10: 3rd Quadrant Characteristic at 25 ºC



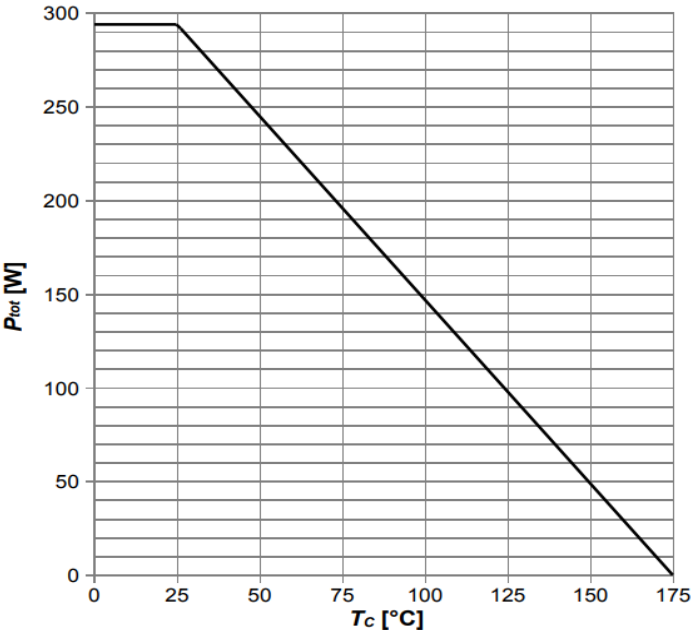
I_{SD}=f(V_{SD})

Diagram 11: Safe operating area(SOA)



V_{GS}=0/18V; T_C=25 °C; T_j<175 °C

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



P_{tot}= f(T_C)

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

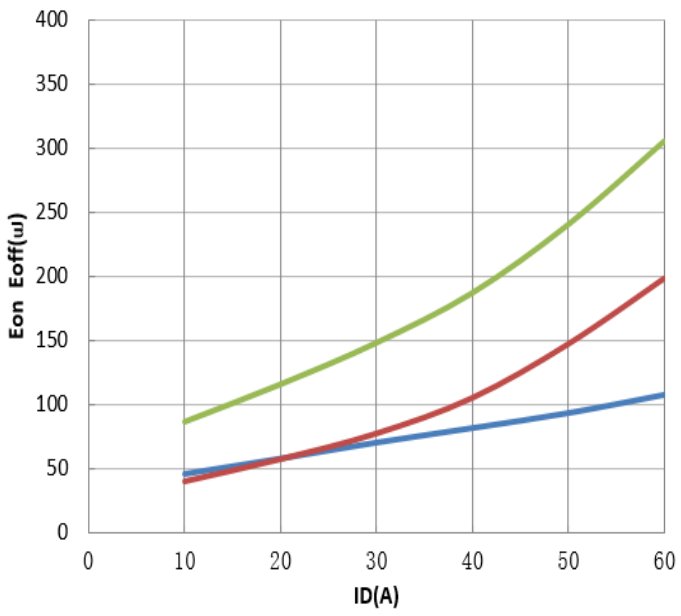


Diagram 14: Clamped Inductive Switching Energy vs. RG(ext)

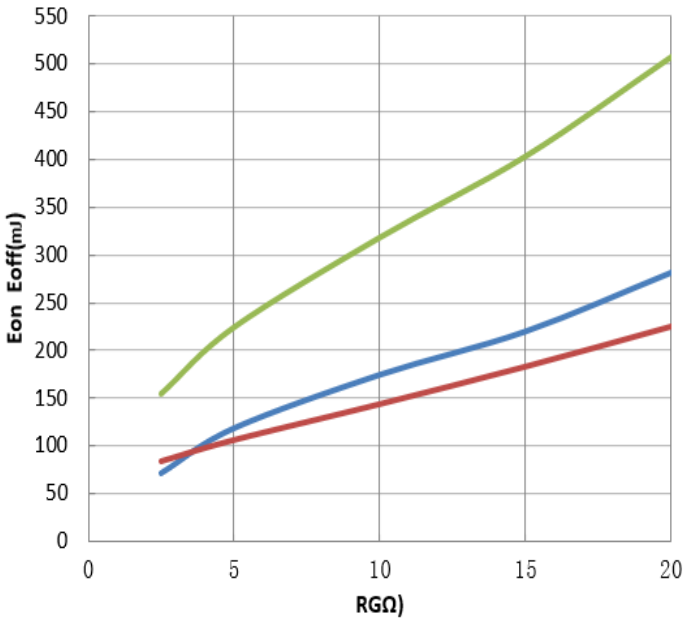


Diagram 15: Clamped Inductive Switching Energy vs. Temperature

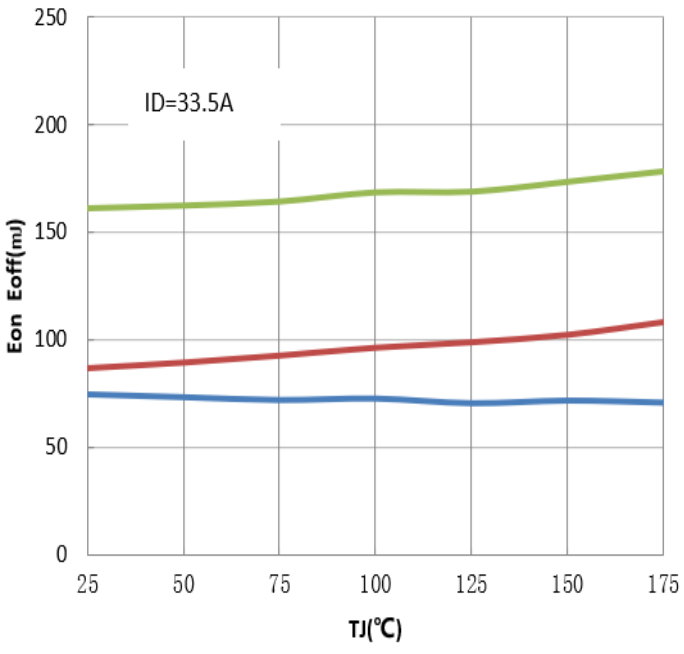


Diagram 16: Switching Times vs. RG(ext)

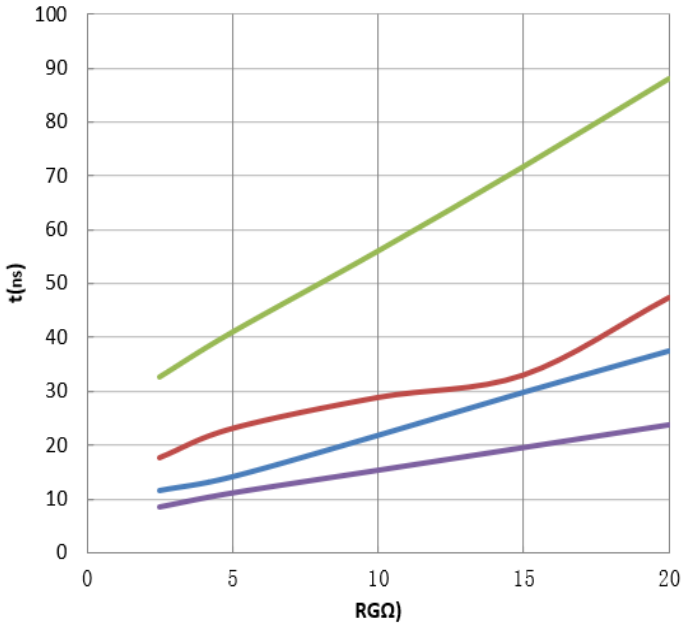
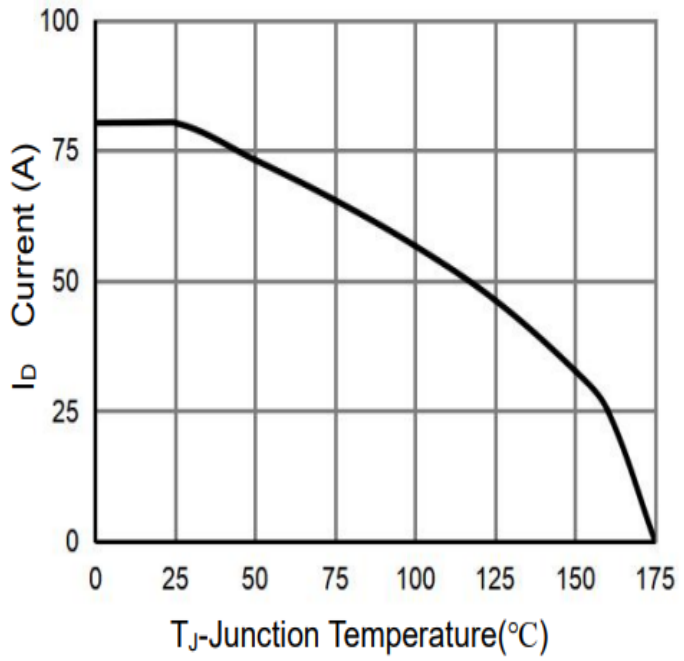
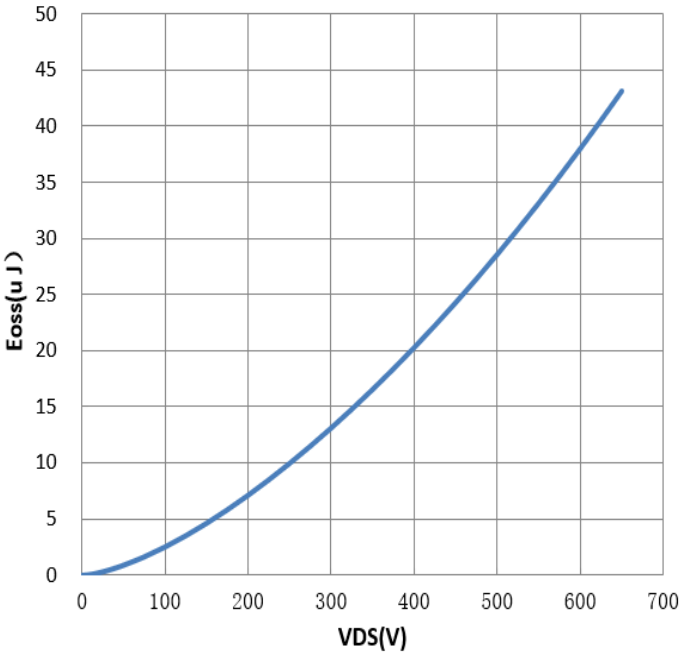


Diagram 17: Continuous Drian Current Derating vs. Case Temperature



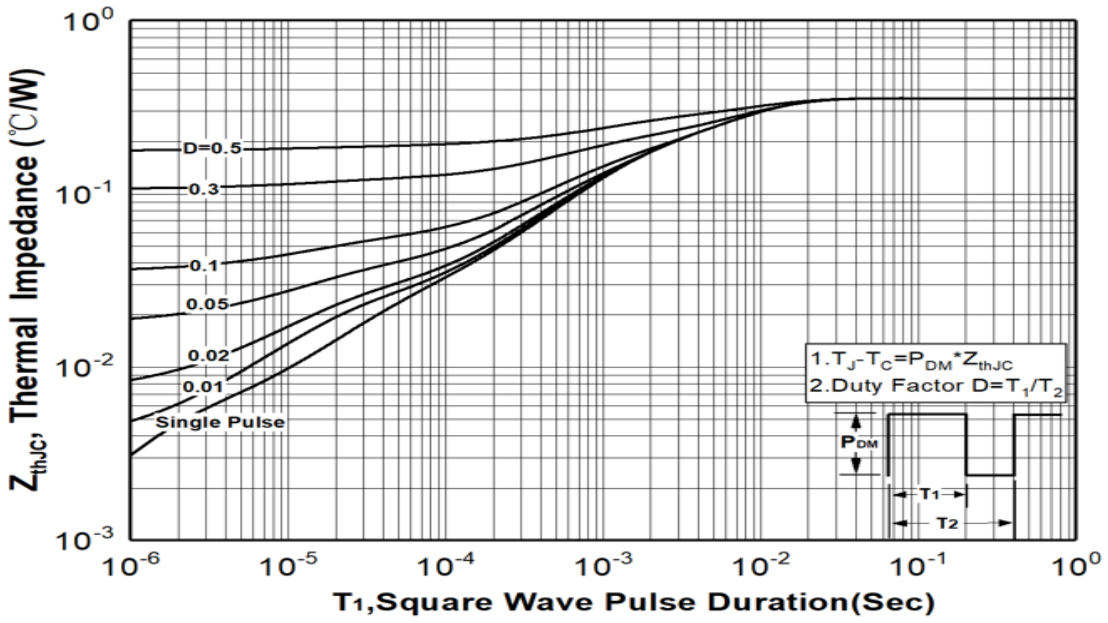
I_{DS}= f(T_C)

Diagram 18: Output Capacitor Stored Energy



Eoss=f(VDS)

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



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

5 Test Circuits

Table 8 Diode characteristics

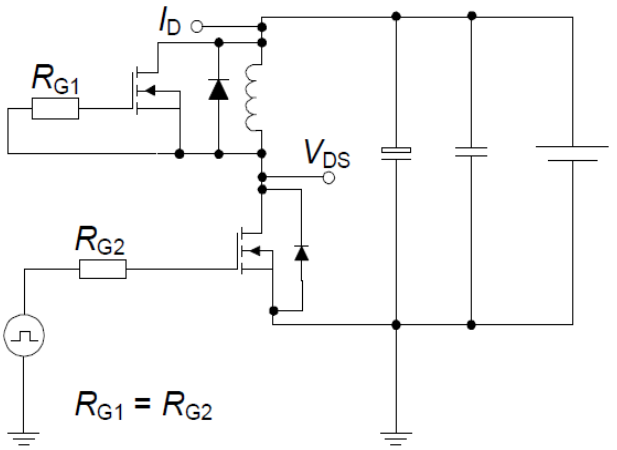
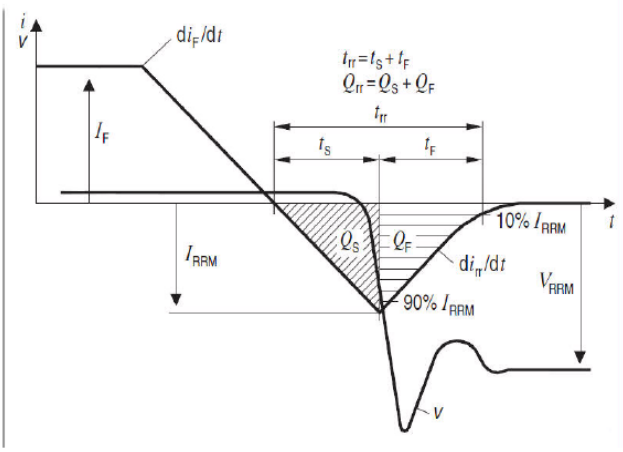
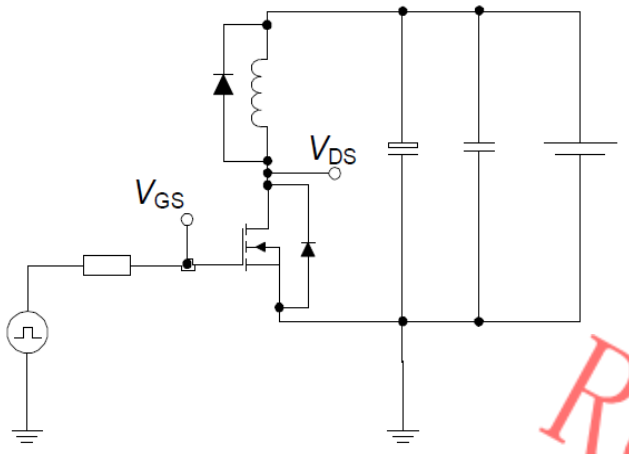
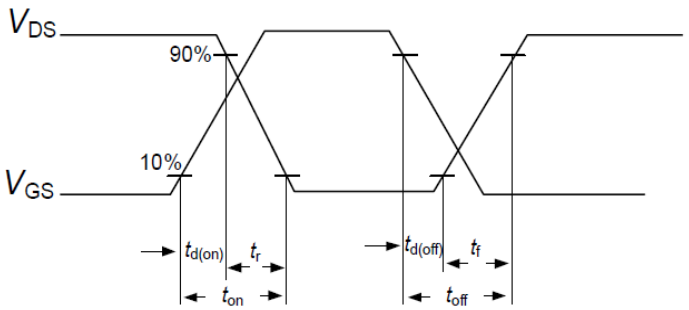
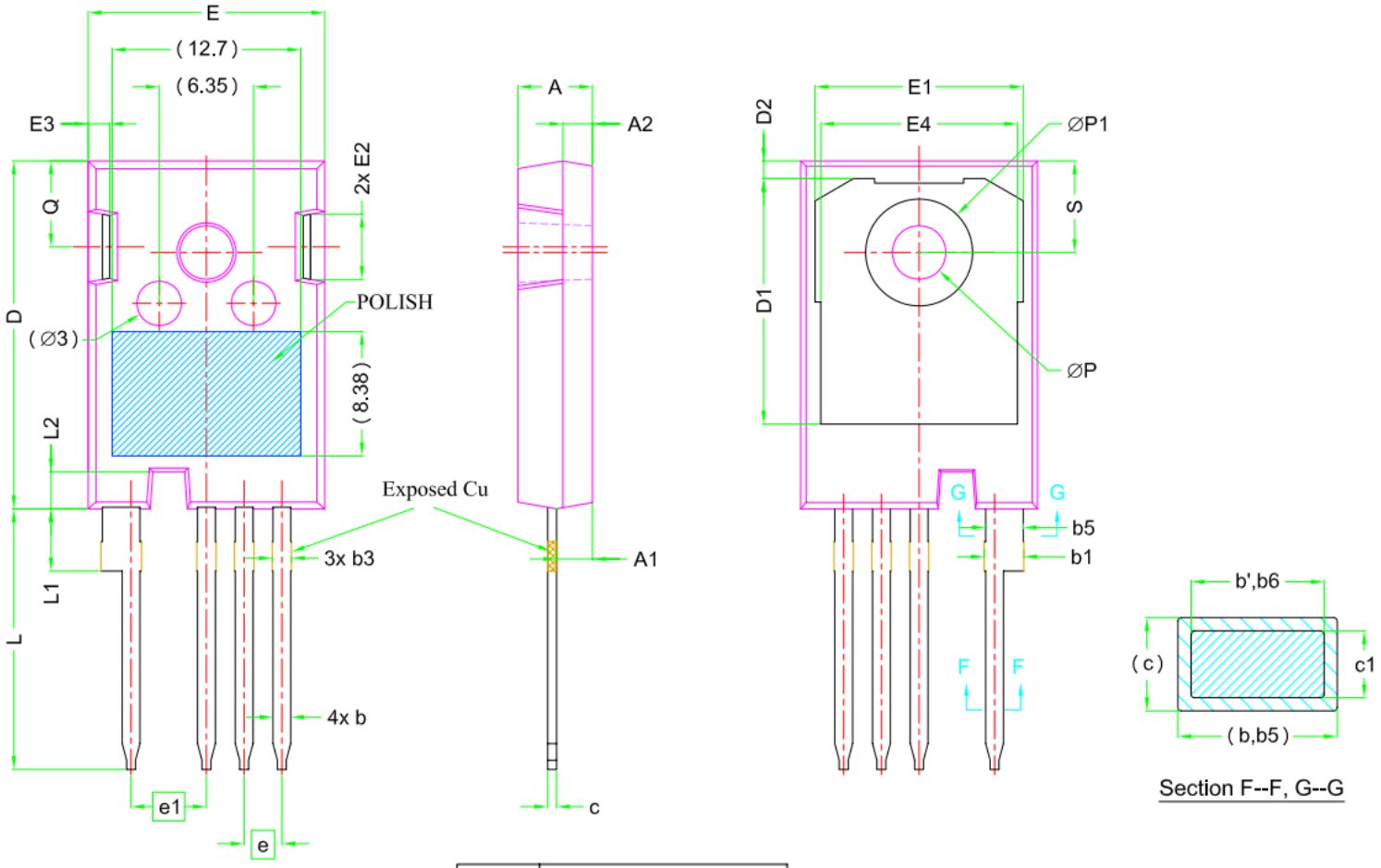
Test circuit for diode characteristics	Diode recovery waveform
	

Table 9 Switching times

Switching times test circuit for inductive load	Switching times waveform
	

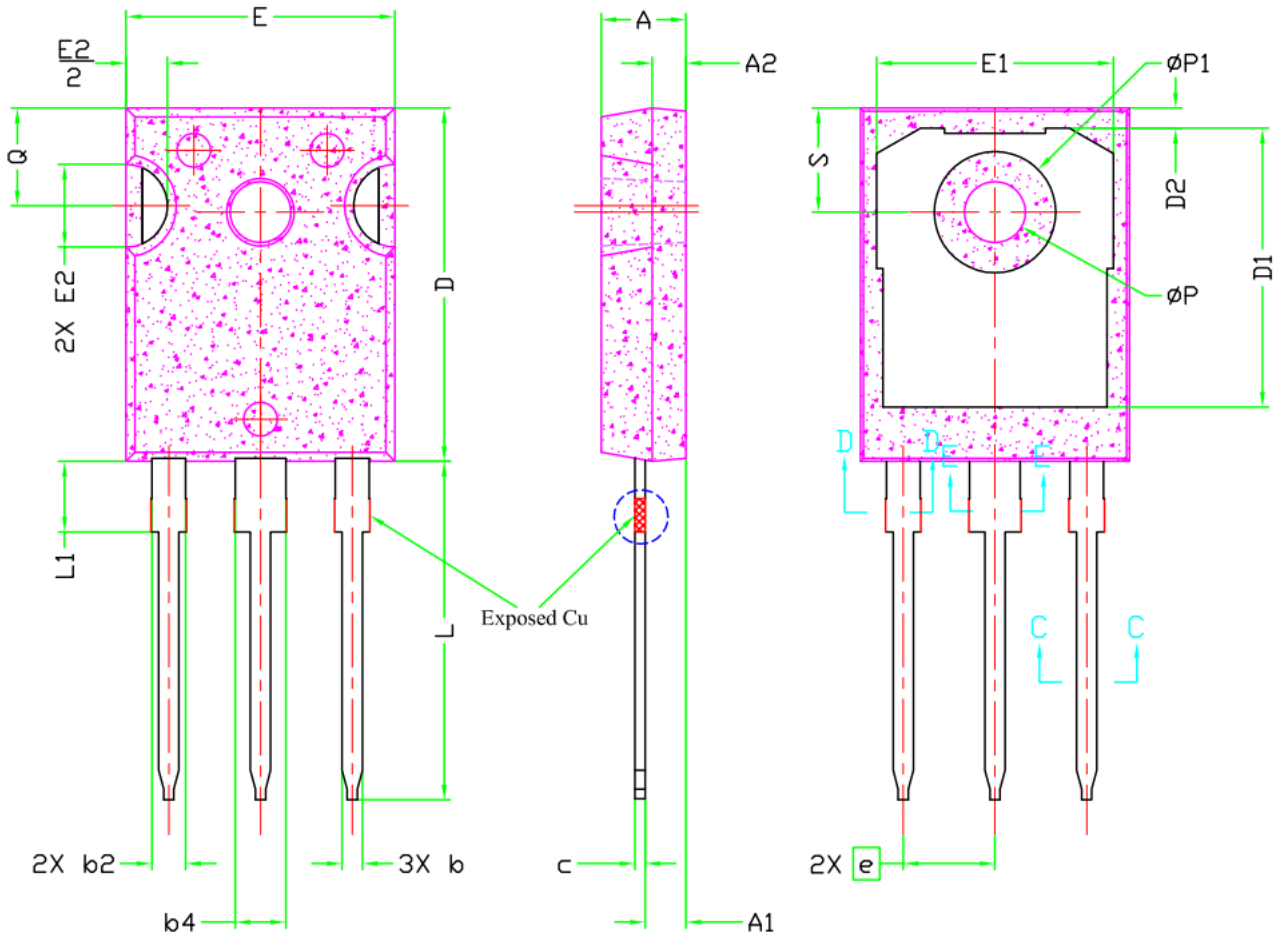
6 Package Outlines

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

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
ØP	3.56	3.61	3.65	7
ØP1	7.19REF.			
Q	5.39	5.79	6.20	
S	6.04	6.17	6.30	

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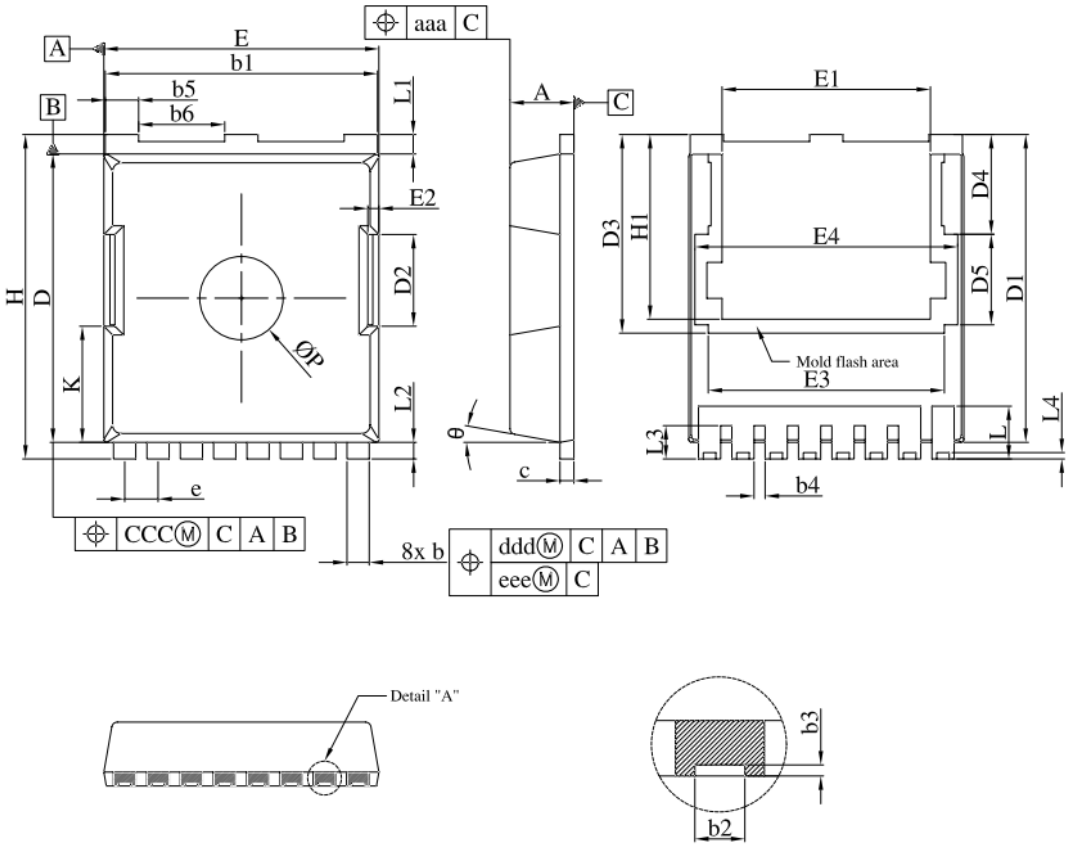

SYMBOL	COMMON MILLIMETER		
	MIN.	NOMINAL	MAX.
A	2.20	2.30	2.40
b	0.70	0.80	0.90
b1	9.70	9.80	9.90
b2	0.36	0.45	0.55
b3	0.05	0.100	/
b4	0.30	0.40	0.50
b5	1.10	1.20	1.30
b6	3.00	3.10	3.20
c	0.40	0.50	0.60
D	10.28	10.38	10.55
D1	10.98	11.08	11.18
D2	3.20	3.30	3.40
D3		7.15	
D4		3.59	
D5		3.26	
e	1.10	1.20	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)

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