

Objective:

- Diagnose relay misoperations/component failures during faults using the temporal event data from the protection relays, and prognose possible cascaded failures.
- Develop a real-time reference too to assist on-field decision making for day-to-day operations, and training.

Motivation:

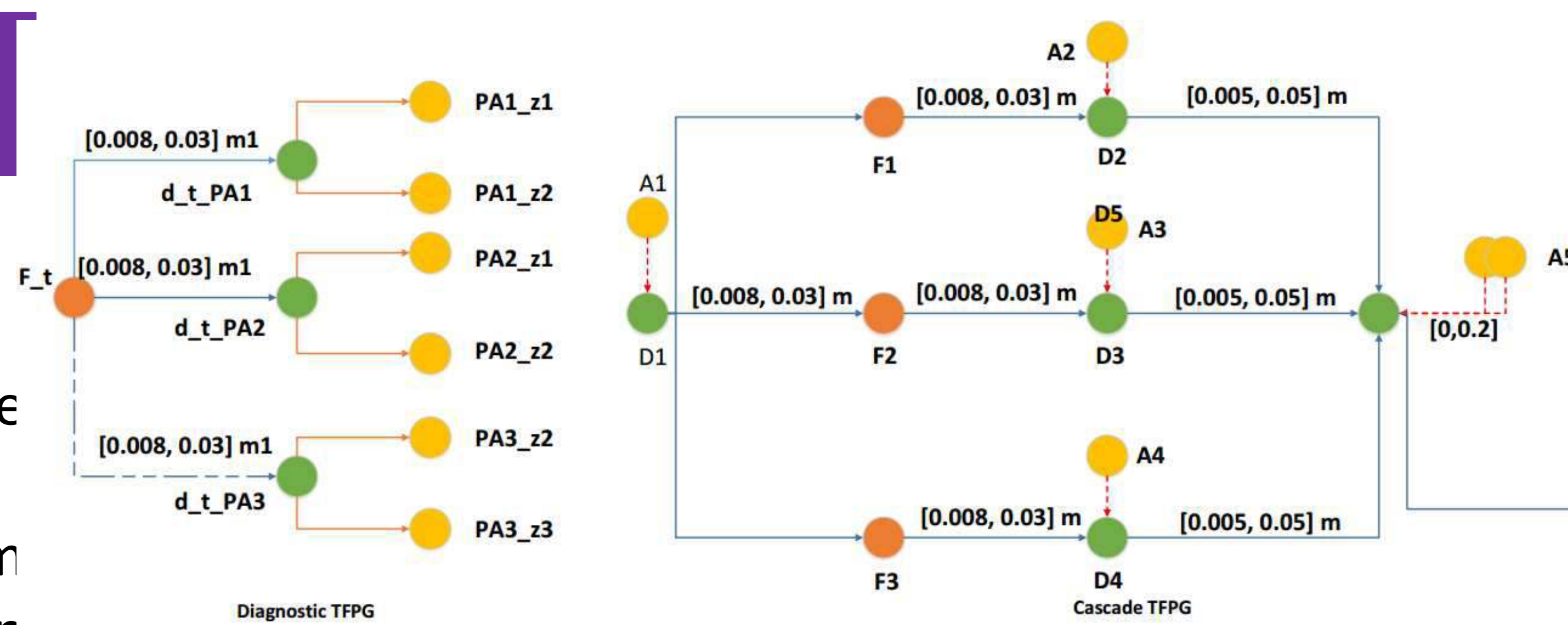
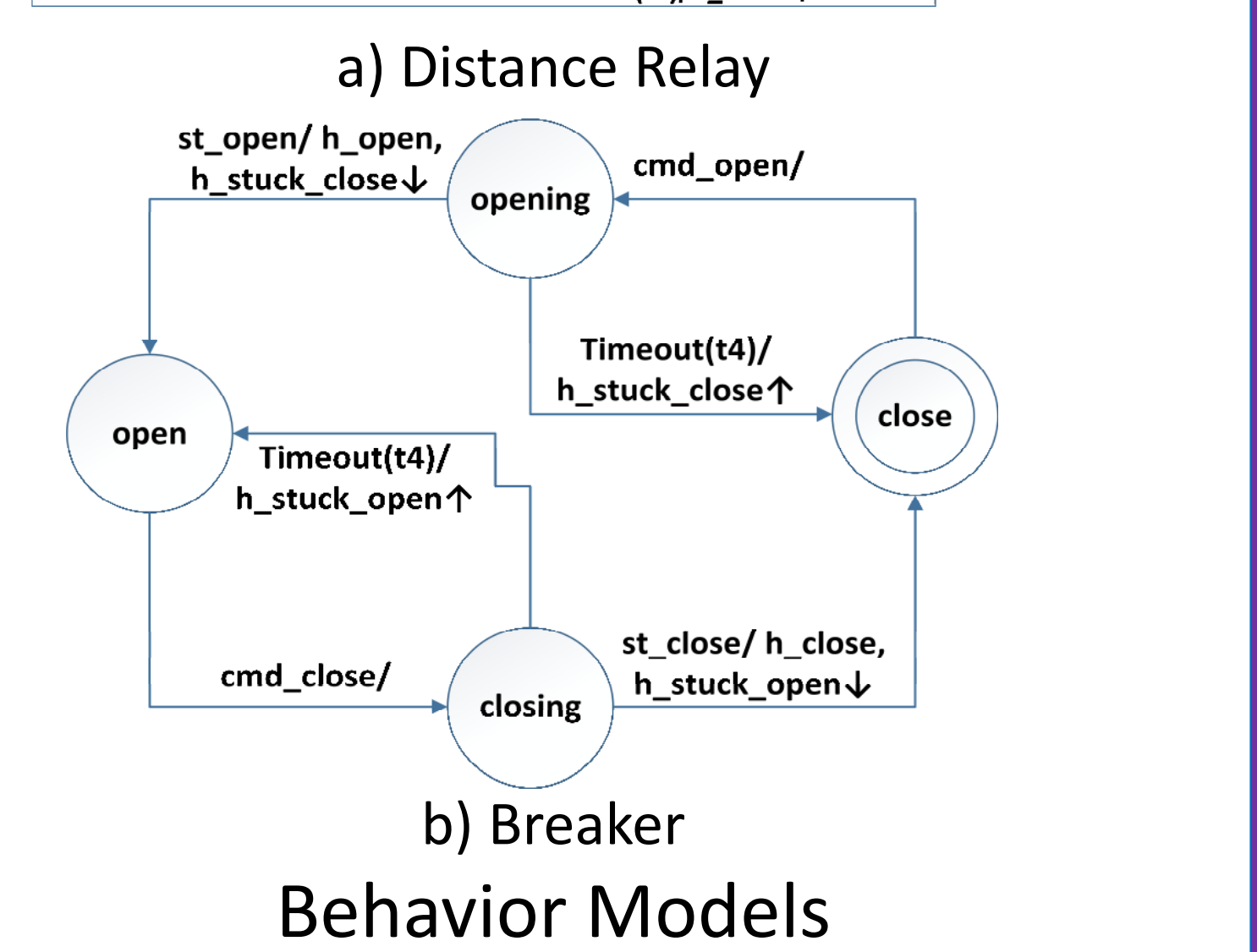
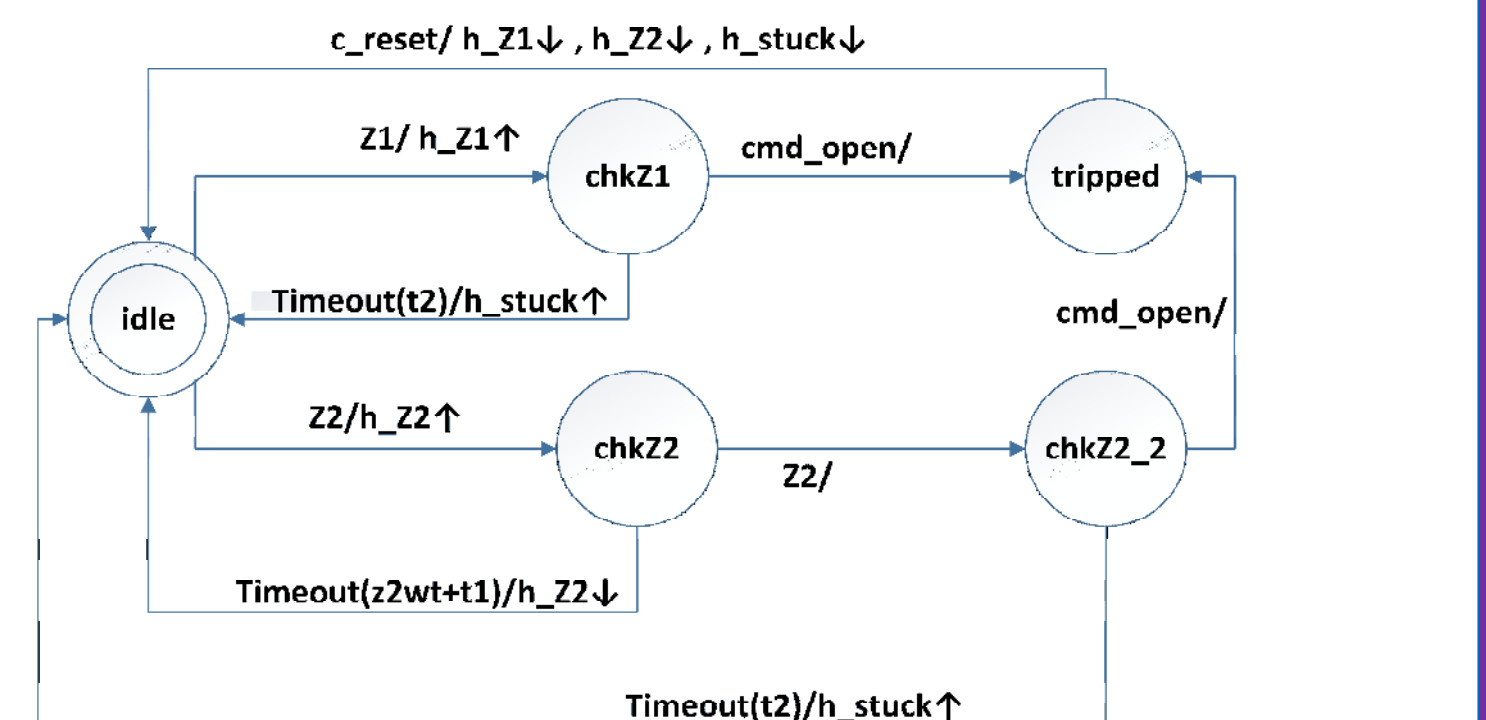
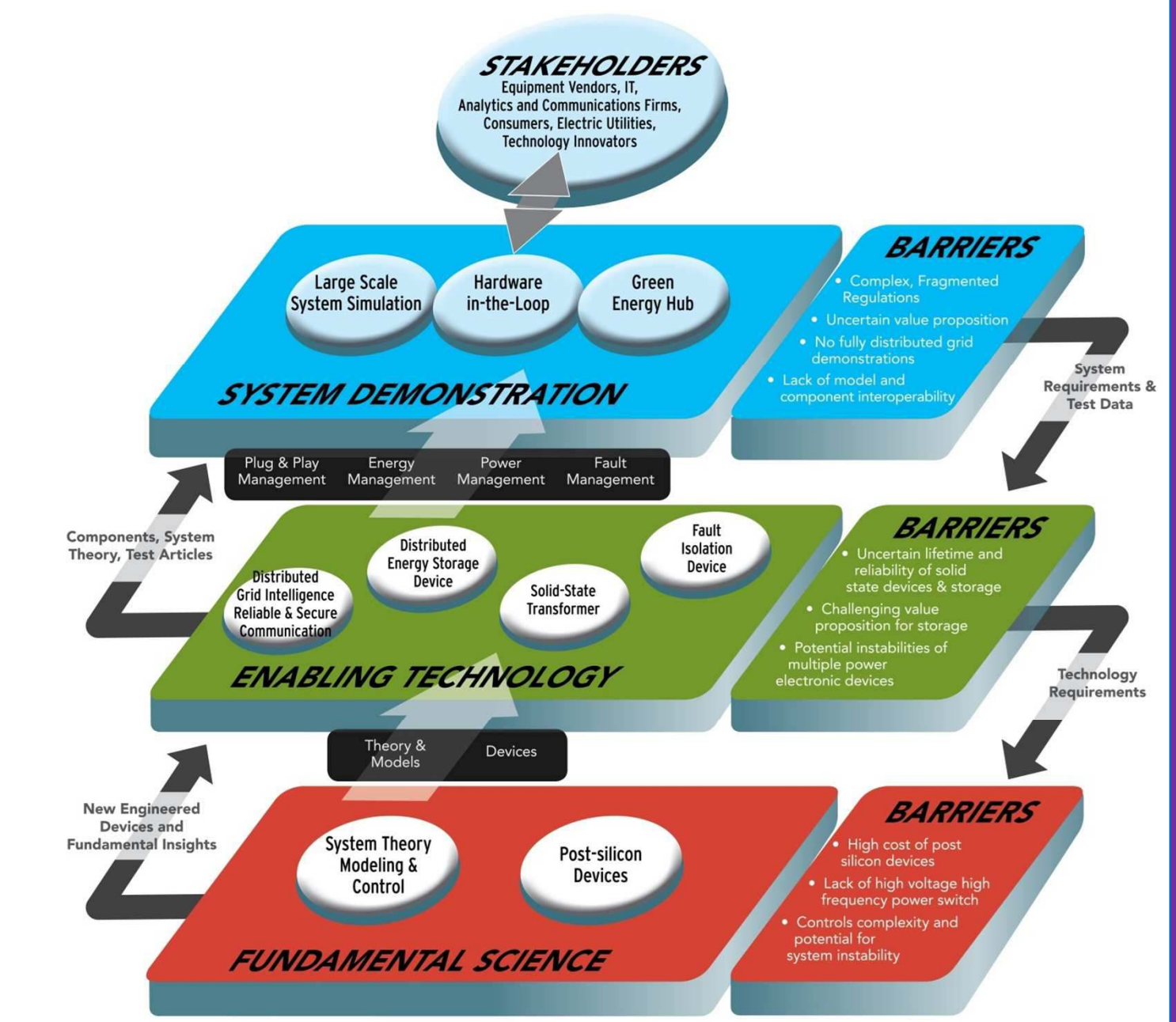
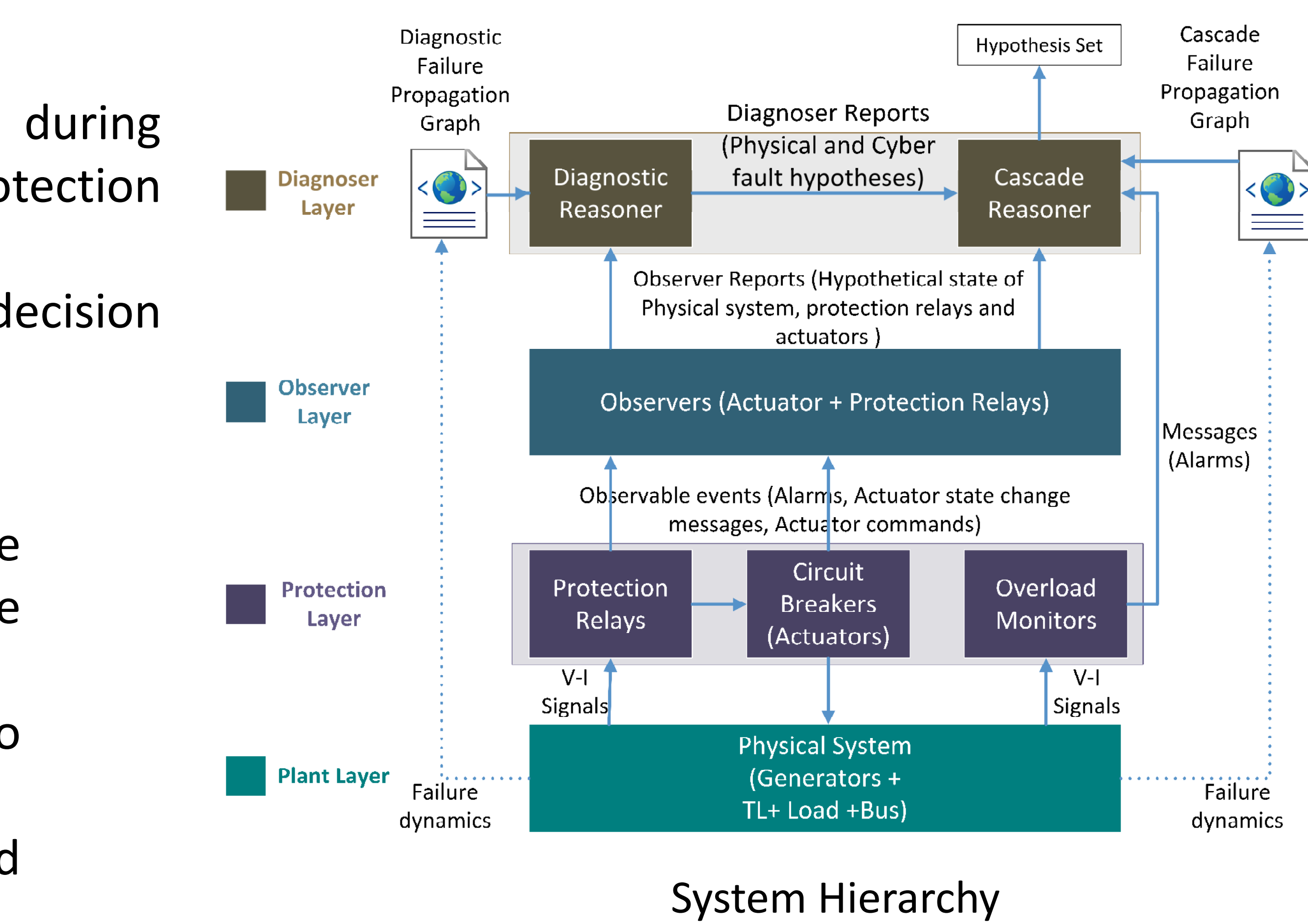
- Utilize the protection device flags to assess the system condition at any given time, and hypothesize the fault propagation
- Minimize human error and lack of coordination to make grid operations more resilient.
- Coordinate between different sections of grid without exchanging system data

Technical Approach:

Temporal Causal Diagrams (TCD)

Composed of

- 1) 'Timed Failure Propagation Graphs' to capture the faults in network and effects across the system
- 2) 'Timed Discrete Event Models' of the system components which arrest the propagation of fault in a network.



TFPG Graphs for a simple 2-source system

Hierarchical Reasoning

Use of external simulators to refine system level hypothesis

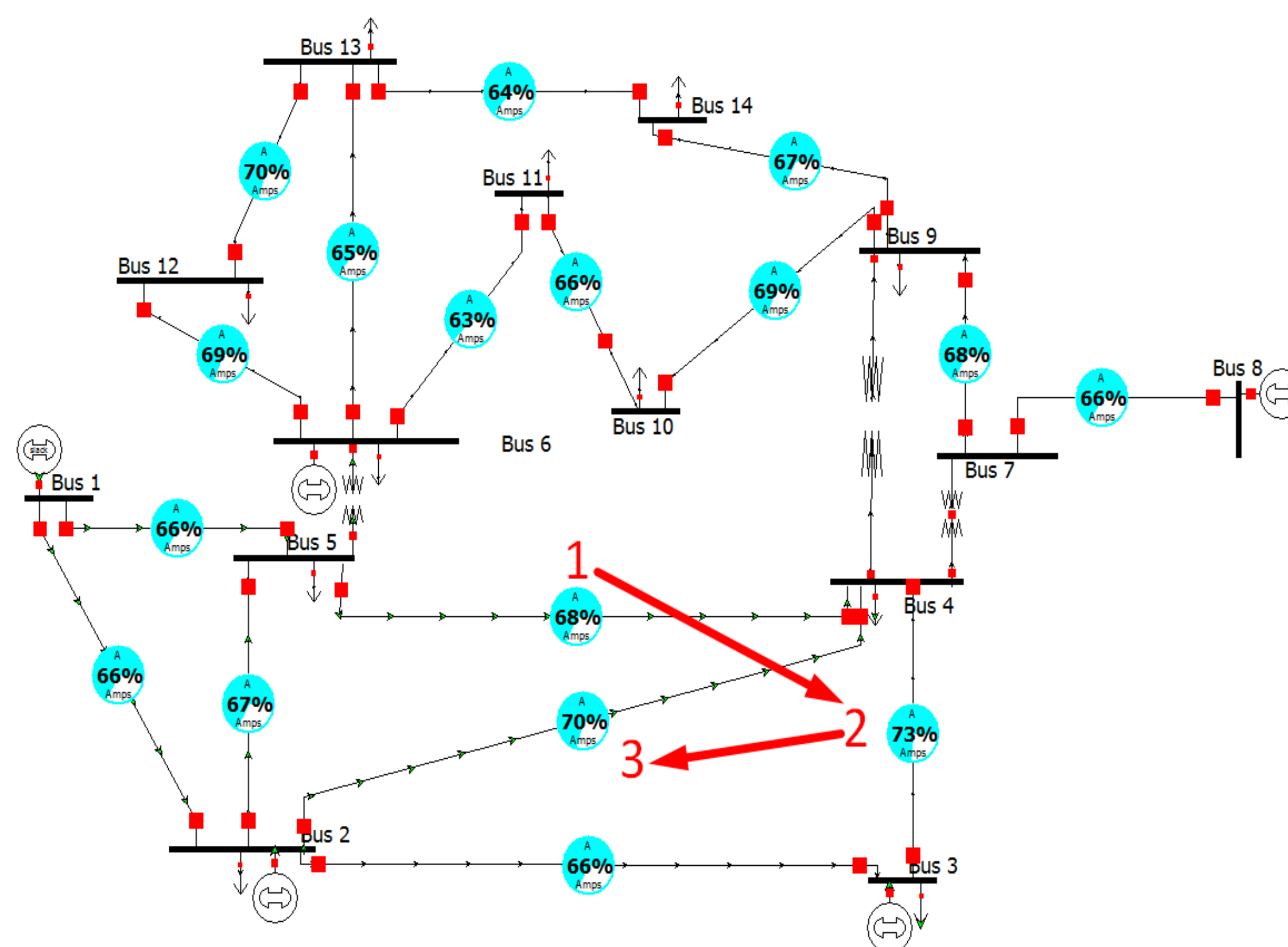
Accomplishments:

- Modeling use cases for a cascade scenario for IEEE 14 Bus system, and faults followed by relay mis-operation.
- Development of accurate Reasoners and appropriate observers to test against the above use cases
- Successful demo presenting 1) The fault scenarios and Cascade failures with corresponding relay operations as observed from the system using the Real Time Digital Simulator, 2) Observing the same scenarios from Reasoner's perspective:
- ✓ System level Reasoner was able to identify relay misoperation, and prognose next possible failures.

Next Steps:

- Integrate the Reasoners using the hierarchical architecture.
- Refine prognostic techniques, design algorithms, and evaluate performance.
- Develop TCD component models of common smart grid transmission system.
- Demonstrate the functionality of the reasoner in Real time.

Case Study – IEEE 14 Bus System



- E1 • Fault in Line TL5_4
- E2 • Distance PA11 Relays trip and isolate the line L5_4
- E3 • Power redistribution
- E4 • Overload in line TL3_4
- E5 • Distance Relay for line TL3_4 trips due to load encroachment
- E6 • Power redistribution
- E7 • Lines L2_4 and L6_11 experience overload.
- E8 • Inadequate Zone 2 settings for relays attached to L2_4 forces a misoperation.
- E9 • Blackout

Simulation and Diagnosis Results

