International
IOR Rectifier

PD- 95537

**SMPS MOSFET**

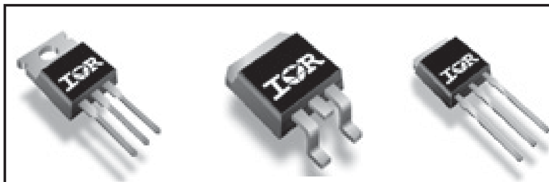
# IRFB33N15DPbF
# IRFS33N15DPbF
# IRFSL33N15DPbF

HEXFET® Power MOSFET

### Applications
- High frequency DC-DC converters
- Lead-Free

| $V_{DSS}$ | $R_{DS(on)}$ max | $I_D$ |
|---|---|---|
| **150V** | **0.056Ω** | **33A** |

### Benefits
- Low Gate-to-Drain Charge to Reduce Switching Losses
- Fully Characterized Capacitance Including Effective $C_{OSS}$ to Simplify Design, (See App. Note AN1001)
- Fully Characterized Avalanche Voltage and Current



| TO-220AB | $D^2$Pak | TO-262 |
|---|---|---|
| IRFB33N15D | IRFS33N15D | IRFSL33N15D |

### Absolute Maximum Ratings

| | 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 | 130 | |
| $P_D$ @$T_A$ = 25°C | Power Dissipation ⑦ | 3.8 | W |
| $P_D$ @$T_C$ = 25°C | Power Dissipation | 170 | |
| | Linear Derating Factor | 1.1 | W/°C |
| $V_{GS}$ | Gate-to-Source Voltage | ± 30 | V |
| dv/dt | Peak Diode Recovery dv/dt ③ | 4.4 | V/ns |
| $T_J$ | Operating Junction and | -55 to + 175 | °C |
| $T_{STG}$ | Storage Temperature Range | | |
| | Soldering Temperature, for 10 seconds | 300 (1.6mm from case ) | |
| | Mounting torqe, 6-32 or M3 screw⑥ | 10 lbf•in (1.1N•m) | |

### Typical SMPS Topologies

- Telecom 48V input Active Clamp Forward Converter

Notes ① through ⑦ are on page 11



7/21/04

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

| | 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 | ––– | 0.18 | ––– | V/°C | Reference to 25°C, $I_D$ = 1mA ⑥ |
| $R_{DS(on)}$ | Static Drain-to-Source On-Resistance | ––– | ––– | 0.056 | Ω | $V_{GS}$ = 10V, $I_D$ = 20A ④ |
| $V_{GS(th)}$ | Gate Threshold Voltage | 3.0 | ––– | 5.5 | V | $V_{DS}$ = $V_{GS}$, $I_D$ = 250μA |
| $I_{DSS}$ | Drain-to-Source Leakage Current | ––– | ––– | 25 | μA | $V_{DS}$ = 150V, $V_{GS}$ = 0V |
| | | ––– | ––– | 250 | | $V_{DS}$ = 120V, $V_{GS}$ = 0V, $T_J$ = 150°C |
| $I_{GSS}$ | Gate-to-Source Forward Leakage | ––– | ––– | 100 | nA | $V_{GS}$ = 30V |
| | Gate-to-Source Reverse Leakage | ––– | ––– | -100 | | $V_{GS}$ = -30V |

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

| | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| $g_{fs}$ | Forward Transconductance | 14 | ––– | ––– | S | $V_{DS}$ = 50V, $I_D$ = 20A |
| $Q_g$ | Total Gate Charge | ––– | 60 | 90 | nC | $I_D$ = 20A |
| $Q_{gs}$ | Gate-to-Source Charge | ––– | 17 | 26 | | $V_{DS}$ = 120V |
| $Q_{gd}$ | Gate-to-Drain ("Miller") Charge | ––– | 27 | 41 | | $V_{GS}$ = 10V, ④⑥ |
| $t_{d(on)}$ | Turn-On Delay Time | ––– | 13 | ––– | ns | $V_{DD}$ = 75V |
| $t_r$ | Rise Time | ––– | 38 | ––– | | $I_D$ = 20A |
| $t_{d(off)}$ | Turn-Off Delay Time | ––– | 23 | ––– | | $R_G$ = 3.6Ω |
| $t_f$ | Fall Time | ––– | 21 | ––– | | $V_{GS}$ = 10VΩ ④ |
| $C_{iss}$ | Input Capacitance | ––– | 2020 | ––– | pF | $V_{GS}$ = 0V |
| $C_{oss}$ | Output Capacitance | ––– | 400 | ––– | | $V_{DS}$ = 25V |
| $C_{rss}$ | Reverse Transfer Capacitance | ––– | 91 | ––– | | ƒ = 1.0MHz⑥ |
| $C_{oss}$ | Output Capacitance | ––– | 2440 | ––– | | $V_{GS}$ = 0V, $V_{DS}$ = 1.0V, ƒ = 1.0MHz |
| $C_{oss}$ | Output Capacitance | ––– | 180 | ––– | | $V_{GS}$ = 0V, $V_{DS}$ = 120V, ƒ = 1.0MHz |
| $C_{oss}$ eff. | Effective Output Capacitance | ––– | 320 | ––– | | $V_{GS}$ = 0V, $V_{DS}$ = 0V to 120V ⑤ |

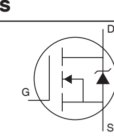
## Avalanche Characteristics

| | Parameter | Typ. | Max. | Units |
|---|---|---|---|---|
| $E_{AS}$ | Single Pulse Avalanche Energy②⑥ | ––– | 330 | mJ |
| $I_{AR}$ | Avalanche Current① | ––– | 20 | A |
| $E_{AR}$ | Repetitive Avalanche Energy① | ––– | 17 | mJ |

## Thermal Resistance

| | Parameter | Typ. | Max. | Units |
|---|---|---|---|---|
| $R_{\theta JC}$ | Junction-to-Case | ––– | 0.90 | °C/W |
| $R_{\theta CS}$ | Case-to-Sink, Flat, Greased Surface ⑥ | 0.50 | ––– | |
| $R_{\theta JA}$ | Junction-to-Ambient⑥ | ––– | 62 | |
| $R_{\theta JA}$ | Junction-to-Ambient⑦ | ––– | 40 | |

## Diode Characteristics

| | 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) ①⑥ | ––– | ––– | 130 | | |
| $V_{SD}$ | Diode Forward Voltage | ––– | ––– | 1.3 | V | $T_J$ = 25°C, $I_S$ = 20A, $V_{GS}$ = 0V ④ |
| $t_{rr}$ | Reverse Recovery Time | ––– | 150 | ––– | ns | $T_J$ = 25°C, $I_F$ = 20A |
| $Q_{rr}$ | Reverse RecoveryCharge | ––– | 920 | ––– | nC | di/dt = 100A/μs ④ |
| $t_{on}$ | Forward Turn-On Time | Intrinsic turn-on time is negligible (turn-on is dominated by $L_S$+$L_D$) | | | | |

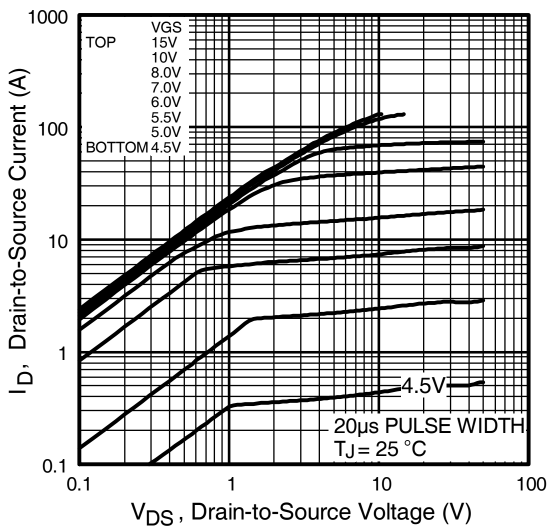



**Fig 1.** Typical Output Characteristics

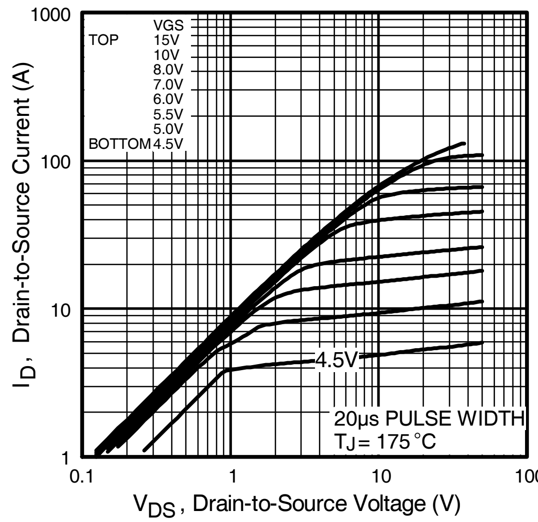



**Fig 2.** Typical Output Characteristics

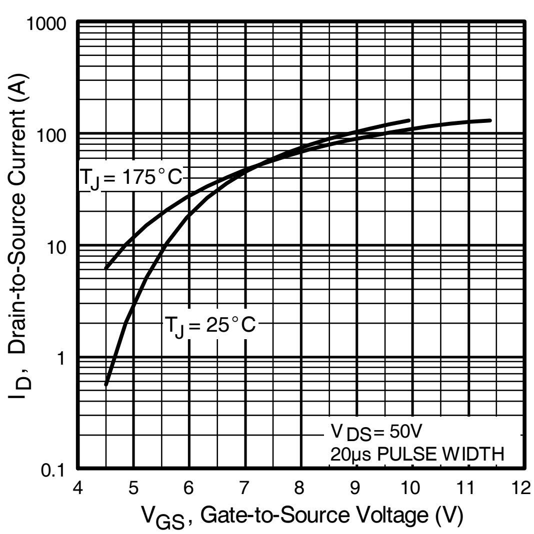



**Fig 3.** Typical Transfer Characteristics

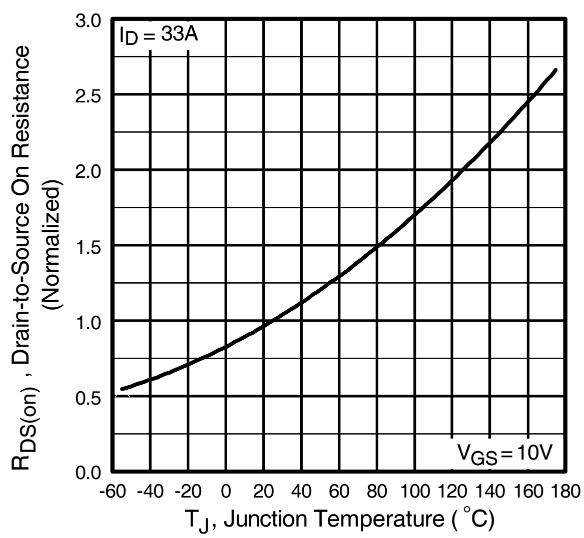



**Fig 4.** Normalized On-Resistance
Vs. Temperature

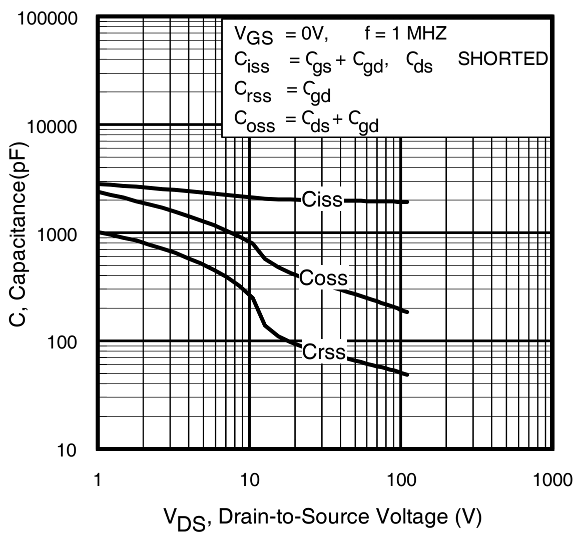



**Fig 5.** Typical Capacitance Vs. Drain-to-Source Voltage

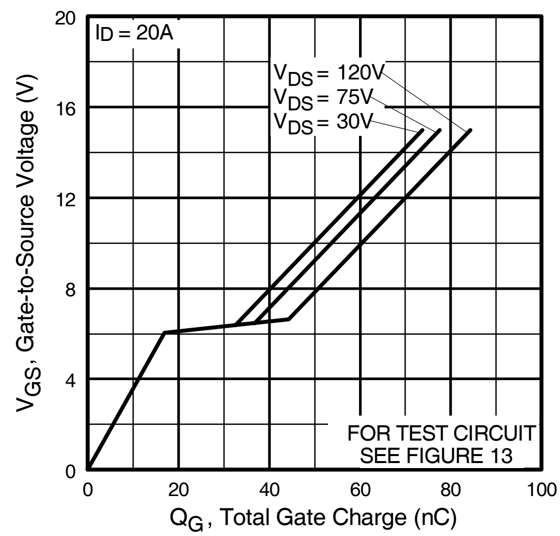



**Fig 6.** Typical Gate Charge Vs. Gate-to-Source Voltage

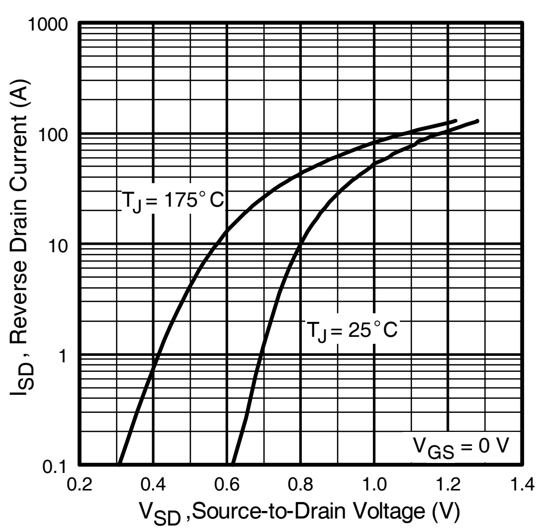



**Fig 7.** Typical Source-Drain Diode Forward Voltage

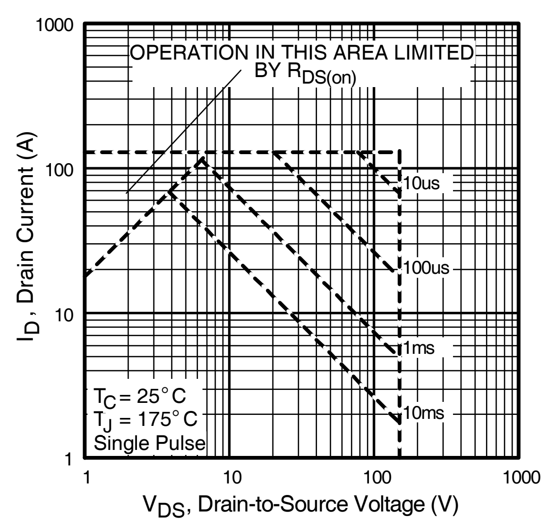



**Fig 8.** Maximum Safe Operating Area

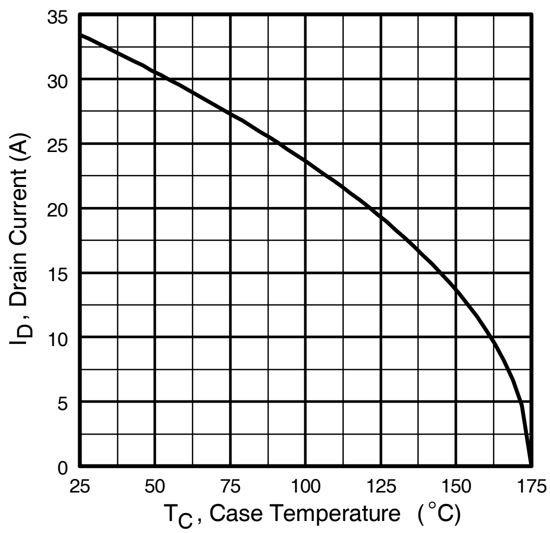



**Fig 9.** Maximum Drain Current Vs. Case Temperature

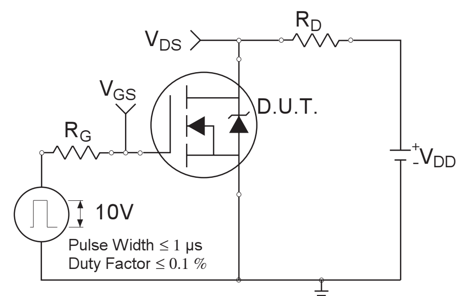



**Fig 10a.** Switching Time Test Circuit

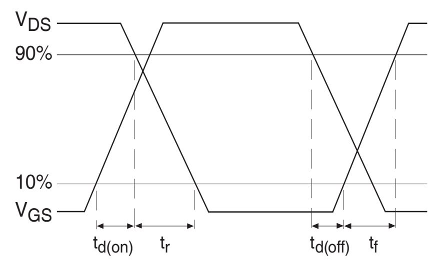



**Fig 10b.** Switching Time Waveforms

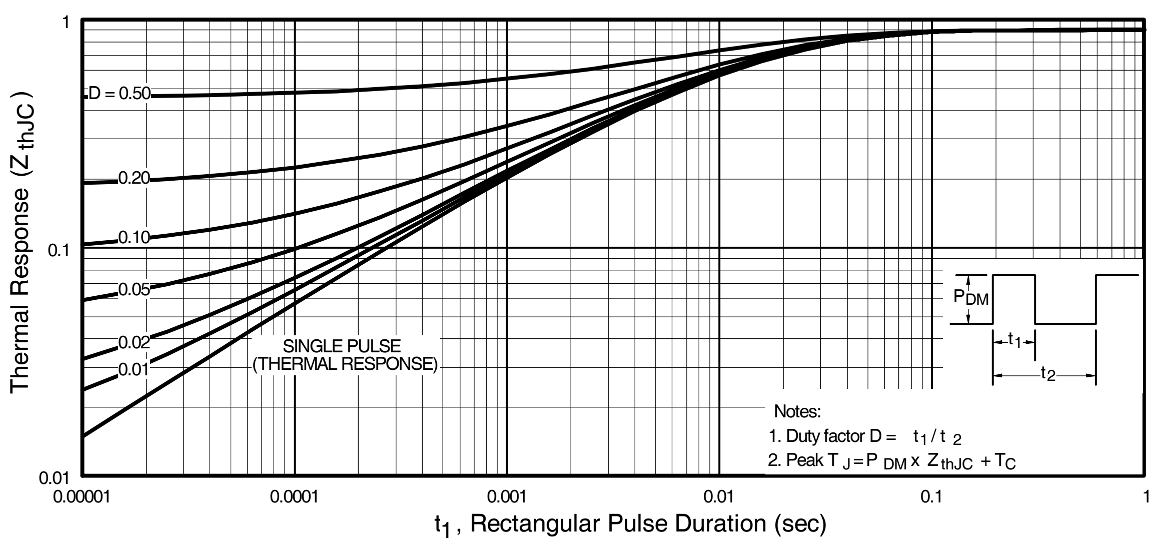



**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case

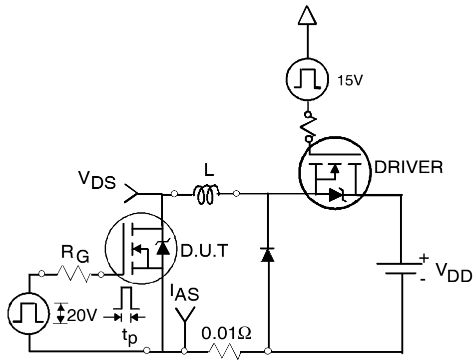



**Fig 12a.** Unclamped Inductive Test Circuit

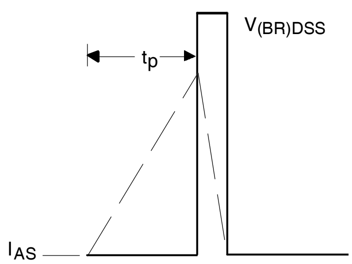



**Fig 12b.** Unclamped Inductive Waveforms

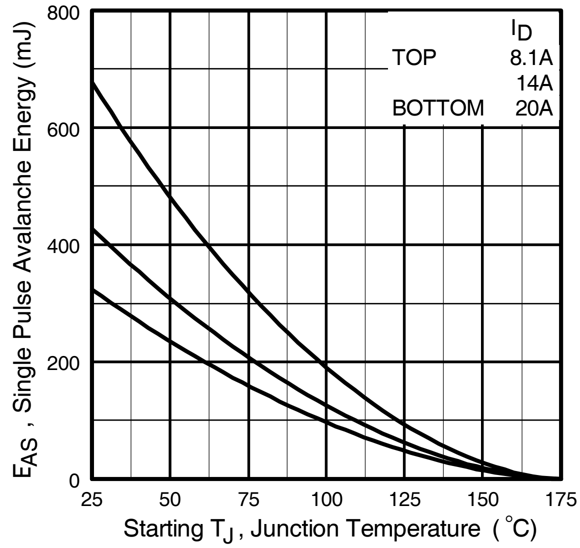



**Fig 12c.** Maximum Avalanche Energy
Vs. Drain Current

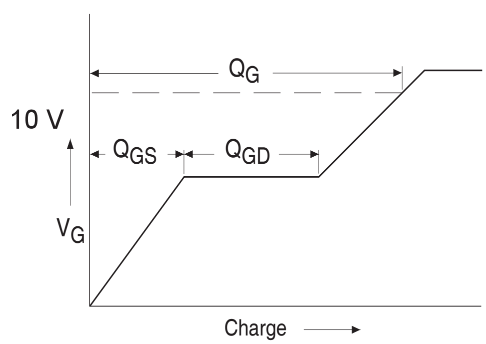



**Fig 13a.** Basic Gate Charge Waveform

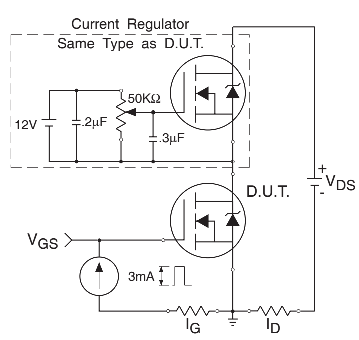
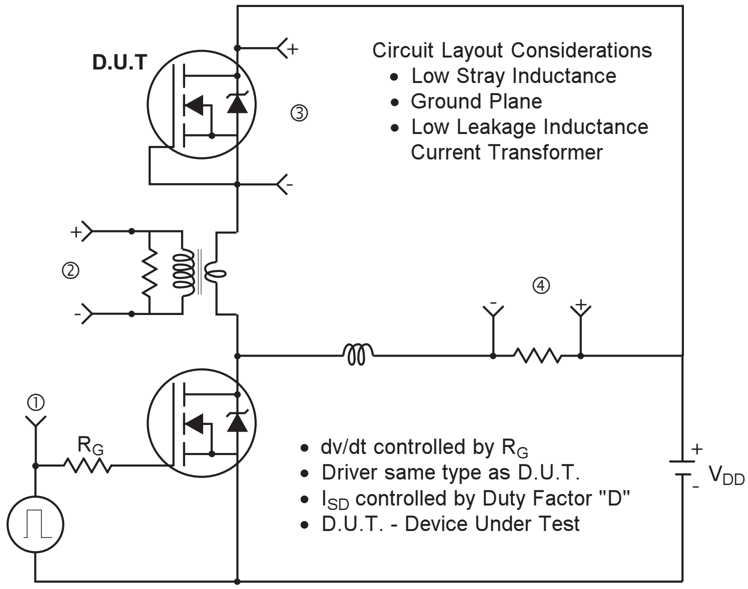
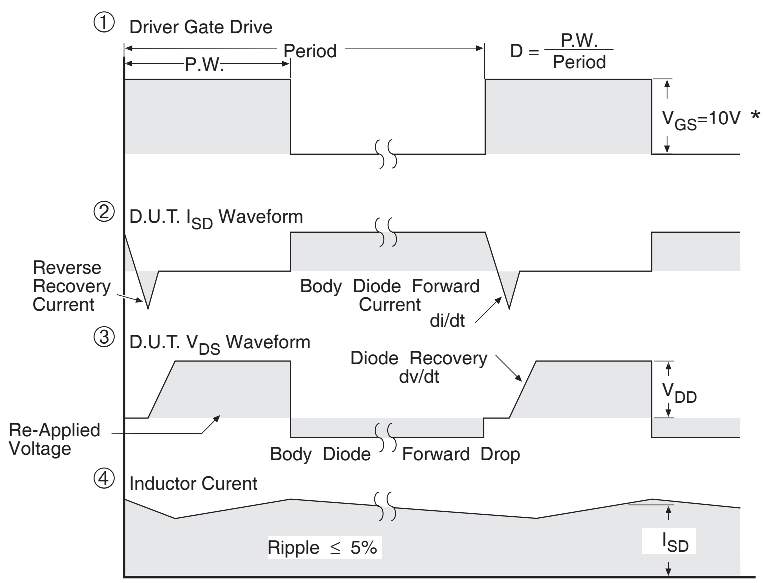



**Fig 13b.** Gate Charge Test Circuit

## Peak Diode Recovery dv/dt Test Circuit



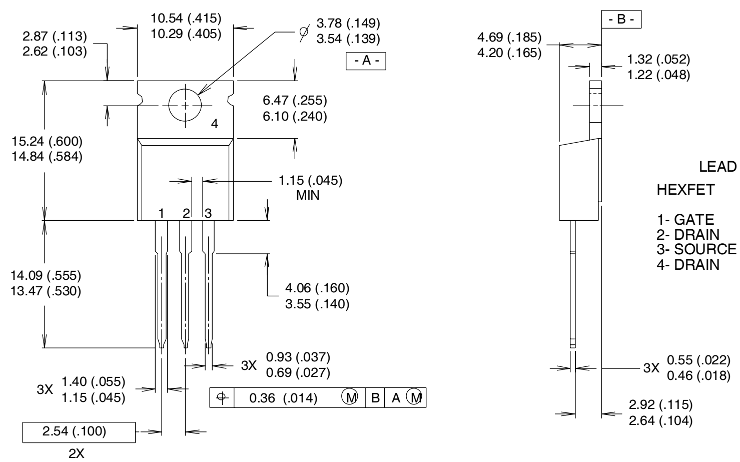




* $V_{GS}$ = 5V for Logic Level Devices

**Fig 14.** For N-Channel HEXFET® Power MOSFETs

## TO-220AB Package Outline

Dimensions are shown in millimeters (inches)




LEAD ASSIGNMENTS

| HEXFET | IGBTs, CoPACK |
|---|---|
| 1- GATE | 1- GATE |
| 2- DRAIN | 2- COLLECTOR |
| 3- SOURCE | 3- EMITTER |
| 4- DRAIN | 4- COLLECTOR |

NOTES:

1 DIMENSIONING & TOLERANCING PER ANSI Y14.5M, 1982.

2 CONTROLLING DIMENSION : INCH

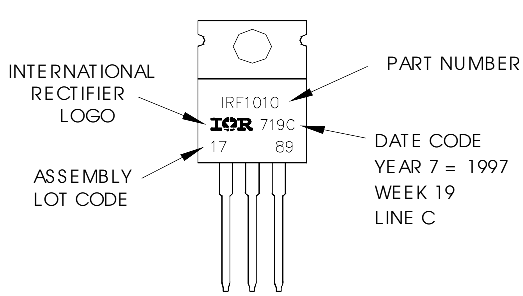
3 OUTLINE CONFORMS TO JEDEC OUTLINE TO-220AB.

4 HEATSINK & LEAD MEASUREMENTS DO NOT INCLUDE BURRS.

## TO-220AB Part Marking Information

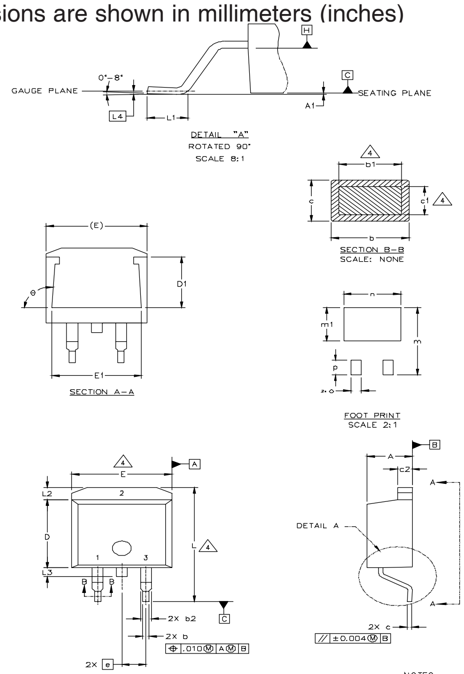
EXAMPLE: THIS IS AN IRF1010
LOT CODE 1789
ASSEMBLED ON WW 19, 1997
IN THE ASSEMBLY LINE "C"

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



## D2Pak Package Outline

Dimensions are shown in millimeters (inches)

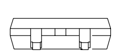



| SYMBOL | DIMENSIONS | | | | NOTES |
|---|---|---|---|---|---|
| | MILLIMETERS | | INCHES | | |
| | MIN. | MAX. | MIN. | MAX. | |
| A | 4.06 | 4.83 | .160 | .190 | |
| A1 | | 0.127 | | .005 | |
| b | 0.51 | 0.99 | .020 | .039 | |
| b1 | 0.51 | 0.89 | .020 | .035 | 4 |
| b2 | 1.14 | 1.40 | .045 | .055 | |
| c | 0.43 | 0.63 | .017 | .025 | |
| c1 | 0.38 | 0.74 | .015 | .029 | 4 |
| c2 | 1.14 | 1.40 | .045 | .055 | |
| D | 8.51 | 9.65 | .335 | .380 | 3 |
| D1 | 5.33 | | .210 | | |
| E | 9.65 | 10.67 | .380 | .420 | 3 |
| E1 | 6.22 | | .245 | | |
| e | 2.54 BSC | | .100 BSC | | |
| L | 14.61 | 15.88 | .575 | .625 | |
| L1 | 1.78 | 2.79 | .070 | .110 | |
| L2 | | 1.65 | | .065 | |
| L3 | 1.27 | 1.78 | .050 | .070 | |
| L4 | 0.25 BSC | | .010 BSC | | |
| m | 17.78 | | .700 | | |
| m1 | 8.89 | | .350 | | |
| n | 11.43 | | .450 | | |
| o | 2.08 | | .082 | | |
| p | 3.81 | | .150 | | |
| θ | 90° | 93° | 90° | 93° | |

LEAD ASSIGNMENTS

| HEXFET | IGBTs, CoPACK | DIODES |
|---|---|---|
| 1.- GATE | 1.- GATE | 1.- ANODE * |
| 2.- DRAIN | 2.- COLLECTOR | 2.- CATHODE |
| 3.- SOURCE | 3.- EMITTER | 3.- ANODE |

* PART DEPENDENT.

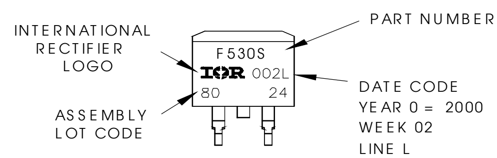


NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
3. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.127 [.005"] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
4. DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.
5. CONTROLLING DIMENSION: INCH.

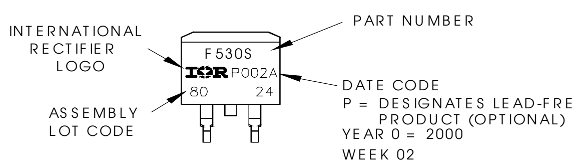
## D2Pak Part Marking Information (Lead-Free)

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

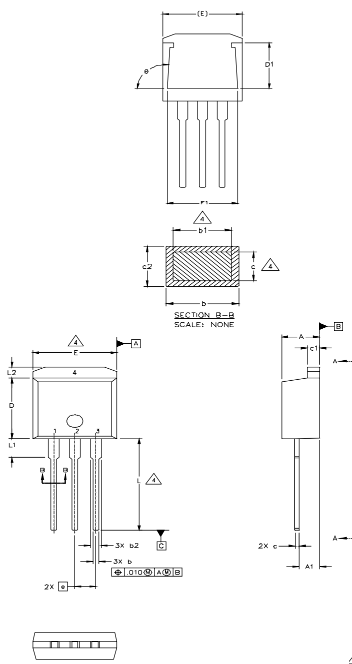
Note: "P" in assembly line position indicates "Lead-Free"




OR



## TO-262 Package Outline




| SYMBOL | DIMENSIONS | | | | NOTES |
|---|---|---|---|---|---|
| | MILLIMETERS | | INCHES | | |
| | MIN. | MAX. | MIN. | MAX. | |
| A | 4.06 | 4.83 | .160 | .190 | |
| A1 | 2.03 | 2.92 | .080 | .115 | |
| b | 0.51 | 0.99 | .020 | .039 | |
| b1 | 0.51 | 0.89 | .020 | .035 | 4 |
| b2 | 1.14 | 1.40 | .045 | .055 | |
| c | 0.38 | 0.63 | .015 | .025 | 4 |
| c1 | 1.14 | 1.40 | .045 | .055 | |
| c2 | 0.43 | .063 | .017 | .029 | |
| D | 8.51 | 9.65 | .335 | .380 | 3 |
| D1 | 5.33 | | .210 | | |
| E | 9.65 | 10.67 | .380 | .420 | 3 |
| E1 | 6.22 | | .245 | | |
| e | 2.54 BSC | | .100 BSC | | |
| L | 13.46 | 14.09 | .530 | .555 | |
| L1 | 3.56 | 3.71 | .140 | .146 | |
| L2 | | 1.65 | | .065 | |

LEAD ASSIGNMENTS

HEXFET

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

IGBT

1 - GATE
2 - COLLECTOR
3 - EMITTER

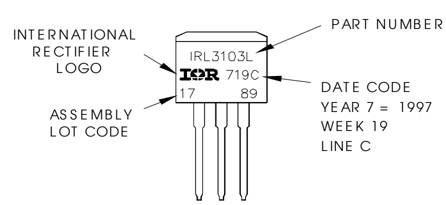
NOTES:

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. DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.
5. CONTROLLING DIMENSION: INCH.

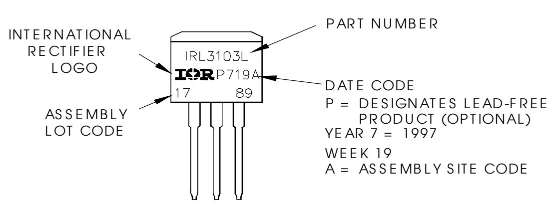
## TO-262 Part Marking Information

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

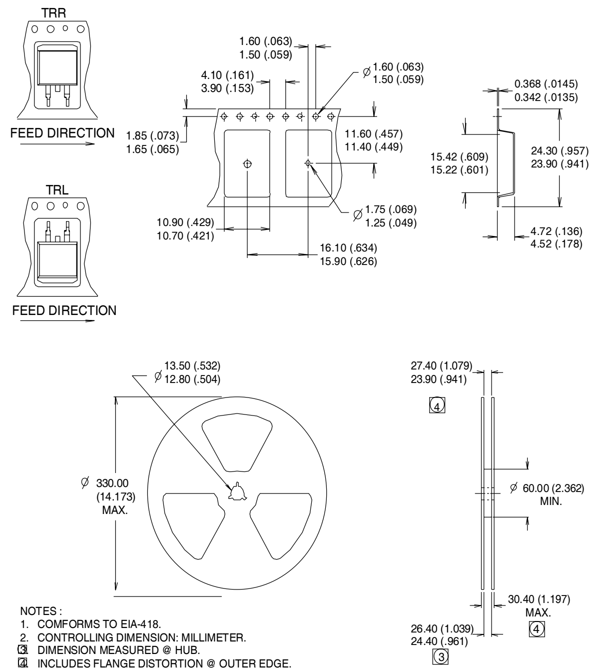
Note: "P" in assembly line position indicates "Lead-Free"




OR



## D²Pak Tape & Reel Infomation




**Notes:**

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

② Starting $T_J$ = 25°C, L = 1.7mH $R_G$ = 25Ω, $I_{AS}$ = 20A.

③ $I_{SD} \leq$ 20A, di/dt ≤ 280A/μs, $V_{DD} \leq V_{(BR)DSS}$, $T_J \leq$ 175°C

④ Pulse width ≤ 300μs; duty cycle ≤ 2%.

⑤ $C_{oss}$ eff. is a fixed capacitance that gives the same charging time as $C_{oss}$ while $V_{DS}$ is rising from 0 to 80% $V_{DSS}$

⑥ This is only applied to TO-220AB package

⑦ This is applied to D²Pak, when mounted on 1" square PCB ( FR-4 or G-10 Material ).
For recommended footprint and soldering techniques refer to application note #AN-994.

Data and specifications subject to change without notice.

International
IOR Rectifier

**IR WORLD HEADQUARTERS:** 233 Kansas St., El Segundo, California 90245, USA Tel: (310) 252-7105
TAC Fax: (310) 252-7903
Visit us at www.irf.com for sales contact information.07/04

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