Total Ionizing Dose Test Report for the UC1823A Pulse Width Modulator

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I. Introduction

The purpose of this study is to examine the total ionizing dose susceptibility for the UC1823A pulse width modulator manufactured by Texas Instruments, Inc. The part is suspected to be vulnerable to enhanced low dose rate sensitivity (ELDRS).

II. Device Description

The UC1823A is a pulse width modulator (PWM) controller. Table I shows the part and test information. Figure 1 shows the pin configuration of the 16-terminal dual in-line package (DIP.) The detailed device specifications can be found in the manufacturer's datasheet [1].

Table I
Test and part information.

Generic Part Number	UC1823A
DLA drawing	5962-8990502VEA
Manufacturer	Texas Instruments
Lot/Date Code	1345
Quantity tested	10
Part Function	Pulse Width Modulator
Package Style	16-pin dual-inline-package
Test Equipment	Keithley 2430 1kW pulse meter, Keithley 2425 100W source meter, oscilloscope, power supply.
Test Engineer	James Forney
Dose Levels	3, 6, 9, 12, 18, and 30 krad(Si)
Target Dose Rate	10 mrad(Si)/s

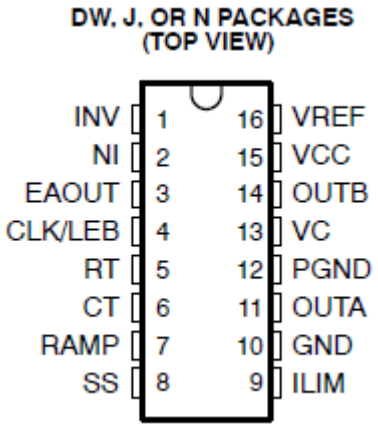

Figure 1. Pin configuration for the UC1823A.

III. Test Method

A. Irradiation Procedure

The irradiation procedures and dosimetry requirements conform to MIL-STD-883-H Test Method 1019 [2]. The irradiation was be carried out in a room air source gamma ray facility. Active dosimetry was performed using air ionization probes. The devices under test (DUT) were be placed inside a standard Pb/Al filter box.

B. Device Characterization

Ten samples were irradiated under the bias configuration shown in Figure 2. The parts were operational during exposure. Five samples were characterized *in situ*, where the parts remained actively biased after exposure. The other five samples were characterized after they were taken out of their biased state. Table II shows the parameters to be extracted for each set of bias condition. Note that only critical parameters (e.g. output voltage, supply current, and possibly input bias current and offset voltage) are extracted for the parts that remain biased on. The test conditions are also shown below.

We evaluated the different bias conditions due to the total dose response of some PWMs, where the parts that are continuously biased on can show higher total dose tolerance than parts that are switched off prior to characterization [3].

The control samples were characterized before the irradiated devices. The DUTs were characterized in the same order throughout the test. The measurement sequence was also be consistent throughout the test.

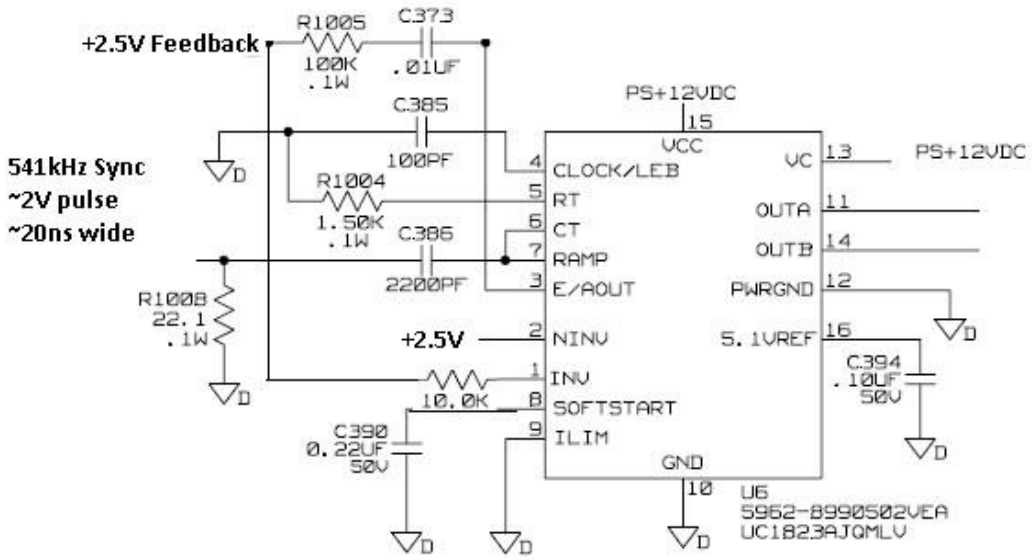

Figure 1. Schematic diagram of the irradiation bias configuration.

Test Conditions

Test temperature: Room temperature
Frequency: 541 kHz
Supply voltage: 12 V
Non-inverting V_{IN}: 2.5 V
Device parameters: *Refer to datasheet for measurement conditions*

Table II
Device parameters.

	Irradiation bias condition	
Parameter	**Switched on/off**	**Continuously on**
Output	Low-level output saturation High-level output saturation	Low-level output saturation High-level output saturation
Vref	V_O	V_O
Oscillator	I_{OSC}	
	f_{OSC}	
Error Amplifier	I_B	
	I_{OS}	
	V_{OS}	
PWM Comparator	I_B	
UVLO	Start threshold	
	Stop threshold	
Supply Current	I_{CC}	I_{CC}

IV. Results

All parts remained functional throughout the irradiation up to 30 krad(Si). The two bias conditions yielded similar results. Figure 2 shows the average input bias current of the error amplifier vs. total dose for the parts that were taken out of their biased state during characterization. Figure 3 shows the average input offset voltage of the error amplifier vs. total dose for the same set of parts. All other measured parameters showed negligible drift with total dose. Raw data attachment files can be found in the Appendix.

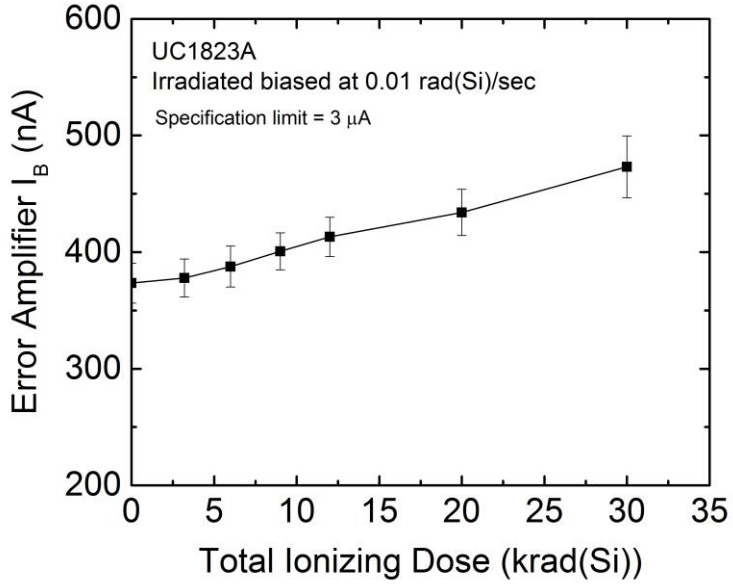

Figure 2. Input bias current vs. total dose for parts irradiated under bias.

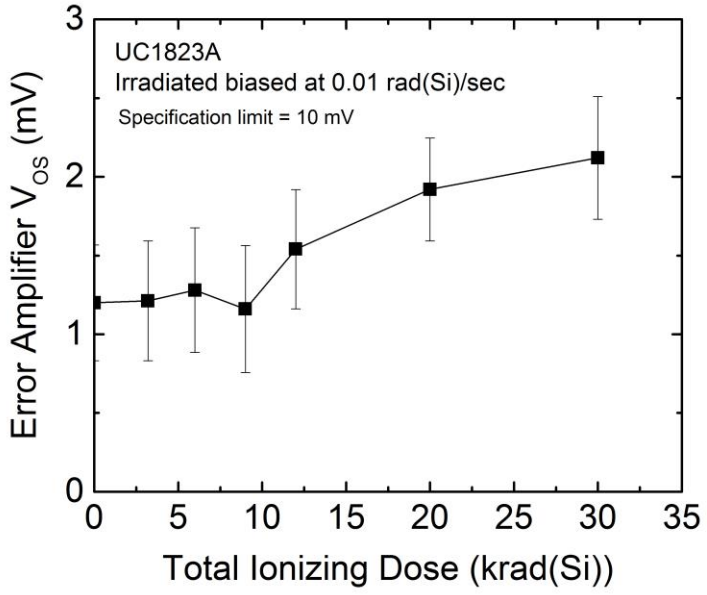

Figure 3. Input offset voltage vs. total dose for parts irradiated under bias.

V. Reference

[1] Texas Instruments, "High-speed PWM controller," UC1823 datasheet, Aug. 1995 [Revised Sept. 2010].

[2] MIL-STD-883-H, Test Method 1019.8, Ionizing Radiation (Total Dose) Test Procedure Feb. 26, 2010.

[3] P. Adell *et al*., "Total-dose and single-event effects in DC/DC converter control circuitry," *IEEE Trans. Nucl. Sci*., vol. 50, no. 6, pp. 1867 – 1872, Dec. 2003.

VI. Appendix A

dose rate	0.6	(rad/min)							
	Total Dose (Krad)		0	3.2	6	9	12	20	30
Dut_1		unit							
Reference		V	5.107	5.108	5.1	5.108	5.109	**5.11**	**5.11**
Amplitude (A)		V	10.72	10.68	10.6	10.8	10.64	**10.66**	**10.66**
Amplitude (B)		V	10.48	10.43	10.4	10.6	10.4	**10.4**	**10.39**
Ramp (Peak)		V	2.69	2.73	2.79	2.83	2.72	**2.74**	**2.73**
Ramp (Valley)		V	1.09	1.08	**1**	0.98	1.09	**1.09**	**1.09**
Icc		mA	27.4	26	26.4	26.2	26.3	**26.3**	**26.2**
Frequency (B)		Khz	438	437	437	438.2	439.7	441	**441**
error Amp offset		mV	1.5	1.56	1.7	1.6	1.9	**2**	**2.1**
Error Amp bias +		nA	381	384	391	406	428	459	**521**
Error Amp bias -		nA	401	404	408	416	422	446	**471**
UVLO (start)		v	9	9	9	9.01	9.01	9	**9**
UVLO (stop)		v	8.2	8.4	8.43	8.4	8.4	8.4	**8.4**
	Total Dose (Krad)		0	3.2	6	9	12	20	30
Dut_2		unit							
Reference		V	5.09	5.096	5.096	5.097	5.09	5.097	**5.098**
Amplitude (A)		V	10.72	**10.67**	10.6	10.8	10.75	10.71	**10.71**
Amplitude (B)		V	10.48	10.48	10.4	10.6	10.4	10.47	**10.4**
Ramp (Peak)		V	2.73	2.73	2.72	2.83	2.71	2.71	**2.75**
Ramp (Valley)		V	1.077	1.06	0.962	**0.968**	1.06	1.06	**1.05**
Icc		mA	25.54	25.4	25.7	25.7	25.7	25.5	**25.6**
Frequency (B)		Khz	426	426	425	427.2	427	427.5	**430**
error Amp offset		mV	1.2	1.2	1.2	1.1	1.5	2	**2.1**
Error Amp bias +		nA	341	348	357	377	396	419	**483**
Error Amp bias -		nA	349	354	369	378	385	413	**435**
UVLO (start)		v	9.1	9.1	9.1	9.1	9	9.1	**9**
UVLO (stop)		v	8.1	8.4	8.3	8.3	8.4	8.4	**8.4**
	Total Dose (Krad)		0	3.2	6	9	12	20	30
Dut_3		unit							
Reference		V	5.092	5.09	5.092	5.094	5.094	5.095	**5.097**
Amplitude (A)		V	10.71	10.67	10.6	10.8	10.74	10.72	**10.71**
Amplitude (B)		V	10.4	10.48	10.4	10.6	10.4	10.41	**10.4**
Ramp (Peak)		V	2.83	2.82	2.86	2.98	2.82	2.85	**2.82**
Ramp (Valley)		V	1.11	1.1	1.01	0.984	1.1	1.09	**1.11**
Icc		mA	25.5	25.5	25.9	25.8	25.9	25.7	**25.8**
Frequency (B)		Khz	412	413	413	414	415.6	415.5	**417**
error Amp offset		mV	1.2	1.2	1.2	1	1.4	1.9	**2.1**
Error Amp bias +		nA	382	381	382	395	406	416	**457**
Error Amp bias -		nA	373	374	381	389	393	405	**417**
UVLO (start)		v	9	9.1	9	9.2	9.1	9.1	**9**
UVLO (stop)		v	8.4	8.41	8.4	8.4	8.4	8.5	**8.5**

	Total Dose (Krad)		0	3.2	6	9	12	20	30
Dut_4		unit							
Reference		V	5.103	5.103	5.104	5.105	5.106	5.107	**5.109**
Amplitude (A)		V	10.72	10.67	10.6	10.8	10.72	10.69	**10.69**
Amplitude (B)		V	10.4	10.48	10.4	10.6	10.41	10.41	**10.4**
Ramp (Peak)		V	**2.82**	2.81	2.86	2.96	2.81	2.82	**2.8**
Ramp (Valley)		V	1.105	1.09	0.97	0.999	1.09	1.07	**1.11**
Icc		mA	26.3	26.4	26.5	26.5	26.5	26.4	**26.5**
Frequency (B)		Khz	415	416	415	416.5	418	417.8	**420**
error Amp offset		mV	0.6	0.6	0.7	0.6	1	1.4	**1.6**
Error Amp bias +		nA	381	386	409	421	434	447	**488**
Error Amp bias -		nA	377	387	408	413	421	431	**457**
UVLO (start)		v	9	9	9	9	9	8.9	**9**
UVLO (stop)		v	8.3	8.4	8.3	8.2	8.4	8.3	**8.4**
	Total Dose (Krad)		0	3.2	6	9	12	20	30
Dut_5		unit							
Reference		V	5.09	5.09	5.09	5.092	5.09	5.093	**5.094**
Amplitude (A)		V	**10.64**	10.67	10.6	10.8	10.74	10.69	**10.71**
Amplitude (B)		V	10.4	**10.35**	10.4	10.6	10.4	10.4	**10.4**
Ramp (Peak)		V	2.82	2.81	2.87	2.97	2.81	2.834	**2.81**
Ramp (Valley)		V	1.101	1.086	0.964	0.96	1.08	1.069	**1.08**
Icc		mA	26	26	26	26.2	26.2	26.1	**26.1**
Frequency (B)		Khz	411	411	408	412.6	412	413.7	**415**
error Amp offset		mV	1.5	1.5	1.6	1.5	1.9	2.3	**2.7**
Error Amp bias		nA	**384**	**385**	**387**	**413**	**432**	**468**	**538**
Error Amp bias -		nA	365	375	384	398	414	436	**464**
UVLO (start)		v	9	9	9	9.1	9	8.9	**9**
UVLO (stop)		v	8.4	8.4	8.2	8.3	8.2	8.4	**8.4**
	Total Dose (Krad)		0	3.2	6	9	12	20	30
C		unit							
Reference		V	**5.1**	**5.109**	**5.1**	**5.11E+00**	**5.09**	**5.103**	**5.107**
Amplitude (A)		V	**10.9**	**10.9**	**1.098**	**1.09E+01**	**10.81**	**10.87**	**10.81**
Amplitude (B)		V	**10.6**	**10.6**	**10.6**	**10.6**	**10.48**	**10.4**	**10.42**
Ramp (Peak)		V	**2.92**	**2.93**	**2.94**	**2.95**	**2.832**	**2.88**	**2.84**
Ramp (Valley)		V	**1.4**	**1**	**0.998**	**0.987**	**1.1**	**1**	**1.09**
Icc		mA	**26.2**	**26.5**	**26.7**	**26.1**	**25.6**	**26**	**25.9**
Frequency (B)		Khz	**415**	**413**	**415**	**417**	**412.2**	**414**	**418**
error Amp offset		mV	**1.2**	**1.1**	**1.1**	**1.2**	**1.3**	**1.27**	**1.3**
Error Amp bias		nA	**407**	**406**	**408**	**409**	**409**	**407**	**395**
Error Amp bias -		nA	**586**	**587**	**584**	**588**	**583**	**586**	**588**
UVLO (start)		v	**9.01**	**9**	**9**	**9.1**	**9.1**	**9**	**9**
UVLO (stop)		v	**8.43**	**8.48**	**8.43**	**8.4**	**8.4**	**8.5**	**8.4**

Appendix B – Continuously Biased

dose rate	0.6	(rad/min)							
				3.3	5.4	8.3	12.8	20.9	30.0
	Total Dose (Krad)		0	3.2	6	9	12	18	30
Dut_1		unit							
Reference			5.098	5.097	5.098	5.097	5.097	5.099	5.099
Amplitude (B)			11.6	11.52	11.6	11.6	11.68	11.6	11.68
Frequency (B)			438155.9	437111	436638.1	437708.1	438303.4	441426.9	441176.6
Icc			0.028	0.028	0.029	0.028	0.028	0.028	-0.024
Ramp (Valley)			1.18	1.16	1.85	1.18	1.14	1.2	1.19
Ramp (Peak)			2.767	2.767	2.31	2.767	2.76	2.76	2.777
Amplitude (A)			11.52	11.6	11.6	11.6	11.6	11.52	11.64
Frequency (A)			437741.7	437013.1	437155.4	437892	438099.8	440491.7	441049.5
Error Amp			2.529	2.528	2.529	2.528	2.529	2.53	2.53
	Total Dose (Krad)		0	3.2	6	9	12	20	30
Dut_2		unit							
Reference			5.097	5.095	5.097	5.096	5.096	5.099	5.099
Amplitude (B)			11.6	11.6	11.52	11.6	11.6	11.6	11.68
Frequency (B)			433918.6	436655.3	433712.9	434044.4	435970.7	438321.1	440317
Icc			0.028	0.029	0.03	0.028	0.028	0.029	-0.023
Ramp (Valley)			1.22	1.22	1.25	1.24	1.22	1.22	1.25
Ramp (Peak)			2.8	2.8	2.803	2.793	2.747	2.793	2.81
Amplitude (A)			11.6	11.6	11.6	11.6	11.6	11.68	11.66
Frequency (A)			433150.6	433880.2	433459	434757.8	435667.7	438592.3	439575.3
Error Amp			2.547	2.546	2.547	2.546	2.546	2.548	2.541
	Total Dose (Krad)		0	3.2	6	9	12	20	30
Dut_3		unit							
Reference			5.102	5.1	5.102	5.101	5.102	5.105	5.107
Amplitude (B)			11.6	11.6	11.6	11.68	11.6	11.68	11.68
Frequency (B)			439894	438505.8	447008.7	445935.7	440698.3	444206.1	445633.8
Icc			0.027	0.027	0.027	0.027	0.027	0.027	-0.025
Ramp (Valley)			1.2	1.2	1.25	1.22	1.22	1.22	1.23
Ramp (Peak)			2.81	2.8	2.803	2.807	2.82	2.793	2.81
Amplitude (A)			11.6	11.6	11.68	11.6	11.6	11.68	11.66
Frequency (A)			438258.3	438014.4	438880.4	442297.4	442924.7	444165.6	445876.7
Error Amp			2.546	2.544	2.546	2.544	2.545	2.547	2.541

	Total Dose (Krad)		0	3.2	6	9	12	20	30
Dut_4		**unit**							
Reference			5.094	5.092	5.094	5.092	5.093	5.096	5.097
Amplitude (B)			11.6	11.68	11.6	11.68	11.68	11.68	11.76
Frequency (B)			418027.7	417458.9	417843.5	419965.4	420577.8	425506.9	425154.9
Icc			0.026	0.027	0.028	0.026	0.026	0.026	-0.026
Ramp (Valley)			1.32	1.18	1.21	1.2	1.18	1.2	1.21
Ramp (Peak)			2.773	2.787	2.783	2.78	2.787	2.76	2.783
Amplitude (A)			11.6	11.6	11.6	11.6	11.68	11.68	11.66
Frequency (A)			417631	417205.7	416667.4	417473.7	420293.1	420953.8	423524.9
Error Amp			2.544	2.542	2.544	2.542	2.542	2.544	2.538
	Total Dose (Krad)		**0**	**3.2**	**6**	**9**	**12**	**20**	**30**
Dut_5 (control)		**unit**							
Reference			5.097	5.095	5.097	5.094	5.095	5.097	5.096
Amplitude (B)			11.6	11.52	11.6	11.68	11.68	11.68	11.76
Frequency (B)			423355.3	424782.1	422587.2	420269.1	422093.6	427637.8	424582.9
Icc			0.025	0.026	0.029	0.025	0.025	0.025	-0.027
Ramp (Valley)			1.2	1.2	1.23	1.22	1.2	1.18	1.21
Ramp (Peak)			2.81	2.813	2.81	2.807	2.793	2.787	2.797
Amplitude (A)			11.52	11.6	11.68	11.68	11.6	11.68	11.66
Frequency (A)			422600.7	423848.9	422931.5	421680.8	421699.3	426341.6	424467.5
Error Amp			2.541	2.539	2.541	2.539	2.539	2.541	2.533