Laser Single Event Effects Test Results for Analog Devices AD7414 Temperature Sensor

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I. INTRODUCTION

This study was undertaken to determine the single event effect (SEE) sensitivity by laser stimulation of the Analog Devices AD7414 I^2C, 10-bit digital temperature sensor. Laser testing was done at Naval Research Laboratory's Pulsed Laser SEE Test Facility. The output of the device was monitored for laser-induced errors, which can effectively simulate heavy ion-induced errors.

II. DEVICES TESTED

The Analog Devices AD7414 is a band gap temperature sensor with a 10-bit temperature (analog) to digital converter with high and low set points, operating under I^2C architecture. The devices provide output in the standard I^2C bus format. The output is read into computer based software that controls the I^2C bus and the devices connected to it. There was one device under test (DUT). The DUT was illuminated with the NRL laser. The devices were delidded before exposure. It was noted that the device metalization was ~50% which is acceptable for laser testing because the laser can be placed to hit sensitive regions under the metalization through charge diffusion. The DUT was marked (prior to delidding) on the top: C HA and on the bottom: 0049.

III. TEST FACILITIES

Laser Test Facility: Naval Research Laboratory Pulsed Laser SEE Test Facility.

Laser Information: Ion-induced single event effects were simulated in the circuit under test using short, high-intensity pulses of light produced by the Naval Research Laboratory's Pulsed Laser SEE Test Facility. The laser light was generated using a combination of two lasers – a Nd:YLF solid state laser and a liquid dye laser. The Nd:YLF laser emitted pulses of light with a wavelength of 1.053 nm, which was first frequency-doubled (wavelength = 520 nm) before being used to pump the liquid dye. Emission from the dye laser was controlled by a cavity dumper, which could be adjusted to provide pulse rates from single shot to many MHz. The light emitted by the dye laser had a wavelength of 590 nm and a nominal pulse width of 1ps. At that wavelength the light decays exponentially into the silicon with a 1/e depth of 2 microns. Numerous optical components were used to produce a Gaussian beam whose intensity could be adjusted with the use of neutral density filters. A beam splitter was used to reflect about 5% of the light out of the beam and direct it at a fast photodiode for monitoring light intensity. A microscope objective lens with a magnification of 100X and working distance of 3 mm was used to focus the light down to a spot with a diameter of just over 1 micron. The test circuit was mounted on an X-Y stage having a minimum step size of 0.1 microns. Specific locations in the circuit were probed with the laser light by moving the device until the focused laser light was positioned on the desired location. Two additional beam splitters were used - one to illuminate the device and the other to direct the light reflected from the device's surface onto a CCD camera. The resulting image was observed on a video monitor. The amount of energy required to produce a SEE was determined by gradually increasing the beam intensity using neutral density filters until SEEs were observed. The energy at which SEEs were first observed was noted from the response of the fast photodiode. To calculate the exact energy per pulse incident on the device, use was made of a multiplicative factor obtained from calibrating the light throughput prior to the experiment.

IV. TEST METHODS

Case Temperature: ambient in air

Test Hardware: A custom test set, using an I^2C evaluation board, an HP34401 multimeter, and a laptop computer, was used to supply input to the DUT, monitor the DUT output and monitor the power supply current. The test software captured each single event latchup (SEL) as a spike in power supply current.

Software: Customized LABVIEW® software provided a user interface to control signals to the DUTs. The software also automatically monitored the DUT input, output and power supply current and generated an SEL file history.

Test Techniques: Tests were performed on the DUTs to measure the SEL susceptibility as a function of laser energy (effective LET) for the specific application described in this report. Any deviations from the application described should be reviewed carefully. An SEL was determined to have occurred if the power supply current went off scale and the device ceased functioning. The LABVIEW® software was used to capture all events. Nominal temperature was 25°C and the temperature was acquired once per second.

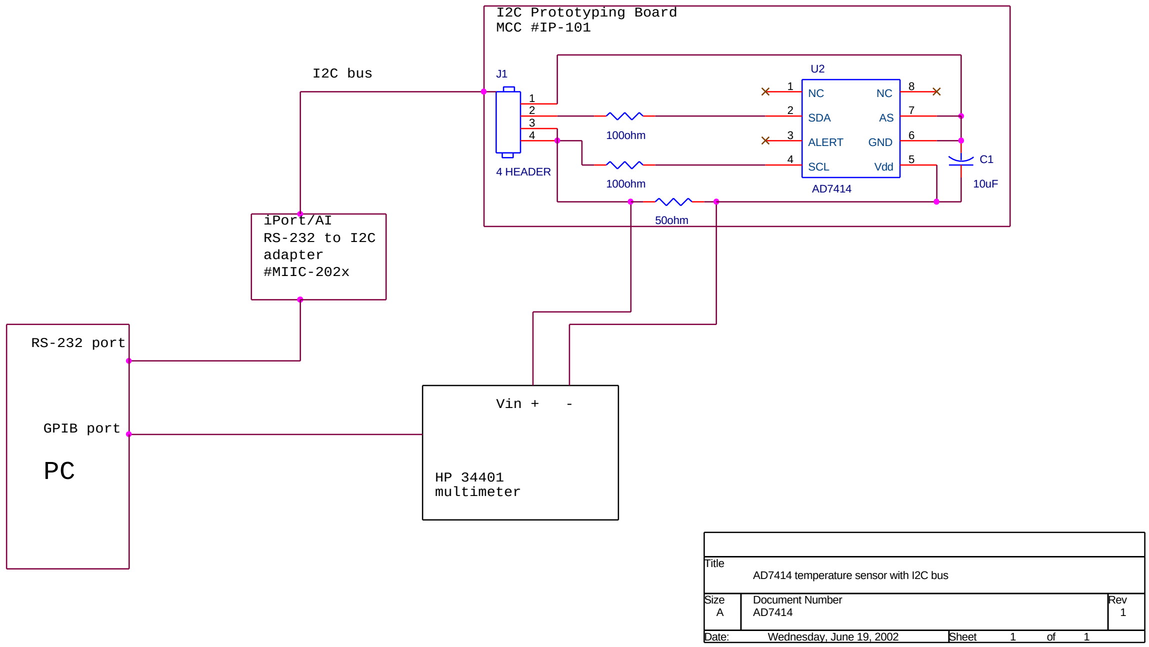

Figure 1. Electrical connection and block diagram of the AD7414 test setup.

V. RESULTS

The DUT was exposed to the laser 6 times. The lowest photodiode amplitude at which SELs were observed was 10mV, which equates to beam energy of 2pJ, which corresponds to an $LET_{EFF} \approx 6$ MeV·cm^2/mg. Several locations on the die produced SELs. The result of an SEL was to cause the temperature reading to go high (output all 9's) and cease transmitting temperatures to the computer. The device reset with power cycling. No other temperature anomalies were noted. It should be noted that there were no immediately destructive SELs up to an $LET_{EFF} \approx 60$ MeV·cm^2/mg. Latent effects were not tested for, however the device continues to function.