

Implementation of Automatic Under Voltage Load Shedding Program in Entergy System

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What is Automatic UVLS Program? (Proposed NERC Definition)

- *An automatic load shedding program consisting of distributed relays and controls used to mitigate the risk of Cascading, voltage instability, voltage collapse, or uncontrolled separation resulting from undervoltage conditions.*
- *Centrally-controlled UVLS is excluded because it is consistent with nature of SPSs.*



New NERC UVLS Standard (Project 2008-02)

- NERC seeks to revise current UVLS standard based on FERC directive
- Modify PRC-010-0 to require that integrated and coordinated approach be included in all protection systems
- SDT decided to consolidate the existing UVLS standards to create a single results based standard
- The proposed standard is currently posted for informal comments – deadline April 16, 2014



Overview of Entergy System

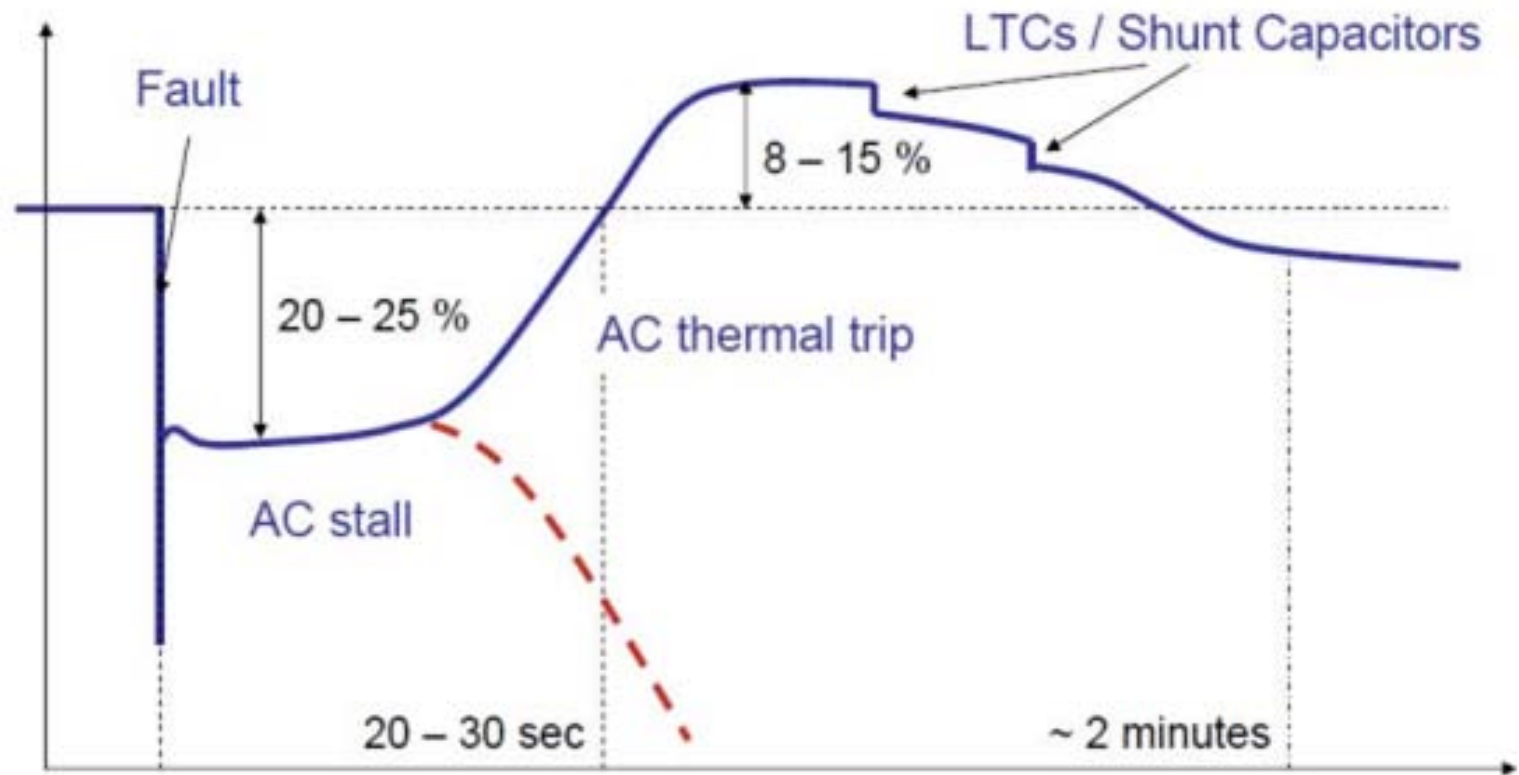
- Over 15,000 miles of transmission lines in four states
- 1,550 substations
- 36,000 MW of connected generation
- 24,000 MW Entergy-owned
- 12,000 MW merchant-owned
- 28,000 MW of load



Background on Western Region

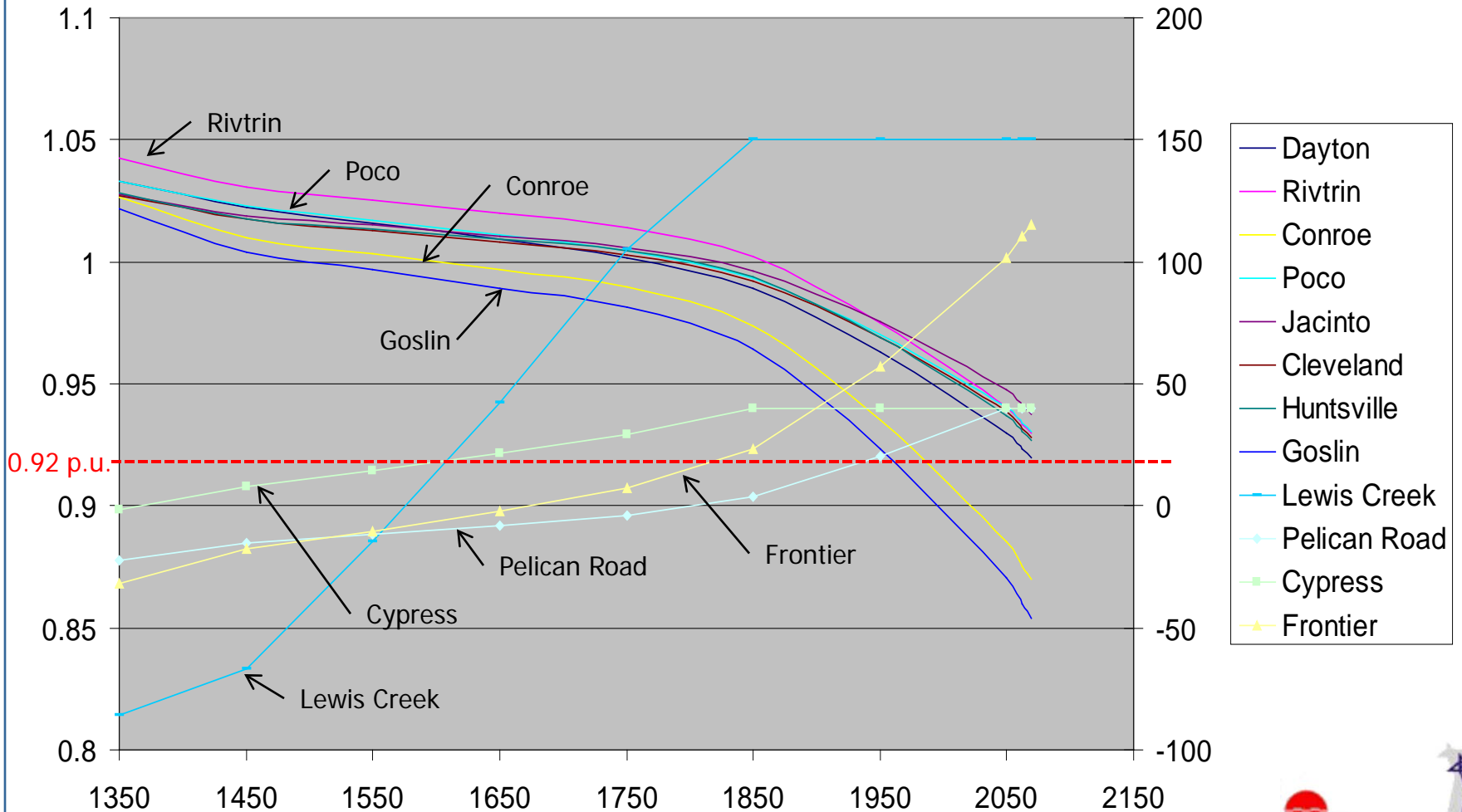
- Western Region load growth: ~ 5.1 % (in past) – with high composition of air conditioning load
- Limited Generation resources: Two Lewis Creek units (260 MW, 150 MVAR each)
- With generation out of service, line outages can lead to potential voltage collapse - FIDVR
- A SCADA based UVLS program was commissioned to meet NERC requirements

FIDVR Event



Voltage during a FIDVR event (courtesy of D. Kosterev, BPA).

PV Curve for Western Region (generation and 230 kV line out)

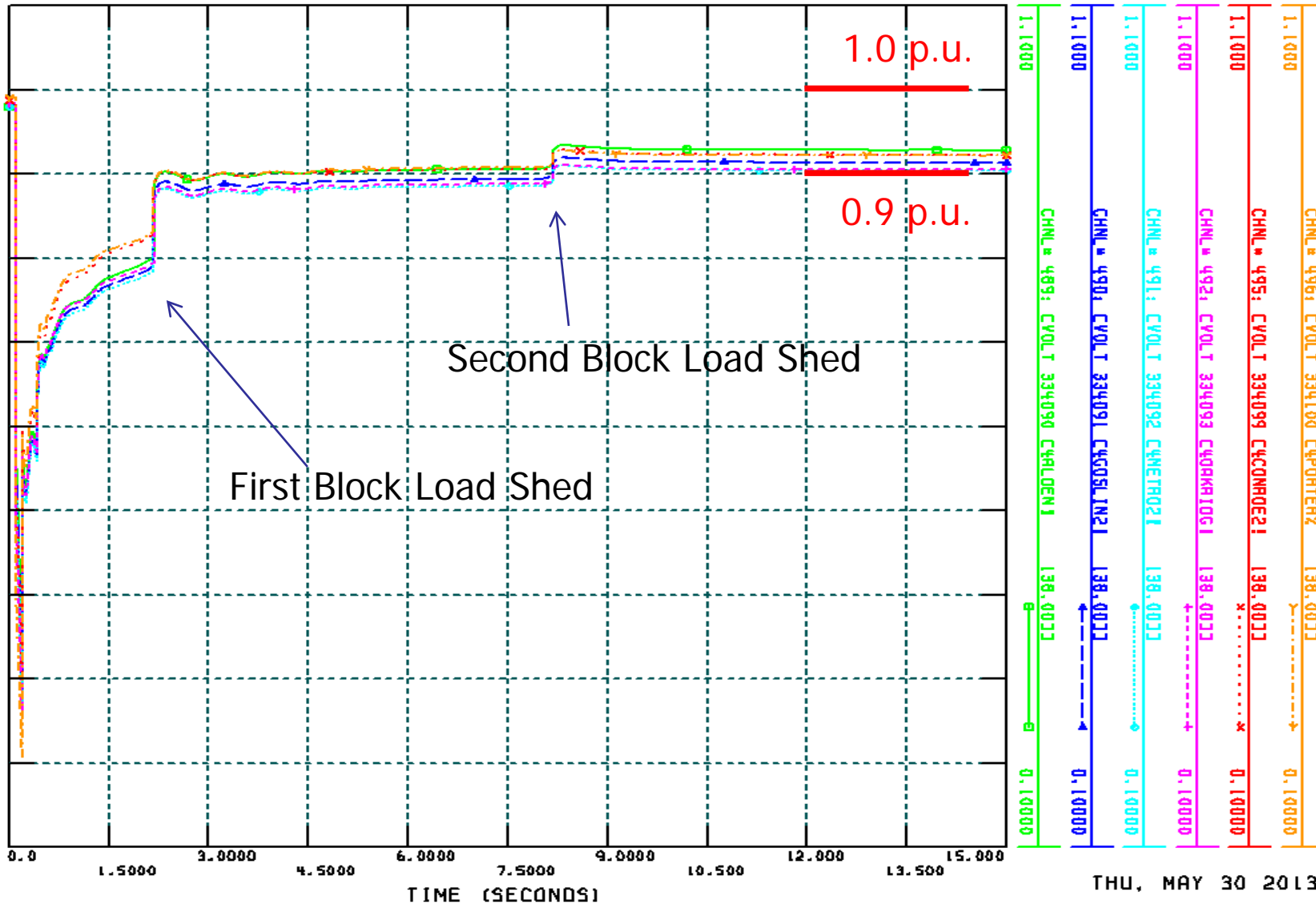


Voltage Plot of Woodlands Area Buses



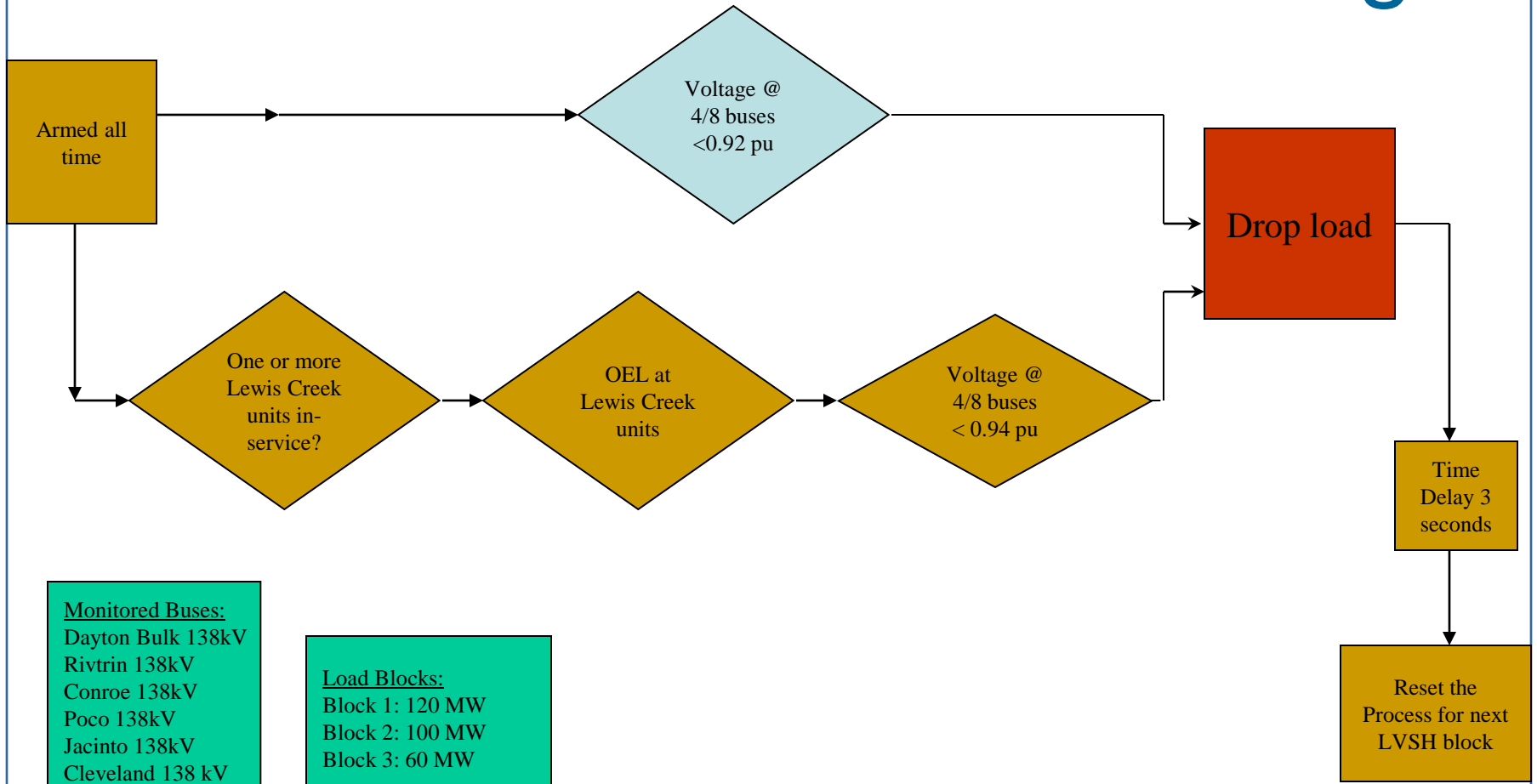
TEST
TEST

FILE: C:\Documents and Settings\...\VSH_fuction_N-2\case6.out



Existing SCADA Based UVLS Program

SCADA Based Load Shed Logic



Monitored Buses:
Dayton Bulk 138kV
Rivtrin 138kV
Conroe 138kV
Poco 138kV
Jacinto 138kV
Cleveland 138 kV
Huntsville 138 kV
Goslin 138 kV

Load Blocks:
Block 1: 120 MW
Block 2: 100 MW
Block 3: 60 MW

The above conditions need to be met for 3 scans to trigger load shedding

New Relay Based UVLS Program

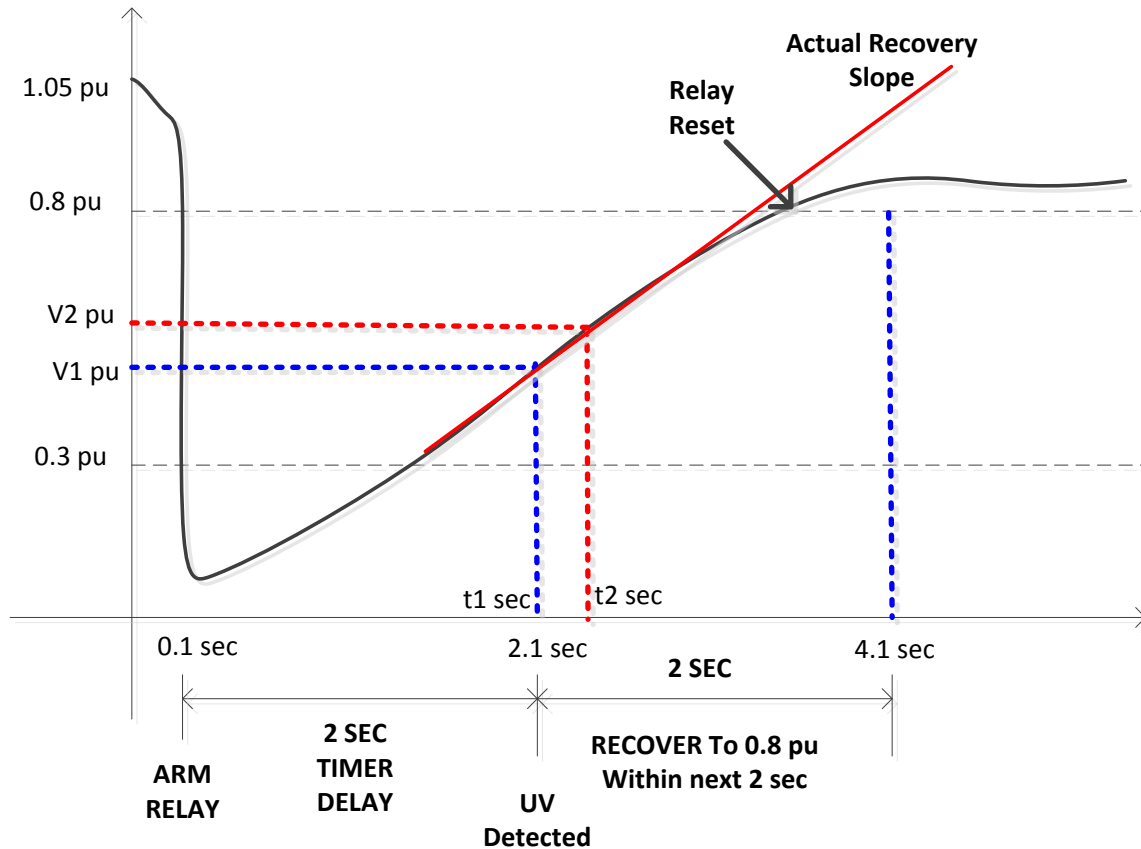
Relay Based UVLS Program

- This program will replace existing SCADA based program
- Load shed decision is based on predicted time to recover above a preset voltage value instead of voltage magnitude
- SEL-451 relays will be installed at 4 selected 138 kV stations
- Relays monitor positive-sequence voltage on high side of 138 kV buses
- Program designed to drop a total of 200 MW load at the 4 stations

Program Overview

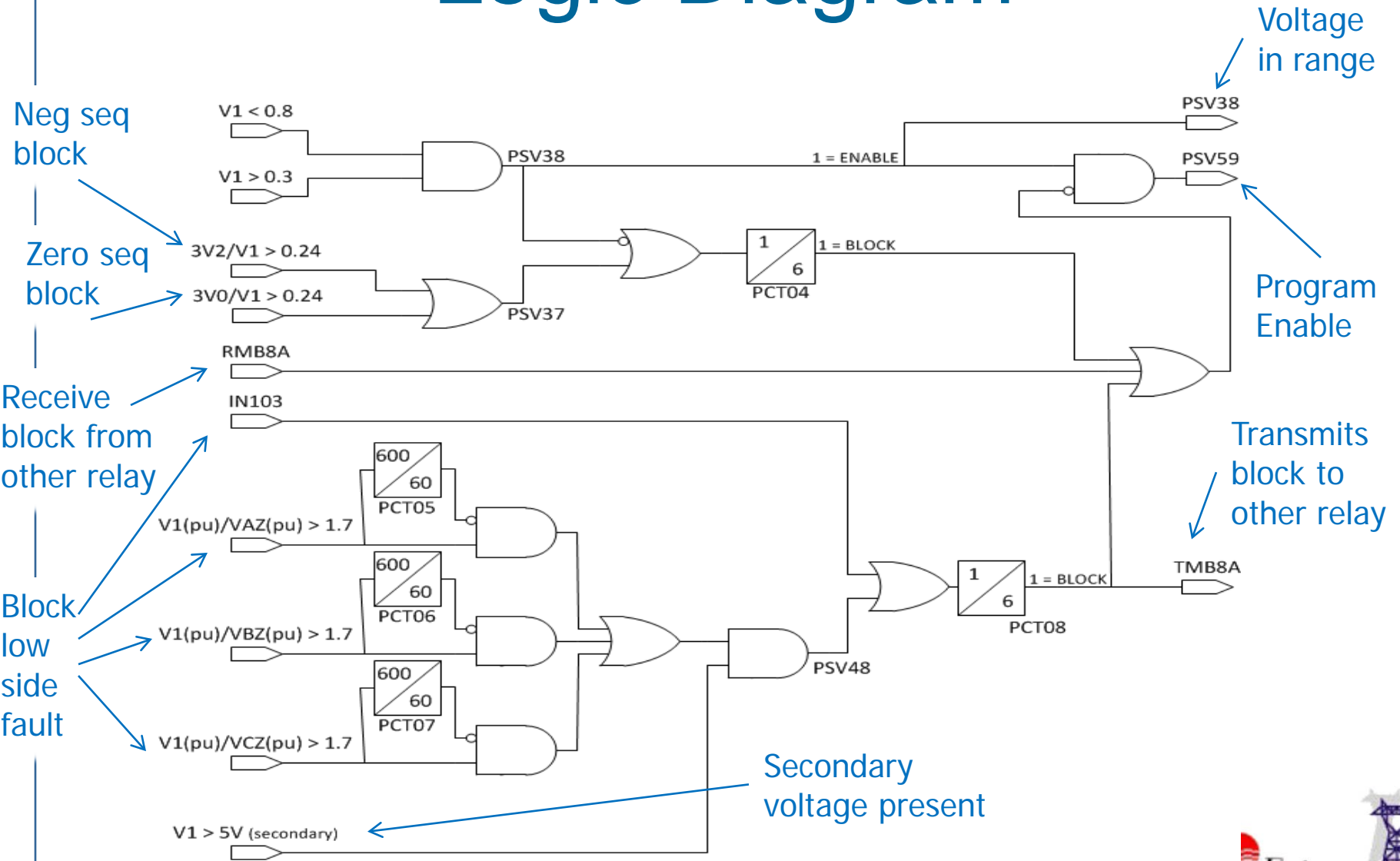
- Positive Sequence Voltage is sampled and saved once per cycle
- Program is enabled when the voltage is below 0.8 p.u.
- 5 consecutive slopes of voltage recovery (with 2, 4, 6, 8 and 10 cycles durations) is used for predicting voltage recovery time
- If all 5 consecutive recovery time predictions $>$ pre-defined set time, Load shed is triggered
- If recovery time $<$ setting time, no action is taken

UVLS Recovery Slope Calculation

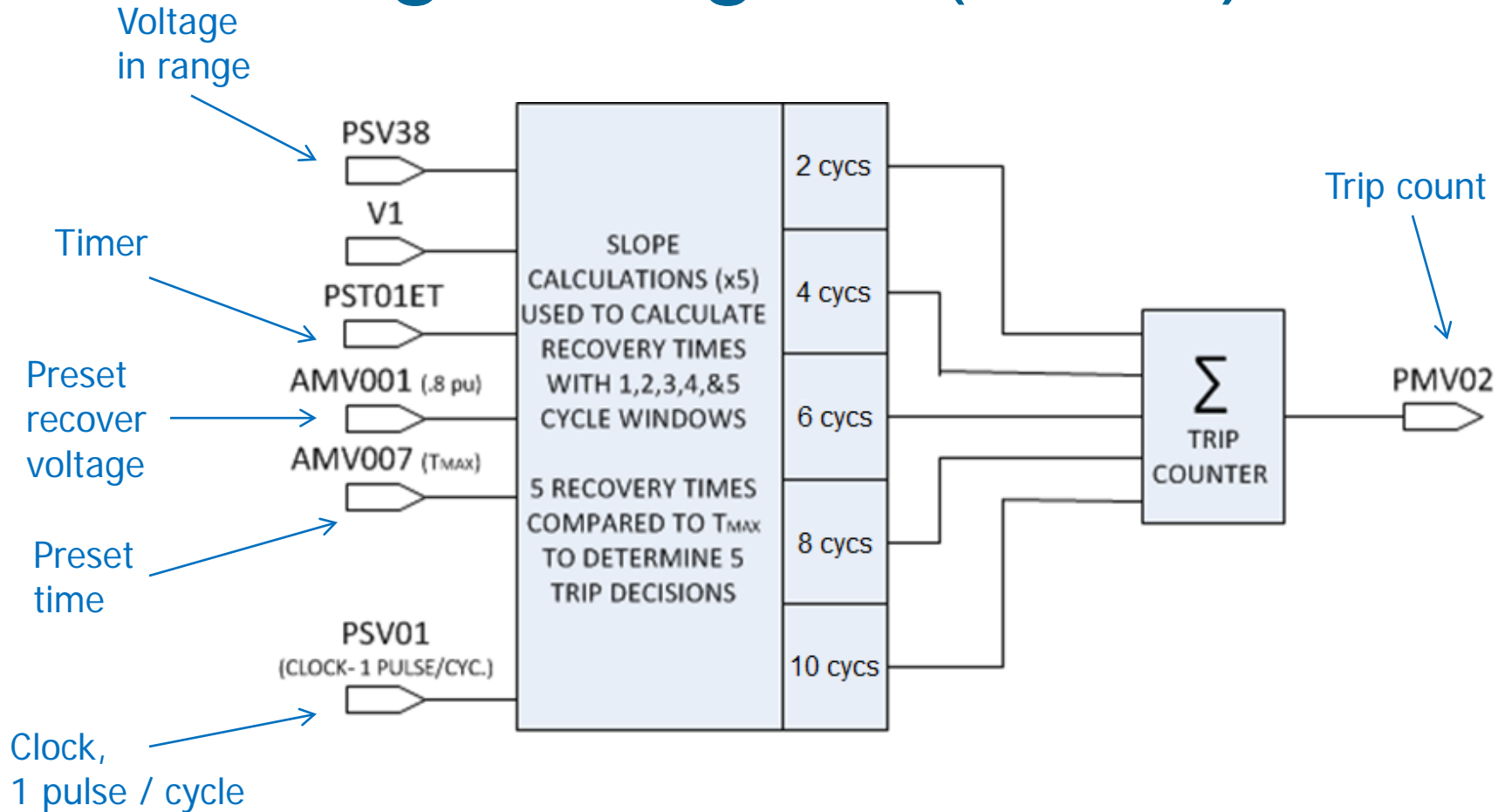


$$S_{actual} = \frac{V_2 - V_1}{t_2 - t_1}$$

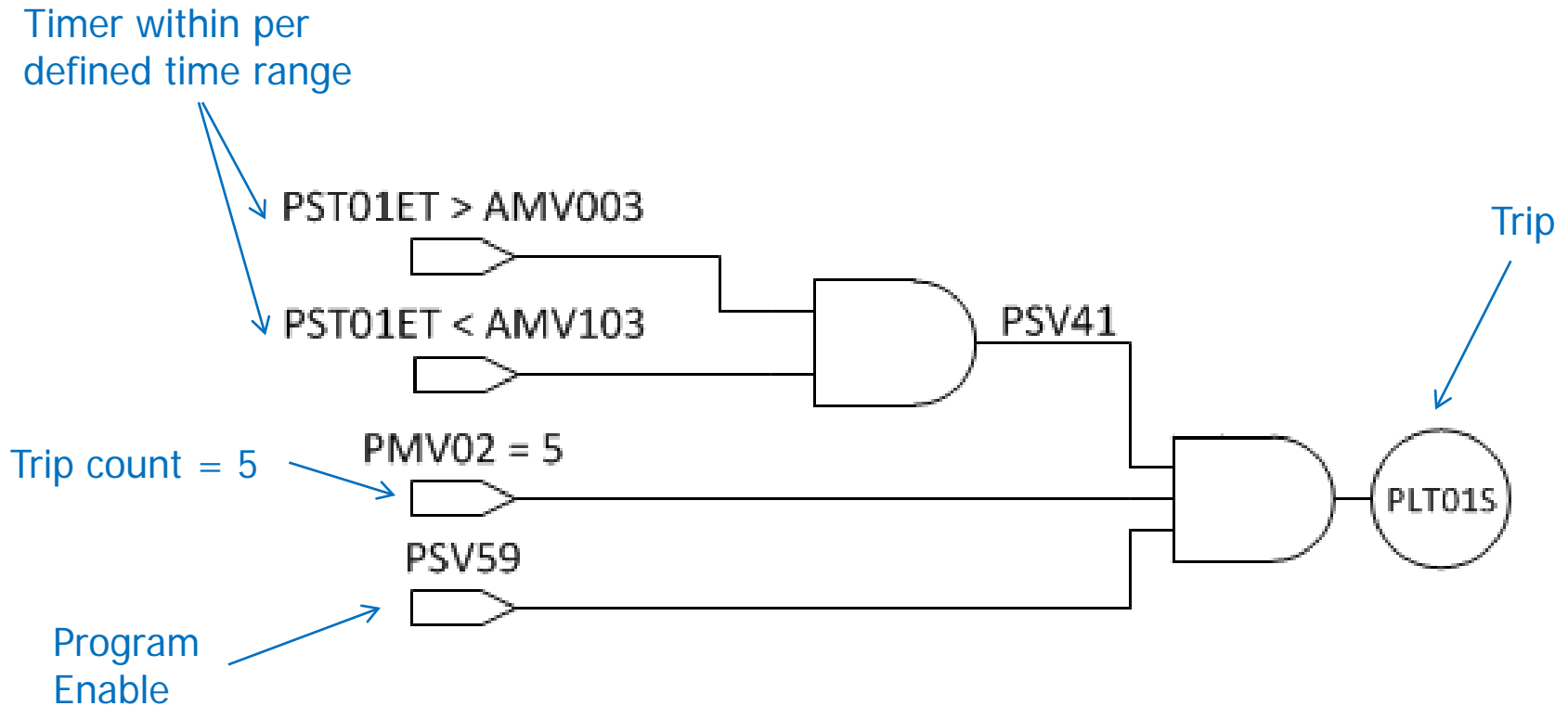
Logic Diagram



Logic Diagram(contd)



Logic Diagram for Tripping

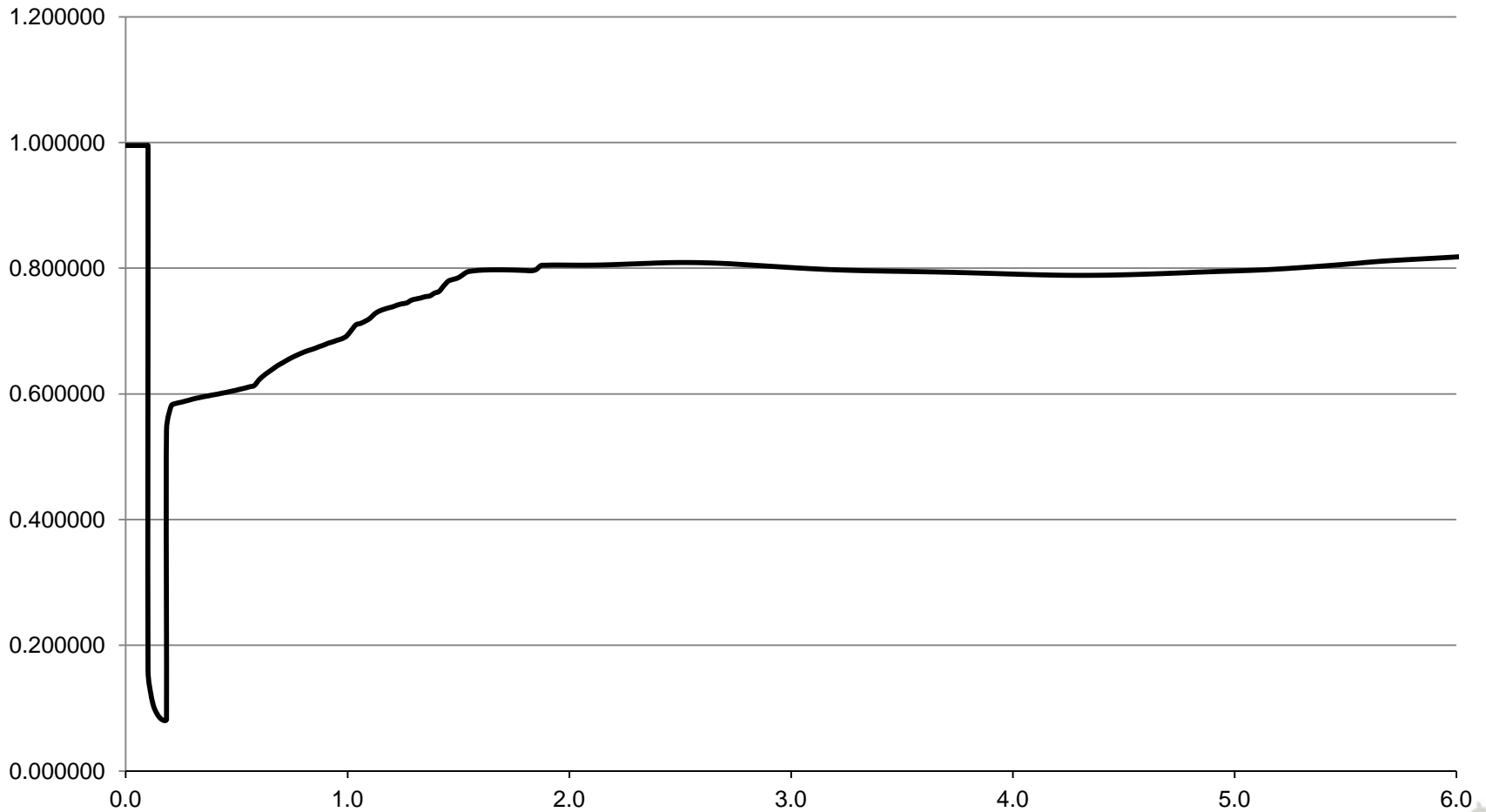


Lab Simulations

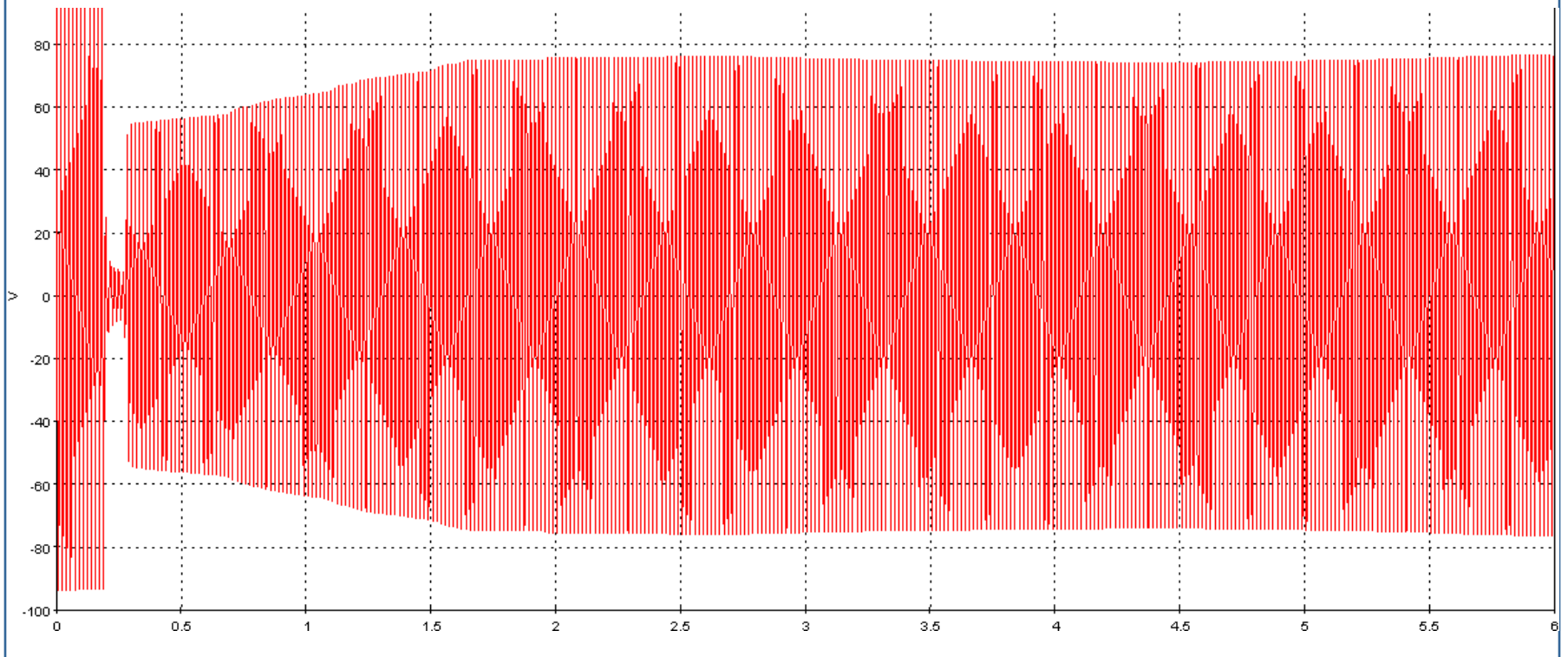
Lab Setup



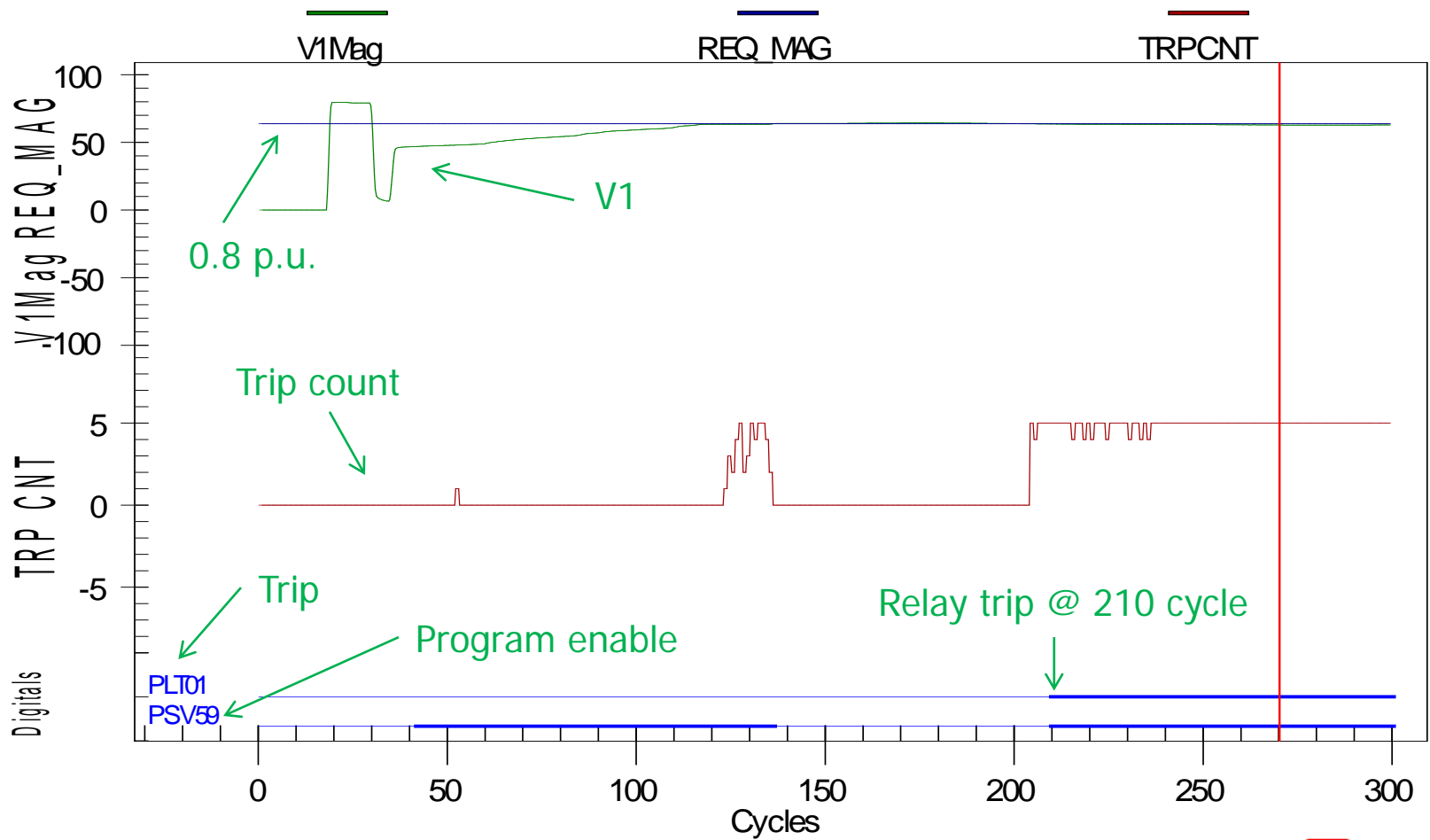
PSS/E Simulations Cases



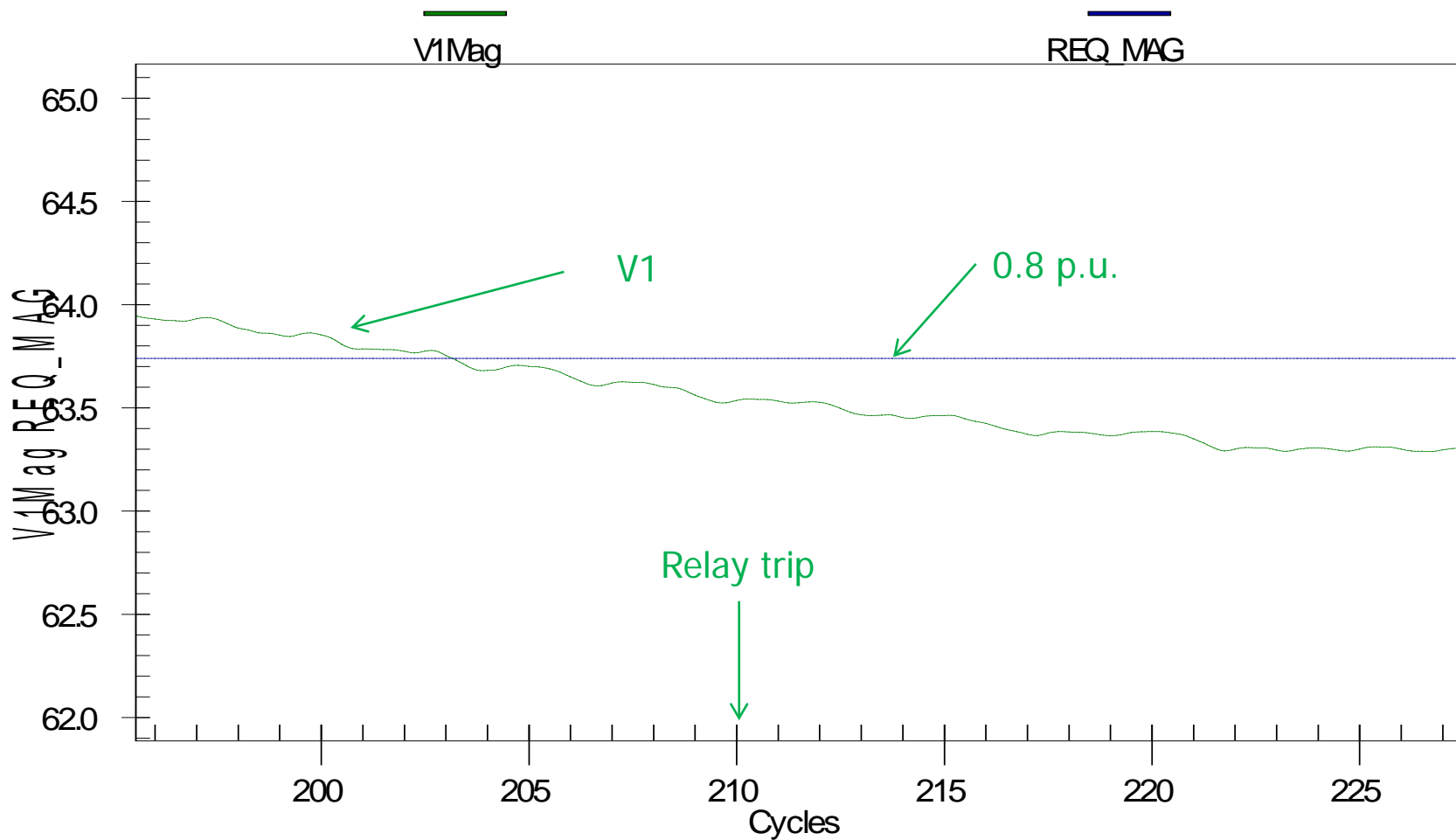
Comtrade File



Relay Event Report



Relay Event Report



SUMMARY

- Relay based UVLS program is more appropriate for addressing FIDVR phenomena
- Faster when compared to SCADA based program
- More localized and independent
- More intelligent and flexible

Questions?