

## 3.5A, 30V, Avalanche Rated, Dual N-Channel LittleFET™ Enhancement Mode Power MOSFET

January 1997

### Features

- 3.5A, 30V
- $r_{DS(ON)} = 0.060\Omega$
- *Temperature Compensating* PSpice Model
- Peak Current vs Pulse Width Curve
- UIS Rating Curve

### Ordering Information

| PART NUMBER | PACKAGE  | BRAND     |
|-------------|----------|-----------|
| RF1K49086   | MS-012AA | RF1K49086 |

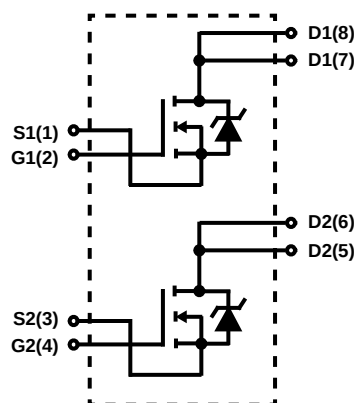
NOTE: When ordering, use the entire part number. For ordering in tape and reel, add the suffix 96 to the part number, i.e. RF1K4908696.

### Description

The RF1K49086 Dual N-Channel power MOSFET is manufactured using an advanced MegaFET process. This process, which uses feature sizes approaching those of LSI integrated circuits, gives optimum utilization of silicon, resulting in outstanding performance. It is designed for use in applications such as switching regulators, switching converters, motor drivers, relay drivers, and low voltage bus switches. This device can be operated directly from integrated circuits.

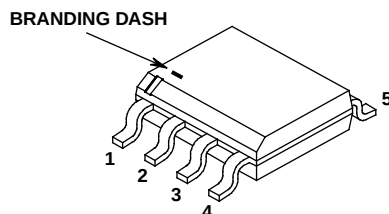
Formerly developmental type TA49086.

### Symbol



### Packaging

JEDEC MS-012AA



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# RF1K49086

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

|                                                  | RF1K49086                 | UNITS                       |
|--------------------------------------------------|---------------------------|-----------------------------|
| Drain to Source Voltage . . . . .                | $V_{DSS}$ 30              | V                           |
| Drain to Gate Voltage . . . . .                  | $V_{DGR}$ 30              | V                           |
| Gate to Source Voltage . . . . .                 | $V_{GS}$ $\pm 20$         | V                           |
| Drain Current                                    |                           |                             |
| Continuous (Pulse Width = 5s) . . . . .          | $I_D$ 3.5                 | A                           |
| Pulsed . . . . .                                 | $I_{DM}$                  | Refer to Peak Current Curve |
| Pulsed Avalanche Rating . . . . .                | $E_{AS}$                  | Refer to UIS Curve          |
| Power Dissipation                                |                           |                             |
| $T_A = 25^{\circ}\text{C}$ . . . . .             | $P_D$ 2                   | W                           |
| Derate Above $25^{\circ}\text{C}$ . . . . .      | 0.016                     | W/ $^{\circ}\text{C}$       |
| Operating and Storage Temperature . . . . .      | $T_{STG}, T_J$ -55 to 150 | $^{\circ}\text{C}$          |
| Soldering Temperature of Leads for 10s . . . . . | $T_L$ 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.

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

| PARAMETERS                             | SYMBOL          | TEST CONDITIONS                                                               |                                              | MIN | TYP | MAX   | UNITS         |
|----------------------------------------|-----------------|-------------------------------------------------------------------------------|----------------------------------------------|-----|-----|-------|---------------|
| Drain to Source Breakdown Voltage      | $BV_{DSS}$      | $I_D = 250\mu A, V_{GS} = 0V$                                                 |                                              | 30  | -   | -     | V             |
| Gate Threshold Voltage                 | $V_{GS(TH)}$    | $V_{GS} = V_{DS}, I_D = 250\mu A$                                             |                                              | 1   | -   | 3     | V             |
| Zero Gate Voltage Drain Current        | $I_{DSS}$       | $V_{DS} = 30V, V_{GS} = 0V$                                                   | $T_A = 25^{\circ}C$                          | -   | -   | 1     | $\mu A$       |
|                                        |                 |                                                                               | $T_A = 150^{\circ}C$                         | -   | -   | 50    | $\mu A$       |
| Gate to Source Leakage Current         | $I_{GSS}$       | $V_{GS} = \pm 20V$                                                            |                                              | -   | -   | 100   | nA            |
| On Resistance                          | $r_{DS(ON)}$    | $I_D = 3.5A$                                                                  | $V_{GS} = 10V$                               | -   | -   | 0.060 | $\Omega$      |
|                                        |                 |                                                                               | $V_{GS} = 4.5V$                              | -   | -   | 0.132 | $\Omega$      |
| Turn-On Time                           | $t_{ON}$        | $V_{DD} = 15V, I_D = 3.5A, R_L = 4.29\Omega, V_{GS} = 10V, R_{GS} = 25\Omega$ |                                              | -   | -   | 50    | ns            |
| Turn-On Delay Time                     | $t_{d(ON)}$     |                                                                               |                                              | -   | 10  | -     | ns            |
| Rise Time                              | $t_r$           |                                                                               |                                              | -   | 30  | -     | ns            |
| Turn-Off Delay Time                    | $t_{d(OFF)}$    |                                                                               |                                              | -   | 60  | -     | ns            |
| Fall Time                              | $t_f$           |                                                                               |                                              | -   | 45  | -     | ns            |
| Turn-Off Time                          | $t_{OFF}$       |                                                                               |                                              | -   | -   | 130   | ns            |
| Total Gate Charge                      | $Q_g(TOT)$      | $V_{GS} = 0V$ to $20V$                                                        | $V_{DD} = 24V, I_D = 3.5A, R_L = 6.86\Omega$ | -   | 35  | 45    | nC            |
| Gate Charge at 10V                     | $Q_g(10)$       | $V_{GS} = 0V$ to $10V$                                                        |                                              | -   | 13  | 17    | nC            |
| Threshold Gate Charge                  | $Q_g(TH)$       | $V_{GS} = 0V$ to $2V$                                                         |                                              | -   | 2.3 | 2.9   | nC            |
| Input Capacitance                      | $C_{ISS}$       | $V_{DS} = 25V, V_{GS} = 0V, f = 1MHz$                                         |                                              | -   | 575 | -     | pF            |
| Output Capacitance                     | $C_{OSS}$       |                                                                               |                                              | -   | 275 | -     | pF            |
| Reverse Transfer Capacitance           | $C_{RSS}$       |                                                                               |                                              | -   | 100 | -     | pF            |
| Thermal Resistance Junction-to-Ambient | $R_{\theta JA}$ | Pulse Width = 1s<br>Device mounted on FR-4 material                           |                                              | -   | -   | 62.5  | $^{\circ}C/W$ |

## Source to Drain Diode Ratings and Specifications

| PARAMETERS            | SYMBOL   | TEST CONDITIONS                                                 | MIN | TYP | MAX  | UNITS |
|-----------------------|----------|-----------------------------------------------------------------|-----|-----|------|-------|
| Forward Voltage       | $V_{SD}$ | $I_{SD} = 3.5\text{A}$                                          | -   | -   | 1.25 | V     |
| Reverse Recovery Time | $t_{rr}$ | $I_{SD} = 3.5\text{A}$ , $dI_{SD}/dt = 100\text{A}/\mu\text{s}$ | -   | -   | 45   | ns    |

## Typical Performance Curves

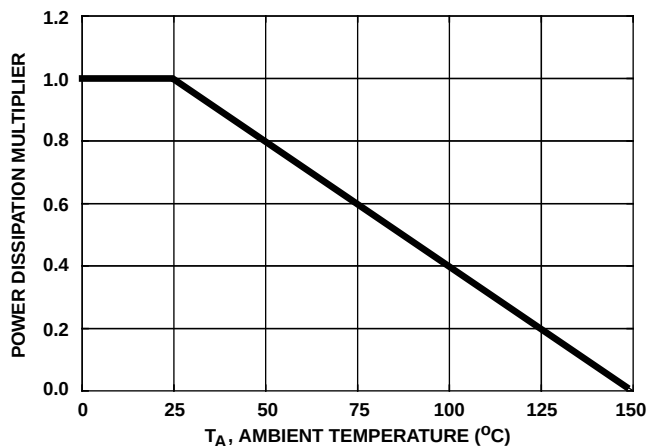


FIGURE 1. NORMALIZED POWER DISSIPATION vs TEMPERATURE DERATING CURVE

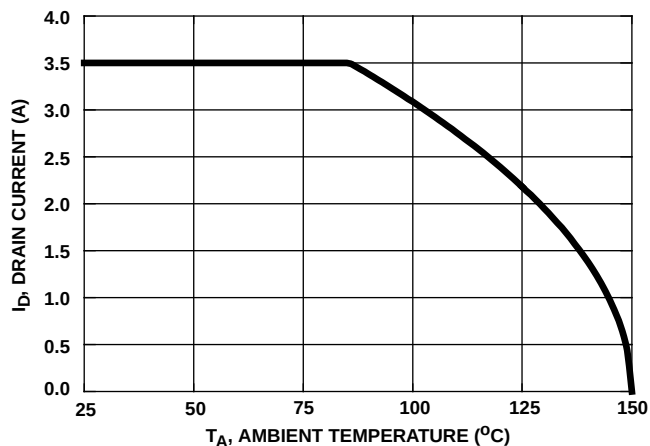


FIGURE 2. MAXIMUM CONTINUOUS DRAIN CURRENT vs TEMPERATURE

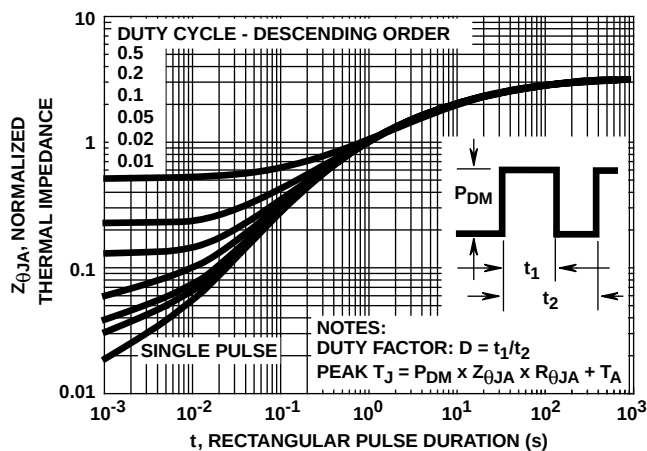


FIGURE 3. NORMALIZED MAXIMUM TRANSIENT THERMAL IMPEDANCE

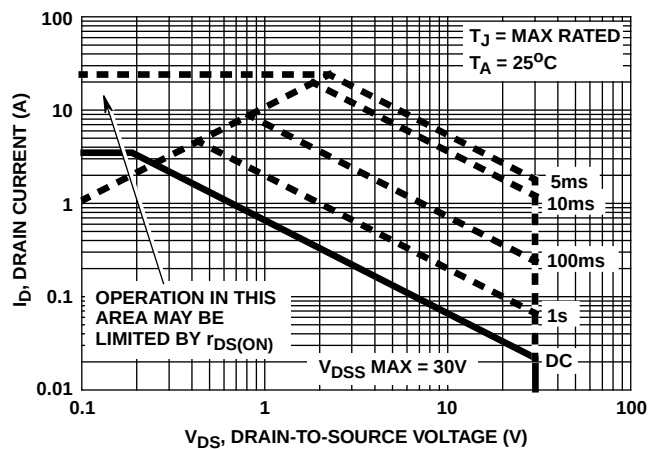


FIGURE 4. FORWARD BIAS SAFE OPERATING AREA

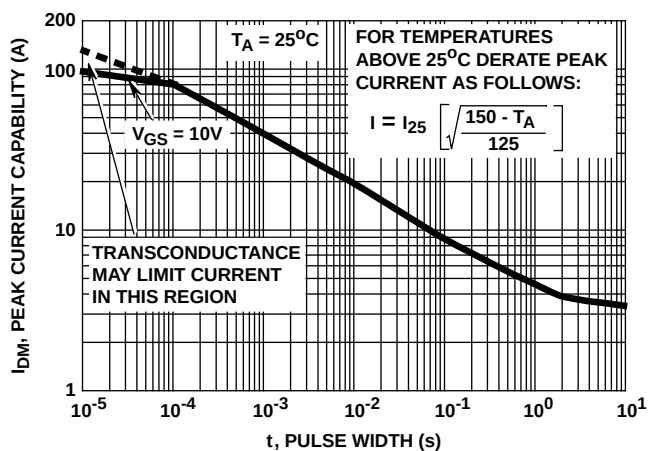
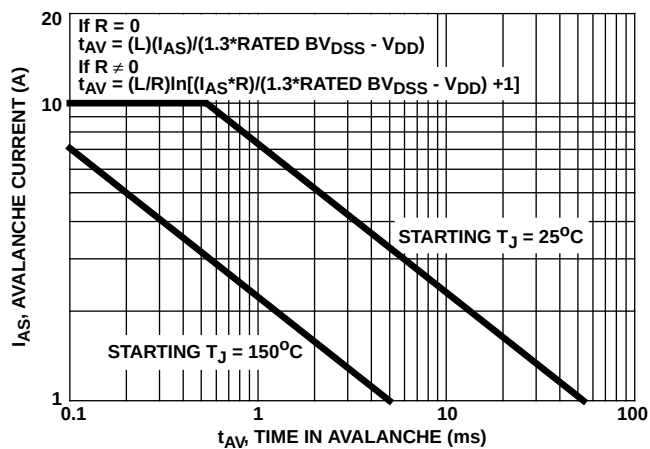


FIGURE 5. PEAK CURRENT CAPABILITY



NOTE: Refer to Harris Application Notes AN9321 and AN9322.

FIGURE 6. UNCLAMPED INDUCTIVE SWITCHING CAPABILITY

# Typical Performance Curves (Continued)

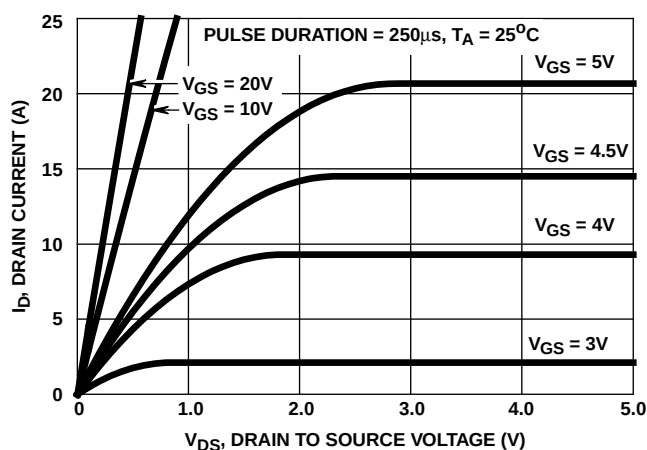


FIGURE 7. SATURATION CHARACTERISTICS

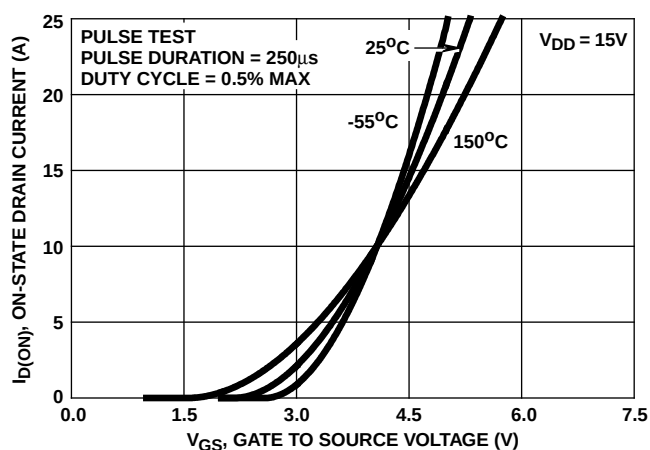


FIGURE 8. TRANSFER CHARACTERISTICS

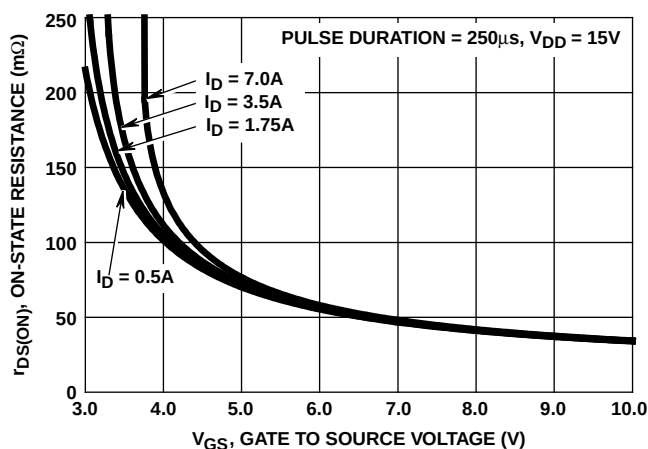
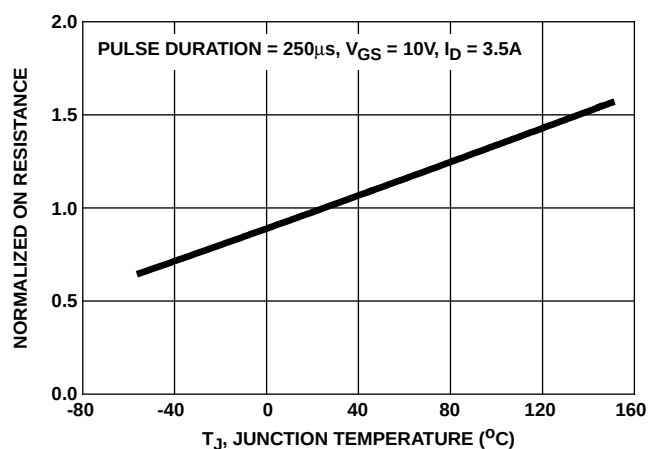
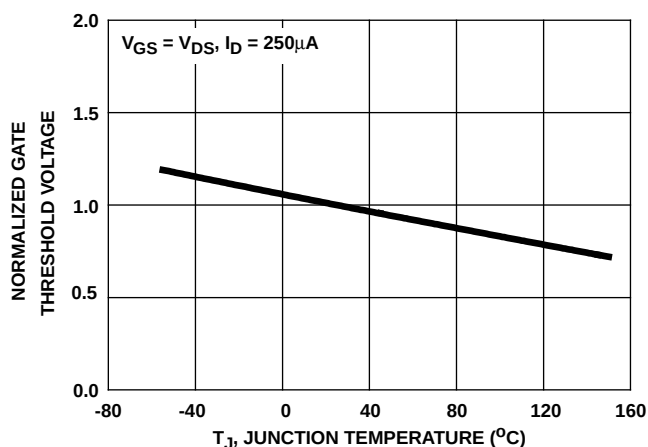
FIGURE 9.  $r_{DS(ON)}$  FOR VARYING CONDITIONS OF GATE VOLTAGE AND DRAIN CURRENTFIGURE 10. NORMALIZED  $r_{DS(ON)}$  vs JUNCTION TEMPERATURE

FIGURE 11. NORMALIZED GATE THRESHOLD VOLTAGE vs JUNCTION TEMPERATURE

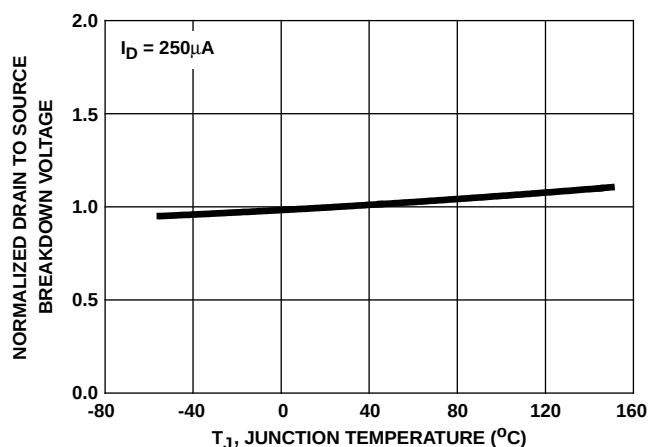


FIGURE 12. NORMALIZED DRAIN TO SOURCE BREAKDOWN VOLTAGE vs JUNCTION TEMPERATURE

# Typical Performance Curves (Continued)

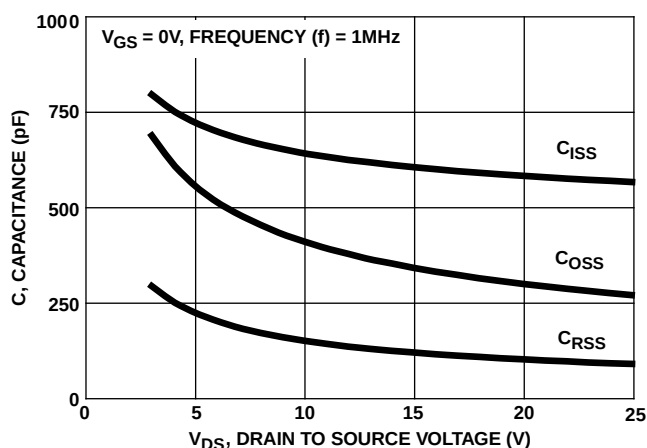
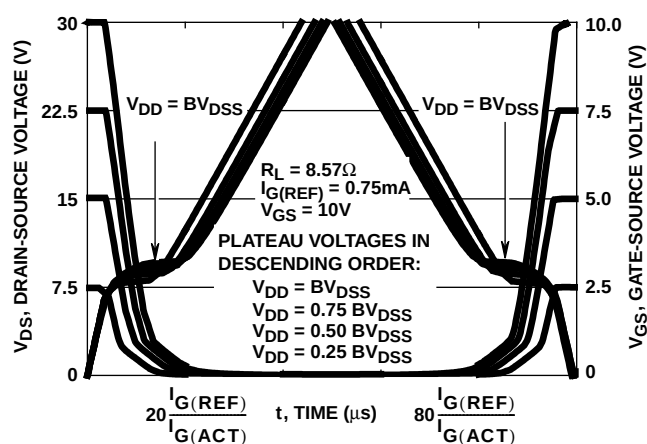


FIGURE 13. CAPACITANCE vs VOLTAGE



NOTE: Refer to Harris Application Notes AN7254 and AN7260.

FIGURE 14. NORMALIZED SWITCHING WAVEFORMS FOR CONSTANT GATE CURRENT

## Test Circuits and Waveforms

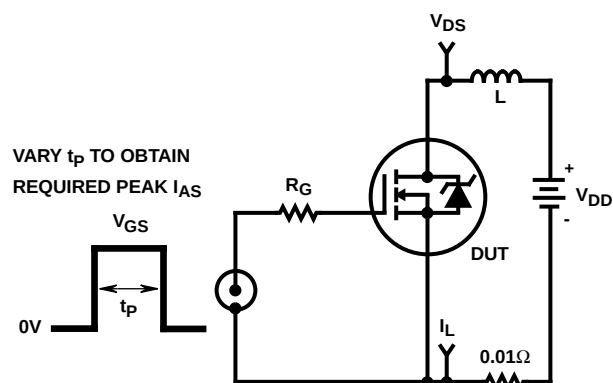


FIGURE 15. UNCLAMPED ENERGY TEST CIRCUIT

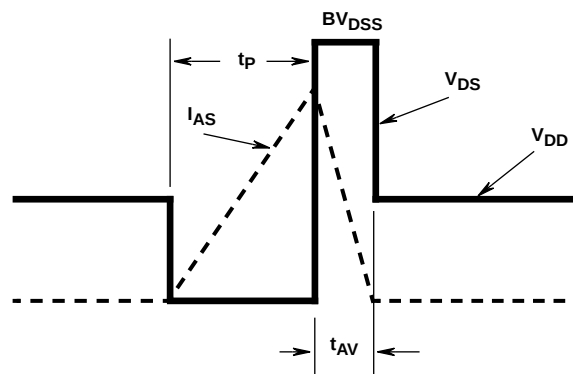


FIGURE 16. UNCLAMPED ENERGY WAVEFORMS

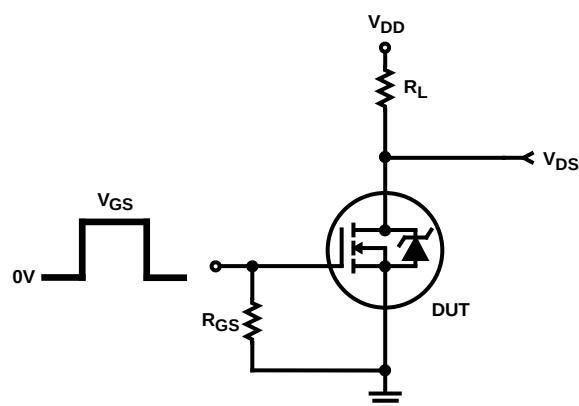


FIGURE 17. RESISTIVE SWITCHING TEST CIRCUIT

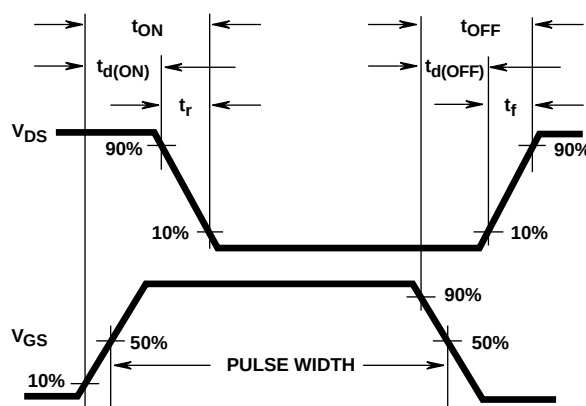


FIGURE 18. RESISTIVE SWITCHING WAVEFORMS

## Soldering Precautions

The soldering process creates a considerable thermal stress on any semiconductor component. The melting temperature of solder is higher than the maximum rated temperature of the device. The amount of time the device is heated to a high temperature should be minimized to assure device reliability. Therefore, the following precautions should always be observed in order to minimize the thermal stress to which the devices are subjected.

1. Always preheat the device.
2. The delta temperature between the preheat and soldering should always be less than 100°C. Failure to preheat the device can result in excessive thermal stress which can damage the device.
3. The maximum temperature gradient should be less than 5°C per second when changing from preheating to soldering.
4. The peak temperature in the soldering process should be at least 30°C higher than the melting point of the solder chosen.
5. The maximum soldering temperature and time must not exceed 260°C for 10 seconds on the leads and case of the device.
6. After soldering is complete, the device should be allowed to cool naturally for at least three minutes, as forced cooling will increase the temperature gradient and may result in latent failure due to mechanical stress.
7. During cooling, mechanical stress or shock should be avoided.

**Temperature Compensated PSPICE Model for the RF1K49086**

SUBCKT RF1K49086 2 1 3; rev 12/15/94

CA 12 8 1.75e-9  
 CB 15 14 1.80e-9  
 CIN 6 8 1.20e-9

DBODY 7 5 DBDMOD  
 DBREAK 5 11 DBKMOD  
 DPLCAP 10 5 DPLCAPMOD

EBREAK 11 7 17 18 33.29  
 EDS 14 8 5 8 1  
 EGS 13 8 6 8 1  
 ESG 6 10 6 8 1  
 EVTO 20 6 18 8 1

IT 8 17 1

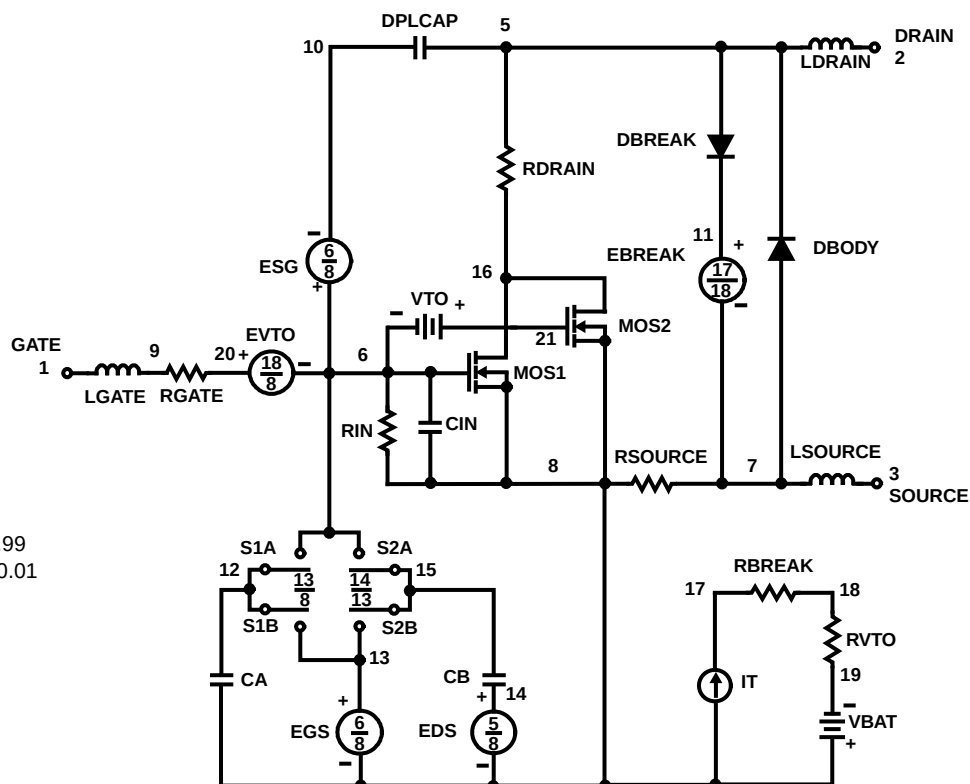
LDRAIN 2 5 1e-9  
 LGATE 1 9 1.233e-9  
 LSOURCE 3 7 0.452e-9

MOS1 16 6 8 8 MOSMOD M = 0.99  
 MOS2 16 21 8 8 MOSMOD M = 0.01

RBREAK 17 18 RBKMOD 1  
 RDRAIN 5 16 RDSMOD 1e-4  
 RGATE 9 20 1.83  
 RIN 6 8 1e9  
 RSOURCE 8 7 RDSMOD 13.5e-3  
 RVTO 18 19 RVTOMOD 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 8 19 DC 1  
 VTO 21 6 0.1



.MODEL DBDMOD D (IS = 2.50e-13 RS = 1.35e-2 TRS1 = 4.31e-5 TRS2 = 2.15e-5 CJO = 9.33e-10 TT = 2.08e-8)  
 .MODEL DBKMOD D (RS = 1.14 TRS1 = 2.23e-3 TRS2 = -8.91e-6)  
 .MODEL DPLCAPMOD D (CJO = 7.99e-10 IS = 1e-30 N = 10)  
 .MODEL MOSMOD NMOS (VTO = 2.15 KP = 6.25 IS = 1e-30 N = 10 TOX = 1 L = 1u W = 1u)  
 .MODEL RBKMOD RES (TC1 = 7.74e-4 TC2 = 1.13e-6)  
 .MODEL RDSMOD RES (TC1 = 4.5e-3 TC2 = -7.45e-7)  
 .MODEL RVTOMOD RES (TC1 = -4.16e-3 TC2 = 2.16e-6)  
 .MODEL S1AMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = -7.15 VOFF = -5.15)  
 .MODEL S1BMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = -5.15 VOFF = -7.15)  
 .MODEL S2AMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = -2.6 VOFF = 2.4)  
 .MODEL S2BMOD VSWITCH (RON = 1e-5 ROFF = 0.1 VON = 2.4 VOFF = -2.6)

.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.