FAIRCHILD SEMICONDUCTOR®

December 2004

FDW2601NZ

Dual N-Channel 2.5V Specified PowerTrench® MOSFET

Features

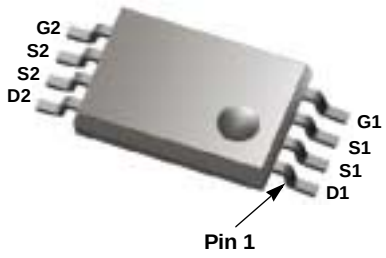
- 8.2A, 30V $r_{DS(ON)}$ = 0.015Ω, V_{GS} = 4.5V
  $r_{DS(ON)}$ = 0.020Ω, V_{GS} = 2.5V
- Extended V_{GS} range (±12 V) for battery applications
- HBM ESD Protection Level of 3.5kV Typical (note 3)
- High performance trench technology for extremely low $r_{DS(ON)}$
- Low profile TSSOP-8 package

Applications

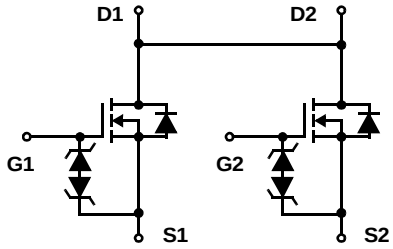
- Load switch
- Battery charge
- Battery disconnect circuits

General Description

This N-Channel MOSFET is produced using Fairchild Semiconductor's advanced PowerTrench process that has been especially tailored to minimize the on-state resistance and yet maintain low gate charge for superior switching performance. These devices are well suited for portable electronics applications.



TSSOP-8



Absolute Maximum Ratings T_A=25°C unless otherwise noted

Symbol	Parameter	Ratings	Units
V_{DSS}	Drain to Source Voltage	30	V
V_{GS}	Gate to Source Voltage	±12	V
I_D	Drain Current Continuous (T_C = 25°C, V_{GS} = 4.5V, $R_{\theta JA}$ = 77°C/W)	8.2	A
	Continuous (T_C = 100°C, V_{GS} = 2.5V, $R_{\theta JA}$ = 77°C/W)	4.5	A
	Pulsed	Figure 4	A
P_D	Power dissipation	1.6	W
	Derate above 25°C	13	mW/°C
T_J, T_{STG}	Operating and Storage Temperature	-55 to 150	°C

Thermal Characteristics

$R_{\theta JA}$	Thermal Resistance Junction to Ambient (Note 1)	77	°C/W
$R_{\theta JA}$	Thermal Resistance Junction to Ambient (Note 2)	114	°C/W

Package Marking and Ordering Information

Device Marking	Device	Package	Reel Size	Tape Width	Quantity
2601NZ	FDW2601NZ	TSSOP-8	13”	12 mm	2500 units
2601NZ	FDW2601NZ_NL (Note 4)	TSSOP-8	13”	12 mm	2500 units

Electrical Characteristics T_A = 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_A=100°C	-	-	5	
I_{GSS}	Gate to Source Leakage Current	V_{GS} = ±12V		-	-	±10	µA
		V_{GS} = ±4.5V				±250	nA
On Characteristics							
$V_{GS(TH)}$	Gate to Source Threshold Voltage	V_{GS} = V_{DS}, I_D = 250µA		0.6	0.8	1.5	V
$r_{DS(ON)}$	Drain to Source On Resistance	I_D = 8.2A, V_{GS} = 4.5V		-	0.011	0.015	Ω
		I_D = 7.9A, V_{GS} = 4.0V		-	0.011	0.016	
		I_D = 7.3A, V_{GS} = 3.1V		-	0.012	0.019	
		I_D = 7.1A, V_{GS} = 2.5V		-	0.012	0.020	
Dynamic Characteristics							
C_{ISS}	Input Capacitance	V_{DS} = 15V, V_{GS} = 0V, f = 1MHz		-	1840	-	pF
C_{OSS}	Output Capacitance			-	250	-	pF
C_{RSS}	Reverse Transfer Capacitance			-	160	-	pF
R_G	Gate Resistance	V_{GS} = 0.5V, f = 1MHz		-	2.6	-	Ω
$Q_{g(TOT)}$	Total Gate Charge at 4.5V	V_{GS} = 0V to 4.5V	V_{DD} = 15V I_D = 8.2A I_g = 1.0mA	-	20	30	nC
$Q_{g(2.5)}$	Total Gate Charge at 2.5V	V_{GS} = 0V to 2.5V		-	12	18	nC
Q_{gs}	Gate to Source Gate Charge			-	2.7	-	nC
Q_{gd}	Gate to Drain “Miller” Charge			-	5.1	-	nC

Switching Characteristics (V_{GS} = 4.5V)

t_{ON}	Turn-On Time	V_{DD} = 15V, I_D = 8.2A V_{GS} = 4.5V, R_{GS} = 6.8Ω	-	-	113	ns
$t_{d(ON)}$	Turn-On Delay Time		-	18	-	ns
t_r	Rise Time		-	57	-	ns
$t_{d(OFF)}$	Turn-Off Delay Time		-	69	-	ns
t_f	Fall Time		-	71	-	ns
t_{OFF}	Turn-Off Time		-	-	210	ns

Drain-Source Diode Characteristics

V_{SD}	Source to Drain Diode Voltage	I_{SD} = 1.3A	-	0.7	1.2	V
t_{rr}	Reverse Recovery Time	I_{SD} = 8.2A, dI_{SD}/dt = 100A/µs	-	-	28	ns
Q_{RR}	Reverse Recovered Charge	I_{SD} = 8.2A, dI_{SD}/dt = 100A/µs	-	-	17	nC

Notes:

1. $R_{\theta JA}$ is 77 ^{o}C/W (steady state) when mounted on a 1 inch^2 copper pad on FR-4.

2. $R_{\theta JA}$ is 114 ^{o}C/W (steady state) when mounted on a mininum copper pad on FR-4.

3. The diode connected to the gate and source serves only as protection against ESD. No gate overvoltage rating is implied.

4. FDW2601NZ_NL is lead free product. FDW2601NZ_NZ marking will appear on the reel label.

Typical Characteristic T_A = 25°C unless otherwise noted

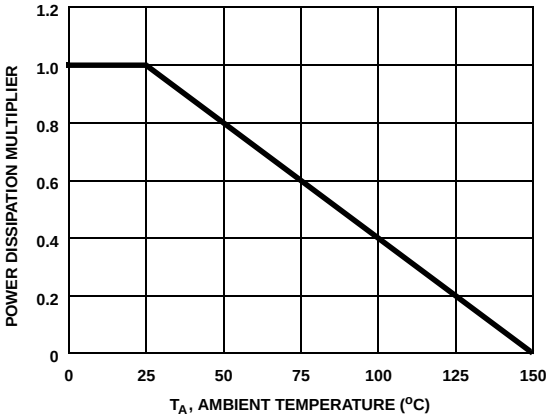


Figure 1. Normalized Power Dissipation vs Ambient Temperature

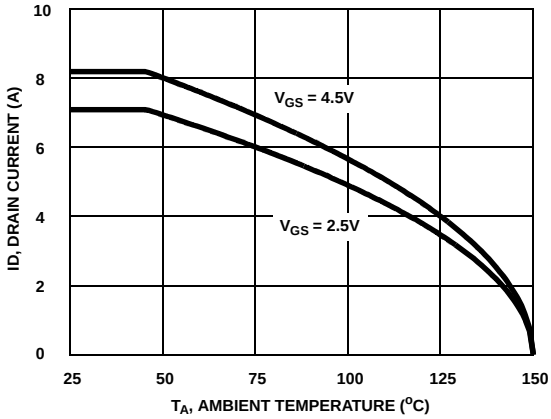


Figure 2. Maximum Continuous Drain Current vs Ambient Temperature

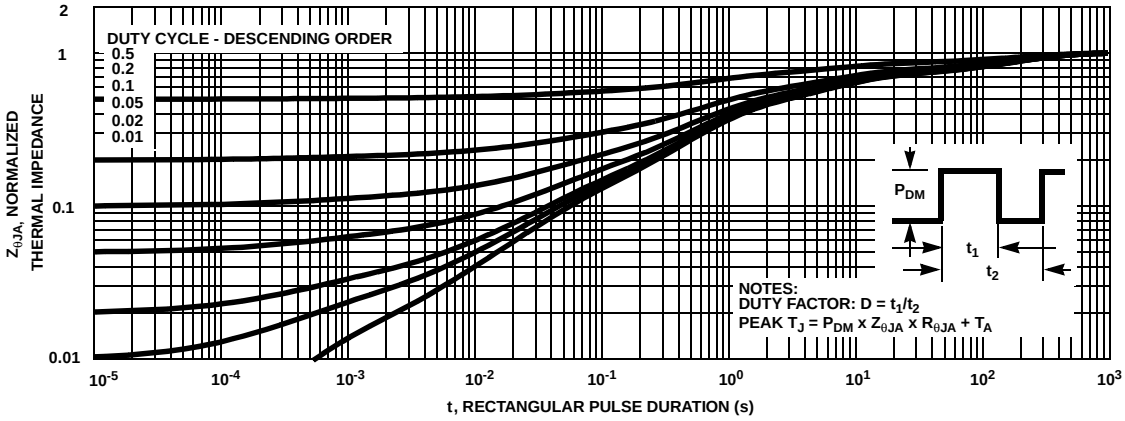


Figure 3. Normalized Maximum Transient Thermal Impedance

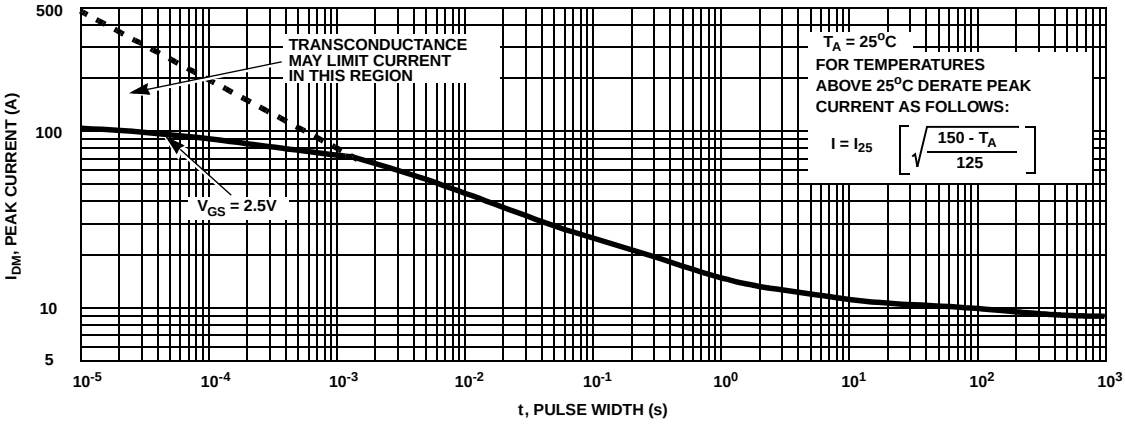


Figure 4. Peak Current Capability

Typical Characteristic (Continued) T_A = 25°C unless otherwise noted

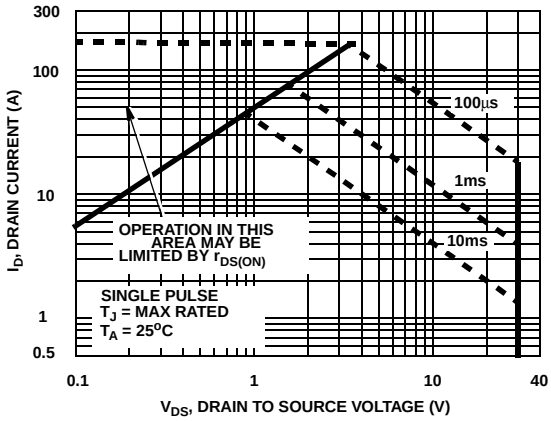


Figure 5. Forward Bias Safe Operating Area

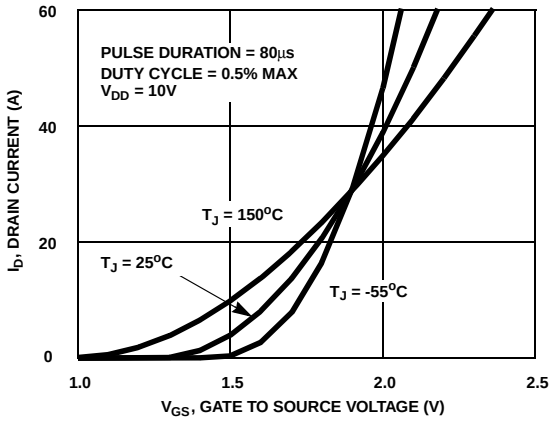


Figure 6. Transfer Characteristics

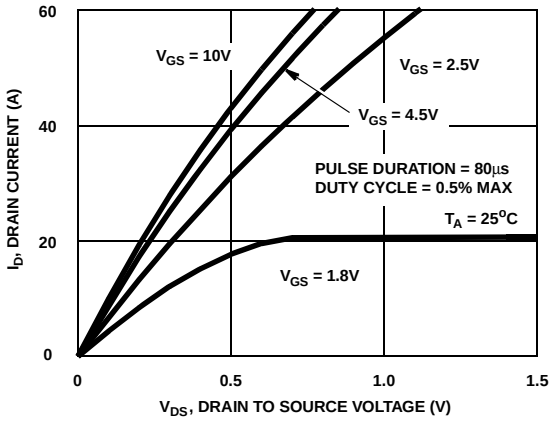


Figure 7. Saturation Characteristics

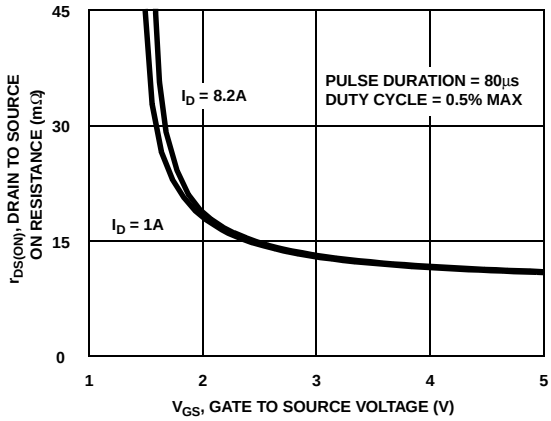


Figure 8. Drain to Source On Resistance vs Gate Voltage and Drain Current

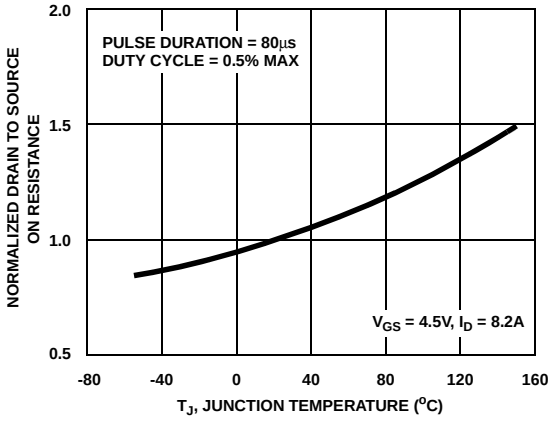


Figure 9. Normalized Drain to Source On Resistance vs Junction Temperature

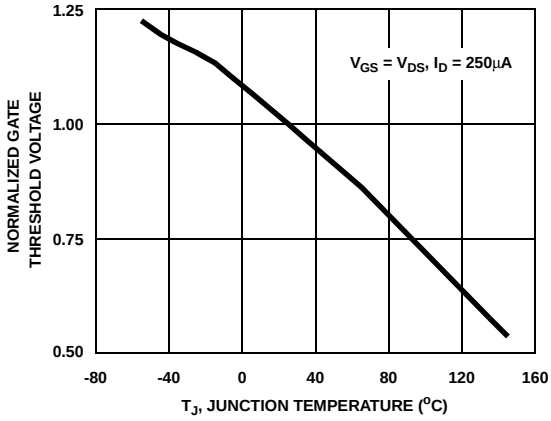


Figure 10. Normalized Gate Threshold Voltage vs Junction Temperature

Typical Characteristic (Continued) T_A = 25°C unless otherwise noted

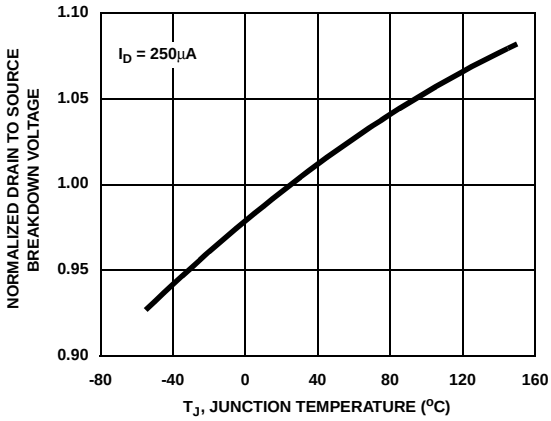


Figure 11. Normalized Drain to Source Breakdown Voltage vs Junction Temperature

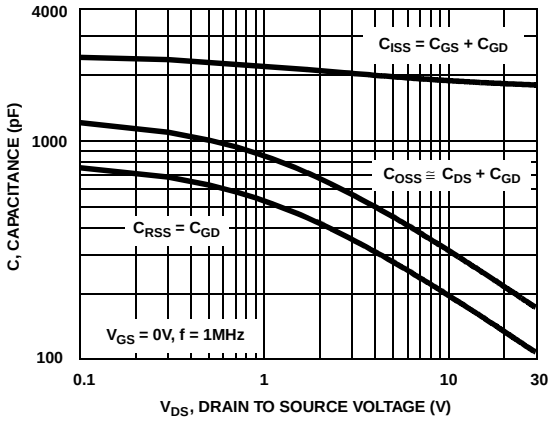


Figure 12. Capacitance vs Drain to Source Voltage

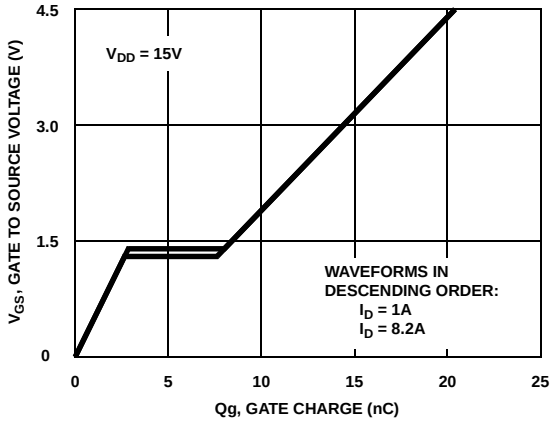


Figure 13. Gate Charge Waveforms for Constant Gate Currents

Test Circuits and Waveforms

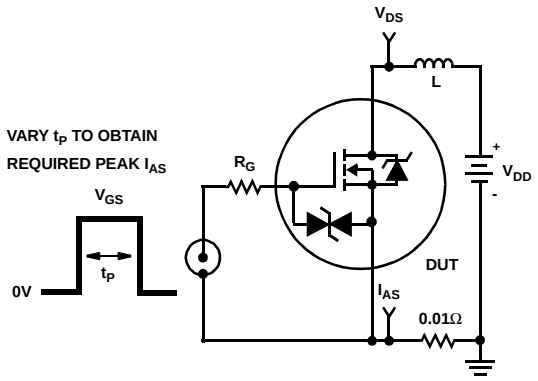


Figure 14. Unclamped Energy Test Circuit

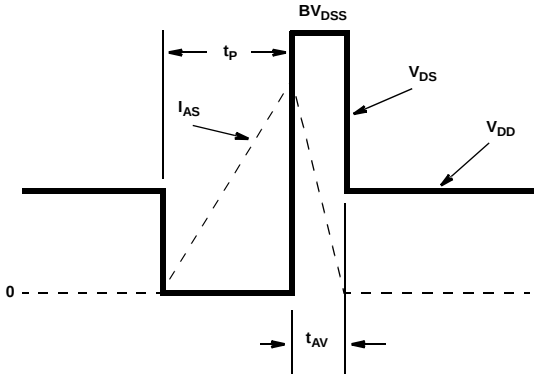


Figure 15. Unclamped Energy Waveforms

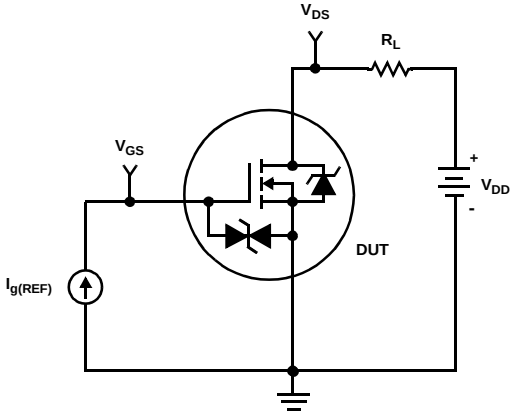


Figure 16. Gate Charge Test Circuit

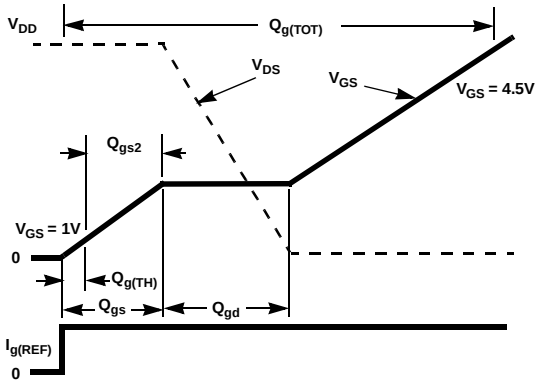


Figure 17. Gate Charge Waveforms

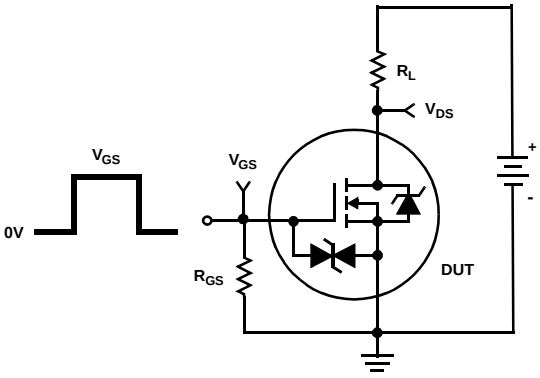


Figure 18. Switching Time Test Circuit

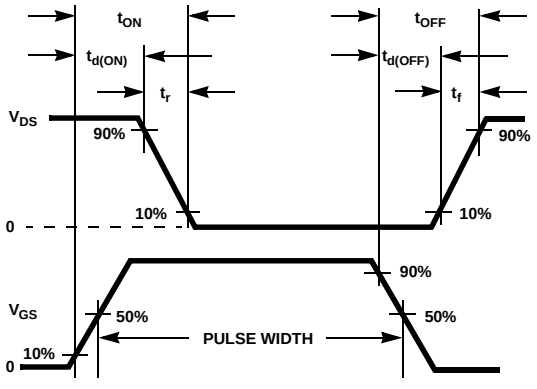
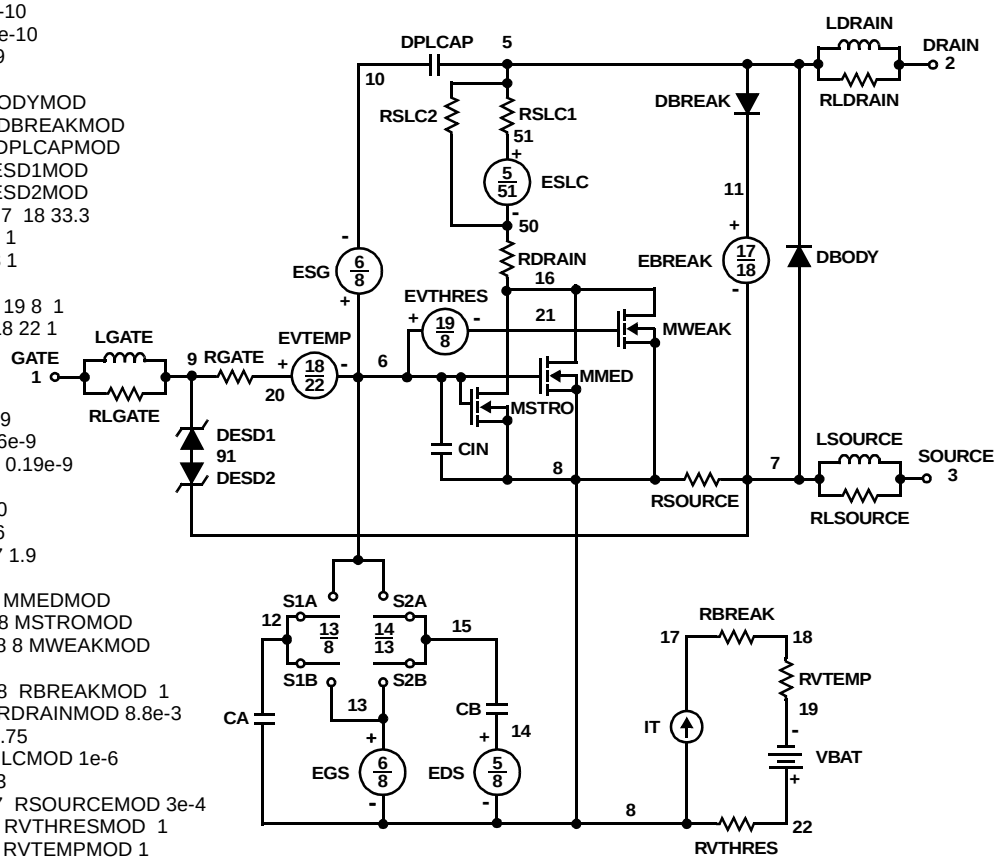


Figure 19. Switching Time Waveforms

PSPICE Electrical Model

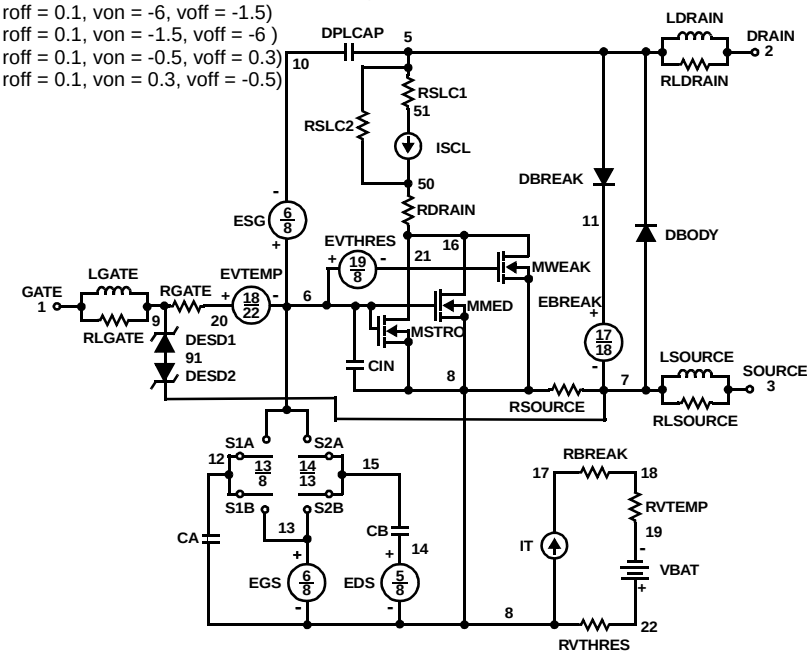
```
.SUBCKT FDW2601NZ  2 1 3 ;       rev June 2004
CA  12  8 19.3e-10
CB  15  14 19.3e-10
CIN  6  8  1.7e-9

DBODY 5 7 DBODYMOD
DBREAK 7 11  DBREAKMOD
DPLCAP 10 5  DPLCAPMOD
DESD1 91 9 DESD1MOD
DESD2 91 7 DESD2MOD
EBREAK 5 11 17  18 33.3
EDS  14  8  5  8 1
EGS  13  8  6  8 1
ESG 6 10 8 6 1
EVTHRES 6 21 19 8  1
EVTEMP 6 20 18 22 1

IT  8  17  1

LDRAIN 2 5 1e-9
LGATE 1  9 0.96e-9
LSOURCE  3  7 0.19e-9

RLDRAIN 2 5 10
RLGATE 1 9 9.6
RLSOURCE 3 7 1.9

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 8.8e-3
RGATE  9  20 2.75
RSLC1 5 51 RSLCMOD 1e-6
RSLC2 5 50 1e3
RSOURCE  8  7  RSOURCEMOD 3e-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*120),2.5))}

.MODEL DBODYMOD D (IS = 18.6e-12 N=0.93  RS = 6.6e-3 IKF=0.2 TRS1 = 1.7e-3  TRS2 = 2e-6  XTI=0.1  TIKF=0.001
CJO =5.2e-10  TT=8.7e-9   M = 0.58)
.MODEL DBREAKMOD D (RS = 1e-1  TRS1 = 9e-3  TRS2 = -2e-5)
.MODEL DPLCAPMOD D (CJO = 0.76e-9  IS = 1e-30  N = 10 M = 0.58)
.MODEL DESD1MOD D (BV=10.5 TBV1=-0.0018 N=9.4 RS=5)
.MODEL DESD2MOD D (BV=10.5 TBV1=-0.0018 N=9.4 RS=5)
.MODEL MMEDMOD NMOS (VTO = 1.0  KP = 1.7  IS=1e-30 N = 10 TOX = 1 L = 1u W = 1u RG = 2.75)
.MODEL MSTROMOD NMOS (VTO = 1.27  KP = 147  IS = 1e-30 N = 10 TOX = 1 L = 1u W = 1u)
.MODEL MWEAKMOD NMOS (VTO = 0.83  KP = 0.05 IS = 1e-30 N = 10 TOX = 1 L = 1u W = 1u RG = 27.5 RS = 0.1)

.MODEL RBREAKMOD RES (TC1 = 8.8e-4  TC2 = -13e-7)
.MODEL RDRAINMOD RES (TC1 = 1e-9  TC2 = 1e-5)
.MODEL RSLCMOD RES (TC1 = 2e-9 TC2 = 5e-8)
.MODEL RSOURCEMOD RES (TC1 = 8.2e-2 TC2 = 1e-6)
.MODEL RVTHRESMOD RES (TC1 = -13e-4 TC2 = -2.8e-6)
.MODEL RVTEMPMOD RES (TC1 = -1.3e-3  TC2 = 1e-6)

.MODEL S1AMOD VSWITCH (RON = 1e-5  ROFF = 0.1  VON = -6  VOFF= -1.5)
.MODEL S1BMOD VSWITCH (RON = 1e-5  ROFF = 0.1  VON = -1.5  VOFF= -6)
.MODEL S2AMOD VSWITCH (RON = 1e-5  ROFF = 0.1  VON = -0.5  VOFF= 0.3)
.MODEL S2BMOD VSWITCH (RON = 1e-5  ROFF = 0.1  VON = 0.3  VOFF= -0.5)
 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 June 2004
template fdw2601nz n2,n1,n3
electrical n2,n1,n3
{
var i iscl
dp..model dbodymod =  (isl = 18.6e-12, nl=0.93, rs = 6.6e-3, trs1 = 1.7e-3, trs2 = 2e-6, xti=0.1, cjo = 5.2e-10, ikf=0.2, tt = 8.7e-9,
m = 0.58, tikf=0.001)
dp..model dbreakmod = (rs = 1e-1, trs1 = 9e-3, trs2 = -2.0e-5)
dp..model dplcapmod =  (cjo = 0.76e-9, isl=10e-30, nl=10, m=0.58)
dp..model desd1mod = (bv=10.5, tbv1=-0.0018, nl=9.4, rs=5)
dp..model desd2mod = (bv=10.5, tbv1=-0.0018, nl=9.4, rs=5)
m..model mmedmod = (type=_n, vto = 1.0, kp=1.7, is=1e-30, tox=1)
m..model mstrongmod = (type=_n, vto = 1.27, kp = 147, is = 1e-30, tox = 1)
m..model mweakmod = (type=_n, vto = 0.83, kp = 0.05, is = 1e-30, tox = 1, rs=0.1)
sw_vcsp..model s1amod =  (ron = 1e-5, roff = 0.1, von = -6, voff = -1.5)
sw_vcsp..model s1bmod =  (ron = 1e-5, roff = 0.1, von = -1.5, voff = -6 )
sw_vcsp..model s2amod =  (ron = 1e-5, roff = 0.1, von = -0.5, voff = 0.3)
sw_vcsp..model s2bmod =  (ron = 1e-5, roff = 0.1, von = 0.3, voff = -0.5)

c.ca n12 n8 = 19.3e-10
c.cb n15 n14 = 19.3e-10
c.cin n6 n8 = 1.7e-9

dp.dbody n7 n5 = model=dbodymod
dp.dbreak n5 n11 = model=dbreakmod
dp.dplcap n10 n5 = model=dplcapmod
dp.desd1 n91 n9 = model=desd1mod
dp.desd2 n91 n7 = model=desd2mod

spe.ebreak n11 n7 n17 n18 = 33.3
spe.eds n14 n8 n5 n8 = 1
spe.egs n13 n8 n6 n8 = 1
spe.esg n6 n10 n6 n8 = 1
spe.evtemp n20 n6 n18 n22 = 1
spe.evthres n6 n21 n19 n8 = 1

i.it n8 n17 = 1

l.ldrain n2 n5 = 1e-9
l.lgate n1 n9 = 0.96e-9
l.lsource n3 n7 = 0.19e-9

res.rldrain n2 n5 = 10
res.rlgate n1 n9 = 9.6
res.rlsource n3 n7 = 1.9

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 = 8.8e-4, tc2 = -13e-7
res.rdrain n50 n16  = 8.8e-3, tc1 = 1e-9, tc2 = 1e-5
res.rgate n9 n20 = 2.75
res.rslc1 n5 n51= 1e-6, tc1 = 2e-9, tc2 =5e-8
res.rslc2 n5 n50 = 1e3
res.rsource n8 n7  = 3e-4, tc1 = 8.2e-2, tc2 =1e-6
res.rvtemp n18 n19  = 1, tc1 = -1.3e-3, tc2 = 1e-6
res.rvthres n22 n8  = 1, tc1 = -13e-4, tc2 = -2.8e-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)*1e6/120))** 2.5))
}
}
```



SPICE Thermal Model

REV June 2004
FDW2601NZ_JA Junction Ambient
Minimum copper pad area

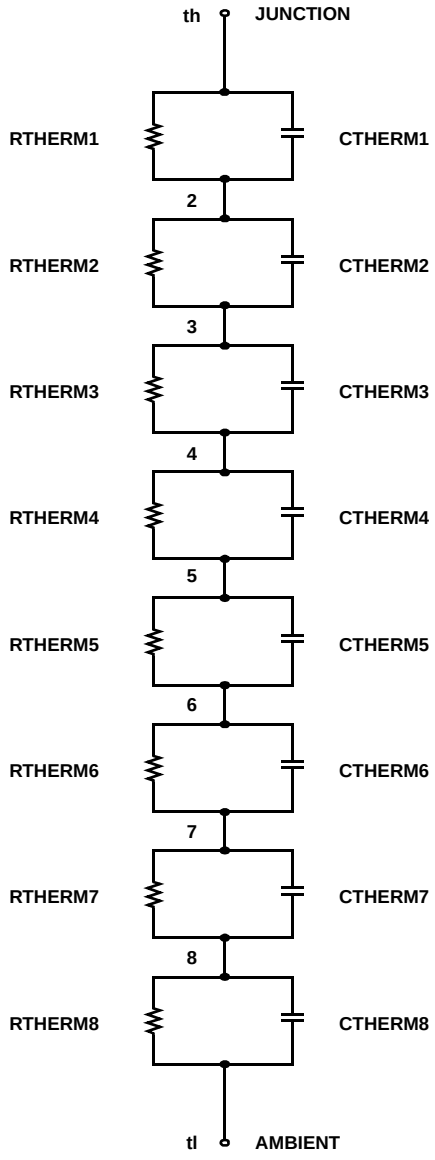
CTHERM1 Junction c2 5.7e-4
CTHERM2 c2 c3 5.72e-4
CTHERM3 c3 c4 5.8e-4
CTHERM4 c4 c5 4.7e-3
CTHERM5 c5 c6 5.1e-3
CTHERM6 c6 c7 0.02
CTHERM7 c7 c8 0.2
CTHERM8 c8 Ambient 6

RTHERM1 Junction c2 0.003
RTHERM2 c2 c3 0.25
RTHERM3 c3 c4 1.0
RTHERM4 c4 c5 1.1
RTHERM5 c5 c6 7.5
RTHERM6 c6 c7 33.6
RTHERM7 c7 c8 33.7
RTHERM8 c8 Ambient 33.8

SABER Thermal Model

SABER thermal model FDW2601NZ
Minimum copper pad area
template thermal_model th tl
thermal_c th, tl
{
ctherm.ctherm1 th c2 = 5.7e-4
ctherm.ctherm2 c2 c3 = 5.72e-4
ctherm.ctherm3 c3 c4 = 5.8e-4
ctherm.ctherm4 c4 c5 = 4.7e-3
ctherm.ctherm5 c5 c6 = 5.1e-3
ctherm.ctherm6 c6 c7 = 0.02
ctherm.ctherm7 c7 c8 = 0.2
ctherm.ctherm8 c8 tl = 6

rtherm.rtherm1 th c2 = 0.003
rtherm.rtherm2 c2 c3 = 0.25
rtherm.rtherm3 c3 c4 = 1.0
rtherm.rtherm4 c4 c5 = 1.1
rtherm.rtherm5 c5 c6 = 7.5
rtherm.rtherm6 c6 c7 = 33.6
rtherm.rtherm7 c7 c8 = 33.7
rtherm.rtherm8 c8 tl = 33.8
}



TRADEMARKS

The following are registered and unregistered trademarks Fairchild Semiconductor owns or is authorized to use and is not intended to be an exhaustive list of all such trademarks.

ACEx™	FACT Quiet Series™	ImpliedDisconnect™	POP™	Stealth™
ActiveArray™	FAST®	IntelliMAX™	Power247™	SuperFET™
Bottomless™	FASTr™	ISOPLANAR™	PowerEdge™	SuperSOT™-3
CoolFET™	FPS™	LittleFET™	PowerSaver™	SuperSOT™-6
CROSSVOLT™	FRFET™	MICROCOUPLER™	PowerTrench®	SuperSOT™-8
DOME™	GlobalOptoisolator™	MicroFET™	QFET®	SyncFET™
EcoSPARK™	GTO™	MicroPak™	QS™	TinyLogic®
E^2CMOS™	HiSeC™	MICROWIRE™	QT Optoelectronics™	TINYOPTO™
EnSigna™	I^2C™	MSX™	Quiet Series™	TruTranslation™
FACT™	*i-Lo*™	MSXPro™	RapidConfigure™	UHC™
		OCX™	RapidConnect™	UltraFET®
Across the board. Around the world.™		OCXPro™	µSerDes™	UniFET™
The Power Franchise®		OPTOLOGIC®	SILENT SWITCHER®	VCX™
Programmable Active Droop™		OPTOPLANAR™	SMART START™	
		PACMAN™	SPM™	

DISCLAIMER

FAIRCHILD SEMICONDUCTOR RESERVES THE RIGHT TO MAKE CHANGES WITHOUT FURTHER NOTICE TO ANY PRODUCTS HEREIN TO IMPROVE RELIABILITY, FUNCTION OR DESIGN. FAIRCHILD DOES NOT ASSUME ANY LIABILITY ARISING OUT OF THE APPLICATION OR USE OF ANY PRODUCT OR CIRCUIT DESCRIBED HEREIN; NEITHER DOES IT CONVEY ANY LICENSE UNDER ITS PATENT RIGHTS, NOR THE RIGHTS OF OTHERS.

LIFE SUPPORT POLICY

FAIRCHILD'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF FAIRCHILD SEMICONDUCTOR CORPORATION.

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, or (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 significant injury to the user.

2. A critical component is 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, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order 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 in order to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.