FAIRCHILD
SEMICONDUCTOR®

FDP8870

N-Channel PowerTrench® MOSFET
30V, 156A, 4.1mΩ

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

- $r_{DS(ON)}$ = 4.1mΩ, V_{GS} = 10V, I_D = 35A

- $r_{DS(ON)}$ = 4.6mΩ, 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

DRAIN
(FLANGE)

SOURCE
DRAIN
GATE

TO-220AB
FDP SERIES

D

G

S
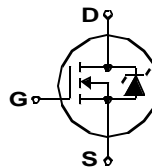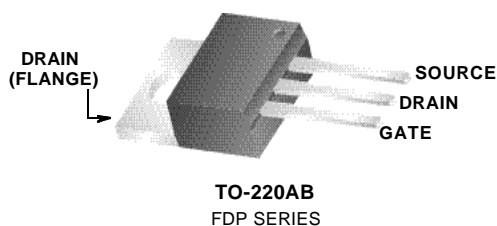
MOSFET Maximum Ratings T_C = 25°C unless otherwise noted

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°C, V_{GS} = 10V) (Note 1)	156	A
	Continuous (T_C = 25°C, V_{GS} = 4.5V) (Note 1)	147	A
	Continuous (T_{amb} = 25°C, V_{GS} = 10V, with $R_{\theta JA}$ = 62°C/W)	19	A
	Pulsed	Figure 4	A
E_{AS}	Single Pulse Avalanche Energy (Note 2)	300	mJ
P_D	Power dissipation	160	W
	Derate above 25°C	1.07	W/°C
T_J, T_{STG}	Operating and Storage Temperature	-55 to 175	°C

Thermal Characteristics

$R_{\theta JC}$	Thermal Resistance Junction to Case TO-220	0.94	°C/W
$R_{\theta JA}$	Thermal Resistance Junction to Ambient TO-220 (Note 3)	62	°C/W

Package Marking and Ordering Information

Device Marking	Device	Package	Reel Size	Tape Width	Quantity
FDP8870	FDP8870	TO-220AB	Tube	N/A	50 units

FDP8870

Electrical Characteristics T_C = 25°C unless otherwise noted

Symbol	Parameter	Test Conditions		Min	Typ	Max	Units
Off Characteristics							
B_{VDSS}	Drain to Source Breakdown Voltage	I_D = 250µA, V_{GS} = 0V		30	-	-	V
I_{DSS}	Zero Gate Voltage Drain Current	V_{DS} = 24V		-	-	1	µA
		V_{GS} = 0V	T_C = 150°C	-	-	250	
I_{GSS}	Gate to Source Leakage Current	V_{GS} = ±20V		-	-	±100	nA
On Characteristics							
$V_{GS(TH)}$	Gate to Source Threshold Voltage	V_{GS} = V_{DS}, I_D = 250µA		1.2	-	2.5	V
$r_{DS(ON)}$	Drain to Source On Resistance	I_D = 35A, V_{GS} = 10V		-	0.0034	0.0041	Ω
		I_D = 35A, V_{GS} = 4.5V		-	0.0040	0.0046	
		I_D = 35A, V_{GS} = 10V, T_J = 175°C		-	0.0051	0.0065	
Dynamic Characteristics							
C_{ISS}	Input Capacitance	V_{DS} = 15V, V_{GS} = 0V, f = 1MHz		-	5200	-	pF
C_{OSS}	Output Capacitance			-	970	-	pF
C_{RSS}	Reverse Transfer Capacitance			-	570	-	pF
R_G	Gate Resistance	V_{GS} = 0.5V, f = 1MHz		-	2.1	-	Ω
$Q_{g(TOT)}$	Total Gate Charge at 10V	V_{GS} = 0V to 10V	V_{DD} = 15V, I_D = 35A, I_g = 1.0mA	-	106	132	nC
$Q_{g(5)}$	Total Gate Charge at 5V	V_{GS} = 0V to 5V		-	56	69	nC
$Q_{g(TH)}$	Threshold Gate Charge	V_{GS} = 0V to 1V		-	5.0	6.5	nC
Q_{gs}	Gate to Source Gate Charge			-	15	-	nC
Q_{gs2}	Gate Charge Threshold to Plateau			-	10	-	nC
Q_{gd}	Gate to Drain "Miller" Charge			-	23	-	nC
Switching Characteristics (V_{GS} = 10V)							
t_{ON}	Turn-On Time	V_{DD} = 15V, I_D = 35A, V_{GS} = 10V, R_{GS} = 3.3Ω		-	-	168	ns
$t_{d(ON)}$	Turn-On Delay Time			-	11	-	ns
t_r	Rise Time			-	105	-	ns
$t_{d(OFF)}$	Turn-Off Delay Time			-	70	-	ns
t_f	Fall Time			-	46	-	ns
t_{OFF}	Turn-Off Time			-	-	173	ns
Drain-Source Diode Characteristics							
V_{SD}	Source to Drain Diode Voltage	I_{SD} = 35A		-	-	1.25	V
		I_{SD} = 15A		-	-	1.0	V
t_{rr}	Reverse Recovery Time	I_{SD} = 35A, dI_{SD}/dt = 100A/µs		-	-	37	ns
Q_{RR}	Reverse Recovered Charge	I_{SD} = 35A, dI_{SD}/dt = 100A/µs		-	-	21	nC

Notes:
1: Package current limitation is 80A.
2: Starting T_J = 25°C, L = 0.15mH, I_{AS} = 64A, V_{DD} = 27V, V_{GS} = 10V.
3: Pulse width = 100s.

Typical Characteristics $T_C = 25°C$ unless otherwise noted

POWER DISSIPATION MULTIPLIER vs **T_C, CASE TEMPERATURE (°C)**
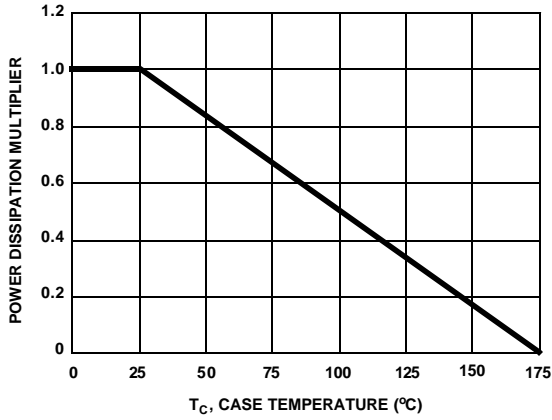
Figure 1. Normalized Power Dissipation vs Case Temperature

I_D, DRAIN CURRENT (A) vs **T_C, CASE TEMPERATURE (°C)**

CURRENT LIMITED BY PACKAGE
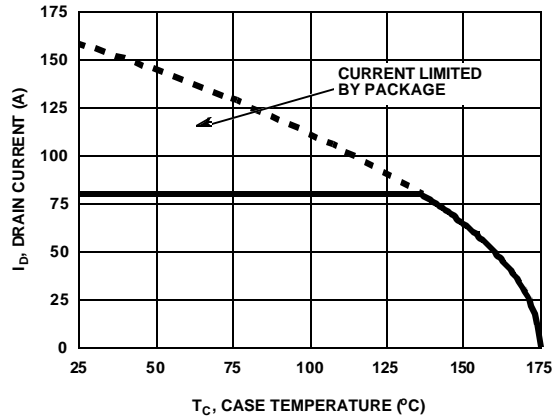
Figure 2. Maximum Continuous Drain Current vs Case Temperature

$Z_{\theta JC}$, NORMALIZED THERMAL IMPEDANCE vs **t, RECTANGULAR PULSE DURATION (s)**

DUTY CYCLE - DESCENDING ORDER
0.5
0.2
0.1
0.05
0.02
0.01

SINGLE PULSE

P_{DM}
t_1
t_2

NOTES:
DUTY FACTOR: $D = t_1/t_2$
PEAK $T_J = P_{DM} \times Z_{\theta JC} \times R_{\theta JC} + T_C$
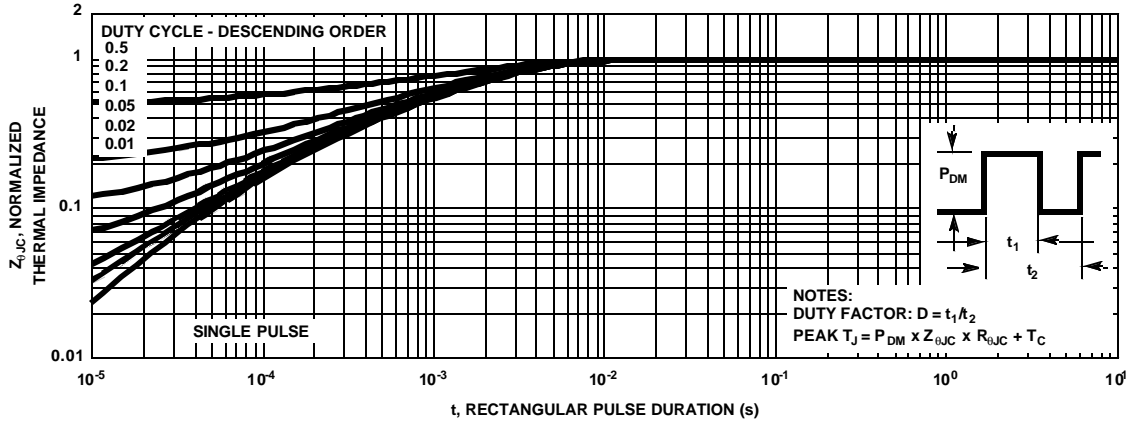
Figure 3. Normalized Maximum Transient Thermal Impedance

I_{DM}, PEAK CURRENT (A) vs **t, PULSE WIDTH (s)**

TRANSCONDUCTANCE MAY LIMIT CURRENT IN THIS REGION

$V_{GS} = 4.5V$

$T_C = 25°C$
FOR TEMPERATURES ABOVE 25°C DERATE PEAK CURRENT AS FOLLOWS:
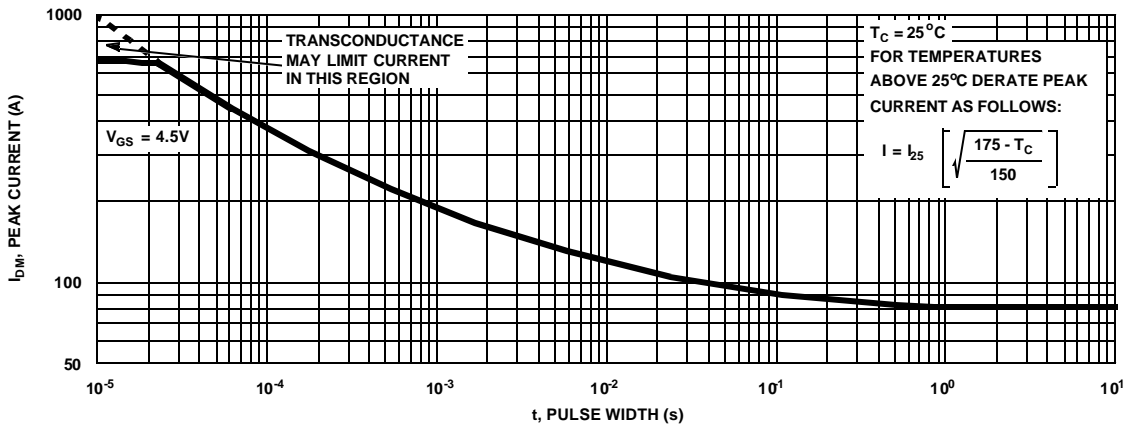
$$I = I_{25} \left[\sqrt{\frac{175 - T_C}{150}} \right]$$

Figure 4. Peak Current Capability

Typical Characteristics $T_C = 25°C$ unless otherwise noted
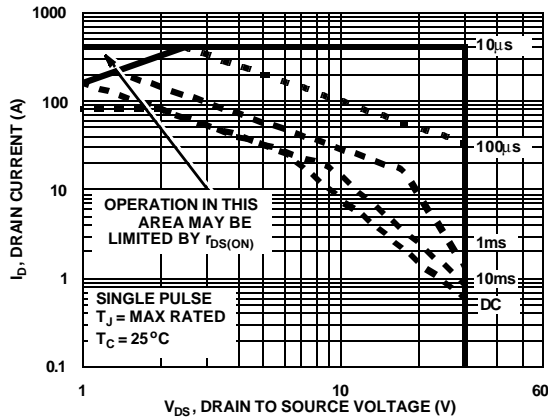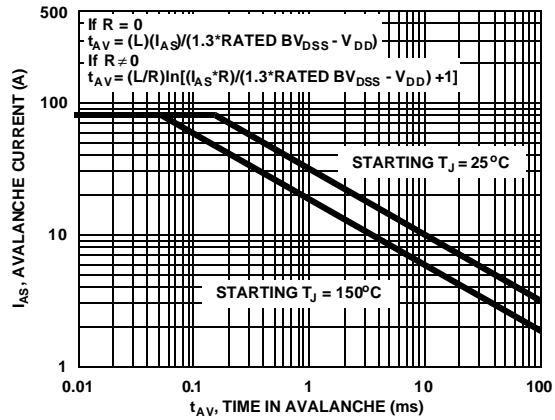

Figure 5. Forward Bias Safe Operating Area

Text in figure:
OPERATION IN THIS AREA MAY BE LIMITED BY $r_{DS(ON)}$
SINGLE PULSE
T_J = MAX RATED
$T_C = 25°C$
$10\mu s$, $100\mu s$, 1ms, 10ms, DC
I_D, DRAIN CURRENT (A)
V_{DS}, DRAIN TO SOURCE VOLTAGE (V)

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

Text in figure:
If R = 0
$t_{AV} = (L)(I_{AS})/(1.3*RATED\ BV_{DSS} - V_{DD})$
If $R \neq 0$
$t_{AV} = (L/R)ln[(I_{AS}*R)/(1.3*RATED\ BV_{DSS} - V_{DD}) +1]$
STARTING $T_J = 25°C$
STARTING $T_J = 150°C$
I_{AS}, AVALANCHE CURRENT (A)
t_{AV}, TIME IN AVALANCHE (ms)
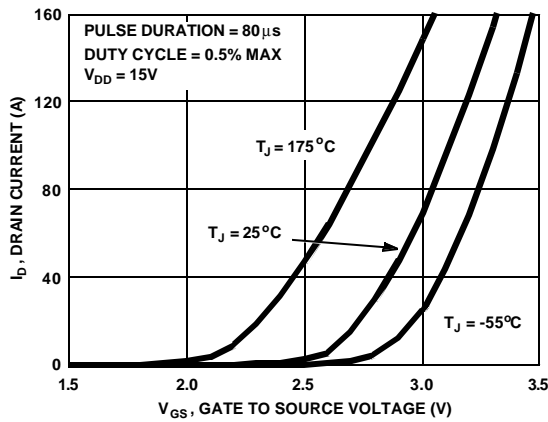
Figure 7. Transfer Characteristics

Text in figure:
PULSE DURATION = $80\mu s$
DUTY CYCLE = 0.5% MAX
V_{DD} = 15V
$T_J = 175°C$
$T_J = 25°C$
$T_J = -55°C$
I_D, DRAIN CURRENT (A)
V_{GS}, GATE TO SOURCE VOLTAGE (V)
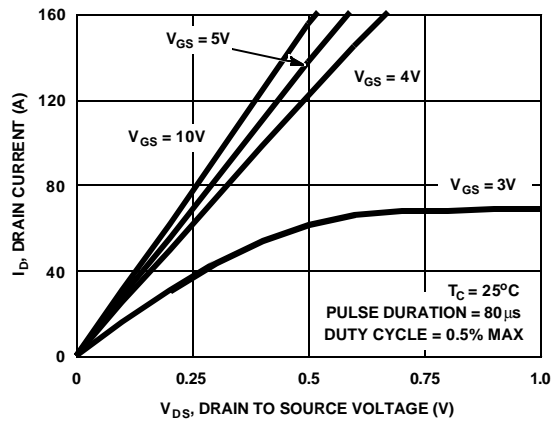
Figure 8. Saturation Characteristics

Text in figure:
V_{GS} = 5V
V_{GS} = 4V
V_{GS} = 10V
V_{GS} = 3V
$T_C = 25°C$
PULSE DURATION = $80\mu s$
DUTY CYCLE = 0.5% MAX
I_D, DRAIN CURRENT (A)
V_{DS}, DRAIN TO SOURCE VOLTAGE (V)
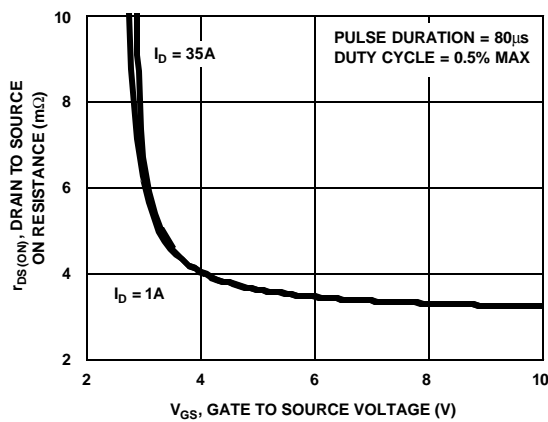
Figure 9. Drain to Source On Resistance vs Gate Voltage and Drain Current

Text in figure:
I_D = 35A
I_D = 1A
PULSE DURATION = $80\mu s$
DUTY CYCLE = 0.5% MAX
$r_{DS (ON)}$, DRAIN TO SOURCE ON RESISTANCE (mΩ)
V_{GS}, GATE TO SOURCE VOLTAGE (V)
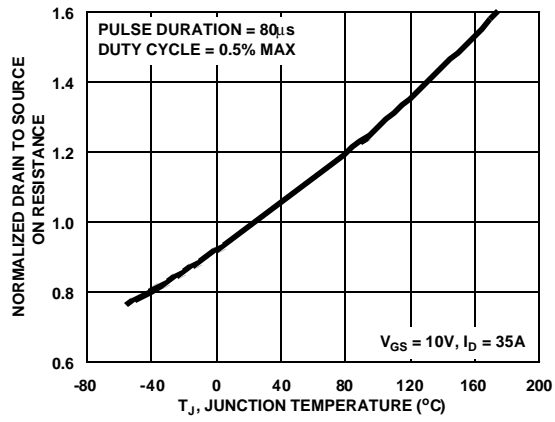
Figure 10. Normalized Drain to Source On Resistance vs Junction Temperature

Text in figure:
PULSE DURATION = $80\mu s$
DUTY CYCLE = 0.5% MAX
V_{GS} = 10V, I_D = 35A
NORMALIZED DRAIN TO SOURCE ON RESISTANCE
T_J, JUNCTION TEMPERATURE (°C)

Typical Characteristics T_C = 25°C unless otherwise noted

$V_{GS} = V_{DS}$, $I_D = 250\mu A$
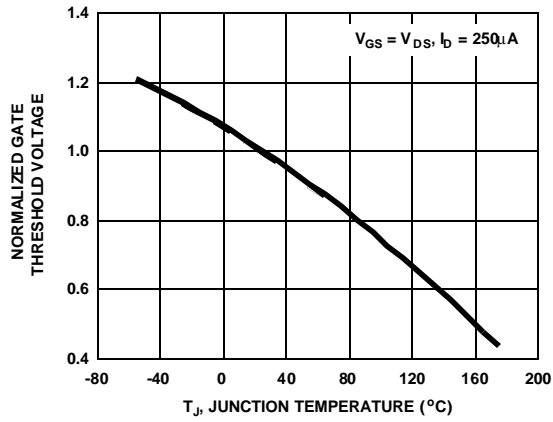
Figure 11. Normalized Gate Threshold Voltage vs Junction Temperature

X-axis: T_J, JUNCTION TEMPERATURE (°C)
Y-axis: NORMALIZED GATE THRESHOLD VOLTAGE

$I_D = 250\mu A$
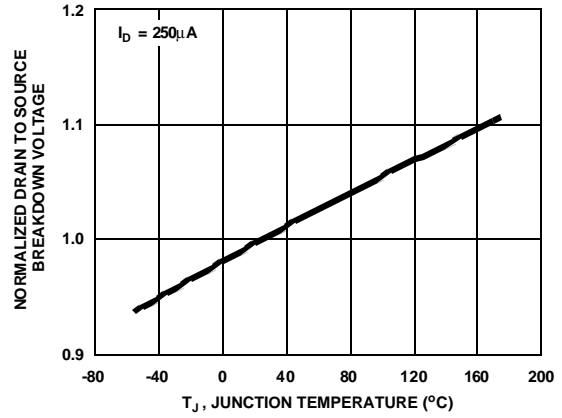
Figure 12. Normalized Drain to Source Breakdown Voltage vs Junction Temperature

X-axis: T_J, JUNCTION TEMPERATURE (°C)
Y-axis: NORMALIZED DRAIN TO SOURCE BREAKDOWN VOLTAGE

$C_{ISS} = C_{GS} + C_{GD}$
$C_{RSS} = C_{GD}$
$C_{OSS} \cong C_{DS} + C_{GD}$
$V_{GS} = 0V$, f = 1MHz
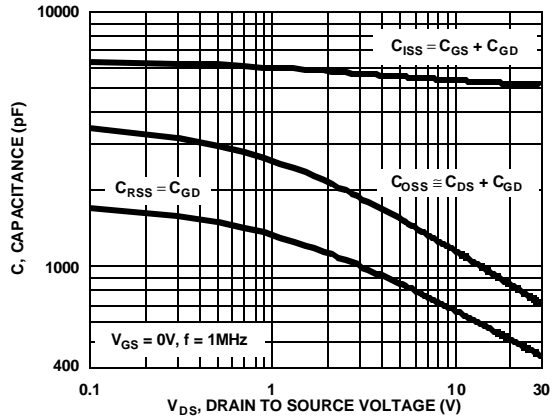
Figure 13. Capacitance vs Drain to Source Voltage

X-axis: V_{DS}, DRAIN TO SOURCE VOLTAGE (V)
Y-axis: C, CAPACITANCE (pF)

$V_{DD} = 15V$

WAVEFORMS IN DESCENDING ORDER:
$I_D = 35A$
$I_D = 5A$
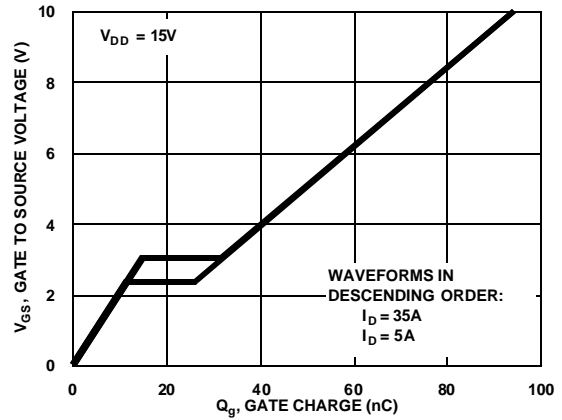
Figure 14. Gate Charge Waveforms for Constant Gate Current

X-axis: Q_g, GATE CHARGE (nC)
Y-axis: V_{GS}, GATE TO SOURCE VOLTAGE (V)
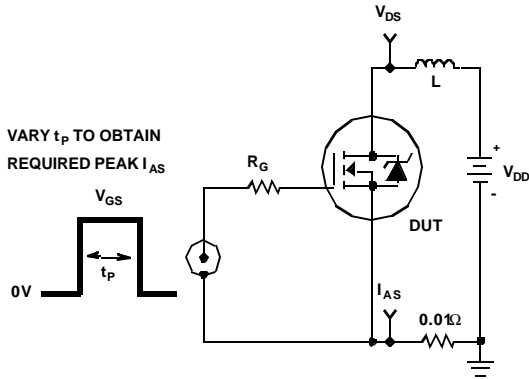
Test Circuits and Waveforms

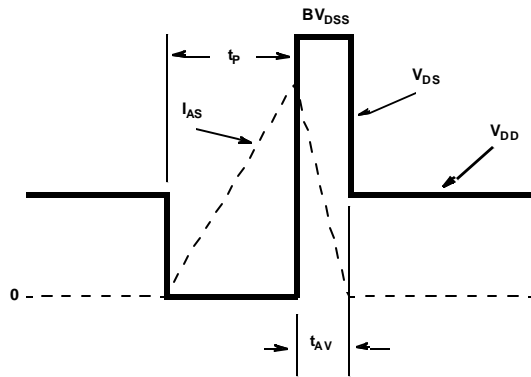**Figure 15. Unclamped Energy Test Circuit**

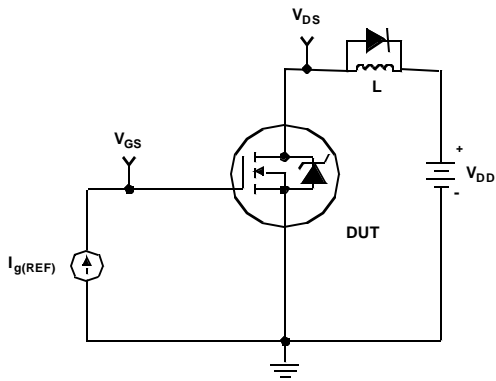**Figure 16. Unclamped Energy Waveforms**

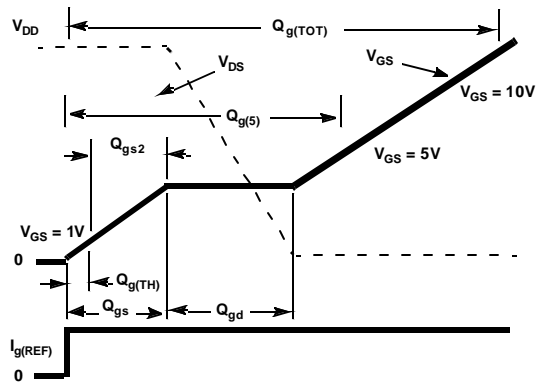**Figure 17. Gate Charge Test Circuit**

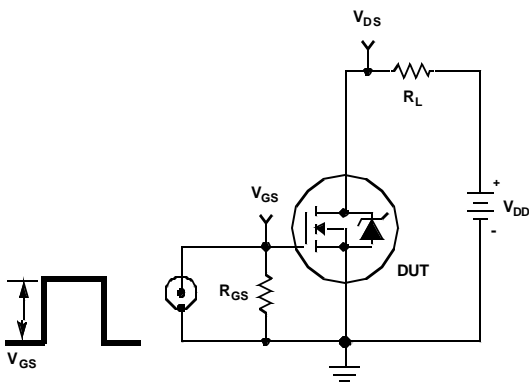**Figure 18. Gate Charge Waveforms**

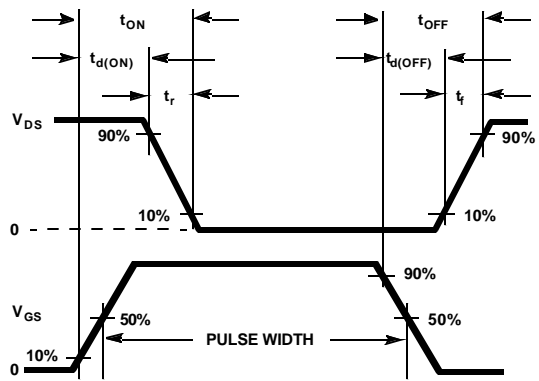**Figure 19. Switching Time Test Circuit**

Figure 20. Switching Time Waveforms

PSPICE Electrical Model

.SUBCKT FDP8870 2 1 3 ; rev December 2003
Ca 12 8 4.5e-9
Cb 15 14 4.5e-9
Cin 6 8 4.7e-9

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

Ebreak 11 7 17 18 33.45
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 3.6e-9
Ldrain 2 5 1.0e-9
Lsource 3 7 3.3e-9

RLgate 1 9 36
RLdrain 2 5 10
RLsource 3 7 33

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 2.15e-3
Rgate 9 20 2.1
RSLC1 5 51 RSLCMOD 1e-6
RSLC2 5 50 1e3
Rsource 8 7 RsourceMOD 9e-4
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=7.5E-12 IKF=17 N=1.01 RS=2.1e-3 TRS1=2e-3 TRS2=2e-7
+ CJO=1.9e-9 M=0.57 TT=9e-11 XTI=2.6)
.MODEL DbreakMOD D (RS=8e-2 TRS1=1e-3 TRS2=-8.9e-6)
.MODEL DplcapMOD D (CJO=1.75e-9 IS=1e-30 N=10 M=0.4)

.MODEL MmedMOD NMOS (VTO=2.1 KP=30 IS=1e-30 N=10 TOX=1 L=1u W=1u RG=2.1 T_ABS=25)
.MODEL MstroMOD NMOS (VTO=2.51 KP=650 IS=1e-30 N=10 TOX=1 L=1u W=1u T_ABS=25)
.MODEL MweakMOD NMOS (VTO=1.67 KP=0.1 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=-9e-7)
.MODEL RdrainMOD RES (TC1=2.3e-3 TC2=5e-6)
.MODEL RSLCMOD RES (TC1=1e-4 TC2=1e-6)
.MODEL RsourceMOD RES (TC1=8e-3 TC2=1e-6)
.MODEL RvthresMOD RES (TC1=-2.3e-3 TC2=-9e-6)
.MODEL RvtempMOD RES (TC1=-3e-3 TC2=2e-7)

.MODEL S1AMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=-4 VOFF=-2)
.MODEL S1BMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=-2 VOFF=-4)
.MODEL S2AMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=-1 VOFF=-0.5)
.MODEL S2BMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=-0.5 VOFF=-1)
.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.
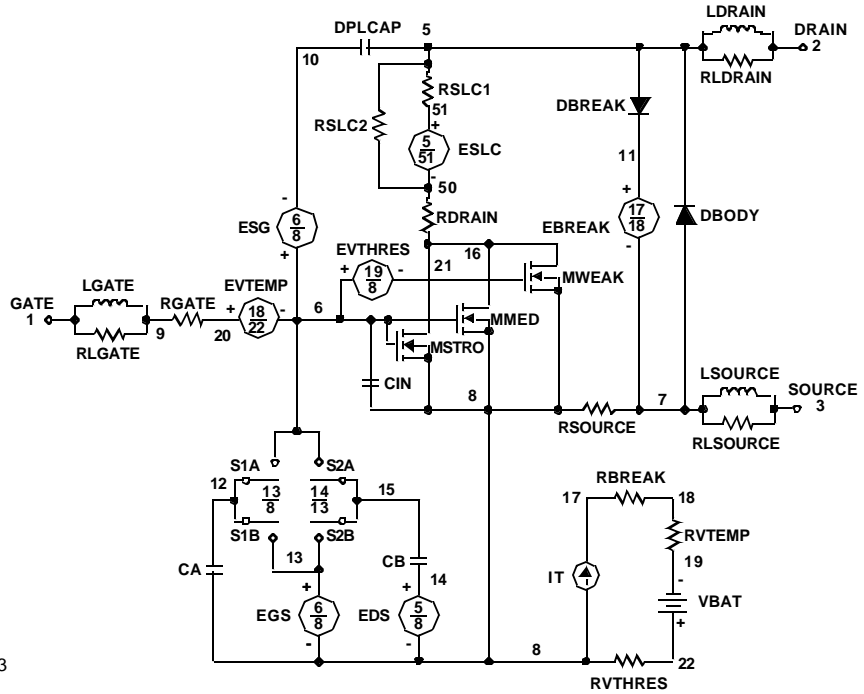
SABER Electrical Model

rev December 2003
template FDP8870 n2,n1,n3 =m_temp
electrical n2,n1,n3
number m_temp=25
{
var i iscl
dp..model dbodymod = (isl=7.5e-12,ikf=17,nl=1.01,rs=2.1e-3,trs1=2e-3,trs2=2e-7,cjo=1.9e-9,m=0.57,tt=9e-11,xti=2.6)
dp..model dbreakmod = (rs=8e-2,trs1=1e-3,trs2=-8.9e-6)
dp..model dplcapmod = (cjo=1.75e-9,isl=10e-30,nl=10,m=0.4)
m..model mmedmod = (type=_n,vto=2.1,kp=30,is=1e-30, tox=1)
m..model mstrongmod = (type=_n,vto=2.51,kp=650,is=1e-30, tox=1)
m..model mweakmod = (type=_n,vto=1.67,kp=0.1,is=1e-30, tox=1,rs=0.1)
sw_vcsp..model s1amod = (ron=1e-5,roff=0.1,von=-4,voff=-2)
sw_vcsp..model s1bmod = (ron=1e-5,roff=0.1,von=-2,voff=-4)
sw_vcsp..model s2amod = (ron=1e-5,roff=0.1,von=-1,voff=-0.5)
sw_vcsp..model s2bmod = (ron=1e-5,roff=0.1,von=-0.5,voff=-1)
c.ca n12 n8 = 4.5e-9
c.cb n15 n14 = 4.5e-9
c.cin n6 n8 = 4.7e-9

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

spe.ebreak n11 n7 n17 n18 = 33.45
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 = 3.6e-9
l.ldrain n2 n5 = 1.0e-9
l.lsource n3 n7 = 3.3e-9

res.rlgate n1 n9 = 36
res.rldrain n2 n5 = 10
res.rlsource n3 n7 = 33

m.mmed n16 n6 n8 n8 = model=mmedmod, l=1u, w=1u, temp=m_temp
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=-9e-7
res.rdrain n50 n16 = 2.15e-3, tc1=2.3e-3,tc2=5e-6
res.rgate n9 n20 = 2.1
res.rslc1 n5 n51 = 1e-6, tc1=1e-4,tc2=1e-6
res.rslc2 n5 n50 = 1e3
res.rsource n8 n7 = 9e-4, tc1=8e-3,tc2=1e-6
res.rvthres n22 n8 = 1, tc1=-2.3e-3,tc2=-9e-6
res.rvtemp n18 n19 = 1, tc1=-3e-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
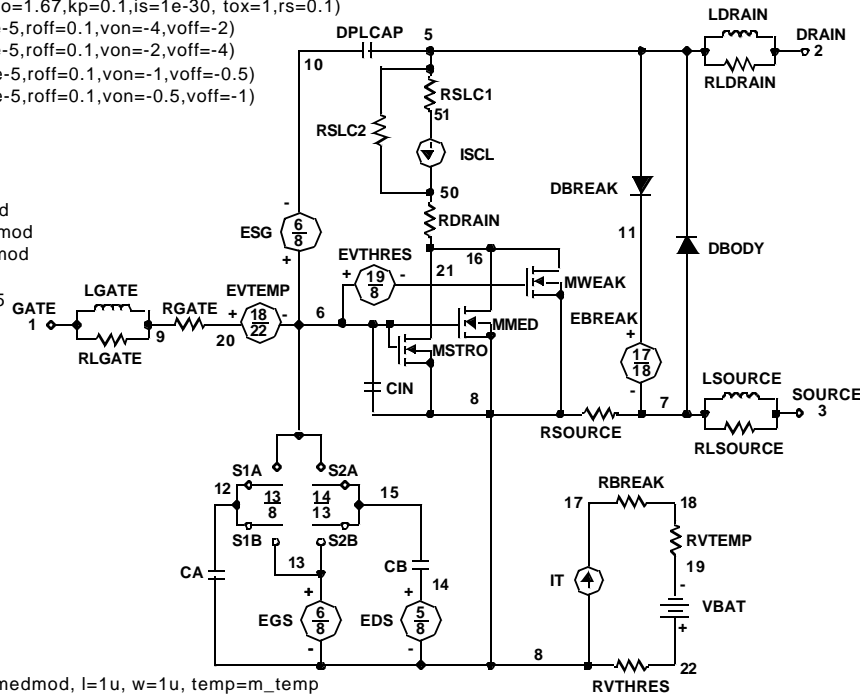
v.vbat n22 n19 = dc=1
equations {
i (n51->n50) +=iscl
iscl: v(n51,n50) = ((v(n5,n51)/(1e-9+abs(v(n5,n51))))*((abs(v(n5,n51)*1e6/500))** 10))
}
}

PSPICE Thermal Model

REV 23 December 2003

FDP8870T

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
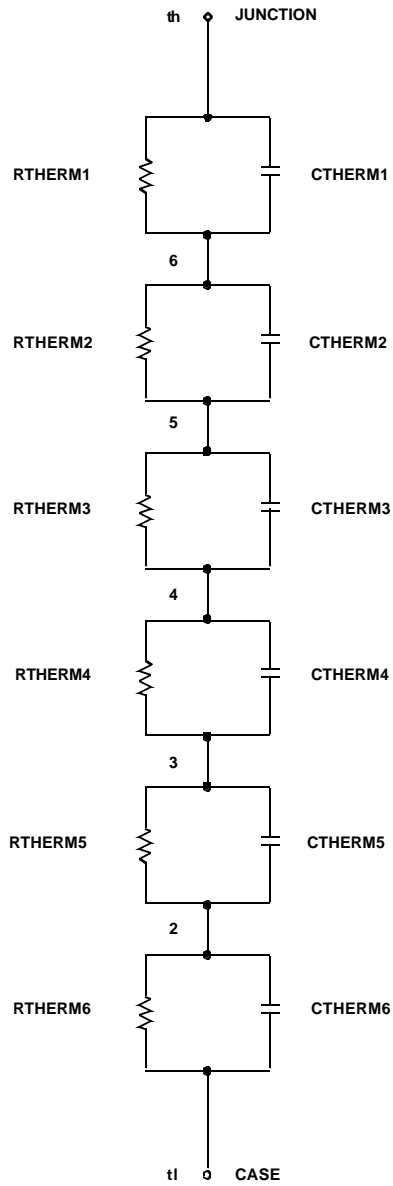RTHERM5 3 2 1.72e-1
RTHERM6 2 TL 2e-1

SABER Thermal Model

SABER thermal model FDP8870T
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
}

th ○ JUNCTION

RTHERM1   CTHERM1

6

RTHERM2   CTHERM2

5

RTHERM3   CTHERM3

4

RTHERM4   CTHERM4

3

RTHERM5   CTHERM5

2

RTHERM6   CTHERM6

tl ○ CASE

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