

January 1998

### Features

- 100A (Note 1), 55V
- **Low On-Resistance**,  $r_{DS(ON)} = 0.008\Omega$
- **Temperature Compensating PSPICE Model**
- **Thermal Impedance SPICE Model**
- **UIS Rating Curve**
- **Related Literature**
  - TB334, "Guidelines for Soldering Surface Mount Components to PC Boards"

### Ordering Information

PART NUMBER	PACKAGE	BRAND
HRF3205	TO-220AB	HRF3205
HRF3205L	TO-262AA	HRF3205S
HRF3205S	TO-263AB	HRF3205S

NOTE: When ordering, use the entire part number. Add the suffix T to obtain the TO-263AB variant in tape and reel, e.g., HRF3205S3ST.

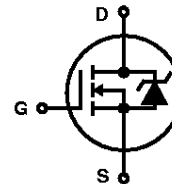
### Description

These are N-Channel enhancement mode silicon gate power field effect transistors. They are advanced power MOSFETs designed, tested, and guaranteed to withstand a specified level of energy in the breakdown avalanche mode of operation. All of these power MOSFETs are designed for applications such as switching regulators, switching converters, motor drivers, relay drivers, and drivers for high power bipolar switching transistors requiring high speed and low gate drive power. These types can be operated directly from integrated circuits.

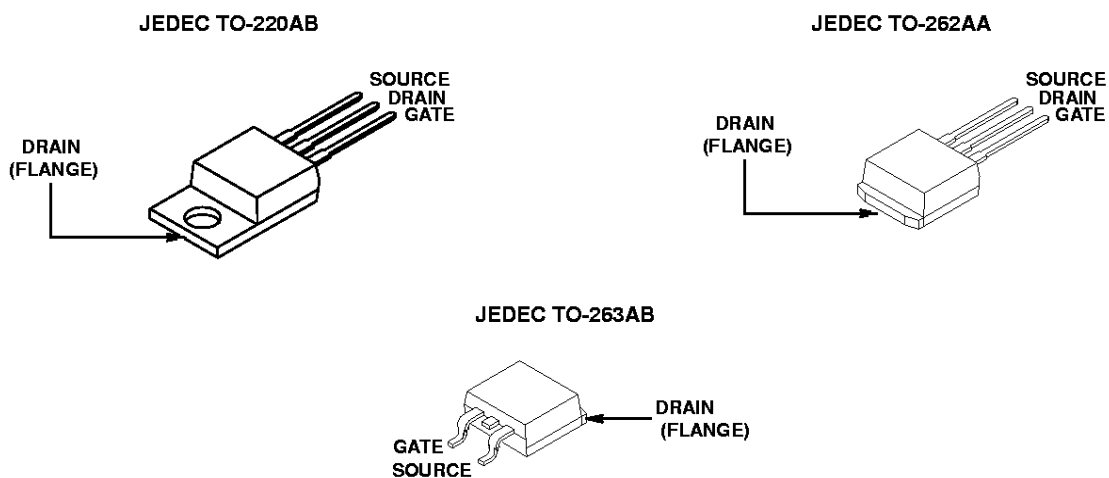
NOTE:

1. Calculated continuous current based on maximum allowable junction temperature. Package limited to 75A continuous, see Figure 9.

### Symbol



### Packaging



## HRF3205, HRF3205L, HRF3205S

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

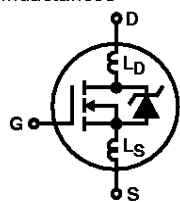
Drain to Source Voltage (Note 2)	$V_{DSS}$	55	V
Drain to Gate Voltage ( $R_{GS} = 20k\Omega$ ) (Note 2)	$V_{DGR}$	55	V
Gate to Source Voltage	$V_{GS}$	$\pm 20V$	V
Drain Current			
Continuous (Note 1)	$I_D$	100	A
Pulsed Drain Current (Note 3)	$I_{DM}$	390	A
Pulsed Avalanche Rating	$E_{AS}$	Figure 10	
Power Dissipation	$P_D$	175	W
Derate Above $25^\circ\text{C}$		1.17	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	$BV_{DSS}$	$I_D = 250\mu\text{A}, V_{GS} = 0V$	55	-	-	V	
Gate to Source Threshold Voltage	$V_{GS(TH)}$	$V_{GS} = V_{DS}, I_D = 250\mu\text{A}$	2	-	4	V	
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 55V, V_{GS} = 0V$	-	-	25	$\mu\text{A}$	
		$V_{DS} = 44V, V_{GS} = 0V, T_C = 150^\circ\text{C}$	-	-	250	$\mu\text{A}$	
Gate to Source Leakage Current	$I_{GSS}$	$V_{GS} = \pm 20V$	-	-	100	nA	
Breakdown Voltage Temperature Coefficient	$\Delta V_{(BR)DSS} / \Delta T_J$	Reference to $25^\circ\text{C}, I_D = 1\text{mA}$	-	0.057	-	V	
Drain to Source On Resistance	$r_{DS(ON)}$	$I_D = 59A, V_{GS} = 10V$ (Note 4)	-	0.0065	0.008	$\Omega$	
Turn-On Delay Time	$t_{d(ON)}$	$V_{DD} = 28V, I_D \cong 59A,$ $R_L = 0.47\Omega, V_{GS} = 10V,$ $R_{GS} = 2.5\Omega$ (Figure 16 and 17) (Note 4)	-	14	-	ns	
Rise Time	$t_r$		-	100	-	ns	
Turn-Off Delay Time	$t_{d(OFF)}$		-	43	-	ns	
Fall Time	$t_f$		-	70	-	ns	
Total Gate Charge	$Q_g$	$V_{DD} = 44V$ $I_D \cong 59A,$ $V_{GS} = 10V$ (Figures 6, 14, 15) (Note 3)	-	-	170	nC	
Gate to Source Charge	$Q_{gs}$		-	-	32	nC	
Gate to Drain "Miller" Charge	$Q_{gd}$		-	-	74	nC	
Input Capacitance	$C_{ISS}$	$V_{DS} = 25V, V_{GS} = 0V,$ $f = 1\text{MHz}$ (Figure 5)	-	4000	-	pF	
Output Capacitance	$C_{OSS}$		-	1300	-	pF	
Reverse Transfer Capacitance	$C_{RSS}$		-	480	-	pF	
Internal Source Inductance	$L_S$	Measured From the Contact Screw on Tab to Center of Die Measured From the Drain Lead, 6mm (0.25in) From Package to Center of Die	Modified MOSFET Symbol Showing the Internal Devices Inductances 	-	7.5	-	nH
Internal Drain Inductance	$L_D$	Measured From the Source Lead, 6mm (0.25in) From Header to Source Bonding Pad		-	4.5	-	nH

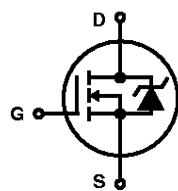
# HRF3205, HRF3205L, HRF3205S

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

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Thermal Resistance Junction to Case	$R_{\theta JC}$		-	-	0.85	$^\circ\text{C/W}$
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	TO-220 and TO-262	-	-	62	$^\circ\text{C/W}$
		TO-263 (PCB Mount Steady State)	-	-	40	$^\circ\text{C/W}$

## Source to Drain Diode Specifications

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Continuous Source to Drain Current	$I_{SD}$	MOSFET Symbol Showing The Integral Reverse P-N Junction Diode	-	-	100 (Note 1)	A
Pulsed Source to Drain Current (Note 3)	$I_{SDM}$		-	-	390	A
Source to Drain Diode Voltage	$V_{SD}$	$I_{SD} = 59\text{A}$ (Note 4)	-	-	1.3	V
Reverse Recovery Time	$t_{rr}$	$I_{SD} = 59\text{A}$ , $dI_{SD}/dt = 100\text{A}/\mu\text{s}$ (Note 4)	-	110	170	ns
Reverse Recovered Charge	$Q_{RR}$	$I_{SD} = 59\text{A}$ , $dI_{SD}/dt = 100\text{A}/\mu\text{s}$ (Note 4)	-	450	680	nC



### NOTES:

3. Repetitive rating; pulse width limited by maximum junction temperature (See Figure 11).
4. Pulse width  $\leq 300\mu\text{s}$ ; duty cycle  $\leq 2\%$ .

## Typical Performance Curves

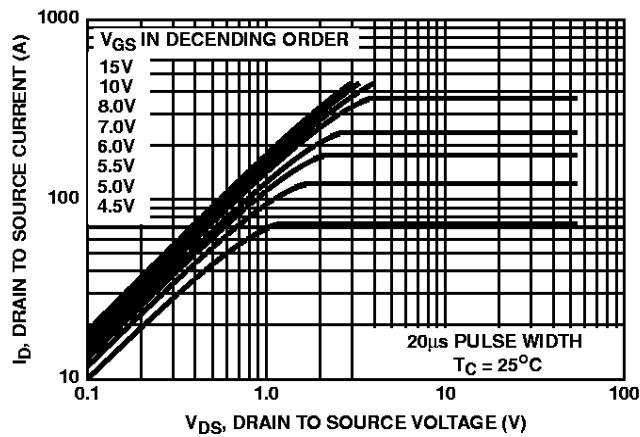


FIGURE 1. OUTPUT CHARACTERISTICS

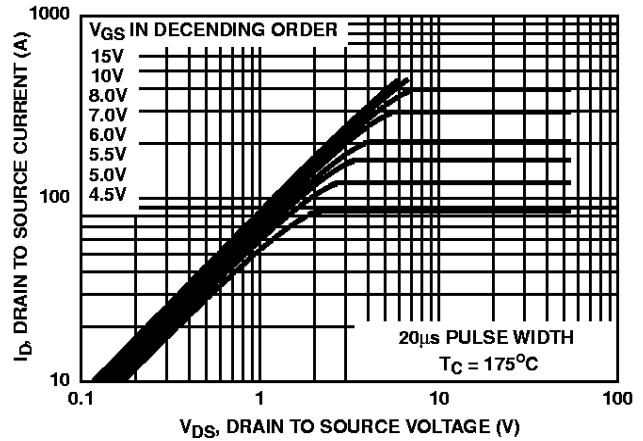


FIGURE 2. OUTPUT CHARACTERISTICS

Typical Performance Curves (Continued)

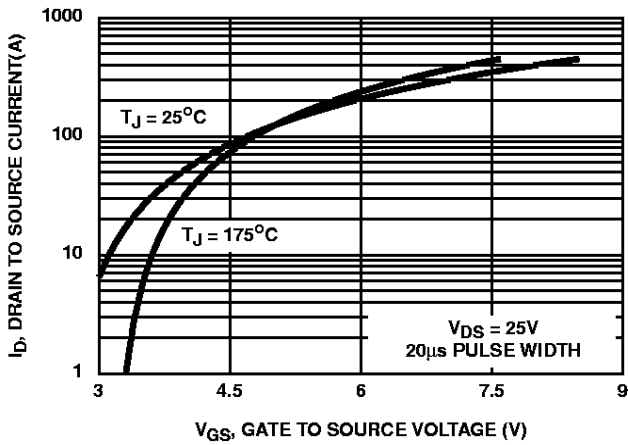


FIGURE 3. TRANSFER CHARACTERISTICS

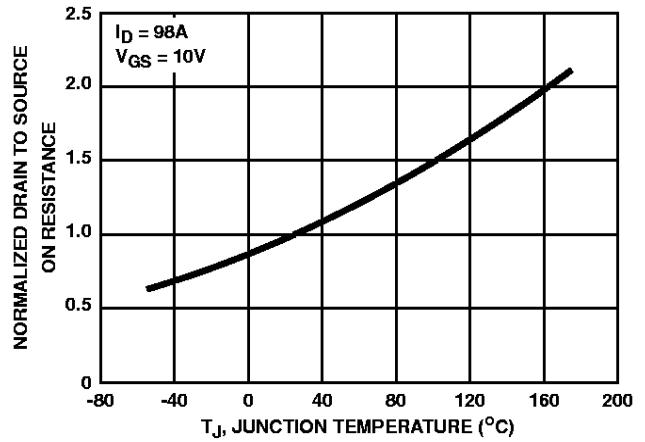


FIGURE 4. NORMALIZED DRAIN TO SOURCE ON RESISTANCE vs JUNCTION TEMPERATURE

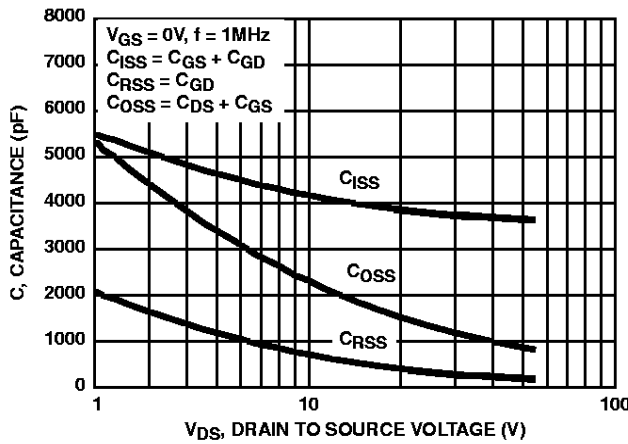


FIGURE 5. CAPACITANCE vs DRAIN TO SOURCE VOLTAGE

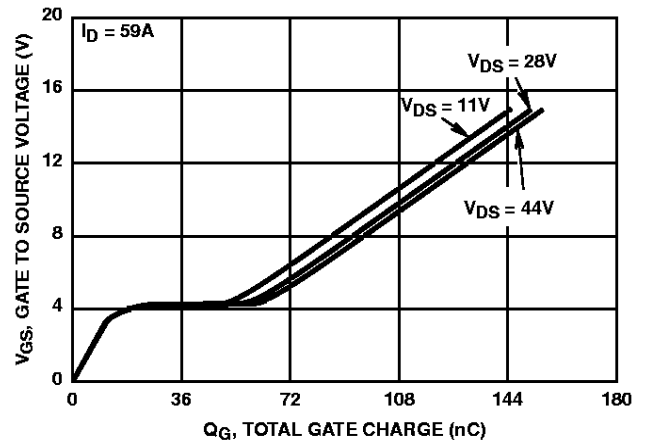


FIGURE 6. GATE CHARGE WAVEFORMS FOR CONSTANT GATE CURRENT

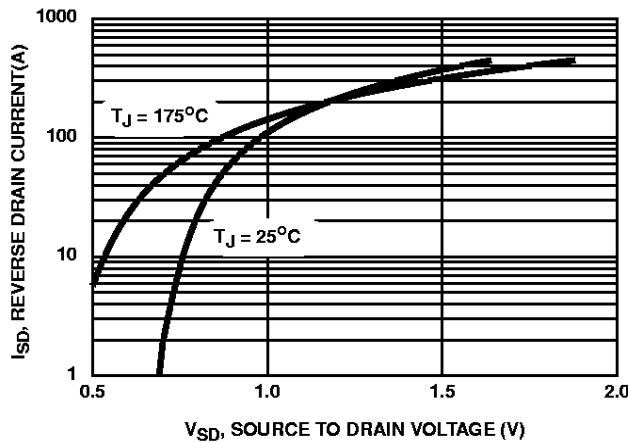


FIGURE 7. SOURCE-DRAIN DIODE FORWARD VOLTAGE

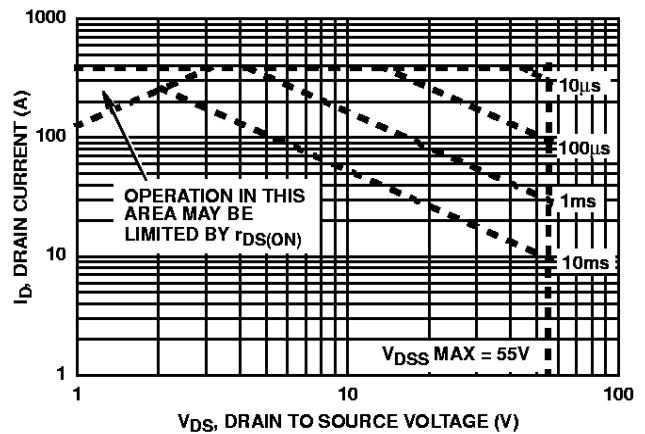


FIGURE 8. FORWARD BIAS SAFE OPERATING AREA

Typical Performance Curves (Continued)

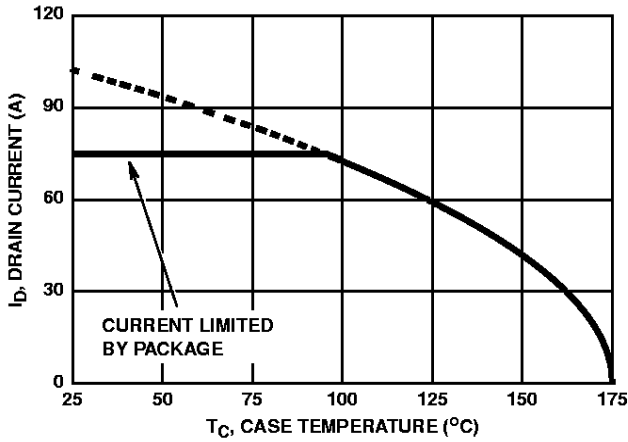


FIGURE 9. MAXIMUM CONTINUOUS DRAIN CURRENT vs CASE TEMPERATURE

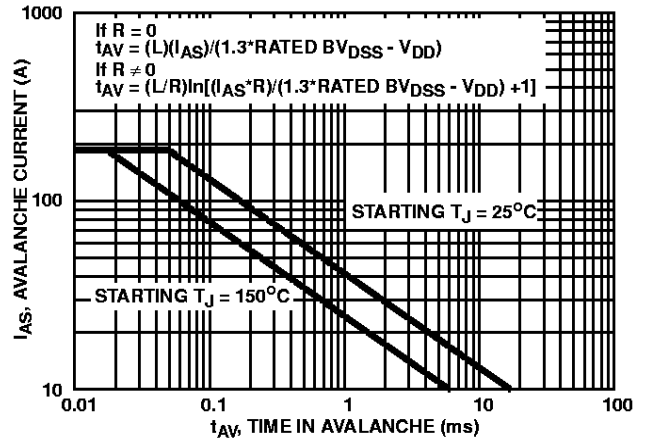


FIGURE 10. UNCLAMPED INDUCTIVE SWITCHING CAPABILITY

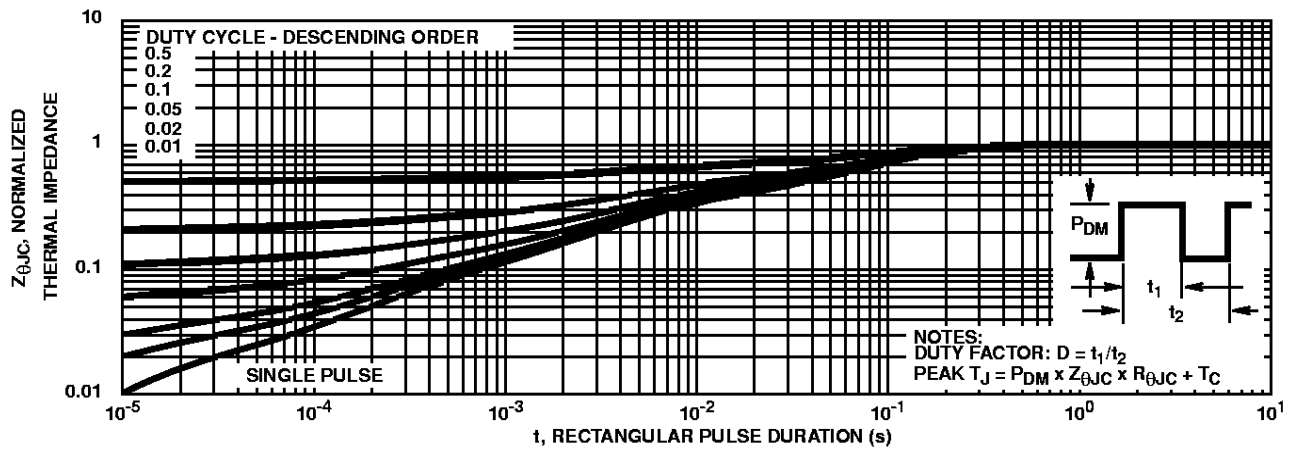


FIGURE 11. NORMALIZED MAXIMUM TRANSIENT THERMAL IMPEDANCE

Test Circuits and Waveforms

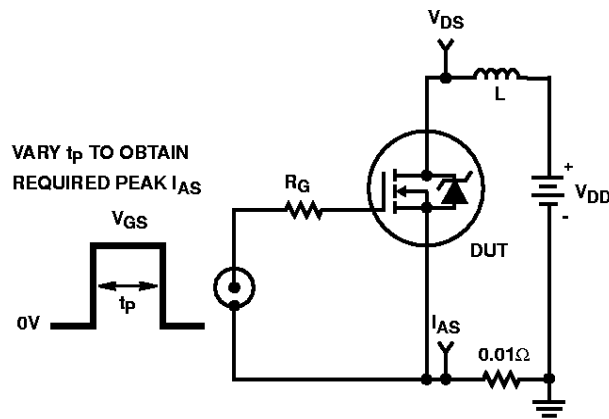


FIGURE 12. UNCLAMPED ENERGY TEST CIRCUIT

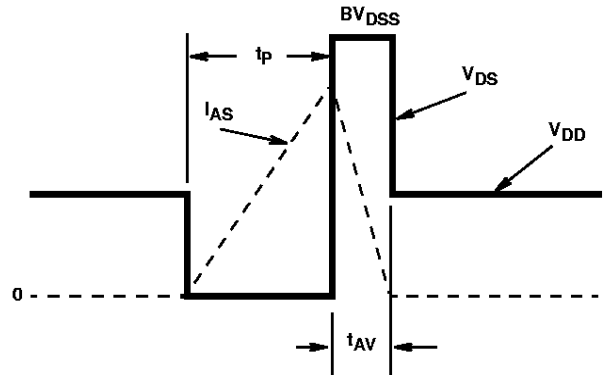


FIGURE 13. UNCLAMPED ENERGY WAVEFORMS

Test Circuits and Waveforms (Continued)

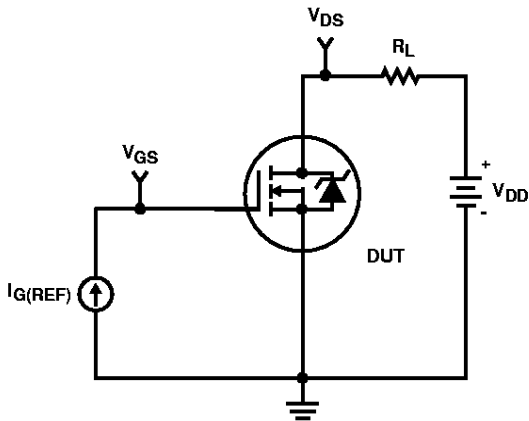


FIGURE 14. GATE CHARGE TEST CIRCUIT

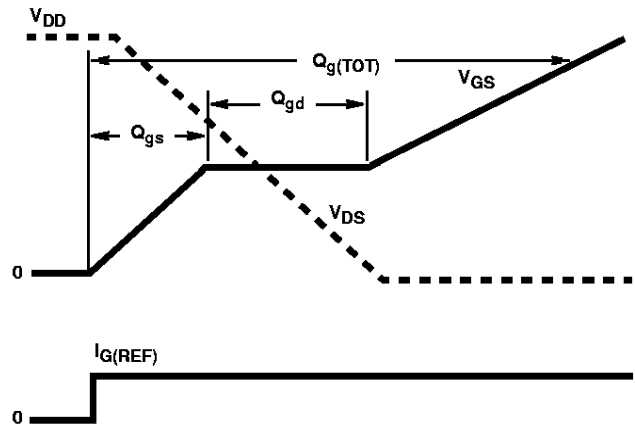


FIGURE 15. GATE CHARGE WAVEFORM

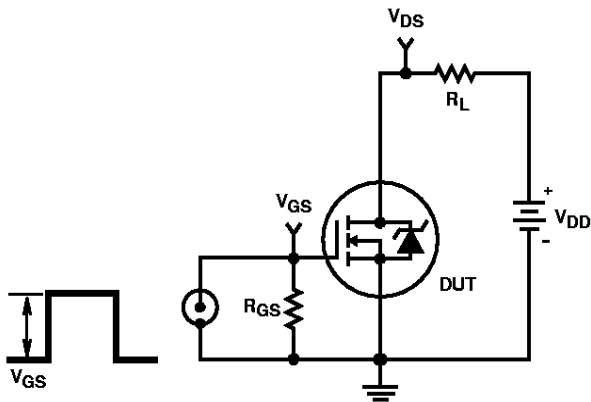


FIGURE 16. SWITCHING TIME TEST CIRCUIT

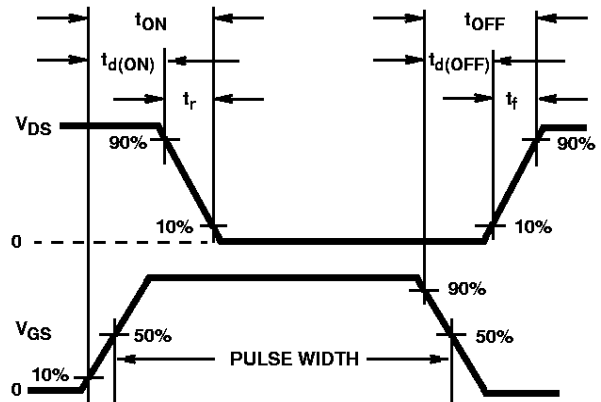


FIGURE 17. RESISTIVE SWITCHING WAVEFORMS

# HRF3205, HRF3205L, HRF3205S

## PSPICE Electrical Model

SUBCKT HRF3205P3 2 1 3 ; rev 7/25/97

CA 12 8 4.9e-9  
 CB 15 14 4.9e-9  
 CIN 6 8 3.45e-9

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

EBREAK 11 7 17 18 57  
 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 2.6e-9  
 LSOURCE 3 7 1.1e-9  
 K1 LGATE LSOURCE 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 3.5e-4  
 RGATE 9 20 0.36  
 RLDRAIN 2 5 10  
 RLGATE 1 9 26  
 RLSOURCE 3 7 11  
 RSLC1 5 51 RSLCMOD 1e-6  
 RSLC2 5 50 1e3  
 RSOURCE 8 7 RSOURCEMOD 4.5e-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

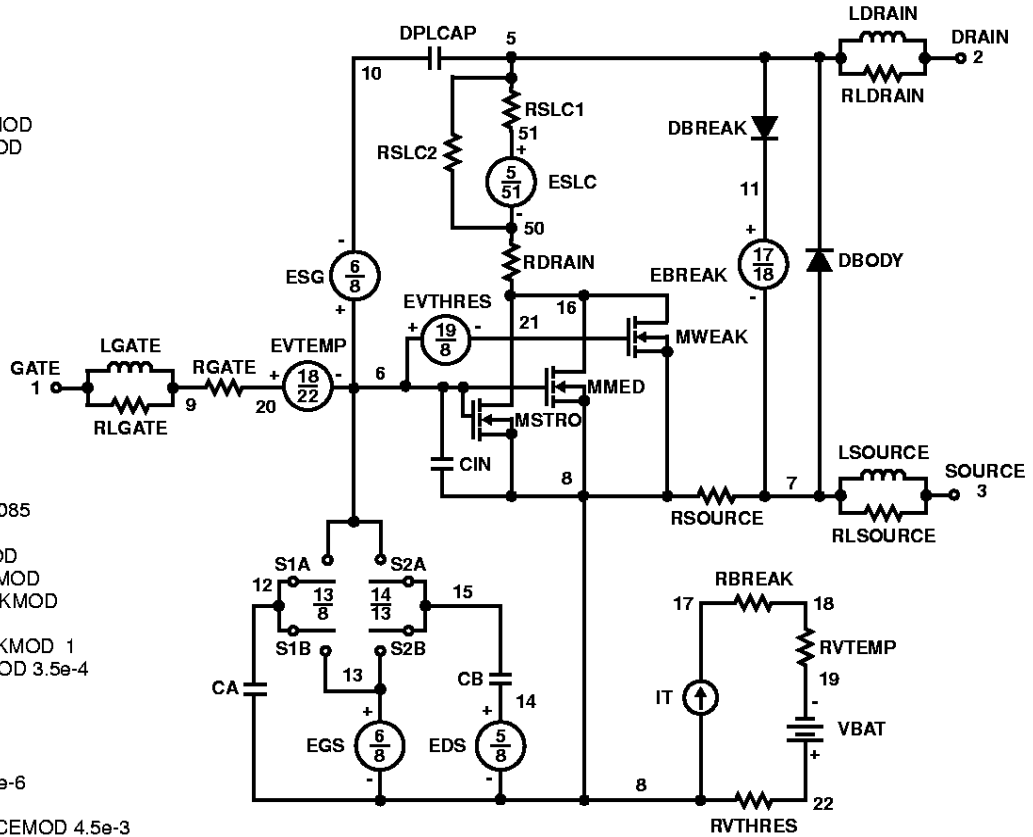
ESLC 51 50 VALUE={(V(5,51)/ABS(V(5,51)))\*(PWR(V(5,51)/(1e-6\*550),3))}

.MODEL DBODYMOD D (IS = 4.25e-12 RS = 1.8e-3 TRS1 = 2.75e-3 TRS2 = 5e-6 CJO = 5.95e-9 TT = 4e-7 M = 0.55)  
 .MODEL DBREAKMOD D (RS = 0.06 IKF = 30 TRS1 = -3e-3 TRS2 = 3e-6)  
 .MODEL DPLCAPMOD D (CJO = 4.45e-9 IS = 1e-30 N = 1 M = 0.88 VJ = 1.45)  
 .MODEL MMEDMOD NMOS (VTO = 2.93 KP = 9.5 IS = 1e-30 N = 10 TOX = 1 L = 1u W = 1u RG = 1)  
 .MODEL MSTROMOD NMOS (VTO = 3.23 KP = 150 IS = 1e-30 N = 10 TOX = 1 L = 1u W = 1u)  
 .MODEL MWEAKMOD NMOS (VTO = 2.35 KP = 0.02 IS = 1e-30 N = 10 TOX = 1 L = 1u W = 1u RG = 10)  
 .MODEL RBREAKMOD RES (TC1 = 8e-4 TC2 = 4e-6)  
 .MODEL RDRAINMOD RES (TC1 = 8e-2 TC2 = 5e-6)  
 .MODEL RSLCMOD RES (TC1 = 1e-4 TC2 = 1.05e-6)  
 .MODEL RSOURCEMOD RES (TC1 = 1e-4 TC2 = 1.5e-5)  
 .MODEL RVTHRESMOD RES (TC1 = -2.3e-3 TC2 = -1.2e-5)  
 .MODEL RVTEMPMOD RES (TC1 = -2.2e-3 TC2 = -7e-6)

.MODEL S1AMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = -9 VOFF = -4)  
 .MODEL S1BMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = -4 VOFF = -9)  
 .MODEL S2AMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = 0 VOFF = 2.5)  
 .MODEL S2BMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = 2.5 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.



# HRF3205, HRF3205L, HRF3205S

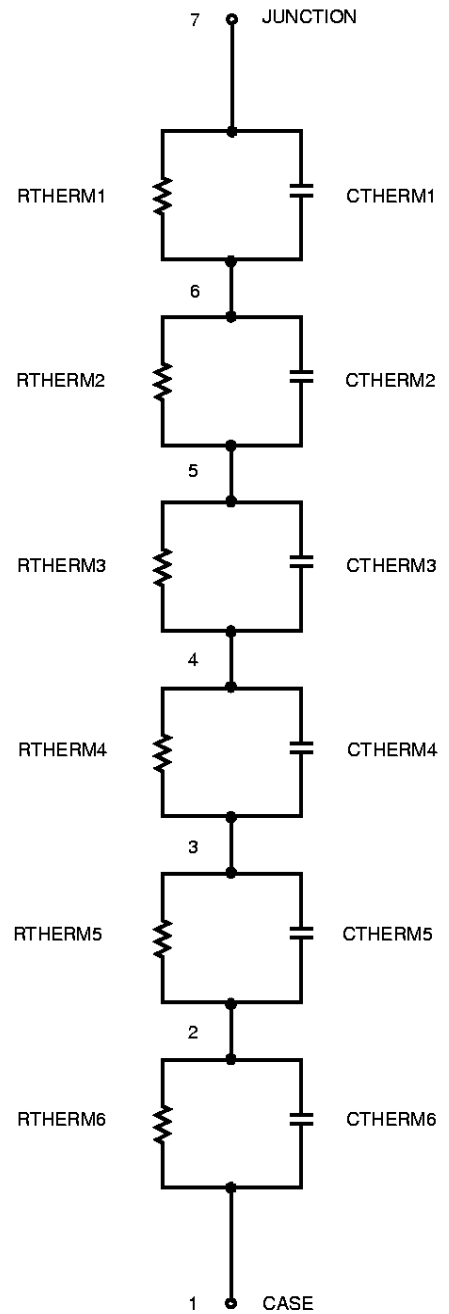
## SPICE Thermal Model

REV 25 July 97

HRF3205

CTHERM1 7 6 2.53e-5  
CTHERM2 6 5 1.38e-3  
CTHERM3 5 4 7.00e-3  
CTHERM4 4 3 2.50e-2  
CTHERM5 3 2 1.33e-1  
CTHERM6 2 1 5.75e-1

R THERM1 7 6 7.78e-4  
R THERM2 6 5 8.55e-3  
R THERM3 5 4 3.00e-2  
R THERM4 4 3 1.42e-1  
R THERM5 3 2 2.65e-1  
R THERM6 2 1 2.33e-1

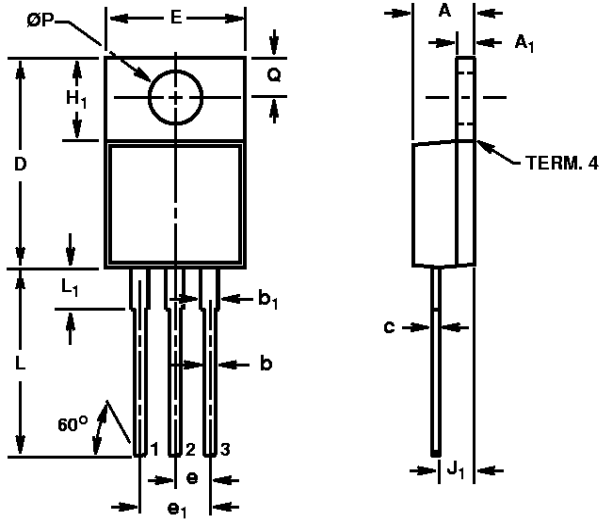




HRF3205, HRF3205L, HRF3205S

**TO-220AB (Alternate Version)**

3 LEAD JEDEC TO-220AB PLASTIC PACKAGE



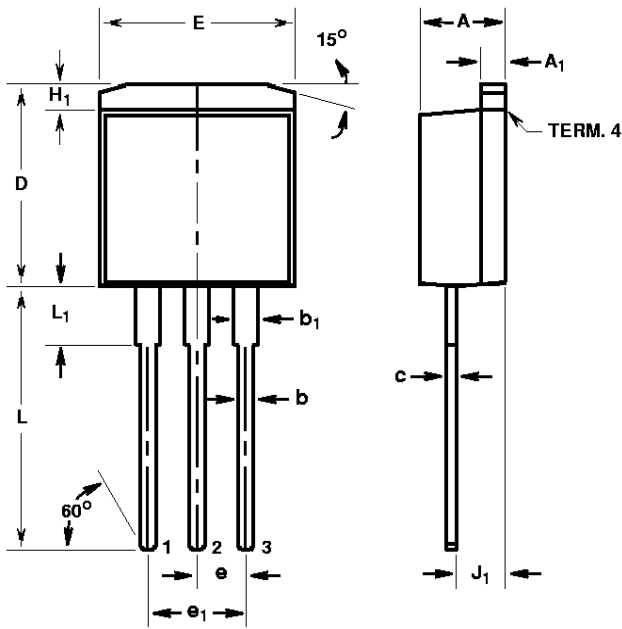
SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.170	0.180	4.32	4.57	-
A <sub>1</sub>	0.048	0.052	1.22	1.32	2, 4
b	0.030	0.034	0.77	0.86	2, 4
b <sub>1</sub>	0.045	0.055	1.15	1.39	2, 4
c	0.018	0.022	0.46	0.55	2, 4
D	0.590	0.610	14.99	15.49	-
E	0.395	0.405	10.04	10.28	-
e	0.100 TYP		2.54 TYP		5
e <sub>1</sub>	0.200 BSC		5.08 BSC		5
H <sub>1</sub>	0.235	0.255	5.97	6.47	-
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	3
ØP	0.149	0.153	3.79	3.88	-
Q	0.105	0.115	2.66	2.92	-

NOTES:

1. These dimensions are within allowable dimensions of Rev. J of JEDEC TO-220AB outline dated 3-24-87.
2. Dimension (without solder).
3. Solder finish uncontrolled in this area.
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 3 dated 7-97.

# HRF3205, HRF3205L, HRF3205S

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

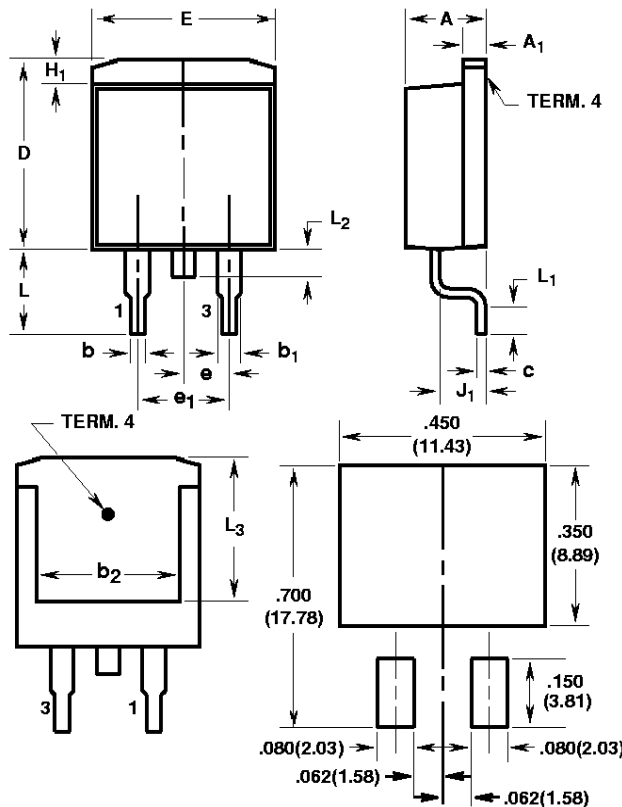


SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.170	0.180	4.32	4.57	-
A <sub>1</sub>	0.048	0.052	1.22	1.32	3, 4
b	0.030	0.034	0.77	0.86	3, 4
b <sub>1</sub>	0.045	0.055	1.15	1.39	3, 4
c	0.018	0.022	0.46	0.55	3, 4
D	0.405	0.425	10.29	10.79	-
E	0.395	0.405	10.04	10.28	-
e	0.100 TYP		2.54 TYP		5
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:**

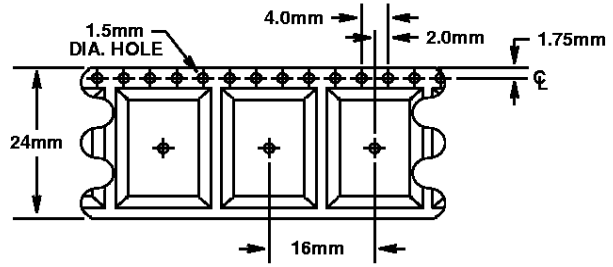
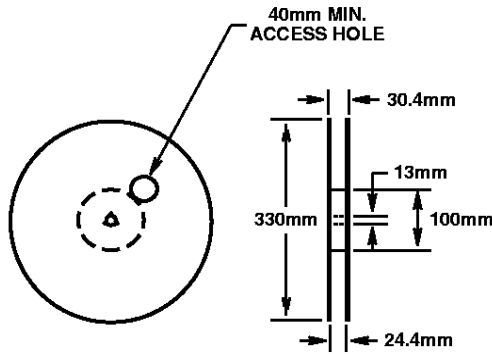
9. These dimensions are within allowable dimensions of Rev. C of JEDEC TO-263AB outline dated 2-92.
10. L<sub>3</sub> and b<sub>2</sub> dimensions established a minimum mounting surface for terminal 4.
11. Solder finish uncontrolled in this area.
12. Dimension (without solder).
13. Add typically 0.002 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.

**MINIMUM PAD SIZE RECOMMENDED FOR SURFACE-MOUNTED APPLICATIONS**

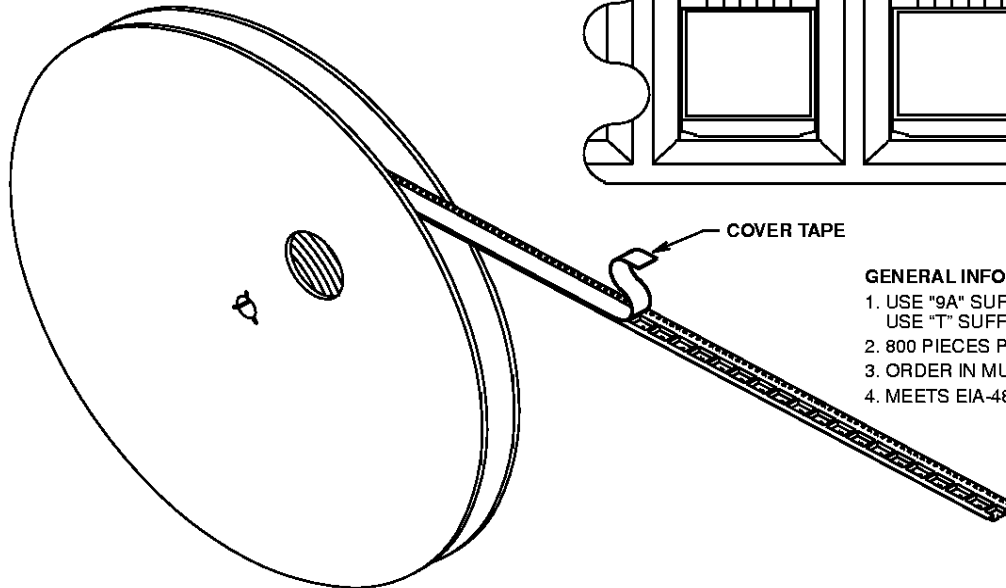
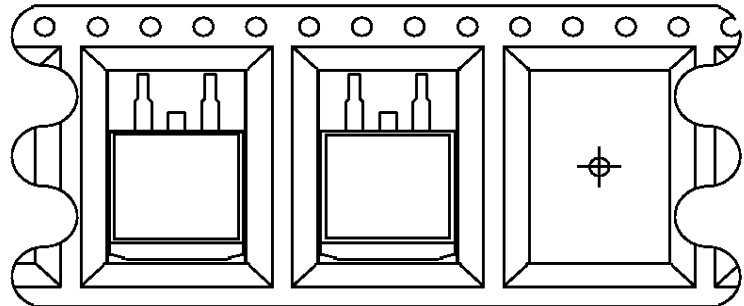
**HRF3205, HRF3205L, HRF3205S**

**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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