

FDD8876 / FDU8876

N-Channel PowerTrench® MOSFET 30V, 73A, 8.2mΩ

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.

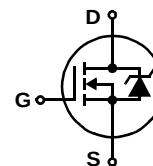
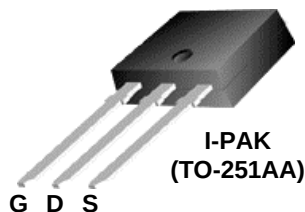
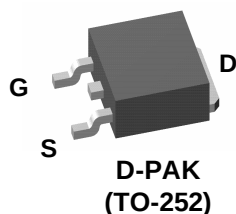
Applications

- DC/DC converters



Features

- $r_{DS(ON)} = 8.2m\Omega$ $V_{GS} = 10V$, $I_D = 35A$
- $r_{DS(ON)} = 10m\Omega$ $V_{GS} = 4.5V$, $I_D = 35A$
- High performance trench technology for extremely low $r_{DS(ON)}$
- Low gate charge
- High power and current handling capability
- RoHS Compliant



MOSFET Maximum Ratings $T_C = 25^\circ C$ 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 ($T_C = 25^\circ C$, $V_{GS} = 10V$) (Note 1)	73	A
	Continuous ($T_C = 25^\circ C$, $V_{GS} = 4.5V$) (Note 1)	66	A
	Continuous ($T_{amb} = 25^\circ C$, $V_{GS} = 10V$, with $R_{\theta JA} = 52^\circ C/W$)	15	A
	Pulsed	Figure 4	A
E_{AS}	Single Pulse Avalanche Energy (Note 2)	95	mJ
P_D	Power dissipation	70	W
	Derate above $25^\circ C$	0.47	W/ $^\circ C$
T_J, T_{STG}	Operating and Storage Temperature	-55 to 175	$^\circ C$

Thermal Characteristics

$R_{\theta JC}$	Thermal Resistance Junction to Case TO-252, TO-251	2.14	$^\circ C/W$
$R_{\theta JA}$	Thermal Resistance Junction to Ambient TO-252, TO-251	100	$^\circ C/W$
$R_{\theta JA}$	Thermal Resistance Junction to Ambient TO-252, 1in ² copper pad area	52	$^\circ C/W$

Package Marking and Ordering Information

Device Marking	Device	Package	Reel Size	Tape Width	Quantity
FDD8876	FDD8876	TO-252AA	13"	12mm	2500 units
FDU8876	FDU8876	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	$I_D = 35\text{A}$, $V_{GS} = 10\text{V}$	-	0.0066	0.0082	Ω
		$I_D = 35\text{A}$, $V_{GS} = 4.5\text{V}$	-	0.008	0.010	
		$I_D = 35\text{A}$, $V_{GS} = 10\text{V}$, $T_J = 175^\circ\text{C}$	-	0.011	0.013	

Dynamic Characteristics

C_{ISS}	Input Capacitance	$V_{DS} = 15\text{V}$, $V_{GS} = 0\text{V}$, $f = 1\text{MHz}$	-	1700	-	pF
C_{OSS}	Output Capacitance		-	330	-	pF
C_{RSS}	Reverse Transfer Capacitance		-	200	-	pF
R_G	Gate Resistance	$V_{GS} = 0.5\text{V}$, $f = 1\text{MHz}$	-	2.2	-	Ω
$Q_{g(TOT)}$	Total Gate Charge at 10V	$V_{GS} = 0\text{V}$ to 10V	-	34	47	nC
$Q_{g(5)}$	Total Gate Charge at 5V	$V_{GS} = 0\text{V}$ to 5V	-	18	26	nC
$Q_{g(TH)}$	Threshold Gate Charge	$V_{GS} = 0\text{V}$ to 1V	-	1.4	1.9	nC
Q_{gs}	Gate to Source Gate Charge	$V_{DD} = 15\text{V}$ $I_D = 35\text{A}$ $I_g = 1.0\text{mA}$	-	4.2	-	nC
Q_{gs2}	Gate Charge Threshold to Plateau		-	2.8	-	nC
Q_{gd}	Gate to Drain "Miller" Charge		-	8.0	-	nC
			-			

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

t_{ON}	Turn-On Time	$V_{DD} = 15\text{V}$, $I_D = 35\text{A}$ $V_{GS} = 10\text{V}$, $R_{GS} = 10\Omega$	-	-	149	ns
$t_{d(ON)}$	Turn-On Delay Time		-	8	-	ns
t_r	Rise Time		-	91	-	ns
$t_{d(OFF)}$	Turn-Off Delay Time		-	44	-	ns
t_f	Fall Time		-	37	-	ns
t_{OFF}	Turn-Off Time		-	-	122	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	$I_{SD} = 35\text{A}$, $dI_{SD}/dt = 100\text{A}/\mu\text{s}$	-	-	26	ns
Q_{RR}	Reverse Recovered Charge	$I_{SD} = 35\text{A}$, $dI_{SD}/dt = 100\text{A}/\mu\text{s}$	-	-	12	nC

Notes:

- 1: Package current limitation is 35A.
- 2: Starting $T_J = 25^\circ\text{C}$, $L = 0.24\text{mH}$, $I_{AS} = 28\text{A}$, $V_{DD} = 27\text{V}$, $V_{GS} = 10\text{V}$.

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

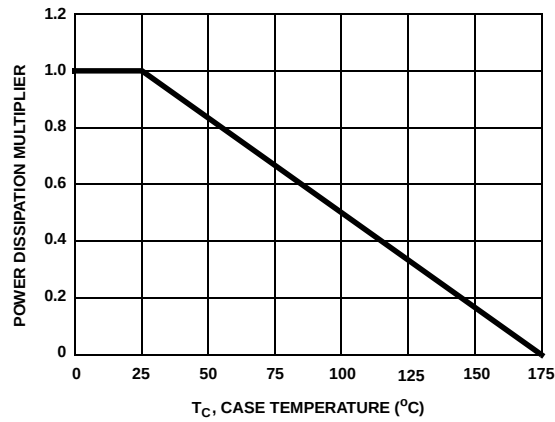


Figure 1. Normalized Power Dissipation vs Case Temperature

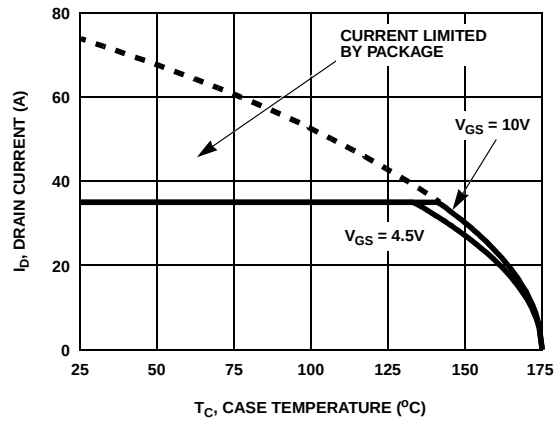


Figure 2. Maximum Continuous Drain Current vs Case Temperature

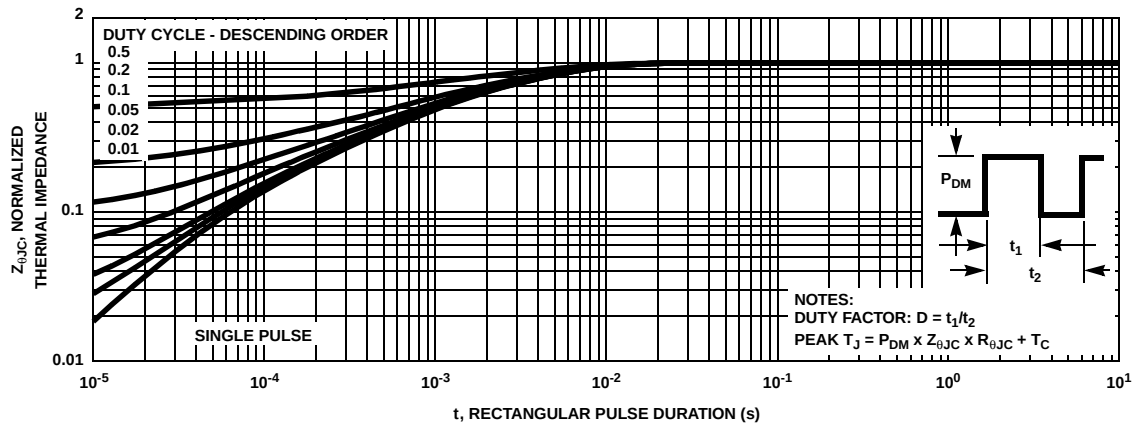


Figure 3. Normalized Maximum Transient Thermal Impedance

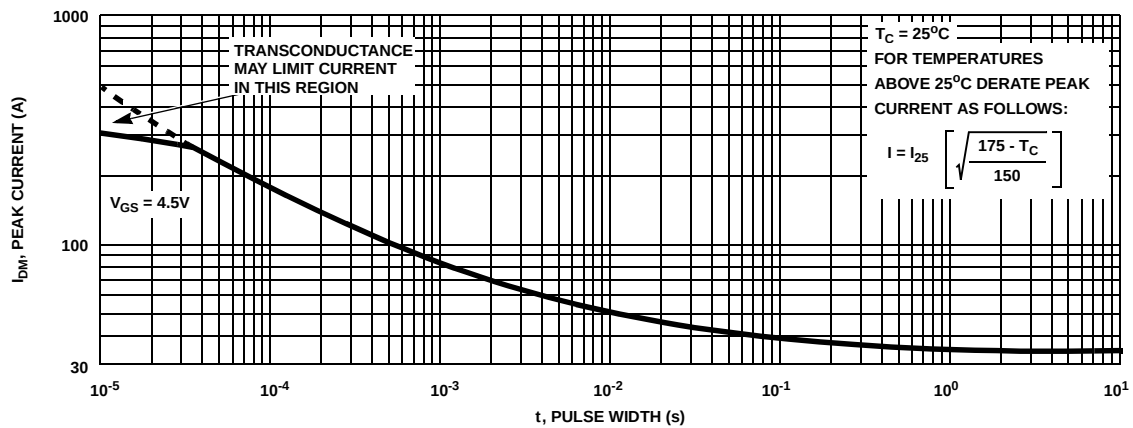


Figure 4. Peak Current Capability

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

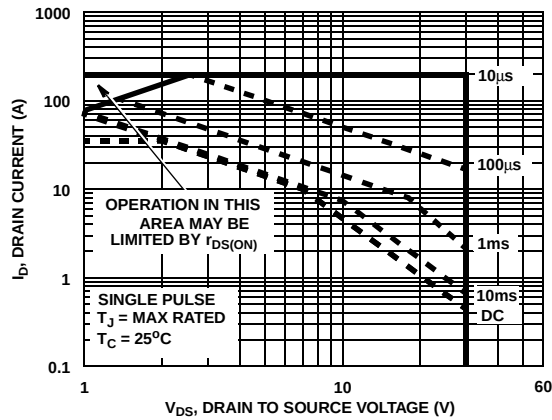
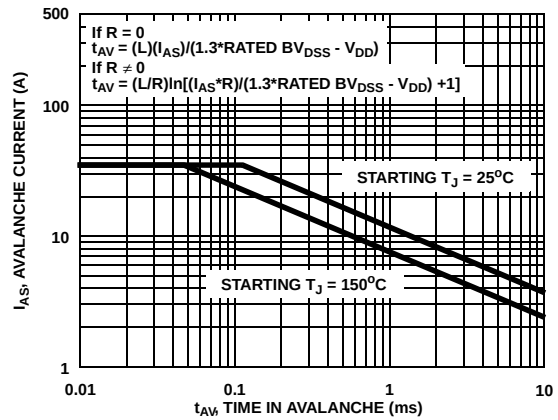


Figure 5. Forward Bias Safe Operating Area



NOTE: Refer to Fairchild Application Notes AN7514 and AN7515

Figure 6. Unclamped Inductive Switching Capability

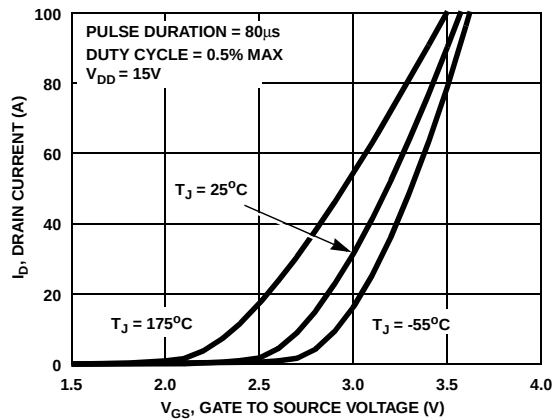


Figure 7. Transfer Characteristics

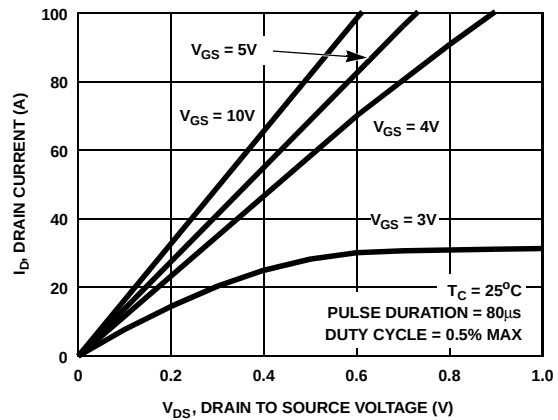


Figure 8. Saturation Characteristics

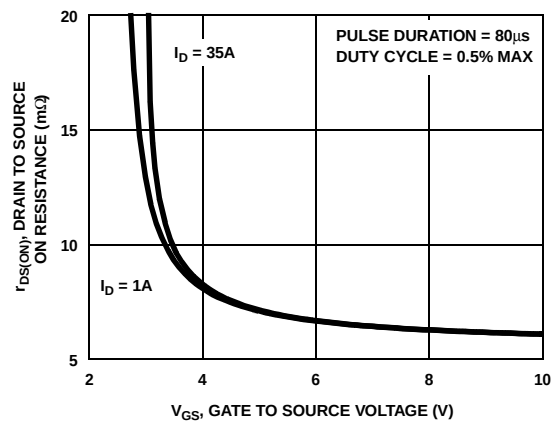


Figure 9. Drain to Source On Resistance vs Gate Voltage and Drain Current

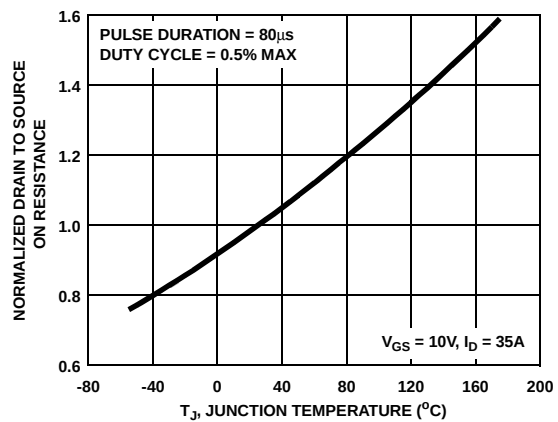


Figure 10. Normalized Drain to Source On Resistance vs Junction Temperature

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

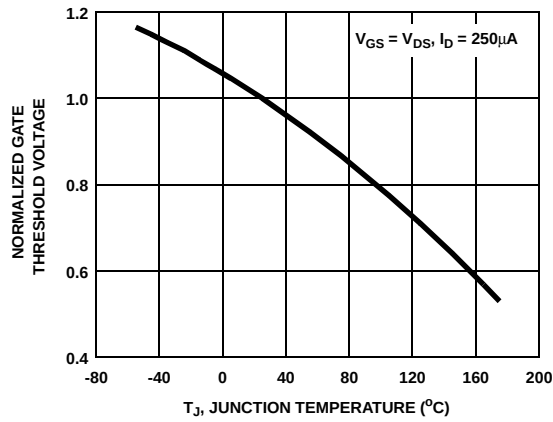


Figure 11. Normalized Gate Threshold Voltage vs Junction Temperature

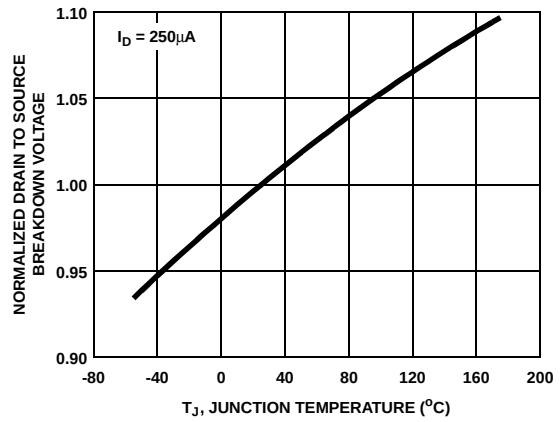


Figure 12. Normalized Drain to Source Breakdown Voltage vs Junction Temperature

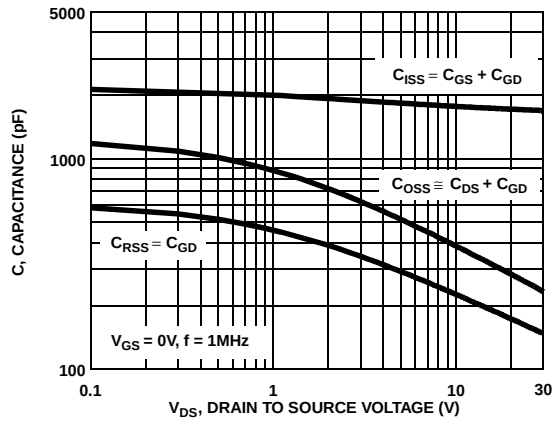


Figure 13. Capacitance vs Drain to Source Voltage

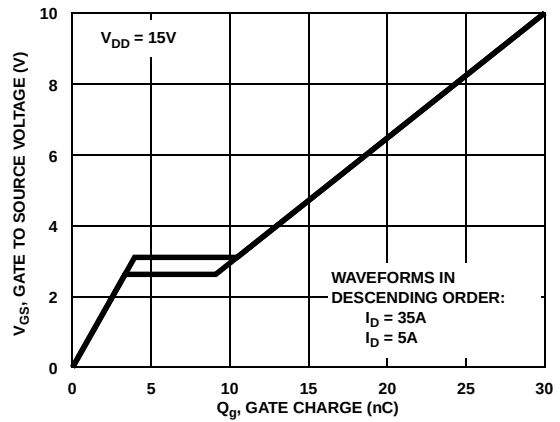


Figure 14. Gate Charge Waveforms for Constant Gate Current

Test Circuits and Waveforms

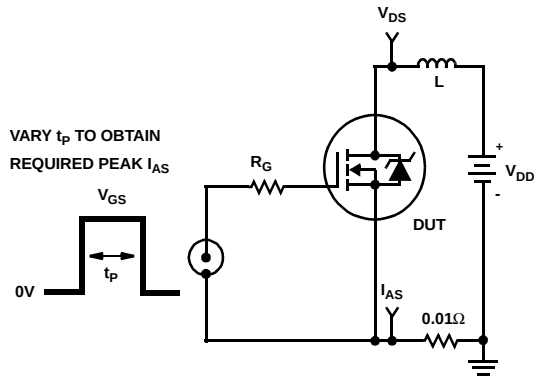


Figure 15. Unclamped Energy Test Circuit

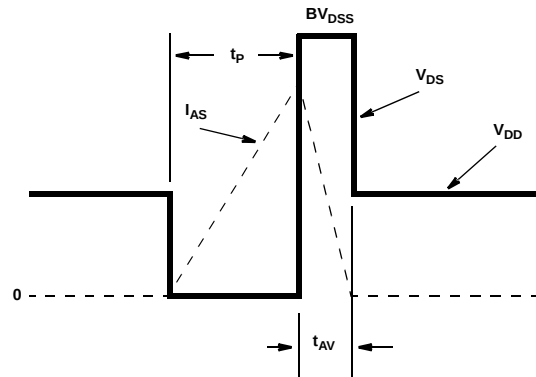


Figure 16. Unclamped Energy Waveforms

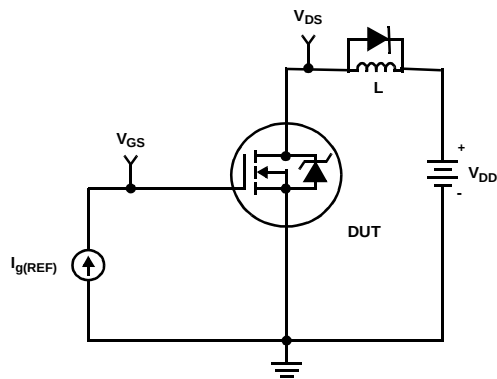


Figure 17. Gate Charge Test Circuit

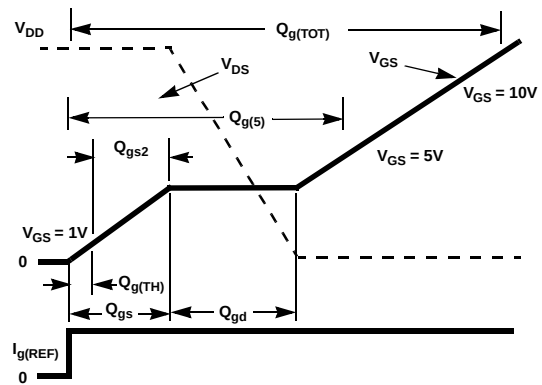


Figure 18. Gate Charge Waveforms

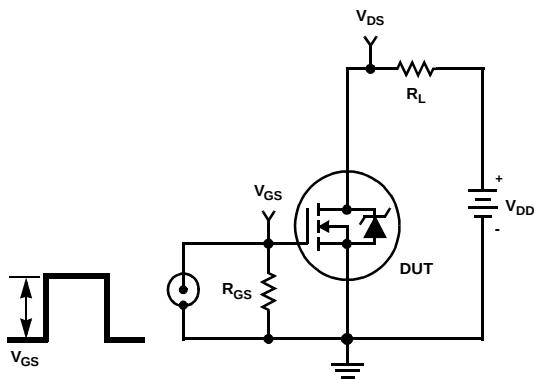


Figure 19. Switching Time Test Circuit

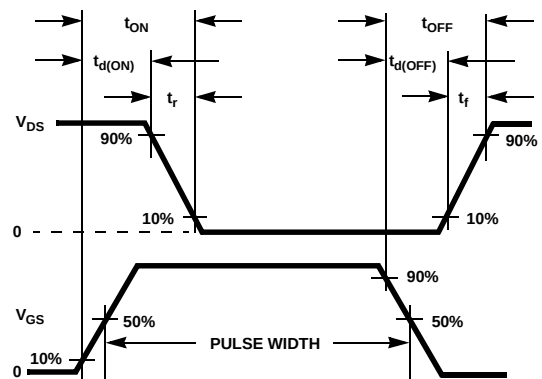


Figure 20. Switching Time Waveforms

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 $R_{\theta JA}$ ($^{\circ}\text{C/W}$) 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

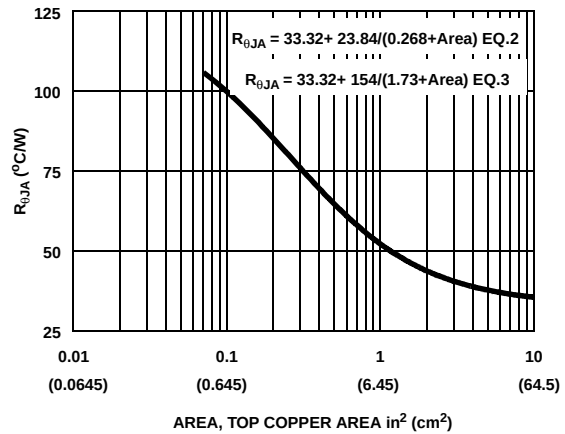


Figure 21. Thermal Resistance vs Mounting Pad Area

PSPICE Electrical Model

.SUBCKT FDD8876 2 1 3 ; rev January 2004

Ca 12 8 1.9e-9

Cb 15 14 1.6e-9

Cin 6 8 1.55e-9

Dbody 7 5 DbodyMOD

Dbreak 5 11 DbreakMOD

Dplcap 10 5 DplcapMOD

Ebreak 11 7 17 18 33.15

Eds 14 8 5 8 1

Egs 13 8 6 8 1

Esg 6 10 6 8 1

Evthres 6 21 19 8 1

Evttemp 20 6 18 22 1

It 8 17 1

Lgate 1 9 4.7e-9

Ldrain 2 5 1.0e-9

Lsource 3 7 1.7e-9

RLgate 1 9 47

RLdrain 2 5 10

RLsource 3 7 17

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 2.9e-3

Rgate 9 20 2.2

RSLC1 5 51 RSLCMOD 1e-6

RSLC2 5 50 1e3

Rsource 8 7 RsourceMOD 2.7e-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*300),10))}}

.MODEL DbodyMOD D (IS=3E-12 IKF=10 N=1.01 RS=3.4e-3 TRS1=8e-4 TRS2=2e-7
+ CJO=6.3e-10 M=0.57 TT=1e-17 XTI=2)

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

.MODEL DplcapMOD D (CJO=6.1e-10 IS=1e-30 N=10 M=0.41)

.MODEL MmedMOD NMOS (VTO=1.95 KP=10 IS=1e-30 N=10 TOX=1 L=1u W=1u RG=2.2 T_ABS=25)

.MODEL MstroMOD NMOS (VTO=2.45 KP=250 IS=1e-30 N=10 TOX=1 L=1u W=1u T_ABS=25)

.MODEL MweakMOD NMOS (VTO=1.65 KP=0.05 IS=1e-30 N=10 TOX=1 L=1u W=1u RG=22 RS=0.1 T_ABS=25)

.MODEL RbreakMOD RES (TC1=8.3e-4 TC2=-8e-7)

.MODEL RdrainMOD RES (TC1=1e-4 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=-1.7e-3 TC2=-8.2e-6)

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

.MODEL S1AMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=-4 VOFF=-3.5)

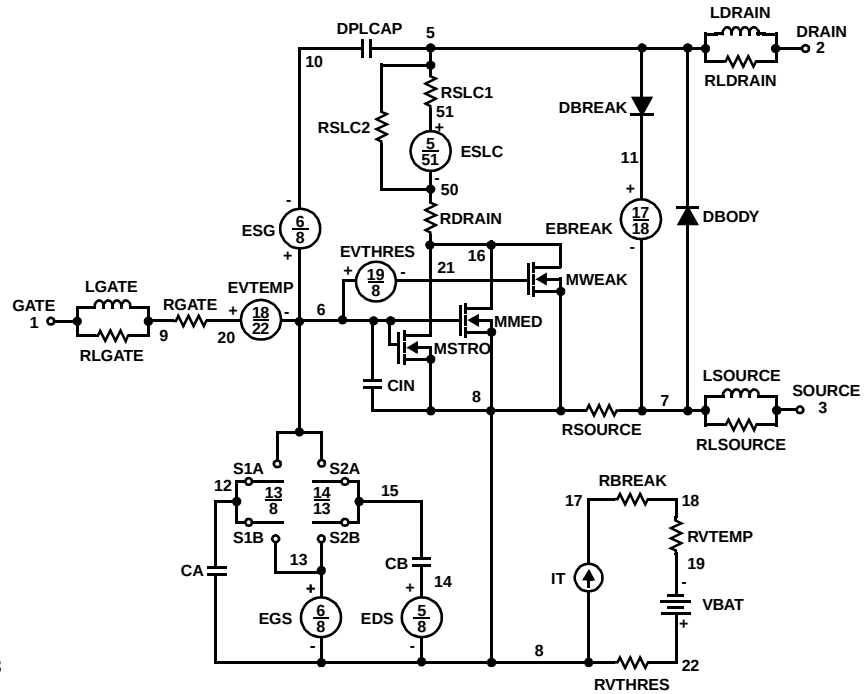
.MODEL S1BMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=-3.5 VOFF=-4)

.MODEL S2AMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=-2 VOFF=-1.5)

.MODEL S2BMOD VSWITCH (RON=1e-5 ROFF=0.1 VON=-1.5 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.



SABER Electrical Model

rev January 2004

template FDD8876 n2,n1,n3 =m_temp

electrical n2,n1,n3

number m_temp=25

{

var i iscl

dp..model dbodymod = (isl=3e-12,ikf=10,nl=1.01,rs=3.4e-3,trs1=8e-4,trs2=2e-7,cjo=6.3e-10,m=0.57,tt=1e-17,xti=2)

dp..model dbreakmod = (rs=1,trs1=1e-3,trs2=-8.9e-6)

dp..model dplcapmod = (cjo=6.1e-10,isl=10e-30,nl=10,m=0.41)

m..model mmedmod = (type=_n,vto=1.95,kp=10,is=1e-30,tox=1)

m..model mstrongmod = (type=_n,vto=2.45,kp=250,is=1e-30,tox=1)

m..model mweakmod = (type=_n,vto=1.65,kp=0.05,is=1e-30,tox=1,rs=0.1)

sw_vcsp..model s1amod = (ron=1e-5,roff=0.1,von=-4,voff=-3.5)

sw_vcsp..model s1bmod = (ron=1e-5,roff=0.1,von=-3.5,voff=-4)

sw_vcsp..model s2amod = (ron=1e-5,roff=0.1,von=-2,voff=-1.5)

sw_vcsp..model s2bmod = (ron=1e-5,roff=0.1,von=-1.5,voff=-2)

c.ca n12 n8 = 1.9e-9

c.cb n15 n14 = 1.6e-9

c.cin n6 n8 = 1.55e-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 = 33.15

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 = 4.7e-9

l.ldrain n2 n5 = 1.0e-9

l.lsource n3 n7 = 1.7e-9

res.rlgate n1 n9 = 47

res.rldrain n2 n5 = 10

res.rlsource n3 n7 = 17

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=-8e-7

res.rdrain n50 n16 = 2.9e-3, tc1=1e-4,tc2=8e-6

res.rgate n9 n20 = 2.2

res.rslc1 n5 n51 = 1e-6, tc1=9e-4,tc2=1e-6

res.rslc2 n5 n50 = 1e3

res.rsource n8 n7 = 2.7e-3, tc1=7.5e-3,tc2=1e-6

res.rvthres n22 n8 = 1, tc1=-1.7e-3,tc2=-8.2e-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

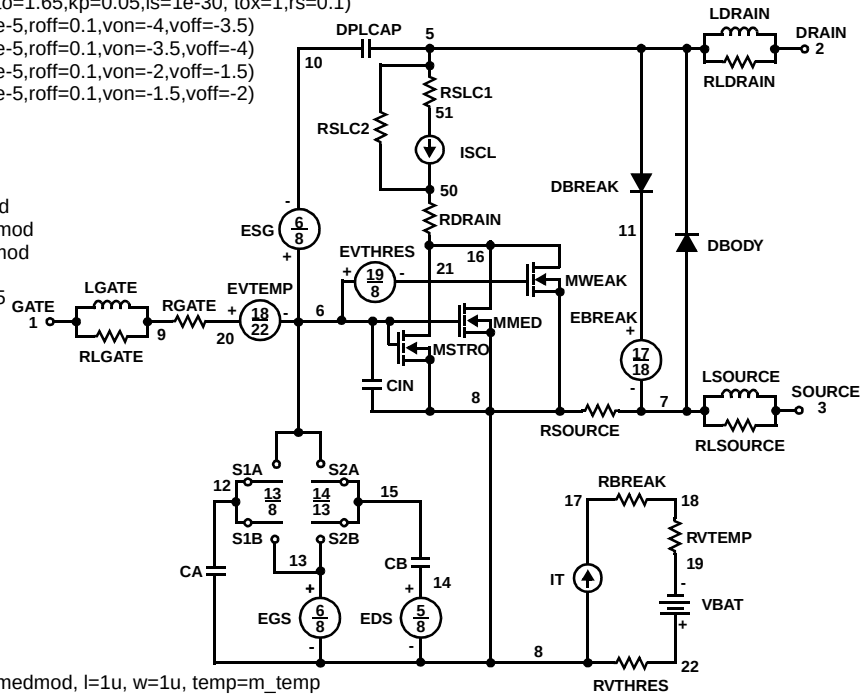
equations {

i (n51->n50) +=iscl

iscl: v(n51,n50) = ((v(n5,n51)/(1e-9+abs(v(n5,n51))))*((abs(v(n5,n51)*1e6/300))** 10))

}

}



PSPICE Thermal Model

REV 23 January 2004

FDD8876T

CTHERM1 TH 6 7e-4
 CTHERM2 6 5 9e-4
 CTHERM3 5 4 2e-3
 CTHERM4 4 3 2.5e-3
 CTHERM5 3 2 6e-3
 CTHERM6 2 TL 1.1e-2

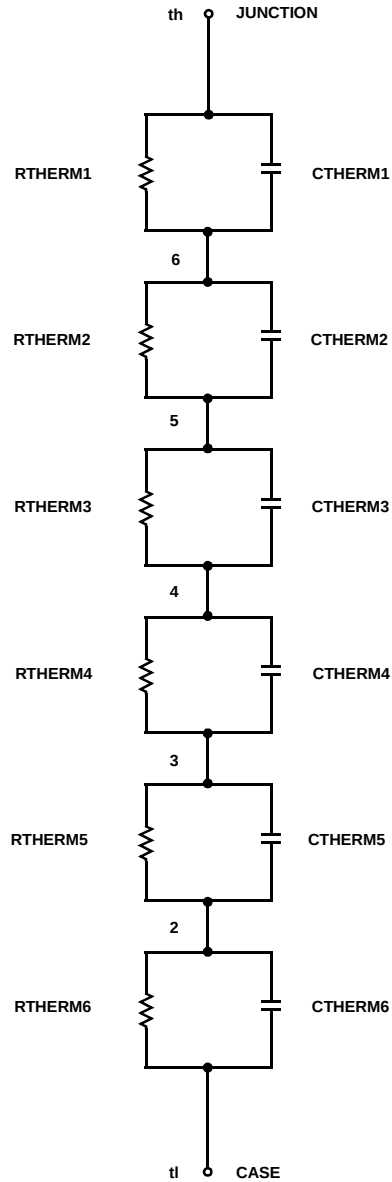
RTHERM1 TH 6 7.0e-2
 RTHERM2 6 5 1.1e-1
 RTHERM3 5 4 2.2e-1
 RTHERM4 4 3 3.2e-1
 RTHERM5 3 2 4.9e-1
 RTHERM6 2 TL 5e-1

SABER Thermal Model

SABER thermal model FDD8876T
 template thermal_model th tl
 thermal_c th, tl

```
{
  ctherm.ctherm1 th 6 =7e-4
  ctherm.ctherm2 6 5 =9e-4
  ctherm.ctherm3 5 4 =2e-3
  ctherm.ctherm4 4 3 =2.5e-3
  ctherm.ctherm5 3 2 =6e-3
  ctherm.ctherm6 2 tl =1.1e-2
```

```
  rtherm.rtherm1 th 6 =7.0e-2
  rtherm.rtherm2 6 5 =1.1e-1
  rtherm.rtherm3 5 4 =2.2e-1
  rtherm.rtherm4 4 3 =3.2e-1
  rtherm.rtherm5 3 2 =4.9e-1
  rtherm.rtherm6 2 tl =5e-1
}
```





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Build it Now TM	F-PFS TM	Power-SPM TM	the power franchise
CorePLUS TM	FRFET®	PowerTrench®	TinyBoost TM
CorePOWER TM	Global Power Resource SM	Programmable Active Droop TM	TinyBuck TM
CROSSVOLT TM	Green FPS TM	QFET®	TinyLogic®
CTL TM	Green FPS TM e-Series TM	QS TM	TINYOPTO TM
Current Transfer Logic TM	GTO TM	Quiet Series TM	TinyPower TM
EcoSPARK®	IntelliMAX TM	RapidConfigure TM	TinyPWM TM
EfficientMax TM	ISOPANAR TM	Saving our world 1mW at a time TM	TinyWire TM
EZSWITCH TM *	MegaBuck TM	SmartMax TM	µSerDes TM
	MICROCOUPLER TM	SMART START TM	
	MicroFET TM	SPM®	UHC®
Fairchild®	MicroPak TM	STEALTH TM	Ultra FRFET TM
Fairchild Semiconductor®	MillerDrive TM	SuperFET TM	UniFET TM
FACT Quiet Series TM	MotionMax TM	SuperSOT TM -3	VCX TM
FACT®	Motion-SPM TM	SuperSOT TM -6	VisualMax TM
FAST®	OPTOLOGIC®	SuperSOT TM -8	
FastvCore TM	OPTOPLANAR®	SuperMOS TM	
FlashWriter® *			

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As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury of the user.
2. A critical component in any component of a life support, device, or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

PRODUCT STATUS DEFINITIONS

Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
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

Компания «Океан Электроники» предлагает заключение долгосрочных отношений при поставках импортных электронных компонентов на взаимовыгодных условиях!

Наши преимущества:

- Поставка оригинальных импортных электронных компонентов напрямую с производств Америки, Европы и Азии, а так же с крупнейших складов мира;
- Широкая линейка поставок активных и пассивных импортных электронных компонентов (более 30 млн. наименований);
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Помощь Конструкторского Отдела и консультации квалифицированных инженеров;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Поставка электронных компонентов под контролем ВП;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- При необходимости вся продукция военного и аэрокосмического назначения проходит испытания и сертификацию в лаборатории (по согласованию с заказчиком);
- Поставка специализированных компонентов военного и аэрокосмического уровня качества (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Actel, Aeroflex, Peregrine, VPT, Syfer, Eurofarad, Texas Instruments, MS Kennedy, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Компания «Океан Электроники» является официальным дистрибьютором и эксклюзивным представителем в России одного из крупнейших производителей разъемов военного и аэрокосмического назначения «JONHON», а так же официальным дистрибьютором и эксклюзивным представителем в России производителя высокотехнологичных и надежных решений для передачи СВЧ сигналов «FORSTAR».



JONHON

«JONHON» (основан в 1970 г.)

Разъемы специального, военного и аэрокосмического назначения:

(Применяются в военной, авиационной, аэрокосмической, морской, железнодорожной, горно- и нефтедобывающей отраслях промышленности)

«FORSTAR» (основан в 1998 г.)

ВЧ соединители, коаксиальные кабели,
кабельные сборки и микроволновые компоненты:

(Применяются в телекоммуникациях гражданского и специального назначения, в средствах связи, РЛС, а так же военной, авиационной и аэрокосмической отраслях промышленности).



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