ESA ESTEC
Keplerlaan 1
2201 AZ Noordwijk
The Netherlands

TL1431_TID_TEST_REPORT

TL1431QDREP
Date Code: 2045
2.5V Adjustable voltage reference
Texas Instruments

TL1431AIYDT
Date Code: 2130 and 2037
2.5V Adjustable voltage reference
STMicroelectronics

Prepared by	Florian Krimmel

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CHANGE LOG

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CHANGE RECORD

Issue Number	1	Revision Number	0
Reason for change	Date	Pages	Paragraph(s)
Creation	11/05/2022	All	All

DISTRIBUTION

Name/Organisational Unit

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1. INTRODUCTION

The current report presents the TID results on the Bandgap Voltage Reference TL1431

- TL1431QDREP, date code: 2045, Texas Instruments
- TL1431AIYDT, date code: 2130, STMicroelectronics
- TL1431AIYDT, date code: 2037, 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

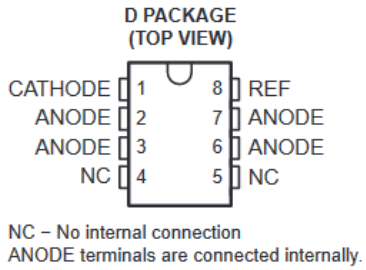
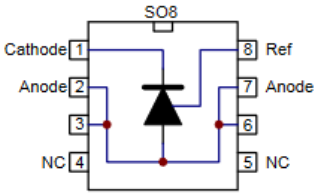
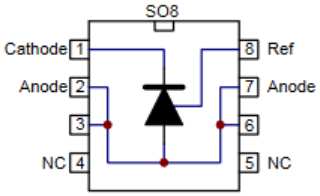
Part number	TL1431QDREP	TL1431AIYDT	TL1431AIYDT
Manufacturer	Texas Instruments	STMicroelectronics	STMicroelectronics
Function	2.5V Adjustable voltage reference	2.5V Adjustable voltage reference	2.5V Adjustable voltage reference
Technology	Bipolar	Bipolar	Bipolar
Package			
Date Code [yyww]	2045	2130	2037
Distributor	Mouser	Mouser	Mouser
Part # (sample n°) date code	5 samples unbiased (n° C30 to C34) 5 samples biased (n° C35 to C39) 1 reference unbiased (n° REF23) 1 reference biased (n° REF73)	5 samples unbiased (n° C40 to C44) 5 samples biased (n° C45 to C49) 1 reference unbiased (n° REF24) 1 reference biased (n° REF74)	5 samples unbiased (n° C50 to C54) 5 samples biased (n° C55 to C59) 1 reference unbiased (n° REF25) 1 reference biased (n° REF75)

Table 1: Part & procurement information

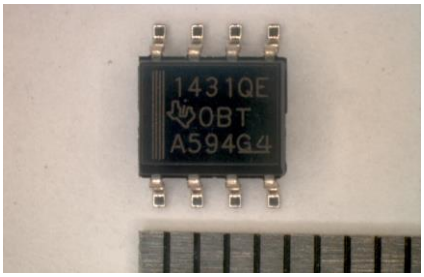
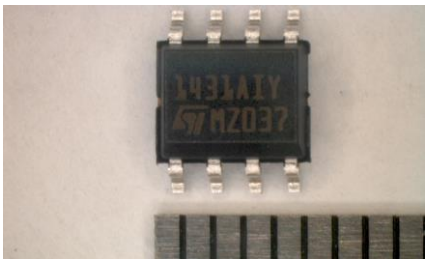
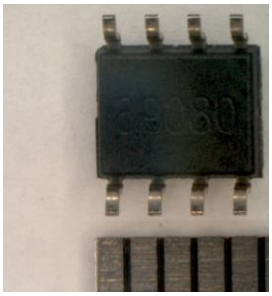
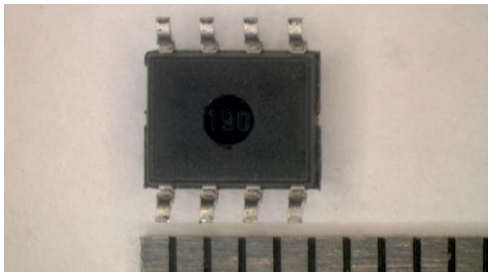
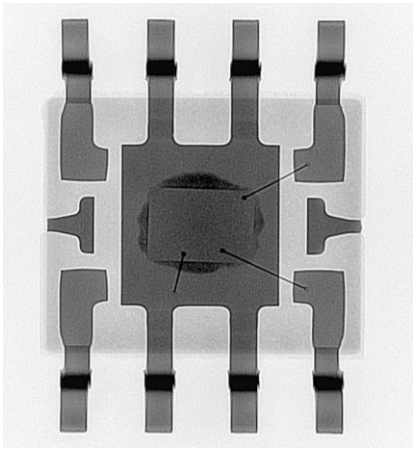
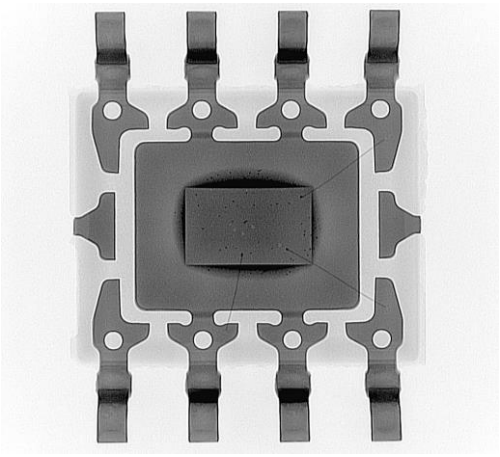
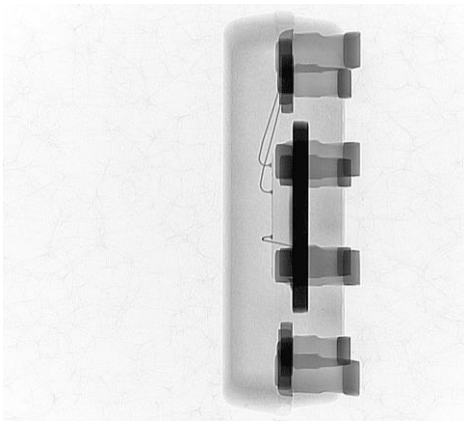
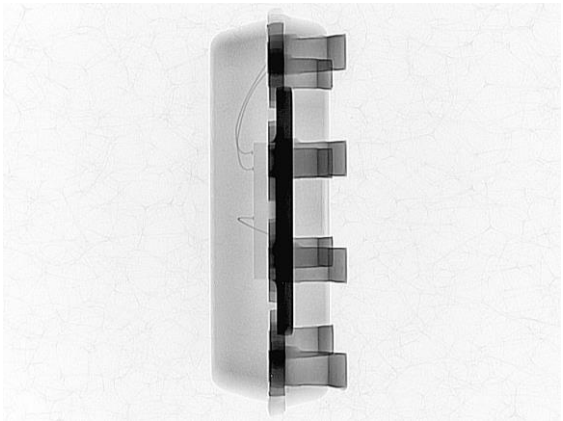
Part number	TL1431QDREP	TL1431AIYDT
Package marking top		
Package marking bottom		
X-ray top view		
X-ray side view		

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.

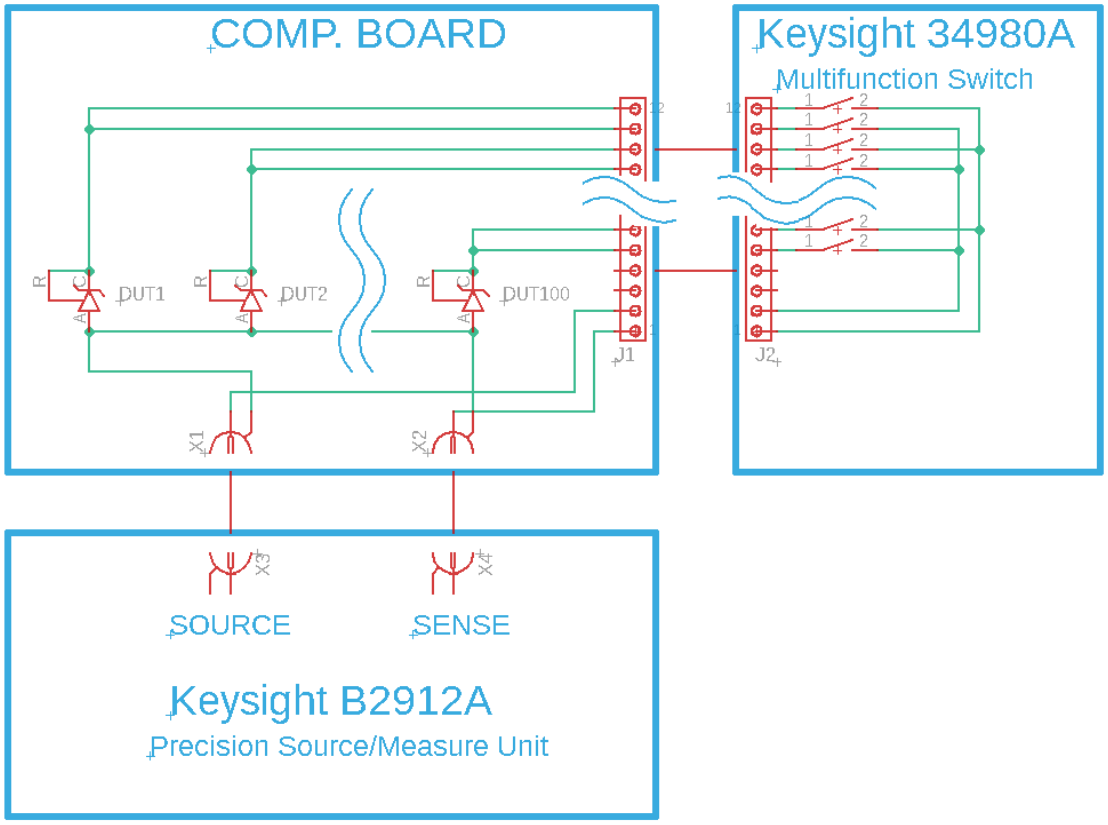


Figure 1: Simplified schematic of the overall test set-up

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
TL1431QDREP	10	mA
TL1431AIYDT	10	mA

Table 2: Biasing conditions during irradiation

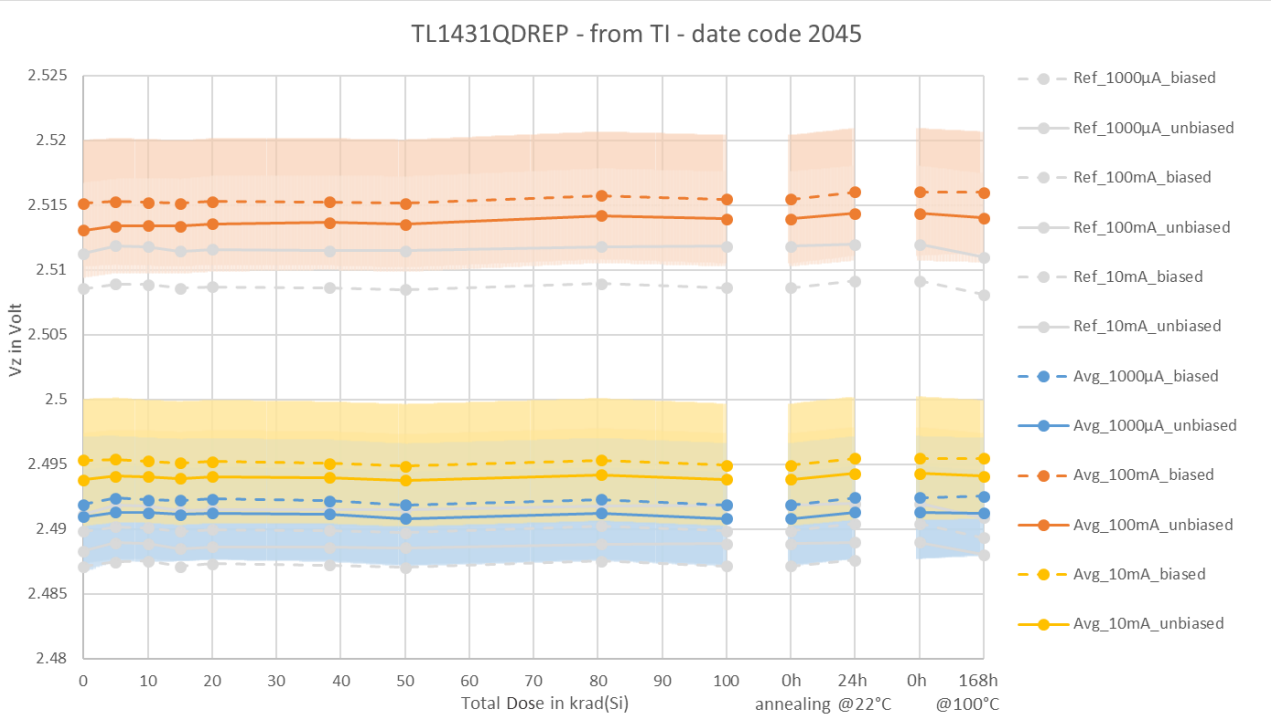
8. TID RESULTS

8.1. TID RESULTS - TL1431QDREP - from TI - date code 2045

TL1431QDREP - from TI - date code 2045 - @ I-min 1000µA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
C30	unbiased	2.4915	2.4918	2.4918	2.4916	2.4916	2.4916	2.4912	2.4916	2.4912	2.4916	2.4918
C31		2.4878	2.4880	2.4880	2.4878	2.4880	2.4878	2.4875	2.4879	2.4875	2.4879	2.4881
C32		2.4891	2.4899	2.4899	2.4897	2.4898	2.4899	2.4894	2.4899	2.4895	2.4900	2.4906
C33		2.4970	2.4972	2.4972	2.4971	2.4972	2.4970	2.4968	2.4971	2.4967	2.4973	2.4965
C34		2.4894	2.4896	2.4896	2.4894	2.4896	2.4895	2.4892	2.4896	2.4892	2.4897	2.4891
C35	biased	2.4935	2.4936	2.4934	2.4933	2.4934	2.4932	2.4930	2.4934	2.4930	2.4935	2.4936
C36		2.4964	2.4965	2.4964	2.4962	2.4963	2.4962	2.4959	2.4963	2.4959	2.4965	2.4956
C37		2.4969	2.4969	2.4968	2.4967	2.4967	2.4966	2.4962	2.4967	2.4963	2.4968	2.4973
C38		2.4859	2.4859	2.4858	2.4855	2.4857	2.4855	2.4852	2.4856	2.4851	2.4857	2.4861
C39		2.4868	2.4890	2.4888	2.4895	2.4895	2.4894	2.4891	2.4895	2.4891	2.4897	2.4902
REF23	Ref unbiased	2.4883	2.4889	2.4889	2.4885	2.4886	2.4886	2.4886	2.4888	2.4889	2.4890	2.4880
REF73	Ref biased	2.4871	2.4875	2.4875	2.4871	2.4873	2.4872	2.4870	2.4875	2.4871	2.4876	2.4867

TL1431QDREP - from TI - date code 2045 - @ I-typ 10mA											Limit acc. DS: Vz = 2.5V ± 1.2% (2.47V – 2.53V)	
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
C30	unbiased	2.4942	2.4945	2.4945	2.4943	2.4944	2.4944	2.4941	2.4945	2.4941	2.4946	2.4946
C31		2.4905	2.4907	2.4907	2.4905	2.4907	2.4906	2.4904	2.4909	2.4904	2.4909	2.4909
C32		2.4924	2.4928	2.4928	2.4925	2.4927	2.4927	2.4925	2.4930	2.4926	2.4931	2.4935
C33		2.4998	2.5000	2.5000	2.4999	2.5000	2.4999	2.4997	2.5001	2.4998	2.5002	2.4994
C34		2.4922	2.4924	2.4923	2.4922	2.4924	2.4923	2.4921	2.4925	2.4922	2.4927	2.4920
C35	biased	2.4964	2.4964	2.4963	2.4962	2.4963	2.4961	2.4960	2.4964	2.4960	2.4966	2.4965
C36		2.4993	2.4994	2.4993	2.4991	2.4992	2.4991	2.4989	2.4994	2.4990	2.4995	2.4986
C37		2.4997	2.4998	2.4996	2.4995	2.4996	2.4995	2.4992	2.4997	2.4993	2.4998	2.5001
C38		2.4886	2.4886	2.4885	2.4884	2.4884	2.4883	2.4880	2.4885	2.4881	2.4887	2.4889
C39		2.4926	2.4927	2.4925	2.4924	2.4925	2.4924	2.4921	2.4926	2.4922	2.4928	2.4932
REF23	Ref unbiased	2.4911	2.4918	2.4918	2.4914	2.4915	2.4915	2.4915	2.4918	2.4918	2.4920	2.4909
REF73	Ref biased	2.4898	2.4902	2.4901	2.4898	2.4900	2.4899	2.4897	2.4902	2.4899	2.4904	2.4893

TL1431QDREP - from TI - date code 2045 - @ I-max 100mA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
C30	unbiased	2.5130	2.5133	2.5134	2.5133	2.5135	2.5136	2.5134	2.5141	2.5138	2.5143	2.5141
C31		2.5096	2.5099	2.5100	2.5099	2.5101	2.5102	2.5101	2.5108	2.5105	2.5110	2.5107
C32		2.5123	2.5126	2.5126	2.5125	2.5127	2.5129	2.5127	2.5134	2.5131	2.5136	2.5140
C33		2.5192	2.5195	2.5196	2.5195	2.5197	2.5198	2.5197	2.5203	2.5201	2.5205	2.5195
C34		2.5113	2.5116	2.5116	2.5116	2.5117	2.5118	2.5118	2.5123	2.5121	2.5125	2.5117
C35	biased	2.5168	2.5169	2.5169	2.5168	2.5169	2.5170	2.5168	2.5175	2.5172	2.5178	2.5176
C36		2.5193	2.5194	2.5194	2.5193	2.5194	2.5194	2.5193	2.5200	2.5197	2.5202	2.5193
C37		2.5191	2.5193	2.5191	2.5190	2.5192	2.5191	2.5191	2.5197	2.5194	2.5199	2.5202
C38		2.5078	2.5079	2.5079	2.5078	2.5079	2.5079	2.5077	2.5084	2.5080	2.5086	2.5087
C39		2.5127	2.5129	2.5128	2.5128	2.5129	2.5129	2.5127	2.5133	2.5130	2.5135	2.5142
REF23	Ref unbiased	2.5113	2.5119	2.5118	2.5115	2.5116	2.5115	2.5115	2.5118	2.5118	2.5120	2.5110
REF73	Ref biased	2.5086	2.5089	2.5089	2.5086	2.5087	2.5086	2.5085	2.5089	2.5086	2.5092	2.5081



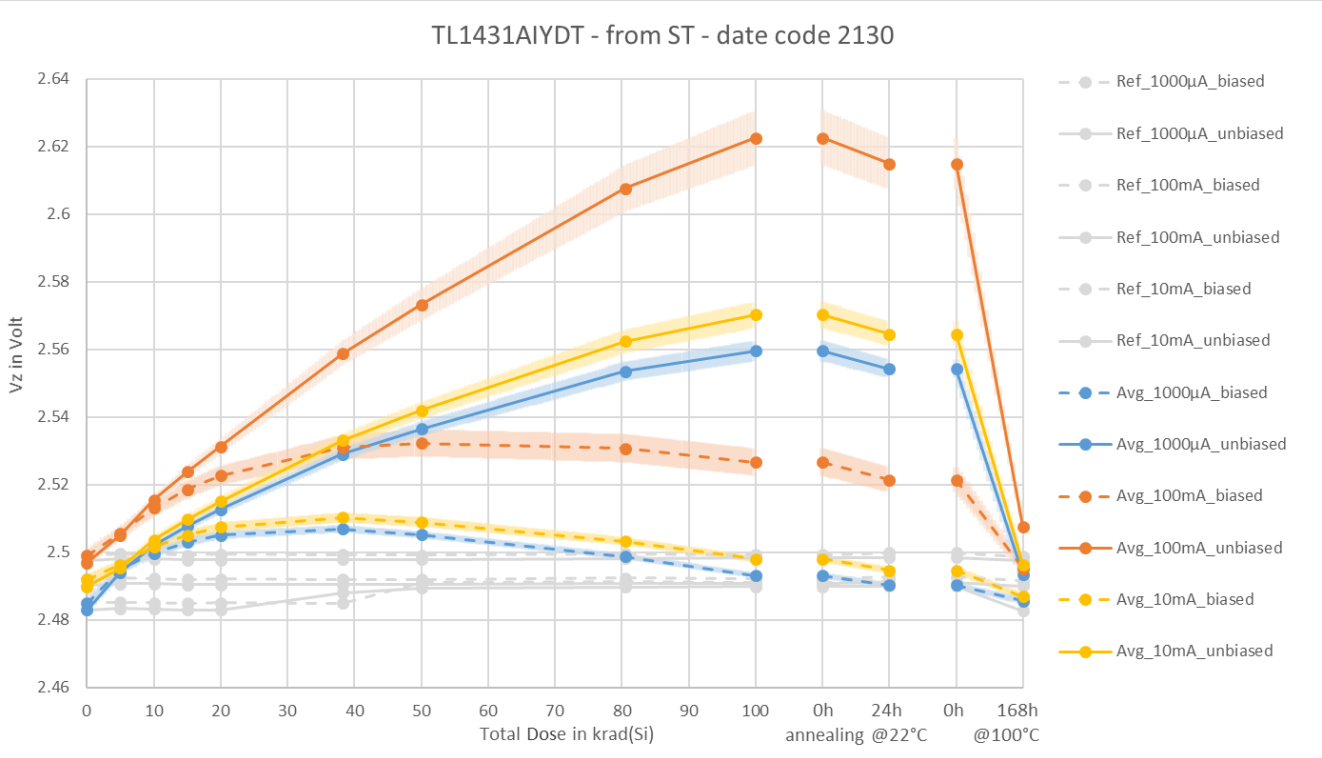
For all curves, which show an average over all measured samples, the coloured interval behind the curves represent +/- one standard deviation.

8.2. TID RESULTS - TL1431AIYDT - from ST - date code 2130

TL1431AIYDT - from ST - date code 2130 - @ I-min 1000µA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
C40	unbiased	2.4847	2.4959	2.5039	2.5097	2.5149	2.5316	2.5393	2.5567	2.5627	2.5571	2.4969
C41		2.4828	2.4936	2.5018	2.5074	2.5122	2.5287	2.5367	2.5545	2.5611	2.5556	2.4943
C42		2.4829	2.4942	2.5024	2.5082	2.5131	2.5294	2.5373	2.5546	2.5608	2.5554	2.4948
C43		2.4827	2.4938	2.5014	2.5069	2.5115	2.5270	2.5337	2.5494	2.5549	2.5502	2.4887
C44		2.4820	2.4931	2.5010	2.5068	2.5118	2.5282	2.5357	2.5525	2.5582	2.5529	2.4932
C45	biased	2.4853	2.4950	2.4999	2.5032	2.5051	2.5067	2.5050	2.4979	2.4923	2.4893	2.4857
C46		2.4865	2.4958	2.5007	2.5039	2.5058	2.5078	2.5059	2.4994	2.4940	2.4912	2.4866
C47		2.4858	2.4953	2.5003	2.5035	2.5055	2.5072	2.5054	2.4987	2.4927	2.4898	2.4859
C48		2.4822	2.4928	2.4976	2.5008	2.5031	2.5052	2.5035	2.4979	2.4928	2.4898	2.4839
C49		2.4851	2.4955	2.5003	2.5036	2.5057	2.5077	2.5060	2.4999	2.4940	2.4910	2.4859
REF24	Ref unbiased	2.4830	2.4834	2.4833	2.4829	2.4830	2.4880	2.4894	2.4897	2.4899	2.4900	2.4827
REF74	Ref biased	2.4851	2.4853	2.4851	2.4849	2.4850	2.4849	2.4910	2.4914	2.4912	2.4917	2.4846

TL1431AIYDT - from ST - date code 2130 - @ I-typ 10mA											Limit acc. DS: Vz = 2.5V ± 1.2% (2.47V – 2.53V)	
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
C40	unbiased	2.4916	2.4971	2.5055	2.5117	2.5173	2.5358	2.5448	2.5658	2.5736	2.5679	2.4988
C41		2.4892	2.4949	2.5034	2.5095	2.5148	2.5331	2.5426	2.5641	2.5726	2.5666	2.4962
C42		2.4899	2.4955	2.5039	2.5102	2.5156	2.5337	2.5428	2.5638	2.5718	2.5661	2.4966
C43		2.4895	2.4950	2.5028	2.5086	2.5135	2.5304	2.5382	2.5569	2.5639	2.5589	2.4952
C44		2.4889	2.4944	2.5025	2.5088	2.5142	2.5322	2.5411	2.5612	2.5691	2.5632	2.4950
C45	biased	2.4923	2.4965	2.5018	2.5054	2.5077	2.5104	2.5092	2.5029	2.4976	2.4942	2.4870
C46		2.4930	2.4972	2.5024	2.5059	2.5082	2.5111	2.5097	2.5038	2.4986	2.4956	2.4878
C47		2.4928	2.4968	2.5023	2.5058	2.5082	2.5109	2.5096	2.5038	2.4981	2.4948	2.4872
C48		2.4895	2.4941	2.4991	2.5026	2.5051	2.5078	2.5065	2.5015	2.4966	2.4933	2.4850
C49		2.4924	2.4969	2.5020	2.5056	2.5081	2.5111	2.5097	2.5044	2.4989	2.4956	2.4871
REF24	Ref unbiased	2.4902	2.4908	2.4907	2.4904	2.4905	2.4904	2.4904	2.4908	2.4909	2.4910	2.4900
REF74	Ref biased	2.4920	2.4924	2.4923	2.4920	2.4922	2.4920	2.4920	2.4924	2.4922	2.4927	2.4916

TL1431AIYDT - from ST - date code 2130 - @ I-max 100mA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
C40	unbiased	2.4987	2.5068	2.5175	2.5260	2.5337	2.5622	2.5771	2.6122	2.6277	2.6199	2.5104
C41		2.4965	2.5049	2.5158	2.5243	2.5318	2.5605	2.5760	2.6126	2.6290	2.6208	2.5082
C42		2.4973	2.5055	2.5161	2.5246	2.5323	2.5601	2.5750	2.6105	2.6257	2.6181	2.5083
C43		2.4960	2.5038	2.5135	2.5212	2.5279	2.5529	2.5655	2.5960	2.6090	2.6023	2.5052
C44		2.4961	2.5042	2.5145	2.5229	2.5305	2.5582	2.5726	2.6066	2.6215	2.6135	2.5061
C45	biased	2.4997	2.5065	2.5142	2.5200	2.5242	2.5331	2.5347	2.5330	2.5289	2.5234	2.4960
C46		2.4999	2.5065	2.5138	2.5192	2.5232	2.5315	2.5326	2.5308	2.5268	2.5218	2.4960
C47		2.5002	2.5068	2.5147	2.5204	2.5248	2.5338	2.5354	2.5342	2.5298	2.5243	2.4961
C48		2.4958	2.5023	2.5090	2.5140	2.5179	2.5248	2.5255	2.5237	2.5198	2.5150	2.4924
C49		2.4993	2.5063	2.5136	2.5191	2.5234	2.5320	2.5332	2.5322	2.5279	2.5226	2.4955
REF24	Ref unbiased	2.4976	2.4982	2.4981	2.4978	2.4978	2.4978	2.4978	2.4981	2.4983	2.4984	2.4974
REF74	Ref biased	2.4991	2.4996	2.4994	2.4992	2.4994	2.4993	2.4992	2.4996	2.4994	2.4999	2.4988

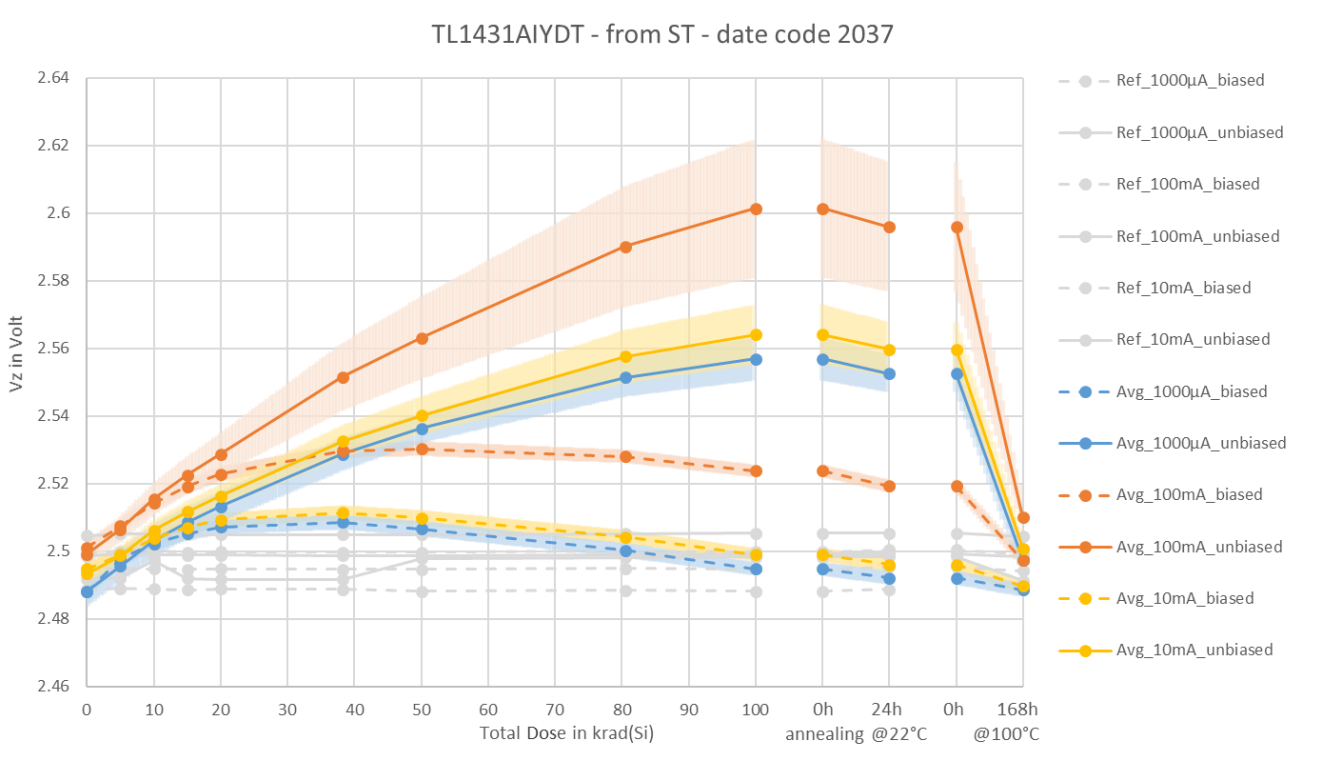


8.3. TID RESULTS - TL1431AIYDT - from ST - date code 2037

TL1431AIYDT - from ST - date code 2037 - @ I-min 1000µA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
C50	unbiased	2.4894	2.5008	2.5085	2.5138	2.5185	2.5343	2.5413	2.5576	2.5635	2.5587	2.5024
C51		2.4950	2.5000	2.5075	2.5126	2.5170	2.5325	2.5398	2.5557	2.5617	2.5567	2.5019
C52		2.4858	2.4910	2.4979	2.5039	2.5086	2.5236	2.5321	2.5456	2.5505	2.5470	2.4940
C53		2.4840	2.4952	2.5031	2.5083	2.5130	2.5290	2.5366	2.5529	2.5585	2.5536	2.4961
C54		2.4864	2.4915	2.4984	2.5043	2.5090	2.5240	2.5321	2.5454	2.5499	2.5465	2.4933
C55	biased	2.4859	2.4961	2.5008	2.5036	2.5057	2.5073	2.5053	2.4991	2.4937	2.4910	2.4870
C56		2.4884	2.4983	2.5029	2.5057	2.5076	2.5088	2.5069	2.5003	2.4948	2.4922	2.4893
C57		2.4884	2.4983	2.5029	2.5059	2.5079	2.5093	2.5073	2.5009	2.4955	2.4930	2.4893
C58		2.4903	2.5004	2.5050	2.5081	2.5101	2.5115	2.5097	2.5033	2.4976	2.4950	2.4910
C59		2.4874	2.4954	2.4999	2.5027	2.5046	2.5059	2.5039	2.4978	2.4923	2.4896	2.4861
REF25	Ref unbiased	2.4917	2.4921	2.4974	2.4919	2.4917	2.4916	2.4979	2.4982	2.4983	2.4984	2.4912
REF75	Ref biased	2.4888	2.4891	2.4889	2.4887	2.4888	2.4887	2.4882	2.4884	2.4882	2.4888	2.4886

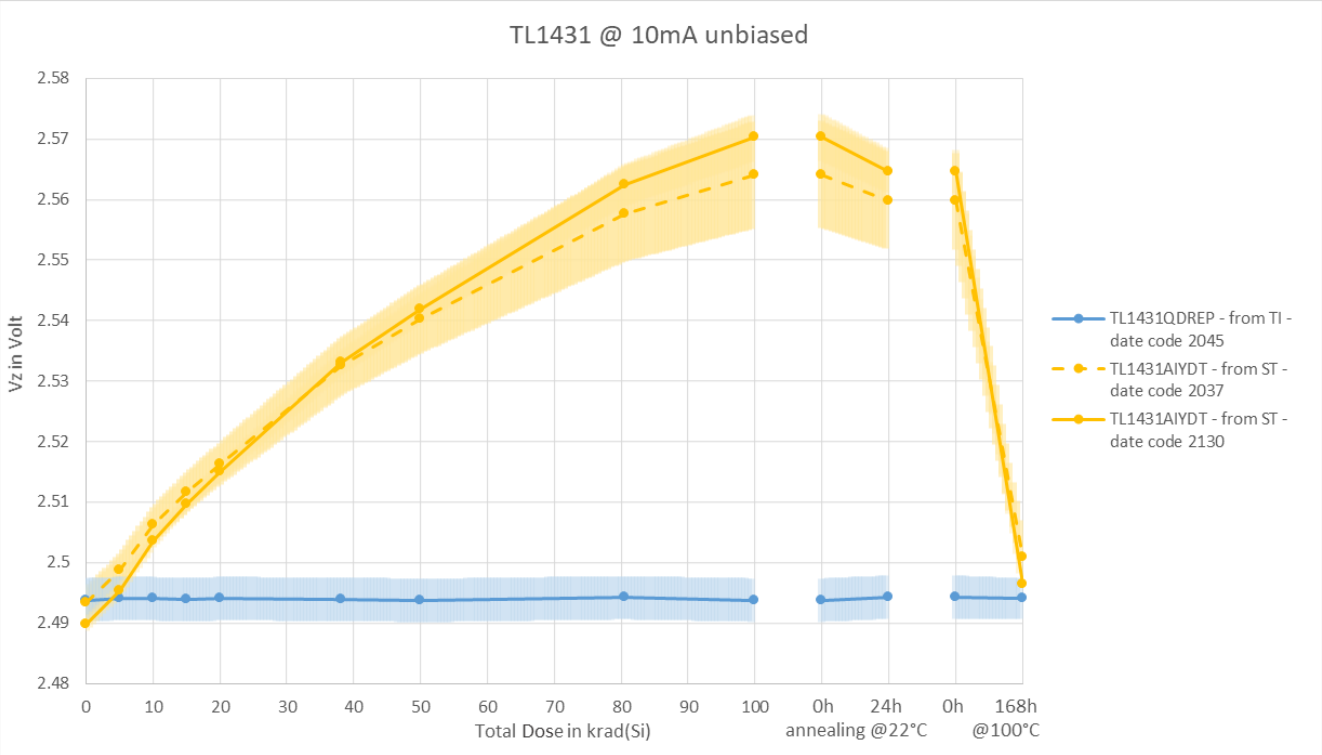
TL1431AIYDT - from ST - date code 2037 - @ I-typ 10mA											Limit acc. DS: Vz = 2.5V ± 1.2% (2.47V – 2.53V)	
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
C50	unbiased	2.4964	2.5019	2.5099	2.5157	2.5206	2.5379	2.5460	2.5653	2.5726	2.5677	2.5042
C51		2.4959	2.5012	2.5089	2.5145	2.5192	2.5363	2.5447	2.5635	2.5709	2.5658	2.5037
C52		2.4918	2.4967	2.5035	2.5087	2.5131	2.5275	2.5344	2.5492	2.5548	2.5513	2.4996
C53		2.4907	2.4965	2.5046	2.5102	2.5153	2.5329	2.5414	2.5607	2.5678	2.5626	2.4978
C54		2.4923	2.4972	2.5041	2.5092	2.5135	2.5279	2.5343	2.5493	2.5544	2.5510	2.4989
C55	biased	2.4930	2.4973	2.5023	2.5055	2.5077	2.5100	2.5085	2.5029	2.4977	2.4948	2.4881
C56		2.4956	2.4996	2.5046	2.5077	2.5098	2.5118	2.5103	2.5044	2.4992	2.4962	2.4903
C57		2.4953	2.4996	2.5045	2.5078	2.5100	2.5121	2.5106	2.5049	2.4997	2.4969	2.4905
C58		2.4972	2.5016	2.5066	2.5099	2.5121	2.5143	2.5129	2.5071	2.5017	2.4988	2.4921
C59		2.4927	2.4968	2.5014	2.5046	2.5067	2.5089	2.5072	2.5018	2.4966	2.4937	2.4873
REF25	Ref unbiased	2.4985	2.4991	2.4991	2.4988	2.4988	2.4988	2.4988	2.4991	2.4992	2.4993	2.4983
REF75	Ref biased	2.4946	2.4950	2.4948	2.4946	2.4947	2.4947	2.4946	2.4950	2.4947	2.4954	2.4942

TL1431AIYDT - from ST - date code 2037 - @ I-max 100mA												
DUT No.	krad (Si)	0	5	10	15	20	38.2	50	80.5	100	Room Temp. annealing	100°C annealing
C50	unbiased	2.5029	2.5108	2.5207	2.5285	2.5353	2.5610	2.5738	2.6051	2.6185	2.6122	2.5149
C51		2.5024	2.5101	2.5198	2.5272	2.5339	2.5593	2.5726	2.6036	2.6169	2.6103	2.5144
C52		2.4966	2.5027	2.5105	2.5167	2.5221	2.5404	2.5497	2.5704	2.5789	2.5750	2.5067
C53		2.4970	2.5051	2.5153	2.5228	2.5298	2.5558	2.5691	2.6006	2.6136	2.6069	2.5081
C54		2.4970	2.5034	2.5112	2.5173	2.5227	2.5412	2.5501	2.5709	2.5792	2.5751	2.5058
C55	biased	2.4991	2.5054	2.5122	2.5170	2.5207	2.5276	2.5281	2.5257	2.5215	2.5170	2.4956
C56		2.5018	2.5082	2.5150	2.5199	2.5237	2.5306	2.5313	2.5289	2.5246	2.5200	2.4980
C57		2.5018	2.5082	2.5150	2.5201	2.5237	2.5305	2.5311	2.5289	2.5246	2.5202	2.4984
C58		2.5035	2.5100	2.5167	2.5217	2.5254	2.5322	2.5330	2.5304	2.5259	2.5215	2.4996
C59		2.4992	2.5054	2.5120	2.5169	2.5206	2.5276	2.5282	2.5264	2.5222	2.5176	2.4952
REF25	Ref unbiased	2.5046	2.5052	2.5052	2.5049	2.5049	2.5049	2.5049	2.5052	2.5053	2.5054	2.5044
REF75	Ref biased	2.4996	2.5000	2.5000	2.4997	2.4999	2.4998	2.4997	2.5000	2.4999	2.5004	2.4994



8.1. Comparison Manufacturer and Date Code

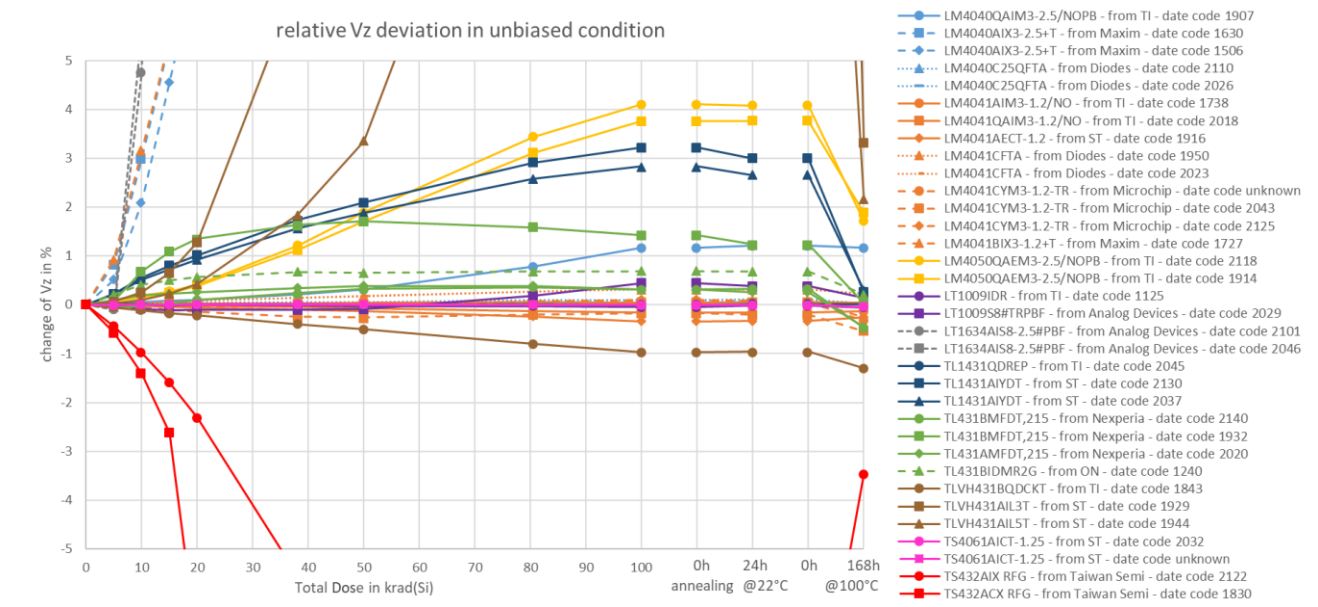
The following graph shows the different behaviour of all measured TL1431 voltage references with different date codes and from different manufacturers.

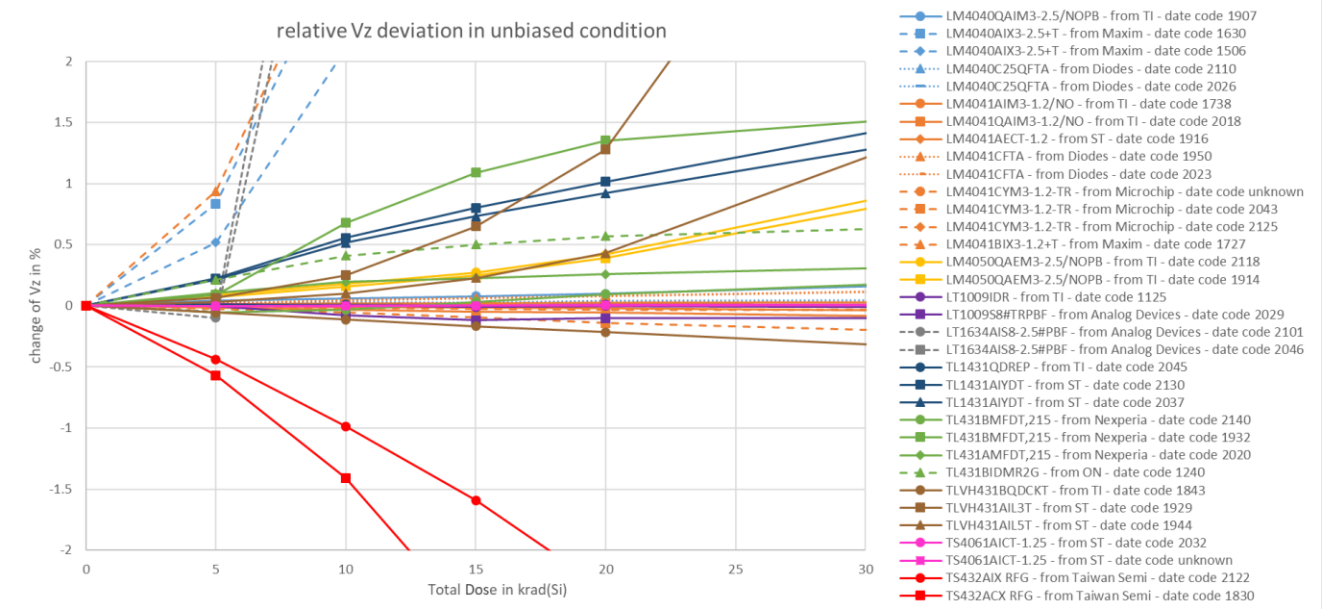


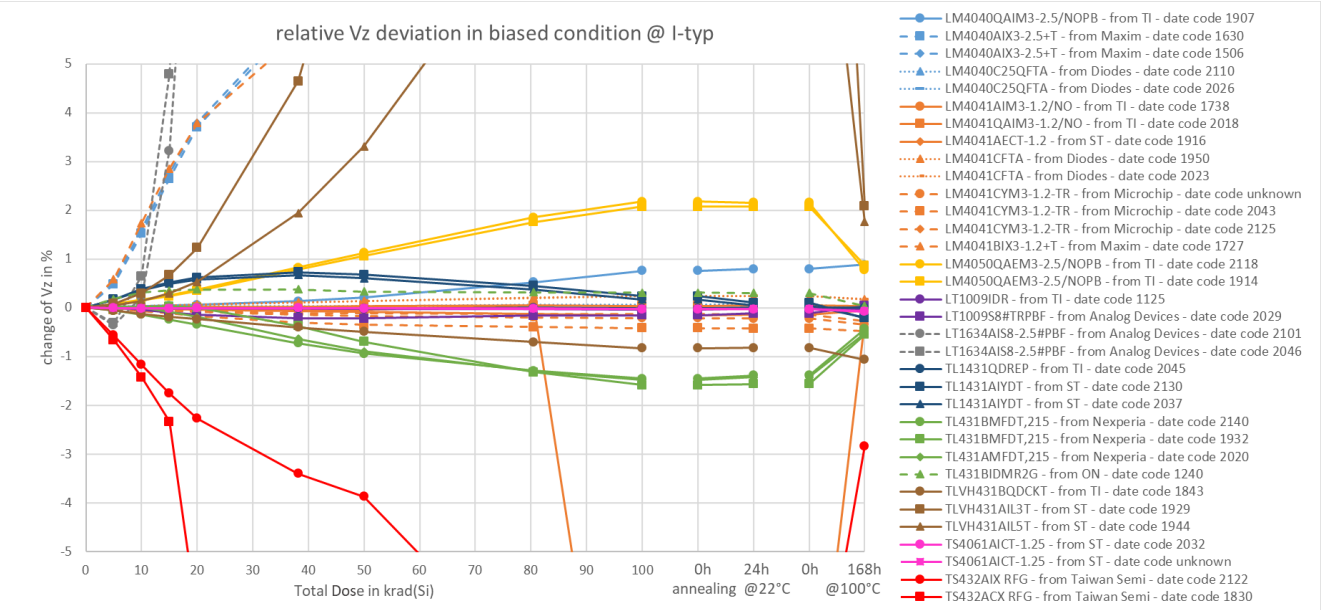
All curves plotted show the average value of all unbiased tested samples (worst case) and the interval behind the curves represent +/- one standard deviation.

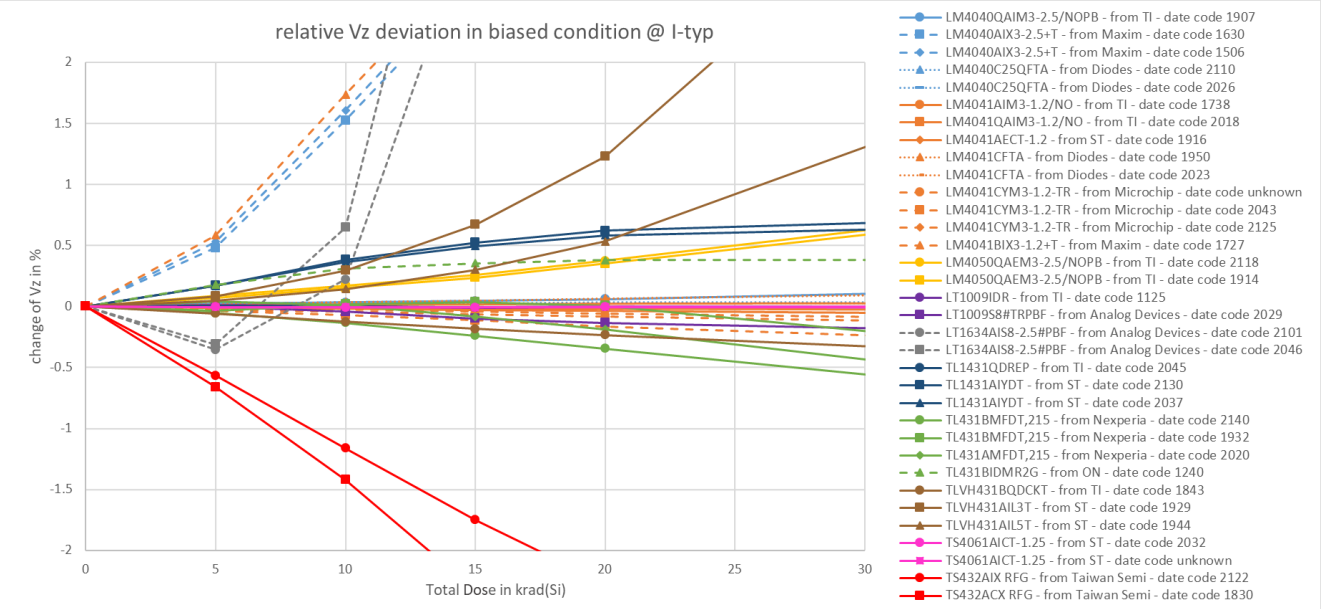
8.2. Comparison with other tested Bandgap References

The following four graphs show the results of the TL1431 Bandgap Voltage References compared to different Bandgap References part types, which were tested at the same time with the same test setup than the TL1431. 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 below 20 krad.

The deviation of tested components from the two different date codes show a similar behaviour in respect of TID effects.
The deviation of tested components from the two different manufactures however show a very different behaviour.

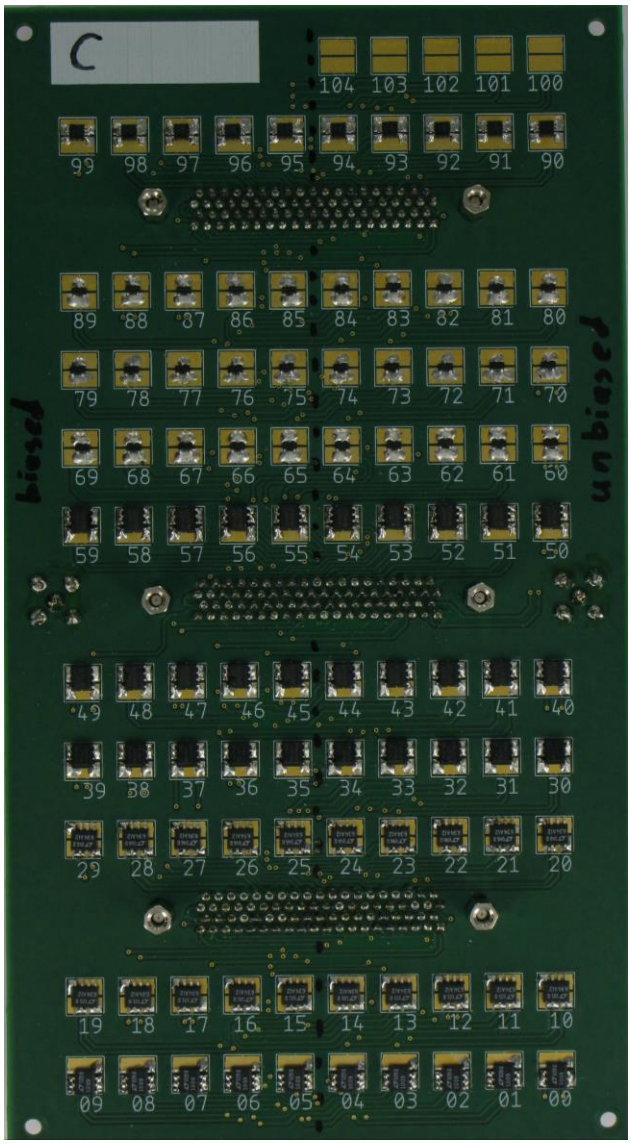
In general, a higher deviation was found for the unbiased samples.

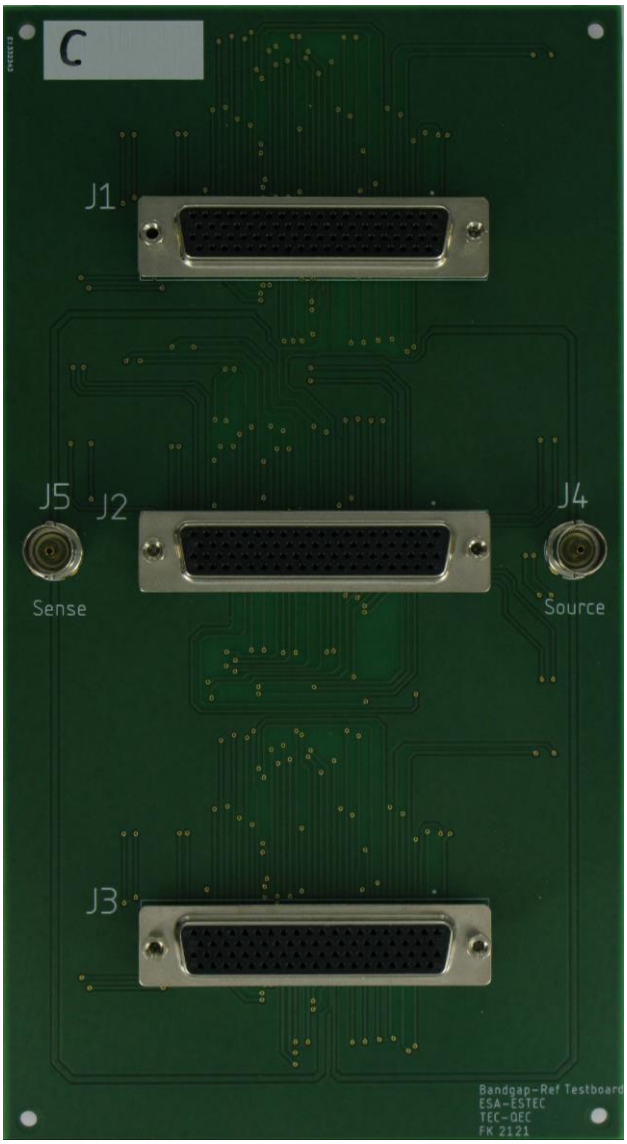
ANNEX A – DATASHEET

Part Type	Manufacturer	Link to Datasheet
TL1431QDREP	Texas Instruments	https://www.ti.com/lit/ds/symlink/tl1431-q1.pdf?HQS=dis-dk-null-digikeymode-dsf-pf-null-wwe&ts=1618212379928
TL1431AIYDT	STMicroelectronics	https://www.st.com/content/ccc/resource/technical/document/datasheet/43/6d/9e/69/31/63/4b/6e/CD00001246.pdf/files/CD00001246.pdf/jcr:content/translations/en.CD00001246.pdf

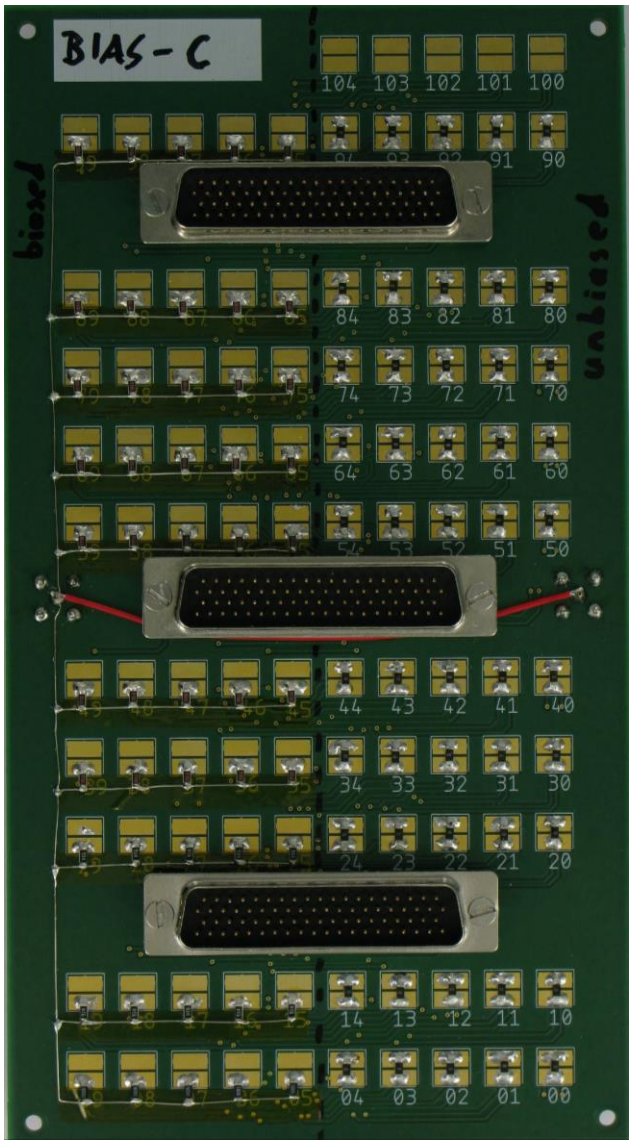
ANNEX B – SET-UP

Test board front- and backside with the TL1431 on position 30 to 59 on board C:

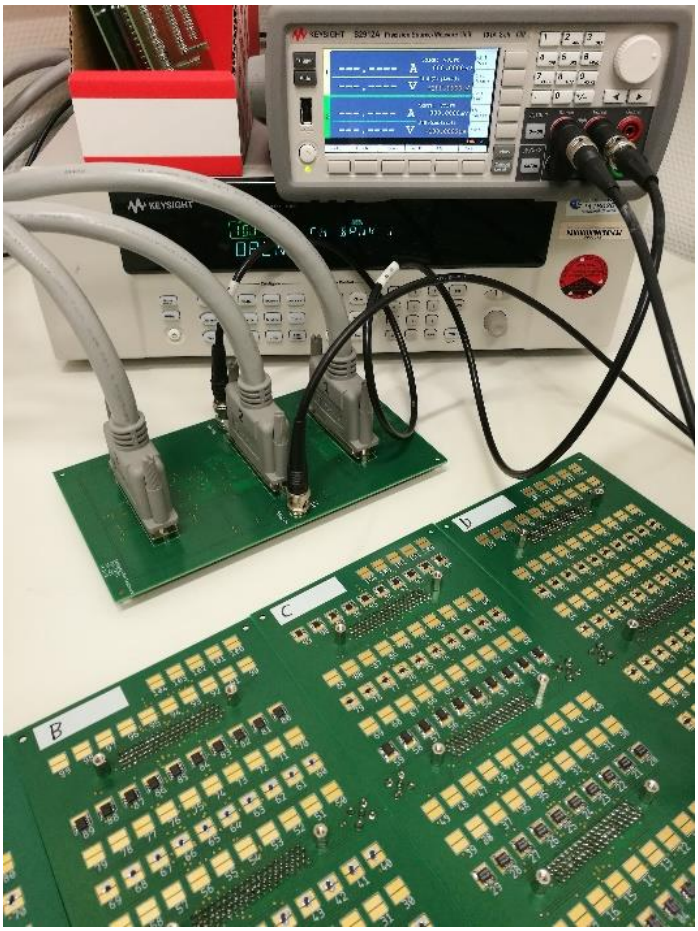




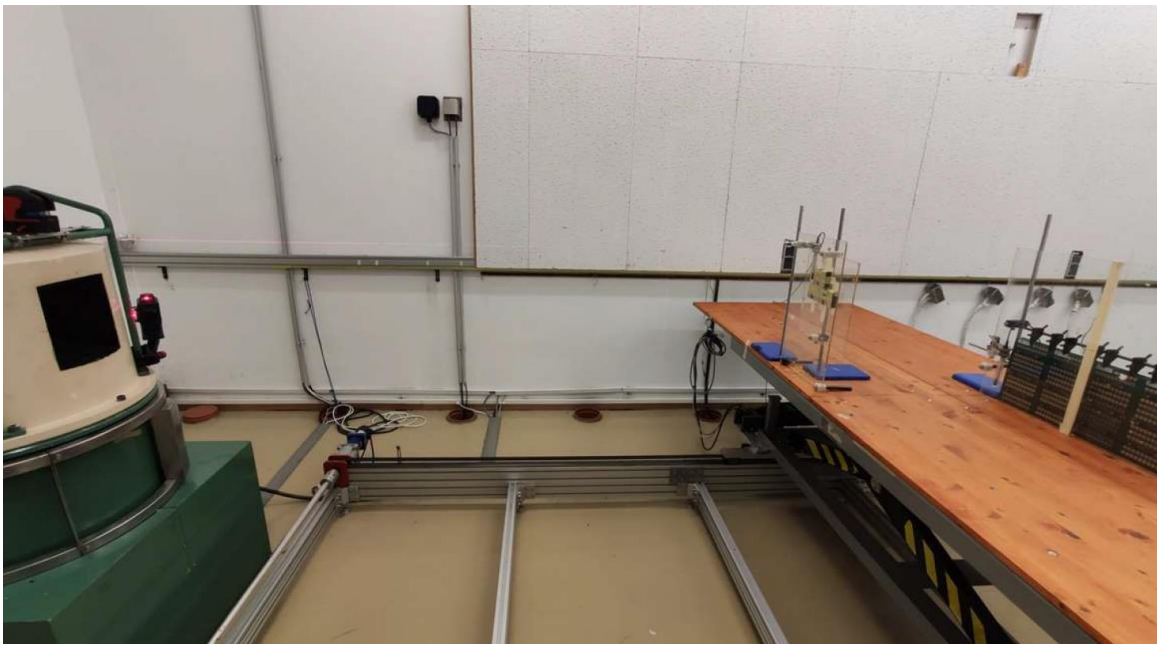
Biasing board front- and backside with the biasing resistors on it:

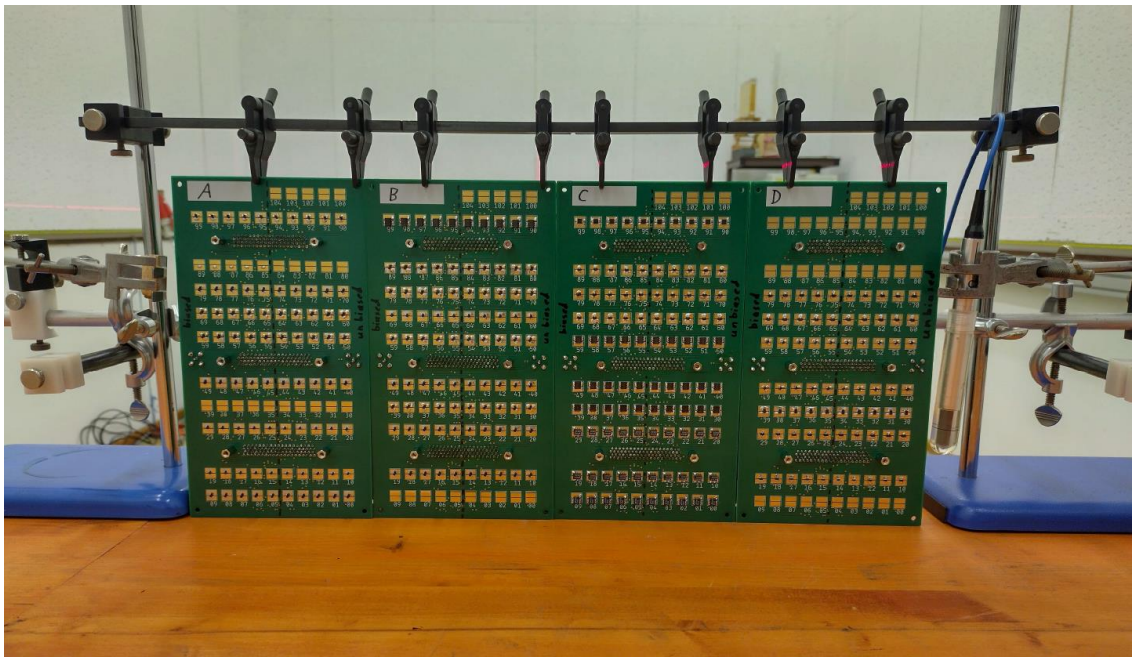


Measurement setup with the cable connection from the Test Board to the Switching Matrix and the Source Measure Unit:



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

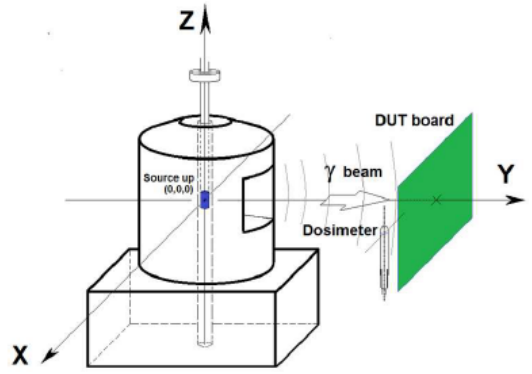


Figure 1 Co-60 irradiator head and board positioning sketch

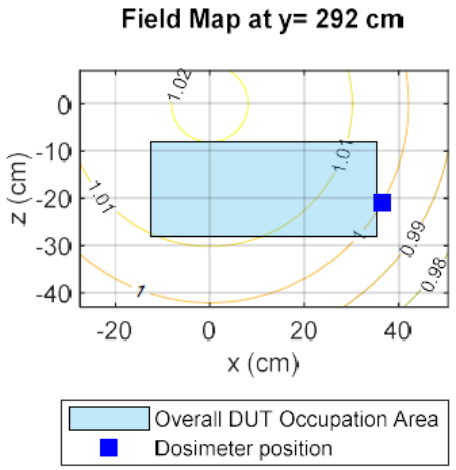


Figure 2: Qualitative indication of dose rate distribution normalized to dosemeter readings. Axes origin located at source centre. Graphs for information only, of the run with highest dose rate.