

## 100A, 55V, 0.008 Ohm, N-Channel, Power MOSFETs

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

## Ordering Information

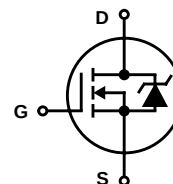
| PART NUMBER | PACKAGE  | BRAND    |
|-------------|----------|----------|
| HRF3205     | TO-220AB | HRF3205  |
| HRF3205S    | TO-263AB | HRF3205S |

**NOTE:** When ordering, use the entire part number. Add the suffix T to obtain the TO-263AB variant in tape and reel, e.g., HRF3205ST.

## Features

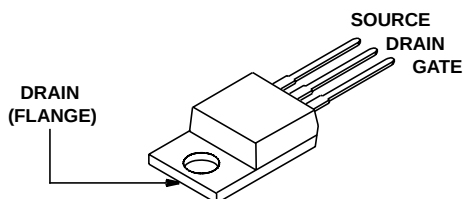
- 100A, 55V (See Note)
- Low On-Resistance,  $r_{DS(ON)} = 0.008\Omega$
- Temperature Compensating PSPICE® Model
- Thermal Impedance SPICE Model
- UIS Rating Curve
- Related Literature
  - TB334, "Guidelines for Soldering Surface Mount Components to PC Boards"

## Symbol

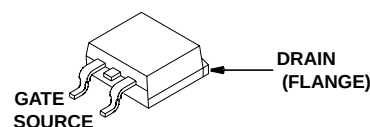


## Packaging

**JEDEC TO-220AB**



**JEDEC TO-263AB**



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

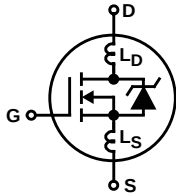
|                                                                          |                |                  |                             |
|--------------------------------------------------------------------------|----------------|------------------|-----------------------------|
| Drain to Source 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 . . . . .                                         | $V_{GS}$       | $\pm 20\text{V}$ | V                           |
| Drain Current                                                            |                |                  |                             |
| Continuous . . . . .                                                     | $I_D$          | 100              | A                           |
| Pulsed Drain Current (Note 2) . . . . .                                  | $I_{DM}$       | 390              | A                           |
| Pulsed Avalanche Rating . . . . .                                        | $E_{AS}$       | Figure 10        |                             |
| Power Dissipation . . . . .                                              | $P_D$          | 175              | W                           |
| Derate Above $25^{\circ}\text{C}$ . . . . .                              |                | 1.17             | $\text{W}/^{\circ}\text{C}$ |
| 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:

1.  $T_J = 25^{\circ}\text{C}$  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                                                                                                                       | $BV_{DSS}$                        | $I_D = 250\mu\text{A}$ , $V_{GS} = 0\text{V}$                                                                             | 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                                                                                                                         | $I_{DSS}$                         | $V_{DS} = 55\text{V}$ , $V_{GS} = 0\text{V}$                                                                              | -   | -      | 25    | $\mu\text{A}$               |
|                                                                                                                                                         |                                   | $V_{DS} = 44\text{V}$ , $V_{GS} = 0\text{V}$ , $T_C = 150^{\circ}\text{C}$                                                | -   | -      | 250   | $\mu\text{A}$               |
| Gate to Source Leakage Current                                                                                                                          | $I_{GSS}$                         | $V_{GS} = \pm 20\text{V}$                                                                                                 | -   | -      | 100   | nA                          |
| Breakdown Voltage Temperature Coefficient                                                                                                               | $\Delta V_{(BR)DSS} / \Delta T_J$ | Reference to $25^{\circ}\text{C}$ , $I_D = 250\mu\text{A}$                                                                | -   | 0.057  | -     | V                           |
| Drain to Source On Resistance                                                                                                                           | $r_{DS(ON)}$                      | $I_D = 59\text{A}$ , $V_{GS} = 10\text{V}$ (Figure 4)                                                                     | -   | 0.0065 | 0.008 | $\Omega$                    |
| Turn-On Delay Time                                                                                                                                      | $t_{d(ON)}$                       | $V_{DD} = 28\text{V}$ , $I_D \equiv 59\text{A}$ ,<br>$R_L = 0.47\Omega$ , $V_{GS} = 10\text{V}$ ,<br>$R_{GS} = 2.5\Omega$ | -   | 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                                                                                                                                       | $Q_g$                             | $V_{DD} = 44\text{V}$ , $I_D \equiv 59\text{A}$ ,<br>$V_{GS} = 10\text{V}$ , $I_{g(REF)} = 3\text{mA}$<br>(Figure 6)      | -   | -      | 170   | nC                          |
| Gate to Source Charge                                                                                                                                   | $Q_{gs}$                          |                                                                                                                           | -   | -      | 32    | nC                          |
| Gate to Drain "Miller" Charge                                                                                                                           | $Q_{gd}$                          |                                                                                                                           | -   | -      | 74    | nC                          |
| Input Capacitance                                                                                                                                       | $C_{ISS}$                         | $V_{DS} = 25\text{V}$ , $V_{GS} = 0\text{V}$ ,<br>$f = 1\text{MHz}$ (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                                                                   | -   | 7.5    | -     | nH                          |
|                                                                                                                                                         |                                   | Measured From the Drain Lead, 6mm (0.25in) From Package to Center of Die                                                  |     |        |       |                             |
| Internal Drain Inductance                                                                                                                               | $L_D$                             | Measured From the Source Lead, 6mm (0.25in) From Header to Source Bonding Pad                                             | -   | 4.5    | -     | nH                          |
| Modified MOSFET Symbol Showing the Internal Devices Inductances<br> |                                   |                                                                                                                           |     |        |       |                             |
| Thermal Resistance Junction to Case                                                                                                                     | $R_{\theta JC}$                   |                                                                                                                           | -   | -      | 0.85  | $^{\circ}\text{C}/\text{W}$ |
| Thermal Resistance Junction to Ambient                                                                                                                  | $R_{\theta JA}$                   | TO-220                                                                                                                    | -   | -      | 62    | $^{\circ}\text{C}/\text{W}$ |
|                                                                                                                                                         |                                   | TO-263 (PCB Mount, Steady State)                                                                                          | -   | -      | 40    | $^{\circ}\text{C}/\text{W}$ |

## Source to Drain Diode Specifications

| PARAMETER                               | SYMBOL    | TEST CONDITIONS                                                           | MIN | TYP | MAX             | UNITS |
|-----------------------------------------|-----------|---------------------------------------------------------------------------|-----|-----|-----------------|-------|
| Continuous Source to Drain Current      | $I_{SD}$  | MOSFET<br>Symbol Showing<br>The Integral<br>Reverse P-N<br>Junction Diode | -   | -   | 100<br>(Note 1) | A     |
| Pulsed Source to Drain Current (Note 2) | $I_{SDM}$ |                                                                           | -   | -   | 390             | A     |
| Source to Drain Diode Voltage           | $V_{SD}$  | $I_{SD} = 59A$ (Note 4)                                                   | -   | -   | 1.3             | V     |
| Reverse Recovery Time                   | $t_{rr}$  | $I_{SD} = 59A$ , $dI_{SD}/dt = 100A/\mu s$ (Note 4)                       | -   | 110 | 170             | ns    |
| Reverse Recovered Charge                | $Q_{RR}$  | $I_{SD} = 59A$ , $dI_{SD}/dt = 100A/\mu s$ (Note 4)                       | -   | 450 | 680             | nC    |

NOTE:

2. Repetitive rating; pulse width limited by maximum junction temperature (See Figure 11)

## Typical Performance Curves

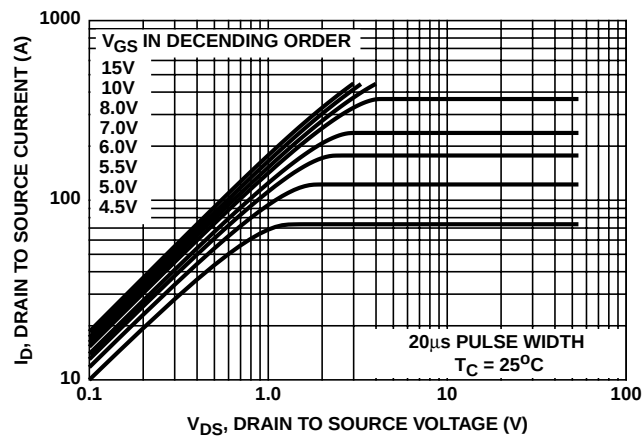


FIGURE 1. OUTPUT CHARACTERISTICS

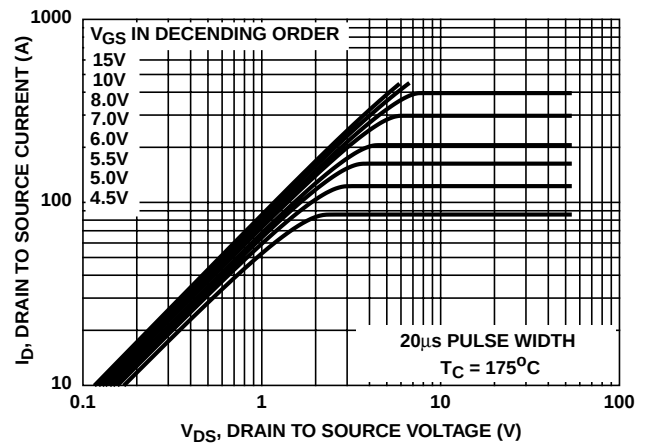


FIGURE 2. OUTPUT CHARACTERISTICS

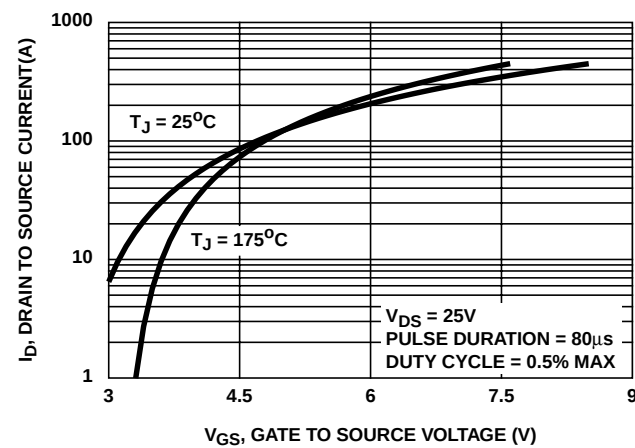


FIGURE 3. TRANSFER CHARACTERISTICS

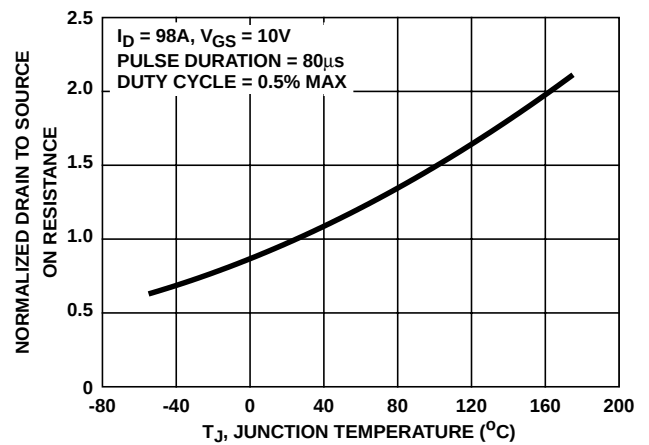


FIGURE 4. NORMALIZED DRAIN TO SOURCE ON RESISTANCE vs JUNCTION TEMPERATURE

Typical Performance Curves (Continued)

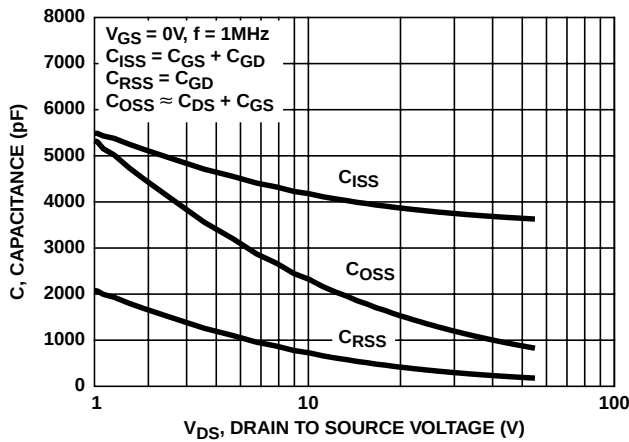


FIGURE 5. CAPACITANCE vs DRAIN TO SOURCE VOLTAGE

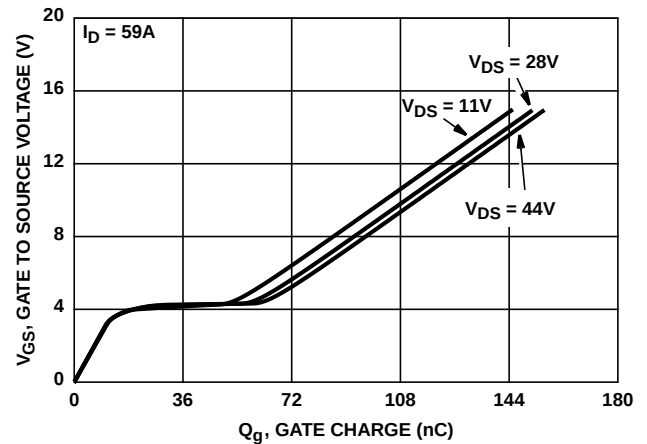


FIGURE 6. GATE CHARGE WAVEFORMS FOR CONSTANT GATE CURRENT

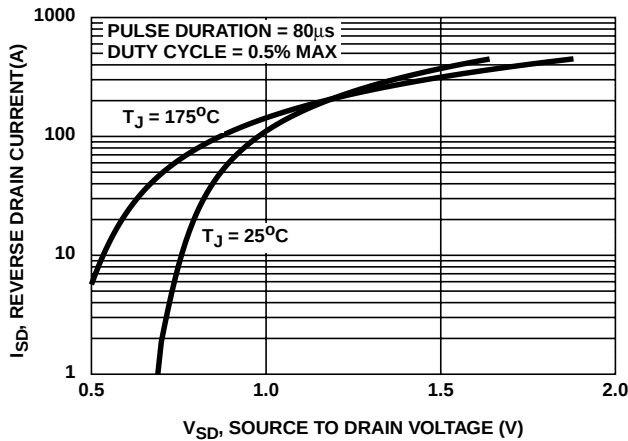


FIGURE 7. SOURCE TO DRAIN DIODE FORWARD VOLTAGE

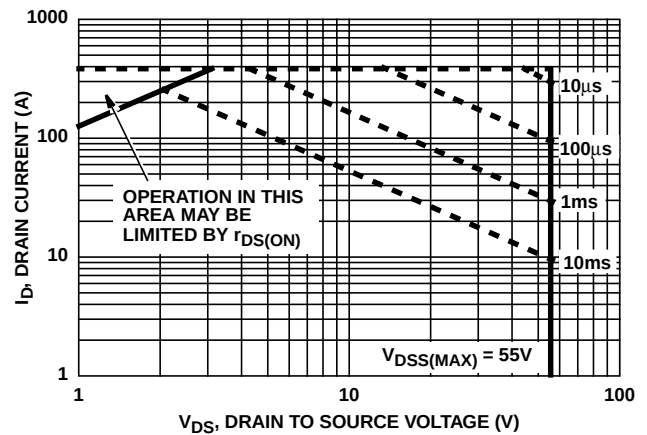


FIGURE 8. FORWARD BIAS SAFE OPERATING AREA

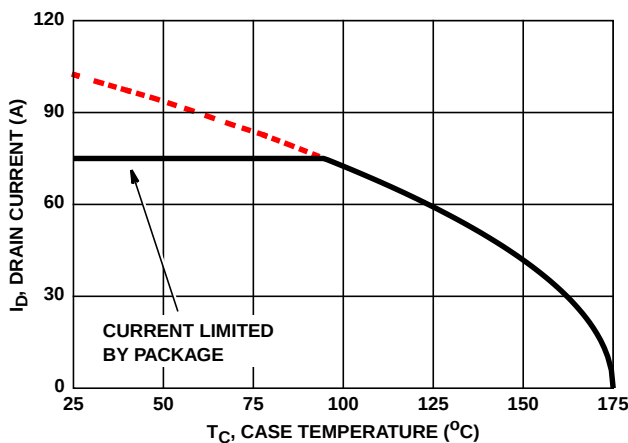


FIGURE 9. MAXIMUM CONTINUOUS DRAIN CURRENT vs CASE TEMPERATURE

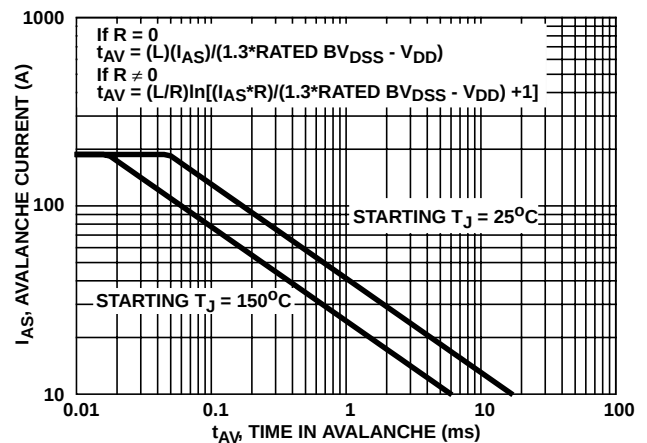


FIGURE 10. UNCLAMPED INDUCTIVE SWITCHING CAPABILITY

## Typical Performance Curves (Continued)

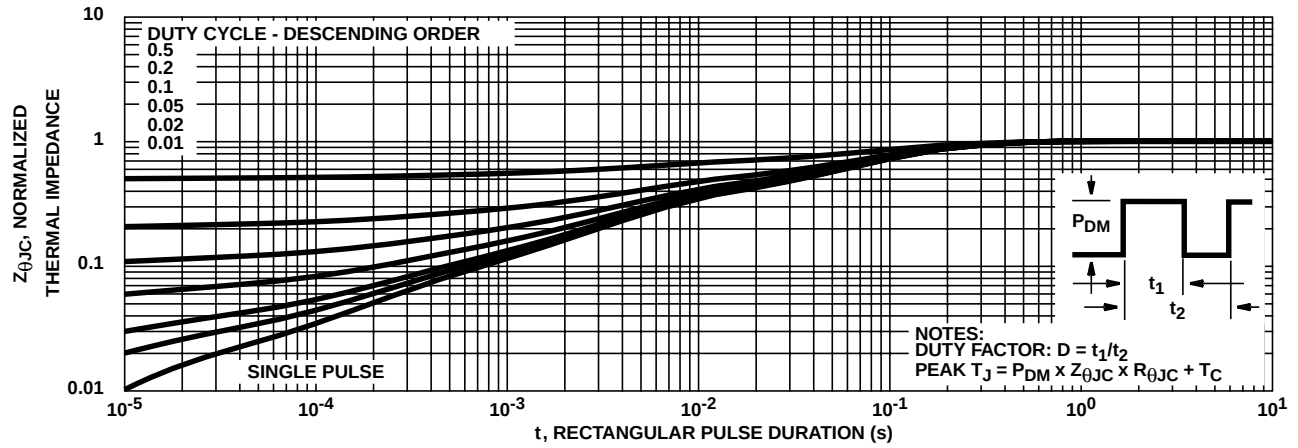


FIGURE 11. NORMALIZED MAXIMUM TRANSIENT THERMAL IMPEDANCE

## Test Circuits and Waveforms

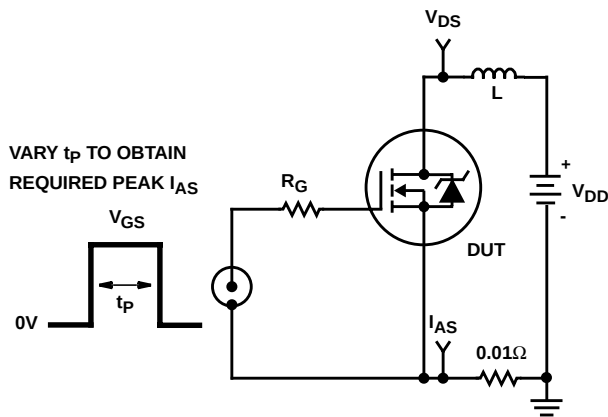


FIGURE 12. UNCLAMPED ENERGY TEST CIRCUIT

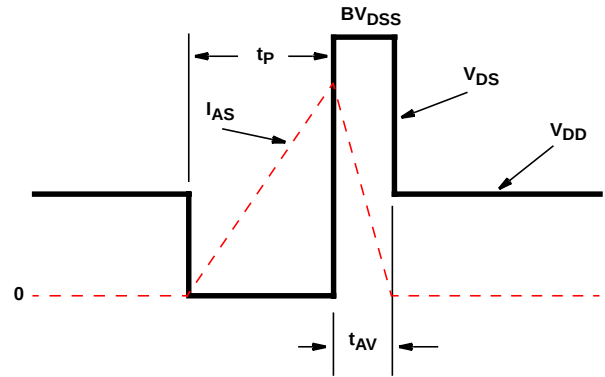


FIGURE 13. UNCLAMPED ENERGY WAVEFORMS

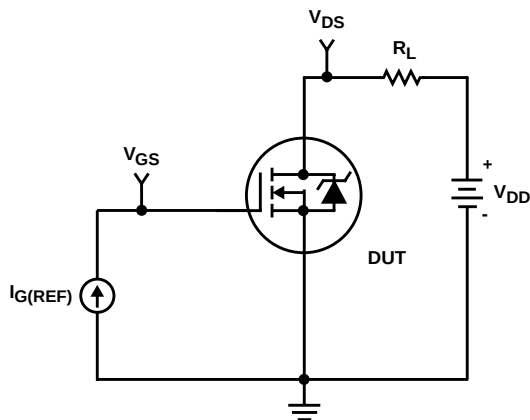


FIGURE 14. GATE CHARGE TEST CIRCUIT

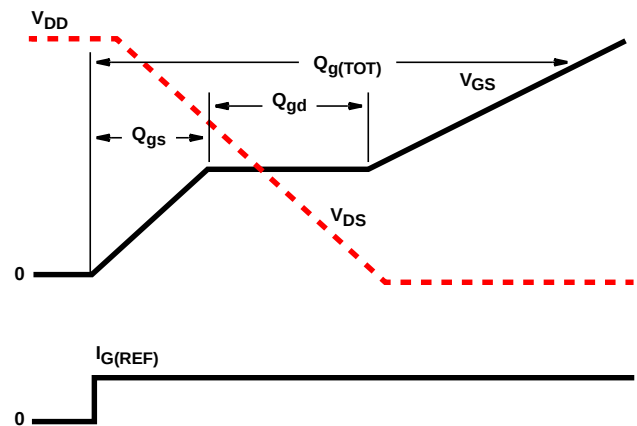


FIGURE 15. GATE CHARGE WAVEFORM

**Test Circuits and Waveforms** (Continued)

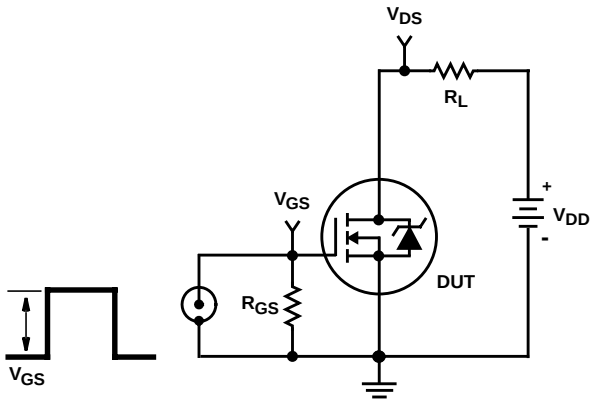


FIGURE 16. SWITCHING TIME TEST CIRCUIT

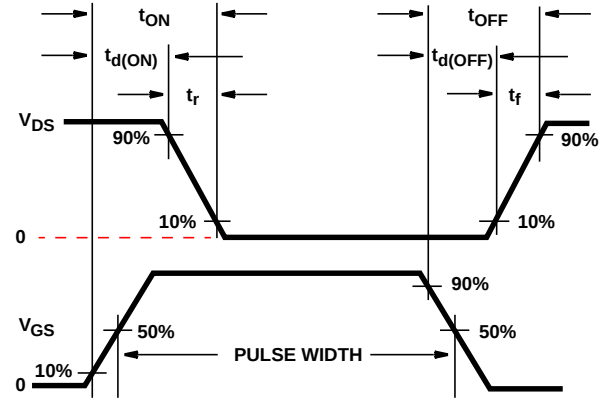


FIGURE 17. RESISTIVE SWITCHING WAVEFORMS

## 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

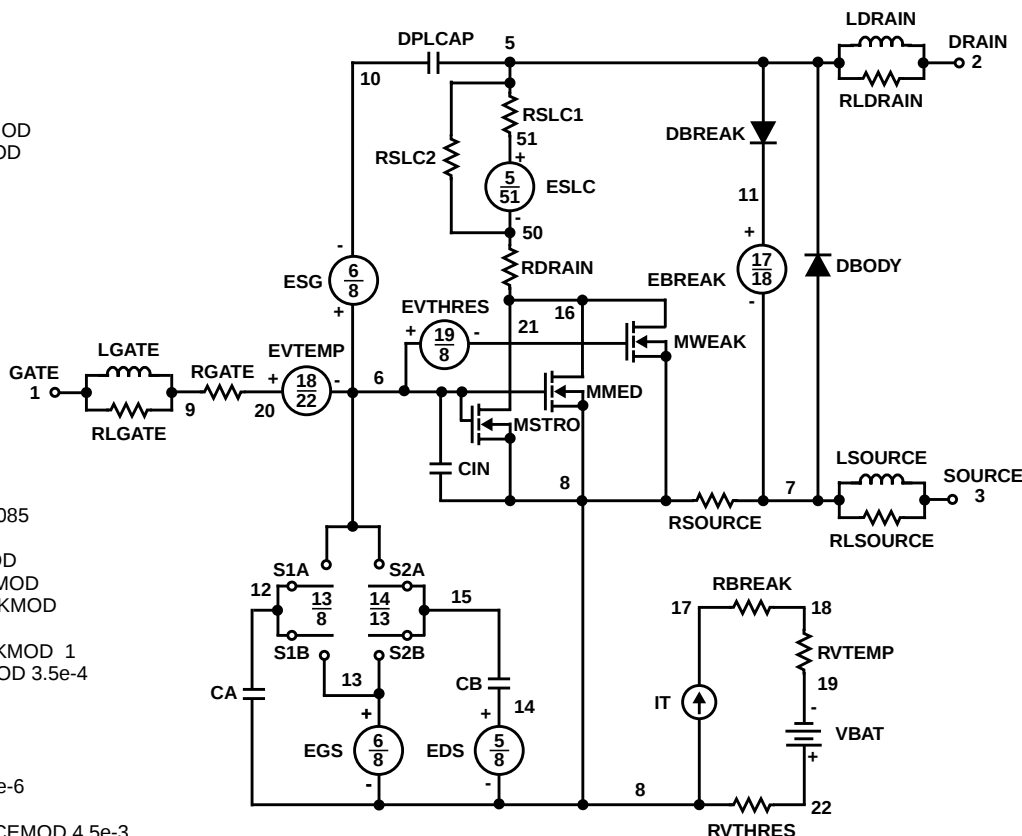
ESLC 51 50 VALUE={(V(5,51)/ABS(V(5,51)))\*(PWR(V(5,51)/(1e-6\*550),3))}

.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.



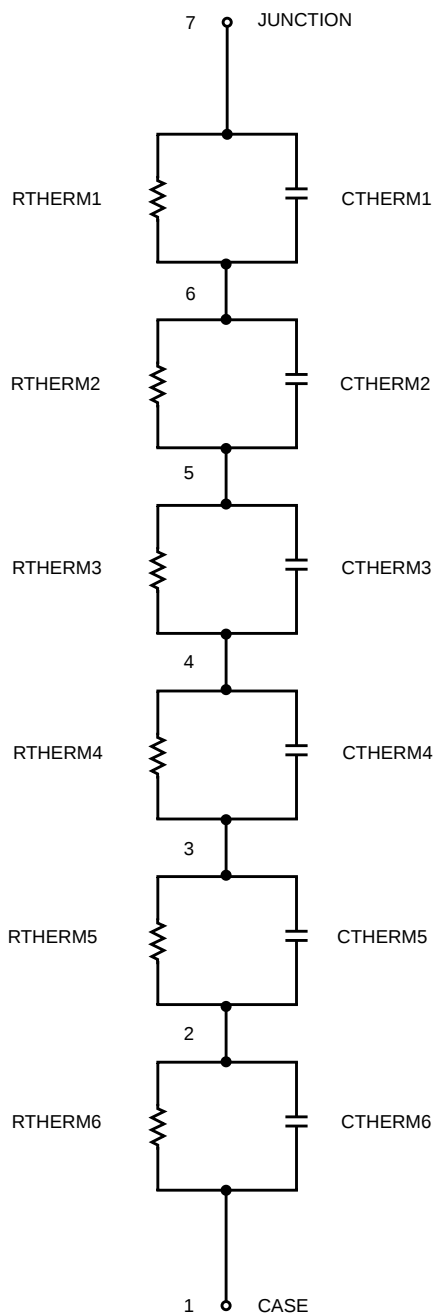
## SPICE Thermal Model

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

RTHERM1 7 6 7.78e-4  
 RTHERM2 6 5 8.55e-3  
 RTHERM3 5 4 3.00e-2  
 RTHERM4 4 3 1.42e-1  
 RTHERM5 3 2 2.65e-1  
 RTHERM6 2 1 2.33e-1



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