# Low Dose Rate TID Testing of Candidate Components for ESA Projects

*A. Mohammadzadeh (TEC-QCA)*

*B. Nickson (TEC-QCA)*

# Irradiation Test Scope

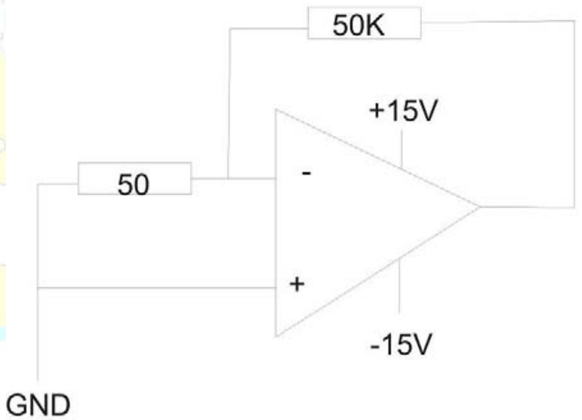
- Test initiated in response to ESA project request
- Tests performed on bipolar transistors and linear devices
- All test performed at low dose rates accounting for possible ELDRS effects
- In total 6 different component types were tested
- Project provided operating conditions during irradiation and component samples
- Work in progress

# Test samples

Analog Device: OP200

<u>Dual low offset, low power op-amp.</u>

- Date code 0616
- 4 Samples available
- 2 irradiated biased
- 1 irradiated unbiased
- 1 reference

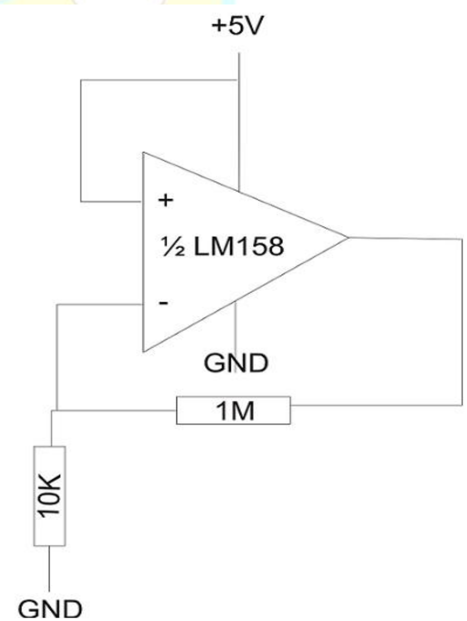



# Test samples

National Semiconductors: LM158

<u>Low power dual op-amp</u>

- Date code 0411
- 4 Samples available
- 2 irradiated biased
- 1 irradiated unbiased
- 1 reference

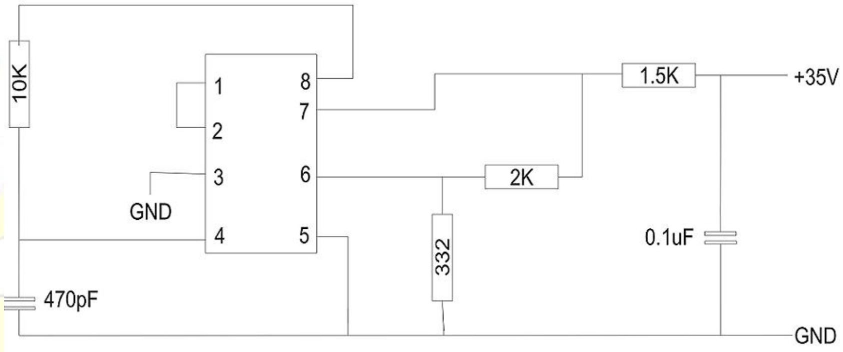



# Test samples

Texas Instruments: UC1842AJ


## Current Mode PWM Controller

- Date code 0535
- 4 Samples available
- 2 irradiated biased
- 1 irradiated unbiased
- 1 reference

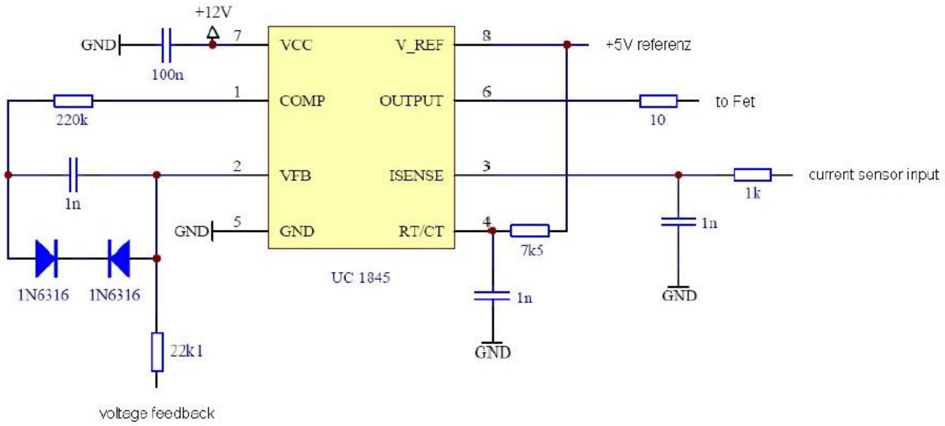


# Test samples

Texas Instruments: UC1845

<u>Current Mode PWM Controller</u>

- Date code 0413
- 4 Samples available
- 2 irradiated biased
- 1 irradiated unbiased
- 1 reference

# Test samples

STM JV2N3810

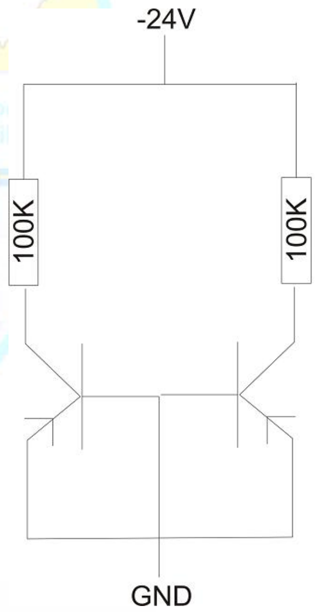
<u>PNP Transistor</u>

• Date code 0325

• 4 Samples available

• 3 irradiated biased

•1 reference

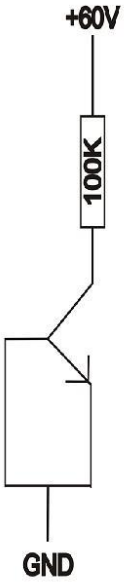



# Test samples

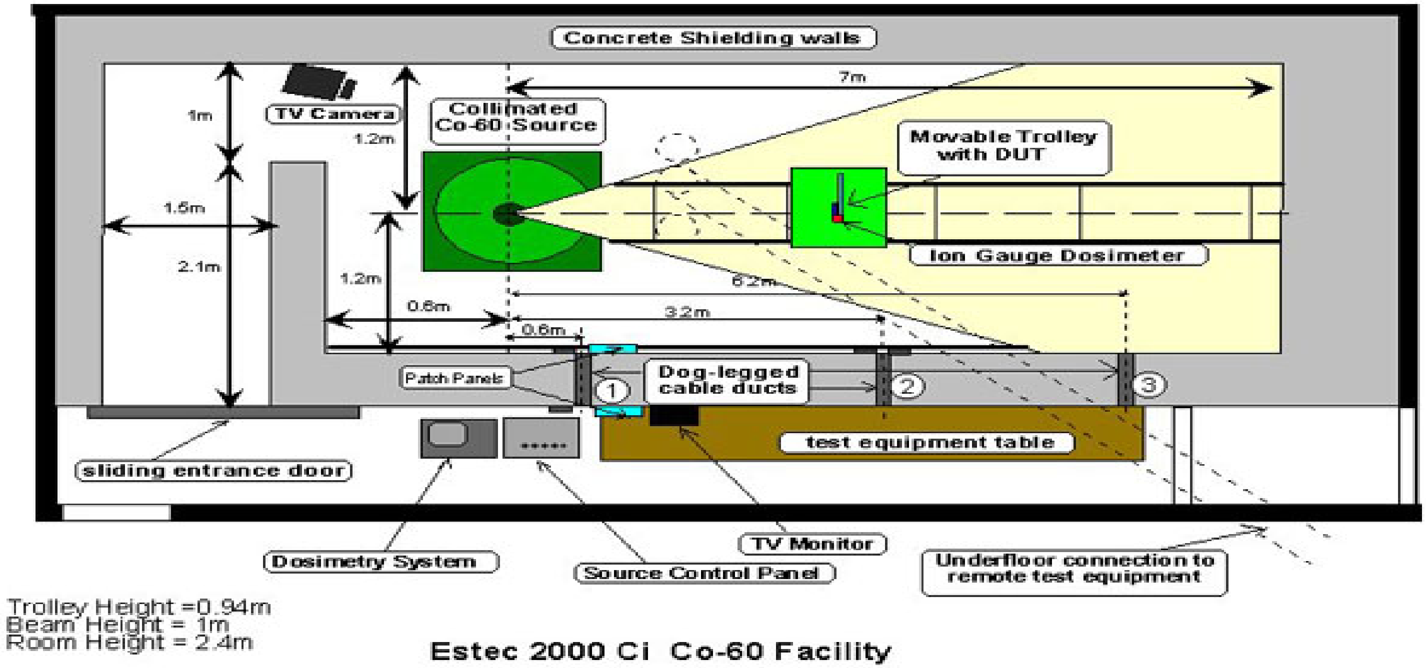
Microsemi JANTXV2N5154

<u>NPN Power transistor</u>

- Date code 9927
- 4 Samples available
- 2 irradiated biased
- 1 irradiated unbiased
- 1 reference

# Test Facility and Dosimetry




Dosimetry and Thermal conditions:

• Calibrated NE2571, 0.6cc air ionisation chamber read by a calibrated Farmer 2670 dosimeter.

• Ionising chamber placed in the same plane as devices under test All tests performed at 20 ± 3 ºC

# Irradiation History

• All devices were irradiated at 30rad(Si) / h

• Irradiation was performed to a total dose of 62.3krad(Si) (not a project requirement).

• Parametric tests performed for 9 irradiation steps at the following intervals: 3.1, 5.8, 8.9, 13.4, 18.7, 26.7, 44.5, 53.4 and 62.3krad(Si)

• The time between two consecutive irradiation runs < 60 minutes.

• Following irradiation 168h, 100$^{o}$C annealing was performed.

• Total irradiation duration approximately 87days

• Irradiation to high TID doses not required by project however, performed for general interest.

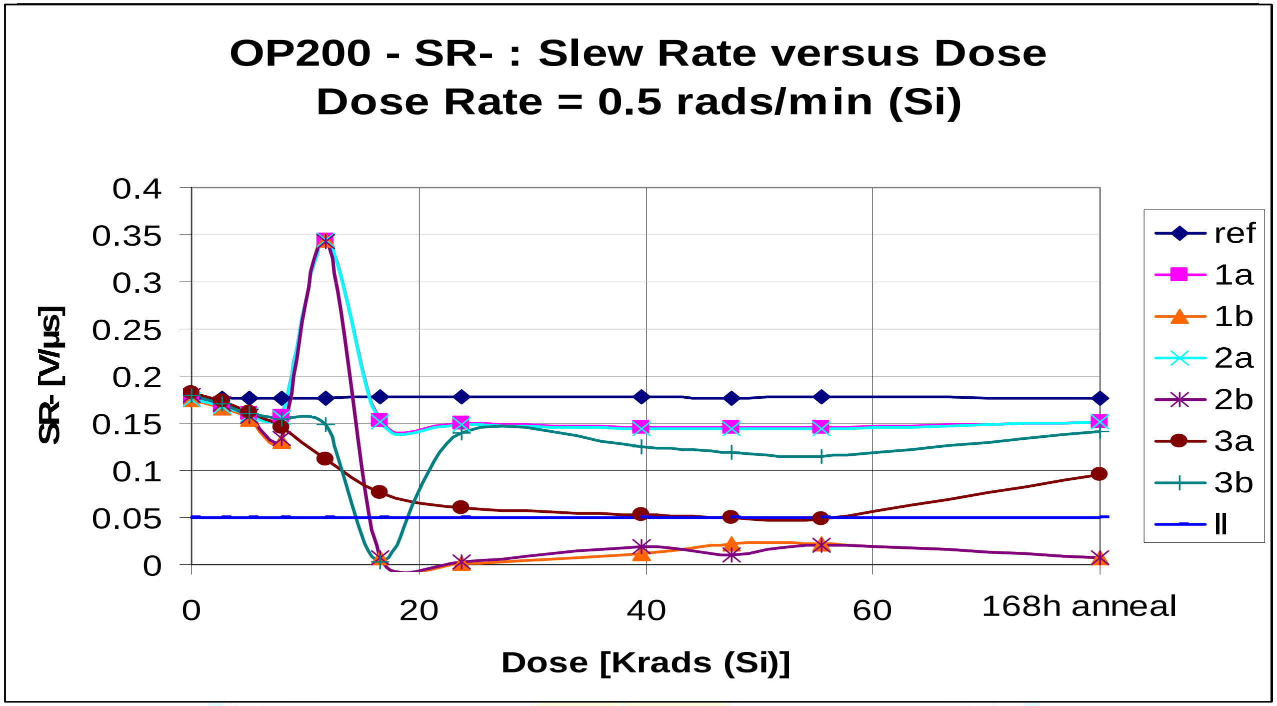
# Parametric tests

• All tests performed employing a SZ M3000 automatic parametric tests system (software UTS-Version 2.5.1)

• For each device the following parameters were measured.

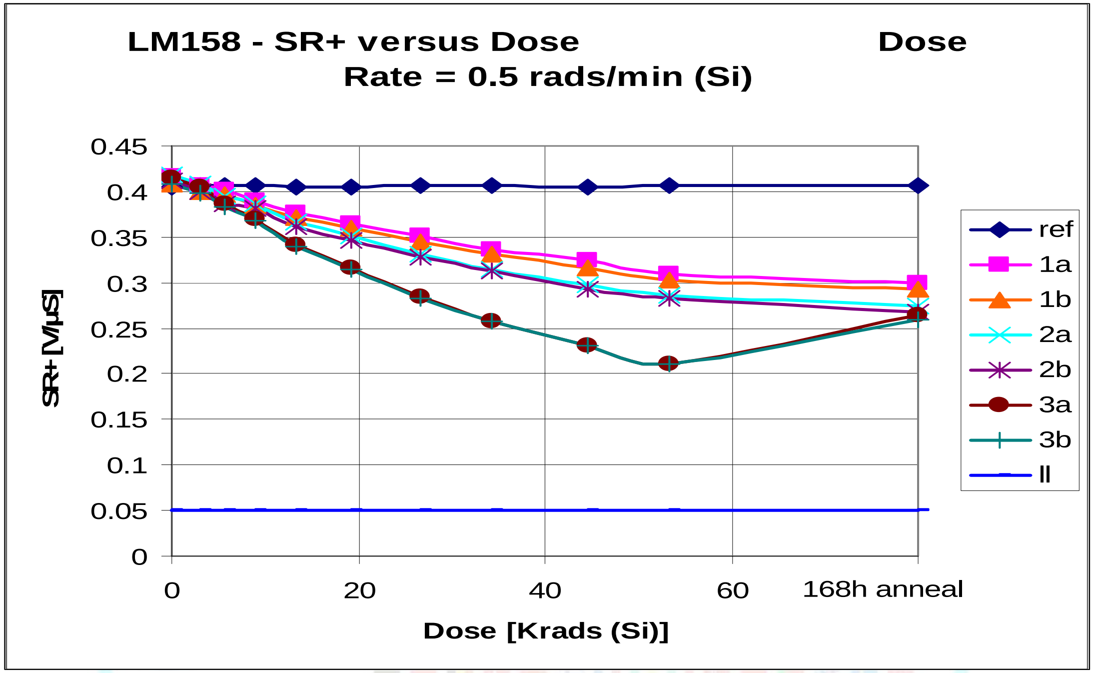
| Device | Parameters Tested |
|---|---|
| OP200 | Ios, Ib+, Ib-, Is+, Is-, Avo, Vo+, Vo-, SR+, SR-, Vos |
| LM158 | Ios, Ib+, Ib-, Is+, Is-, Avo, Vo+, Vo-, SR+, SR-, Vos |
| UC1842, 1845 | Start Threshold, Min. Op-Volt., Start up Curr, Op-Supply Curr, Vcc zener volt, Ref-Out volt, Line Reg, Load Reg, Output Short Circuit, Init-Accuracy, Amplitude, In-Voltage, In-Bias Curr, Out-Sink Curr, Out-Source Curr, Vout low, Max. Curr. Sense Sig, In-Bias Curr, Output low, Output high, |
| 2N3810 | Vce (BR), Icb, Ieb, Vce (Sat), hfe1, Vbe |
| 2N5154 | Vce, Ieb, Vce (Sat), hfe1, cut off, Vbe (Sat) |

# Results OP200



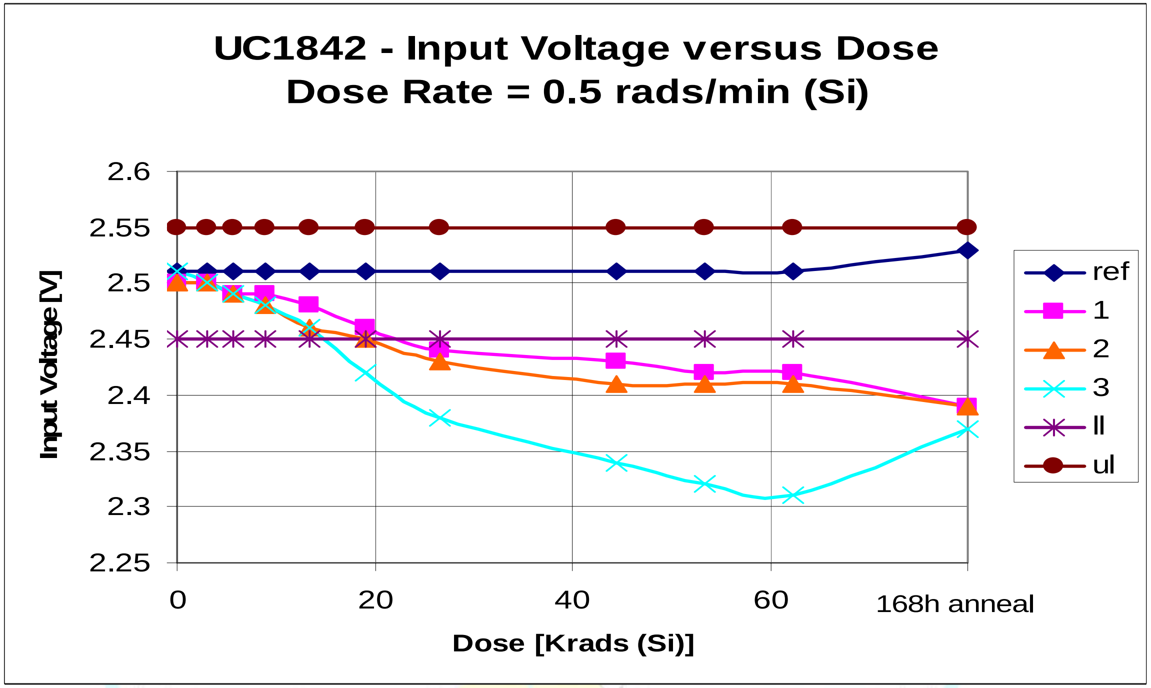

- **Ios out of spec for biased devices between 8.9 and 13.4krad(Si). Ios does recover at 18.7krad(Si), however gradually degrades and out of spec again at around 40krad(Si). SR out of spec from around 18krad(Si). Some recovery observed after annealing.**
- **Degradation trend also seen in other parameters such as Ib and Is but not out of spec.**
- **SR for unbiased devices out of spec between 27 and 40krad(Si).**
- **Spread in device data observed**

# Results LM158




- Ios out of spec between 3.1 and 8.9krad(Si) for all devices.
- Ib- out of spec above 18krad(Si). Ib+ out of spec relatively early however recovers and out of spec again above approximately 40krad(Si)
- SR some degradation was observed however, these were not out of spec
- No recovery after annealing for biased devices however, some recovery observed for unbiased device.

# Results UC1842



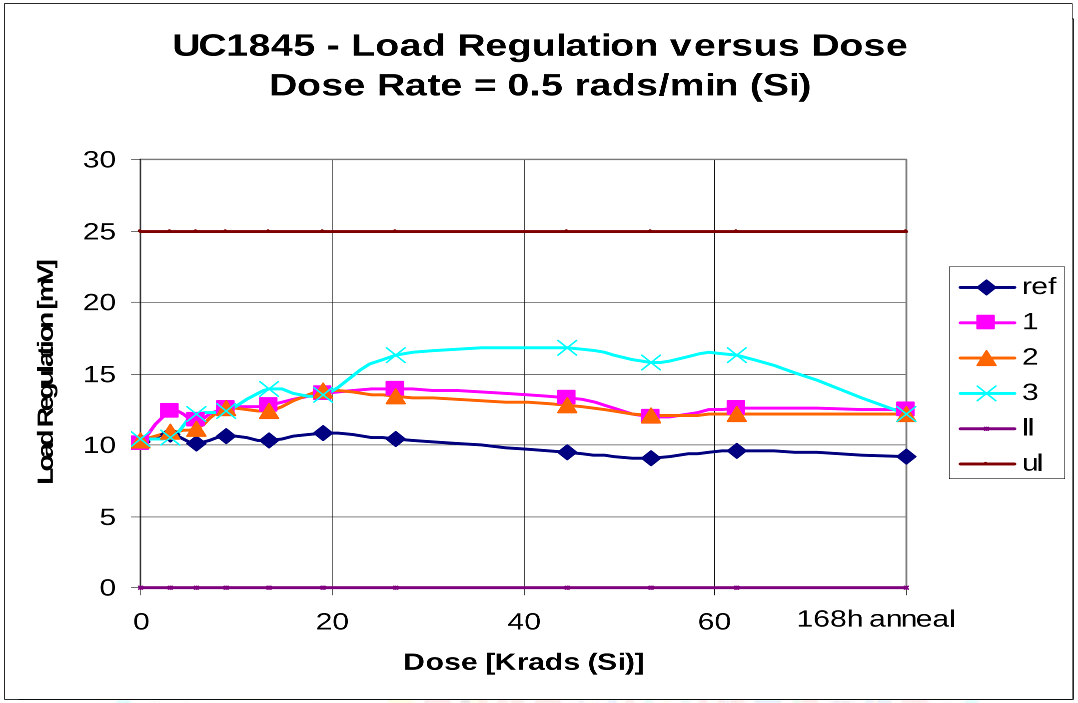

• **Most parameters within specification up to 62krad(Si), however:**

•**Ref Output out of spec between 3.1 and 8.9krad(Si), for devices 1 and 2 while device 3, unbiased, out of spec between 8.9 and 13.3krad(Si).**

• **Input Voltage out of spec between 13.3 and 26krad(Si) for all devices.**

• **Post annealing recovery observed for unbiased device while additional degradation observed for biased devices.**

# Results UC1845



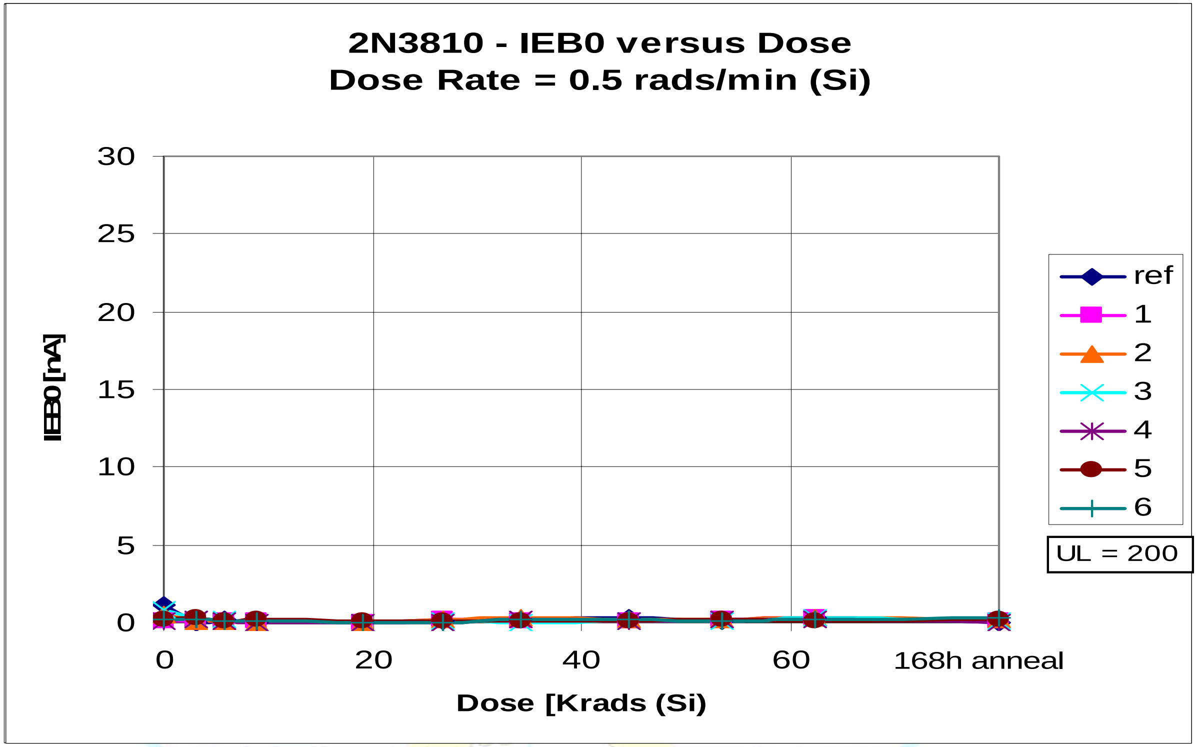

- **Most parameters within specification up to 62krad(Si), however:**

**•Ref Output out of spec between 3.1 and 5.8krad(Si), for devices 1 and 3 (unbiased) while device 2, out of spec between 5.8 and 8.9krad(Si).**

- **Input Bias Current out of spec between 13 and 30krad(Si) for all devices.**

- **Post annealing response of biased and unbiased devices similar.**

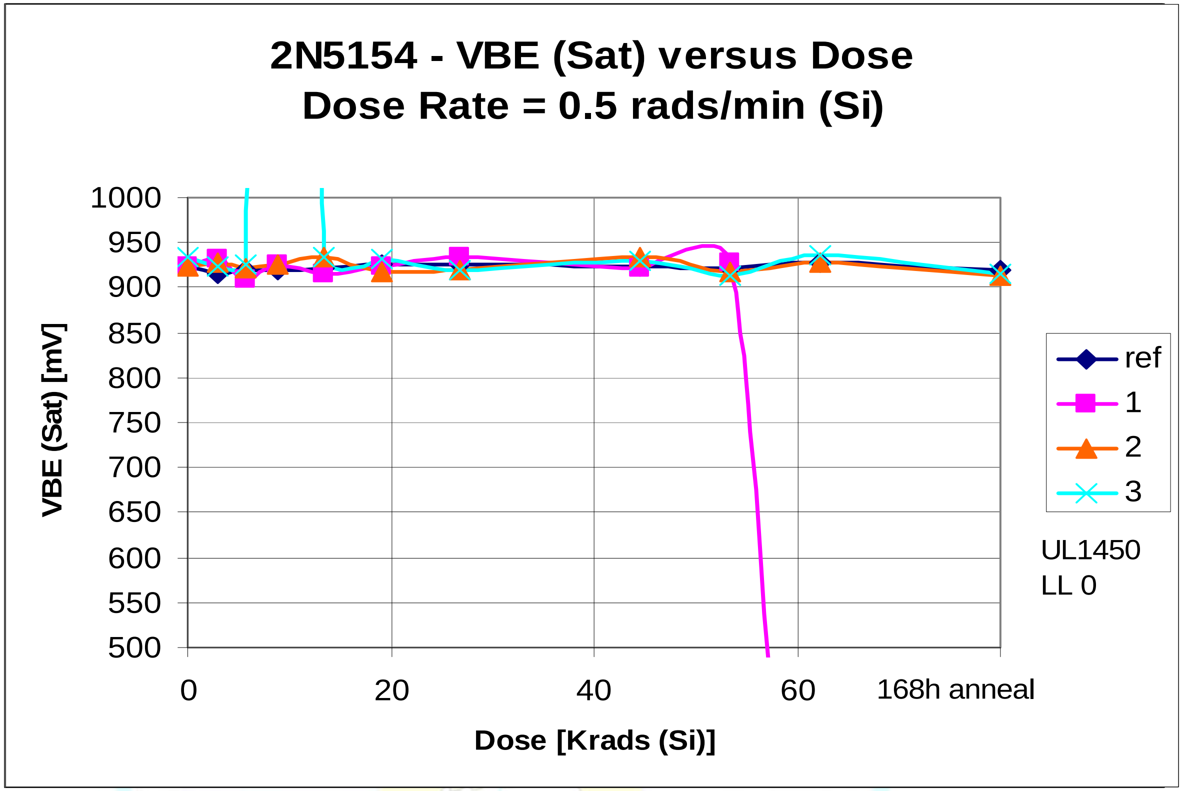
# Results 2N3810




• **All three samples were biased during irradiation**

• **Devices performed well up to 62krad(Si). No parameters out of specification.**

# Results 2N5154




• VBE(sat) and VCE(sat) device 3 (unbiased) out of spec between 5.8 and 8.9krad(Si) however, recovered at 13.3krad(Si). Devices 1 and 2 (biased) performed well up to approximately 53krad(Si) where device 1 out of spec for VBE(sat), VCE(sat) and VCE(BR).

• No conclusive changes following annealing

# Conclusion

- Low Dose Rate irradiation tests performed on 6 bipolar based devices
- Irradiation performed at 30rad(Si)/h
- Most devices performed well with respect to project low TID requirement
- However, some devices out of specification as early as between 3 and 5krad(Si)
- Unfortunately, sample sizes low, however, provide a good indication of device performance
- Ongoing activity, final suitability of devices planned assessed together with project
- Final reports including will be available on TEC-QCA database on ESCIES **(http://www.escies.org/).**

# Future Work

• Continuation of Low Dose Rate irradiation tests for ESA projects (internal activity)

• Detailed investigation of Dose Rate dependency of bipolar based devices (internal back ground activity) in support of definition of ESA ELDRS policy