E2.01 Radiation Tolerant GPU Architecture

Team Photon

Texas State University

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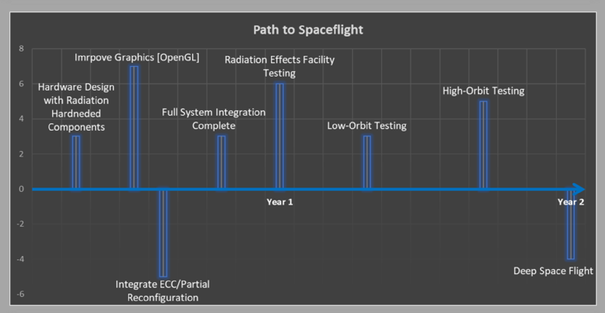
Background

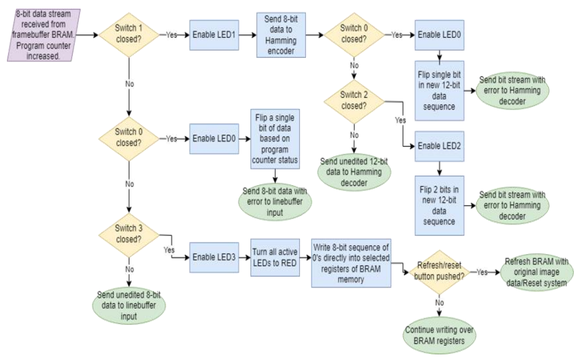
This proof-of-concept GPU (POCGPU) architecture shows the viability of using readily available software and hardware components to develop GPU applications that have a potential path to a flight system. Since this is proof-of-concept, there will be no actual radiation testing but rather use the injection of errors. The POCGPU architecture should be scalable, allowing the architecture to be used for both low resolution and higher-resolution applications. The proof-of-concept architecture will be able to display graphics onto two different sized screens. It is anticipated that this work will lead to future work in GPU applications suitable for deep space missions.

Design Requirements

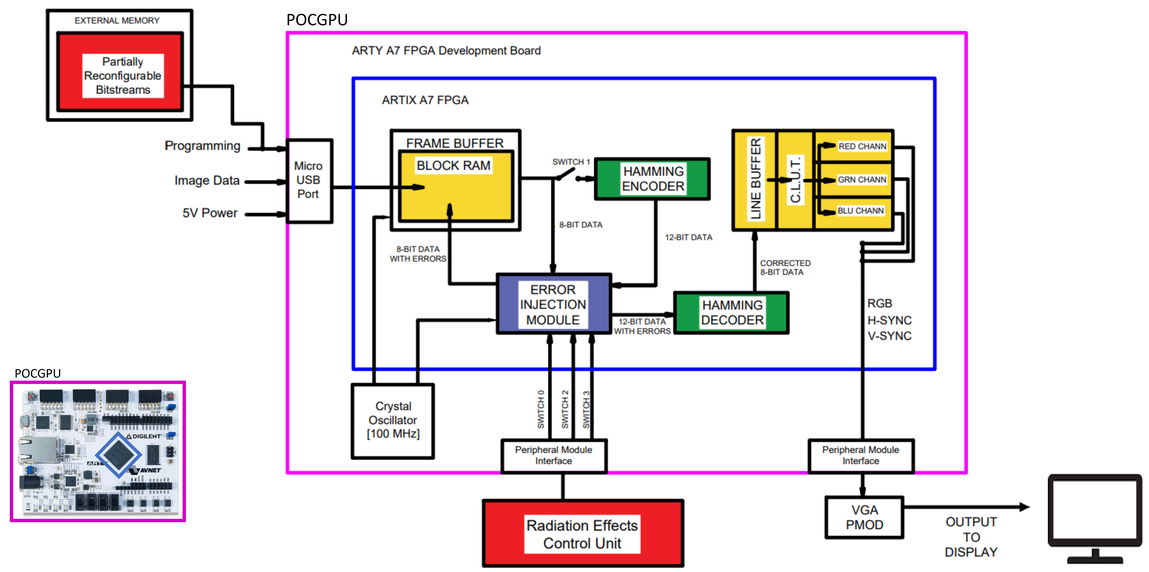
- Scalable graphics outputs for different screen resolutions
- Use of commercial-off-the-shelf parts
- Utilizes open-source graphics data processing
- Error detection and correction algorithms embedded into the system
- Simulation of single-event-upsets/latch-ups due to ionizing radiation



Error Injection Process



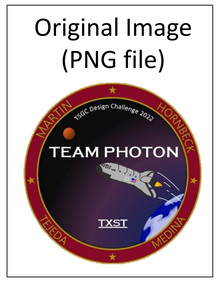
System Block Diagram



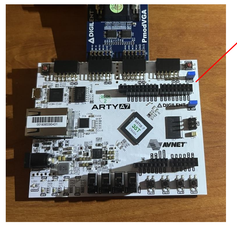
SUBROUTINE	KEY	OWNER
GRAPHICS PROCESSING		ERIC TEJEDA
ERROR DETECTION		PATRICK HORNBECK
ERROR INJECTION		RICHARD MEDINA
ERROR CORRECTION		CONNOR MARTIN

*CLUT: Color Look-up Table

Design Concept



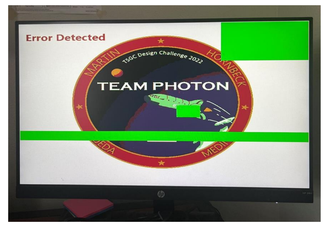
PNG is converted to BMP file and uploaded to internal memory of POCGPU



POCGPU built on Arty A7 development board

Image is displayed onto screen via VGA

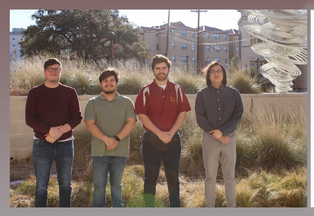
Errors are injected into system that simulate the effects of use in a high radiation environment



Errors are mitigated and original image is revived

Important Notes

- Errors may or may not be visible on screen depending on severity.
- Single bit errors are mitigated before the bitstream reaches the screen.
- All images shown on monitor were processed and displayed with the teams POCGPU.
- POCGPU: Proof-of-Concept GPU



Team Photon

(from left to right)

- Patrick Hornbeck
- Eric Tejeda
- Connor Martin (PM)
- Richard Medina

Feature	Description
Scalable	The system will have the ability to scale the output to different resolutions and screen sizes. Allowing for a wider range of uses.
Error Detection	The system will be able to determine when an error occurs. Errors will range from small upsets to catastrophic latch-ups.
Error Mitigation	Once an error is detected, the system will be able to correct the error and allow the graphics to continue to be displayed.
Partial Reconfiguration (stretch goal)	If a section of the graphics processing unit becomes unusable due to errors, the system will be able to replace the corrupted section with a backup copy of the section from memory.

Design Considerations

- A controller that can process graphics while keeping the number of active components low, while keeping a high level of design freedom.
- Graphical outputs that represent the concepts we are attempting to prove that can be completed in a reasonable time frame.
- The development board should be able to port over open-source graphics processing software.
- Injected errors should simulate the harsh effects of use in a high radiation environment.

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Open-source code used: https://projectf.io/

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