Summary & Results of Enhanced Low Dose Rate Sensitivity (ELDRS) Testing Performed at the ESTEC Co-60 Facility

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7th D/TEC-QCA Final Presentation Day
Jyväskylä, Finland. May 25th, 2005

Outline

- Introduction: ELDRS
- Goal
- Selection of components and biasing
- Experimental set-up for irradiation and parametric measurements
- Results
- Conclusion

Introduction: ELDRS

- In recent years, increasing concern in the radiation effects community regarding ELDRS
- Bipolar integrated devices are potentially susceptible to this phenomenon
- Standard high-dose rate testing followed by an anneal period does not always tell the complete story

Goal

- Assess the ELDRS sensitivity of bipolar integrated devices and also transistors
- Employ Radiation Hard or Radiation Tolerant devices
- Investigate ELDRS bias dependency
- Investigate annealing effects
- First part of a programme to devise an ELDRS test philosophy

Selection of components and biasing

- Selection criteria of the devices to be tested:
  - Of interest to ESA projects
  - Available in Radiation Hard or Radiation Tolerant versions
  - Compatibility with available test system
  - Frame time

- Parts for ELDRS testing:
  - OP400AY: quad operational amplifier
  - OP484 (DIL and FP): quad operational amplifier
  - LM117H : adjustable positive regulator
  - 2N6989U : quad FP npn 2N2222A transistor

Selection of components and biasing

part	function	data code	quality level	RHA level dose rate: 3-18krad(Si)/min	package	biased irradiated	unbiased irradiated	non-irradiated reference
OP400AY Analog Devices	Quad op-amp	0304	V	no	CERDIP-14	3	1	1
OP484AY Analog Devices	Quad op-amp	0239	V	100krad(Si)	CERDIP-14	3	1	1
OP484AM Analog Devices	Quad op-amp	0247	V	100krad(Si)	FP-14	3	1	1
LM117H National Semiconductor	Positive voltage regulator		V	100krad(Si)	TO-39	2	0	0
2N6989U Microsemi	Quad npn transistor	0347	JANS	no	LCC-20	2	0	1

Experimental set-up for irradiation and parametric measurements and constraints

- In total 8-weeks required to achieve the specified total dose levels.

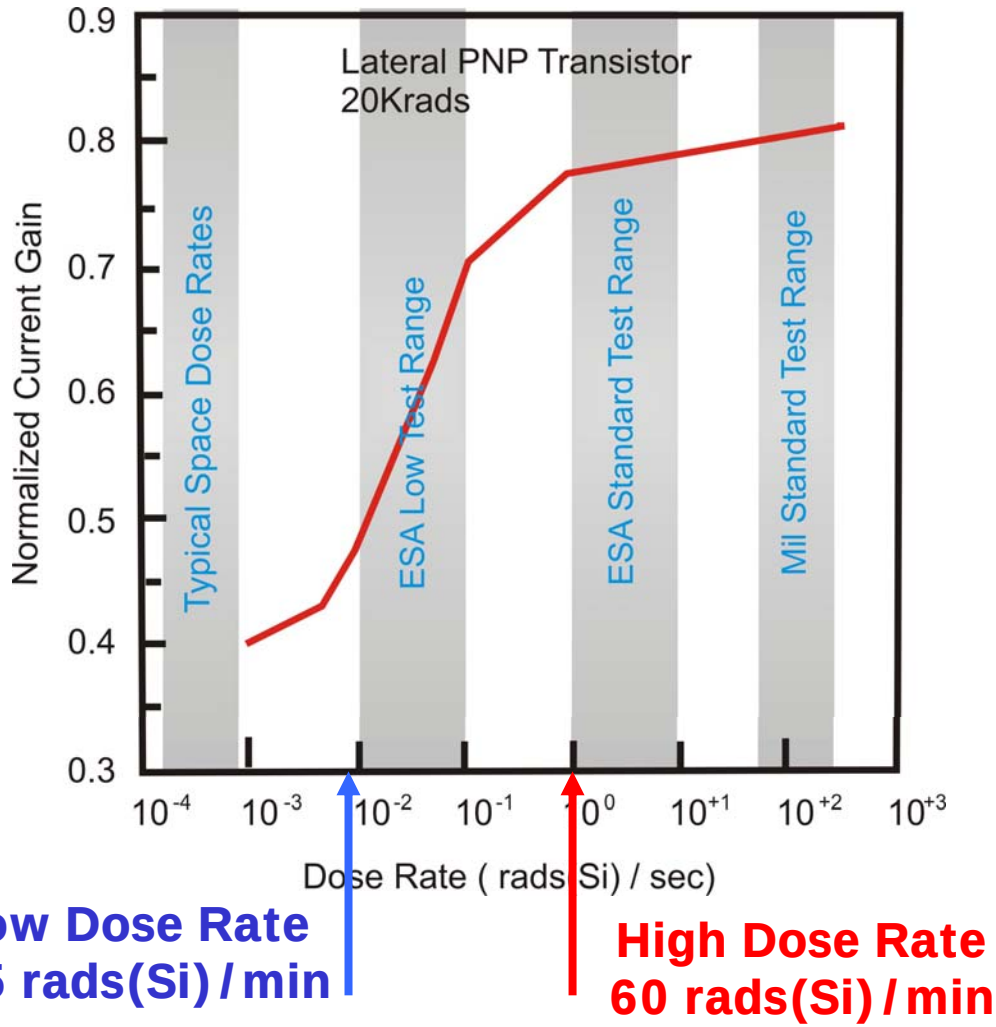
- Practical difficulty in obtaining 8-weeks of irradiation testing in the busy schedule of an irradiation facility

- Dose rate = 0.5 rad(Si)/min

  $\rightarrow$ lowest feasible at the ESA/ESTEC facility

In addition, quad transistor tested at high dose rate for comparison (60 rad(Si)/min)

Experimental set-up for irradiation and parametric measurements



Experimental set-up for irradiation and parametric measurements

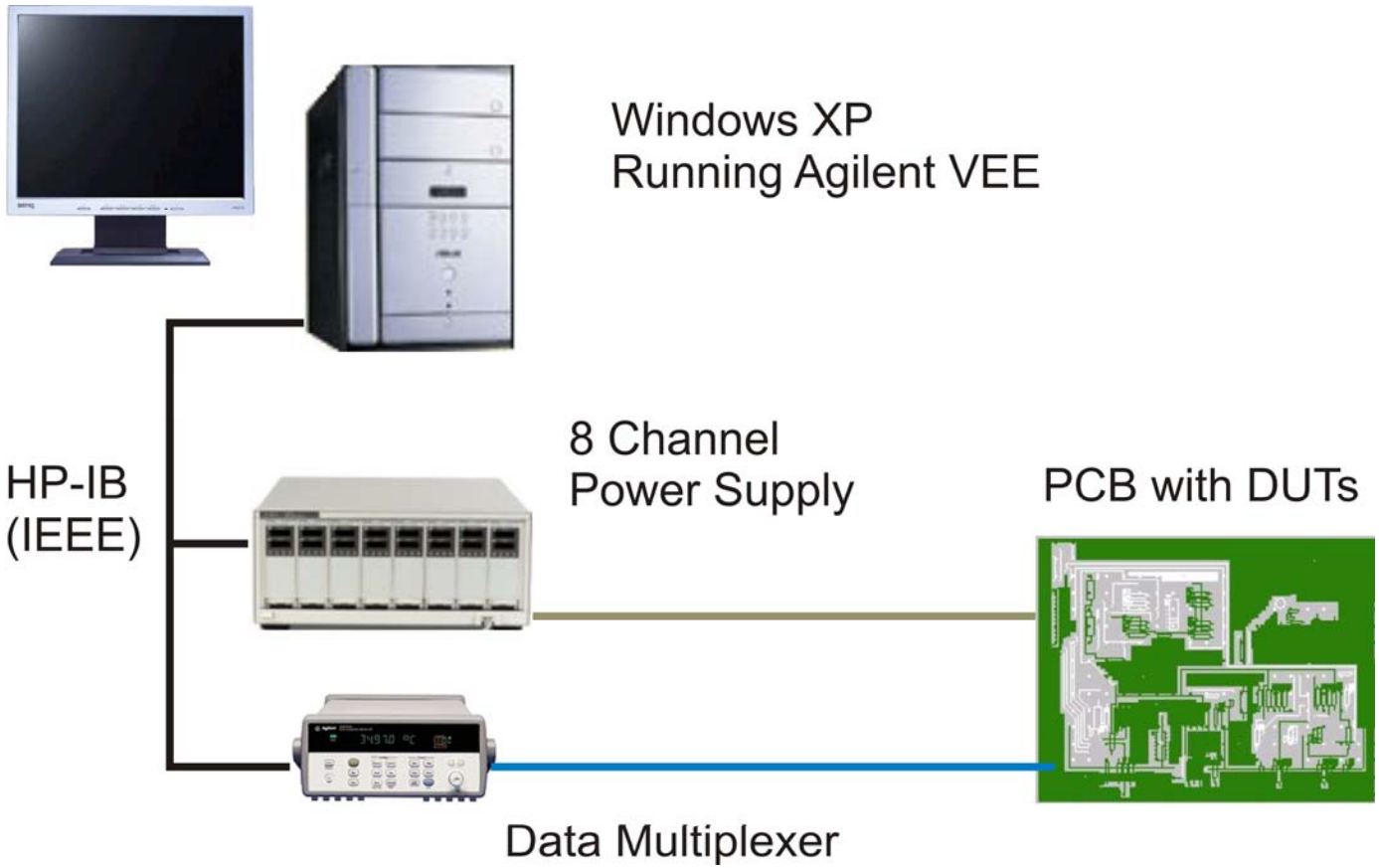
- Highest TID achievable within the available time
  $\Rightarrow$ TID level tested: 20 krad(Si)

- Investigation of parameter drift within the first 10 to 20krad(Si)

- Investigate the possibility of identifying ELDRS sensitivity in a relatively short time period (avoiding extremely long irradiation runs)

- Two sets of measurements:
  - automatic during irradiation
  - parametric

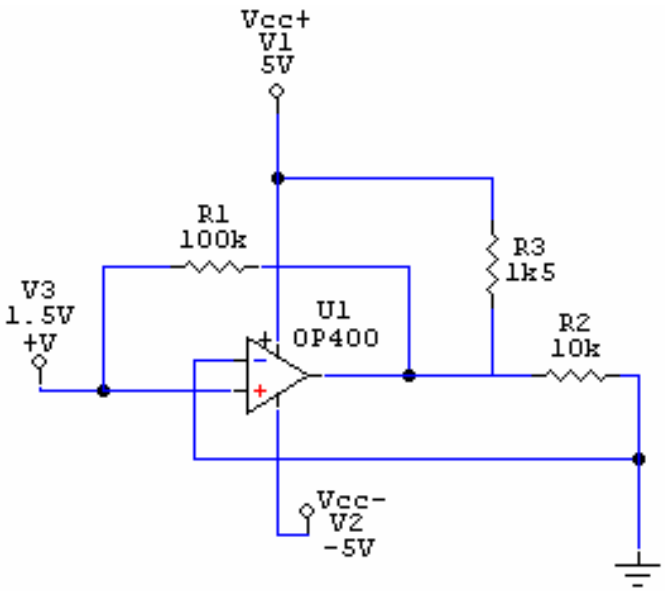
Experimental set-up for irradiation and parametric measurements

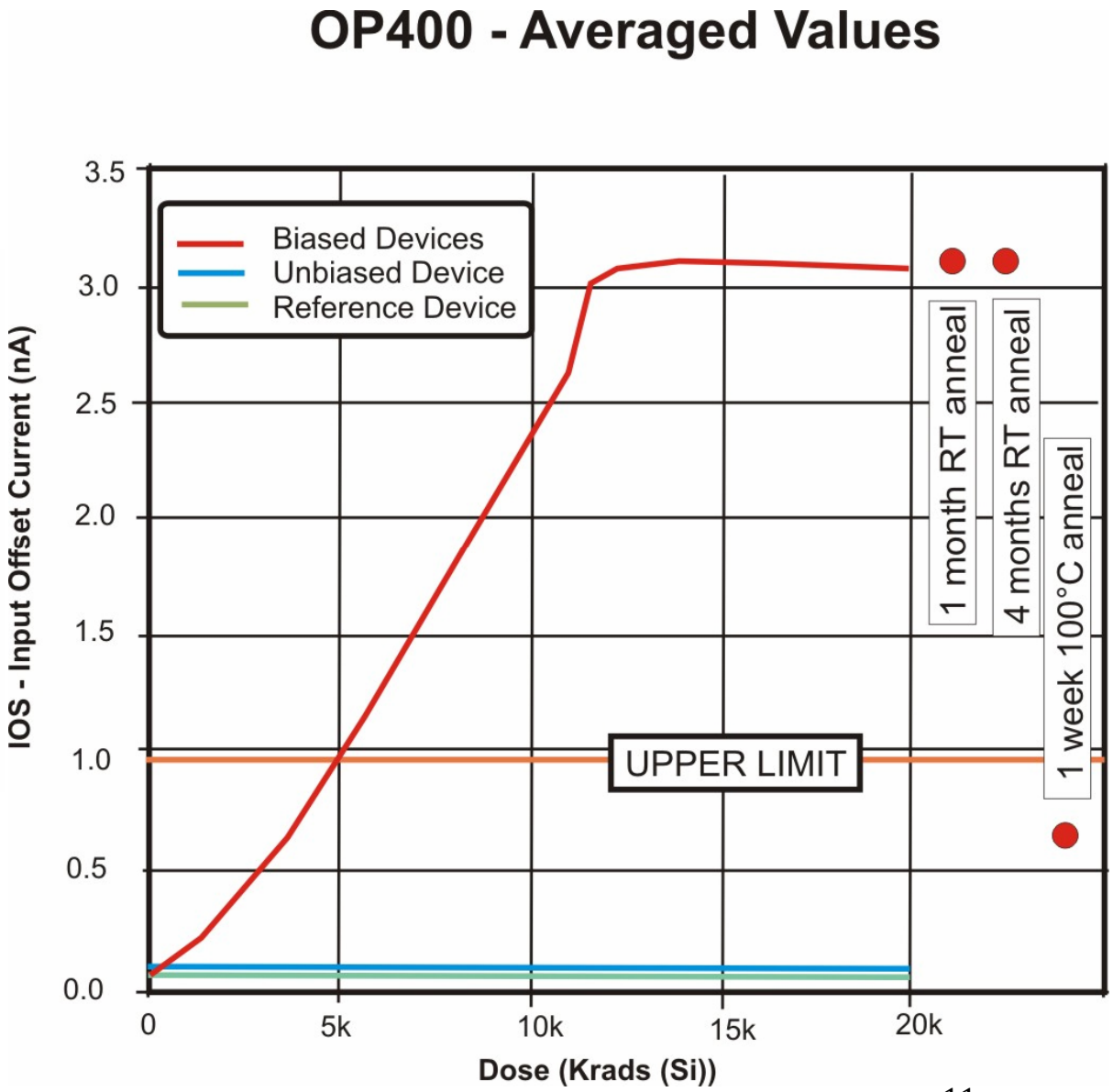


Results

OP400

Input offset current

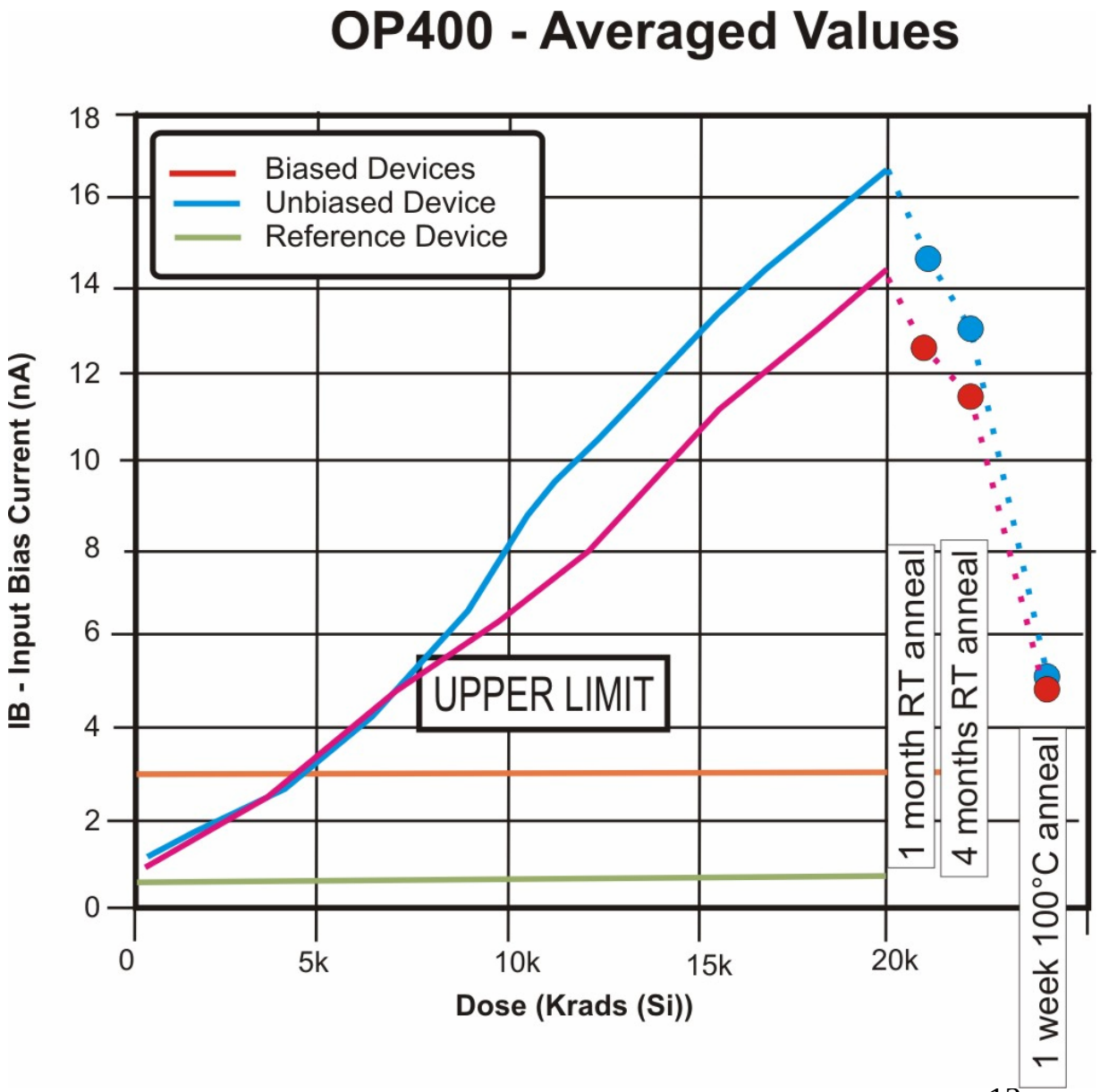




Results

OP400

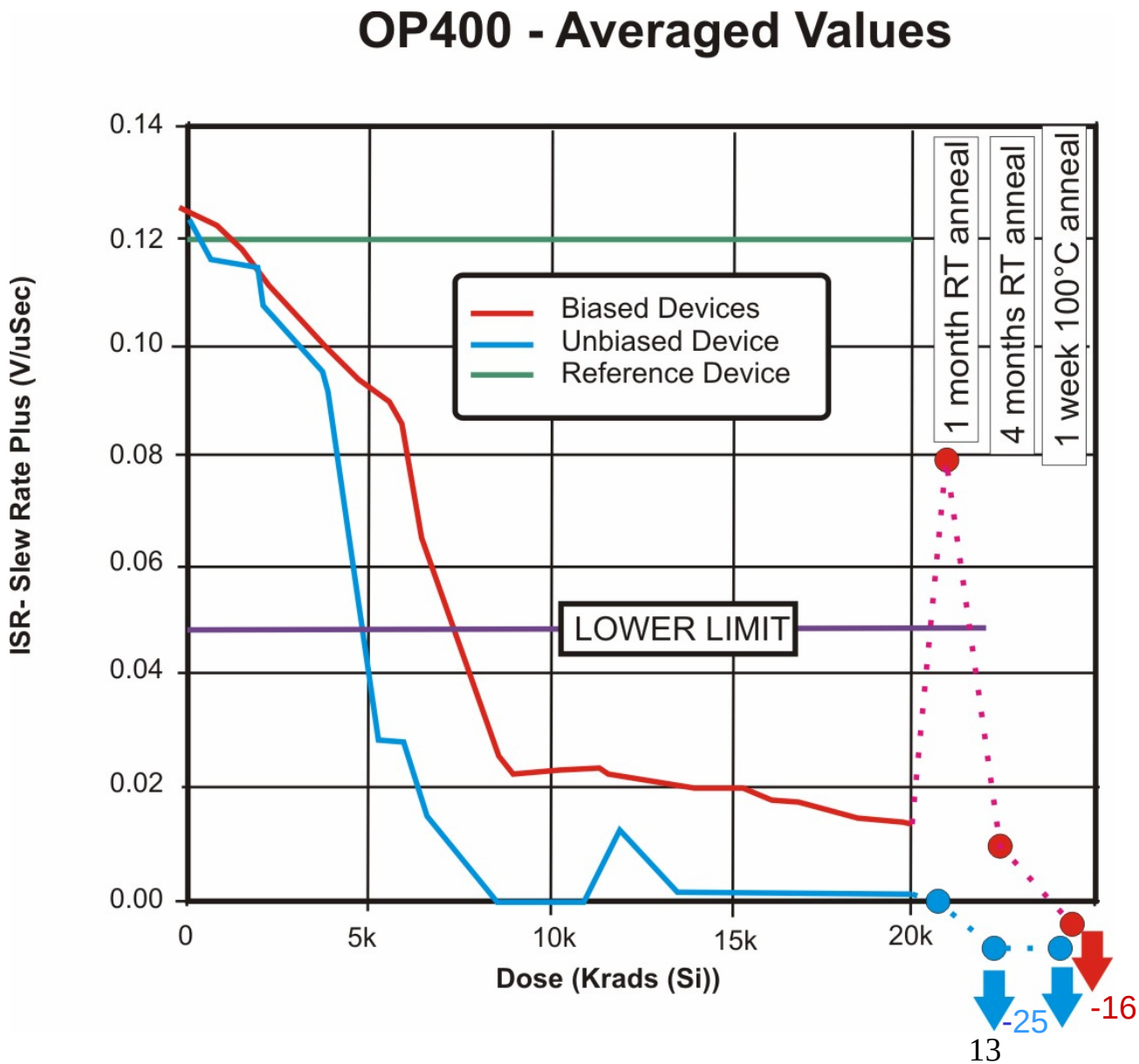
Input bias current



Results

OP400

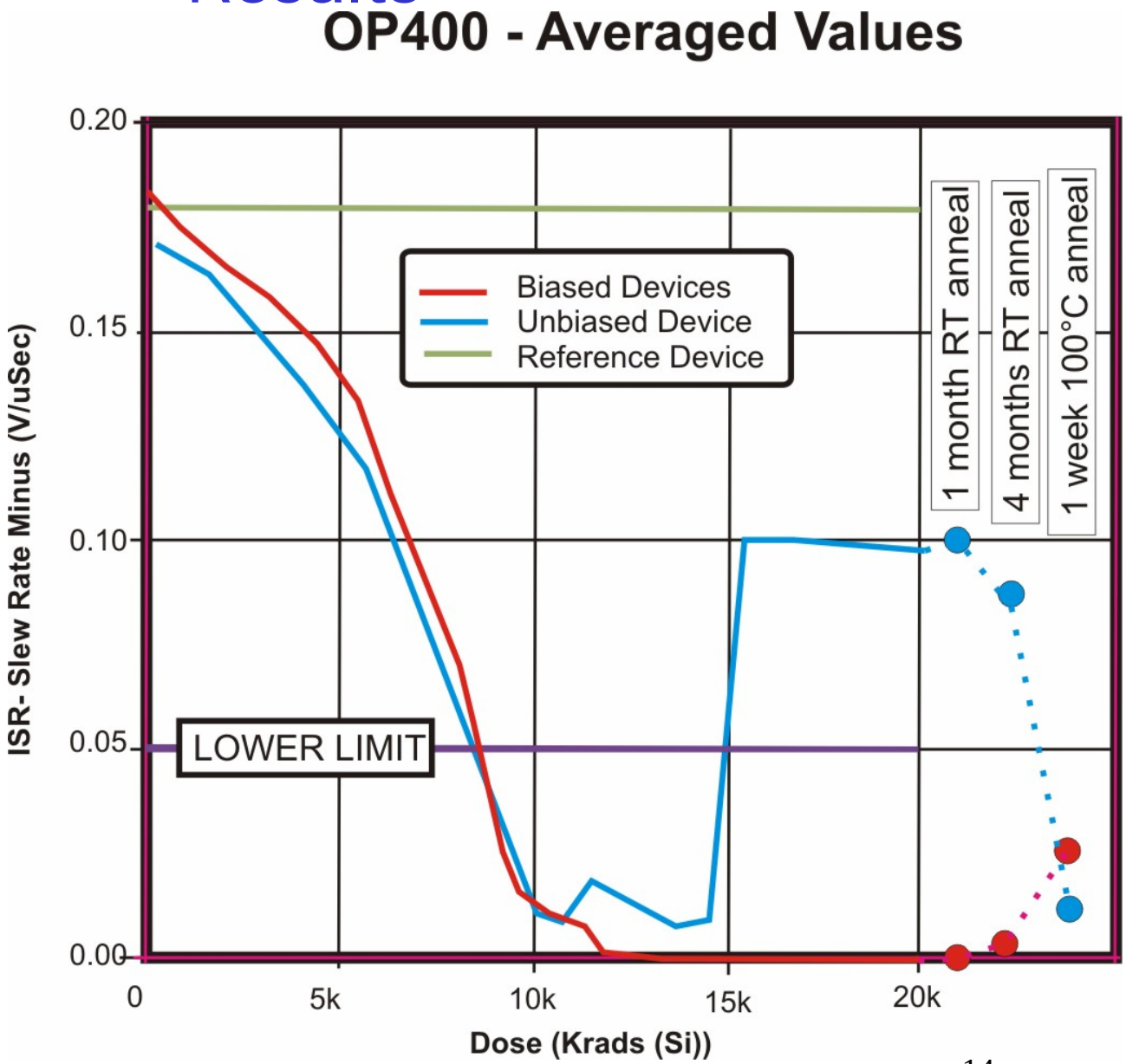
Positive slew rate



Results

OP400

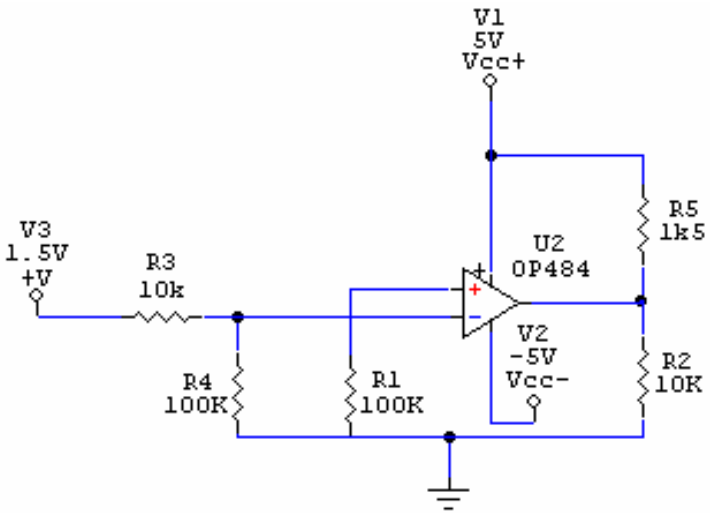
Negative slew rate

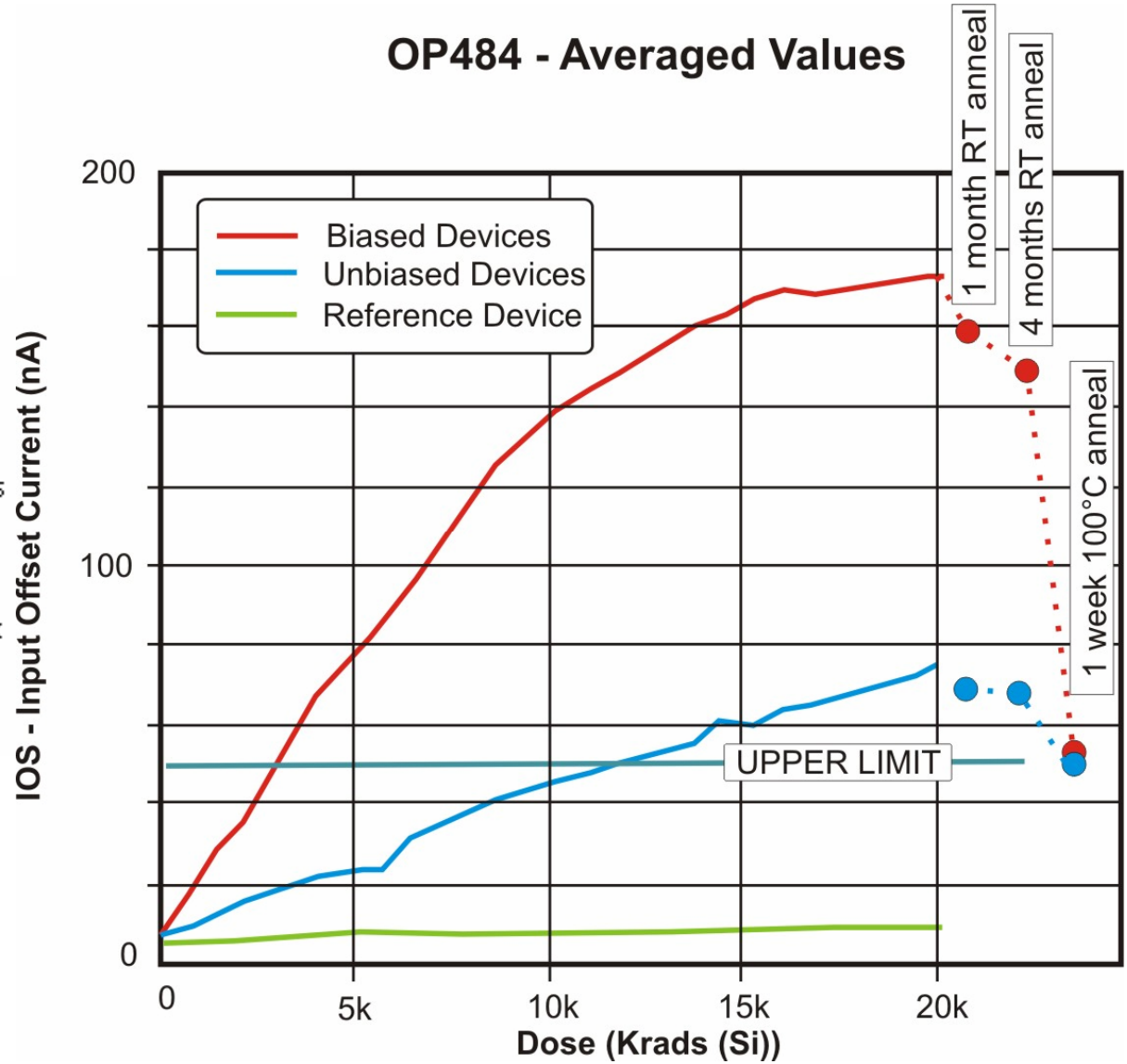


Results

OP484

Input Offset Current

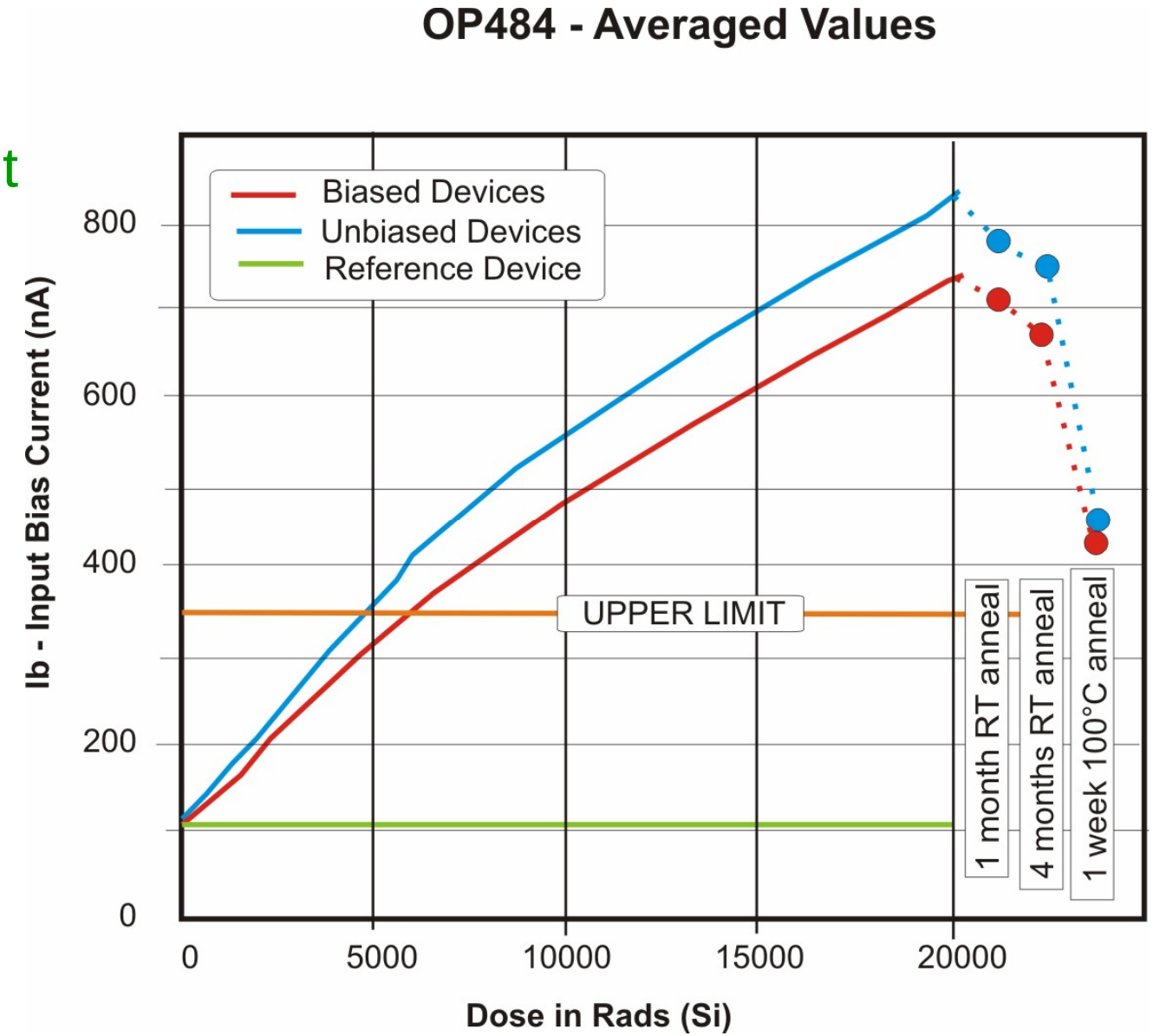




Results

OP484

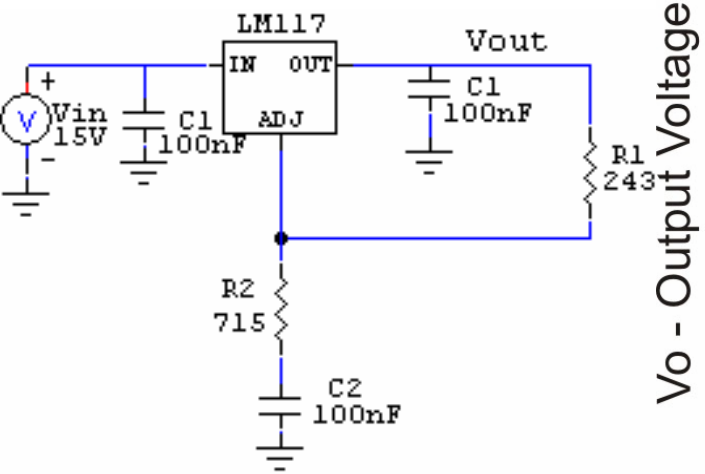
Input Bias Current

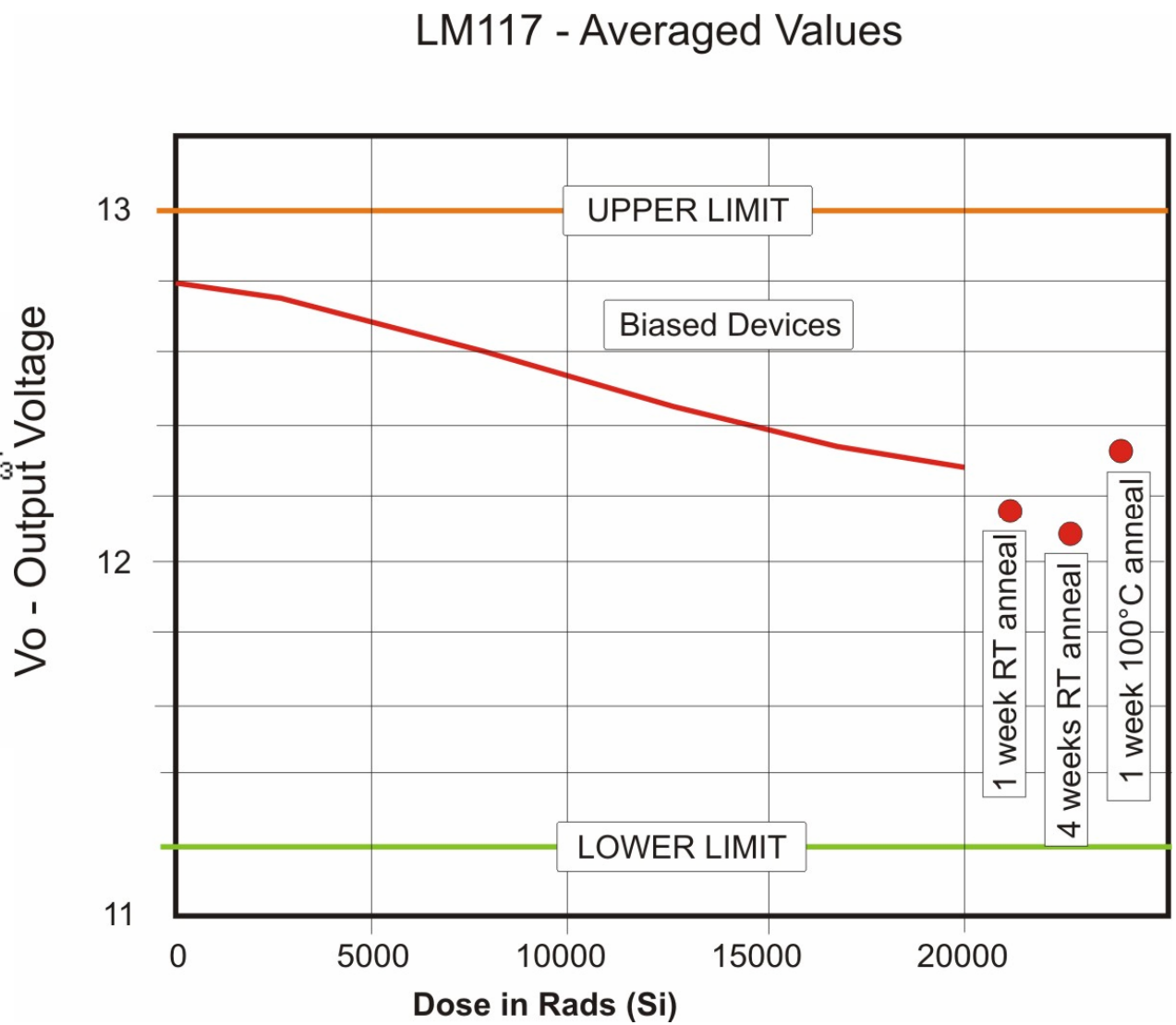


Results

LM117

Output Voltage

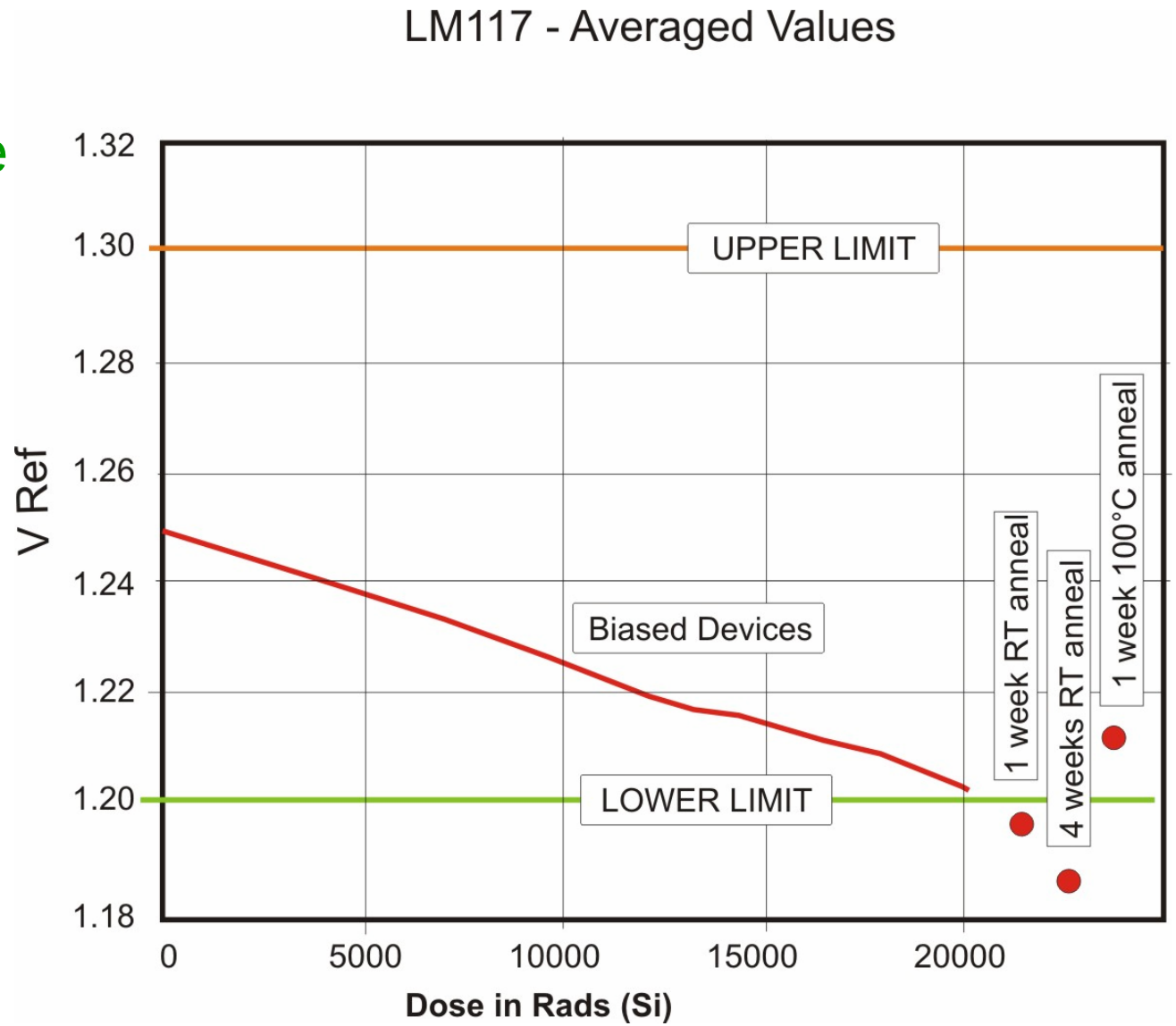




Results

LM117

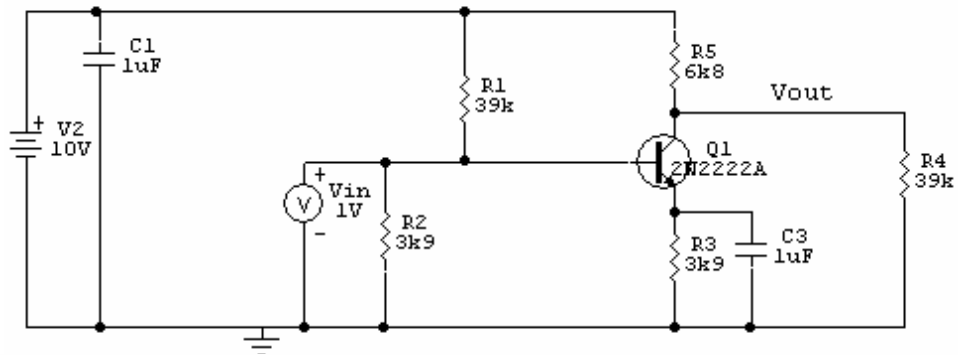
Reference Voltage

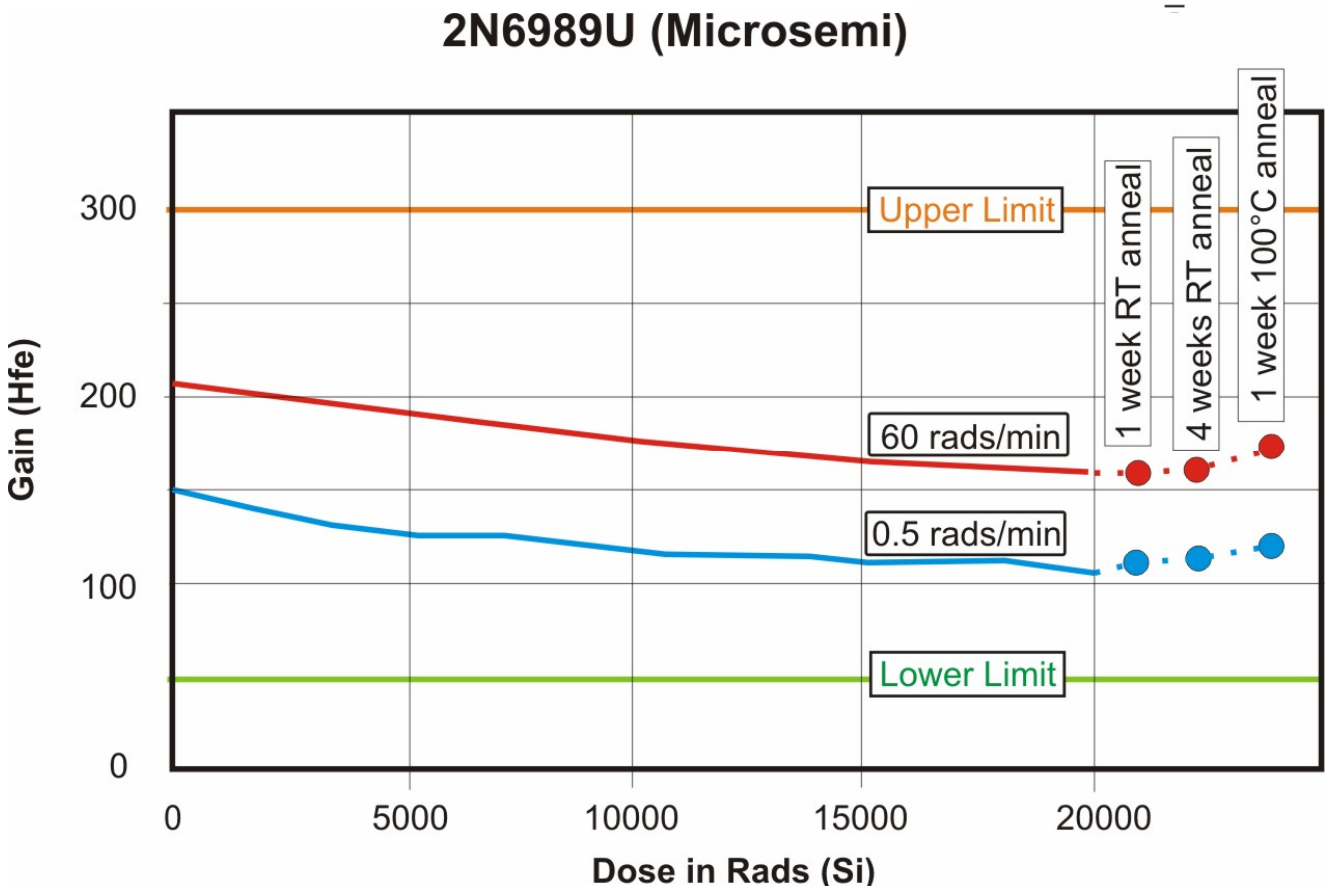


Results

2N6989U

Gain





Conclusion

- Bipolar integrated circuits and transistors employed to investigate the ELDRS effects
- Effects of bias and annealing investigated
- Suitability for use is application dependent
- LDR 0.5 rad(Si)/min: after 5 krad(Si), some parameters out of specification, however, all devices still functional after 20 krad(Si)
- Annealing:
  - 1-month at room temperature: little recovery, in some cases additional degradation observed
  - 1-week annealing at 100°C: some recovery observed
- HDR 60 rad(Si)/min for quad transistors: parameter drift has similar trend as for LDR tests

References

- C.C. Yui et al – “Total Dose Bias Dependency & ELDRS Effects in Bipolar Linear Devices” – JPL on-line report
- S.S. McClure et al – “Continuing Evaluation of Bipolar Linear Devices For Total Dose Bias Dependency & ELDRS Effects” – JPL on-line report
- M. Shaneyfelt et al – “Elimination of ELDRS and Thermal-Stress Effects in Bipolar Linear Devices” – Sandia on-line report
- J. Seiler et al – “Effect of Passivation on ELDRS of National LM124 Operational Amplifiers” – NSREC 2004 proc.
- B. Nickson et al – “Co-60 Low Dose Rate Testing of the LM137 Voltage Regulator” – 6th TEC-QCA Final Presentation Day

This presentation is available on
https://escies.org/public/radiation/esa/qcadays.html
and later on four reports will be issued.