

January 1998

### Features

- 56A, 55V
- *Ultra Low On-Resistance*,  $r_{DS(ON)} = 0.016\Omega$
- Diode Exhibits Both High Speed and Soft Recovery
- *Temperature Compensating* PSPICE Model
- *Thermal Impedance* SPICE Model
- Peak Current vs Pulse Width Curve
- UIS Rating Curve
- Related Literature
  - TB334, "Guidelines for Soldering Surface Mount Components to PC Boards"

### Ordering Information

PART NUMBER	PACKAGE	BRAND
HUF75333G3	TO-247	75333G
HUF75333P3	TO-220AB	75333P
HUF75333S3	TO-262AA	75333S
HUF75333S3S	TO-263AB	75333S

NOTE: When ordering, use the entire part number. Add the suffix T to obtain the TO-263AB variant in tape and reel, e.g., HUF75333S3ST.

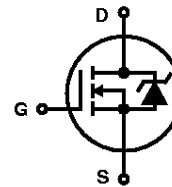


### Description

The HUF75333 N-Channel power MOSFET is manufactured using the innovative UltraFET™ process. This advanced process technology achieves the lowest possible 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 converters, motor drivers, relay drivers, low-voltage bus switches, and power management in portable and battery-operated products.

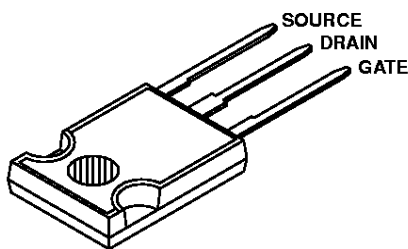
Formerly developmental type TA75333.

### Symbol

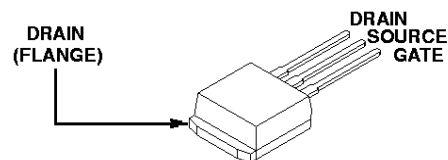


### Packaging

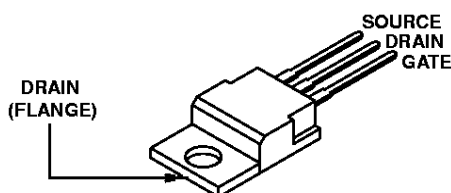
JEDEC STYLE TO-247



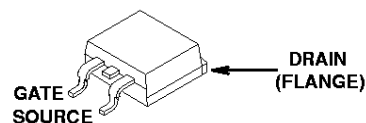
JEDEC TO-262AA



JEDEC TO-220AB



JEDEC TO-263AB



# HUF75333G3, HUF75333P3, HUF75333S3, HUF75333S3S

## Absolute Maximum Ratings $T_C = 25^\circ\text{C}$ , Unless Otherwise Specified

Drain to Source Voltage (Note 1)	$V_{DSS}$	55	V
Drain to Gate Voltage ( $R_{GS} = 20\text{k}\Omega$ ) (Note 1)	$V_{DGR}$	55	V
Gate to Source Voltage	$V_{GS}$	20	V
Drain Current			
Continuous (Figure 2)	$I_D$	56	A
Pulsed Drain Current	$I_{DM}$	Figure 5	
Pulsed Avalanche Rating	$E_{AS}$	Figure 6,14,15	
Power Dissipation	$P_D$	111	W
Derate Above $25^\circ\text{C}$		0.74	W/ $^\circ\text{C}$
Operating and Storage Temperature	$T_J, T_{STG}$	-55 to 175	$^\circ\text{C}$
Maximum Temperature for Soldering			
Leads at 0.063in (1.6mm) from Case for 10s	$T_L$	300	$^\circ\text{C}$
Package Body for 10s, See Techbrief 334	$T_{pkg}$	260	$^\circ\text{C}$

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

### NOTE:

- $T_J = 25^\circ\text{C}$  to  $150^\circ\text{C}$ .

## Electrical Specifications $T_C = 25^\circ\text{C}$ , Unless Otherwise Specified

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Drain to Source Breakdown Voltage	$BV_{DSS}$	$I_D = 250\mu\text{A}, V_{GS} = 0\text{V}$ (Figure 11)	55	-	-	V
Gate to Source Threshold Voltage	$V_{GS(TH)}$	$V_{GS} = V_{DS}, I_D = 250\mu\text{A}$ (Figure 10)	2	-	4	V
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 50\text{V}, V_{GS} = 0\text{V}$	-	-	1	$\mu\text{A}$
		$V_{DS} = 45\text{V}, V_{GS} = 0\text{V}, T_C = 150^\circ\text{C}$	-	-	250	$\mu\text{A}$
Gate to Source Leakage Current	$I_{GSS}$	$V_{GS} = \pm 20\text{V}$	-	-	$\pm 100$	nA
Drain to Source On Resistance	$r_{DS(ON)}$	$I_D = 56\text{A}, V_{GS} = 10\text{V}$ (Figure 9)	-	0.013	0.016	$\Omega$
Turn-On Time	$t_{ON}$	$V_{DD} = 30\text{V}, I_D \cong 56\text{A}, R_L = 0.535\Omega, V_{GS} = 10\text{V}, R_{GS} = 6.8\Omega$ (Figure 18, 19)	-	-	$\pm 100$	ns
Turn-On Delay Time	$t_{d(ON)}$		-	12	-	ns
Rise Time	$t_r$		-	55	-	ns
Turn-Off Delay Time	$t_{d(OFF)}$		-	11	-	ns
Fall Time	$t_f$		-	25	-	ns
Turn-Off Time	$t_{OFF}$		-	-	55	ns
Total Gate Charge	$Q_{g(TOT)}$	$V_{GS} = 0\text{V}$ to $20\text{V}$	-	70	85	nC
Gate Charge at 10V	$Q_{g(10)}$	$V_{GS} = 0\text{V}$ to $10\text{V}$				
Threshold Gate Charge	$Q_{g(TH)}$	$V_{GS} = 0\text{V}$ to $2\text{V}$				
Input Capacitance	$C_{ISS}$	$V_{DS} = 25\text{V}, V_{GS} = 0\text{V}, f = 1\text{MHz}$ (Figure 12)	-	1300	-	pF
Output Capacitance	$C_{OSS}$		-	480	-	pF
Reverse Transfer Capacitance	$C_{RSS}$		-	115	-	pF
Thermal Resistance, Junction to Case	$R_{\theta JC}$	(Figure 3)	-	-	1.35	$^\circ\text{C/W}$
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	TO-247	-	-	30	$^\circ\text{C/W}$
		TO-220, TO-262 and TO-263	-	-	62	$^\circ\text{C/W}$

## Source to Drain Diode Specifications

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Source to Drain Diode Voltage	$V_{SD}$	$I_{SD} = 56\text{A}$	-	-	1.25	V
Reverse Recovery Time	$t_{rr}$	$I_{SD} = 56\text{A}, dI_{SD}/dt = 100\text{A}/\mu\text{s}$	-	-	75	ns
Reverse Recovered Charge	$Q_{RR}$	$I_{SD} = 56\text{A}, dI_{SD}/dt = 100\text{A}/\mu\text{s}$	-	-	140	nC

Typical Performance Curves

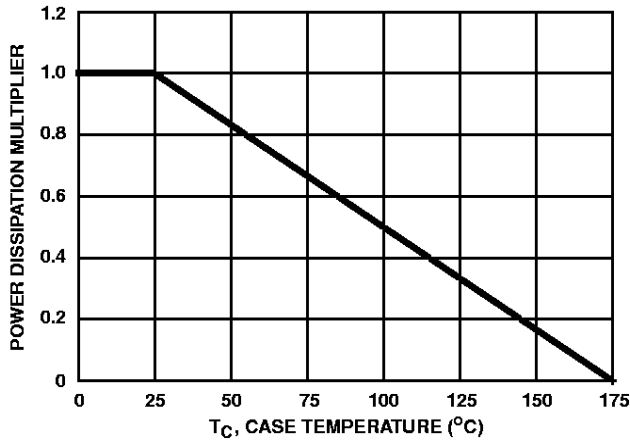


FIGURE 1. NORMALIZED POWER DISSIPATION vs CASE TEMPERATURE

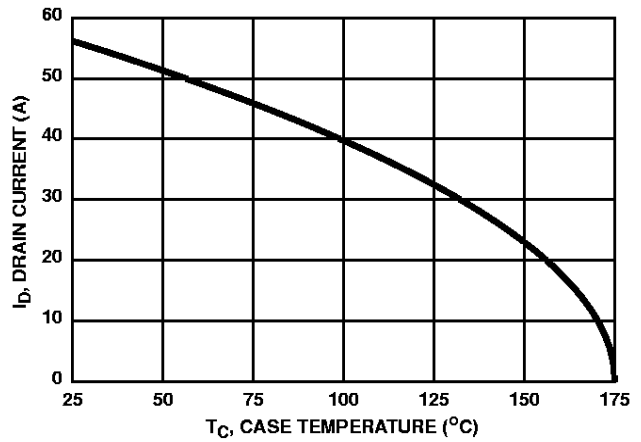


FIGURE 2. MAXIMUM CONTINUOUS DRAIN CURRENT vs CASE TEMPERATURE

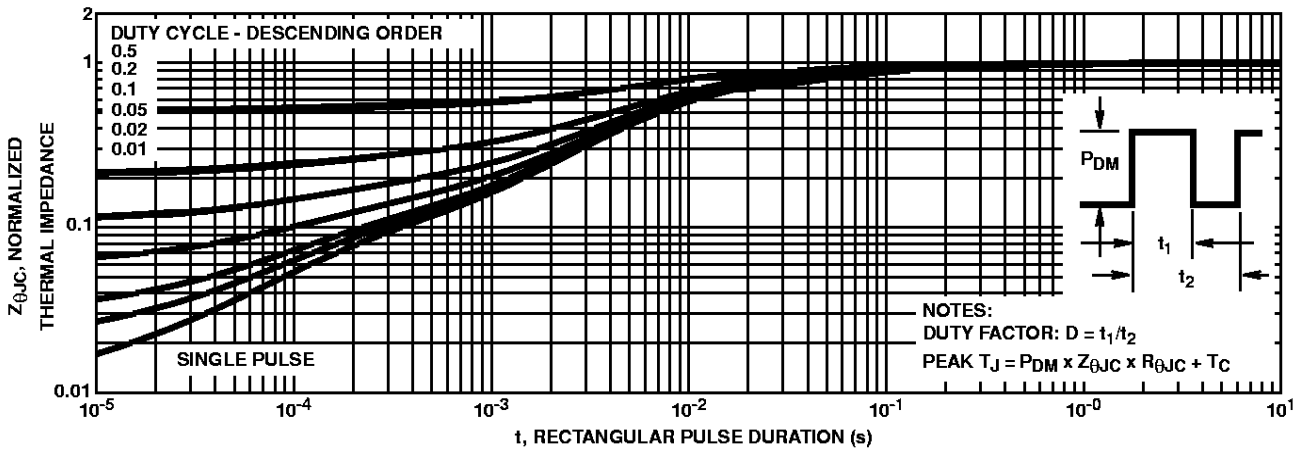


FIGURE 3. NORMALIZED MAXIMUM TRANSIENT THERMAL IMPEDANCE

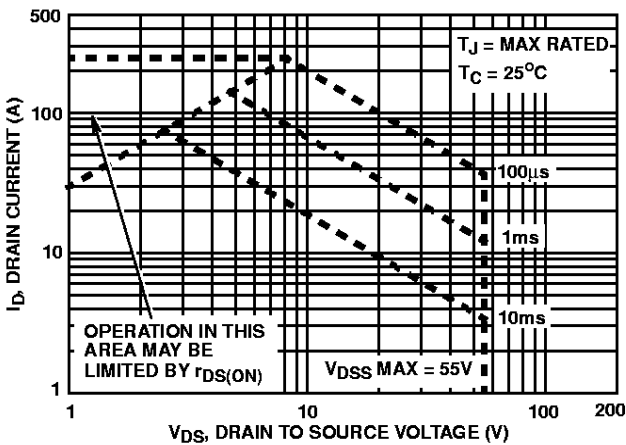


FIGURE 4. FORWARD BIAS SAFE OPERATING AREA

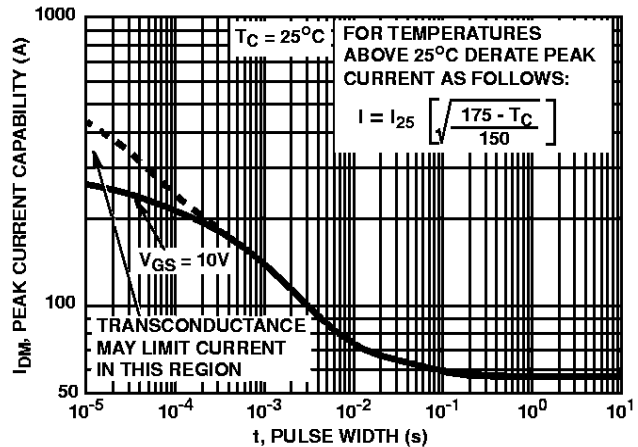
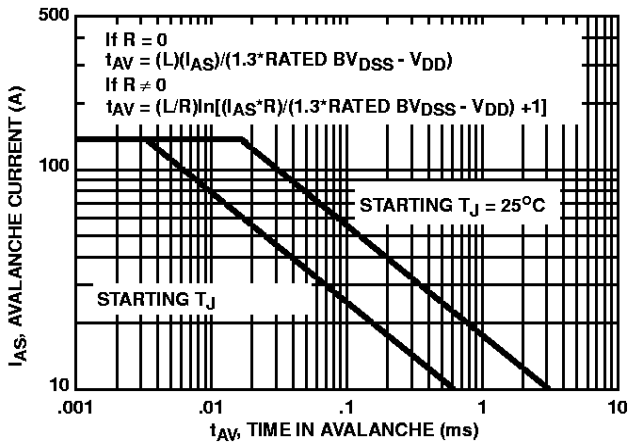


FIGURE 5. PEAK CURRENT CAPABILITY

Typical Performance Curves (Continued)



NOTE: Refer to Harris Application Notes AN9321 and AN9322.

FIGURE 6. UNCLAMPED INDUCTIVE SWITCHING CAPABILITY

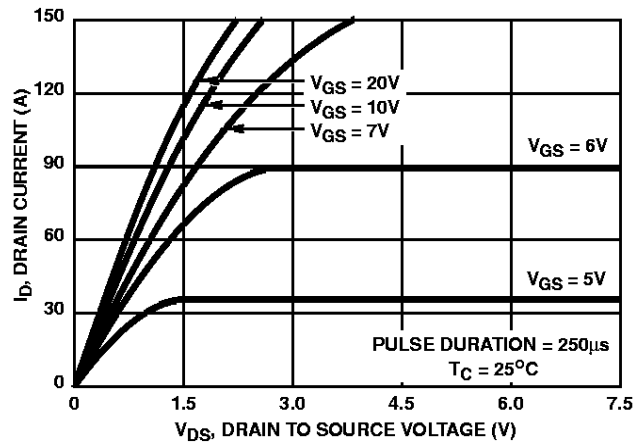


FIGURE 7. SATURATION CHARACTERISTICS

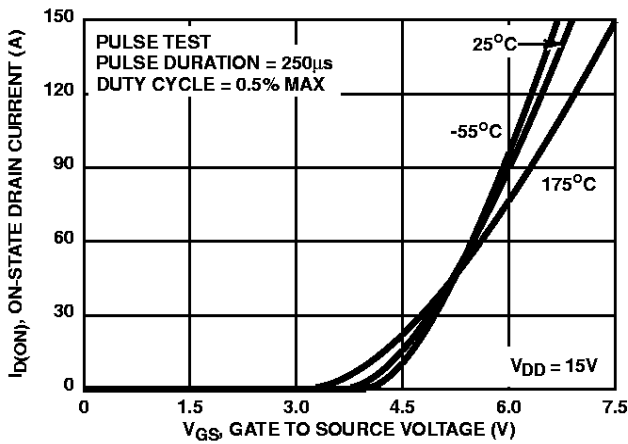


FIGURE 8. TRANSFER CHARACTERISTICS

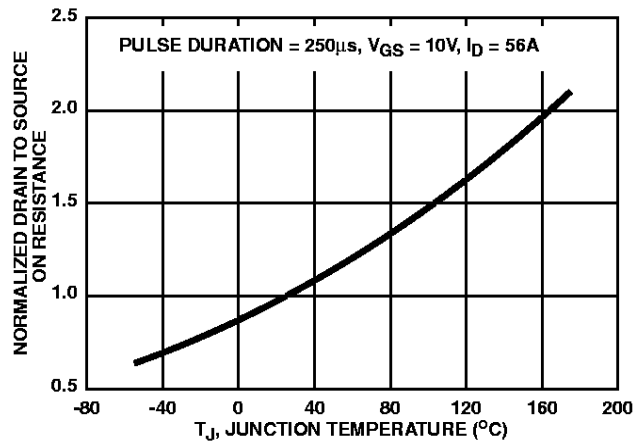


FIGURE 9. NORMALIZED DRAIN TO SOURCE ON RESISTANCE vs JUNCTION TEMPERATURE

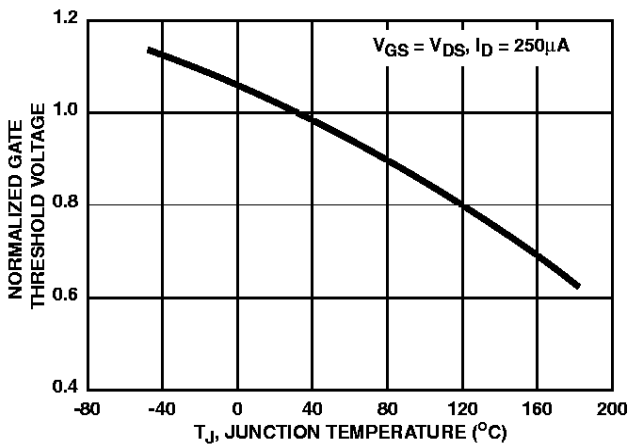


FIGURE 10. NORMALIZED GATE THRESHOLD VOLTAGE vs JUNCTION TEMPERATURE

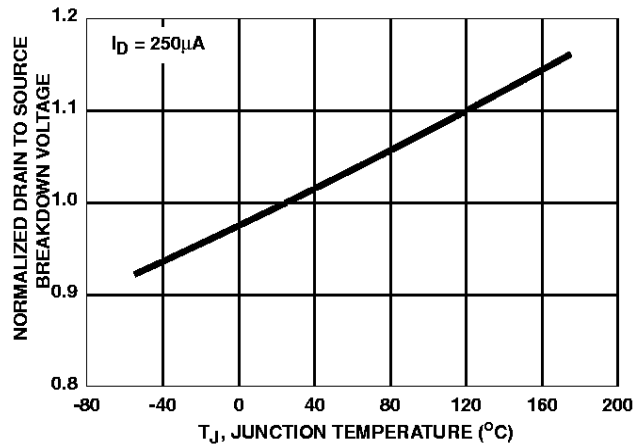


FIGURE 11. NORMALIZED DRAIN TO SOURCE BREAKDOWN VOLTAGE vs JUNCTION TEMPERATURE

Typical Performance Curves (Continued)

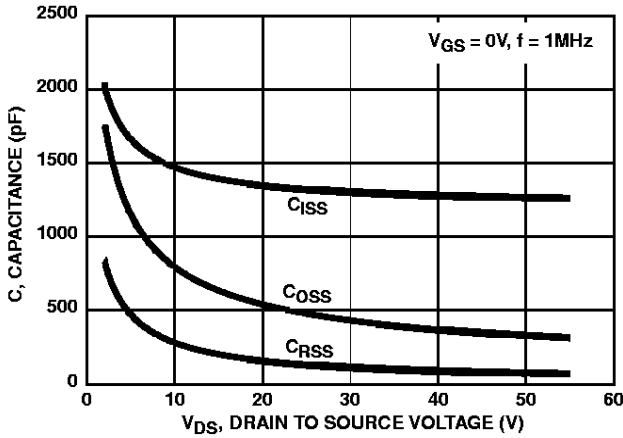
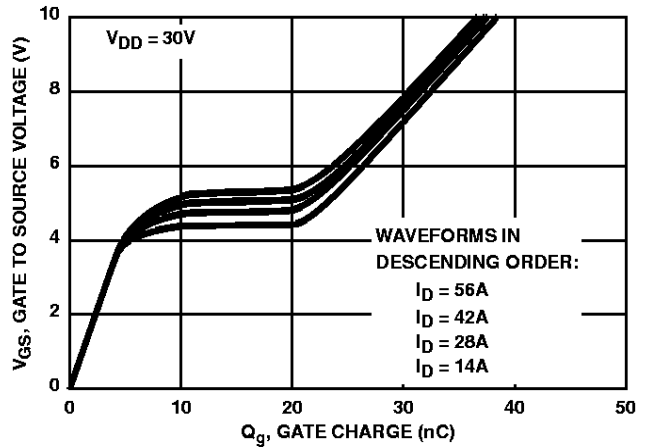


FIGURE 12. CAPACITANCE vs DRAIN TO SOURCE VOLTAGE



NOTE: Refer to Harris Application Notes AN7254 and AN7260.

FIGURE 13. GATE CHARGE WAVEFORMS FOR CONSTANT GATE CURRENT

Test Circuits and Waveforms

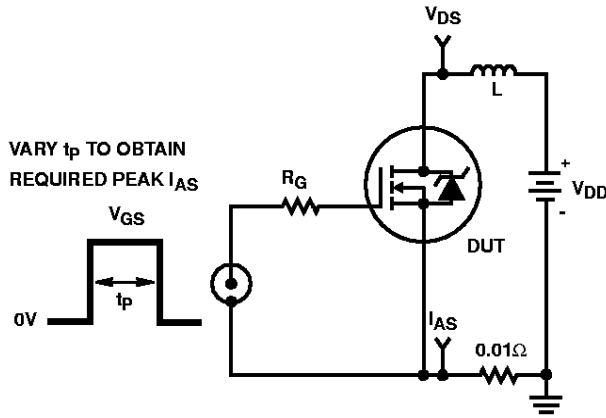


FIGURE 14. UNCLAMPED ENERGY TEST CIRCUIT

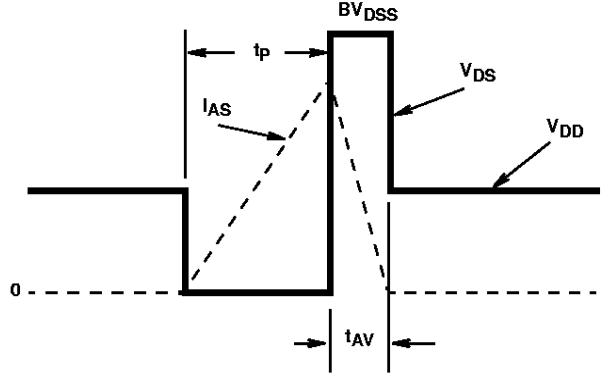


FIGURE 15. UNCLAMPED ENERGY WAVEFORMS

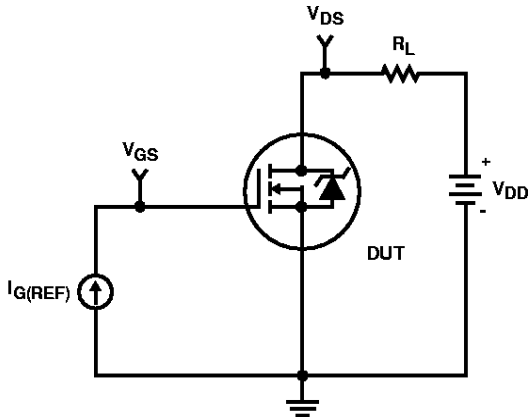


FIGURE 16. GATE CHARGE TEST CIRCUIT

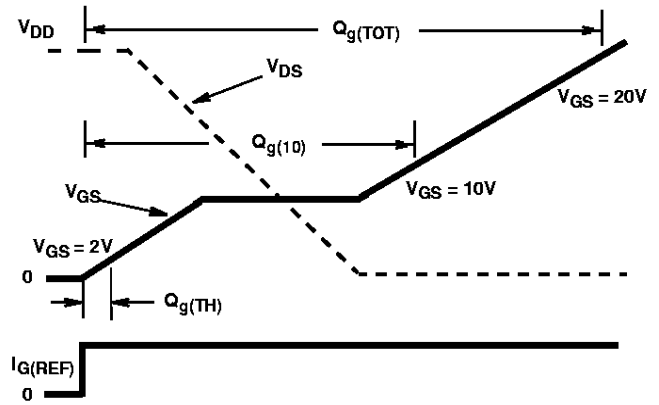


FIGURE 17. GATE CHARGE WAVEFORM

**Test Circuits and Waveforms** (Continued)

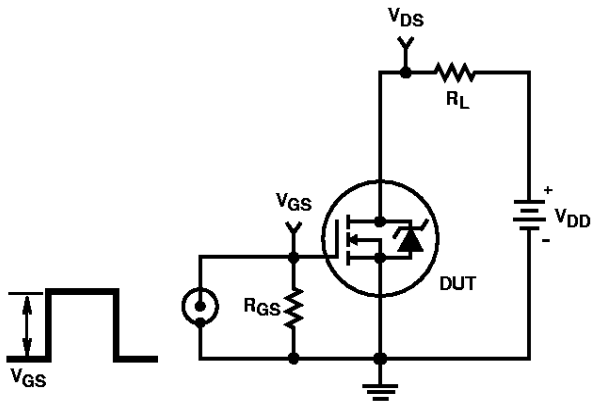


FIGURE 18. SWITCHING TIME TEST CIRCUIT

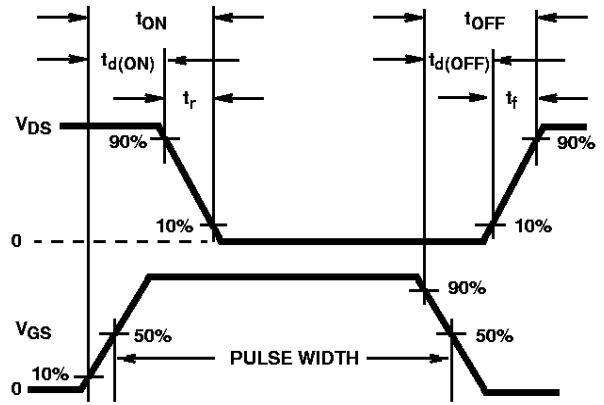


FIGURE 19. RESISTIVE SWITCHING WAVEFORMS

# HUF75333G3, HUF75333P3, HUF75333S3, HUF75333S3S

## PSPICE Electrical Model

SUBCKT HUF75333 2 1 3 ; rev 6/30/97

CA 12 8 1.8e-9  
 CB 15 14 1.73e-9  
 CIN 6 8 1.19e-9

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

EBREAK 11 7 17 18 58.85  
 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 1e-9  
 LSOURCE 3 7 1e-9  
 K1 LSOURCE LGATE 0.0085

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 4.50e-3  
 RGATE 9 20 1  
 RLDRAIN 2 5 10  
 RLGATE 3 7 10  
 RLSOURCE 3 7 11  
 RSLC1 5 51 RSLCMOD 1e-6  
 RSLC2 5 50 1e3  
 RSOURCE 8 7 RSOURCEMOD 5.95e-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

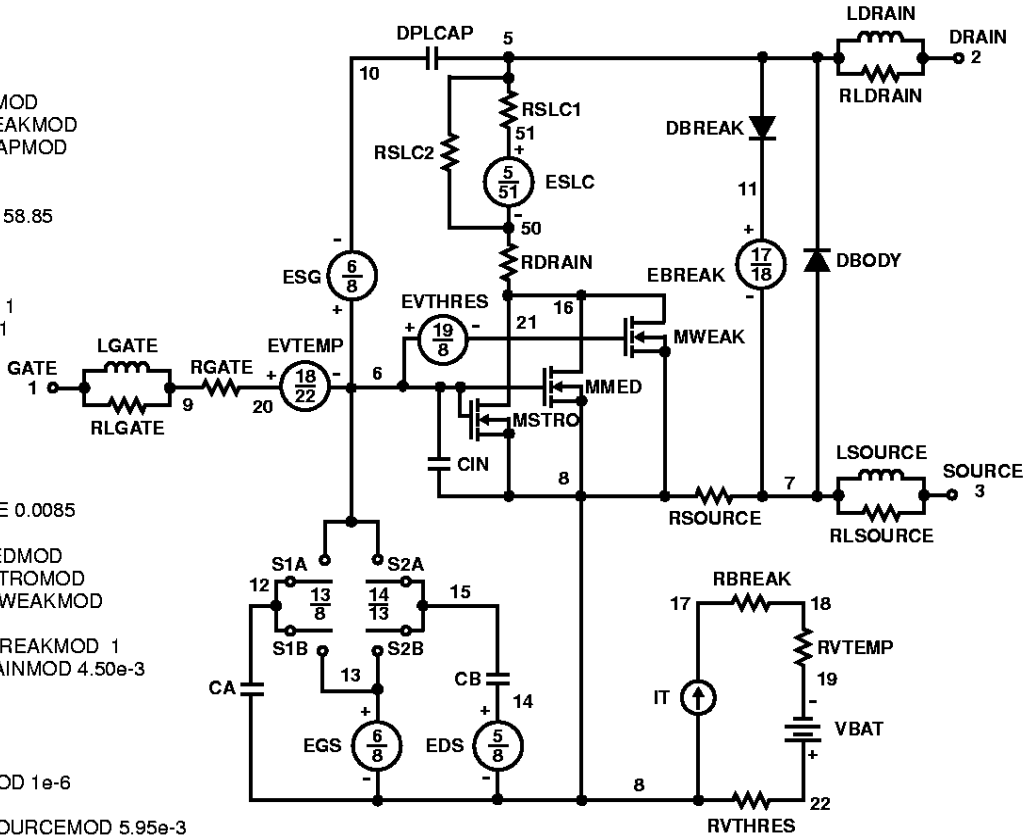
ESLC 51 50 VALUE={(V(5,51)/ABS(V(5,51)))\*(PWR(V(5,51)/(1e-6\*609),2.5))}

.MODEL DBODYMOD D (IS = 1.3e-12 RS = 0.003 TRS1 = 2.7e-3 TRS2 = 7e-7 CJO = 1.7e-9 TT = 40e-8 M = 0 IKF = 20 XTI = 6)  
 .MODEL DBREAKMOD D (RS = 0.1e-1 TRS1 = -4e-4 TRS2 = 1.55e-5 IKF = 1e-5)  
 .MODEL DPLCAPMOD D (CJO = 1.8e-9 IS = 1e-30 N = 1 M = 0.9 vj = 1.45)  
 .MODEL MMEDMOD NMOS (VTO = 3.183 KP = 2 IS = 1e-30 N = 10 TOX = 1 L = 1u W = 1u RG = 1)  
 .MODEL MSTROMOD NMOS (VTO = 3.66 KP = 51.5 IS = 1e-30 N = 10 TOX = 1 L = 1u W = 1u)  
 .MODEL MWEAKMOD NMOS (VTO = 2.703 KP = 0.008 IS = 1e-30 N = 10 TOX = 1 L = 1u W = 1u RG = 10)  
 .MODEL RBREAKMOD RES (TC1 = 1.05e-3 TC2 = 4.5e-7)  
 .MODEL RDRAINMOD RES (TC1 = 1.16e-2 TC2 = 1.7e-5)  
 .MODEL RSLCMOD RES (TC1 = 3.96e-3 TC2 = 2.7e-6)  
 .MODEL RSOURCEMOD RES (TC1 = 1e-3 TC2 = 1e-5)  
 .MODEL RVTHRESMOD RES (TC = -2.8e-3 TC2 = -1.0e-6)  
 .MODEL RVTEMPMOD RES (TC1 = -2.75e-3 TC2 = 0.5e-6)

.MODEL S1AMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = -8 VOFF = -3)  
 .MODEL S1BMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = -3 VOFF = -3)  
 .MODEL S2AMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = 0 VOFF = 0.5)  
 .MODEL S2BMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = 0.5 VOFF = 0)

.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.



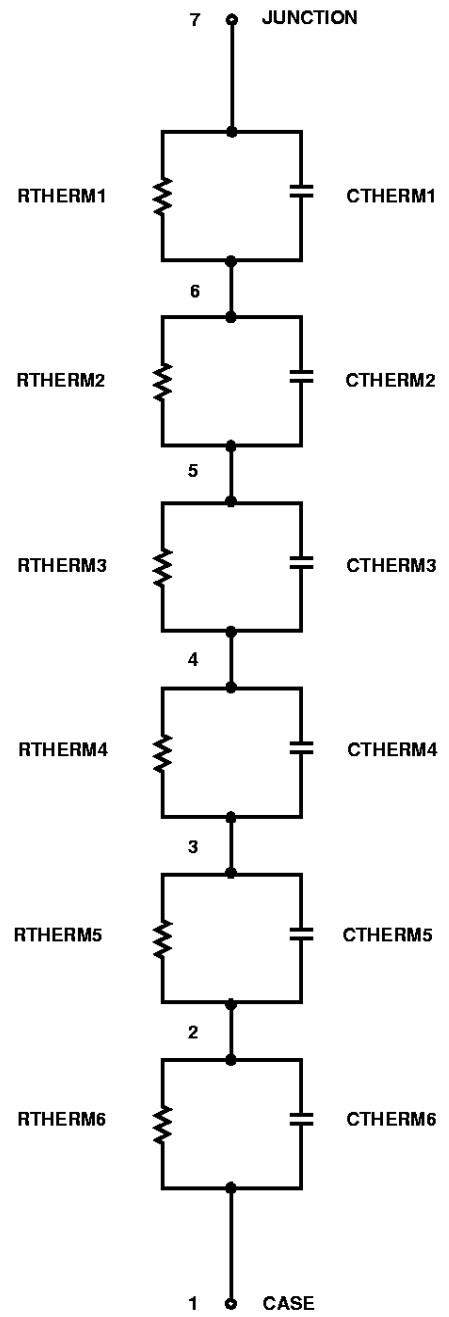
**SPICE Thermal Model**

REV June 97

HUF75333

CTHERM1 7 6 4.90e-7  
 CHERM2 6 5 4.50e-4  
 CHERM3 5 4 1.80e-3  
 CHERM4 4 3 8.50e-3  
 CHERM5 3 2 1.35e-1  
 CHERM6 2 1 3.00

RHERM1 7 6 7.00e-6  
 RHERM2 6 5 8.00e-3  
 RHERM3 5 4 6.50e-2  
 RHERM4 4 3 6.40e-1  
 RHERM5 3 2 3.35e-1  
 RHERM6 2 1 0.70e-1

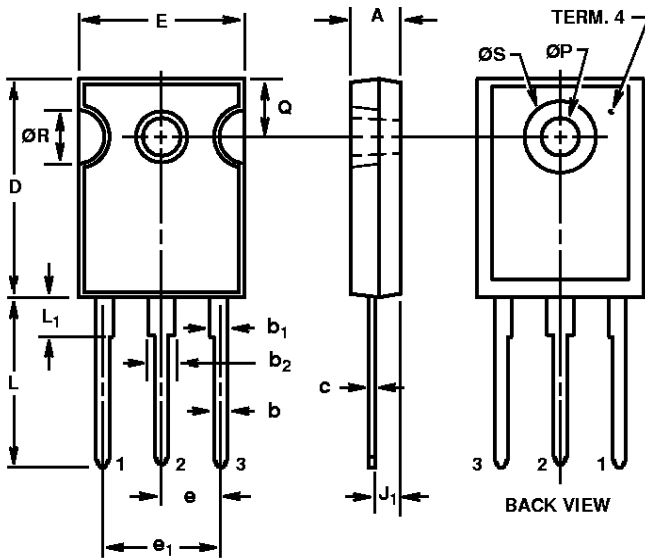




# HUF75333G3, HUF75333P3, HUF75333S3, HUF75333S3S

## TO-247

### 3 LEAD JEDEC STYLE TO-247 PLASTIC PACKAGE



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.180	0.190	4.58	4.82	-
b	0.046	0.051	1.17	1.29	2, 3
b <sub>1</sub>	0.060	0.070	1.53	1.77	1, 2
b <sub>2</sub>	0.095	0.105	2.42	2.66	1, 2
c	0.020	0.026	0.51	0.66	1, 2, 3
D	0.800	0.820	20.32	20.82	-
E	0.605	0.625	15.37	15.87	-
e	0.219 TYP		5.56 TYP		4
e <sub>1</sub>	0.438 BSC		11.12 BSC		4
J <sub>1</sub>	0.090	0.105	2.29	2.66	5
L	0.620	0.640	15.75	16.25	-
L <sub>1</sub>	0.145	0.155	3.69	3.93	1
$\varnothing P$	0.138	0.144	3.51	3.65	-
Q	0.210	0.220	5.34	5.58	-
$\varnothing R$	0.195	0.205	4.96	5.20	-
$\varnothing S$	0.260	0.270	6.61	6.85	-

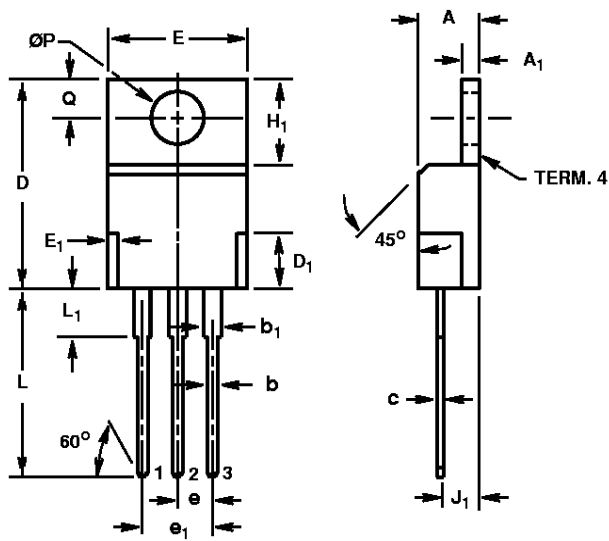
#### NOTES:

1. Lead dimension and finish uncontrolled in L<sub>1</sub>.
2. Lead dimension (without solder).
3. Add typically 0.002 inches (0.05mm) for solder coating.
4. Position of lead to be measured 0.250 inches (6.35mm) from bottom of dimension D.
5. Position of lead to be measured 0.100 inches (2.54mm) from bottom of dimension D.
6. Controlling dimension: Inch.
7. Revision 1 dated 1-93.

HUF75333G3, HUF75333P3, HUF75333S3, HUF75333S3S

**TO-220AB**

3 LEAD JEDEC TO-220AB PLASTIC PACKAGE



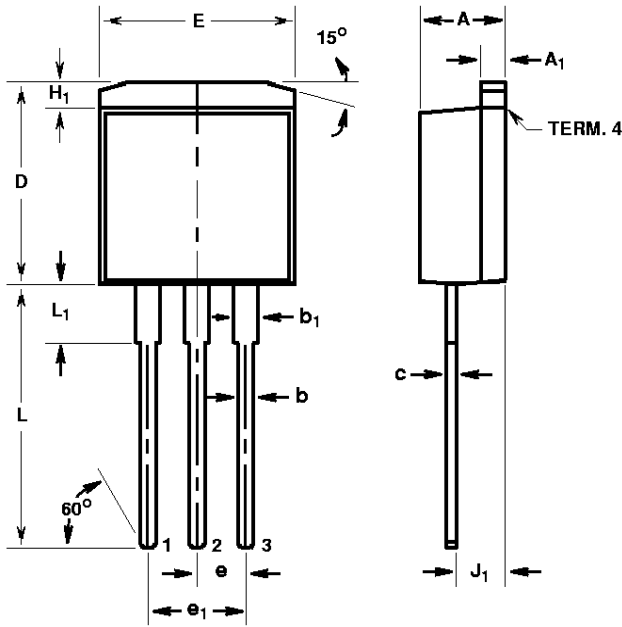
SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.170	0.180	4.32	4.57	-
A <sub>1</sub>	0.048	0.052	1.22	1.32	-
b	0.030	0.034	0.77	0.86	3, 4
b <sub>1</sub>	0.045	0.055	1.15	1.39	2, 3
c	0.014	0.019	0.36	0.48	2, 3, 4
D	0.590	0.610	14.99	15.49	-
D <sub>1</sub>	-	0.160	-	4.06	-
E	0.395	0.410	10.04	10.41	-
E <sub>1</sub>	-	0.030	-	0.76	-
e	0.100 TYP		2.54 TYP		5
e <sub>1</sub>	0.200 BSC		5.08 BSC		5
H <sub>1</sub>	0.235	0.255	5.97	6.47	-
J <sub>1</sub>	0.100	0.110	2.54	2.79	6
L	0.530	0.550	13.47	13.97	-
L <sub>1</sub>	0.130	0.150	3.31	3.81	2
$\varnothing P$	0.149	0.153	3.79	3.88	-
Q	0.102	0.112	2.60	2.84	-

NOTES:

1. These dimensions are within allowable dimensions of Rev. J of JEDEC TO-220AB outline dated 3-24-87.
2. Lead dimension and finish uncontrolled in L<sub>1</sub>.
3. Lead dimension (without solder).
4. Add typically 0.002 inches (0.05mm) for solder coating.
5. Position of lead to be measured 0.250 inches (6.35mm) from bottom of dimension D.
6. Position of lead to be measured 0.100 inches (2.54mm) from bottom of dimension D.
7. Controlling dimension: Inch.
8. Revision 2 dated 7-97.

# HUF75333G3, HUF75333P3, HUF75333S3, HUF75333S3S

## TO-262AA 3 LEAD JEDEC TO-262AA PLASTIC PACKAGE

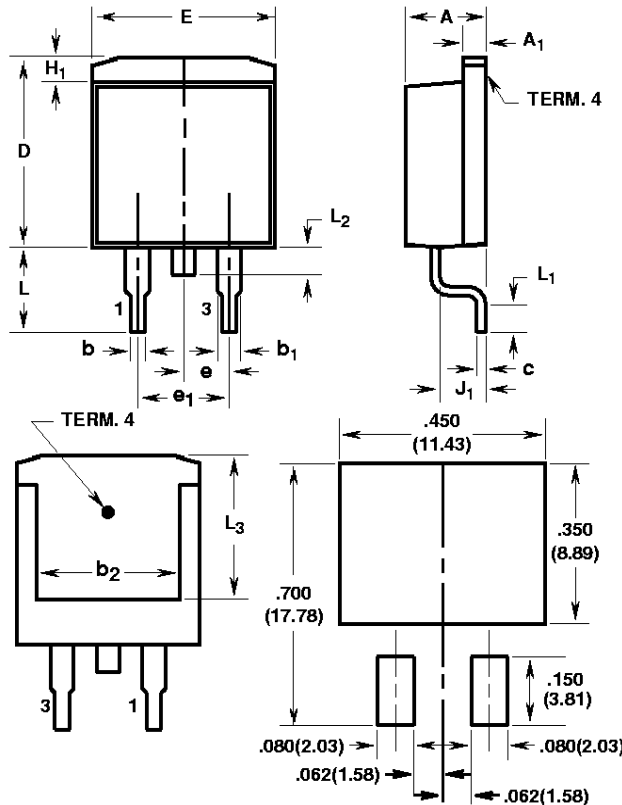


SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.170	0.180	4.32	4.57	-
A <sub>1</sub>	0.048	0.052	1.22	1.32	3, 4
b	0.030	0.034	0.77	0.86	3, 4
b <sub>1</sub>	0.045	0.055	1.15	1.39	3, 4
c	0.018	0.022	0.46	0.55	3, 4
D	0.405	0.425	10.29	10.79	-
E	0.395	0.405	10.04	10.28	-
e	0.100 TYP		2.54 TYP		5
e <sub>1</sub>	0.200 BSC		5.08 BSC		5
H <sub>1</sub>	0.045	0.055	1.15	1.39	-
J <sub>1</sub>	0.095	0.105	2.42	2.66	6
L	0.530	0.550	13.47	13.97	-
L <sub>1</sub>	0.110	0.130	2.80	3.30	2

**NOTES:**

1. These dimensions are within allowable dimensions of Rev. A of JEDEC TO-262AA outline dated 6-90.
2. Solder finish uncontrolled in this area.
3. Dimension (without solder).
4. Add typically 0.002 inches (0.05mm) for solder plating.
5. Position of lead to be measured 0.250 inches (6.35mm) from bottom of dimension D.
6. Position of lead to be measured 0.100 inches (2.54mm) from bottom of dimension D.
7. Controlling dimension: Inch.
8. Revision 5 dated 7-97.

## TO-263AB SURFACE MOUNT JEDEC TO-263AB PLASTIC PACKAGE



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.170	0.180	4.32	4.57	-
A <sub>1</sub>	0.048	0.052	1.22	1.32	4, 5
b	0.030	0.034	0.77	0.86	4, 5
b <sub>1</sub>	0.045	0.055	1.15	1.39	4, 5
b <sub>2</sub>	0.310	-	7.88	-	2
c	0.018	0.022	0.46	0.55	4, 5
D	0.405	0.425	10.29	10.79	-
E	0.395	0.405	10.04	10.28	-
e	0.100 TYP		2.54 TYP		7
e <sub>1</sub>	0.200 BSC		5.08 BSC		7
H <sub>1</sub>	0.045	0.055	1.15	1.39	-
J <sub>1</sub>	0.095	0.105	2.42	2.66	-
L	0.175	0.195	4.45	4.95	-
L <sub>1</sub>	0.090	0.110	2.29	2.79	4, 6
L <sub>2</sub>	0.050	0.070	1.27	1.77	3
L <sub>3</sub>	0.315	-	8.01	-	2

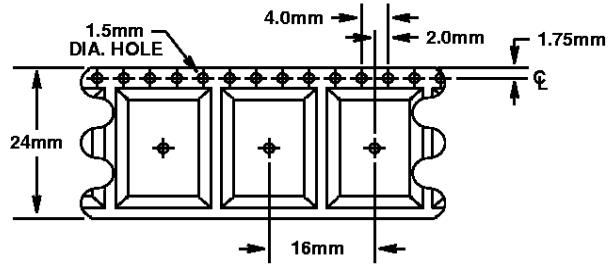
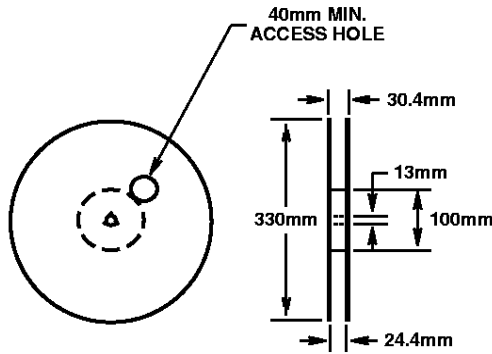
**NOTES:**

9. These dimensions are within allowable dimensions of Rev. C of JEDEC TO-263AB outline dated 2-92.
10. L<sub>3</sub> and b<sub>2</sub> dimensions established a minimum mounting surface for terminal 4.
11. Solder finish uncontrolled in this area.
12. Dimension (without solder).
13. Add typically 0.002 inches (0.05mm) for solder plating.
14. L<sub>1</sub> is the terminal length for soldering.
15. Position of lead to be measured 0.120 inches (3.05mm) from bottom of dimension D.
16. Controlling dimension: Inch.
17. Revision 8 dated 7-97.

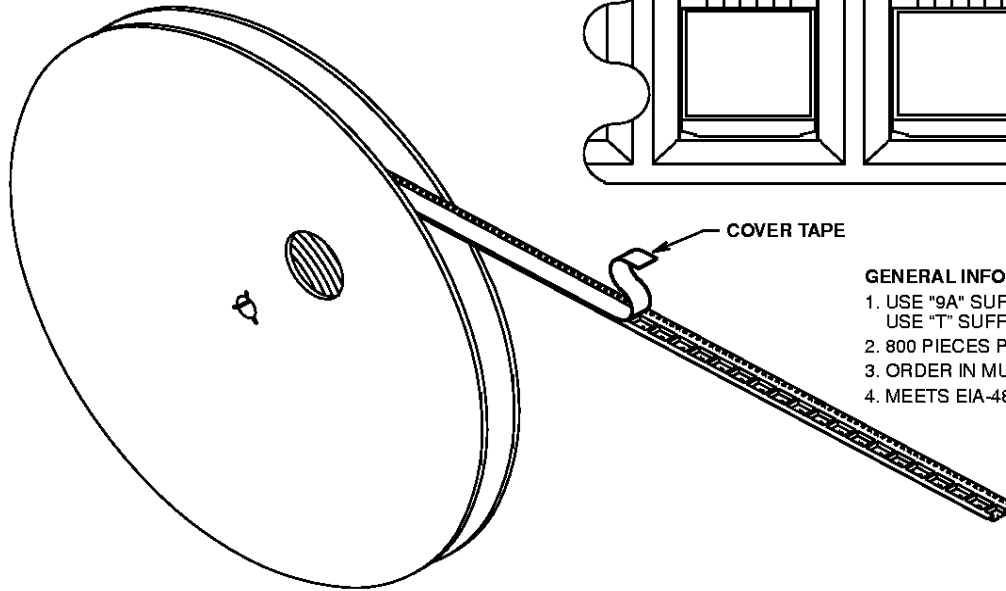
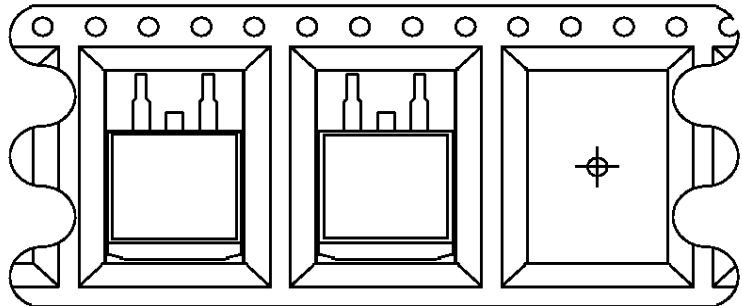
HUF75333G3, HUF75333P3, HUF75333S3, HUF75333S3S

**TO-263AB**

24mm TAPE AND REEL



USER DIRECTION OF FEED



**GENERAL INFORMATION**

1. USE "9A" SUFFIX ON PART NUMBER.  
USE "T" SUFFIX ON PART FOR "HUF" SERIES.
2. 800 PIECES PER REEL.
3. ORDER IN MULTIPLES OF FULL REELS ONLY.
4. MEETS EIA-481 REVISION "A" SPECIFICATIONS.

Revision 8 dated 7-97

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