

## HUFA75433S3S

### N-Channel UltraFET® MOSFETs 60V, 64A, 16mΩ

#### General Description

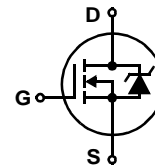
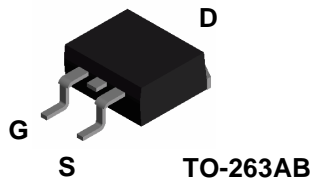
These N-Channel power MOSFETs are manufactured using the innovative UltraFET® process. This advanced process technology achieves very low on-resistance per silicon area, resulting in outstanding performance. This device is capable of withstanding high energy in the avalanche mode and the diode exhibits very low reverse recovery time and stored charge. It was designed for use in applications where power efficiency is important, such as switching regulators, switching convertors, motor drivers, relay drivers, low-voltage bus switches, and power management in portable and battery-operated products.

#### Applications

- Motor and Load Control
- Powertrain Management

#### Features

- 175°C Maximum Junction Temperature
- UIS Capability (Single Pulse and Repetitive Pulse)
- Ultra-Low On-Resistance  $r_{DS(ON)} = 0.016\Omega$ ,  $V_{GS} = 10V$



#### MOSFET Maximum Ratings $T_C = 25^\circ\text{C}$ unless otherwise noted

Symbol	Parameter	Ratings	Units
$V_{DSS}$	Drain to Source Voltage	60	V
$V_{GS}$	Gate to Source Voltage	$\pm 20$	V
$I_D$	Drain Current		
	Continuous ( $T_C = 25^\circ\text{C}$ , $V_{GS} = 10V$ )	64	A
	Continuous ( $T_C = 125^\circ\text{C}$ , $V_{GS} = 10V$ , $R_{\theta JA} = 43^\circ\text{C/W}$ )	5	A
	Pulsed	Figure 4	A
$E_{AS}$	Single Pulse Avalanche Energy (Note 1)	250	mJ
$P_D$	Power dissipation	150	W
	Derate above $25^\circ\text{C}$	1	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-263	1	$^\circ\text{C/W}$
$R_{\theta JA}$	Thermal Resistance Junction to Ambient TO-263	62	$^\circ\text{C/W}$
$R_{\theta JA}$	Thermal Resistance Junction to Ambient TO-263, 1in <sup>2</sup> copper pad area	43	$^\circ\text{C/W}$

This product has been designed to meet the extreme test conditions and environment demanded by the automotive industry. For a copy of the requirements, see AEC Q101 at: <http://www.aecouncil.com/>

Reliability data can be found at: <http://www.fairchildsemi.com/products/discrete/reliability/index.html>.

All Fairchild Semiconductor products are manufactured, assembled and tested under ISO9000 and QS9000 quality systems certification.

## Package Marking and Ordering Information

Device Marking	Device	Package	Reel Size	Tape Width	Quantity
75433S3	HUFA75433S3ST	TO-263	330mm	24mm	800 units
75433S3	HUFA75433S3S	TO-263	Tube	N/A	50 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	$I_D = 250\mu\text{A}, V_{GS} = 0\text{V}$	60	-	-	V
$I_{DSS}$	Zero Gate Voltage Drain Current	$V_{DS} = 55\text{V}, V_{GS} = 0\text{V}$	-	-	1	$\mu\text{A}$
		$V_{DS} = 45\text{V}, V_{GS} = 0\text{V}$ $T_C = 150^\circ\text{C}$	-	-	250	
$I_{GSS}$	Gate to Source Leakage Current	$V_{GS} = \pm 20\text{V}$	-	-	$\pm 100$	nA

### On Characteristics

$V_{GS(TH)}$	Gate to Source Threshold Voltage	$V_{GS} = V_{DS}, I_D = 250\mu\text{A}$	2	-	4	V
$r_{DS(ON)}$	Drain to Source On Resistance	$I_D = 64\text{A}, V_{GS} = 10\text{V}$	-	0.013	0.016	$\Omega$
		$I_D = 64\text{A}, V_{GS} = 10\text{V}, T_J = 175^\circ\text{C}$	-	0.029	0.035	

### Dynamic Characteristics

$C_{ISS}$	Input Capacitance	$V_{DS} = 25\text{V}, V_{GS} = 0\text{V}, f = 1\text{MHz}$	-	1550	-	pF	
$C_{OSS}$	Output Capacitance		-	540	-	pF	
$C_{RSS}$	Reverse Transfer Capacitance		-	150	-	pF	
$Q_{g(TOT)}$	Total Gate Charge at 20V	$V_{GS} = 0\text{V to } 20\text{V}$	$V_{DD} = 30\text{V}$ $I_D = 64\text{A}$ $I_g = 1.0\text{mA}$	90	117	nC	
$Q_{g(10)}$	Total Gate Charge at 10V	$V_{GS} = 0\text{V to } 10\text{V}$		-	50	65	nC
$Q_{g(TH)}$	Threshold Gate Charge	$V_{GS} = 0\text{V to } 2\text{V}$		-	3	3.9	nC
$Q_{gs}$	Gate to Source Gate Charge			-	6	-	nC
$Q_{gd}$	Gate to Drain "Miller" Charge			-	20	-	nC

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

$t_{ON}$	Turn-On Time	$V_{DD} = 30\text{V}, I_D = 64\text{A}$ $V_{GS} = 10\text{V}, R_{GS} = 6.2\Omega$	-	-	155	ns
$t_{d(ON)}$	Turn-On Delay Time		-	11	-	ns
$t_r$	Rise Time		-	92	-	ns
$t_{d(OFF)}$	Turn-Off Delay Time		-	39	-	ns
$t_f$	Fall Time		-	26	-	ns
$t_{OFF}$	Turn-Off Time		-	-	98	ns

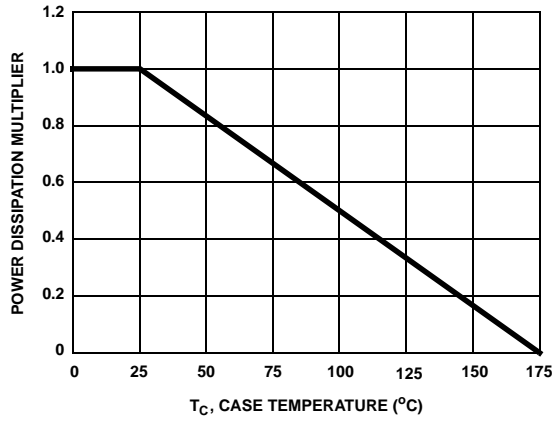
### Drain-Source Diode Characteristics

$V_{SD}$	Source to Drain Diode Voltage	$I_{SD} = 64\text{A}$	-	-	1.25	V
		$I_{SD} = 32\text{A}$	-	-	1.0	V
$t_{rr}$	Reverse Recovery Time	$I_{SD} = 64\text{A}, dI_{SD}/dt = 100\text{A}/\mu\text{s}$	-	-	37	ns
$Q_{RR}$	Reverse Recovered Charge	$I_{SD} = 64\text{A}, dI_{SD}/dt = 100\text{A}/\mu\text{s}$	-	-	42	nC

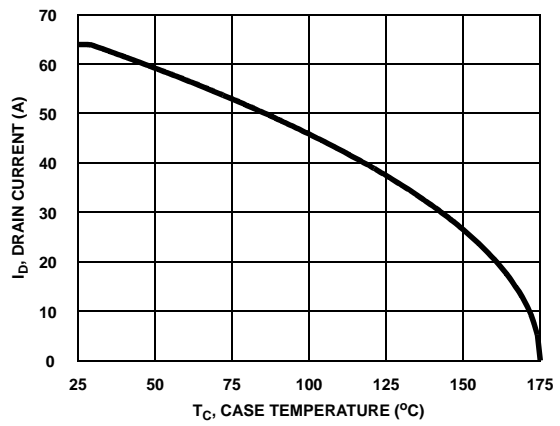
#### Notes:

1: Starting  $T_J = 25^\circ\text{C}$ ,  $L = 200\mu\text{H}$ ,  $I_{AS} = 50\text{A}$

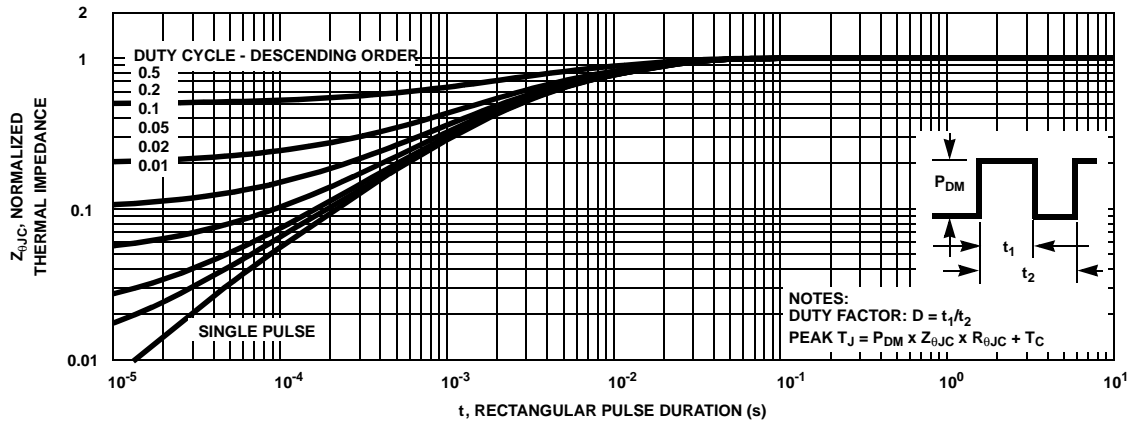
**Typical Characteristics**  $T_C = 25^\circ\text{C}$  unless otherwise noted



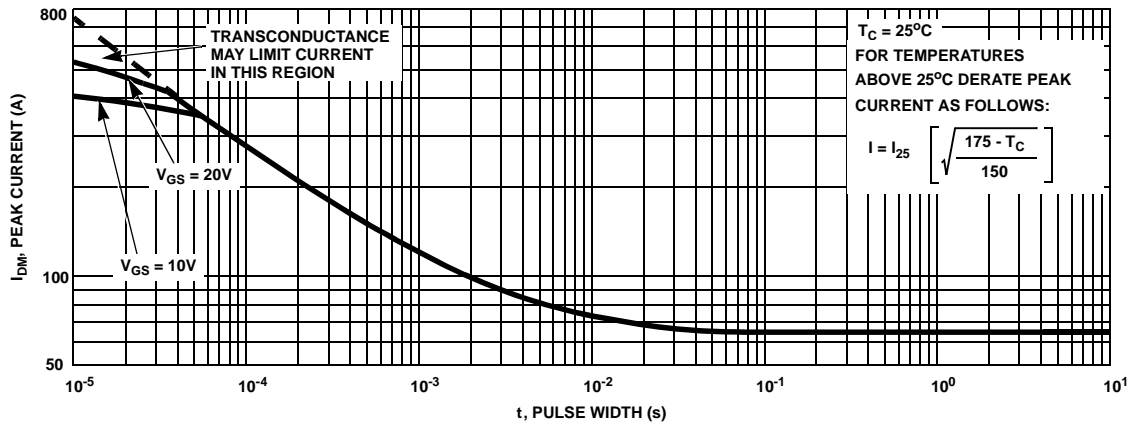
**Figure 1. Normalized Power Dissipation vs Ambient Temperature**



**Figure 2. Maximum Continuous Drain Current vs Case Temperature**

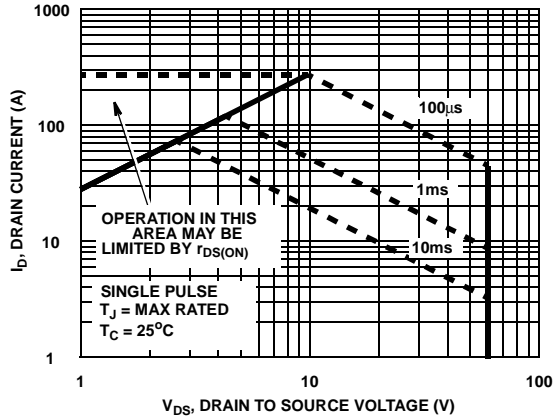


**Figure 3. Normalized Maximum Transient Thermal Impedance**

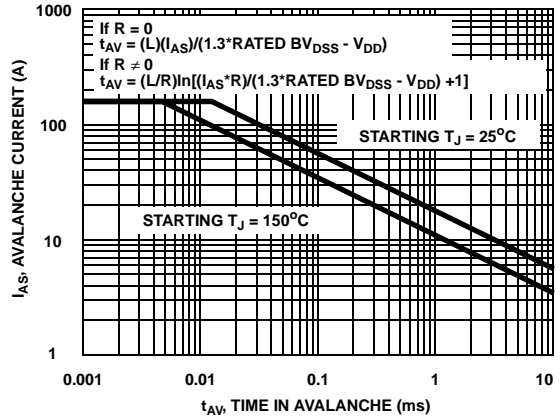


**Figure 4. Peak Current Capability**

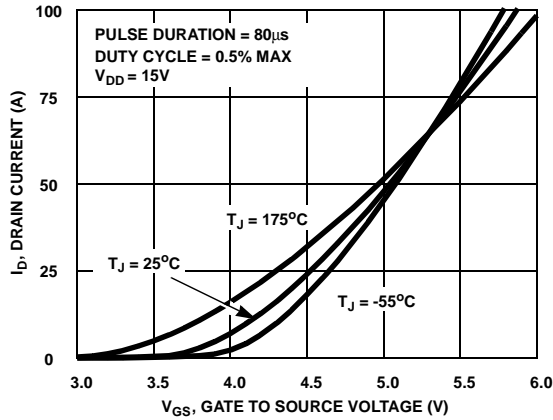
**Typical Characteristics**  $T_C = 25^\circ\text{C}$  unless otherwise noted



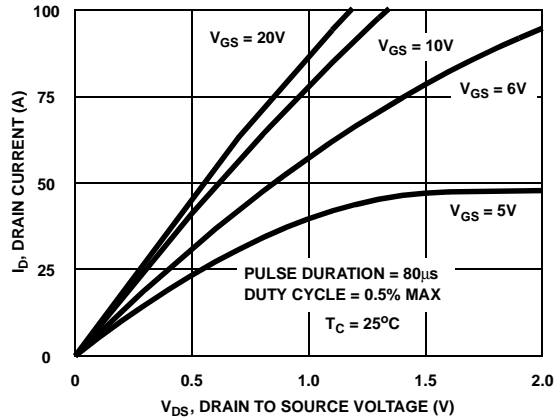
**Figure 5. Forward Bias Safe Operating Area**



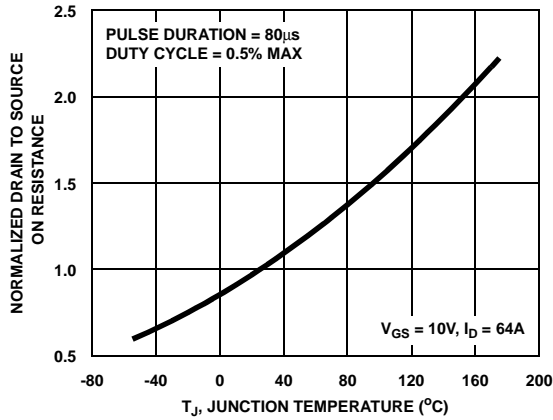
**Figure 6. Unclamped Inductive Switching Capability**



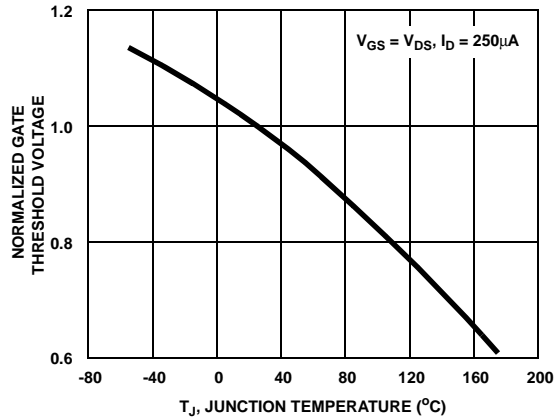
**Figure 7. Transfer Characteristics**



**Figure 8. Saturation Characteristics**

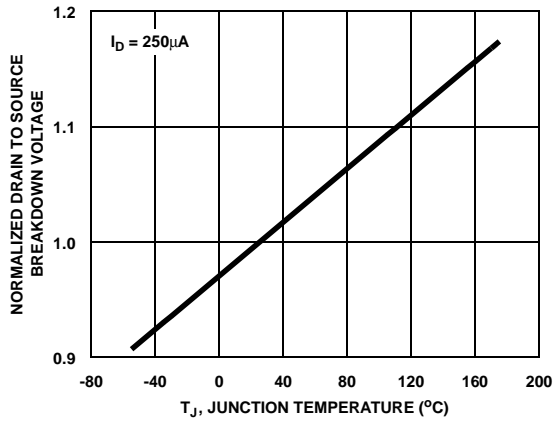


**Figure 9. Normalized Drain to Source On Resistance vs. Junction Temperature**

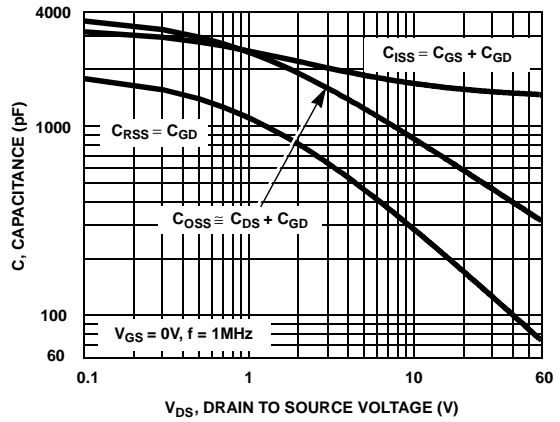


**Figure 10. Normalized Gate Threshold Voltage vs. Junction Temperature**

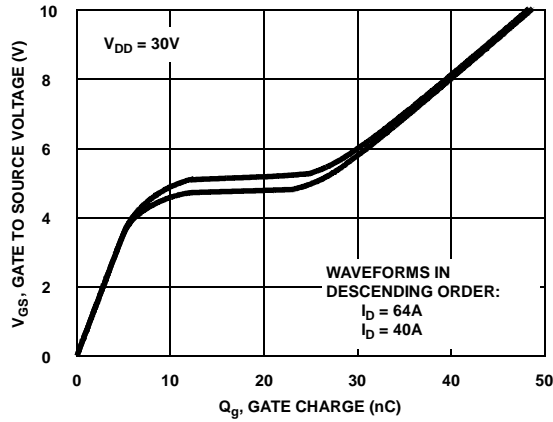
**Typical Characteristics**  $T_C = 25^\circ\text{C}$  unless otherwise noted



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

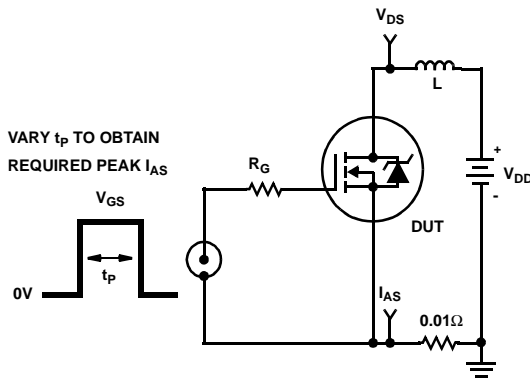


**Figure 12. Capacitance vs Drain to Source Voltage**

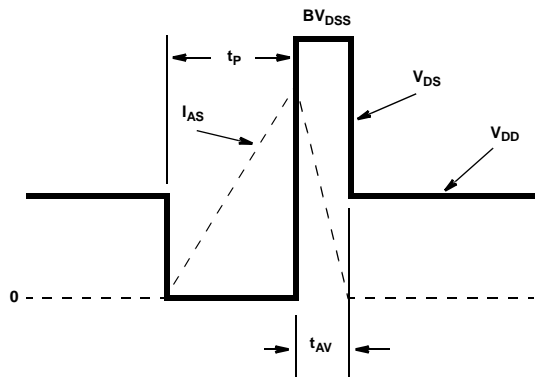


**Figure 13. Gate Charge Waveforms for Constant Gate Currents**

**Test Circuits and Waveforms**



**Figure 14. Unclamped Energy Test Circuit**



**Figure 15. Unclamped Energy Waveforms**

Test Circuits and Waveforms (Continued)

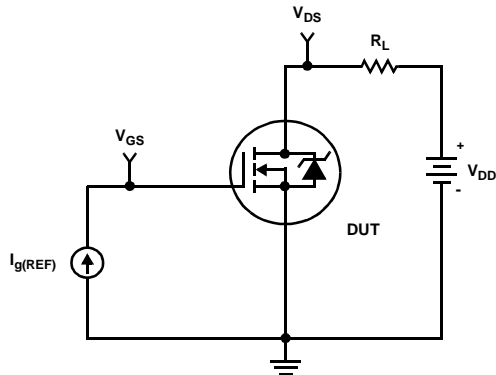


Figure 16. Gate Charge Test Circuit

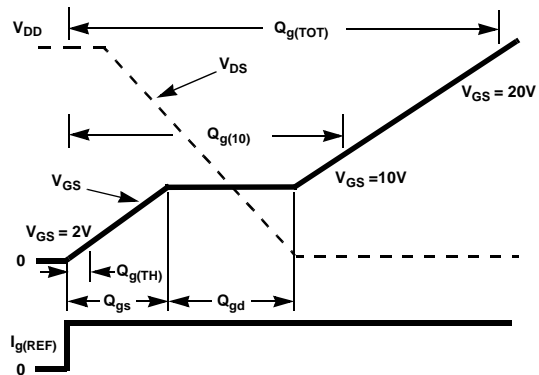


Figure 17. Gate Charge Waveforms

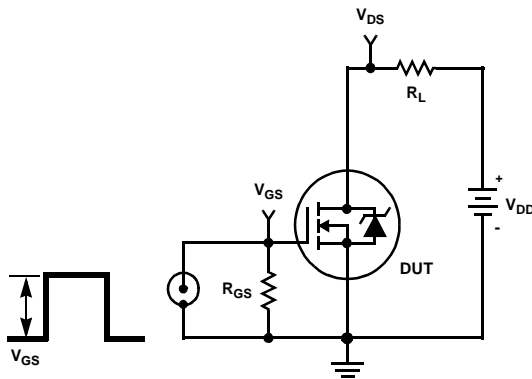


Figure 18. Switching Time Test Circuit

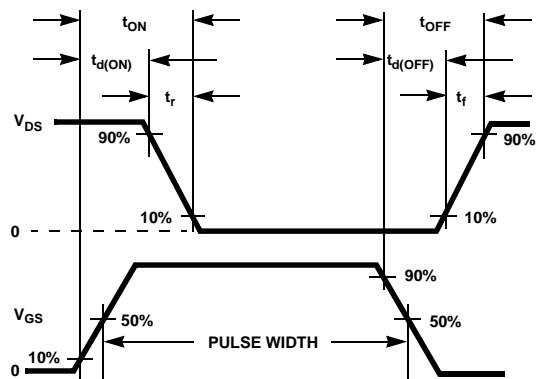


Figure 19. Switching Time Waveforms

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

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

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:

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 20 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 20 or by calculation using Equation 2. The area, in square inches is the top copper area including the gate and source pads.

$$R_{\theta JA} = 26.51 + \frac{19.84}{(0.268 + Area)} \quad (EQ. 2)$$

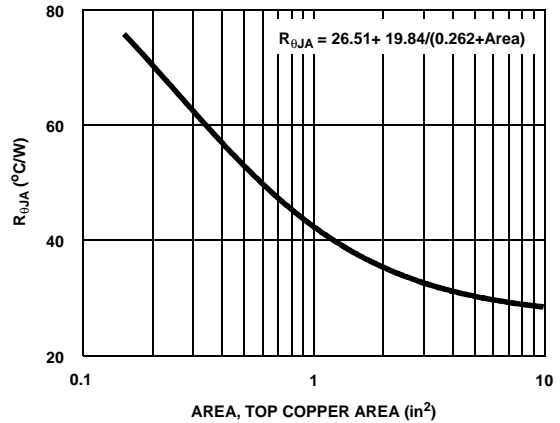


Figure 20. Thermal Resistance vs Mounting Pad Area

**PSPICE Electrical Model**

.SUBCKT HUFA75433S3S February 2002  
 CA 12 8 2.5e-9  
 CB 15 14 2.8e-9  
 CIN 6 8 1.4e-9

DBODY 7 5 DBODYMOD  
 DBREAK 5 11 DBREAKMOD  
 DPLCAP 10 5 DPLCAPMOD

EBREAK 11 7 17 18 65.5  
 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 6.57e-9  
 LDRAIN 2 5 1e-9  
 LSOURCE 3 7 3.4e-9

RLGATE 1 9 65.7  
 RLDRAIN 2 5 10  
 RLSOURCE 3 7 34

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 2.7e-3  
 RGATE 9 20 1.53  
 RSLC1 5 51 RSLCMOD 1e-6  
 RSLC2 5 50 1e3  
 RSOURCE 8 7 RSOURCEMOD 6.9e-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\*215),2.5))}

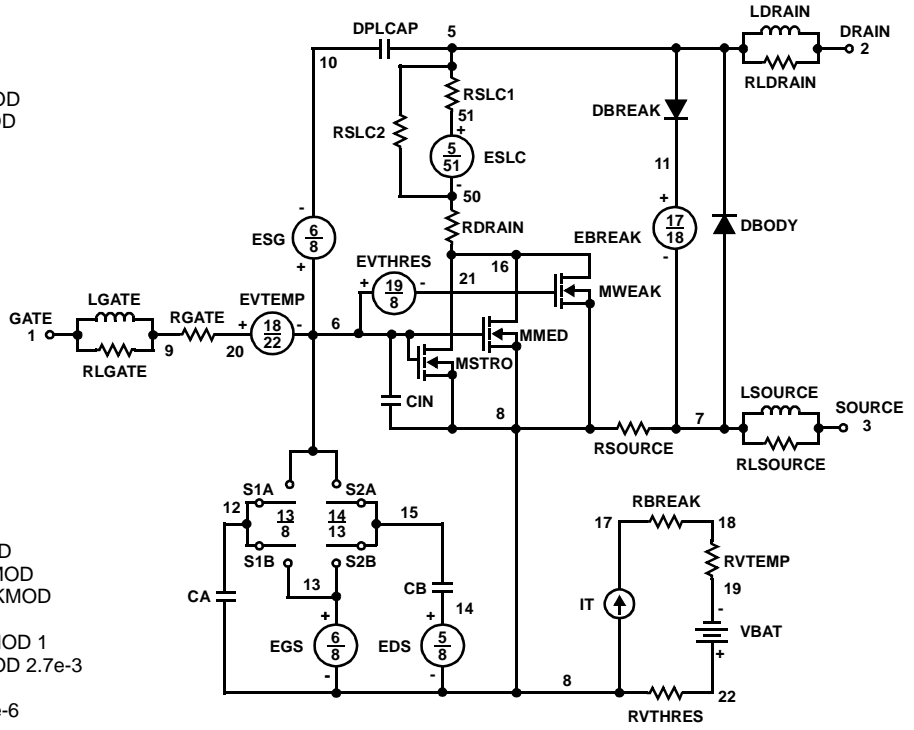
.MODEL DBODYMOD D (IS = 1.3e-12 RS = 3.05e-3 TRS1 = 2.4e-3 TRS2 = 1.5e-7 CJO = 1.92e-9 TT = 5e-9 M = 0.50 XTI=4.5)  
 .MODEL DBREAKMOD D (RS = 2.2 TRS1 = 2.4e-3 TRS2 = -2e-5)  
 .MODEL DPLCAPMOD D (CJO = 1.93e-9 IS = 1e-30 N = 10 M = 0.79)

.MODEL MmedMOD NMOS (VTO=2.93 KP=2.6 IS=1e-30 N=10 TOX=1 L=1u W=1u RG=1.53)  
 .MODEL MstroMOD NMOS (VTO=3.55 KP=70 IS=1e-30 N=10 TOX=1 L=1u W=1u)  
 .MODEL MweakMOD NMOS (VTO=2.62 KP=0.05 IS=1e-30 N=10 TOX=1 L=1u W=1u RG=15.3 RS=0.1)

.MODEL RBREAKMOD RES (TC1 = 1.2e-3 TC2 = -1.7e-8)  
 .MODEL RDRAINMOD RES (TC1 = 2e-2 TC2 = 5.1e-5)  
 .MODEL RSLCMOD RES (TC1 = 3e-3 TC2 = 2.9e-6)  
 .MODEL RSOURCEMOD RES (TC1 = 1e-3 TC2 = 1e-6)  
 .MODEL RVTEMPMOD RES (TC1 = -2.8e-3 TC2 = 1e-6)  
 .MODEL RVTHRESMOD RES (TC1 = -2.1e-3 TC2 = -1.1e-5)

.MODEL S1AMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = -6 VOFF= -3)  
 .MODEL S1BMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = -3 VOFF= -6)  
 .MODEL S2AMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = -0.4 VOFF= 0.3)  
 .MODEL S2BMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = 0.3 VOFF= -0.4)  
 .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 February 2002  
 template HUFA75433S3S n2,n1,n3  
 electrical n2,n1,n3

```

{
var i iscl
dp..model dbodymod = (isl=1.3e-12,rs=3.05e-3,trs1=2.4e-3,trs2=1.5e-7,cjo=1.92e-9,tt=5e-9,m=0.50,xti=4.5)
dp..model dbreakmod = (rs=2.2,trs1=2.4e-3,trs2=-2e-5)
dp..model dplcapmod = (cjo=1.93e-9,isl=10e-30,nl=10,m=0.79)
m..model mmedmod = (type=_n,vto=2.93,kp=2.6,is=1e-30, tox=1)
m..model mstrongmod = (type=_n,vto=3.55,kp=70,is=1e-30, tox=1)
m..model mweakmod = (type=_n,vto=2.62,kp=0.05,is=1e-30, tox=1,rs=0.1)
sw_vcsp..model s1amod = (ron=1e-5,roff=0.1,von=-6,voff=-3)
sw_vcsp..model s1bmod = (ron=1e-5,roff=0.1,von=-3,voff=-6)
sw_vcsp..model s2amod = (ron=1e-5,roff=0.1,von=-0.4,voff=0.3)
sw_vcsp..model s2bmod = (ron=1e-5,roff=0.1,von=0.3,voff=-0.4)
c.ca n12 n8 = 2.5e-9
c.cb n15 n14 = 2.8e-9
c.cin n6 n8 = 1.4e-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 = 65.5
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 = 6.57e-9
l.ldrain n2 n5 = 1e-9
l.lsource n3 n7 = 3.4e-9
    
```

```

res.rlgate n1 n9 = 65.7
res.rldrain n2 n5 = 10
res.rlsource n3 n7 = 34
    
```

```

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=1.2e-3,tc2=-1.7e-8
res.rdrain n50 n16 = 2.7e-3, tc1=2e-2,tc2=5.1e-5
res.rgate n9 n20 = 1.53
res.rslc1 n5 n51 = 1e-6, tc1=3e-3,tc2=2.9e-6
res.rslc2 n5 n50 = 1e3
res.rsource n8 n7 = 6.9e-3, tc1=1e-3,tc2=1e-6
res.rvthres n22 n8 = 1, tc1=-2.1e-3,tc2=-1.1e-5
res.rvtemp n18 n19 = 1, tc1=-2.8e-3,tc2=1e-6
    
```

```

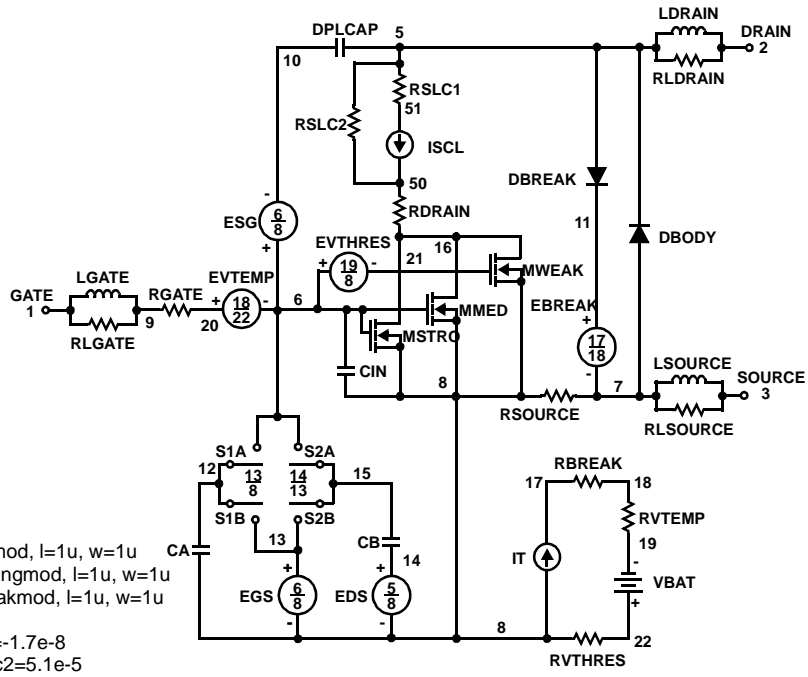
sw_vcsp.s1a n6 n12 n13 n8 = model=s1amod
sw_vcsp.s1b n13 n12 n13 n8 = model=s1bmod
sw_vcsp.s2a n6 n15 n14 n13 = model=s2amod
sw_vcsp.s2b n13 n15 n14 n13 = model=s2bmod
    
```

```

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))*1e6/215))** 2.5))
}
    
```



**SPICE Thermal Model**

REV 23 February 2002

HUFA75433S3

CTHERM1 TH 6 4.9e-4  
 CTHERM2 6 5 4.5e-3  
 CTHERM3 5 4 6.0e-3  
 CTHERM4 4 3 8.5e-3  
 CTHERM5 3 2 0.8e-2  
 CTHERM6 2 TL 4.2e-2

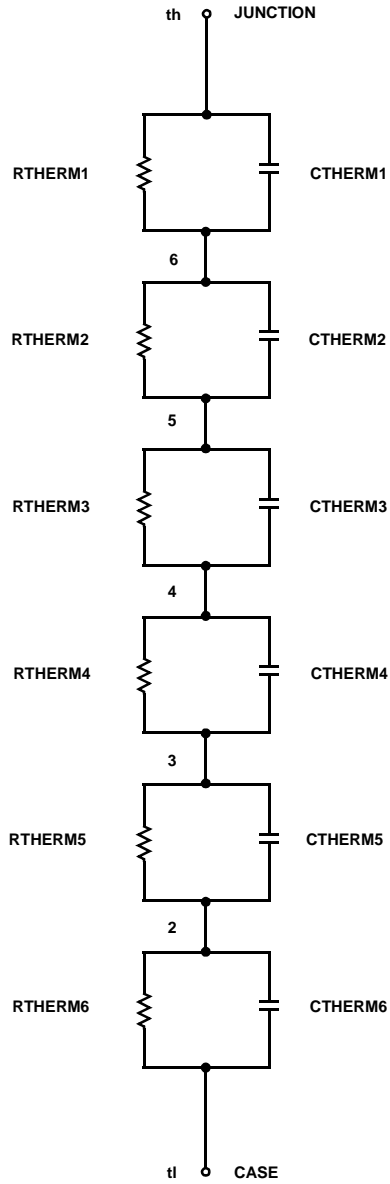
RTHERM1 TH 6 6.0e-4  
 RTHERM2 6 5 6.8e-3  
 RTHERM3 5 4 3.3e-2  
 RTHERM4 4 3 9.9e-2  
 RTHERM5 3 2 3.3e-1  
 RTHERM6 2 TL 3.5e-1

**SABER Thermal Model**

SABER thermal model HUFA75433S3  
 template thermal\_model th tl  
 thermal\_c th, tl

```
{
    ctherm.ctherm1 th 6 =4.9e-4
    ctherm.ctherm2 6 5 =4.5e-3
    ctherm.ctherm3 5 4 =6.0e-3
    ctherm.ctherm4 4 3 =8.5e-3
    ctherm.ctherm5 3 2 =0.8e-2
    ctherm.ctherm6 2 tl =4.2e-2

    rtherm.rtherm1 th 6 =6.0e-4
    rtherm.rtherm2 6 5 =6.8e-3
    rtherm.rtherm3 5 4 =3.3e-2
    rtherm.rtherm4 4 3 =9.9e-2
    rtherm.rtherm5 3 2 =3.3e-1
    rtherm.rtherm6 2 tl =3.5e-1
}
```



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## PRODUCT STATUS DEFINITIONS

### Definition of Terms

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