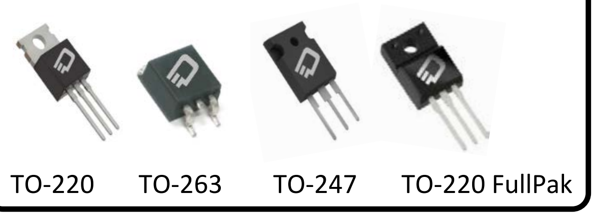
+FET™

D3S099N65

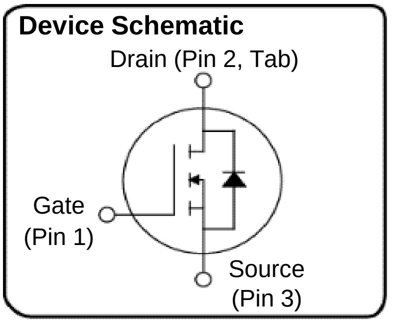
650V, 99mΩ, 33.6 A Super Junction Power MOSFET

Ordering Information

Part Number	Package Option
D3S099N65B-U	TO-220
D3S099N65D-U	TO-247
D3S099N65E-T	TO-263
D3S099N65F-U	TO-220 FullPak



Description



+FET™ is an advanced Super Junction Power MOSFET offering excellent efficiency through low Rds-ON and low gate charge. +FET™ is a rugged device with precision charge balance implementation designed for demanding uses such as enterprise power computing power supplies, motor control, lighting and other challenging power conversion applications.

LEAD-FREE RoHS

Features

- LOW $R_{DS(ON)}$
- FAST SWITCHING
- HIGH E_{AS}
- REL TEST SPEC: JESD-22
- LOW OUTPUT CAPACITANCE

Benefits

- LOW CONDUCTION LOSSES
- HIGH EFFICIENCY
- EXCELLENT AVALANCHE PERFORMANCE

Table 1 Key Performance Parameters

Parameters	Value	Unit
V_{DS} @ $T_{J\ max}$	710	V
RDS(on),max	<99	mΩ
Q_g ,typ	56	nC
$I_{D\ @\ 25C}$	33.6	A
Coss	72	pf

Applications

- POWER FACTOR CORRECTION
- SERVER POWER SUPPLIES
- TELECOM POWER SUPPLIES
- INVERTERS
- MOTOR CONTROL

Table of contents

@ T_J = 25ºC ,unless otherwise specified

Table 2 Maximum ratings

Parameter	Symbol	Values				Unit	Note/Test Condition
		Min.	Typ.	Max 220, 263 &247	Max 220FP		
Continuous drain current(1)	I_D			33.6	15.9	A	T_C = 25ºC
				21.3	10.1		T_C = 100ºC
Pulsed drain current(2)	$I_{D,pulse}$			135	63.8	A	T_C = 25ºC
Avalanche energy,single pulse	E_{AS}			534	534	mJ	I_D=6.6A, V_{DD}=50V
Avalanche energy,repetitive	E_{AR}			1.34	1.34	mJ	I_D=6.6A, V_{DD}=50V
Avalanche current, repetitive	I_{AR}			6.6	6.6	A	
MOSFET dv/dt ruggedness	dv/dt			50	50	V/ns	V_{DS}=…480V
Gate source voltage	V_{GS}	-30		30	30	V	static
		-30		30	30		AC (f > 1HZ)
Power dissipation for TO-220	P_{tot}			272	61	W	T_C = 25ºC
Operating and storage temperature	T_j , T_{stg}	-55		150	150	ºC	
Mounting torque				60		Ncm	M3 and M3.5 screws
					50		M3 screws
Continuous diode forward current	I_S			33.6	15.9	A	T_C = 25ºC
Diode pulsed current	$I_{S,pulse}$			135	63.8	A	T_C = 25ºC
Reverse diode dv/dt(3)	dv/dt			15	15	V/ns	V_{DS}=…480V, I_{SD}<I_D T_J= 25ºC
Maximum diode commutation speed	dif/dt			500	500	A/us	

Table 3 Thermal characteristics

Parameter	Symbol	Values				Unit	Note/Test Condition
		Min.	Typ.	Max 220, 263 & 247	Max 220FP		
Thermal resistance, Junction-case	R_{thJC}			0.5	2.25	ºC/W	
Thermal resistance, Junction-ambient	R_{thJA}			43.4	46	ºC/W	Leaded
Soldering temperature, wavesoldering only allowed at leads	T_{sold}			260	260	ºC	1.6mm form case for 10s

Table 4 Static characteristics

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Drain to source breakdown voltage	$V_{(BR)DSS}$	650			V	V_{GS}=0V, I_D=1mA
Gate threshold voltage	$V_{GS(TH)}$	2.3	3.2	4.5	V	V_{DS}=V_{GS}, I_D=194uA
Zero gate voltage drain current	I_{DSS}			1	uA	V_{DS}=650V, V_{GS}=0V, T_J = 25ºC
				40		V_{DS}=650V, V_{GS}=0V, T_J = 150ºC
Gate to source leakage current	I_{GSS}			100	nA	V_{GS}=±20V, V_{DS}=0V
Drain-source on-state resistance	$R_{DS(On)}$		94	99	mΩ	V_{GS}=10V, I_D=16.8A, T_J = 25ºC
			190		mΩ	V_{GS}=10V, I_D=16.8A, T_J = 150ºC
Gate resistance	R_G		1		Ω	Scaf-F

Table 5 Dynamic characterristics

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Input capacitance	C_{iss}		2222		pF	V_{GS}=0V, V_{DS}=100V, f=1MHz
Output capacitance	C_{oss}		72		pF	
Reverse transfer capacitance	C_{rss}		13		pF	
Effective output capacitance, energy related 1	$C_{o(er)}$		105		pF	V_{DS}=0…480V, V_{GS}= 0V
Effective output capacitance, time related 2	$C_{o(tr)}$		331		pF	I_D=constant, V_{DS}=0…480V, V_{GS}= 0V
Turn on delay time	$t_{d(on)}$		18		ns	V_{DD}=400V, I_D=16.8A, R_G=1.0Ω, V_{GS}=10V
Rising time	t_r		25		ns	
Turn off delay time	$t_{d(off)}$		41		ns	
Fall time	t_f		22		ns	

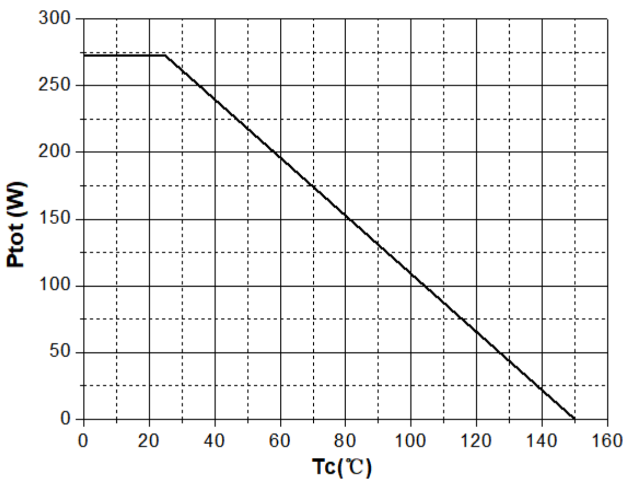
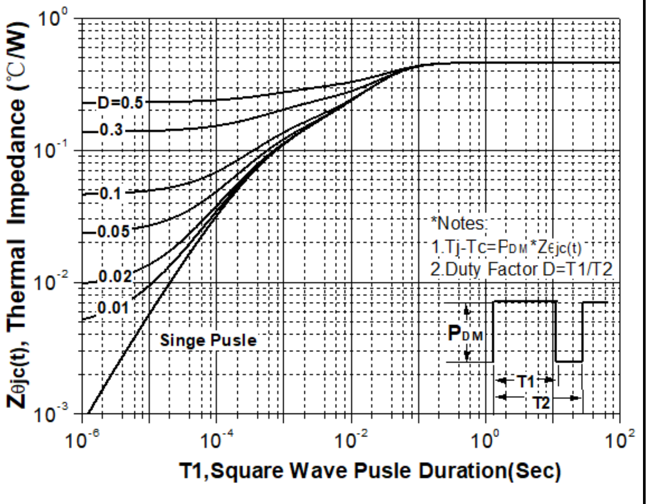
Table 6 Gate charge characteristics

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Total gate charge	Q_g		56		nC	V_{DD}=480V, V_{GS}=0 to10V I_D=16.8A
Gate-source charge	Q_{gs}		14		nC	
Gate-drain charge	Q_{gd}		23		nC	
Gate plateau voltage	$V_{plateau}$		5.0		V	

Table 7 Reverse diode characteristics

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min	Typ	Max		
Diode forward voltage	V_{SD}		0.87	0.96	V	I_F=33.6A, V_{GS}=0V, T_J = 25ºC
Reverse recovery time	t_{rr}		452		ns	I_F=33.6A,dI_F/dt=100A/us
Reverse recovery charge	Q_{rr}		8.0		uC	
Peak reverse recovery current	I_{rrm}		36		A	

Table 8 Thermal Performance

<table>
<tr><td>Power dissipation（TO220, TO263 & TO247）</td><td>Max. transient thermal impedance（TO220,TO263 & TO247）</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>$P_{tot}=f(T_C)$</td><td>$Z_{thJC}=f(t_P)$;parameter:$D=t_P/T$</td></tr>
</table>

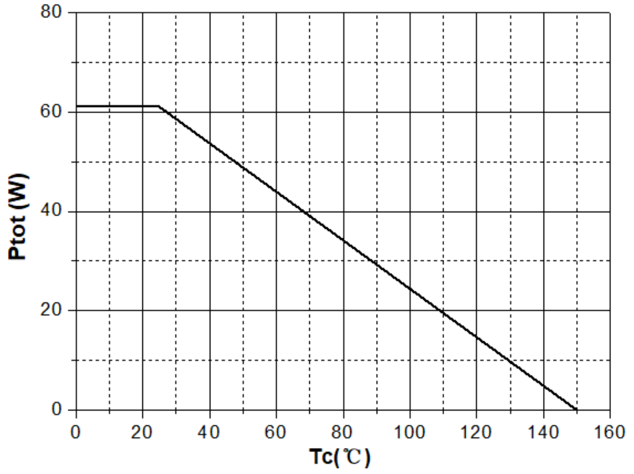
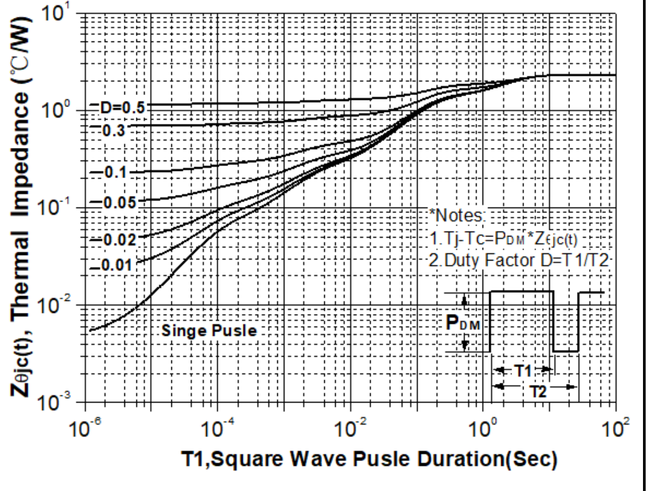
<table>
<tr><td>Power dissipation（TO220F）</td><td>Max. transient thermal impedance（TO220F）</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>$P_{tot}=f(T_C)$</td><td>$Z_{thJC}=f(t_P)$;parameter:$D=t_P/T$</td></tr>
</table>

Table 9 Output Characteristics

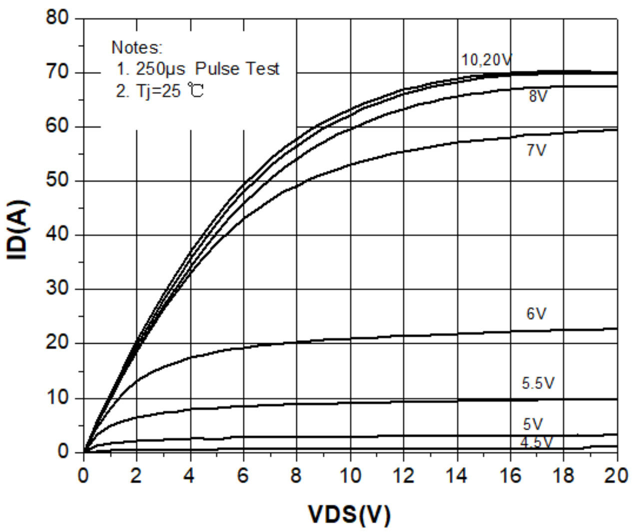
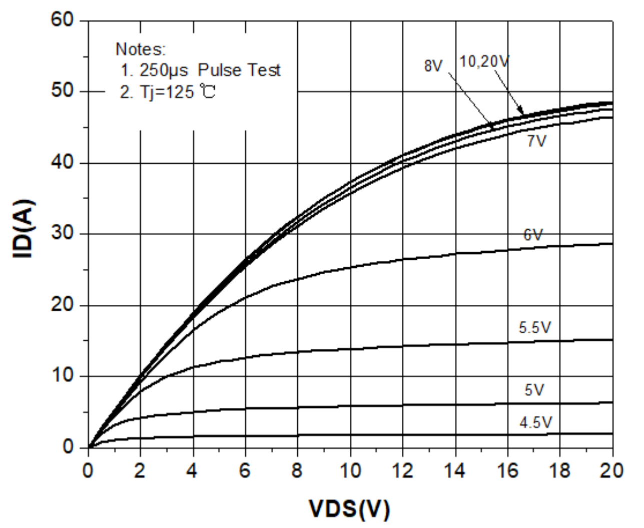
<table>
<tr><td>Typical output characteristicsT_j= 25ºC</td><td>Typical output characteristics T_j= 125ºC</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>I_D=f(V_{DS}); T_j = 25ºC ;parameter:V_{GS}</td><td>I_D=f(V_{DS}); T_j = 125ºC ;parameter:V_{GS}</td></tr>
</table>

Table 10 Drain Source Resistance

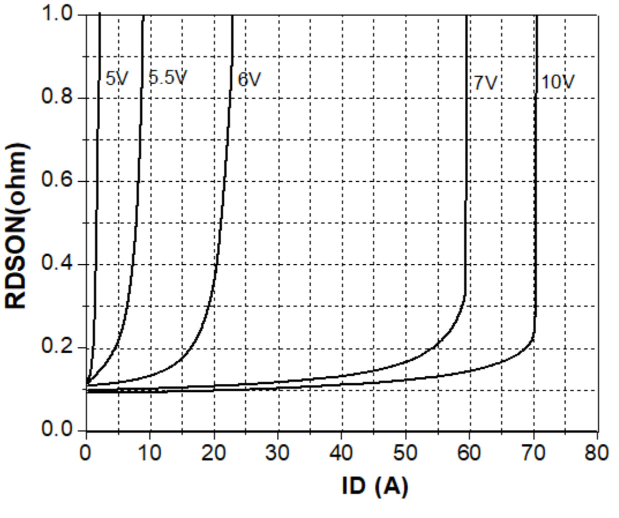
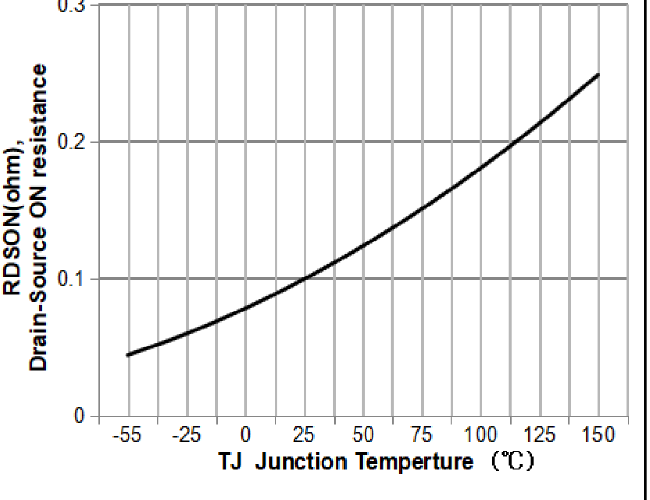
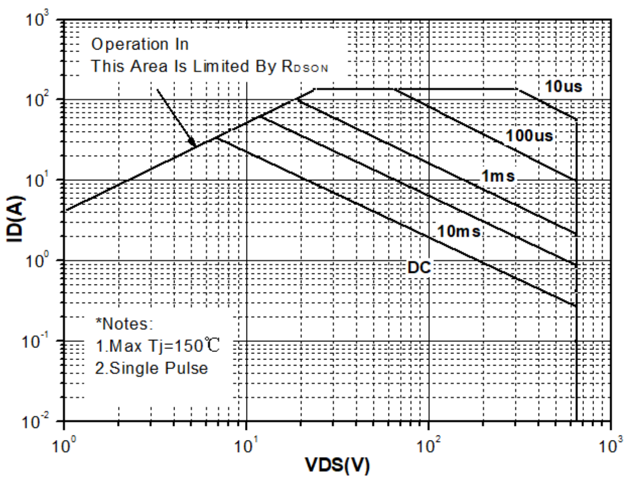
<table>
<tr><td>Typical drain-source on-state resistance</td><td>Drain-source on-state resistance</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>$R_{DS(On)}$=f(I_D); T_j = 25ºC parameter:V_{GS}</td><td>$R_{DS(On)}$=f(T_j); I_D = 12.8A :V_{GS}=10V</td></tr>
</table>

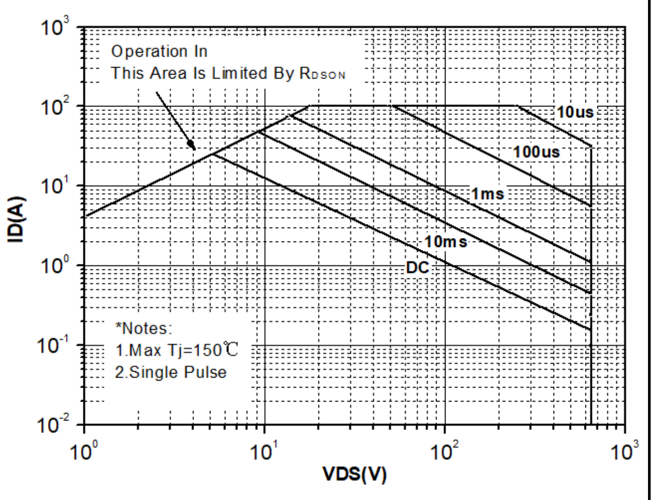
Table 11 Safe Operating Area

Safe operating area T_C= 25°C（TO220, TO263 & TO247）



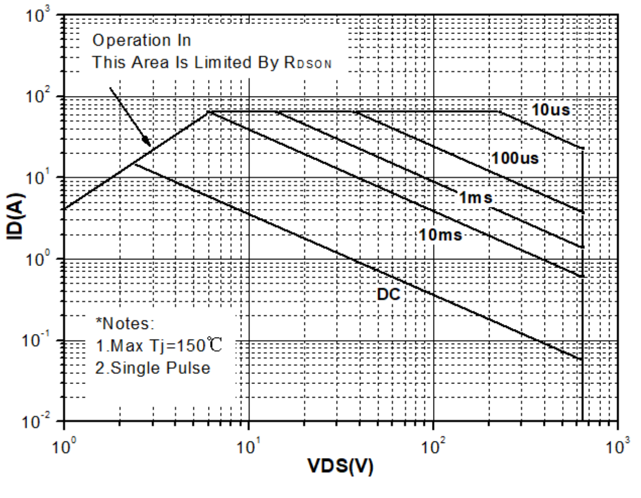
I_D=f(V_{DS}); T_C = 25°C ;D=0;parameter:t_P

Safe operating area T_C= 80°C（TO220, TO263 & TO247）



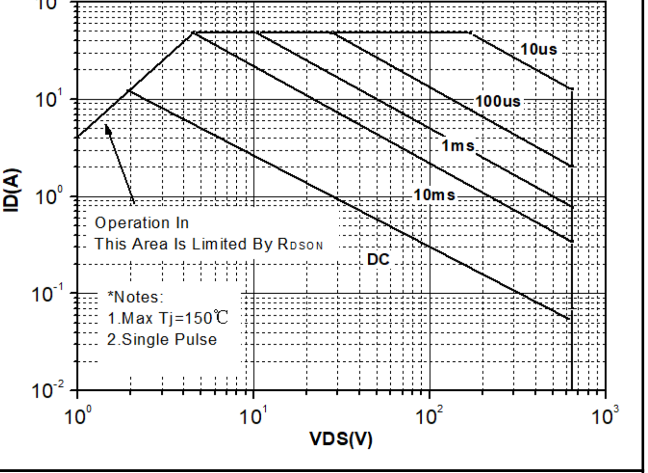
I_D=f(V_{DS}); T_C = 80°C ;D=0;parameter:t_P

Safe operating area T_C= 25°C（TO220F）



I_D=f(V_{DS}); T_C = 25°C ;D=0;parameter:t_P

Safe operating area T_C= 80°C（TO220F）



I_D=f(V_{DS}); T_C = 80°C ;D=0;parameter:t_P

Table 12 Capacitances and Gate Charge

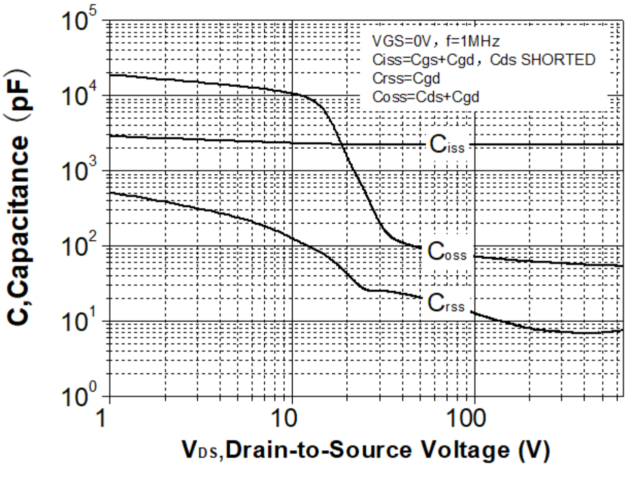
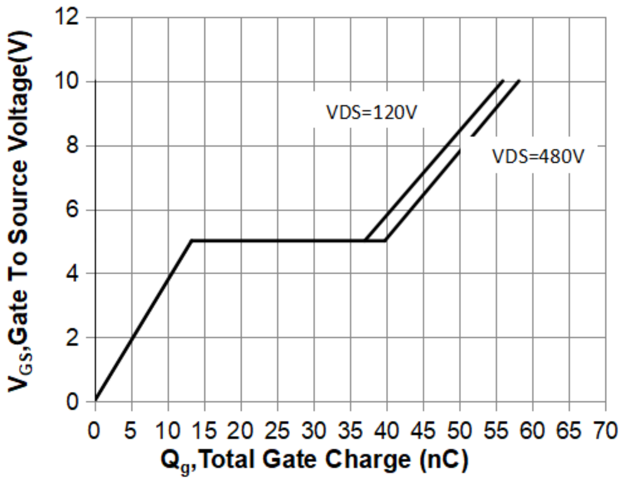
Typical Capacitances	Typical Gate charge
	
V_{gs}=0v, Freq.= 1MHz	I_D=f(Q_{gate}); I_D = 16.8A pulsed; parameter:V_{DD}

Table 13 Diode Characteristics and Avalanche Energy

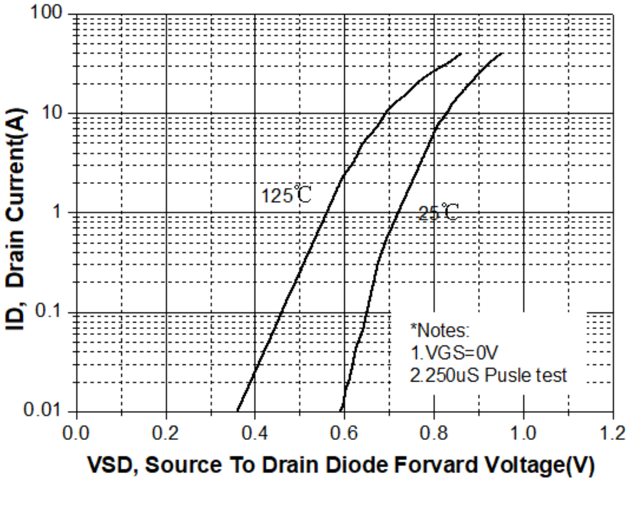
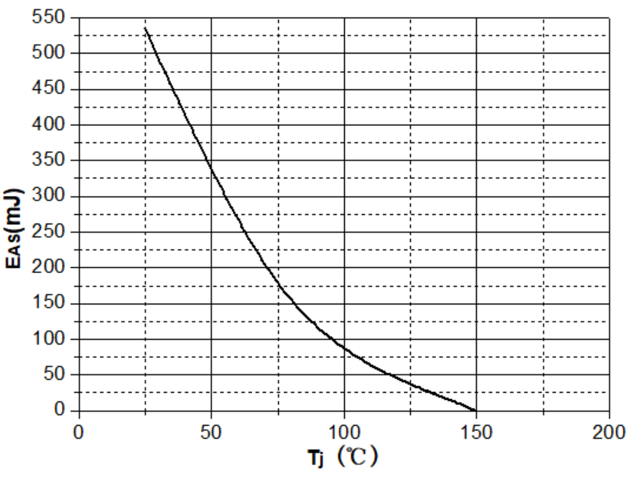
Forward characteristics of reverse diode	Avalanche energy
	
I_F=f(V_{SD}); parameter:T_j	E_{AS}=f(T_j); I_D = 6.6A ; V_{DD} = 50V

Table 14 Breakdown Voltage and Transfer Characteristics

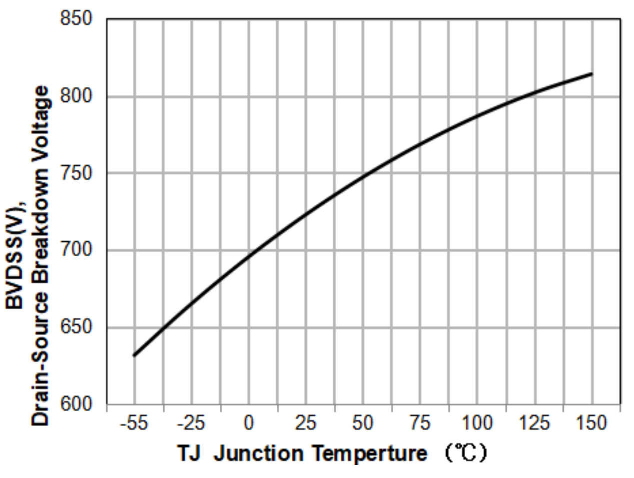
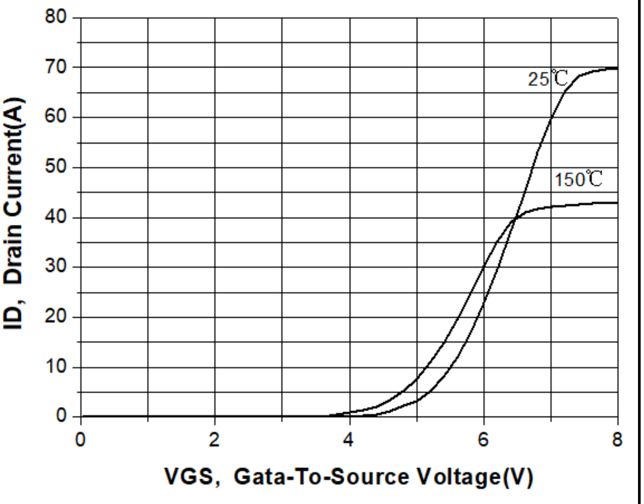
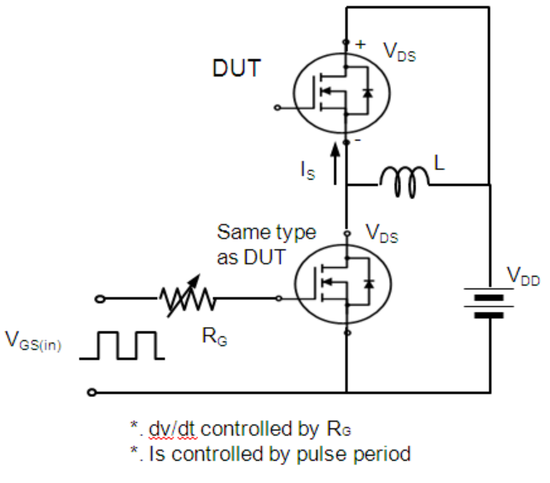
Drain-source breakdown voltage	Transfer Characteristics
	
$V_{BR(DSS)}=f(T_j)$; $I_D = 1mA$	$I_D=f(V_{GS})$; $\lvert V_{DS}\rvert > 2\lvert I_D\rvert R_{DS(On)max}$;parameter:$T_j$

Table 15 Diode Recovery Characteristic

Test Circuit For Diode Recovery



Test Waveform For Diode Recovery

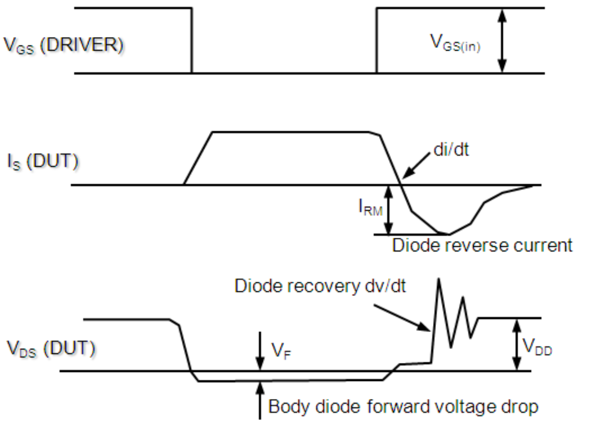
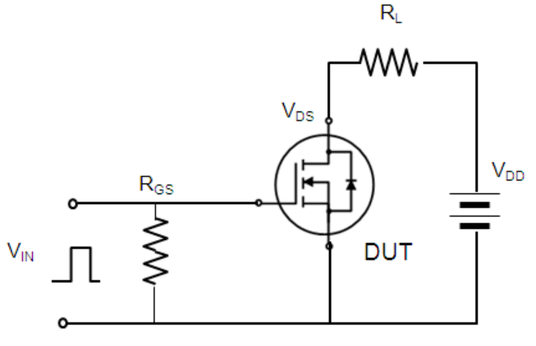


Table 16 Switching Time Characteristic

Test Circuit for Switching Time



Test Waveform for Switching Time

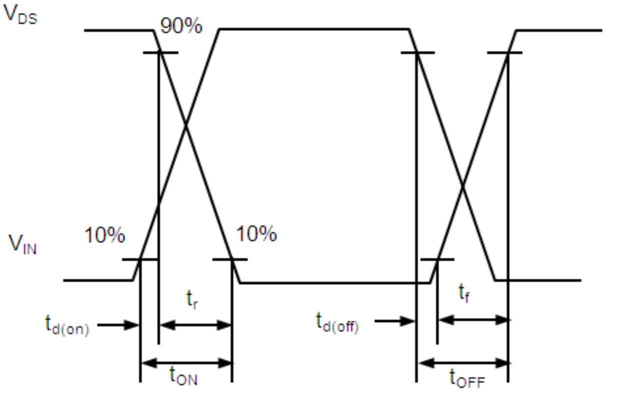
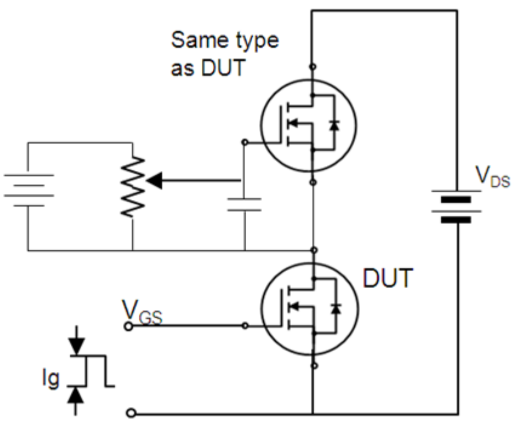


Table 17 Gate Charge Characteristic

Test Circuit For Gate Charge



Test Waveform For Gate Charge

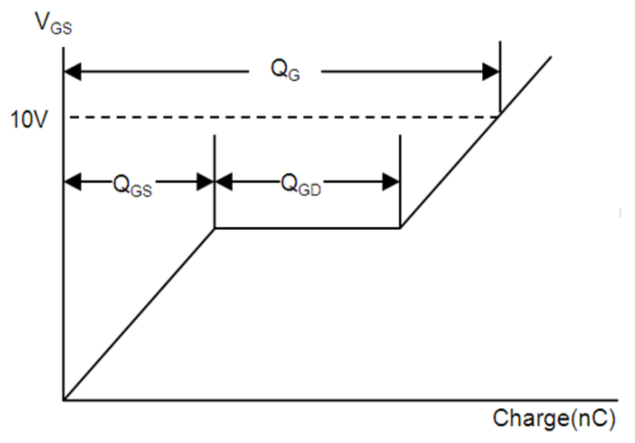
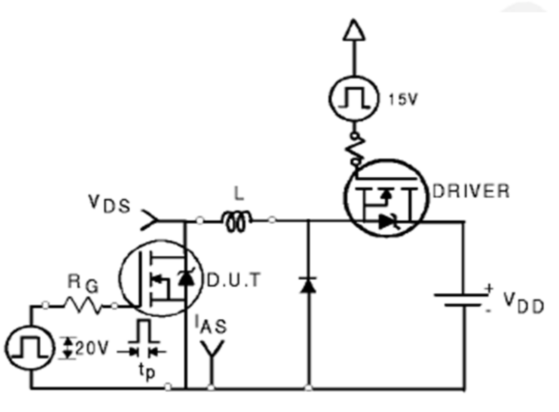
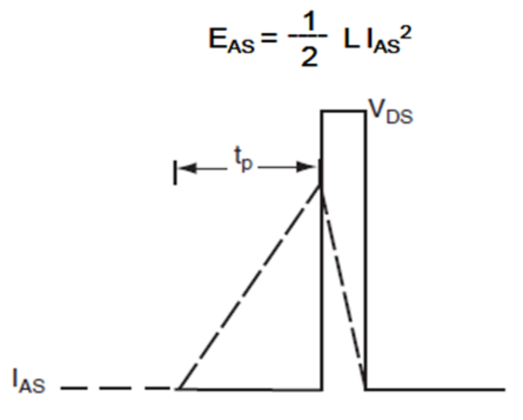


Table 18 Unclamped Inductive Characteristic

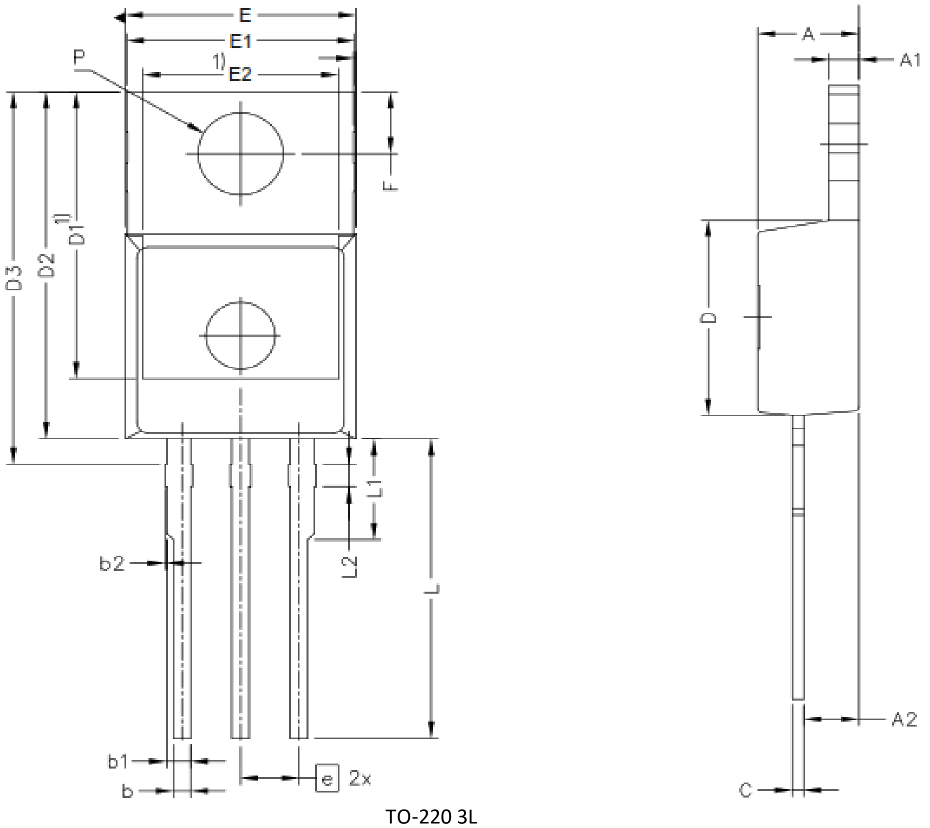
Test Circuit For Unclamped Inductive



Test Waveform For Unclamped Inductive



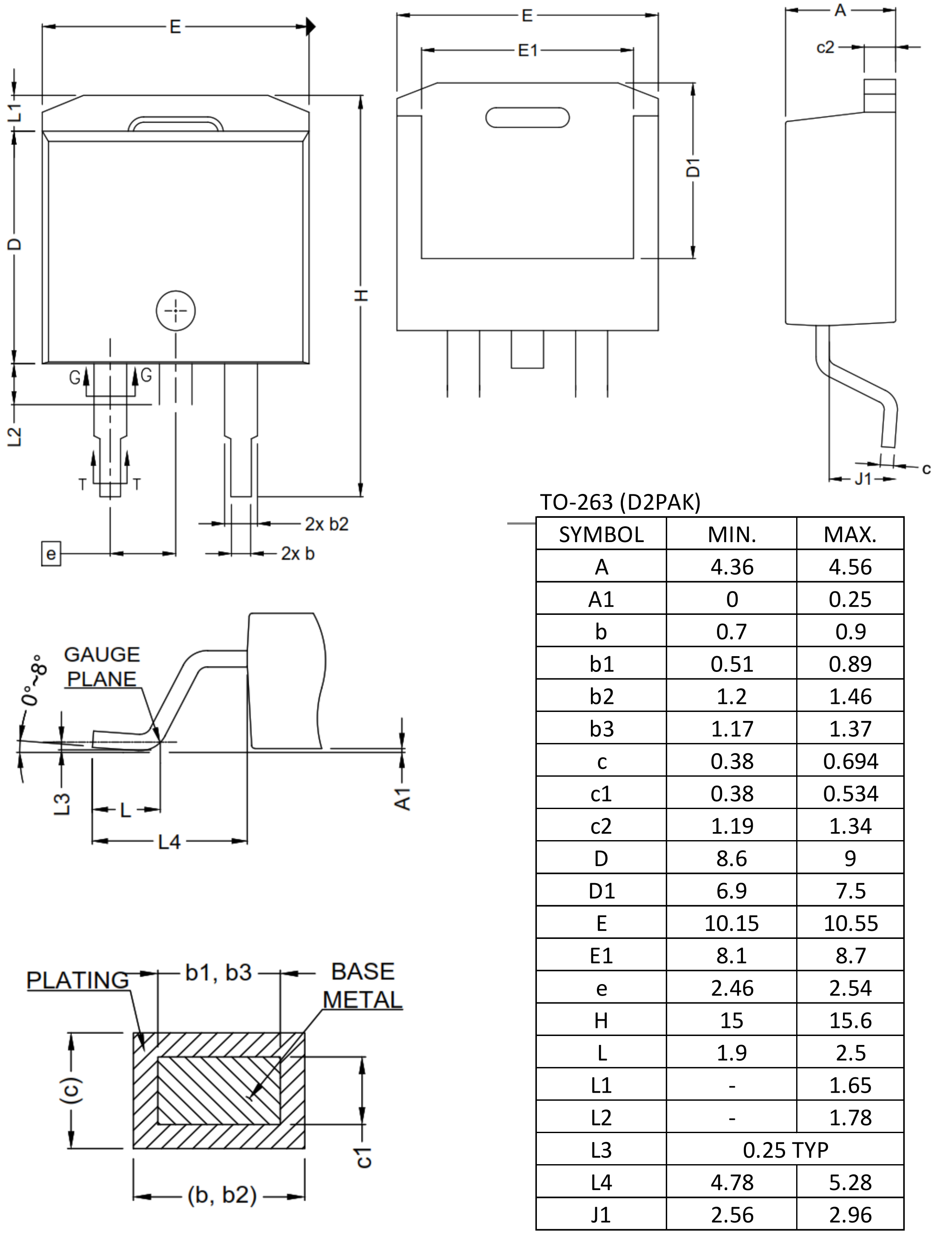
4a) TO-220



TO-220 3L

SYMBOL	MIN	MAX
A	4.20	4.60
A1	1.20	1.40
A2	2.20	2.60
b	0.65	0.85
b1	0.95	1.15
b2		0.15
C	0.40	0.60
D	9.05	9.45
D1	12.95	
D2	15.35	15.95
D3	16.50	17.10
E	9.80	10.20
E1	9.70	10.10
E2	8.50	
e	2.46	2.54
F	2.60	3.00
L	13.00	14.00
L1	4.35	4.75
L2	0.90	1.10
P	3.55	3.85

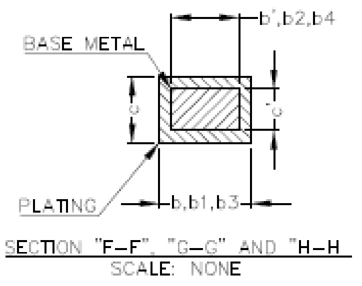
4b) TO-263



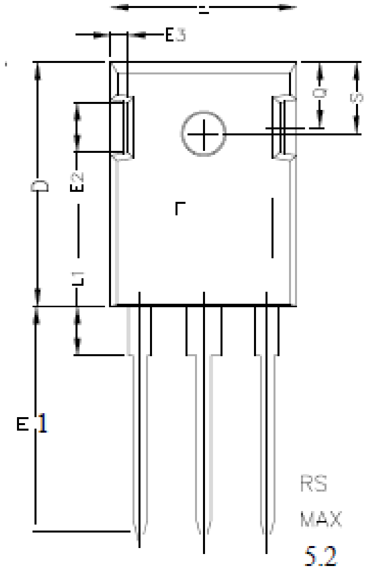
TO-263 (D2PAK)

SYMBOL	MIN.	MAX.
A	4.36	4.56
A1	0	0.25
b	0.7	0.9
b1	0.51	0.89
b2	1.2	1.46
b3	1.17	1.37
c	0.38	0.694
c1	0.38	0.534
c2	1.19	1.34
D	8.6	9
D1	6.9	7.5
E	10.15	10.55
E1	8.1	8.7
e	2.46	2.54
H	15	15.6
L	1.9	2.5
L1	-	1.65
L2	-	1.78
L3	0.25 TYP	
L4	4.78	5.28
J1	2.56	2.96

4c) TO-247

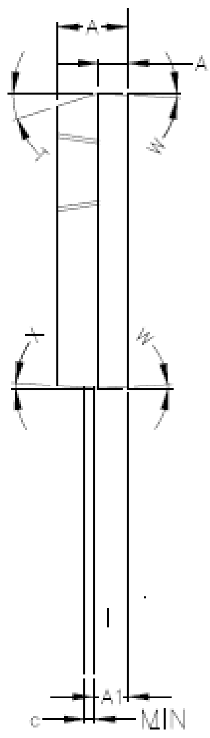


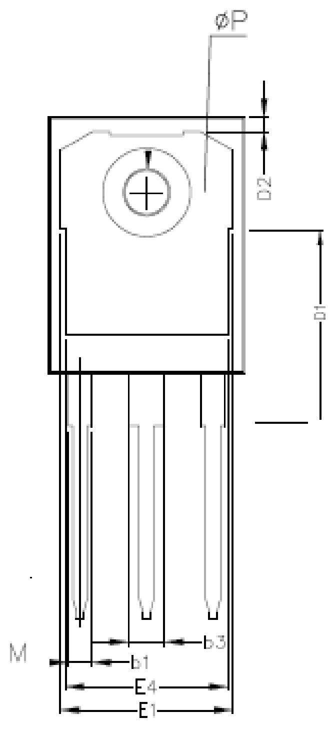
1. ALL METAL SURFACES: TIN PLATED,EXCEPT AREA OF CUT
2. DIMENSIONING & TOLERANCEING CONFIRM TO ASME Y14.5M-1994.
3. ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.
4. THIS DRAWING WILL MEET ALL DIMENSIONS REQUIREMENT OF JEDEC outlines TO-247 AD.



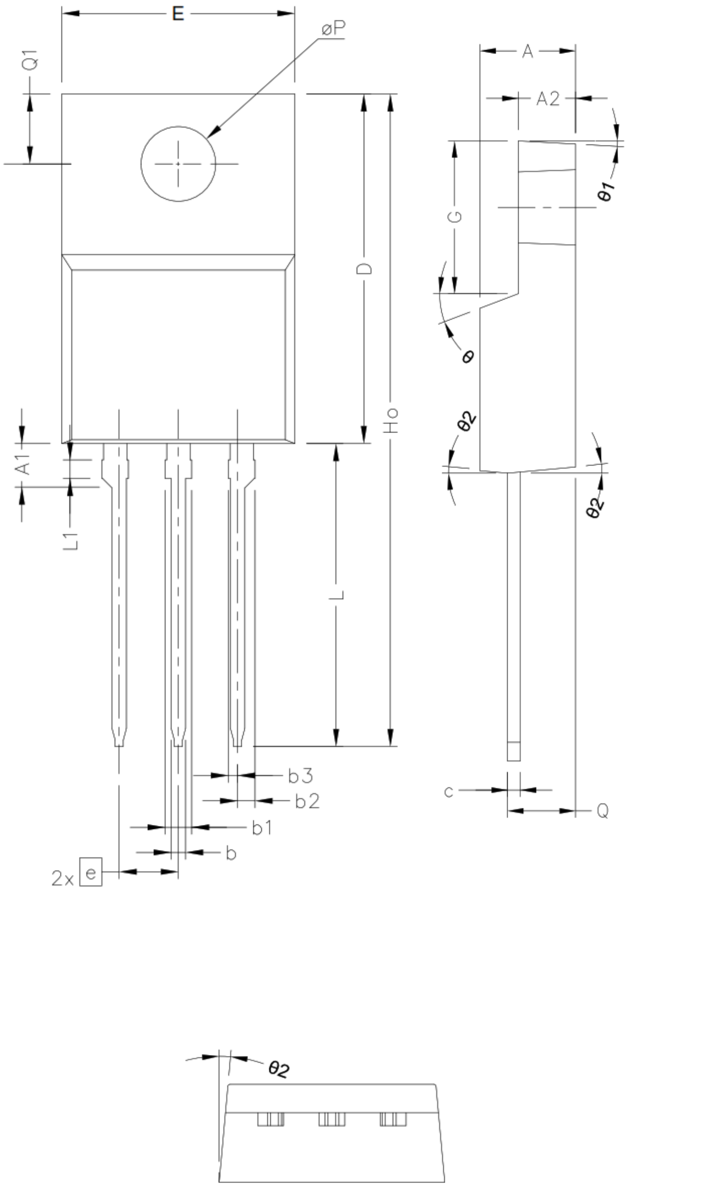
SYM	MILLIMETERS	
	MIN	MAX
A	4.83	5.21
A1	2.29	2.54
A2	1.91	2.16
b'	1.07	1.28
b	1.07	1.33
b1	1.91	2.41
b2	1.91	2.16
b3	2.87	3.38
b4	2.87	3.13
c'	0.55	0.65
c	0.55	0.68
D	20.80	21.10
D1	16.25	17.65
D2	0.95	1.25
E	15.75	16.13
E1	13.10	14.15
E2	3.68	5.10
E3	1.00	1.90
E4	12.38	13.43
e	5.44 BSC	
N	3	
L	19.81	20.32
L1	4.10	4.40
øP	3.51	3.65
Q	5.49	6.00
S	6.04	6.30
T	17.5° ref	
W	3.5° ref.	
X	4° ref	

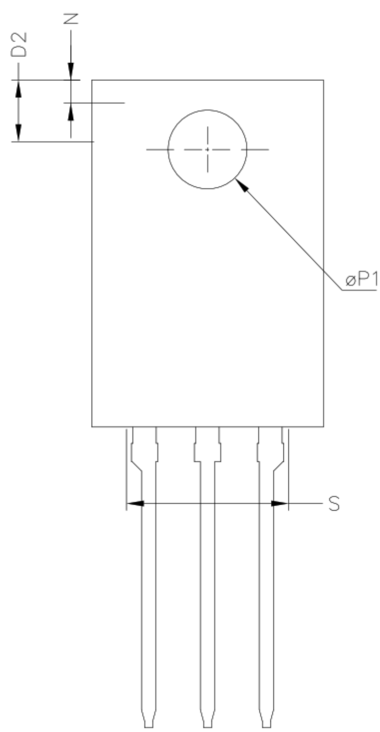
1 - GATE
2 - DRAIN (COLLECTOR)
3 - SOURCE (EMITTER)
4 - DRAIN (COLLECTOR)





4d) TO-220 FullPak





SYMBOL	MIN	MAX
A	4.30	4.70
A1	1.80	2.10
A2	2.50	2.90
b	0.54	0.84
b1	0.99	1.29
b2	0.56	0.93
b3	0.24	0.55
c	0.49	0.79
D	14.70	15.30
D2	2.66	
e	2.29	2.79
E	9.70	10.30
G	6.70	7.10
Ho	28.00	
L	12.50	13.50
L1	0.70	0.90
N	2.86	
øP	3.05	3.40
øP1	3.40	
Q	3.10	3.30
Q1	2.70	3.30
S	7.00	
Θ1	3 deg.	
Θ2	5 deg.	

Revision History

Revision	Release Date	Comments
1.0	1-Nov-2016	Preliminary Datasheet Draft
2.0	1-July-2017	Update tables and package detail
2.5	20-Nov-2017	Added TO247 Package
2.6	11-Dec-2017	Added Test Circuits
3.0	2-Jan 2019	Updated/update tables and charts

Resources

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