FSS9130D, FSS9130R

HARRIS SEMICONDUCTOR

Radiation Hardened, SEGR Resistant P-Channel Power MOSFETs

June 1997

Features

- 6A, -100V, $r_{DS(ON)} = 0.660\Omega$
- 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^2 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 - 1.5nA Per-RAD(Si)/s Typically
- Neutron - Maintain Pre-RAD Specifications for 3E13 Neutrons/cm^2
  - Usable to 3E14 Neutrons/cm^2

Description

The Discrete Products Operation of Harris Semiconductor 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 Harris 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.

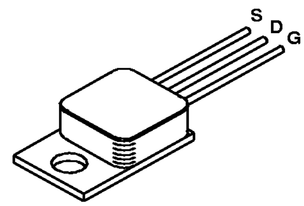
This MOSFET is an enhancement-mode silicon-gate power field-effect transistor of the vertical DMOS (VDMOS) structure. It is specially designed and processed to be radiation tolerant. The MOSFET is well suited for applications exposed to radiation environments such as switching regulation, switching converters, 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.

Reliability screening is available as either commercial, TXV equivalent of MIL-S-19500, or Space equivalent of MIL-S-19500. Contact Harris Semiconductor for any desired deviations from the data sheet.

FORMERLY AVAILABLE AS TYPE TA17736

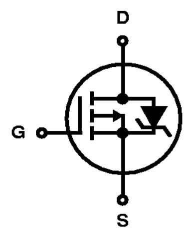
Package

TO-257AA



CAUTION: Beryllia Warning per MIL-S-19500 refer to package specifications.

Symbol



Absolute Maximum Ratings $T_C = 25^oC$, Unless Otherwise Specified

Parameter	Symbol	FSS9130D, FSS9130R	UNITS
Drain-Source Voltage	V_{DS}	-100	V
Drain-Gate Voltage ($R_{GS} = 20k\Omega$)	V_{DGR}	-100	V
Continuous Drain Current			
$T_C = 25^oC$	I_D	6	A
$T_C = 100^oC$	I_D	4	A
Pulsed Drain Current	I_{DM}	18	A
Gate-Source Voltage	V_{GS}	±20	V
Maximum Power Dissipation			
$T_C = 25^oC$	P_T	50	W
$T_C = 100^oC$	P_T	20	W
Derated Above 25^{o}C		0.40	W/^{o}C
Single Pulsed Avalanche Current, L = 100µH, (See Test Figure)	I_{AS}	18	A
Continuous Source Current (Body Diode)	I_S	6	A
Pulsed Source Current (Body Diode)	I_{SM}	18	A
Operating and Storage Temperature	T_J, T_{STG}	-55 to 150	^{o}C
Lead Temperature (During Soldering) (Distance >0.063 in. (1.6mm) from Case, 10s Max)	T_L	300	^{o}C

CAUTION: These devices are sensitive to electrostatic discharge. Users should follow proper IC Handling Procedures.

File Number **4082.1**

Electrical Specifications $T_C = 25^oC$, Unless Otherwise Specified

PARAMETER	SYMBOL	TEST CONDITIONS		MIN	TYP	MAX	UNITS
Drain-Source Breakdown Voltage	BV_{DSS}	$I_D = 1mA$, $V_{GS} = 0V$		-100	-	-	V
Gate Threshold Voltage	$V_{GS(TH)}$	$V_{GS} = V_{DS}$, $I_D = 1mA$	$T_C = -55^oC$	-	-	-7.0	V
			$T_C = 25^oC$	-2.0	-	-6.0	V
			$T_C = 125^oC$	-1.0	-	-	V
Zero Gate Voltage Drain Current	I_{DSS}	$V_{DS} = -80V$, $V_{GS} = 0V$	$T_C = 25^oC$	-	-	25	μA
			$T_C = 125^oC$	-	-	250	μA
Gate-Source Leakage Current	I_{GSS}	$V_{GS} = \pm 20V$	$T_C = 25^oC$	-	-	100	nA
			$T_C = 125^oC$	-	-	200	nA
Drain-Source On-State Voltage	$V_{DS(ON)}$	$V_{GS} = -12V$, $I_D = 6A$		-	-	-4.16	V
On Resistance	$r_{DS(ON)12}$	$I_D = 4A$, $V_{GS} = -12V$	$T_C = 25^oC$	-	0.370	0.660	Ω
			$T_C = 125^oC$	-	-	1.089	Ω
Turn-On Delay Time	$t_{d(ON)}$	$V_{DD} = -50V$, $I_D = 6A$, $R_L = 8.3\Omega$, $V_{GS} = -12V$, $R_{GS} = 7.5\Omega$		-	-	70	ns
Rise Time	t_r			-	-	160	ns
Turn-Off Delay Time	$t_{d(OFF)}$			-	-	110	ns
Fall Time	t_f			-	-	130	ns
Total Gate Charge	$Q_{g(TOT)}$	$V_{GS} = 0V$ to $-20V$	$V_{DD} = -50V$, $I_D = 6A$	-	-	62	nC
Gate Charge at 12V	$Q_{g(12)}$	$V_{GS} = 0V$ to $-12V$		-	32	40	nC
Threshold Gate Charge	$Q_{g(TH)}$	$V_{GS} = 0V$ to $-2V$		-	-	2.6	nC
Gate Charge Source	Q_{gs}			-	6.3	8.8	nC
Gate Charge Drain	Q_{gd}			-	13	18	nC
Plateau Voltage	$V_{(PLATEAU)}$	$I_D = 6A$, $V_{DS} = -15V$		-	-7	-	V
Input Capacitance	C_{ISS}	$V_{DS} = -25V$, $V_{GS} = 0V$, f = 1MHz		-	840	-	pF
Output Capacitance	C_{OSS}			-	300	-	pF
Reverse Transfer Capacitance	C_{RSS}			-	75	-	pF
Thermal Resistance Junction to Case	$R_{\theta JC}$			-	-	2.5	$^oC/W$
Thermal Resistance Junction to Ambient	$R_{\theta JA}$			-	-	60	$^oC/W$

Source-Drain Diode Specifications

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Forward Voltage	V_{SD}	$I_{SD} = 6A$	-0.6	-	-1.8	V
Reverse Recovery Time	t_{rr}	$I_{SD} = 6A$, $dI_{SD}/dt = 100A/\mu s$	-	-	190	ns

Electrical Specifications up to 100K RAD $T_C = 25^oC$, Unless Otherwise Specified

PARAMETER		SYMBOL	TEST CONDITIONS	MIN	MAX	UNITS
Drain-Source Breakdown Volts	(Note 3)	BV_{DSS}	$V_{GS} = 0$, $I_D = 1mA$	-100	-	V
Gate-Source Threshold Volts	(Note 3)	$V_{GS(TH)}$	$V_{GS} = V_{DS}$, $I_D = 1mA$	-2.0	-6.0	V
Gate-Body Leakage	(Notes 2, 3)	I_{GSS}	$V_{GS} = \pm20V$, $V_{DS} = 0V$	-	100	nA
Zero-Gate Leakage	(Note 3)	I_{DSS}	$V_{GS} = 0$, $V_{DS} = -80V$	-	25	μA
Drain-Source On-State Volts	(Notes 1, 3)	$V_{DS(ON)}$	$V_{GS} = -12V$, $I_D = 6A$	-	-4.16	V
Drain-Source On Resistance	(Notes 1, 3)	$r_{DS(ON)12}$	$V_{GS} = -12V$, $I_D = 4A$	-	0.660	Ω

NOTES:
1. Pulse test, 300μs 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 1)

TEST	SYMBOL	ENVIRONMENT (NOTE 2)			APPLIED V_{GS} BIAS (V)	(NOTE 3) MAXIMUM V_{DS} BIAS (V)
		ION SPECIES	TYPICAL LET (MeV/mg/cm)	TYPICAL RANGE (μ)		
Single Event Effects Safe Operating Area	SEESOA	Ni	26	43	20	-100
		Br	37	36	10	-100
		Br	37	36	15	-80
		Br	37	36	20	-50

NOTES:
1. Testing conducted at Brookhaven National Labs; sponsored by Naval Surface Warfare Center (NSWC), Crane, IN.
2. Fluence = 1E5 ions/cm^2 (typical), T = 25^oC.
3. Does not exhibit Single Event Burnout (SEB) or Single Event Gate Rupture (SEGR).

Performance Curves

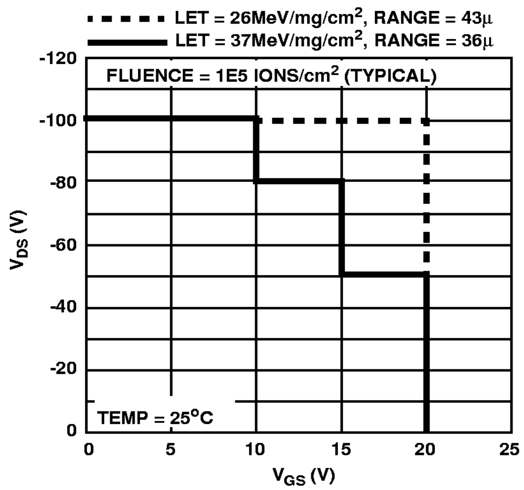


FIGURE 1. SINGLE EVENT EFFECTS SAFE OPERATING AREA

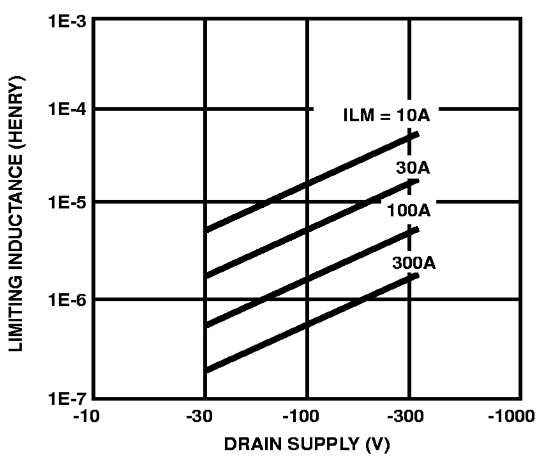


FIGURE 2. TYPICAL DRAIN INDUCTANCE REQUIRED TO LIMIT GAMMA DOT CURRENT TO I_{AS}

Performance Curves (Continued)

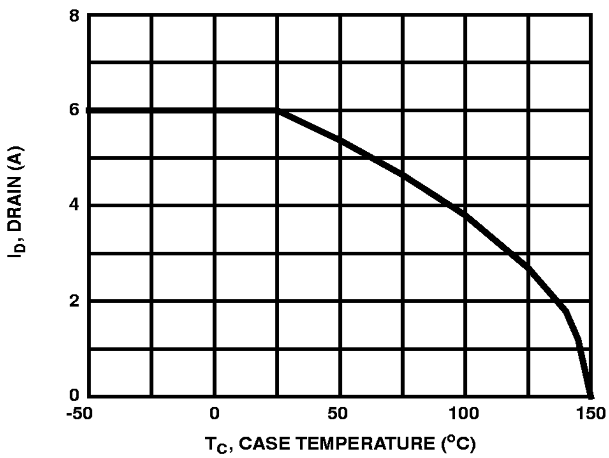


FIGURE 3. MAXIMUM CONTINUOUS DRAIN CURRENT vs TEMPERATURE

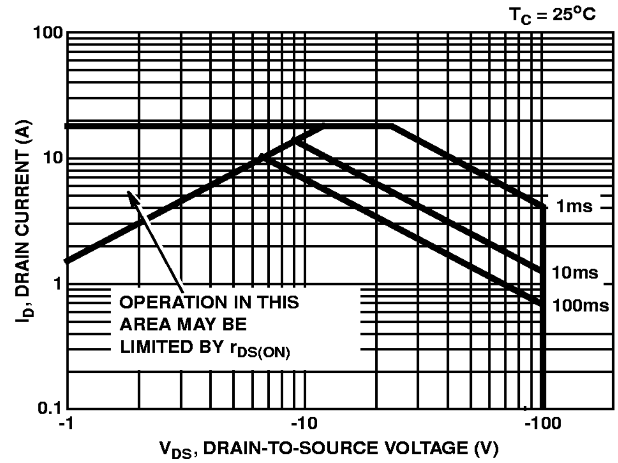


FIGURE 4. SAFE OPERATING CURVE

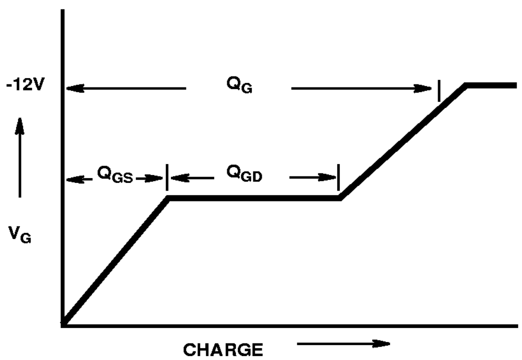


FIGURE 5. BASIC GATE CHARGE WAVEFORM

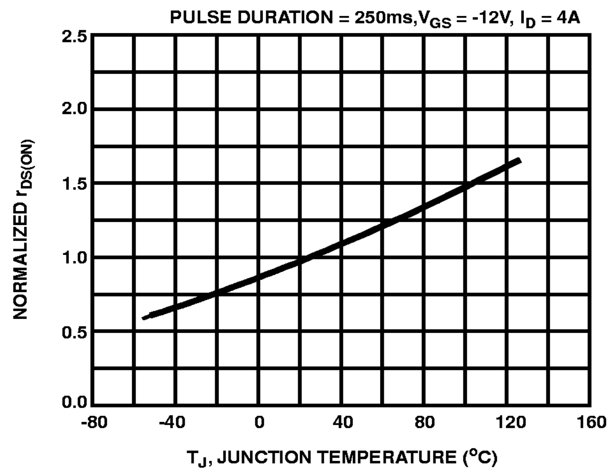


FIGURE 6. NORMALIZED $r_{DS(ON)}$ vs JUNCTION TEMPERATURE

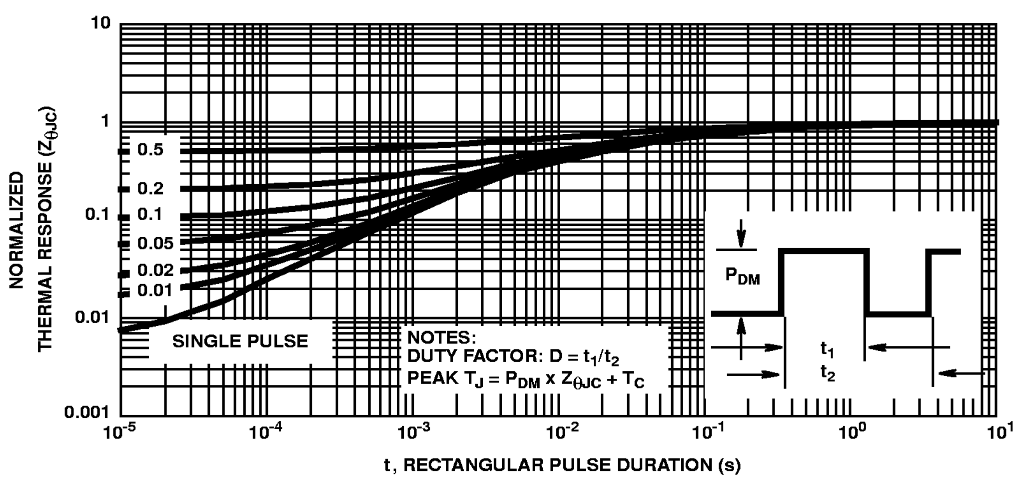


FIGURE 7. NORMALIZED MAXIMUM TRANSIENT THERMAL RESPONSE

Performance Curves (Continued)

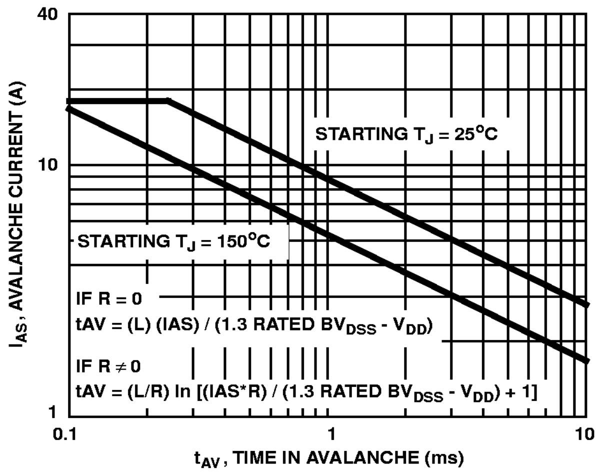


FIGURE 8. UNCLAMPED INDUCTIVE SWITCHING

Test Circuits and Waveforms

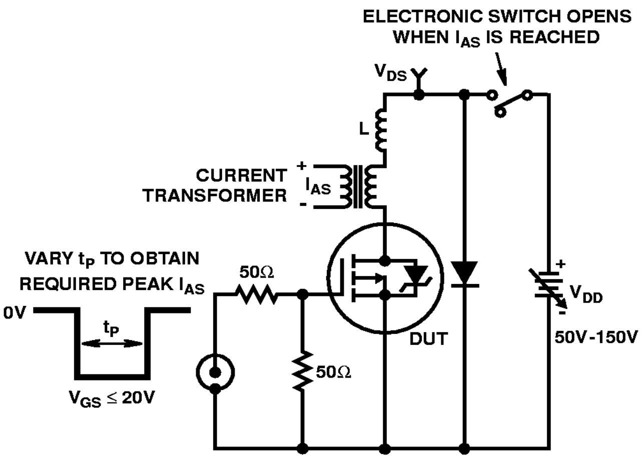


FIGURE 9. UNCLAMPED ENERGY TEST CIRCUIT

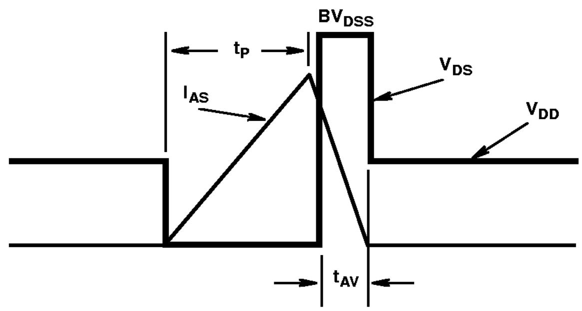


FIGURE 10. UNCLAMPED ENERGY WAVEFORMS

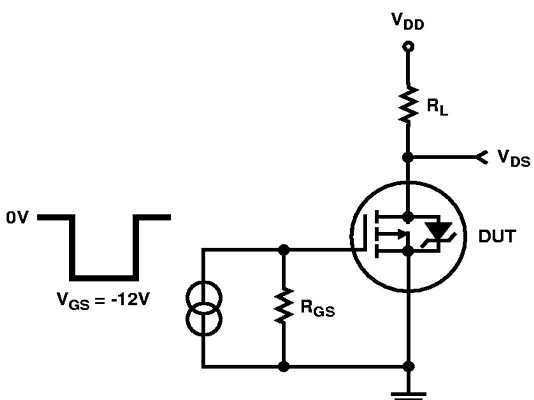


FIGURE 11. RESISTIVE SWITCHING TEST CIRCUIT

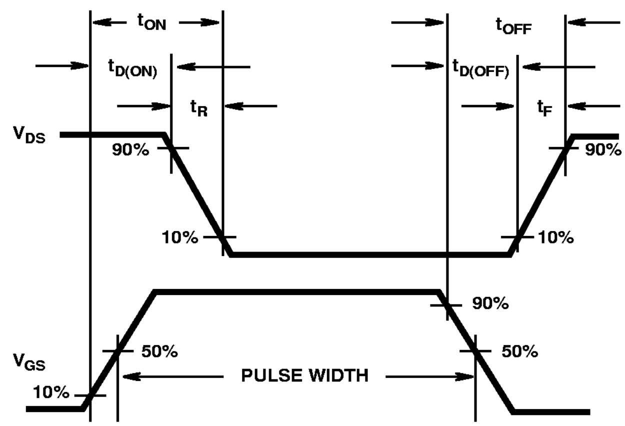


FIGURE 12. RESISTIVE SWITCHING WAVEFORMS

Screening Information

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

Delta Tests and Limits (JANTXV Equivalent, JANS Equivalent) $T_C = 25^oC$, Unless Otherwise Specified

PARAMETER	SYMBOL	TEST CONDITIONS	MAX	UNITS
Gate-Source Leakage Current	I_{GSS}	$V_{GS} = \pm20V$	±20 (Note 1)	nA
Zero Gate Voltage Drain Current	I_{DSS}	V_{DS} = 80% Rated Value	±25 (Note 1)	µA
On Resistance	$r_{DS(ON)}$	$T_C = 125^oC$ at Rated I_D	±20% (Note 2)	Ω
Gate Threshold Voltage	$V_{GS(TH)}$	I_D = 1.0mA	±20% (Note 2)	V

NOTES:

1. Or 100% of initial reading (whichever is greater).
2. Of initial reading.

Screening Information

TEST	JANTXV EQUIVALENT	JANS EQUIVALENT
Gate Stress	V_{GS} = -30V, t = 250µs	V_{GS} = -30V, t = 250µs
Pind	Optional	Required
PDA	10%	5%
Pre Burn-In Tests (Note 1)	MIL-S-19500 Group A, Subgroup 2 (All Static Tests at 25^oC)	MIL-S-19500 Group A, Subgroup 2 (All Static Tests at 25^oC)
Steady State Gate Bias (Gate Stress)	MIL-STD-750, Method 1042, Condition B V_{GS} = 80% of Rated Value, $T_A = 150^oC$, Time = 48 hours	MIL-STD-750, Method 1042, Condition B V_{GS} = 80% of Rated Value, $T_A = 150^oC$, Time = 48 hours
Interim Electrical Tests (Note 1)	All Delta Parameters Listed in the Delta Tests and Limits Table	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, $T_A = 150^oC$, Time = 160 hours	MIL-STD-750, Method 1042, Condition A V_{DS} = 80% of Rated Value, $T_A = 150^oC$, Time = 240 hours
Final Electrical Tests (Note 1)	MIL-S-19500, Group A, Subgroup 2	MIL-S-19500, Group A, Subgroups 2 and 3

NOTE:

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

Additional Screening Tests

PARAMETER	SYMBOL	TEST CONDITIONS	MAX	UNITS
Safe Operating Area	SOA	V_{DS} = -80V, t = 10ms	1.56	A
Unclamped Inductive Switching	I_{AS}	$V_{GS(PEAK)}$ = -15V, L = 0.1mH	18	A
Thermal Response	ΔV_{SD}	t_H = 100ms; V_H = -25V; I_H = 1A	90	mV
Thermal Impedance	ΔV_{SD}	t_H = 500ms; V_H = -25V; I_H = 1A	125	mV

Rad Hard Data Packages - Harris Power Transistors

TXV Equivalent

1. Rad Hard TXV Equivalent - Standard Data Package
   - A. Certificate of Compliance
   - B. Assembly Flow Chart
   - C. Preconditioning - Attributes Data Sheet
   - D. Group A - Attributes Data Sheet
   - E. Group B - Attributes Data Sheet
   - F. Group C - Attributes Data Sheet
   - G. Group D - Attributes Data Sheet

2. Rad Hard TXV Equivalent - Optional Data Package

- A. Certificate of Compliance
- B. Assembly Flow Chart
- C. Preconditioning
  - Attributes Data Sheet
  - Precondition Lot Traveler
  - Pre and Post Burn-In Read and Record Data
- D. Group A
  - Attributes Data Sheet
  - Group A Lot Traveler
- E. Group B
  - Attributes Data Sheet
  - Group B Lot Traveler
  - Pre and Post Read and Record Data for Intermittent Operating Life (Subgroup B3)
  - Bond Strength Data (Subgroup B3)
  - Pre and Post High Temperature Operating Life Read and Record Data (Subgroup B6)
- F. Group C
  - Attributes Data Sheet
  - Group C Lot Traveler
  - Pre and Post Read and Record Data for Intermittent Operating Life (Subgroup C6)
  - Bond Strength Data (Subgroup C6)
- G. Group D
  - Attributes Data Sheet
  - Group D Lot Traveler
  - Pre and Post RAD Read and Record Data

Class S - Equivalents

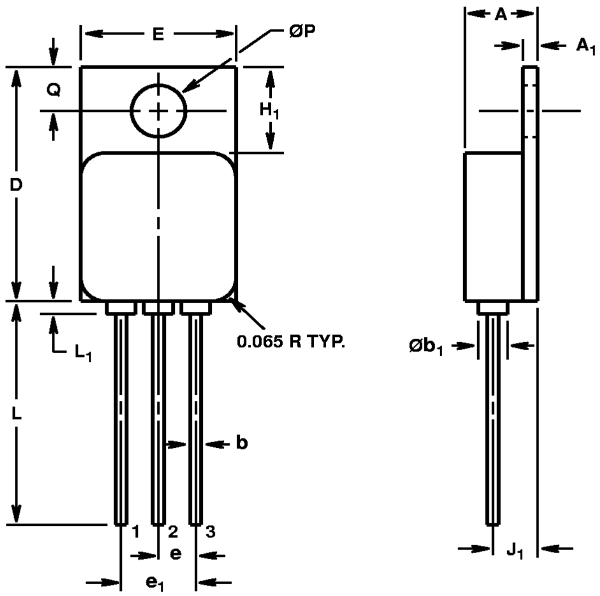
1. Rad Hard "S" Equivalent - Standard Data Package
   - A. Certificate of Compliance
   - B. Serialization Records
   - C. Assembly Flow Chart
   - D. SEM Photos and Report
   - E. Preconditioning
     - Attributes Data Sheet
     - Hi-Rel Lot Traveler
     - HTRB - Hi Temp Gate Stress Post Reverse Bias 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. Rad Hard Max. "S" Equivalent - 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-257AA

3 LEAD JEDEC TO-257AA HERMETIC METAL PACKAGE



SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.190	0.200	4.83	5.08	-
A_1	0.035	0.045	0.89	1.14	-
Øb	0.025	0.035	0.64	0.88	2, 3
Øb_1	0.060	0.090	1.53	2.28	-
D	0.645	0.665	16.39	16.89	-
E	0.410	0.420	10.42	10.66	-
e	0.100 TYP		2.54 TYP		4
e_1	0.200 BSC		5.08 BSC		4
H_1	0.230	0.250	5.85	6.35	-
J_1	0.110	0.130	2.80	3.30	4
L	0.600	0.650	15.24	16.51	-
L_1	-	0.035	-	0.88	-
ØP	0.140	0.150	3.56	3.81	-
Q	0.113	0.133	2.88	3.37	-

NOTES:

1. These dimensions are within allowable dimensions of Rev. B of JEDEC TO-257AA dated 9-88.
2. Add typically 0.002 inches (0.05mm) for solder coating.
3. Lead dimension (without solder).
4. Position of lead to be measured 0.150 inches (3.81mm) from bottom of dimension D.
5. Die to base BeO isolated, terminals to case ceramic isolated.
6. Controlling dimension: Inch.
7. Revision 1 dated 1-93.

WARNING!

BERYLLIA WARNING PER MIL-S-19500

Packages containing beryllium oxide (BeO) shall not be ground, machined, sandblasted, or subject to any mechanical operation which will produce dust containing any beryllium compound. Packages containing any beryllium compound shall not be subjected to any chemical process (etching, etc.) which will produce fumes containing beryllium or its compounds.

All Harris Semiconductor products are manufactured, assembled and tested under **ISO9000** quality systems certification.

Sales Office Headquarters

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