

# AUIRFS4410Z AUIRFSL4410Z

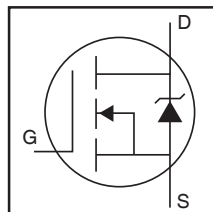
## Features

- Advanced Process Technology
- Ultra Low On-Resistance
- 175°C Operating Temperature
- Fast Switching
- Repetitive Avalanche Allowed up to  $T_{jmax}$
- Lead-Free, RoHS Compliant
- Automotive Qualified \*

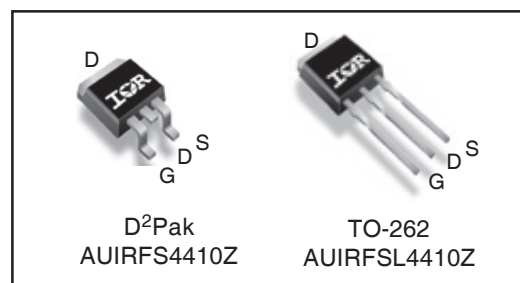
## Description

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.

HEXFET® Power MOSFET



|              |      |              |
|--------------|------|--------------|
| $V_{DSS}$    |      | <b>100V</b>  |
| $R_{DS(on)}$ | typ. | <b>7.2mΩ</b> |
|              | max. | <b>9.0mΩ</b> |
| $I_D$        |      | <b>97A</b>   |



|          |          |          |
|----------|----------|----------|
| <b>G</b> | <b>D</b> | <b>S</b> |
| Gate     | Drain    | Source   |

## Absolute Maximum Ratings

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only; and functional operation of the device at these or any other condition beyond those indicated in the specifications is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability. The thermal resistance and power dissipation ratings are measured under board mounted and still air conditions. Ambient temperature ( $T_A$ ) is 25°C, unless otherwise specified.

|                                   | Parameter                                                  | Max.                       | Units |
|-----------------------------------|------------------------------------------------------------|----------------------------|-------|
| $I_D$ @ $T_C = 25^\circ\text{C}$  | Continuous Drain Current, $V_{GS}$ @ 10V                   | 97                         | A     |
| $I_D$ @ $T_C = 100^\circ\text{C}$ | Continuous Drain Current, $V_{GS}$ @ 10V                   | 69                         |       |
| $I_{DM}$                          | Pulsed Drain Current ①                                     | 390                        |       |
| $P_D$ @ $T_C = 25^\circ\text{C}$  | Maximum Power Dissipation                                  | 230                        | W     |
|                                   | Linear Derating Factor                                     | 1.5                        | W/°C  |
| $V_{GS}$                          | Gate-to-Source Voltage                                     | ± 20                       | V     |
| $dv/dt$                           | Peak Diode Recovery ③                                      | 16                         | V/ns  |
| $E_{AS}$ (Thermally limited)      | Single Pulse Avalanche Energy ②                            | 242                        | mJ    |
| $I_{AR}$                          | Avalanche Current                                          | See Fig. 14, 15, 22a, 22b, | A     |
| $E_{AR}$                          | Repetitive Avalanche Energy ④                              |                            | mJ    |
| $T_J$<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                        |       |

## Thermal Resistance

|                 | Parameter                                 | Typ. | Max. | Units |
|-----------------|-------------------------------------------|------|------|-------|
| $R_{\theta JC}$ | Junction-to-Case ⑤                        | —    | 0.65 | °C/W  |
| $R_{\theta JA}$ | Junction-to-Ambient (PCB Mount) , D²Pak ⑥ | —    | 40   |       |

HEXFET® is a registered trademark of International Rectifier.

\*Qualification standards can be found at <http://www.irf.com/>

**Static Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)**

|                                 | Parameter                            | Min. | Typ. | Max. | Units               | Conditions                                           |
|---------------------------------|--------------------------------------|------|------|------|---------------------|------------------------------------------------------|
| $V_{(BR)DSS}$                   | Drain-to-Source Breakdown Voltage    | 100  | —    | —    | V                   | $V_{GS} = 0V, I_D = 250\mu A$                        |
| $\Delta V_{(BR)DSS}/\Delta T_J$ | Breakdown Voltage Temp. Coefficient  | —    | 0.12 | —    | V/ $^\circ\text{C}$ | Reference to $25^\circ\text{C}$ , $I_D = 5mA$ ①      |
| $R_{DS(on)}$                    | Static Drain-to-Source On-Resistance | —    | 7.2  | 9.0  | m $\Omega$          | $V_{GS} = 10V, I_D = 58A$ ④                          |
| $V_{GS(th)}$                    | Gate Threshold Voltage               | 2.0  | —    | 4.0  | V                   | $V_{DS} = V_{GS}, I_D = 150\mu A$                    |
| $g_{fs}$                        | Forward Transconductance             | 140  | —    | —    | S                   | $V_{DS} = 10V, I_D = 58A$                            |
| $I_{DSS}$                       | Drain-to-Source Leakage Current      | —    | —    | 20   | $\mu A$             | $V_{DS} = 100V, V_{GS} = 0V$                         |
|                                 |                                      | —    | —    | 250  |                     | $V_{DS} = 80V, V_{GS} = 0V, T_J = 125^\circ\text{C}$ |
| $I_{GSS}$                       | Gate-to-Source Forward Leakage       | —    | —    | 100  | nA                  | $V_{GS} = 20V$                                       |
|                                 | Gate-to-Source Reverse Leakage       | —    | —    | -100 |                     | $V_{GS} = -20V$                                      |
| $R_G$                           | Internal Gate Resistance             | —    | 0.70 | —    | $\Omega$            |                                                      |

**Dynamic Electrical Characteristics @  $T_J = 25^\circ\text{C}$  (unless otherwise specified)**

|                             | Parameter                                     | Min. | Typ. | Max. | Units | Conditions                                               |
|-----------------------------|-----------------------------------------------|------|------|------|-------|----------------------------------------------------------|
| $Q_g$                       | Total Gate Charge                             | —    | 83   | 120  | nC    | $I_D = 58A$                                              |
| $Q_{gs}$                    | Gate-to-Source Charge                         | —    | 19   | —    |       | $V_{DS} = 50V$                                           |
| $Q_{gd}$                    | Gate-to-Drain ("Miller") Charge               | —    | 27   | —    |       | $V_{GS} = 10V$ ④                                         |
| $Q_{sync}$                  | Total Gate Charge Sync. ( $Q_g - Q_{gd}$ )    | —    | 56   | —    |       | $I_D = 58A, V_{DS} = 0V, V_{GS} = 10V$ ④                 |
| $t_{d(on)}$                 | Turn-On Delay Time                            | —    | 16   | —    | ns    | $V_{DD} = 65V$                                           |
| $t_r$                       | Rise Time                                     | —    | 52   | —    |       | $I_D = 58A$                                              |
| $t_{d(off)}$                | Turn-Off Delay Time                           | —    | 43   | —    |       | $R_G = 2.7\Omega$                                        |
| $t_f$                       | Fall Time                                     | —    | 57   | —    |       | $V_{GS} = 10V$ ④                                         |
| $C_{iss}$                   | Input Capacitance                             | —    | 4820 | —    | pF    | $V_{GS} = 0V$                                            |
| $C_{oss}$                   | Output Capacitance                            | —    | 340  | —    |       | $V_{DS} = 50V$                                           |
| $C_{rss}$                   | Reverse Transfer Capacitance                  | —    | 170  | —    |       | $f = 1.0MHz$ , See Fig.5                                 |
| $C_{oss \text{ eff. (ER)}}$ | Effective Output Capacitance (Energy Related) | —    | 420  | —    |       | $V_{GS} = 0V, V_{DS} = 0V \text{ to } 80V$ ⑥, See Fig.11 |
| $C_{oss \text{ eff. (TR)}}$ | Effective Output Capacitance (Time Related)   | —    | 690  | —    |       | $V_{GS} = 0V, V_{DS} = 0V \text{ to } 80V$ ⑤             |

**Diode Characteristics**

|           | Parameter                                 | Min.                                                                 | Typ. | Max. | Units | Conditions                                                              |
|-----------|-------------------------------------------|----------------------------------------------------------------------|------|------|-------|-------------------------------------------------------------------------|
| $I_S$     | Continuous Source Current<br>(Body Diode) | —                                                                    | —    | 97   | A     | MOSFET symbol<br>showing the<br>integral reverse<br>p-n junction diode. |
| $I_{SM}$  | Pulsed Source Current<br>(Body Diode) ①   | —                                                                    | —    | 390  |       |                                                                         |
| $V_{SD}$  | Diode Forward Voltage                     | —                                                                    | —    | 1.3  | V     | $T_J = 25^\circ\text{C}, I_S = 58A, V_{GS} = 0V$ ④                      |
| $t_{rr}$  | Reverse Recovery Time                     | —                                                                    | 38   | 57   | ns    | $T_J = 25^\circ\text{C}$ $V_R = 85V$ ,                                  |
|           |                                           | —                                                                    | 46   | 69   |       | $T_J = 125^\circ\text{C}$ $I_F = 58A$                                   |
| $Q_{rr}$  | Reverse Recovery Charge                   | —                                                                    | 53   | 80   | nC    | $T_J = 25^\circ\text{C}$ $di/dt = 100A/\mu s$ ④                         |
|           |                                           | —                                                                    | 82   | 120  |       | $T_J = 125^\circ\text{C}$                                               |
| $I_{RRM}$ | Reverse Recovery Current                  | —                                                                    | 2.5  | —    | A     | $T_J = 25^\circ\text{C}$                                                |
| $t_{on}$  | 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  $T_J = 25^\circ\text{C}$ ,  $L = 0.143mH$   
 $R_G = 25\Omega$ ,  $I_{AS} = 58A$ ,  $V_{GS} = 10V$ . Part not recommended for use above this value.
- ③  $I_{SD} \leq 58A$ ,  $di/dt \leq 610A/\mu s$ ,  $V_{DD} \leq V_{(BR)DSS}$ ,  $T_J \leq 175^\circ\text{C}$ .
- ④ Pulse width  $\leq 400\mu s$ ; duty cycle  $\leq 2\%$ .

- ⑤  $C_{oss \text{ eff. (TR)}}$  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  $C_{oss \text{ eff. (ER)}}$  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 techniques refer to application note #AN-994.
- ⑧  $R_\theta$  is measured at  $T_J$  approximately  $90^\circ\text{C}$ .

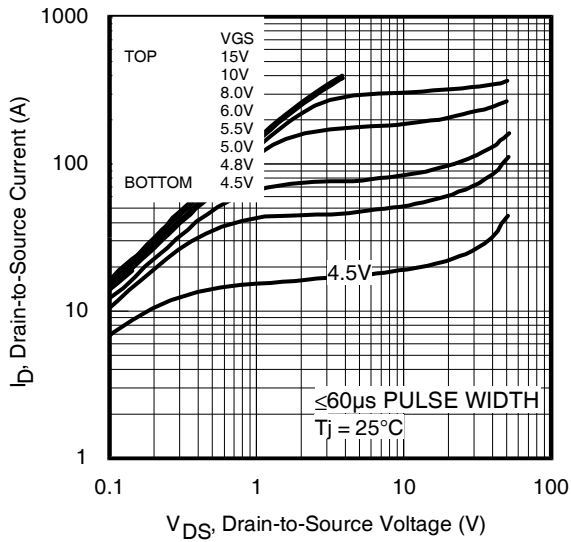
## Qualification Information<sup>†</sup>

|                                   |                      |                                                                                                                                                                         |      |
|-----------------------------------|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| <b>Qualification Level</b>        |                      | Automotive<br>(per AEC-Q101) <sup>††</sup>                                                                                                                              |      |
|                                   |                      | Comments: This part number(s) passed Automotive qualification. IR's Industrial and Consumer qualification level is granted by extension of the higher Automotive level. |      |
| <b>Moisture Sensitivity Level</b> |                      | 3L-D2 PAK                                                                                                                                                               | MSL1 |
|                                   |                      | 3L-TO-262                                                                                                                                                               | N/A  |
| <b>ESD</b>                        | Machine Model        | Class M4(+/- 800V) <sup>†††</sup><br>AEC-Q101-002                                                                                                                       |      |
|                                   | Human Body Model     | Class H2(+/- 3000V) <sup>†††</sup><br>AEC-Q101-001                                                                                                                      |      |
|                                   | Charged Device Model | Class C5(+/- 2000V) <sup>†††</sup><br>AEC-Q101-005                                                                                                                      |      |
| <b>RoHS Compliant</b>             |                      | Yes                                                                                                                                                                     |      |

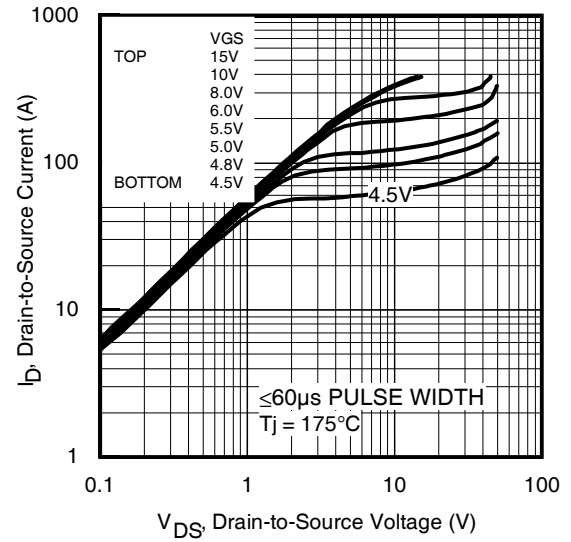
† Qualification standards can be found at International Rectifier's web site: <http://www.irf.com/>

†† Exceptions (if any) to AEC-Q101 requirements are noted in the qualification report.

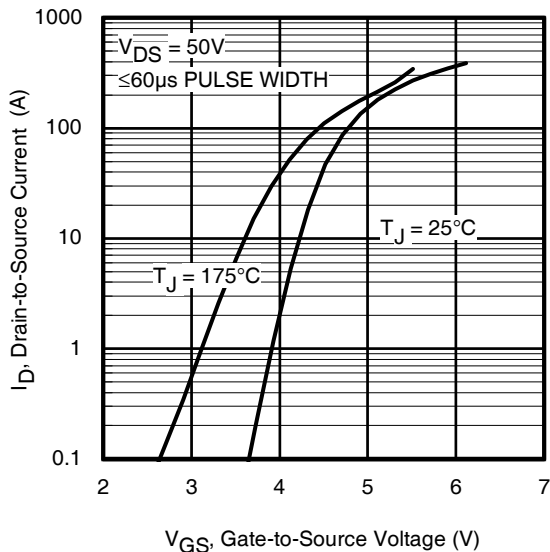
††† Highest passing voltage



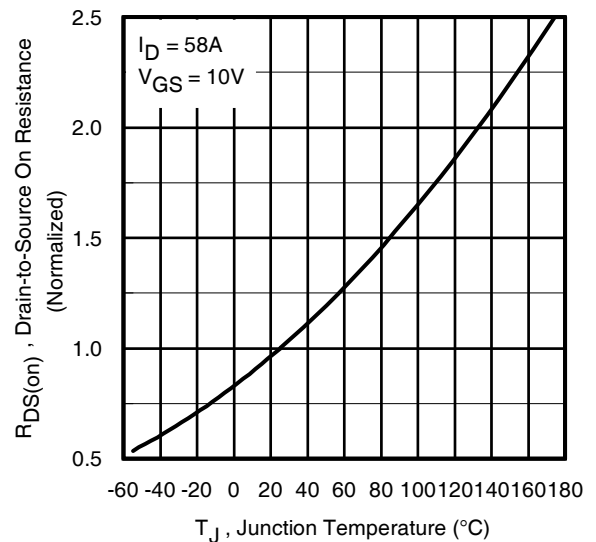
**Fig 1.** Typical Output Characteristics



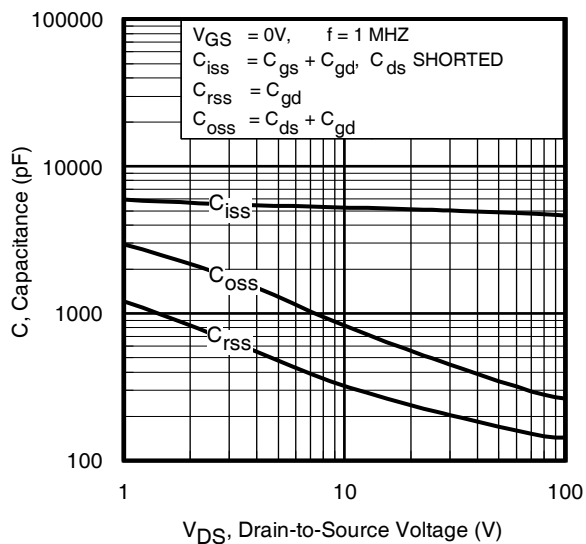
**Fig 2.** Typical Output Characteristics



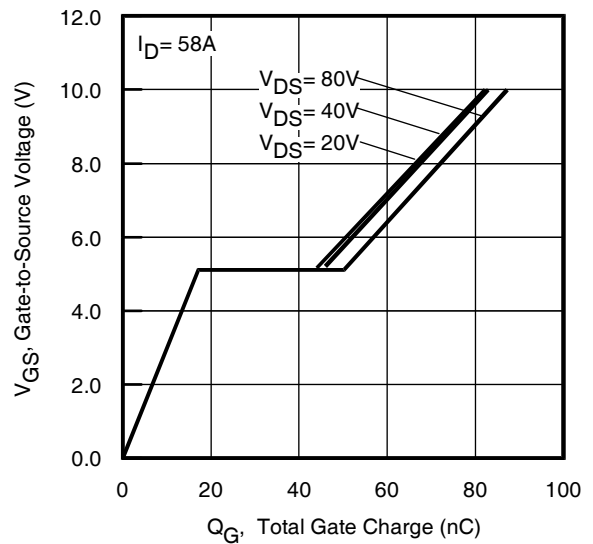
**Fig 3.** Typical Transfer Characteristics



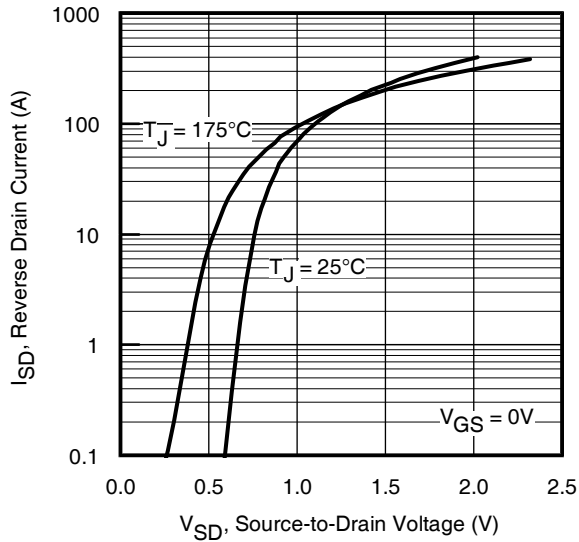
**Fig 4.** Normalized On-Resistance vs. Temperature



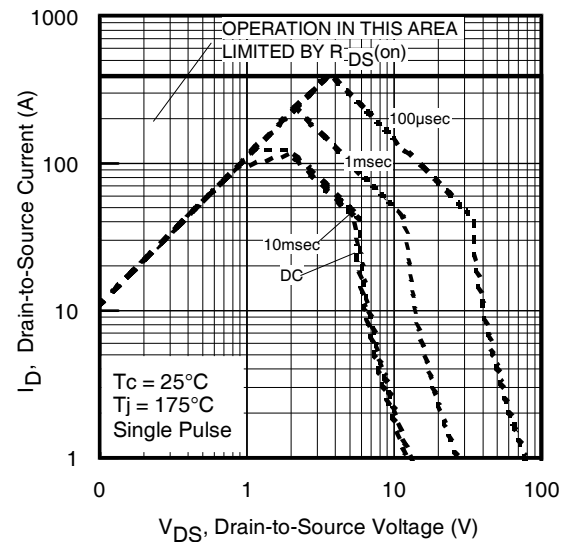
**Fig 5.** Typical Capacitance vs. Drain-to-Source Voltage



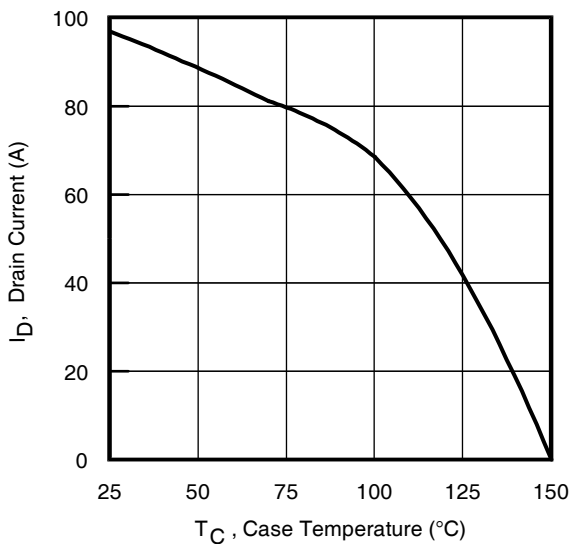
**Fig 6.** Typical Gate Charge vs. Gate-to-Source Voltage



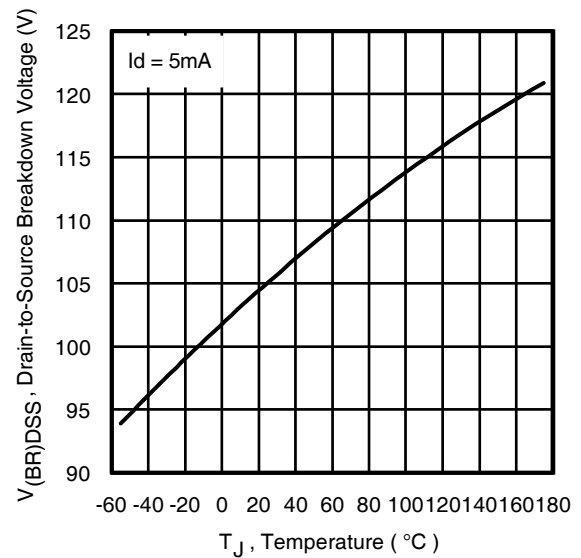
**Fig 7.** Typical Source-Drain Diode Forward Voltage



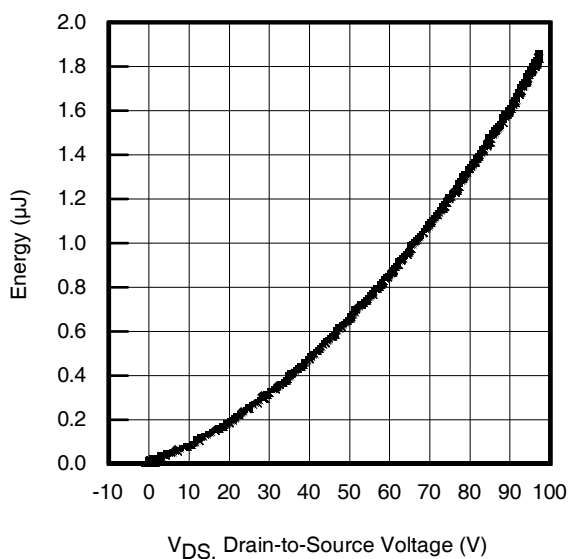
**Fig 8.** Maximum Safe Operating Area



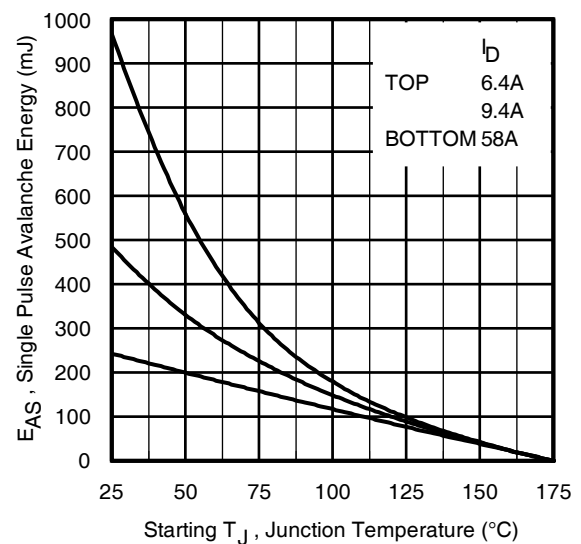
**Fig 9.** Maximum Drain Current vs. Case Temperature



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



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



**Fig 12.** Maximum Avalanche Energy vs. Drain Current

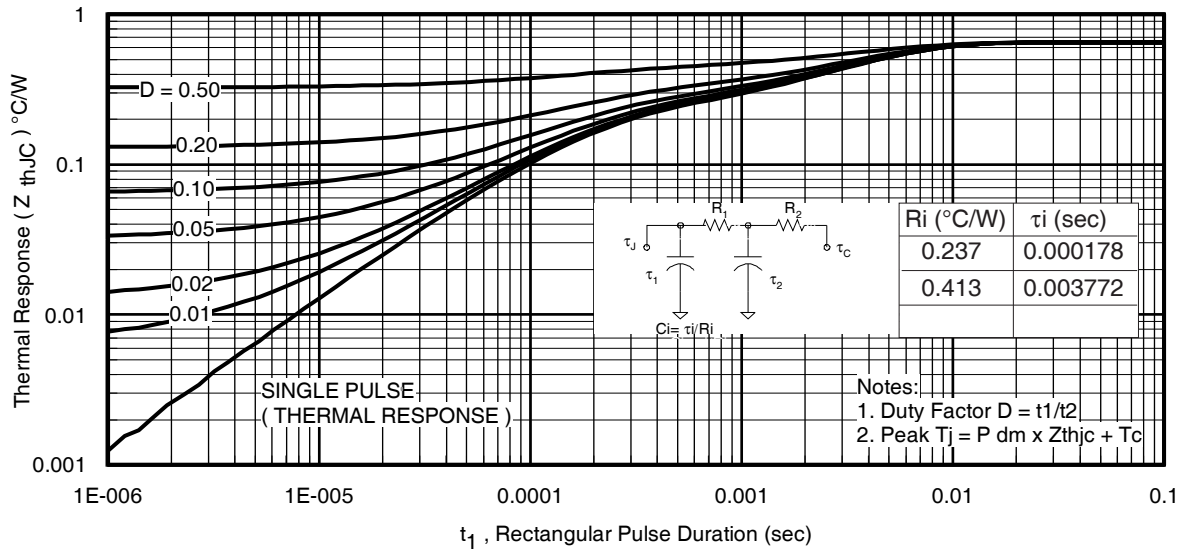


Fig 13. Maximum Effective Transient Thermal Impedance, Junction-to-Case

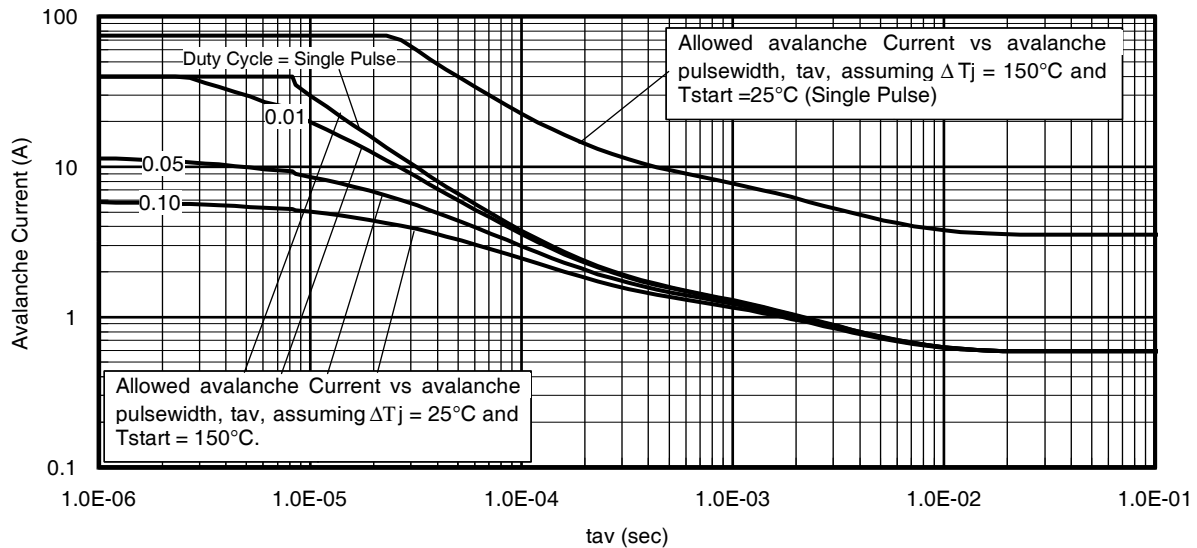


Fig 14. Typical Avalanche Current vs. Pulsewidth

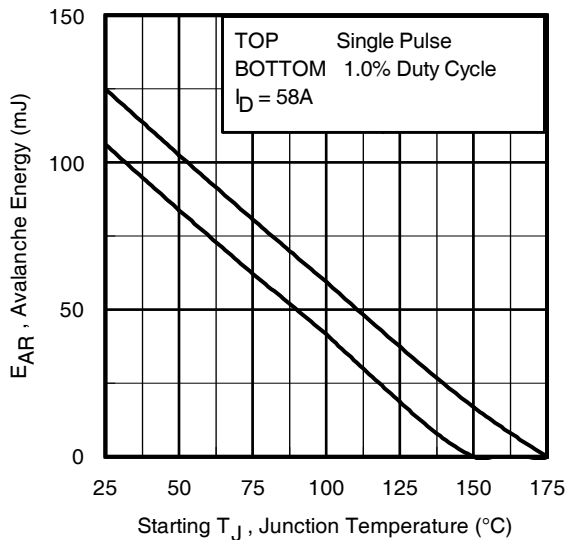


Fig 15. Maximum Avalanche Energy vs. Temperature

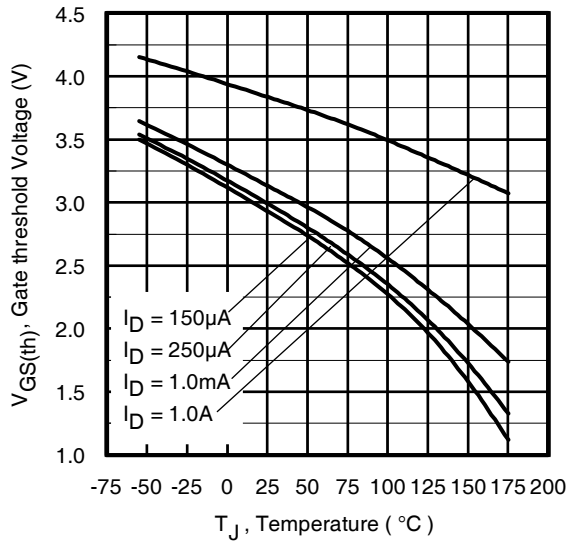
**Notes on Repetitive Avalanche Curves , Figures 14, 15:**  
(For further info, see AN-1005 at [www.irf.com](http://www.irf.com))

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  $25^{\circ}\text{C}$  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)

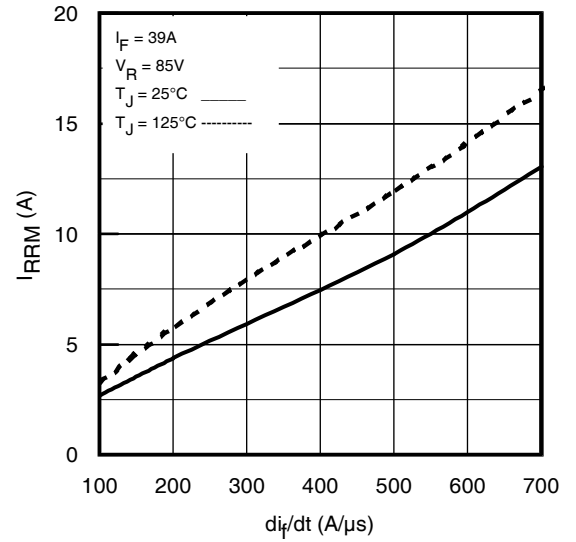
$$P_{D(ave)} = 1/2 (1.3 \cdot BV \cdot I_{av}) = \Delta T / Z_{thJC}$$

$$I_{av} = 2\Delta T / [1.3 \cdot BV \cdot Z_{th}]$$

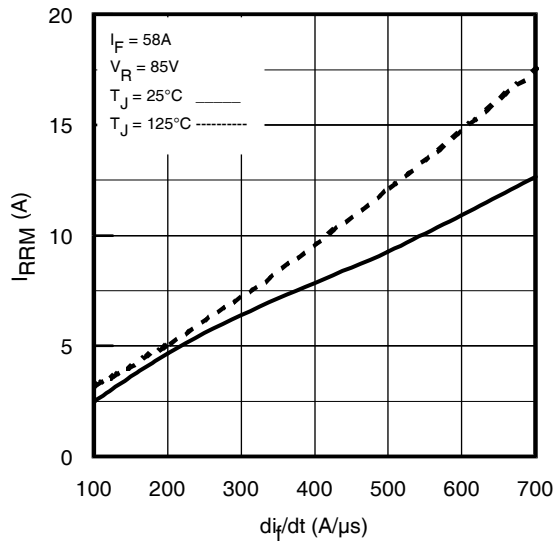
$$E_{AS(AR)} = P_{D(ave)} \cdot t_{av}$$



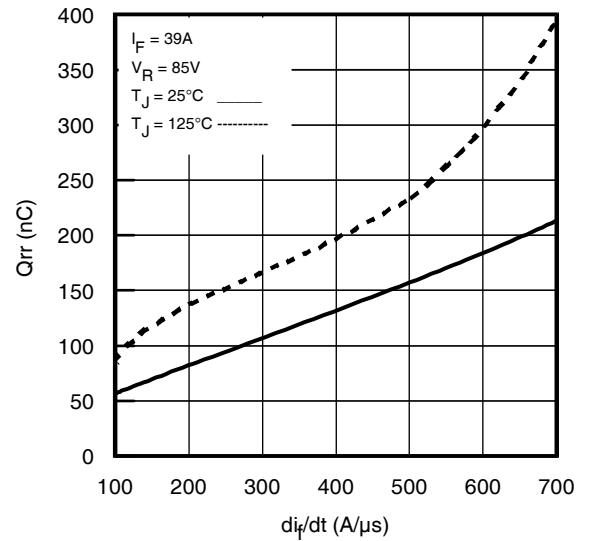
**Fig 16.** Threshold Voltage vs. Temperature



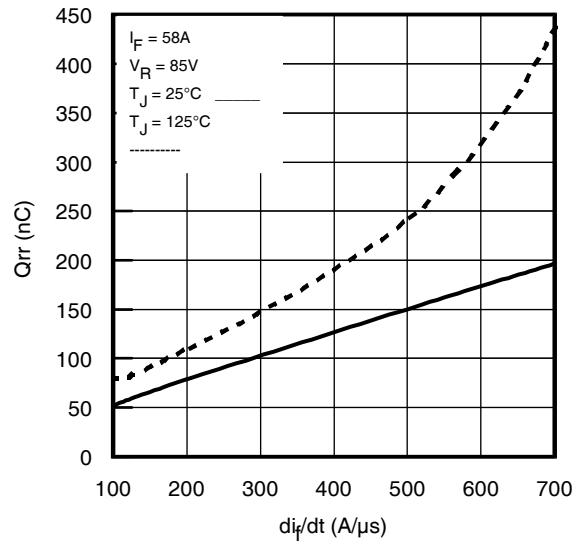
**Fig. 17 -** Typical Recovery Current vs.  $di_T/dt$



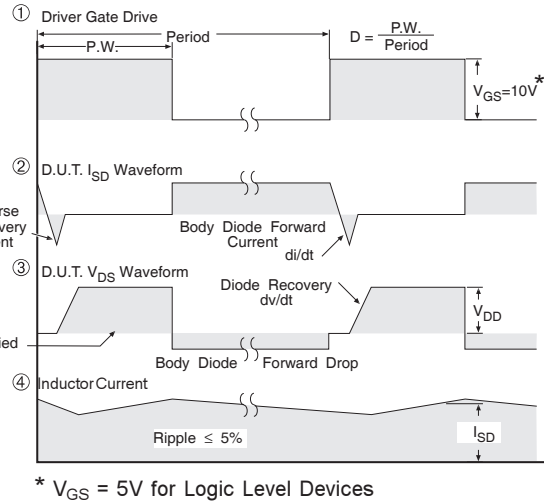
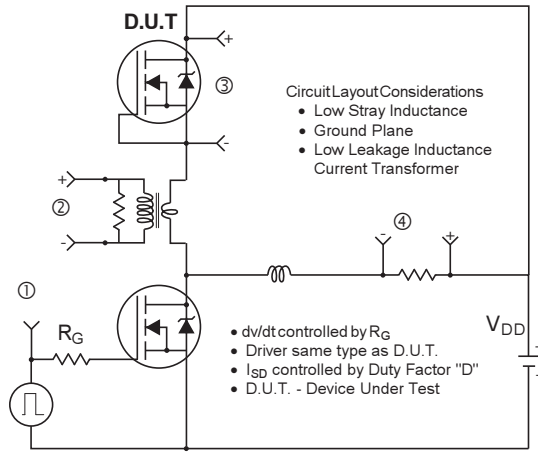
**Fig. 18 -** Typical Recovery Current vs.  $di_T/dt$



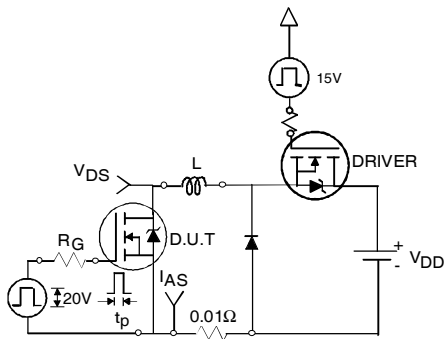
**Fig. 19 -** Typical Stored Charge vs.  $di_T/dt$



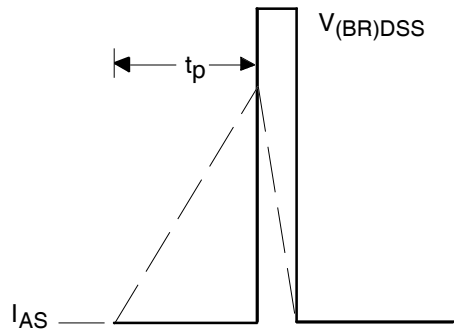
**Fig. 20 -** Typical Stored Charge vs.  $di_T/dt$



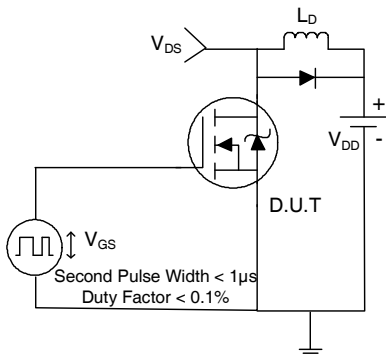
**Fig 21. Peak Diode Recovery  $dv/dt$  Test Circuit for N-Channel HEXFET® Power MOSFETs**



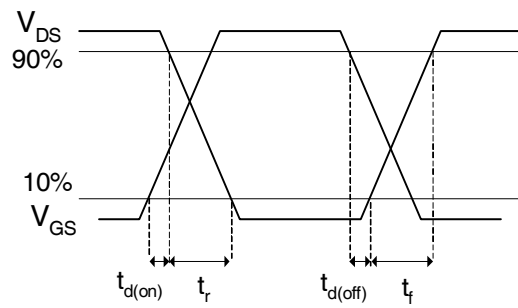
**Fig 22a. Unclamped Inductive Test Circuit**



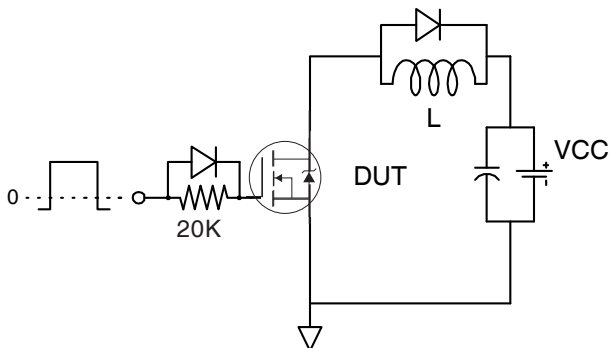
**Fig 22b. Unclamped Inductive Waveforms**



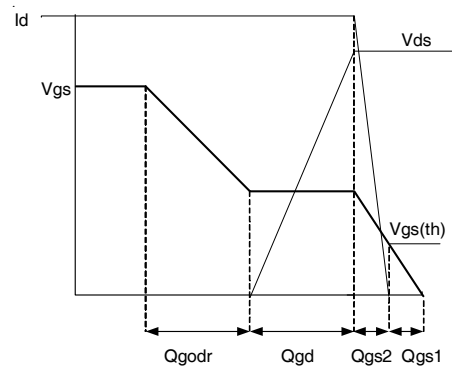
**Fig 23a. Switching Time Test Circuit**



**Fig 23b. Switching Time Waveforms**



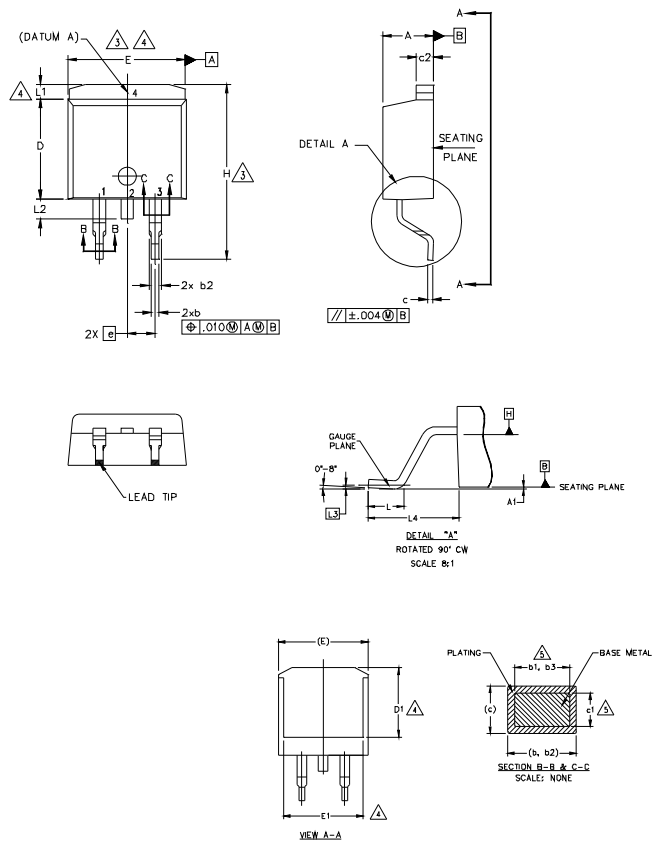
**Fig 24a. Gate Charge Test Circuit**



**Fig 24b. Gate Charge Waveform**

## D<sup>2</sup>Pak (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 [0.005"] 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 | 5     |
| A1     | 0.00        | 0.254 | .000     | .010 |       |
| b      | 0.51        | 0.99  | .020     | .039 |       |
| b1     | 0.51        | 0.89  | .020     | .035 |       |
| b2     | 1.14        | 1.78  | .045     | .070 |       |
| b3     | 1.14        | 1.73  | .045     | .068 | 5     |
| c      | 0.38        | 0.74  | .015     | .029 | 5     |
| c1     | 0.38        | 0.58  | .015     | .023 |       |
| 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 |      | 4     |
| H      | 14.61       | 15.88 | .575     | .625 |       |
| L      | 1.78        | 2.79  | .070     | .110 |       |
| L1     | —           | 1.65  | —        | .066 |       |
| L2     | 1.27        | 1.78  | —        | .070 |       |
| L3     | 0.25 BSC    |       | .010 BSC |      | 4     |
| L4     | 4.78        | 5.28  | .188     | .208 |       |

### LEAD ASSIGNMENTS

#### HEXFET

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

#### IGBTs, CoPACK

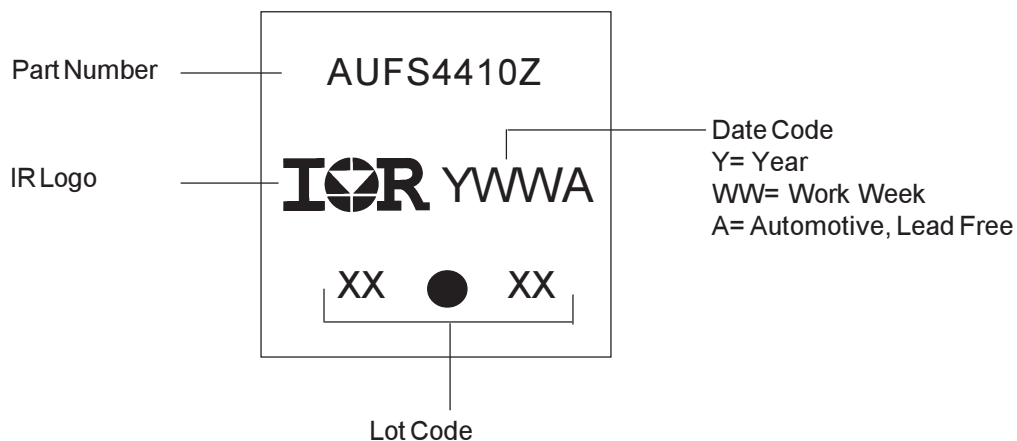
- 1.— GATE
- 2, 4.— COLLECTOR
- 3.— EMITTER

#### DIODES

- 1.— ANODE \*
- 2, 4.— CATHODE
- 3.— ANODE

\* PART DEPENDENT.

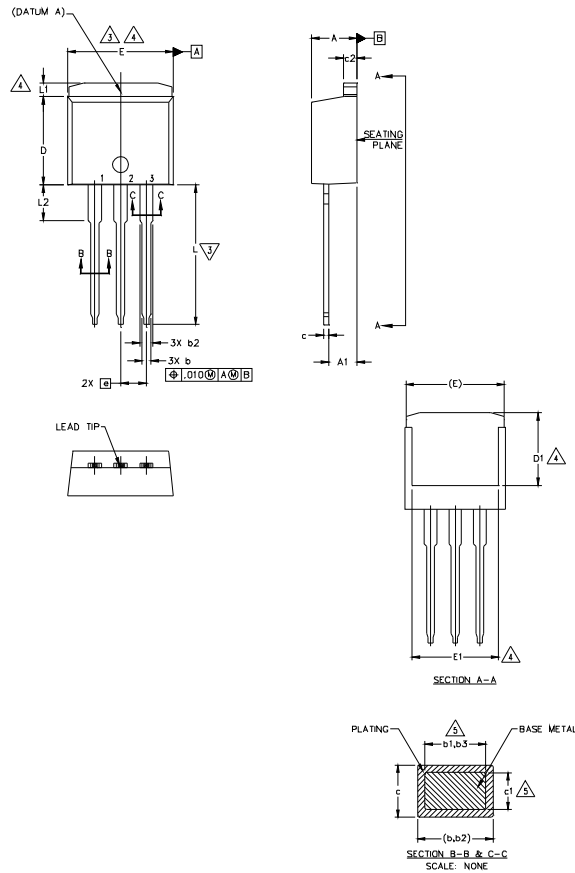
## D<sup>2</sup>Pak Part Marking Information



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

## 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 [0.005"] 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 | 5     |
| A1     | 2.03        | 3.02  | .080     | .119 |       |
| b      | 0.51        | 0.99  | .020     | .039 |       |
| b1     | 0.51        | 0.89  | .020     | .035 |       |
| b2     | 1.14        | 1.78  | .045     | .070 | 5     |
| b3     | 1.14        | 1.73  | .045     | .068 |       |
| 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     | —    |       |
| E      | 9.65        | 10.67 | .380     | .420 | 3,4   |
| E1     | 6.22        | —     | .245     | —    |       |
| e      | 2.54 BSC    |       | .100 BSC |      | 4     |
| L      | 13.46       | 14.10 | .530     | .555 |       |
| L1     | —           | 1.65  | —        | .065 |       |
| L2     | 3.56        | 3.71  | .140     | .146 |       |

### LEAD ASSIGNMENTS

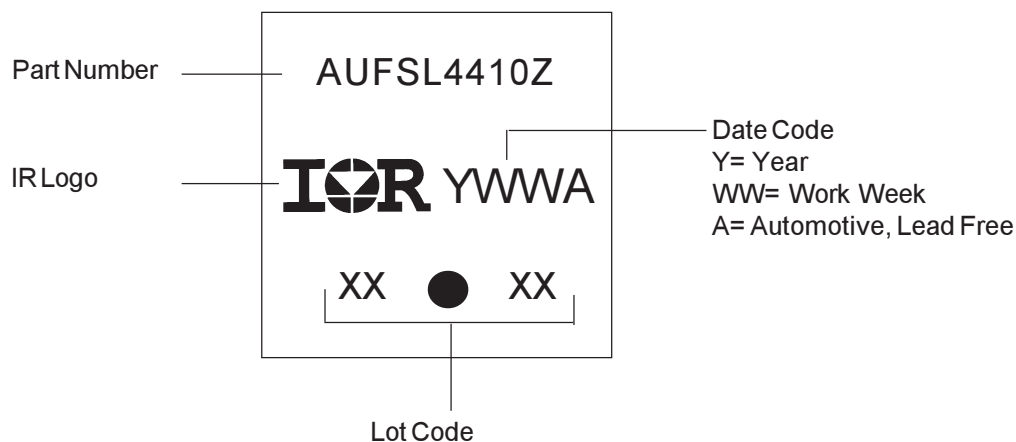
#### HEXFET

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

#### IGBTs, CoPACK

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

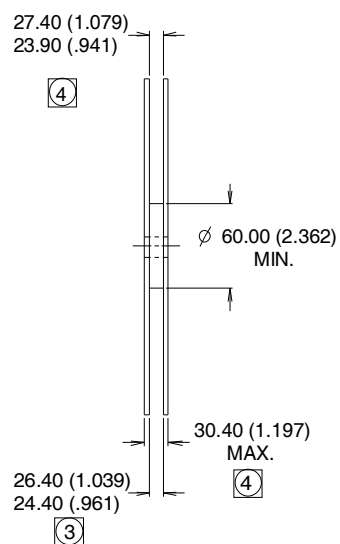
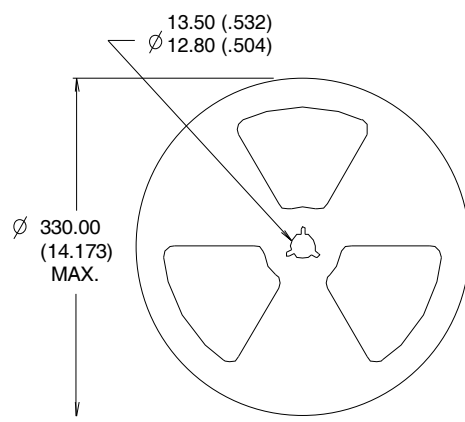
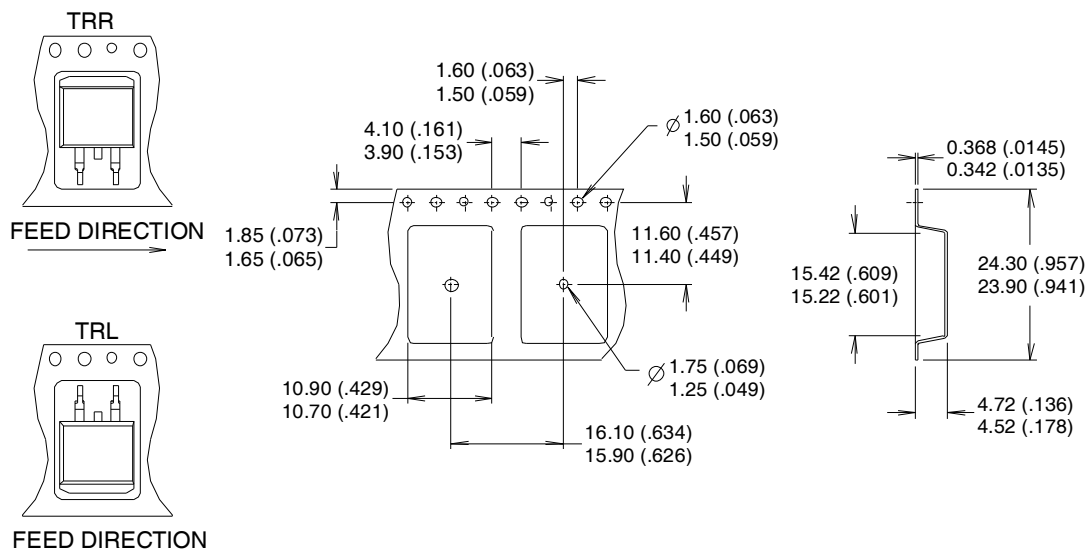
## TO-262 Part Marking Information



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

## D<sup>2</sup>Pak (TO-263AB) Tape & Reel Information

Dimensions are shown in millimeters (inches)



NOTES :

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

## Ordering Information

| Base part    | Package Type | Standard Pack       |          | Complete Part Number |
|--------------|--------------|---------------------|----------|----------------------|
|              |              | Form                | Quantity |                      |
| AUIRFSL4410Z | TO-262       | Tube                | 50       | AUIRFSL4410Z         |
| AUIRFS4410Z  | D2Pak        | Tube                | 50       | AUIRFS4410Z          |
|              |              | Tape and Reel Left  | 800      | AUIRFS4410ZTRL       |
|              |              | Tape and Reel Right | 800      | AUIRFS4410ZTRR       |

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