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ON Semiconductor®

# FDB8896-F085

# N-Channel PowerTrench<sup>®</sup> MOSFET 30V, 93A, $5.7m\Omega$

#### **General Description**

This N-Channel MOSFET has been designed specifically to improve the overall efficiency of DC/DC converters using either synchronous or conventional switching PWM controllers. It has been optimized for low gate charge, low  $r_{\text{DS}(\text{ON})}$  and fast switching speed.

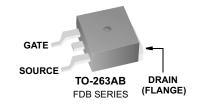
#### **Applications**

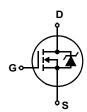
· DC/DC converters



#### **Features**

- $r_{DS(ON)} = 5.7 \text{m}\Omega$ ,  $V_{GS} = 10 \text{V}$ ,  $I_D = 35 \text{A}$
- $r_{DS(ON)} = 6.8 \text{m}\Omega$ ,  $V_{GS} = 4.5 \text{V}$ ,  $I_D = 35 \text{A}$
- High performance trench technology for extremely low r<sub>DS(ON)</sub>
- · Low gate charge
- · High power and current handling capability
- Qualified to AEC Q101
- RoHS Compliant





## MOSFET Maximum Ratings T<sub>C</sub> = 25°C unless otherwise noted

Symbol	Parameter	Ratings	Units	
V <sub>DSS</sub>	Drain to Source Voltage	30	V	
V <sub>GS</sub>	Gate to Source Voltage	±20	V	
I <sub>D</sub>	Drain Current			
	Continuous (T <sub>C</sub> = 25°C, V <sub>GS</sub> = 10V) (Note 1)	93	Α	
	Continuous (T <sub>C</sub> = 25°C, V <sub>GS</sub> = 4.5V) (Note 1)	85	Α	
	Continuous ( $T_{amb} = 25^{\circ}C$ , $V_{GS} = 10V$ , with $R_{\theta JA} = 43^{\circ}C/W$ )	19	Α	
	Pulsed	Figure 4	Α	
E <sub>AS</sub>	Single Pulse Avalanche Energy (Note 2)	74	mJ	
P <sub>D</sub>	Power dissipation	80	W	
	Derate above 25°C	0.53	W/°C	
T <sub>J</sub> , T <sub>STG</sub>	Operating and Storage Temperature	-55 to 175	°C	

#### **Thermal Characteristics**

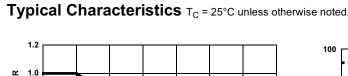
$R_{\theta JC}$	Thermal Resistance Junction to Case TO-263	1.88	°C/W
$R_{\theta JA}$	Thermal Resistance Junction to Ambient TO-263 ( Note 3)	62	°C/W
$R_{\theta JA}$	Thermal Resistance Junction to Ambient TO-263, 1in <sup>2</sup> copper pad area	43	°C/W

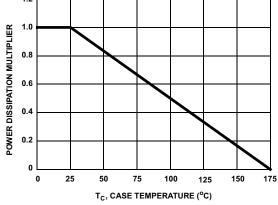
#### **Package Marking and Ordering Information**

Device Marking	Device	Package	Reel Size	Tape Width	Quantity
FDB8896	FDB8896-F085	TO-263AB	330mm	24mm	800 units

Symbol	Parameter	Test Conditions	Min	Тур	Max	Units
Off Chara	ecteristics					
B <sub>VDSS</sub>	Drain to Source Breakdown Voltage	I <sub>D</sub> = 250μA, V <sub>GS</sub> = 0V	30	-	-	V
I <sub>DSS</sub>	Zero Gate Voltage Drain Current	V <sub>DS</sub> = 24V	-	-	1	μΑ
		$V_{GS} = 0V$ $T_C = 150^{\circ}C$	-	-	250	
$I_{GSS}$	Gate to Source Leakage Current	$V_{GS} = \pm 20V$	-	-	±100	nA
On Chara	ecteristics					
V <sub>GS(TH)</sub>	Gate to Source Threshold Voltage	$V_{GS} = V_{DS}, I_{D} = 250 \mu A$	1.2	-	2.5	V
00(111)	Take to course timeshed temage	I <sub>D</sub> = 35A, V <sub>GS</sub> = 10V	-	0.0049	0.0057	
_	Desire to Course On Bosisters	I <sub>D</sub> = 35A, V <sub>GS</sub> = 4.5V	-	0.0059	0.0068	
r <sub>DS(ON)</sub>	Drain to Source On Resistance	$I_D = 35A, V_{GS} = 10V,$ $T_J = 175^{\circ}C$	-	0.0078	0.0094	Ω
Dynamia	Characteristics	0				
C <sub>ISS</sub>	Characteristics Input Capacitance	1	_	2525	-	pF
	Output Capacitance	$V_{DS} = 15V, V_{GS} = 0V,$		490	_	рF
C <sub>OSS</sub>	Reverse Transfer Capacitance	f = 1MHz		300	_	рF
R <sub>G</sub>	Gate Resistance	V <sub>GS</sub> = 0.5V, f = 1MHz	+	2.3	_	Ω
Q <sub>q(TOT)</sub>	Total Gate Charge at 10V	V <sub>GS</sub> = 0V to 10V	_	48	67	nC
$Q_{g(5)}$	Total Gate Charge at 5V	V <sub>GS</sub> = 0V to 5V	-	25	36	nC
Q <sub>g(TH)</sub>	Threshold Gate Charge	$V_{DD} = 15V$	_	2.3	3.0	nC
Q <sub>qs</sub>	Gate to Source Gate Charge	ID 00/1	_	8	-	nC
Q <sub>gs2</sub>	Gate Charge Threshold to Plateau	I <sub>g</sub> = 1.0mA	-	5.7	-	nC
Q <sub>gd</sub>	Gate to Drain "Miller" Charge		-	9.5	-	nC
	g Characteristics (V <sub>GS</sub> = 10V)		I.	I	I.	
ton	Turn-On Time		T -	_	167	ns
t <sub>d(ON)</sub>	Turn-On Delay Time	$\dashv$	_	9	-	ns
t <sub>r</sub>	Rise Time	V <sub>DD</sub> = 15V, I <sub>D</sub> = 35A	_	102	_	ns
t <sub>d(OFF)</sub>	Turn-Off Delay Time	$V_{GS} = 4.5V, R_{GS} = 6.2\Omega$	_	58	_	ns
t <sub>f</sub>	Fall Time		_	44	-	ns
toff	Turn-Off Time		-	-	153	ns
	urce Diode Characteristics	•	ı			
	T	I <sub>SD</sub> = 35A	-	-	1.25	V
$V_{SD}$	Source to Drain Diode Voltage	I <sub>SD</sub> = 20A	-	-	1.0	V
t <sub>rr</sub>	Reverse Recovery Time	$I_{SD} = 35A, dI_{SD}/dt = 100A/\mu s$	-	-	27	ns
Q <sub>RR</sub>	Reverse Recovered Charge	I <sub>SD</sub> = 35A, dI <sub>SD</sub> /dt = 100A/μs		_	12	nC

- Notes: 1: Package current limitation is 80A. 2: Starting  $T_J$  = 25°C, L = 36 $\mu$ H,  $I_{AS}$  = 64A,  $V_{DD}$  = 27V,  $V_{GS}$  = 10V. 3: Pulse width = 100s.





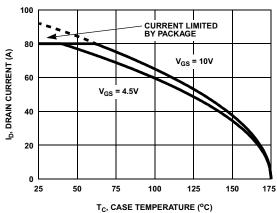


Figure 1. Normalized Power Dissipation vs Case Temperature

Figure 2. Maximum Continuous Drain Current vs Case Temperature

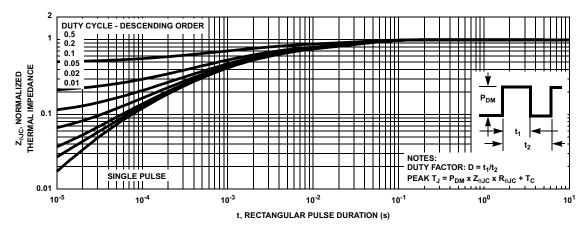


Figure 3. Normalized Maximum Transient Thermal Impedance

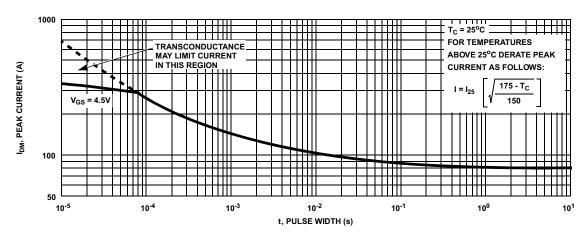


Figure 4. Peak Current Capability



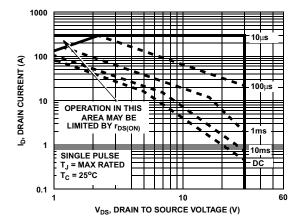


Figure 5. Forward Bias Safe Operating Area

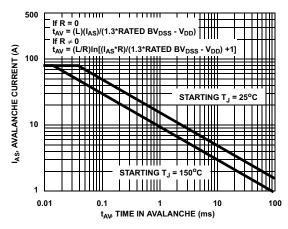


Figure 6. Unclamped Inductive Switching Capability

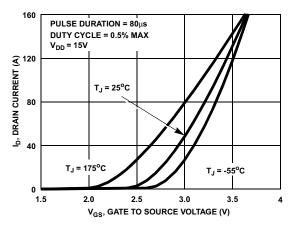


Figure 7. Transfer Characteristics

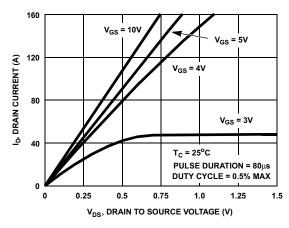


Figure 8. Saturation Characteristics

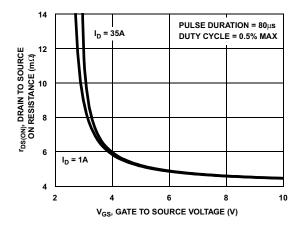


Figure 9. Drain to Source On Resistance vs Gate Voltage and Drain Current

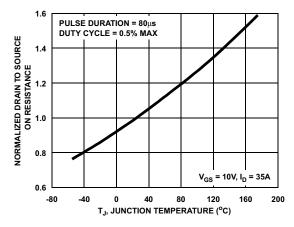


Figure 10. Normalized Drain to Source On Resistance vs Junction Temperature

# **Typical Characteristics** T<sub>C</sub> = 25°C unless otherwise noted

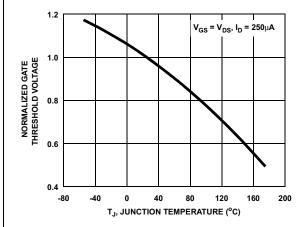


Figure 11. Normalized Gate Threshold Voltage vs Junction Temperature

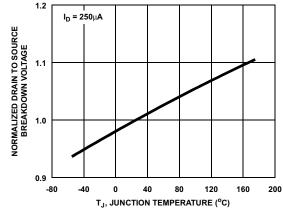


Figure 12. Normalized Drain to Source Breakdown Voltage vs Junction Temperature

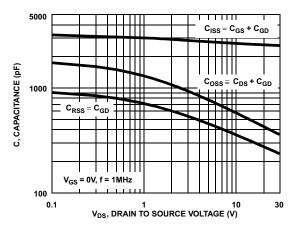


Figure 13. Capacitance vs Drain to Source Voltage

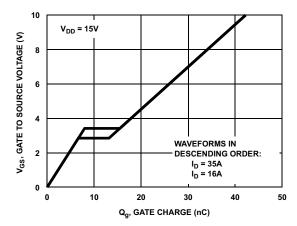


Figure 14. Gate Charge Waveforms for Constant Gate Current

## **Test Circuits and Waveforms**

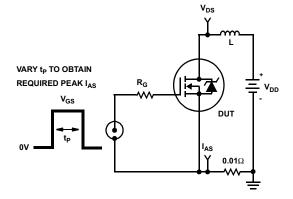


Figure 15. Unclamped Energy Test Circuit

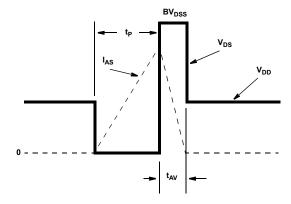


Figure 16. Unclamped Energy Waveforms

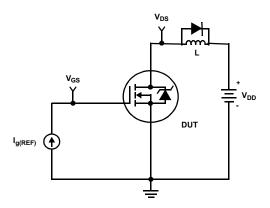


Figure 17. Gate Charge Test Circuit

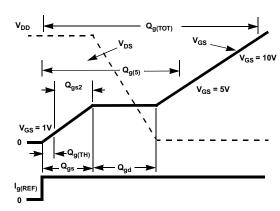


Figure 18. Gate Charge Waveforms

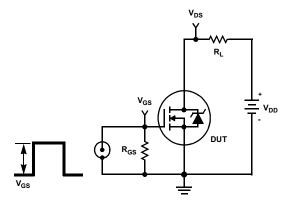


Figure 19. Switching Time Test Circuit

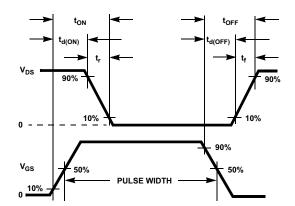


Figure 20. Switching Time Waveforms

#### Thermal Resistance vs. Mounting Pad Area

The maximum rated junction temperature,  $T_{JM}$ , and the thermal resistance of the heat dissipating path determines the maximum allowable device power dissipation,  $P_{DM}$ , in an application. Therefore the application's ambient temperature,  $T_A$  (°C), and thermal resistance  $R_{\theta JA}$  (°C/W) must be reviewed to ensure that  $T_{JM}$  is never exceeded. Equation 1 mathematically represents the relationship and serves as the basis for establishing the rating of the part.

$$P_{DM} = \frac{(T_{JM} - T_A)}{R_{\theta JA}} \tag{EQ. 1}$$

In using surface mount devices such as the TO-263 package, the environment in which it is applied will have a significant influence on the part's current and maximum power dissipation ratings. Precise determination of  $P_{DM}$  is complex and influenced by many factors:

- Mounting pad area onto which the device is attached and whether there is copper on one side or both sides of the board.
- The number of copper layers and the thickness of the board.
- 3. The use of external heat sinks.
- 4. The use of thermal vias.
- 5. Air flow and board orientation.
- For non steady state applications, the pulse width, the duty cycle and the transient thermal response of the part, the board and the environment they are in.

ON Semiconductor provides thermal information to assist the designer's preliminary application evaluation. Figure 21

defines the  $R_{\theta JA}$  for the device as a function of the top copper (component side) area. This is for a horizontally positioned FR-4 board with 1oz copper after 1000 seconds of steady state power with no air flow. This graph provides the necessary information for calculation of the steady state junction temperature or power dissipation. Pulse applications can be evaluated using the ON Semiconductor device Spice thermal model or manually utilizing the normalized maximum transient thermal impedance curve.

Thermal resistances corresponding to other copper areas can be obtained from Figure 21 or by calculation using Equation 2 or 3. Equation 2 is used for copper area defined in inches square and equation 3 is for area in centimeters square. The area, in square inches or square centimeters is

$$R_{\theta JA} = 26.51 + \frac{19.84}{(0.262 + Area)}$$
 (EQ. 2)

Area in Inches Squared

$$R_{\theta JA} = 26.51 + \frac{128}{(1.69 + Area)}$$
 (EQ. 3)

Area in Centimeters Squared

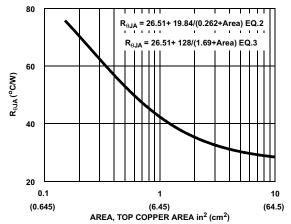
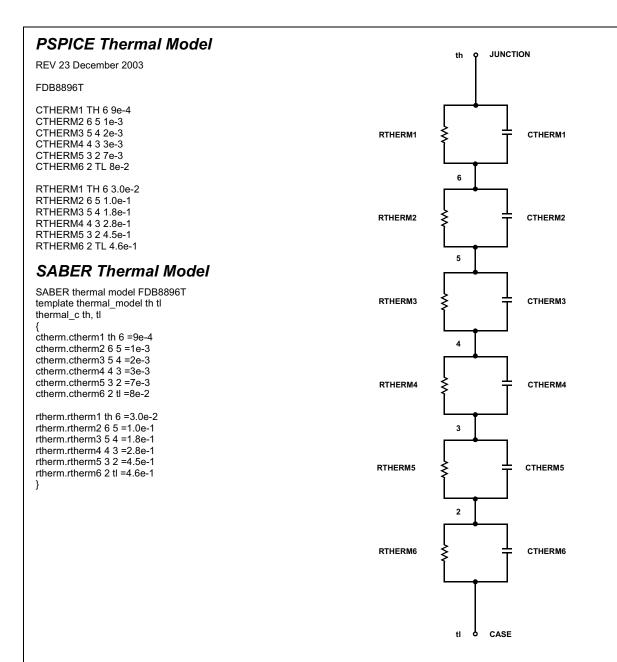


Figure 21. Thermal Resistance vs Mounting
Pad Area

#### **PSPICE Electrical Model** .SUBCKT FDB8896 2 1 3 ; rev December 2003 Ca 12 8 2 3e-9 LDRAIN DPLCAP DRAIN Cb 15 14 2.3e-9 Cin 6 8 2.3e-9 10 RLDRAIN RSLC1 Dbody 7 5 DbodyMOD DBREAK Dbreak 5 11 DbreakMOD RSLC2 Dplcap 10 5 DplcapMOD FSI C 11 Ebreak 11 7 17 18 33 50 Eds 14 8 5 8 1 17 18 DBODY RDRAIN EBREAK **ESG** Egs 13 8 6 8 1 **FVTHRFS** Esg 6 10 6 8 1 $\binom{19}{8}$ MWFAK Evthres 6 21 19 8 1 LGATE **EVTEMP** Evtemp 20 6 18 22 1 GATE **RGATE** (18 22 国 MMFD 9 20 MSTR It 8 17 1 RI GATE LSOURCE CIN SOURCE Lgate 1 9 5.5e-9 Ldrain 2 5 1.0e-9 RSOURCE I source 3 7 2 7e-9 RLSOURCE RBREAK RLgate 1 9 55 13 8 18 RLdrain 2 5 10 RLsource 3 7 27 RVTEMP S<sub>1</sub>B o S2B СВ 19 CA Mmed 16 6 8 8 MmedMOD ΙT 14 Mstro 16 6 8 8 MstroMOD VBAT EGS Mweak 16 21 8 8 MweakMOD 8 Rbreak 17 18 RbreakMOD 1 **RVTHRES** Rdrain 50 16 RdrainMOD 2.1e-3 Rgate 9 20 2.3 RSLC1 5 51 RSLCMOD 1e-6 RSLC2 5 50 1e3 Rsource 8 7 RsourceMOD 2e-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),10))} .MODEL DbodyMOD D (IS=4E-12 IKF=10 N=1.01 RS=2.6e-3 TRS1=8e-4 TRS2=2e-7 + CJO=8.8e-10 M=0.57 TT=1e-16 XTI=2.2) .MODEL DbreakMOD D (RS=8e-2 TRS1=1e-3 TRS2=-8.9e-6) .MODEL DplcapMOD D (CJO=9.4e-10 IS=1e-30 N=10 M=0.4) .MODEL MmedMOD NMOS (VTO=1.98 KP=10 IS=1e-30 N=10 TOX=1 L=1u W=1u RG=2.3 T ABS=25) .MODEL MstroMOD NMOS (VTO=2.4 KP=350 IS=1e-30 N=10 TOX=1 L=1u W=1u T ABS=25) .MODEL MweakMOD NMOS (VTO=1.68 KP=0.05 IS=1e-30 N=10 TOX=1 L=1u W=1u RG=23 RS=0.1 T\_ABS=25) .MODEL RbreakMOD RES (TC1=8.3e-4 TC2=-4e-7) .MODEL RdrainMOD RES (TC1=1.2e-3 TC2=8e-6) .MODEL RSLCMOD RES (TC1=9e-4 TC2=1e-6) .MODEL RsourceMOD RES (TC1=7.5e-3 TC2=1e-6) .MODEL RvthresMOD RES (TC1=-2.4e-3 TC2=-8.8e-6) .MODEL RytempMOD RES (TC1=-2.6e-3 TC2=2e-7) .MODEL S1AMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=-4 VOFF=-3) .MODEL S1BMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=-3 VOFF=-4) .MODEL S2AMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=-2 VOFF=-0.5) .MODEL S2BMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=-0.5 VOFF=-2) **FNDS** 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 December 2003
template FDB8896 n2,n1,n3 =m temp
electrical n2,n1,n3
number m_temp=25
dp..model dbodymod = (isl=4e-12,ikf=10,nl=1.01,rs=2.6e-3,trs1=8e-4,trs2=2e-7,cjo=8.8e-10,m=0.57,tt=1e-16,xti=2.2)
dp..model dbreakmod = (rs=8e-2,trs1=1e-3,trs2=-8.9e-6)
dp..model dplcapmod = (cjo=9.4e-10,isl=10e-30,nl=10,m=0.4)
m..model mmedmod = (type=_n, vto=1.98, kp=10, is=1e-30, tox=1)
m..model mstrongmod = (type=_n,vto=2.4,kp=350,is=1e-30, tox=1)
m..model mweakmod = (type=_n,vto=1.68,kp=0.05,is=1e-30,tox=1,rs=0.1)
                                                                                                            LDRAIN
sw_vcsp..model s1amod = (ron=1e-5,roff=0.1,von=-4,voff=-3)
                                                                    DPLCAP
                                                                                                                     DRAIN
sw_vcsp..model s1bmod = (ron=1e-5,roff=0.1,von=-3,voff=-4)
                                                                 10
sw vcsp..model s2amod = (ron=1e-5,roff=0.1,von=-2,voff=-0.5)
                                                                                                           RLDRAIN
sw vcsp..model s2bmod = (ron=1e-5,roff=0.1,von=-0.5,voff=-2)
                                                                               RSLC1
c.ca n12 n8 = 2.3e-9
                                                                               51
                                                                  RSLC2 ₹
c.cb n15 n14 = 2.3e-9
                                                                                 ISCI
c.cin n6 n8 = 2.3e-9
                                                                                           DBREAK
                                                                                50
dp.dbody n7 n5 = model=dbodymod
                                                                               RDRAIN
                                                               <u>6</u>8
dp.dbreak n5 n11 = model=dbreakmod
                                                          FSG
                                                                                                           DBODY
dp.dplcap n10 n5 = model=dplcapmod
                                                                    EVTHRES
                                                                       19
8
                                                                                            MWEAK
                                         LGATE
                                                        EVTEMP
spe.ebreak n11 n7 n17 n18 = 33
                                  GATE
                                                                                 ₩МЕD
                                                                                             EBREAK
spe.eds n14 n8 n5 n8 = 1
                                                                          ✓MSTRO
spe.eqs n13 n8 n6 n8 = 1
                                         RLGATE
spe.esg n6 n10 n6 n8 = 1
                                                                                                           LSOURCE
spe.evthres n6 n21 n19 n8 = 1
                                                                          CIN
                                                                                                                    SOURCE
spe.evtemp n20 n6 n18 n22 = 1
                                                                                          RSOURCE
                                                                                                          RLSOURCE
i.it n8 n17 = 1
                                                                                                RBREAK
                                                                  <u>14</u>
13
I.lgate n1 n9 = 5.5e-9
I.Idrain n2 n5 = 1.0e-9
                                                                                                        ₹RVTEMP
                                                         S1B
                                                                  o S2B
I.Isource n3 n7 = 2.7e-9
                                                                                                         19
                                                   CA
                                                                                           IT
                                                                                              (♠)
                                                                              14
res.rlgate n1 n9 = 55
                                                                                                           VBAT
res.rldrain n2 n5 = 10
                                                            EGS
                                                                      EDS
res.rlsource n3 n7 = 27
m.mmed n16 n6 n8 n8 = model=mmedmod, I=1u, w=1u, temp=m_temp
                                                                                               RVTHRES
m.mstrong n16 n6 n8 n8 = model=mstrongmod, l=1u, w=1u, temp=m_temp
m.mweak n16 n21 n8 n8 = model=mweakmod, l=1u, w=1u, temp=m_temp
res.rbreak n17 n18 = 1, tc1=8.3e-4,tc2=-4e-7
res.rdrain n50 n16 = 2.1e-3, tc1=1.2e-3,tc2=8e-6
res.rgate n9 n20 = 2.3
res.rslc1 n5 n51 = 1e-6, tc1=9e-4,tc2=1e-6
res.rslc2 n5 n50 = 1e3
res.rsource n8 n7 = 2e-3, tc1=7.5e-3,tc2=1e-6
res.rvthres n22 n8 = 1, tc1=-2.4e-3,tc2=-8.8e-6
res.rvtemp n18 n19 = 1. tc1=-2.6e-3.tc2=2e-7
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 {
(v(n51,n50) = ((v(n5,n51)/(1e-9+abs(v(n5,n51))))*((abs(v(n5,n51)*1e6/500))** 10))
```



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