

Formerly FSL430R4

June 1998

**2A, 500V, 2.50 Ohm, Rad Hard,  
N-Channel Power MOSFET**

## Features

- 2A, 500V,  $r_{DS(ON)} = 2.50\Omega$
- Total Dose
  - Meets Pre-RAD Specifications to 100K RAD (Si)
- Single Event
  - Safe Operating Area Curve for Single Event Effects
  - SEE Immunity for LET of 36MeV/mg/cm<sup>2</sup> with  $V_{DS}$  up to 80% of Rated Breakdown and  $V_{GS}$  of 10V Off-Bias
- Dose Rate
  - Typically Survives 3E9 RAD (Si)/s at 80%  $BV_{DSS}$
  - Typically Survives 2E12 if Current Limited to  $I_{DM}$
- Photo Current
  - 8.0nA Per-RAD(Si)/s Typically
- Neutron
  - Maintain Pre-RAD Specifications
  - for 3E12 Neutrons/cm<sup>2</sup>
  - Usable to 3E13 Neutrons/cm<sup>2</sup>

## Ordering Information

PART NUMBER	PACKAGE	BRAND
JANSR2N7398	TO-205AF	JANSR2N7398

Die Family TA17639.

MIL-PRF-19500/631.

## Description

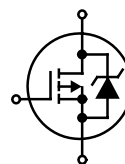
The Discrete Products Operation of Intersil Corporation has developed a series of Radiation Hardened MOSFETs specifically designed for commercial and military space applications. Enhanced Power MOSFET immunity to Single Event Effects (SEE), Single Event Gate Rupture (SEGR) in particular, is combined with 100K RADS of total dose hardness to provide devices which are ideally suited to harsh space environments. The dose rate and neutron tolerance necessary for military applications have not been sacrificed.

The Intersil portfolio of SEGR resistant radiation hardened MOSFETs includes N-Channel and P-Channel devices in a variety of voltage, current and on-resistance ratings. Numerous packaging options are also available.

This MOSFET is an enhancement-mode silicon-gate power field-effect transistor of the vertical DMOS (VDMOS) structure. It is specially designed and processed to be radiation tolerant. The MOSFET is well suited for applications exposed to radiation environments such as switching regulation, switching converters, motor drives, relay drivers and drivers for high-power bipolar switching transistors requiring high speed and low gate drive power. This type can be operated directly from integrated circuits.

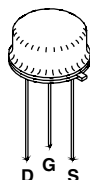
Also available at other radiation and screening levels. See us on the web, Intersil's home page: <http://www.intersil.com>. Contact your local Intersil Sales Office for additional information.

## Symbol



## Package

TO-205AF



# JANSR2N7398

## Absolute Maximum Ratings $T_C = 25^\circ\text{C}$ , Unless Otherwise Specified

	JANSR2N7398	UNITS
Drain to Source Voltage	500	V
Drain to Gate Voltage ( $R_{GS} = 20\text{k}\Omega$ )	500	V
Continuous Drain Current		
$T_C = 25^\circ\text{C}$	2	A
$T_C = 100^\circ\text{C}$	1	A
Pulsed Drain Current	6	A
Gate to Source Voltage	$\pm 20$	V
Maximum Power Dissipation		
$T_C = 25^\circ\text{C}$	25	W
$T_C = 100^\circ\text{C}$	10	W
Linear Derating Factor	0.20	W/ $^\circ\text{C}$
Single Pulsed Avalanche Current, $L = 100\mu\text{H}$ , (See Test Figure)	6	A
Continuous Source Current (Body Diode)	2	A
Pulsed Source Current (Body Diode)	6	A
Operating and Storage Temperature	-55 to 150	$^\circ\text{C}$
Lead Temperature (During Soldering)	300	$^\circ\text{C}$
(Distance $>0.063\text{in}$ (1.6mm) from Case, 10s Max)		
Weight (Typical)	1.0	g

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

## Electrical Specifications $T_C = 25^\circ\text{C}$ , Unless Otherwise Specified

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Drain to Source Breakdown Voltage	$BV_{DSS}$	$I_D = 1\text{mA}$ , $V_{GS} = 0\text{V}$	500	-	-	V
Gate Threshold Voltage	$V_{GS(TH)}$	$V_{GS} = V_{DS}$ , $I_D = 1\text{mA}$	$T_C = -55^\circ\text{C}$	-	5.0	V
			$T_C = 25^\circ\text{C}$	1.5	4.0	V
			$T_C = 125^\circ\text{C}$	0.5	-	V
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 400\text{V}$ , $V_{GS} = 0\text{V}$	$T_C = 25^\circ\text{C}$	-	25	$\mu\text{A}$
			$T_C = 125^\circ\text{C}$	-	250	$\mu\text{A}$
Gate to Source Leakage Current	$I_{GSS}$	$V_{GS} = \pm 20\text{V}$	$T_C = 25^\circ\text{C}$	-	100	nA
			$T_C = 125^\circ\text{C}$	-	200	nA
Drain to Source On-State Voltage	$V_{DS(ON)}$	$V_{GS} = 12\text{V}$ , $I_D = 2\text{A}$	-	-	5.25	V
Drain to Source On Resistance	$r_{DS(ON)12}$	$I_D = 1\text{A}$ , $V_{GS} = 12\text{V}$	$T_C = 25^\circ\text{C}$	-	1.80	$\Omega$
			$T_C = 125^\circ\text{C}$	-	4.80	$\Omega$
Turn-On Delay Time	$t_{d(ON)}$	$V_{DD} = 250\text{V}$ , $I_D = 2\text{A}$ , $R_L = 125\Omega$ , $V_{GS} = 12\text{V}$ , $R_{GS} = 7.5\Omega$	-	-	80	ns
Rise Time	$t_r$		-	-	100	ns
Turn-Off Delay Time	$t_{d(OFF)}$		-	-	150	ns
Fall Time	$t_f$		-	-	140	ns
Total Gate Charge (Not on Slash Sheet)	$Q_{g(TOT)}$	$V_{GS} = 0\text{V}$ to 20V	$V_{DD} = 250\text{V}$ , $I_D = 2\text{A}$	-	52	nC
Gate Charge at 12V	$Q_{g(12)}$	$V_{GS} = 0\text{V}$ to 12V		-	28	nC
Threshold Gate Charge (Not on Slash Sheet)	$Q_{g(TH)}$	$V_{GS} = 0\text{V}$ to 2V		-	2.1	nC
Gate Charge Source	$Q_{gs}$			-	4.7	nC
Gate Charge Drain	$Q_{gd}$			-	13	nC
Thermal Resistance Junction to Case	$R_{\theta JC}$			-	5.0	$^\circ\text{C/W}$
Thermal Resistance Junction to Ambient	$R_{\theta JA}$		-	-	175	$^\circ\text{C/W}$

# JANSR2N7398

## Source to Drain Diode Specifications

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Forward Voltage	$V_{SD}$	$I_{SD} = 2A$	0.6	-	1.8	V
Reverse Recovery Time	$t_{rr}$	$I_{SD} = 2A, dI_{SD}/dt = 100A/\mu s$	-	-	390	ns

## Electrical Specifications up to 100K RAD $T_C = 25^\circ C$ , Unless Otherwise Specified

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	MAX	UNITS
Drain to Source Breakdown Volts (Note 3)	$BV_{DSS}$	$V_{GS} = 0, I_D = 1mA$	500	-	V
Gate to Source Threshold Volts (Note 3)	$V_{GS(TH)}$	$V_{GS} = V_{DS}, I_D = 1mA$	1.5	4.0	V
Gate to Body Leakage (Notes 2, 3)	$I_{GSS}$	$V_{GS} = \pm 20V, V_{DS} = 0V$	-	100	nA
Zero Gate Leakage (Note 3)	$I_{DSS}$	$V_{GS} = 0, V_{DS} = 400V$	-	25	$\mu A$
Drain to Source On-State Volts (Notes 1, 3)	$V_{DS(ON)}$	$V_{GS} = 12V, I_D = 2A$	-	5.25	V
Drain to Source On Resistance (Notes 1, 3)	$r_{DS(ON)12}$	$V_{GS} = 12V, I_D = 1A$	-	2.50	$\Omega$

### NOTES:

1. Pulse test, 300 $\mu s$  Max.
2. Absolute value.
3. Insitu Gamma bias must be sampled for both  $V_{GS} = 12V, V_{DS} = 0V$  and  $V_{GS} = 0V, V_{DS} = 80\% BV_{DSS}$ .

## Single Event Effects (SEB, SEGR) (Note 4)

TEST	SYMBOL	ENVIRONMENT (NOTE 5)			APPLIED $V_{GS}$ BIAS (V)	(NOTE 6) MAXIMUM $V_{DS}$ BIAS (V)
		ION SPECIES	TYPICAL LET (MeV/mg/cm <sup>2</sup> )	TYPICAL RANGE ( $\mu$ )		
Single Event Effects Safe Operating Area	SEESOA	Ni	26	43	-15	500
		Ni	26	43	-20	450
		Br	37	36	-5	500
		Br	37	36	-10	400
		Br	37	36	-15	100

### NOTES:

4. Testing conducted at Brookhaven National Labs; sponsored by Naval Surface Warfare Center (NSWC), Crane, IN.
5. Fluence = 1E5 ions/cm<sup>2</sup> (typical),  $T = 25^\circ C$ .
6. Does not exhibit Single Event Burnout (SEB) or Single Event Gate Rupture (SEGR).

## Typical Performance Curves Unless Otherwise Specified

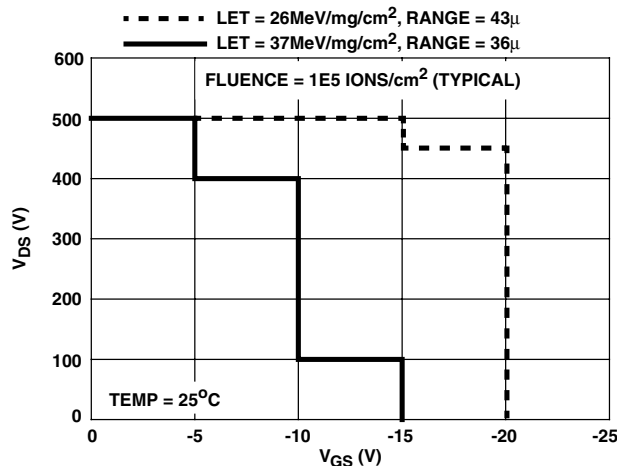


FIGURE 1. SINGLE EVENT EFFECTS SAFE OPERATING AREA

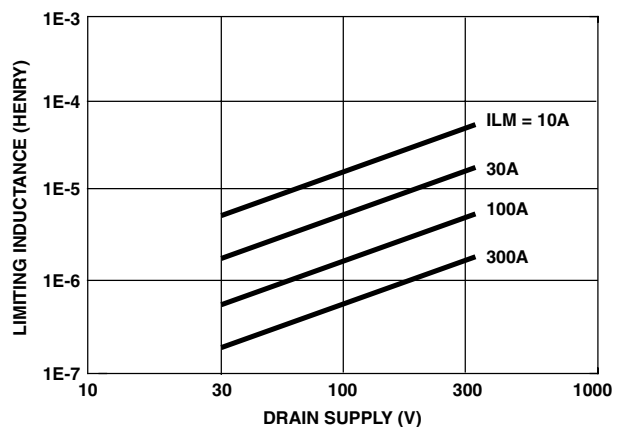


FIGURE 2. DRAIN INDUCTANCE REQUIRED TO LIMIT GAMMA DOT CURRENT TO  $I_{AS}$

**Typical Performance Curves** Unless Otherwise Specified (Continued)

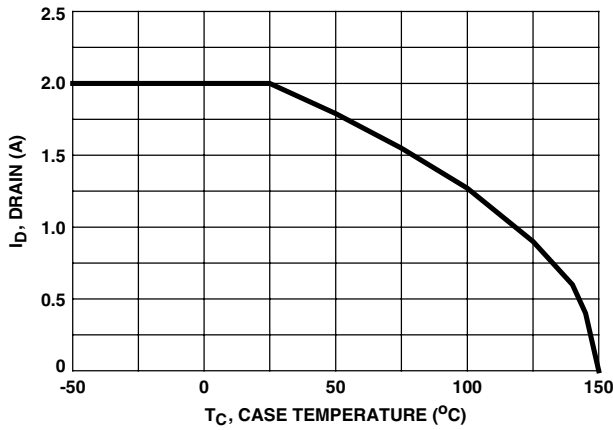


FIGURE 3. MAXIMUM CONTINUOUS DRAIN CURRENT vs TEMPERATURE

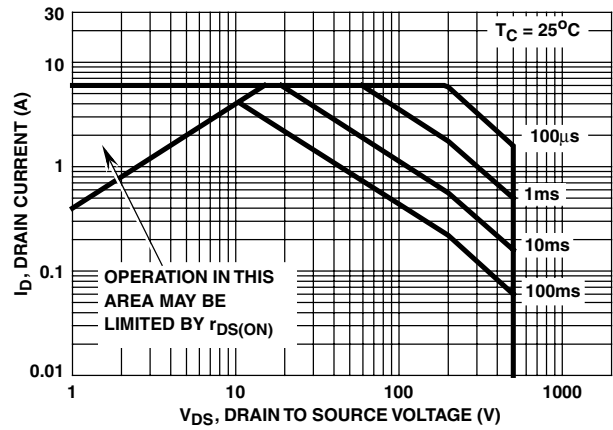


FIGURE 4. FORWARD BIAS SAFE OPERATING CURVE

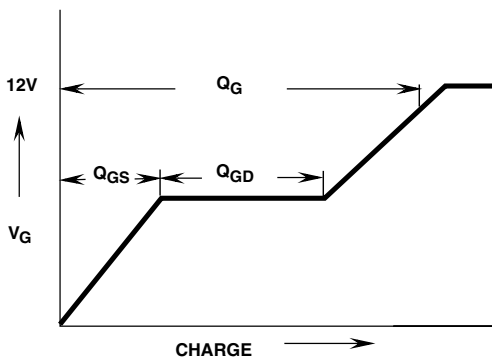


FIGURE 5. BASIC GATE CHARGE WAVEFORM

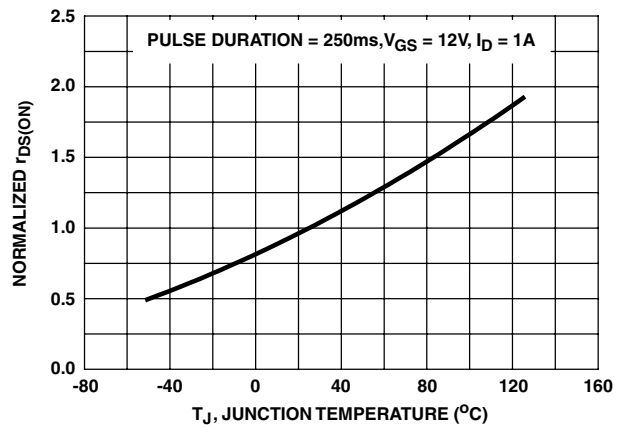


FIGURE 6. NORMALIZED  $r_{DS(ON)}$  vs JUNCTION TEMPERATURE

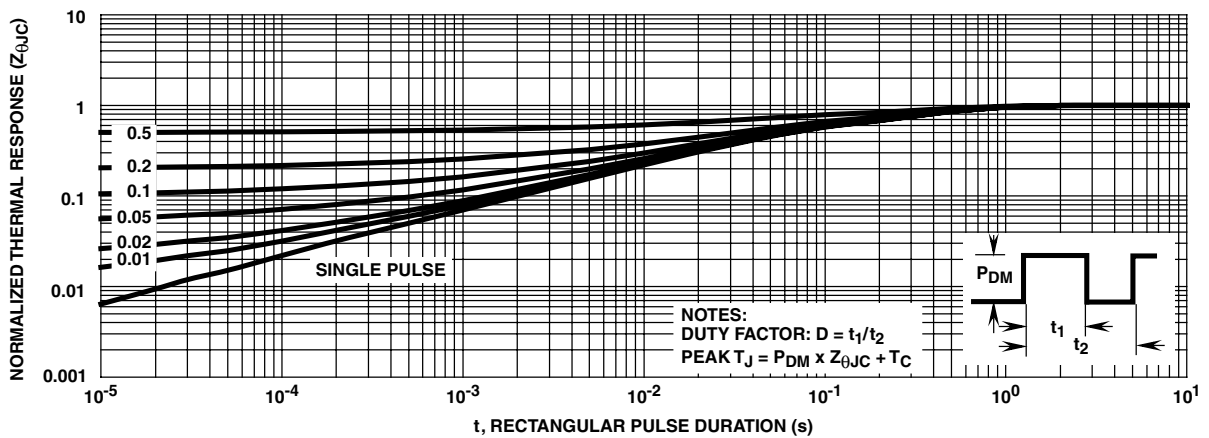


FIGURE 7. NORMALIZED MAXIMUM TRANSIENT THERMAL RESPONSE

**Typical Performance Curves** Unless Otherwise Specified (Continued)

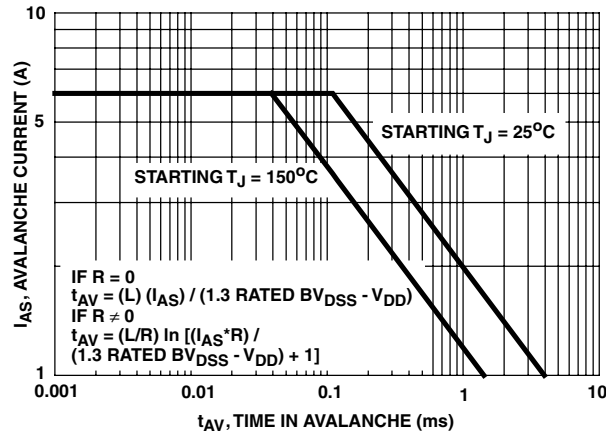


FIGURE 8. UNCLAMPED INDUCTIVE SWITCHING

**Test Circuits and Waveforms**

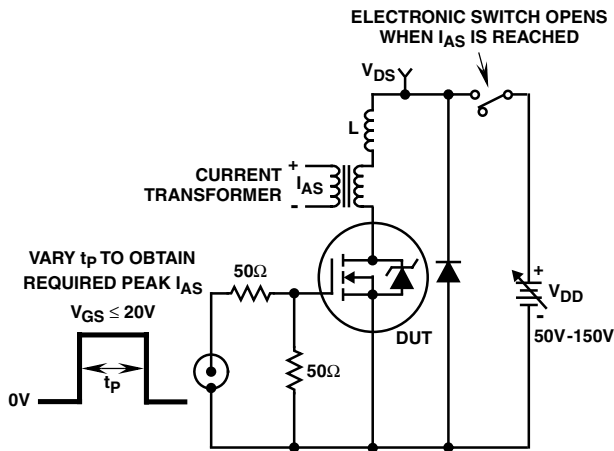


FIGURE 9. UNCLAMPED ENERGY TEST CIRCUIT

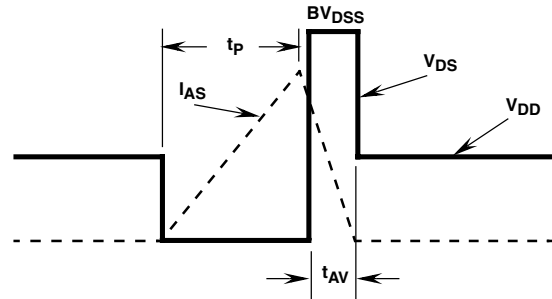


FIGURE 10. UNCLAMPED ENERGY WAVEFORMS

# Test Circuits and Waveforms

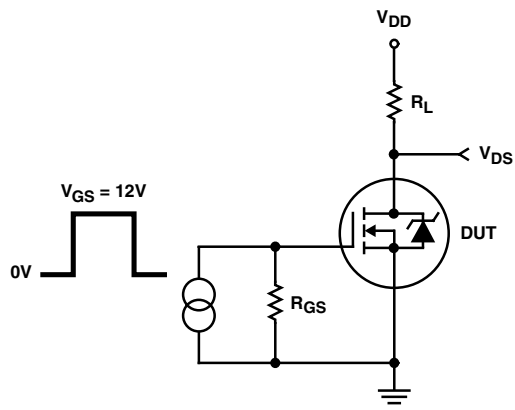


FIGURE 11. RESISTIVE SWITCHING TEST CIRCUIT

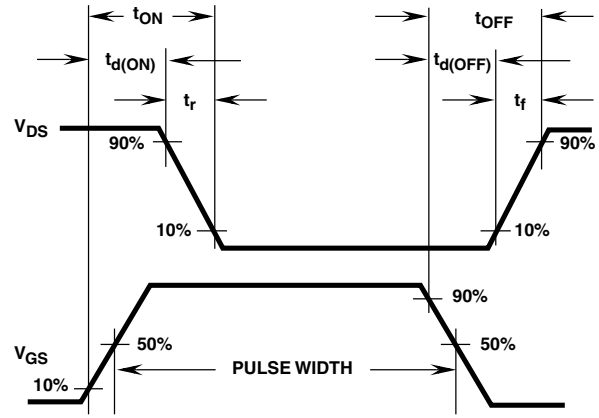


FIGURE 12. RESISTIVE SWITCHING WAVEFORMS

## JANSR2N7398

### Screening Information

Screening is performed in accordance with the latest revision in effect of MIL-S-19500, (Screening Information Table).

**Delta Tests and Limits (JANS)**  $T_C = 25^\circ\text{C}$ , Unless Otherwise Specified

PARAMETER	SYMBOL	TEST CONDITIONS	MAX	UNITS
Gate to Source Leakage Current	$I_{GSS}$	$V_{GS} = \pm 20\text{V}$	$\pm 20$ (Note 7)	nA
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 80\%$ Rated Value	$\pm 25$ (Note 7)	$\mu\text{A}$
Drain to Source On Resistance	$r_{DS(ON)}$	$T_C = 25^\circ\text{C}$ at Rated $I_D$	$\pm 20\%$ (Note 8)	$\Omega$
Gate Threshold Voltage	$V_{GS(TH)}$	$I_D = 1.0\text{mA}$	$\pm 20\%$ (Note 8)	V

NOTES:

7. Or 100% of Initial Reading (whichever is greater).
8. Of Initial Reading.

### Screening Information

TEST	JANS
Gate Stress	$V_{GS} = 30\text{V}$ , $t = 250\mu\text{s}$
Pind	Required
Pre Burn-In Tests (Note 9)	MIL-S-19500 Group A, Subgroup 2 (All Static Tests at $25^\circ\text{C}$ )
Steady State Gate Bias (Gate Stress)	MIL-STD-750, Method 1042, Condition B $V_{GS} = 80\%$ of Rated Value, $T_A = 150^\circ\text{C}$ , Time = 48 hours
Interim Electrical Tests (Note 9)	All Delta Parameters Listed in the Delta Tests and Limits Table
Steady State Reverse Bias (Drain Stress)	MIL-STD-750, Method 1042, Condition A $V_{DS} = 80\%$ of Rated Value, $T_A = 150^\circ\text{C}$ , Time = 240 hours
PDA	5%
Final Electrical Tests (Note 9)	MIL-S-19500, Group A, Subgroups 2 and 3

NOTE:

9. Test limits are identical pre and post burn-in.

### Additional Screening Tests

PARAMETER	SYMBOL	TEST CONDITIONS	MAX	UNITS
Safe Operating Area	SOA	$V_{DS} = 200\text{V}$ , $t = 10\text{ms}$	0.56	A
Unclamped Inductive Switching	$I_{AS}$	$V_{GS(PEAK)} = 15\text{V}$ , $L = 0.1\text{mH}$	6	A
Thermal Response	$\Delta V_{SD}$	$t_H = 10\text{ms}$ ; $V_H = 25\text{V}$ ; $I_H = 2\text{A}$	125	mV
Thermal Impedance	$\Delta V_{SD}$	$t_H = 500\text{ms}$ ; $V_H = 25\text{V}$ ; $I_H = 1\text{A}$	250	mV

## ***Rad Hard Data Packages - Intersil Power Transistors***

### **1. JANS Rad Hard - Standard Data Package**

- A. Certificate of Compliance
- B. Serialization Records
- C. Assembly Flow Chart
- D. SEM Photos and Report
- E. Preconditioning
  - Attributes Data Sheet
  - Hi-Rel Lot Traveler
  - HTRB - Hi Temp Gate Stress Post Reverse
  - Bias Data and Delta Data
  - HTRB - Hi Temp Drain Stress Post Reverse
  - Bias Delta Data
- F. Group A
  - Attributes Data Sheet
- G. Group B
  - Attributes Data Sheet
- H. Group C
  - Attributes Data Sheet
- I. Group D
  - Attributes Data Sheet

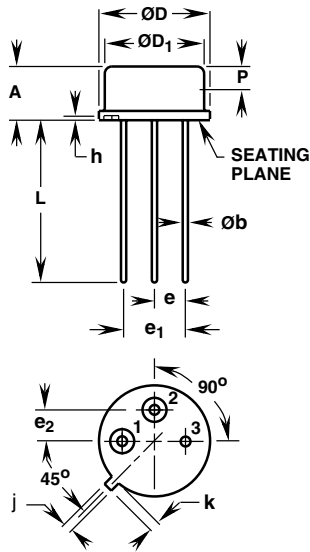
### **2. JANS Rad Hard - Optional Data Package**

- A. Certificate of Compliance
- B. Serialization Records
- C. Assembly Flow Chart
- D. SEM Photos and Report
- E. Preconditioning
  - Attributes Data Sheet
  - Hi-Rel Lot Traveler
  - HTRB - Hi Temp Gate Stress Post Reverse Bias Data and Delta Data
  - HTRB - Hi Temp Drain Stress Post Reverse Bias Delta Data
  - X-Ray and X-Ray Report
- F. Group A
  - Attributes Data Sheet
  - Hi-Rel Lot Traveler
  - Subgroups A2, A3, A4, A5 and A7 Data
- G. Group B
  - Attributes Data Sheet
  - Hi-Rel Lot Traveler
  - Subgroups B1, B3, B4, B5 and B6 Data
- H. Group C
  - Attributes Data Sheet
  - Hi-Rel Lot Traveler
  - Subgroups C1, C2, C3 and C6 Data
- I. Group D
  - Attributes Data Sheet
  - Hi-Rel Lot Traveler
  - Pre and Post Radiation Data



**TO-205AF**

**3 LEAD JEDEC TO-205AF HERMETIC METAL CAN PACKAGE**



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.160	0.180	4.07	4.57	-
Øb	0.016	0.021	0.41	0.53	2, 3
ØD	0.350	0.370	8.89	9.39	-
ØD <sub>1</sub>	0.315	0.335	8.01	8.50	-
e	0.095	0.105	2.42	2.66	4
e <sub>1</sub>	0.190	0.210	4.83	5.33	4
e <sub>2</sub>	0.095	0.105	2.42	2.66	4
h	0.010	0.020	0.26	0.50	-
j	0.028	0.034	0.72	0.86	-
k	0.029	0.045	0.74	1.14	-
L	0.500	0.560	12.70	14.22	3
P	0.075	-	1.91	-	5

NOTES:

1. These dimensions are within allowable dimensions of Rev. E of JEDEC TO-205AF outline dated 11-82.
2. Lead dimension (without solder).
3. Solder coating may vary along lead length, add typically 0.002 inches (0.05mm) for solder coating.
4. Position of lead to be measured 0.100 inches (2.54mm) from bottom of seating plane.
5. This zone controlled for automatic handling. The variation in actual diameter within this zone shall not exceed 0.010 inches (0.254mm).
6. Lead no. 3 butt welded to stem base.
7. Controlling dimension: Inch.
8. Revision 3 dated 6-94.

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.