TITLE:- Event Horizons in Energy Systems: Modeling Overload Relay Dynamics for Autonomous Spacecraft Resilience

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Abstract:- In Autonomous Orbital Nodes such as Project SOLIS, energy Distribution integrity is Critical. Overload Relay Trips, Triggered by excessive Current Draw or Voltage Collapse, represents a Class of Internal Electrodynamic failure Capable of Destabilizing Subsystems rapidly.

Introduction:- An Overload Relay Trip occurs when Current load Exceeds Safety Thresholds beyond Recoverable margins. Unlike Random failure, these are force-driven Collapses – where a system's own power Requirements skills itself unless managed. In space, no manual reset exists; hence automatic fallback and self-isolation protocols are mandatory.

Definition of Overload Relay Trip:- "Overload relay trip" is forced Disconnection of Power Paths to present Thermal or mechanical Destruction of Critical Components when energy exceeds Design thresholds.

Physical Principles:- Core Laws Involved;

- ★ Ohm's Law - > $V = IR$
- ★ Power Law - > $P = IV$
- ★ Thermal Stress Equation;

$$Q = I^2Rt$$

Where., Q = thermal energy generated

I = Current

R = Resistance

t = time

Excessive Q leads to conductor melting, Semiconductor Destruction, and core failure.

Dynamics Load behaviour:- Load is not Constant in SOLIS System. Spikes Occurs due to;

- ★ *Solar Intensity Fluctuations*
- ★ *Communication Burst Activity*
- ★ *Environmental Reaction Events (Micrometeorite Shielding Activation)*

Thus., Dynamic load Monitoring becomes Non-linear and requires predictive Adjustment, not Static Thresholds.

Relay Activation Models:- Simplified models;

- ★ *Thermal model - > Activates after Accumulated heat*
- ★ *Magnetic model - > Activates Instantly if Current overshoot happens Sharply.*

Both Modeled by Exponential Functions;

$$Trip = T_o * e^{-k(Iactual/Irated)}$$

Mathematical Failure Modeling:- *Probability of Overload Trip;*

$$P_{trip} = 1 - e^{-\lambda \Delta I}$$

Where., λ = Relay Sensitivity factor

ΔI = Excess Current Margin

Critical Subsystems Affected: -

Subsystem	*Risk if Trip fails*
CPU Core	*Meltdown, Catastrophic damage*
Communication Stack	*Total Radio Blackouts*
Power Banks	*Thermal Runaways, Explosion Risk*
Navigation Circuits	*Control Signal Corruption*

Simulation Parameters:-

Parameter	*Value*
Nominal Load	*1.0 Amps*
Trip Point	*1.5 Amps Sustained for > 2 seconds*
Emergency Cutoff	*2.2 Amps Instantaneously*

Thermodynamics parallels:- Relay trip is a self-defense Entropy operation. It is equivalent to an energy valve preventing localized heat death. Thus;

$$\delta S_{saved} \propto \delta E_{cutoff}$$

Energy Saved = Entropy Prevented

Future Research Extensions:- ★ *Smart Relays with quantum-tuned thresholds.*

★ *Load Prediction using AI (Dynamic pre-trip Anticipation)*

★ *Magnetic Switch Relays immune to space radiation Distortion.*

In Project SOLIS, I propose.,

"Every power path is a probabilistic river of entropy; relay trips for artificial event horizons collapsing paths to solve spacetime stability".

Which means., Every relays is like a Black Hole event Horizons and saving systems from their own energy collapse.

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