Preliminary Low Temperature Tests of a Digital Signal Processor

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Abstract: This paper describes an initial experiment performed to assess the electrical behavior of the Innovative Integration board containing a Digital Signal Processor (DSP) with its JTAG (Blackhawk) connector at low temperatures. The objective of the experiment is to determine the lowest temperature at which the DSP can operate. The DSP was tested at various low-temperatures and a Genetic Algorithm was used as the DSP test program.

1. Introduction

This paper describes preliminary experimental results to determine the lowest temperature at which a DSP is able to operate. The final goal of the project is to develop *Self-Reconfigurable Electronics for Extreme Environments (SRE-EE)* technology, which will be validated with a demonstration of a self-reconfigurable Integrated Circuit (IC) that would operate under extreme temperature and radiation, without the protection of thermal controls and radiation shields. We will develop and validate the SRE-EE technology by demonstrating a Self-Reconfigurable Analog Array (SRAA) IC in sustained (over 300 hours) operation at temperatures between -180°C and 120°C, and irradiated to 300KRad total ionizing dose (TID). This temperature range is a characteristic of the Moon and Mars environments and the TID reflects the cumulative dose during very long Mars missions or missions beyond the Moon and Mars, such as for Jupiter's Icy Moons Oribiter (JIMO).

This particular experiment focuses on low-temperature characterization of a DSP that will run a reconfiguration algorithm (usually a Genetic Algorithm or GA) to program the SRAA

2. Experimental Setup

A 320C6701 DSP was tested in a board fabricated by Innovative Integration (SBC62). The board communicates with a PC through a JTAG connection. During the test only the

DSP board was placed on the low-temperature chamber: the PC and the JTAG were outside.

The DSP was tested by running a simple GA whose target was a simple optimization problem (the maximization of the number of '1's in the chromosomes). This problem is solved in less than 1 minute, after 464 generations (iterations). The GA results are deterministic, i.e., the same for each run. Refer to [1] for details on Genetic Algorithms.

3. Test Procedure and Results

The temperature of the chamber/test article has been driven to 0°C with a scan rate of 5°C/min from room temperature. The dwell time at 0°C temperature was for 8 minutes and electrical measurements were made during this time. Later, the temperature of the chamber has been driven to –30°C, –60°C, –90°C, –120°C at a scan rate of 5°C/min and electrical measurements were made respectively during the dwell (Figure 1).

A Failure was observed during the testing at –120°C step. Electrical measurements were made at –90°C again and the DSP regained its characteristics. This procedure was repeated again: the temperature was driven to –90°C, –100°C, –110°C and –120°C to narrow the temperature range. The dwell time at each temperature was for 5 minutes and electrical measurements were made during this time. The DSP was functioning at –90°C, –100°C, and –110°C. The failure was again observed during the testing in a temperature range of –110°C to –120°C. During the failure the DSP did not communicate with the PC. The PC-DSP communication link was the only means to read out the DSP outputs in this experiment.

4. Conclusions

The DSP Board works down to -110°C but, failed for during further lower temperatures. The board worked as expected when temperature was raised after the failure observed at lower temperatures. Nevertheless, it is not possible yet to conclude which component(s) failed: DSP chip, JTAG connector or other chips populating the SBC62 board. Future tests may therefore include inserting thermal cover/protection for other chips in the board to study the effect of low-temperatures in the DSP only and replace JTAG communication to serial communication (between PC and DSP) to identify if the problem is in the JTAG connector.

ACKNOWLEDGEMENT

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Reference:

[1] – Goldberg, D. E., "Genetic Algorithms in Search, Optimization and Machine Learning", Addison-Wesley, 1989.

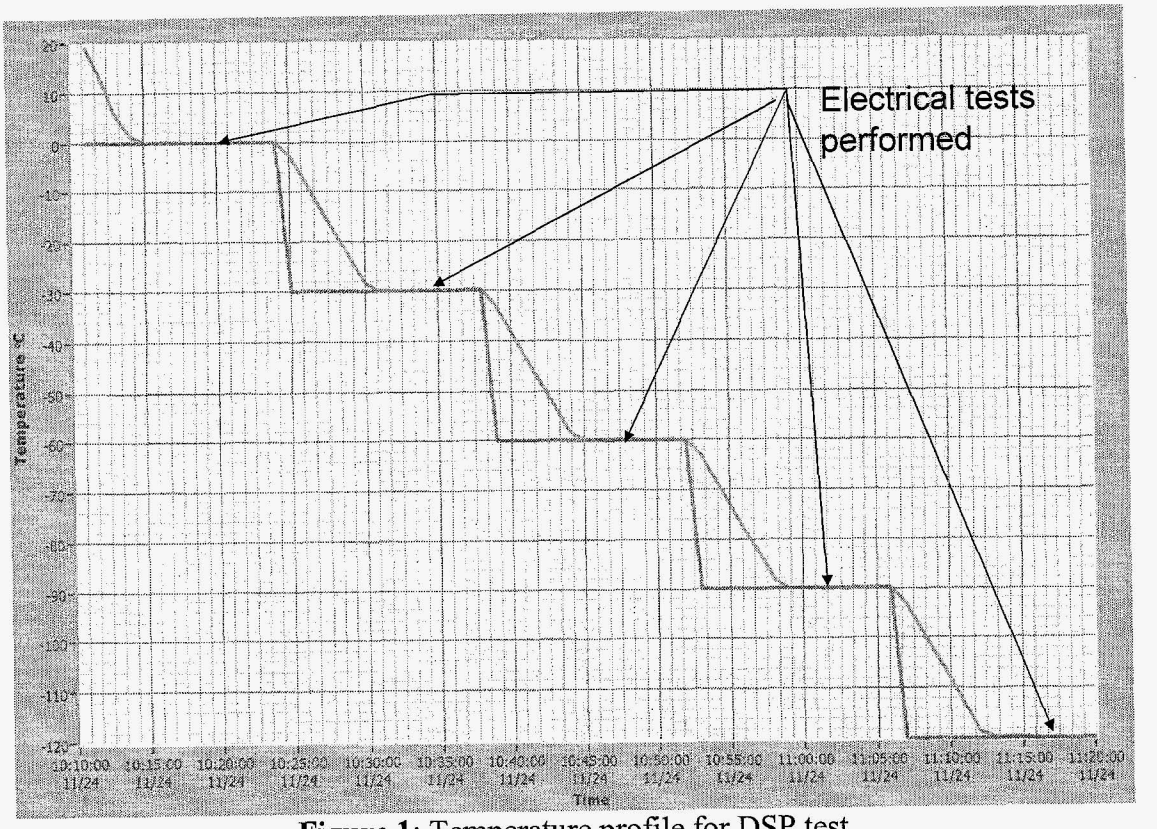

Figure 1: Temperature profile for DSP test.