



January 2002

ISL9N302AP3

N-Channel Logic Level PWM Optimized UltraFET® Trench Power MOSFETs

General Description

This device employs a new advanced trench MOSFET technology and features low gate charge while maintaining low on-resistance.

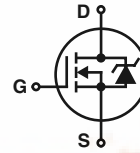
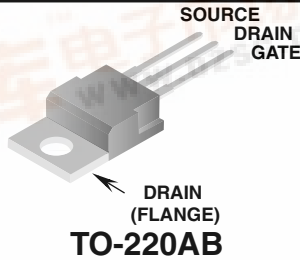
Optimized for switching applications, this device improves the overall efficiency of DC/DC converters and allows operation to higher switching frequencies.

Applications

- DC/DC converters

Features

- Fast switching
- $r_{DS(ON)} = 0.0019\Omega$ (Typ), $V_{GS} = 10V$
- $r_{DS(ON)} = 0.0027\Omega$ (Typ), $V_{GS} = 4.5V$
- Q_g (Typ) = 110nC, $V_{GS} = 5V$
- Q_{gd} (Typ) = 31nC
- C_{ISS} (Typ) = 11000pF



MOSFET Maximum Ratings $T_A = 25^\circ\text{C}$ unless otherwise noted

Symbol	Parameter	Ratings	Units
V_{DSS}	Drain to Source Voltage	30	V
V_{GS}	Gate to Source Voltage	± 20	V
I_D	Drain Current		
	Continuous ($T_C = 25^\circ\text{C}$, $V_{GS} = 10V$)	75	A
	Continuous ($T_C = 100^\circ\text{C}$, $V_{GS} = 4.5V$)	75	A
	Pulsed	Figure 4	A
P_D	Power dissipation	345	W
	Derate above 25°C	2.3	W/ $^\circ\text{C}$
T_J, T_{STG}	Operating and Storage Temperature	-55 to 175	$^\circ\text{C}$

Thermal Characteristics

$R_{\theta JC}$	Thermal Resistance Junction to Case TO-220	0.43	$^\circ\text{C}/\text{W}$
$R_{\theta JA}$	Thermal Resistance Junction to Ambient TO-220	62	$^\circ\text{C}/\text{W}$

Package Marking and Ordering Information

Device Marking	Device	Package	Reel Size	Tape Width	Quantity
N302AP	ISL9N302AP3	TO-220AB	Tube	N/A	50



Electrical Characteristics $T_A = 25^\circ\text{C}$ unless otherwise noted

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
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Off Characteristics

B_{VDSS}	Drain to Source Breakdown Voltage	$I_D = 250\mu\text{A}$, $V_{GS} = 0\text{V}$	30	-	-	V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = 25\text{V}$ $V_{GS} = 0\text{V}$ $T_C = 150^\circ$	-	-	1	μA
I_{GSS}	Gate to Source Leakage Current	$V_{GS} = \pm 20\text{V}$	-	-	± 100	nA

On Characteristics

$V_{GS(TH)}$	Gate to Source Threshold Voltage	$V_{GS} = V_{DS}$, $I_D = 250\mu\text{A}$	1	-	3	V
$r_{DS(ON)}$	Drain to Source On Resistance	$I_D = 75\text{A}$, $V_{GS} = 10\text{V}$	-	0.0019	0.0025	Ω
		$I_D = 75\text{A}$, $V_{GS} = 4.5\text{V}$	-	0.0027	0.0033	

Dynamic Characteristics

C_{ISS}	Input Capacitance	$V_{DS} = 15\text{V}$, $V_{GS} = 0\text{V}$, $f = 1\text{MHz}$	-	11000	-	pF	
C_{OSS}	Output Capacitance		-	2000	-	pF	
C_{RSS}	Reverse Transfer Capacitance		-	900	-	pF	
$Q_{g(TOT)}$	Total Gate Charge at 10V	$V_{GS} = 0\text{V}$ to 10V	$V_{DD} = 15\text{V}$ $I_D = 75\text{A}$ $I_g = 1.0\text{mA}$	200	300	nC	
$Q_{g(5)}$	Total Gate Charge at 5V	$V_{GS} = 0\text{V}$ to 5V		-	110	165	nC
$Q_{g(TH)}$	Threshold Gate Charge	$V_{GS} = 0\text{V}$ to 1V		-	12	18	nC
Q_{gs}	Gate to Source Gate Charge			-	25	-	nC
Q_{gd}	Gate to Drain "Miller" Charge			-	31	-	nC

Switching Characteristics ($V_{GS} = 4.5\text{V}$)

t_{ON}	Turn-On Time	$V_{DD} = 15\text{V}$, $I_D = 28\text{A}$ $V_{GS} = 4.5\text{V}$, $R_{GS} = 1.5\Omega$	-	-	224	ns
$t_{d(ON)}$	Turn-On Delay Time		-	29	-	ns
t_r	Rise Time		-	120	-	ns
$t_{d(OFF)}$	Turn-Off Delay Time		-	45	-	ns
t_f	Fall Time		-	34	-	ns
t_{OFF}	Turn-Off Time		-	-	119	ns

Switching Characteristics ($V_{GS} = 10\text{V}$)

t_{ON}	Turn-On Time	$V_{DD} = 15\text{V}$, $I_D = 28\text{A}$ $V_{GS} = 10\text{V}$, $R_{GS} = 1.5\Omega$	-	-	204	ns
$t_{d(ON)}$	Turn-On Delay Time		-	16	-	ns
t_r	Rise Time		-	120	-	ns
$t_{d(OFF)}$	Turn-Off Delay Time		-	70	-	ns
t_f	Fall Time		-	30	-	ns
t_{OFF}	Turn-Off Time		-	-	150	ns

Unclamped Inductive Switching

t_{AV}	Avalanche Time	$I_D = 7.2\text{A}$, $L = 3.0\text{mH}$	480	-	-	μs
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Drain-Source Diode Characteristics

V_{SD}	Source to Drain Diode Voltage	$I_{SD} = 75\text{A}$	-	-	1.25	V
		$I_{SD} = 40\text{A}$	-	-	1.0	V
t_{rr}	Reverse Recovery Time	$I_{SD} = 75\text{A}$, $dI_{SD}/dt = 100\text{A}/\mu\text{s}$	-	-	42	ns
Q_{RR}	Reverse Recovered Charge	$I_{SD} = 75\text{A}$, $dI_{SD}/dt = 100\text{A}/\mu\text{s}$	-	-	34	nC

Typical Characteristic

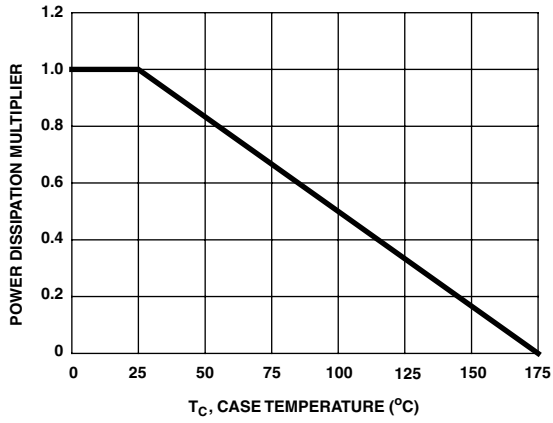


Figure 1. Normalized Power Dissipation vs Ambient Temperature

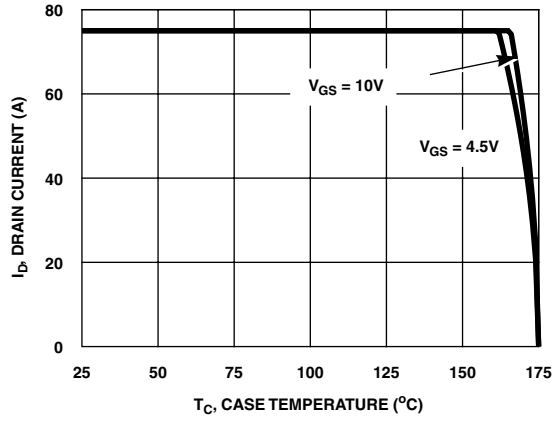


Figure 2. Maximum Continuous Drain Current vs Case Temperature

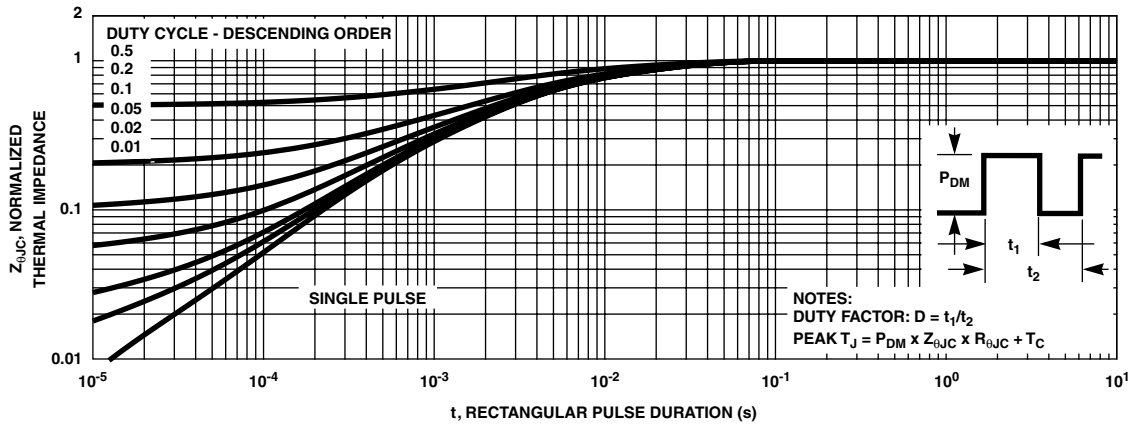


Figure 3. Normalized Maximum Transient Thermal Impedance

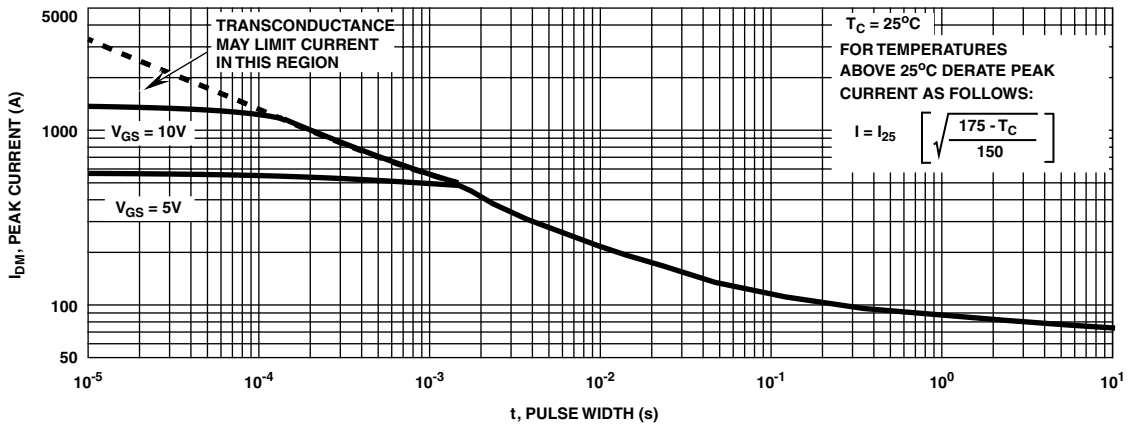


Figure 4. Peak Current Capability

Typical Characteristic (Continued)

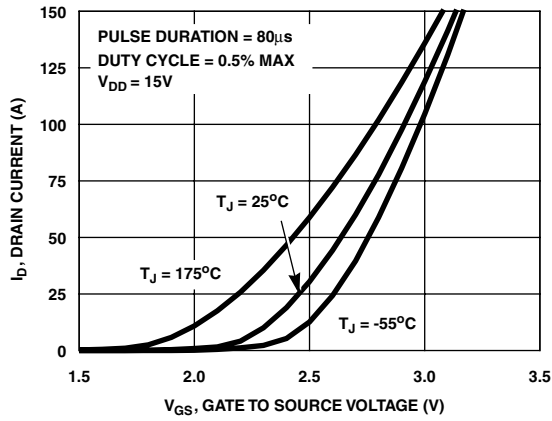


Figure 5. Transfer Characteristics

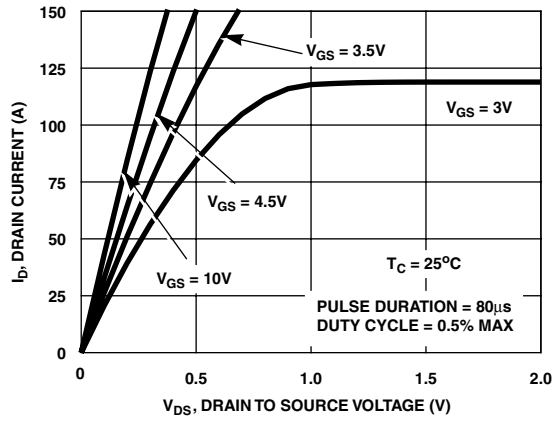


Figure 6. Saturation Characteristics

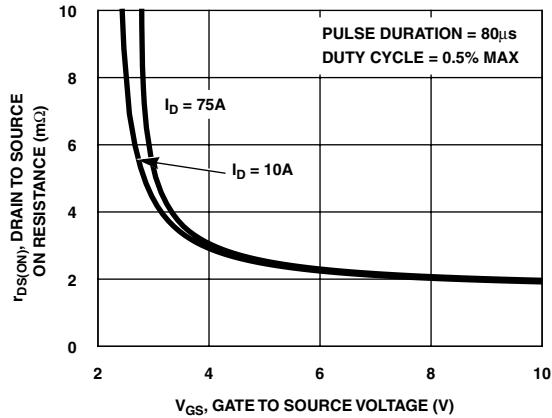


Figure 7. Drain to Source On Resistance vs Gate Voltage and Drain Current

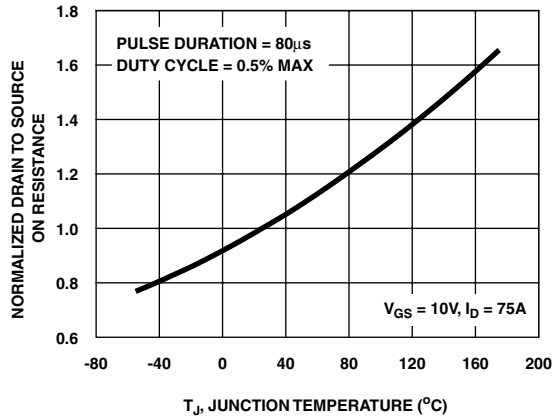


Figure 8. Normalized Drain to Source On Resistance vs Junction Temperature

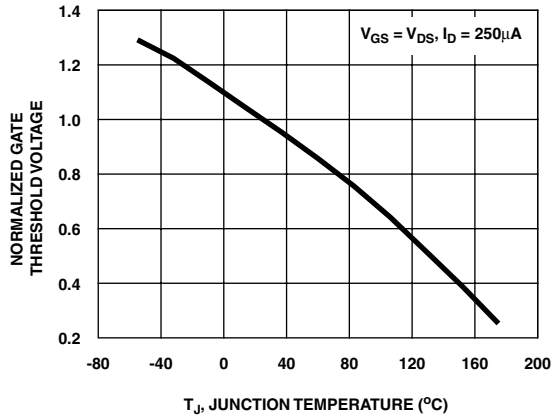


Figure 9. Normalized Gate Threshold Voltage vs Junction Temperature

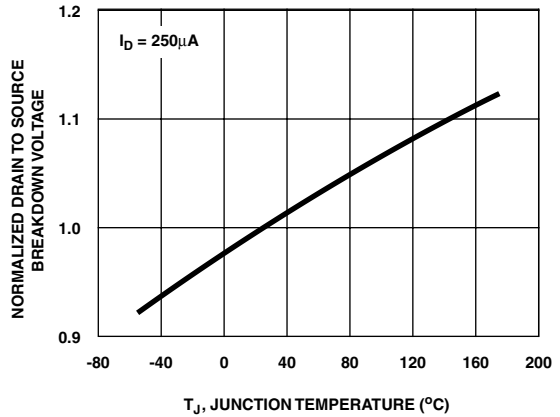


Figure 10. Normalized Drain to Source Breakdown Voltage vs Junction Temperature

Typical Characteristic (Continued)

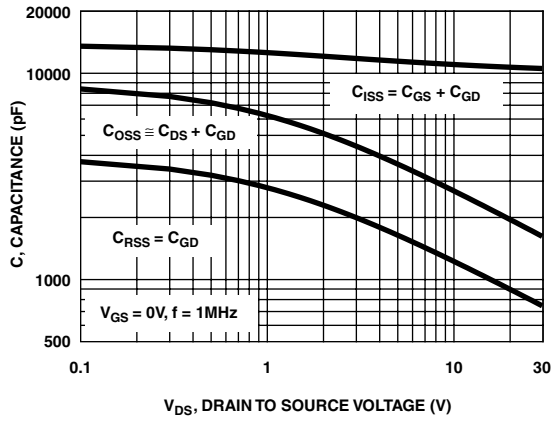


Figure 11. Capacitance vs Drain to Source Voltage

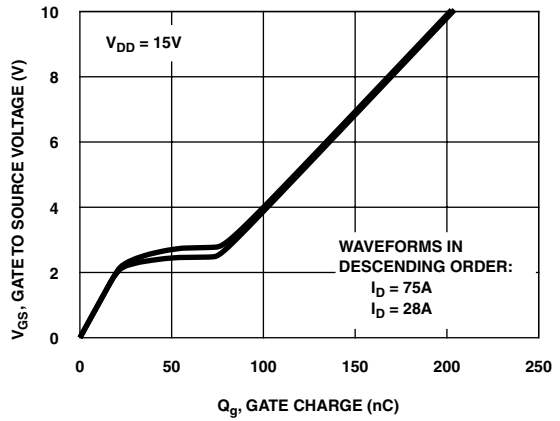


Figure 12. Gate Charge Waveforms for Constant Gate Currents

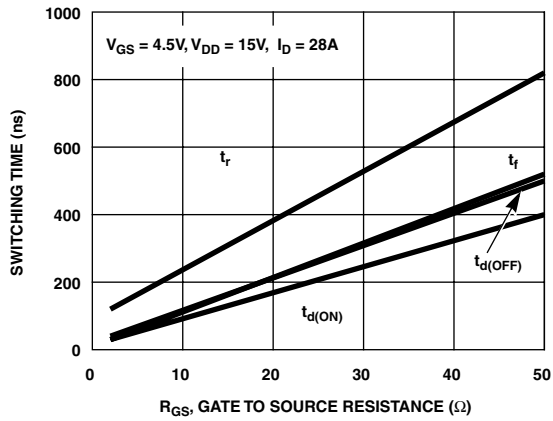


Figure 13. Switching Time vs Gate Resistance

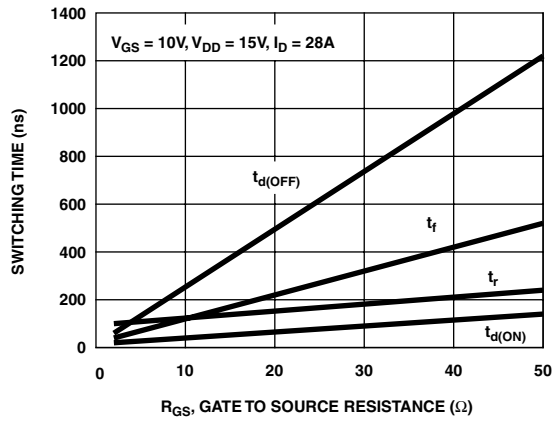


Figure 14. Switching Time vs Gate Resistance

Test Circuits and Waveforms

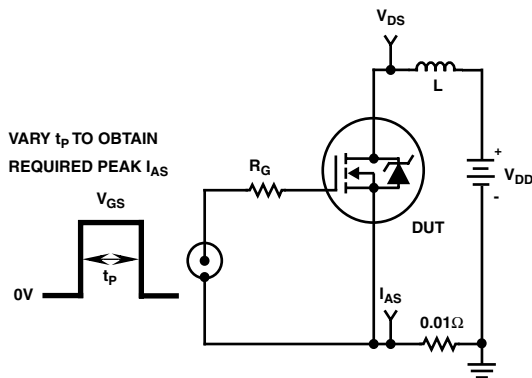


Figure 15. Unclamped Energy Test Circuit

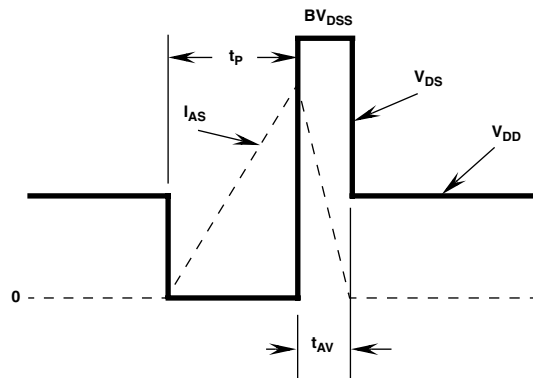


Figure 16. Unclamped Energy Waveforms

Test Circuits and Waveforms (Continued)

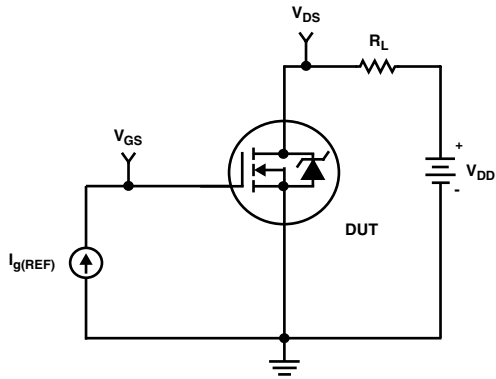


Figure 17. Gate Charge Test Circuit

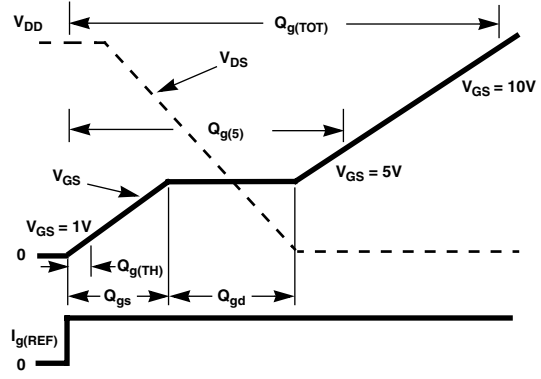


Figure 18. Gate Charge Waveforms

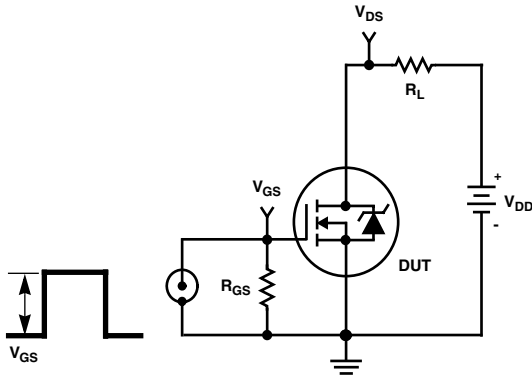


Figure 19. Switching Time Test Circuit

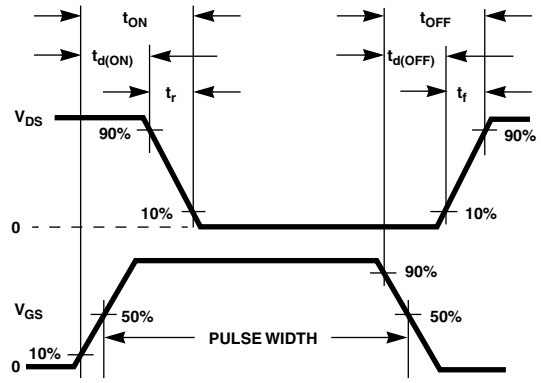


Figure 20. Switching Time Waveforms

PSPICE Electrical Model

SUBCKT ISL9N302AP3 2 1 3 ; rev Nov 2001

CA 12 8 9e-9
 Cb 15 14 5.5e-9
 Cin 6 8 1e-8

Dbody 7 5 DbodyMOD
 Dbreak 5 11 DbreakMOD
 Dplcap 10 5 DplcapMOD

Ebreak 11 7 17 18 30.4
 Eds 14 8 5 8 1
 Egs 13 8 6 8 1
 Esg 6 10 6 8 1
 Evthres 6 21 19 8 1
 Evtemp 20 6 18 22 1

It 8 17 1

Lgate 1 9 5.618e-9
 Ldrain 2 5 1e-9
 Lsource 3 7 1.98e-9

RLgate 1 9 56.1
 RLdrain 2 5 15
 RLsource 3 7 19.8

Mmed 16 6 8 8 MmedMOD
 Mstro 16 6 8 8 MstroMOD
 Mweak 16 21 8 8 MweakMOD

Rbreak 17 18 RbreakMOD 1
 Rdrain 50 16 RdrainMOD 4e-4
 Rgate 9 20 5.93e-1
 RSLC1 5 51 RSLCMOD 1e-6
 RSLC2 5 50 1e3
 Rsource 8 7 RsourceMOD 1.3e-3
 Rvthres 22 8 RvthresMOD 1
 Rvtemp 18 19 RvtempMOD 1
 S1a 6 12 13 8 S1AMOD
 S1b 13 12 13 8 S1BMOD
 S2a 6 15 14 13 S2AMOD
 S2b 13 15 14 13 S2BMOD

Vbat 22 19 DC 1

ESLC 51 50 VALUE={{(V(5,51)/ABS(V(5,51)))*(PWR(V(5,51)/(1e-6*500),3))}}

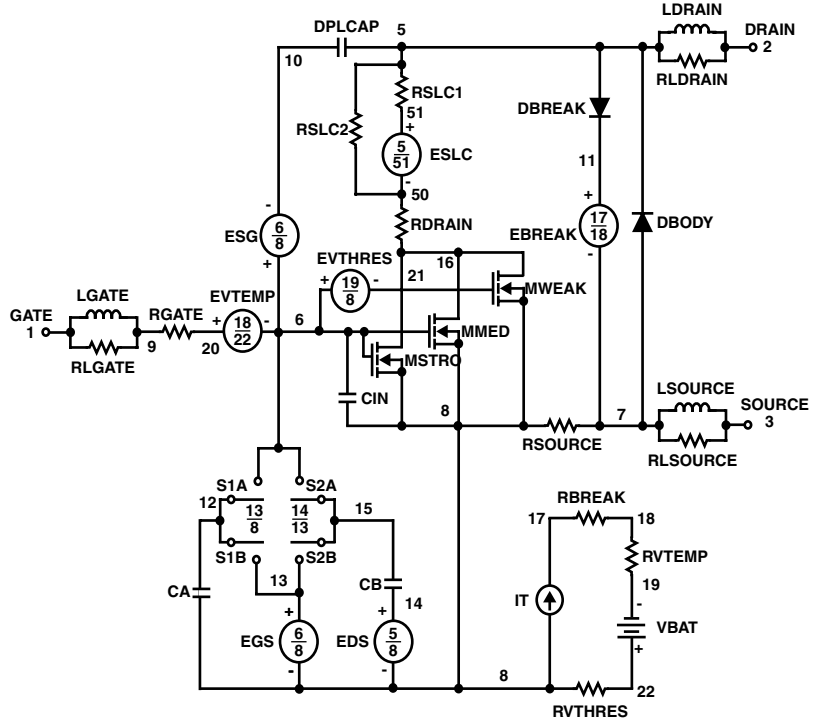
.MODEL DbodyMOD D (IS=2e-10 N=1.05 RS=1.8e-3 TRS1=9e-4 TRS2=1e-6 + CJO=4.9e-9 M=4.9e-1 TT=1e-13 XTI=0)
 .MODEL DbreakMOD D (RS=2.5e-1 TRS1=1e-3 TRS2=-8.9e-6)
 .MODEL DplcapMOD D (CJO=3.5e-9 IS=1e-30 N=10 M=4.7e-1)

.MODEL MstroMOD NMOS (VTO=2.1 KP=550 IS=1e-25 N=10 TOX=1 L=1u W=1u)
 .MODEL MmedMOD NMOS (VTO=1.6 KP=30 IS=1e-30 N=10 TOX=1 L=1u W=1u RG=5.93e-1)
 .MODEL MweakMOD NMOS (VTO=1.22 KP=1e-1 IS=1e-40 N=10 TOX=1 L=1u W=1u RG=5.93 RS=1e-1)

.MODEL RbreakMOD RES (TC1=1e-3 TC2=-7e-7)
 .MODEL RdrainMOD RES (TC1=1.2e-2 TC2=2.5e-5)
 .MODEL RSLCMOD RES (TC1=3.5e-9 TC2=5e-6)
 .MODEL RsourceMOD RES (TC1=1e-3 TC2=1e-6)
 .MODEL RvthresMOD RES (TC1=-2.9e-3 TC2=-9e-6)
 .MODEL RvtempMOD RES (TC1=-1.8e-3 TC2=1e-6)

.MODEL S1AMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=-3.5 VOFF=-1.5)
 .MODEL S1BMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=-1.5 VOFF=-3.5)
 .MODEL S2AMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=-0.4 VOFF=0.1)
 .MODEL S2BMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=0.1 VOFF=-0.4)
 .ENDS

NOTE: For further discussion of the PSPICE model, consult **A New PSPICE Sub-Circuit for the Power MOSFET Featuring Global Temperature Options**; IEEE Power Electronics Specialist Conference Records, 1991, written by William J. Hepp and C. Frank Wheatley.



SABER Electrical Model

REV Nov 2001

template ISL9N302AP3 n2,n1,n3

electrical n2,n1,n3

```

{
var i iscl
dp..model dbodymod = (isl=2e-10,nl=1.05,rs=1.8e-3,trs1=9e-4,trs2=1e-6,cjo=4.9e-9,m=4.9e-1,tt=1e-13,xti=0)
dp..model dbreakmod = (rs=2.5e-1,trs1=1e-3,trs2=-8.9e-6)
dp..model dplcapmod = (cjo=3.5e-9,isl=10e-30,nl=10,m=4.7e-1)
m..model mstrongmod = (type=_n,vto=2.1,kp=550, is=1e-25, tox=1)
m..model mmedmod = (type=_n,vto=1.6,kp=30, is=1e-30, tox=1)
m..model mweakmod = (type=_n,vto=1.22,kp=1e-1, is=1e-40, tox=1,rs=1e-1)
sw_vcsp..model s1amod = (ron=1e-5,roff=0.1,von=-3.5,voff=-1.5)
sw_vcsp..model s1bmod = (ron=1e-5,roff=0.1,von=-1.5,voff=-3.5)
sw_vcsp..model s2amod = (ron=1e-5,roff=0.1,von=-0.4,voff=0.1)
sw_vcsp..model s2bmod = (ron=1e-5,roff=0.1,von=0.1,voff=-0.4)
c.ca n12 n8 = 5e-9
c.cb n15 n14 = 5.5e-9
c.cin n6 n8 = 1e-8

```

```

dp.dbody n7 n5 = model=dbodymod
dp.dbreak n5 n11 = model=dbreakmod
dp.dplcap n10 n5 = model=dplcapmod

```

```

spe.ebreak n11 n7 n17 n18 = 30.4
spe.eds n14 n8 n5 n8 = 1
spe.egs n13 n8 n6 n8 = 1
spe.esg n6 n10 n6 n8 = 1
spe.evthres n6 n21 n19 n8 = 1
spe.evtemp n20 n6 n18 n22 = 1

```

```
i.it n8 n17 = 1
```

```

l.lgate n1 n9 = 5.618e-9
l.ldrain n2 n5 = 1e-9
l.lsource n3 n7 = 1.98e-9

```

```

res.rlgate n1 n9 = 56.1
res.rldrain n2 n5 = 15
res.rlsource n3 n7 = 19.8

```

```

m.mmed n16 n6 n8 n8 = model=mmedmod, l=1u, w=1u
m.mstrong n16 n6 n8 n8 = model=mstrongmod, l=1u, w=1u
m.mweak n16 n21 n8 n8 = model=mweakmod, l=1u, w=1u

```

```

res.rbreak n17 n18 = 1, tc1=1e-3,tc2=-7e-7
res.rdrain n50 n16 = 4e-4, tc1=1.2e-2,tc2=2.5e-5
res.rgate n9 n20 = 5.93e-1
res.rslc1 n5 n51 = 1e-6, tc1=3.5e-9,tc2=5e-6
res.rslc2 n5 n50 = 1e3
res.rsource n8 n7 = 1.3e-3, tc1=1e-3,tc2=1e-6
res.rvthres n22 n8 = 1, tc1=-2.9e-3,tc2=-9e-6
res.rvtemp n18 n19 = 1, tc1=-1.8e-3,tc2=1e-6
sw_vcsp.s1a n6 n12 n13 n8 = model=s1amod
sw_vcsp.s1b n13 n12 n13 n8 = model=s1bmod
sw_vcsp.s2a n6 n15 n14 n13 = model=s2amod
sw_vcsp.s2b n13 n15 n14 n13 = model=s2bmod

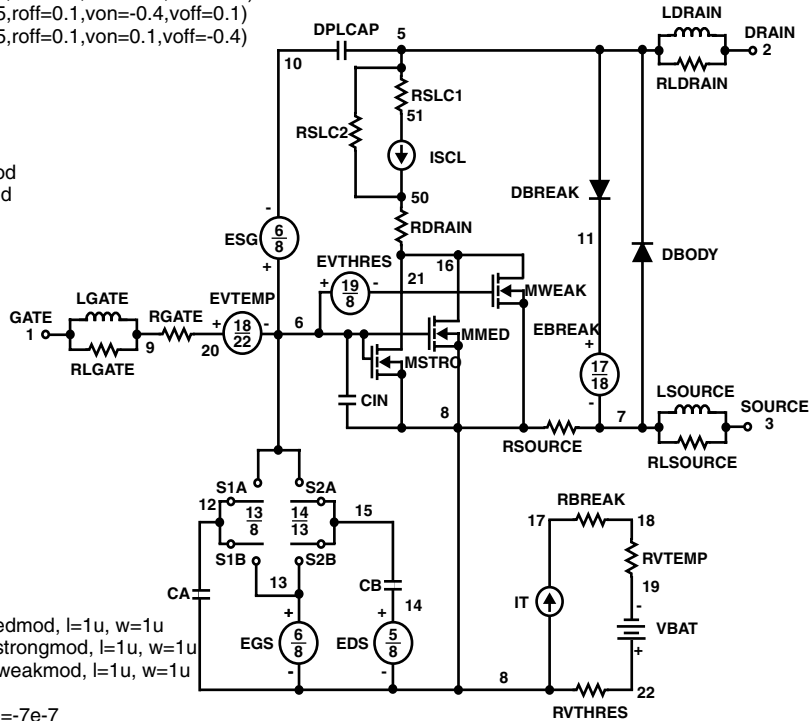
```

```
v.vbat n22 n19 = dc=1
```

```

equations {
i (n51->n50) +=iscl
iscl: v(n51,n50) = ((v(n5,n51)/(1e-9+abs(v(n5,n51)))))*((abs(v(n5,n51))*1e6/500)** 3)
}

```



SPICE Thermal Model

REV May 2001

TISL9N302AP3

CTHERM1 th 6 4.5e-3
 CTHERM2 6 5 2e-2
 CTHERM3 5 4 1.5e-2
 CTHERM4 4 3 2.5e-2
 CTHERM5 3 2 7e-2
 CTHERM6 2 tl 2.5e-1

RTHERM1 th 6 2e-3
 RTHERM2 6 5 8.5e-3
 RTHERM3 5 4 6e-2
 RTHERM4 4 3 8e-2
 RTHERM5 3 2 9e-2
 RTHERM6 2 tl 1e-1

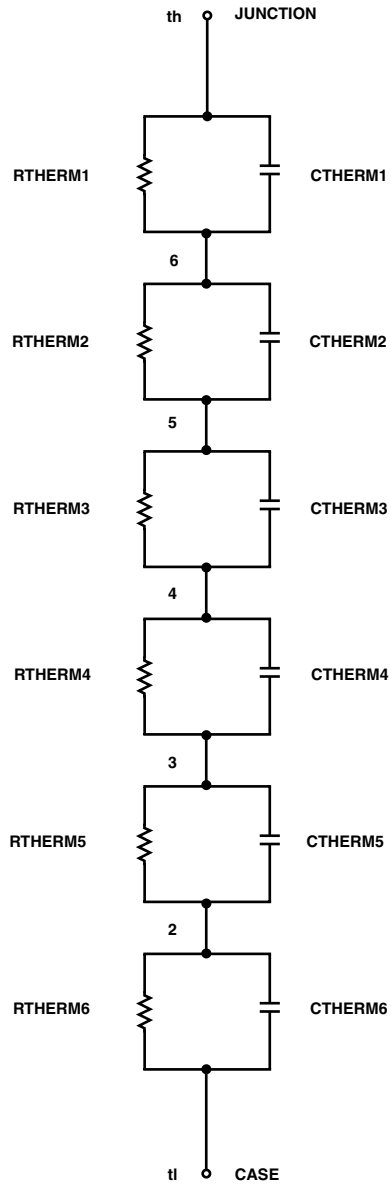
SABER Thermal Model

SABER thermal model TISL9N302AP3

```

template thermal_model th tl
thermal_c th, tl
{
  ctherm.ctherm1 th 6 = 4.5e-3
  ctherm.ctherm2 6 5 = 2e-2
  ctherm.ctherm3 5 4 = 1.5e-2
  ctherm.ctherm4 4 3 = 2.5e-2
  ctherm.ctherm5 3 2 = 7e-2
  ctherm.ctherm6 2 tl = 2.5e-1

  rtherm.rtherm1 th 6 = 2e-3
  rtherm.rtherm2 6 5 = 8.5e-3
  rtherm.rtherm3 5 4 = 6e-2
  rtherm.rtherm4 4 3 = 8e-2
  rtherm.rtherm5 3 2 = 9e-2
  rtherm.rtherm6 2 tl = 1e-1
}
    
```



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CROSSVOLT TM	GlobalOptoisolator TM	POP TM	SuperSOT TM -3	
DenseTrench TM	GTO TM	Power247 TM	SuperSOT TM -6	
DOME TM	HiSeC TM	PowerTrench [®]	SuperSOT TM -8	
EcoSPARK TM	ISOPLANAR TM	QFET TM	SyncFET TM	
E ² CMOS TM	LittleFET TM	QS TM	TinyLogic TM	
EnSigna TM	MicroFET TM	QT Optoelectronics TM	TruTranslation TM	
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