

# MOSFET – Power, N-Channel, Logic Level, UltraFET

60 V, 20 A, 27 mΩ

## HUFA76429D3

### Features

- Ultra Low On-Resistance
  - ◆  $r_{DS(ON)} = 0.023 \Omega$ ,  $V_{GS} = 10 V$
  - ◆  $r_{DS(ON)} = 0.027 \Omega$ ,  $V_{GS} = 5 V$
- Simulation Models
  - ◆ Temperature Compensated PSPICE™ and Saber® Electrical Models
  - ◆ Spice and SABER Thermal Impedance Models
  - ◆ [www.onsemi.com](http://www.onsemi.com)
- Peak Current vs. Pulse Width Curve
- UIS Rating Curve
- Switching Time vs.  $R_{GS}$  Curves

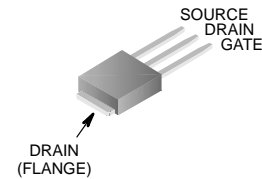
### ABSOLUTE MAXIMUM RATINGS ( $T_C = 25^\circ C$ unless otherwise noted)

Rating		Symbol	HUFA76429D3	Unit
Drain to Source Voltage (Note 1)		$V_{DSS}$	60	V
Drain to Gate Voltage ( $R_{GS} = 20 k\Omega$ ) (Note 1)		$V_{DGR}$	60	V
Gate to Source Voltage		$V_{GS}$	$\pm 16$	V
Drain Current	Continuous ( $T_C = 25^\circ C$ , $V_{GS} = 5 V$ )	$I_D$	20	A
	Continuous ( $T_C = 25^\circ C$ , $V_{GS} = 10 V$ ) (Figure 2)	$I_D$	20	A
	Continuous ( $T_C = 100^\circ C$ , $V_{GS} = 5 V$ )	$I_D$	20	A
	Continuous ( $T_C = 100^\circ C$ , $V_{GS} = 4.5 V$ ) (Figure 2)	$I_D$	20	A
	Pulsed Drain Current	$I_{DM}$	Figure 4	
Pulsed Avalanche Rating		UIS	Figures 6, 17, 18	
Power Dissipation		$P_D$	110	W
	Derate Above $25^\circ C$		0.74	W/ $^\circ C$
Operating and Storage Temperature		$T_J, T_{STG}$	-55 to 175	$^\circ C$
Maximum Temperature for Soldering	Leads at 0.063 in (1.6 mm) from Case for 10 s	$T_L$	300	$^\circ C$
	Package Body for 10 s, See Techbrief TB334	$T_{pkg}$	260	$^\circ C$

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

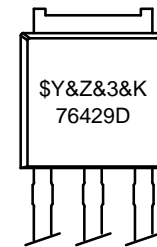
1.  $T_J = 25^\circ C$  to  $150^\circ C$ .

$V_{DSS}$	$r_{DS(ON)} \text{ MAX}$	$I_D \text{ MAX}$
60 V	23 mΩ @ 10 V	20 A
	27 mΩ @ 4.5 V	
	29 mΩ @ 4.5 V	

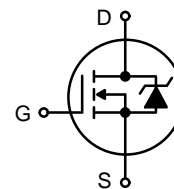


DPAK3 (IPAK)  
JEDEC (TO-251AA)  
CASE 369AR

### MARKING DIAGRAM



\$Y = Logo  
&Z = Assembly Plant Code  
&3 = 3-Digit Date Code  
&K = 2-Digits Lot Run Traceability Code  
76429D = Device Code



N-Channel

### ORDERING INFORMATION

Part Number	Package	Marking	Shipping
HUFA76429D3	DPAK3 (IPAK) (TO-251AA)	76429D	1800 Units / Tube

# HUFA76429D3

## ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
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### OFF STATE SPECIFICATIONS

Drain to Source Breakdown Voltage	BV <sub>DSS</sub>	I <sub>D</sub> = 250 μA, V <sub>GS</sub> = 0 V (Figure 12)	60	–	–	V
		I <sub>D</sub> = 250 μA, V <sub>GS</sub> = 0 V, T <sub>C</sub> = –40°C (Figure 12)	55	–	–	V
Zero Gate Voltage Drain Current	I <sub>DSS</sub>	V <sub>DS</sub> = 55 V, V <sub>GS</sub> = 0 V	–	–	1	μA
		V <sub>DS</sub> = 50 V, V <sub>GS</sub> = 0 V, T <sub>C</sub> = 150°C	–	–	250	μA
Gate to Source Leakage Current	I <sub>GSS</sub>	V <sub>GS</sub> = ±16 V	–	–	±100	nA

### ON STATE SPECIFICATIONS

Gate to Source Threshold Voltage	V <sub>GS(TH)</sub>	V <sub>GS</sub> = V <sub>DS</sub> , I <sub>D</sub> = 250 μA (Figure 11)	1	–	3	V
Drain to Source On Resistance	r <sub>DS(ON)</sub>	I <sub>D</sub> = 20 A, V <sub>GS</sub> = 10 V (Figures 9, 10)	–	0.0205	0.023	Ω
		I <sub>D</sub> = 20 A, V <sub>GS</sub> = 5 V (Figure 9)	–	0.024	0.027	Ω
		I <sub>D</sub> = 20 A, V <sub>GS</sub> = 4.5 V (Figure 9)	–	0.025	0.029	Ω

### THERMAL SPECIFICATIONS

Thermal Resistance Junction to Case	R <sub>θJC</sub>	TO–251	–	–	1.36	°C/W
Thermal Resistance Junction to Ambient	R <sub>θJA</sub>		–	–	100	°C/W

### SWITCHING SPECIFICATIONS (V<sub>GS</sub> = 4.5 V)

Turn–On Time	t <sub>ON</sub>	V <sub>DD</sub> = 30 V, I <sub>D</sub> = 20 A V <sub>GS</sub> = 4.5 V, R <sub>GS</sub> = 7.5 Ω (Figures 15, 21, 22)	–	–	220	ns
Turn–On Delay Time	t <sub>d(ON)</sub>		–	13	–	ns
Rise Time	t <sub>r</sub>		–	134	–	ns
Turn–Off Delay Time	t <sub>d(OFF)</sub>		–	30	–	ns
Fall Time	t <sub>f</sub>		–	55	–	ns
Turn–Off Time	t <sub>OFF</sub>		–	–	130	ns

### SWITCHING SPECIFICATIONS (V<sub>GS</sub> = 10 V)

Turn–On Time	t <sub>ON</sub>	V <sub>DD</sub> = 30 V, I <sub>D</sub> = 20 A V <sub>GS</sub> = 10 V, R <sub>GS</sub> = 8.2 Ω (Figures 16, 21, 22)	–	–	65	ns
Turn–On Delay Time	t <sub>d(ON)</sub>		–	7.7	–	ns
Rise Time	t <sub>r</sub>		–	36	–	ns
Turn–Off Delay Time	t <sub>d(OFF)</sub>		–	60	–	ns
Fall Time	t <sub>f</sub>		–	56	–	ns
Turn–Off Time	t <sub>OFF</sub>		–	–	175	ns

### GATE CHARGE SPECIFICATIONS

Total Gate Charge	Q <sub>g(TOT)</sub>	V <sub>GS</sub> = 0 V to 10 V	V <sub>DD</sub> = 30 V, I <sub>D</sub> = 20 A, I <sub>g(REF)</sub> = 1.0 mA (Figures 14, 19, 20)	–	38	46	nC
Gate Charge at 5 V	Q <sub>g(5)</sub>	V <sub>GS</sub> = 0 V to 5 V		–	21	25	nC
Threshold Gate Charge	Q <sub>g(TH)</sub>	V <sub>GS</sub> = 0 V to 1 V		–	1.3	1.6	nC
Gate to Source Gate Charge	Q <sub>gs</sub>			–	3.8	–	nC
Gate to Drain "Miller" Charge	Q <sub>gd</sub>			–	9.7	–	nC

### CAPACITANCE SPECIFICATIONS

Input Capacitance	C <sub>ISS</sub>	V <sub>DS</sub> = 25 V, V <sub>GS</sub> = 0 V, f = 1 MHz (Figure 13)	–	1480	–	pF
Output Capacitance	C <sub>OSS</sub>		–	440	–	pF
Reverse Transfer Capacitance	C <sub>RSS</sub>		–	90	–	pF

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

# HUFA76429D3

## SOURCE TO DRAIN DIODE SPECIFICATIONS

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Source to Drain Diode Voltage	$V_{SD}$	$I_{SD} = 20 \text{ A}$	-	-	1.25	V
		$I_{SD} = 10 \text{ A}$	-	-	1.00	V
Reverse Recovery Time	$t_{rr}$	$I_{SD} = 20 \text{ A}, dI_{SD}/dt = 100 \text{ A}/\mu\text{s}$	-	-	80	ns
Reverse Recovered Charge	$Q_{RR}$	$I_{SD} = 20 \text{ A}, dI_{SD}/dt = 100 \text{ A}/\mu\text{s}$	-	-	230	nC

TYPICAL PERFORMANCE CURVES

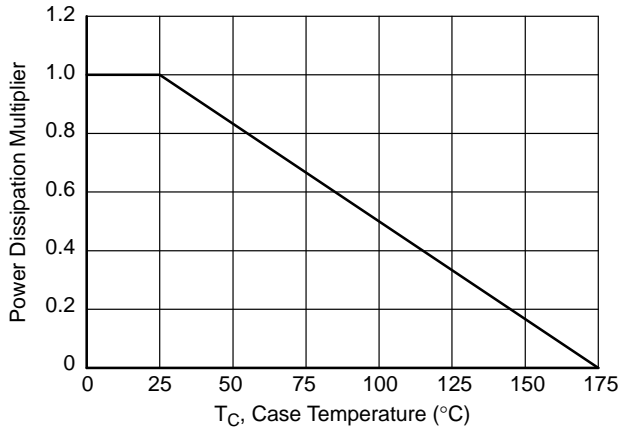


Figure 1. Normalized Power Dissipation vs. Case Temperature

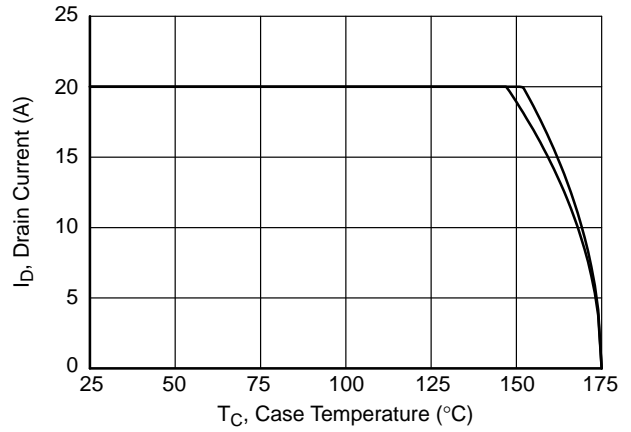


Figure 2. Maximum Continuous Drain Current vs. Case Temperature

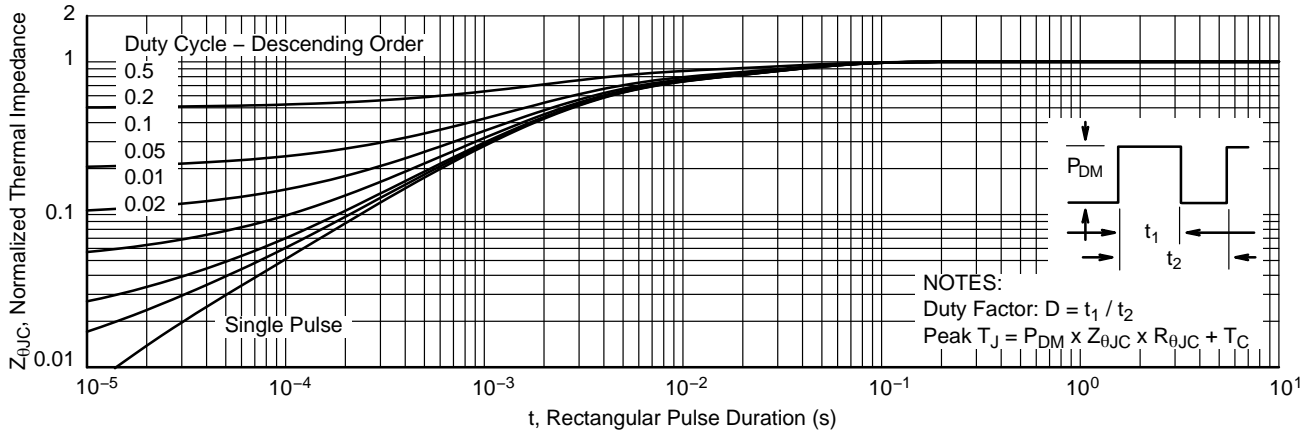


Figure 3. Normalized Maximum Transient Thermal Impedance

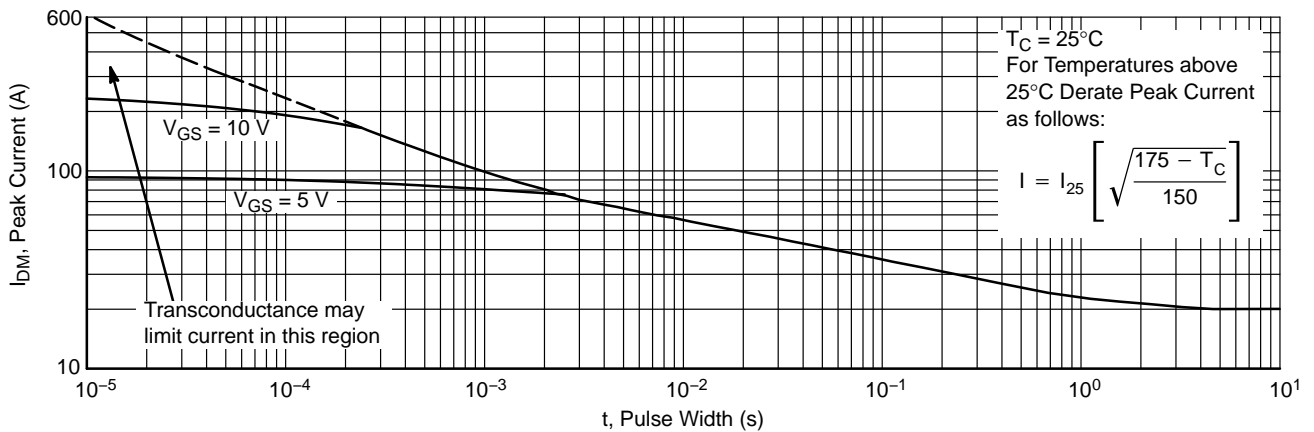


Figure 4. Peak Current Capability

TYPICAL PERFORMANCE CURVES (Continued)

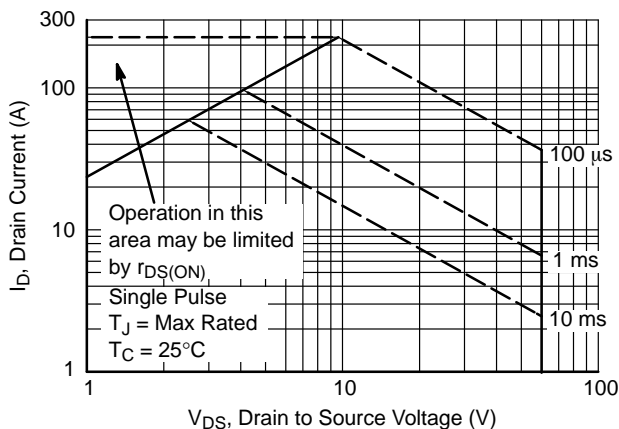
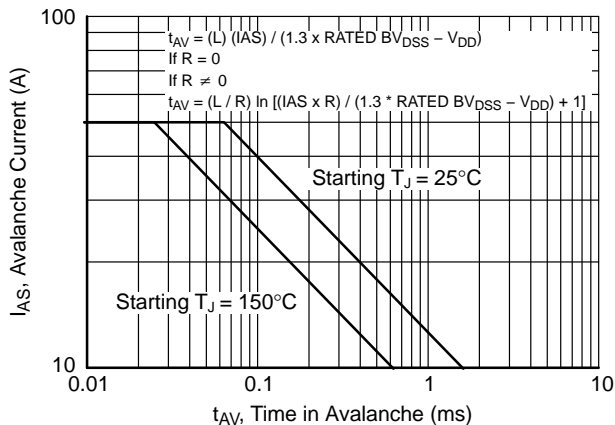


Figure 5. Forward Bias Safe Operating Area



NOTE: Refer to onsemi Application Notes AN9321 and AN9322.  
Figure 6. Unclamped Inductive Switching Capability

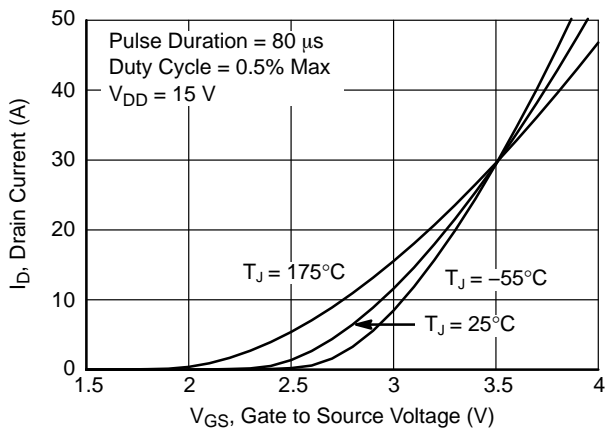


Figure 7. Transfer Characteristics

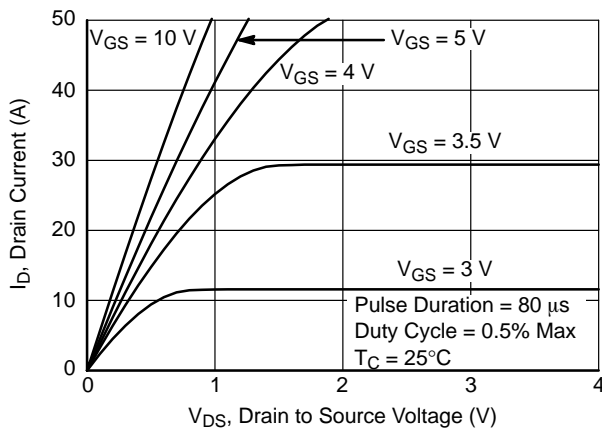


Figure 8. Saturation Characteristics

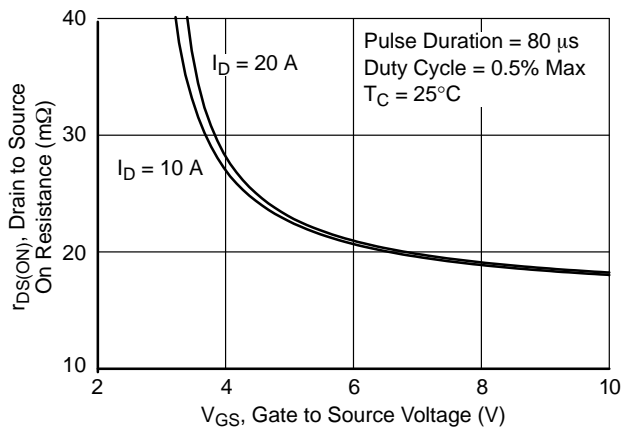


Figure 9. Drain to Source On Resistance vs. Gate Voltage and Drain Current

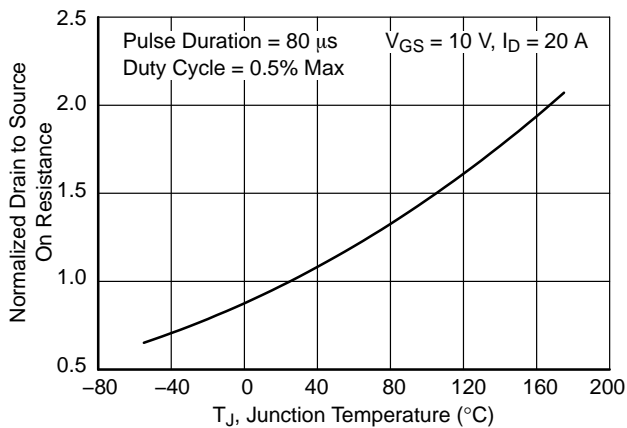


Figure 10. Normalized Drain to Source On Resistance vs. Junction Temperature

TYPICAL PERFORMANCE CURVES (Continued)

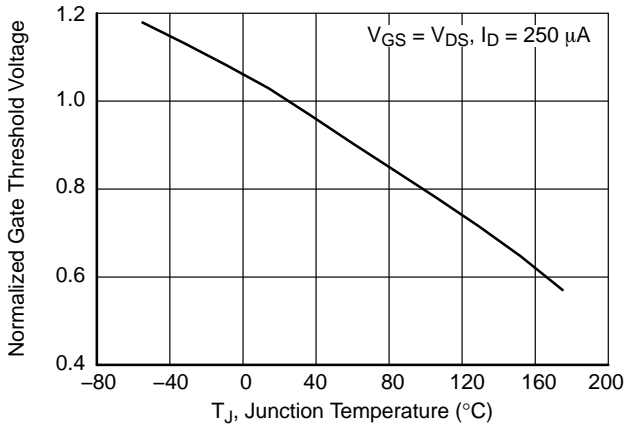


Figure 11. Normalized Gate Threshold Voltage vs. Junction Temperature

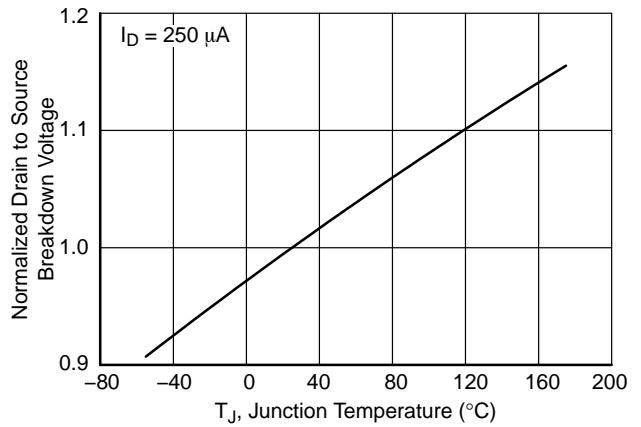


Figure 12. Normalized Drain to Source Breakdown Voltage vs. Junction Temperature

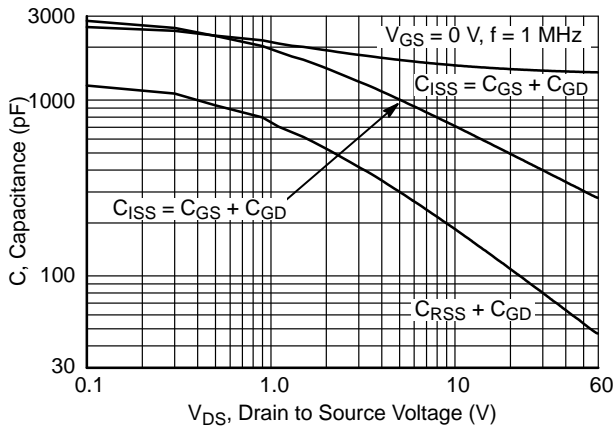
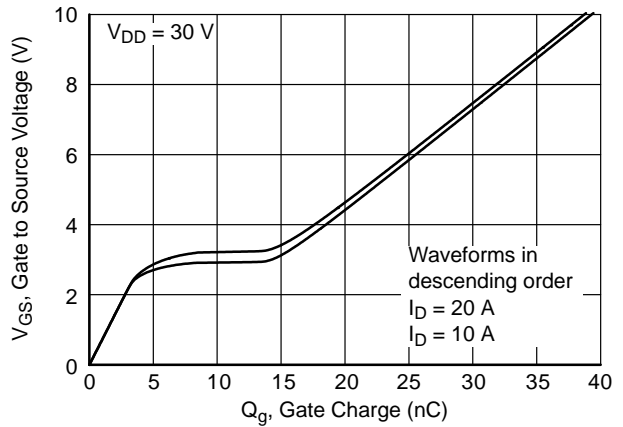


Figure 13. Capacitance vs. Drain to Source Voltage



NOTE: Refer to onsemi Application Notes AN7254 and AN7260.

Figure 14. Gate Charge Waveforms for Constant Gate Current

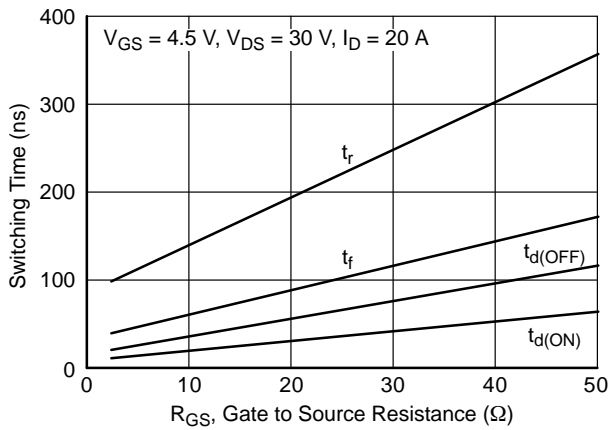


Figure 15. Switching Time vs. Gate Resistance

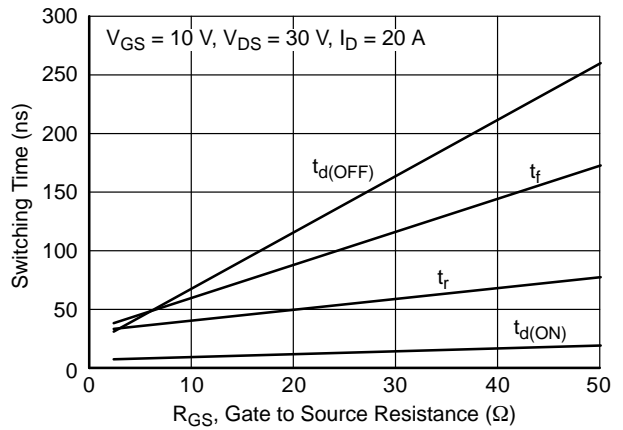


Figure 16. Switching Time vs. Gate Resistance

TEST CIRCUITS AND WAVEFORMS

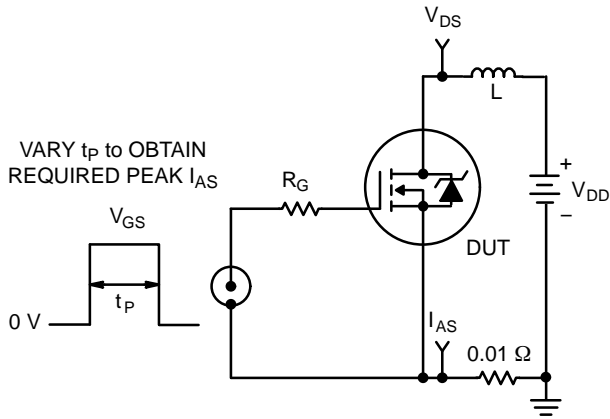


Figure 17. Unclamped Energy Test Circuit

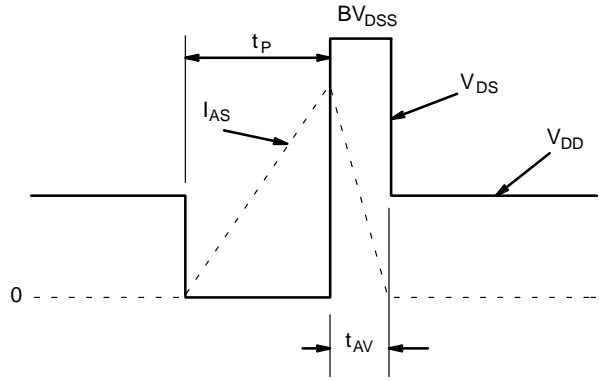


Figure 18. Unclamped Energy Waveforms

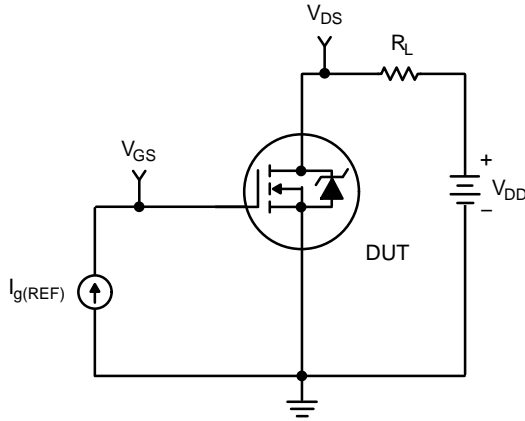


Figure 19. Gate Charge Test Circuit

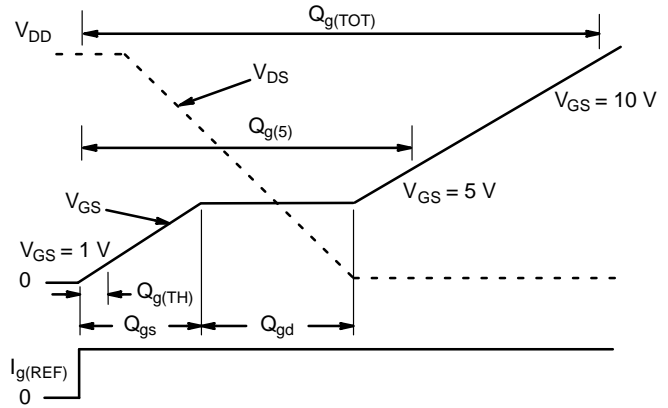


Figure 20. Gate Charge Waveforms

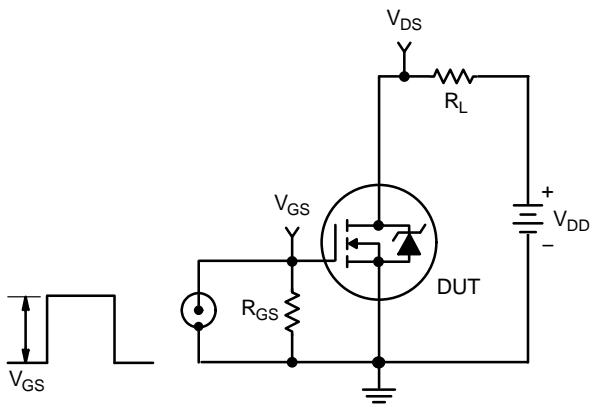


Figure 21. Switching Time Test Circuit

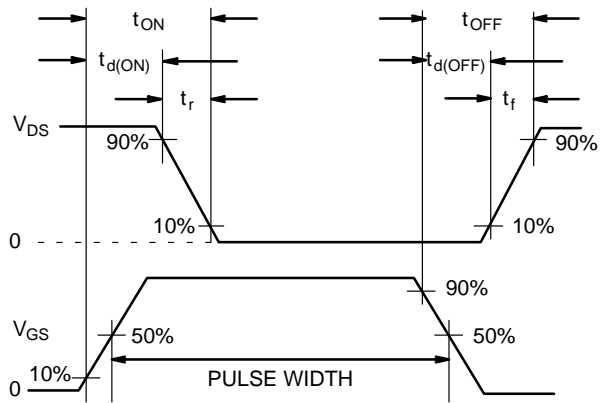


Figure 22. Switching Time Waveforms

# HUFA76429D3

## PSPICE ELECTRICAL MODEL

.SUBCKT HUFA76429D3 2 1 3 ; rev 5 July 1999

CA 12 8 2.03e-9  
CB 15 14 2.03e-9  
CIN 6 8 1.39e-9

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

EBREAK 11 7 17 18 68.10  
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

LDRAIN 2 5 1e-9  
LGATE 1 9 5.42e-9  
LSOURCE 3 7 4.16e-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 9.1e-3  
RGATE 9 20 2.80  
RLDRAIN 2 5 10  
RLGATE 1 9 54.2  
RLSOURCE 3 7 41.6  
RSLC1 5 51 RSLCMOD 1e-6  
RSLC2 5 50 1e3  
RSOURCE 8 7 RSOURCEMOD 6.5e-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\*117),3)) }

.MODEL DBODYMOD D (IS = 1.25e-12 IKF = 10 RS = 8.40e-3 TRS1 = 2.05e-3 TRS2 = 3.85e-6 CJO = 1.68e-9 TT =  
4.90e-8 M = 0.48 XTI = 4.35)  
.MODEL DBREAKMOD D (RS = 1.68e-1 TRS1 = 1e-3 TRS2 = -1e-6)  
.MODEL DPLCAPMOD D (CJO = 1.28e-9 IS = 1e-30 N = 10 M = 0.8)  
.MODEL MMEDMOD NMOS (VTO = 1.98 KP = 3.2 IS = 1e-30 N = 10 TOX = 1 L = 1u W = 1u RG = 2.80)  
.MODEL MSTROMOD NMOS (VTO = 2.30 KP = 52 IS = 1e-30 N = 10 TOX = 1 L = 1u W = 1u)  
.MODEL MWEAKMOD NMOS (VTO = 1.72 KP = 0.08 IS = 1e-30 N = 10 TOX = 1 L = 1u W = 1u RG = 28.0 RS = 0.1)  
.MODEL RBREAKMOD RES (TC1 = 1.15e-3 TC2 = -5.40e-7)



## HUFA76429D3

```

.MODEL RDRAINMOD RES (TC1 = 7.85e-3 TC2 = 1.95e-5)
.MODEL RSLCMOD RES (TC1 = 4.97e-3 TC2 = 5.05e-6)
.MODEL RSOURCEMOD RES (TC1 = 1.5e-3 TC2 = 1e-6)
.MODEL RVTHRESMOD RES (TC1 = -1.85e-3 TC2 = -4.48e-6)
.MODEL RVTEMPMOD RES (TC1 = -1.92e-3 TC2 = 9.50e-7)

.MODEL S1AMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = -6.2 VOFF= -2.4)
.MODEL S1BMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = -2.4 VOFF= -6.2)
.MODEL S2AMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = -1.1 VOFF= 0.5)
.MODEL S2BMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = 0.5 VOFF= -1.1)

.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.

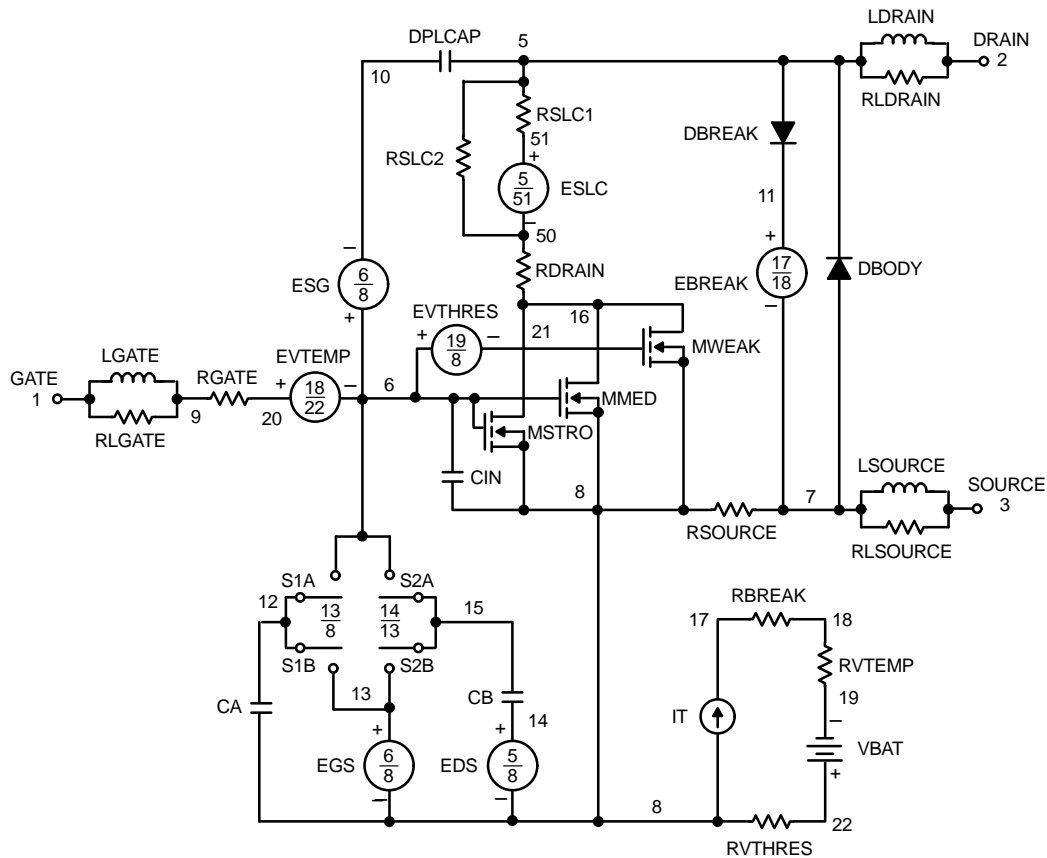


Figure 23.

# HUFA76429D3

## SABER ELECTRICAL MODEL

REV 5 July 1999

```
template HUFA76429d3 n2,n1,n3
electrical n2,n1,n3
{
var i iscl
d..model dbodymod = (is = 1.25e-12, cjo = 1.68e-9, tt = 4.90e-8, xti = 4.35, m = 0.48)
d..model dbreakmod = ()
d..model dplcapmod = (cjo = 1.28e-9, is = 1e-30, n = 10, m = 0.8)
m..model mmedmod = (type=_n, vto = 1.98, kp = 3.2, is = 1e-30, tox = 1)
m..model mstrongmod = (type=_n, vto = 2.30, kp = 52, is = 1e-30, tox = 1)
m..model mweakmod = (type=_n, vto = 1.72, kp = 0.08, is = 1e-30, tox = 1)
sw_vcsp..model s1amod = (ron = 1e-5, roff = 0.1, von = -6.2, voff = -2.4)
sw_vcsp..model s1bmod = (ron = 1e-5, roff = 0.1, von = -2.4, voff = -6.2)
sw_vcsp..model s2amod = (ron = 1e-5, roff = 0.1, von = -1.1, voff = 0.5)
sw_vcsp..model s2bmod = (ron = 1e-5, roff = 0.1, von = 0.5, voff = -1.1)

c.ca n12 n8 = 2.03e-9
c.cb n15 n14 = 2.03e-9
c.cin n6 n8 = 1.39e-9

d.dbody n7 n71 = model=dbodymod
d.dbreak n72 n11 = model=dbreakmod
d.dplcap n10 n5 = model=dplcapmod

i.it n8 n17 = 1

l.l drain n2 n5 = 1e-9
l.l gate n1 n9 = 5.42e-9
l.l source n3 n7 = 4.16e-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 = 1.15e-3, tc2 = -5.40e-7
res.rbody n71 n5 = 8.40e-3, tc1 = 2.05e-3, tc2 = 3.85e-6
res.rdbreak n72 n5 = 1.68e-1, tc1 = 1.00e-3, tc2 = -1.00e-6
res.rdrain n50 n16 = 9.10e-3, tc1 = 7.85e-3, tc2 = 1.95e-5
res.rgate n9 n20 = 2.80
res.rldrain n2 n5 = 10
res.rlgate n1 n9 = 54.2
res.rlsource n3 n7 = 41.6
res.rslc1 n5 n51 = 1e-6, tc1 = 4.97e-3, tc2 = 5.05e-6
res.rslc2 n5 n50 = 1e3
res.rsource n8 n7 = 6.5e-3, tc1 = 1.5e-3, tc2 = 1e-6
res.rvtemp n18 n19 = 1, tc1 = -1.92e-3, tc2 = 9.50e-7
res.rvthres n22 n8 = 1, tc1 = -1.85e-3, tc2 = -4.48e-6

spe.ebreak n11 n7 n17 n18 = 68.10
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
```

# HUFA76429D3

```

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)*1e6/117))** 3))
}
}

```

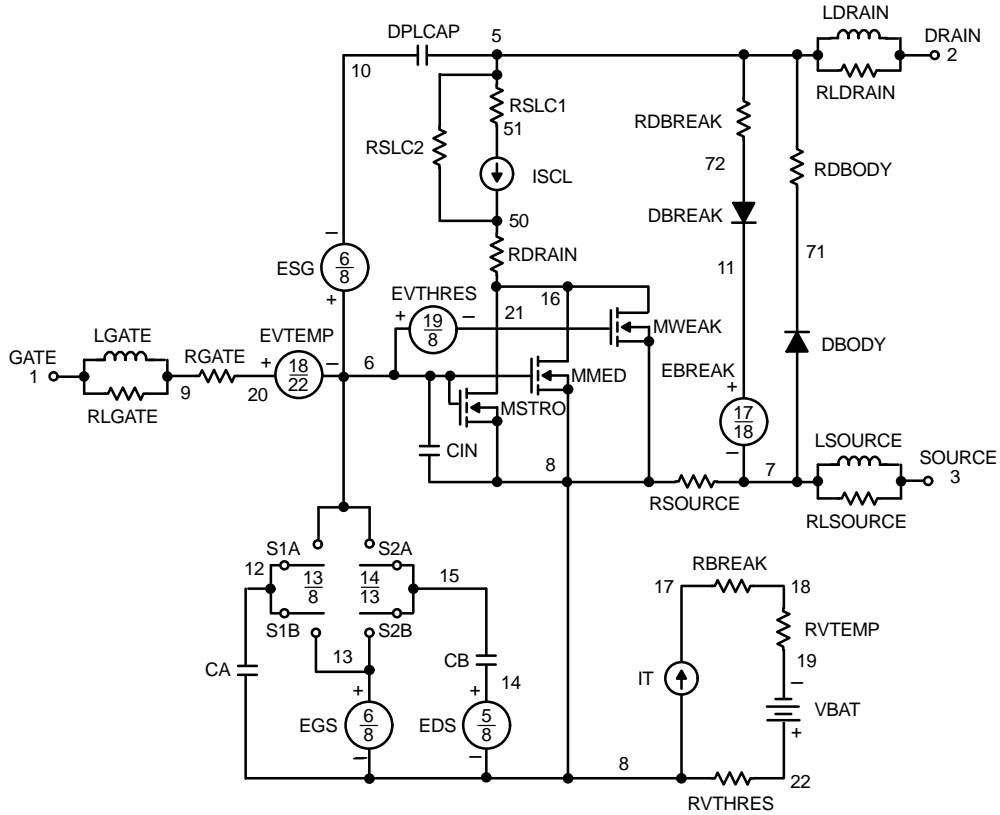


Figure 24.

# HUFA76429D3

## SPICE THERMAL MODEL

REV 26 July 1999

HUFA76429D3

CTHERM1 th 6 2.45e-3  
 CTHERM2 6 5 8.15e-3  
 CTHERM3 5 4 7.40e-3  
 CTHERM4 4 3 7.45e-3  
 CTHERM5 3 2 1.01e-2  
 CTHERM6 2 tl 7.49e-2

RTHERM1 th 6 9.00e-3  
 RTHERM2 6 5 1.80e-2  
 RTHERM3 5 4 9.15e-2  
 RTHERM4 4 3 2.43e-1  
 RTHERM5 3 2 3.50e-1  
 RTHERM6 2 tl 3.62e-1

## SABER THERMAL MODEL

SABER thermal model HUFA76429D3

```

template thermal_model th tl
thermal_c th, tl
{
    ctherm.ctherm1 th 6 = 2.45e-3
    ctherm.ctherm2 6 5 = 8.15e-3
    ctherm.ctherm3 5 4 = 7.40e-3
    ctherm.ctherm4 4 3 = 7.45e-3
    ctherm.ctherm5 3 2 = 1.01e-2
    ctherm.ctherm6 2 tl = 7.49e-2

    rtherm.rtherm1 th 6 = 9.00e-3
    rtherm.rtherm2 6 5 = 1.80e-2
    rtherm.rtherm3 5 4 = 9.15e-2
    rtherm.rtherm4 4 3 = 2.43e-1
    rtherm.rtherm5 3 2 = 3.50e-1
    rtherm.rtherm6 2 tl = 3.62e-1
}
    
```

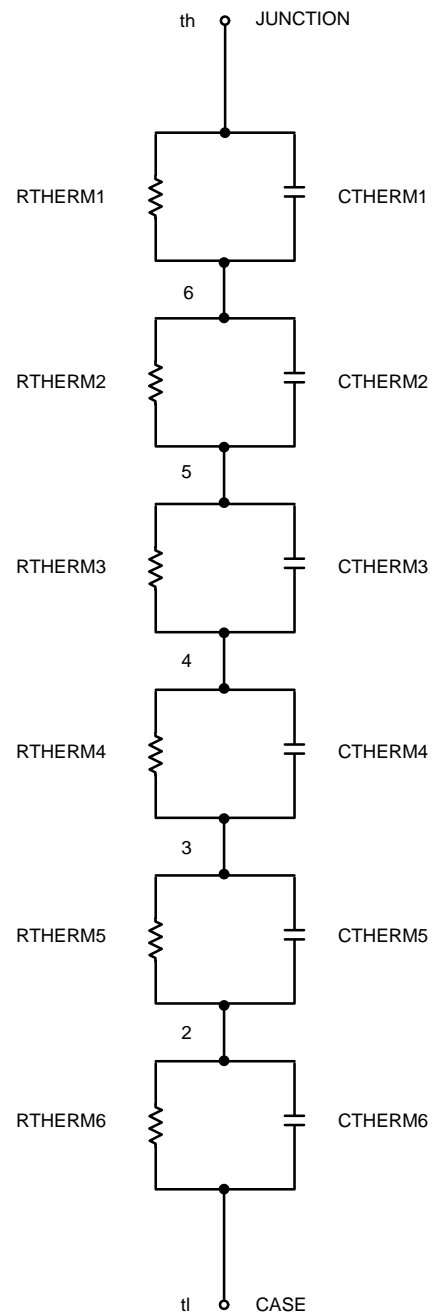
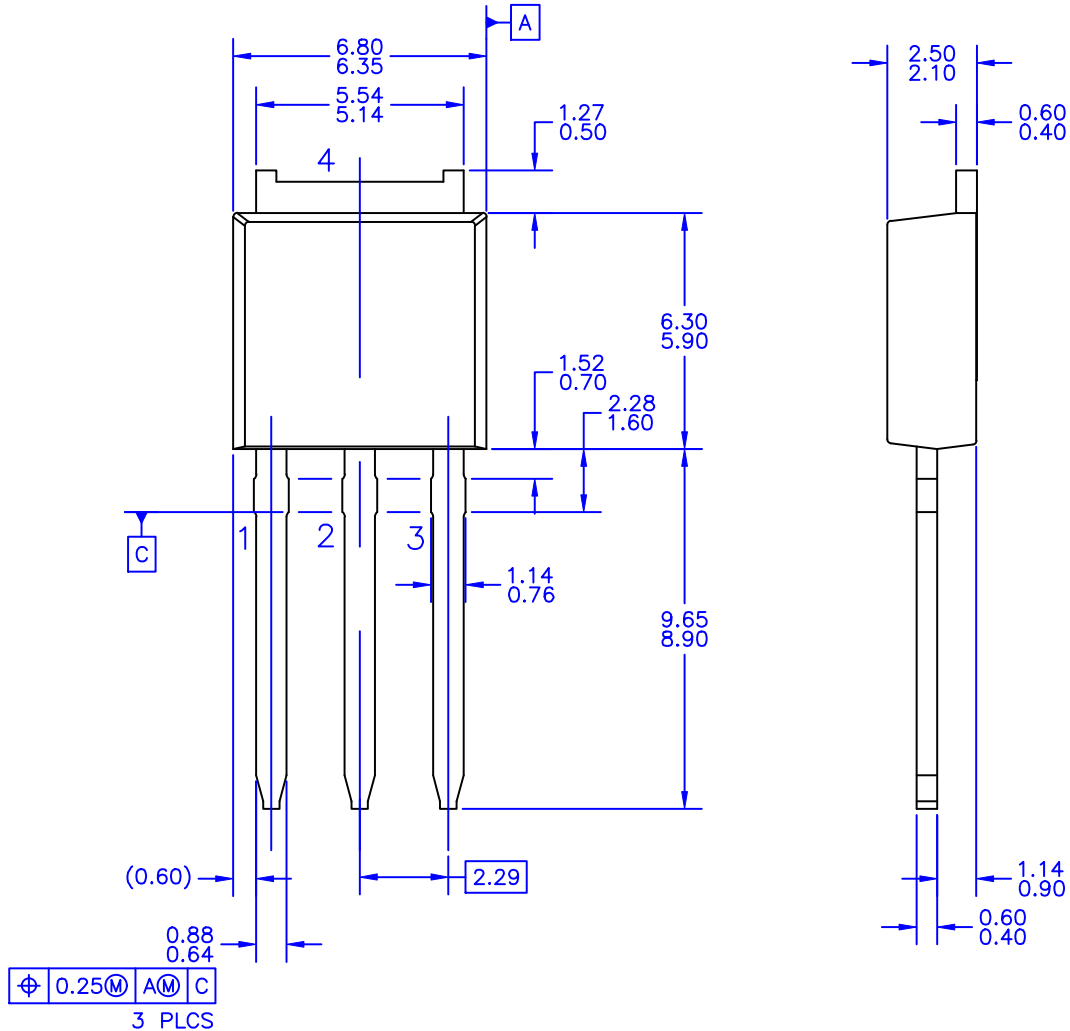


Figure 25.

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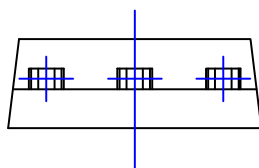
**DPAK3 (IPAK)**  
CASE 369AR  
ISSUE O

DATE 30 SEP 2016



NOTES: UNLESS OTHERWISE SPECIFIED

- A) ALL DIMENSIONS ARE IN MILLIMETERS.
- B) THIS PACKAGE CONFORMS TO JEDEC, TO-251, ISSUE C, VARIATION AA, DATED SEP 1988.
- C) DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.



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