

FDD8870 / FDU8870

N-Channel PowerTrench® MOSFET 30V, 160A, 3.9mΩ

General Description

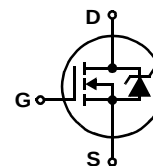
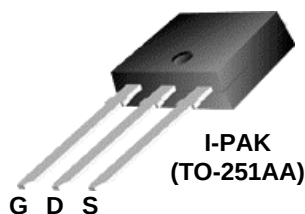
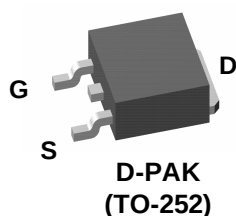
This N-Channel MOSFET has been designed specifically to improve the overall efficiency of DC/DC converters using either synchronous or conventional switching PWM controllers. It has been optimized for low gate charge, low $r_{DS(ON)}$ and fast switching speed.

Applications

- DC/DC converters

Features

- $r_{DS(ON)} = 3.9m\Omega$ $V_{GS} = 10V$, $I_D = 35A$
- $r_{DS(ON)} = 4.4m\Omega$ $V_{GS} = 4.5V$, $I_D = 35A$
- High performance trench technology for extremely low $r_{DS(ON)}$
- Low gate charge
- High power and current handling capability



MOSFET Maximum Ratings $T_C = 25^\circ\text{C}$ 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 ($T_C = 25^\circ\text{C}$, $V_{GS} = 10V$) (Note 1)	160	A
	Continuous ($T_C = 25^\circ\text{C}$, $V_{GS} = 4.5V$) (Note 1)	150	A
	Continuous ($T_{amb} = 25^\circ\text{C}$, $V_{GS} = 10V$, with $R_{\theta JA} = 52^\circ\text{C/W}$)	21	A
	Pulsed	Figure 4	A
E_{AS}	Single Pulse Avalanche Energy (Note 2)	690	mJ
P_D	Power dissipation	160	W
	Derate above 25°C	1.07	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-252, TO-251	0.94	$^\circ\text{C/W}$
$R_{\theta JA}$	Thermal Resistance Junction to Ambient TO-252, TO-251	100	$^\circ\text{C/W}$
$R_{\theta JA}$	Thermal Resistance Junction to Ambient TO-252, 1in ² copper pad area	52	$^\circ\text{C/W}$

Package Marking and Ordering Information

Device Marking	Device	Package	Reel Size	Tape Width	Quantity
FDD8870	FDD8870	TO-252AA	13"	12mm	2500 units
FDU8870	FDU8870	TO-251AA	Tube	N/A	75 units

Electrical Characteristics $T_C = 25^\circ\text{C}$ 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	$V_{DS} = 24\text{V}$ $V_{GS} = 0\text{V}$ $T_C = 150^\circ\text{C}$	-	-	1 250	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	$V_{GS} = V_{DS}$, $I_D = 250\mu\text{A}$	1.2	-	2.5	V
$r_{DS(ON)}$	Drain to Source On Resistance	$I_D = 35\text{A}$, $V_{GS} = 10\text{V}$	-	0.0032	0.0039	Ω
		$I_D = 35\text{A}$, $V_{GS} = 4.5\text{V}$	-	0.0036	0.0044	
		$I_D = 35\text{A}$, $V_{GS} = 10\text{V}$, $T_J = 175^\circ\text{C}$	-	0.0051	0.0063	

Dynamic Characteristics

C_{ISS}	Input Capacitance	$V_{DS} = 15\text{V}$, $V_{GS} = 0\text{V}$, $f = 1\text{MHz}$	-	5160	-	pF
C_{OSS}	Output Capacitance		-	990	-	pF
C_{RSS}	Reverse Transfer Capacitance		-	590	-	pF
R_G	Gate Resistance	$V_{GS} = 0.5\text{V}$, $f = 1\text{MHz}$	-	2.1	-	Ω
$Q_{g(TOT)}$	Total Gate Charge at 10V	$V_{GS} = 0\text{V}$ to 10V	-	91	118	nC
$Q_{g(5)}$	Total Gate Charge at 5V	$V_{GS} = 0\text{V}$ to 5V	-	48	62	nC
$Q_{g(TH)}$	Threshold Gate Charge	$V_{GS} = 0\text{V}$ to 1V	-	5	6.5	nC
Q_{gs}	Gate to Source Gate Charge	$V_{DD} = 15\text{V}$ $I_D = 35\text{A}$ $I_g = 1.0\text{mA}$	-	14	-	nC
Q_{gs2}	Gate Charge Threshold to Plateau		-	9	-	nC
Q_{gd}	Gate to Drain "Miller" Charge		-	18	-	nC

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

t_{ON}	Turn-On Time	$V_{DD} = 15\text{V}$, $I_D = 35\text{A}$ $V_{GS} = 10\text{V}$, $R_{GS} = 3.3\Omega$	-	-	139	ns
$t_{d(ON)}$	Turn-On Delay Time		-	9	-	ns
t_r	Rise Time		-	83	-	ns
$t_{d(OFF)}$	Turn-Off Delay Time		-	83	-	ns
t_f	Fall Time		-	42	-	ns
t_{OFF}	Turn-Off Time		-	-	189	ns

Drain-Source Diode Characteristics

V_{SD}	Source to Drain Diode Voltage	$I_{SD} = 35\text{A}$	-	-	1.25	V
		$I_{SD} = 15\text{A}$	-	-	1.0	V
t_{rr}	Reverse Recovery Time	$I_{SD} = 35\text{A}$, $dI_{SD}/dt = 100\text{A}/\mu\text{s}$	-	-	37	ns
Q_{RR}	Reverse Recovered Charge	$I_{SD} = 35\text{A}$, $dI_{SD}/dt = 100\text{A}/\mu\text{s}$	-	-	21	nC

Notes:

- 1: Package current limitation is 35A.
- 2: Starting $T_J = 25^\circ\text{C}$, $L = 1.77\text{mH}$, $I_{AS} = 28\text{A}$, $V_{DD} = 27\text{V}$, $V_{GS} = 10\text{V}$.

Typical Characteristics $T_C = 25^\circ\text{C}$ unless otherwise noted



Figure 1. Normalized Power Dissipation vs Case Temperature

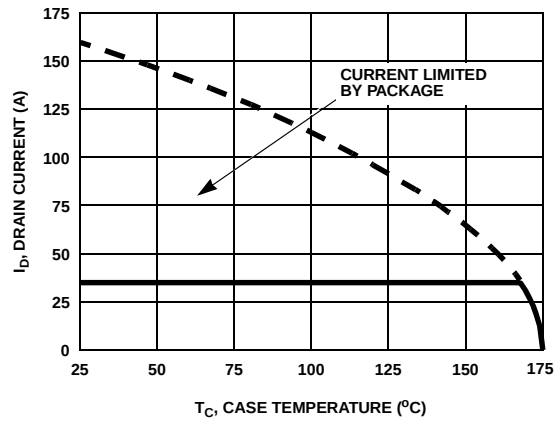


Figure 2. Maximum Continuous Drain Current vs Case Temperature



Figure 3. Normalized Maximum Transient Thermal Impedance

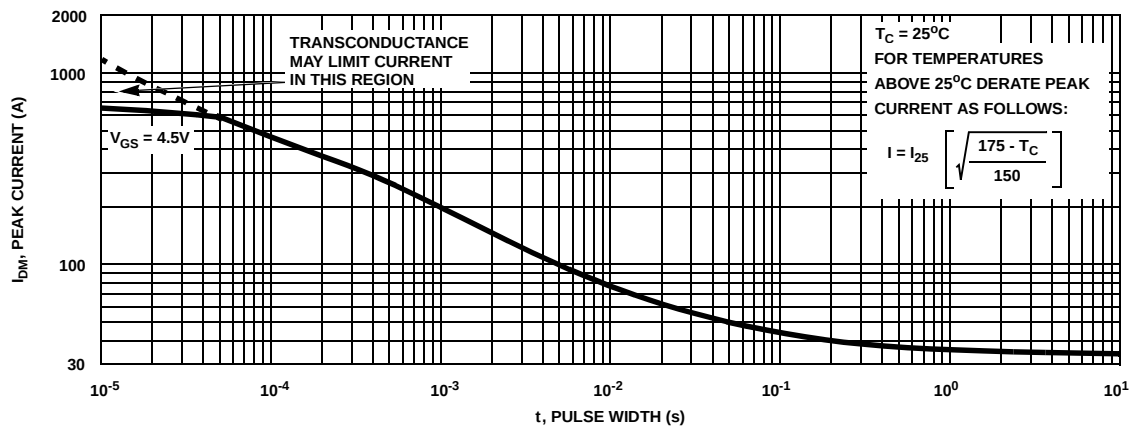


Figure 4. Peak Current Capability

Typical Characteristics $T_C = 25^\circ\text{C}$ unless otherwise noted

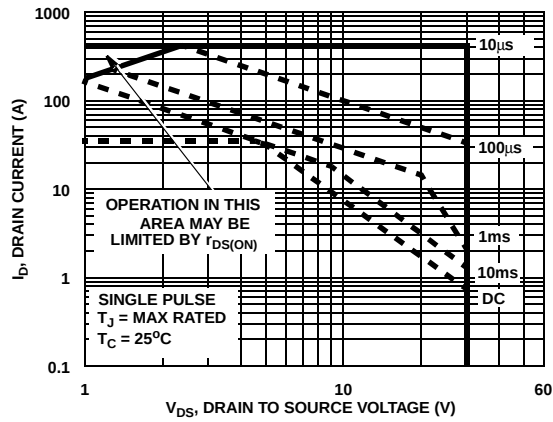
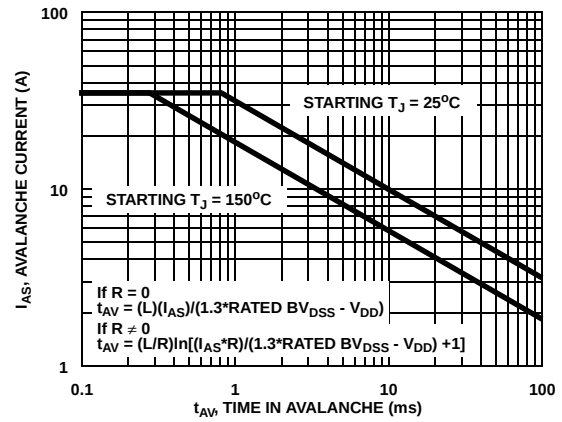


Figure 5. Forward Bias Safe Operating Area



NOTE: Refer to Fairchild Application Notes AN7514 and AN7515
Figure 6. Unclamped Inductive Switching Capability

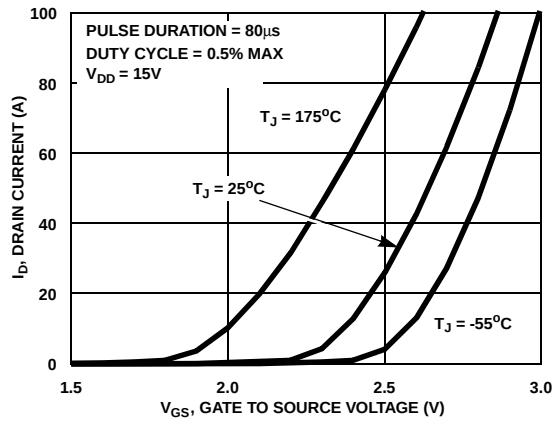


Figure 7. Transfer Characteristics

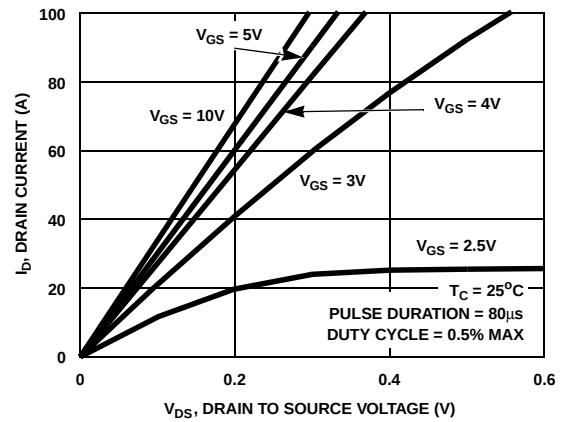


Figure 8. Saturation Characteristics

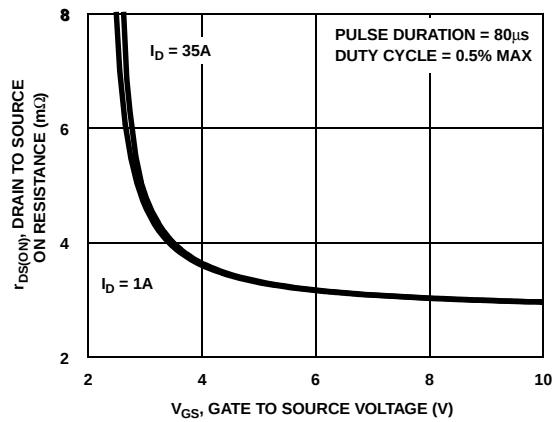


Figure 9. Drain to Source On Resistance vs Gate Voltage and Drain Current

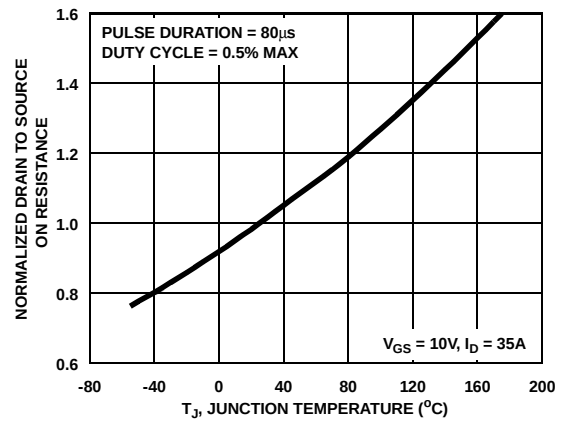


Figure 10. Normalized Drain to Source On Resistance vs Junction Temperature

Typical Characteristics $T_C = 25^\circ\text{C}$ unless otherwise noted

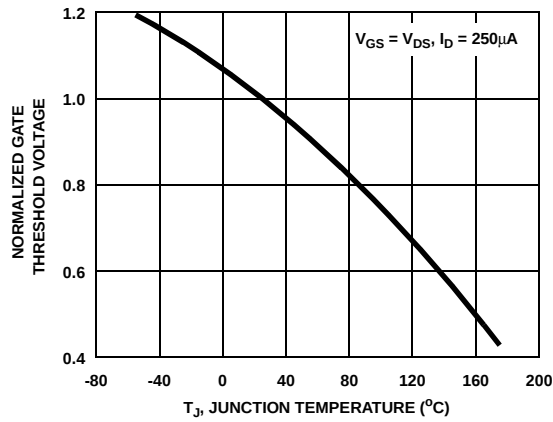


Figure 11. Normalized Gate Threshold Voltage vs Junction Temperature



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

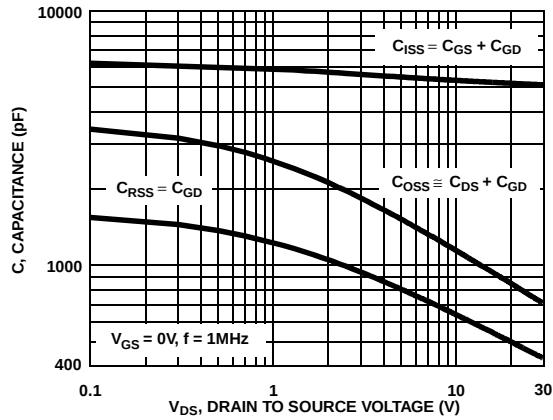


Figure 13. Capacitance vs Drain to Source Voltage

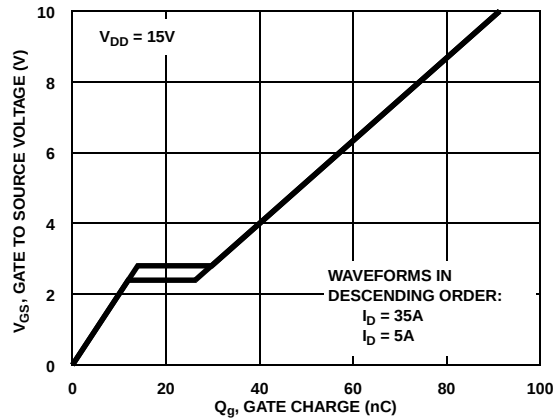


Figure 14. Gate Charge Waveforms for Constant Gate Current

Test Circuits and Waveforms



Figure 15. Unclamped Energy Test Circuit



Figure 16. Unclamped Energy Waveforms



Figure 17. Gate Charge Test Circuit

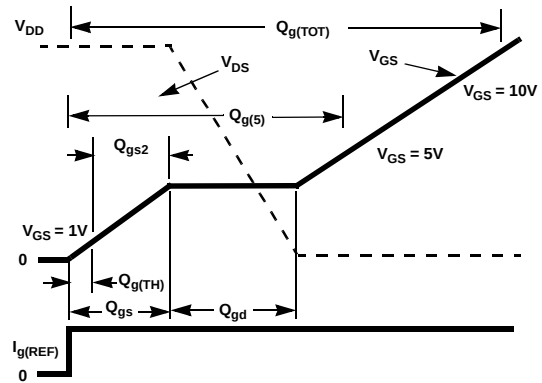


Figure 18. Gate Charge Waveforms



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 ($^{\circ}\text{C}$), and thermal resistance $R_{\theta JA}$ ($^{\circ}\text{C}/\text{W}$) 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.

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

In using surface mount devices such as the TO-252 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:

1. Mounting pad area onto which the device is attached and whether there is copper on one side or both sides of the board.
2. 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.
6. 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.

Fairchild 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 Fairchild 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 the top copper area including the gate and source pads.

$$R_{\theta JA} = 33.32 + \frac{23.84}{(0.268 + \text{Area})} \quad (\text{EQ. 2})$$

Area in Inches Squared

$$R_{\theta JA} = 33.32 + \frac{154}{(1.73 + \text{Area})} \quad (\text{EQ. 3})$$

Area in Centimeters Squared

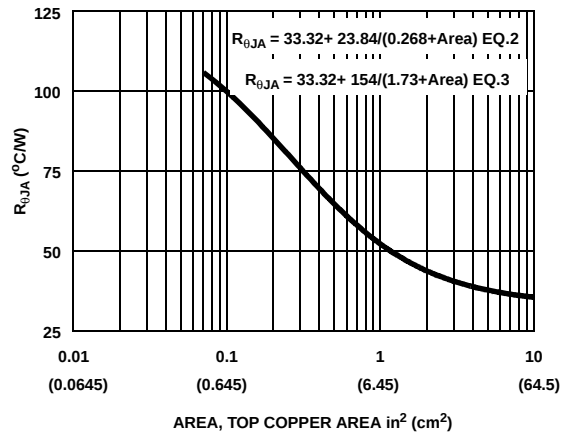


Figure 21. Thermal Resistance vs Mounting Pad Area

PSPICE Electrical Model

.SUBCKT FDD8870 2 1 3 ; rev July 2003

Ca 12 8 4.2e-9

Cb 15 14 4.2e-9

Cin 6 8 4.7e-9

Dbody 7 5 DbodyMOD

Dbreak 5 11 DbreakMOD

Dplcap 10 5 DplcapMOD

Ebreak 11 7 17 18 32.7

Eds 14 8 5 8 1

Egs 13 8 6 8 1

Esg 6 10 6 8 1

Evthres 6 21 19 8 1

Etemp 20 6 18 22 1

It 8 17 1

Lgate 1 9 5e-9

Ldrain 2 5 1.0e-9

Lsource 3 7 2e-9

RLgate 1 9 50

RLdrain 2 5 10

RLsource 3 7 20

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 1.57e-3

Rgate 9 20 2.1

RSLC1 5 51 RSLCMOD 1e-6

RSLC2 5 50 1e3

Rsource 8 7 RsourceMOD 1.2e-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=1.3E-11 IKF=10 N=1.01 RS=1.8e-3 TRS1=8e-4 TRS2=2e-7
+ CJO=2e-9 M=0.57 TT=1e-10 XTI=0.9)

.MODEL DbreakMOD D (RS=8e-2 TRS1=1e-3 TRS2=-8.9e-6)

.MODEL DplcapMOD D (CJO=1.6e-9 IS=1e-30 N=10 M=0.38)

.MODEL MmedMOD NMOS (VTO=1.76 KP=10 IS=1e-30 N=10 TOX=1 L=1u W=1u RG=2.1 T_ABS=25)

.MODEL MstroMOD NMOS (VTO=2.2 KP=650 IS=1e-30 N=10 TOX=1 L=1u W=1u T_ABS=25)

.MODEL MweakMOD NMOS (VTO=1.47 KP=0.05 IS=1e-30 N=10 TOX=1 L=1u W=1u RG=21 RS=0.1 T_ABS=25)

.MODEL RbreakMOD RES (TC1=8.3e-4 TC2=-4e-7)

.MODEL RdrainMOD RES (TC1=2e-4 TC2=8e-6)

.MODEL RSLCMOD RES (TC1=9e-4 TC2=1e-6)

.MODEL RsourceMOD RES (TC1=8e-3 TC2=1e-6)

.MODEL RvthresMOD RES (TC1=-2e-3 TC2=-9.5e-6)

.MODEL RvtempMOD RES (TC1=-2.6e-3 TC2=2e-7)

.MODEL S1AMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=-4 VOFF=-3)

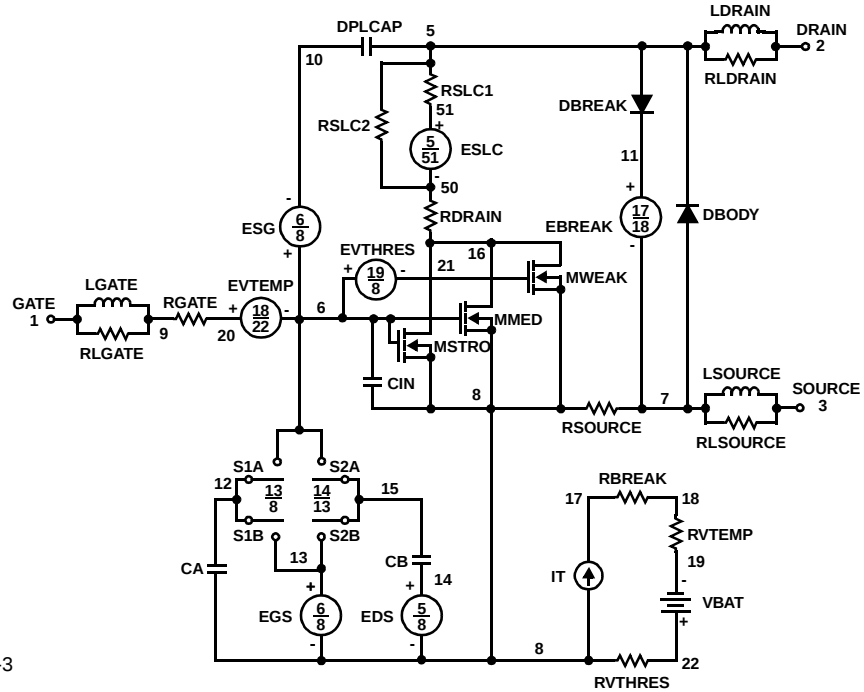
.MODEL S1BMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=-3 VOFF=-4)

.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)

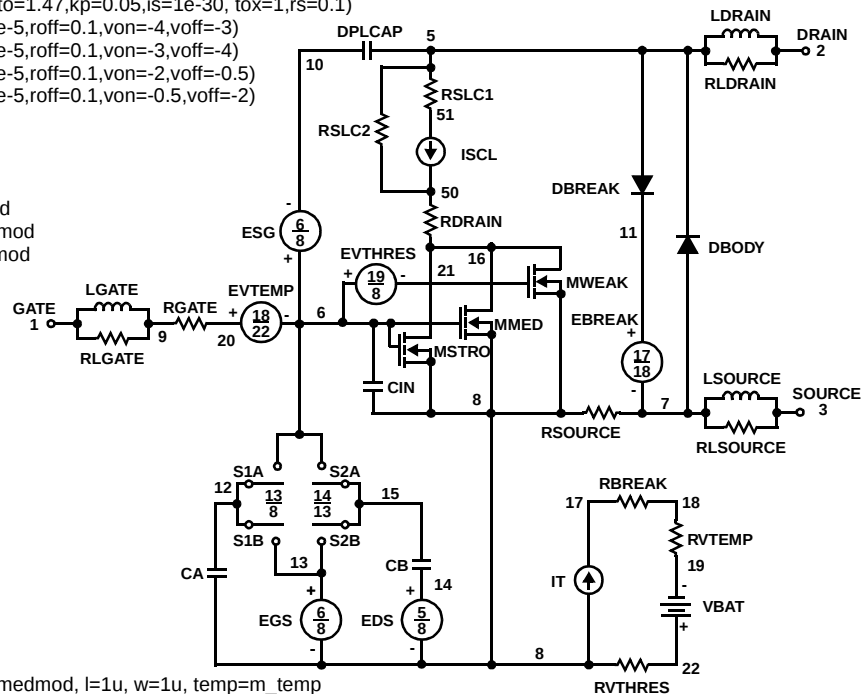
.ENDS

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.



FDD8870 / FDU8870

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PSPICE Thermal Model

REV 23 July 2003

FDD8870T

CTHERM1 TH 6 1e-3
 CTHERM2 6 5 2e-3
 CTHERM3 5 4 3e-3
 CTHERM4 4 3 9e-3
 CTHERM5 3 2 1e-2
 CTHERM6 2 TL 2e-2

RTHERM1 TH 6 3e-2
 RTHERM2 6 5 8e-2
 RTHERM3 5 4 1.1e-1
 RTHERM4 4 3 1.6e-1
 RTHERM5 3 2 1.72e-1
 RTHERM6 2 TL 2e-1

SABER Thermal Model

SABER thermal model FDD8870T
 template thermal_model th tl
 thermal_c th, tl

```
{
  ctherm.ctherm1 th 6 =1e-3
  ctherm.ctherm2 6 5 =2e-3
  ctherm.ctherm3 5 4 =3e-3
  ctherm.ctherm4 4 3 =9e-3
  ctherm.ctherm5 3 2 =1e-2
  ctherm.ctherm6 2 tl =2e-2
```

```
  rtherm.rtherm1 th 6 =3e-2
  rtherm.rtherm2 6 5 =8e-2
  rtherm.rtherm3 5 4 =1.1e-1
  rtherm.rtherm4 4 3 =1.6e-1
  rtherm.rtherm5 3 2 =1.72e-1
  rtherm.rtherm6 2 tl =2e-1
}
```





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Definition of Terms

Datasheet Identification	Product Status	Definition
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Preliminary	First Production	This datasheet contains preliminary data; supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve the design.
Obsolete	Not In Production	This datasheet contains specifications on a product that is discontinued by Fairchild Semiconductor. The datasheet is for reference information only.

Rev. I34



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