

**RADIATION HARDENED  
POWER MOSFET  
THRU-HOLE (Low-Ohmic TO-254AA)**
**100V, P-CHANNEL**  
**REF: MIL-PRF-19500/713**  
**R5 TECHNOLOGY**
**Product Summary**

| Part Number | Radiation Level | RDS(on) | I <sub>D</sub> | QPL Part Number |
|-------------|-----------------|---------|----------------|-----------------|
| IRHMS597160 | 100 kRads(Si)   | 0.05Ω   | -45A           | JANSR2N7550T1   |
| IRHMS593160 | 300 kRads(Si)   | 0.05Ω   | -45A           | JANSF2N7550T1   |


**Description**

IR HiRel R5 technology provides high performance power MOSFETs for space applications. These devices have been characterized for Single Event Effects (SEE) with useful performance up to an LET of 80 (MeV/(mg/cm<sup>2</sup>)). The combination of low RDS(on) and low gate charge reduces the power losses in switching applications such as DC to DC converters and motor control. These devices retain all of the well established advantages of MOSFETs such as voltage control, fast switching and temperature stability of electrical parameters.

**Features**

- Single Event Effect (SEE) Hardened
- Identical Pre- and Post-Electrical Test Conditions
- Repetitive Avalanche Ratings
- Dynamic dv/dt Ratings
- Simple Drive Requirements
- Hermetically Sealed
- Electrically Isolated
- Ceramic Eyelets
- Light Weight
- High Electrical Conductive Package
- ESD Rating: Class 3A per MIL-STD-750, Method 1020

**Absolute Maximum Ratings**
**Pre-Irradiation**

| Symbol                                                           | Parameter                                           | Value                                   | Units |
|------------------------------------------------------------------|-----------------------------------------------------|-----------------------------------------|-------|
| I <sub>D1</sub> @ V <sub>GS</sub> = -12V, T <sub>C</sub> = 25°C  | Continuous Drain Current                            | -45                                     | A     |
| I <sub>D2</sub> @ V <sub>GS</sub> = -12V, T <sub>C</sub> = 100°C | Continuous Drain Current                            | -28.5                                   |       |
| I <sub>DM</sub> @ T <sub>C</sub> = 25°C                          | Pulsed Drain Current ①                              | -180                                    |       |
| P <sub>D</sub> @ T <sub>C</sub> = 25°C                           | Maximum Power Dissipation                           | 208                                     | W     |
|                                                                  | Linear Derating Factor                              | 1.67                                    | W/°C  |
| V <sub>GS</sub>                                                  | Gate-to-Source Voltage                              | ± 20                                    | V     |
| E <sub>AS</sub>                                                  | Single Pulse Avalanche Energy ②                     | 480                                     | mJ    |
| I <sub>AR</sub>                                                  | Avalanche Current ①                                 | -45                                     | A     |
| E <sub>AR</sub>                                                  | Repetitive Avalanche Energy ①                       | 20.8                                    | mJ    |
| dv/dt                                                            | Peak Diode Recovery dv/dt ③                         | -6.0                                    | V/ns  |
| T <sub>J</sub><br>T <sub>STG</sub>                               | Operating Junction and<br>Storage Temperature Range | -55 to + 150                            | °C    |
|                                                                  | Lead Temperature                                    | 300 ((0.063in./1.6mm from case for 10s) |       |
|                                                                  | Weight                                              | 9.3 (Typical)                           | g     |

For Footnotes, refer to the page 2.

## Electrical Characteristics @ T<sub>J</sub> = 25°C (Unless Otherwise Specified)

Pre-Irradiation

| Symbol                              | Parameter                                  | Min. | Typ.  | Max. | Units | Test Conditions                                                                                                                                                  |
|-------------------------------------|--------------------------------------------|------|-------|------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| BV <sub>DSS</sub>                   | Drain-to-Source Breakdown Voltage          | -100 | —     | —    | V     | V <sub>GS</sub> = 0V, I <sub>D</sub> = -1.0mA                                                                                                                    |
| ΔBV <sub>DSS</sub> /ΔT <sub>J</sub> | Breakdown Voltage Temp. Coefficient        | —    | -0.13 | —    | V/°C  | Reference to 25°C, I <sub>D</sub> = -1.0mA                                                                                                                       |
| R <sub>DS(on)</sub>                 | Static Drain-to-Source On-State Resistance | —    | —     | 0.05 | Ω     | V <sub>GS</sub> = -12V, I <sub>D2</sub> = -28.5A ④                                                                                                               |
| V <sub>GS(th)</sub>                 | Gate Threshold Voltage                     | -2.0 | —     | -4.0 | V     | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = -1.0mA                                                                                                      |
| G <sub>fs</sub>                     | Forward Transconductance                   | 24   | —     | —    | S     | V <sub>DS</sub> = -15V, I <sub>D2</sub> = -28.5A ④                                                                                                               |
| I <sub>DSS</sub>                    | Zero Gate Voltage Drain Current            | —    | —     | -10  | μA    | V <sub>DS</sub> = -80V, V <sub>GS</sub> = 0V                                                                                                                     |
|                                     |                                            | —    | —     | -25  |       | V <sub>DS</sub> = -80V, V <sub>GS</sub> = 0V, T <sub>J</sub> = 125°C                                                                                             |
| I <sub>GSS</sub>                    | Gate-to-Source Leakage Forward             | —    | —     | -100 | nA    | V <sub>GS</sub> = -20V                                                                                                                                           |
|                                     | Gate-to-Source Leakage Reverse             | —    | —     | 100  |       | V <sub>GS</sub> = 20V                                                                                                                                            |
| Q <sub>G</sub>                      | Total Gate Charge                          | —    | —     | 170  | nC    | I <sub>D1</sub> = -45A                                                                                                                                           |
| Q <sub>GS</sub>                     | Gate-to-Source Charge                      | —    | —     | 65   |       | V <sub>DS</sub> = -50V                                                                                                                                           |
| Q <sub>GD</sub>                     | Gate-to-Drain ('Miller') Charge            | —    | —     | 30   |       | V <sub>GS</sub> = -12V                                                                                                                                           |
| t <sub>d(on)</sub>                  | Turn-On Delay Time                         | —    | —     | 35   | ns    | V <sub>DD</sub> = -50V                                                                                                                                           |
| t <sub>r</sub>                      | Rise Time                                  | —    | —     | 100  |       | I <sub>D1</sub> = -45A                                                                                                                                           |
| t <sub>d(off)</sub>                 | Turn-Off Delay Time                        | —    | —     | 100  |       | R <sub>G</sub> = 1.20Ω                                                                                                                                           |
| t <sub>f</sub>                      | Fall Time                                  | —    | —     | 120  |       | V <sub>GS</sub> = -12V                                                                                                                                           |
| L <sub>S</sub> + L <sub>D</sub>     | Total Inductance                           | —    | 6.8   | —    | nH    | Measured from Drain lead (6mm /0.25in. from package) to Source lead (6mm /0.25in. from package) with Source wires internally bonded from Source Pin to Drain Pad |
| C <sub>iss</sub>                    | Input Capacitance                          | —    | 6110  | —    | pF    | V <sub>GS</sub> = 0V                                                                                                                                             |
| C <sub>oss</sub>                    | Output Capacitance                         | —    | 1574  | —    |       | V <sub>DS</sub> = -25V                                                                                                                                           |
| C <sub>rss</sub>                    | Reverse Transfer Capacitance               | —    | 115   | —    |       | f = 1.0MHz                                                                                                                                                       |

## Source-Drain Diode Ratings and Characteristics

| Symbol          | Parameter                              | Min.                                                                                           | Typ. | Max. | Units | Test Conditions                                                                           |
|-----------------|----------------------------------------|------------------------------------------------------------------------------------------------|------|------|-------|-------------------------------------------------------------------------------------------|
| I <sub>S</sub>  | Continuous Source Current (Body Diode) | —                                                                                              | —    | -45  | A     |                                                                                           |
| I <sub>SM</sub> | Pulsed Source Current (Body Diode) ①   | —                                                                                              | —    | -180 |       |                                                                                           |
| V <sub>SD</sub> | Diode Forward Voltage                  | —                                                                                              | —    | -5.0 | V     | T <sub>J</sub> = 25°C, I <sub>S</sub> = -45A, V <sub>GS</sub> = 0V④                       |
| t <sub>rr</sub> | Reverse Recovery Time                  | —                                                                                              | —    | 200  | ns    | T <sub>J</sub> = 25°C, I <sub>F</sub> = -45A, V <sub>DD</sub> ≤ -50V<br>di/dt = 100A/μs ④ |
| Q <sub>rr</sub> | Reverse Recovery Charge                | —                                                                                              | —    | 1.6  | μC    |                                                                                           |
| t <sub>on</sub> | Forward Turn-On Time                   | Intrinsic turn-on time is negligible (turn-on is dominated by L <sub>S</sub> +L <sub>D</sub> ) |      |      |       |                                                                                           |

## Thermal Resistance

| Symbol            | Parameter                                  | Min. | Typ. | Max. | Units |
|-------------------|--------------------------------------------|------|------|------|-------|
| R <sub>θJC</sub>  | Junction-to-Case                           | —    | —    | 0.60 | °C/W  |
| R <sub>θJCS</sub> | Case -to- Sink                             | —    | 0.21 | —    |       |
| R <sub>θJA</sub>  | Junction-to-Ambient (Typical socket mount) | —    | —    | 48   |       |

### Footnotes:

- ① Repetitive Rating; Pulse width limited by maximum junction temperature.
- ② V<sub>DD</sub> = -50V, starting T<sub>J</sub> = 25°C, L = 0.48mH, Peak I<sub>L</sub> = -45A, V<sub>GS</sub> = -12V
- ③ I<sub>SD</sub> ≤ -45A, di/dt ≤ -365A/μs, V<sub>DD</sub> ≤ -100V, T<sub>J</sub> ≤ 150°C
- ④ Pulse width ≤ 300 μs; Duty Cycle ≤ 2%
- ⑤ Total Dose Irradiation with V<sub>GS</sub> Bias. -12 volt V<sub>GS</sub> applied and V<sub>DS</sub> = 0 during irradiation per MIL-STD-750, Method 1019, condition A.
- ⑥ Total Dose Irradiation with V<sub>DS</sub> Bias. -80 volt V<sub>DS</sub> applied and V<sub>GS</sub> = 0 during irradiation per MIL-STD-750, Method 1019, condition A.

## Radiation Characteristics

IR HiRel radiation hardened MOSFETs are tested to verify their radiation hardness capability. The hardness assurance program at IR HiRel is comprised of two radiation environments. Every manufacturing lot is tested for total ionizing dose (per notes 5 and 6) using the TO-3 package. Both pre- and post-irradiation performance are tested and specified using the same drive circuitry and test conditions in order to provide a direct comparison.

**Table1. Electrical Characteristics @ Tj = 25°C, Post Total Dose Irradiation ⑤⑥**

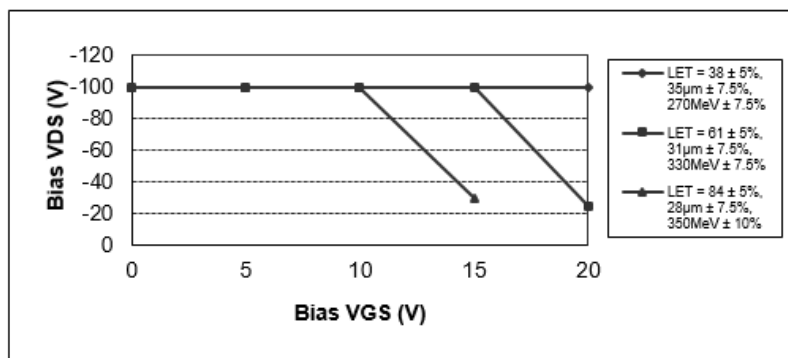
| Symbol              | Parameter                                                  | 100 kRads (Si) <sup>1</sup> |      | 300 kRads (Si) <sup>2</sup> |      | Units | Test Conditions                                             |
|---------------------|------------------------------------------------------------|-----------------------------|------|-----------------------------|------|-------|-------------------------------------------------------------|
|                     |                                                            | Min.                        | Max. | Min.                        | Max. |       |                                                             |
| BV <sub>DSS</sub>   | Drain-to-Source Breakdown Voltage                          | -100                        | —    | -100                        | —    | V     | V <sub>GS</sub> = 0V, I <sub>D</sub> = -1.0mA               |
| V <sub>GS(th)</sub> | Gate Threshold Voltage                                     | -2.0                        | -4.0 | -2.0                        | -5.0 | V     | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = -1.0mA |
| I <sub>GSS</sub>    | Gate-to-Source Leakage Forward                             | —                           | -100 | —                           | -100 | nA    | V <sub>GS</sub> = -20V                                      |
| I <sub>GSS</sub>    | Gate-to-Source Leakage Reverse                             | —                           | 100  | —                           | 100  | nA    | V <sub>GS</sub> = 20V                                       |
| I <sub>DSS</sub>    | Zero Gate Voltage Drain Current                            | —                           | -10  | —                           | -10  | μA    | V <sub>DS</sub> = -80V, V <sub>GS</sub> = 0V                |
| R <sub>DS(on)</sub> | Static Drain-to-Source ④<br>On-State Resistance (TO-3)     | —                           | 0.05 | —                           | 0.05 | Ω     | V <sub>GS</sub> = -12V, I <sub>D2</sub> = -28.5A            |
| R <sub>DS(on)</sub> | Static Drain-to-Source ④<br>On-State Resistance (TO-254AA) | —                           | 0.05 | —                           | 0.05 | Ω     | V <sub>GS</sub> = -12V, I <sub>D2</sub> = -28.5A            |
| V <sub>SD</sub>     | Diode Forward Voltage                                      | —                           | -5.0 | —                           | -5.0 | V     | V <sub>GS</sub> = 0V, I <sub>S</sub> = -45A                 |

1. Part number IRHMS597160 (JANSR2N7550T1)
2. Part numbers IRHMS593160 (JANSF2N7550T1)

IR HiRel radiation hardened MOSFETs have been characterized in heavy ion environment for Single Event Effects (SEE). Single Event Effects characterization is illustrated in Fig. a and Table 2.

**Table 2. Typical Single Event Effect Safe Operating Area**

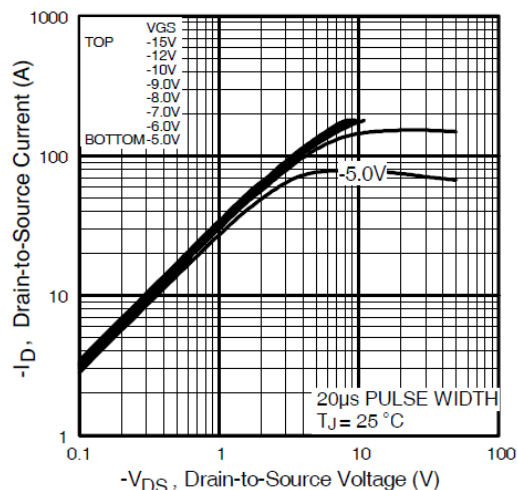
| LET<br>(MeV/(mg/cm <sup>2</sup> )) | Energy<br>(MeV) | Range<br>(μm) | VDS (V) |         |          |          |          |
|------------------------------------|-----------------|---------------|---------|---------|----------|----------|----------|
|                                    |                 |               | @VGS=0V | @VGS=5V | @VGS=10V | @VGS=15V | @VGS=20V |
| 38 ± 5%                            | 270 ± 7.5%      | 35 ± 7.5%     | -100    | -100    | -100     | -100     | -100     |
| 61 ± 5%                            | 330 ± 7.5%      | 31 ± 7.5%     | -100    | -100    | -100     | -100     | -25      |
| 84 ± 5%                            | 350 ± 10%       | 28 ± 7.5%     | -100    | -100    | -100     | -30      | —        |



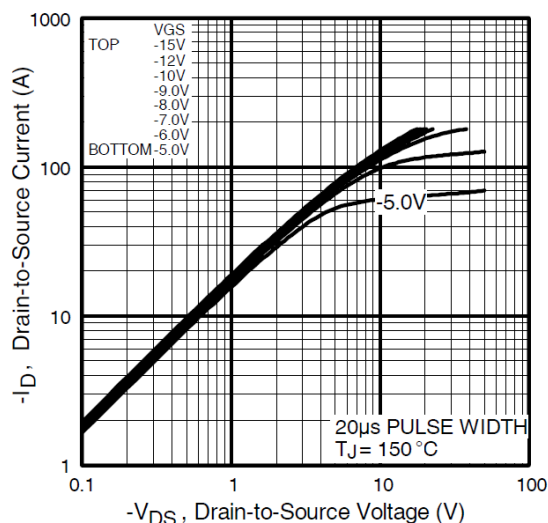
**Fig a.** Typical Single Event Effect, Safe Operating Area

For Footnotes, refer to the page 2.

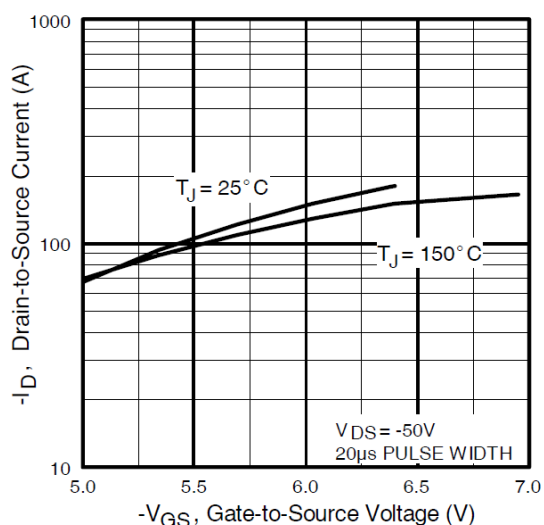
**Pre-Irradiation**



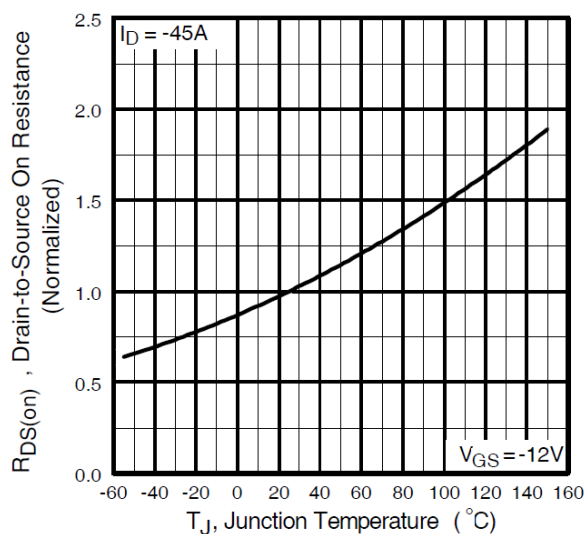
**Fig 1. Typical Output Characteristics**



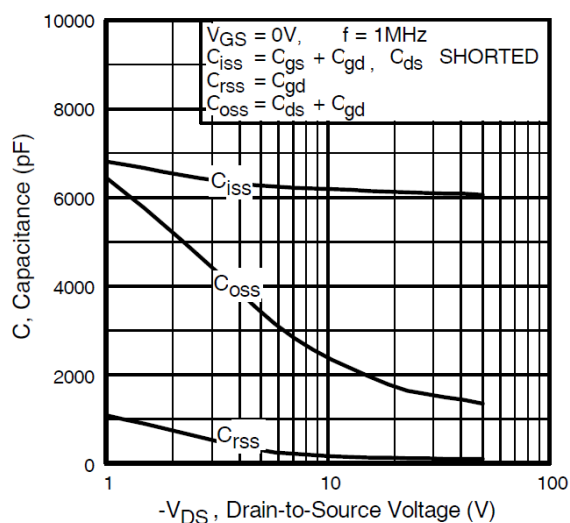
**Fig 2. Typical Output Characteristics**



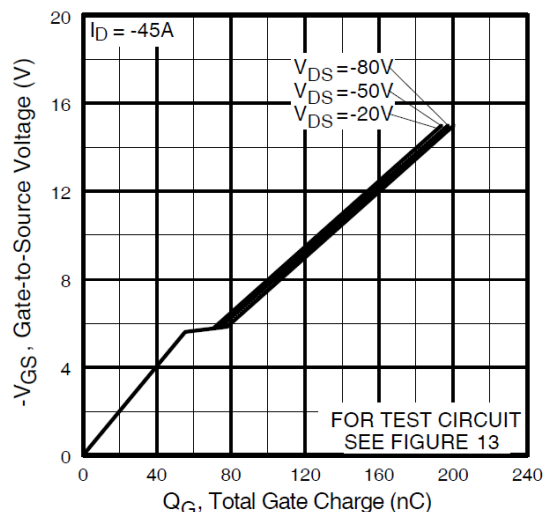
**Fig 3. Typical Transfer Characteristics**



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

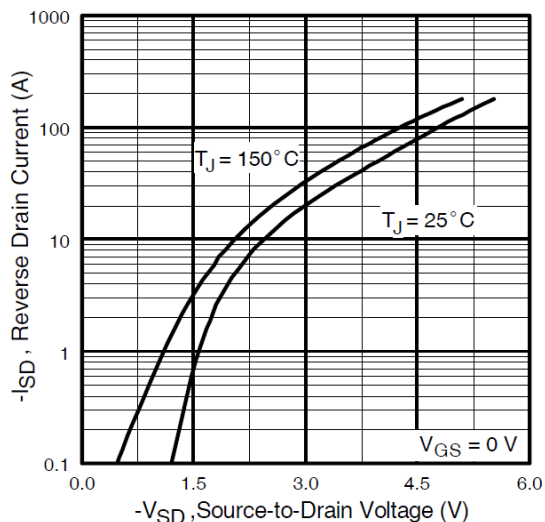


**Fig 5. Typical Capacitance Vs. Drain-to-Source Voltage**

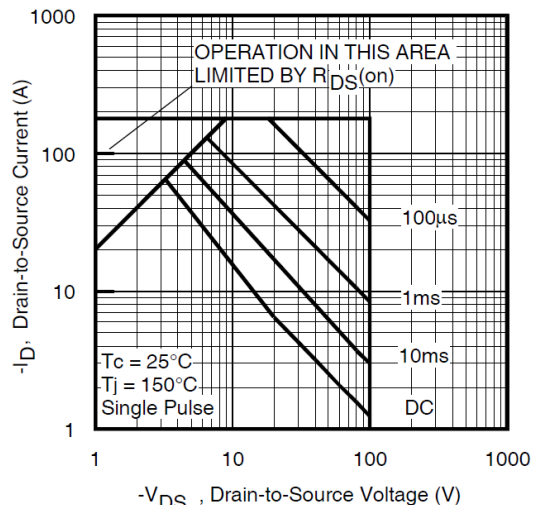


**Fig 6. Typical Gate Charge Vs. Gate-to-Source Voltage**

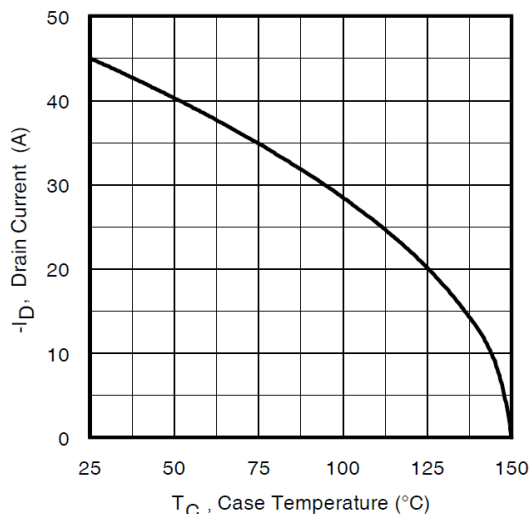
**Pre-Irradiation**



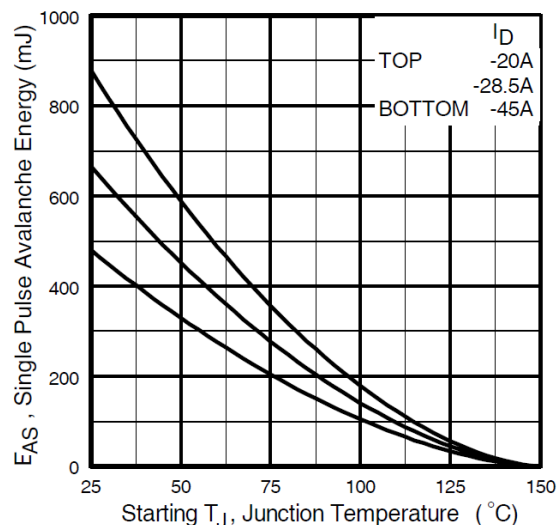
**Fig 7.** Typical Source-Drain Diode Forward Voltage



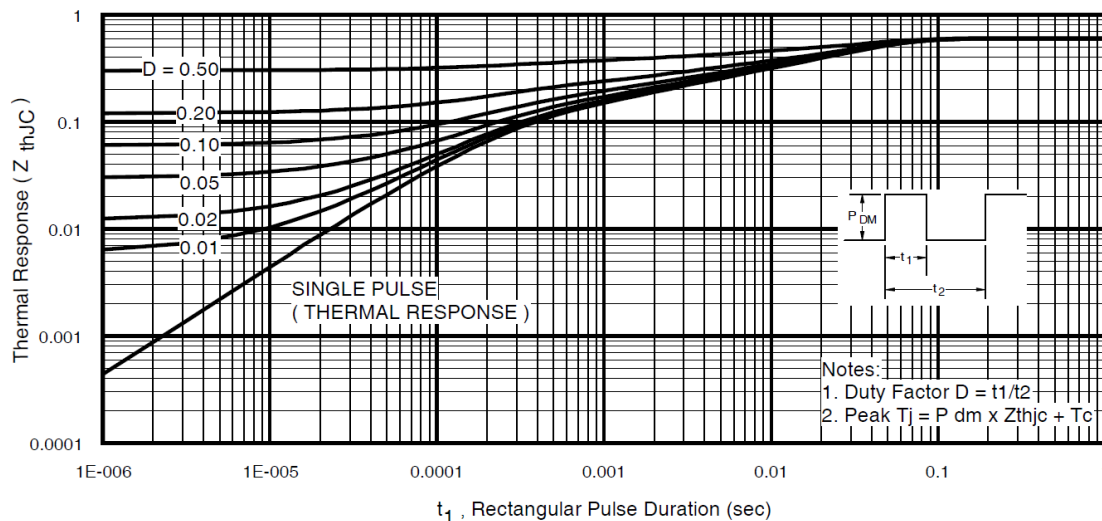
**Fig 8.** Maximum Safe Operating Area



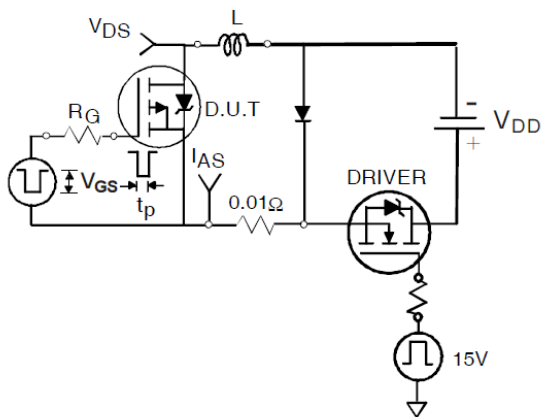
**Fig 9.** Maximum Drain Current Vs. Case Temperature



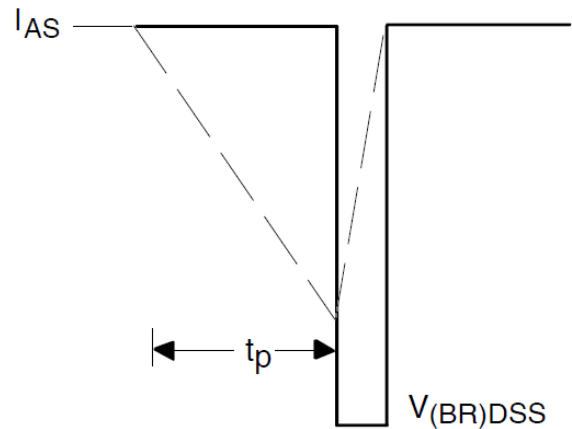
**Fig 10.** Maximum Avalanche Energy Vs. Drain Current



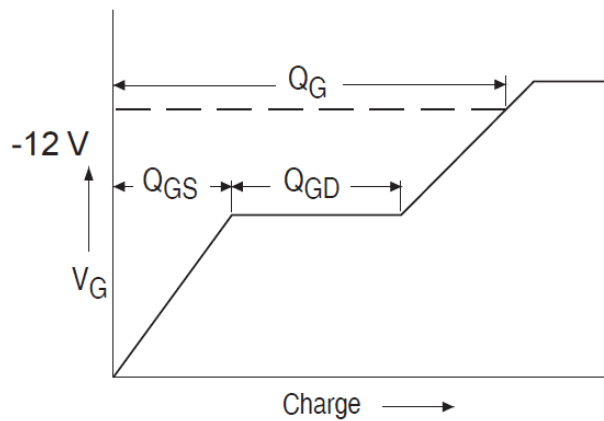
**Fig 11.** Maximum Effective Transient Thermal Impedance, Junction-to-Case



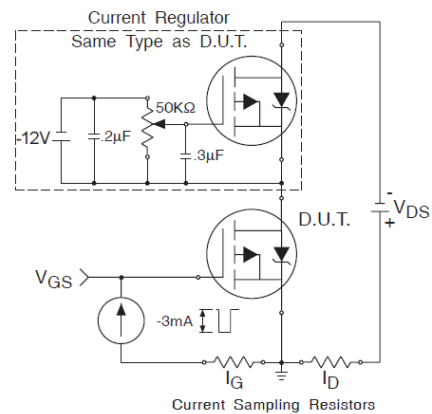
**Fig 12a.** Unclamped Inductive Test Circuit



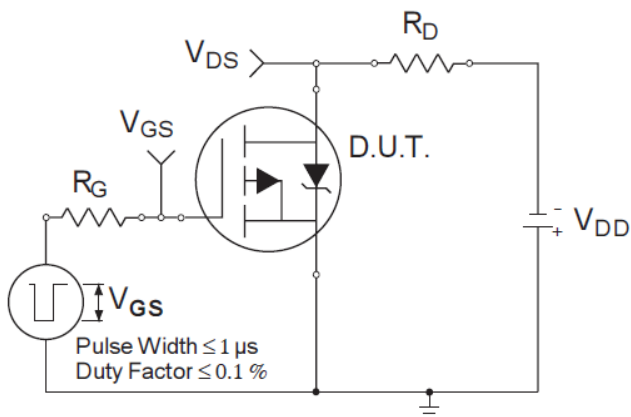
**Fig 12b.** Unclamped Inductive Wave-



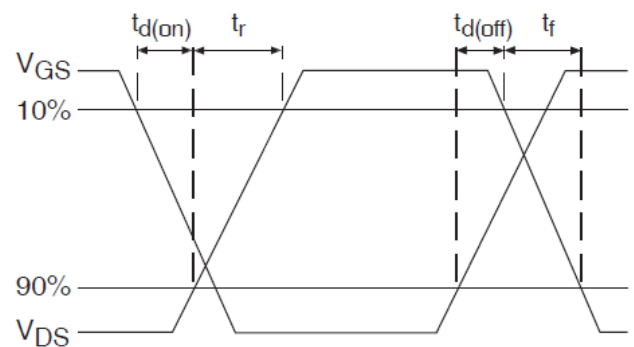
**Fig 13a.** Gate Charge Waveform



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



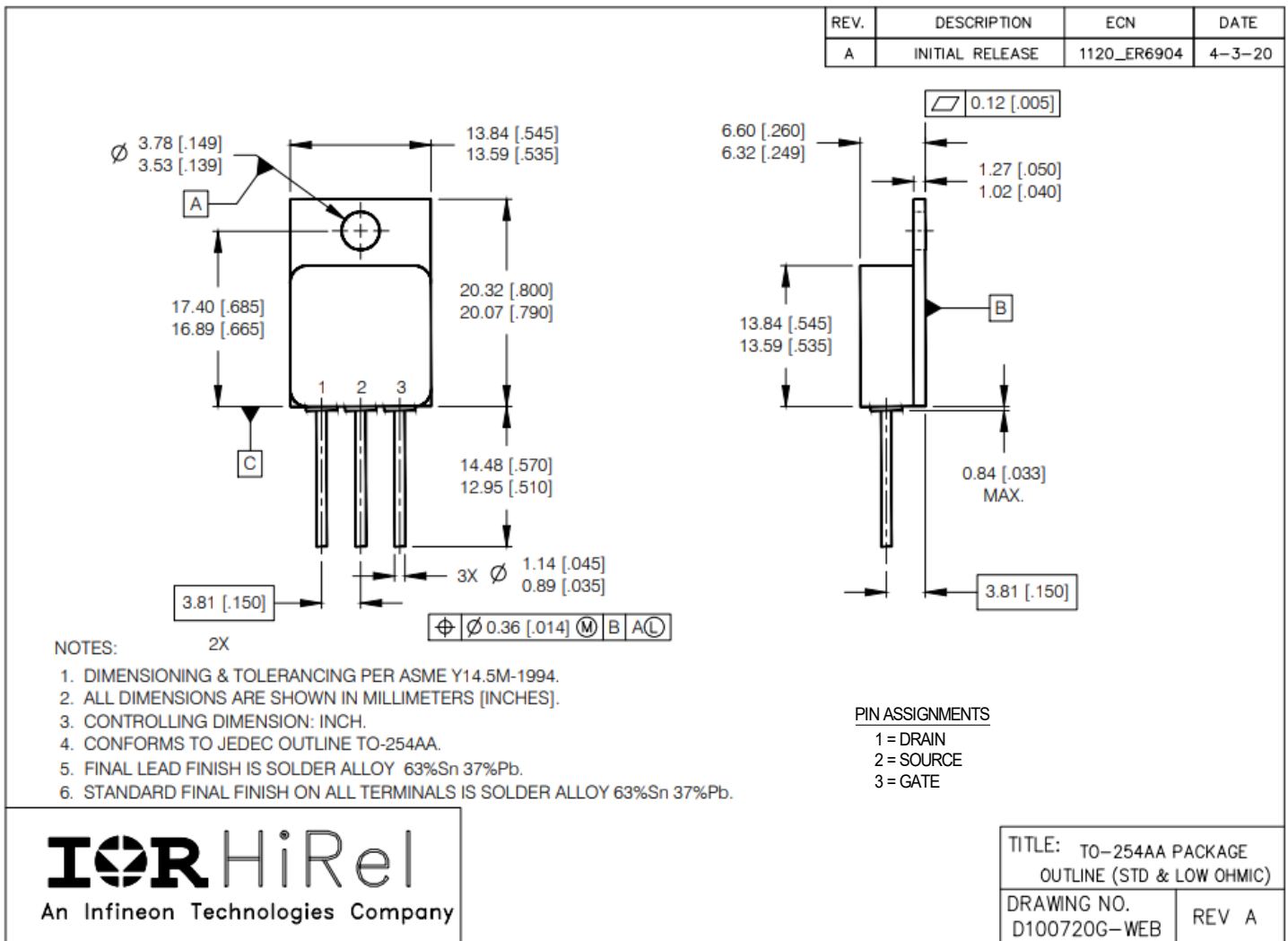
**Fig 14a.** Switching Time Test Circuit



**Fig 14b.** Switching Time Waveforms

Note: For the most updated package outline, please see the website: [Low-Ohmic TO-254AA](http://www.infineon.com/lowohmic)

## Case Outline and Dimensions - Low-Ohmic TO-254AA



### BERYLLIA WARNING PER MIL-PRF-19500

Package containing beryllia shall not be ground, sandblasted, machined, or have other operations performed on them which will produce beryllia or beryllium dust. Furthermore, beryllium oxide packages shall not be placed in acids that will produce fumes containing beryllium.

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