ESA ESTEC
Keplerlaan 1
2201 AZ Noordwijk
The Netherlands

TLVH431_TID_TEST_REPORT

TLVH431BQDCKT
Date Code: 1843
1.24V Adjustable voltage reference
Texas Instruments

TLVH431AIL3T
Date Code: 1929
1.24V Adjustable voltage reference
STMicroelectronics

TLVH431AIL5T
Date Code: 1944
1.24V Adjustable voltage reference
STMicroelectronics

Prepared by	Florian Krimmel

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CHANGE LOG

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Creation	11/05/2022	All	All

DISTRIBUTION

Name/Organisational Unit

Table of Contents

1. INTRODUCTION

The current report presents the TID results on the Bandgap Voltage Reference TLVH431

- TLVH431BQDCKT, date code: 1843, Texas Instruments
- TLVH431AIL3T, date code: 1929, STMicroelectronics
- TLVH431AIL5T, date code: 1944, STMicroelectronics

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

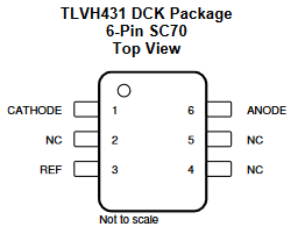
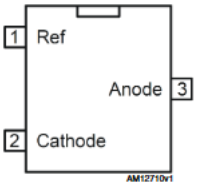
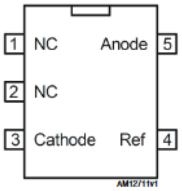
Part number	TLVH431BQDCKT	TLVH431AIL3T	TLVH431AIL5T
Manufacturer	Texas Instruments	STMicroelectronics	STMicroelectronics
Function	1.24V Adjustable voltage reference	1.24V Adjustable voltage reference	1.24V Adjustable voltage reference
Technology	Bipolar	Bipolar	Bipolar
Package		 SOT23-3L	 SOT23-5L
Date Code [yyww]	1843	1929	1944
Distributor	Mouser	Farnell	Mouser
Part # (sample n°) date code	5 samples unbiased (n° D10 to D14) 5 samples biased (n° D15 to D19) 1 reference unbiased (n° REF31) 1 reference biased (n° REF81)	5 samples unbiased (n° D20 to D24) 5 samples biased (n° D25 to D29) 1 reference unbiased (n° REF32) 1 reference biased (n° REF82)	5 samples unbiased (n° D30 to D34) 5 samples biased (n° D35 to D39) 1 reference unbiased (n° REF33) 1 reference biased (n° REF83)

Table 1: Part & procurement information

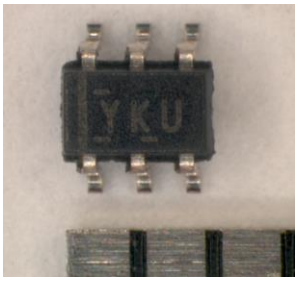
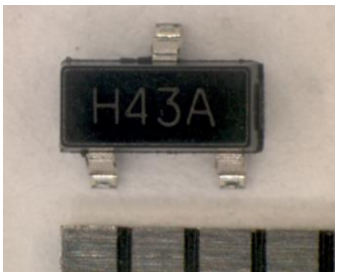
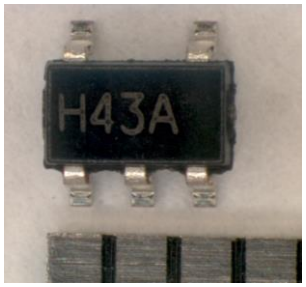
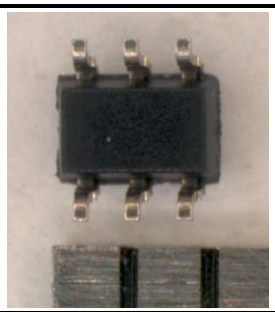
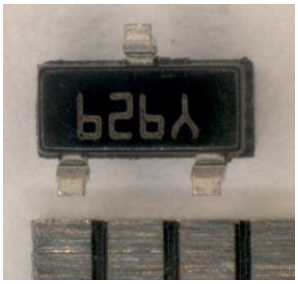
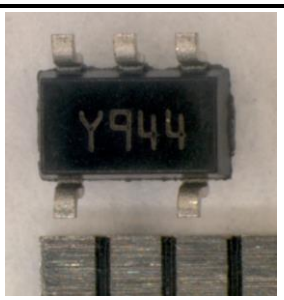
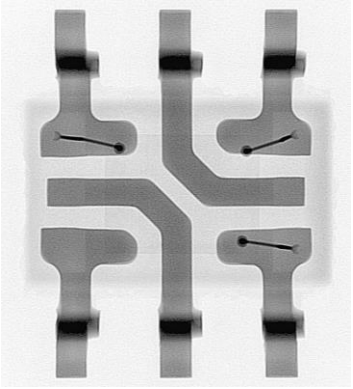
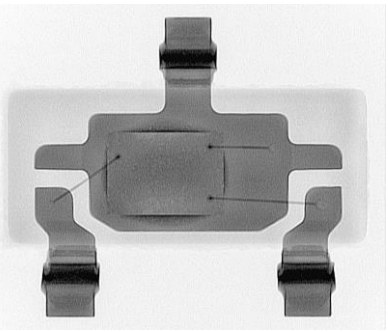
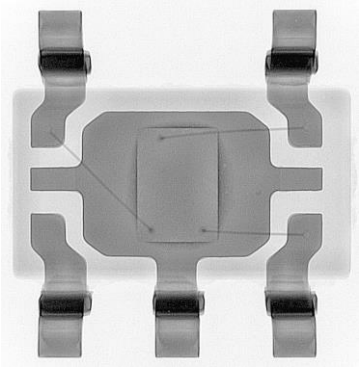
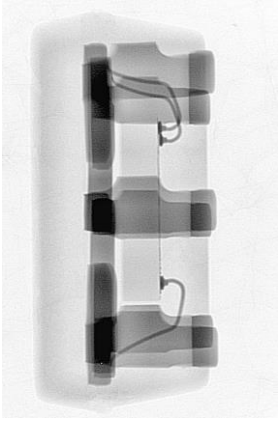
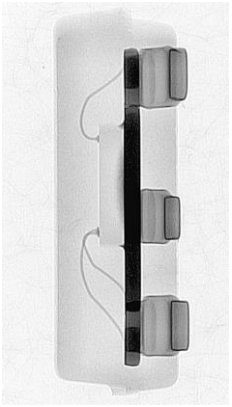
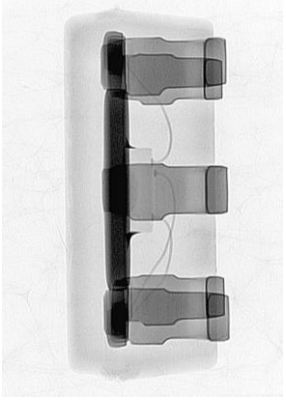
Part number	TLVH431BQDCKT	TLVH431AIL3T	TLVH431AIL5T
Package marking top			
Package marking bottom			
X-ray top view			
X-ray side view			

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.

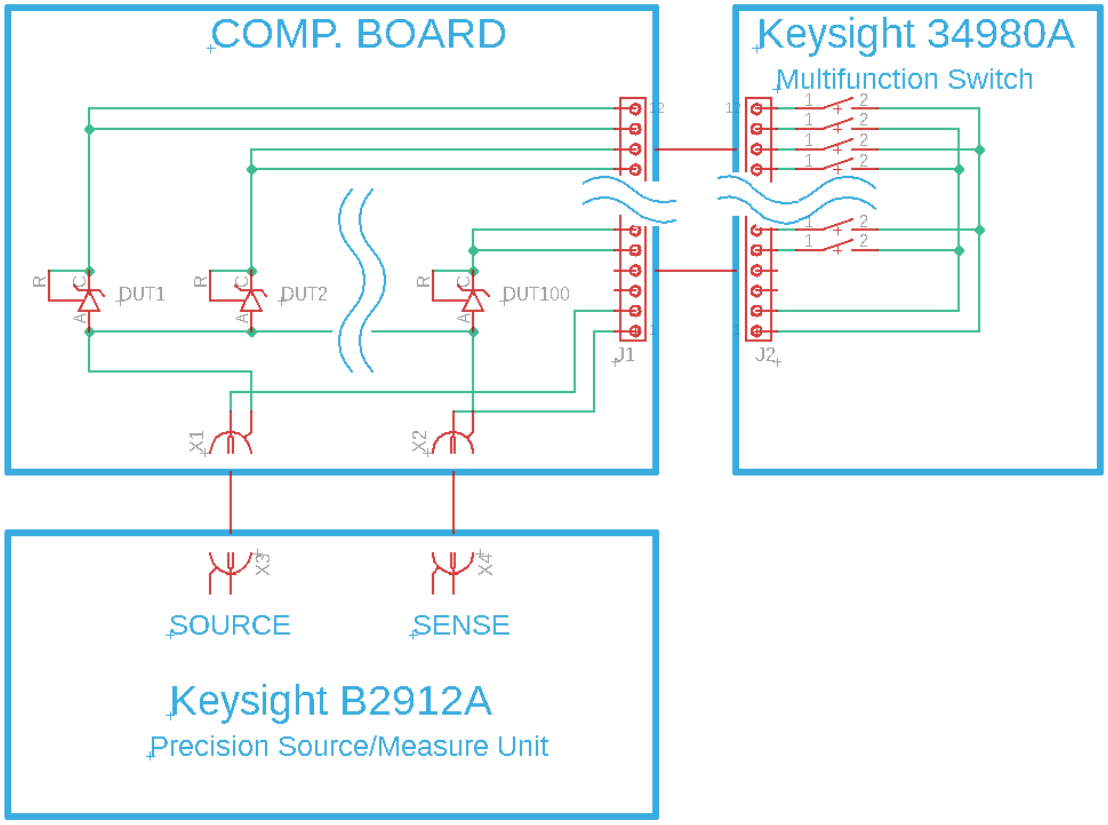


Figure 1: Simplified schematic of the overall test set-up

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 x 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
TLVH431BQDCKT	10	mA
TLVH431AIL3T	10	mA
TLVH431AIL5T	10	mA

Table 2: Biasing conditions during irradiation

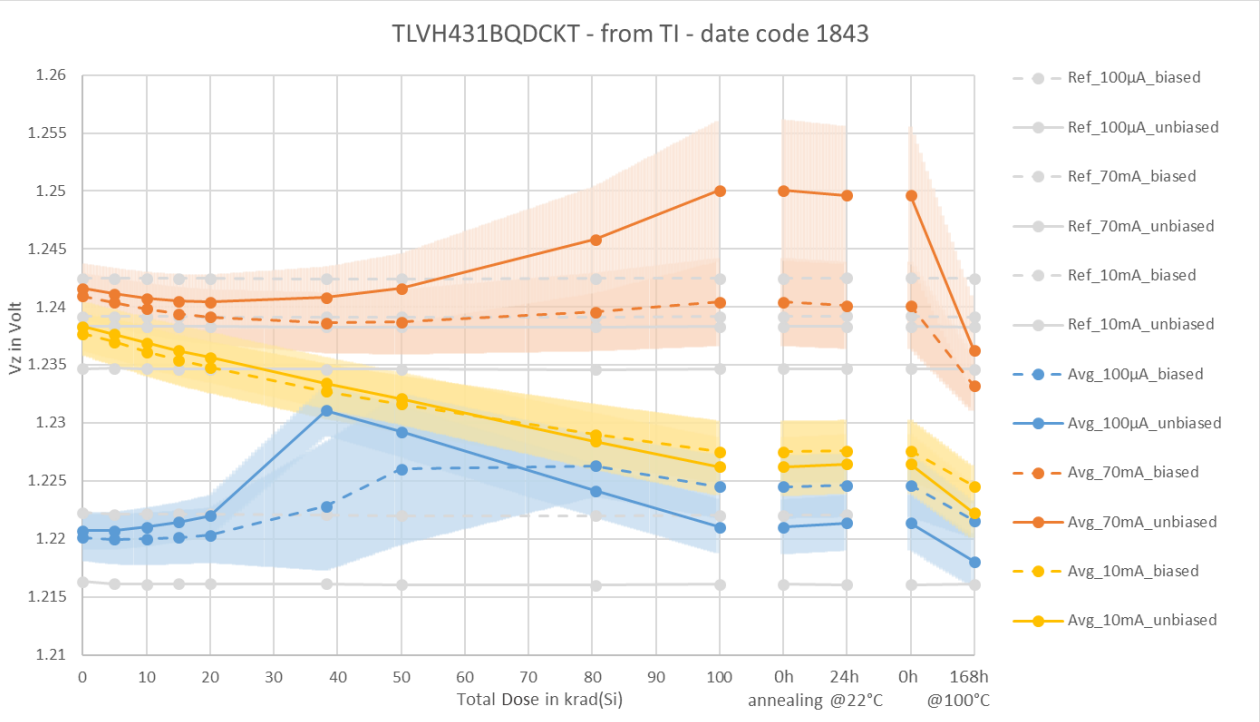
8. TID RESULTS

8.1. TID RESULTS - TLVH431BQDCKT - from TI - date code 1843

TLVH431BQDCKT - from TI - date code 1843 - @ I-min 100µA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
D10	unbiased	1.2199	1.2200	1.2204	1.2209	1.2215	1.2298	1.2280	1.2228	1.2196	1.2199	1.2179
D11		1.2201	1.2200	1.2202	1.2206	1.2211	1.2296	1.2278	1.2228	1.2197	1.2201	1.2157
D12		1.2204	1.2203	1.2206	1.2210	1.2216	1.2306	1.2287	1.2235	1.2202	1.2205	1.2163
D13		1.2196	1.2197	1.2200	1.2204	1.2209	1.2305	1.2286	1.2235	1.2204	1.2208	1.2190
D14		1.2236	1.2236	1.2240	1.2245	1.2251	1.2349	1.2332	1.2282	1.2252	1.2256	1.2214
D15	biased	1.2169	1.2165	1.2163	1.2163	1.2164	1.2165	1.2166	1.2219	1.2200	1.2201	1.2191
D16		1.2223	1.2222	1.2222	1.2224	1.2226	1.2230	1.2320	1.2289	1.2271	1.2272	1.2230
D17		1.2198	1.2198	1.2200	1.2202	1.2205	1.2317	1.2220	1.2275	1.2257	1.2259	1.2224
D18		1.2204	1.2202	1.2202	1.2203	1.2204	1.2207	1.2292	1.2260	1.2242	1.2243	1.2212
D19		1.2213	1.2212	1.2213	1.2215	1.2217	1.2223	1.2304	1.2273	1.2254	1.2255	1.2223
REF31	Ref unbiased	1.2163	1.2161	1.2161	1.2161	1.2161	1.2161	1.2161	1.2160	1.2161	1.2161	1.2161
REF81	Ref biased	1.2223	1.2221	1.2221	1.2221	1.2221	1.2221	1.2220	1.2220	1.2220	1.2221	1.2221

TLVH431BQDCKT - from TI - date code 1843 - @ I-typ 10mA											Limit acc. DS: Vz = 1.24V ± 1.61% (1.22V – 1.26V)	
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
D10	unbiased	1.2370	1.2362	1.2355	1.2349	1.2343	1.2322	1.2309	1.2272	1.2250	1.2252	1.2221
D11		1.2369	1.2362	1.2354	1.2347	1.2342	1.2319	1.2306	1.2269	1.2247	1.2249	1.2198
D12		1.2379	1.2372	1.2364	1.2356	1.2351	1.2328	1.2314	1.2274	1.2249	1.2252	1.2204
D13		1.2378	1.2372	1.2365	1.2358	1.2352	1.2329	1.2315	1.2279	1.2258	1.2260	1.2232
D14		1.2421	1.2414	1.2407	1.2401	1.2395	1.2374	1.2361	1.2327	1.2307	1.2310	1.2256
D15	biased	1.2347	1.2337	1.2327	1.2319	1.2312	1.2289	1.2276	1.2247	1.2231	1.2232	1.2220
D16		1.2398	1.2392	1.2384	1.2377	1.2371	1.2352	1.2340	1.2314	1.2300	1.2301	1.2260
D17		1.2381	1.2375	1.2367	1.2360	1.2355	1.2336	1.2326	1.2302	1.2287	1.2288	1.2253
D18		1.2375	1.2367	1.2359	1.2351	1.2345	1.2324	1.2312	1.2286	1.2271	1.2272	1.2241
D19		1.2385	1.2378	1.2370	1.2363	1.2357	1.2337	1.2326	1.2301	1.2287	1.2287	1.2253
REF31	Ref unbiased	1.2347	1.2347	1.2347	1.2347	1.2347	1.2346	1.2346	1.2346	1.2347	1.2347	1.2346
REF81	Ref biased	1.2392	1.2392	1.2392	1.2392	1.2392	1.2392	1.2391	1.2392	1.2392	1.2392	1.2392

TLVH431BQDCKT - from TI - date code 1843 - @ I-max 70mA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
D10	unbiased	1.2404	1.2400	1.2397	1.2395	1.2395	1.2404	1.2417	1.2475	1.2532	1.2526	1.2377
D11		1.2400	1.2395	1.2390	1.2386	1.2385	1.2384	1.2387	1.2410	1.2436	1.2434	1.2318
D12		1.2409	1.2403	1.2398	1.2395	1.2393	1.2391	1.2393	1.2412	1.2436	1.2434	1.2323
D13		1.2414	1.2410	1.2407	1.2405	1.2404	1.2410	1.2420	1.2476	1.2530	1.2524	1.2387
D14		1.2454	1.2450	1.2447	1.2445	1.2445	1.2452	1.2463	1.2518	1.2569	1.2564	1.2408
D15	biased	1.2378	1.2370	1.2363	1.2357	1.2353	1.2344	1.2342	1.2342	1.2345	1.2342	1.2295
D16		1.2431	1.2426	1.2421	1.2417	1.2415	1.2410	1.2409	1.2417	1.2425	1.2422	1.2348
D17		1.2416	1.2412	1.2407	1.2404	1.2403	1.2401	1.2405	1.2423	1.2437	1.2434	1.2352
D18		1.2406	1.2400	1.2394	1.2389	1.2386	1.2379	1.2378	1.2383	1.2389	1.2387	1.2322
D19		1.2416	1.2411	1.2406	1.2403	1.2401	1.2398	1.2401	1.2414	1.2426	1.2422	1.2342
REF31	Ref unbiased	1.2384	1.2384	1.2383	1.2383	1.2383	1.2383	1.2383	1.2383	1.2383	1.2383	1.2383
REF81	Ref biased	1.2425	1.2425	1.2425	1.2425	1.2425	1.2424	1.2424	1.2425	1.2425	1.2425	1.2425



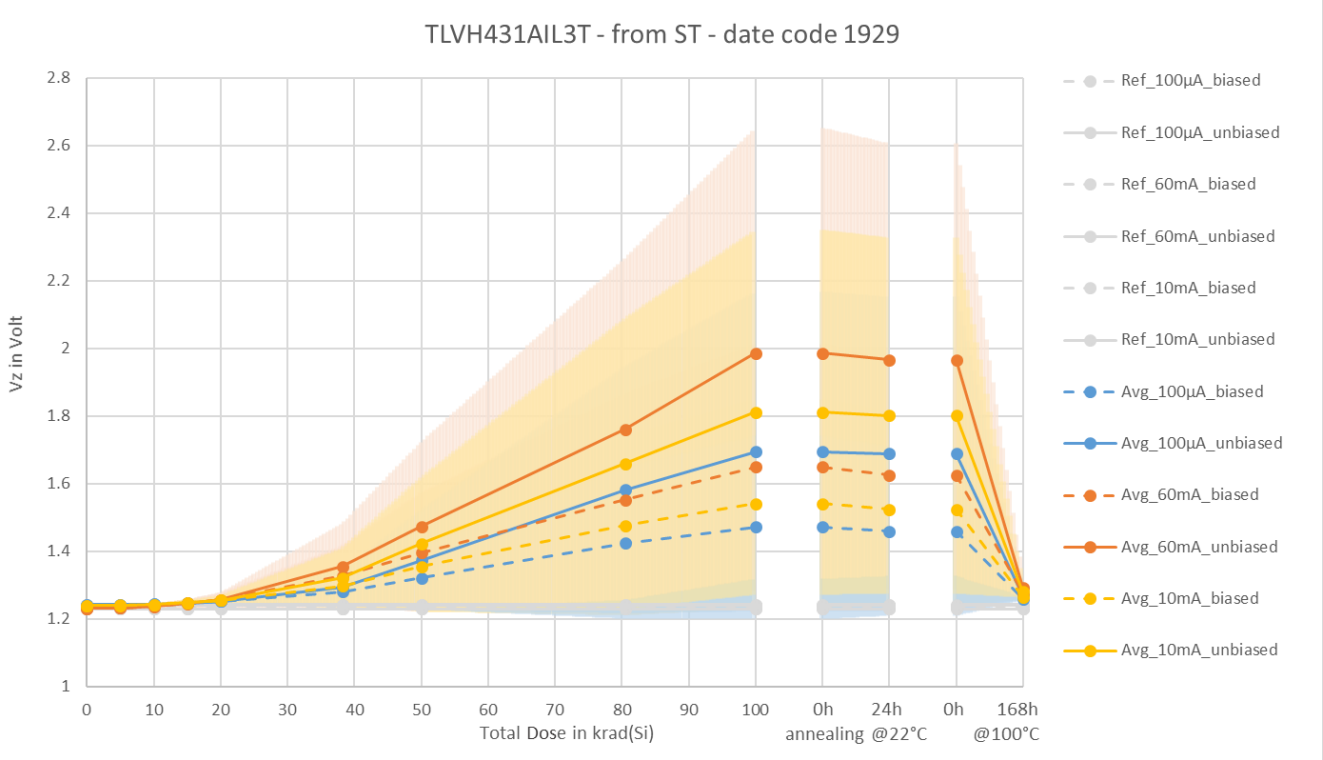
For all curves, which show an average over all measured samples, the coloured interval behind the curves represent +/- one standard deviation.

8.2. TID RESULTS - TLVH431AIL3T - from ST - date code 1929

TLVH431AIL3T - from ST - date code 1929 - @ I-min 100µA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
D20	unbiased	1.2416	1.2418	1.2423	1.2433	1.2450	1.2584	1.2730	1.3226	1.3602	1.3596	1.2611
D21		1.2426	1.2428	1.2430	1.2439	1.2454	1.2590	1.2732	1.3150	1.3469	1.3470	1.2603
D22		1.2411	1.2416	1.2432	1.2477	1.2556	1.3161	1.4449	1.8565	2.0570	2.0456	1.2784
D23		1.2412	1.2414	1.2418	1.2429	1.2450	1.2597	1.2753	1.3299	1.3668	1.3660	1.2601
D24		1.2419	1.2428	1.2462	1.2549	1.2683	1.3705	1.5991	2.0833	2.3430	2.3230	1.2844
D25	biased	1.2416	1.2420	1.2430	1.2445	1.2468	1.2609	1.2733	1.3101	1.3331	1.3309	1.2579
D26		1.2417	1.2423	1.2434	1.2453	1.2483	1.2668	1.2824	1.3274	1.3544	1.3513	1.2583
D27		1.2417	1.2430	1.2471	1.2552	1.2676	1.3444	1.4864	1.8244	1.9565	1.9051	1.2655
D28		1.2413	1.2418	1.2427	1.2443	1.2468	1.2631	1.2772	1.3191	1.3438	1.3409	1.2567
D29		1.2419	1.2425	1.2437	1.2457	1.2491	1.2693	1.2877	1.3402	1.3686	1.3667	1.2594
REF32	Ref unbiased	1.2423	1.2423	1.2423	1.2423	1.2423	1.2423	1.2423	1.2423	1.2423	1.2423	1.2423
REF82	Ref biased	1.2415	1.2415	1.2414	1.2414	1.2414	1.2414	1.2414	1.2414	1.2415	1.2415	1.2415

TLVH431AIL3T - from ST - date code 1929 - @ I-typ 10mA											Limit acc. DS: Vz = 1.24V ± 2.18% (1.213V – 1.267V)	
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
D20	unbiased	1.2390	1.2395	1.2405	1.2423	1.2451	1.2649	1.2852	1.3546	1.4464	1.4457	1.2690
D21		1.2402	1.2406	1.2413	1.2431	1.2458	1.2656	1.2842	1.3432	1.3875	1.3867	1.2678
D22		1.2390	1.2400	1.2431	1.2502	1.2618	1.3452	1.5419	1.9864	2.2174	2.2001	1.2955
D23		1.2386	1.2390	1.2399	1.2418	1.2451	1.2660	1.2870	1.3599	1.4482	1.4464	1.2669
D24		1.2397	1.2415	1.2471	1.2594	1.2779	1.4656	1.7117	2.2502	2.5558	2.5257	1.3031
D25	biased	1.2391	1.2398	1.2412	1.2436	1.2471	1.2673	1.2849	1.3369	1.3697	1.3664	1.2622
D26		1.2395	1.2404	1.2421	1.2452	1.2499	1.2767	1.2991	1.3631	1.4018	1.3972	1.2635
D27		1.2395	1.2415	1.2480	1.2600	1.2777	1.3897	1.5907	1.9471	2.0911	2.0335	1.2744
D28		1.2388	1.2395	1.2410	1.2435	1.2474	1.2708	1.2910	1.3503	1.3861	1.3817	1.2610
D29		1.2396	1.2405	1.2424	1.2456	1.2507	1.2799	1.3059	1.3800	1.4523	1.4383	1.2649
REF32	Ref unbiased	1.2397	1.2397	1.2397	1.2397	1.2397	1.2396	1.2397	1.2397	1.2397	1.2397	1.2397
REF82	Ref biased	1.2393	1.2393	1.2393	1.2393	1.2393	1.2393	1.2393	1.2393	1.2393	1.2393	1.2393

TLVH431AIL3T - from ST - date code 1929 - @ I-max 60mA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
D20	unbiased	1.2291	1.2303	1.2325	1.2358	1.2407	1.2710	1.2995	1.4147	1.5414	1.5414	1.2756
D21		1.2312	1.2322	1.2342	1.2375	1.2422	1.2715	1.2977	1.3816	1.4746	1.4702	1.2744
D22		1.2315	1.2338	1.2398	1.2511	1.2681	1.4013	1.6376	2.1401	2.4171	2.3965	1.3174
D23		1.2285	1.2294	1.2314	1.2347	1.2398	1.2707	1.2998	1.4088	1.5413	1.5388	1.2711
D24		1.2319	1.2355	1.2453	1.2633	1.2895	1.5567	1.8337	2.4603	2.9529	2.8834	1.3270
D25	biased	1.2301	1.2316	1.2347	1.2392	1.2452	1.2773	1.3036	1.3782	1.4249	1.4201	1.2707
D26		1.2313	1.2332	1.2370	1.2428	1.2506	1.2918	1.3246	1.4160	1.4945	1.4805	1.2739
D27		1.2315	1.2359	1.2472	1.2658	1.2913	1.4852	1.7084	2.1102	2.2938	2.2241	1.2906
D28		1.2294	1.2309	1.2342	1.2389	1.2456	1.2819	1.3117	1.3959	1.4667	1.4524	1.2687
D29		1.2311	1.2330	1.2370	1.2430	1.2515	1.2957	1.3332	1.4594	1.5648	1.5490	1.2755
REF32	Ref unbiased	1.2299	1.2299	1.2299	1.2299	1.2299	1.2300	1.2300	1.2300	1.2299	1.2299	1.2299
REF82	Ref biased	1.2307	1.2308	1.2308	1.2308	1.2308	1.2308	1.2308	1.2309	1.2308	1.2308	1.2308

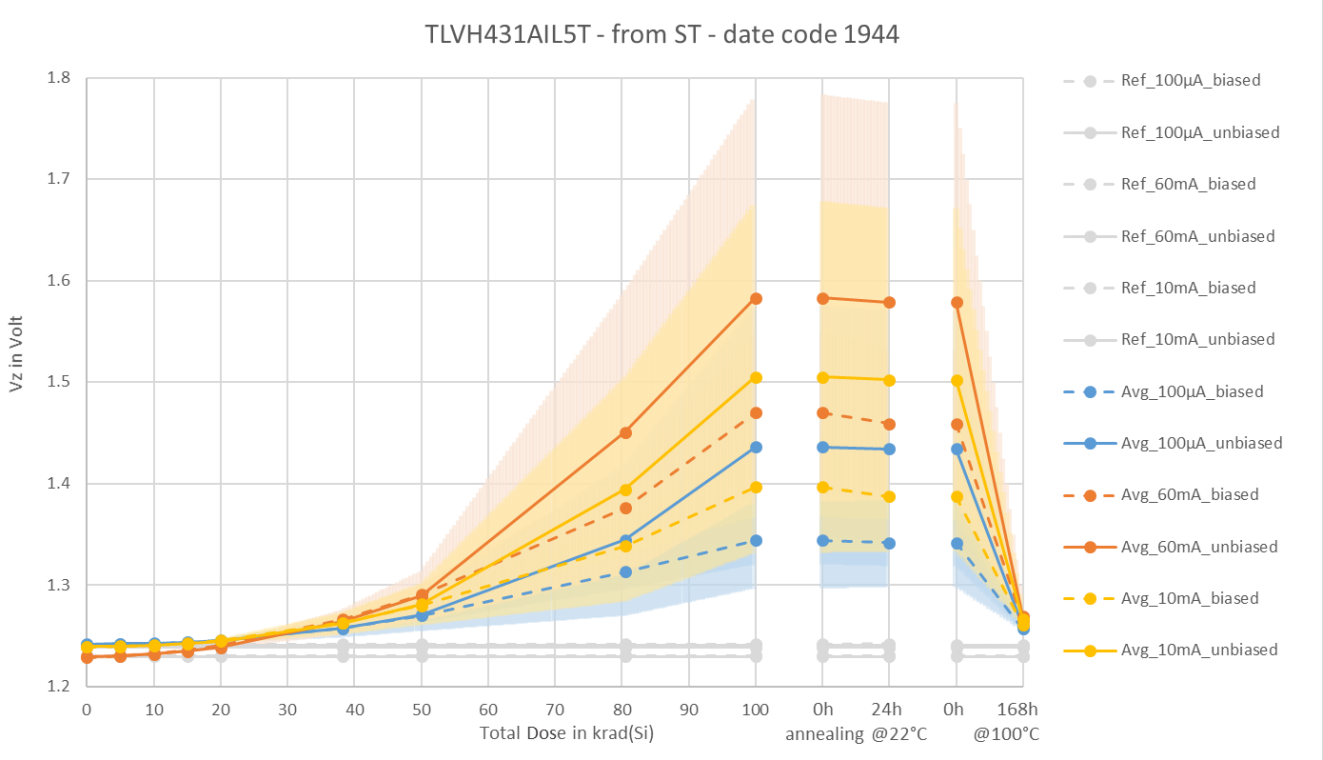


8.3. TID RESULTS - TLVH431AIL5T - from ST - date code 1944

TLVH431AIL5T - from ST - date code 1944 - @ I-min 100µA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
D30	unbiased	1.2421	1.2423	1.2429	1.2439	1.2457	1.2599	1.2766	1.3575	1.5146	1.5113	1.2631
D31		1.2412	1.2413	1.2417	1.2421	1.2431	1.2512	1.2596	1.2985	1.3345	1.3357	1.2573
D32		1.2416	1.2419	1.2428	1.2447	1.2480	1.2709	1.2959	1.4666	1.6365	1.6307	1.2643
D33		1.2424	1.2426	1.2429	1.2433	1.2440	1.2491	1.2551	1.2776	1.2981	1.2989	1.2538
D34		1.2421	1.2423	1.2426	1.2433	1.2447	1.2554	1.2675	1.3220	1.3963	1.3944	1.2590
D35	biased	1.2413	1.2416	1.2425	1.2437	1.2456	1.2575	1.2700	1.3164	1.3527	1.3495	1.2578
D36		1.2409	1.2413	1.2421	1.2433	1.2452	1.2565	1.2678	1.3043	1.3289	1.3268	1.2554
D37		1.2410	1.2414	1.2420	1.2429	1.2444	1.2529	1.2612	1.2899	1.3108	1.3096	1.2558
D38		1.2417	1.2421	1.2430	1.2446	1.2471	1.2630	1.2784	1.3309	1.3664	1.3647	1.2574
D39		1.2412	1.2417	1.2425	1.2438	1.2459	1.2591	1.2732	1.3253	1.3615	1.3588	1.2577
REF33	Ref unbiased	1.2409	1.2410	1.2409	1.2409	1.2409	1.2409	1.2409	1.2409	1.2410	1.2410	1.2410
REF83	Ref biased	1.2420	1.2420	1.2420	1.2420	1.2420	1.2419	1.2420	1.2420	1.2420	1.2421	1.2420

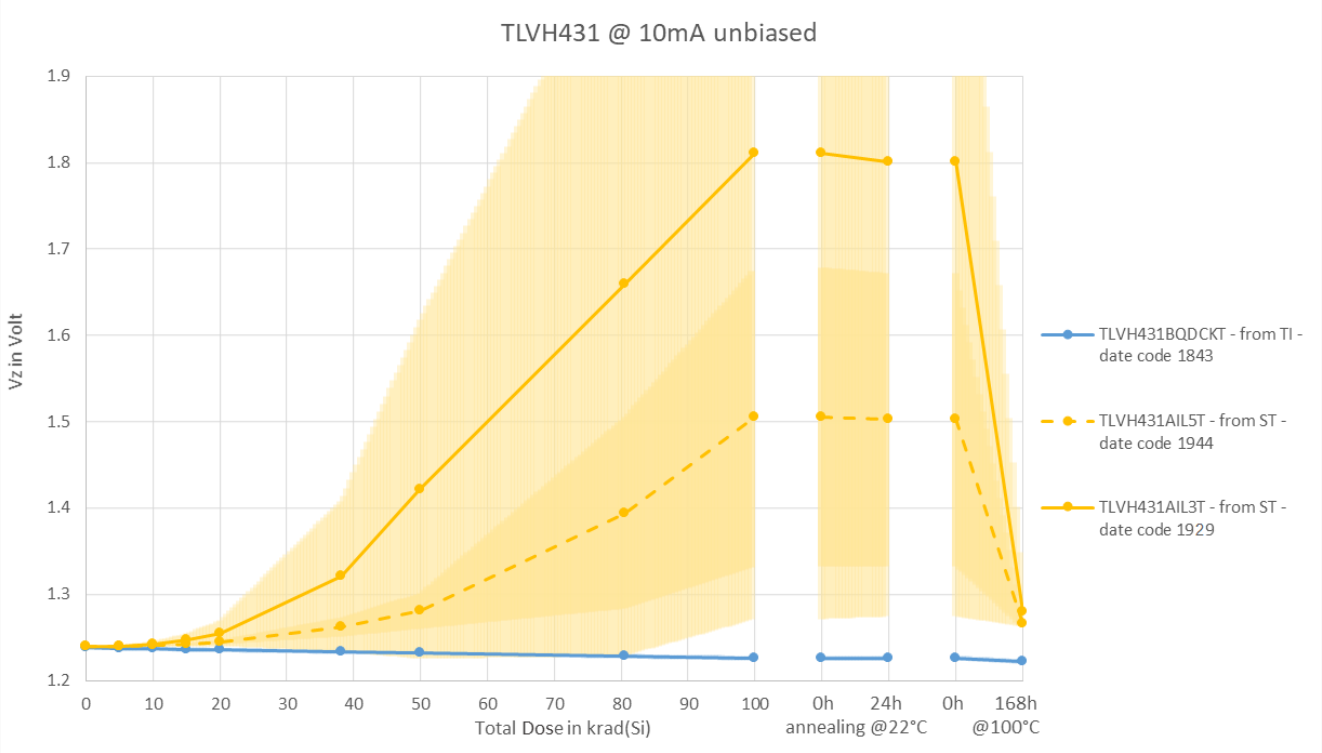
TLVH431AIL5T - from ST - date code 1944 - @ I-typ 10mA											Limit acc. DS: Vz = 1.24V ± 2.18% (1.213V – 1.267V)	
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
D30	unbiased	1.2396	1.2400	1.2410	1.2427	1.2455	1.2656	1.2881	1.4428	1.6093	1.6031	1.2708
D31		1.2387	1.2390	1.2397	1.2407	1.2424	1.2550	1.2671	1.3209	1.3710	1.3721	1.2641
D32		1.2389	1.2394	1.2408	1.2438	1.2483	1.2793	1.3124	1.5645	1.7417	1.7339	1.2718
D33		1.2402	1.2405	1.2411	1.2419	1.2431	1.2515	1.2599	1.2917	1.3188	1.3192	1.2587
D34		1.2398	1.2401	1.2409	1.2422	1.2445	1.2605	1.2777	1.3523	1.4851	1.4829	1.2657
D35	biased	1.2389	1.2395	1.2407	1.2426	1.2453	1.2624	1.2798	1.3429	1.4019	1.3896	1.2621
D36		1.2388	1.2393	1.2405	1.2425	1.2453	1.2617	1.2771	1.3271	1.3608	1.3580	1.2591
D37		1.2388	1.2393	1.2402	1.2416	1.2438	1.2561	1.2676	1.3067	1.3350	1.3333	1.2590
D38		1.2388	1.2394	1.2408	1.2433	1.2470	1.2692	1.2903	1.3614	1.4436	1.4286	1.2609
D39		1.2388	1.2395	1.2407	1.2427	1.2458	1.2649	1.2844	1.3552	1.4423	1.4259	1.2619
REF33	Ref unbiased	1.2386	1.2386	1.2386	1.2386	1.2386	1.2386	1.2386	1.2386	1.2386	1.2387	1.2386
REF83	Ref biased	1.2397	1.2397	1.2397	1.2397	1.2397	1.2397	1.2397	1.2397	1.2397	1.2398	1.2397

TLVH431AIL5T - from ST - date code 1944 - @ I-max 60mA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
D30	unbiased	1.2293	1.2302	1.2320	1.2347	1.2389	1.2672	1.2978	1.5201	1.6967	1.6911	1.2745
D31		1.2293	1.2301	1.2316	1.2337	1.2366	1.2558	1.2737	1.3492	1.4513	1.4512	1.2685
D32		1.2274	1.2283	1.2305	1.2346	1.2409	1.2822	1.3261	1.6549	1.8521	1.8416	1.2731
D33		1.2312	1.2319	1.2331	1.2346	1.2368	1.2497	1.2616	1.3067	1.3429	1.3427	1.2597
D34		1.2310	1.2318	1.2334	1.2358	1.2396	1.2633	1.2875	1.4224	1.5722	1.5685	1.2699
D35	biased	1.2297	1.2308	1.2331	1.2365	1.2411	1.2675	1.2923	1.3787	1.4942	1.4801	1.2684
D36		1.2297	1.2308	1.2332	1.2365	1.2411	1.2659	1.2879	1.3566	1.4040	1.3993	1.2640
D37		1.2297	1.2308	1.2327	1.2353	1.2390	1.2582	1.2750	1.3296	1.3683	1.3659	1.2637
D38		1.2254	1.2264	1.2288	1.2327	1.2383	1.2697	1.2984	1.4151	1.5441	1.5277	1.2614
D39		1.2296	1.2308	1.2333	1.2368	1.2419	1.2707	1.2983	1.3999	1.5390	1.5217	1.2679
REF33	Ref unbiased	1.2297	1.2297	1.2298	1.2297	1.2298	1.2298	1.2298	1.2298	1.2298	1.2298	1.2297
REF83	Ref biased	1.2303	1.2303	1.2303	1.2303	1.2303	1.2304	1.2303	1.2304	1.2303	1.2304	1.2303



8.4. Comparison Manufacturer and Date Code

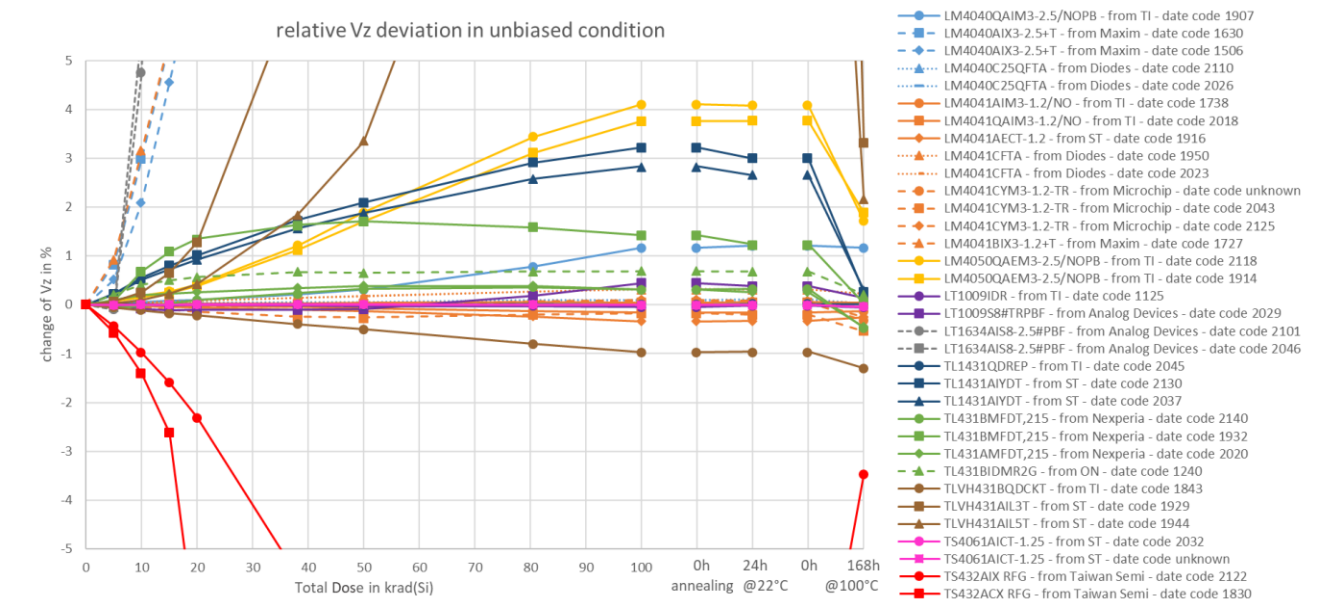
The following graph shows the different behaviour of all measured TLVH431 voltage references with different date codes and from different manufacturers.

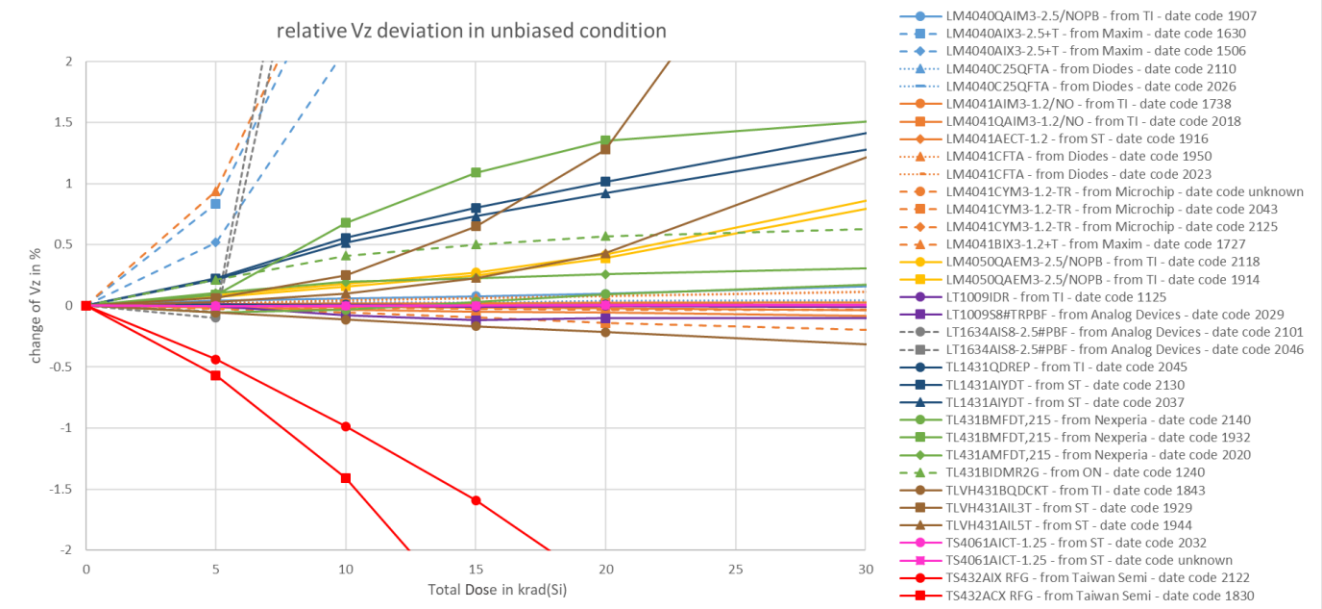


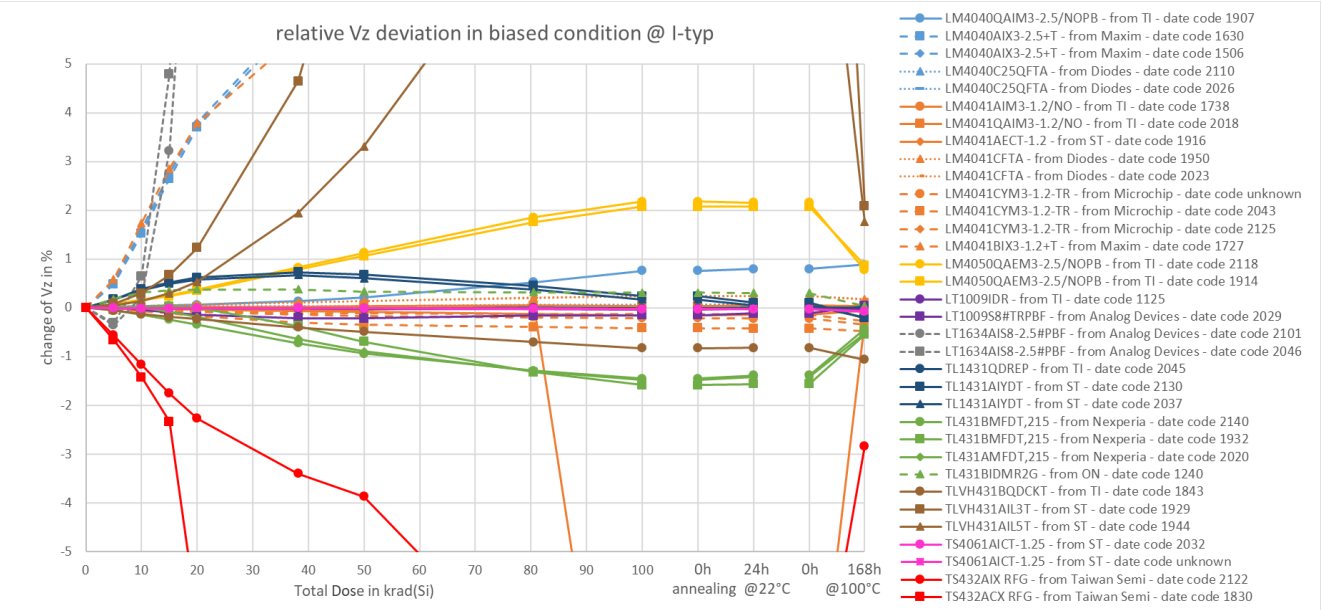
All curves plotted show the average value of all unbiased tested samples (worst case) and the interval behind the curves represent +/- one standard deviation.

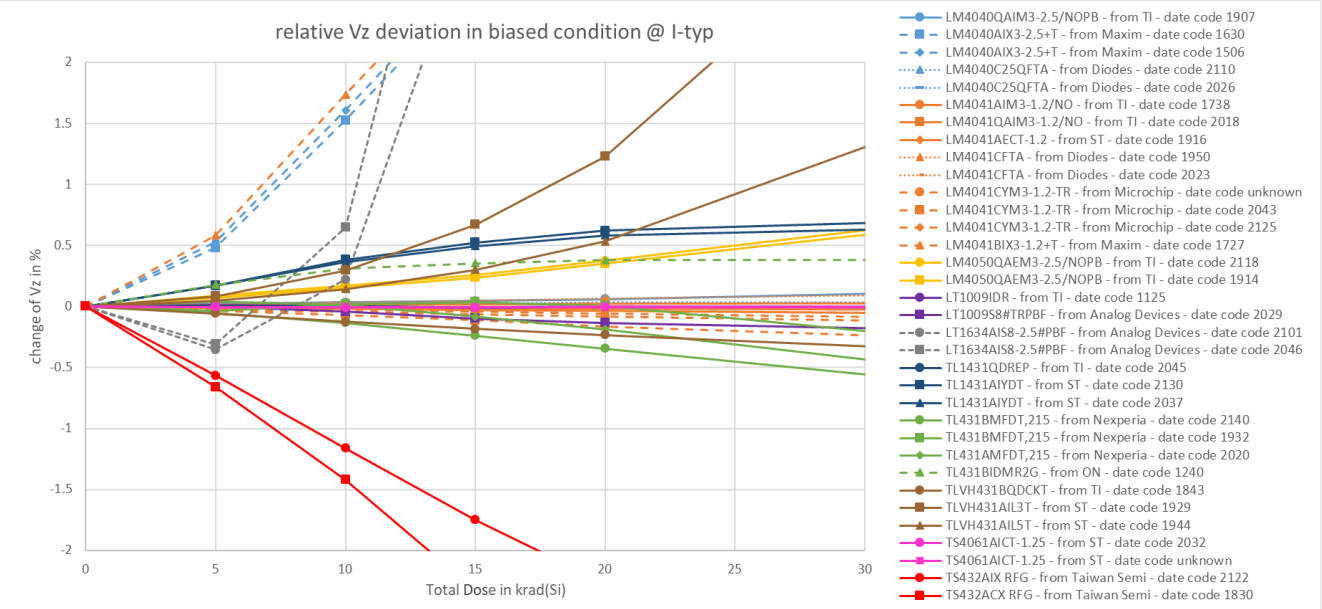
8.5. Comparison with other tested Bandgap References

The following four graphs show the results of the TLVH431 Bandgap Voltage References compared to different Bandgap References part types, which were tested at the same time with the same test setup than the TLVH431. 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
24h
0h
168h
annealing @22°C
@100°C
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

All tested components with different date codes and from different manufacturers stayed inside specification limits up to a dose around 15 krad.

The deviation of tested components from the two different date codes shows a different behaviour in respect of TID effects.
The deviation of tested components from the two different manufactures shows a very different behaviour as well.

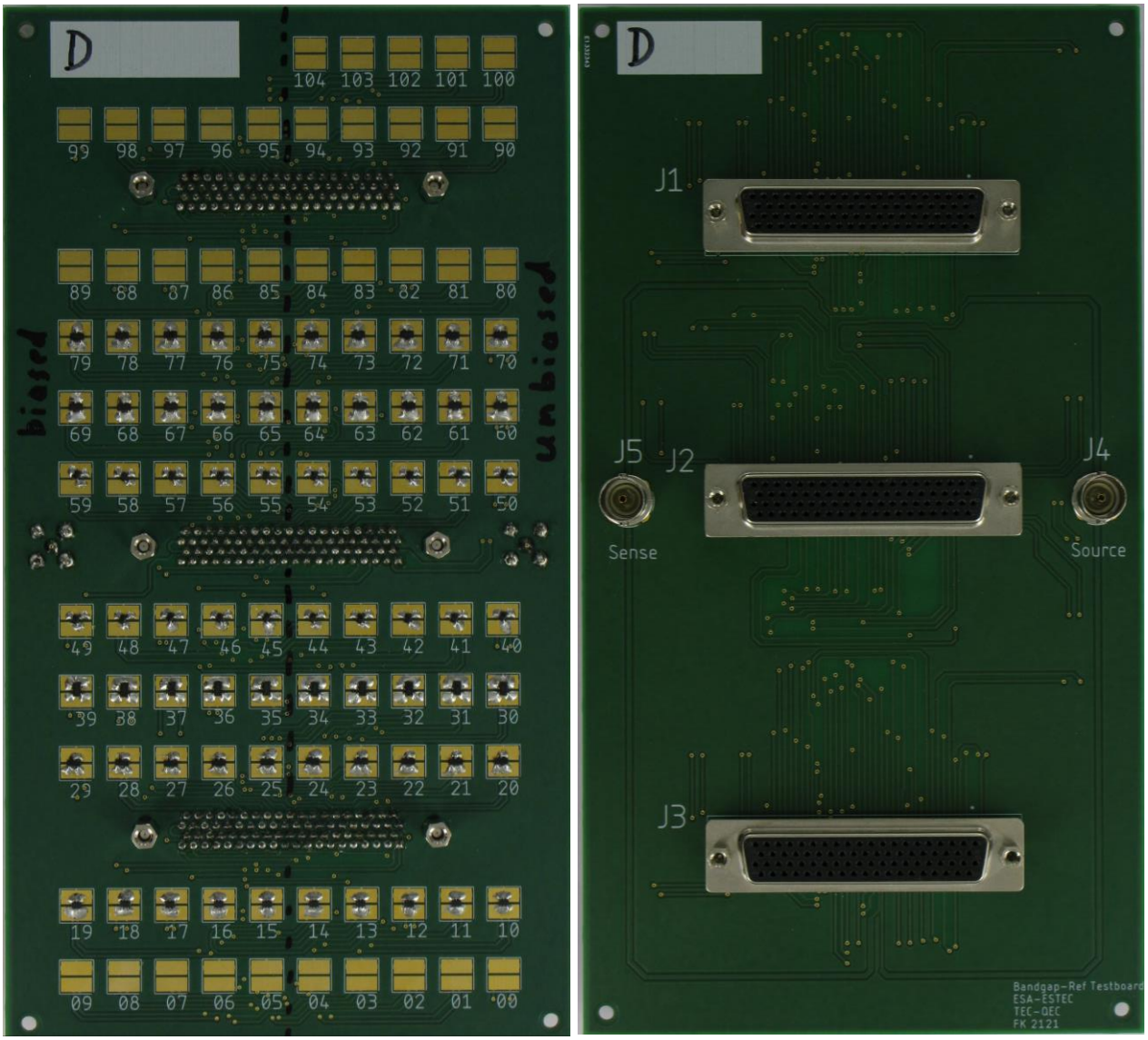
In general, a higher deviation was found for the unbiased samples.

ANNEX A – DATASHEET

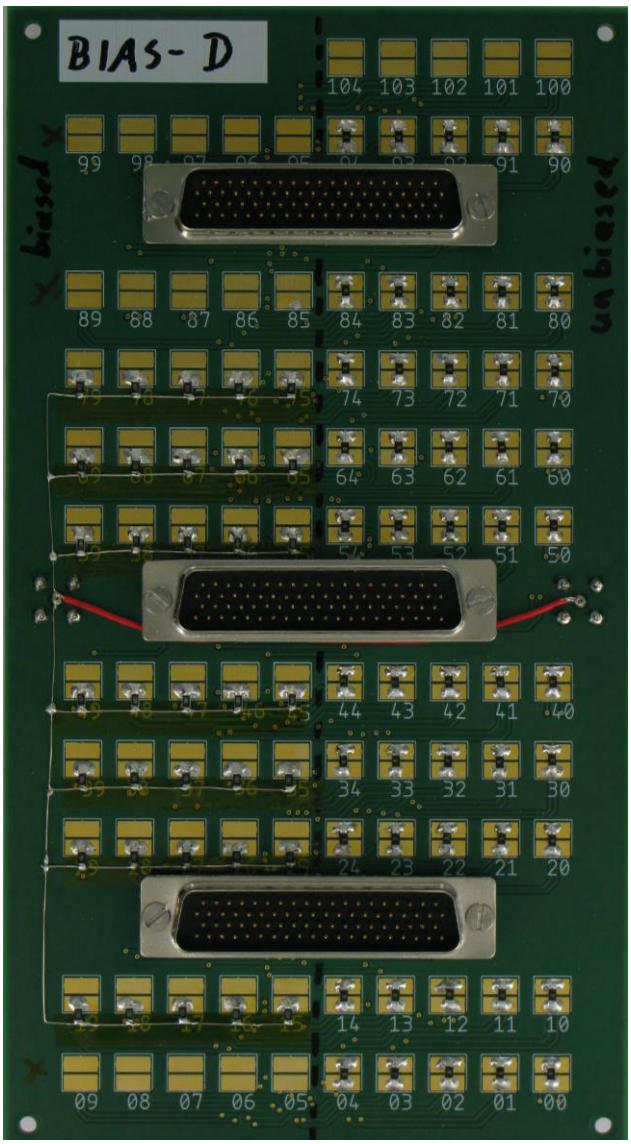
Part Type	Manufacturer	Link to Datasheet
TLVH431BQDCKT	Texas Instruments	https://www.ti.com/lit/ds/symlink/tlvh431b.pdf?ts=1660815473795&ref_url=https%253A%252F%252Fwww.ti.com%252Fproduct%252FTLVH431B%252Fpart-details%252FTLVH431BQDCKT
TLVH431AIL3T TLVH431AIL5T	STMicroelectronics	https://www.st.com/content/ccc/resource/technical/document/datasheet/59/e3/67/c7/33/76/47/48/DM00057412.pdf/files/DM00057412.pdf/jcr:content/translations/en.DM00057412.pdf

ANNEX B – SET-UP

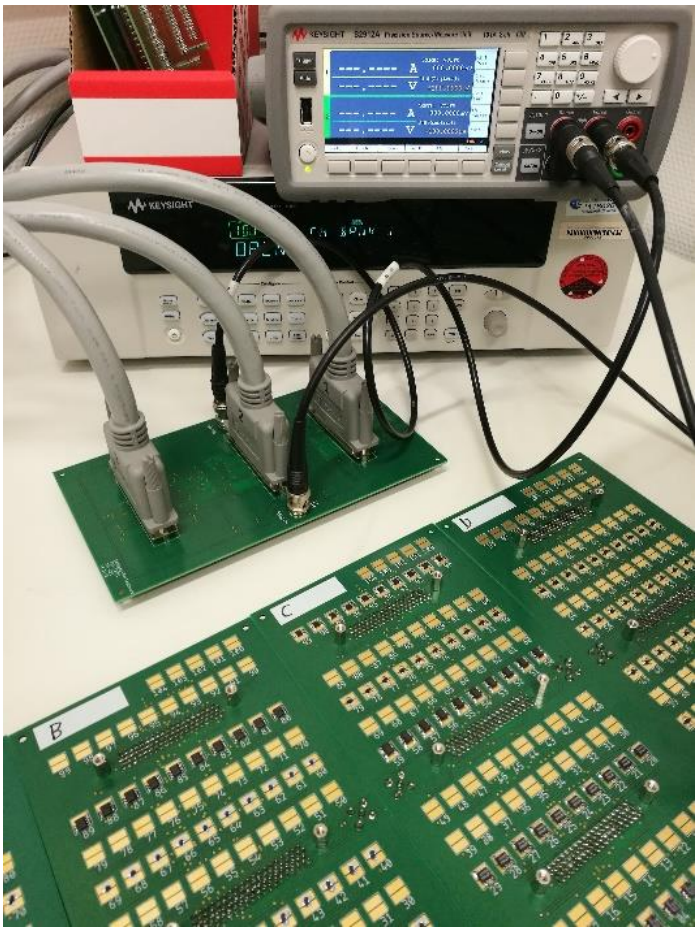
Test board front- and backside with the TLVH431 on position 10 to 39 on board D:



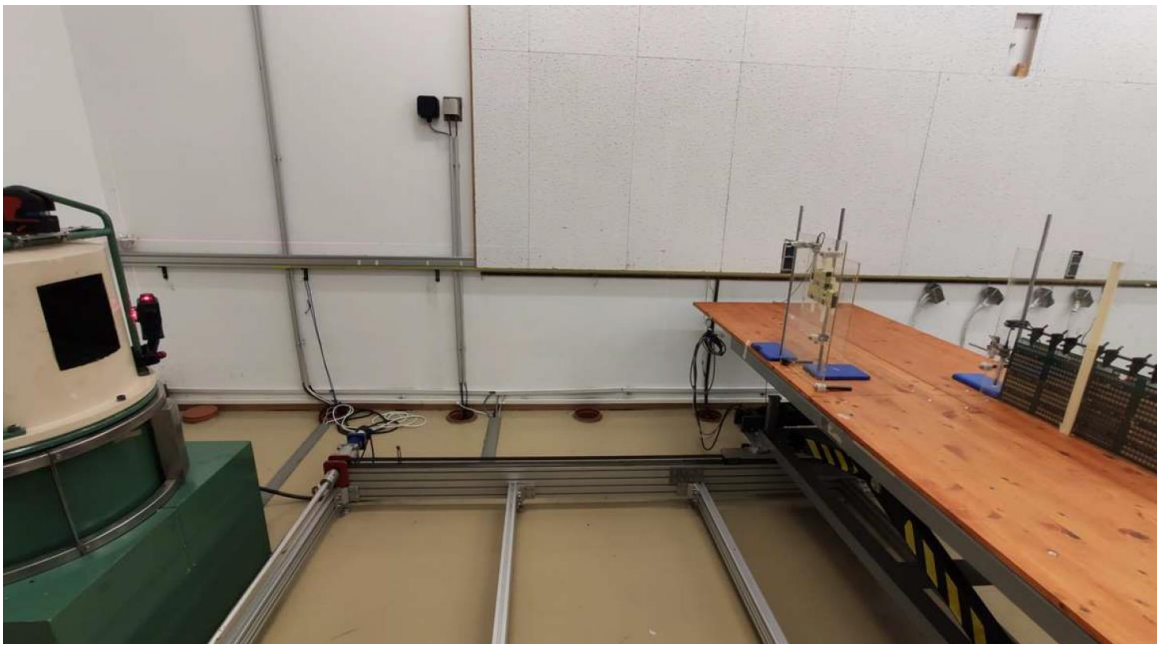
Biasing board front- and backside with the biasing resistors on it:

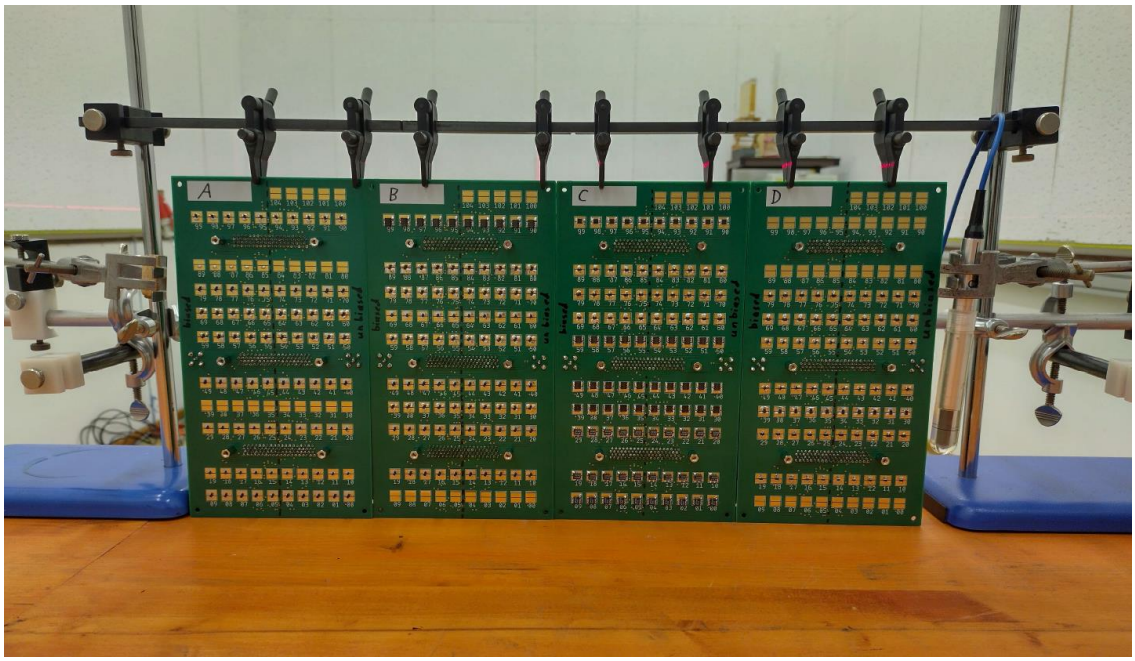


Measurement setup with the cable connection from the Test Board to the Switching Matrix and the Source Measure Unit:



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

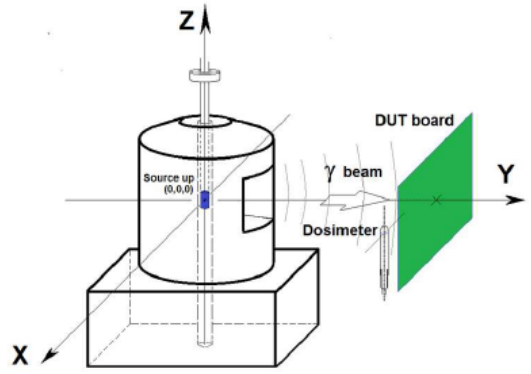


Figure 1 Co-60 irradiator head and board positioning sketch

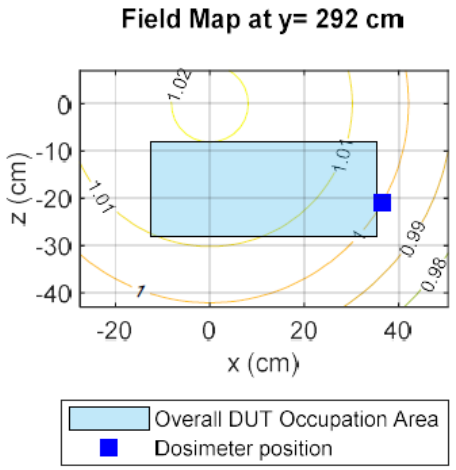


Figure 2: Qualitative indication of dose rate distribution normalized to dosemeter readings. Axes origin located at source centre. Graphs for information only, of the run with highest dose rate.