ESA ESTEC
Keplerlaan 1
2201 AZ Noordwijk
The Netherlands

LM4041_TID_TEST_REPORT

LM4041AIM3-1.2/NO
Date Code: 1738
1.225V Bandgap Voltage Reference
Texas Instruments

LM4041QAIM3-1.2/NO
Date Code: 2018
1.225V Bandgap Voltage Reference
Texas Instruments

LM4041AECT-1.2
Date Code: 1916
1.225V Bandgap Voltage Reference
STMicroelectronics

LM4041CFTA
Date Code: 1950 and 2023
1.225V Bandgap Voltage Reference
Diodes Incorporated

LM4041CYM3-1.2-TR
Date Code: 2043 and 2125
1.225V Bandgap Voltage Reference
Microchip Technology

LM4041BIX3-1.2+T
Date Code: 1727
1.225V Bandgap Voltage Reference
Maxim Integrated

Prepared by	Florian Krimmel
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DISTRIBUTION

Name/Organisational Unit

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1. INTRODUCTION

The current report presents the TID results on the Bandgap Voltage Reference LM4041

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- LM4041QAIM3-1.2/NO, date code: 2018, Texas Instruments
- LM4041AECT-1.2, date code: 1916, STMicroelectronics
- LM4041CFTA, date code: 1950 and 2023, Diodes Incorporated
- LM4041CYM3-1.2-TR, date code: 2043 and 2125, Microchip Technology
- LM4041BIX3-1.2+T, date code: 1727, Maxim Integrated

The test campaign was performed between the 24th January and 18th February 2022 at the ESTEC 60Co facility.

Additional information on the context is provided in the test plan [RD01].

2. DOCUMENTS

2.1. Applicable documents

AD01 ESCC22900 Total Dose Steady-state irradiation test method, June 2016

2.2. Reference documents

RD01 TID_COTS_Bandgap-ref_test_plan

RD02 RA0005344 Radiation Test Summary

3. PART & PROCUREMENT INFORMATION

Part number	LM4041AIM3-1.2/NO	LM4041QAIM3-1.2/NO	LM4041AECT-1.2
Manufacturer	Texas Instruments	Texas Instruments	STMicroelectronics
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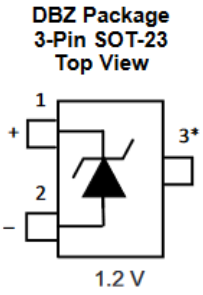
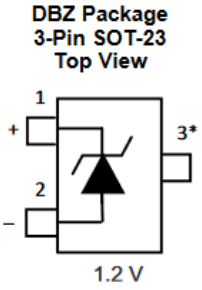
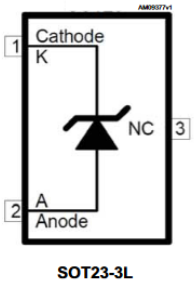
Technology	Bipolar	Bipolar	Bipolar
Package			
Date Code [yyww]	1738	2018	1916
Distributor	RS Components	Mouser	Mouser
Part # (sample n°) date code	5 samples unbiased (n° A60 to A64) 5 samples biased (n° A65 to A69) 1 reference unbiased (n° REF06) 1 reference biased (n° REF56)	5 samples unbiased (n° A70 to A74) 5 samples biased (n° A75 to A79) 1 reference unbiased (n° REF07) 1 reference biased (n° REF57)	5 samples unbiased (n° A90 to A94) 5 samples biased (n° A95 to A99) 1 reference unbiased (n° REF09) 1 reference biased (n° REF59)

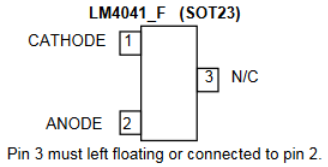
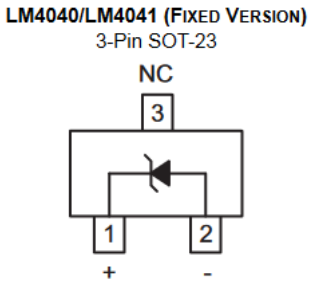
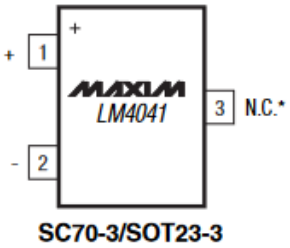
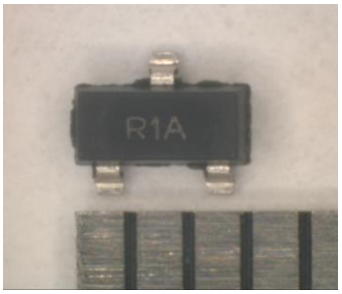
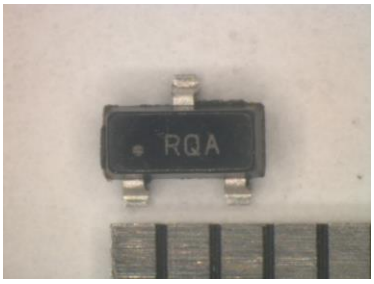
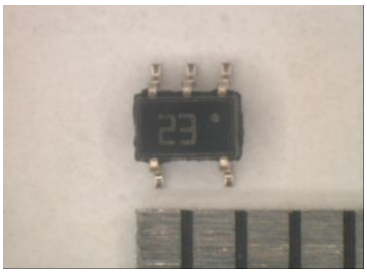
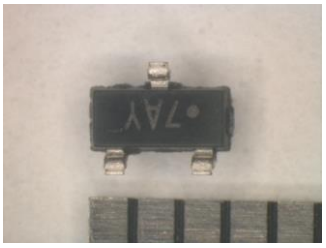
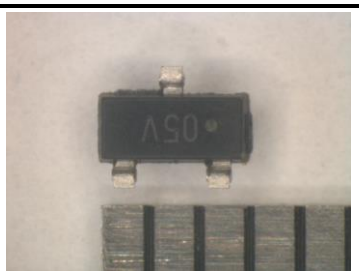
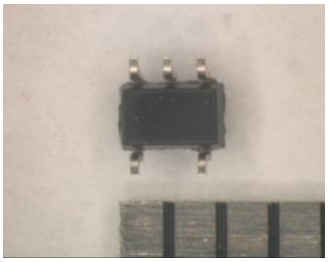
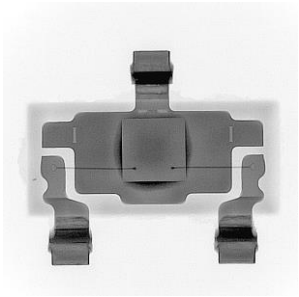
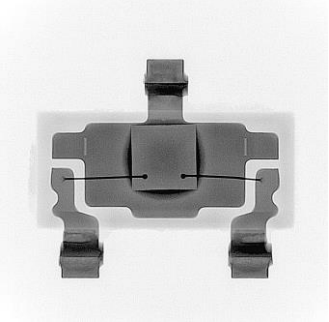
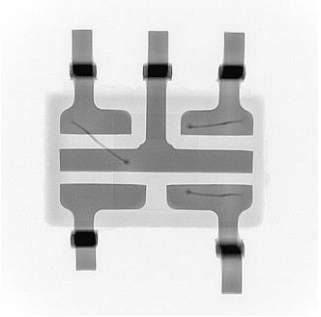
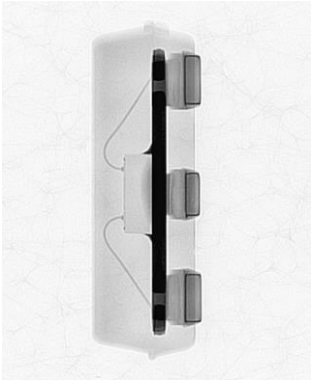
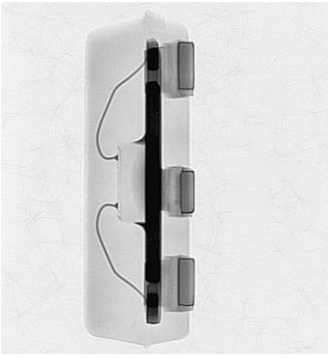
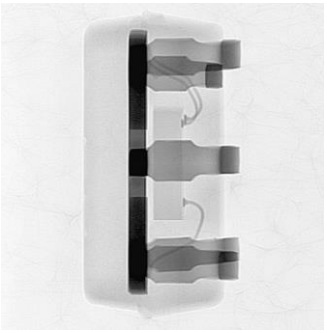
Part number	LM4041CFTA	LM4041CYM3-1.2-TR	LM4041BIX3-1.2+T
Manufacturer	Diodes Incorporated	Microchip Technology	Maxim Integrated
Function	1.225V Bandgap Voltage Reference	1.225V Bandgap Voltage Reference	1.225V Bandgap Voltage Reference
Technology	Bipolar	Bipolar	Bipolar
Package			
Date Code [yyww]	1950 and 2023	2043, 2125 and unknown	1727
Distributor	Mouser and Farnell	Mouser and Digikey	Mouser
Part # (sample n°) date code	2x5 samples unbiased (n° B10 to B14) 1950 (n° B20 to B24) 2023 2x5 samples biased (n° B15 to B19) 1950 (n° B25 to B29) 2023 2x1 reference unbiased (n° REF11) 1950 (n° REF12) 2023 2x1 reference biased (n° REF61) 1950 (n° REF62) 2023	3x5 samples unbiased (n° B30 to B34) ---- (n° B40 to B44) 2043 (n° B50 to B54) 2125 3x5 samples biased (n° B35 to B39) ---- (n° B45 to B49) 2043 (n° B55 to B59) 2125 3x1 reference unbiased (n° REF13) ---- (n° REF14) 2043 (n° REF15) 2125 3x1 reference biased (n° REF63) ---- (n° REF64) 2043 (n° REF65) 2125	5 samples unbiased (n° B60 to B64) 5 samples biased (n° B65 to B69) 1 reference unbiased (n° REF16) 1 reference biased (n° REF66)

Table 1: Part & procurement information

Part number	LM4041AIM3-1.2/NO	LM4041QAIM3-1.2/NO	LM4041AECT-1.2
Package marking top			
Package marking bottom			
X-ray top view			
X-ray side view			

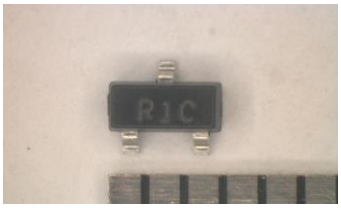
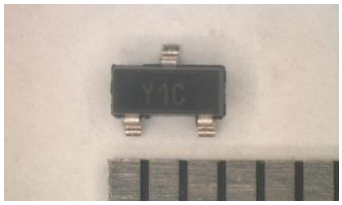
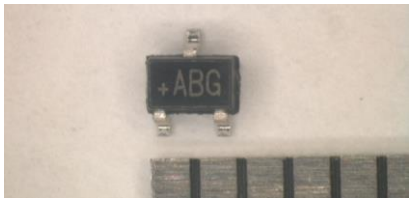
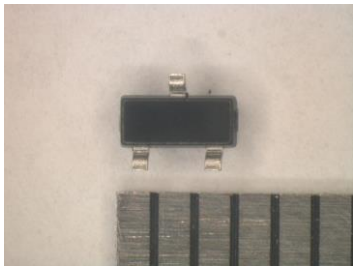
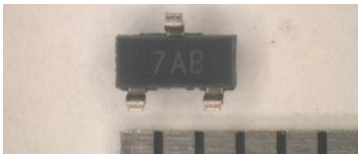
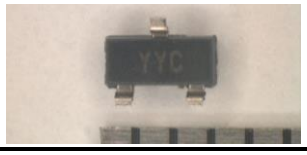
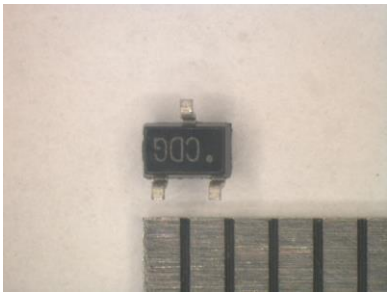
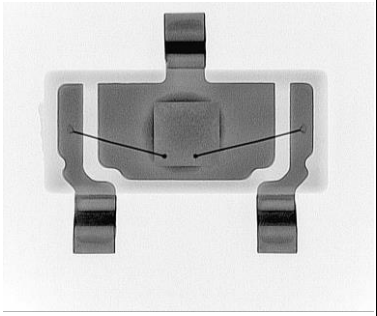
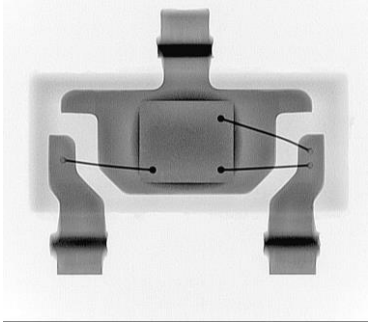
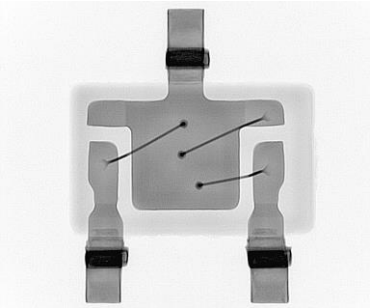
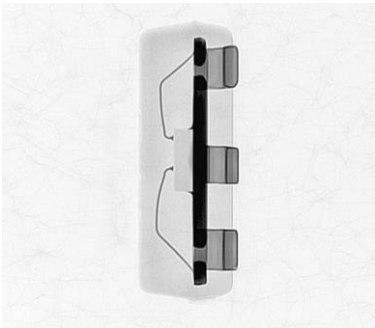
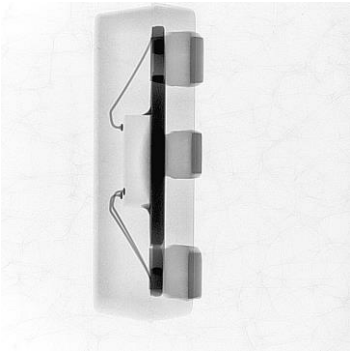
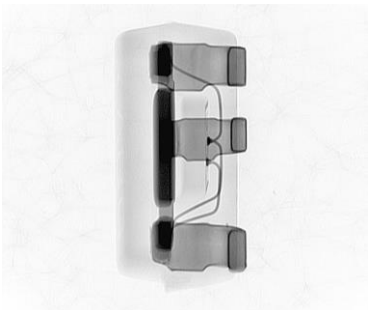
Part number	LM4041CFTA	LM4041CYM3-1.2-TR	LM4041BIX3-1.2+T
Package marking top			
Package marking bottom		Date Code: unknown  Date Code: 2043  Date Code: 2125 	
X-ray top view			
X-ray side view			

Table 2: Package marking X-ray of the DUT

4. DOSIMETRY AND IRRADIATION FACILITY

IRRADIATION FACILITY

Source:	C060
Localization:	ESTEC, Netherlands
Dosimetry:	Electrometer: Farmer model 2670 – s/n 491
	Ionisation chamber: PTW TW30012-10 s/n 000417

IRRADIATION TIMING

TID steps (krad(Si))	0, 5, 10, 15, 20, 38.2, 50, 80.5, 100
Dose rate (rad(Si)/h)	240 - 260

ANNEALING TIMING		Condition during annealing
Annealing 22°C	24 h	Biased for those tested biased
		Unbiased for those tested unbiased
Ageing 100°C	168h	ON for those tested ON
		Unbiased for those tested unbiased

Values are provided in TID(H_20), the conversion to TID(Si) is done using the conversion factor of: 0.898.

5. TEST SET-UP

5.1. Test set-up overview

The set-up to measure at specific TID steps outside the irradiation chamber is schematically depicted in the Figure 1. Inside the radiation chamber the component boards with the DUTs on it are connected to the biasing boards which have a determined resistor to create the right value of biasing current (typical current acc. to datasheet) from a 12V supply for each biased component. Additionally to that, there are also 0-Ohm resistors on the biasing boards to connect all pins of the unbiased components.

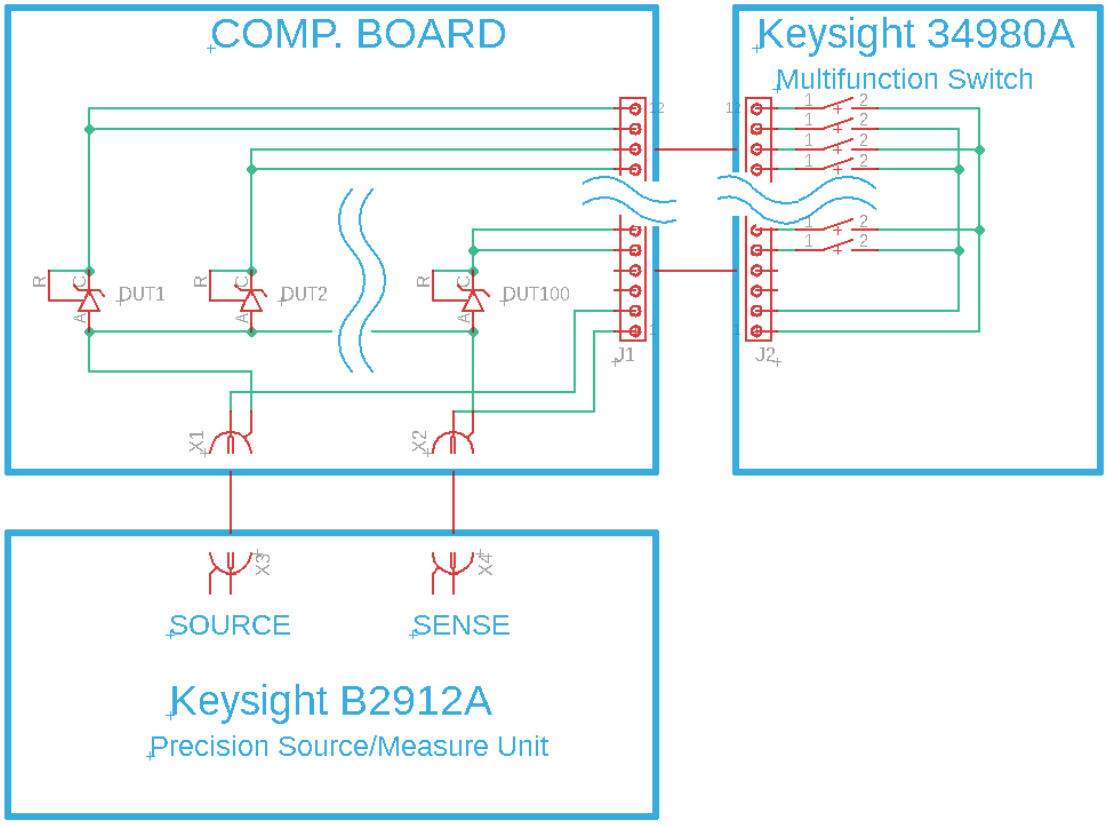


Figure 1: Simplified schematic of the overall test set-up

Four PCBs which were specially designed for this purpose could allow to accommodate both biased and unbiased components for this component and also other bandgap reference components at the same time on a 12*22 cm² PCB. This size of the boards limits the TID variation across board to less than 10%. Set-up pictures are provided in Annex B.

During each defined TID step a PC laptop was used to acquire the voltage (V_Z) as well as the input current (I_Z) of each of the samples from the source measure unit (SMU). The laptop time is synchronised to the time used for controlling the Co60 facility.

5.2. Test equipment

TEST EQUIPMENT	PARAMETER MEASURED
1 x Keysight B2912A 2412A Precision Source/Measure Unit (SMU)	Providing 6 different I_Z currents acc. to datasheet of the components: I_{min}, $0.8xI_{typ}$, I_{typ}, $3.14xI_{typ}$, $10xI_{typ}$, I_{max} V_{max} = 5.0 V
1 x Keysight 34980A Multifunction Switch	Switching through all up to 100 samples solder on one board.
1 x Laptop with LabView	Logging and saving the V_Z and I_Z measurements using an in-house VI.

6. TEST PARAMETERS

The following two parameters are measured:

PARAMETERS	SYMBOLS
Reverse Breakdown Voltage	V_Z
Reverse Current	I_Z

7. BIASING CONDITIONS

All biased samples are continuously biased with the typical value of I_Z according to the datasheet of each part type:

Table summarised the main biasing conditions

PART TYPE	Value	Unit
LM4041AIM3-1.2/NO	100	µA
LM4041QAIM3-1.2/NO	100	µA
LM4041AECT-1.2	100	µA
LM4041CFTA	100	µA
LM4041CYM3-1.2-TR	100	µA
LM4041BIX3-1.2+T	100	µA

Table 2: Biasing conditions during irradiation

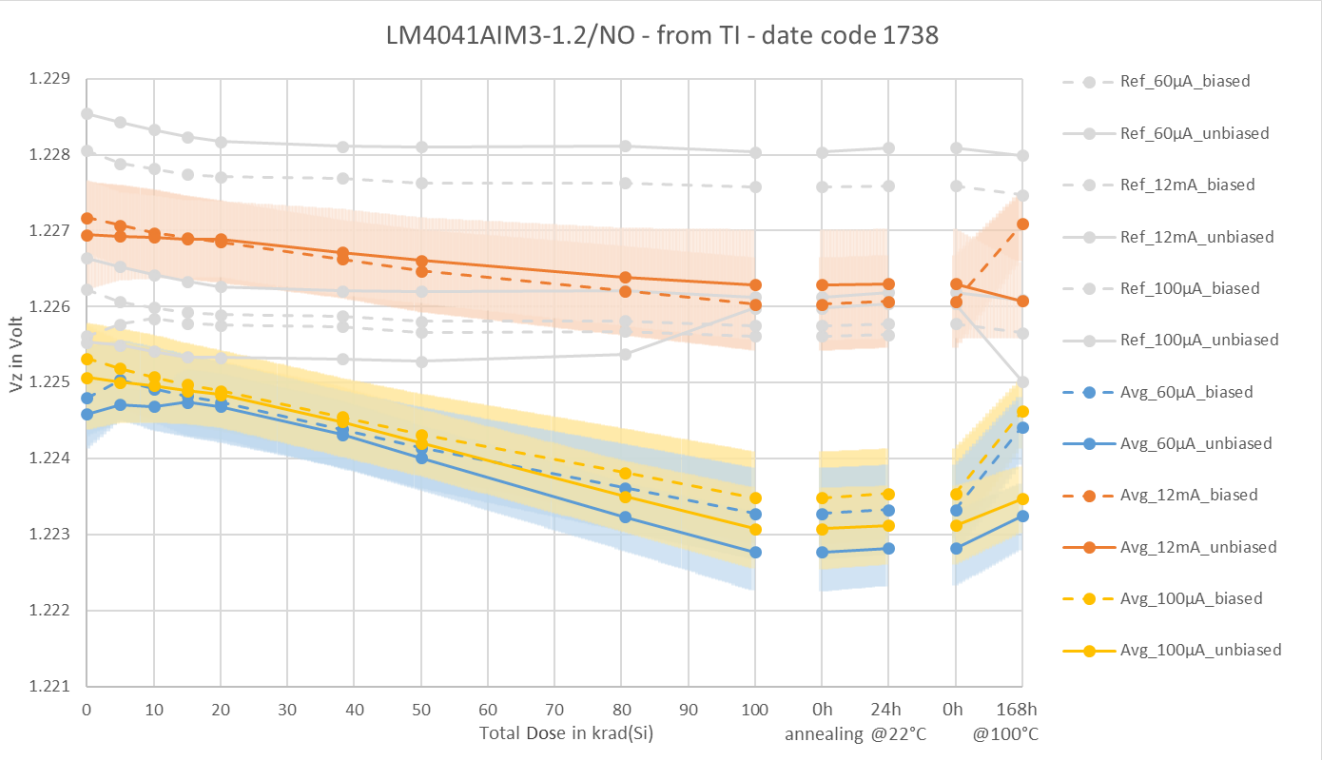
8. TID RESULTS

8.1. TID RESULTS - LM4041AIM3-1.2/NO - from TI - date code 1738

LM4041AIM3-1.2/NO - from TI - date code 1738 - @ I-min 60µA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
A60	unbiased	1.2247	1.2246	1.2246	1.2245	1.2245	1.2241	1.2238	1.2233	1.2229	1.2229	1.2227
A61		1.2246	1.2248	1.2248	1.2246	1.2245	1.2240	1.2236	1.2226	1.2220	1.2222	1.2234
A62		1.2243	1.2244	1.2245	1.2244	1.2245	1.2242	1.2240	1.2233	1.2229	1.2230	1.2230
A63		1.2250	1.2250	1.2250	1.2255	1.2255	1.2251	1.2247	1.2239	1.2235	1.2235	1.2238
A64		1.2244	1.2247	1.2247	1.2246	1.2245	1.2242	1.2239	1.2231	1.2226	1.2226	1.2233
A65	biased	1.2249	1.2247	1.2245	1.2244	1.2242	1.2238	1.2236	1.2230	1.2227	1.2228	1.2244
A66		1.2257	1.2255	1.2254	1.2253	1.2252	1.2249	1.2247	1.2242	1.2239	1.2239	1.2251
A67		1.2239	1.2243	1.2242	1.2242	1.2241	1.2238	1.2236	1.2230	1.2226	1.2226	1.2242
A68		1.2246	1.2252	1.2250	1.2250	1.2249	1.2246	1.2244	1.2239	1.2236	1.2236	1.2245
A69		1.2248	1.2255	1.2254	1.2253	1.2252	1.2248	1.2245	1.2240	1.2237	1.2237	1.2239
REF6	Ref unbiased	1.2255	1.2255	1.2254	1.2253	1.2253	1.2253	1.2253	1.2254	1.2260	1.2260	1.2250
REF56	Ref biased	1.2256	1.2258	1.2258	1.2258	1.2258	1.2257	1.2257	1.2257	1.2256	1.2256	1.2255

LM4041AIM3-1.2/NO - from TI - date code 1738 - @ I-typ 100µA											Limit acc. DS: Vz = 1.225V ± 0.75% (1.2158V – 1.2342V)	
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
A60	unbiased	1.2248	1.2248	1.2247	1.2247	1.2246	1.2242	1.2240	1.2235	1.2231	1.2231	1.2229
A61		1.2252	1.2250	1.2249	1.2248	1.2246	1.2241	1.2238	1.2229	1.2223	1.2224	1.2236
A62		1.2244	1.2245	1.2246	1.2246	1.2247	1.2244	1.2242	1.2236	1.2232	1.2233	1.2232
A63		1.2262	1.2259	1.2258	1.2257	1.2256	1.2253	1.2249	1.2242	1.2238	1.2239	1.2241
A64		1.2247	1.2248	1.2248	1.2248	1.2247	1.2244	1.2241	1.2233	1.2229	1.2229	1.2236
A65	biased	1.2251	1.2248	1.2247	1.2245	1.2244	1.2240	1.2238	1.2233	1.2229	1.2230	1.2246
A66		1.2259	1.2257	1.2256	1.2255	1.2254	1.2250	1.2248	1.2244	1.2241	1.2241	1.2253
A67		1.2247	1.2245	1.2244	1.2243	1.2243	1.2240	1.2237	1.2231	1.2228	1.2228	1.2244
A68		1.2254	1.2253	1.2252	1.2251	1.2250	1.2248	1.2245	1.2241	1.2238	1.2238	1.2247
A69		1.2255	1.2257	1.2256	1.2255	1.2254	1.2250	1.2247	1.2242	1.2239	1.2239	1.2241
REF6	Ref unbiased	1.2266	1.2265	1.2264	1.2263	1.2263	1.2262	1.2262	1.2262	1.2261	1.2262	1.2261
REF56	Ref biased	1.2262	1.2261	1.2260	1.2259	1.2259	1.2259	1.2258	1.2258	1.2257	1.2258	1.2257

LM4041AIM3-1.2/NO - from TI - date code 1738 - @ I-max 12mA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
A60	unbiased	1.2266	1.2266	1.2266	1.2266	1.2266	1.2264	1.2264	1.2263	1.2262	1.2262	1.2255
A61		1.2270	1.2268	1.2268	1.2267	1.2266	1.2262	1.2260	1.2256	1.2254	1.2254	1.2261
A62		1.2263	1.2265	1.2266	1.2266	1.2268	1.2267	1.2267	1.2266	1.2265	1.2265	1.2259
A63		1.2282	1.2279	1.2279	1.2278	1.2278	1.2277	1.2275	1.2274	1.2273	1.2274	1.2268
A64		1.2265	1.2267	1.2267	1.2267	1.2267	1.2265	1.2264	1.2261	1.2260	1.2260	1.2261
A65	biased	1.2270	1.2268	1.2266	1.2265	1.2264	1.2262	1.2260	1.2258	1.2256	1.2257	1.2272
A66		1.2277	1.2275	1.2275	1.2274	1.2273	1.2271	1.2270	1.2268	1.2266	1.2266	1.2278
A67		1.2265	1.2263	1.2262	1.2262	1.2262	1.2260	1.2258	1.2254	1.2252	1.2252	1.2267
A68		1.2272	1.2271	1.2270	1.2270	1.2269	1.2268	1.2266	1.2264	1.2262	1.2262	1.2270
A69		1.2274	1.2276	1.2276	1.2275	1.2274	1.2271	1.2270	1.2267	1.2266	1.2266	1.2267
REF6	Ref unbiased	1.2285	1.2284	1.2283	1.2282	1.2282	1.2281	1.2281	1.2281	1.2280	1.2281	1.2280
REF56	Ref biased	1.2281	1.2279	1.2278	1.2277	1.2277	1.2277	1.2276	1.2276	1.2276	1.2276	1.2275



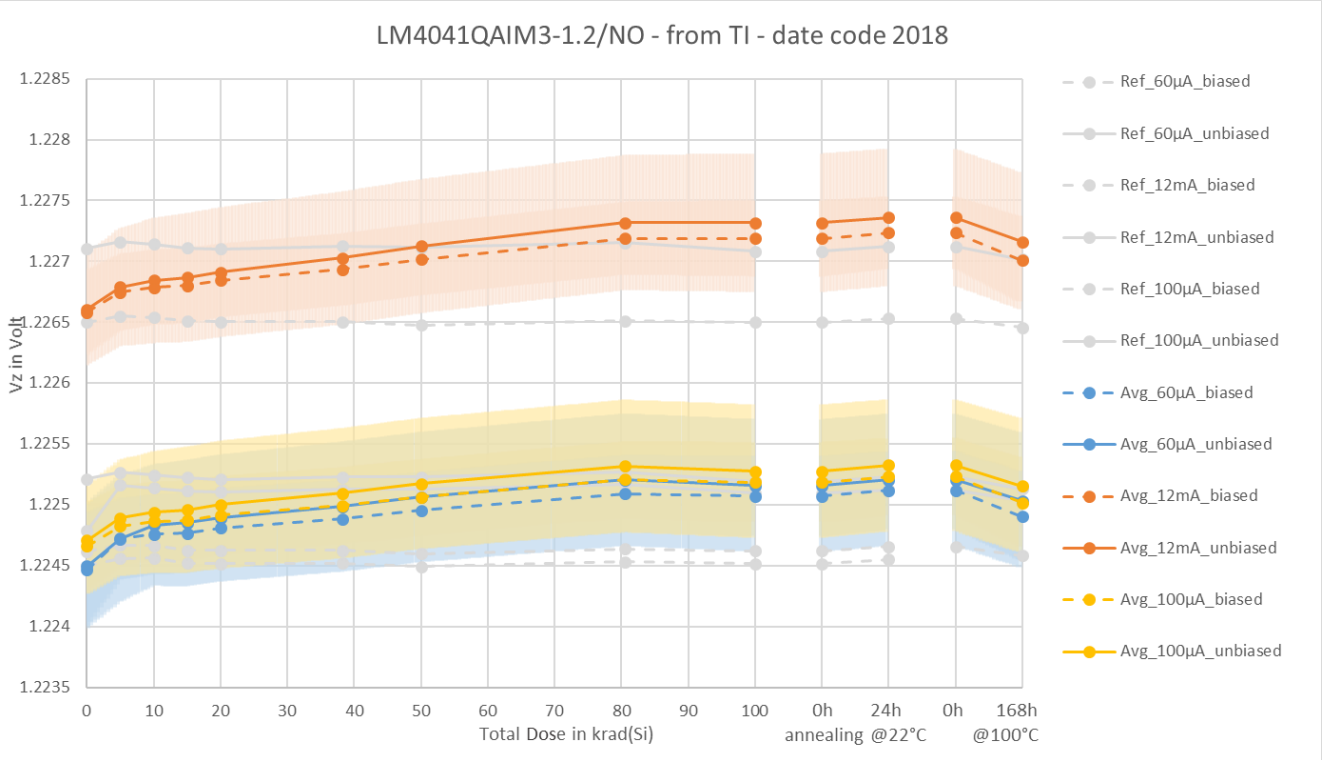
For all curves, which show an average over all measured samples, the coloured interval behind the curves represent +/- one standard deviation.

8.2. TID RESULTS - LM4041QAIM3-1.2/NO - from TI - date code 2018

LM4041QAIM3-1.2/NO - from TI - date code 2018 - @ I-min 60µA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
A70	unbiased	1.2246	1.2249	1.2250	1.2251	1.2251	1.2253	1.2254	1.2256	1.2256	1.2257	1.2249
A71		1.2242	1.2244	1.2244	1.2244	1.2245	1.2246	1.2246	1.2248	1.2248	1.2248	1.2250
A72		1.2253	1.2255	1.2256	1.2257	1.2257	1.2258	1.2259	1.2260	1.2259	1.2259	1.2260
A73		1.2240	1.2243	1.2247	1.2246	1.2247	1.2248	1.2248	1.2249	1.2248	1.2248	1.2248
A74		1.2244	1.2244	1.2244	1.2245	1.2245	1.2246	1.2247	1.2248	1.2248	1.2248	1.2244
A75	biased	1.2239	1.2244	1.2244	1.2245	1.2245	1.2246	1.2246	1.2248	1.2248	1.2249	1.2248
A76		1.2250	1.2251	1.2252	1.2252	1.2252	1.2253	1.2253	1.2255	1.2255	1.2255	1.2248
A77		1.2248	1.2250	1.2250	1.2250	1.2251	1.2252	1.2252	1.2254	1.2254	1.2254	1.2255
A78		1.2242	1.2244	1.2245	1.2245	1.2245	1.2246	1.2247	1.2248	1.2247	1.2248	1.2246
A79		1.2244	1.2246	1.2247	1.2247	1.2248	1.2249	1.2249	1.2250	1.2249	1.2250	1.2248
REF7	Ref unbiased	1.2248	1.2252	1.2251	1.2251	1.2251	1.2251	1.2251	1.2252	1.2251	1.2251	1.2250
REF57	Ref biased	1.2245	1.2246	1.2246	1.2245	1.2245	1.2245	1.2245	1.2245	1.2245	1.2246	1.2245

LM4041QAIM3-1.2/NO - from TI - date code 2018 - @ I-typ 100µA											Limit acc. DS: Vz = 1.225V ± 0.75% (1.2158V – 1.2342V)	
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
A70	unbiased	1.2247	1.2250	1.2252	1.2252	1.2253	1.2254	1.2255	1.2257	1.2257	1.2258	1.2251
A71		1.2243	1.2245	1.2245	1.2245	1.2246	1.2247	1.2247	1.2249	1.2249	1.2249	1.2251
A72		1.2254	1.2257	1.2257	1.2258	1.2258	1.2259	1.2260	1.2261	1.2260	1.2260	1.2261
A73		1.2247	1.2248	1.2248	1.2248	1.2248	1.2249	1.2249	1.2250	1.2249	1.2250	1.2250
A74		1.2245	1.2245	1.2246	1.2246	1.2246	1.2247	1.2248	1.2249	1.2249	1.2249	1.2246
A75	biased	1.2244	1.2245	1.2246	1.2246	1.2246	1.2247	1.2247	1.2249	1.2250	1.2250	1.2249
A76		1.2251	1.2252	1.2253	1.2253	1.2253	1.2254	1.2254	1.2256	1.2256	1.2256	1.2249
A77		1.2249	1.2251	1.2251	1.2251	1.2252	1.2253	1.2253	1.2255	1.2255	1.2255	1.2257
A78		1.2243	1.2245	1.2246	1.2246	1.2246	1.2247	1.2248	1.2249	1.2249	1.2249	1.2247
A79		1.2245	1.2248	1.2248	1.2248	1.2249	1.2250	1.2250	1.2252	1.2251	1.2251	1.2249
REF7	Ref unbiased	1.2252	1.2253	1.2252	1.2252	1.2252	1.2252	1.2252	1.2253	1.2252	1.2252	1.2251
REF57	Ref biased	1.2246	1.2247	1.2247	1.2246	1.2246	1.2246	1.2246	1.2246	1.2246	1.2247	1.2246

LM4041QAIM3-1.2/NO - from TI - date code 2018 - @ I-max 12mA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
A70	unbiased	1.2266	1.2269	1.2270	1.2271	1.2272	1.2273	1.2274	1.2277	1.2278	1.2278	1.2271
A71		1.2261	1.2263	1.2264	1.2264	1.2264	1.2266	1.2267	1.2269	1.2269	1.2269	1.2271
A72		1.2273	1.2276	1.2276	1.2277	1.2277	1.2279	1.2279	1.2281	1.2281	1.2281	1.2281
A73		1.2266	1.2267	1.2267	1.2267	1.2267	1.2268	1.2269	1.2270	1.2270	1.2270	1.2270
A74		1.2264	1.2265	1.2265	1.2265	1.2265	1.2266	1.2267	1.2269	1.2269	1.2269	1.2266
A75	biased	1.2264	1.2265	1.2265	1.2265	1.2266	1.2267	1.2267	1.2269	1.2270	1.2270	1.2269
A76		1.2271	1.2272	1.2272	1.2272	1.2272	1.2273	1.2274	1.2275	1.2276	1.2276	1.2269
A77		1.2268	1.2270	1.2270	1.2271	1.2271	1.2272	1.2273	1.2275	1.2275	1.2275	1.2276
A78		1.2262	1.2264	1.2265	1.2265	1.2265	1.2266	1.2267	1.2269	1.2269	1.2269	1.2267
A79		1.2264	1.2266	1.2267	1.2267	1.2268	1.2269	1.2270	1.2271	1.2270	1.2271	1.2269
REF7	Ref unbiased	1.2271	1.2272	1.2271	1.2271	1.2271	1.2271	1.2271	1.2272	1.2271	1.2271	1.2270
REF57	Ref biased	1.2265	1.2266	1.2265	1.2265	1.2265	1.2265	1.2265	1.2265	1.2265	1.2265	1.2265

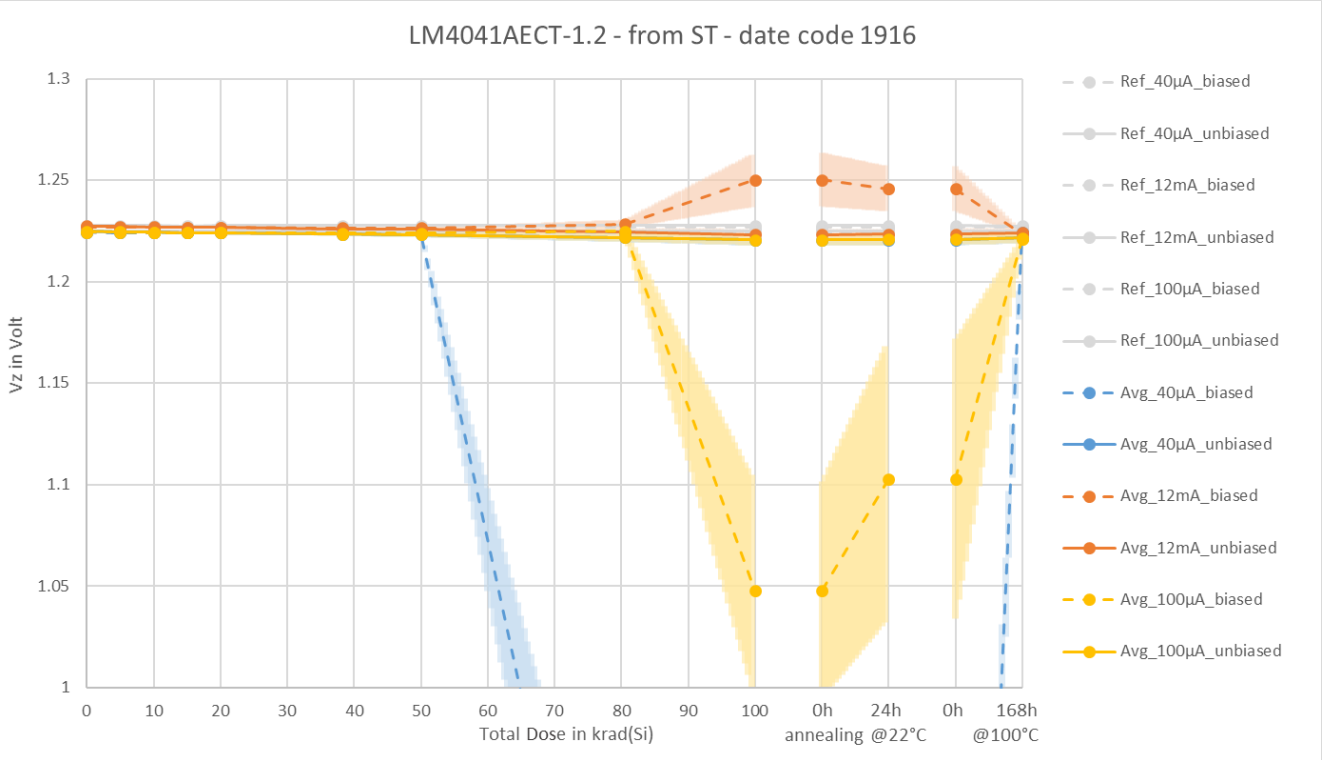


8.3. TID RESULTS - LM4041AECT-1.2 - from ST - date code 1916

LM4041AECT-1.2 - from ST - date code 1916 - @ I-min 40µA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
A90	unbiased	1.2240	1.2239	1.2238	1.2237	1.2237	1.2235	1.2234	1.2229	1.2223	1.2224	1.2230
A91		1.2249	1.2248	1.2247	1.2247	1.2246	1.2244	1.2243	1.2234	1.2225	1.2226	1.2237
A92		1.2262	1.2256	1.2251	1.2243	1.2239	1.2222	1.2213	1.2181	1.2160	1.2161	1.2173
A93		1.2242	1.2241	1.2239	1.2238	1.2238	1.2233	1.2230	1.2218	1.2202	1.2204	1.2208
A94		1.2247	1.2246	1.2245	1.2244	1.2244	1.2241	1.2239	1.2229	1.2217	1.2219	1.2233
A95	biased	1.2238	1.2237	1.2236	1.2236	1.2235	1.2234	1.2233	0.7614	0.4186	0.4642	1.2206
A96		1.2244	1.2243	1.2242	1.2241	1.2241	1.2239	1.2238	0.7145	0.4245	0.4748	1.2272
A97		1.2248	1.2247	1.2246	1.2246	1.2245	1.2244	1.2243	0.6714	0.3944	0.4420	1.2302
A98		1.2243	1.2243	1.2242	1.2242	1.2241	1.2240	1.2239	0.8670	0.5543	0.5991	1.2221
A99		1.2242	1.2242	1.2241	1.2240	1.2240	1.2238	1.2237	0.8054	0.4991	0.5446	1.2217
REF9	Ref unbiased	1.2250	1.2250	1.2250	1.2249	1.2249	1.2249	1.2249	1.2250	1.2250	1.2250	1.2249
REF59	Ref biased	1.2242	1.2241	1.2241	1.2241	1.2242	1.2241	1.2242	1.2242	1.2242	1.2242	1.2242

LM4041AECT-1.2 - from ST - date code 1916 - @ I-typ 100µA											Limit acc. DS: Vz = 1.225V ± 0.75% (1.2158V – 1.2342V)	
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
A90	unbiased	1.2240	1.2239	1.2239	1.2238	1.2238	1.2236	1.2235	1.2230	1.2224	1.2225	1.2231
A91		1.2249	1.2249	1.2248	1.2247	1.2247	1.2244	1.2243	1.2235	1.2226	1.2227	1.2237
A92		1.2262	1.2256	1.2251	1.2244	1.2239	1.2222	1.2213	1.2181	1.2161	1.2162	1.2173
A93		1.2242	1.2241	1.2240	1.2238	1.2238	1.2233	1.2231	1.2219	1.2203	1.2204	1.2209
A94		1.2247	1.2247	1.2246	1.2245	1.2244	1.2241	1.2240	1.2230	1.2218	1.2220	1.2234
A95	biased	1.2238	1.2237	1.2237	1.2236	1.2236	1.2234	1.2233	1.2240	1.0331	1.0846	1.2207
A96		1.2244	1.2244	1.2243	1.2242	1.2242	1.2240	1.2238	1.2252	1.0074	1.0476	1.2200
A97		1.2248	1.2248	1.2247	1.2246	1.2246	1.2244	1.2243	1.2274	1.0068	1.0440	1.2203
A98		1.2244	1.2244	1.2243	1.2242	1.2242	1.2240	1.2239	1.2238	1.1365	1.2098	1.2222
A99		1.2243	1.2242	1.2241	1.2241	1.2240	1.2238	1.2237	1.2241	1.0560	1.1285	1.2218
REF9	Ref unbiased	1.2250	1.2251	1.2250	1.2250	1.2250	1.2250	1.2250	1.2250	1.2250	1.2251	1.2250
REF59	Ref biased	1.2242	1.2242	1.2242	1.2242	1.2242	1.2242	1.2242	1.2242	1.2242	1.2242	1.2242

LM4041AECT-1.2 - from ST - date code 1916 - @ I-max 12mA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
A90	unbiased	1.2266	1.2265	1.2265	1.2264	1.2263	1.2261	1.2260	1.2256	1.2251	1.2251	1.2256
A91		1.2274	1.2274	1.2273	1.2272	1.2271	1.2269	1.2268	1.2260	1.2252	1.2252	1.2262
A92		1.2287	1.2281	1.2276	1.2268	1.2264	1.2247	1.2238	1.2207	1.2187	1.2188	1.2198
A93		1.2269	1.2268	1.2266	1.2265	1.2265	1.2260	1.2257	1.2246	1.2230	1.2232	1.2235
A94		1.2272	1.2272	1.2271	1.2270	1.2269	1.2266	1.2265	1.2255	1.2244	1.2246	1.2259
A95	biased	1.2264	1.2263	1.2262	1.2262	1.2262	1.2260	1.2259	1.2275	1.2506	1.2463	1.2235
A96		1.2270	1.2269	1.2268	1.2267	1.2267	1.2265	1.2264	1.2290	1.2576	1.2512	1.2228
A97		1.2274	1.2274	1.2273	1.2272	1.2272	1.2270	1.2269	1.2318	1.2674	1.2603	1.2232
A98		1.2269	1.2269	1.2268	1.2268	1.2267	1.2266	1.2265	1.2267	1.2327	1.2311	1.2248
A99		1.2268	1.2267	1.2267	1.2266	1.2265	1.2264	1.2263	1.2272	1.2431	1.2397	1.2244
REF9	Ref unbiased	1.2276	1.2276	1.2276	1.2276	1.2276	1.2276	1.2276	1.2276	1.2276	1.2276	1.2275
REF59	Ref biased	1.2267	1.2267	1.2267	1.2267	1.2267	1.2267	1.2267	1.2267	1.2267	1.2267	1.2267

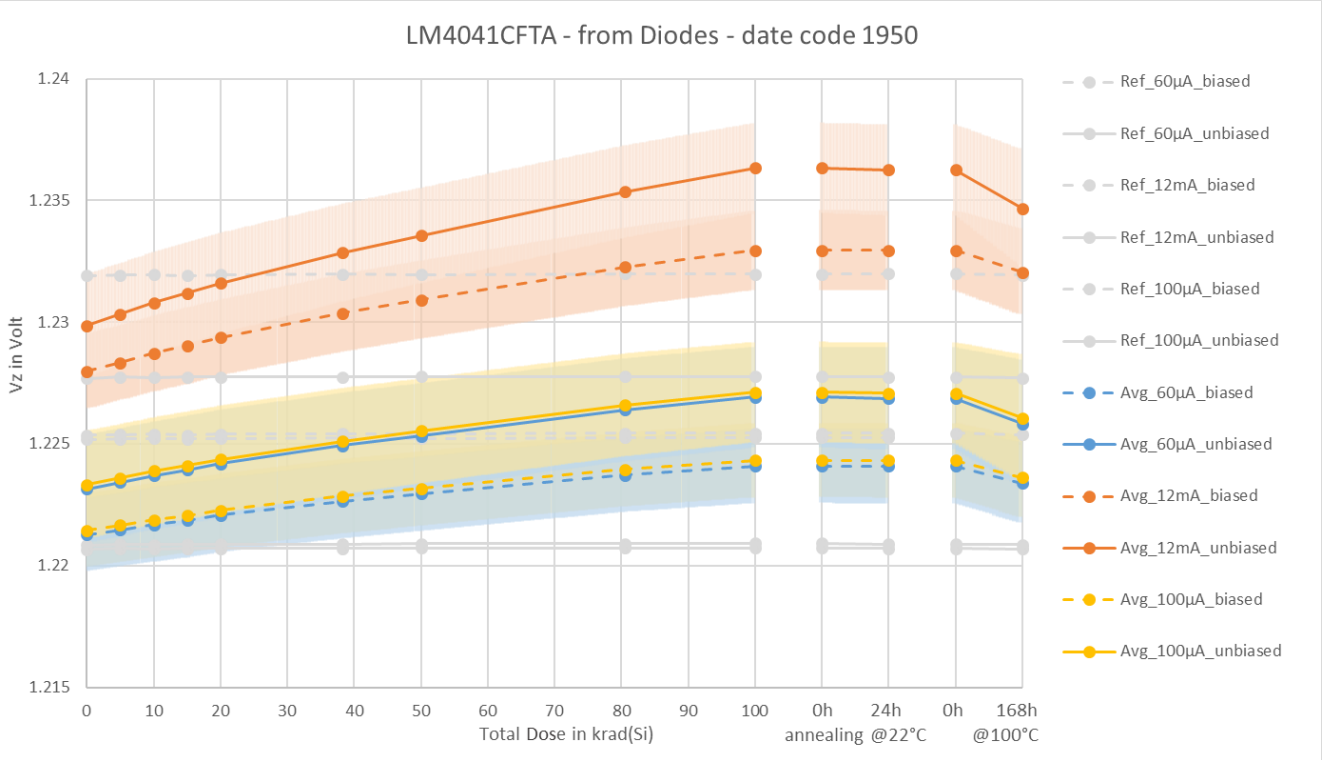


8.4. TID RESULTS - LM4041CFTA - from Diodes - date code 1950

LM4041CFTA - from Diodes - date code 1950 - @ I-min 60µA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
B10	unbiased	1.2201	1.2204	1.2207	1.2210	1.2212	1.2221	1.2225	1.2238	1.2245	1.2243	1.2225
B11		1.2263	1.2266	1.2269	1.2271	1.2274	1.2281	1.2286	1.2297	1.2302	1.2302	1.2297
B12		1.2233	1.2236	1.2238	1.2240	1.2242	1.2248	1.2251	1.2260	1.2264	1.2264	1.2254
B13		1.2224	1.2228	1.2231	1.2233	1.2236	1.2244	1.2249	1.2261	1.2267	1.2267	1.2254
B14		1.2236	1.2238	1.2241	1.2243	1.2246	1.2252	1.2256	1.2265	1.2269	1.2268	1.2262
B15	biased	1.2196	1.2198	1.2200	1.2201	1.2204	1.2209	1.2212	1.2220	1.2223	1.2223	1.2214
B16		1.2221	1.2223	1.2225	1.2227	1.2229	1.2235	1.2238	1.2245	1.2249	1.2249	1.2240
B17		1.2234	1.2236	1.2239	1.2240	1.2242	1.2248	1.2252	1.2259	1.2263	1.2263	1.2258
B18		1.2207	1.2209	1.2211	1.2213	1.2215	1.2221	1.2225	1.2233	1.2237	1.2237	1.2231
B19		1.2206	1.2208	1.2210	1.2211	1.2214	1.2219	1.2222	1.2230	1.2233	1.2233	1.2226
REF11	Ref unbiased	1.2207	1.2207	1.2207	1.2207	1.2207	1.2207	1.2207	1.2207	1.2207	1.2207	1.2207
REF61	Ref biased	1.2252	1.2252	1.2252	1.2252	1.2252	1.2252	1.2252	1.2253	1.2253	1.2253	1.2252

LM4041CFTA - from Diodes - date code 1950 - @ I-typ 100µA											Limit acc. DS: Vz = 1.225V ± 1.15% (1.2109V – 1.2391V)	
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
B10	unbiased	1.2203	1.2206	1.2209	1.2211	1.2214	1.2222	1.2227	1.2240	1.2247	1.2246	1.2227
B11		1.2265	1.2267	1.2271	1.2273	1.2276	1.2283	1.2287	1.2299	1.2304	1.2304	1.2300
B12		1.2235	1.2237	1.2240	1.2242	1.2244	1.2250	1.2253	1.2262	1.2266	1.2266	1.2256
B13		1.2226	1.2229	1.2233	1.2235	1.2238	1.2246	1.2251	1.2263	1.2269	1.2269	1.2256
B14		1.2238	1.2240	1.2243	1.2245	1.2247	1.2254	1.2258	1.2267	1.2271	1.2271	1.2264
B15	biased	1.2198	1.2200	1.2202	1.2203	1.2206	1.2211	1.2214	1.2222	1.2226	1.2225	1.2216
B16		1.2223	1.2225	1.2227	1.2229	1.2231	1.2237	1.2240	1.2247	1.2251	1.2251	1.2242
B17		1.2236	1.2238	1.2241	1.2242	1.2244	1.2250	1.2254	1.2261	1.2265	1.2265	1.2261
B18		1.2209	1.2211	1.2213	1.2215	1.2217	1.2223	1.2227	1.2236	1.2240	1.2240	1.2234
B19		1.2208	1.2210	1.2212	1.2213	1.2216	1.2221	1.2224	1.2232	1.2236	1.2235	1.2229
REF11	Ref unbiased	1.2208	1.2209	1.2209	1.2209	1.2209	1.2209	1.2209	1.2209	1.2209	1.2209	1.2209
REF61	Ref biased	1.2254	1.2254	1.2254	1.2254	1.2254	1.2254	1.2254	1.2254	1.2254	1.2254	1.2254

LM4041CFTA - from Diodes - date code 1950 - @ I-max 12mA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
B10	unbiased	1.2270	1.2275	1.2280	1.2284	1.2288	1.2302	1.2311	1.2332	1.2344	1.2342	1.2316
B11		1.2328	1.2333	1.2338	1.2342	1.2346	1.2358	1.2365	1.2384	1.2393	1.2393	1.2383
B12		1.2300	1.2304	1.2308	1.2311	1.2315	1.2326	1.2332	1.2347	1.2354	1.2354	1.2340
B13		1.2292	1.2297	1.2302	1.2307	1.2311	1.2325	1.2333	1.2353	1.2364	1.2363	1.2345
B14		1.2304	1.2308	1.2312	1.2316	1.2320	1.2331	1.2337	1.2353	1.2361	1.2361	1.2350
B15	biased	1.2262	1.2265	1.2268	1.2272	1.2275	1.2284	1.2290	1.2303	1.2309	1.2309	1.2298
B16		1.2288	1.2292	1.2295	1.2299	1.2302	1.2312	1.2318	1.2331	1.2337	1.2337	1.2326
B17		1.2301	1.2305	1.2309	1.2312	1.2315	1.2326	1.2331	1.2345	1.2352	1.2352	1.2345
B18		1.2276	1.2280	1.2284	1.2288	1.2291	1.2302	1.2308	1.2322	1.2330	1.2330	1.2322
B19		1.2272	1.2275	1.2279	1.2282	1.2285	1.2295	1.2300	1.2313	1.2320	1.2319	1.2311
REF11	Ref unbiased	1.2277	1.2277	1.2277	1.2278	1.2277	1.2278	1.2278	1.2278	1.2278	1.2277	1.2277
REF61	Ref biased	1.2319	1.2319	1.2320	1.2319	1.2320	1.2320	1.2320	1.2320	1.2320	1.2320	1.2319

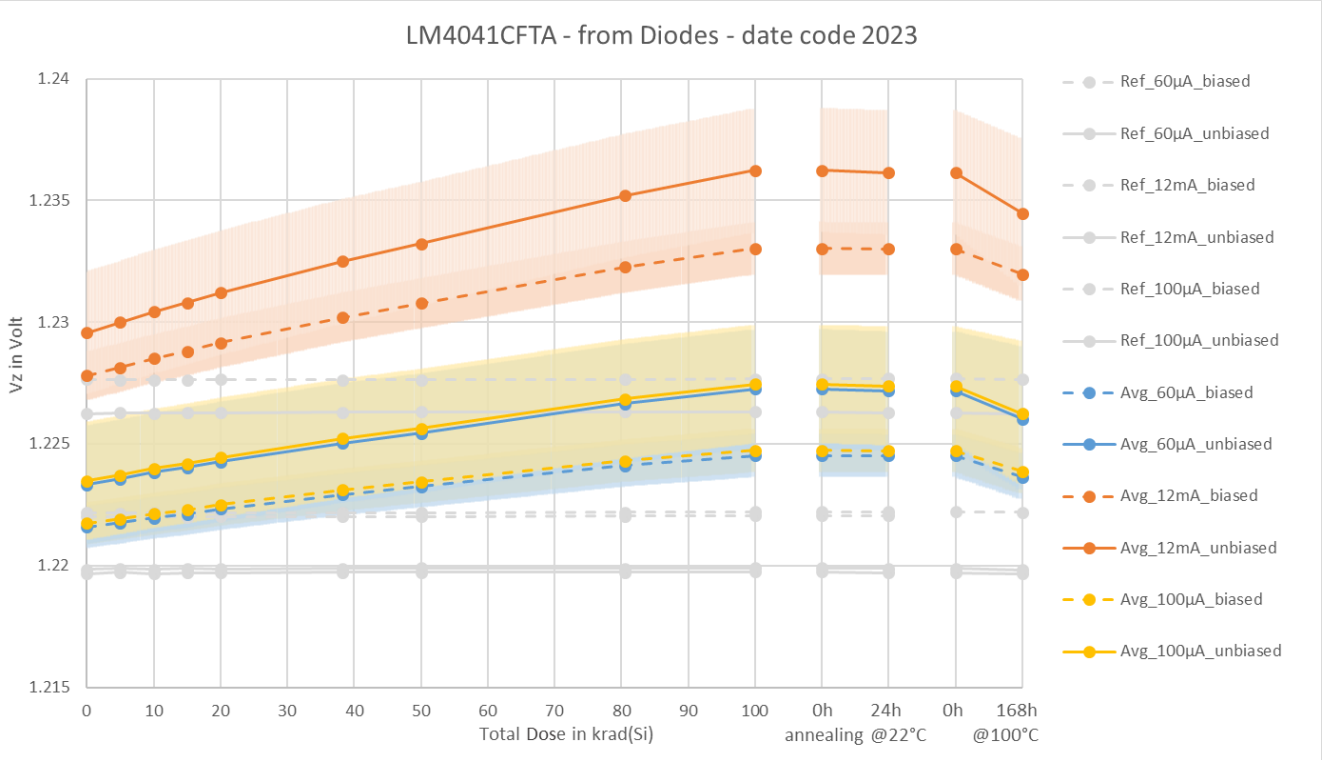


8.5. TID RESULTS - LM4041CFTA - from Diodes - date code 2023

LM4041CFTA - from Diodes - date code 2023 - @ I-min 60µA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
B20	unbiased	1.2275	1.2278	1.2281	1.2283	1.2285	1.2293	1.2296	1.2308	1.2314	1.2313	1.2312
B21		1.2233	1.2235	1.2238	1.2240	1.2242	1.2251	1.2255	1.2269	1.2277	1.2275	1.2259
B22		1.2223	1.2226	1.2228	1.2230	1.2232	1.2239	1.2243	1.2253	1.2259	1.2258	1.2246
B23		1.2215	1.2218	1.2220	1.2222	1.2225	1.2233	1.2237	1.2248	1.2254	1.2253	1.2238
B24		1.2220	1.2222	1.2225	1.2227	1.2229	1.2237	1.2241	1.2254	1.2261	1.2260	1.2247
B25	biased	1.2210	1.2211	1.2213	1.2215	1.2217	1.2222	1.2225	1.2232	1.2236	1.2236	1.2228
B26		1.2210	1.2212	1.2214	1.2215	1.2217	1.2224	1.2227	1.2236	1.2240	1.2240	1.2229
B27		1.2230	1.2232	1.2234	1.2236	1.2238	1.2244	1.2247	1.2255	1.2259	1.2259	1.2251
B28		1.2213	1.2215	1.2218	1.2219	1.2222	1.2228	1.2232	1.2241	1.2245	1.2245	1.2239
B29		1.2216	1.2218	1.2220	1.2221	1.2223	1.2229	1.2232	1.2241	1.2246	1.2246	1.2236
REF12	Ref unbiased	1.2197	1.2197	1.2197	1.2197	1.2197	1.2197	1.2197	1.2197	1.2198	1.2197	1.2197
REF62	Ref biased	1.2220	1.2220	1.2220	1.2220	1.2220	1.2220	1.2220	1.2220	1.2221	1.2221	1.2220

LM4041CFTA - from Diodes - date code 2023 - @ I-typ 100µA											Limit acc. DS: Vz = 1.225V ± 1.15% (1.2109V – 1.2391V)	
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
B20	unbiased	1.2277	1.2279	1.2282	1.2284	1.2287	1.2294	1.2298	1.2310	1.2315	1.2315	1.2314
B21		1.2234	1.2237	1.2239	1.2242	1.2244	1.2252	1.2257	1.2271	1.2279	1.2278	1.2261
B22		1.2225	1.2227	1.2230	1.2231	1.2234	1.2241	1.2245	1.2255	1.2261	1.2260	1.2248
B23		1.2217	1.2219	1.2222	1.2224	1.2226	1.2235	1.2239	1.2250	1.2256	1.2255	1.2241
B24		1.2222	1.2224	1.2227	1.2229	1.2231	1.2239	1.2243	1.2256	1.2262	1.2262	1.2249
B25	biased	1.2211	1.2213	1.2215	1.2216	1.2218	1.2224	1.2227	1.2234	1.2238	1.2238	1.2231
B26		1.2211	1.2213	1.2215	1.2217	1.2219	1.2226	1.2229	1.2238	1.2242	1.2242	1.2231
B27		1.2232	1.2234	1.2236	1.2237	1.2240	1.2245	1.2249	1.2257	1.2261	1.2261	1.2254
B28		1.2215	1.2217	1.2219	1.2221	1.2223	1.2229	1.2233	1.2243	1.2247	1.2247	1.2241
B29		1.2217	1.2219	1.2222	1.2223	1.2225	1.2231	1.2234	1.2244	1.2248	1.2248	1.2238
REF12	Ref unbiased	1.2199	1.2199	1.2199	1.2199	1.2199	1.2199	1.2199	1.2199	1.2199	1.2199	1.2198
REF62	Ref biased	1.2222	1.2222	1.2222	1.2222	1.2222	1.2222	1.2222	1.2222	1.2222	1.2222	1.2222

LM4041CFTA - from Diodes - date code 2023 - @ I-max 12mA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
B20	unbiased	1.2339	1.2344	1.2348	1.2352	1.2356	1.2369	1.2376	1.2395	1.2405	1.2404	1.2397
B21		1.2295	1.2299	1.2303	1.2307	1.2312	1.2325	1.2333	1.2355	1.2368	1.2366	1.2343
B22		1.2285	1.2289	1.2293	1.2297	1.2300	1.2312	1.2319	1.2337	1.2346	1.2345	1.2328
B23		1.2277	1.2282	1.2286	1.2290	1.2293	1.2307	1.2313	1.2332	1.2342	1.2341	1.2321
B24		1.2282	1.2287	1.2291	1.2295	1.2299	1.2312	1.2320	1.2341	1.2352	1.2352	1.2333
B25	biased	1.2271	1.2275	1.2278	1.2281	1.2284	1.2293	1.2299	1.2312	1.2318	1.2318	1.2310
B26		1.2272	1.2276	1.2279	1.2282	1.2286	1.2297	1.2303	1.2318	1.2325	1.2325	1.2312
B27		1.2295	1.2299	1.2302	1.2305	1.2309	1.2319	1.2325	1.2340	1.2348	1.2347	1.2338
B28		1.2274	1.2277	1.2281	1.2284	1.2288	1.2299	1.2305	1.2321	1.2330	1.2329	1.2321
B29		1.2278	1.2281	1.2285	1.2288	1.2291	1.2302	1.2307	1.2323	1.2331	1.2331	1.2318
REF12	Ref unbiased	1.2262	1.2263	1.2263	1.2263	1.2263	1.2263	1.2263	1.2263	1.2263	1.2263	1.2262
REF62	Ref biased	1.2277	1.2276	1.2276	1.2276	1.2276	1.2276	1.2276	1.2277	1.2277	1.2277	1.2277

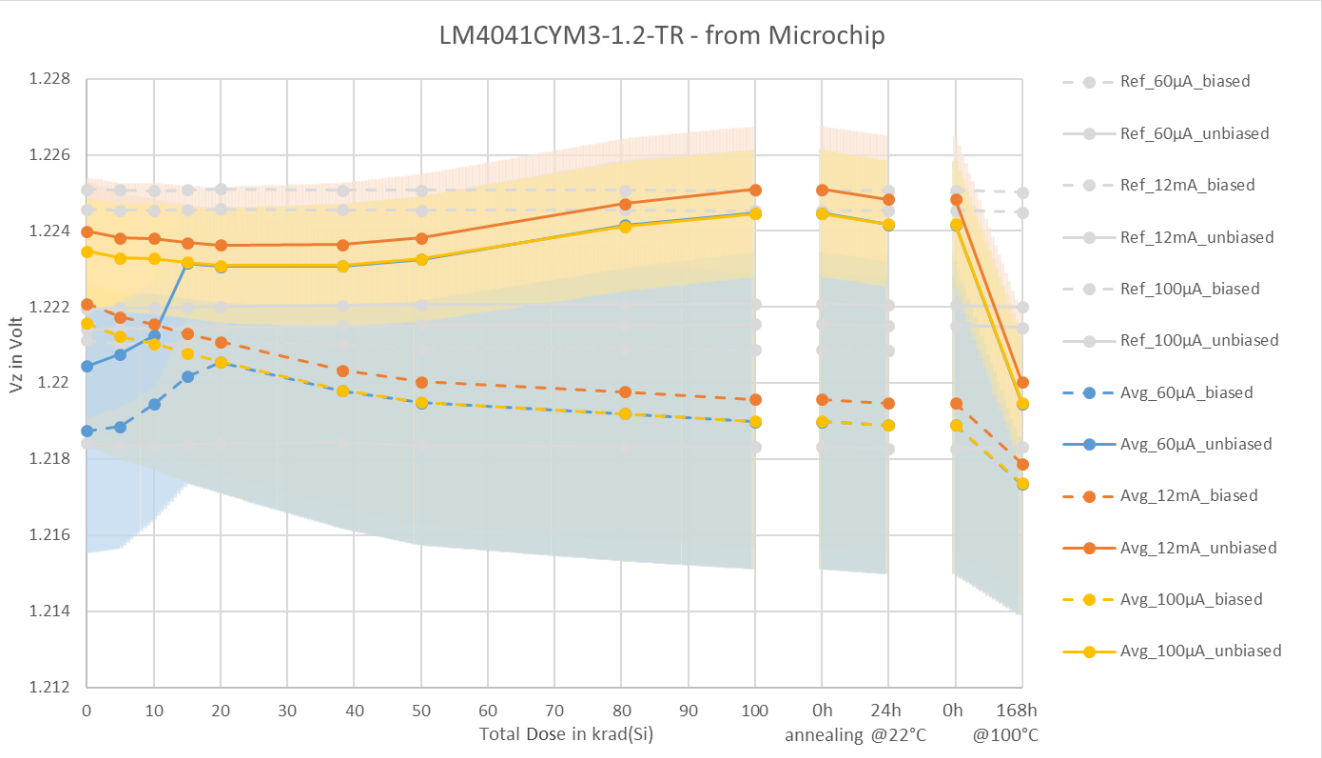


8.6. TID RESULTS - LM4041CYM3-1.2-TR - from Microchip

LM4041CYM3-1.2-TR - from Microchip - @ I-min 60µA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
B30	unbiased	1.2216	1.2218	1.2223	1.2242	1.2242	1.2243	1.2245	1.2254	1.2257	1.2254	1.2206
B31		1.2198	1.2201	1.2205	1.2224	1.2221	1.2219	1.2219	1.2227	1.2230	1.2227	1.2177
B32		1.2185	1.2187	1.2192	1.2211	1.2210	1.2210	1.2212	1.2220	1.2224	1.2221	1.2177
B33		1.2206	1.2210	1.2216	1.2233	1.2233	1.2234	1.2237	1.2248	1.2252	1.2248	1.2202
B34		1.2218	1.2221	1.2226	1.2248	1.2247	1.2248	1.2249	1.2259	1.2261	1.2258	1.2212
B35	biased	1.2198	1.2199	1.2202	1.2220	1.2218	1.2213	1.2211	1.2209	1.2208	1.2206	1.2187
B36		1.2167	1.2168	1.2189	1.2187	1.2185	1.2180	1.2178	1.2176	1.2175	1.2174	1.2154
B37		1.2203	1.2206	1.2210	1.2213	1.2227	1.2222	1.2220	1.2219	1.2216	1.2216	1.2209
B38		1.2144	1.2144	1.2146	1.2160	1.2156	1.2143	1.2137	1.2131	1.2129	1.2127	1.2123
B39		1.2225	1.2225	1.2226	1.2228	1.2241	1.2232	1.2229	1.2225	1.2222	1.2222	1.2195
REF13	Ref unbiased	1.2184	1.2184	1.2183	1.2184	1.2184	1.2184	1.2184	1.2183	1.2183	1.2183	1.2183
REF63	Ref biased	1.2211	1.2210	1.2210	1.2211	1.2211	1.2210	1.2209	1.2209	1.2209	1.2209	1.2209

LM4041CYM3-1.2-TR - from Microchip - @ I-typ 100µA											Limit acc. DS: Vz = 1.225V ± 1.15% (1.2109V – 1.2391V)	
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
B30	unbiased	1.2245	1.2243	1.2243	1.2243	1.2242	1.2243	1.2245	1.2253	1.2257	1.2254	1.2206
B31		1.2230	1.2228	1.2226	1.2224	1.2221	1.2219	1.2219	1.2227	1.2230	1.2227	1.2177
B32		1.2215	1.2212	1.2212	1.2211	1.2210	1.2210	1.2212	1.2220	1.2223	1.2221	1.2177
B33		1.2233	1.2232	1.2233	1.2233	1.2233	1.2234	1.2238	1.2248	1.2252	1.2249	1.2202
B34		1.2251	1.2249	1.2249	1.2248	1.2247	1.2249	1.2249	1.2258	1.2261	1.2258	1.2212
B35	biased	1.2227	1.2223	1.2222	1.2220	1.2218	1.2213	1.2211	1.2209	1.2208	1.2206	1.2187
B36		1.2194	1.2190	1.2189	1.2187	1.2186	1.2180	1.2178	1.2176	1.2175	1.2174	1.2154
B37		1.2232	1.2231	1.2230	1.2228	1.2227	1.2222	1.2220	1.2219	1.2216	1.2216	1.2209
B38		1.2173	1.2169	1.2165	1.2160	1.2156	1.2143	1.2137	1.2131	1.2129	1.2127	1.2123
B39		1.2254	1.2249	1.2246	1.2244	1.2241	1.2232	1.2229	1.2225	1.2222	1.2222	1.2195
REF13	Ref unbiased	1.2214	1.2214	1.2214	1.2214	1.2215	1.2215	1.2215	1.2215	1.2216	1.2215	1.2215
REF63	Ref biased	1.2246	1.2245	1.2245	1.2246	1.2246	1.2246	1.2245	1.2246	1.2245	1.2245	1.2245

LM4041CYM3-1.2-TR - from Microchip - @ I-max 12mA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
B30	unbiased	1.2250	1.2248	1.2248	1.2248	1.2248	1.2249	1.2251	1.2259	1.2263	1.2260	1.2211
B31		1.2235	1.2233	1.2231	1.2229	1.2227	1.2224	1.2224	1.2233	1.2237	1.2234	1.2183
B32		1.2220	1.2218	1.2217	1.2216	1.2215	1.2216	1.2217	1.2226	1.2230	1.2228	1.2182
B33		1.2239	1.2238	1.2239	1.2239	1.2239	1.2240	1.2243	1.2255	1.2259	1.2256	1.2208
B34		1.2256	1.2255	1.2255	1.2253	1.2253	1.2254	1.2255	1.2264	1.2267	1.2264	1.2218
B35	biased	1.2232	1.2228	1.2227	1.2225	1.2224	1.2219	1.2217	1.2215	1.2214	1.2212	1.2193
B36		1.2199	1.2195	1.2194	1.2192	1.2191	1.2185	1.2183	1.2181	1.2180	1.2179	1.2159
B37		1.2237	1.2236	1.2235	1.2234	1.2232	1.2227	1.2225	1.2224	1.2222	1.2221	1.2214
B38		1.2178	1.2174	1.2170	1.2165	1.2161	1.2149	1.2143	1.2137	1.2135	1.2133	1.2128
B39		1.2259	1.2254	1.2252	1.2249	1.2246	1.2237	1.2234	1.2231	1.2228	1.2228	1.2200
REF13	Ref unbiased	1.2220	1.2220	1.2220	1.2220	1.2220	1.2220	1.2221	1.2221	1.2221	1.2221	1.2220
REF63	Ref biased	1.2251	1.2251	1.2251	1.2251	1.2251	1.2251	1.2251	1.2251	1.2251	1.2251	1.2250

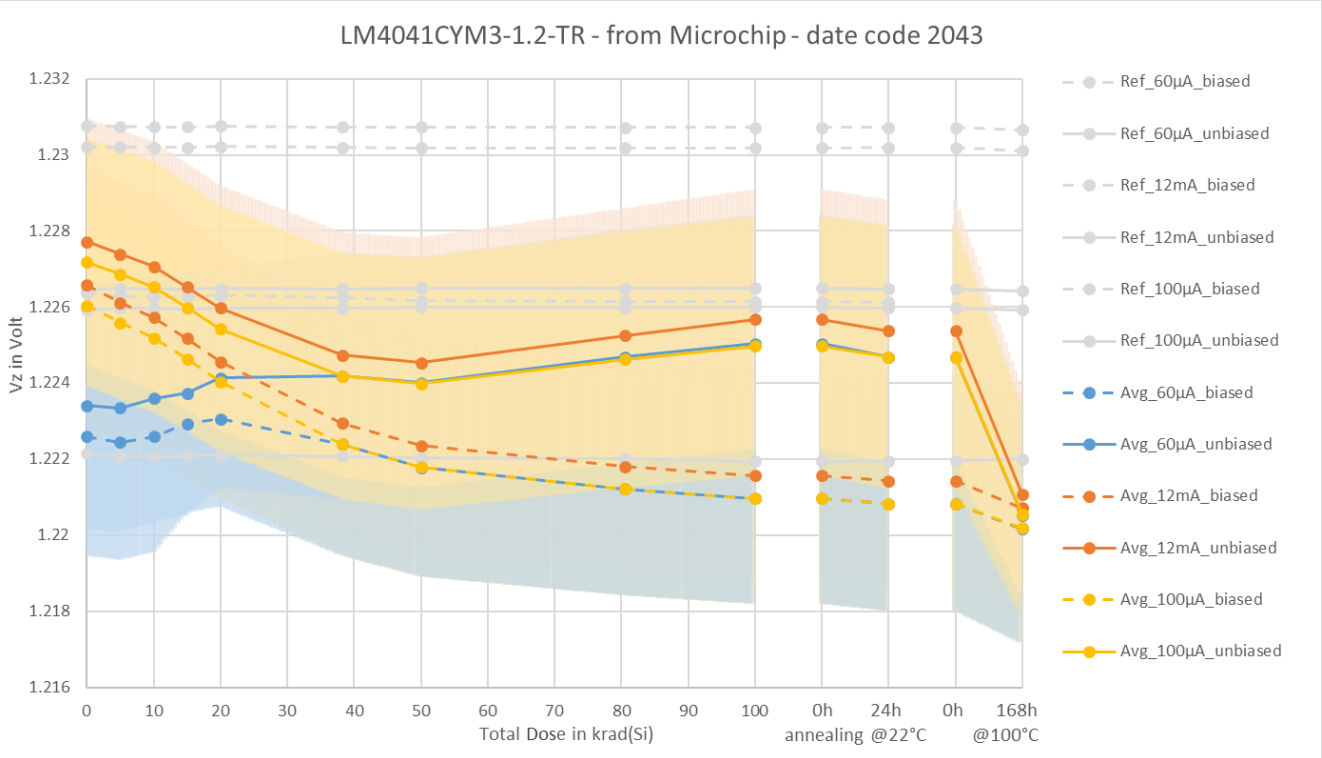


8.7. TID RESULTS - LM4041CYM3-1.2-TR - from Microchip - date code 2043

LM4041CYM3-1.2-TR - from Microchip - date code 2043 - @ I-min 60µA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
B40	unbiased	1.2277	1.2276	1.2279	1.2280	1.2279	1.2284	1.2282	1.2290	1.2294	1.2291	1.2235
B41		1.2252	1.2251	1.2253	1.2253	1.2254	1.2257	1.2256	1.2262	1.2265	1.2262	1.2224
B42		1.2234	1.2233	1.2236	1.2238	1.2240	1.2244	1.2243	1.2248	1.2252	1.2249	1.2210
B43		1.2216	1.2215	1.2218	1.2219	1.2235	1.2226	1.2226	1.2236	1.2239	1.2235	1.2192
B44		1.2192	1.2192	1.2194	1.2196	1.2200	1.2198	1.2194	1.2199	1.2202	1.2198	1.2165
B45	biased	1.2178	1.2177	1.2180	1.2198	1.2193	1.2179	1.2174	1.2170	1.2167	1.2165	1.2153
B46		1.2246	1.2244	1.2244	1.2243	1.2241	1.2238	1.2231	1.2225	1.2222	1.2221	1.2223
B47		1.2256	1.2255	1.2257	1.2256	1.2254	1.2254	1.2248	1.2243	1.2240	1.2239	1.2230
B48		1.2213	1.2211	1.2214	1.2214	1.2228	1.2212	1.2207	1.2201	1.2200	1.2199	1.2195
B49		1.2238	1.2235	1.2235	1.2236	1.2236	1.2237	1.2230	1.2222	1.2219	1.2218	1.2208
REF14	Ref unbiased	1.2222	1.2221	1.2221	1.2221	1.2221	1.2221	1.2220	1.2220	1.2220	1.2220	1.2220
REF64	Ref biased	1.2264	1.2263	1.2263	1.2263	1.2263	1.2263	1.2262	1.2262	1.2261	1.2261	1.2261

LM4041CYM3-1.2-TR - from Microchip - date code 2043 - @ I-typ 100µA											Limit acc. DS: Vz = 1.225V ± 1.15% (1.2109V – 1.2391V)	
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
B40	unbiased	1.2315	1.2312	1.2308	1.2303	1.2296	1.2284	1.2282	1.2289	1.2293	1.2291	1.2235
B41		1.2290	1.2286	1.2283	1.2277	1.2271	1.2258	1.2255	1.2261	1.2264	1.2262	1.2224
B42		1.2272	1.2269	1.2266	1.2262	1.2257	1.2244	1.2243	1.2248	1.2252	1.2249	1.2211
B43		1.2253	1.2249	1.2246	1.2241	1.2235	1.2226	1.2226	1.2235	1.2238	1.2235	1.2192
B44		1.2230	1.2227	1.2223	1.2218	1.2212	1.2198	1.2194	1.2198	1.2201	1.2197	1.2166
B45	biased	1.2212	1.2207	1.2203	1.2198	1.2193	1.2179	1.2174	1.2170	1.2167	1.2165	1.2154
B46		1.2279	1.2275	1.2270	1.2264	1.2257	1.2238	1.2231	1.2225	1.2222	1.2221	1.2223
B47		1.2290	1.2287	1.2284	1.2278	1.2271	1.2254	1.2248	1.2243	1.2240	1.2239	1.2230
B48		1.2248	1.2243	1.2240	1.2235	1.2229	1.2212	1.2207	1.2201	1.2200	1.2199	1.2195
B49		1.2273	1.2267	1.2262	1.2257	1.2252	1.2237	1.2231	1.2222	1.2219	1.2218	1.2208
REF14	Ref unbiased	1.2259	1.2260	1.2260	1.2260	1.2260	1.2260	1.2260	1.2260	1.2260	1.2260	1.2259
REF64	Ref biased	1.2302	1.2302	1.2302	1.2302	1.2302	1.2302	1.2302	1.2302	1.2302	1.2302	1.2301

LM4041CYM3-1.2-TR - from Microchip - date code 2043 - @ I-max 12mA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
B40	unbiased	1.2320	1.2317	1.2314	1.2308	1.2302	1.2289	1.2288	1.2296	1.2301	1.2298	1.2240
B41		1.2295	1.2292	1.2288	1.2282	1.2276	1.2263	1.2261	1.2267	1.2271	1.2268	1.2229
B42		1.2278	1.2274	1.2272	1.2267	1.2263	1.2250	1.2248	1.2254	1.2258	1.2255	1.2216
B43		1.2258	1.2255	1.2252	1.2246	1.2241	1.2232	1.2231	1.2241	1.2246	1.2242	1.2198
B44		1.2236	1.2232	1.2229	1.2224	1.2218	1.2204	1.2199	1.2205	1.2208	1.2205	1.2171
B45	biased	1.2217	1.2213	1.2209	1.2204	1.2199	1.2185	1.2179	1.2176	1.2174	1.2171	1.2159
B46		1.2285	1.2280	1.2276	1.2269	1.2262	1.2243	1.2237	1.2230	1.2228	1.2227	1.2228
B47		1.2295	1.2292	1.2289	1.2283	1.2276	1.2260	1.2253	1.2249	1.2246	1.2245	1.2235
B48		1.2253	1.2249	1.2245	1.2240	1.2234	1.2218	1.2213	1.2207	1.2206	1.2205	1.2200
B49		1.2278	1.2273	1.2267	1.2263	1.2257	1.2242	1.2236	1.2228	1.2225	1.2224	1.2213
REF14	Ref unbiased	1.2264	1.2265	1.2265	1.2265	1.2265	1.2265	1.2265	1.2265	1.2265	1.2265	1.2264
REF64	Ref biased	1.2308	1.2307	1.2307	1.2307	1.2308	1.2307	1.2307	1.2307	1.2307	1.2307	1.2307

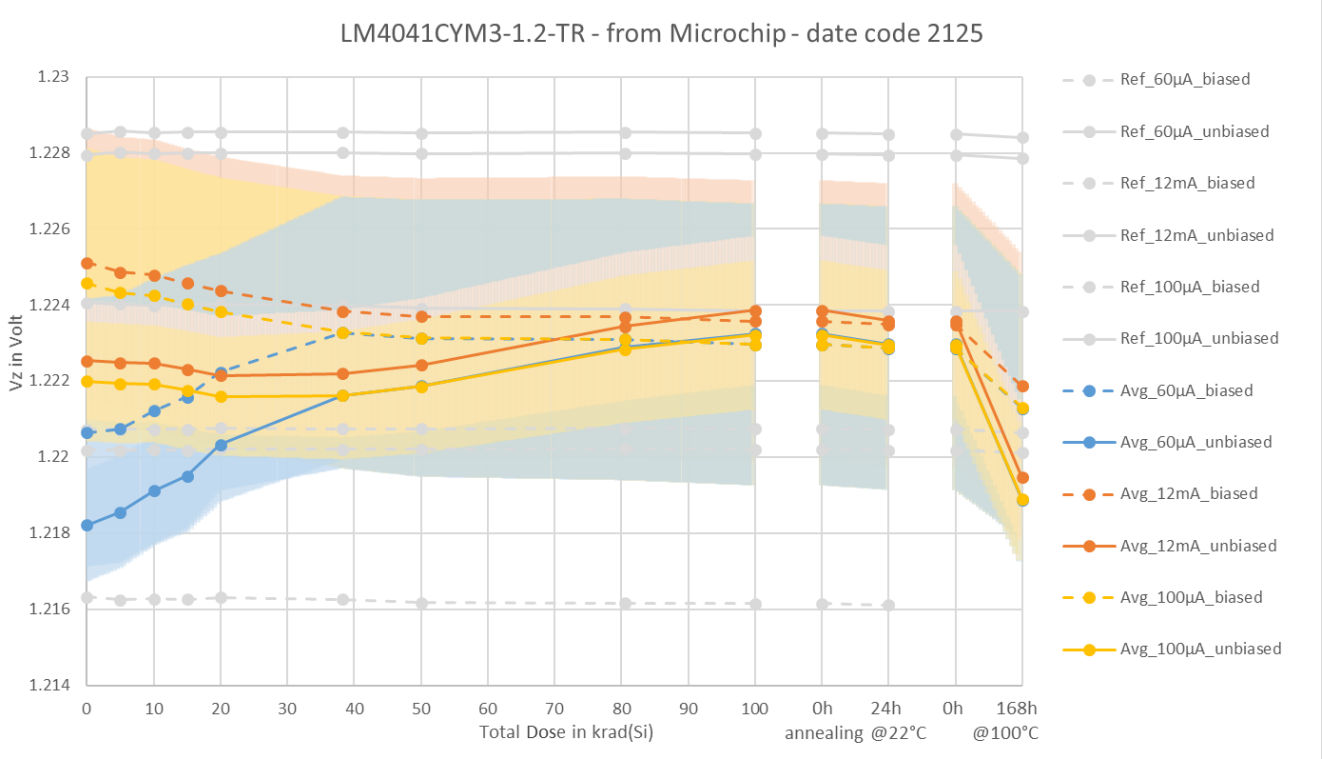


8.8. TID RESULTS - LM4041CYM3-1.2-TR - from Microchip - date code 2125

LM4041CYM3-1.2-TR - from Microchip - date code 2125 - @ I-min 60µA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
B50	unbiased	1.2171	1.2176	1.2182	1.2185	1.2192	1.2203	1.2205	1.2213	1.2215	1.2213	1.2178
B51		1.2177	1.2181	1.2187	1.2190	1.2194	1.2208	1.2212	1.2224	1.2229	1.2226	1.2184
B52		1.2208	1.2211	1.2217	1.2221	1.2227	1.2245	1.2249	1.2261	1.2265	1.2262	1.2215
B53		1.2179	1.2182	1.2187	1.2190	1.2209	1.2208	1.2209	1.2216	1.2219	1.2216	1.2169
B54		1.2175	1.2178	1.2183	1.2189	1.2194	1.2218	1.2220	1.2230	1.2234	1.2231	1.2200
B55	biased	1.2177	1.2178	1.2184	1.2188	1.2211	1.2206	1.2204	1.2203	1.2201	1.2200	1.2183
B56		1.2172	1.2172	1.2177	1.2180	1.2183	1.2195	1.2193	1.2192	1.2192	1.2191	1.2176
B57		1.2251	1.2252	1.2255	1.2258	1.2260	1.2275	1.2275	1.2275	1.2274	1.2273	1.2256
B58		1.2198	1.2199	1.2204	1.2207	1.2210	1.2223	1.2221	1.2220	1.2218	1.2217	1.2211
B59		1.2235	1.2236	1.2242	1.2246	1.2248	1.2265	1.2264	1.2265	1.2264	1.2263	1.2239
REF15	Ref unbiased	1.2241	1.2240	1.2240	1.2240	1.2240	1.2240	1.2239	1.2239	1.2238	1.2238	1.2238
REF65	Ref biased	1.2163	1.2163	1.2163	1.2163	1.2163	1.2163	1.2162	1.2162	1.2162	1.2161	1.2161

LM4041CYM3-1.2-TR - from Microchip - date code 2125 - @ I-typ 100µA											Limit acc. DS: Vz = 1.225V ± 1.15% (1.2109V – 1.2391V)	
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
B50	unbiased	1.2208	1.2208	1.2208	1.2206	1.2204	1.2203	1.2204	1.2212	1.2215	1.2213	1.2178
B51		1.2213	1.2213	1.2212	1.2210	1.2208	1.2208	1.2212	1.2224	1.2229	1.2226	1.2184
B52		1.2247	1.2247	1.2246	1.2245	1.2243	1.2245	1.2249	1.2261	1.2265	1.2262	1.2215
B53		1.2214	1.2213	1.2213	1.2211	1.2209	1.2208	1.2209	1.2216	1.2219	1.2216	1.2169
B54		1.2217	1.2216	1.2217	1.2216	1.2216	1.2218	1.2220	1.2230	1.2234	1.2231	1.2200
B55	biased	1.2216	1.2214	1.2214	1.2213	1.2211	1.2206	1.2204	1.2203	1.2202	1.2200	1.2184
B56		1.2209	1.2206	1.2205	1.2203	1.2201	1.2195	1.2193	1.2192	1.2192	1.2191	1.2176
B57		1.2290	1.2288	1.2286	1.2283	1.2281	1.2275	1.2275	1.2275	1.2274	1.2273	1.2256
B58		1.2239	1.2236	1.2235	1.2232	1.2230	1.2223	1.2221	1.2220	1.2218	1.2217	1.2211
B59		1.2274	1.2272	1.2273	1.2271	1.2269	1.2265	1.2264	1.2265	1.2264	1.2263	1.2239
REF15	Ref unbiased	1.2279	1.2280	1.2280	1.2280	1.2280	1.2280	1.2280	1.2280	1.2280	1.2279	1.2279
REF65	Ref biased	1.2202	1.2202	1.2202	1.2202	1.2202	1.2202	1.2202	1.2202	1.2202	1.2202	1.2201

LM4041CYM3-1.2-TR - from Microchip - date code 2125 - @ I-max 12mA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
B50	unbiased	1.2214	1.2213	1.2213	1.2211	1.2209	1.2209	1.2210	1.2218	1.2221	1.2219	1.2184
B51		1.2219	1.2218	1.2218	1.2216	1.2214	1.2214	1.2217	1.2230	1.2235	1.2232	1.2189
B52		1.2253	1.2252	1.2252	1.2250	1.2248	1.2250	1.2254	1.2267	1.2271	1.2269	1.2220
B53		1.2220	1.2219	1.2219	1.2217	1.2215	1.2214	1.2215	1.2222	1.2225	1.2222	1.2175
B54		1.2223	1.2222	1.2222	1.2222	1.2221	1.2223	1.2226	1.2236	1.2240	1.2237	1.2206
B55	biased	1.2222	1.2220	1.2220	1.2218	1.2217	1.2211	1.2210	1.2209	1.2208	1.2207	1.2189
B56		1.2215	1.2212	1.2211	1.2209	1.2206	1.2201	1.2199	1.2198	1.2198	1.2197	1.2181
B57		1.2295	1.2293	1.2291	1.2289	1.2286	1.2281	1.2281	1.2281	1.2280	1.2279	1.2261
B58		1.2244	1.2241	1.2240	1.2237	1.2235	1.2229	1.2227	1.2226	1.2224	1.2223	1.2217
B59		1.2280	1.2277	1.2278	1.2276	1.2274	1.2270	1.2270	1.2271	1.2270	1.2269	1.2245
REF15	Ref unbiased	1.2285	1.2286	1.2285	1.2285	1.2285	1.2285	1.2285	1.2285	1.2285	1.2285	1.2284
REF65	Ref biased	1.2207	1.2207	1.2207	1.2207	1.2208	1.2207	1.2207	1.2208	1.2207	1.2207	1.2206

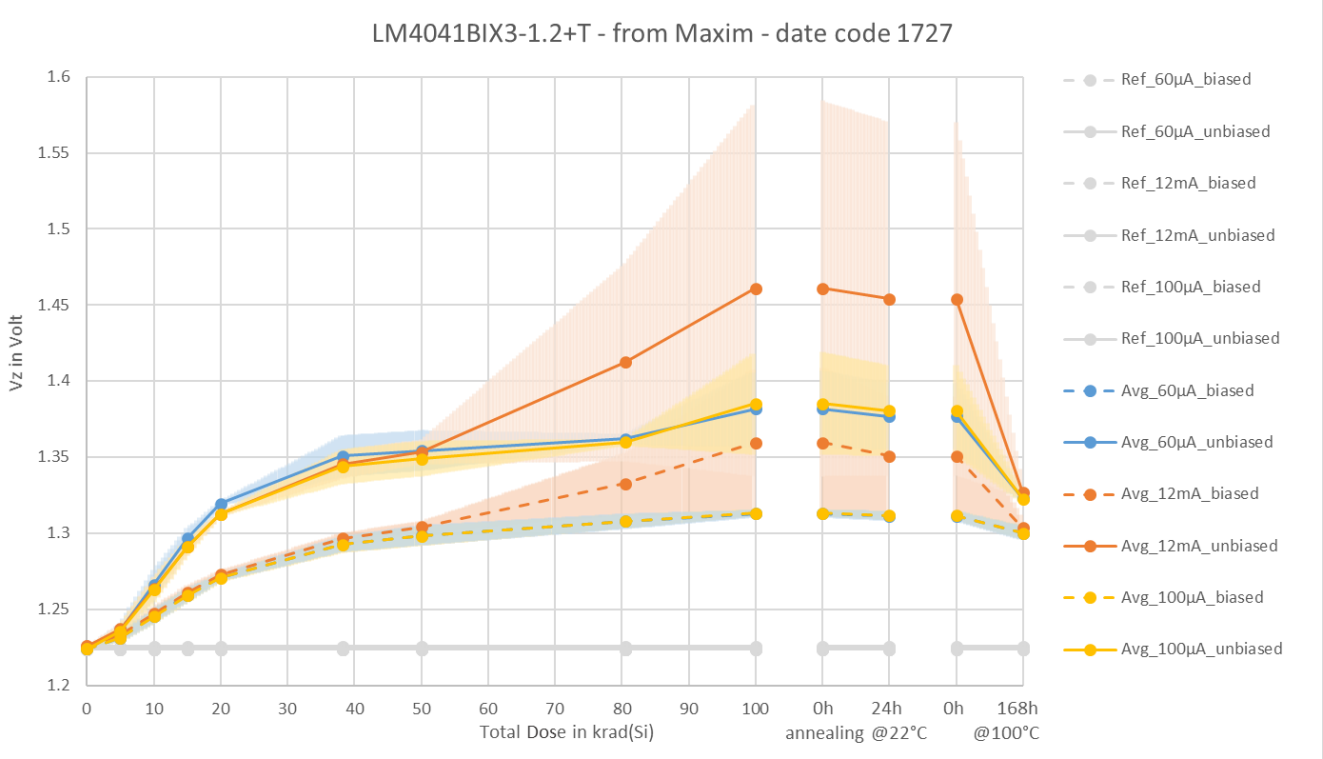


8.9. TID RESULTS - LM4041BIX3-1.2+T - from Maxim - date code 1727

LM4041BIX3-1.2+T - from Maxim - date code 1727 - @ I-min 60µA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
B60	unbiased	1.2240	1.2337	1.2606	1.2933	1.3219	1.3611	1.3631	1.3639	1.3654	1.3631	1.3269
B61		1.2242	1.2338	1.2597	1.2909	1.3193	1.3588	1.3627	1.3619	1.3629	1.3606	1.3245
B62		1.2240	1.2332	1.2583	1.2911	1.3191	1.3621	1.3662	1.3661	1.3657	1.3631	1.3242
B63		1.2246	1.2410	1.2761	1.3029	1.3172	1.3351	1.3394	1.3611	1.4204	1.4109	1.3198
B64		1.2243	1.2409	1.2778	1.3046	1.3205	1.3372	1.3404	1.3569	1.3940	1.3863	1.3194
B65	biased	1.2242	1.2324	1.2487	1.2611	1.2718	1.2874	1.2919	1.3036	1.3126	1.3097	1.2930
B66		1.2242	1.2295	1.2429	1.2579	1.2707	1.2969	1.3023	1.3088	1.3116	1.3109	1.3005
B67		1.2247	1.2357	1.2526	1.2663	1.2748	1.2871	1.2912	1.3019	1.3104	1.3075	1.3001
B68		1.2242	1.2304	1.2434	1.2576	1.2698	1.2976	1.3049	1.3141	1.3169	1.3166	1.3060
B69		1.2239	1.2290	1.2411	1.2544	1.2679	1.2959	1.3034	1.3108	1.3132	1.3125	1.3013
REF16	Ref unbiased	1.2239	1.2239	1.2239	1.2239	1.2239	1.2239	1.2239	1.2239	1.2239	1.2239	1.2239
REF66	Ref biased	1.2239	1.2239	1.2238	1.2238	1.2238	1.2238	1.2238	1.2238	1.2238	1.2238	1.2238

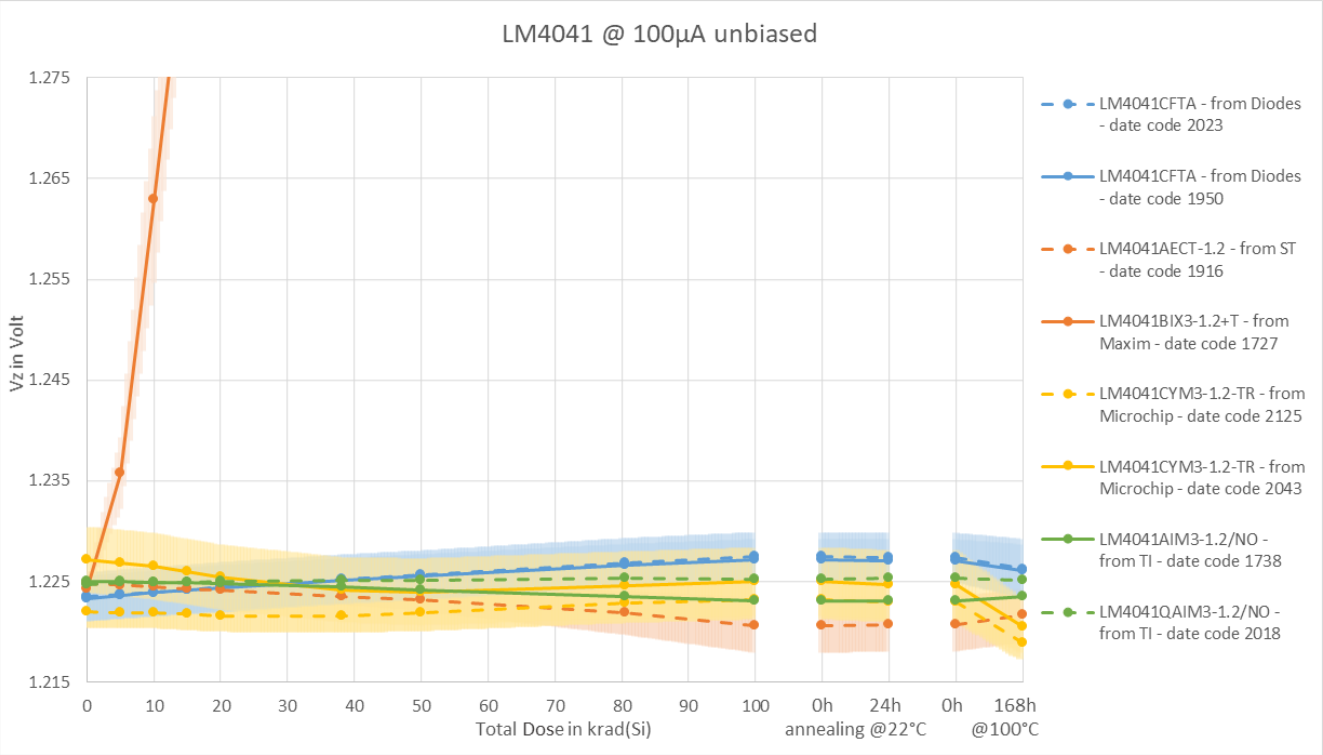
LM4041BIX3-1.2+T - from Maxim - date code 1727 - @ I-typ 100µA											Limit acc. DS: Vz = 1.225V ± 0.85% (1.2146V – 1.2354V)	
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
B60	unbiased	1.2240	1.2332	1.2580	1.2883	1.3145	1.3527	1.3567	1.3601	1.3627	1.3612	1.3268
B61		1.2243	1.2335	1.2569	1.2861	1.3119	1.3500	1.3565	1.3579	1.3603	1.3583	1.3242
B62		1.2240	1.2329	1.2557	1.2862	1.3123	1.3536	1.3593	1.3619	1.3625	1.3607	1.3241
B63		1.2246	1.2396	1.2712	1.2965	1.3107	1.3304	1.3360	1.3620	1.4348	1.4247	1.3196
B64		1.2243	1.2396	1.2725	1.2979	1.3138	1.3323	1.3369	1.3570	1.4066	1.3981	1.3193
B65	biased	1.2242	1.2323	1.2484	1.2608	1.2714	1.2869	1.2916	1.3042	1.3140	1.3108	1.2931
B66		1.2242	1.2295	1.2427	1.2575	1.2703	1.2965	1.3019	1.3084	1.3116	1.3108	1.3005
B67		1.2247	1.2356	1.2524	1.2660	1.2744	1.2867	1.2911	1.3026	1.3118	1.3085	1.3001
B68		1.2242	1.2304	1.2432	1.2574	1.2694	1.2971	1.3042	1.3137	1.3167	1.3164	1.3061
B69		1.2239	1.2290	1.2409	1.2541	1.2677	1.2953	1.3029	1.3104	1.3131	1.3123	1.3014
REF16	Ref unbiased	1.2239	1.2240	1.2239	1.2239	1.2239	1.2239	1.2239	1.2239	1.2240	1.2240	1.2239
REF66	Ref biased	1.2239	1.2239	1.2239	1.2238	1.2238	1.2238	1.2238	1.2238	1.2238	1.2238	1.2238

LM4041BIX3-1.2+T - from Maxim - date code 1727 - @ I-max 12mA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
B60	unbiased	1.2257	1.2347	1.2589	1.2884	1.3141	1.3531	1.3590	1.3664	1.3734	1.3721	1.3308
B61		1.2260	1.2351	1.2579	1.2862	1.3110	1.3503	1.3578	1.3637	1.3700	1.3683	1.3279
B62		1.2257	1.2343	1.2567	1.2865	1.3123	1.3534	1.3610	1.3670	1.3710	1.3695	1.3280
B63		1.2263	1.2408	1.2712	1.2965	1.3111	1.3345	1.3447	1.4988	1.6159	1.5997	1.3236
B64		1.2260	1.2407	1.2727	1.2976	1.3141	1.3359	1.3447	1.4664	1.5741	1.5611	1.3233
B65	biased	1.2259	1.2341	1.2504	1.2630	1.2740	1.2924	1.3002	1.3571	1.4181	1.3986	1.2962
B66		1.2259	1.2312	1.2445	1.2594	1.2724	1.2995	1.3059	1.3159	1.3223	1.3211	1.3039
B67		1.2264	1.2374	1.2542	1.2682	1.2771	1.2924	1.3000	1.3519	1.4083	1.3875	1.3030
B68		1.2259	1.2320	1.2449	1.2592	1.2714	1.3001	1.3080	1.3208	1.3266	1.3259	1.3095
B69		1.2256	1.2307	1.2427	1.2560	1.2696	1.2983	1.3067	1.3173	1.3230	1.3218	1.3049
REF16	Ref unbiased	1.2256	1.2256	1.2256	1.2256	1.2256	1.2256	1.2256	1.2256	1.2256	1.2256	1.2256
REF66	Ref biased	1.2256	1.2256	1.2255	1.2255	1.2255	1.2255	1.2255	1.2255	1.2255	1.2255	1.2255



8.1. Comparison Manufacturer and Date Code

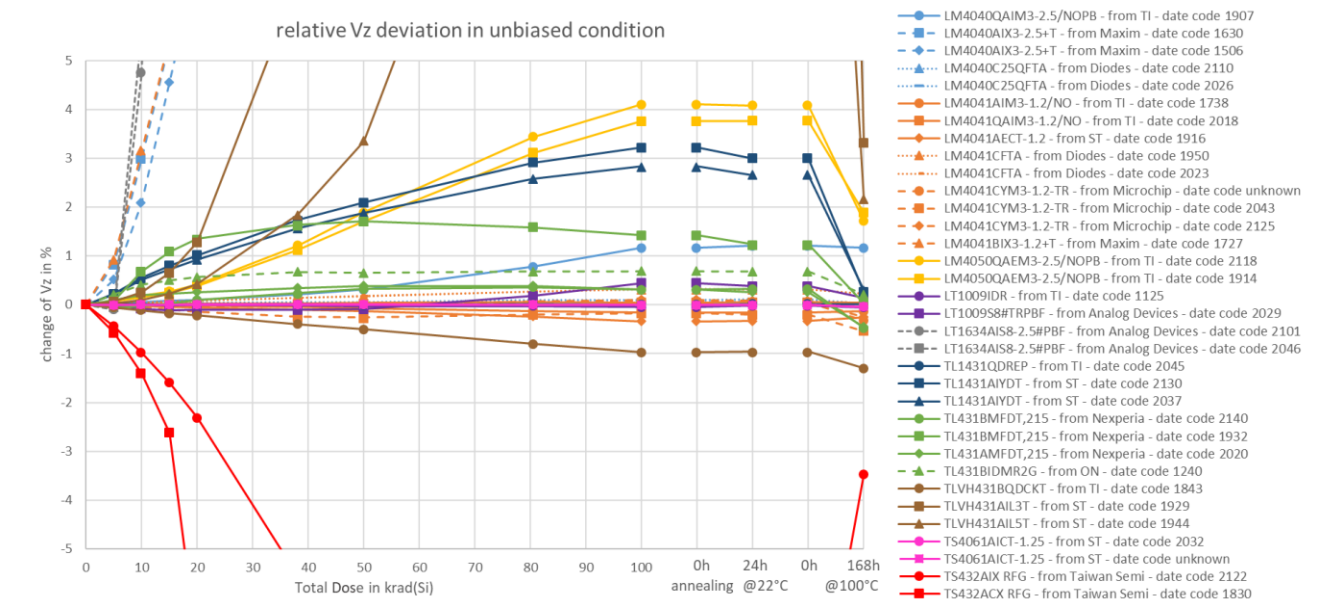
The following graph shows the different behaviour of all measured LM4041 voltage references from different manufacturers and with a different date code.

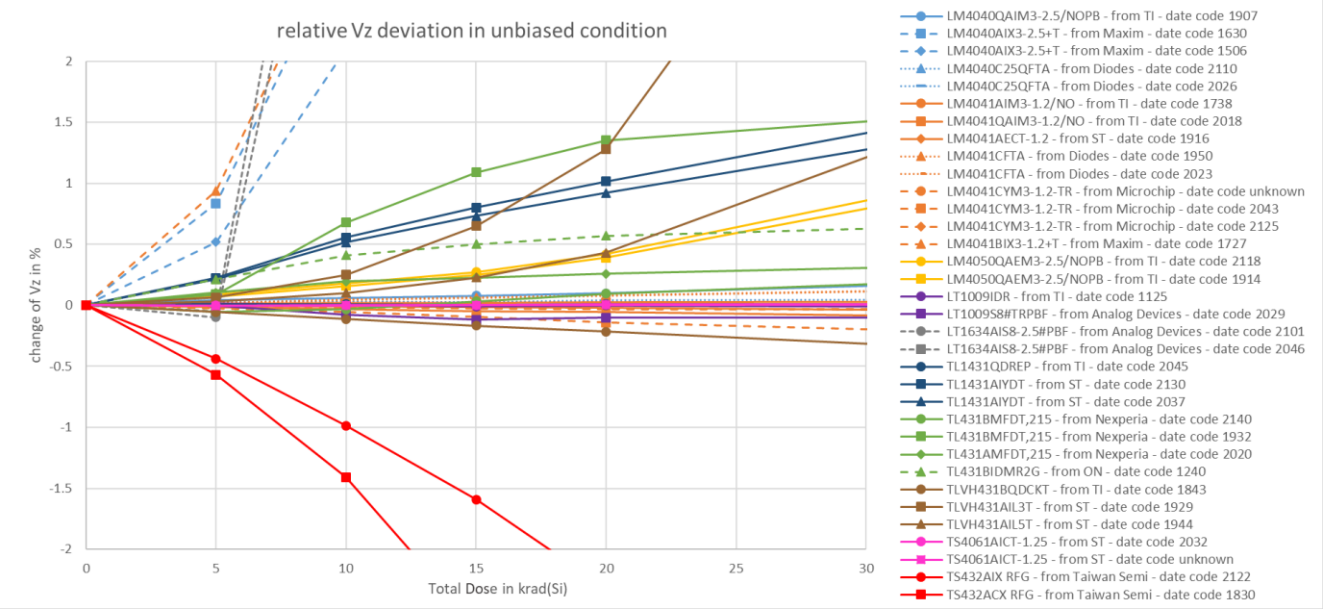


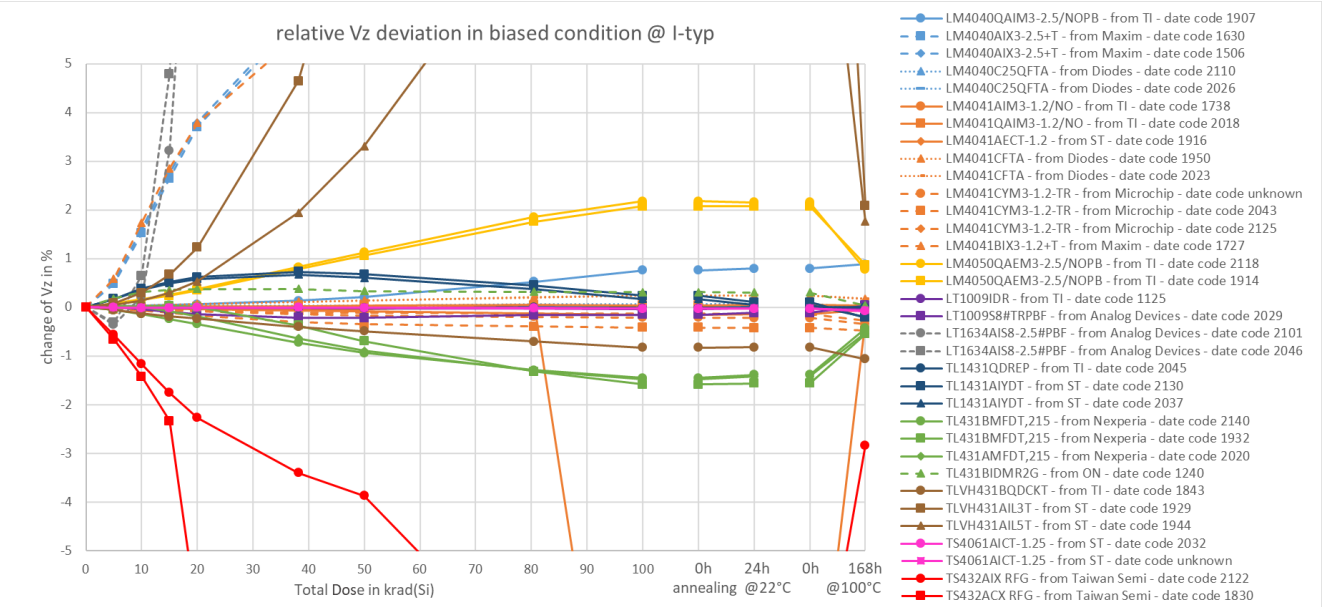
All curves plotted show the average value of all unbiased tested samples (worst case) and the interval behind the curves represent +/- one standard deviation.

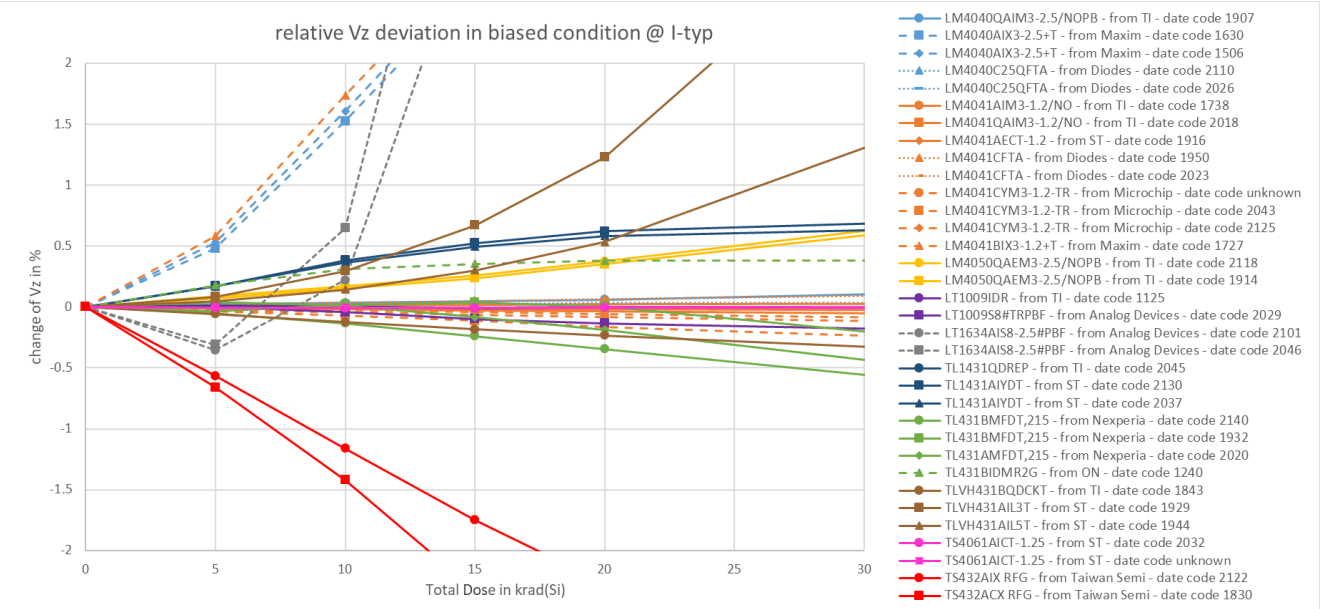
8.2. Comparison with other tested Bandgap References

The following four graphs show the results of the LM4041 Bandgap Voltage References compared to different Bandgap References part types, which were tested at the same time with the same test setup than the LM4041. Additional information on these tests is provided in the Radiation Test Summary [RD02].






relative Vz deviation in biased condition @ I-typ
change of Vz in %
Total Dose in krad(Si)
0h annealing @22°C
24h
0h @100°C
168h
LM4040QAIM3-2.5/NOPB - from TI - date code 1907
LM4040AIX3-2.5+T - from Maxim - date code 1630
LM4040AIX3-2.5+T - from Maxim - date code 1506
LM4040C25QFTA - from Diodes - date code 2110
LM4040C25QFTA - from Diodes - date code 2026
LM4041AIM3-1.2/NO - from TI - date code 1738
LM4041QAIM3-1.2/NO - from TI - date code 2018
LM4041AECT-1.2 - from ST - date code 1916
LM4041CFTA - from Diodes - date code 1950
LM4041CFTA - from Diodes - date code 2023
LM4041CYM3-1.2-TR - from Microchip - date code unknown
LM4041CYM3-1.2-TR - from Microchip - date code 2043
LM4041CYM3-1.2-TR - from Microchip - date code 2125
LM4041BIX3-1.2+T - from Maxim - date code 1727
LM4050QAEM3-2.5/NOPB - from TI - date code 2118
LM4050QAEM3-2.5/NOPB - from TI - date code 1914
LT1009IDR - from TI - date code 1125
LT1009S8#TRPBF - from Analog Devices - date code 2029
LT1634AIS8-2.5#PBF - from Analog Devices - date code 2101
LT1634AIS8-2.5#PBF - from Analog Devices - date code 2046
TL1431QDREP - from TI - date code 2045
TL1431AIYDT - from ST - date code 2130
TL1431AIYDT - from ST - date code 2037
TL431BMFDT,215 - from Nexperia - date code 2140
TL431BMFDT,215 - from Nexperia - date code 1932
TL431AMFDT,215 - from Nexperia - date code 2020
TL431BIDMR2G - from ON - date code 1240
TLVH431BQDCKT - from TI - date code 1843
TLVH431AIL3T - from ST - date code 1929
TLVH431AIL5T - from ST - date code 1944
TS4061AICT-1.25 - from ST - date code 2032
TS4061AICT-1.25 - from ST - date code unknown
TS432AIX RFG - from Taiwan Semi - date code 2122
TS432ACX RFG - from Taiwan Semi - date code 1830


relative Vz deviation in biased condition @ I-typ
change of Vz in %
Total Dose in krad(Si)
LM4040QAIM3-2.5/NOPB - from TI - date code 1907
LM4040AIX3-2.5+T - from Maxim - date code 1630
LM4040AIX3-2.5+T - from Maxim - date code 1506
LM4040C25QFTA - from Diodes - date code 2110
LM4040C25QFTA - from Diodes - date code 2026
LM4041AIM3-1.2/NO - from TI - date code 1738
LM4041QAIM3-1.2/NO - from TI - date code 2018
LM4041AECT-1.2 - from ST - date code 1916
LM4041CFTA - from Diodes - date code 1950
LM4041CFTA - from Diodes - date code 2023
LM4041CYM3-1.2-TR - from Microchip - date code unknown
LM4041CYM3-1.2-TR - from Microchip - date code 2043
LM4041CYM3-1.2-TR - from Microchip - date code 2125
LM4041BIX3-1.2+T - from Maxim - date code 1727
LM4050QAEM3-2.5/NOPB - from TI - date code 2118
LM4050QAEM3-2.5/NOPB - from TI - date code 1914
LT1009IDR - from TI - date code 1125
LT1009S8#TRPBF - from Analog Devices - date code 2029
LT1634AIS8-2.5#PBF - from Analog Devices - date code 2101
LT1634AIS8-2.5#PBF - from Analog Devices - date code 2046
TL1431QDREP - from TI - date code 2045
TL1431AIYDT - from ST - date code 2130
TL1431AIYDT - from ST - date code 2037
TL431BMFDT,215 - from Nexperia - date code 2140
TL431BMFDT,215 - from Nexperia - date code 1932
TL431AMFDT,215 - from Nexperia - date code 2020
TL431BIDMR2G - from ON - date code 1240
TLVH431BQDCKT - from TI - date code 1843
TLVH431AIL3T - from ST - date code 1929
TLVH431AIL5T - from ST - date code 1944
TS4061AICT-1.25 - from ST - date code 2032
TS4061AICT-1.25 - from ST - date code unknown
TS432AIX RFG - from Taiwan Semi - date code 2122
TS432ACX RFG - from Taiwan Semi - date code 1830

9. CONCLUSION

Except the part type of one manufacturer, which went out of specification already below 10krad, all other tested part types stayed inside a 1% deviation up to 100 krad.

It was also noticed that this deviation could lead to a higher but also a lower reference voltage.

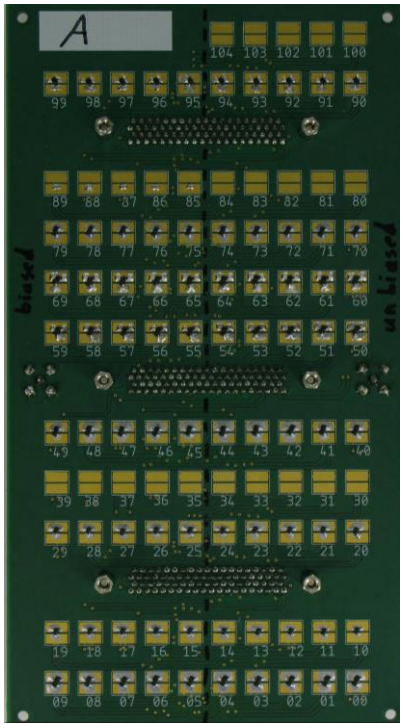
In general, a higher deviation was found for the unbiased samples.

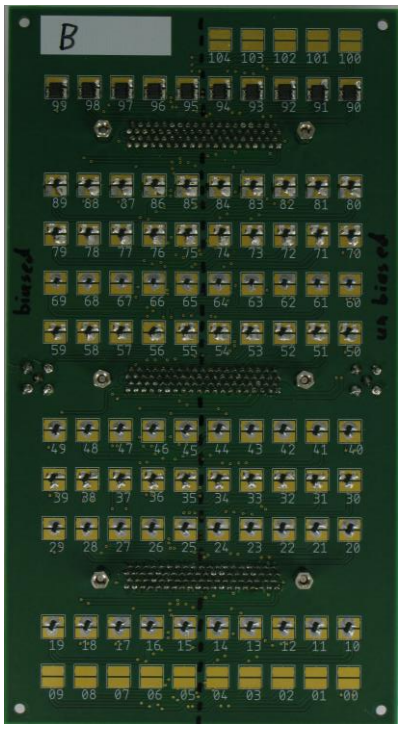
ANNEX A – DATASHEET

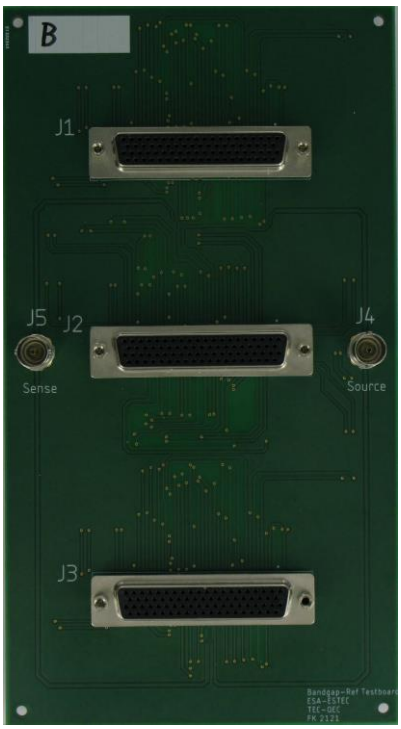
Part Type	Manufacturer	Link to Datasheet
LM4041AIM3-1.2/NO LM4041QAIM3-1.2/NO	Texas Instruments	https://www.ti.com/lit/ds/symlink/lm4041-n.pdf?ts=1659381843976&ref_url=https%253A%252F%252Fwww.ti.com%252Fproduct%252FLM4041-N%252Fpart-details%252FLM4041AIM3-1.2%252FNOPB
LM4041AECT-1.2	STMicroelectronics	https://www.st.com/content/ccc/resource/technical/document/datasheet/f3/bc/c2/cc/f2/dd/48/2b/DM00028684.pdf/files/DM00028684.pdf/jcr:content/translations/en.DM00028684.pdf
LM4041CFTA	Diodes Incorporated	https://www.diodes.com/assets/Datasheets/LM4041.pdf
LM4041CYM3-1.2-TR	Microchip Technology	https://ww1.microchip.com/downloads/en/DeviceDoc/LM4040-41-Precision-Micropower-Shunt-Voltage-Reference-DS20005757B.pdf
LM4041BIX3-1.2+T	Maxim Integrated	https://datasheets.maximintegrated.com/en/ds/LM4041.pdf

ANNEX B – SET-UP

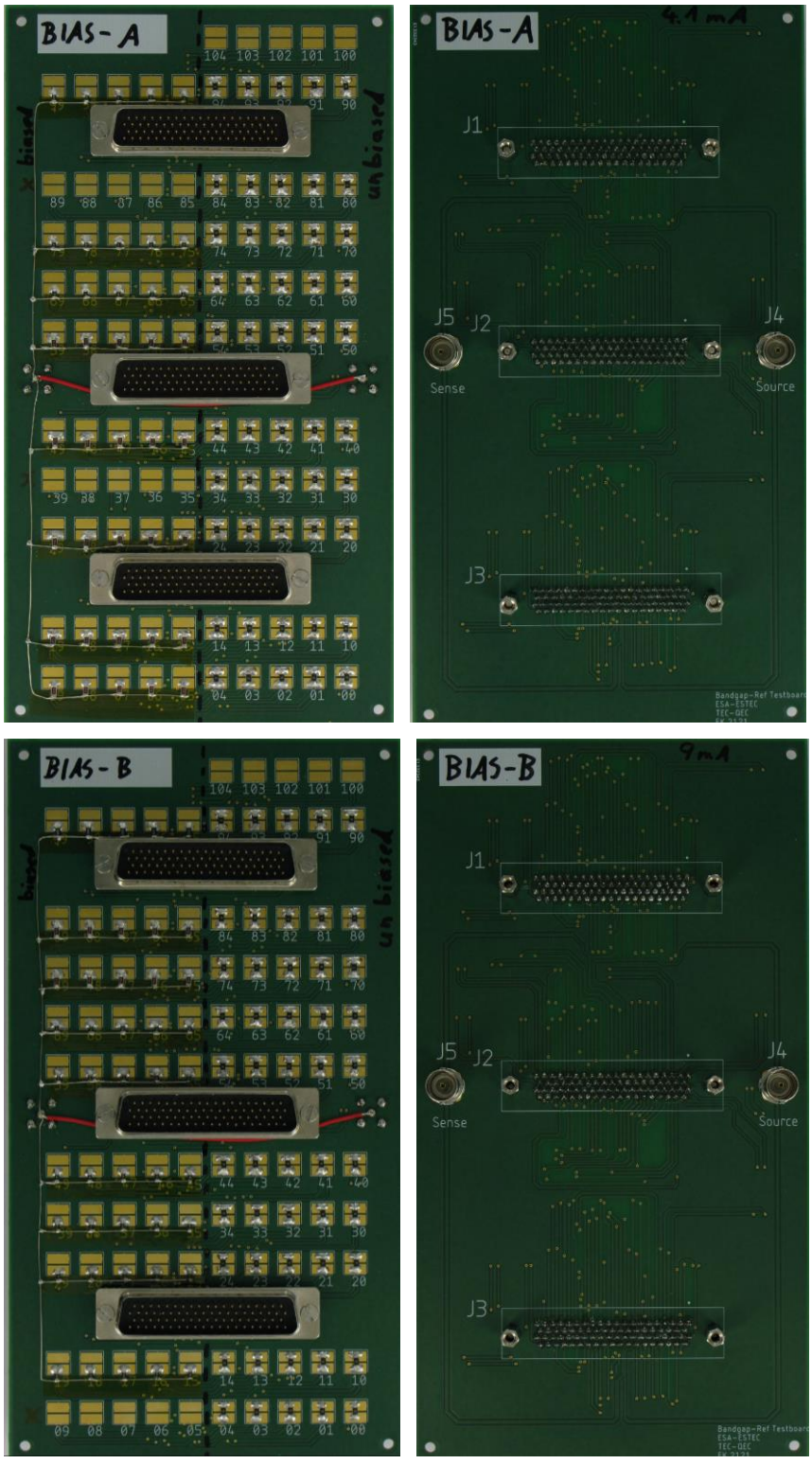
Test board front- and backside with the LM4041 on position 60 to 99 on board A and position10 to 69 on board B:



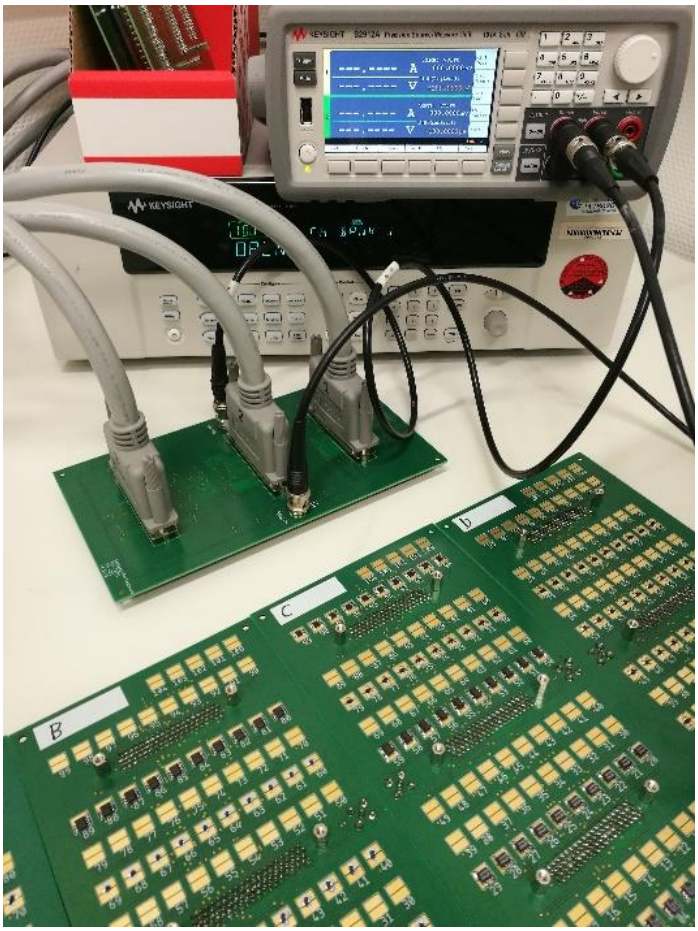




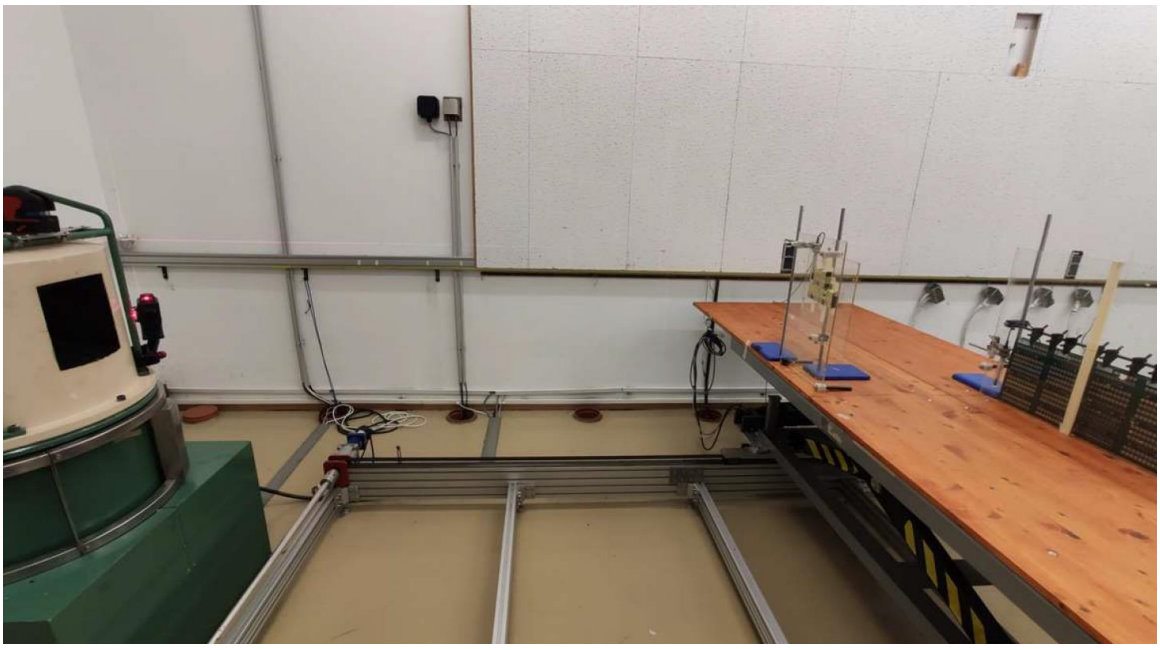
Biasing board front- and backside with the biasing resistors on it:

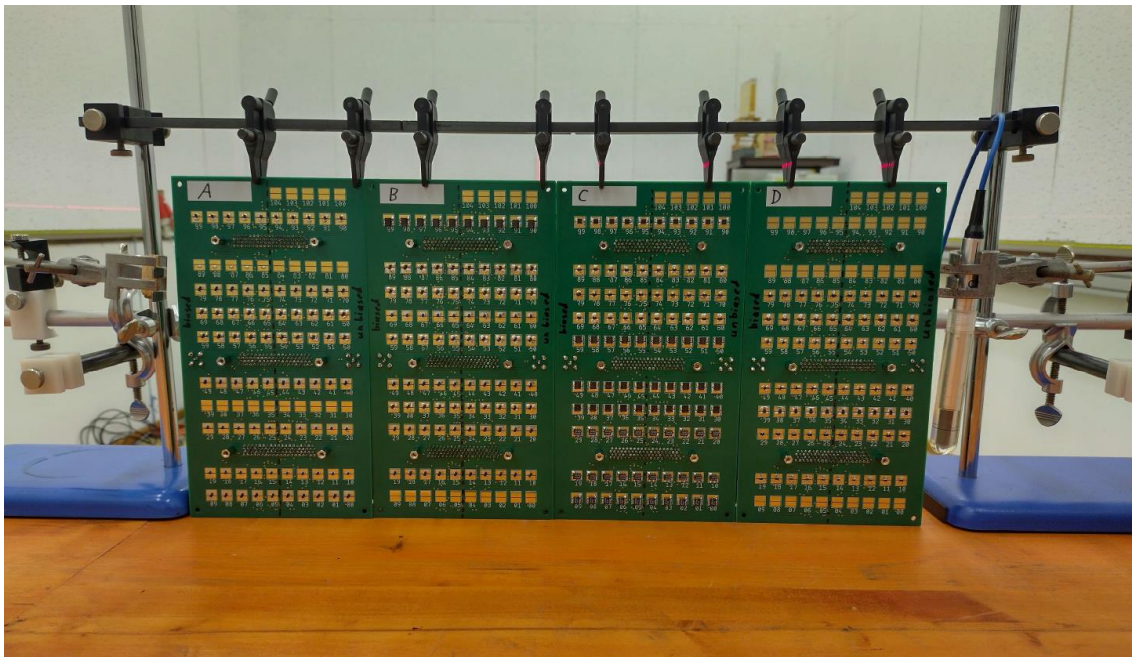


Measurement setup with the cable connection from the Test Board to the Switching Matrix and the Source Measure Unit:



Position of the boards inside the Co60 irradiation chamber:





ANNEX C – RADIATION TEST SUMMARY – IRRADIATION STEPS

Irr. Run	Start Date & Time (CET)	End Date & Time (CET)	Total Ionising Dose (water)	Dose Rate (water)
1	24-01-2022 18:11:39	25-01-2022 13:37:10	55.69 Gy	2.867 Gy/h
2	25-01-2022 15:13:42	26-01-2022 11:52:43	55.67 Gy	2.696 Gy/h
3	26-01-2022 13:30:18	27-01-2022 10:16:45	55.68 Gy	2.680 Gy/h
4	27-01-2022 12:11:47	28-01-2022 08:55:59	55.68 Gy	2.685 Gy/h
5	28-01-2022 10:31:55	31-01-2022 09:30:00	202.3 Gy	2.851 Gy/h
6	31-01-2022 11:18:44	02-02-2022 09:21:12	131.8 Gy	2.863 Gy/h
7	02-02-2022 11:05:44	07-02-2022 09:55:08	339.6 Gy	2.858 Gy/h
8	07-02-2022 11:41:36	10-02-2022 15:46:14	217.1 Gy	2.854 Gy/h
		Total	1.114 kGy	

Note: *The uncertainty budgets (according to TEC-QEC/PR001 section 12) are: 4.2 % (k=2) for absorbed dose to water and 4.4% (k=2) for absorbed dose rate to water*

	units	Min.	Max.	Time-weighted Average
Temperature	°C	20.9	21.2	20.93
Pressure	mbar	996.6	1034.5	1019.01
Relative Humidity	%	47.1	54	51.45

Dosimeter position relative to ^{60}Co source		
X	cm	36.5
Y	cm	292
Z	cm	-21

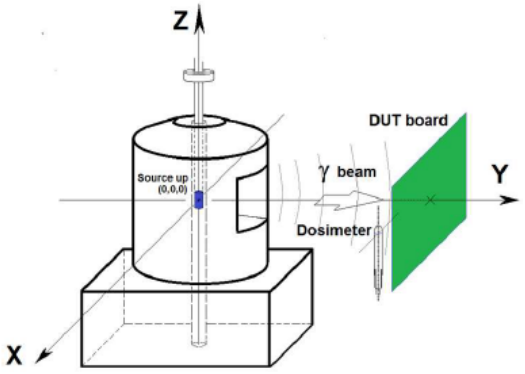


Figure 1 Co-60 irradiator head and board positioning sketch

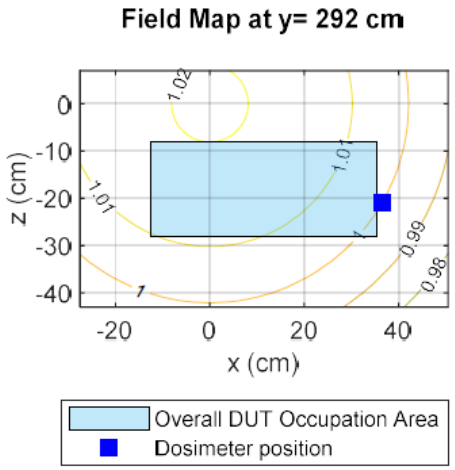


Figure 2: Qualitative indication of dose rate distribution normalized to dosemeter readings. Axes origin located at source centre. Graphs for information only, of the run with highest dose rate.