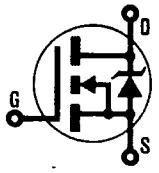
INTERNATIONAL RECTIFIER IOR

# REPETITIVE AVALANCHE AND dv/dt RATED*

# HEXFET® TRANSISTORS




## N-CHANNEL

**IRF720**
**IRF721**
**IRF722**
**IRF723**

TO-220

### 400 Volt, 1.8 Ohm HEXFET
### TO-220AB Plastic Package

The HEXFET® technology is the key to International Rectifier's advanced line of power MOSFET transistors. The efficient geometry and unique processing of this latest "State of the Art" design achieves: very low on-state resistance combined with high transconductance; superior reverse energy and diode recovery dv/dt capability.

The HEXFET transistors also feature all of the well established advantages of MOSFETs such as voltage control, very fast switching, ease of paralleling and temperature stability of the electrical parameters.

They are well suited for applications such as switching power supplies, motor controls, inverters, choppers, audio amplifiers and high energy pulse circuits.

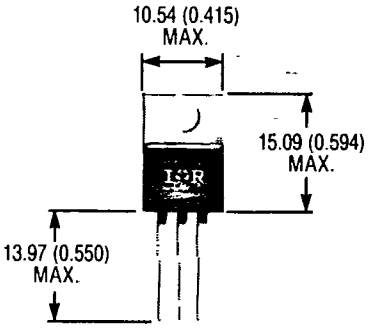
### Product Summary

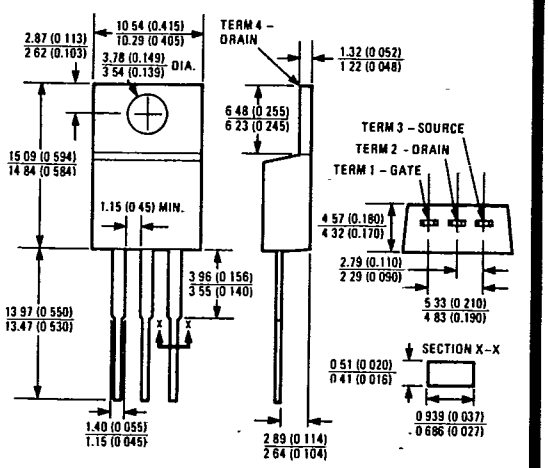
| Part Number | $BV_{DSS}$ | $R_{DS(on)}$ | $I_D$ |
|---|---|---|---|
| IRF720 | 400V | 1.8Ω | 3.3A |
| IRF721 | 350V | 1.8Ω | 3.3A |
| IRF722 | 400V | 2.5Ω | 2.8A |
| IRF723 | 350V | 2.5Ω | 2.8A |

### FEATURES:

- Repetitive Avalanche Ratings
- Dynamic dv/dt Rating
- Simple Drive Requirements
- Ease of Paralleling

### CASE STYLE AND DIMENSIONS




**Case Style TO-220AB**
Dimensions in Millimeters and (Inches)

*This data sheet applies to product with batch codes that begin with a digit, ie. 2A3B

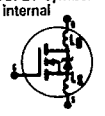
## Absolute Maximum Ratings

| Parameter | | IRF720, IRF721 | IRF722, IRF723 | Units |
|---|---|---|---|---|
| $I_D$ @ $T_C$ = 25°C | Continuous Drain Current | 3.3 | 2.8 | A |
| $I_D$ @ $T_C$ = 100°C | Continuous Drain Current | 2.1 | 1.8 | A |
| $I_{DM}$ | Pulsed Drain Current ① | 13 | 11 | A |
| $P_D$ @ $T_C$ = 25°C | Max. Power Dissipation | 50 | | W |
| | Linear Derating Factor | 0.40 | | W/K ⑤ |
| $V_{GS}$ | Gate-to-Source Voltage | ±20 | | V |
| $E_{AS}$ | Single Pulse Avalanche Energy ② | 190 (See Fig. 14) | | mJ |
| $I_{AR}$ | Avalanche Current ① (Repetitive or Non-Repetitive) | 3.3 (See $E_{AR}$) | | A |
| $E_{AR}$ | Repetitive Avalanche Energy ① | 5.0 (See $I_{AR}$) | | mJ |
| dv/dt | Peak Diode Recovery dv/dt ③ | 4.0 (See Fig. 17) | | V/ns |
| $T_J$<br>$T_{STG}$ | Operating Junction<br>Storage Temperature Range | −55 to 150 | | °C |
| | Lead Temperature | 300 (0.063 in. (1.6mm) from case for 10s) | | °C |

## Electrical Characteristics @ $T_J$ = 25°C (Unless Otherwise Specified)

| Parameter | | Type | Min. | Typ. | Max. | Units | Test Conditions |
|---|---|---|---|---|---|---|---|
| $BV_{DSS}$ | Drain-to-Source Breakdown Voltage | IRF720 IRF722 | 400 | — | — | V | $V_{GS}$ = 0V, $I_D$ = 250 μA |
| | | IRF721 IRF723 | 350 | | | | |
| $R_{DS(on)}$ | Static Drain-to-Source On-State Resistance ④ | IRF720 IRF721 | — | 1.6 | 1.8 | Ω | $V_{GS}$ = 10V, $I_D$ = 1.8A |
| | | IRF722 IRF723 | — | 1.8 | 2.5 | | |
| $I_{D(on)}$ | On-State Drain Current ④ | IRF720 IRF721 | 3.3 | — | — | A | $V_{DS}$ > $I_{D(on)}$ X $R_{DS(on)}$ Max.<br>$V_{GS}$ = 10V |
| | | IRF722 IRF723 | 2.8 | | | | |
| $V_{GS(th)}$ | Gate Threshold Voltage | ALL | 2.0 | — | 4.0 | V | $V_{DS}$ = $V_{GS}$, $I_D$ = 250μA |
| $g_{fs}$ | Forward Transconductance ④ | ALL | 1.8 | 2.7 | — | S (℧) | $I_{DS}$ = 1.8A, $V_{DS}$ ≥ 50V |
| $I_{DSS}$ | Zero Gate Voltage Drain Current | ALL | — | — | 250 | μA | $V_{DS}$ = Max. Rating, $V_{GS}$ = 0V |
| | | | — | — | 1000 | | $V_{DS}$ = 0.8 x Max. Rating<br>$V_{GS}$ = 0V, $T_J$ = 125°C |
| $I_{GSS}$ | Gate-to-Source Leakage Forward | ALL | — | — | 500 | nA | $V_{GS}$ = 20V |
| $I_{GSS}$ | Gate-to-Source Leakage Reverse | ALL | — | — | −500 | nA | $V_{GS}$ = −20V |
| $Q_g$ | Total Gate Charge | ALL | — | 13 | 20 | nC | $V_{GS}$ = 10V, $I_D$ = 3.3A |
| $Q_{gs}$ | Gate-to-Source Charge | ALL | — | 2.2 | 3.3 | nC | $V_{DS}$ = 0.8 x Max. Rating<br>See Fig. 16 |
| $Q_{gd}$ | Gate-to-Drain ("Miller") Charge | | — | 7.2 | 11 | nC | (Independent of operating temperature) |
| $t_{d(on)}$ | Turn-On Delay Time | ALL | — | 10 | 15 | ns | $V_{DD}$ = 200V, $I_D$ ≈ 3.3A, $R_G$ = 18Ω |
| $t_r$ | Rise Time | ALL | — | 14 | 21 | ns | $R_D$ = 56Ω |
| $t_{d(off)}$ | Turn-Off Delay Time | ALL | — | 30 | 45 | ns | See Fig. 15 |
| $t_f$ | Fall Time | ALL | — | 13 | 20 | ns | (Independent of operating temperature) |
| $L_D$ | Internal Drain Inductance | ALL | — | 4.5 | — | nH | Measured from the drain lead, 6mm (0.25 in.) from package to center of die. |
| $L_S$ | Internal Source Inductance | ALL | — | 7.5 | — | nH | Measured from the source lead, 6mm (0.25 in.) from package to source bonding pad. |
| $C_{iss}$ | Input Capacitance | ALL | — | 350 | — | pF | $V_{GS}$ = 0V, $V_{DS}$ = 25V |
| $C_{oss}$ | Output Capacitance | ALL | — | 64 | — | pF | f = 1.0 MHz |
| $C_{rss}$ | Reverse Transfer Capacitance | ALL | — | 8.1 | — | pF | See Fig. 10 |

Modified MOSFET symbol showing the internal inductances.



## Source-Drain Diode Ratings and Characteristics

| | Parameter | Type | Min. | Typ. | Max. | Units | Test Conditions |
|---|---|---|---|---|---|---|---|
| $I_S$ | Continuous Source Current (Body Diode) | ALL | – | – | 3.3 | A | Modified MOSFET symbol showing the integral Reverse p-n junction rectifier.  |
| $I_{SM}$ | Pulsed Source Current (Body Diode) ① | ALL | – | – | 13 | A | |
| $V_{SD}$ | Diode Forward Voltage ④ | ALL | – | – | 1.6 | V | $T_J$ = 25°C, $I_S$ = 3.3A, $V_{GS}$ = 0V |
| $t_{rr}$ | Reverse Recovery Time | ALL | 120 | 270 | 600 | ns | $T_J$ = 25°C, $I_F$ = 3.3A, di/dt = 100 A/μs |
| $Q_{RR}$ | Reverse Recovery Charge | ALL | 0.64 | 1.4 | 3.0 | μC | |
| $t_{on}$ | Forward Turn-On Time | ALL | Intrinsic turn-on time is negligible. Turn-on speed is substantially controlled by $L_S$ + $L_D$. | | | | |

## Thermal Resistance

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $R_{thJC}$ | Junction-to-Case | ALL | – | – | 2.5 | K/W ⑤ | |
| $R_{thCS}$ | Case-to-Sink | ALL | – | 0.50 | – | K/W ⑤ | Mounting surface flat, smooth, and greased |
| $R_{thJA}$ | Junction-to-Ambient | ALL | – | – | 80 | K/W ⑤ | Typical socket mount |

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## Typical SPICE Computer Model Parameters (For More Information See Application Note AN-975)

| Device | Level, SPICE MOSFET Model | W (m), Channel Width | L (μm), Channel Length | Theta (1/V), Mobility Modulation | UO ($CM^2$/V-S), Surface Mobility | VTO (V), Threshold Voltage | R1 (Ω), Drain Resistance | R2 (Ω), Source Resistance | RG (Ω), Gate Resistance |
|---|---|---|---|---|---|---|---|---|---|
| ALL | 3 | 0.279 | 1.2 | 0.30 | 450 | 4.00 | 1.4 | 0.02 | 1.5 |

| CGSO (pf), Gate-Source Capacitance | CGD (F) Gate-Drain Capacitance | E1 (V), Voltage Dependent Voltage Source | LD (nH), Drain Inductance | LS (nH), Source Inductance | LG (nH), Gate Inductance | IS (A), Diode Saturation Current | RS (Ω), Diode Bulk Resistance |
|---|---|---|---|---|---|---|---|
| 770 | C6 | 2 + 0.995 VDG | 4.5 | 7.5 | 7.5 | $3.6 \times 10^{-13}$ | 0.026 |

C6 = 1500 pf + $1.8 \times 10^{-22}$ $(V_{GE})^{48}$

① Repetitive Rating; Pulse width limited by maximum junction temperature (see figure 5) Refer to current HEXFET reliability report

② @ $V_{DD}$ = 50V, Starting $T_J$ = 25°C, L = 31 mH, $R_G$ = 25Ω, Peak $I_L$ = 3.3A.

③ $I_{SD}$ ≤ 3.3A, di/dt ≤ 65A/μs, $V_{DD}$ ≤ $BV_{DSS}$, $T_J$ ≤ 150°C Suggested $R_G$ = 18Ω

④ Pulse width ≤ 300 μs; Duty Cycle ≤ 2%

⑤ K/W = °C/W W/K = W/°C

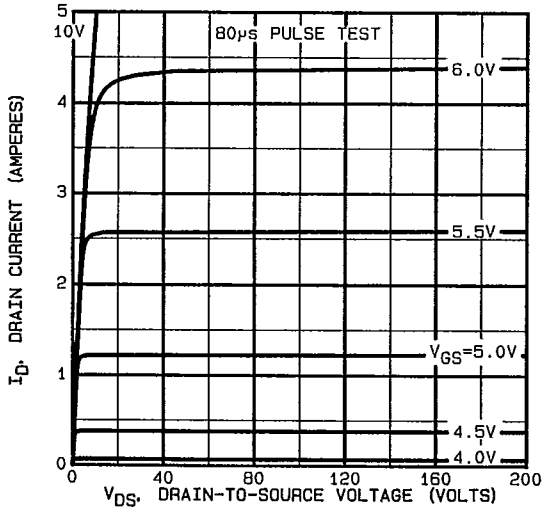


Fig. 1 — Typical Output Characteristics

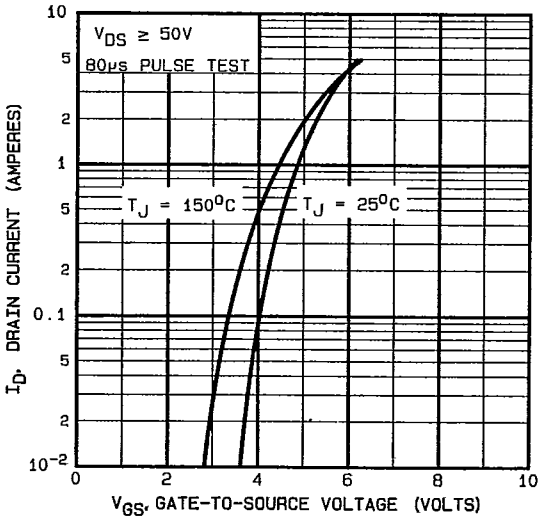


Fig. 2 — Typical Transfer Characteristics

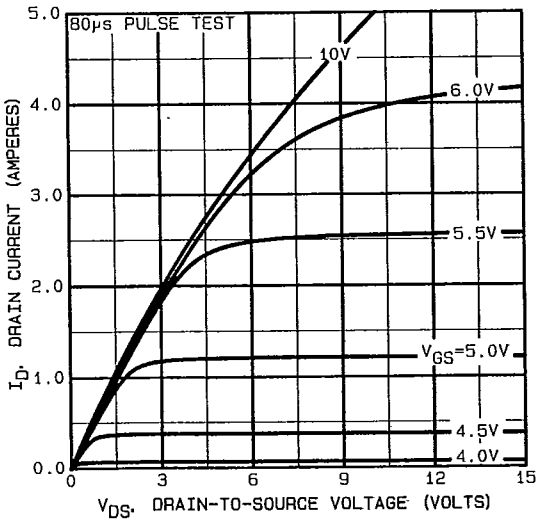


Fig. 3 — Typical Saturation Characteristics

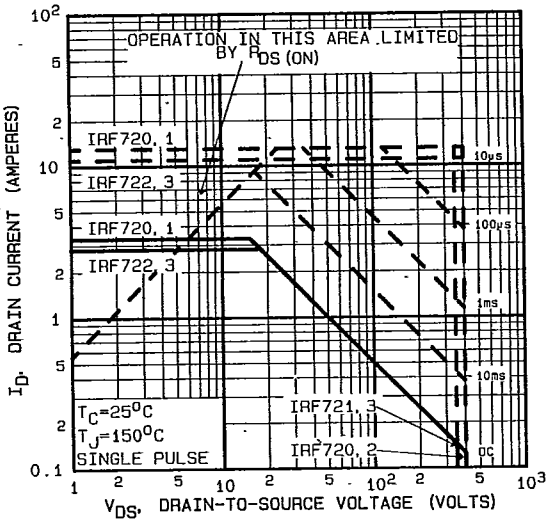


Fig. 4 — Maximum Safe Operating Area

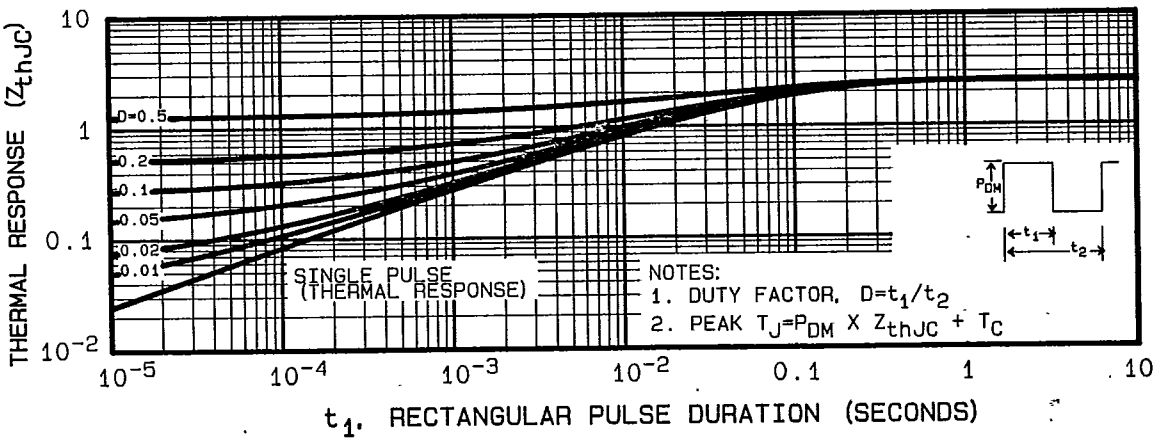


Fig. 5 — Maximum Effective Transient Thermal Impedance, Junction-to-Case Vs. Pulse Duration

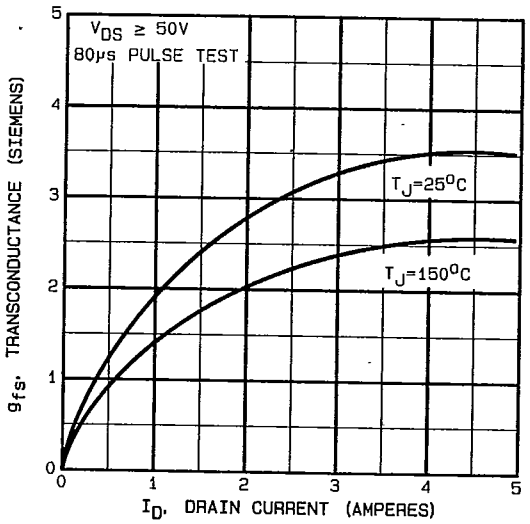


Fig. 6 — Typical Transconductance Vs. Drain Current

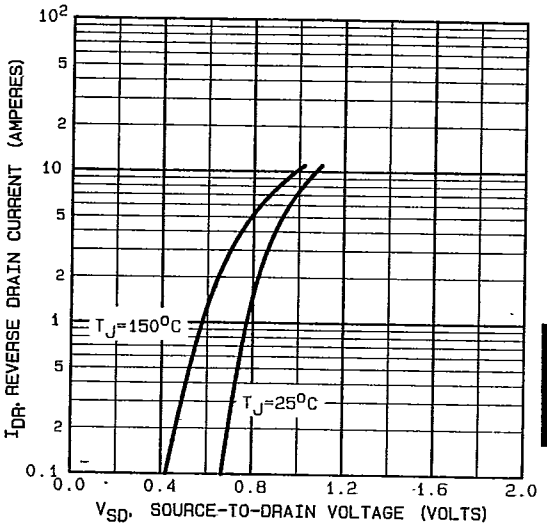


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Fig. 7 — Typical Source-Drain Diode Forward Voltage

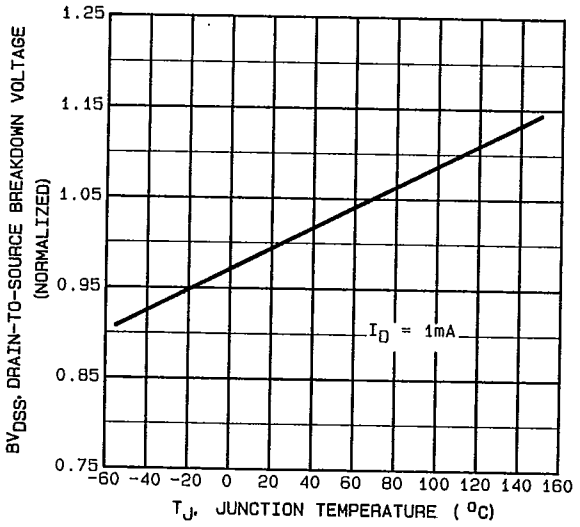


Fig. 8 — Breakdown Voltage Vs. Temperature

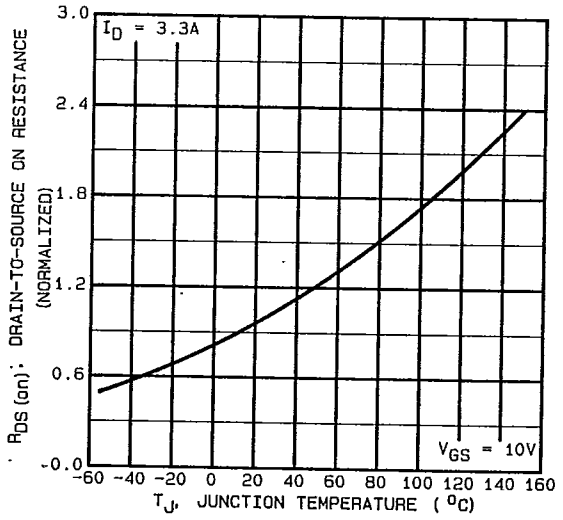


Fig 9 — Normalized On-Resistance Vs. Temperature

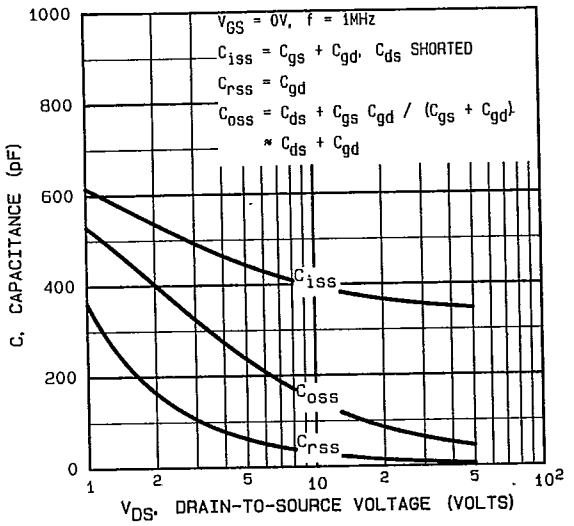


Fig. 10 — Typical Capacitance Vs. Drain-to-Source Voltage

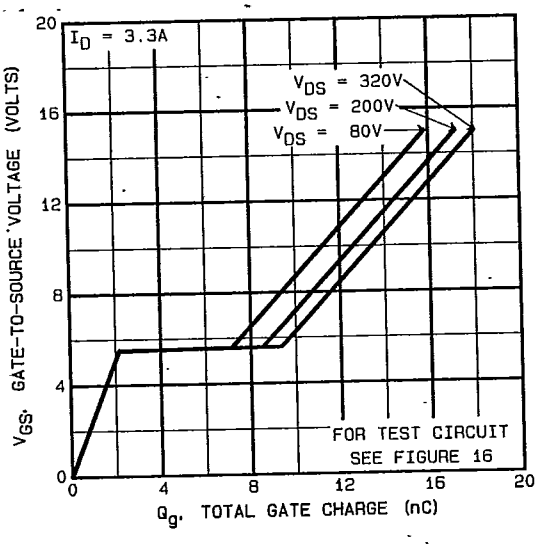


Fig. 11 — Typical Gate Charge Vs. Gate-to-Source Voltage

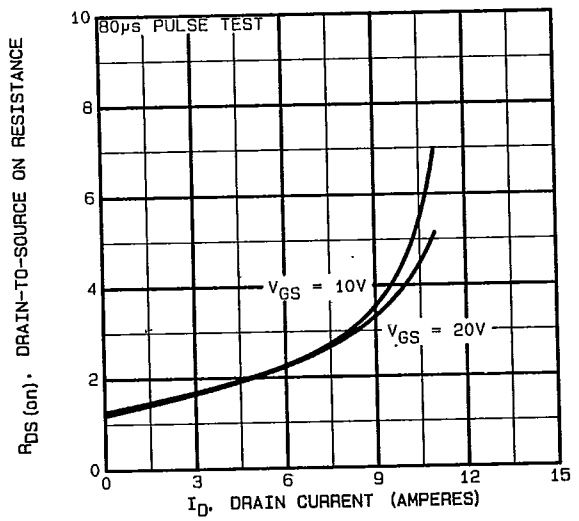


Fig. 12 — Typical On-Resistance Vs. Drain Current

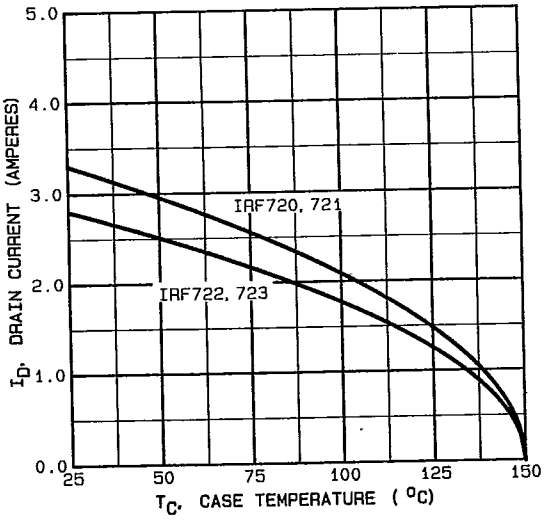


Fig. 13 — Maximum Drain Current Vs. Case Temperature

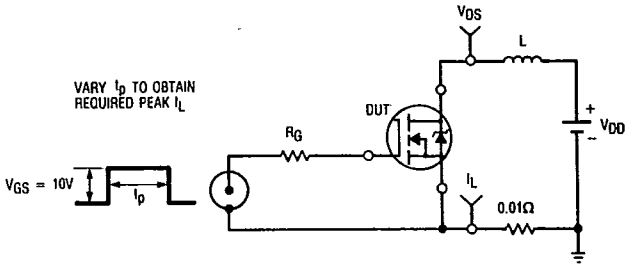


Fig. 14a — Unclamped Inductive Test Circuit

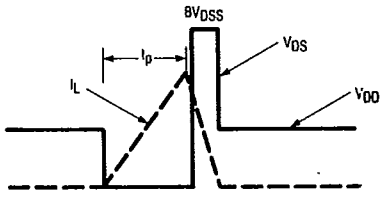


Fig. 14b — Unclamped Inductive Waveforms

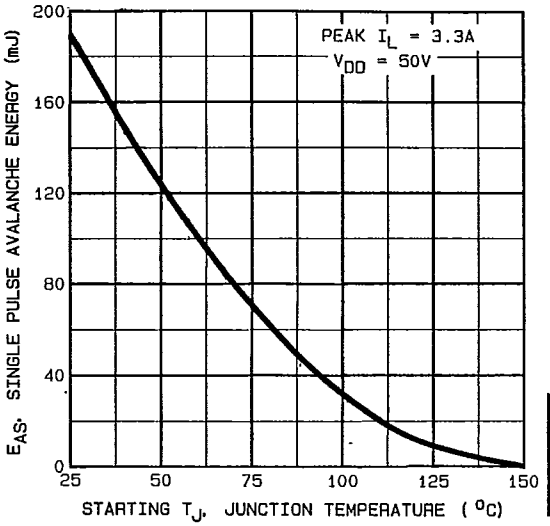


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Fig. 14c — Maximum Avalanche Energy Vs. Starting Junction Temperature

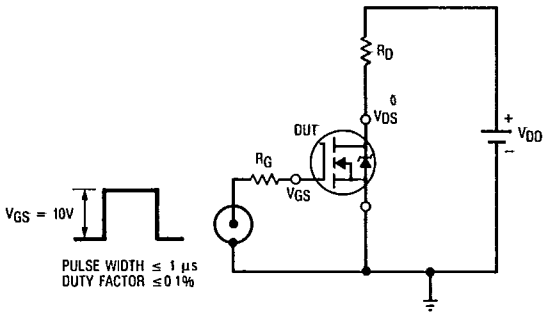


Fig. 15a — Switching Time Test Circuit

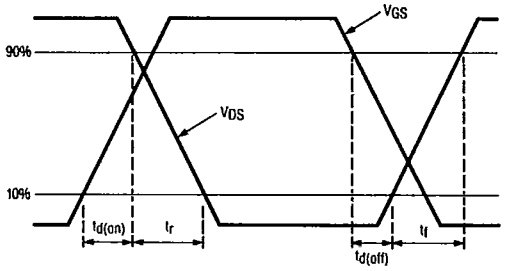


Fig. 15b — Switching Time Waveforms

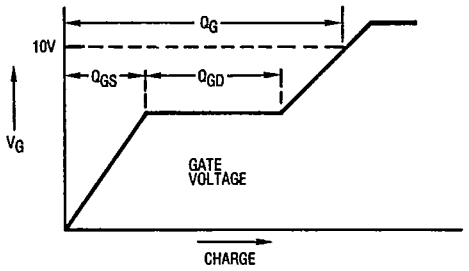


Fig. 16a — Basic Gate Charge Waveform

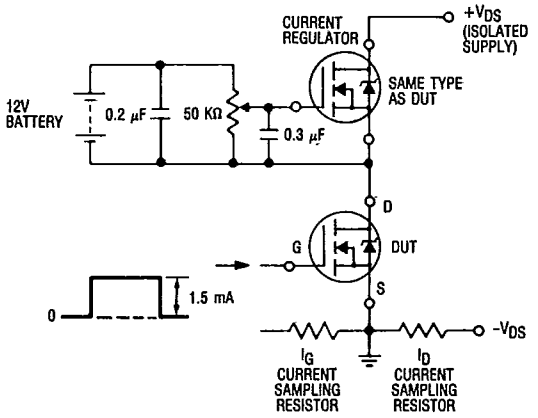


Fig. 16b — Gate Charge Test Circuit

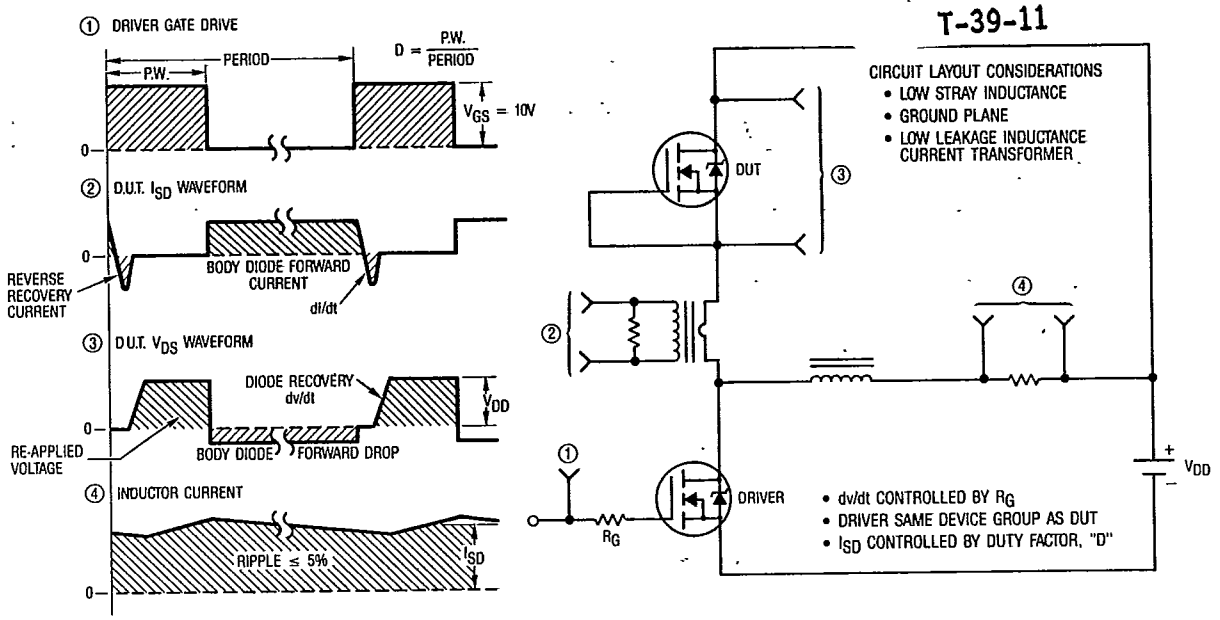


**Fig. 17 — Peak Diode Recovery dv/dt Test Circuit**

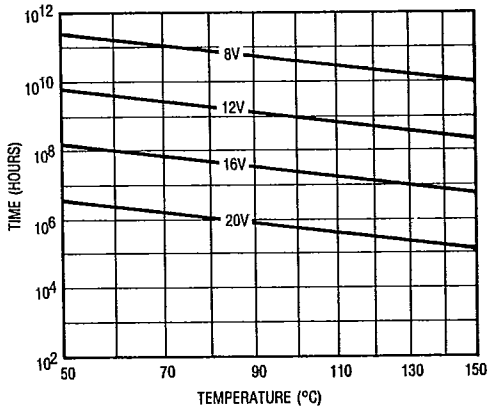


***Fig. 18 — Typical Time to Accumulated 1% Gate Failure**

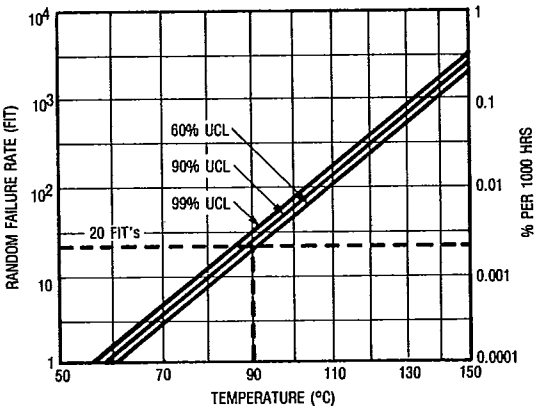


***Fig. 19 — Typical High Temperature Reverse Bias (HTRB) Failure Rate**

*The data shown is correct as of April 15, 1987. This information is updated on a quarterly basis; for the latest reliability data, please contact your local IR field office.