



RADIATION PERFORMANCE OF ACTEL PRODUCTS

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I. TOTAL IONIZATION DOSE (TID) PERFORMANCE

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

1. Two criteria are used to define the TID tolerance. One is if DC/AC parametrics (primarily static I_{CC}) fall out of the specification, and the other is if functional failure occurs.
2. 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 make the I_{CC} the first parameter go out of specification. It is not practical to perform tests at the dose rate of real space environment (from few mrad(Si)/s to hundred μ rad(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} is the total dose irradiated on the DUT (device under test), T_{rad} is the irradiation time and T_{anneal} is the anneal time. Extrapolation of the I_{CC} annealing curve is necessary to find the tolerance under the very slow dose rate in real space environment. However, this was rarely done (an example is in reference [HIR97]).

3. 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)
4. RH1020 is QML qualified and guaranteed for 300 krad(Si).

TABLE I. TOTAL IONIZATION 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	Yes
A1020S									
MEC	1.0µm	5.0V	U1RT02 25	7k	>>7k	0.0694	NASA/Actel	ACT99	Yes
RH1020									
LMFS	1.0µm	5.0V		300k ⁴		~150	LMFS	LM97	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	Yes
MEC	1.0µm	5.0V		5-10k		0.01-0.06	Unisys	EEE96	Yes
MEC	1.0µm	5.0V			18k	0.16	SAAB/ESA	ESA96	Yes
MEC	1.0µm	5.0V		10k		0.0028	HIREC	HIR97	Yes
MEC	1.0µm	5.0V	U11H466	6k	>9k		NASA/Actel		Sold Out
MEC	1.0µm	5.0V	U1H486	12k	>>12k	0.021	NASA/Actel	ACT99a	Yes
A1280XL									
WIN	0.8µm	5.0V		2.5k		0.2-2	NASA/Actel	RAD97	Yes
CSM	0.6µm	5.0V		2.5k		0.2-2	NASA/Actel	RAD97	Yes
RH1280									
LMFS	0.8µm	5.0V			2.0M ³	171	LMFS	LM95a	Yes
LMFS	0.8µm	5.0V			2.0M ³	164	LMFS	LM95b	Yes
LMFS	0.8µm	5.0V		300k ³		152	LMFS	LM96a	Yes
A1425A									
MEC	0.8µm	5.0V	UCJ014X	20k	40k	0.0694	NASA/Actel		Yes
A1460A									
MEC	0.8µm	5.0V			54k-77k		SAAB/ESA	ESA96	Yes
MEC	0.8µm	5.0V		28k		0.2-2	NASA/Actel	RAD97	Yes
MEC	0.8µm	5.0V	UCK062	12k	23k	0.0694	NASA/Actel	ACT98b	Yes
A14100A									
MEC	0.8µm	5.0V			>50k	0.139	SAAB/ESA	ESA97	Yes
MEC	0.8µm	3.3V			>50k	0.139	SAAB/ESA	ESA97	Yes
MEC	0.8µm	5.0V	UCL055	11k	15k	0.0463	NASA/Actel	ACT98a	Yes
MEC	0.8µm	5.0V	UCL025	20k	32k	0.0463	NASA/Actel		PGA Only
MEC	0.8µm	5.0V	UCL062A	17.5k	>>17.5k	0.0694	NASA/Actel	ACT99b	Yes
WIN	0.8µm	5.0V		5k		0.058	NASA/Actel	RAD97	Yes
A32140DX									
CSM	0.6µm	5.0V			2.2k	0.2-2	NASA/Actel	RAD97	Yes
RT54SX16									

Foundry	Technology	Bias	Lot No	Tolerance (rad (Si))		Dose Rate (rad(Si)/sec)	Tester	Reference	Product Availability
				DC/AC Spec	Functional				
MEC	0.6μm	3.3/5.0V	Rev 1	100k		0.28	NASA/Actel	NS98	Yes
MEC	0.6μm	3.3/5.0V	P05 (rev0)	75k	100k	0.28	NASA/Actel	ACT99c	Yes
<i>RH54SX16</i>									
LMFS	0.6μm	3.3/5.0V		>200k		0.2-2	NASA/Actel	RAD97	Pre-prod

II. DOSE RATE (PROMPT DOSE) PERFORMANCE

TABLE II. DOSE RATE (PROMPT DOSE) PERFORMANCE OF ACTEL PRODUCTS

Foundry	Technology	Dose Rate (rad(Si)/sec)		Temperature	Tester	Reference	Product Availability
		Upset	Survivability				
<i>RH1020</i>							
LMFS	0.8μm	3.8x10 ⁷	>3.0x10 ¹⁰	125°C	LMFS	LM98	Yes
<i>RH1280</i>							
LMFS	0.8μm	1.0x10 ⁹	>3.5x10 ¹⁰	125°C	LMFS	LM96a	Yes

III. SINGLE EVENT UPSET (SEU) AND SINGLE EVENT LATCH-UP (SEL) PERFORMANCE

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

1. Devices with low ($< 37.5 \text{ MeV-cm}^2/\text{mg}$) 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.
2. SEU LET_{th} is defined at when upset starts. $\text{LET}_{0.1}$ is defined at 10% of the saturation cross section.
3. In the “Bit” column, C-C means 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.
4. The worst case bias condition sometimes was applied. For SEU, the worst case is 90% nominal V_{CC} , and 110% nominal V_{CC} for SEL.

TABLE III. SINGLE EVENT UPSET AND SINGLE EVENT LATCH-UP PERFORMANCE OF ACTEL PRODUCTS

Device	Bit	Tech/ Foundry	Bias (volts)	LET _{th}	LET _{0.1}	X-section (cm ² /bit)	Latchup	Proton Xsec cm ² /FF	Reference	Availability
				(MeV-cm ² /mg)	LET _{th}					
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	Yes
A1020B		1.0/MEC	5.5				37		NS97	Yes
A1020B		1.0 / TI	5.5				22		NS97	Yes
A1020S	C-C	1.0/MEC	5.0/5.5		~25	2.0x10 ⁻⁶	No (>120)		NASA	Yes
A1020S	4C	1.0/MEC	5.0	37.2		1.0x10 ⁻⁷			NASA	Yes
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
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	Yes
A1280XL	S	0.8/WIN	5.0					Yes	EEE97	Yes
A1280XL	I/O	0.8/WIN	5.0					0	EEE97	Yes
A1280XL	C-C	0.6/CSM	5.0					0	EEE97	Yes
A1280XL	S	0.6/CSM	5.0					Yes	EEE97	Yes
A1280XL	I/O	0.6/CSM	5.0					0	EEE97	Yes
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

Device	Bit	Tech/ Foundry	Bias (volts)	LET _{th}	LET _{0.1}	X-section (cm ² /bit)	Latchup LET _{th}	Proton Xsec cm ² /FF	Reference	Availability
				(MeV-cm ² /mg)						
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
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	Yes
A32200DX		0.6/CSM	5.5				16		NS97	Yes
SX										
RT54SX16	FF	0.6/MEC	3.0	17		3.0x10 ⁻⁶	No (>80)	0	RAD97	Yes
RH54SX16	FF	0.6/LMFS	3.0	19		1.5x10 ⁻⁶	No (>80)	0	RAD97	Pre-prod
RT54SX16	FF	0.6/MEC	3.0					6.3x10 ⁻¹⁵	NS98	Yes
RT54SX16		0.6/MEC	3.6				No (>120)		NASA	Yes
RT54SX16	C-C	0.6	3.0	43		2.0x10 ⁻⁸			NASA	Special P&R

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