Fault Tolerance and Fuel Detection in Spacecrafts

1 Abstract

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1. Motivation: Our interest in this project arises from a deep fascination with space exploration. The development of a fault-tolerant system for space missions is essential to ensure high reliability in extreme and remote environments. The key motivations include maintaining mission continuity despite system failures, minimizing the need for human intervention, and safeguard- ing astronaut safety. Historical mission failures, such as Apollo 13 (1970) and challenges with the James Webb Space Telescope, highlight the critical need for robust fault-tolerant systems to enhance the success and safety of future space missions.

2. Problem Statement: The objective of this project is to design a digital circuit-based fault- tolerant system that employs FSM logic for state management and utilizes linear feedback shift registers (LFSRs) for generating random inputs. The system will transition between various operational states based on fault detection and recovery inputs. It will implement built-in error detection and correction mechanisms using comparators and manage subsystem recovery through a priority queue based on their significance

Key components:

Finite State Machine (FSM):

• The FSM will define various operational states of the system (e.g., normal operation, fault detection, recovery).

• State transitions will occur in response to random inputs generated by LFSRs and fault detection signals.

Linear Feedback Shift Registers (LFSRs):

• LFSRs will produce pseudo-random inputs to simulate operational conditions and test the system's response to various fault scenarios.

Fault Detection and Recovery:

- The system will include built-in error detection using comparators to identify discrepancies in fuel level readings or operational states.
- Upon fault detection, the system will transition to a recovery state, where it will utilize a priority queue to manage the recovery process based on the significance of the affected subsystems.

3. Features:

- FSMs are often used in autonomous recovery systems to improve spacecraft reliability.
- Linear Feedback Shift Registers (LFSRs) are used to generate random inputs.
- Priority Queue Implementation: Prioritizes recovery tasks, focusing on the most critical systems first to maintain mission integrity.
- Automated Recovery Protocols: This enables the system to self-correct without human intervention.
- Real-Time Display: Provides astronauts or ground control with accurate fuel level data, which is crucial for mission planning and safety.

2 References:

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3 GiHub ID:

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