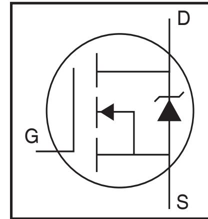
International
IOR Rectifier

# IRFR4615PbF
# IRFU4615PbF

HEXFET® Power MOSFET

### Applications

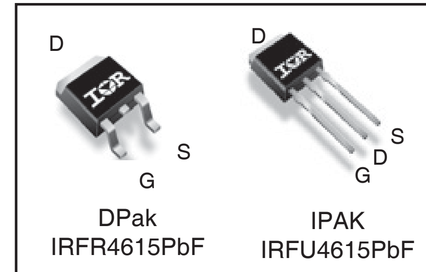
- High Efficiency Synchronous Rectification in SMPS
- Uninterruptible Power Supply
- High Speed Power Switching
- Hard Switched and High Frequency Circuits




| | | |
|---|---|---|
| $V_{DSS}$ | | 150V |
| $R_{DS(on)}$ | typ. | 34mΩ |
| | max. | 42mΩ |
| $I_D$ | | 33A |

### Benefits

- Improved Gate, Avalanche and Dynamic dV/dt Ruggedness
- Fully Characterized Capacitance and Avalanche SOA
- Enhanced body diode dV/dt and dI/dt Capability
- Lead-Free




DPak IRFR4615PbF | IPAK IRFU4615PbF

| G | D | S |
|---|---|---|
| Gate | Drain | Source |

| Base Part Number | Package Type | Standard Pack | | Orderable Part Number |
|---|---|---|---|---|
| | | Form | Quantity | |
| IRFR4615PbF | D-PAK | Tube/Bulk | 75 | IRFR4615PbF |
| IRFR4615TRLPbF | | Tape and Reel Left | 3000 | IRFR4615TRLPbF |
| IRFU4615PbF | I-PAK | Tube/Bulk | 75 | IRFU4615PbF |

### Absolute Maximum Ratings

| Symbol | Parameter | Max. | Units |
|---|---|---|---|
| $I_D$ @ $T_C$ = 25°C | Continuous Drain Current, $V_{GS}$ @ 10V | 33 | A |
| $I_D$ @ $T_C$ = 100°C | Continuous Drain Current, $V_{GS}$ @ 10V | 24 | |
| $I_{DM}$ | Pulsed Drain Current ① | 140 | |
| $P_D$ @$T_C$ = 25°C | Maximum Power Dissipation | 144 | W |
| | Linear Derating Factor | 0.96 | W/°C |
| $V_{GS}$ | Gate-to-Source Voltage | ± 20 | V |
| dv/dt | Peak Diode Recovery ③ | 38 | V/ns |
| $T_J$<br>$T_{STG}$ | Operating Junction and<br>Storage Temperature Range | -55 to + 175 | °C |
| | Soldering Temperature, for 10 seconds<br>(1.6mm from case) | 300 | |

### Avalanche Characteristics

| | | | |
|---|---|---|---|
| $E_{AS\ (Thermally\ limited)}$ | Single Pulse Avalanche Energy ② | 109 | mJ |
| $I_{AR}$ | Avalanche Current ① | See Fig. 14, 15, 22a, 22b, | A |
| $E_{AR}$ | Repetitive Avalanche Energy ① | | mJ |

### Thermal Resistance

| Symbol | Parameter | Typ. | Max. | Units |
|---|---|---|---|---|
| $R_{\theta JC}$ | Junction-to-Case ⑧ | —— | 1.045 | °C/W |
| $R_{\theta JA}$ | Junction-to-Ambient (PCB Mount) ⑦ | —— | 50 | |
| $R_{\theta JA}$ | Junction-to-Ambient | —— | 110 | |

Notes ① through ⑧ are on page 11

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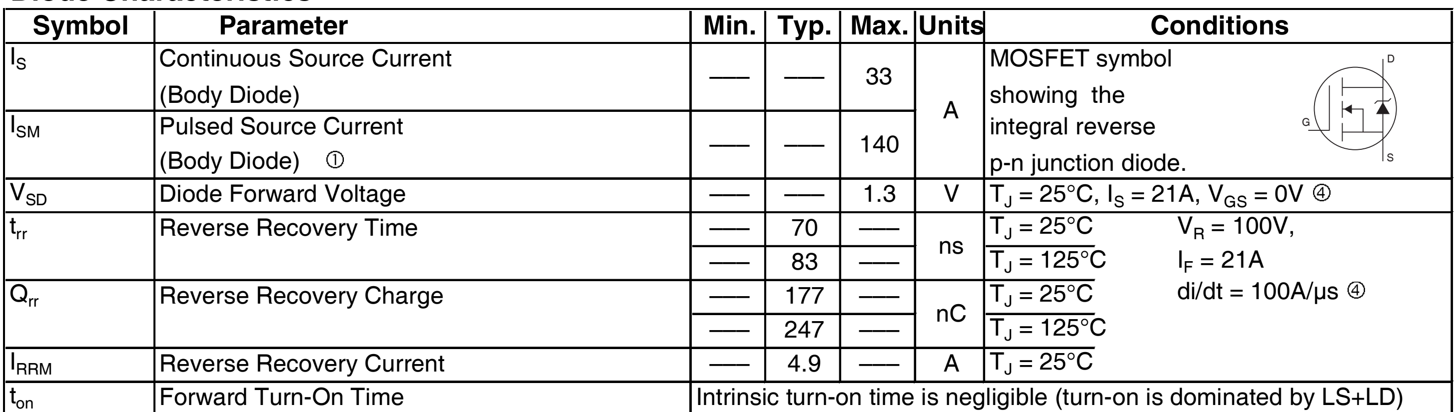
### Static @ $T_J$ = 25°C (unless otherwise specified)

| Symbol | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| $V_{(BR)DSS}$ | Drain-to-Source Breakdown Voltage | 150 | ––– | ––– | V | $V_{GS}$ = 0V, $I_D$ = 250μA |
| $\Delta V_{(BR)DSS}/\Delta T_J$ | Breakdown Voltage Temp. Coefficient | ––– | 0.19 | ––– | V/°C | Reference to 25°C, $I_D$ = 5mA ① |
| $R_{DS(on)}$ | Static Drain-to-Source On-Resistance | ––– | 34 | 42 | mΩ | $V_{GS}$ = 10V, $I_D$ = 21A ④ |
| $V_{GS(th)}$ | Gate Threshold Voltage | 3.0 | ––– | 5.0 | V | $V_{DS}$ = $V_{GS}$, $I_D$ = 100μA |
| $I_{DSS}$ | Drain-to-Source Leakage Current | ––– | ––– | 20 | μA | $V_{DS}$ = 150V, $V_{GS}$ = 0V |
| | | ––– | ––– | 250 | | $V_{DS}$ = 150V, $V_{GS}$ = 0V, $T_J$ = 125°C |
| $I_{GSS}$ | Gate-to-Source Forward Leakage | ––– | ––– | 100 | nA | $V_{GS}$ = 20V |
| | Gate-to-Source Reverse Leakage | ––– | ––– | -100 | | $V_{GS}$ = -20V |
| $R_{G(int)}$ | Internal Gate Resistance | ––– | 2.7 | ––– | Ω | |

### Dynamic @ $T_J$ = 25°C (unless otherwise specified)

| Symbol | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| gfs | Forward Transconductance | 35 | ––– | ––– | S | $V_{DS}$ = 50V, $I_D$ = 21A |
| $Q_g$ | Total Gate Charge | ––– | 26 | | nC | $I_D$ = 21A |
| $Q_{gs}$ | Gate-to-Source Charge | ––– | 8.6 | ––– | | $V_{DS}$ = 75V |
| $Q_{gd}$ | Gate-to-Drain ("Miller") Charge | ––– | 9.0 | ––– | | $V_{GS}$ = 10V ④ |
| $Q_{sync}$ | Total Gate Charge Sync. ($Q_g$ - $Q_{gd}$) | ––– | 17 | ––– | | $I_D$ = 21A, $V_{DS}$ =0V, $V_{GS}$ = 10V |
| $t_{d(on)}$ | Turn-On Delay Time | ––– | 15 | ––– | ns | $V_{DD}$ = 98V |
| $t_r$ | Rise Time | ––– | 35 | ––– | | $I_D$ = 21A |
| $t_{d(off)}$ | Turn-Off Delay Time | ––– | 25 | ––– | | $R_G$ = 7.3Ω |
| $t_f$ | Fall Time | ––– | 20 | ––– | | $V_{GS}$ = 10V ④ |
| $C_{iss}$ | Input Capacitance | ––– | 1750 | ––– | pF | $V_{GS}$ = 0V |
| $C_{oss}$ | Output Capacitance | ––– | 155 | ––– | | $V_{DS}$ = 50V |
| $C_{rss}$ | Reverse Transfer Capacitance | ––– | 40 | ––– | | $f$ = 1.0MHz (See Fig.5) |
| $C_{oss}$ eff. (ER) | Effective Output Capacitance (Energy Related) ⑥ | ––– | 179 | ––– | | $V_{GS}$ = 0V, $V_{DS}$ = 0V to 120V ⑥(See Fig.11) |
| $C_{oss}$ eff. (TR) | Effective Output Capacitance (Time Related) ⑤ | ––– | 382 | ––– | | $V_{GS}$ = 0V, $V_{DS}$ = 0V to 120V ⑤ |

### Diode Characteristics



| Symbol | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| $I_S$ | Continuous Source Current (Body Diode) | ––– | ––– | 33 | A | MOSFET symbol showing the integral reverse p-n junction diode. |
| $I_{SM}$ | Pulsed Source Current (Body Diode) ① | ––– | ––– | 140 | | |
| $V_{SD}$ | Diode Forward Voltage | ––– | ––– | 1.3 | V | $T_J$ = 25°C, $I_S$ = 21A, $V_{GS}$ = 0V ④ |
| $t_{rr}$ | Reverse Recovery Time | ––– | 70 | ––– | ns | $T_J$ = 25°C; $V_R$ = 100V, |
| | | ––– | 83 | ––– | | $T_J$ = 125°C; $I_F$ = 21A |
| $Q_{rr}$ | Reverse Recovery Charge | ––– | 177 | ––– | nC | $T_J$ = 25°C; di/dt = 100A/μs ④ |
| | | ––– | 247 | ––– | | $T_J$ = 125°C |
| $I_{RRM}$ | Reverse Recovery Current | ––– | 4.9 | ––– | A | $T_J$ = 25°C |
| $t_{on}$ | Forward Turn-On Time | Intrinsic turn-on time is negligible (turn-on is dominated by LS+LD) | | | | |

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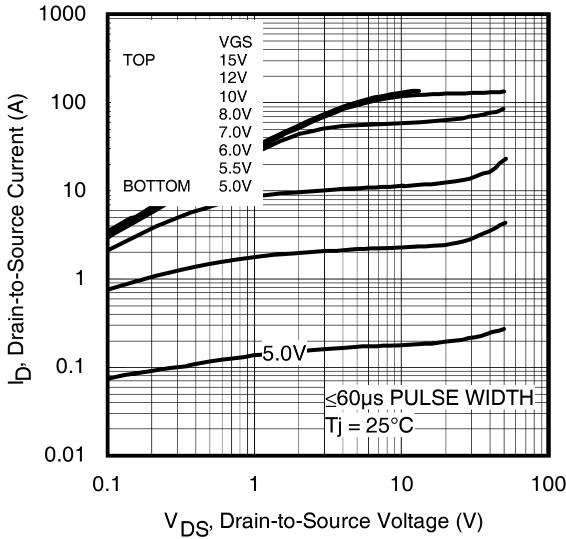


**Fig 1.** Typical Output Characteristics

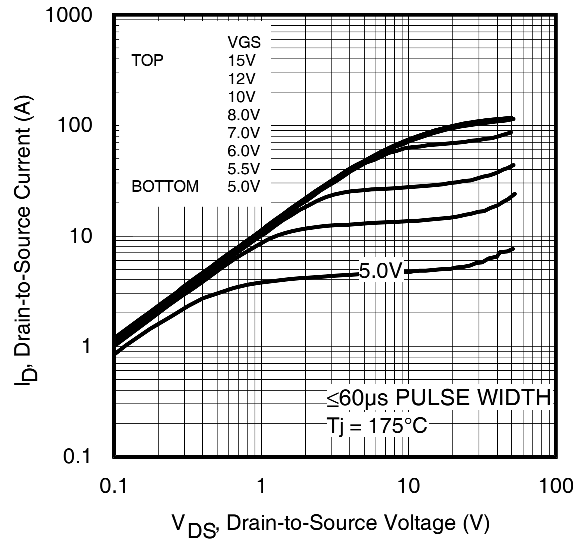


**Fig 2.** Typical Output Characteristics

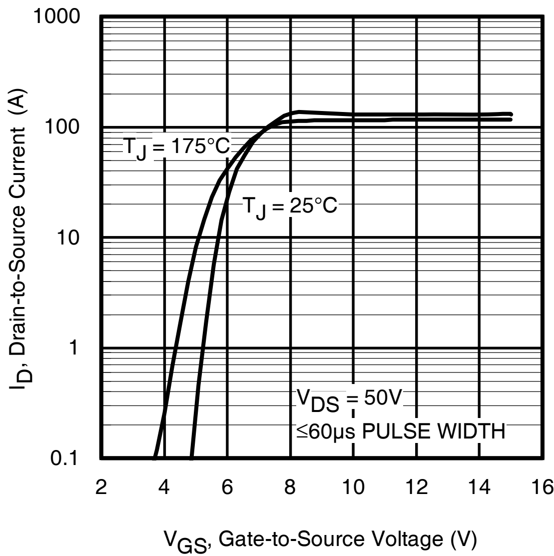


**Fig 3.** Typical Transfer Characteristics

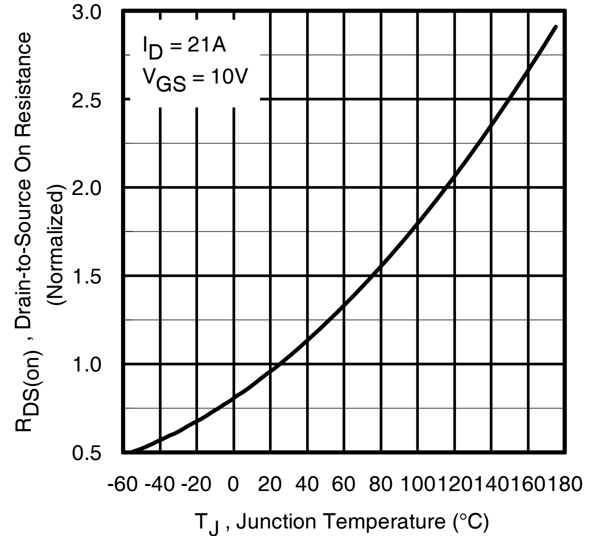


**Fig 4.** Normalized On-Resistance vs. Temperature

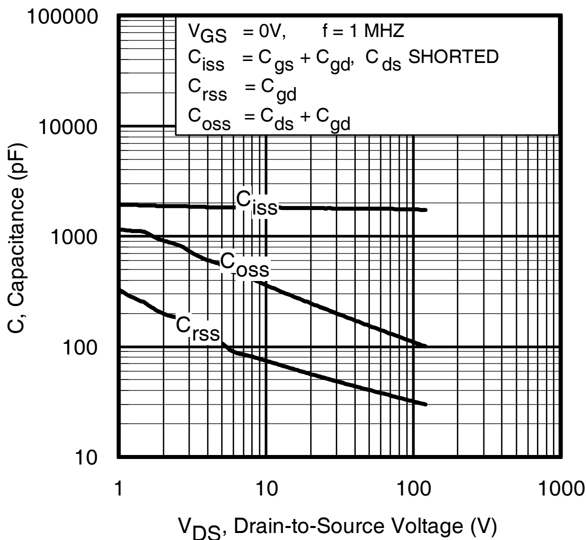


**Fig 5.** Typical Capacitance vs. Drain-to-Source Voltage

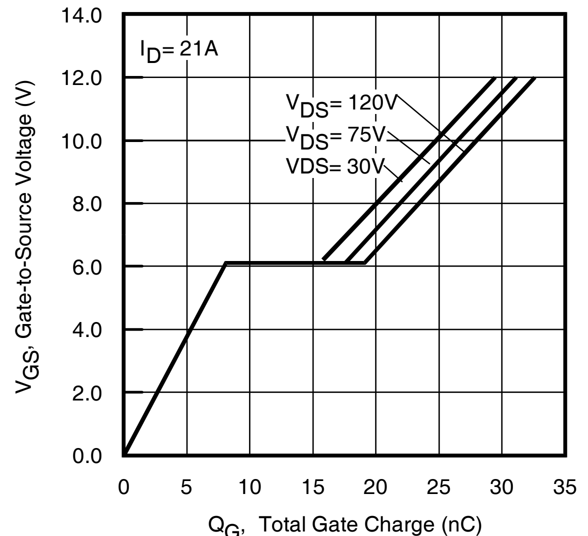


**Fig 6.** Typical Gate Charge vs. Gate-to-Source Voltage

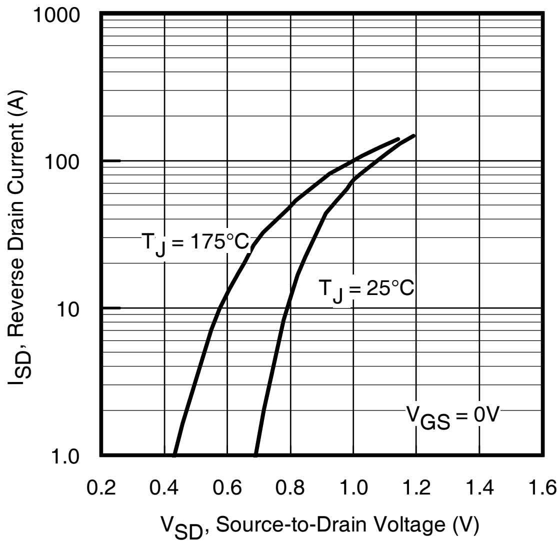


**Fig 7.** Typical Source-Drain Diode Forward Voltage

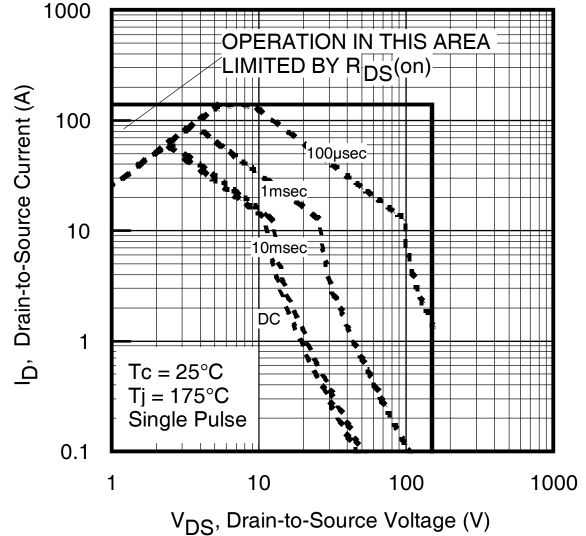


**Fig 8.** Maximum Safe Operating Area

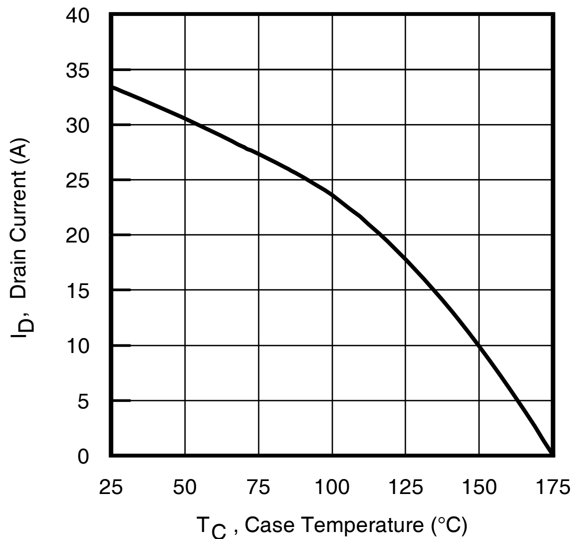


**Fig 9.** Maximum Drain Current vs. Case Temperature

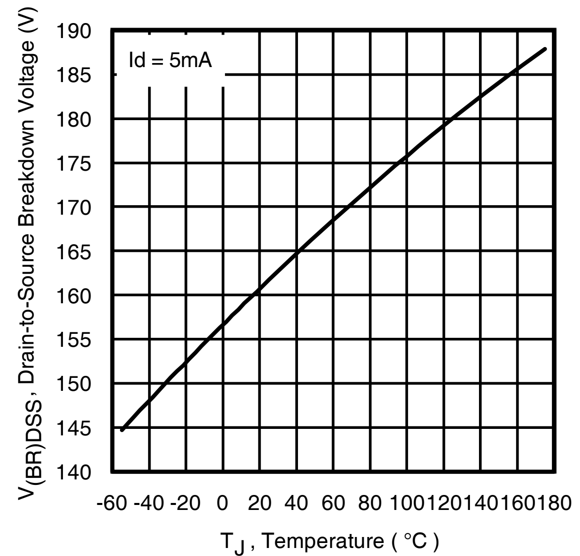


**Fig 10.** Drain-to-Source Breakdown Voltage

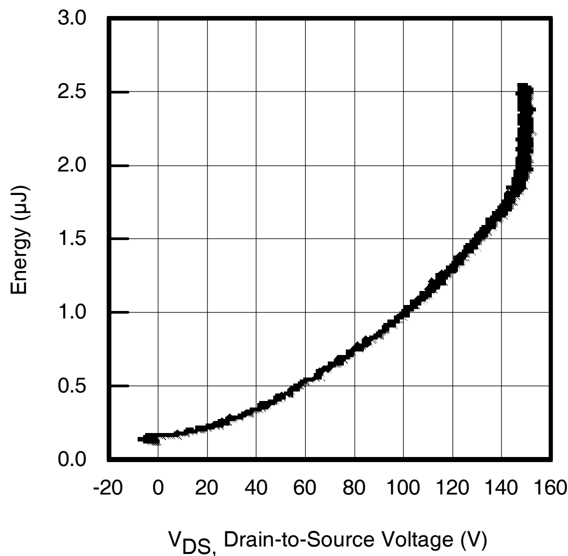


**Fig 11.** Typical $C_{OSS}$ Stored Energy

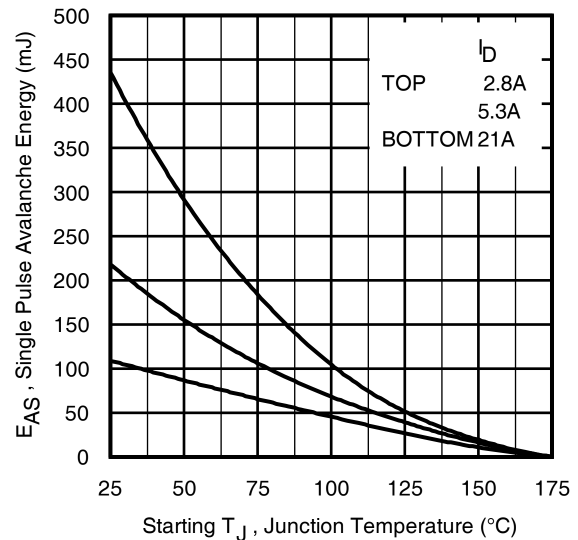


**Fig 12.** Maximum Avalanche Energy vs. DrainCurrent

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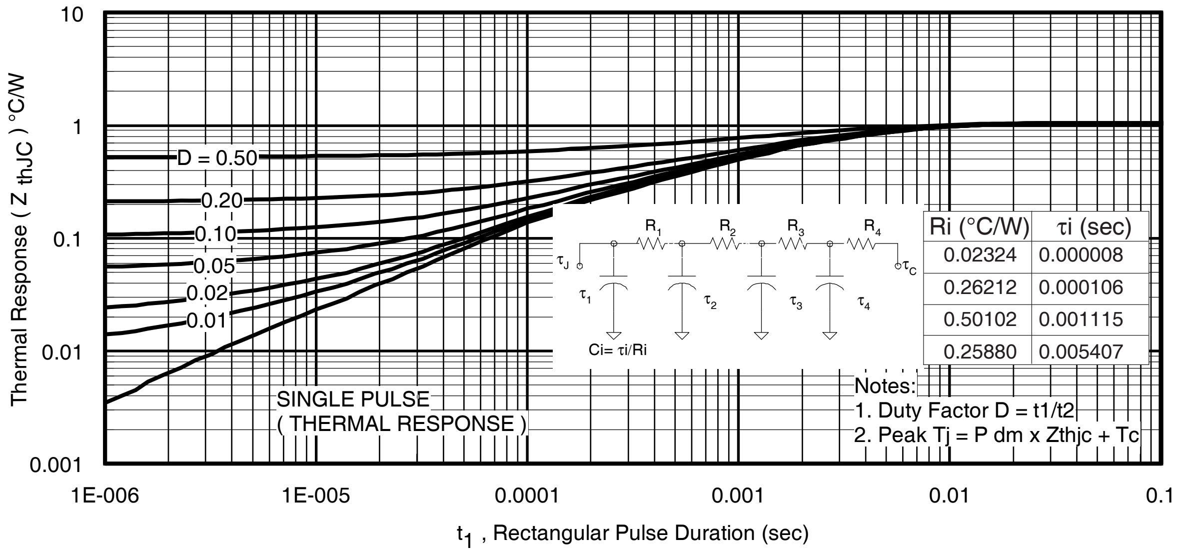



| Ri (°C/W) | τi (sec) |
|---|---|
| 0.02324 | 0.000008 |
| 0.26212 | 0.000106 |
| 0.50102 | 0.001115 |
| 0.25880 | 0.005407 |

**Fig 13.** Maximum Effective Transient Thermal Impedance, Junction-to-Case

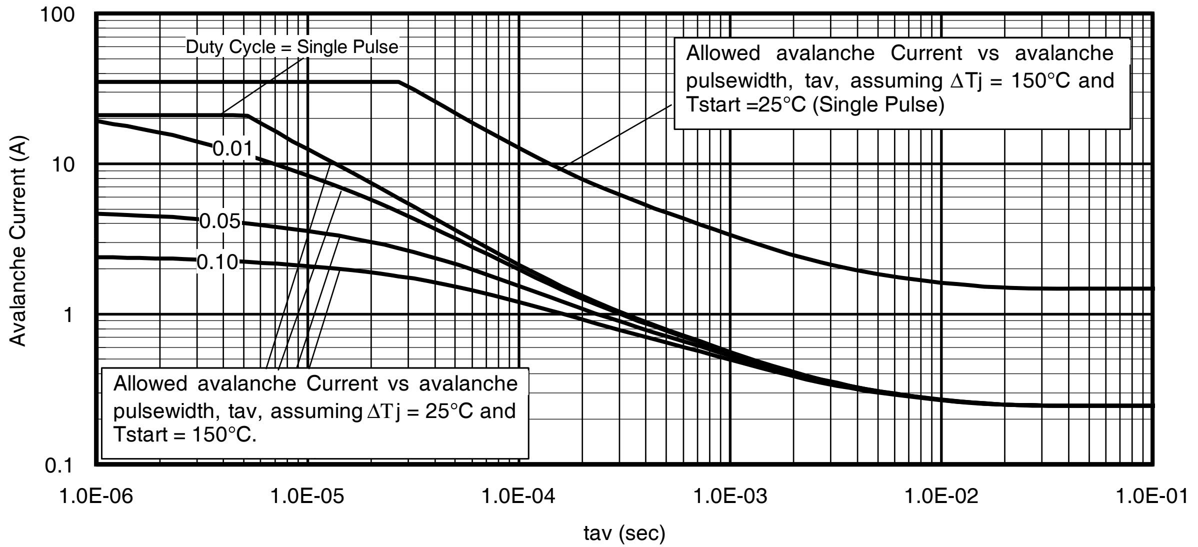



**Fig 14.** Typical Avalanche Current vs.Pulsewidth

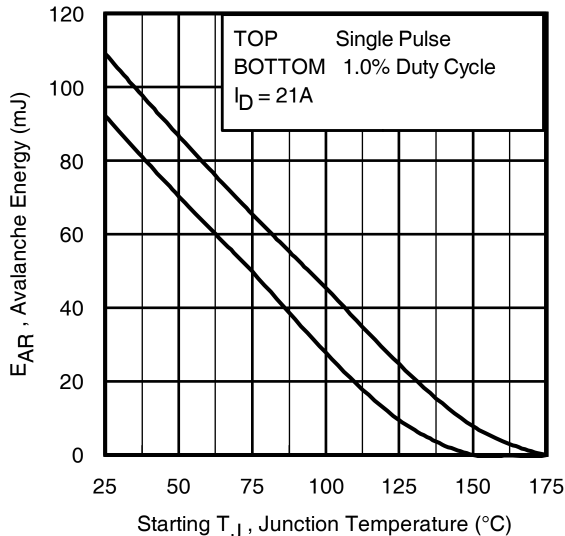



**Fig 15.** Maximum Avalanche Energy vs. Temperature

**Notes on Repetitive Avalanche Curves , Figures 14, 15:**
**(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 16a, 16b.
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. $\Delta T$ = Allowable rise in junction temperature, not to exceed $T_{jmax}$ (assumed as 25°C in Figure 14, 15).
   $t_{av}$ = Average time in avalanche.
   D = Duty cycle in avalanche = $t_{av} \cdot f$
   $Z_{thJC}(D, t_{av})$ = Transient thermal resistance, see Figures 13)

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

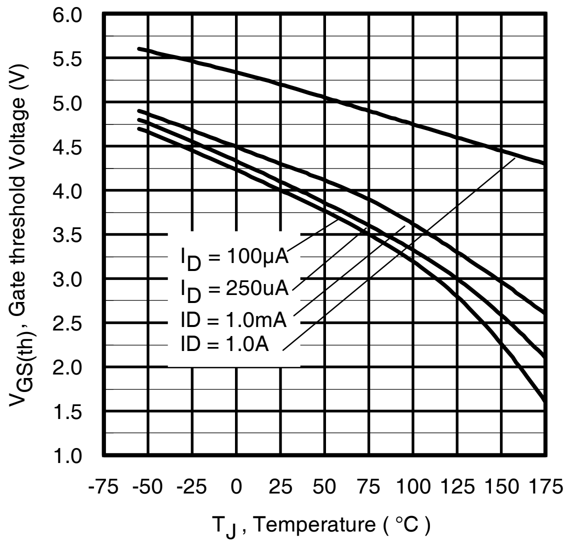



**Fig 16.** Threshold Voltage vs. Temperature

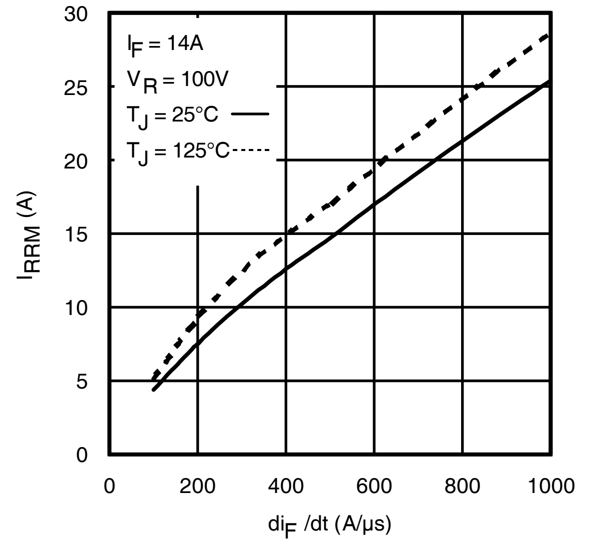



**Fig. 17 -** Typical Recovery Current vs. $di_f/dt$

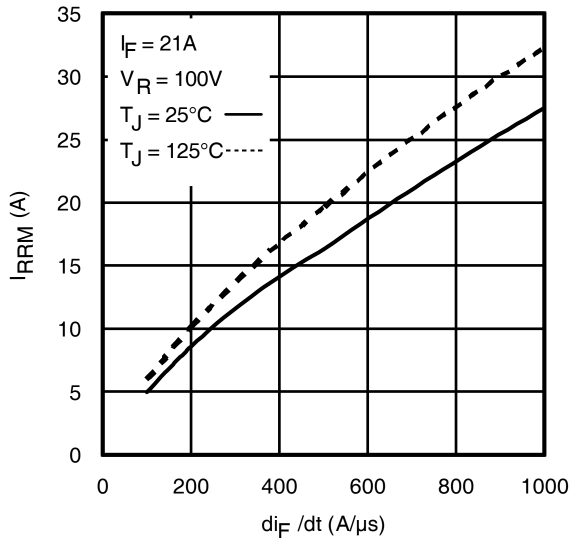



**Fig. 18 -** Typical Recovery Current vs. $di_f/dt$

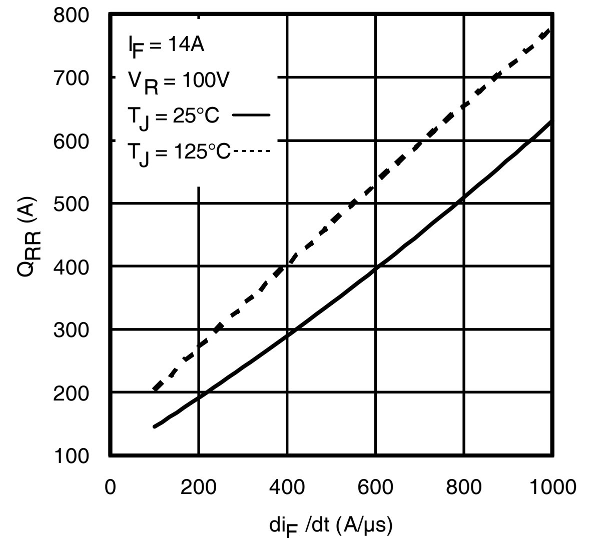



**Fig. 19 -** Typical Stored Charge vs. $di_f/dt$

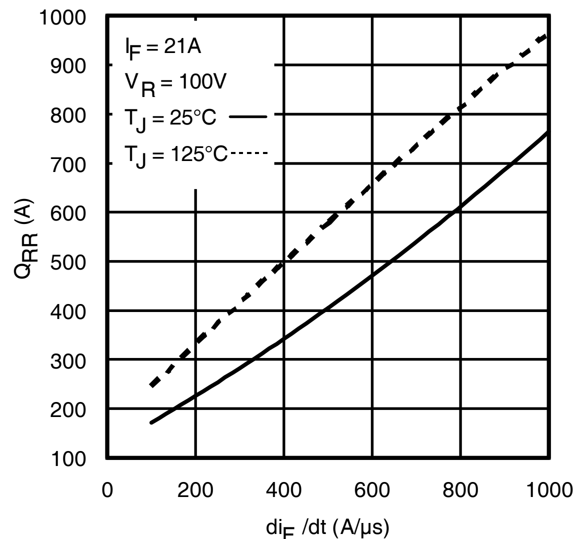
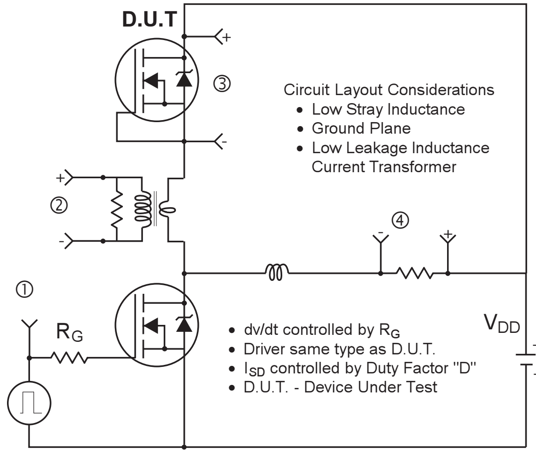



**Fig. 20 -** Typical Stored Charge vs. $di_f/dt$



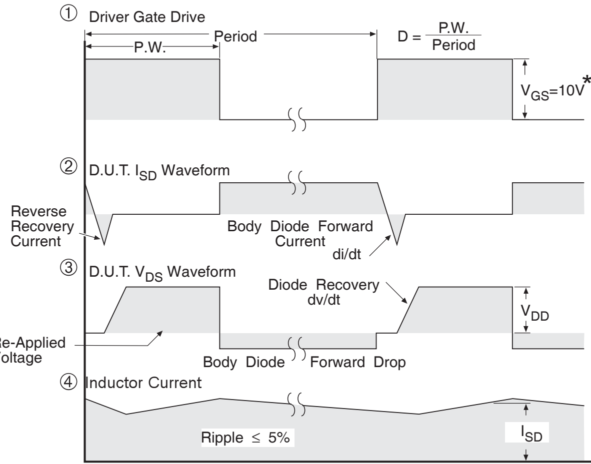




**Fig 21.** Peak Diode Recovery dv/dt Test Circuit for N-Channel HEXFET® Power MOSFETs

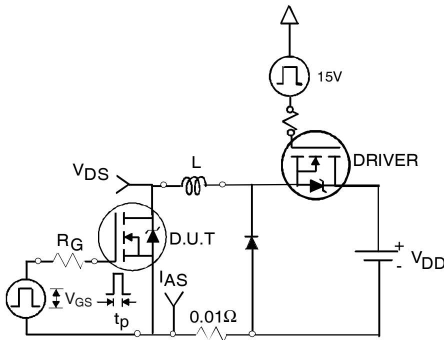



**Fig 22a.** Unclamped Inductive Test Circuit

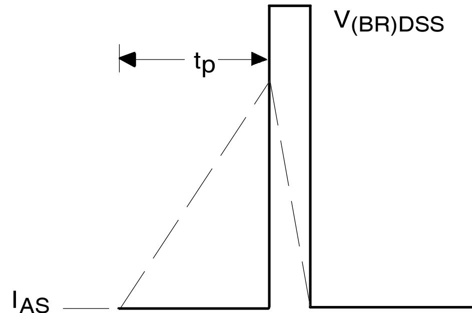



**Fig 22b.** Unclamped Inductive Waveforms

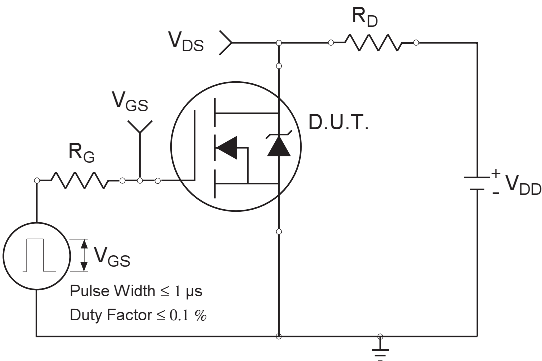



**Fig 23a.** Switching Time Test Circuit

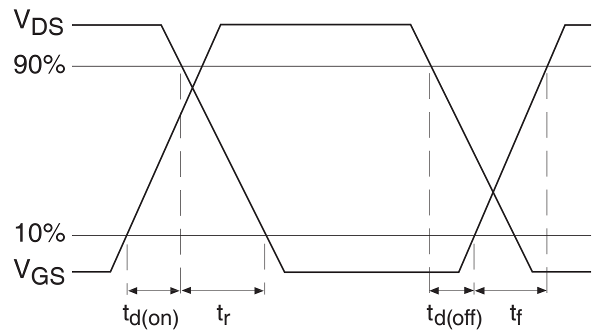



**Fig 23b.** Switching Time Waveforms

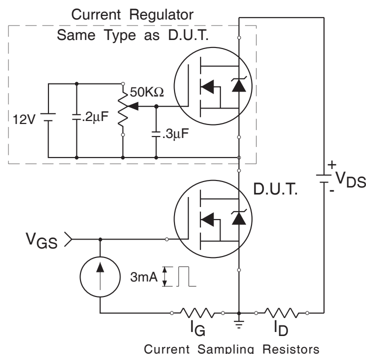



**Fig 24a.** Gate Charge Test Circuit

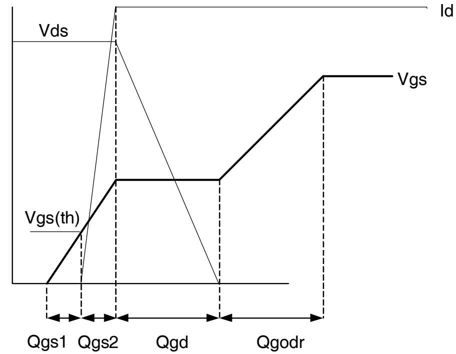
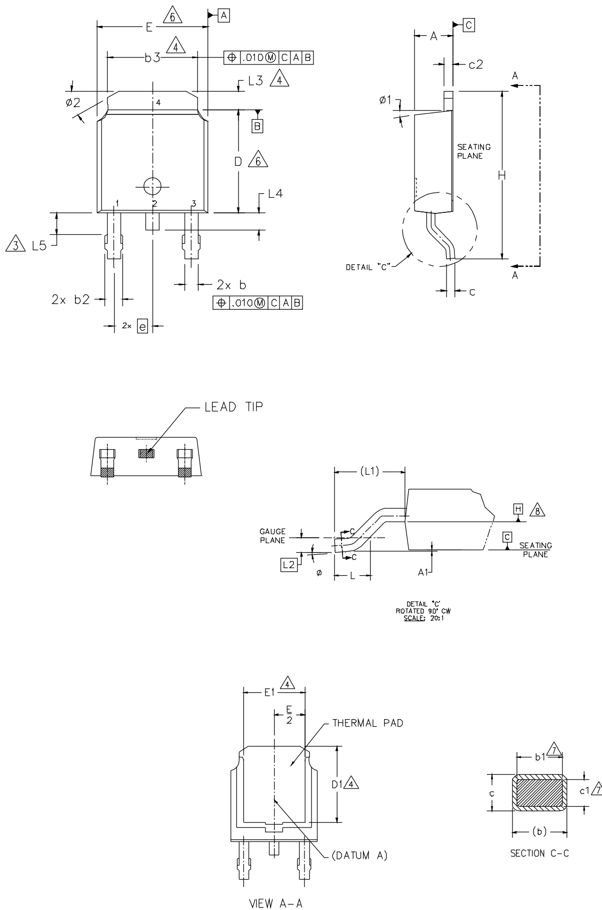



**Fig 24b.** Gate Charge Waveform

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

Dimensions are shown in millimeters (inches)




NOTES:

1. – DIMENSIONING AND TOLERANCING PER ASME Y14.5M–1994
2. – DIMENSION ARE SHOWN IN INCHES [MILLIMETERS].
3. – LEAD DIMENSION UNCONTROLLED IN L5.
4. – DIMENSION D1, E1, L3 & b3 ESTABLISH A MINIMUM MOUNTING SURFACE FOR THERMAL PAD.
5. – SECTION C–C DIMENSIONS APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN .005 AND 0.10 [0.13 AND 0.25] FROM THE LEAD TIP.
6. – DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005 [0.13] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
7. – DIMENSION b1 & c1 APPLIED TO BASE METAL ONLY.
8. – DATUM A & B TO BE DETERMINED AT DATUM PLANE H.
9. – 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 | |
| b1 | 0.65 | 0.79 | .025 | .031 | 7 |
| b2 | 0.76 | 1.14 | .030 | .045 | |
| b3 | 4.95 | 5.46 | .195 | .215 | 4 |
| c | 0.46 | 0.61 | .018 | .024 | |
| c1 | 0.41 | 0.56 | .016 | .022 | 7 |
| c2 | 0.46 | 0.89 | .018 | .035 | |
| 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 BSC | | .090 BSC | | |
| H | 9.40 | 10.41 | .370 | .410 | |
| L | 1.40 | 1.78 | .055 | .070 | |
| L1 | 2.74 BSC | | .108 REF. | | |
| L2 | 0.51 BSC | | .020 BSC | | |
| L3 | 0.89 | 1.27 | .035 | .050 | 4 |
| L4 | – | 1.02 | – | .040 | |
| L5 | 1.14 | 1.52 | .045 | .060 | 3 |
| ø | 0° | 10° | 0° | 10° | |
| ø1 | 0° | 15° | 0° | 15° | |
| ø2 | 25° | 35° | 25° | 35° | |

LEAD ASSIGNMENTS

HEXFET

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

IGBT & CoPAK

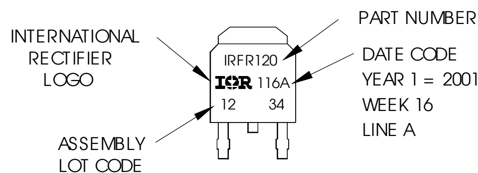
1. – GATE
2. – COLLECTOR
3. – EMITTER
4. – COLLECTOR

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

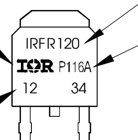
EXAMPLE: THIS IS AN IRFR120
WITH ASSEMBLY
LOT CODE 1234
ASSEMBLED ON WW 16, 2001
IN THE ASSEMBLY LINE "A"

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

"P̄" in assembly line position indicates "Lead-Free" qualification to the consumer-level




OR




INTERNATIONAL RECTIFIER LOGO

ASSEMBLY LOT CODE

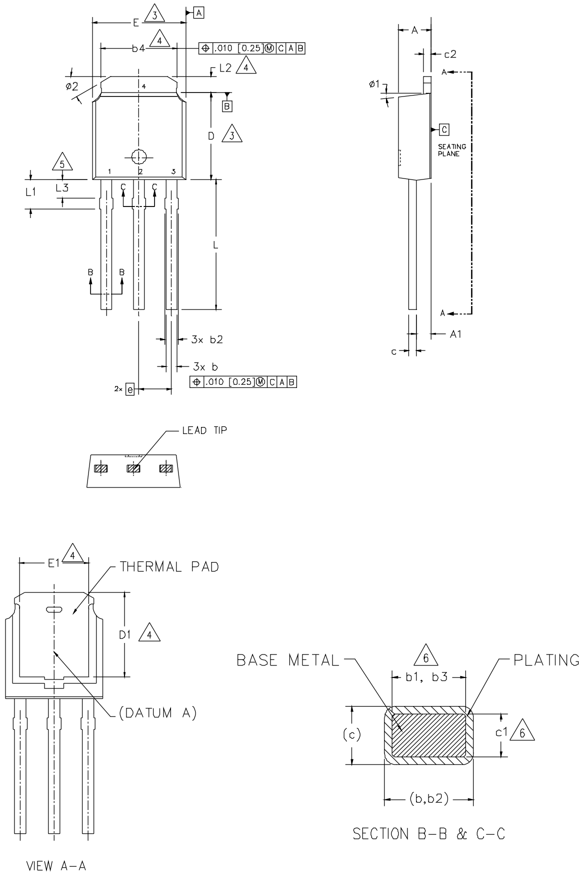
PART NUMBER

DATE CODE
P = DESIGNATES LEAD-FREE PRODUCT (OPTIONAL)
P̄ = DESIGNATES LEAD-FREE PRODUCT QUALIFIED TO THE CONSUMER LEVEL (OPTIONAL)
YEAR 1 = 2001
WEEK 16
A = ASSEMBLY SITE CODE

**Note: For the most current drawing please refer to IR website at http://www.irf.com/package/**

## I-Pak (TO-251AA) Package Outline

Dimensions are shown in millimeters (inches)




NOTES:

1.– DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994

2.– DIMENSION ARE SHOWN IN INCHES [MILLIMETERS].

3.– DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005 [0.13] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST 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 & c1 APPLY TO BASE METAL ONLY.

7.– OUTLINE CONFORMS TO JEDEC OUTLINE TO-251AA (Date 06/02).

8.– CONTROLLING DIMENSION : INCHES.

| SYMBOL | DIMENSIONS | | | | NOTES |
|---|---|---|---|---|---|
| | MILLIMETERS | | INCHES | | |
| | MIN. | MAX. | MIN. | MAX. | |
| A | 2.18 | 2.39 | .086 | .094 | |
| A1 | 0.89 | 1.14 | .035 | .045 | |
| b | 0.64 | 0.89 | .025 | .035 | |
| b1 | 0.65 | 0.79 | .025 | .031 | 6 |
| b2 | 0.76 | 1.14 | .030 | .045 | |
| b3 | 0.76 | 1.04 | .030 | .041 | 6 |
| b4 | 4.95 | 5.46 | .195 | .215 | 4 |
| c | 0.46 | 0.61 | .018 | .024 | |
| c1 | 0.41 | 0.56 | .016 | .022 | 6 |
| c2 | 0.46 | 0.89 | .018 | .035 | |
| D | 5.97 | 6.22 | .235 | .245 | 3 |
| D1 | 5.21 | – | .205 | – | 4 |
| E | 6.35 | 6.73 | .250 | .265 | 3 |
| E1 | 4.32 | – | .170 | – | 4 |
| e | 2.29 BSC | | .090 BSC | | |
| L | 8.89 | 9.65 | .350 | .380 | |
| L1 | 1.91 | 2.29 | .045 | .090 | |
| L2 | 0.89 | 1.27 | .035 | .050 | 4 |
| L3 | 1.14 | 1.52 | .045 | .060 | 5 |
| ø1 | 0° | 15° | 0° | 15° | |
| ø2 | 25° | 35° | 25° | 35° | |

LEAD ASSIGNMENTS

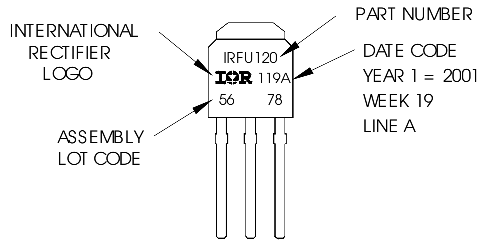
HEXFET

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

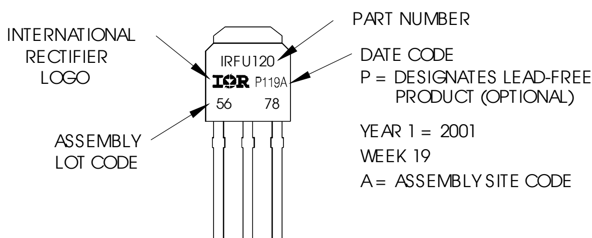
## I-Pak (TO-251AA) Part Marking Information

EXAMPLE: THIS IS AN IRFU120
WITH ASSEMBLY
LOT CODE 5678
ASSEMBLED ON WW 19, 2001
IN THE ASSEMBLY LINE "A"

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



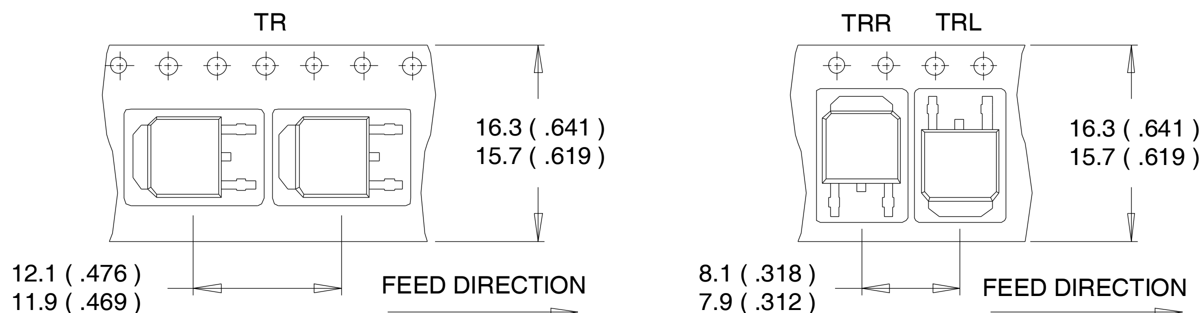

OR



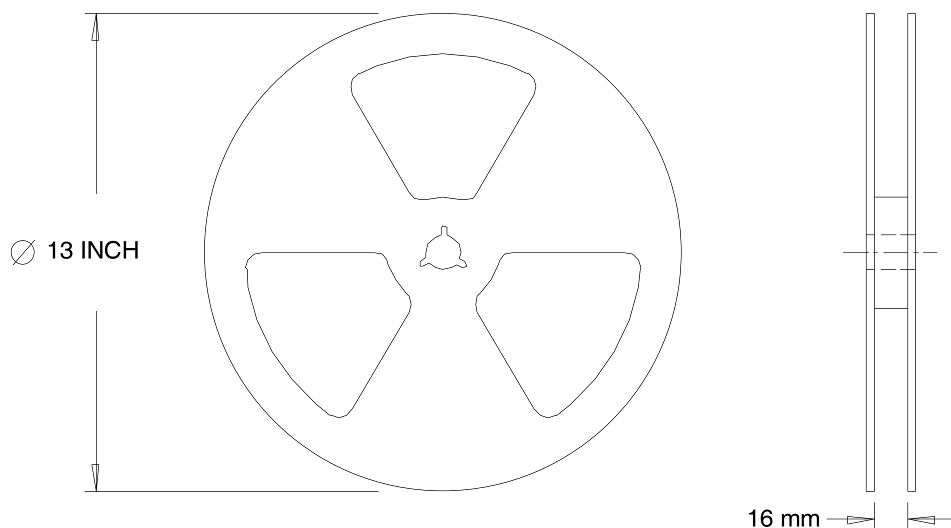

**Note: For the most current drawing please refer to IR website at http://www.irf.com/package/**

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

Dimensions are shown in millimeters (inches)




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




NOTES :
1. OUTLINE CONFORMS TO EIA-481.

**Note: For the most current drawing please refer to IR website at http://www.irf.com/package/**

**Qualification Information†**

| Qualification level | Industrial (per JEDEC JESD47F†† guidelines) | |
|---|---|---|
| Moisture Sensitivity Level | D-PAK | MSL1 (per JEDEC J-STD-020D††) |
| | I-PAK | Not applicable |
| RoHS Compliant | Yes | |

† Qualification standards can be found at International Rectifier's web site http://www.irf.com/product-info/reliability
†† Applicable version of JEDEC standard at the time of product release.

**Notes:**

① Repetitive rating; pulse width limited by max. junction temperature.
② Limited by $T_{Jmax}$, starting $T_J$ = 25°C, L = 0.51mH $R_G$ = 25Ω, $I_{AS}$ = 21A, $V_{GS}$ =10V. Part not recommended for use above this value .
③ $I_{SD} \leq$ 21A, di/dt ≤ 549A/µs, $V_{DD} \leq V_{(BR)DSS}$, $T_J \leq$ 175°C.
④ Pulse width ≤ 400µs; duty cycle ≤ 2%.
⑤ $C_{oss}$ eff. (TR) is a fixed capacitance that gives the same charging time as $C_{oss}$ while $V_{DS}$ is rising from 0 to 80% $V_{DSS}$.
⑥ $C_{oss}$ eff. (ER) is a fixed capacitance that gives the same energy as $C_{oss}$ while $V_{DS}$ is rising from 0 to 80% $V_{DSS}$.
⑦ When mounted on 1" square PCB (FR-4 or G-10 Material). For recom mended footprint and soldering techniques refer to application note #AN-994
⑧ $R_\theta$ is measured at $T_J$ approximately 90°C

**Revision History**

| Date | Comments |
|---|---|
| 5/16/2013 | • Updated datasheet to new IR corporate formatting template<br>• Updated Orderable part number from "IRFR4615TRPbF" to "IRFR4615TRLPbF", on page 1 |

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