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ESA-QCA00135-R97

Sensibilité aux événements singuliers des processeurs de signaux digitaux de la famille ADSP - 21020

La sensibilité aux effets singuliers du processeur de signal ADSP - 21020 de chez Analog Device a été testée sur des échantillons du commerce grâce à une source Cf^{252} et un accélérateur d'ions lourds. Les résultats portant sur 3 lots de pièces sont comparés et les faits importants sont soulignés.

Abstract

Radiation performance verification is one of the key elements in the development of a European radiation tolerant high performance 32-bit floating-point Digital Signal Processor (DSP). This project, both ESA and EC sponsored, transfers the US Analog Devices 21020 DSP design into a European semiconductor foundry having a suitable process for space qualification. The European DSP, the TSC21020E, will be manufactured by TEMIC/Matra MHS using their SCMOS 2RT+, 0.6 micron, 1 poly/3 metal process. In parallel with the design transfer, large efforts were put into the development of radiation test boards and test systems for verification tests.

One test system, the Single Event Effects (SEE) system, developed by Fraunhofer/IMS2 in Dresden, was used during Californium-252 laboratory testing at ESTEC and during two heavy ion test campaigns, one at Brookhaven National Laboratory and one at University Catholique de Louvain, Belgium. In this paper we present SEE results from these test sites where commercially available ADSP21020 DSP's from Analog Devices were tested. The Cf-252 results are presented in a summary format whereas the heavy ion results are detailed in depth. Test coverage and test conditions are also given together with a test site analysis and comparison of results.

The ESA Automated Transfer Vehicle (ATV) project will be one of the first users of the TSC21020E if it successfully passes the various planned tests. However, ATV need devices now for their flight demonstrator (to fly in May 1997) so the above mentioned radiation activity was brought forward in order to SEE characterise DSP's from the ATV demonstrator flight lot. These tests, performed on two ADSP-21020 devices from Analog Devices, were primarily carried out in order to characterise the ADSPs latch-up (SEL) behaviour and get a first impression of their Single Event Upset (SEU) response. In addition and for comparison, devices from two other lots were also tested at the same time. In total, data are presented for the three lots: ATV d/c 9211/9528, 2nd lot d/c 9426 and a new lot d/c 9623. The 1996 lot represents the latest AD re-design with DSP's processed and assembled at the new Singapore foundry.

Test System, Conditions and Facilities

Main features of the SEE test system will be described, test parameters and conditions given as well as test facility details and features.

SEE Results

"CASE"

Initial experience in testing ADSP-21020 DSP were obtained during a number of tests performed at ESTEC using the "CASE" system. Devices tested (file), Fluence in particles per cm^2, number of register SEUs, 0-1/1-0 transitions, register cross section results per cm^2, number of SELs, latch-up cross section results per device and numbers of other types of errors are presented in Table 1. As can be seen from this table fairly consistent data were obtained on the two devices tested from the ATV flight lot. Results show an average SEU sensitivity of 3.0E-7 cm^2/per bit but an uneven 0-1/1-0 bit error distribution. The 0-1 bit flip sensitivity is

File	Fluence	SEU	0-1	1-0	Per Bit	SEL	Device	CC	Wd	AE	DS	MU
1000	583300	872	187	685	3.2E-7	229	3.9E-4	34	12	25	5	0
1001	713925	969	184	785	3.0E-7	291	4.1E-4	11	27	11	16	0
1002	1101525	1490	340	1150	2.9E-7	454	4.1E-4	73	41	27	24	0
1003	508482	678	134	544	2.9E-7	220	4.3E-4	19	17	10	11	0
1004	449825	627	132	495	3.0E-7	163	3.6E-4	21	14	11	6	0
2000	737200	988	193	795	2.9E-7	335	4.5E-4	33	20	25	12	0
2001	535325	770	164	606	3.1E-7	245	4.6E-4	32	22	12	14	0
ATV	4629582	6394	1334	5060	**3.0E-7**	1937	**4.2E-4**	223	153	121	88	0

Table 1. "CASE" Results for ATV ADSP-21020.

1.23E-7 cm²/per bit in respect to the 1-0 of 4.74E-7 cm²/per bit, thus a 20 % to 80 % ratio. The average SEL sensitivity of 4.2E-4 cm²/device appear quite high for a Cf-252 test. Finally all other errors, corrupted control flow, watch-dog, address and failing DSP response have been measured to be 1.26E-4 cm²/device. *(the final table will show results from all three lots)*

Heavy Ion

Two devices from each of the three lots were heavy ion tested at BNL. Results for the two devices from the ATV flight lot are presented here in graphical form in Figures 1 to 4. These graphs shows, as a function of LET, the SEE cross section sensitivity per cm² per bit or per device. Register SEU sensitivity and 0-1/1-0 transitions (per bit) are presented in Figure 1. The strong preference for 1 to 0 bit flips are clearly visible. The 0 to 1 bit flip threshold LET is 11.5 MeV/(mg/cm²) with a ratio of 1/99. The ratio changes to 14/86, then stay fairly constant but climes towards the end to 37/63. The register SEU statistic at higher LETs is poor due to increased latch-up sensitivity which can be seen in Figure 2. The SEL threshold LET was found to be around 16.0 MeV/(mg/cm²) with a saturated level of >4.0E-2 cm²/device where 1 latch-up at a LET of 42.3 MeV/(mg/cm²) occur per 23 ions/cm².

Other than register SEU errors, corrupted control flow, watch-dog, address and failing DSP response errors have been grouped together as SEU device errors and plotted in Figure 3. The threshold for these errors follows the register 1 to 0 bit flip sensitivity but increases with a different slope. However, with all SEE data presented as cross section results per cm² per device, Figure 4 gives the full device sensitivity when testing 4608 register bits with a 50/50 test pattern.
(data from all three lots will be included and discussed)

Conclusions

With the verification of the SEE test system, the "Register test" programme and the SEE characterisation of three Analog Devices lots, the basic ground work has been performed for a full SEE characterisation of the TSC21020E, the European, radiation tolerant, high performance, 32-bit floating-point, DSP. Additionally, the SEE characterisation for ATV together with the data on the other lots have contributed significantly to our knowledge on the usage of ADSP-21020 in space.