POWER

Power Management Systems for Offshore Vessels

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Dynamic Positioning Committee
Marine Technology Society

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Power Management Systems for Offshore Vessels

Dynamic Positioning Conference

Lew Weingarth, *Transocean*

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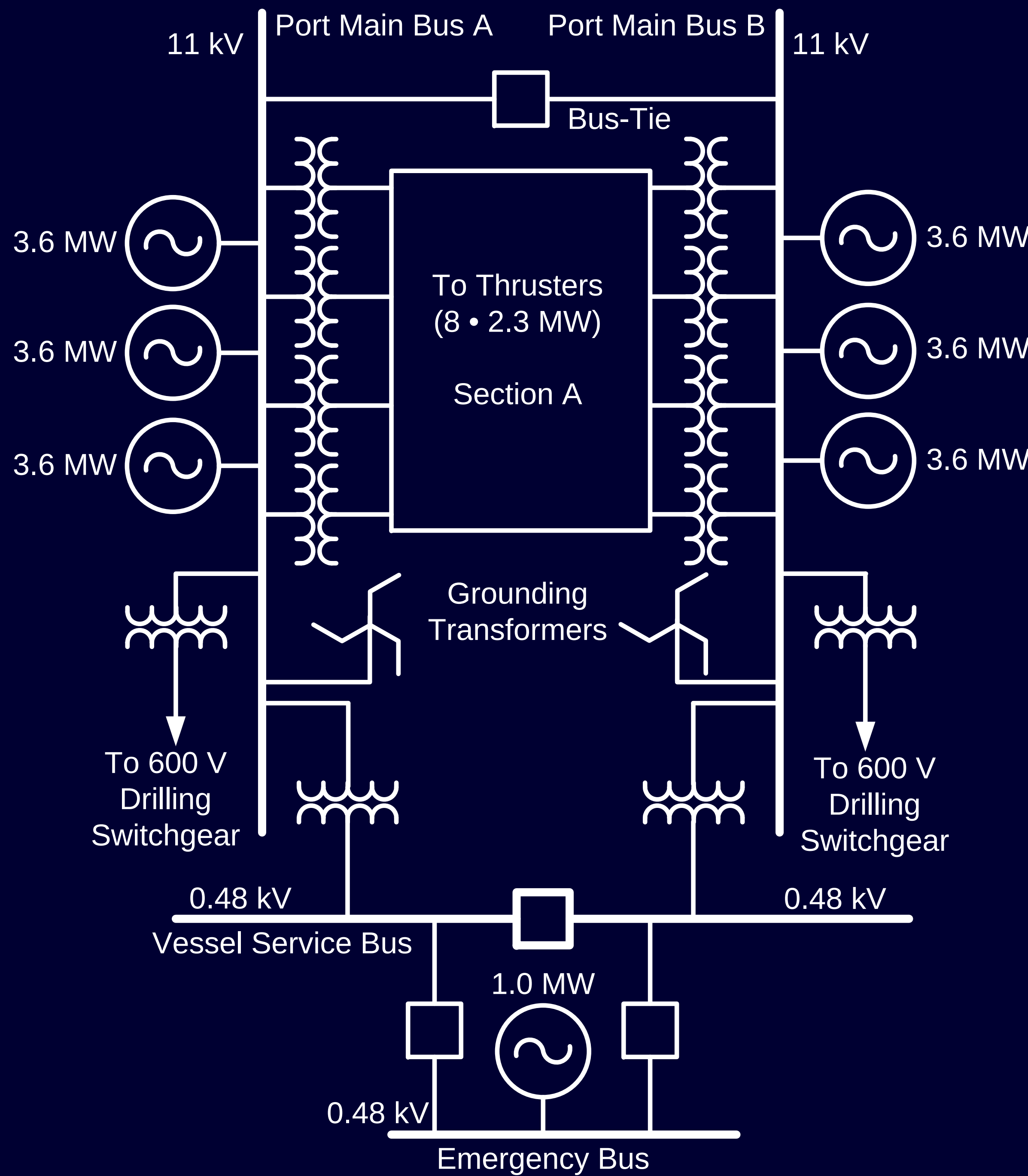
Importance of Power Plants

- Current rates for rigs > $500,000 / day
- Power plant reliability affects client cost and drilling contractor revenue
- Power plant failures create costlier downtime than DP faults
- Often twice as much time spent convincing everyone that power plant is fixed than is required to fix power plant

Typical DP Rig Power System

- State-of-the-art drilling rig costs
  - $400M to $900M USD
  - 2 years to build
- DP rig power plant configurations
  - Single / dual bus (6 thrusters)
  - Dual bus (8 / 17 thrusters)
  - 18 configurations in Transocean
  - Dozens of configurations in the industry

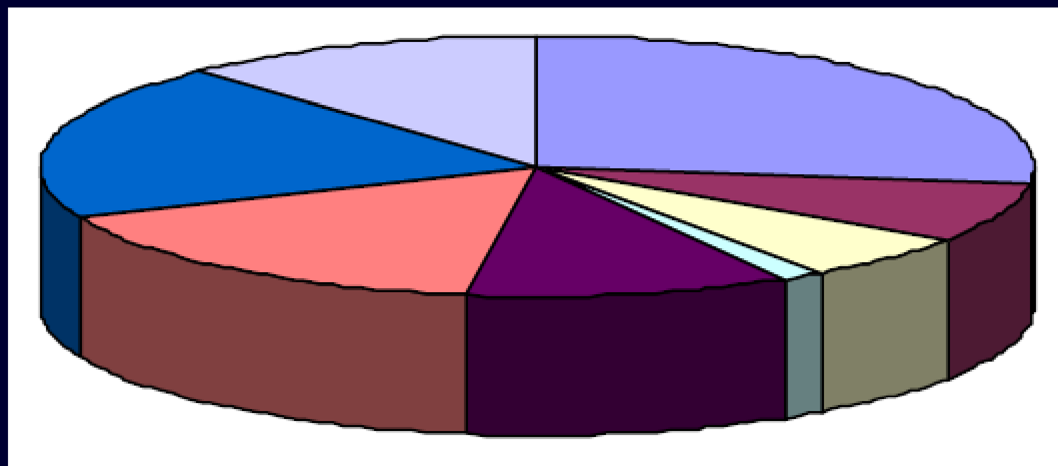
Example DP Rig Power System



Cost of DP Incidents

- High costs
  - Loss of revenue / reputation
  - Delayed production
  - Risk to personnel, equipment
  - Potential environmental impact
- Reduction of DP incidents – major focus
- Power plant faults – main cause

DP Incidents



- Computer
- Electrical
- Environment
- External Force
- Human Error
- Power
- Reference
- Thrusters

IMCA statistics for 2007 DP Incidents (reproduced courtesy of IMCA DP Station Keeping Incident Report 2007)

DP Power Plant Faults

- Individual equipment faults addressed with maintenance, procedures, and redundancy
- Common-mode faults often end in blackout (limited protection)

PMS for DP Power Plants

- Other industries have even higher downtime costs and an even higher focus on power plant reliability
- Sophisticated simulation reduces installation time
- Industrial grade equipment provides high reliability

PMS for DP Power Plants

- Industrial grade equipment built with MIL-SPEC components provides high reliability
- Detection of impending failure rather than detecting failure improves reliability

Proposed Solution

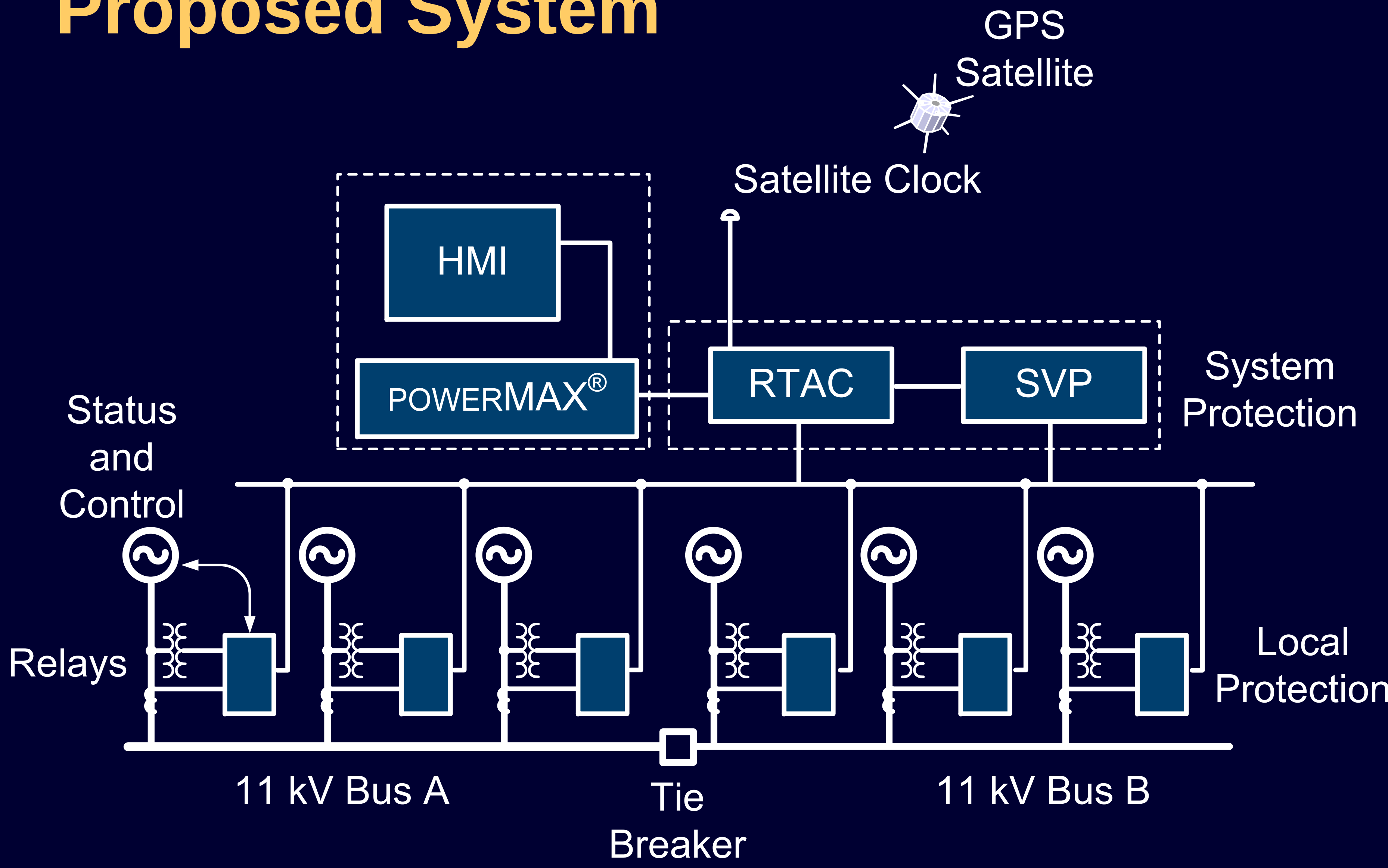
- Local protection
  - Protection and controls
  - Communication

- System protection
  - Protection and controls
  - Communication
  - Engineering station

Proposed Solution

- Common-mode faults
- Design verification
- Security
- Reliability

Proposed System



Local Protection Block

- Generator protection and control
  - Power – P & Q
  - Differential
  - Loss of excitation
  - Under- and overvoltage
  - Under- and overfrequency
- Synchrophasor data collection

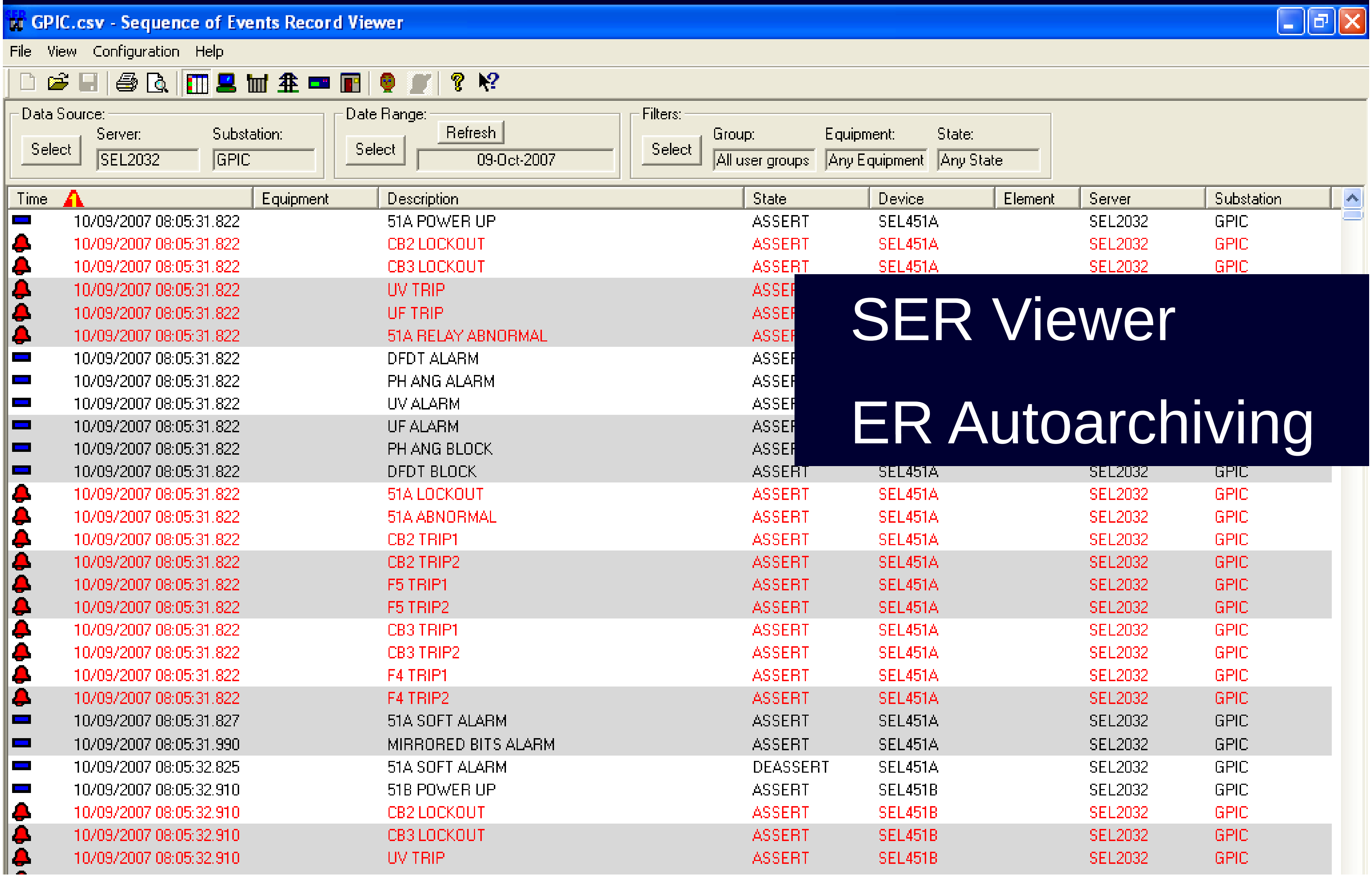
System Protection Block

- Power management system
  - Load dependent start / stop
  - Generator control and order selection
  - Blackout start / recovery
- Engineering diagnostics
  - SOE / ER
  - HMI

Communications Options

- Synchrophasors
- Protocols
  - DNP3 / Modbus®
  - IEC 61131
  - MIRRORED BITS® communications
  - IEC 61850
- Fiber optics

Sequence of Events

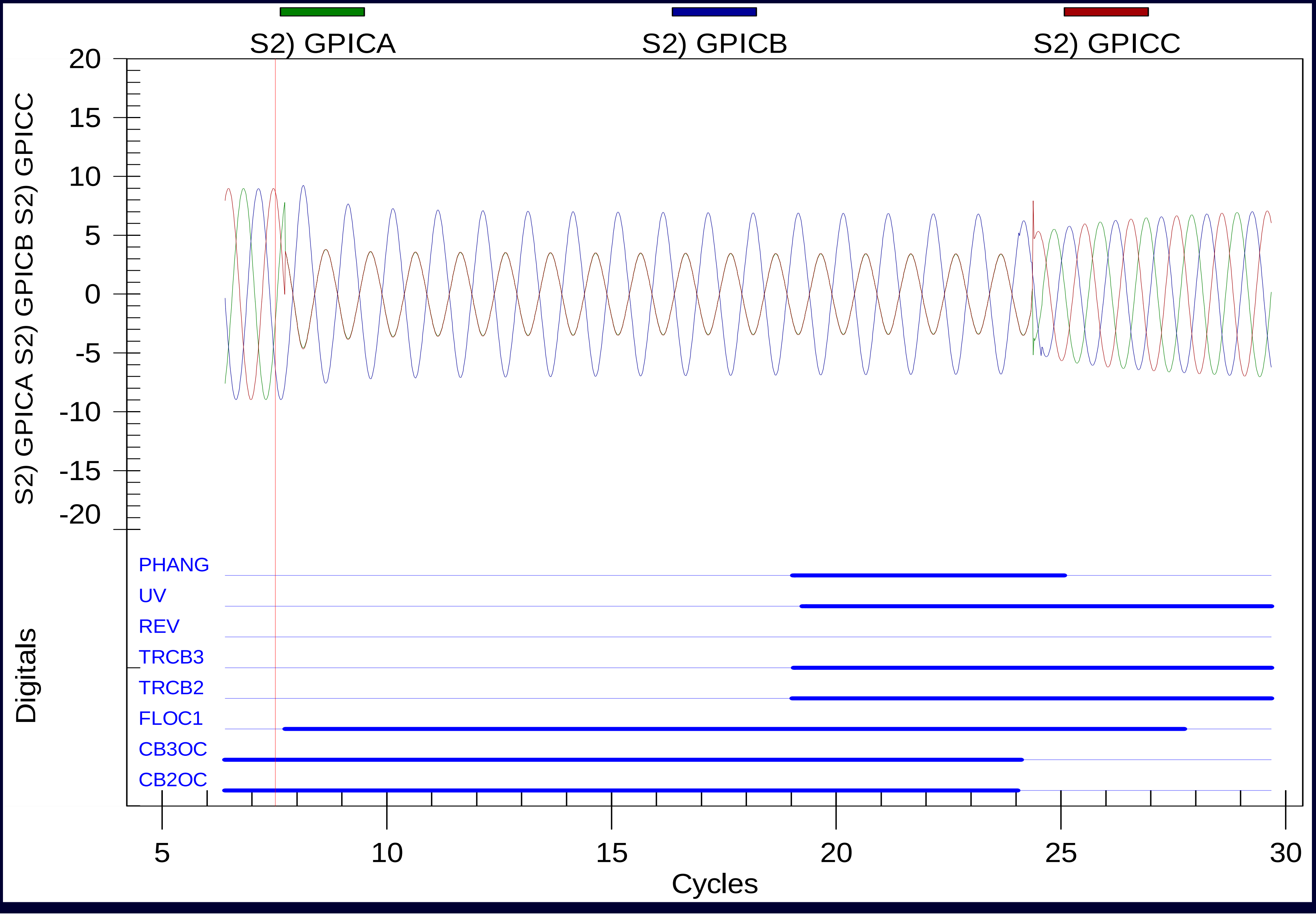


Time	Equipment	Description	State	Device	Element	Server	Substation
10/09/2007 08:05:31.822		51A POWER UP	ASSERT	SEL451A		SEL2032	GPIC
10/09/2007 08:05:31.822		CB2 LOCKOUT	ASSERT	SEL451A		SEL2032	GPIC
10/09/2007 08:05:31.822		CB3 LOCKOUT	ASSERT	SEL451A		SEL2032	GPIC
10/09/2007 08:05:31.822		UV TRIP	ASSEF				
10/09/2007 08:05:31.822		UF TRIP	ASSEF				
10/09/2007 08:05:31.822		51A RELAY ABNORMAL	ASSEF				
10/09/2007 08:05:31.822		DFDT ALARM	ASSEF				
10/09/2007 08:05:31.822		PH ANG ALARM	ASSEF				
10/09/2007 08:05:31.822		UV ALARM	ASSEF				
10/09/2007 08:05:31.822		UF ALARM	ASSEF				
10/09/2007 08:05:31.822		PH ANG BLOCK	ASSEF				
10/09/2007 08:05:31.822		DFDT BLOCK	ASSERT	SEL451A		SEL2032	GPIC
10/09/2007 08:05:31.822		51A LOCKOUT	ASSERT	SEL451A		SEL2032	GPIC
10/09/2007 08:05:31.822		51A ABNORMAL	ASSERT	SEL451A		SEL2032	GPIC
10/09/2007 08:05:31.822		CB2 TRIP1	ASSERT	SEL451A		SEL2032	GPIC
10/09/2007 08:05:31.822		CB2 TRIP2	ASSERT	SEL451A		SEL2032	GPIC
10/09/2007 08:05:31.822		F5 TRIP1	ASSERT	SEL451A		SEL2032	GPIC
10/09/2007 08:05:31.822		F5 TRIP2	ASSERT	SEL451A		SEL2032	GPIC
10/09/2007 08:05:31.822		CB3 TRIP1	ASSERT	SEL451A		SEL2032	GPIC
10/09/2007 08:05:31.822		CB3 TRIP2	ASSERT	SEL451A		SEL2032	GPIC
10/09/2007 08:05:31.822		F4 TRIP1	ASSERT	SEL451A		SEL2032	GPIC
10/09/2007 08:05:31.822		F4 TRIP2	ASSERT	SEL451A		SEL2032	GPIC
10/09/2007 08:05:31.827		51A SOFT ALARM	ASSERT	SEL451A		SEL2032	GPIC
10/09/2007 08:05:31.990		MIRRORED BITS ALARM	ASSERT	SEL451A		SEL2032	GPIC
10/09/2007 08:05:32.825		51A SOFT ALARM	DEASSERT	SEL451A		SEL2032	GPIC
10/09/2007 08:05:32.910		51B POWER UP	ASSERT	SEL451B		SEL2032	GPIC
10/09/2007 08:05:32.910		CB2 LOCKOUT	ASSERT	SEL451B		SEL2032	GPIC
10/09/2007 08:05:32.910		CB3 LOCKOUT	ASSERT	SEL451B		SEL2032	GPIC
10/09/2007 08:05:32.910		UV TRIP	ASSERT	SEL451B		SEL2032	GPIC

SER Viewer

ER Autoarchiving

Event Report

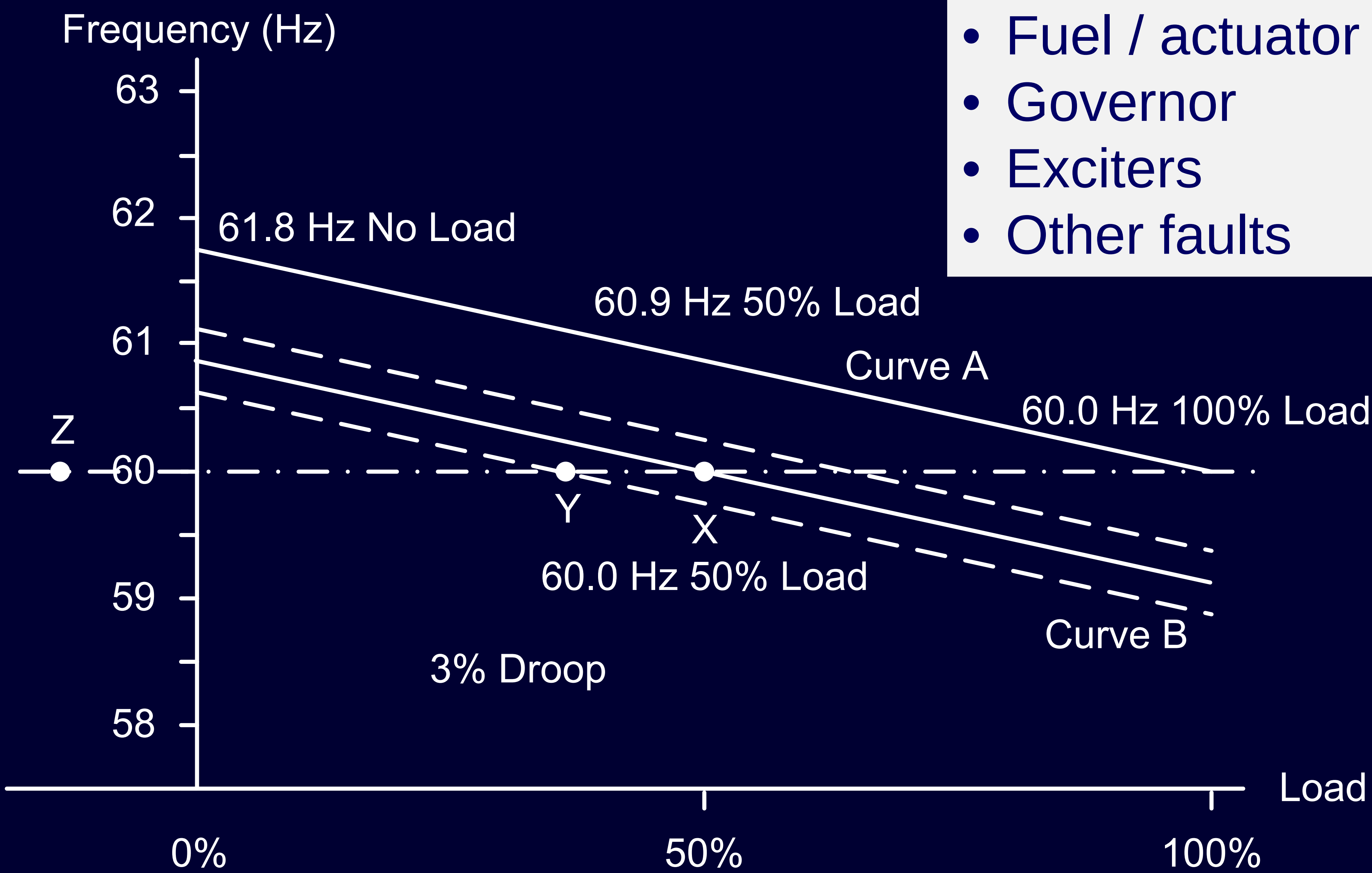


Additional PMS Features

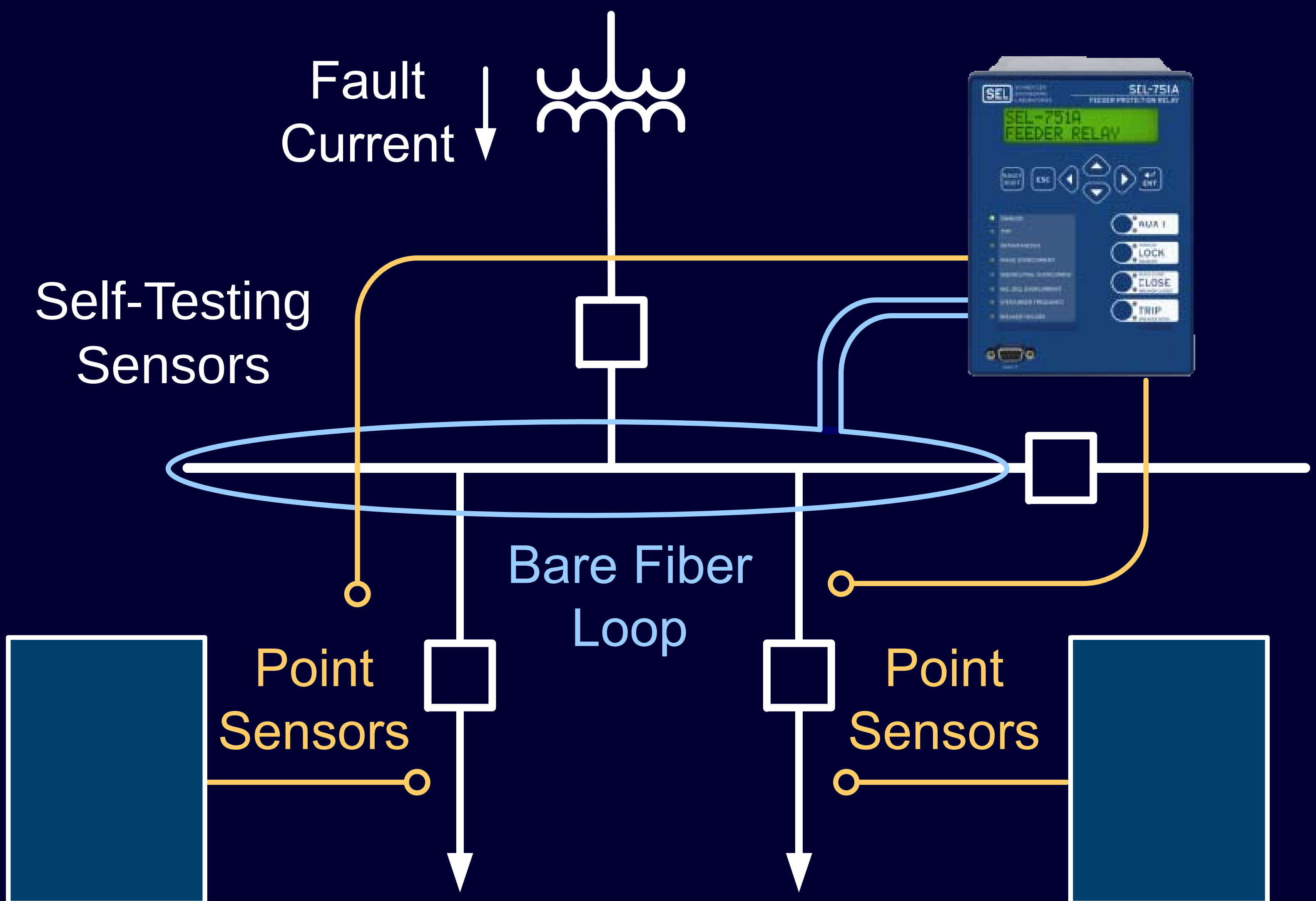
- Synchrophasors
- Flexible synchronizer
- Arc-flash protection
- Additional protection
  - Bus, transformer, and feeder
  - Cable and motor

Common-Mode Faults

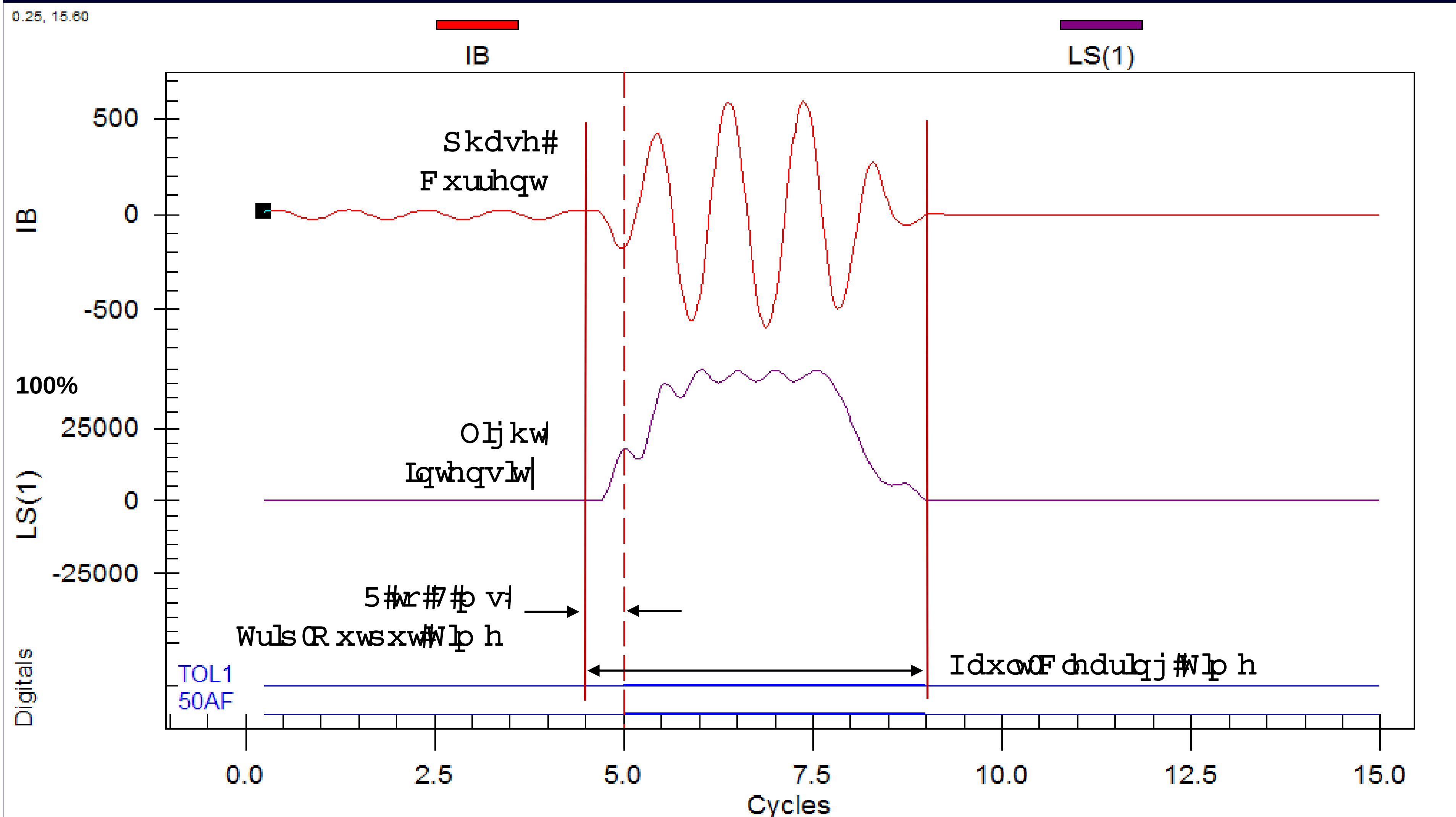
- Fuel / actuator
- Governor
- Exciters
- Other faults



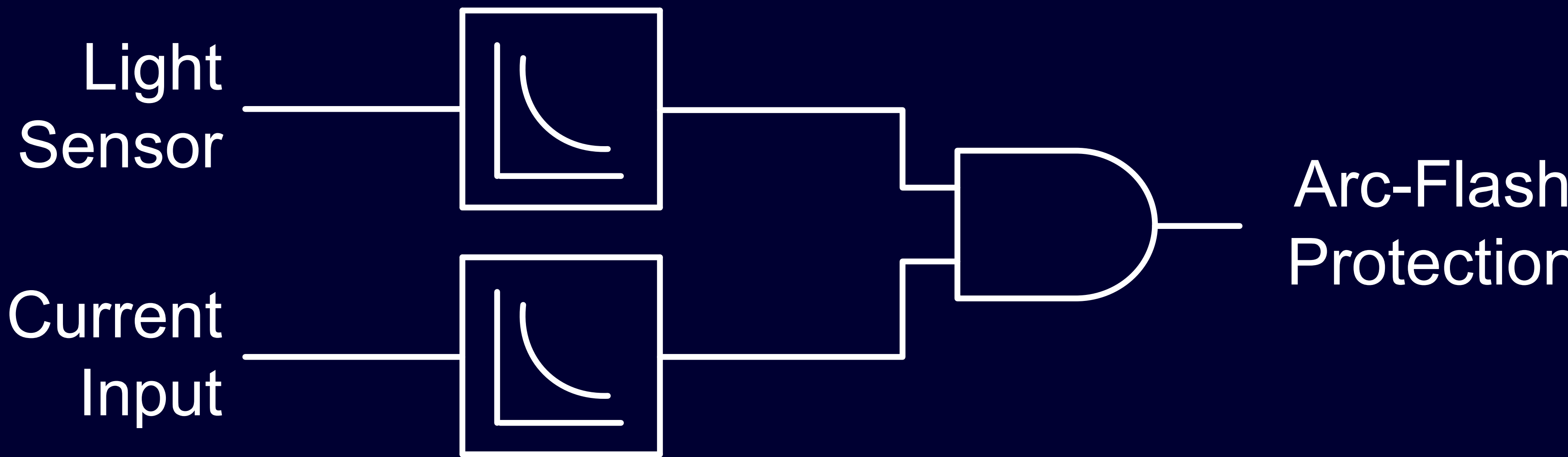
Relay + Arc-Flash Detection = Most Reliable and Economical Solution



Example Report: Arc-Flash Fault



Arc-Flash Mitigation Solution



Arc-Flash Mitigation Solution

- Replace relays
- Revise coordination / protection
- Use proper PPE
- Install warning labels

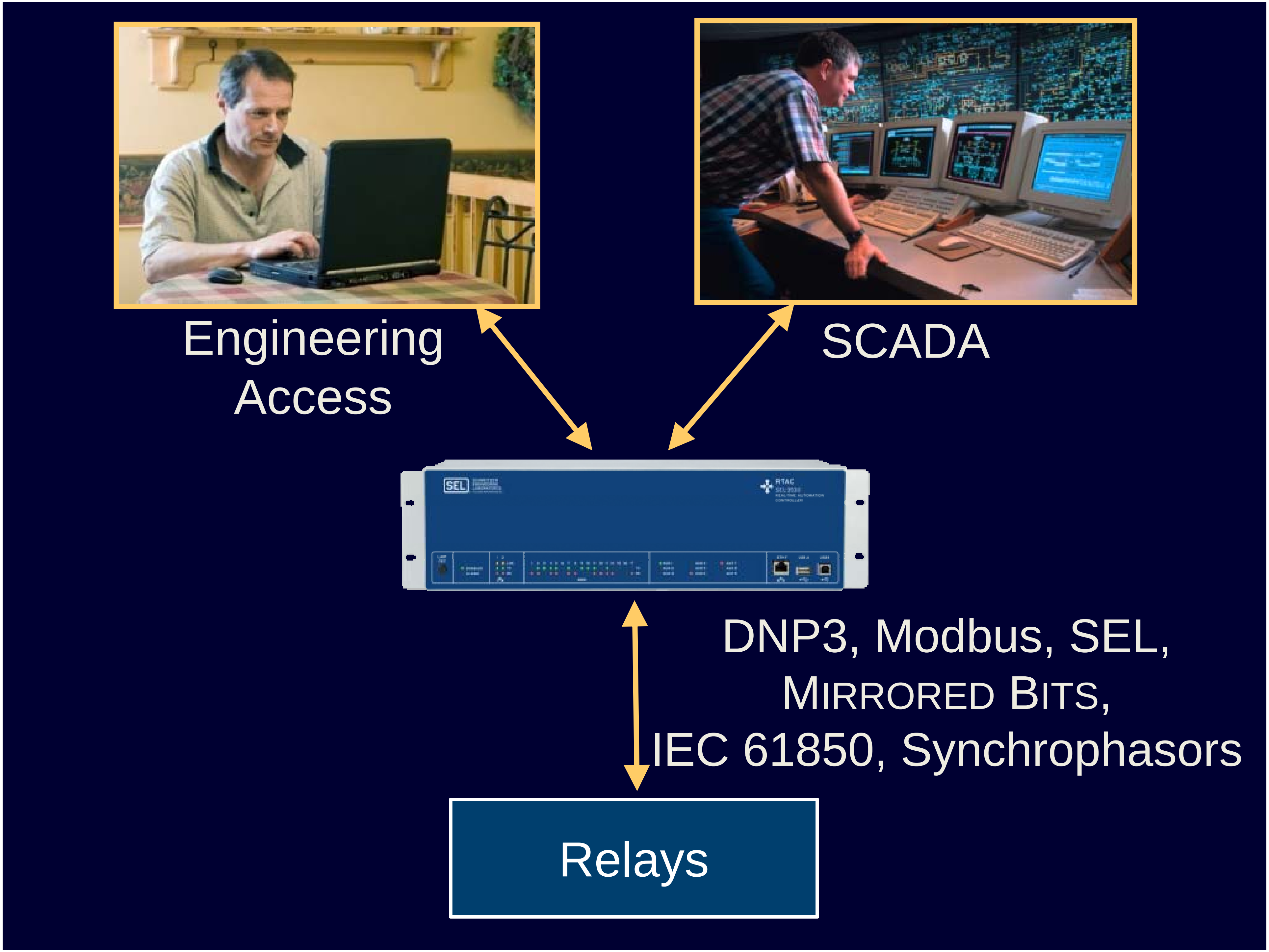
Automation Controller (RTAC)

ACSELERATOR® RTAC

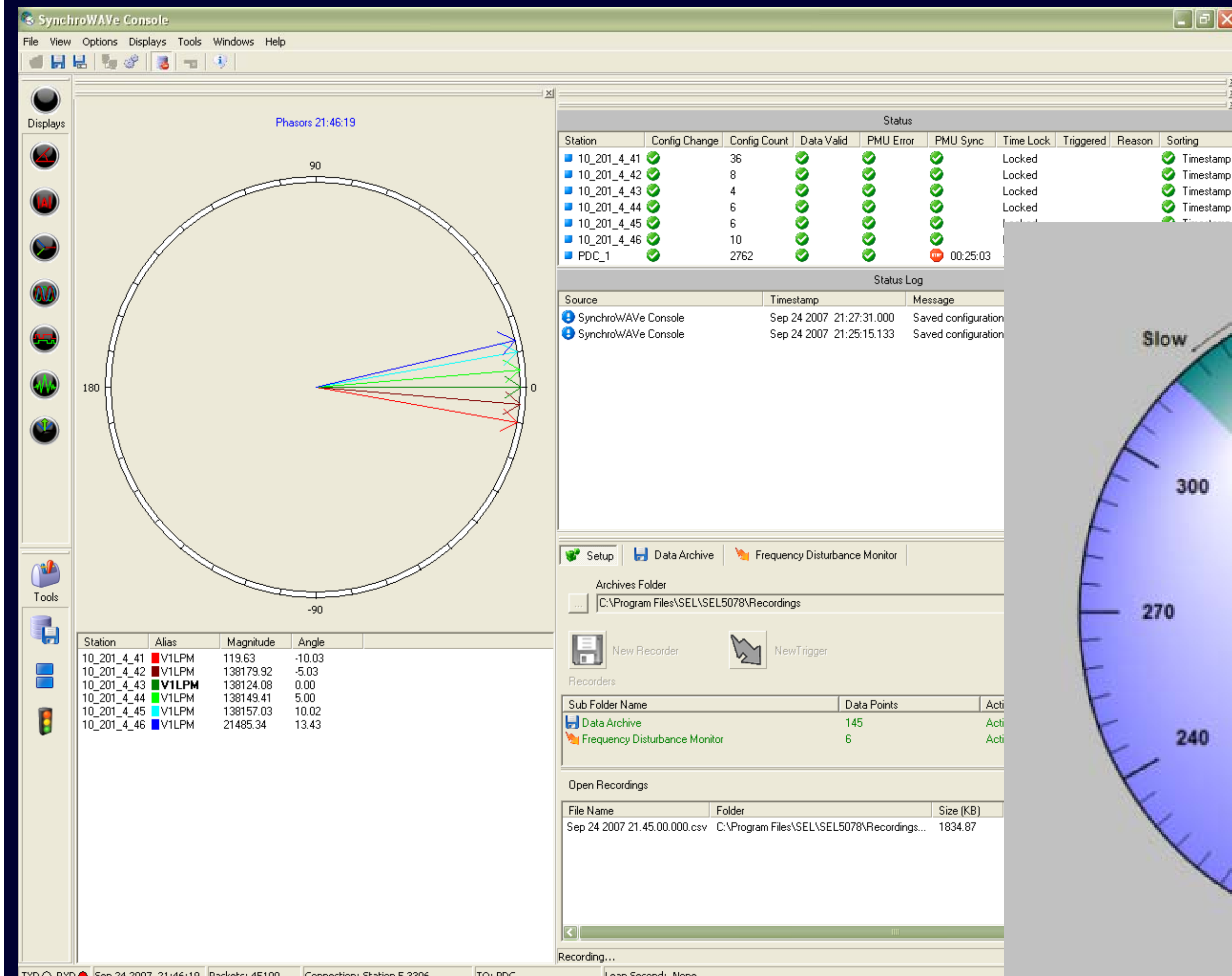
- ✓ Offline configuration
- ✓ Device definition
- ✓ RTAC firmware manager
- ✓ Custom logic programming

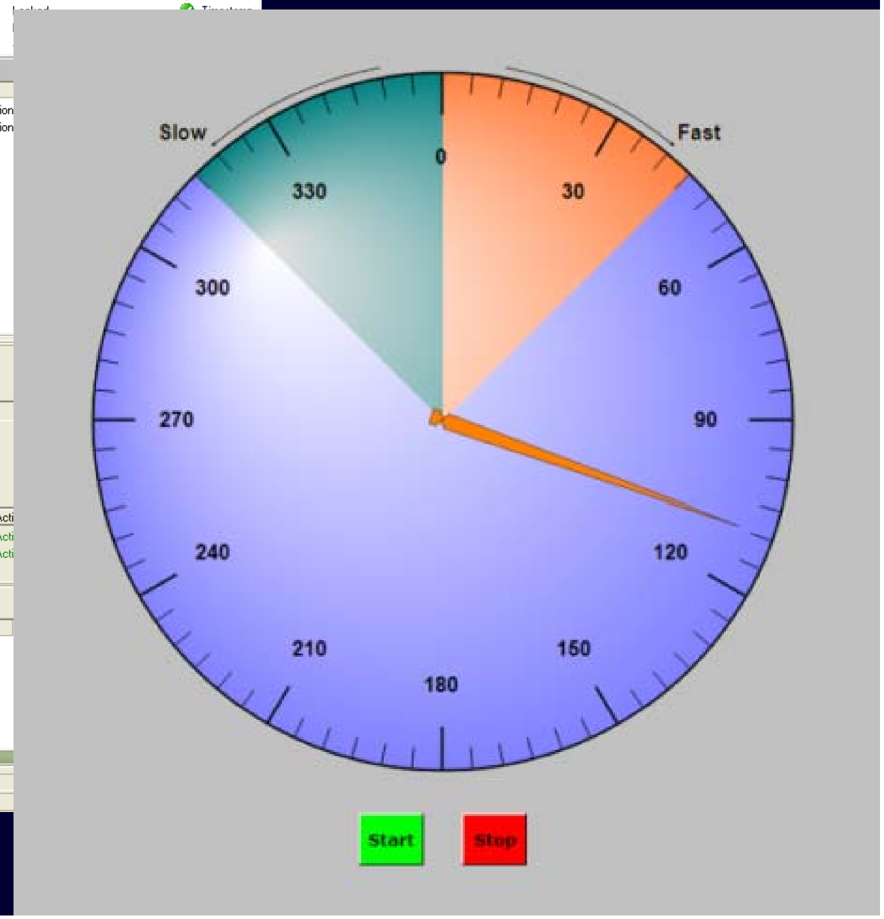
Web Server

- ✓ Communications state
- ✓ System diagnostics
- ✓ User administration
- ✓ Network configuration
- ✓ Alarm panel
- ✓ SER reports
- ✓ Security logs

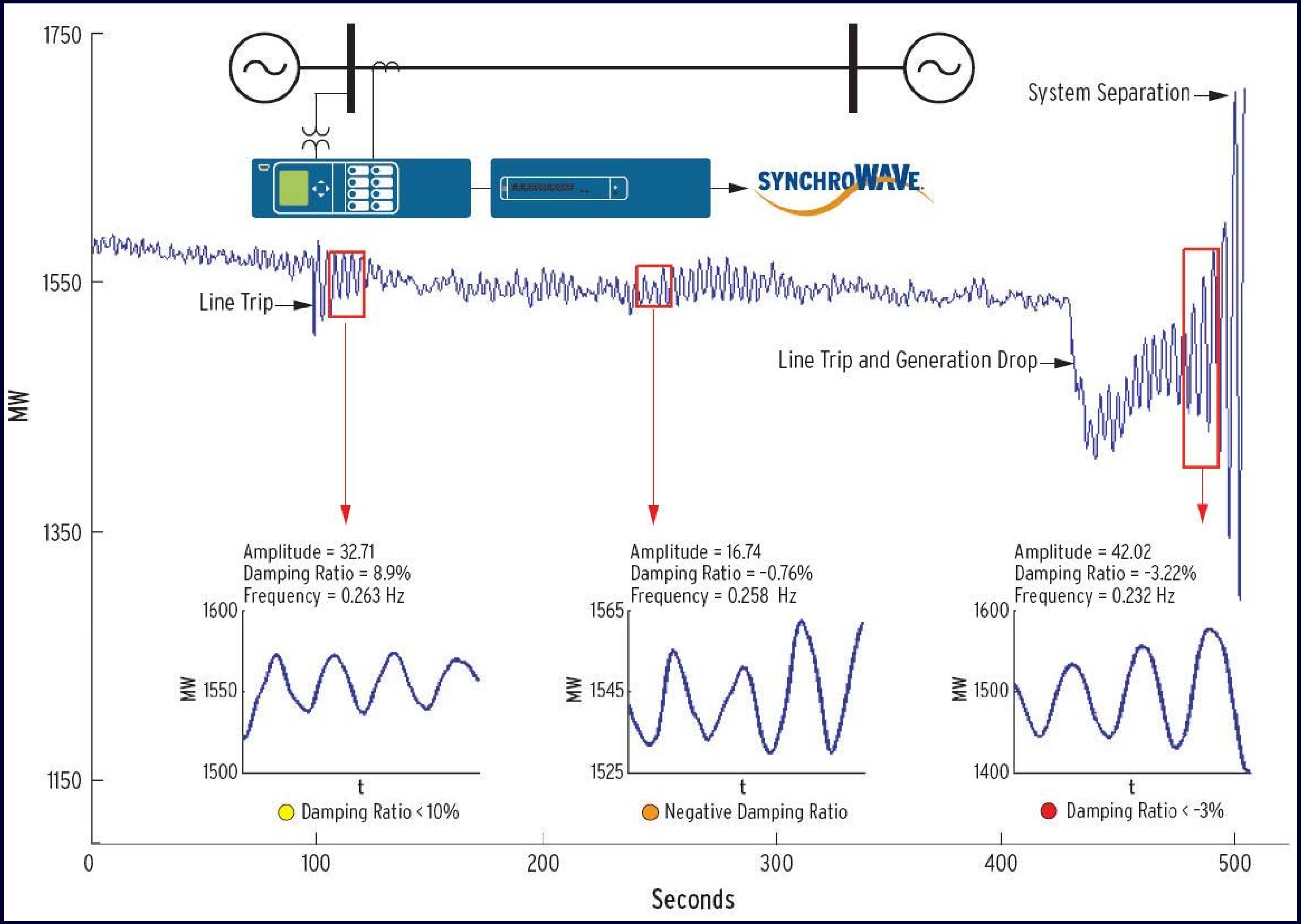

Engineering Access
SCADA
DNP3, Modbus, SEL,
MIRRORED BITS,
IEC 61850, Synchrophasors
Relays

Present Application Data Visualization



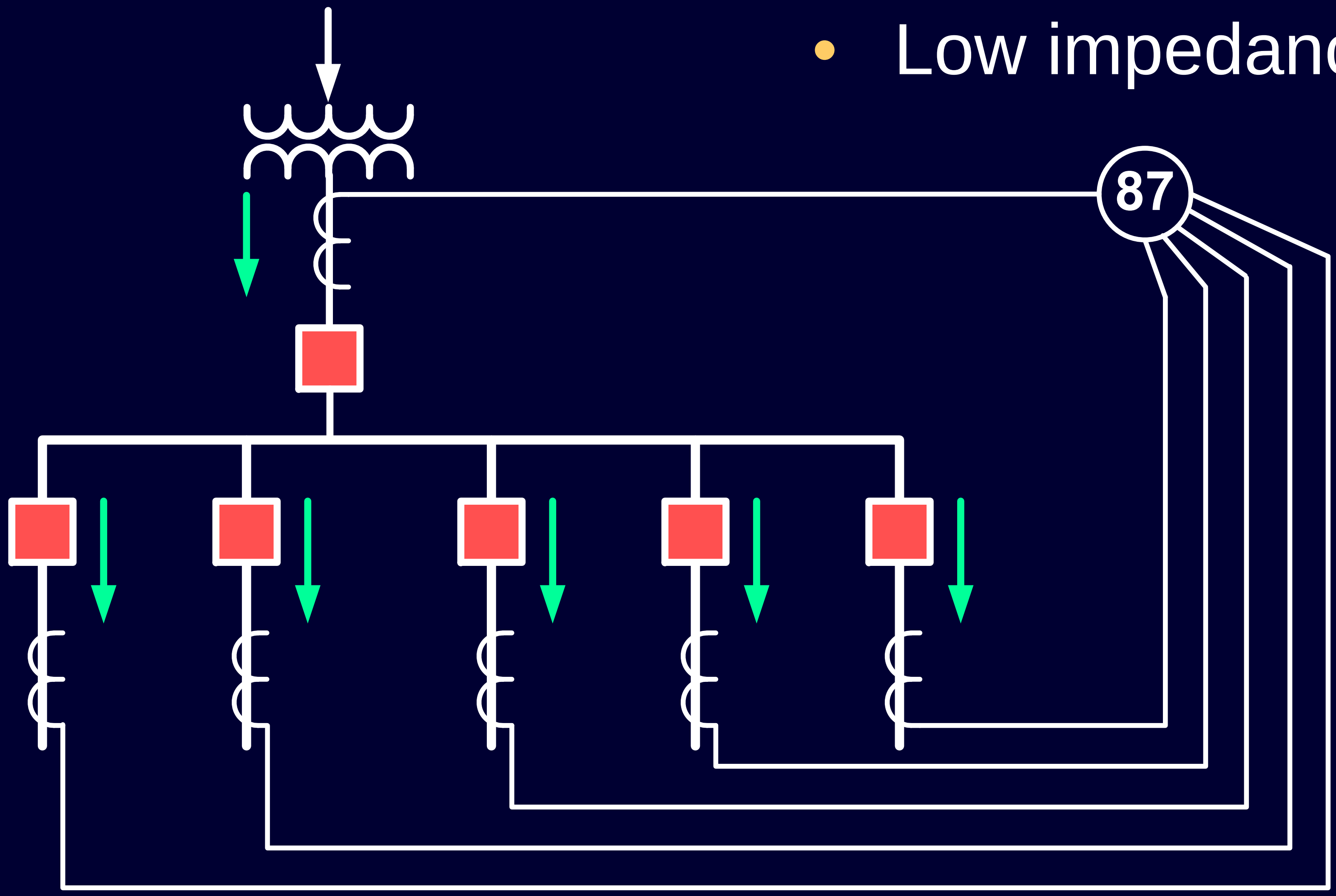


Detect and Respond to Power Oscillations

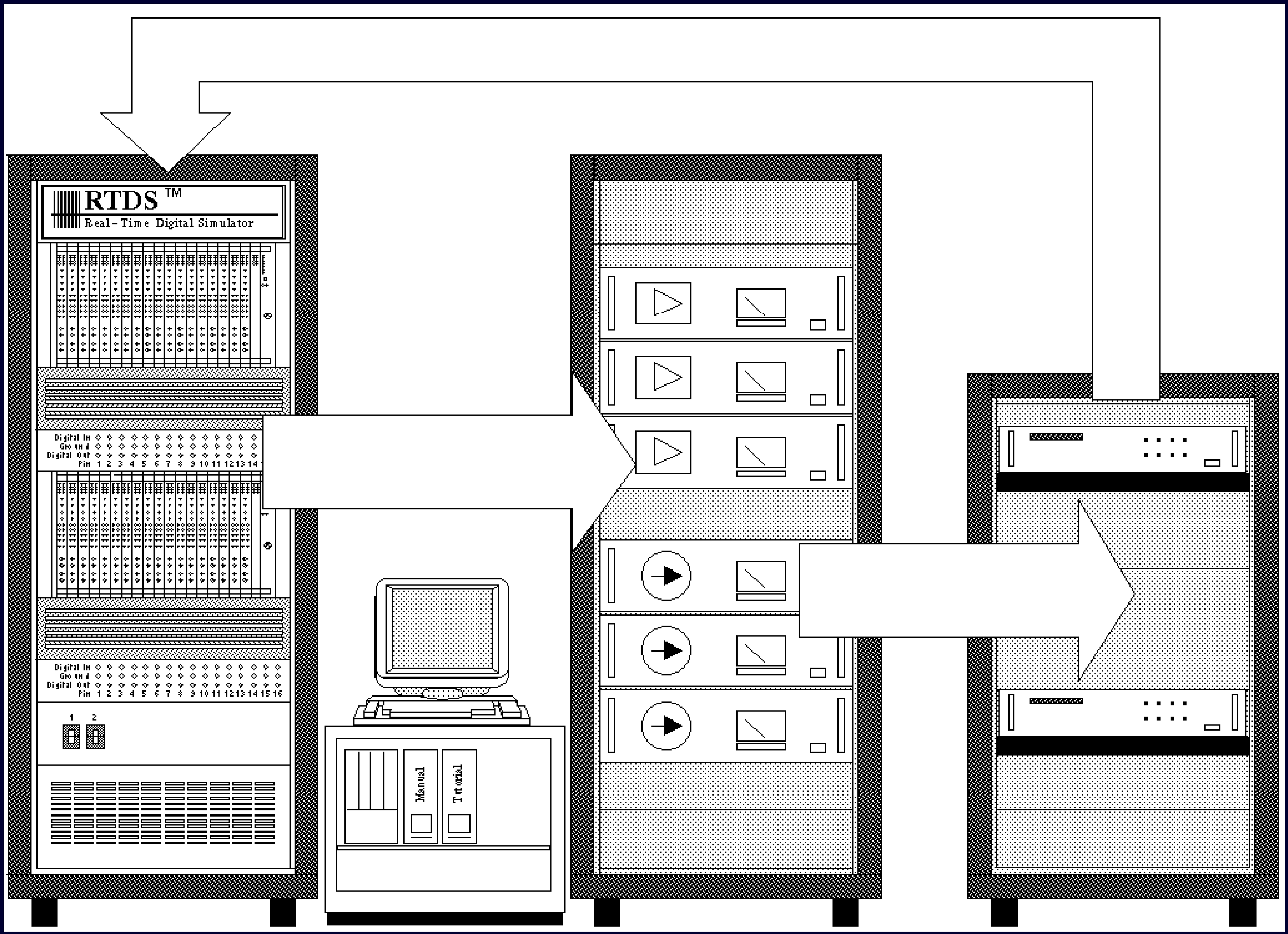


Differential Protection

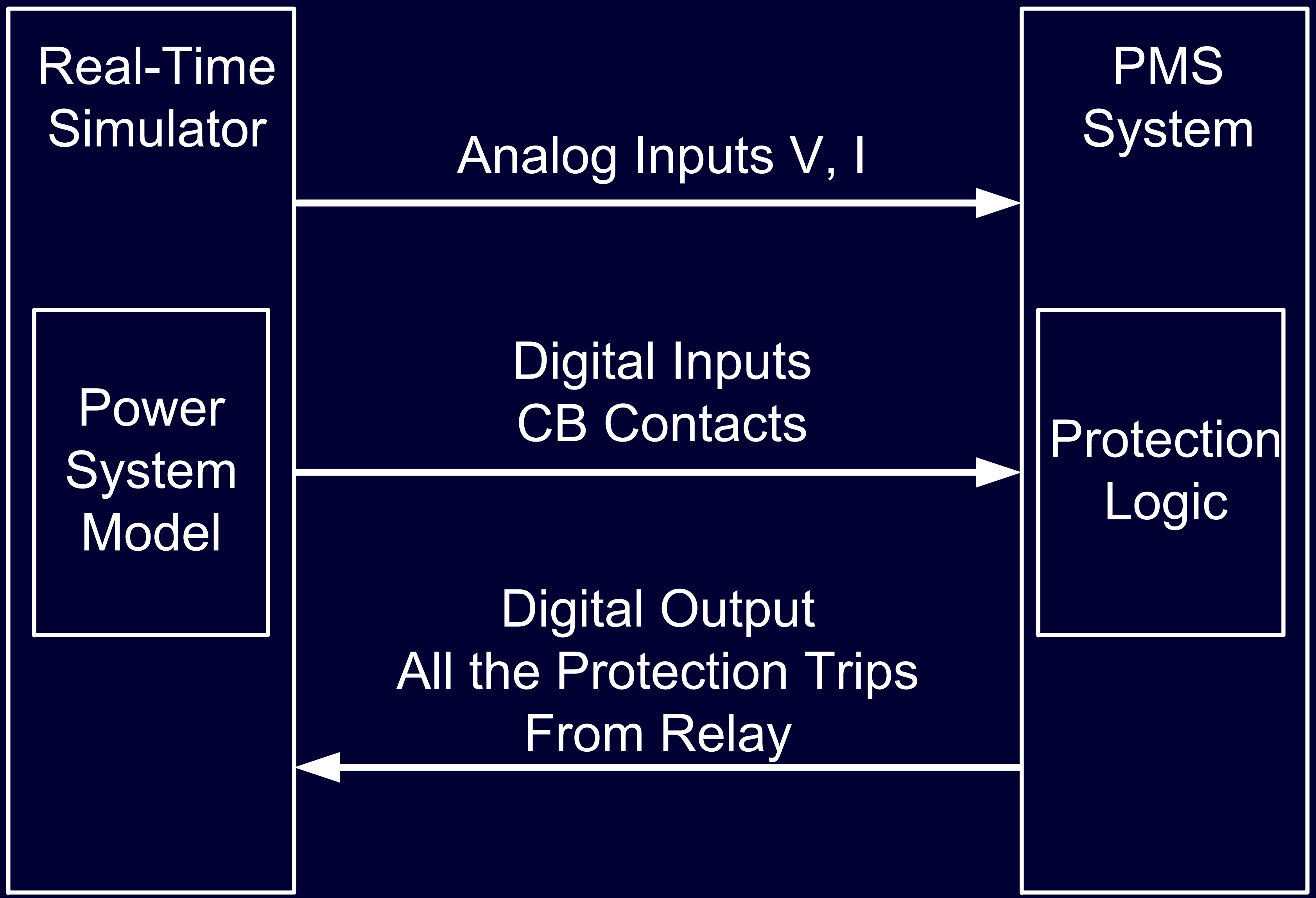
- Blocking scheme
- High impedance
- Low impedance



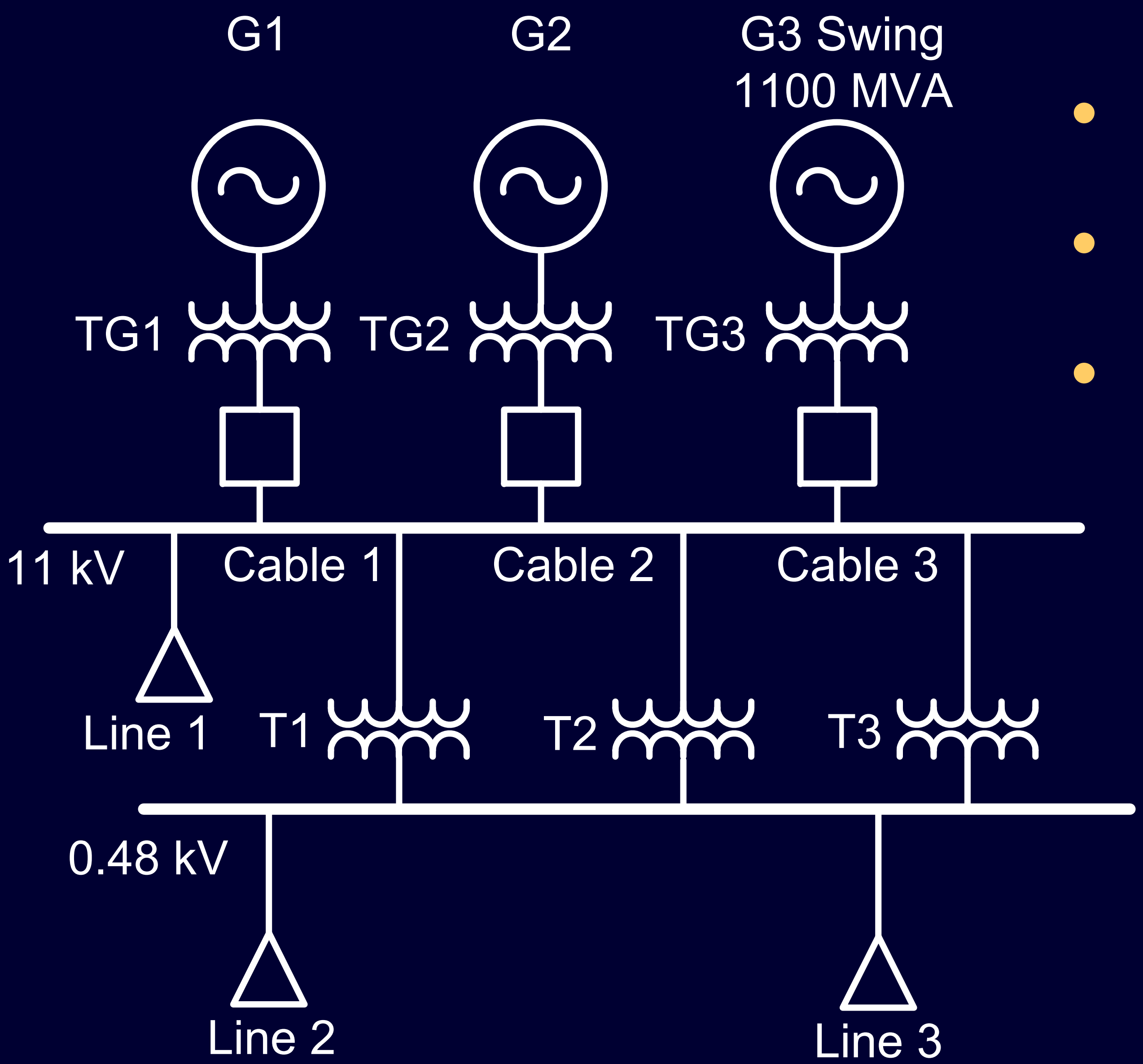
Model Development



Model Development



Model Development



- Load flow
- Short circuit
- Motor starting

Model Validation

- Load shedding
- Exciter response curve
- Governor response curve
- Controls – power factor or VARs, etc.

System Analysis

- Normal system operation
- Black start
- Exciter faults
- Governor faults
- System faults (bus / transformer)
- Contingency

Reliability

Component	Observed MTBF (years)	Unavailability (multiply by 10^{-6})
SEL POWERMAX Controllers and FEP	50	9.1
SEL-2411 PAC	150	3.0
SEL Relays	300+	1.5
Ethernet Switch	50	9.1

Conclusion

- ✓ Expandable and highly reliable system
- ✓ Communications options: synchrophasors, IEC 61850, Modbus / DNP3, MIRRORED BITS communications
- ✓ Design verification and documentation
- ✓ Factory acceptance test with RTDS

Conclusion

- ✓ System / generator protection
- ✓ Arc-flash protection
- ✓ Flexible synchronizer
- ✓ Security
- ✓ Engineering station
- ✓ Analysis tools: SOE, ER
- ✓ Training and on-site support


Questions?