High and Low Dose Rate testing of STMicroelectronics TS4061 1.25V voltage reference

Fabien WIDMER

Enoal LE GOULVEN, Pierre GARCIA, Athina VAROTSOU,

Presentation outline

- The project
- TID tests parameters:
  - Parts,
  - bias conditions,
  - irradiation time log,
  - measured parameters.
- Low and high dose rate results crossing
- Conclusions

Aim of the project

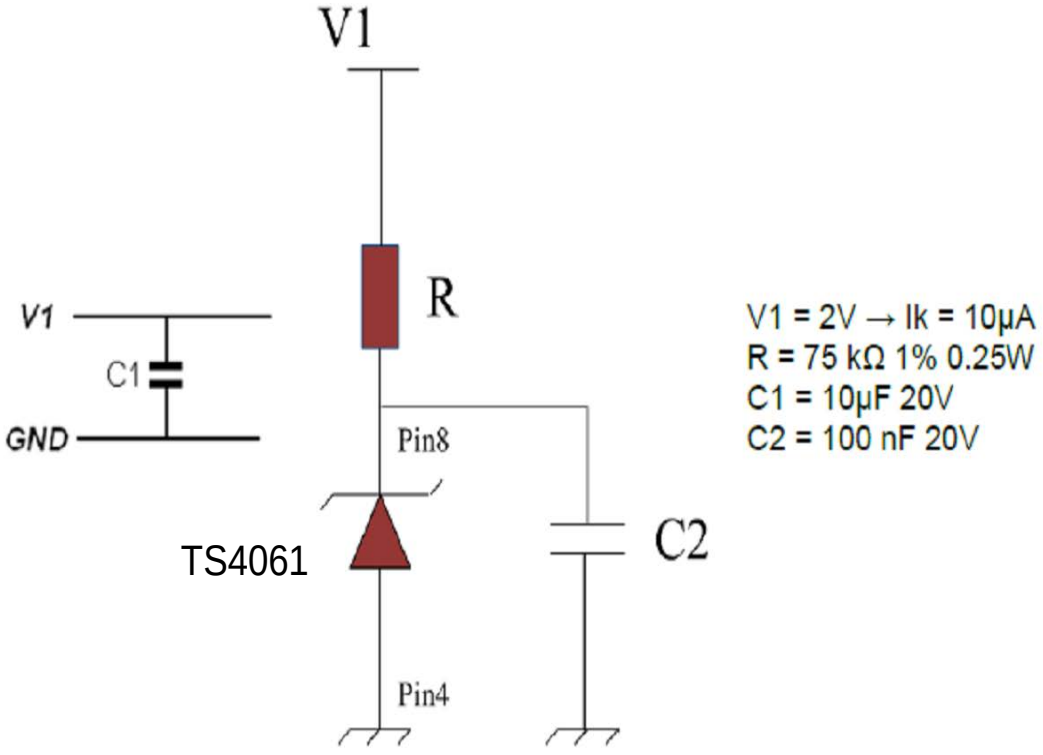
- Context: COO4 of the frame contract *ECI, radiation characterisation of commercial EEE Components for Space Applications*.
- Goal: Qualification of the COTS TS4061 for space application. They shall be tested to TID at low and high dose rates.
- DUT: TS4061 is a 1.25V Shunt Voltage Reference from STMicroelectronics

TID tests: Parts details

PART IDENTIFICATION		
Type:	TS4061	
Manufacturer:	STMicroelectronics	
Function:	1.25V Precision Micropower Shunt Voltage Reference	
PARTS PROCUREMENT INFORMATIONS		
Packaging:	Ceramic flat pack 10 pins	
Date code:	LDR & HDR	31303A
Customer P/O	LDR & HDR	1321
Sample size :	LDR & HDR	10 irradiated samples + 1 reference sample

TID tests: Bias conditions

5 PARTS BIASED IN STATIC ON



V1 = 2V → Ik = 10µA
R = 75 kΩ 1% 0.25W
C1 = 10µF 20V
C2 = 100 nF 20V

5 PARTS UNBIASED

TID tests: Irradiation Details

Low dose rate irradiation facility: ^{60}Co at TRAD (Labege, FRANCE)								
IRRADIATION DETAILS								
Total dose limit (krad(Si))	100							
Level for measurement (krad(Si))	0	9	21	30	50	58	80	100
Dose rate (krad(Si)/h)	0.31							

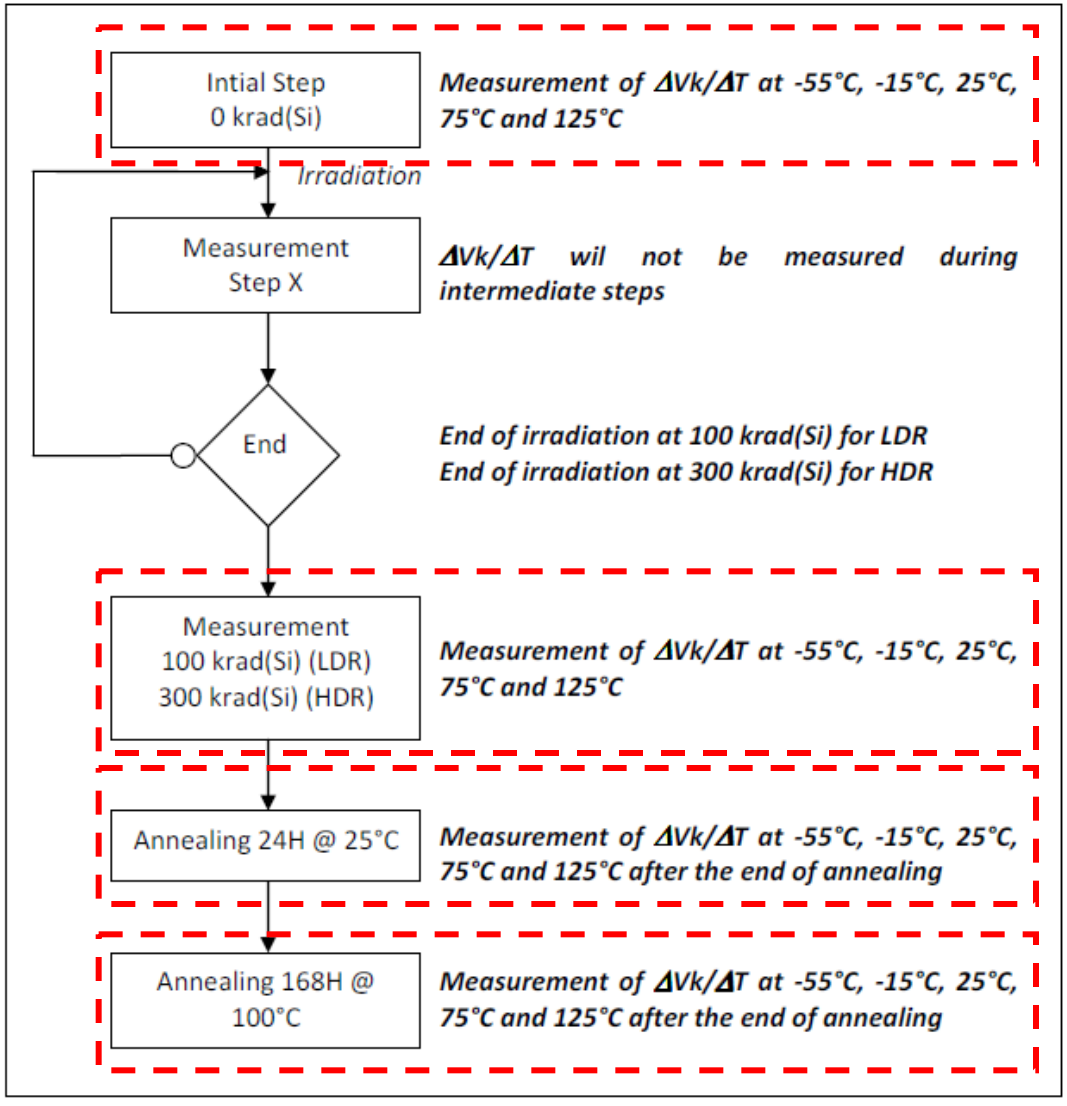
High dose rate irradiation facility: ^{60}Co at SCK-CEN (Mol, BELGIUM)							
IRRADIATION DETAILS							
Total dose limit (krad(Si))	300						
Level for measurement (krad(Si))	0	25	50	75	100	200	300
Dose rate (krad(Si)/h)	180						

Annealing Low and High dose rate
24h @ 25°C
168h @ 100 °C

TID tests: LDR & HDR Specifications

Param.	Symbol	Conditions	Limits	
		Ta = 25°C, unless otherwise specified	Min	Max
Reverse Breakdown Voltage	Vk	Ik = 10µA	1.2487V	1.2512V
Minimum Operating Current	Ikmin	Vk = 1.25V	*Not spec.*	10µA
Average Reverse Breakdown Voltage vs Operating Current Range	DVk1/Ik	10µA ≤ Ik ≤ 1mA	*Not spec.*	1mV
	DVk2/Ik	1mA ≤ Ik ≤ 15mA	*Not spec.*	4mV
Static Impedance	Rka	DIk = 10µA to 10 mA	*Not spec.*	0.3Ω
Wide Band Noise	en	Ik = 10 µA et f = 1 kHz	*Not spec.*	
Average Temperature Coefficient $\frac{Vkmax - Vkmin}{180°C \times Vk(25°C)} \times 10^6$	DVk1/DT	Ik = 10µA	*Not spec.*	35ppm/°C
	DVk2/DT	Ik = 15mA	*Not spec.*	35ppm/°C

TID tests: Average Temperature Coefficient Testing Flow



TID tests: LDR & HDR Results

Param.	LDR up to 107 krad (Si)		HDR up to 100 krad (Si)	
Vk	ON OFF	within spec.	ON OFF	within spec.
Ikmin	ON OFF	within spec.*	ON OFF	within spec.
DVk1/Ik	ON OFF	within spec.	ON OFF	within spec.
DVk2/Ik	ON OFF	within spec.	ON OFF	within spec.
Rka	ON OFF	within spec.	ON OFF	within spec.
en	ON OFF	*No spec. / No significal drift*	ON OFF	*No spec. / No significal drift*
DVk1/DT	ON OFF	out of spec. @ step 107 krad (Si)	ON OFF	*Not tested (tested @ 300krad)*
DVk2/DT	ON OFF	within spec.	ON OFF	*Not tested (tested @ 300krad)*

*Except for 3 atypical parts out of spec after 50krad

TID tests: LDR & HDR Results

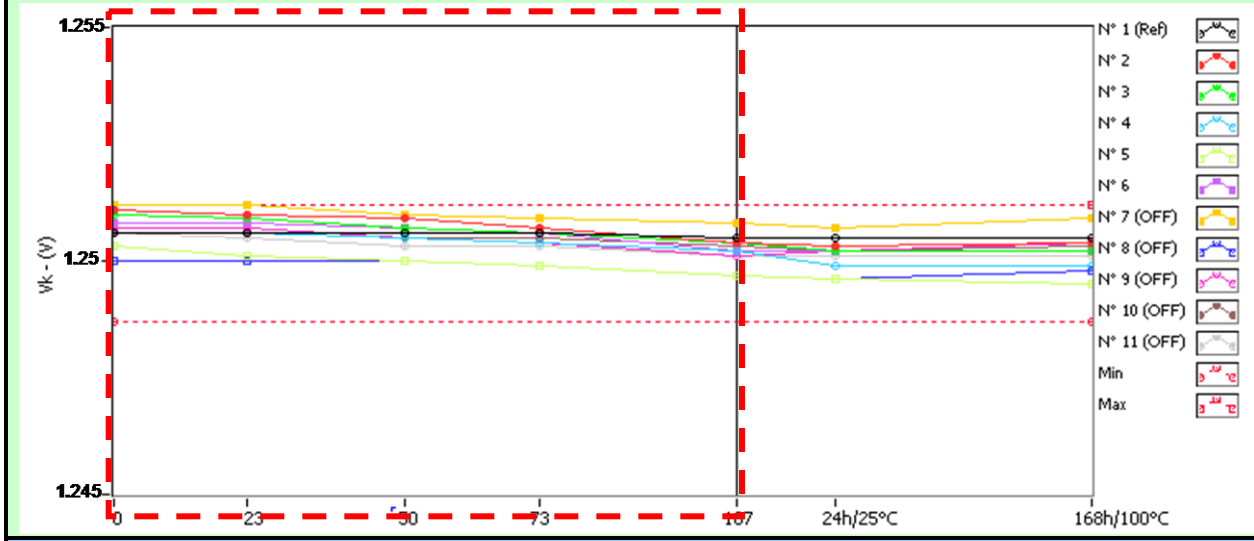
Param.		LDR up to 107 krad (Si)		HDR up to 300 krad (Si)
Vk	ON	Within spec.	ON	out of spec. @ step 200 krad (Si)
	OFF		OFF	out of spec. @ step 300 krad (Si)
Ikmin	ON	Within spec.	ON	Not measurable @ step 200 krad (Si)*
	OFF		OFF	Not measurable @ step 300 krad (Si)*
DVk1/Ik	ON	Within spec.	ON	out of spec. @ step 200 krad (Si)
	OFF		OFF	out of spec. @ step 300 krad (Si)
DVk2/Ik	ON	Within spec.	ON	out of spec. @ step 200 krad (Si)
	OFF		OFF	within spec.
Rka	ON	Within spec.	ON	out of spec. @ step 200 krad (Si)
	OFF		OFF	within spec.
en	ON	No spec. / No significal drift	ON	*No spec. / Drift @ step 100 krad (Si)*
	OFF		OFF	*No spec. / No significal drift*
DVk1/DT	ON	out of spec. @ step 107 krad (Si)	ON	out of spec. @ step 300 krad (Si)
	OFF		OFF	
DVk2/DT	ON	Within spec.	ON	out of spec. @ step 300 krad (Si)
	OFF		OFF	

*Ikmin should be above the maximum rating

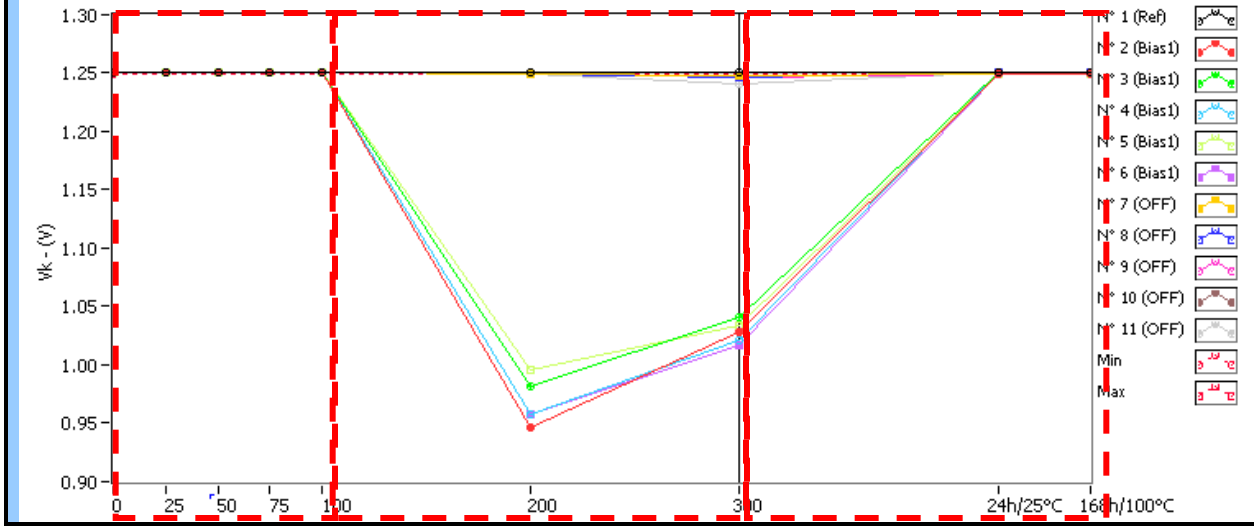
TID tests: Results example (Vk)

Vk (V) | Conditions: Ta=25°C ; Ik = 10µA | Limits: Min = 1.2487V / Max = 1.2512V

Low dose rate



High dose rate



Conclusions

- **Within the specifications under 100krad (Si)**
- **Parts biased OFF less sensitive**
- **No major dose rate impact up to 100krad (Si)**

Thank you for your attention

Any questions ?