Radiation Performance of Actel Products

Version 9

Total Ionizing Dose (TID) Performance

Table 1 lists the TID data of Actel products published in the open domain. Also included is the availability of each product.

Two criteria are used to define the TID tolerance. One is if the DC/AC parametrics (primarily static I_{CC}) fall out of specification, and the other is if functional failure occurs.

The TID tolerance is dependent on the dose rate (rad(Si)/sec). This is because the higher the dose rate, the higher the radiation-enhanced I_{CC}, static or dynamic. Thus, an artificially high dose rate will cause the I_{CC} to be the first parameter to go out of specification. It is not practical to perform tests at the dose rate of a real space environment (from a few mrad(Si)/s to hundreds of mrad(Si)/s). Usually the testing strategy is to irradiate the product at a dose rate chosen for convenience of testing. Then do room temperature (biased) annealing to make the effective dose rate as low as possible. The effective dose rate ($\dot{R}_{eff}$) is:

$$\dot{R}_{eff} = \frac{R_{total}}{T_{rad} + T_{anneal}}$$

Where:

R_{total} = the total dose irradiated on the DUT (device under test)

T_{rad} = the irradiation time, and

T_{anneal} = the anneal time.

Extrapolation of the I_{CC} annealing curve is necessary to find the tolerance under the very slow dose rate in a real space environment. However, this was rarely done (an example is in reference HIR97).

Table 1: Total Ionizing Dose Performance of Actel Products

Foundry	Technology	Bias	Lot No	Tolerance (rad (Si))		Dose Rate (rad(Si)/ sec)	Tester	Reference	Product Availability
				DC/AC Spec	Functional				
A1010/A1020									
MEC	2.0µm	5.0V			>300k	13	APL	JPL92	Obsolete
MEC	2.0µm	5.0V		>100k	>100k		GE ASTRO	JPL92	Obsolete
A1020A									
MEC	1.2µm	5.0V			>100k	79	TRW	JPL92	Obsolete
MEC	1.2µm	5.0V			100k	13	APL	JPL92	Obsolete
A1020B									
MEC	1.0µm	5.0V		7k	20k	0.2-2	NASA/ Actel	RAD97	
RH1020									
LMFS	1.0µm	5.0V		300k[1]		~150	LMFS	LM97	Yes
RT1020									
LMSEC	0.8µm	5.0V	970159	100k	>100k	215.8	NASA/ Actel	ACT99d	Yes
A1280									
MEC	1.2µm	5.0V			20k		HAC	JPL92	Obsolete
MEC	1.2µm	5.0V		5k		13	APL	JPL92	Obsolete
A1280A									
MEC	1.0µm	5.0V		5k-6k		0.003	HIREC	HIR95	
MEC	1.0µm	5.0V		5-10k		0.01-0.06	Unisys	EEE96	
MEC	1.0µm	5.0V			18k	0.16	SAAB/ ESA	ESA96	
MEC	1.0µm	5.0V		10k		0.0028	HIREC	HIR97	
RT1280A									
MEC	1.0µm	5.0V	U1H466	6k	>9k		NASA/ Actel		Sold Out
MEC	1.0µm	5.0V	U1H486	12k	>>12k	0.021	NASA/ Actel	ACT99a	Sold Out
MEC	1.0µm	5.0V	U1H609	10k	32k	0.0694	NASA/ Actel	ACT01a	Yes
MEC	1.0µm	5.0V	U1H611	7.6k	63k	0.0694, 0.104	NASA/ Actel	ACT01	Yes
A1280XL									

Notes:

1. RH1020 is QML qualified and guaranteed for 300 krad(Si).
2. RH1280 is QML qualified and guaranteed for 300 krad(Si). However, it's functionality tolerance is 2 Mrad(Si) for non-military temperature range (0-70 °C).

Table 1: Total Ionizing Dose Performance of Actel Products (Continued)

Foundry	Technology	Bias	Lot No	Tolerance (rad (Si))		Dose Rate (rad(Si)/ sec)	Tester	Reference	Product Availability
				DC/AC Spec	Functional				
WIN	0.8µm	5.0V		2.5k		0.2-2	NASA/ Actel	RAD97	
CSM	0.6µm	5.0V		2.5k		0.2-2	NASA/ Actel	RAD97	
RH1280									
LMFS	0.8µm	5.0V			2.0M[2]	171	LMFS	LM95a	Yes
LMFS	0.8µm	5.0V			2.0M[2]	164	LMFS	LM95b	Yes
LMFS	0.8µm	5.0V		300k[2]		152	LMFS	LM96a	Yes
A1425A									
MEC	0.8µm	5.0V	UCJ014 X	20k	40k	0.0694	NASA/ Actel		Yes
A1460A									
MEC	0.8µm	5.0V			54k-77k		SAAB/ ESA	ESA96	
MEC	0.8µm	5.0V		28k		0.2-2	NASA/ Actel	RAD97	
RT1460A									
MEC	0.8µm	5.0V	UCK062	12k	23k	0.0694	NASA/ Actel	ACT98b	Sold Out
MEC	0.8µm	5.0V	UCK069	16k	>16k	0.0694	NASA/ Actel	ACT00b	Yes
A14100A									
MEC	0.8µm	5.0V			>50k	0.139	SAAB/ ESA	ESA97	
MEC	0.8µm	3.3V			>50k	0.139	SAAB/ ESA	ESA97	
WIN	0.8µm	5.0V		5k		0.058	NASA/ Actel	RAD97	
RT14100A									
MEC	0.8mm	5.0V	UCL055	11k	15k	0.0463	NASA/ Actel	ACT98a	Sold Out
MEC	0.8mm	5.0V	UCL025	20k	32k	0.0463	NASA/ Actel		Sold Out
MEC	0.8mm	5.0V	UCL062 A	17.5k	>>17.5k	0.0694	NASA/ Actel	ACT99b	Sold Out

Notes:

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2. RH1280 is QML qualified and guaranteed for 300 krad(Si). However, it's functionality tolerance is 2 Mrad(Si) for non-military temperature range (0-70 °C).

Table 1: Total Ionizing Dose Performance of Actel Products (Continued)

Foundry	Technology	Bias	Lot No	Tolerance (rad (Si))		Dose Rate (rad(Si)/ sec)	Tester	Reference	Product Availability
				DC/AC Spec	Functional				
MEC	0.8mm	5.0V	UCL072	20k	>20k	0.0694	NASA/ Actel	ACT99e	Sold Out
MEC	0.8mm	5.0V	UCL073	20k	>20k	0.023	NASA/ Actel	ACT99f	Sold Out
MEC	0.8mm	5.0V	UCL082	20k	>20k	0.0694	NASA/ Actel	ACT00c	Yes
A32140DX									
CSM	0.6mm	5.0V			2.2k	0.2-2	NASA/ Actel	RAD97	
RT54SX16									
MEC	0.6mm	3.3/ 5.0V	Rev 1	100k		0.28	NASA/ Actel	NS98	
MEC	0.6mm	3.3/ 5.0V	P05 (rev0)	75k	100k	0.28	NASA/ Actel	ACT99c	Sold Out
MEC	0.6mm	3.3/ 5.0V	T6HP12 (rev1)	80k	>80k	0.28	NASA/ Actel	ACT00a	Ask
MEC	0.6µm	3.3/ 5.0V	T6HP12 D (rev1)	80k	152k (static), 240k (dynamic)	0.28	NASA/ Actel	ACT00f	Yes
RT54SX32									
MEC	0.6mm	3.3/ 5.0V	T6JP01 A	80k	>80k	0.28	NASA/ Actel	ACT00	Sold Out
MEC	0.6mm	3.3/ 5.0V	T6JP03	92k	140k	0.28	NASA/ Actel	ACT00d	Sold Out
MEC	0.6mm	3.3/ 5.0V	T6JP04	90k	130k	0.28	NASA/ Actel	ACT01d	Sold Out
MEC	0.6mm	3.3/ 5.0V	T6JP05	80k	105k	0.28	NASA/ Actel	ACT01c	Sold Out
RT54SX32S									
MEC	0.25µm	2.5/ 3.3V	T25JSP 03N	80k	135k	0.116, 0.28	NASA/ Actel	ACT01b	Yes
MEC	0.25µm	2.5/ 3.3V	T25JS00 1	80k	>100k	0.28	NASA/ Actel	ACT02	
MEC	0.25µm	2.5/ 3.3V	T25JS00 3	66k	>100k	16.7	Actel/ DMEA	ACT03	
MEC	0.25µm	2.5/ 3.3V	T25JS00 4	73k	>100k	16.7	Actel/ DMEA	ACT03a	

Notes:

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2. RH1280 is QML qualified and guaranteed for 300 krad(Si). However, it's functionality tolerance is 2 Mrad(Si) for non-military temperature range (0-70 °C).

Table 1: Total Ionizing Dose Performance of Actel Products (Continued)

Foundry	Technology	Bias	Lot No	Tolerance (rad (Si))		Dose Rate (rad(Si)/ sec)	Tester	Reference	Product Availability
				DC/AC Spec	Functional				
RT54SX72S									
MEC	0.25µm	2.5/ 3.3V	T25KS0 01	70k	>200k	0.28	NASA/ Actel	ACT02a	
MEC	0.25µm	2.5/ 3.3V	T25KS0 04	~50k	>100k	16.7	NASA/ Actel	ACT02b	
MEC	0.25µm	2.5/ 3.3V	T25KS0 05	51k	>113k	0.28	NASA/ Actel	ACT02c	
MEC	0.25µm	2.5/ 3.3V	T25KS0 06	66.8k	>100k	16.7	Actel/ DMEA	ACT03b	
MEC	0.25µm	2.5/ 3.3V	T25KS0 07	51k	>100k	0.28	NASA/ Actel	ACT02d	
MEC	0.25µm	2.5/ 3.3V	T25KS0 08	75k	>100k	0.28	Actel/ DMEA	ACT03c	

Notes:

1. RH1020 is QML qualified and guaranteed for 300 krad(Si).
2. RH1280 is QML qualified and guaranteed for 300 krad(Si). However, it's functionality tolerance is 2 Mrad(Si) for non-military temperature range (0-70 °C).

Dose Rate (Prompt Dose) Performance

Table 2: Dose Rate (Prompt Dose) Performance of Actel Products

Foundry	Technology	Threshold Dose Rate (rad(Si)/sec)		Temperature	Tester	Reference	Product Availability
		Upset	Survivability				
RH1020							
LMFS	0.8µm	$3.8x10^{7}$	$>3.0x10^{10}$	125°C	LMFS	LM98	Yes
RH1280							
LMFS	0.8µm	$1.0x10^{9}$	$>3.5x10^{10}$	125°C	LMFS	LM96a	Yes
RT54SX32							
MEC	0.6µm	$2.76x10^{10}$	$>7.1x10^{10}$	room	Actel/NASA	ACT00	Sold Out
RT54SX32S							
MEC	0.25µm	$1.1x10^{9}$	$>4.9x10^{9}$ (limited by facility problems)	room	Actel/NASA	ACT01e	Yes

Single Event Upset (SEU) and Single Event Latch-Up (SEL) Performance

Table 3 lists the SEU “soft error” data. Also included are the proton upset and single event latch-up (SEL) data.

- Devices with low (< 37.5 MeV-cm^2/mg) SEL LET_{th} are considered not suitable for space applications. Usually, the SEU is not measured once SEL occurs. This is the reason why some of the devices in the table have only SEL data.
- SEU LET_{th} is defined as when upset starts. $LET_{0.1}$ is defined as 10% of the saturation cross section.
- In the “Bit” column, C-C means a flip-flop made of two combinatorial modules, S is sequential module, I/O is input/output module, MS is the “modified sequential module” which only uses the combinatorial part of the sequential module, and FF is the flip-flop module.
- The worst-case bias condition was sometimes applied. The worst case is 90% nominal V_{CC} for SEU, and 110% nominal V_{CC} for SEL.

Table 3: Single Event Upset and Single Event Latch-Up Performance of Actel Products

Device	Bit	Tech/ Foundry	Bias (volts)	LET_{th} (MeV-cm^2/mg)	$LET_{0.1}$ (MeV-cm^2/mg)	X-section (cm^2/bit)	Latch-up LET_{th}	Proton Xsec cm^2/FF	Reference	Availability
ACT 1										
A1010	C-C	2.0/MEC	5.0		25	$5.0x10^{-6}$	No (>125)		JPL92	Obsolete
A1020	C-C	2.0/MEC	5.0		25	$5.0x10^{-6}$	No (>125)		JPL92	Obsolete
A1020A	C-C	1.2/MEC	5.0		22	$3.0x10^{-6}$	No (>80)		JPL92	Obsolete
A1020B	C-C	1.0/MEC	5.0		28	$2.0x10^{-6}$	50		EEE96	
A1020B		1.0/MEC	5.5				37		NS97	
A1020B		1.0/TI	5.5				22		NS97	
A1020S	C-C	1.0/MEC	5.0/5.5		~25	$2.0x10^{-6}$	No (>120)		NASA	Obsolete
A1020S	4C	1.0/MEC	5.0	37.2		$1.0x10^{-7}$			NASA	Obsolete
RH1020	C-C	0.8/LMFS	4.5	>8	25	$1.5x10^{-6}$	No (>74)	$1.5x10^{-15}$	NS98	Yes
ACT 2										
A1280	C-C	1.2/MEC	5.0	23		$3.0x10^{-6}$	No		EEE96	Obsolete
A1280	S	1.2/MEC	5.0	5		$8.0x10^{-6}$	No		EEE96	Obsolete
A1280A	C-C	1.0/MEC	5.0	27		$2.0x10^{-6}$	No (>100)		Koga	Yes
A1280A	C-C	1.0/MEC	5.0	28		$2.0x10^{-6}$	No		EEE96	Yes
A1280A	C-C	1.0/MEC	5.0	26		$3.0x10^{-6}$	No (>120)		ESA96	Yes
A1280A	S	1.0/MEC	5.0	3		$6.2x10^{-6}$	No (>100)		Koga	Yes

Table 3: Single Event Upset and Single Event Latch-Up Performance of Actel Products (Continued)

Device	Bit	Tech/ Foundry	Bias (volts)	LET_{th} (MeV-cm^2/mg)	$LET_{0.1}$ (MeV-cm^2/mg)	X-section (cm^2/bit)	Latch-up LET_{th}	Proton Xsec cm^2/FF	Reference	Availability
A1280A	S	1.0/MEC	5.0	5		$8.0x10^{-6}$	No		EEE96	Yes
A1280A	S	1.0/MEC	5.0	8		$1.5x10^{-6}$	No (>120)		ESA96	Yes
A1280A	S	1.0/MEC	4.5					$1.3x10^{-13}$	NS98	Yes
A1280A	I/O	1.0/MEC	5.0	28			No		EEE96	Yes
A1280A	I/O	1.0/MEC	5.0	15		$3.0x10^{-6}$	No (>120)		ESA96	Yes
A1280XL	C-C	0.8/WIN	5.0					0	EEE97	
A1280XL	S	0.8/WIN	5.0					Yes	EEE97	
A1280XL	I/O	0.8/WIN	5.0					0	EEE97	
A1280XL	C-C	0.6/CSM	5.0					0	EEE97	
A1280XL	S	0.6/CSM	5.0					Yes	EEE97	
A1280XL	I/O	0.6/CSM	5.0					0	EEE97	
RH1280	C-C	0.8/LMFS	4.5	17		$1.1x10^{-6}$	No (>85)		LM96	Yes
RH1280	C-C	0.8/LMFS	4.5	24		$2.0x10^{-6}$	No (>125)		LM95	Yes
RH1280	C-C	0.8/LMFS	5.0	22		$8.0x10^{-6}$	No		EEE96	Yes
RH1280	C-C	0.8/LMFS	5.0	27		$1.7x10^{-6}$	No (>120)		ESA96	Yes
RH1280	C-C	0.8/LMFS	3.3	15		$4.0x10^{-6}$	No (>120)		ESA96	Yes
RH1280	S	0.8/LMFS	4.5	4		$3.2x10^{-6}$	No (>85)		LM96	Yes
RH1280	S	0.8/LMFS	4.5	5		$8.5x10^{-6}$	No (>125)		LM95	Yes
RH1280	S	0.8/LMFS	5.0	3		$9.0x10^{-6}$	No		EEE96	Yes
RH1280	S	0.8/LMFS	5.0	8		$6.0x10^{-6}$	No (>120)		ESA96	Yes
RH1280	S	0.8/LMFS	3.3	5		$1.0x10^{-6}$	No (>120)		ESA96	Yes
RH1280	I/O	0.8/LMFS	5.0	15		$1.0x10^{-6}$	No (>120)		ESA96	Yes
RH1280	I/O	0.8/LMFS	3.3	10		$2.0x10^{-6}$	No (>120)		ESA96	Yes
RH1280	MS	0.8/LMFS	4.5	26		$5.1x10^{-6}$	No (>85)		LM96	Yes
ACT 3										
A1425A		0.8/MEC	5.5				No (>74)		NASA	Yes
A1460A	C-C	0.8/MEC	5.0			$2.0x10^{-7}$	No		EEE96	Yes

Table 3: Single Event Upset and Single Event Latch-Up Performance of Actel Products (Continued)

Device	Bit	Tech/ Foundry	Bias (volts)	LET_{th} (MeV-cm²/mg)	$LET_{0.1}$ (MeV-cm²/mg)	X-section (cm^2/bit)	Latch-up LET_{th}	Proton Xsec cm^2/FF	Reference	Availability
A1460A	C-C	0.8/MEC	5.0	32		$1.5x10^{-6}$	No (>120)		ESA96	Yes
A1460A	C-C	0.8/MEC	5.0	21				0	EEE97a	Yes
A1460A	C-C	0.8/MEC	3.3	25		$8.0x10^{-7}$	No		EEE96	Yes
A1460A	C-C	0.8/MEC	3.3	20		$3.0x10^{-6}$	No (>120)		ESA96	Yes
A1460A	S	0.8/MEC	5.0	>6		$1.0x10^{-6}$	No		EEE96	Yes
A1460A	S	0.8/MEC	5.0	8		$1.0x10^{-5}$	No (>120)		ESA96	Yes
A1460A	S	0.8/MEC	5.0	8				Yes	EEE97a	Yes
A1460A	S	0.8/MEC	3.3	<6		$2.0x10^{-6}$	No		EEE96	Yes
A1460A	S	0.8/MEC	3.3	6		$2.0x10^{-5}$	No (>120)		ESA96	Yes
A1460A	I/O	0.8/MEC	5.0	10		$2.0x10^{-6}$	No (>120)		ESA96	Yes
A1460A	I/O	0.8/MEC	5.0	8				Yes	EEE97a	Yes
A1460A	I/O	0.8/MEC	3.3	8		$7.0x10^{-6}$	No (>120)		ESA96	Yes
A14100A	C-C	0.8/MEC	5.0	28		$1.0x10^{-6}$	No	0	EEE97	Yes
A14100A	C-C	0.8/MEC	5.0	21				0	EEE97a	Yes
A14100A	C-C	0.8/MEC	5.0	30		$1.0x10^{-6}$	No (>112)	0	ESA97	Yes
A14100A	C-C	0.8/MEC	3.3	15		$3.0x10^{-6}$	No (>112)	0	ESA97	Yes
A14100A	S	0.8/MEC	5.0	8				Yes	EEE97	Yes
A14100A	S	0.8/MEC	5.0	8				Yes	EEE97a	Yes
A14100A	S	0.8/MEC	5.0	5		$7.0x10^{-6}$	No (>112)	$1.2x10^{-13}$	ESA97	Yes
A14100A	S	0.8/MEC	3.3	3		$3.0x10^{-6}$	No (>112)	$1.5x10^{-13}$	ESA97	Yes
A14100A	I/O	0.8/MEC	5.0	8				Yes	EEE97	Yes
A14100A	I/O	0.8/MEC	5.0	8				Yes	EEE97a	Yes
A14100A	I/O	0.8/MEC	5.0	15		$2.0x10^{-6}$	No (>112)	$4.0x10^{-14}$	ESA97	Yes
A14100A	I/O	0.8/MEC	3.3	10		$2.5x10^{-6}$	No (>112)	0	ESA97	Yes
DX										
A32140DX		0.6/CSM	5.5				No (>75)		NS97	
A32200DX		0.6/CSM	5.5				16		NS97	

Table 3: Single Event Upset and Single Event Latch-Up Performance of Actel Products (Continued)

Device	Bit	Tech/ Foundry	Bias (volts)	LET_{th} (MeV-cm^2/mg)	$LET_{0.1}$ (MeV-cm^2/mg)	X-section (cm^2/bit)	Latch-up LET_{th}	Proton Xsec cm^2/FF	Reference	Availability
SX										
RT54SX16	R	0.6/MEC	3.0	17		$3.0x10^{-6}$	No (>80)	0	RAD97	Yes
RH54SX16	R	0.6/LMFS	3.0	19		$1.5x10^{-6}$	No (>80)	0	RAD97	No
RH54SX16	C-C	0.6/LMFS	3.0	43		$2.0x10^{-8}$			NASA	No
RT54SX16	R	0.6/MEC	3.0					$6.3x10^{-15}$	NS98	Yes
RT54SX16		0.6/MEC	3.6				No (>120)		NASA	Yes
RT54SX32		0.6/MEC	3.6				No (>120)		NASA	Sold Out
RT54SX32	R	0.6/MEC	3.3		17	$2x10^{-6}$		0	Koga00	Sold Out
RT54SX32S	R	0.25/MEC	2.25	>50		$1.25x10^{-10}$			NASA00	Yes
RT54SX32S	R	0.25/MEC	2.5	63		$1.25x10^{-9}$			Koga01	Yes
RT54SX32S		0.25/MEC	2.75				No (>104)		NASA	Yes
RT54SX72S	R	0.25/MEC	2.25	>50		$2.5x10^{-11}$			NASA	Yes
RT54SX72S		0.25/MEC	2.75				No (>110)		NASA	Yes

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