Power Matters.[™]



TID versus ELDRS on Transistors The Whole Picture

Microsemi Space Forum 2015

Ray DiBugnara Director of Technology and Radiation Services



Microsemi

Contents

- Metrics (Measuring the Radiation Response)
- Common Ground for RAD Comparisons
- Bipolar Junction Transistors
 PNP Transistors TID vs. ELDRS
 NPN Transistors TID vs. ELDRS
 NPN Transistor under Power
 ELDRS 100mRAD/s versus 10mRAD/s?
- Must Have This to be Sure
- Appendix Microsemi ELDR Facility



Metrics

Measuring the Radiation Response



BJT: Example on Calculating "Bracket" [hFE]

Bipolar Transistors:

A special designation has been developed as a measure of the gain drop across irradiation. It is meant to create a value that not only monitors the total drop in gain but also the relative drop in gain vs. the final test requirement:

Calculating [hfe]:

 $\Delta(1/h_{FE}) = 1/h_{FE}2 - 1/h_{FE}1$

hfe1 = initial test reading for hfe hfe2 = test reading after exposure

 $[h_{FE}] = 1/((\Delta(1/h_{FE}) + 1/h_{FE} \min))$

hFE min = Slash Sheet min specification

Example:

 $h_{FE1} = 200$, $h_{FE2} = 125$, $h_{FE} min = 100$

 $\Delta(1/h_{\text{FE}}) = 1/125 - 1/200$ = 0.008 - 0.005 = 0.003

 $[h_{FE}] = 1/(0.003 + 1/100)$

= 1/(0.003 + 0.010) = 1/.013 = 76.9

By definition, always lower than here min. Note: You can always find $\Delta(1/h_{FE})$ again.

(Ref: Mil-Std-750 Test Method 1019.6 Para 3.12)



BJT: Calculating Normalized Delta(1/hFE)

Calculating: Δ (1/hFE):

 $\Delta(1/h_{FE}) = 1/h_{FE}2 - 1/h_{FE}1$ This is invaluable for interpolating and extrapolating the Gamma radiation response of a BJT and folding in displacement damage exposure, but...

Problem:

Cannot compare individual parts within a lot or across various technologies if the gain varies from sample to sample.

Solution:

Calculating Normalized Δ (1/hFE) : Normalized Δ (1/hFE) = 1/(hFE2/hFE1) - 1/(hFE1/hFE1) = 1/(hFE2/hFE1) - 1

Example:

BJT#1 hfe1 = 50 , hfe2 = 25 Δ (1/hfe) = 1/25 - 1/50 = **0.02**

 $\begin{array}{l} \text{BJT\#2 hfe1} = 300 \;, \;\; \text{hfe2} = 150 \\ \Delta \left(1/\text{hfe} \right) = 1/150 - 1/300 \;\; = \textbf{0.003} \end{array}$

Both were affected the same yet you cannot tell from the $\Delta(1/h_{FE})$ values.

Now Normalized (N):

BJT#1 hfe1 = 50 , hfe2 = 25 N Δ (1/hfe) = 1/(25/50) -1 = **1.0**

BJT#2 hfe1 = 300 , hfe2 = 150 N Δ (1/hfe) = 1/(150/300) -1 = **1.0**

Now can compare plus plot on the same scale.

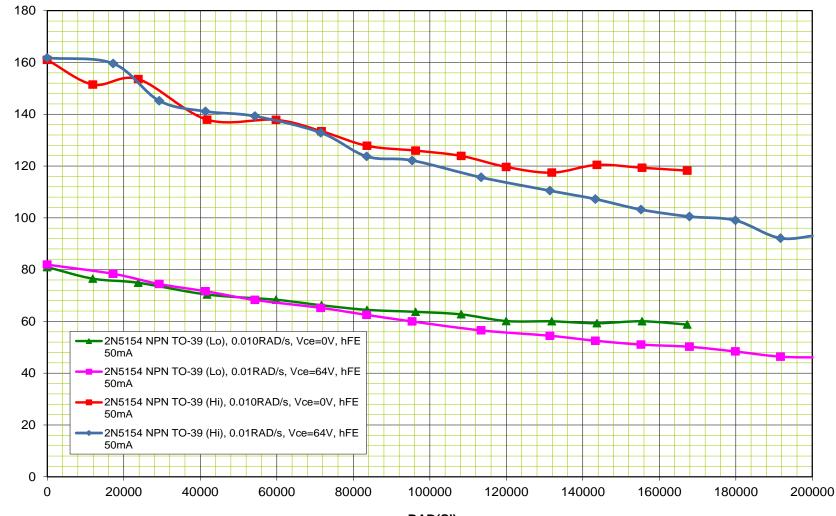


Common Ground for RAD Comparison



Difficulty with hFE Comparison From Same Lot but Different Initial hFE Values (All In Spec by the Way)

JANS2N5154 10mRAD/s Hi-hFE versus Lo-hFE Samples (Bias and Not)

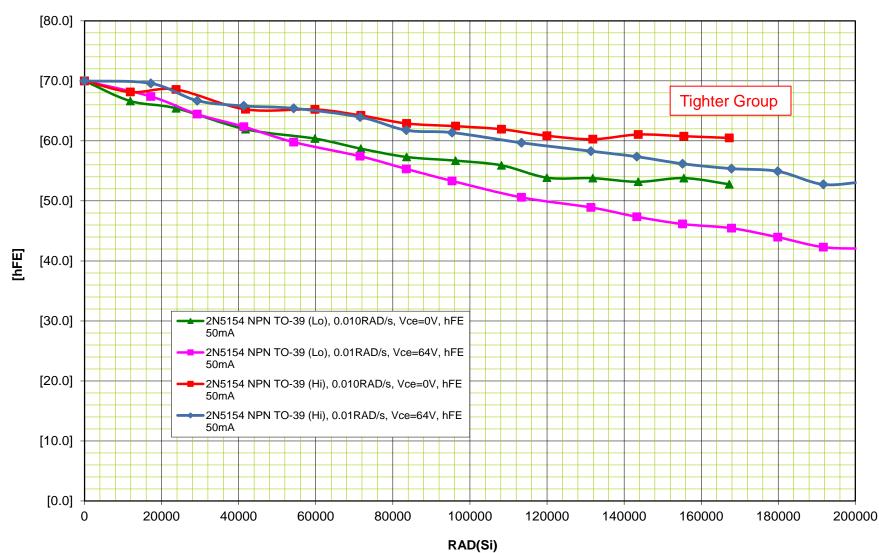


RAD(Si)



Use of [hFE] Comparison Helps From Same Lot but Different Initial hFE Values (All In Spec)

JANS2N5154 10mRAD/s Hi-[hFE] versus Lo-[hFE] Samples (Bias and Not)

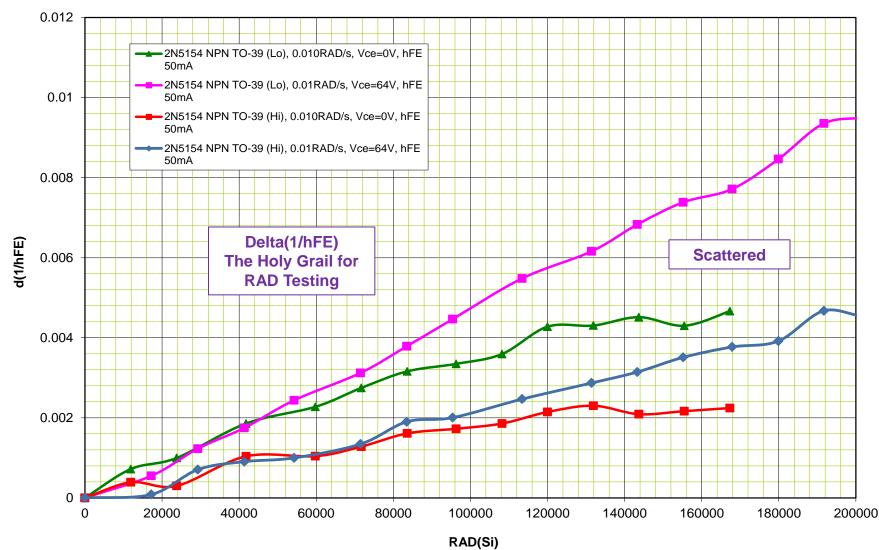




© 2015 Microsemi Corporation. Company Proprietary.

Difficulty with Delta(1/hFE) Comparison From Same Lot but Different Initial hFE Values (All In Spec)

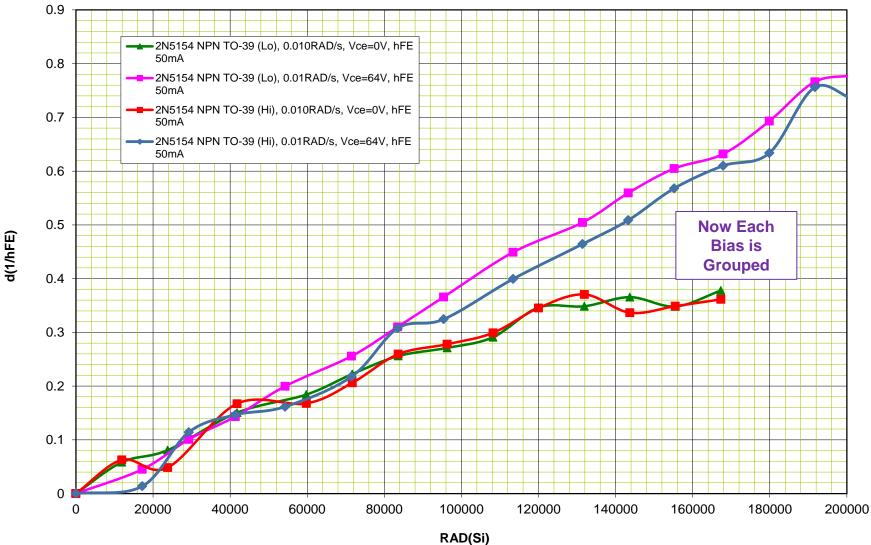
JANS2N5154 10mRAD/s Hi-d(1/hFE) versus Lo-d(1/hFE) Samples (Bias and Not)





Normalized Delta(1/hFE) Really Helps Similarity of the Technology is More Apparent

JANS2N5154 10mRAD/s Hi-Nd(1/hFE) versus Lo-Nd(1/hFE) Samples (Bias and Not)



🏷 Microsemi.

PNP Transistors TID vs. ELDRS



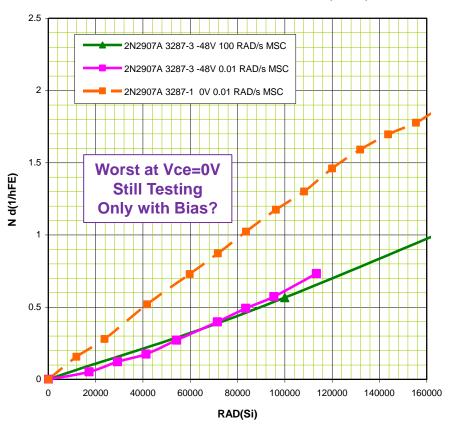
JANSR2N2907A TO-18 Lot 3287 W3, L2.0 PNP 60V With Added Vce=0V ELDRS Data (Not a Group D Requirement)

[80.0] [70.0] [60.0] [50.0] hFE] [40.0] [30.0] [20.0] 2N2907A 3287-3 -48V 100 RAD/s MSC [10.0] 2N2907A 3287-3 -48V 0.01 RAD/s MSC 2N2907A 3287-1 0V 0.01 RAD/s MSC [0.0] 0 20000 40000 60000 80000 100000 120000 140000 160000 RAD(Si)

JANSR2N2907A TID vs. ELDRS [hFE]

The [hFE] is used in Group D for all Bipolar transistors and is defined in Test Method 1019. In general the lowest current Group A hFE is used as the worst case. The value of [hFE] at zero RAD's is equal to the minimum hFE value. A device fails Group D when the [hFE] falls below half of the zero RAD level.

JANSR2N2907A TID vs. ELDRS Normal d(1/hFE)



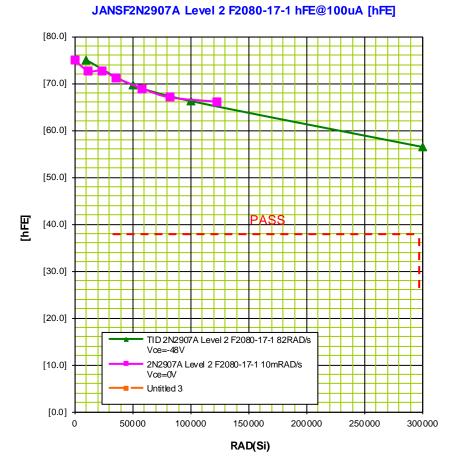
The value of delta(1/hFE) is frequently used as a tool for predicting how well a Bipolar transistor will perform beyond the radiation exposure used for the data. However, it can only be used to compare individual transistors when they start with the same hFE value. A Normalized delta(1/hFE) permits comparisons even when the starting hFE varies from part to part.



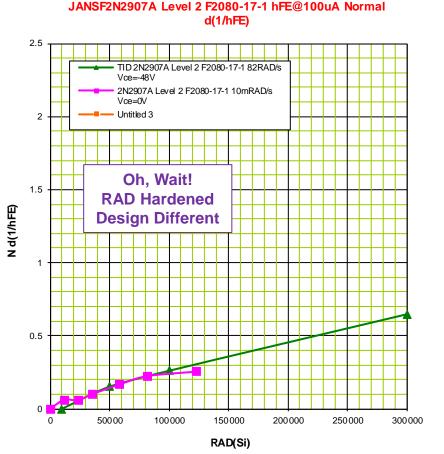
© 2015 Microsemi Corporation. Company Proprietary.

JANSF2N2907A TO-18 Lot F2080 W17, L2.0

PNP 60V New RAD-Hard Design



The [hFE] is used in Group D for all Bipolar transistors and is defined in Test Method 1019. In general the lowest current Group A hFE is used as the worst case. The value of [hFE] at zero RAD's is equal to the minimum hFE value. A device fails Group D when the [hFE] falls below half of the zero RAD level.

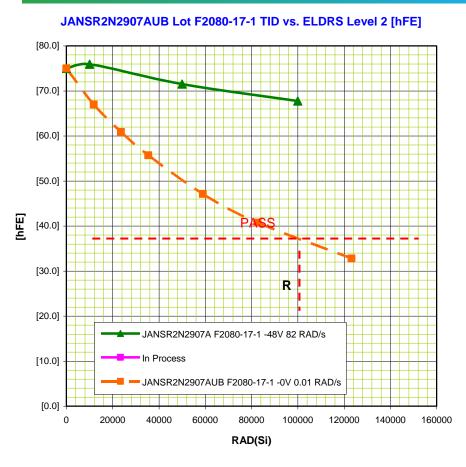


The value of delta(1/hFE) is frequently used as a tool for predicting how well a Bipolar transistor will perform beyond the radiation exposure used for the data. However, it can only be used to compare individual transistors when they start with the same hFE value. A Normalized delta(1/hFE) permits comparisons even when the starting hFE varies from part to part.



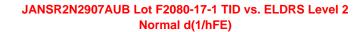
JANSR2N2907AUB Lot Z2080 W17, L2.0

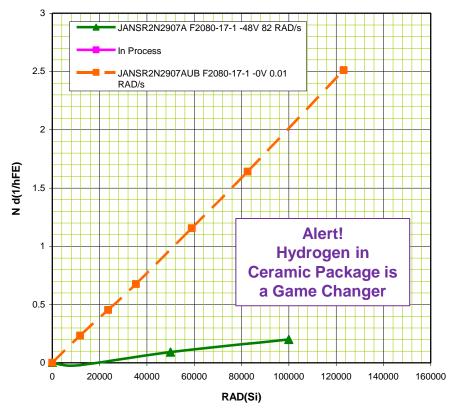
PNP 60V Mitigating UB Package Outgas Phenomenon



The [hFE] is used in Group D for all Bipolar transistors and is defined in Test Method 1019. In general the lowest current Group A hFE is used as the worst case. The value of [hFE] at zero RAD's is equal to the minimum hFE value. A device fails Group D when the [hFE] falls below half of the zero RAD level.

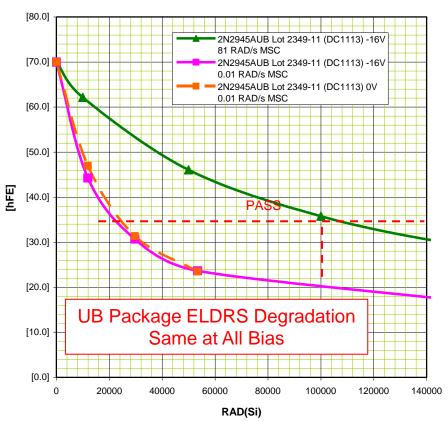
The value of delta(1/hFE) is frequently used as a tool for predicting how well a Bipolar transistor will perform beyond the radiation exposure used for the data. However, it can only be used to compare individual transistors when they start with the same hFE value. A Normalized delta(1/hFE) permits comparisons even when the starting hFE varies from part to part.







JAN2N2945AUB Lot 2349 W11, L0.0M (DC1113) PNP 20V With Added Vce=0V ELDRS Data



JAN2N2945AUB Lot 2349 DC1113 hFE 1mA [hFE]

The [hFE] is used in Group D for all Bipolar transistors and is defined in Test Method 1019. In general the lowest current Group A hFE is used as the worst case. The value of [hFE] at zero RAD's is equal to the minimum hFE value. A device fails Group D when the [hFE] falls below half of the zero RAD level.

14 12 10 **Hydrogen Affects Another PNP** 8 N d(1/hFE) 6 4 2N2945AUB Lot 2349-11 (DC1113) -16V 81 RAD/s MSC 2 2N2945AUB Lot 2349-11 (DC1113) -16V 0.01 RAD/s MSC 2N2945AUB Lot 2349-11 (DC1113) 0V 0.01 RAD/s MSC 0 0 20000 40000 60000 80000 100000 120000 140000 RAD(Si)

JAN2N2945AUB Lot 2349 DC1113 hFE 1mA Normal d(1/hFE)

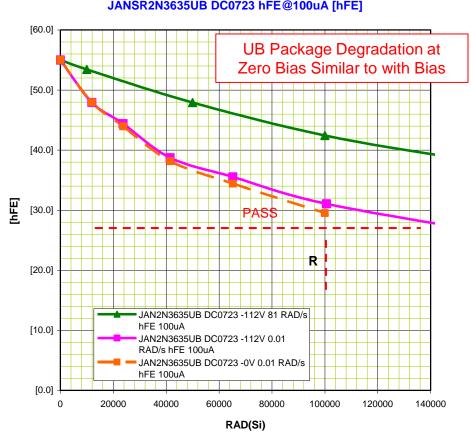
The value of delta(1/hFE) is frequently used as a tool for predicting how well a Bipolar transistor will perform beyond the radiation exposure used for the data. However, it can only be used to compare individual transistors when they start with the same hFE value. A Normalized delta(1/hFE) permits comparisons even when the starting hFE varies from part to part.



© 2015 Microsemi Corporation. Company Proprietary.

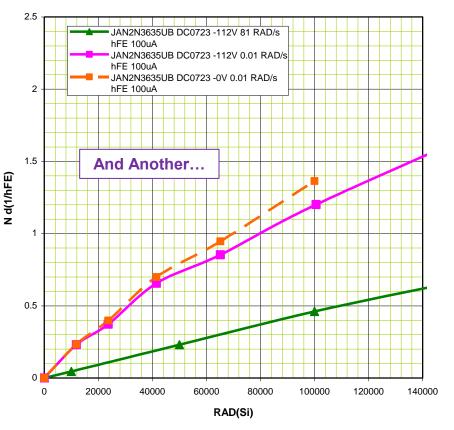
JANSR2N3635UB L0.0P DC0723

PNP 140V With Added Wafer Vce=0V ELDRS Data (Not a Group D Requirement)



The [hFE] is used in Group D for all Bipolar transistors and is defined in Test Method 1019. In general the lowest current Group A hFE is used as the worst case. The value of [hFE] at zero RAD's is equal to the minimum hFE value. A device fails Group D when the [hFE] falls below half of the zero RAD level.

JANSR2N3635UB DC0723 hFE@100uA Normal d(1/hFE)



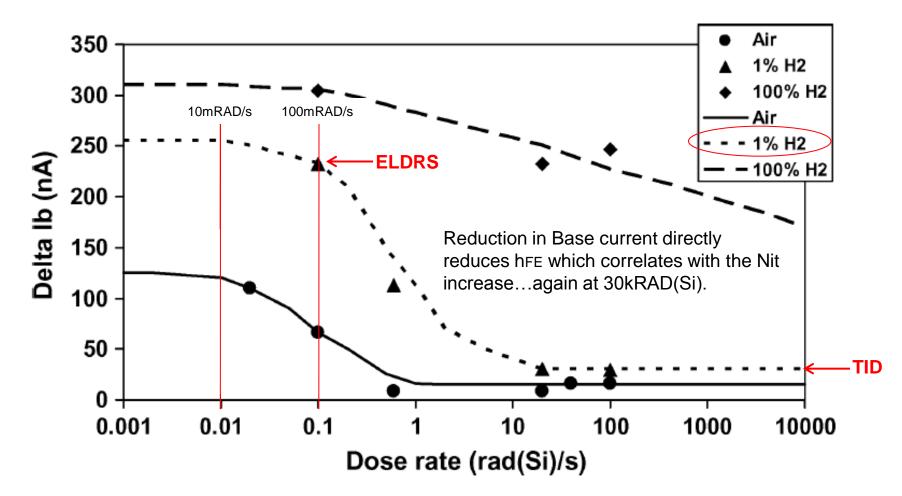
The value of delta(1/hFE) is frequently used as a tool for predicting how well a Bipolar transistor will perform beyond the radiation exposure used for the data. However, it can only be used to compare individual transistors when they start with the same hFE value. A Normalized delta(1/hFE) permits comparisons even when the starting hFE varies from part to part.



Precedent for ELDRS vs. H2 Issues

For PNP Transistors In Linear Circuits (Discrete BJT's Likely a Bit Less)

The Effects of Hydrogen on the Enhanced Low Dose Rate Sensitivity (ELDRS) of Bipolar Linear Circuits Ronald L. Pease, Fellow, IEEE, Philippe Claude Adell, Member, IEEE, Bernard G. Rax, Member, IEEE, Xiao Jie Chen, Student Member, IEEE, Hugh J. Barnaby, Senior Member, IEEE, Keith E. Holbert, Senior Member, IEEE, and Harold P. Hjalmarson



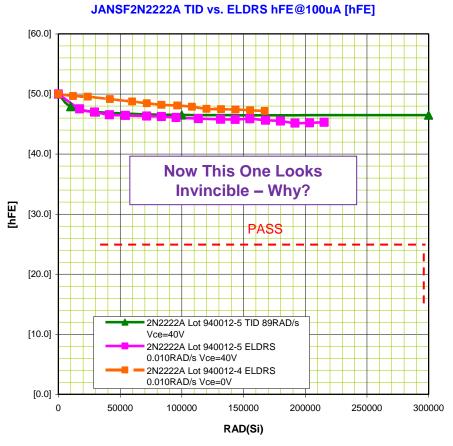


NPN Transistors TID vs. ELDRS



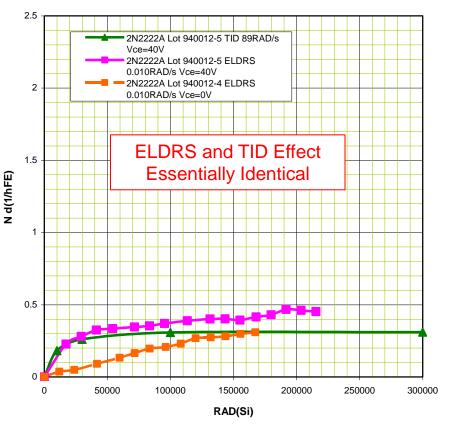
JANSF2N2222A TO-18 Lot 940012 W5, L2.0

NPN 50V With Added Vce=0V ELDRS Data (Not a Group D Requirement)



The [hFE] is used in Group D for all Bipolar transistors and is defined in Test Method 1019. In general the lowest current Group A hFE is used as the worst case. The value of [hFE] at zero RAD's is equal to the minimum hFE value. A device fails Group D when the [hFE] falls below half of the zero RAD level.

JANSF2N2222A TID vs. ELDRS hFE@100uA Normal d(1/hFE)



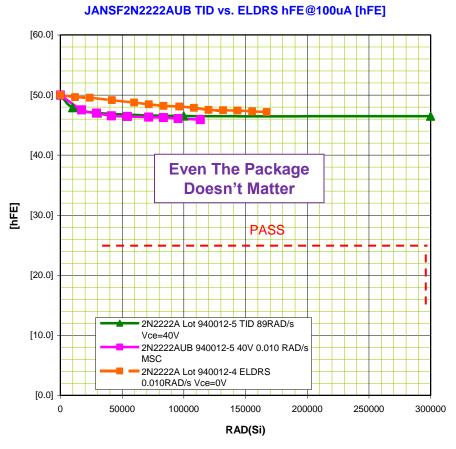
The value of delta(1/hFE) is frequently used as a tool for predicting how well a Bipolar transistor will perform beyond the radiation exposure used for the data. However, it can only be used to compare individual transistors when they start with the same hFE value. A Normalized delta(1/hFE) permits comparisons even when the starting hFE varies from part to part.



© 2015 Microsemi Corporation. Company Proprietary.

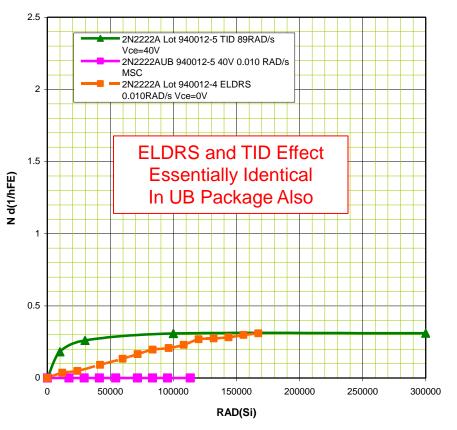
JANSF2N2222AUB Lot 940012 W5, L2.0

NPN 50V With Added Wafer 4 Vce=0V ELDRS Data (Not a Group D Requirement)



The [hFE] is used in Group D for all Bipolar transistors and is defined in Test Method 1019. In general the lowest current Group A hFE is used as the worst case. The value of [hFE] at zero RAD's is equal to the minimum hFE value. A device fails Group D when the [hFE] falls below half of the zero RAD level.

JANSF2N2222AUB TID vs. ELDRS hFE@100uA Normal d(1/hFE)

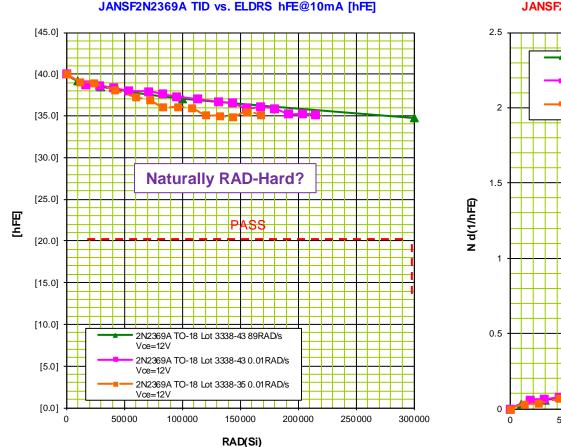


The value of delta(1/hFE) is frequently used as a tool for predicting how well a Bipolar transistor will perform beyond the radiation exposure used for the data. However, it can only be used to compare individual transistors when they start with the same hFE value. A Normalized delta(1/hFE) permits comparisons even when the starting hFE varies from part to part.



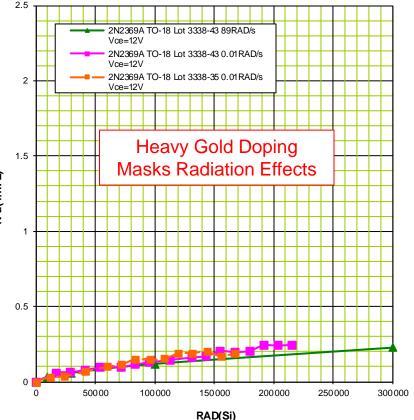
© 2015 Microsemi Corporation. Company Proprietary.

JANSF2N2369A, TO-39, Lot 3338 W43, L0.0 NPN 15V With Added Wafer 35 Vce=0V ELDRS Data (Not a Group D Requirement)



The [hFE] is used in Group D for all Bipolar transistors and is defined in Test Method 1019. In general the lowest current Group A hFE is used as the worst case. The value of [hFE] at zero RAD's is equal to the minimum hFE value. A device fails Group D when the [hFE] falls below half of the zero RAD level.

JANSF2N2369A TID vs. ELDRS hFE@10mA Normal d(1/hFE)



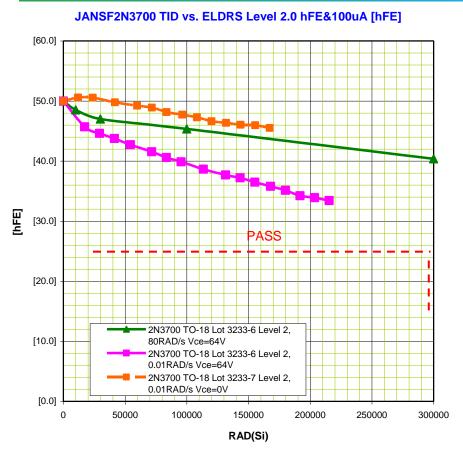
The value of delta(1/hFE) is frequently used as a tool for predicting how well a Bipolar transistor will perform beyond the radiation exposure used for the data. However, it can only be used to compare individual transistors when they start with the same hFE value. A Normalized delta(1/hFE) permits comparisons even when the starting hFE varies from part to part.



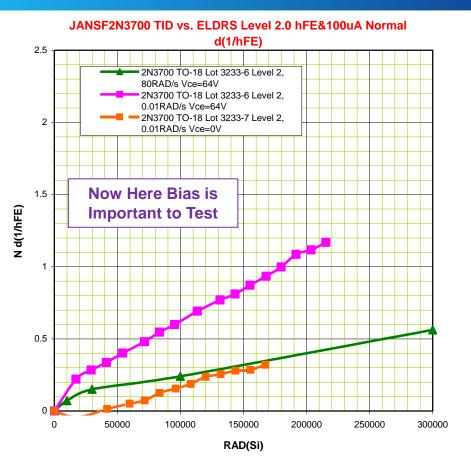
© 2015 Microsemi Corporation. Company Proprietary.

JANSF2N3700 TO-18 Lot 3233 W6, L2.0

NPN 80V With Added Wafer 7 Vce=0V ELDRS Data (Not a Group D Requirement)



The [hFE] is used in Group D for all Bipolar transistors and is defined in Test Method 1019. In general the lowest current Group A hFE is used as the worst case. The value of [hFE] at zero RAD's is equal to the minimum hFE value. A device fails Group D when the [hFE] falls below half of the zero RAD level.



The value of delta(1/hFE) is frequently used as a tool for predicting how well a Bipolar transistor will perform beyond the radiation exposure used for the data. However, it can only be used to compare individual transistors when they start with the same hFE value. A Normalized delta(1/hFE) permits comparisons even when the starting hFE varies from part to part.



© 2015 Microsemi Corporation. Company Proprietary.

JANSR2N3439 TO-39 Lot 3300 W15, L1.5

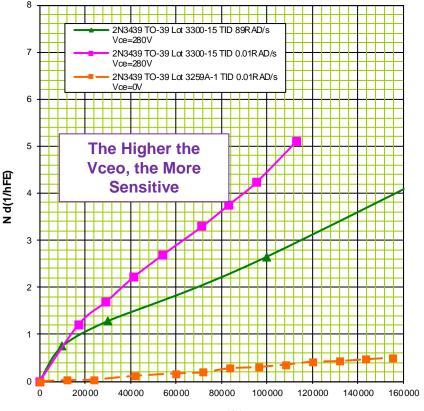
NPN 350V With Added 3259A-1 Vce=0V ELDRS Data (Not a Group D Requirement)

[12.0] [10.0] [8.0] [hFE] [6.0] [4.0] 2N3439 TO-39 Lot 3300-15 TID 89R AD/s [2.0] Vce=280V 2N3439 TO-39 Lot 3300-15 TID 0.01R AD/s Vce=280V 2N3439 TO-39 Lot 3259A-1 TID 0.01R AD/s Vce=0V [0.0] 80000 20000 40000 60000 100000 120000 140000 160000 RAD(Si)

JANSR2N3439A TID vs. ELDRS @ Ic=200uA [hFE]

The [hFE] is used in Group D for all Bipolar transistors and is defined in Test Method 1019. In general the lowest current Group A hFE is used as the worst case. The value of [hFE] at zero RAD's is equal to the minimum hFE value. A device fails Group D when the [hFE] falls below half of the zero RAD level.

JANSR2N3439A TID vs. ELDRS @ Ic=200uA Normal d(1/hFE)



RAD(Si)

The value of delta(1/hFE) is frequently used as a tool for predicting how well a Bipolar transistor will perform beyond the radiation exposure used for the data. However, it can only be used to compare individual transistors when they start with the same hFE value. A Normalized delta(1/hFE) permits comparisons even when the starting hFE varies from part to part.



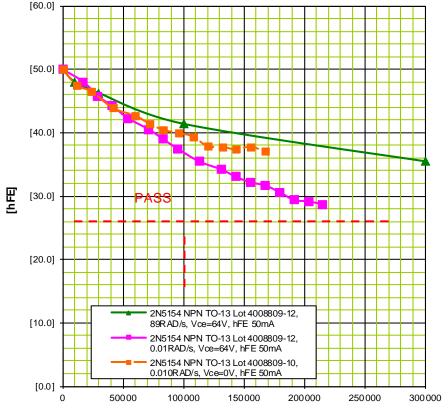
© 2015 Microsemi Corporation. Company Proprietary.

JANSR2N5154 TO-39 Lot 4008809 W12, B1.5

NPN 80V With Added Wafer 10 Vce=0V ELDRS Data (Not a Group D Requirement)

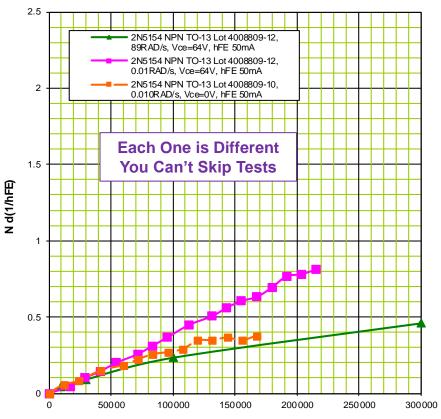
JANSR2N5154 TID vs. ELDRS [hFE]

JANSR2N5154 TID vs. ELDRS Normal d(1/hFE)



RAD(Si)

The [hFE] is used in Group D for all Bipolar transistors and is defined in Test Method 1019. In general the lowest current Group A hFE is used as the worst case. The value of [hFE] at zero RAD's is equal to the minimum hFE value. A device fails Group D when the [hFE] falls below half of the zero RAD level.



RAD(Si)

The value of delta(1/hFE) is frequently used as a tool for predicting how well a Bipolar transistor will perform beyond the radiation exposure used for the data. However, it can only be used to compare individual transistors when they start with the same hFE value. A Normalized delta(1/hFE) permits comparisons even when the starting hFE varies from part to part.



© 2015 Microsemi Corporation. Company Proprietary.

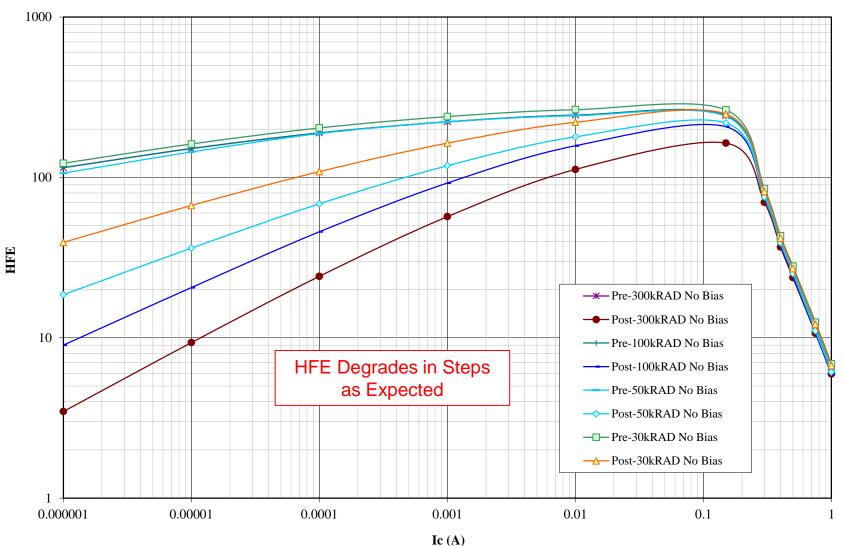
NPN Transistors - Powered



Part 1 of 4: JANS2N3501 DC0207 Not RAD Hard

NPN 80V TID Irradiated with Vce = 0V at 57RAD(Si)/s L0.0

JANS2N3501 HFE vs RAD@Vce=No Bias Lot 9510 W3

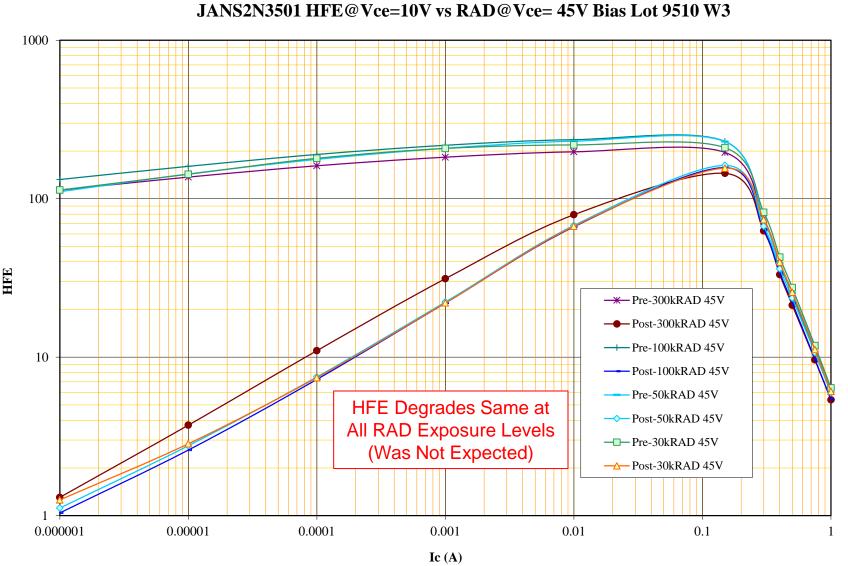




© 2015 Microsemi Corporation. Company Proprietary.

Part 2 of 4: JANS2N3501 DC0207 Not RAD Hard

NPN 80V TID Irradiated with Vce = 45V at 57RAD(Si)/s L0.0

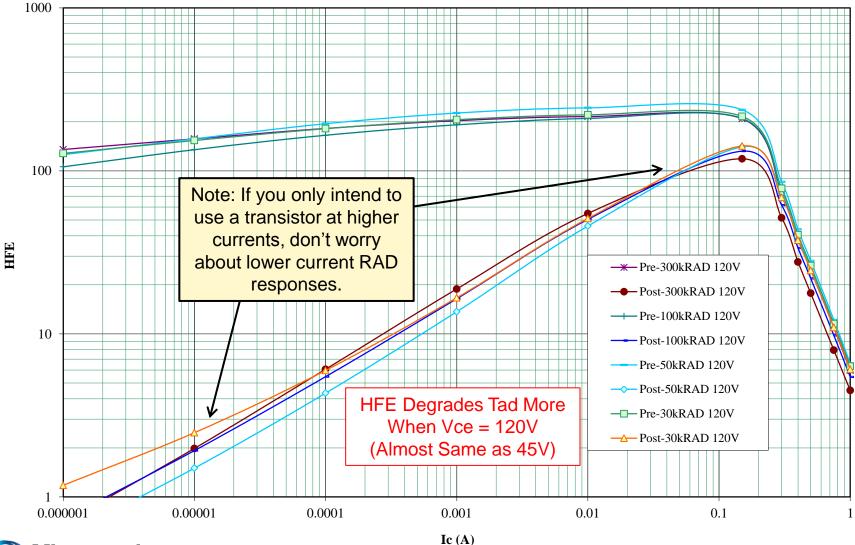




Part 3 of 4: JANS2N3501 DC0207 Not RAD Hard

NPN 80V TID Irradiated with Vce = 120V at 57RAD(Si)/s L0.0



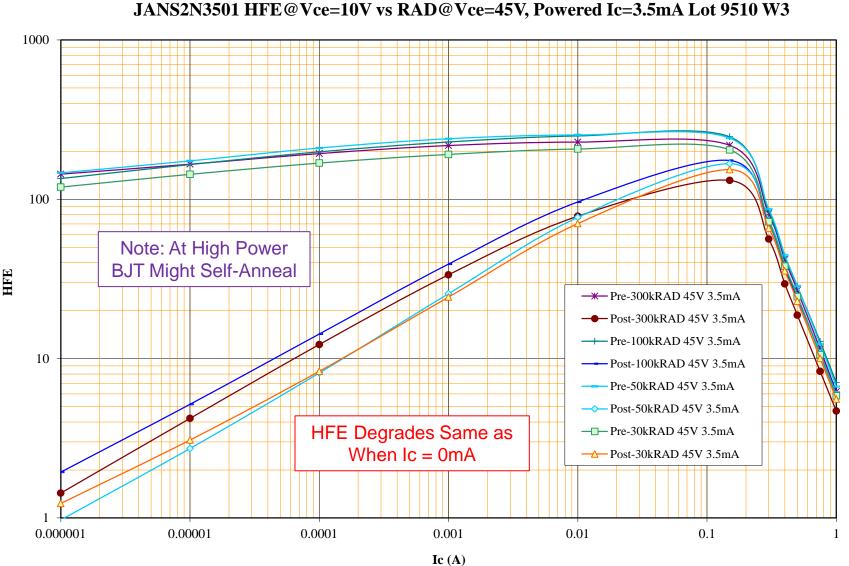


🏷 Microsemi.

^{© 2015} Microsemi Corporation. Company Proprietary.

Part 4 of 4: JANS2N3501 DC0207 Not RAD Hard

NPN 80V TID Irradiated with Vce = 45V Ic=3.5mA at 57RAD(Si)/s L0.0



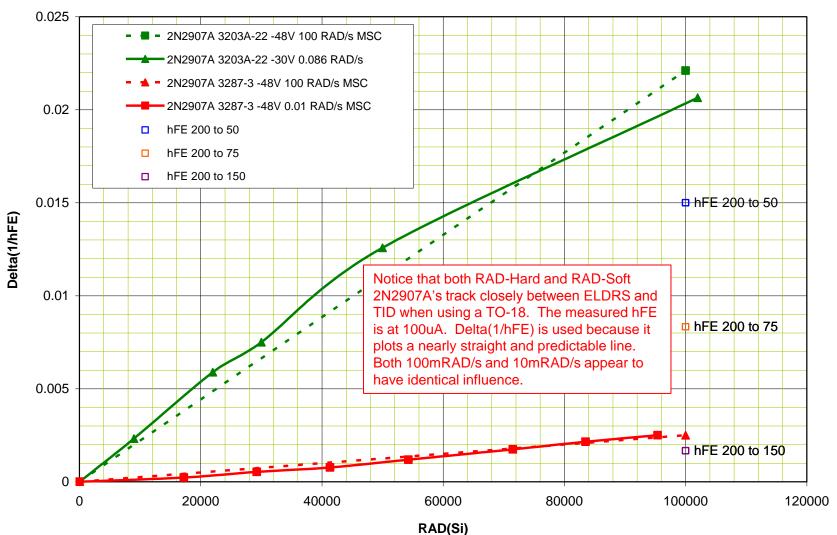
\sub Microsemi.

ELDRS 100mRAD/s versus 10mRAD/s



ELDRS vs. TID: JANSR2N2907A

2N2907A RAD(Si) vs. Delta(1/hFE)

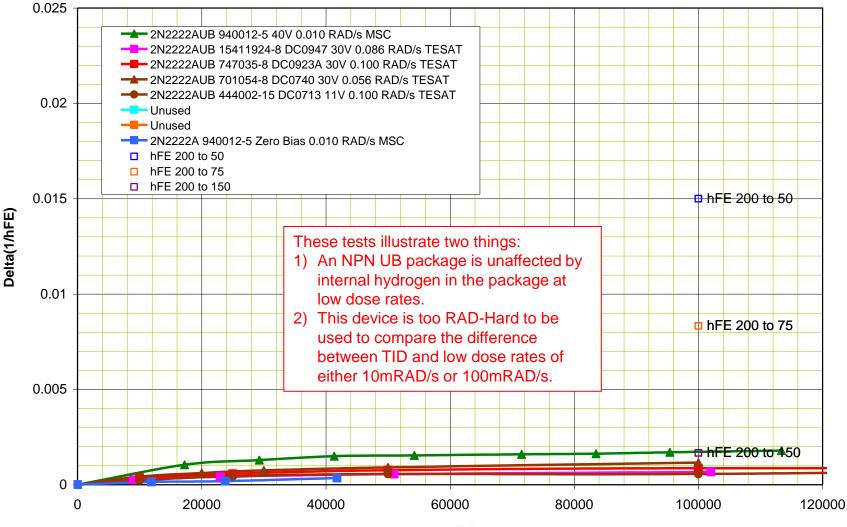




© 2015 Microsemi Corporation. Company Proprietary.

ELDRS vs. TID: JANSR2N2222AUB

2N2222AUB ELDR RAD(Si) vs. Delta(1/hFE)



RAD(Si)



© 2015 Microsemi Corporation. Company Proprietary.

To Be Sure



Minimum RAD Requirements for Discrete

- 1) Do…ELDR 100mRAD/s at 80% Rated Bvceo Small Die Sample = 11 pieces, all ELDRS testing
- 2) Do...ELDR 100mRAD/s at Vce = 0V
- 3) Do…ELDR in Final Package (not Surrogate)
- 4) Do...TID at 80% Rated BVceo (Original TM1019) Small Die Sample = 10 pieces, all TID testing Required for Group D.
- 5) Do...TID at Vce=0V Only if Response Unknown Not required by Group D but better do for PNP
- 6) Do...Consider ELDR 100mRAD/s in Lieu of TID (100kRAD only takes about 2-Weeks)



Microsemi's Response to this Need

Since JAN only specifies TID, Use MSR/MVR:

- 1) Get...ELDR 100mRAD/s at 80% Rated BVceo
- 2) Get...ELDR 100mRAD/s at Vce = 0V
- 3) Get...ELDR in Final Package (not Surrogate)
- 4) Get...TID at 80% Rated BVceo (Original 1019)
- 5) Get...TID at Vce=0V Only if Response Unknown



Wish List



Space Community Expressed Wish List

1) Supply Third Party DPA on Received Lot

Must be independent enough to satisfy Government contract requirements. Could do DPA on entire lot as SOP but for each shipment would have to be a custom line item.

2) Opportunity for Audited Pre-Cap Visual

Logistics can be tricky. Pre-cap must be done immediately before capping.

Photographic record considered except <u>marking</u> and <u>serialization</u> always done <u>after capping</u>.

User resident inspector?



Appendix – Microsemi ELDR Facility



Our ELDR System

Bias Levels = 48 Positions = 576 Total (288/Side) Both 100mRAD/s and 10mRAD/s



C Microsemi.

Programmable Bias Modules in Action

Bias Levels = 48 Positions = 576 Total Both 100mRAD/s and 10mRAD/s



🍋 Microsemi.

How Auto Programming Box Gets its Bias

48.0

Insert and Presto! One of 48 Channels Receives a Unique Bias Voltage (0-1000V) but up to 1200V if Needed.

Flip the Card and the Polarity is Reversed.

Card Can be Trimmed for Spot-On Voltage Settings if desired.

Meter Readout is 1% and Continuous as to What bias the Parts are actually Receiving.



 Microsemi.

© 2015 Microsemi Corporation. Company Proprietary.

Microsemi Radiation Services

PNP BJT Vce

P-Channel FET Vds

NPN BJT Vce N-Channel FET Vds

View From the 10mRAD Side

Bias Levels = 48 Positions = 576 Total Both 100mRAD/s and 10mRAD/s



🏷 Microsemi.

100mRAD/s Report on One Run		
Status of This Information in Main Table (1=Active, 0=Inactive)	=	1
Package Number or Description	=	11
Part Number	=	JANSR2N2907AUB
Date Code	=	1243
Wafer Lot Number	=	F2080-2
Assembly Lot Number or Work Order Number	=	WO#45635
SampleSize	=	5
Record Run Number	=	100038
Board Number (1 to 6)	=	2
Channel BJT A,B,C or D or FET A or B and AG or BG	=	Α
Board Socket Numbers Example: 1 to 10 6 to 10 (0 = n/a)	=	1 to 5
Required Bias Voltage (+/- V)	=	-48
FET Gate Bias Voltage (+/- V)	=	
Note, Comment or Request	=	7.1kRAD (21.3kRAD Total) JMM
Desired Gamma Target Dosage For This Run (RAD)	=	7,100
Run is On? (1=Yes, 0=Closed, Blank=Not Started	=	0
Start Date (Blank = Not Yet) Date and Time (m/d/yy h:mm AM)	=	Wed 10/23/13 11:41 AM
Projected Finish Date (Blank = Not Yet) Date and Time (Day, m/d/yy h:mm AM)	=	RAD Run Ended
Actual Finish Date (Blank = Not Yet) Date and Time (m/d/yy h:mm AM)	=	Thu 10/24/13 7:52 AM
Total Drop Out Interrupt Time if Any (0=None) in Hours	=	0
Actual Received Gamma Dosage (RAD)	=	7,103
Average Dose Rate Today at Selected Part and Board (mRAD/s)	=	97.8
Test Board Number	=	LIC 07963
Package Type	=	UB (LCC3)
Device Type	=	BJT
Number of Biases Required (1=BJT, Diode and 2=FET)	=	1
Maximum Positions per Channel	=	12
Socket Mounting Plane Height (in)	=	0.245
Chip Height Above Socket (in)	=	-0.04

Portion of the automatically generated irradiator report.

Start times and stop times automatically track the age of the source plus the height of the package and socket plus bias conditions.

A copy of the report is recorded electronically plus another copy is printed out to be attached to te traveler.



Summary

- Slash Sheets only require TID at Vce=80% BVceo
- Mil-Std-750 Test Method 1019 allows ELDRS as substitute for TID if customer agrees. DLA says if customer agrees, it's OK with them.
- But how do you get a Part Number that Guarantees all this? Answer: A Parallel Universe of Part Numbers JANSR2Nxxxx becomes MSR2Nxxxx JANTXV2Nxxxx becomes MVR2Nxxxx

BJT ELDRS 100mRAD/s at 80%Bvceo Bias, 11 Samples BJT ELDRS 100mRAD/s at Zero Bias, 11 Samples Taken from the actual JANS and JANTXV Line.

Since 100mRAD/s and 10mRAD/s Shown as Equivalent, Results in a few weeks at a Fraction of the Cost.





Microsemi

SPACE FORUM

Thank You



Power Matters."

Microsemi Corporate Headquarters

One Enterprise, Aliso Viejo, CA 92656 USA Within the USA: +1 (800) 713-4113 Outside the USA: +1 (949) 380-6100 Sales: +1 (949) 380-6136 Fax: +1 (949) 215-4996 email: sales.support@microsemi.com Microsemi Corporation (MSCC) offers a comprehensive portfolio of semiconductor and system solutions for communications, defense & security, aerospace and industrial markets. Products include high-performance and radiation-hardened analog mixed-signal integrated circuits, FPGAs, SoCs and ASICs; power management products; timing and synchronization devices and precise time solutions, setting the world's standard for time; voice processing devices; RF solutions; discrete components; security technologies and scalable anti-tamper products; Ethernet solutions; Power-over-Ethernet ICs and midspans; as well as custom design capabilities and services. Microsemi is headquartered in Aliso Viejo, Calif., and has approximately 3,600 employees globally. Learn more at www.microsemi.com.

Microsemi makes no warranty, representation, or guarantee regarding the information contained herein or the suitability of its products and services for any particular purpose, nor does Microsemi assume any liability whatsoever arising out of the application or use of any product or circuit. The products sold hereunder and any other products sold by Microsemi have been subject to limited testing and should not be used in conjunction with mission-critical equipment or applications. Any performance specifications are believed to be reliable but are not verified, and Buyer must conduct and complete all performance and other testing of the products, alone and together with, or installed in, any end-products. Buyer shall not rely on any data and performance specifications or parameters provided by Microsemi. It is the Buyer's responsibility to independently determine suitability of any products and to test and verify the same. The information provided by Microsemi hereunder is provided "as is, where is" and with all faults, and the entire risk associated with such information is entirely with the Buyer. Microsemi does not grant, explicitly or implicitly, to any party any patent rights, licenses, or any other IP rights, whether with regard to such information itself or anything described by such information. Information provided in this document is proprietary to Microsemi, and Microsemi reserves the right to make any changes to the information in this document or to any products and services at any time without notice.

©2015 Microsemi Corporation. All rights reserved. Microsemi and the Microsemi logo are registered trademarks of Microsemi Corporation. All other trademarks and service marks are the property of their respective owners.

Power Matters.TM 45