Celebrating 25 Years of Innovation

Synchrophasor System Solutions

Roy Moxley - SEL

Making Electric Power Safer, More Reliable, and More Economical®

SEL Solutions Are Available Today

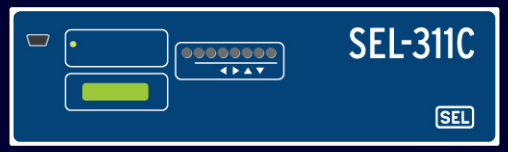
Protection & Control

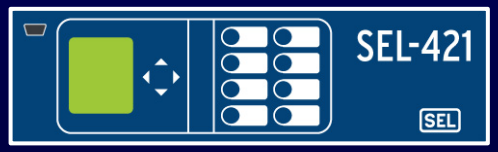
Archiving

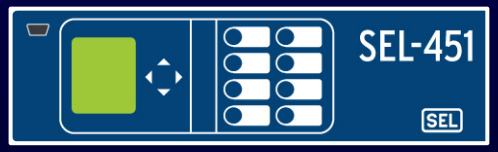
Visualization

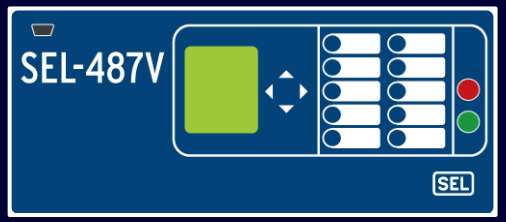
Data Sharing

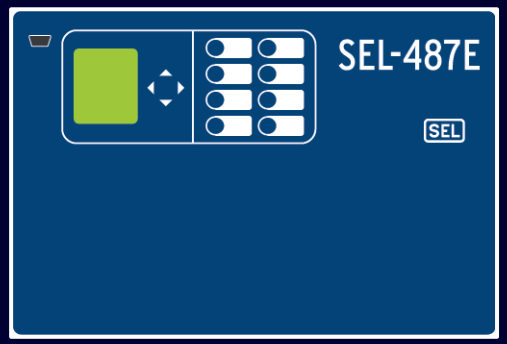
Synchrophasors Are Standard In SEL Products

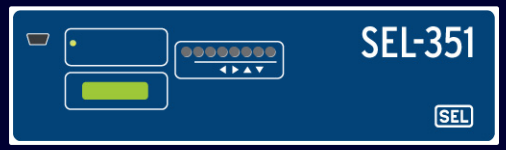




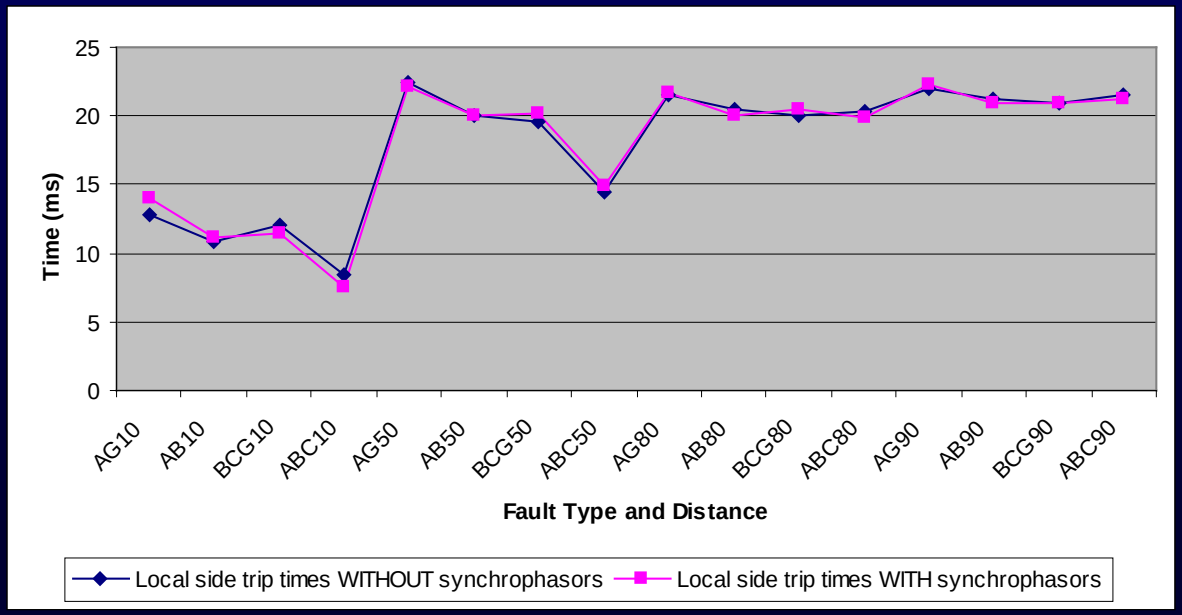




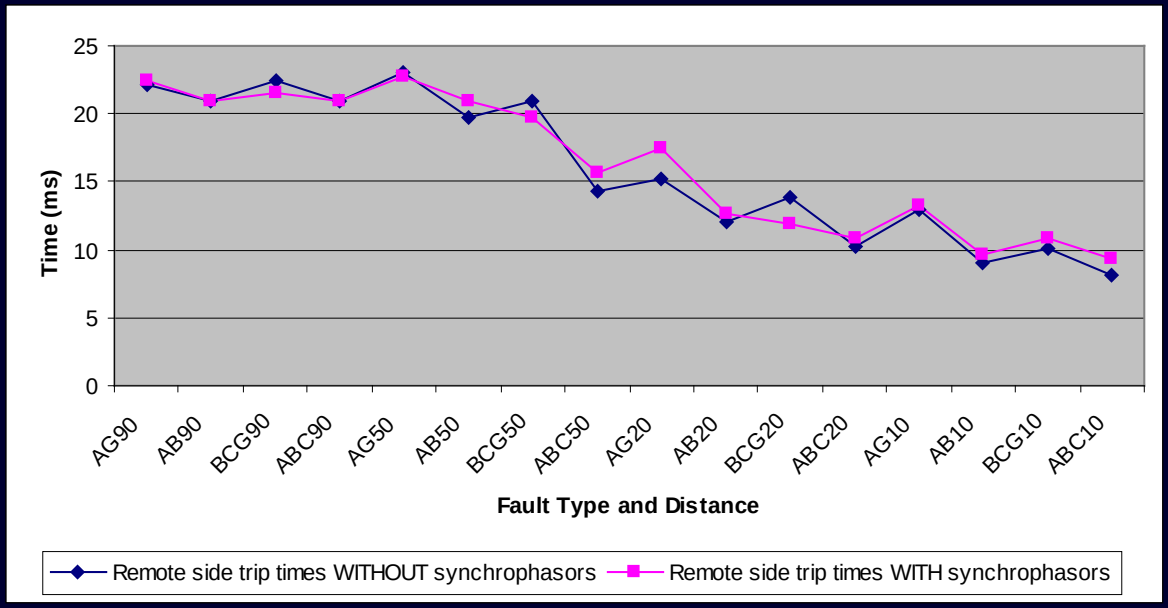




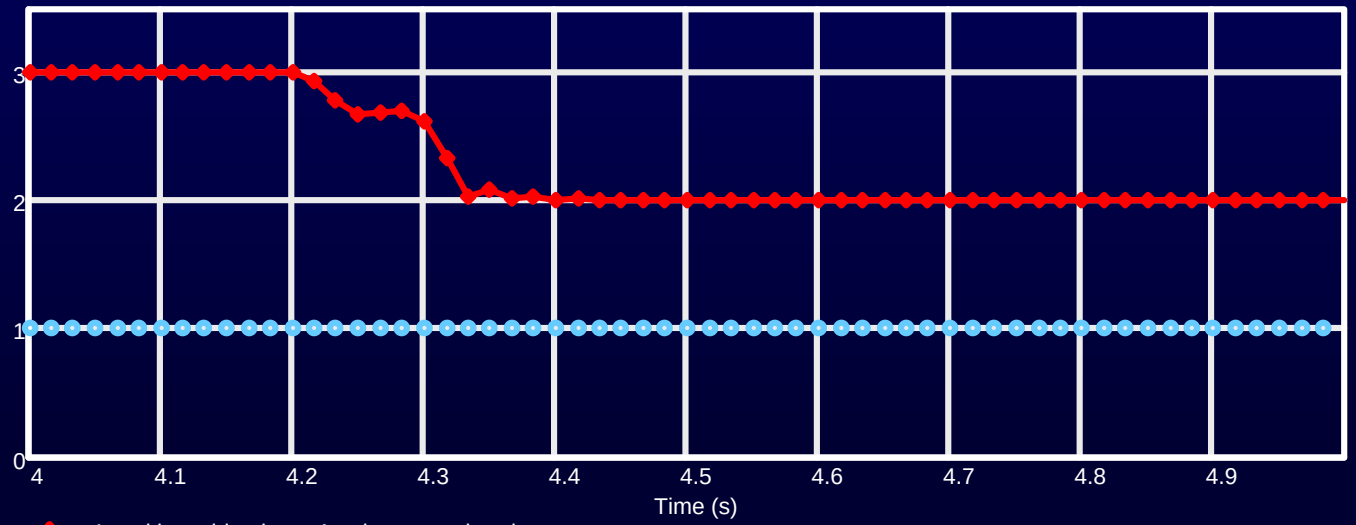
Protection AND Synchrophasors



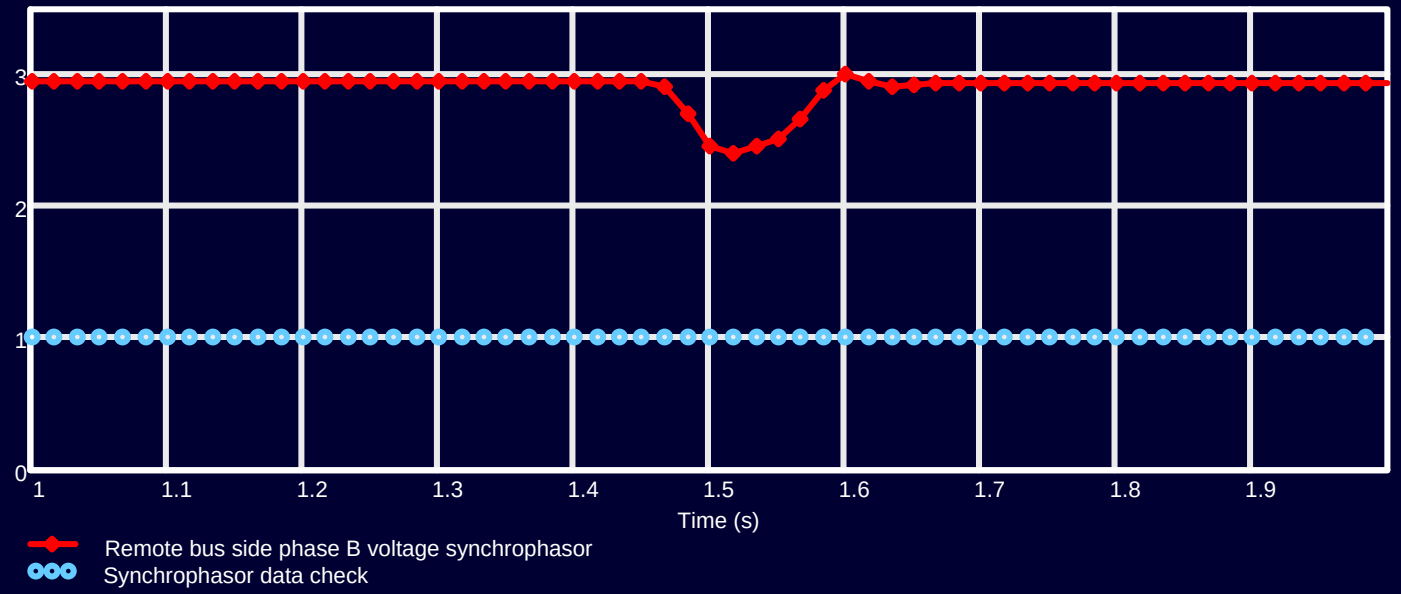
Synchrophasors do not hurt relay performance



Relaying Has No Impact on PMCU Function



No lost data



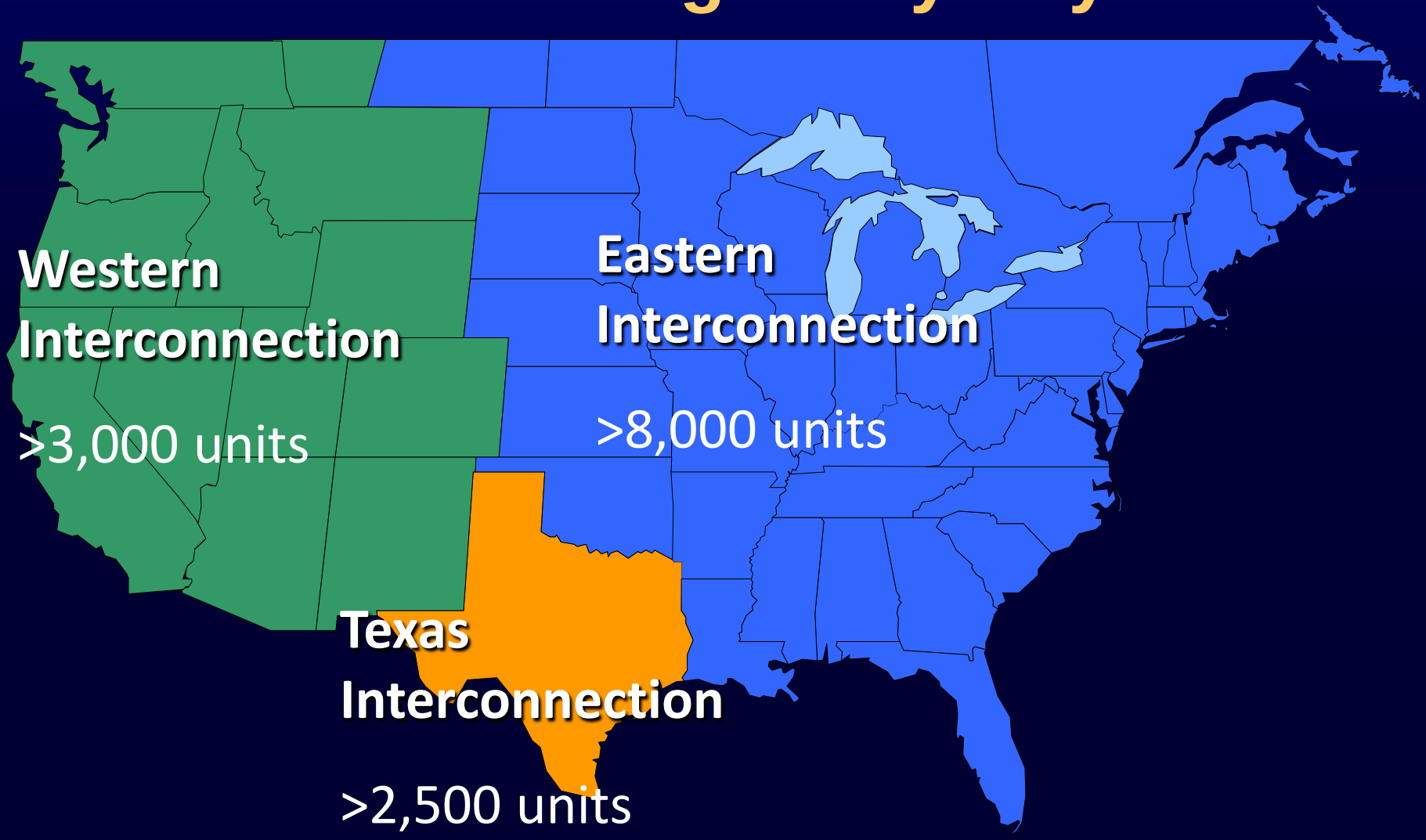
Relays Are Right for Synchrophasors

- No Extra current and voltage connections
- High reliability and availability
- Relays are everywhere

If you want a Free-Standing PMU

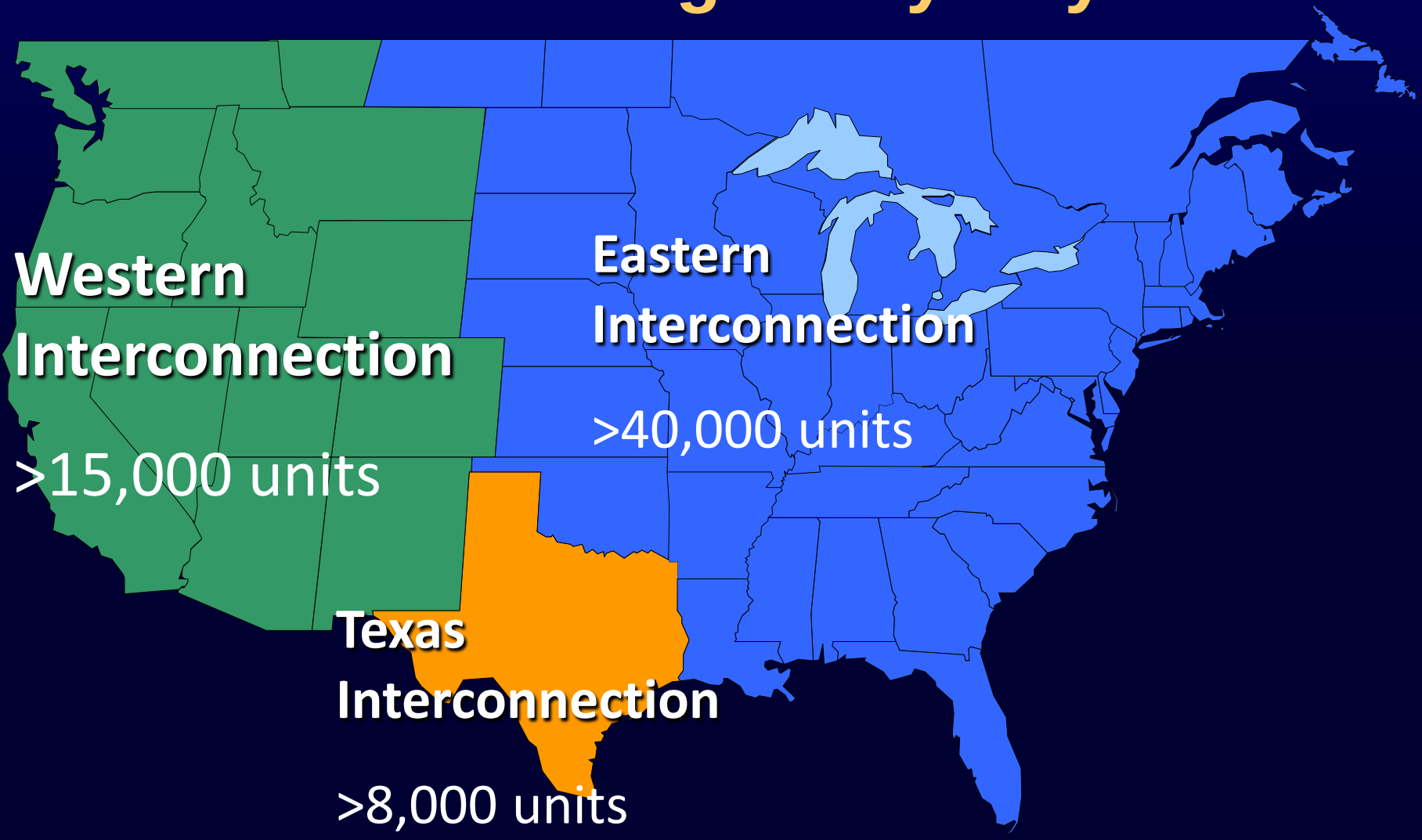
- $1440 SEL-351A : One 3Φ Voltage
  One 3Φ Current
- $7250 SEL-487E : Two 3Φ Voltages
  Six 3Φ Currents

SEL Synchrophasors Are Everywhere, and Growing Every Day!



PMUs with IEEE C37.118 Format (over 30 messages per second)

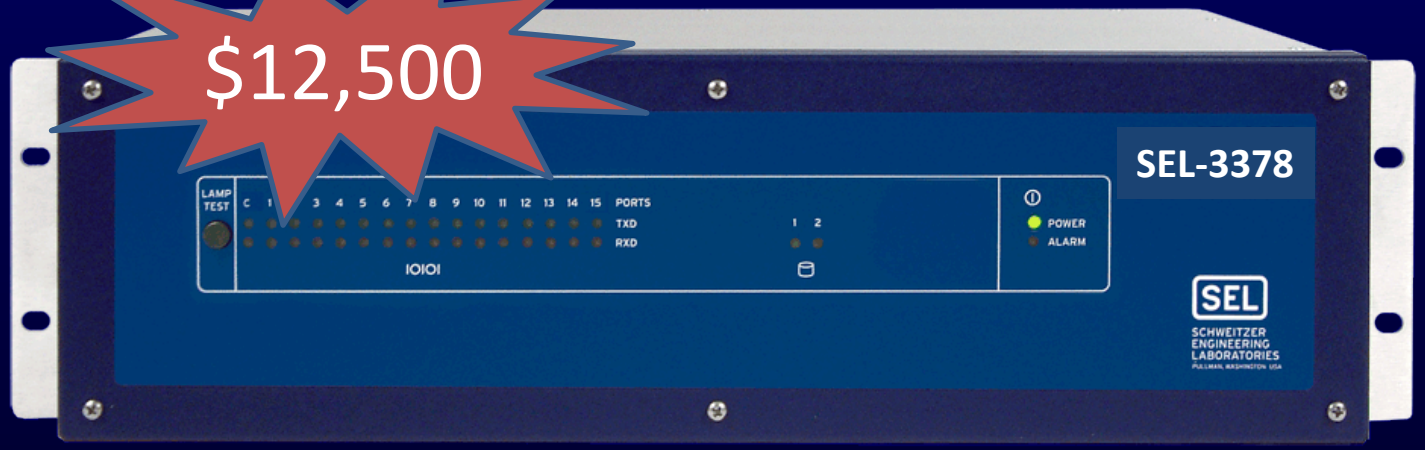
SEL Synchrophasors Are Everywhere, and Growing Every Day!



All PMUs - IEEE C37.118 and SEL Fast Message Formats

Select the Right PDC for Application

$12,500



SYNCHROWAVE®

Server

$7,500

$12,500

RTAC Is Also a PDC

Synchrophasors Are Standard

Automation Controller

Directions are Not Always Clear

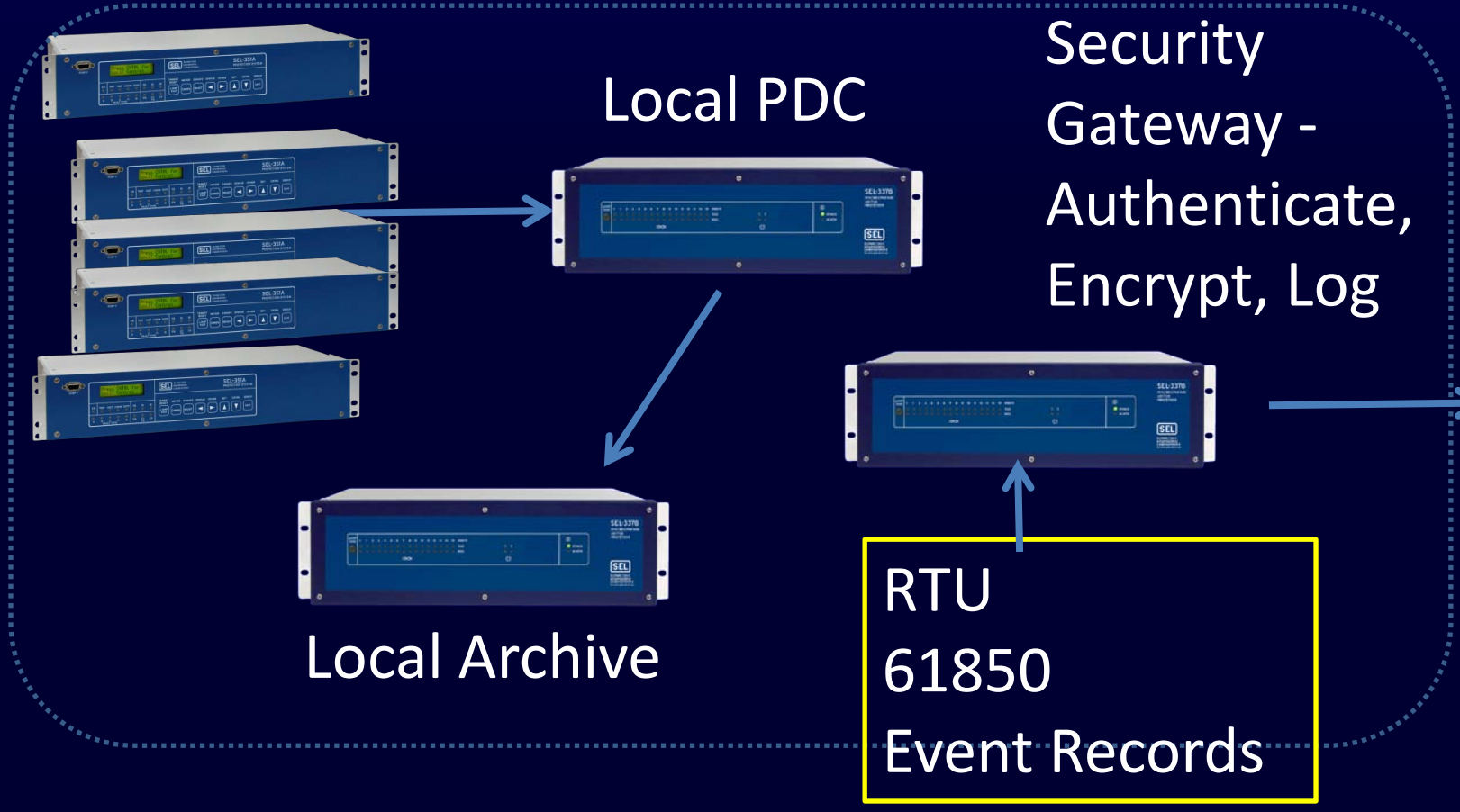
NERC-CIP Does Not Conflict with NASPI

Add Security to Serial Connections

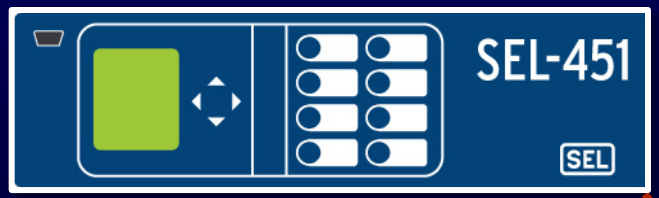
Authenticate
Encrypt

Central
PDC

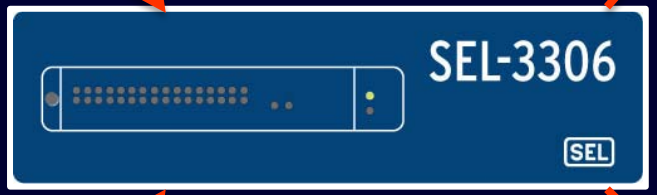
Use Station Security for Ethernet Data Sharing

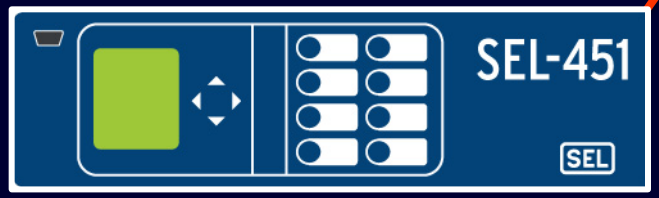


Data Sharing Systems Are Simple



SYNCHROWAVE® Console





EIPP Data Concentrator at TVA

NERC PRC – 002 – 1

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

A. Introduction

1. Title: Disturbance Monitoring and Reporting Requirements

2. Number: PRC-002-1

3. Purpose: To establish requirements for recording and reporting sequence of events (SOE) data, fault recording (FR) data, and dynamic disturbance recording (DDR) data to facilitate analysis of Disturbances.

4. Applicability:

4.1. Transmission Owners

4.2. Generator Owners

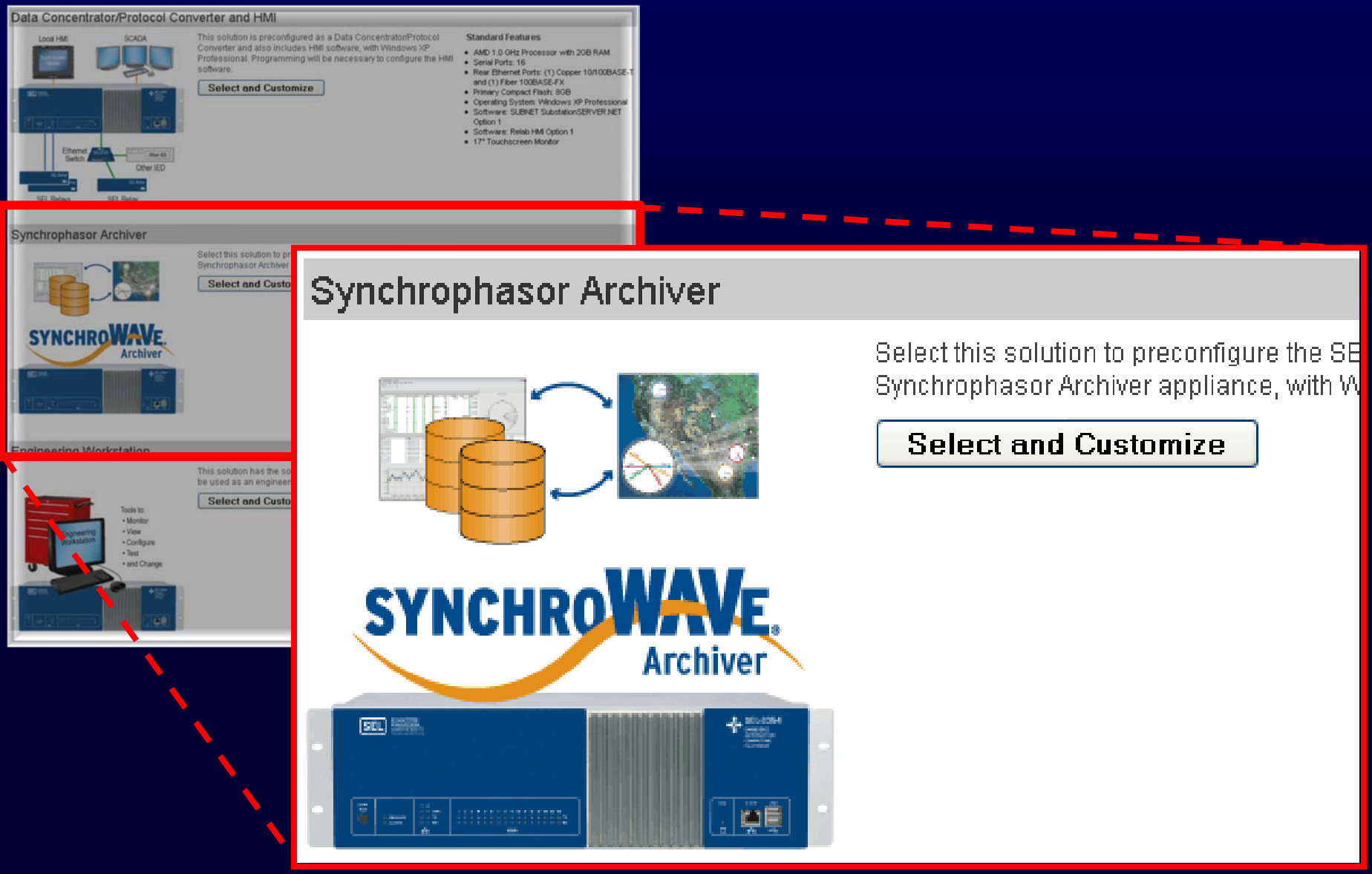
Build a Low-Cost Archiving System

SYNCHROWAVE® Archiver

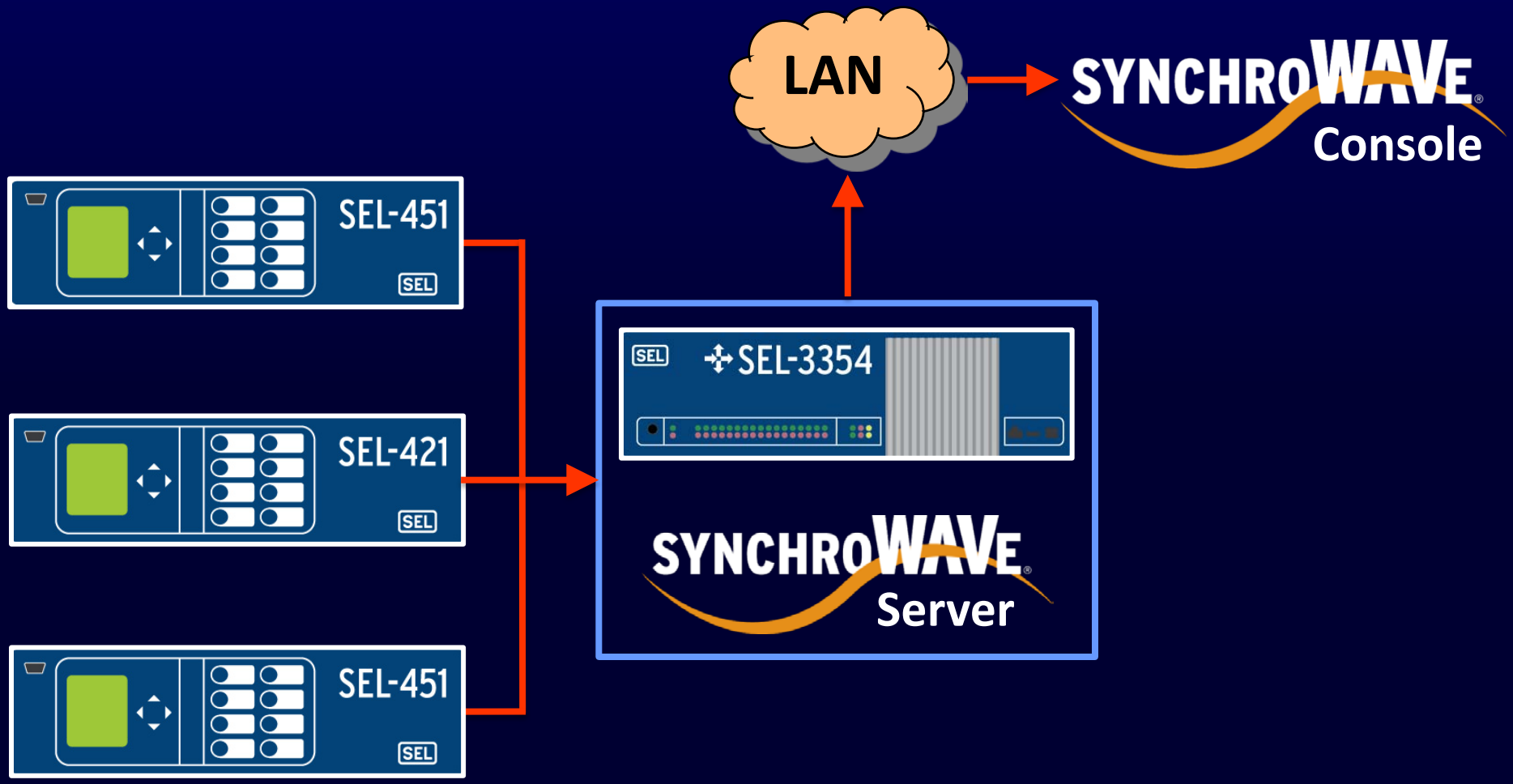
$5,500

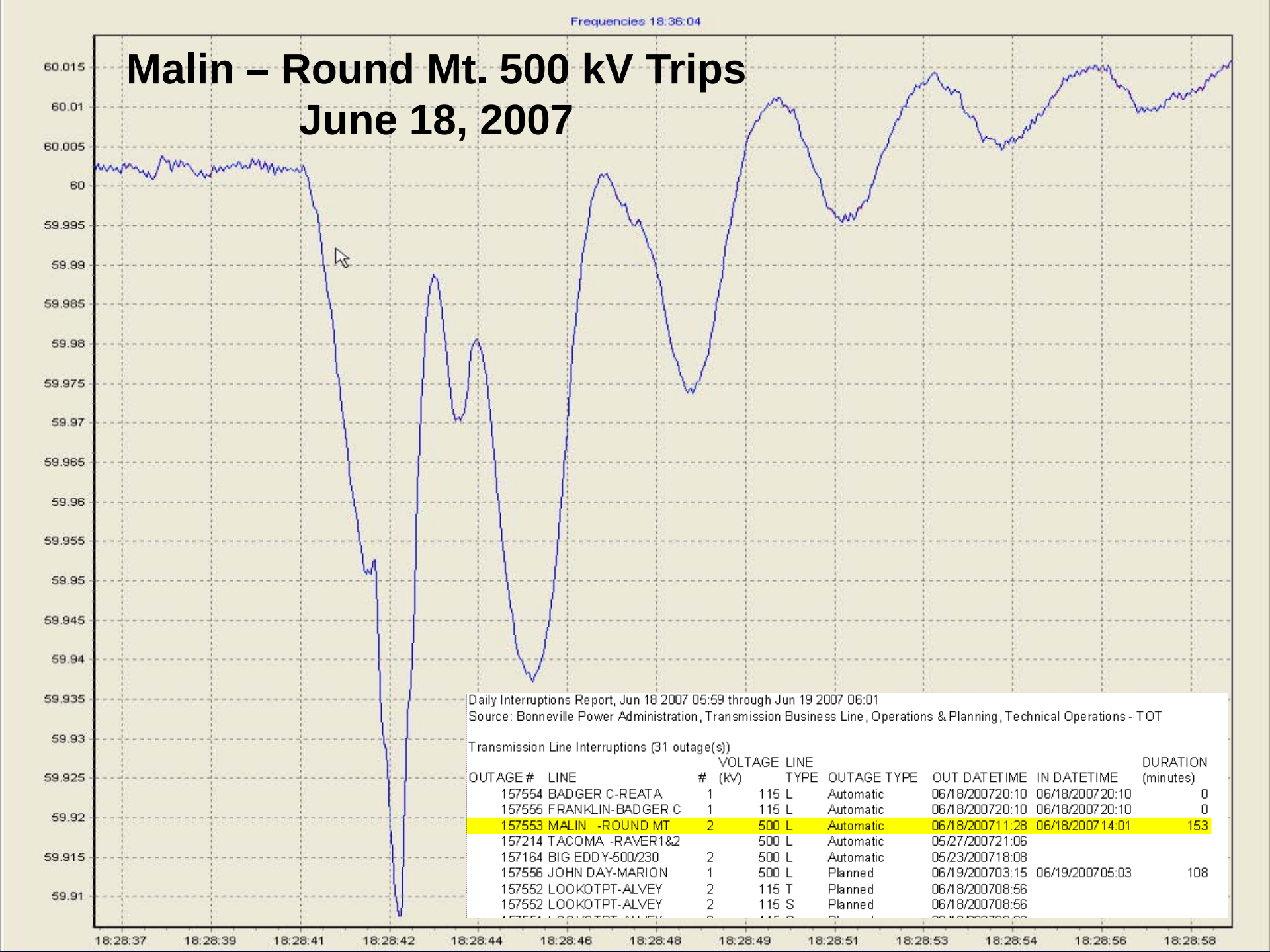
- + Very popular Windows® software solution
- + COMTRADE, .CSV, compressed .CSV
- + Triggered and continuous archiving
- + Order with SEL-3354 or SEL-3351

Order the Archiver Solution



Visualization Systems Are Simple



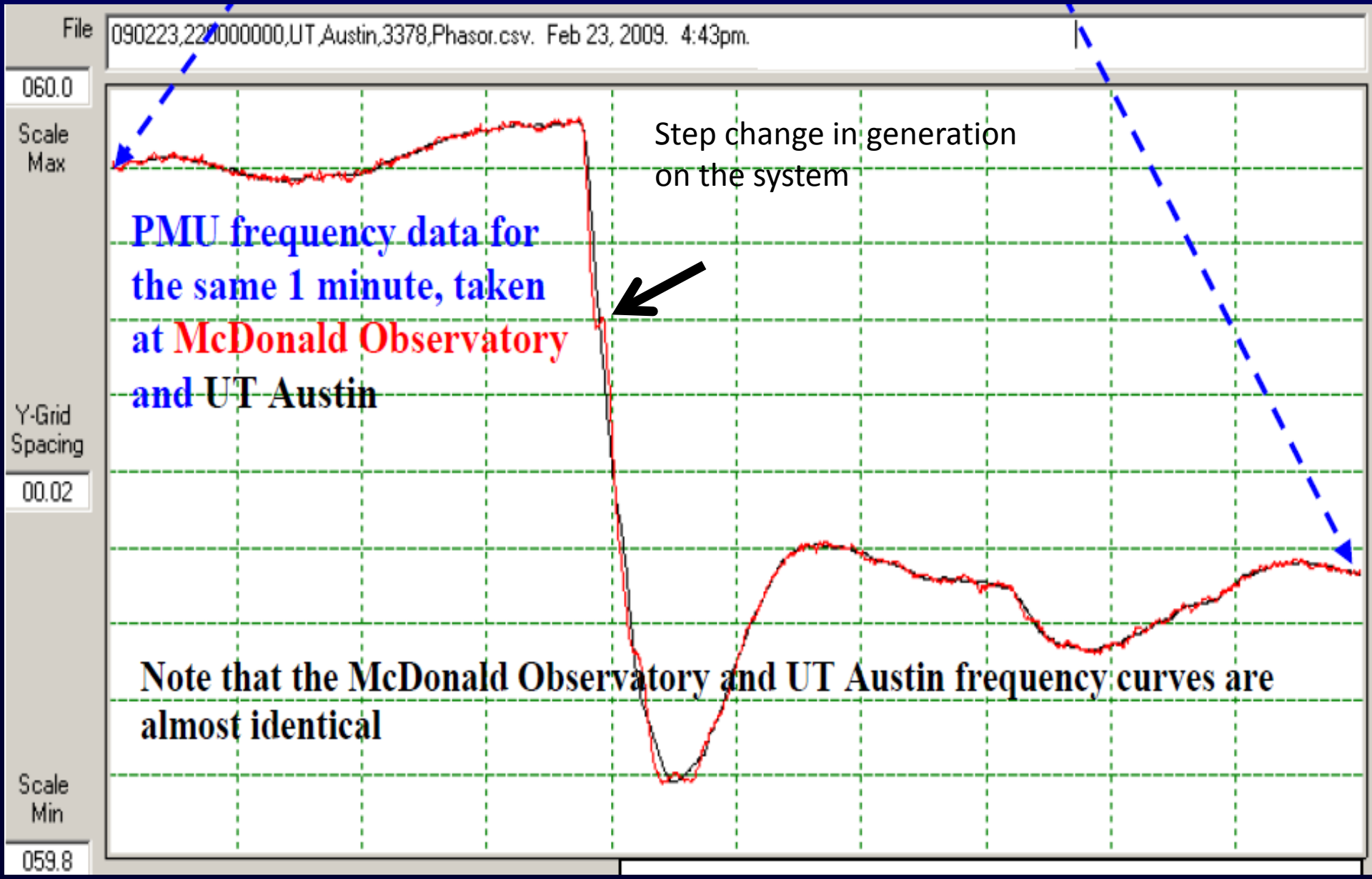


Daily Interruptions Report, Jun 18 2007 05:59 through Jun 19 2007 06:01
Source: Bonneville Power Administration, Transmission Business Line, Operations & Planning, Technical Operations - TOT

Transmission Line Interruptions (31 outage(s))

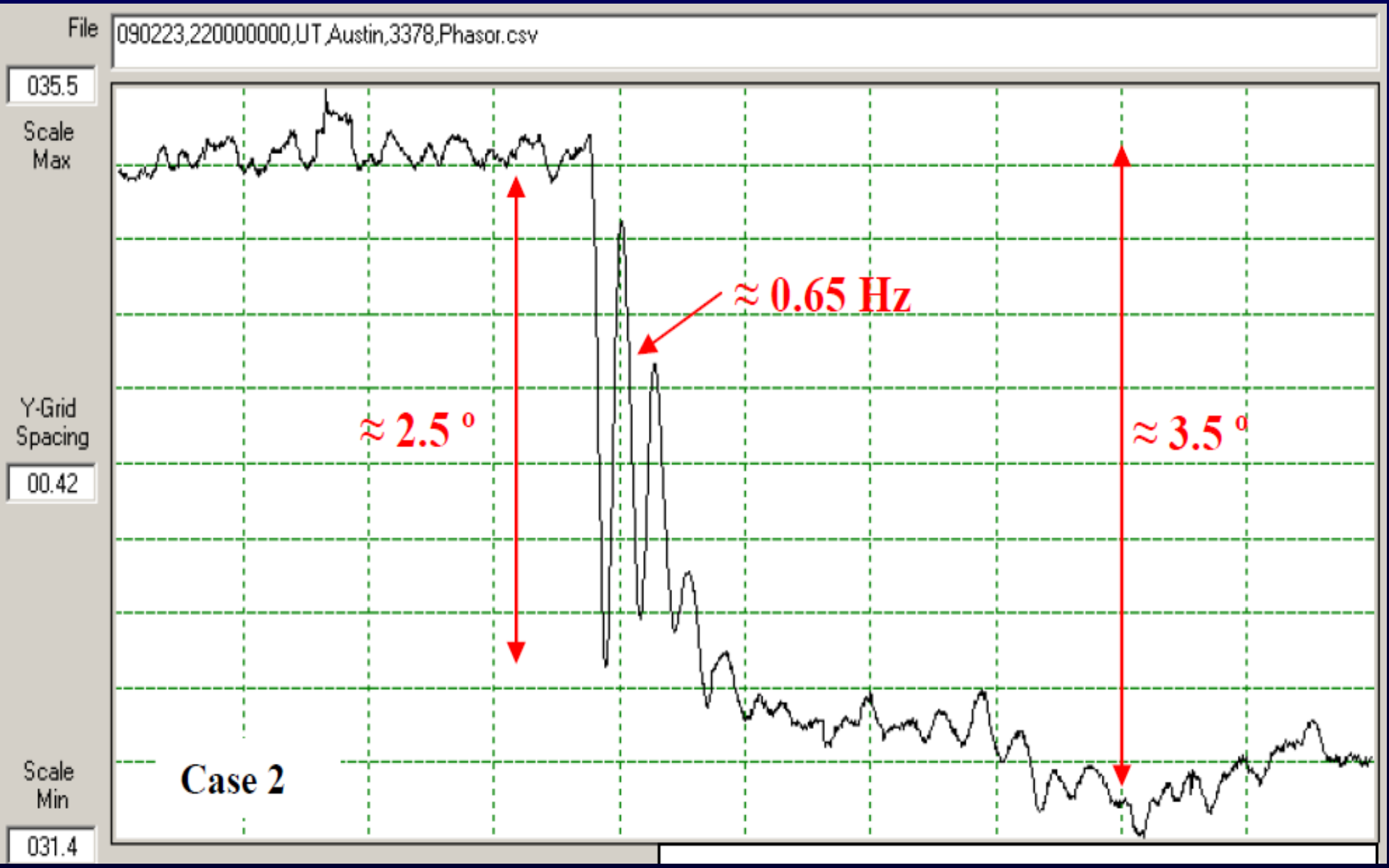
OUTAGE #	LINE	#	VOLTAGE (kV)	LINE TYPE	OUTAGE TYPE	OUT DATETIME	IN DATETIME	DURATION (minutes)
157554	BADGER C-REATA	1	115	L	Automatic	06/18/200720:10	06/18/200720:10	0
157555	FRANKLIN-BADGER C	1	115	L	Automatic	06/18/200720:10	06/18/200720:10	0
157553	MALIN -ROUND MT	2	500	L	Automatic	06/18/200711:28	06/18/200714:01	153
157214	TACOMA -RAVER1&2		500	L	Automatic	05/27/200721:06		
157164	BIG EDDY-500/230	2	500	L	Automatic	05/23/200718:08		
157556	JOHN DAY-MARION	1	500	L	Planned	06/19/200703:15	06/19/200705:03	108
157552	LOOKOTPT-ALVEY	2	115	T	Planned	06/18/200708:56		
157552	LOOKOTPT-ALVEY	2	115	S	Planned	06/18/200708:56		

Frequency Data Lack Detail



1-minute window

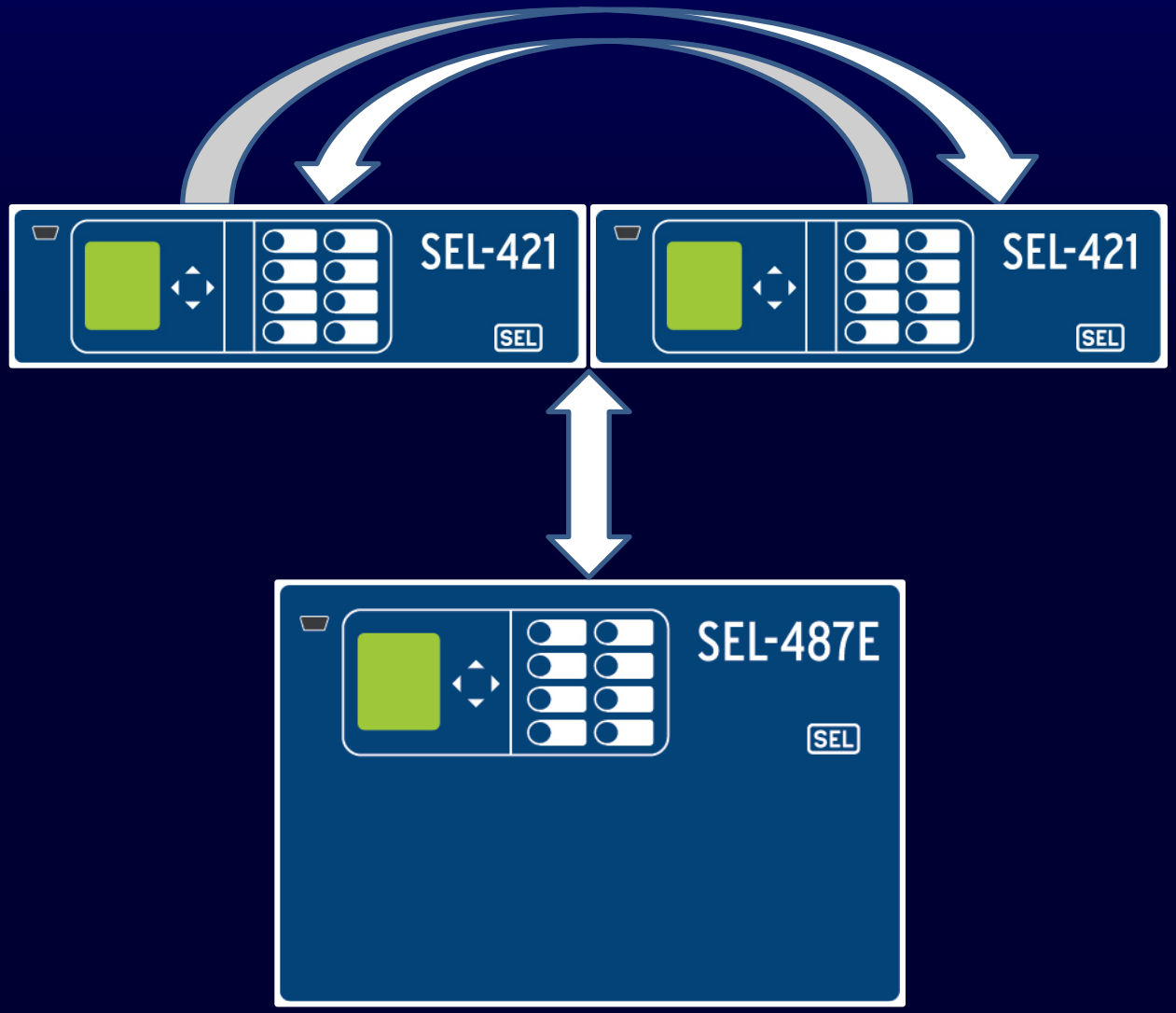
Synchrophasors Provide More Detail



1-minute window

SYNCHROWAVE: Fast and Simple

Real-Time-Control Is Standard in Many SEL Relays

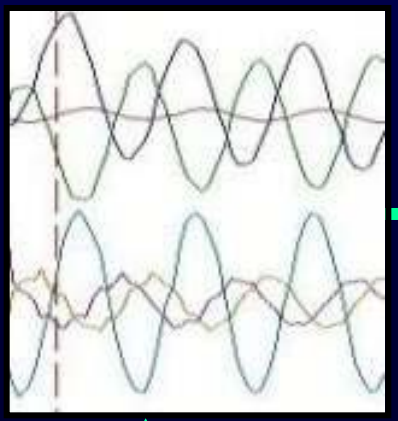


Synchronous Vector Processing

System Measurement

Function Calculation

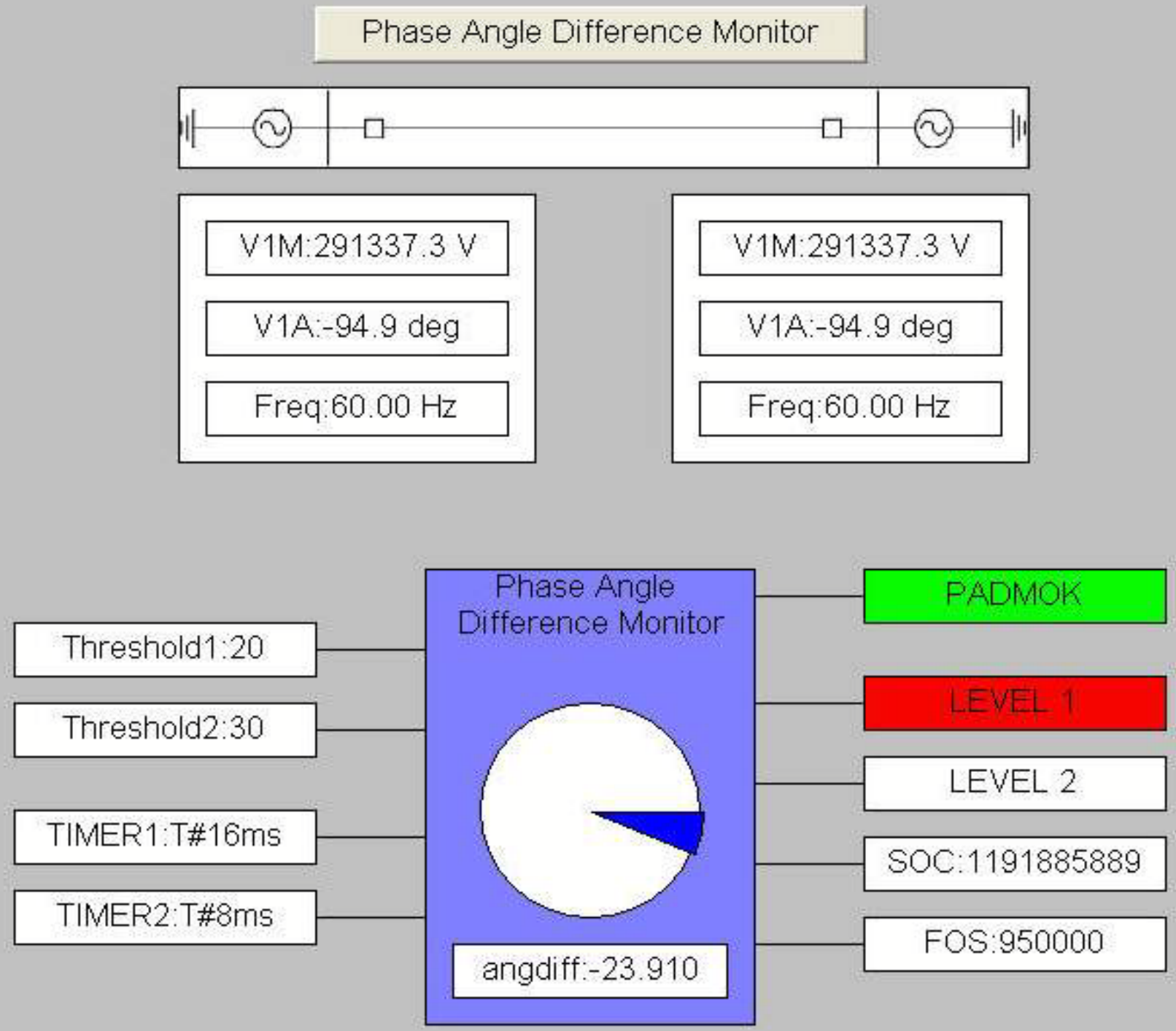
Output Designation



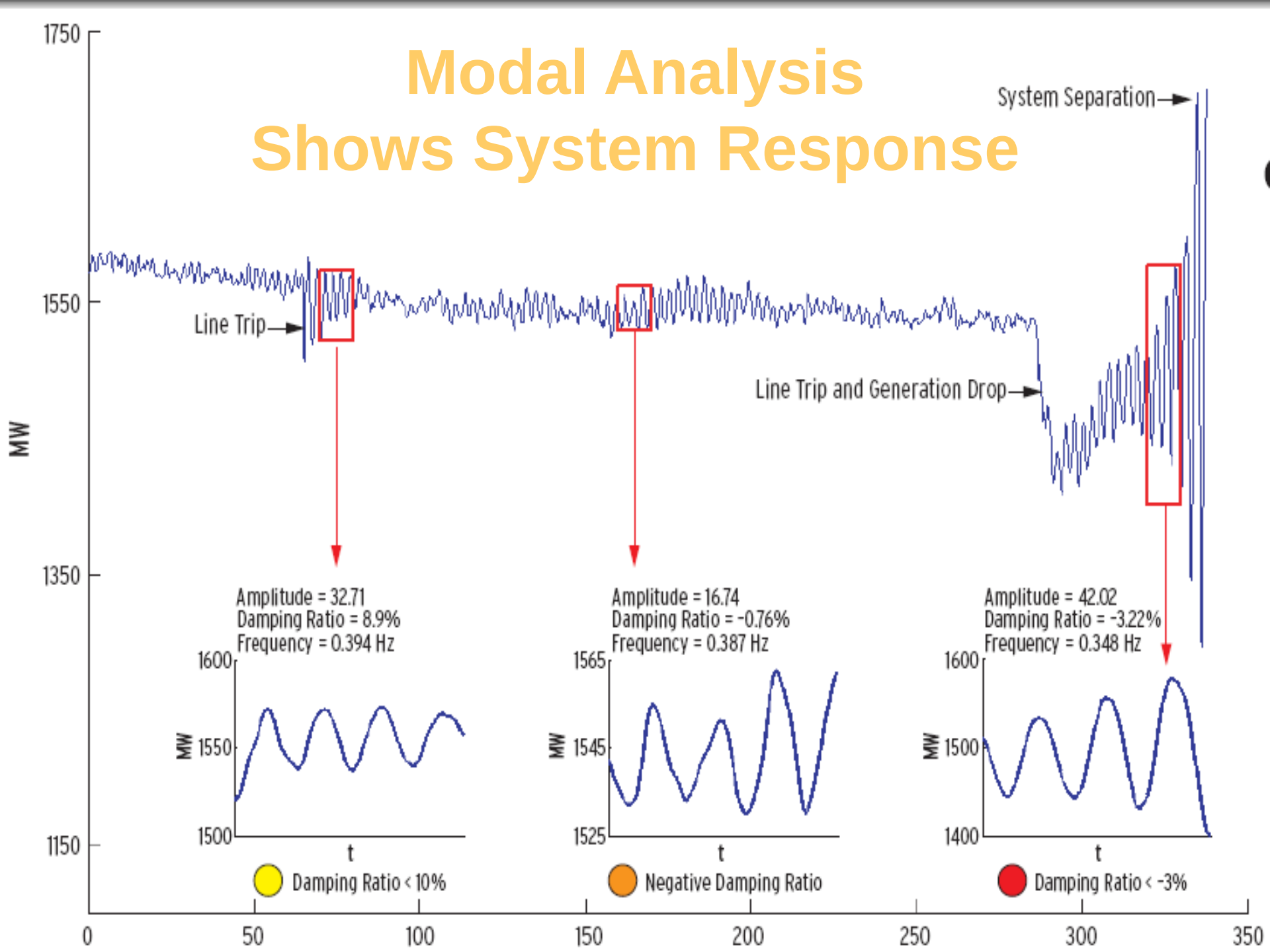
$f_{(x)}$

Send Control to System (Application)

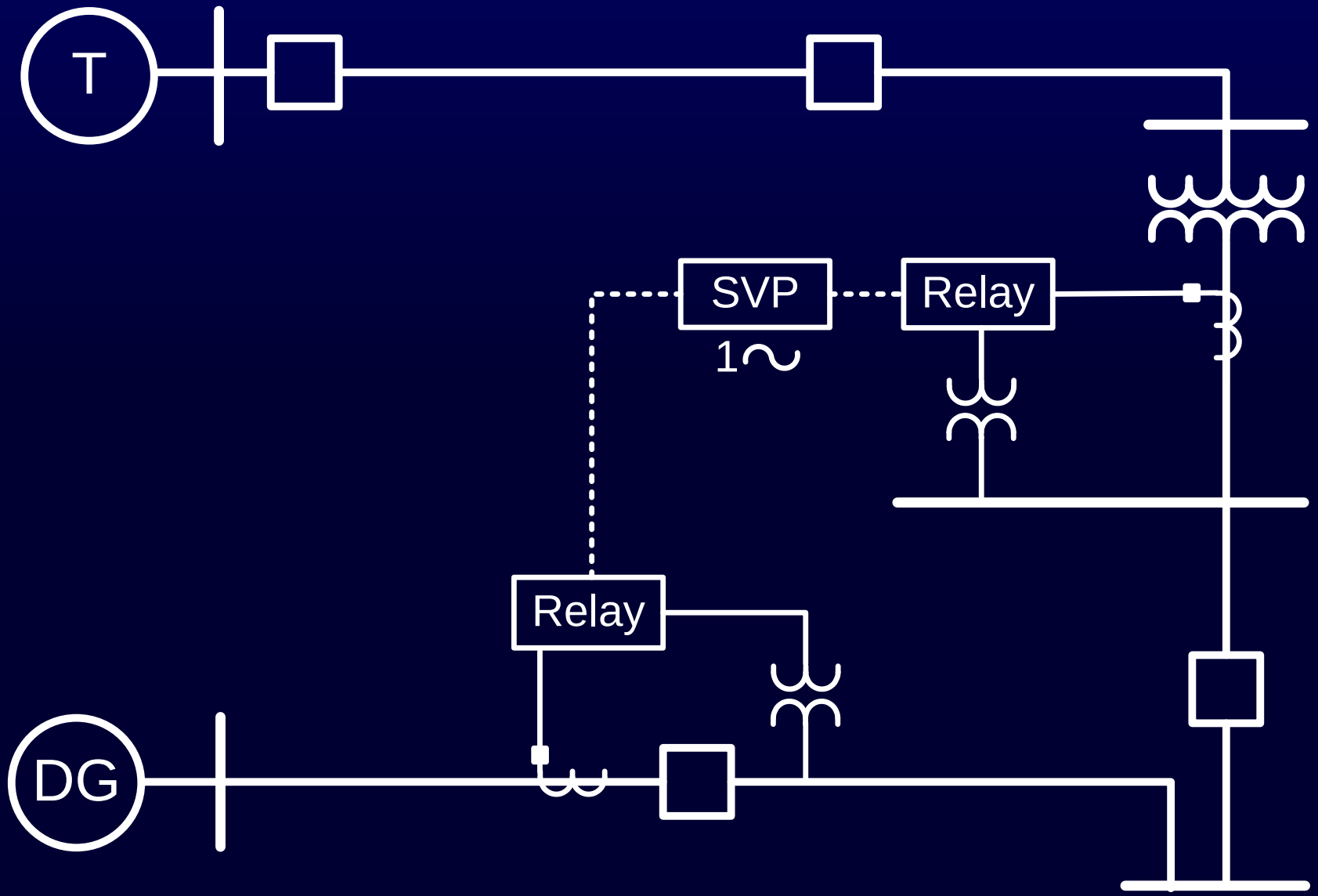
Combine Preconfigured With Custom Functions


Phase Angle Difference Monitor
V1M:291337.3 V
V1A:-94.9 deg
Freq:60.00 Hz
V1M:291337.3 V
V1A:-94.9 deg
Freq:60.00 Hz
Threshold1:20
Threshold2:30
TIMER1:T#16ms
TIMER2:T#8ms
Phase Angle Difference Monitor
angdiff:-23.910
PADMOK
LEVEL 1
LEVEL 2
SOC:1191885889
FOS:950000

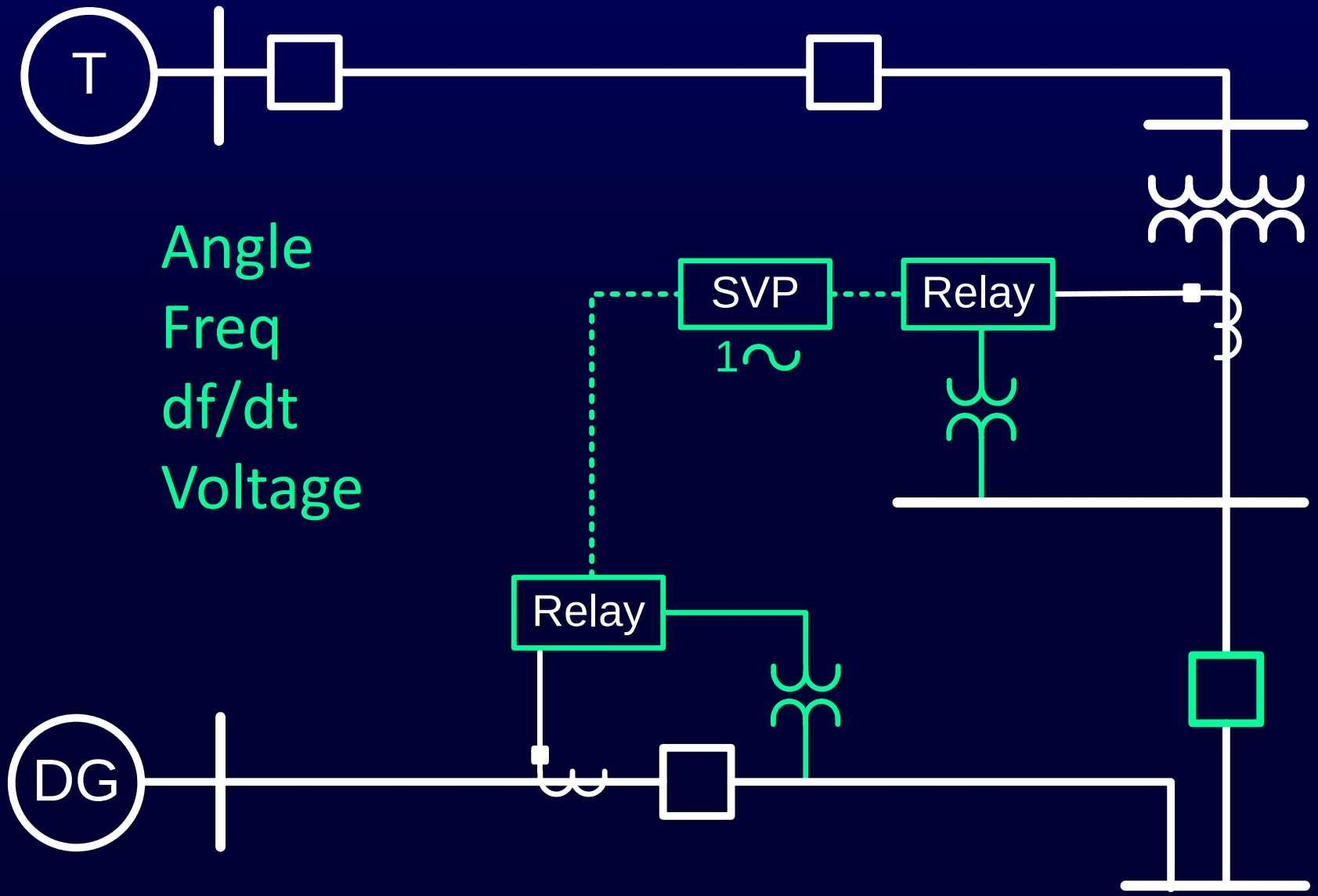
Modal Analysis Shows System Response

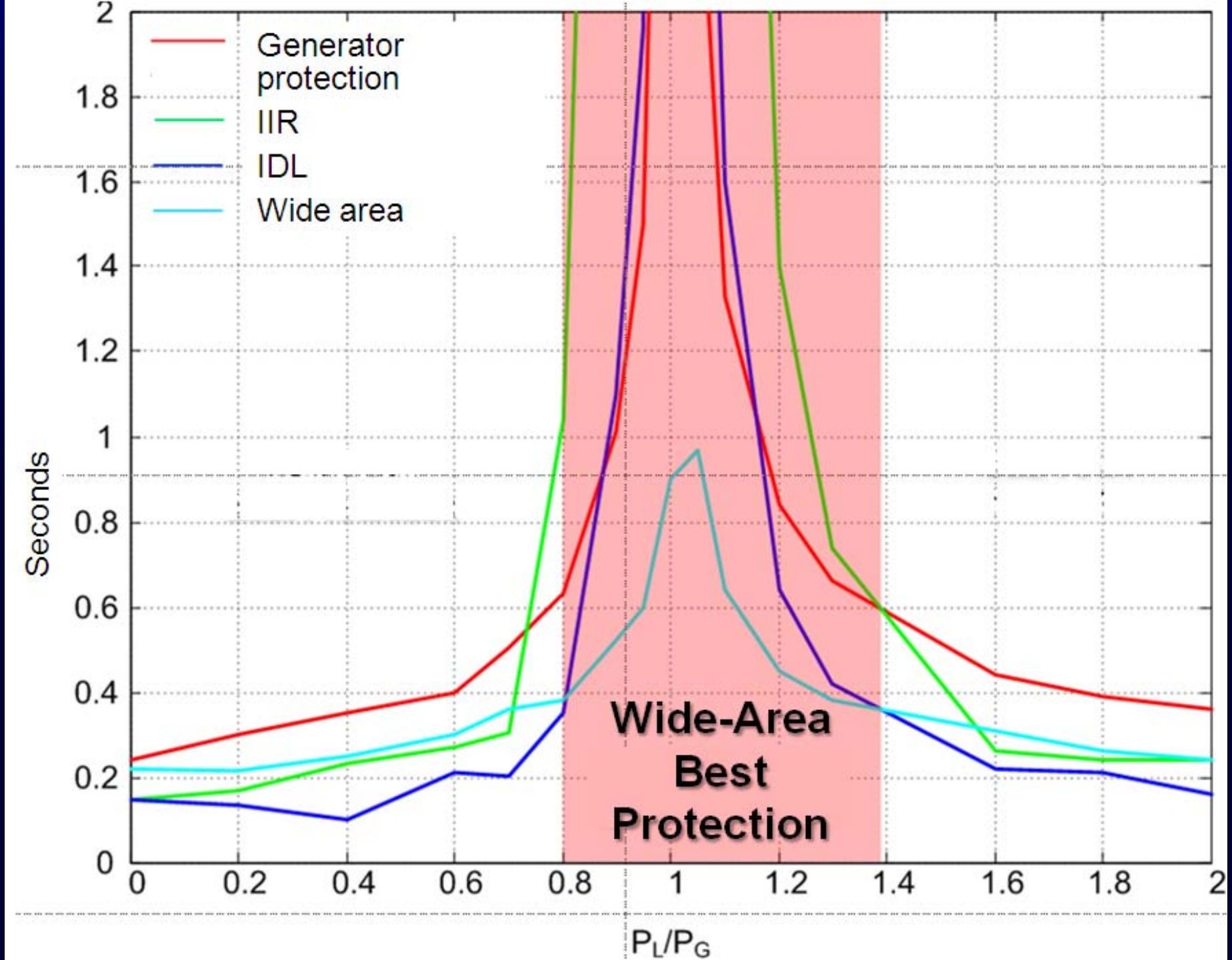


FPL: Distributed Generation Anti-Islanding



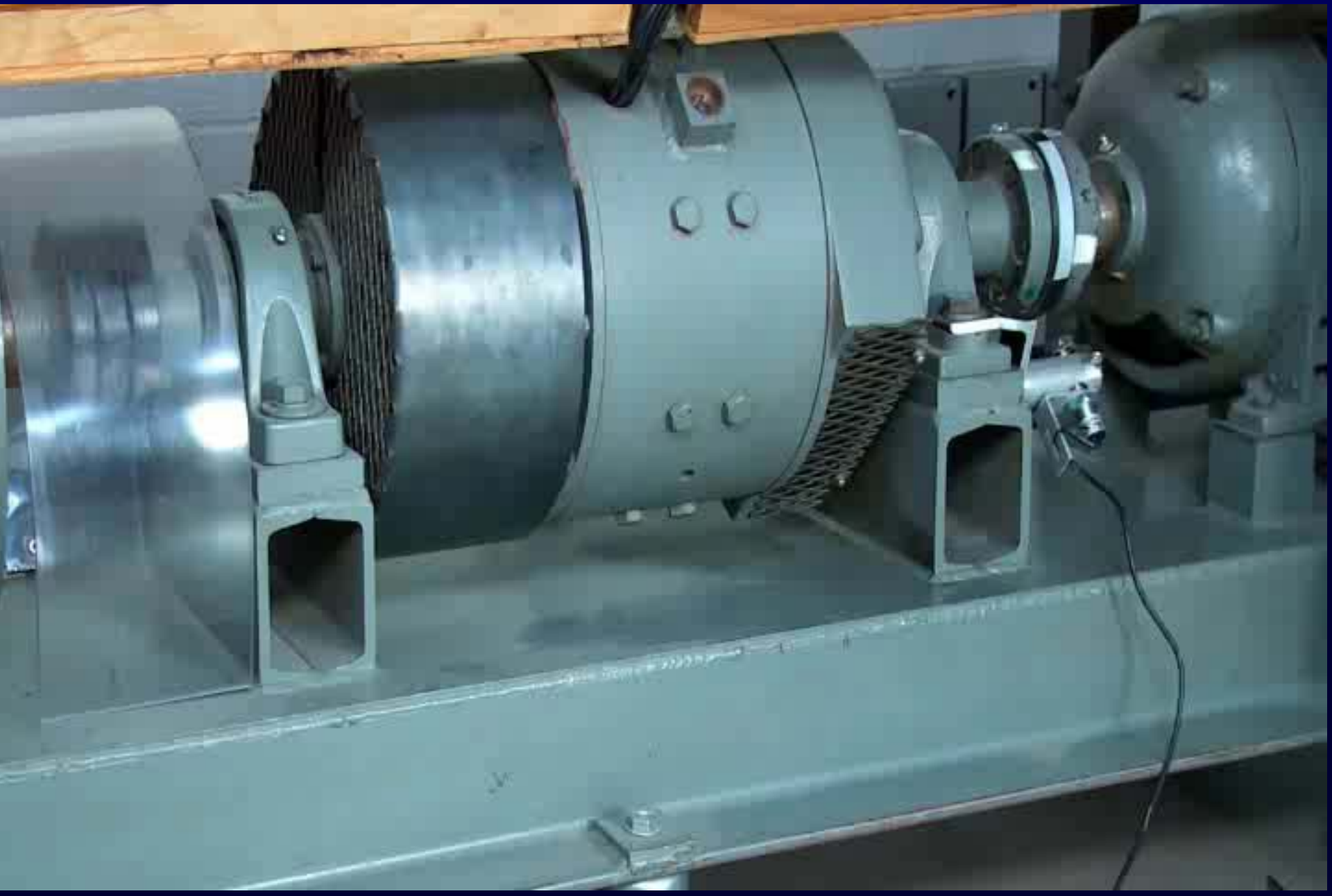
FPL: Distributed Generation Anti-Islanding



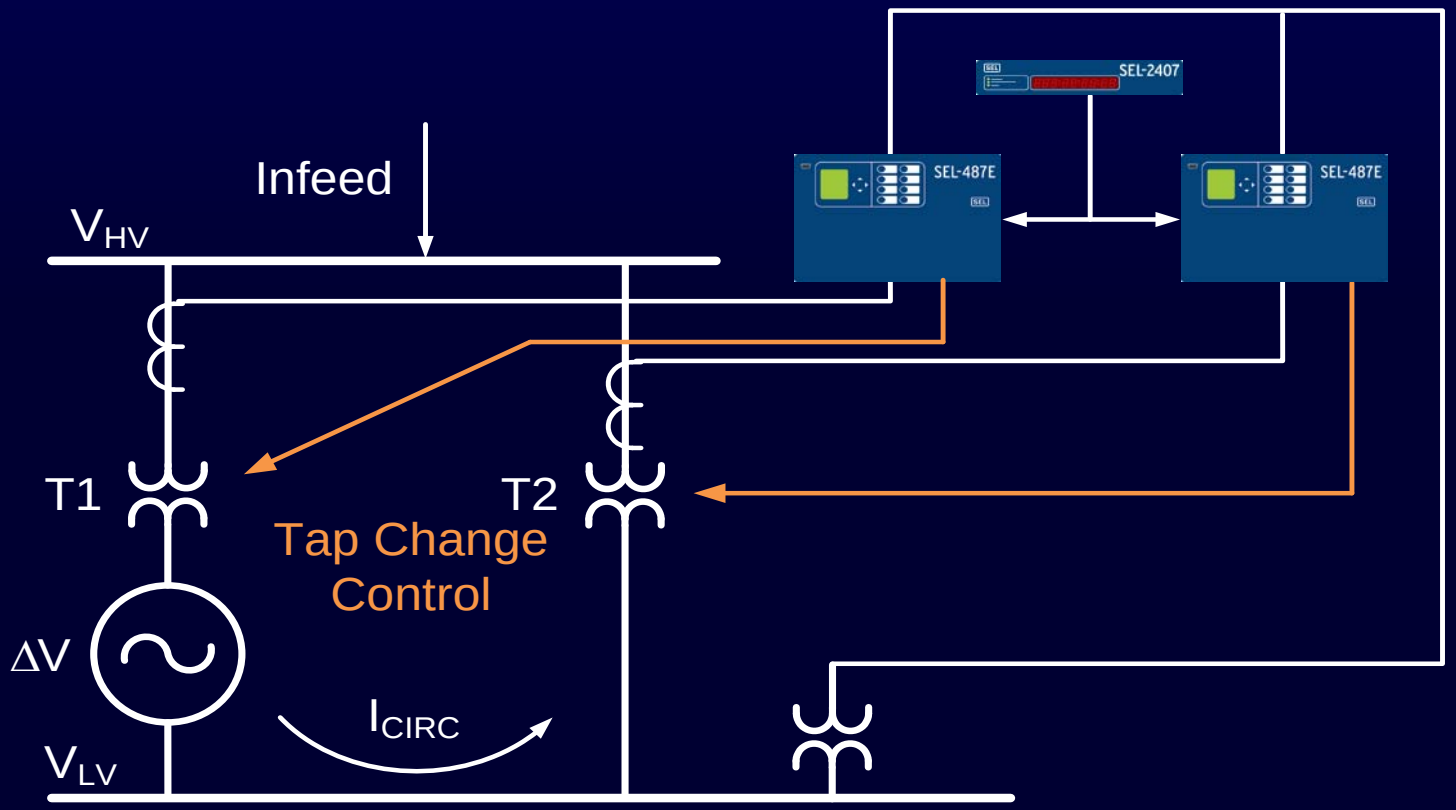

Generator protection
IIR
IDL
Wide area
Wide-Area Best Protection
Seconds
P_L/P_G
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

Improve Generation Models

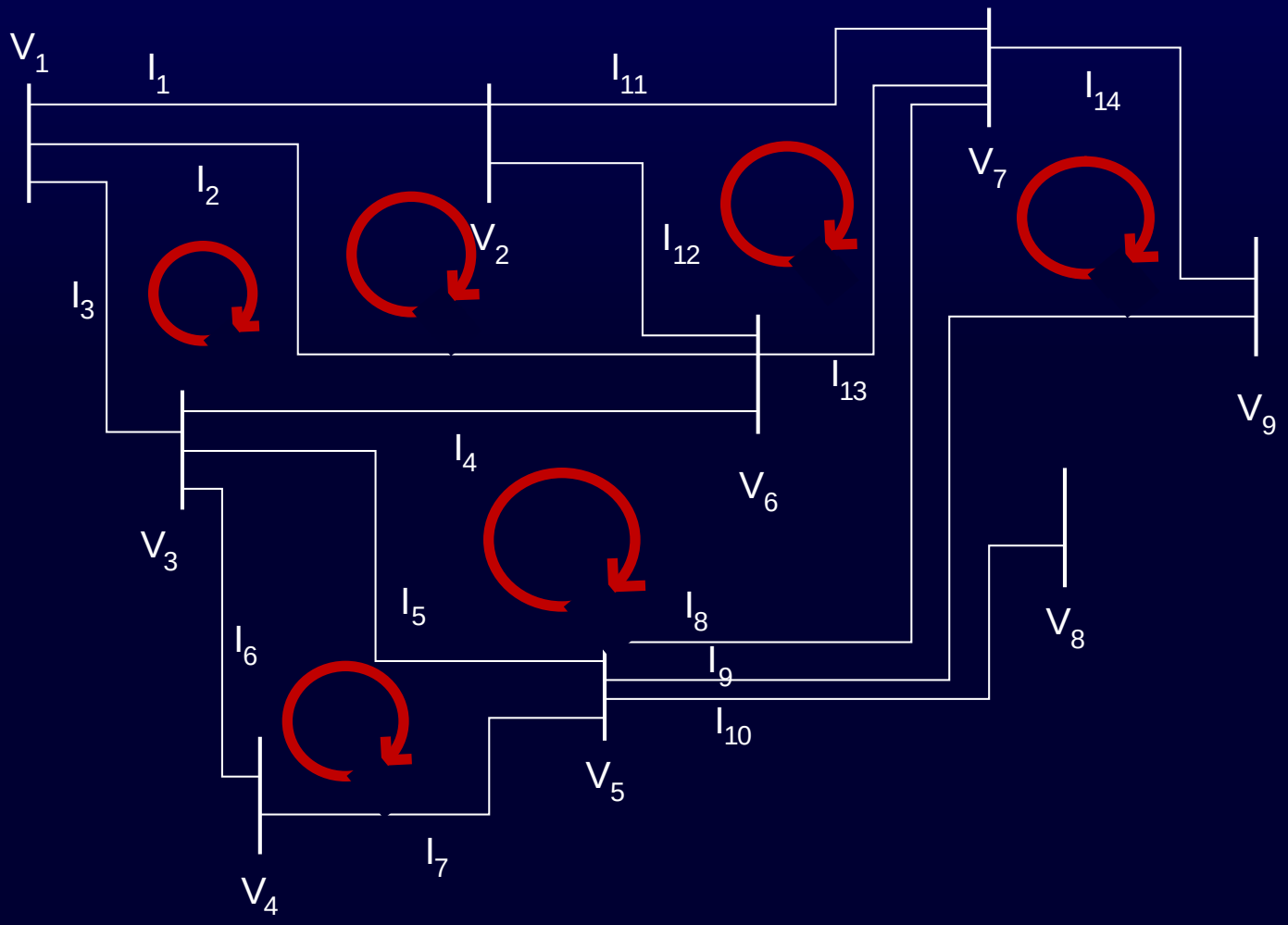
Electric and Optical Inputs



Time-Synchronized Measurements for Wide-Area Control



Grid Efficiency Measurement, and Control



What's In The Future ?

- New Solutions
- New Connections
- New Systems