# International ℞R Rectifier

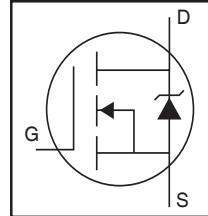# IRFS4010PbF
# IRFSL4010PbF

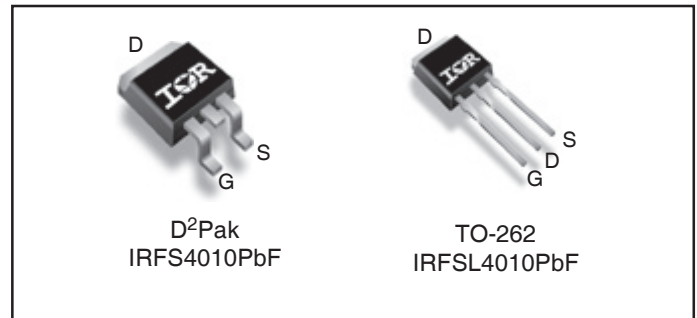HEXFET® Power MOSFET

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

## 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

| | | | |
|---|---|---|---|
| $V_{DSS}$ | | | 100V |
| $R_{DS(on)}$ | typ. | | 3.9mΩ |
| | max. | | 4.7mΩ |
| $I_D$ | | | 180A |



D²Pak
IRFS4010PbF

TO-262
IRFSL4010PbF

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

## Absolute Maximum Ratings

| Symbol | Parameter | Max. | Units |
|---|---|---|---|
| $I_D$ @ $T_C$ = 25°C | Continuous Drain Current, $V_{GS}$ @ 10V | 180 | A |
| $I_D$ @ $T_C$ = 100°C | Continuous Drain Current, $V_{GS}$ @ 10V | 127 | |
| $I_{DM}$ | Pulsed Drain Current ① | 720 | |
| $P_D$ @$T_C$ = 25°C | Maximum Power Dissipation | 375 | W |
| | Linear Derating Factor | 2.5 | W/°C |
| $V_{GS}$ | Gate-to-Source Voltage | ± 20 | V |
| dv/dt | Peak Diode Recovery ③ | 31 | V/ns |
| $T_J$ | Operating Junction and | -55 to + 175 | °C |
| $T_{STG}$ | Storage Temperature Range | | |
| | Soldering Temperature, for 10 seconds (1.6mm from case) | 300 | |

## Avalanche Characteristics

| | | | |
|---|---|---|---|
| $E_{AS\ (Thermally\ limited)}$ | Single Pulse Avalanche Energy ② | 318 | mJ |
| $I_{AR}$ | Avalanche Current ① | See Fig. 14, 15, 22a, 22b, | A |
| $E_{AR}$ | Repetitive Avalanche Energy ④ | | mJ |

## Thermal Resistance

| Symbol | Parameter | Typ. | Max. | Units |
|---|---|---|---|---|
| $R_{\theta JC}$ | Junction-to-Case ⑧ ⑨ | —— | 0.40 | °C/W |
| $R_{\theta JA}$ | Junction-to-Ambient (PCB Mount) ⑦ | —— | 40 | |

# IRFS/SL4010PbF

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

| Symbol | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| $V_{(BR)DSS}$ | Drain-to-Source Breakdown Voltage | 100 | —— | —— | V | $V_{GS}$ = 0V, $I_D$ = 250µA |
| $\Delta V_{(BR)DSS}/\Delta T_J$ | Breakdown Voltage Temp. Coefficient | —— | 0.10 | —— | V/°C | Reference to 25°C, $I_D$ = 5mA① |
| $R_{DS(on)}$ | Static Drain-to-Source On-Resistance | —— | 3.9 | 4.7 | mΩ | $V_{GS}$ = 10V, $I_D$ = 106A ④ |
| $V_{GS(th)}$ | Gate Threshold Voltage | 2.0 | —— | 4.0 | V | $V_{DS}$ = $V_{GS}$, $I_D$ = 250µA |
| $I_{DSS}$ | 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 | —— | —— | 100 | nA | $V_{GS}$ = 20V |
| | Gate-to-Source Reverse Leakage | —— | —— | -100 | | $V_{GS}$ = -20V |
| $R_{G(int)}$ | Internal Gate Resistance | —— | 2.0 | —— | Ω | |

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

| Symbol | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| gfs | Forward Transconductance | 189 | —— | —— | S | $V_{DS}$ = 25V, $I_D$ = 106A |
| $Q_g$ | Total Gate Charge | —— | 143 | 215 | nC | $I_D$ = 106A |
| $Q_{gs}$ | Gate-to-Source Charge | —— | 38 | —— | | $V_{DS}$ = 50V |
| $Q_{gd}$ | Gate-to-Drain ("Miller") Charge | —— | 50 | —— | | $V_{GS}$ = 10V ④ |
| $Q_{sync}$ | Total Gate Charge Sync. ($Q_g$ - $Q_{gd}$) | —— | 93 | | | $I_D$ = 106A, $V_{DS}$ =0V, $V_{GS}$ = 10V |
| $t_{d(on)}$ | Turn-On Delay Time | —— | 21 | —— | ns | $V_{DD}$ = 65V |
| $t_r$ | Rise Time | —— | 86 | —— | | $I_D$ = 106A |
| $t_{d(off)}$ | Turn-Off Delay Time | —— | 100 | —— | | $R_G$ = 2.7Ω |
| $t_f$ | Fall Time | —— | 77 | —— | | $V_{GS}$ = 10V ④ |
| $C_{iss}$ | Input Capacitance | —— | 9575 | —— | pF | $V_{GS}$ = 0V |
| $C_{oss}$ | Output Capacitance | —— | 660 | —— | | $V_{DS}$ = 50V |
| $C_{rss}$ | Reverse Transfer Capacitance | —— | 270 | —— | | $f$ = 1.0MHz See Fig.5 |
| $C_{oss}$ eff. (ER) | Effective Output Capacitance (Energy Related)⑥ | —— | 757 | —— | | $V_{GS}$ = 0V, $V_{DS}$ = 0V to 80V ⑥See Fig.11 |
| $C_{oss}$ eff. (TR) | Effective Output Capacitance (Time Related)⑤ | —— | 1112 | —— | | $V_{GS}$ = 0V, $V_{DS}$ = 0V to 80V ⑤ |

## Diode Characteristics

| Symbol | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| $I_S$ | Continuous Source Current (Body Diode) | —— | —— | 180 | A | MOSFET symbol showing the integral reverse p-n junction diode. |
| $I_{SM}$ | Pulsed Source Current (Body Diode) ① | —— | —— | 720 | | |
| $V_{SD}$ | Diode Forward Voltage | —— | —— | 1.3 | V | $T_J$ = 25°C, $I_S$ = 106A, $V_{GS}$ = 0V ④ |
| $t_{rr}$ | Reverse Recovery Time | —— | 72 | —— | ns | $T_J$ = 25°C    $V_R$ = 85V, |
| | | —— | 81 | —— | | $T_J$ = 125°C    $I_F$ = 106A |
| $Q_{rr}$ | Reverse Recovery Charge | —— | 210 | —— | nC | $T_J$ = 25°C    di/dt = 100A/µs ④ |
| | | —— | 268 | —— | | $T_J$ = 125°C |
| $I_{RRM}$ | Reverse Recovery Current | —— | 5.3 | —— | A | $T_J$ = 25°C |
| $t_{on}$ | Forward Turn-On Time | Intrinsic turn-on time is negligible (turn-on is dominated by LS+LD) | | | | |

**Notes:**

① Repetitive rating; pulse width limited by max. junction temperature.

② Limited by $T_{Jmax}$, starting $T_J$ = 25°C, L = 0.057mH
   $R_G$ = 25Ω, $I_{AS}$ = 106A, $V_{GS}$ =10V. Part not recommended for use above this value .

③ $I_{SD}$ ≤ 106A, di/dt ≤ 1319A/µs, $V_{DD}$ ≤ $V_{(BR)DSS}$, $T_J$ ≤ 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 recommended footprint and soldering echniques refer to application note #AN-994.

⑧ $R_\theta$ is measured at $T_J$ approximately 90°C

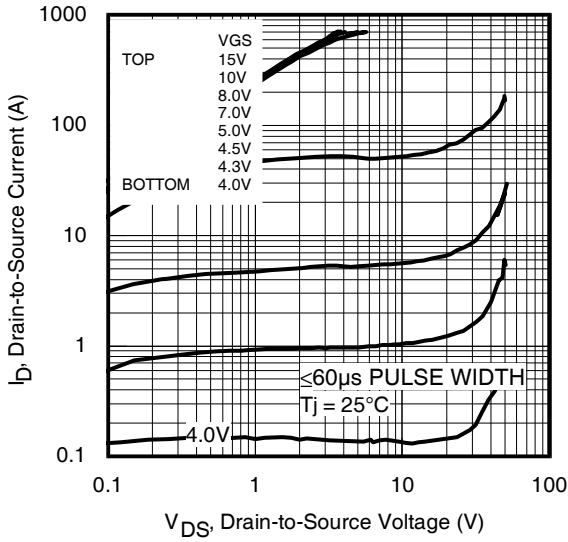⑨ $R_{\theta JC}$ value shown is at time zero

**Fig 1.** Typical Output Characteristics
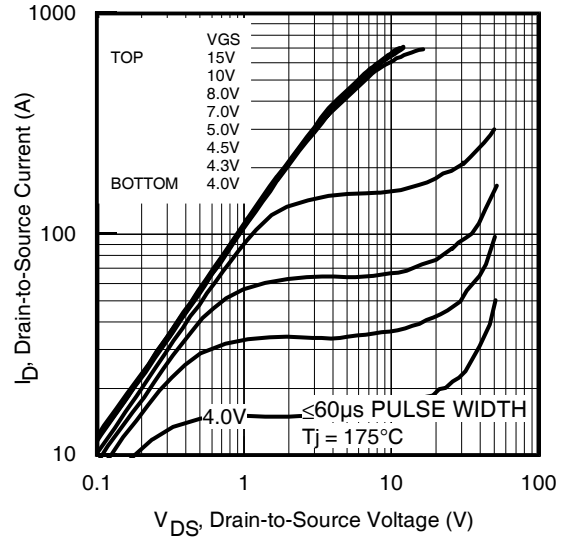


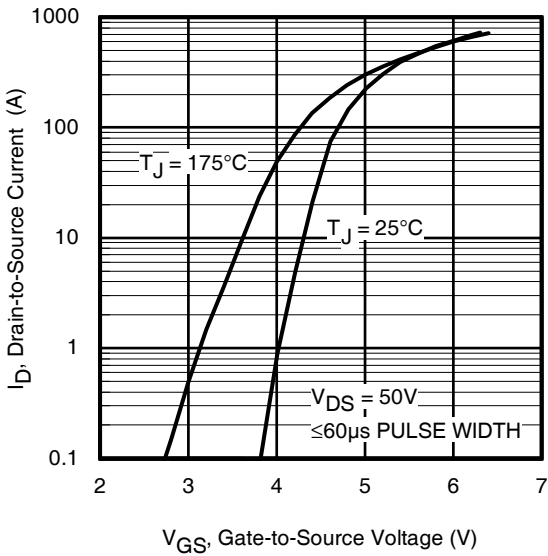**Fig 2.** Typical Output Characteristics



**Fig 3.** Typical Transfer Characteristics
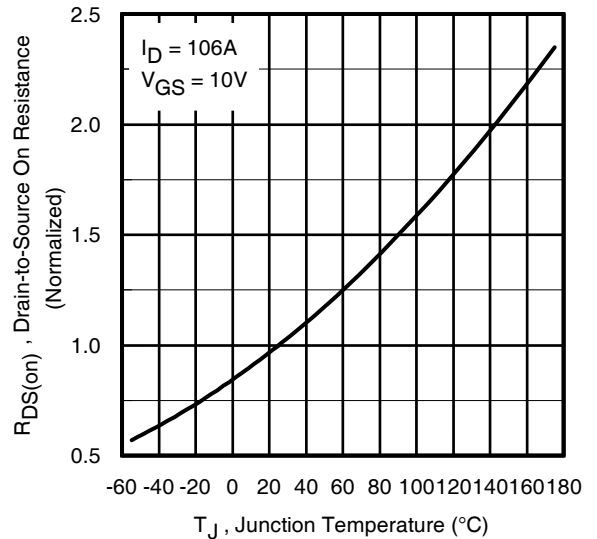


**Fig 4.** Normalized On-Resistance vs. Temperature



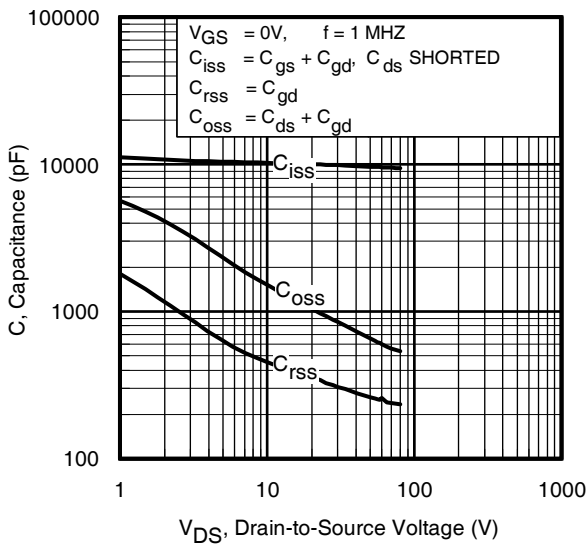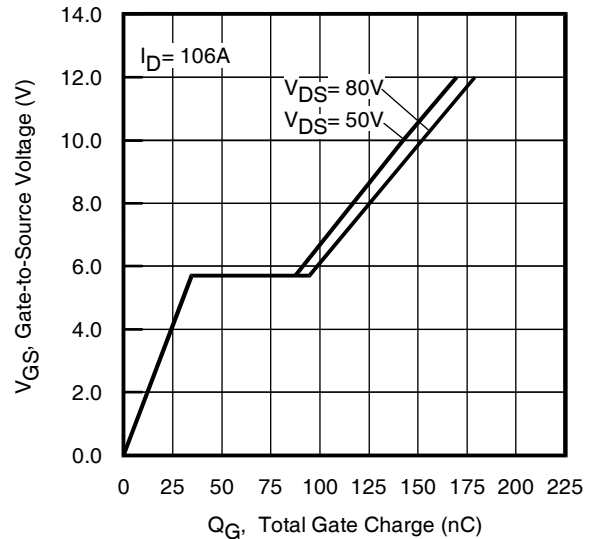**Fig 5.** Typical Capacitance vs. Drain-to-Source Voltage



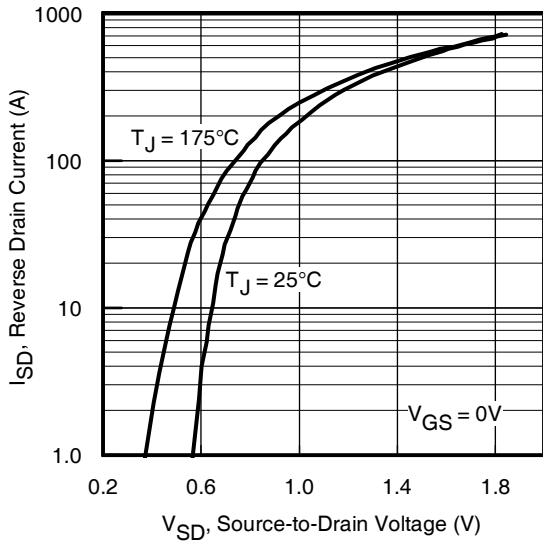**Fig 6.** Typical Gate Charge vs. Gate-to-Source Voltage

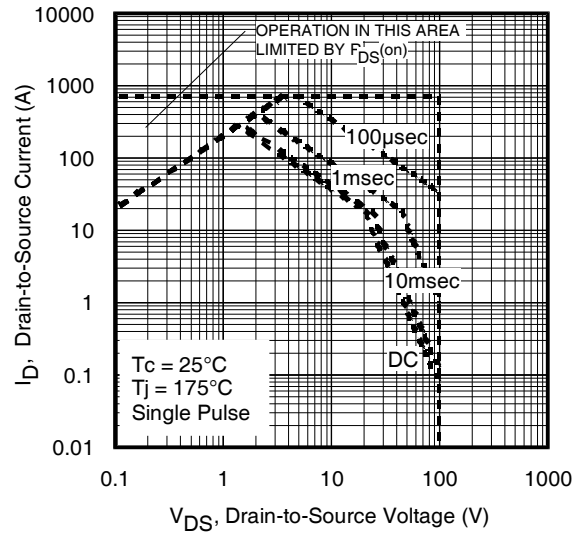Fig 7. Typical Source-Drain Diode Forward Voltage
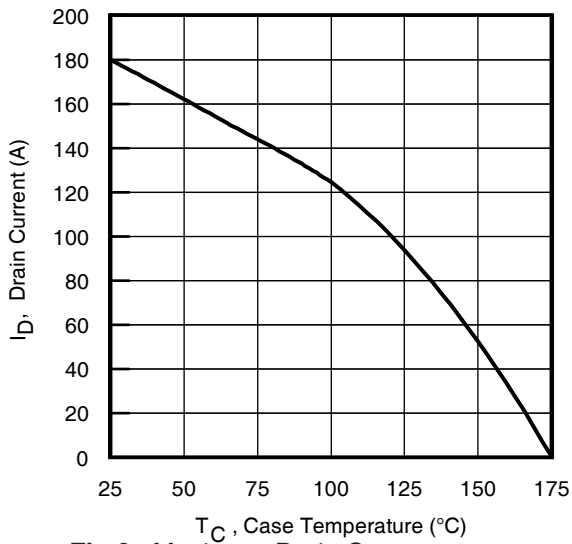
Fig 8. Maximum Safe Operating Area
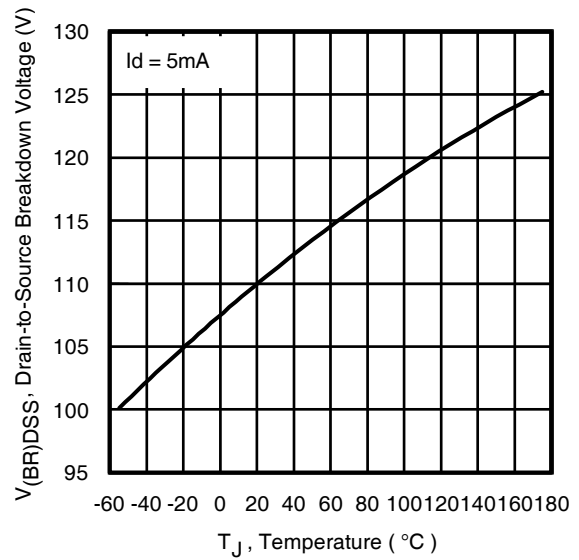
Fig 9. Maximum Drain Current vs. Case Temperature
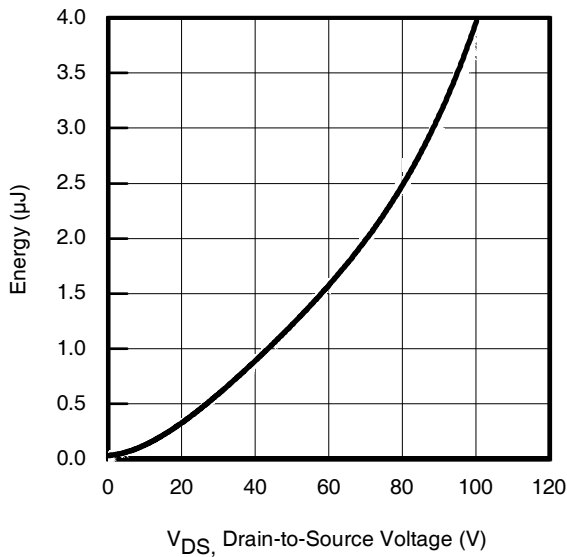
Fig 10. Drain-to-Source Breakdown Voltage

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

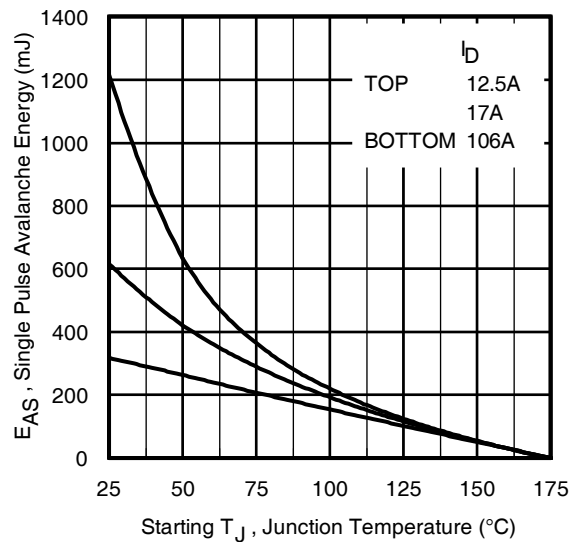Fig 12. Maximum Avalanche Energy vs. DrainCurrent

Table inset in Fig 13:
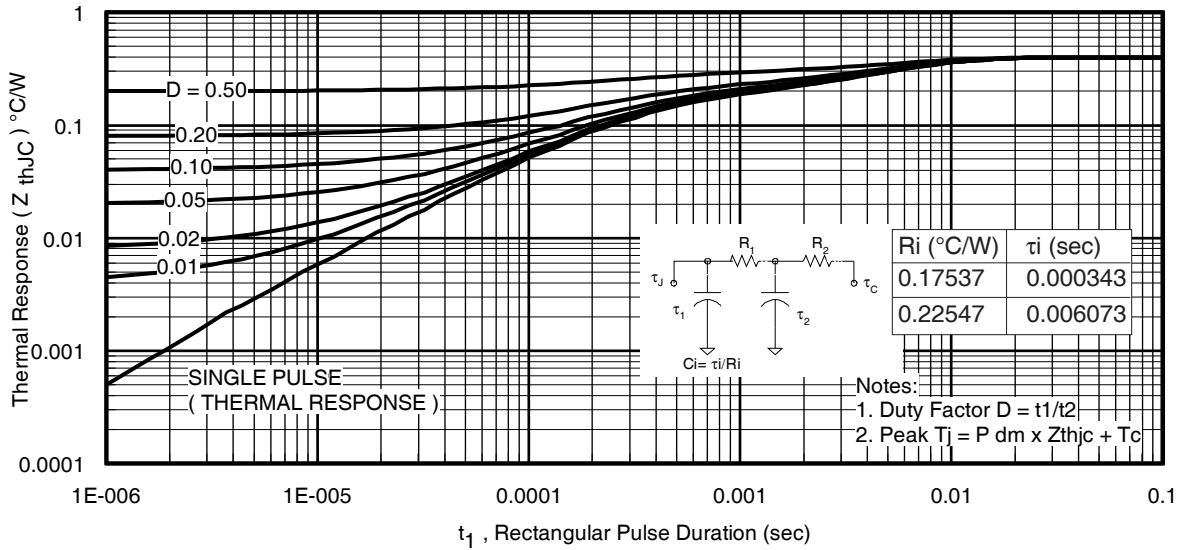
| Ri (°C/W) | τi (sec) |
|-----------|----------|
| 0.17537 | 0.000343 |
| 0.22547 | 0.006073 |

$C_i = \tau_i / R_i$

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

SINGLE PULSE ( THERMAL RESPONSE )

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



Allowed avalanche Current vs avalanche pulsewidth, tav, assuming $\Delta T_j$ = 150°C and Tstart =25°C (Single Pulse)

Allowed avalanche Current vs avalanche pulsewidth, tav, assuming $\Delta T_j$ = 25°C and Tstart = 150°C.

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



TOP      Single Pulse
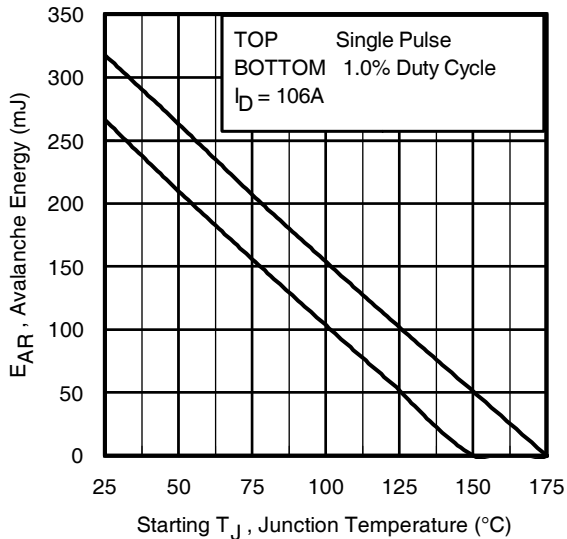BOTTOM  1.0% Duty Cycle
$I_D$ = 106A

**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 22a, 22b.
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)

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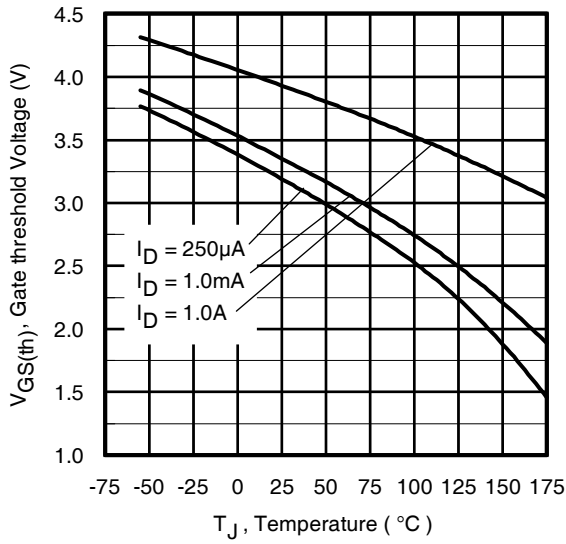$$E_{AS\,(AR)} = P_{D\,(ave)} \cdot t_{av}$$

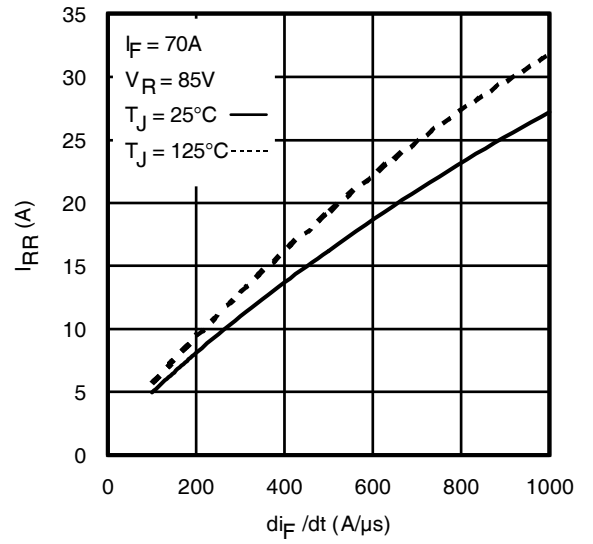**Fig 16.** Threshold Voltage vs. Temperature
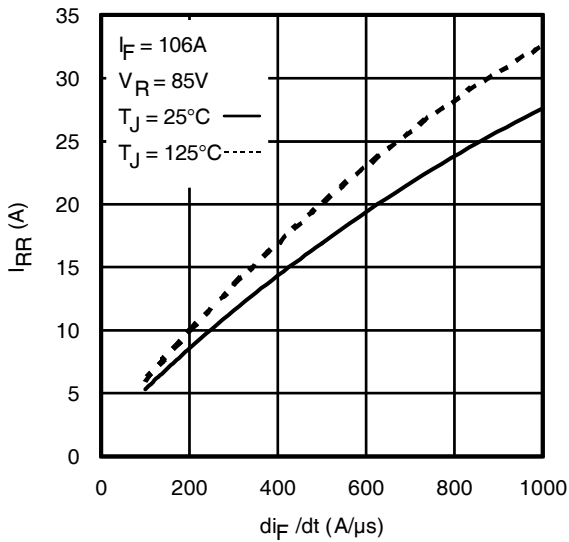


**Fig. 17** - Typical Recovery Current vs. di$_f$/dt
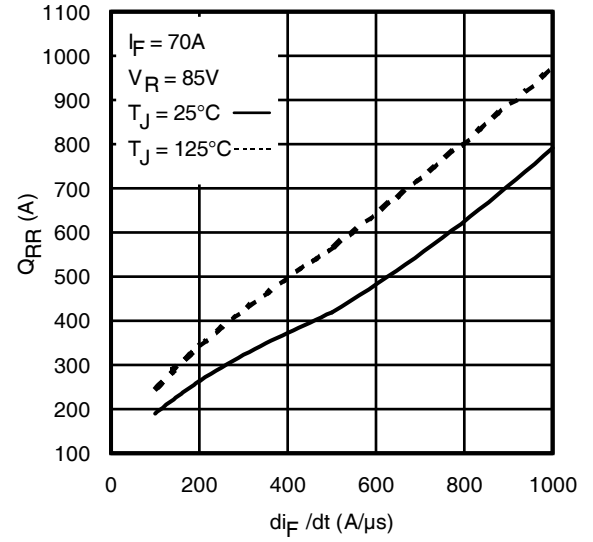


**Fig. 18** - Typical Recovery Current vs. di$_f$/dt
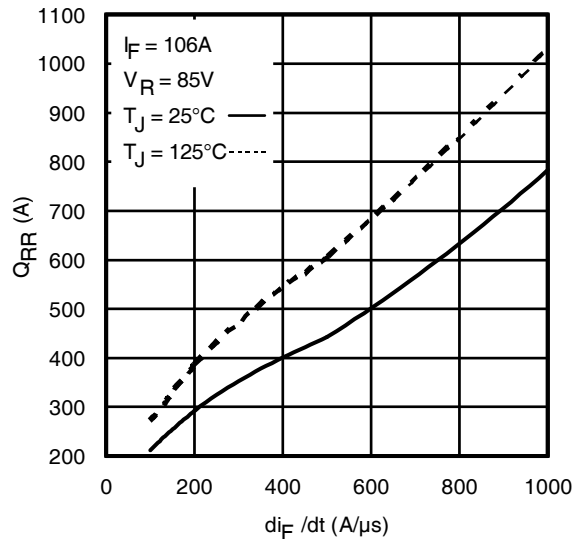


**Fig. 19** - Typical Stored Charge vs. di$_f$/dt
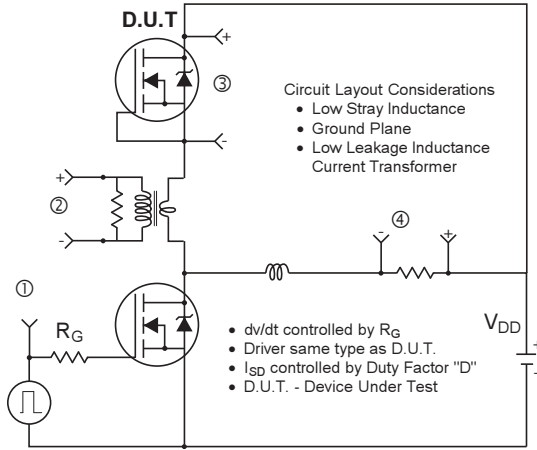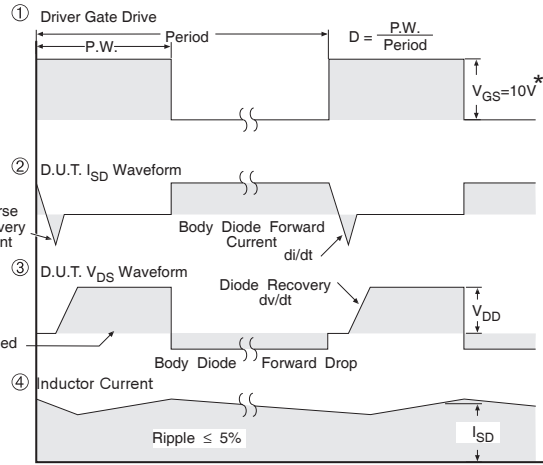


**Fig. 20** - Typical Stored Charge vs. di$_f$/dt

www.irf.com

* $V_{GS}$ = 5V for Logic Level Devices

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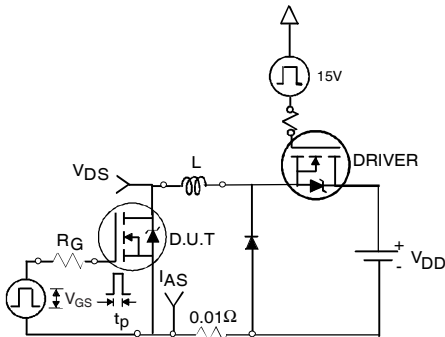HEXFET® Power MOSFETs



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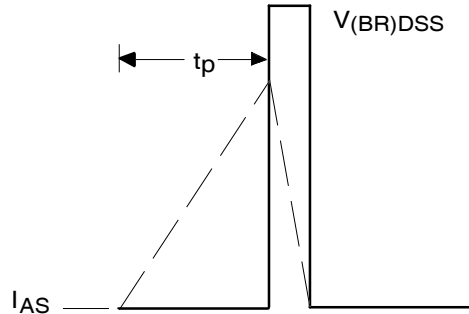


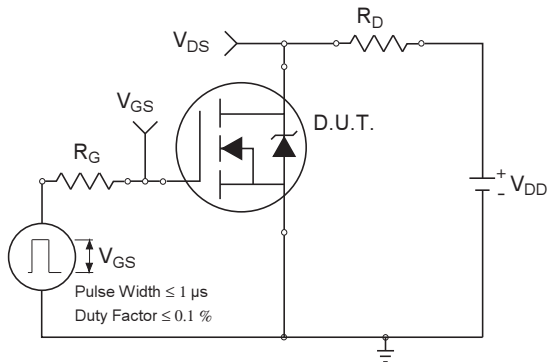**Fig 22b.** Unclamped Inductive Waveforms



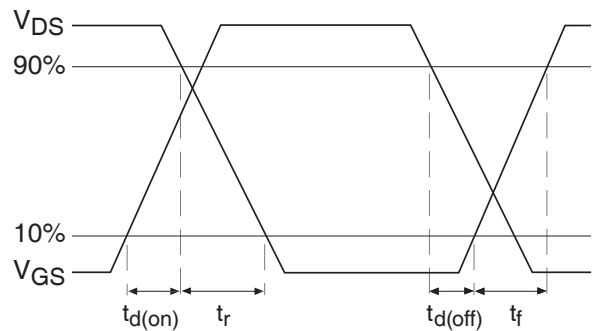**Fig 23a.** Switching Time Test Circuit



**Fig 23b.** Switching Time Waveforms



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



**Fig 24b.** Gate Charge Waveform

International
**IⓇR** Rectifier
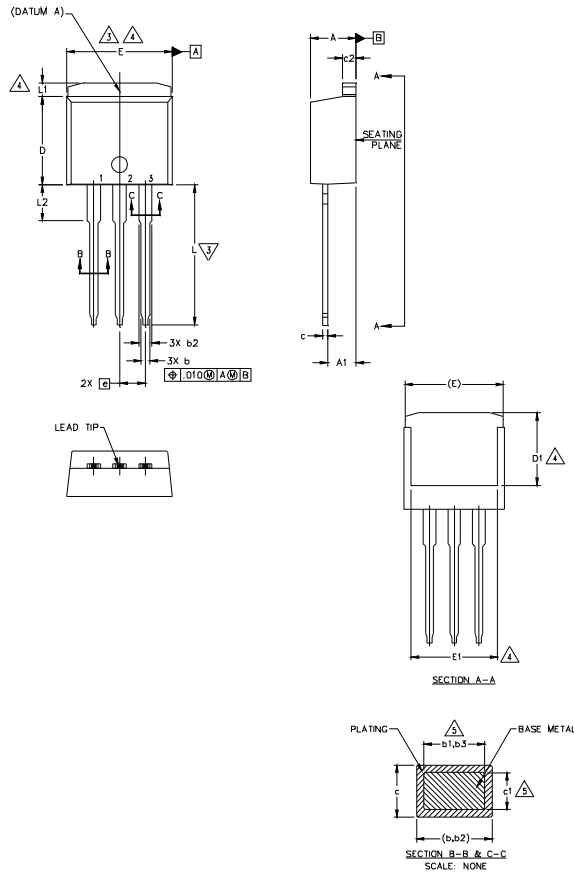
## TO-262 Package Outline

Dimensions are shown in millimeters (inches)



NOTES:

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

2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].

3. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.127 [.005"] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.

4. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSION E, L1, D1 & E1.

5. DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.

6. CONTROLLING DIMENSION: INCH.

7.- OUTLINE CONFORM TO JEDEC TO-262 EXCEPT A1(max.), b(min.) AND D1(min.) WHERE DIMENSIONS DERIVED THE ACTUAL PACKAGE OUTLINE.

| SYMBOL | DIMENSIONS | | | | NOTES |
|---|---|---|---|---|---|
| | MILLIMETERS | | INCHES | | |
| | MIN. | MAX. | MIN. | MAX. | |
| A | 4.06 | 4.83 | .160 | .190 | |
| A1 | 2.03 | 3.02 | .080 | .119 | |
| b | 0.51 | 0.99 | .020 | .039 | |
| b1 | 0.51 | 0.89 | .020 | .035 | 5 |
| b2 | 1.14 | 1.78 | .045 | .070 | |
| b3 | 1.14 | 1.73 | .045 | .068 | 5 |
| c | 0.38 | 0.74 | .015 | .029 | |
| c1 | 0.38 | 0.58 | .015 | .023 | 5 |
| c2 | 1.14 | 1.65 | .045 | .065 | |
| D | 8.38 | 9.65 | .330 | .380 | 3 |
| D1 | 6.86 | – | .270 | – | 4 |
| E | 9.65 | 10.67 | .380 | .420 | 3,4 |
| E1 | 6.22 | – | .245 | – | 4 |
| e | 2.54 BSC | | .100 BSC | | |
| L | 13.46 | 14.10 | .530 | .555 | |
| L1 | – | 1.65 | – | .065 | 4 |
| L2 | 3.56 | 3.71 | .140 | .146 | |

LEAD ASSIGNMENTS

HEXFET

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

IGBTs, CoPACK

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

## TO-262 Part Marking Information

EXAMPLE: THIS IS AN IRL3103L
LOT CODE 1789
ASSEMBLED ON WW 19, 1997
IN THE ASSEMBLY LINE "C"

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



INTERNATIONAL
RECTIFIER
LOGO

PART NUMBER

DATE CODE
YEAR 7 = 1997
WEEK 19
LINE C

ASSEMBLY
LOT CODE

OR



INTERNATIONAL
RECTIFIER
LOGO

PART NUMBER

DATE CODE
P = DESIGNATES LEAD-FREE
     PRODUCT (OPTIONAL)
YEAR 7 = 1997
WEEK 19
A = ASSEMBLY SITE CODE

ASSEMBLY
LOT CODE

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

## D²Pak (TO-263AB) Package Outline

Dimensions are shown in millimeters (inches)



NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M−1994
2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
3. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.127 [.005"] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY AT DATUM H.
4. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSION E, L1, D1 & E1.
5. DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.
6. DATUM A & B TO BE DETERMINED AT DATUM PLANE H.
7. CONTROLLING DIMENSION: INCH.
8. OUTLINE CONFORMS TO JEDEC OUTLINE TO−263AB.

| SYMBOL | DIMENSIONS | | | | NOTES |
|---|---|---|---|---|---|
| | MILLIMETERS | | INCHES | | |
| | MIN. | MAX. | MIN. | MAX. | |
| A | 4.06 | 4.83 | .160 | .190 | |
| A1 | 0.00 | 0.254 | .000 | .010 | |
| b | 0.51 | 0.99 | .020 | .039 | |
| b1 | 0.51 | 0.89 | .020 | .035 | 5 |
| b2 | 1.14 | 1.78 | .045 | .070 | |
| b3 | 1.14 | 1.73 | .045 | .068 | 5 |
| c | 0.38 | 0.74 | .015 | .029 | |
| c1 | 0.38 | 0.58 | .015 | .023 | 5 |
| c2 | 1.14 | 1.65 | .045 | .065 | |
| D | 8.38 | 9.65 | .330 | .380 | 3 |
| D1 | 6.86 | – | .270 | | 4 |
| E | 9.65 | 10.67 | .380 | .420 | 3,4 |
| E1 | 6.22 | – | .245 | | 4 |
| e | 2.54 BSC | | .100 BSC | | |
| H | 14.61 | 15.88 | .575 | .625 | |
| L | 1.78 | 2.79 | .070 | .110 | |
| L1 | – | 1.65 | – | .066 | 4 |
| L2 | 1.27 | 1.78 | – | .070 | |
| L3 | 0.25 BSC | | .010 BSC | | |
| L4 | 4.78 | 5.28 | .188 | .208 | |

LEAD ASSIGNMENTS

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

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

DIODES
1.– ANODE *
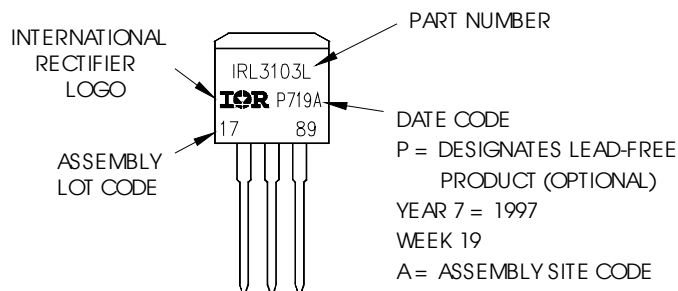2, 4.– CATHODE
3.– ANODE

* PART DEPENDENT.

## D²Pak (TO-263AB) Part Marking Information

EXAMPLE: THIS IS AN IRF530S WITH LOT CODE 8024 ASSEMBLED ON WW 02, 2000 IN THE ASSEMBLY LINE "L"

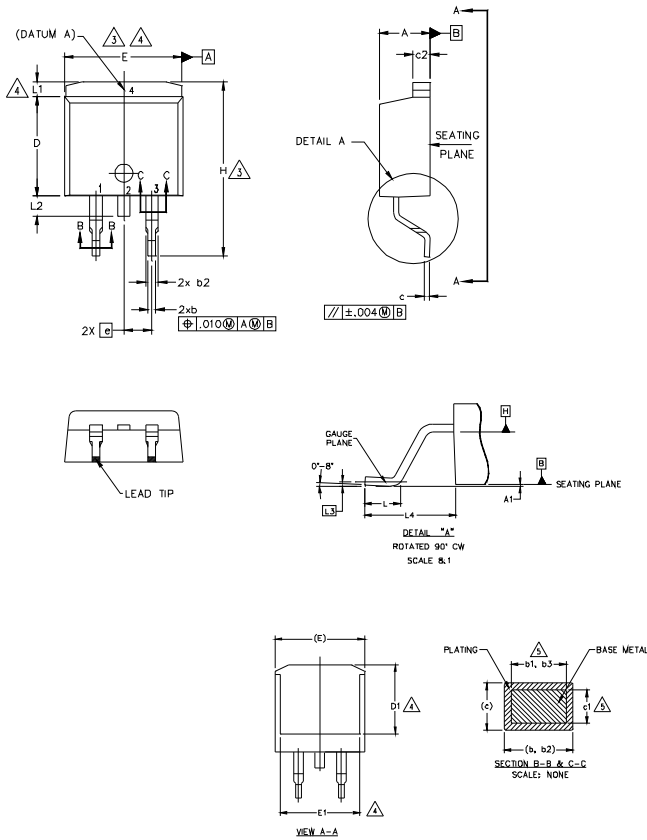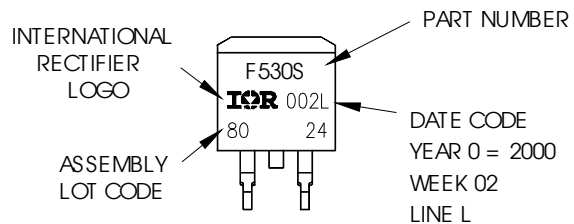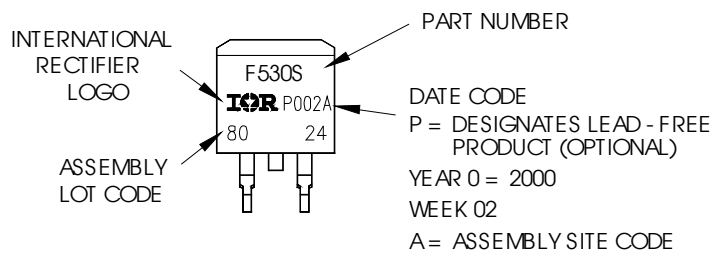Note: "P" in assembly line position indicates "Lead − Free"



INTERNATIONAL RECTIFIER LOGO

PART NUMBER

ASSEMBLY LOT CODE

DATE CODE
YEAR 0 = 2000
WEEK 02
LINE L

OR



INTERNATIONAL RECTIFIER LOGO

PART NUMBER

ASSEMBLY LOT CODE

DATE CODE
P = DESIGNATES LEAD - FREE PRODUCT (OPTIONAL)
YEAR 0 = 2000
WEEK 02
A = ASSEMBLY SITE CODE

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

International
**I☢R** Rectifier

## D²Pak (TO-263AB) Tape & Reel Information
Dimensions are shown in millimeters (inches)

TRR

FEED DIRECTION →

TRL

FEED DIRECTION →

1.60 (.063)
1.50 (.059)

4.10 (.161)
3.90 (.153)

Ø 1.60 (.063)
1.50 (.059)

1.85 (.073)
1.65 (.065)

11.60 (.457)
11.40 (.449)

0.368 (.0145)
0.342 (.0135)

15.42 (.609)
15.22 (.601)

24.30 (.957)
23.90 (.941)

10.90 (.429)
10.70 (.421)

Ø 1.75 (.069)
1.25 (.049)

16.10 (.634)
15.90 (.626)

4.72 (.136)
4.52 (.178)

13.50 (.532)
Ø 12.80 (.504)

27.40 (1.079)
23.90 (.941)

4

Ø 330.00
(14.173)
MAX.

Ø 60.00 (2.362)
MIN.

30.40 (1.197)
MAX.

4

26.40 (1.039)
24.40 (.961)

3

NOTES :
1. COMFORMS TO EIA-418.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION MEASURED @ HUB.
4. INCLUDES FLANGE DISTORTION @ OUTER EDGE.

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

Data and specifications subject to change without notice.
This product has been designed and qualified for the Industrial market.
Qualification Standards can be found on IR's Web site.

International
**I☢R** Rectifier

# X-ON Electronics

Largest Supplier of Electrical and Electronic Components

*Click to view similar products for* MOSFET *category:*

*Click to view products by* Infineon *manufacturer:*

Other Similar products are found below :

614233C  648584F  D2003UK  705463DB  MCH6422-TL-E  FW231A-TL-E  APT5010JFLL  NTNS3A92PZT5G  IRF100S201  JANTX2N5237
2SK2464-TL-E  2SK3818-DL-E  FCA20N60_F109  FDZ595PZ  STD6600NT4G  FQD4P40TM_AM002  FSS804-TL-E  FW217A-TL-2W
APT10050JVFR  2SJ277-DL-E  2SK1691-DL-E  2SK2545(Q,T)  D1014UK  D2294UK  405094E  423220D  MCH6646-TL-E  TPCC8103,L1Q(CM
IRF3710  367-8430-0972-503  VN1206L  424134F  026935X  051075F  SBVS138LT1G  614234A  715780A  NTNS3166NZT5G  751625C  873612G
IPS70R2K0CEAKMA1  APT8015JVFR  APT50M85JVR  APT5010JVFR  APT12031JFLL  APT12040JVR  NTE6400  NVC3S5A51PLZT1G
JANTX2N6796U  JANTX2N6784U