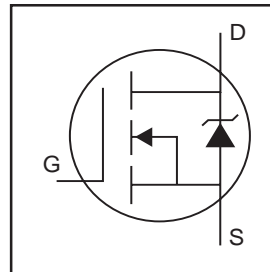**AUTOMOTIVE MOSFET**

# IRFR120ZPbF
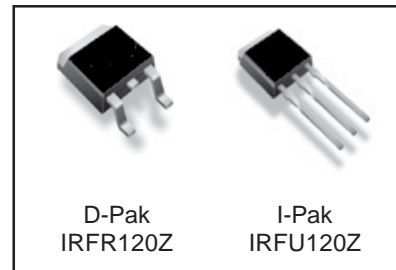# IRFU120ZPbF

HEXFET® Power MOSFET

## Features
- Advanced Process Technology
- Ultra Low On-Resistance
- 175°C Operating Temperature
- Fast Switching
- Repetitive Avalanche Allowed up to Tjmax
- Lead-Free



$V_{DSS} = 100V$

$R_{DS(on)} = 190m\Omega$

$I_D = 8.7A$

## Description
Specifically designed for Automotive applications, this HEXFET® Power MOSFET utilizes the latest processing techniques to achieve extremely low on-resistance per silicon area. Additional features of this design are a 175°C junction operating temperature, fast switching speed and improved repetitive avalanche rating . These features combine to make this design an extremely efficient and reliable device for use in Automotive applications and a wide variety of other applications.



| D-Pak | I-Pak |
| IRFR120Z | IRFU120Z |

## Absolute Maximum Ratings

| | Parameter | Max. | Units |
|---|---|---|---|
| $I_D$ @ $T_C$ = 25°C | Continuous Drain Current, $V_{GS}$ @ 10V (Silicon Limited) | 8.7 | A |
| $I_D$ @ $T_C$ = 100°C | Continuous Drain Current, $V_{GS}$ @ 10V | 6.1 | |
| $I_{DM}$ | Pulsed Drain Current ① | 35 | |
| $P_D$ @$T_C$ = 25°C | Power Dissipation | 35 | W |
| | Linear Derating Factor | 0.23 | W/°C |
| $V_{GS}$ | Gate-to-Source Voltage | ± 20 | V |
| $E_{AS\,(Thermally\,limited)}$ | Single Pulse Avalanche Energy② | 18 | mJ |
| $E_{AS}$ (Tested ) | Single Pulse Avalanche Energy Tested Value ⑥ | 20 | |
| $I_{AR}$ | Avalanche Current ① | See Fig.12a, 12b, 15, 16 | A |
| $E_{AR}$ | Repetitive Avalanche Energy ⑤ | | mJ |
| $T_J$ | Operating Junction and | -55 to + 175 | |
| $T_{STG}$ | Storage Temperature Range | | °C |
| | Soldering Temperature, for 10 seconds | 300 (1.6mm from case ) | |
| | Mounting Torque, 6-32 or M3 screw | 10 lbf•in (1.1N•m) | |

## Thermal Resistance

| | Parameter | Typ. | Max. | Units |
|---|---|---|---|---|
| $R_{\theta JC}$ | Junction-to-Case | —— | 4.28 | °C/W |
| $R_{\theta JA}$ | Junction-to-Ambient (PCB mount) ⑦ | —— | 40 | |
| $R_{\theta JA}$ | Junction-to-Ambient | —— | 110 | |

# IRFR/U120ZPbF

**Electrical Characteristics @ T$_J$ = 25°C (unless otherwise specified)**

| | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| V$_{(BR)DSS}$ | Drain-to-Source Breakdown Voltage | 100 | —— | —— | V | V$_{GS}$ = 0V, I$_D$ = 250µA |
| ΔV$_{(BR)DSS}$/ΔT$_J$ | Breakdown Voltage Temp. Coefficient | —— | 0.084 | —— | V/°C | Reference to 25°C, I$_D$ = 1mA |
| R$_{DS(on)}$ | Static Drain-to-Source On-Resistance | —— | 150 | 190 | mΩ | V$_{GS}$ = 10V, I$_D$ = 5.2A ③ |
| V$_{GS(th)}$ | Gate Threshold Voltage | 2.0 | —— | 4.0 | V | V$_{DS}$ = V$_{GS}$, I$_D$ = 250µA |
| gfs | Forward Transconductance | 16 | —— | —— | S | V$_{DS}$ = 25V, I$_D$ = 5.2A |
| I$_{DSS}$ | Drain-to-Source Leakage Current | —— | —— | 20 | µA | V$_{DS}$ = 100V, V$_{GS}$ = 0V |
| | | —— | —— | 250 | | V$_{DS}$ = 100V, V$_{GS}$ = 0V, T$_J$ = 125°C |
| I$_{GSS}$ | Gate-to-Source Forward Leakage | —— | —— | 200 | nA | V$_{GS}$ = 20V |
| | Gate-to-Source Reverse Leakage | —— | —— | -200 | | V$_{GS}$ = -20V |
| Q$_g$ | Total Gate Charge | —— | 6.9 | 10 | | I$_D$ = 5.2A |
| Q$_{gs}$ | Gate-to-Source Charge | —— | 1.6 | —— | nC | V$_{DS}$ = 80V |
| Q$_{gd}$ | Gate-to-Drain ("Miller") Charge | —— | 3.1 | —— | | V$_{GS}$ = 10V ③ |
| t$_{d(on)}$ | Turn-On Delay Time | —— | 8.3 | —— | | V$_{DD}$ = 50V |
| t$_r$ | Rise Time | —— | 26 | —— | | I$_D$ = 5.2A |
| t$_{d(off)}$ | Turn-Off Delay Time | —— | 27 | —— | ns | R$_G$ = 53 Ω |
| t$_f$ | Fall Time | —— | 23 | —— | | V$_{GS}$ = 10V ③ |
| L$_D$ | Internal Drain Inductance | —— | 4.5 | —— | | Between lead, |
| | | | | | nH | 6mm (0.25in.) |
| L$_S$ | Internal Source Inductance | —— | 7.5 | —— | | from package |
| | | | | | | and center of die contact |
| C$_{iss}$ | Input Capacitance | —— | 310 | —— | | V$_{GS}$ = 0V |
| C$_{oss}$ | Output Capacitance | —— | 41 | —— | | V$_{DS}$ = 25V |
| C$_{rss}$ | Reverse Transfer Capacitance | —— | 24 | —— | pF | $f$ = 1.0MHz |
| C$_{oss}$ | Output Capacitance | —— | 150 | —— | | V$_{GS}$ = 0V, V$_{DS}$ = 1.0V, $f$ = 1.0MHz |
| C$_{oss}$ | Output Capacitance | —— | 26 | —— | | V$_{GS}$ = 0V, V$_{DS}$ = 80V, $f$ = 1.0MHz |
| C$_{oss}$ eff. | Effective Output Capacitance | —— | 57 | —— | | V$_{GS}$ = 0V, V$_{DS}$ = 0V to 80V ④ |

**Source-Drain Ratings and Characteristics**

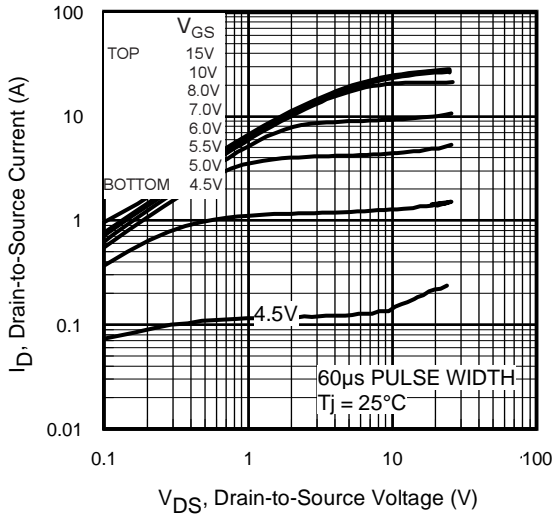| | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| I$_S$ | Continuous Source Current (Body Diode) | —— | —— | 8.7 | A | MOSFET symbol showing the |
| I$_{SM}$ | Pulsed Source Current (Body Diode) ① | —— | —— | 35 | | integral reverse p-n junction diode. |
| V$_{SD}$ | Diode Forward Voltage | —— | —— | 1.3 | V | T$_J$ = 25°C, I$_S$ = 5.2A, V$_{GS}$ = 0V ③ |
| t$_{rr}$ | Reverse Recovery Time | —— | 24 | 36 | ns | T$_J$ = 25°C, I$_F$ = 5.2A, V$_{DD}$ = 50V |
| Q$_{rr}$ | Reverse Recovery Charge | —— | 23 | 35 | nC | di/dt = 100A/µs ③ |
| t$_{on}$ | Forward Turn-On Time | Intrinsic turn-on time is negligible (turn-on is dominated by LS+LD) | | | | |

**Fig 1.** Typical Output Characteristics
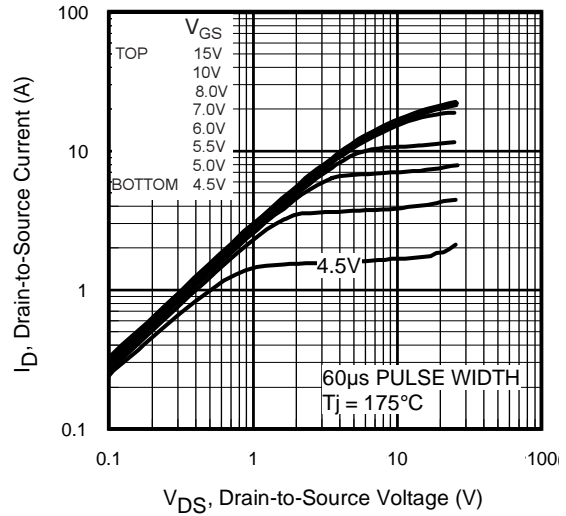


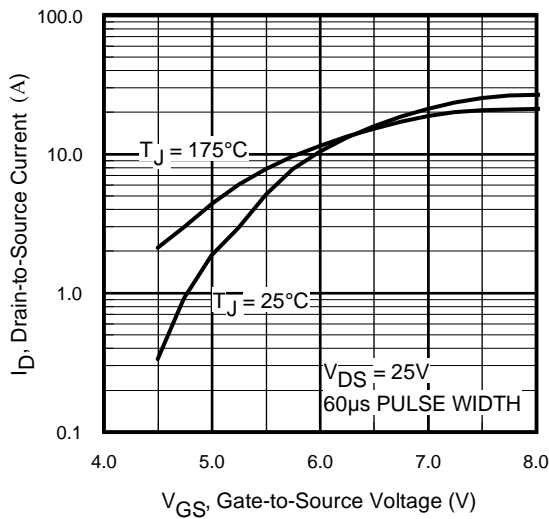**Fig 2.** Typical Output Characteristics



**Fig 3.** Typical Transfer Characteristics
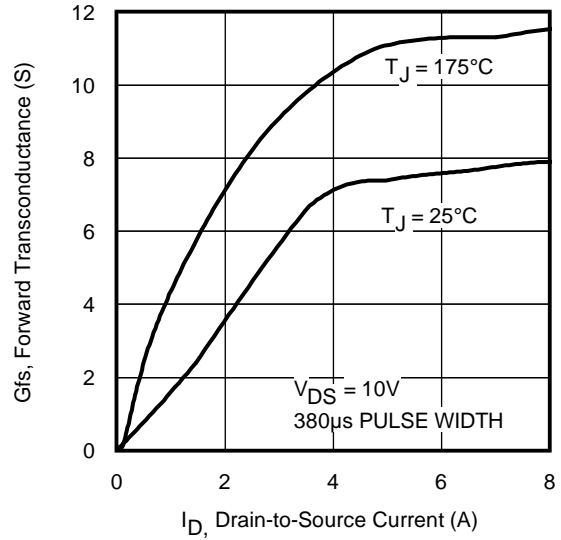


**Fig 4.** Typical Forward Transconductance Vs. Drain Current

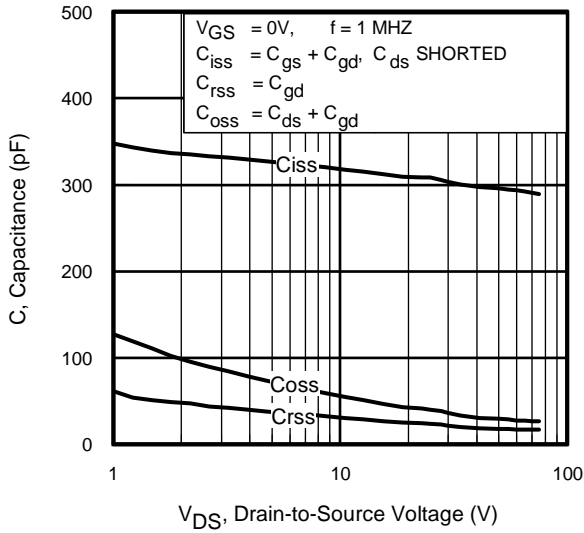# IRFR/U120ZPbF



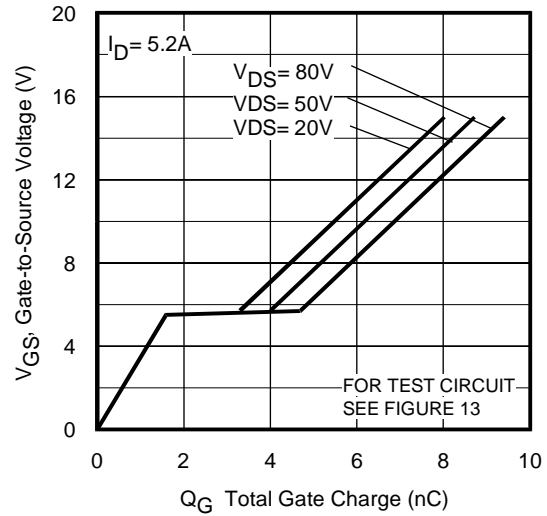**Fig 5.** Typical Capacitance Vs. Drain-to-Source Voltage



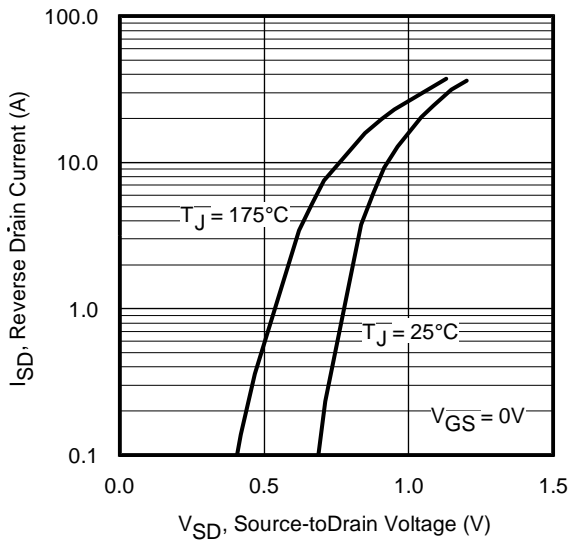**Fig 6.** Typical Gate Charge Vs. Gate-to-Source Voltage



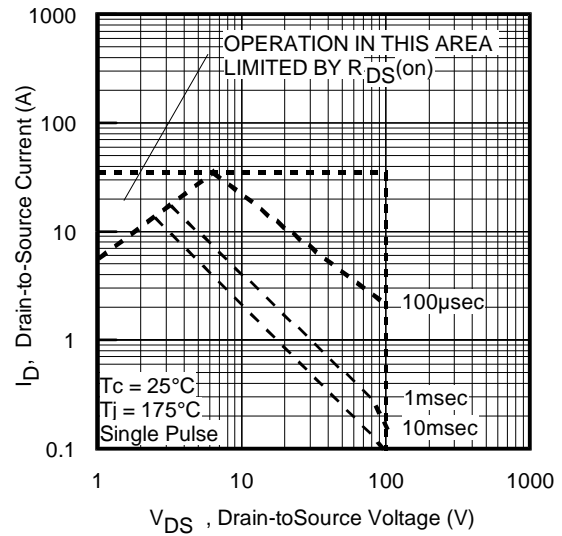**Fig 7.** Typical Source-Drain Diode Forward Voltage
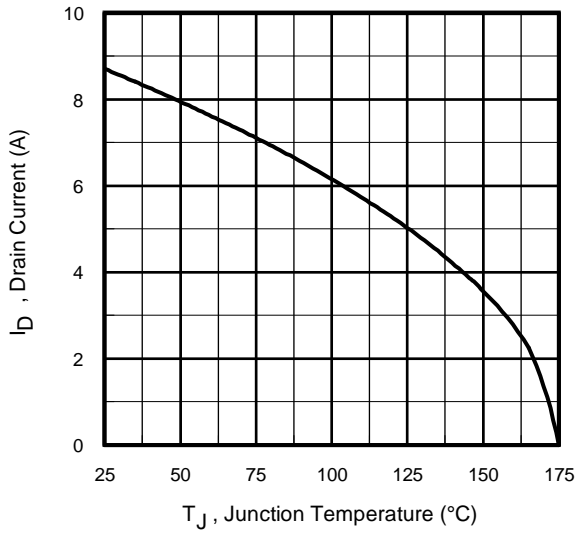


**Fig 8.** Maximum Safe Operating Area
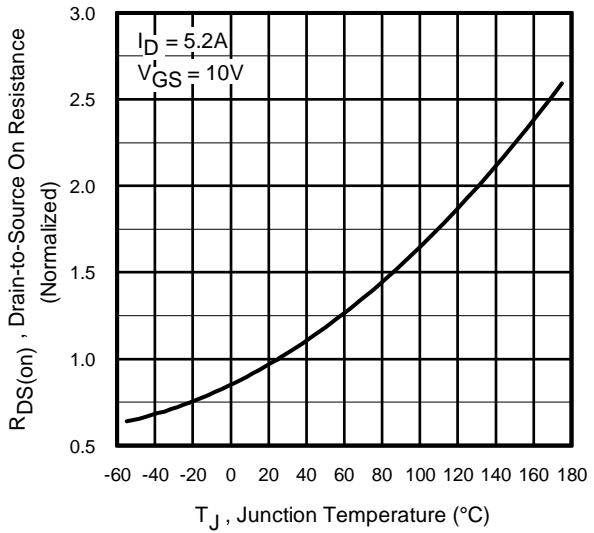
Fig 9. Maximum Drain Current Vs. Case Temperature

Fig 10. Normalized On-Resistance Vs. Temperature

| Ri (°C/W) | τi (sec) |
| --- | --- |
| 0.33747 | 0.000053 |
| 1.793 | 0.000125 |
| 2.150 | 0.000474 |

Notes:
1. Duty Factor D = t1/t2
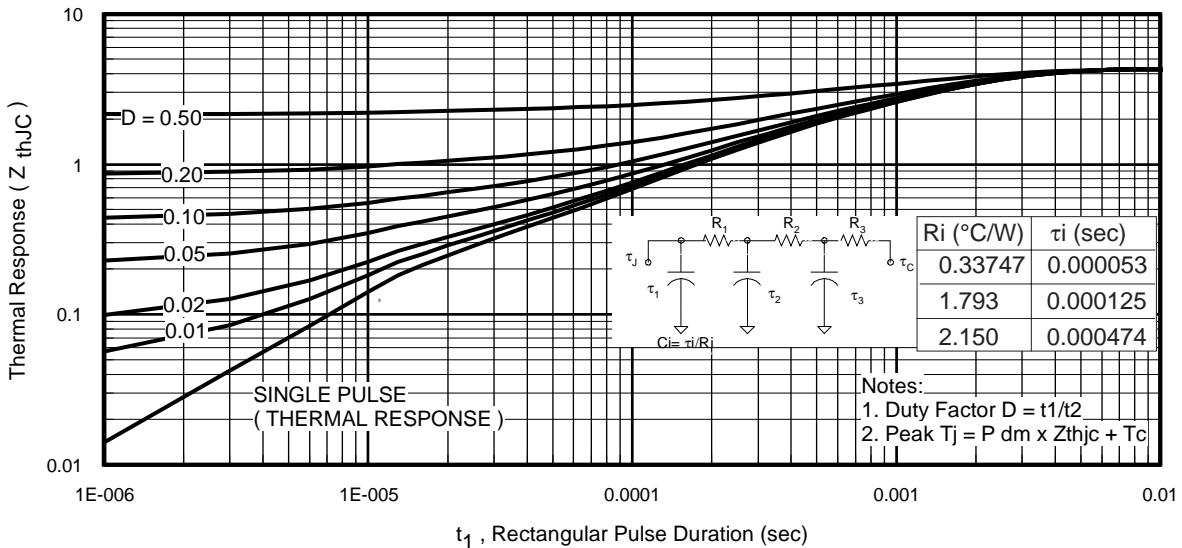2. Peak Tj = P dm x Zthjc + Tc

Fig 11. Maximum Effective Transient Thermal Impedance, Junction-to-Case
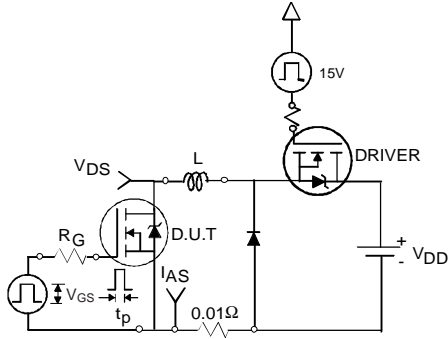
# IRFR/U120ZPbF



**Fig 12a.** Unclamped Inductive Test Circuit



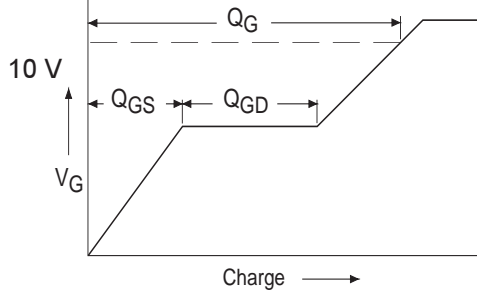**Fig 12b.** Unclamped Inductive Waveforms
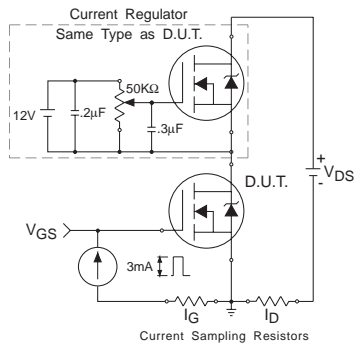


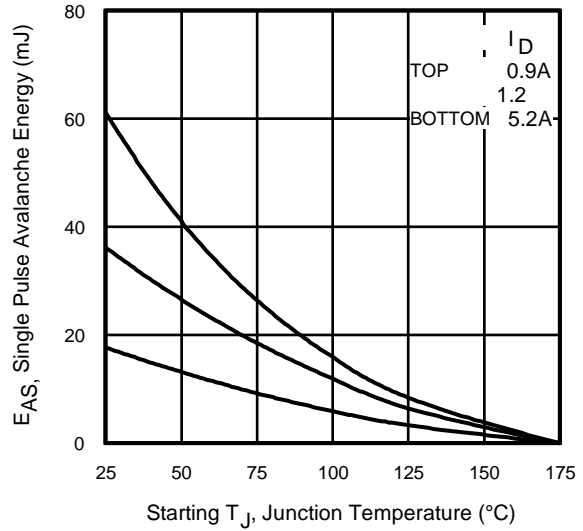**Fig 13a.** Basic Gate Charge Waveform



**Fig 13b.** Gate Charge Test Circuit



**Fig 12c.** Maximum Avalanche Energy
Vs. Drain Current



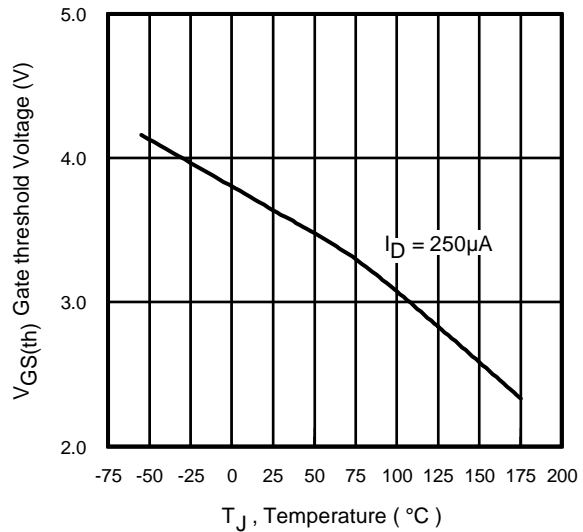**Fig 14.** Threshold Voltage Vs. Temperature
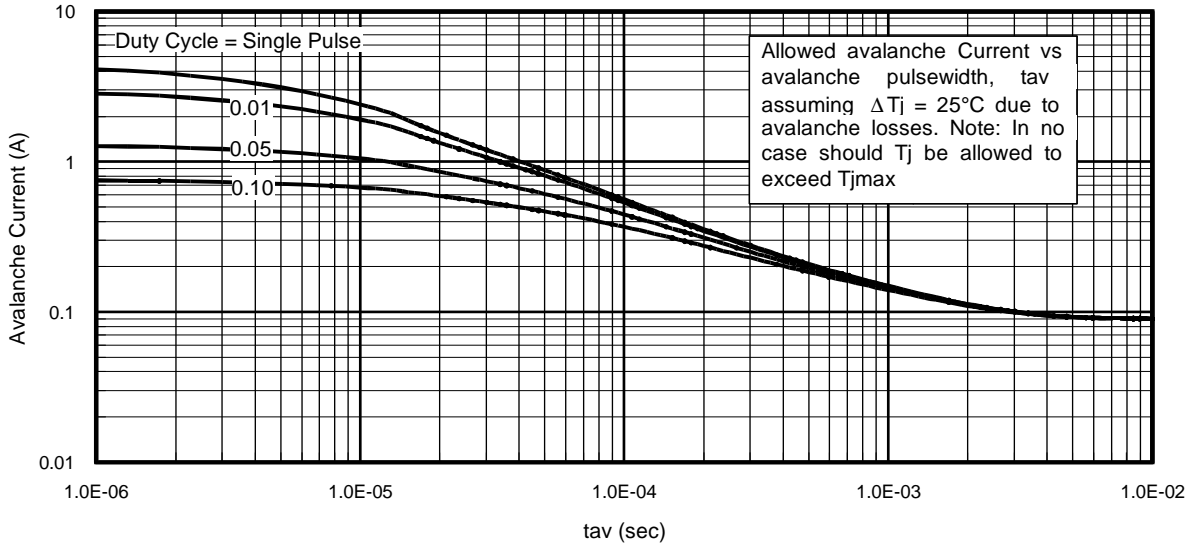
www.kersemi.com

Allowed avalanche Current vs avalanche pulsewidth, tav assuming ∆Tj = 25°C due to avalanche losses. Note: In no case should Tj be allowed to exceed Tjmax

**Fig 15.** Typical Avalanche Current Vs.Pulsewidth



TOP       Single Pulse
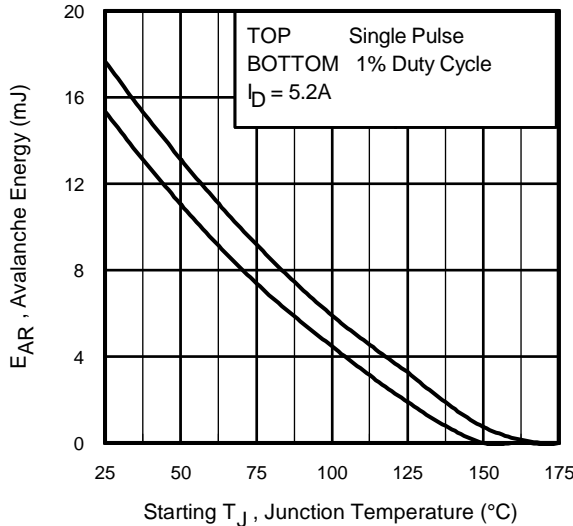BOTTOM   1% Duty Cycle
$I_D$ = 5.2A

**Fig 16.** Maximum Avalanche Energy Vs. Temperature

**Notes on Repetitive Avalanche Curves , Figures 15, 16:**
**(For further info, see AN-1005 at www.irf.com)**
1. Avalanche failures assumption:
   Purely a thermal phenomenon and failure occurs at a temperature far in excess of $T_{jmax}$. This is validated for every part type.
2. Safe operation in Avalanche is allowed as long as $T_{jmax}$ is not exceeded.
3. Equation below based on circuit and waveforms shown in Figures 12a, 12b.
4. $P_{D (ave)}$ = Average power dissipation per single avalanche pulse.
5. BV = Rated breakdown voltage (1.3 factor accounts for voltage increase during avalanche).
6. $I_{av}$ = Allowable avalanche current.
7. ∆T = Allowable rise in junction temperature, not to exceed $T_{jmax}$ (assumed as 25°C in Figure 15, 16).
   $t_{av}$ = Average time in avalanche.
   D = Duty cycle in avalanche = $t_{av} \cdot f$
   $Z_{thJC}(D, t_{av})$ = Transient thermal resistance, see figure 11)

$$P_{D (ave)} = 1/2 ( 1.3 \cdot BV \cdot I_{av}) = \Delta T / Z_{thJC}$$
$$I_{av} = 2\Delta T / [1.3 \cdot BV \cdot Z_{th}]$$
$$E_{AS (AR)} = P_{D (ave)} \cdot t_{av}$$

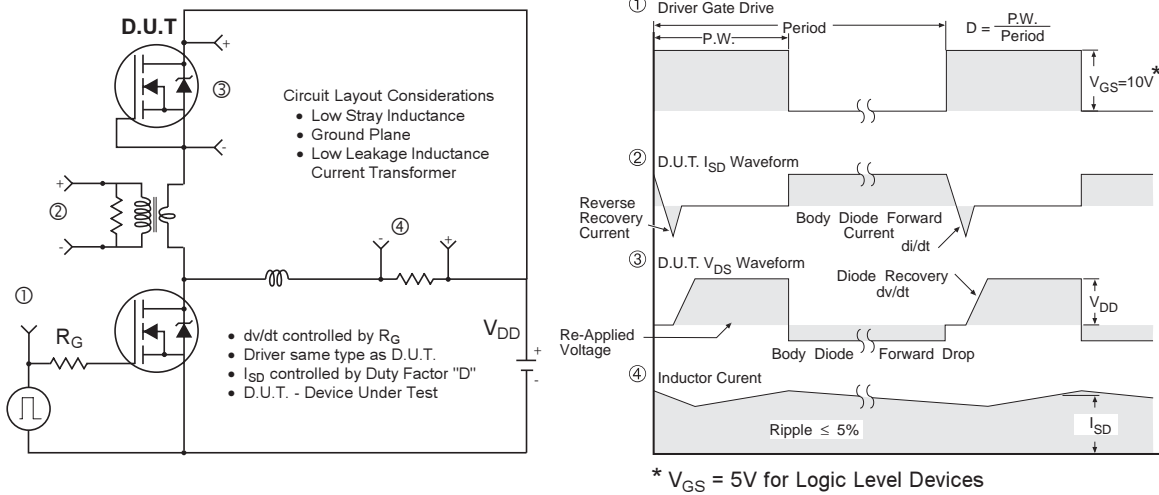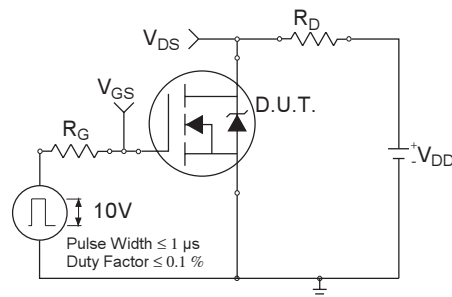**Fig 17.** Peak Diode Recovery dv/dt Test Circuit for N-Channel HEXFET® Power MOSFETs
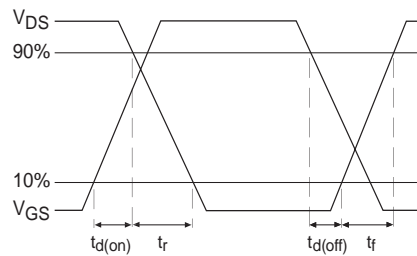


**Fig 18a.** Switching Time Test Circuit



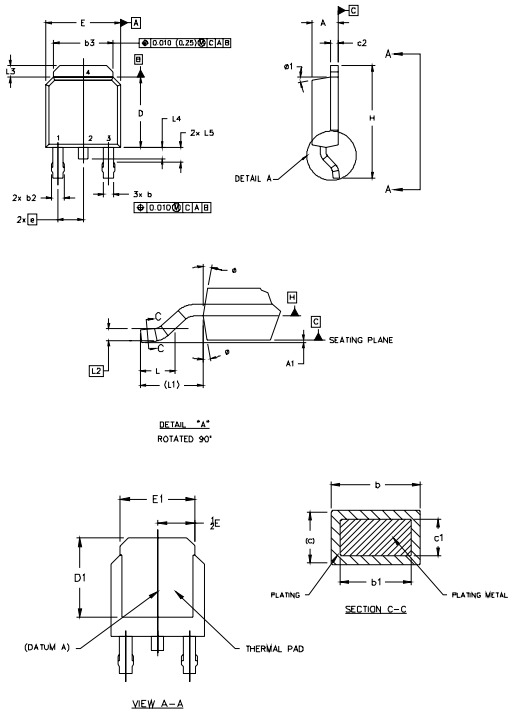**Fig 18b.** Switching Time Waveforms

## D-Pak (TO-252AA) Package Outline

Dimensions are shown in millimeters (inches)

NOTES:
1.0  DIMENSIONING AND TOLERANCING PER ASME Y14.5 M – 1994.
2.0  DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS].
3.0  LEAD DIMENSION UNCONTROLLED IN L5
4.0  DIMENSION D1 AND E1 ESTABLISH A MINIMUM MOUNTING SURFACE FOR THERMAL PAD.
5.0  SECTION C–C DIMENSIONS APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN .005 [0.127] AND
     .010 [0.2540 FROM THE LEAD TIP.
6.0  DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED
     .005" (0.127) PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST
     EXTREMES OF THE PLASTIC BODY.
7.0  OUTLINE CONFORMS TO JEDEC OUTLINE TO–252AA.

| SYMBOL | DIMENSIONS | | | | NOTES |
| | MILLIMETERS | | INCHES | | |
| | MIN. | MAX. | MIN. | MAX. | |
| A | 2.18 | 2.39 | .086 | .094 | |
| A1 | | 0.13 | | .005 | |
| b | 0.64 | 0.89 | .025 | .035 | 5 |
| b1 | 0.64 | 0.79 | .025 | 0.031 | 5 |
| b2 | 0.76 | 1.14 | .030 | .045 | |
| b3 | 4.95 | 5.46 | .195 | .215 | |
| c | 0.46 | 0.61 | .018 | .024 | 5 |
| c1 | 0.41 | 0.56 | .016 | .022 | 5 |
| c2 | .046 | 0.89 | .018 | .035 | 5 |
| D | 5.97 | 6.22 | .235 | .245 | 6 |
| D1 | 5.21 | – | .205 | – | 4 |
| E | 6.35 | 6.73 | .250 | .265 | 6 |
| E1 | 4.32 | – | .170 | – | 4 |
| e | 2.29 | | .090 BSC | | |
| H | 9.40 | 10.41 | .370 | .410 | |
| L | 1.40 | 1.78 | .055 | .070 | |
| L1 | 2.74 REF. | | .108 REF. | | |
| L2 | 0.051 BSC | | .020 BSC | | |
| L3 | 0.89 | 1.27 | .035 | .050 | |
| L4 | | 1.02 | | .040 | |
| L5 | 1.14 | 1.52 | .045 | .060 | 3 |
| ø | 0° | 10° | 0° | 10° | |
| ø1 | 0° | 15° | 0° | 15° | |

LEAD ASSIGNMENTS

HEXFET
1.– GATE
2.– DRAIN
3.– SOURCE
4.– DRAIN
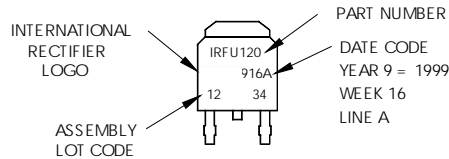
IGBTs, CoPACK
1.– GATE
2.– COLLECTOR
3.– EMITTER
4.– COLLECTOR

## D-Pak (TO-252AA) Part Marking Information

EXAMPLE:  THIS IS AN IRFR120
          WITH ASSEMBLY
          LOT CODE 1234
          ASSEMBLED ON WW 16, 1999
          IN THE ASSEMBLY LINE "A"

Note: "P" in assembly line position
      indicates "Lead-Free"

INTERNATIONAL RECTIFIER LOGO
PART NUMBER
DATE CODE
YEAR 9 = 1999
WEEK 16
LINE A
ASSEMBLY LOT CODE
IRFU120
916A
12   34

OR

INTERNATIONAL RECTIFIER LOGO
PART NUMBER
DATE CODE
P = DESIGNATES LEAD-FREE
    PRODUCT (OPTIONAL)
YEAR 9 = 1999
WEEK 16
A = ASSEMBLY SITE CODE
ASSEMBLY LOT CODE
IRFU120
P916A
12   34

# IRFR/U120ZPbF

## I-Pak (TO-251AA) Package Outline <span>Dimensions are shown in millimeters (inches)</span>



NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5 M− 1994.
2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
3. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.005" (0.127) PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
4. THERMAL PAD CONTOUR OPTION WITHIN DIMENSION b4, L2, E1 & D1.
5. LEAD DIMENSION UNCONTROLLED IN L3.
6. DIMENSION b1, b3 APPLY TO BASE METAL ONLY.
7. OUTLINE CONFORMS TO JEDEC OUTLINE TO−251AA.
8. CONTROLLING DIMENSION : INCHES.

LEAD ASSIGNMENTS

HEXFET

1.− GATE
2.− DRAIN
3.− SOURCE
4.− DRAIN

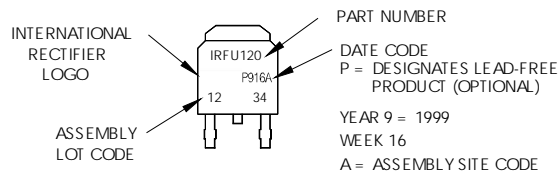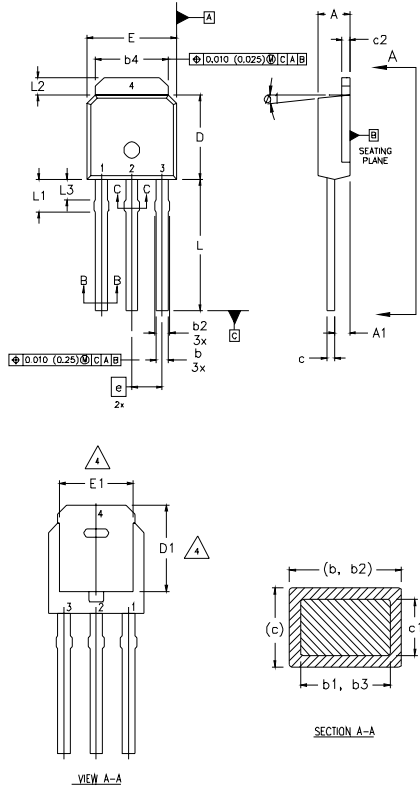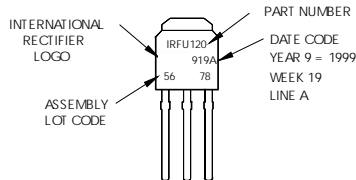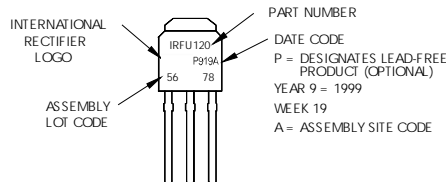| SYMBOL | DIMENSIONS | | | | NOTES |
| | MILLIMETERS | | INCHES | | |
| | MIN. | MAX. | MIN. | MAX. | |
|---|---|---|---|---|---|
| A | 2.18 | 2.39 | 0.086 | .094 | |
| A1 | 0.89 | 1.14 | 0.035 | 0.045 | |
| b | 0.64 | 0.89 | 0.025 | 0.035 | |
| b1 | 0.64 | 0.79 | 0.025 | 0.031 | 4 |
| b2 | 0.76 | 1.14 | 0.030 | 0.045 | |
| b3 | 0.76 | 1.04 | 0.030 | 0.041 | |
| b4 | 5.00 | 5.46 | 0.195 | 0.215 | 4 |
| c | 0.46 | 0.61 | 0.018 | 0.024 | |
| c1 | 0.41 | 0.56 | 0.016 | 0.022 | |
| c2 | .046 | 0.86 | 0.018 | 0.035 | |
| D | 5.97 | 6.22 | 0.235 | 0.245 | 3, 4 |
| D1 | 5.21 | – | 0.205 | – | 4 |
| E | 6.35 | 6.73 | 0.250 | 0.265 | 3, 4 |
| E1 | 4.32 | – | 0.170 | – | 4 |
| e | 2.29 | | 0.090 BSC | | |
| L | 8.89 | 9.60 | 0.350 | 0.380 | |
| L1 | 1.91 | 2.29 | 0.075 | 0.090 | |
| L2 | 0.89 | 1.27 | 0.035 | 0.050 | 4 |
| L3 | 1.14 | 1.52 | 0.045 | 0.060 | 5 |
| ø1 | 0° | 15° | 0° | 15° | |

## I-Pak (TO-251AA) Part Marking Information



EXAMPLE:  THIS IS AN IRFU120
WITH ASSEMBLY
LOT CODE 5678
ASSEMBLED ON WW 19, 1999
IN THE ASSEMBLY LINE "A"

**Note:** "P" in assembly line position indicates "Lead-Free"

INTERNATIONAL RECTIFIER LOGO

PART NUMBER

DATE CODE
YEAR 9 = 1999
WEEK 19
LINE A

ASSEMBLY LOT CODE

IRFU120
919A
56   78

OR



INTERNATIONAL RECTIFIER LOGO

PART NUMBER

DATE CODE
P = DESIGNATES LEAD-FREE PRODUCT (OPTIONAL)
YEAR 9 = 1999
WEEK 19
A = ASSEMBLY SITE CODE

ASSEMBLY LOT CODE

IRFU120
P919A
56   78

## D-Pak (TO-252AA) Tape & Reel Information

Dimensions are shown in millimeters (inches)

TR

16.3 ( .641 )
15.7 ( .619 )

12.1 ( .476 )
11.9 ( .469 )

FEED DIRECTION

TRR   TRL

16.3 ( .641 )
15.7 ( .619 )

8.1 ( .318 )
7.9 ( .312 )

FEED DIRECTION

NOTES :
1. CONTROLLING DIMENSION : MILLIMETER.
2. ALL DIMENSIONS ARE SHOWN IN MILLIMETERS ( INCHES ).
3. OUTLINE CONFORMS TO EIA-481 & EIA-541.

$\varnothing$ 13 INCH

16 mm

NOTES :
1. OUTLINE CONFORMS TO EIA-481.

**Notes:**

① Repetitive rating; pulse width limited by
   max. junction temperature. (See fig. 11).

② Limited by $T_{Jmax}$, starting $T_J = 25°C$, L = 1.29mH
   $R_G = 25\Omega$, $I_{AS} = 5.2A$, $V_{GS} = 10V$. Part not
   recommended for use above this value.

③ Pulse width ≤ 1.0ms; duty cycle ≤ 2%.

④ $C_{oss}$ eff. is a fixed capacitance that gives the same charging time
   as $C_{oss}$ while $V_{DS}$ is rising from 0 to 80% $V_{DSS}$ .

⑤ Limited by $T_{Jmax}$ , see Fig.12a, 12b, 15, 16 for typical repetitive
   avalanche performance.

⑥ This value determined from sample failure population. 100%
   tested to this value in production.

⑦ When mounted on 1" square PCB (FR-4 or G-10 Material) .
   For recommended footprint and soldering techniques refer to
   application note #AN-994