Problem Definition

Introduction

In this section, an overview of the project will be offered. The needs description of this project will detail the product's purpose, its history, and its utility. More importantly, the overall purpose of the fast particle detector will be detailed. The stakeholder list describes the involved parties who may benefit from the detector's production. In the project goals section, the details of the detector are laid out into an intuitive objective tree which breaks down the many aspects of the product. This includes the basic range of conditions that the detector is expected to be able to operate in as well the basic operation of the detector. The final and possibly one of the more important sections is the section which describes the product's constraints. As it is with most things, the product has certain qualities which make it constrained in one way or another. A product must be designed with these constrains in mind; otherwise, the product may fail to meet its design objectives.

Needs Description

As field programmable gate arrays (FPGAs) become larger and more capable there is ever increasing interest in researching reconfigurable computing strategies that would allow these devices to change while in operating so they can perform different tasks at different times. This is of particular interest to the aerospace industry where weight and mass are very significant constraints. The main idea behind the project is to be able to use an FPGA to act as different systems at different stages of a mission.

One of the largest problems that must be overcome is that FPGAs are very sensitive to radiation since a radiation strike can alter the SRAM that controls the hardware configuration of the FPGA. The earth and low earth orbits are protected from the majority of the solar radiation by the earth’s magnetic field but as high orbits and deep space missions will require radiation protection. In a conventional digital circuit this radiation would cause a single flipped bit that would lead to an incorrect value being stored in memory. While this is a problem an FPGA has the added concern of a radiation striking the SRAM that controls the hardware configuration. If this happens then the logic on the FPGA will become damaged and the damaged portion of the board must be shut down in order to restore the original configuration that is stored in ROM.

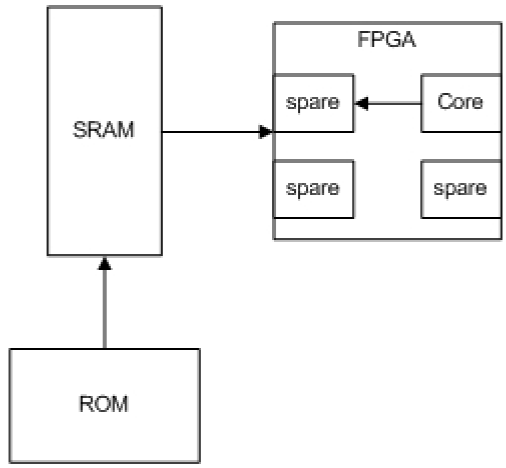

Figure 1: above, FPGA Memory Outline

The purpose of this detector will be to detect when there is a when a radiation strike occurs and a piece of logic, such as a micro-processor core, has been compromised. When this occurs the compromised core could switch to an unused core and the damaged core could be shut down. The portion of the SRAM controlling the damaged core could then be reloaded to its original value from the ROM. At this point the core is once again ready to be used and it will sit dormant as a spare core until needed.

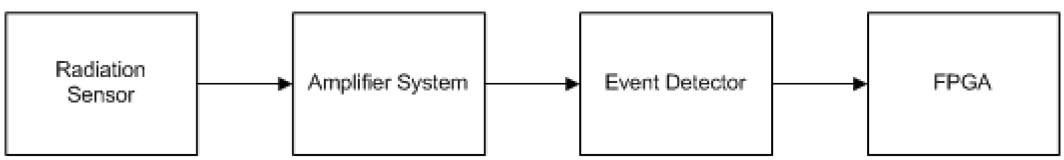

Figure 2: above, Radiation Sensor setup

This is an ongoing project and as there are many aspects that have been developed previously. This includes the radiation sensor and the amplification circuitry that connects the radiation sensor to the FPGA. This development effort is focusing solely on the logic to store and output the amplified sensor data to the FPGA.

The main issue with capturing the signal from sensor in the FPGA is that the FPGA is running at 100MHz and the radiation pulses can be as short as 5ns meaning that the pulses can occur entirely within a period and miss the clock edge. This requires that a separate block of logic that will run at a higher clock frequency so as to be able to capture the short radiation pulses.

Another issue that is significant is to demonstrate that the system is operating as desired. This is important because NASA is funding this research and will need to be able to see that a functional device is produced. In order to show that the detector is able to detect and process the radiation pulses as desired it will be necessary to produce a graphical user interface to show the output of the event detector.

Stakeholder List

The stakeholders are:

- NASA- The Marshall Space Flight Center is funding the research.
- Businesses - The companies that build the parts used in the system as well as companies that build deep space systems could potentially find this research valuable.

Project Goals

The goal of this project is to create an event detector to process signals that come from the radiation detector and amplifier system. This radiation strikes can last as little as 5 ns and occur as quickly as 2 ns apart. The system must be able to record the location of the strike and continue to record strikes while the system is restoring the damaged portion of the FPGA. If a strike occurs while the FPGA is being restored then the restoration is voided. For this reason the event detector must be able to record two FPGA clock cycles worth of events. To accomplish this the system must be able to record at least four radiation strikes in a row. The other constraint is that there is a small budget for the event detector and ideally it will be able to go directly on the FPGA and not require any additional hardware but if a low cost component can be found that satisfies the functionality required that can also be considered.

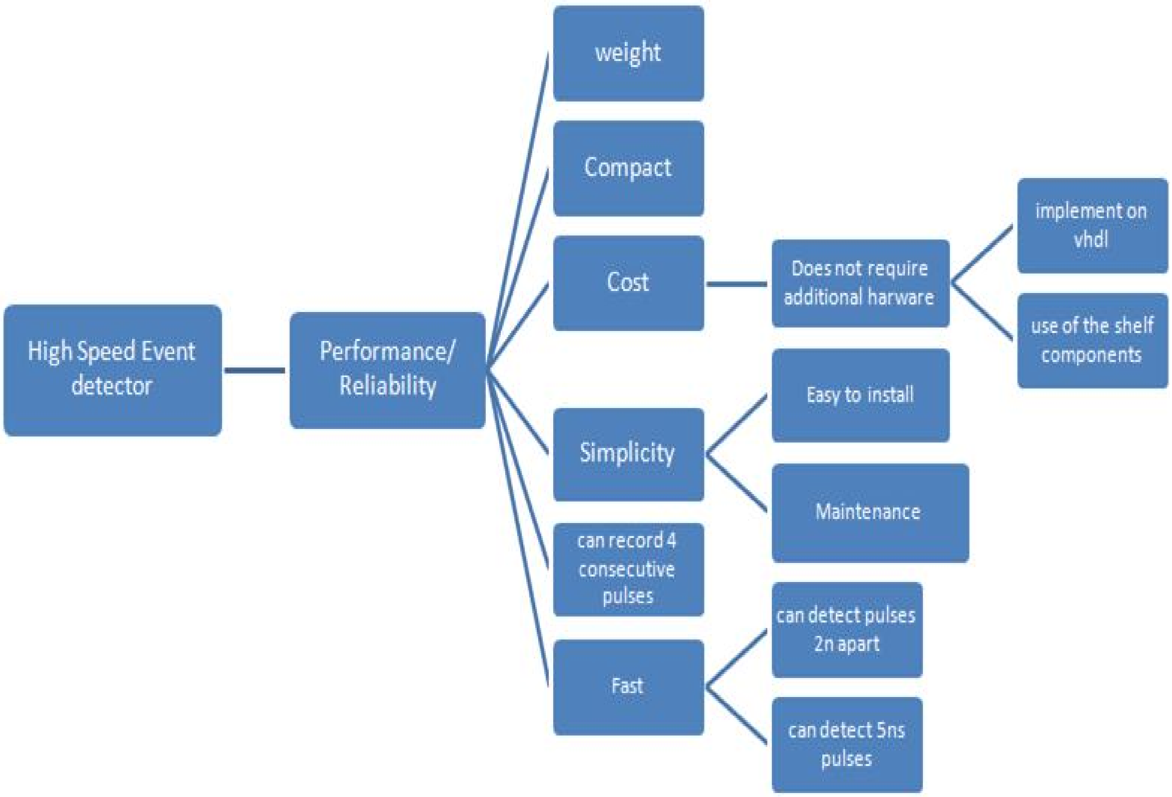

Figure 3: above, an objective tree outlining the basic objectives of the event detector.

Project Constraints

All of these constraints will be incorporated into the final design to make the event detector satisfy the requirements put forth by the customer.

- Speed - The event detector must be able to operate fast enough to capture pulses as short as 5ns that take place as little as 2ns apart.
- Amplitude - A radiation event will appear as a 0V to 2.5V pulse which will be captured by the detector.

- Reporting - The system must be able to report the location of the strike as measured by the sensor.
- Demonstrating- The system must be able to be adequately demonstrated to show that it functions as desired.
- Cost - The system must be able to be built without adding significantly to the overall cost of the project.
- Weight - It is very expensive to ship things into space so ideally the system will not add significant weight to the overall system.
- Reliable - The system must operate reliably so that it can be depended on for this critical task..