



Celebrating
25 YEARS OF INNOVATION

Displaying and Using Synchrophasor Data

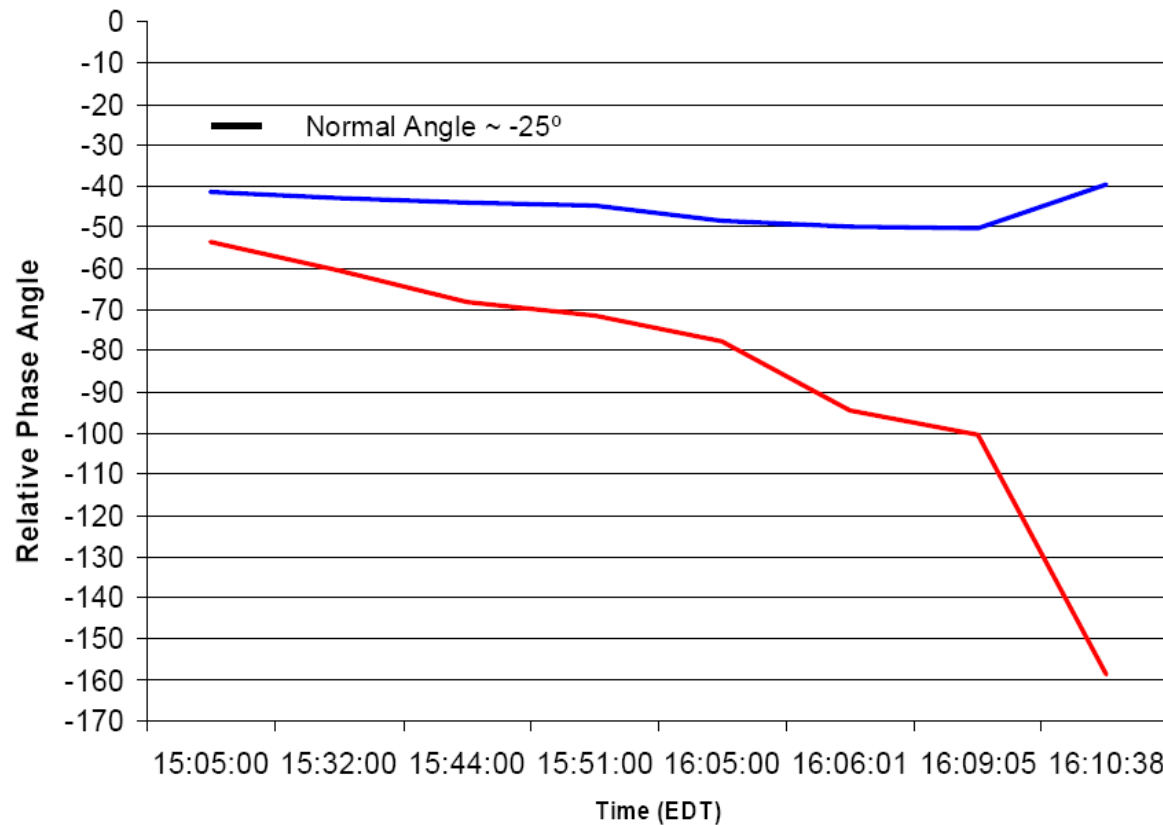
Using all of the C37.118 Information

Roy Moxley – Schweitzer Engineering Laboratories

Phase Angle – Friend and Foe

NORTH AMERICAN ELECTRIC RELIABILITY COUNCIL

Angular Separation Analysis



Reference:
Browns Ferry

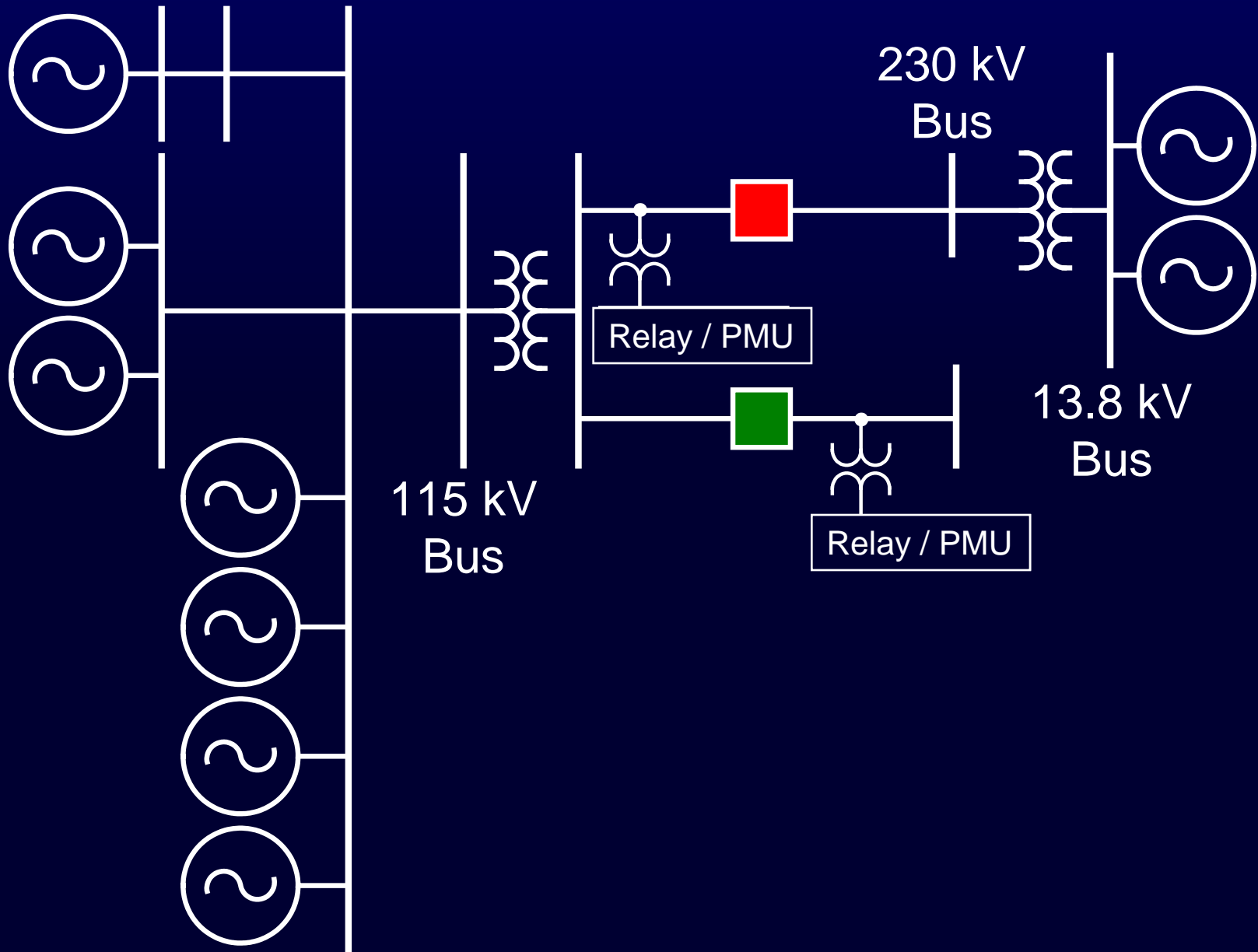
— Cleveland — West MI



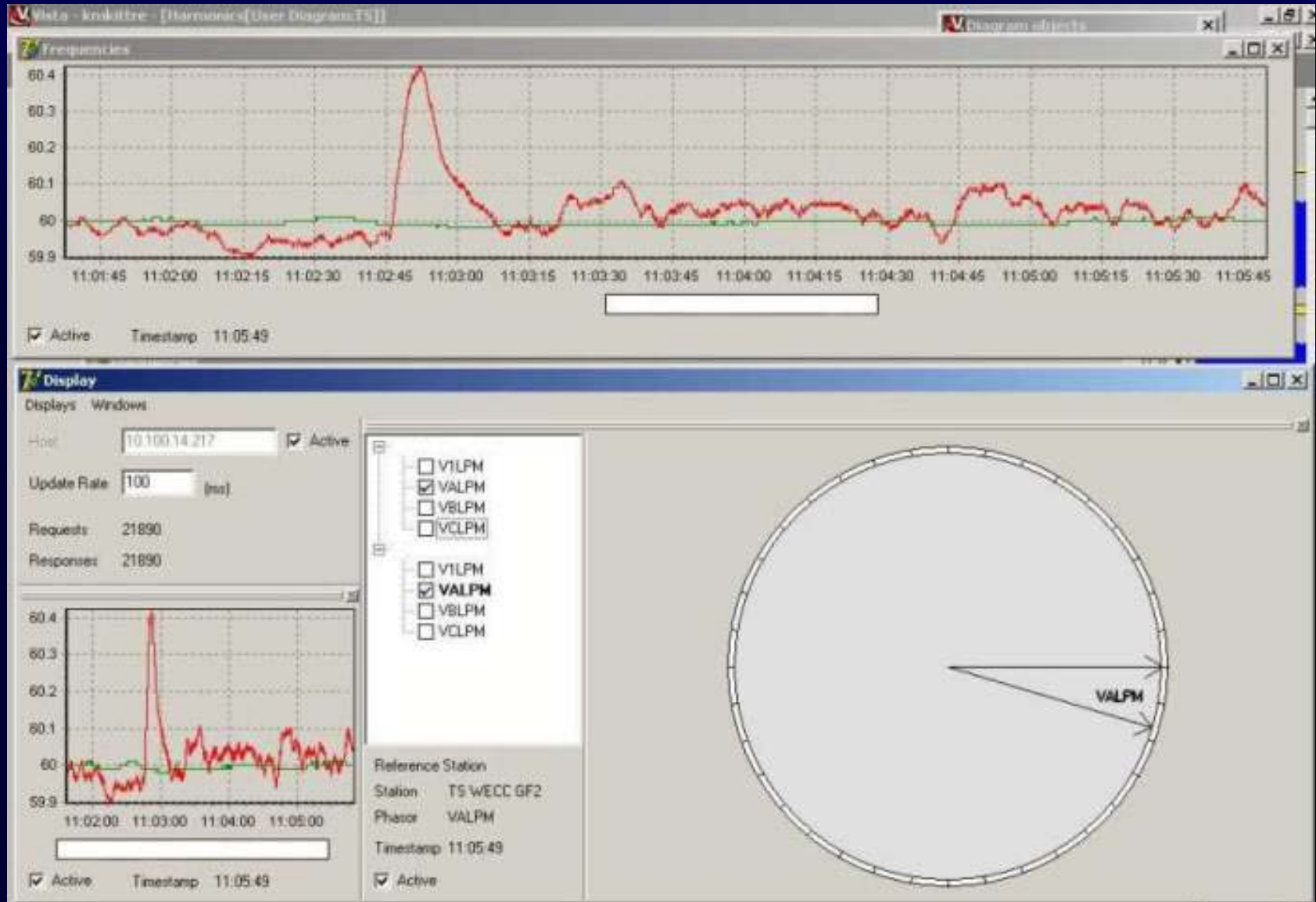
The Entire C37.118 Message

- **Status** - Configuration, Data Validity, PMU Error,
- **Phasors** – Voltage, Current
- **Frequency, Rate of Change of Frequency**
- **Analogs** – Anything available from the PMU, or PDC
- **Digitals** – Alarms, Breaker Status,

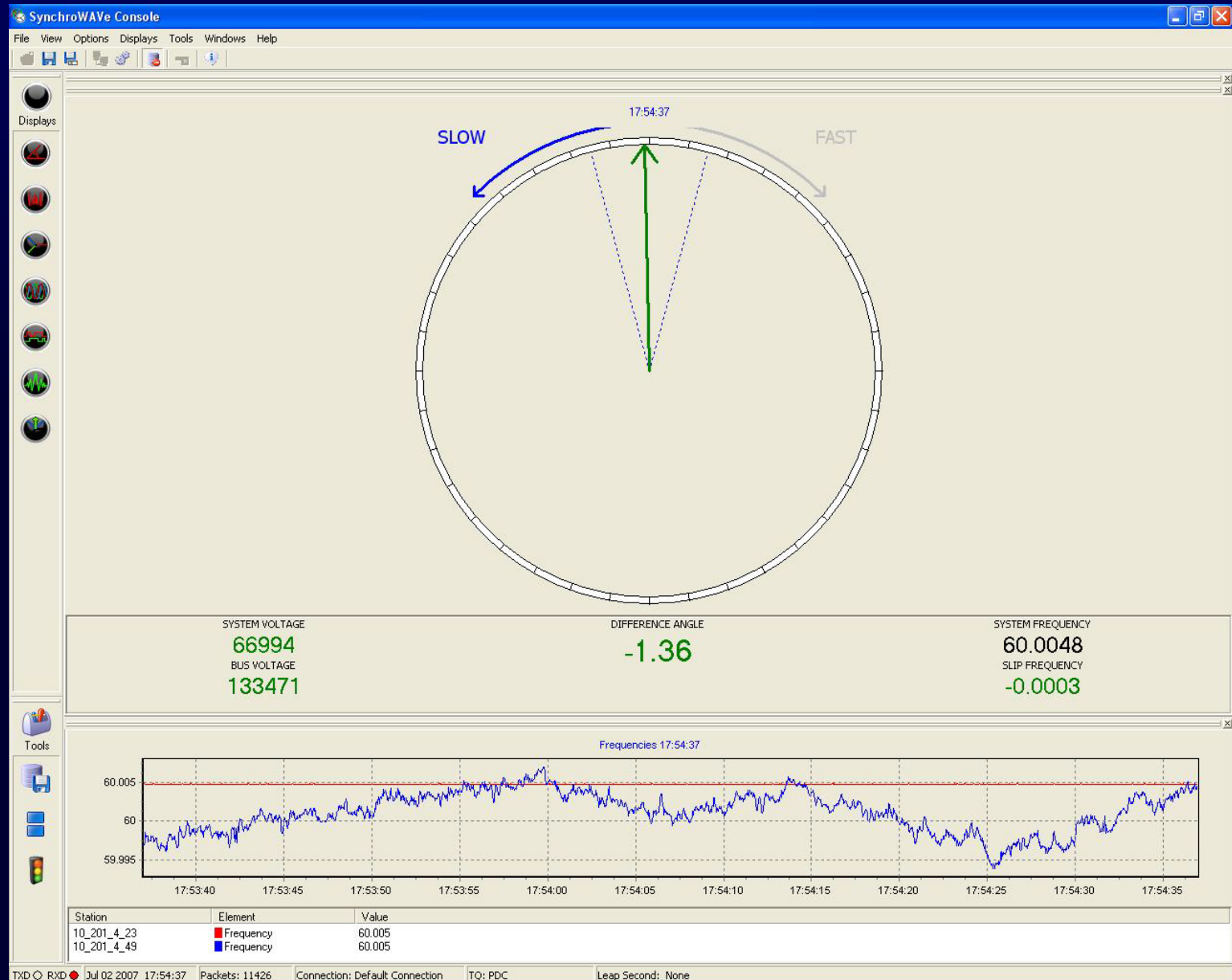
Apply Remote Synchronizing



Early Visualization

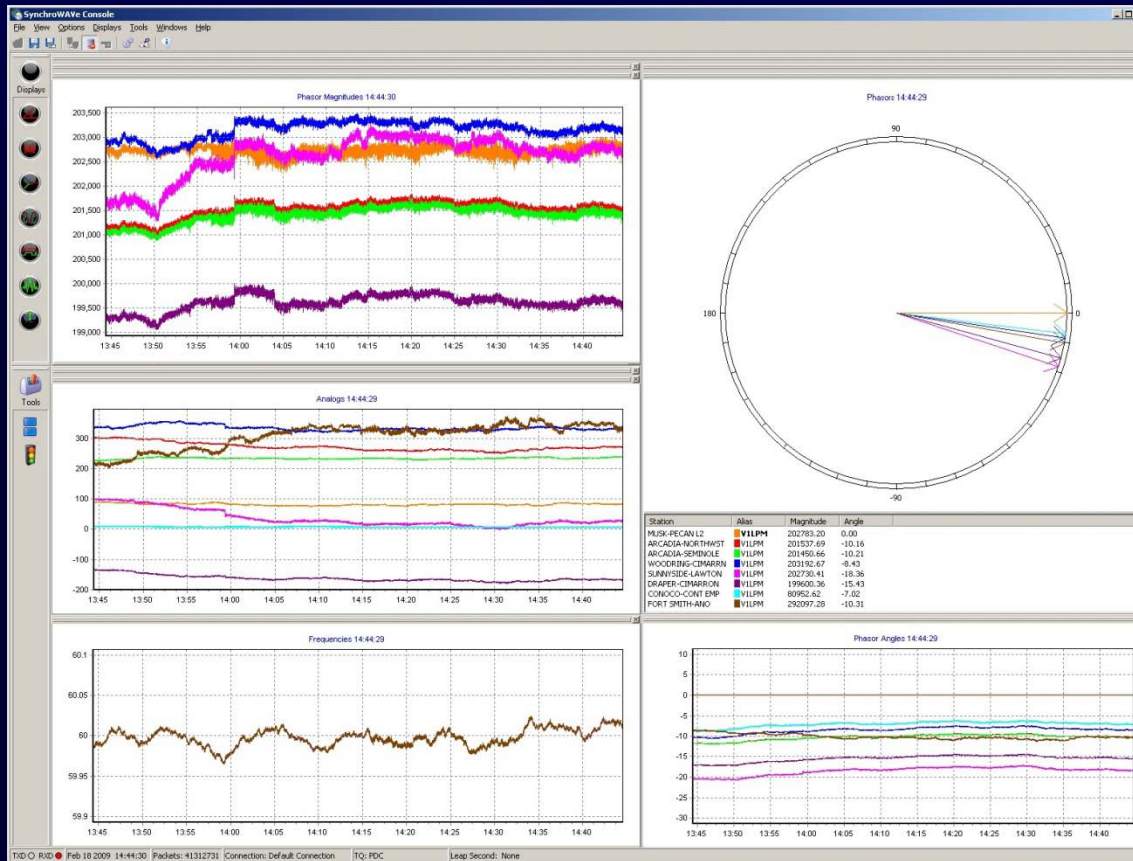


Synchroscope View for Intuitive Control



One Utility's View

Bus Voltage



Instantaneous
Phase Angles

Line
MVA

PMU ID

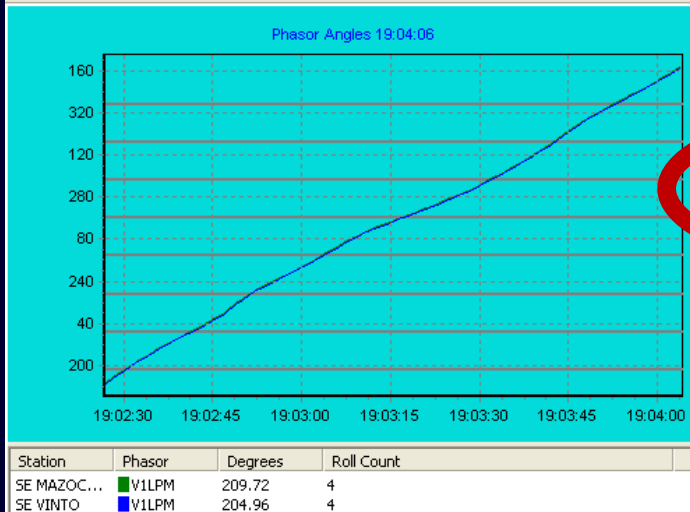
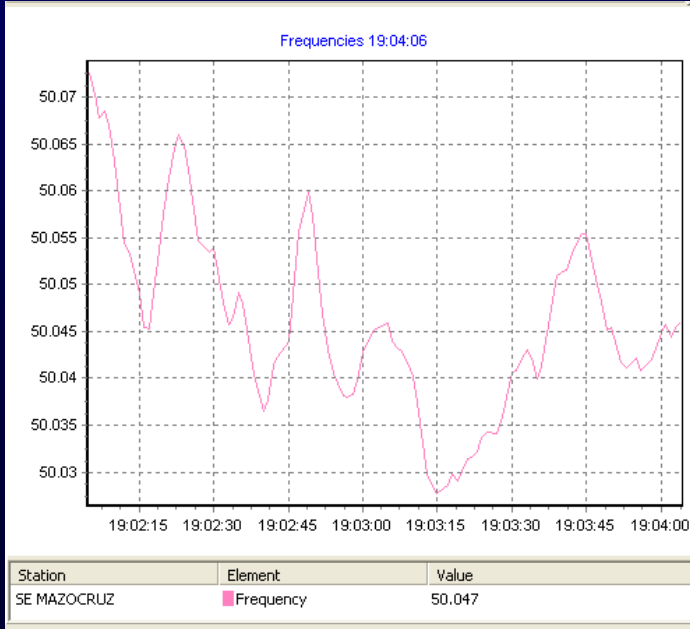
Trended
Phase Angles

Frequency

There's More to the Picture

Status is Part
of the
Synchrophasor
Message

-90



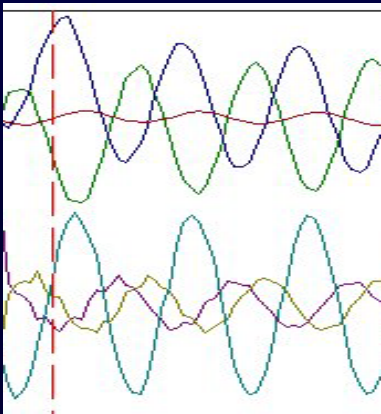
Station	Alias	Magnitude	Angle
SE MAZOC...	I1WPM	142.67	15.76
SE MAZOC...	V1LPM	138587.34	0.00
SE VINTO	I1WPM	140.01	-171.91
SE VINTO	V1LPM	137500.92	-4.77

Status							
Station	Config Change	Config Count	Data Valid	PMU Error	PMU Sync	Time Lock	Triggered
SE MAZOCRUZ	✓	4	✓	✓	✓	Locked	
SE VINTO	✓	3	✓	✓	✓	Locked	

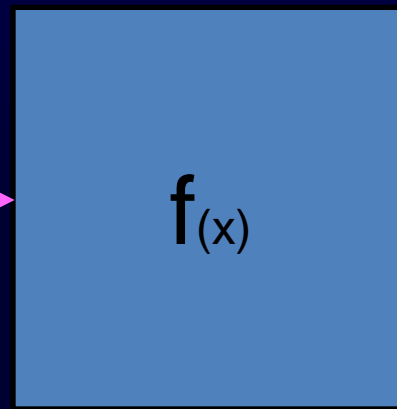
Source	Timestamp	Message
Status Handler	Mar 19 2009 11:39:44.000	Accepted new station configuration
Connection: '127.0.0.1: 4722' ID: 3	Mar 19 2009 11:39:44.000	Received new configuration
Connection: '127.0.0.1: 4722' ID: 3		Requesting synchrophasors
Connection: '127.0.0.1: 4722' ID: 3		Established communications
SynchroWAVE Console		Selected Connection: Connection: '127.0.0.1: 4722' ID: 3
SynchroWAVE Console		Loaded configuration file successfully
SynchroWAVE Console		Selected Connection: Connection: '127.0.0.1: 4722' ID: 3
SynchroWAVE Console		Loading configuration file 'C:\Program Files\SEL\SEL5078\SEL-507...
SynchroWAVE Console		Loaded initialization file successfully
SynchroWAVE Console		Loading initialization file 'C:\Program Files\SEL\SEL5078\SEL-5078.ini'

Synchronous Vector Processing

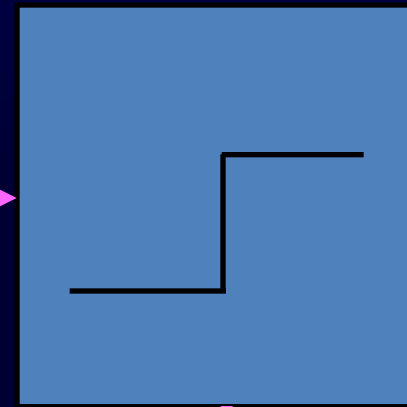
System
Measurement



Function
Calculation



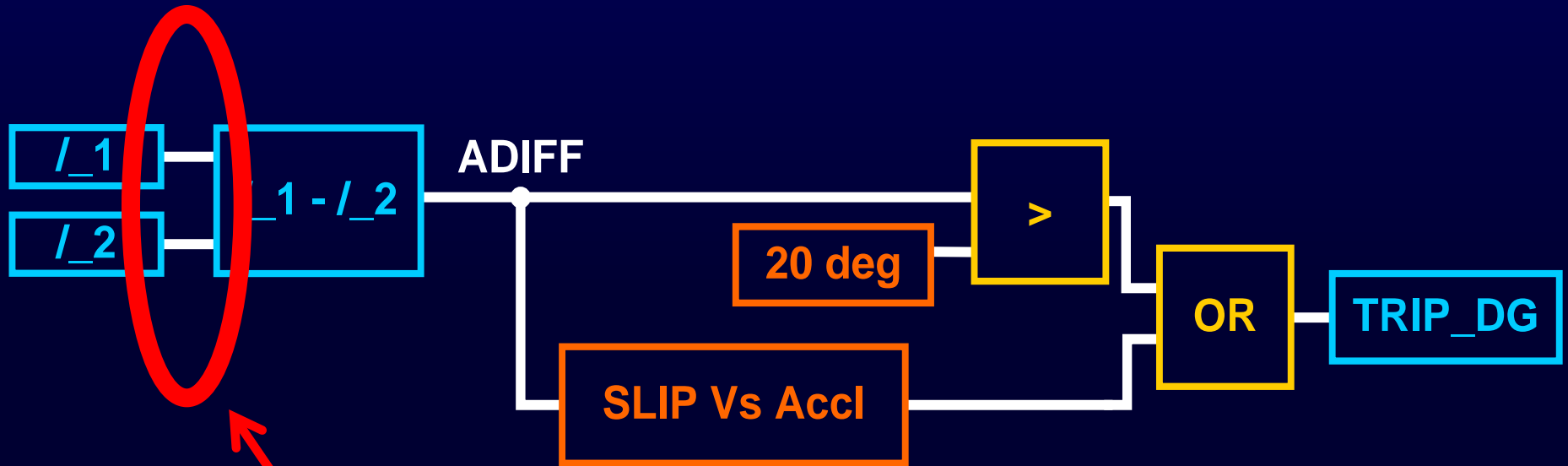
Output
Designation



Send Control to System
(Application)

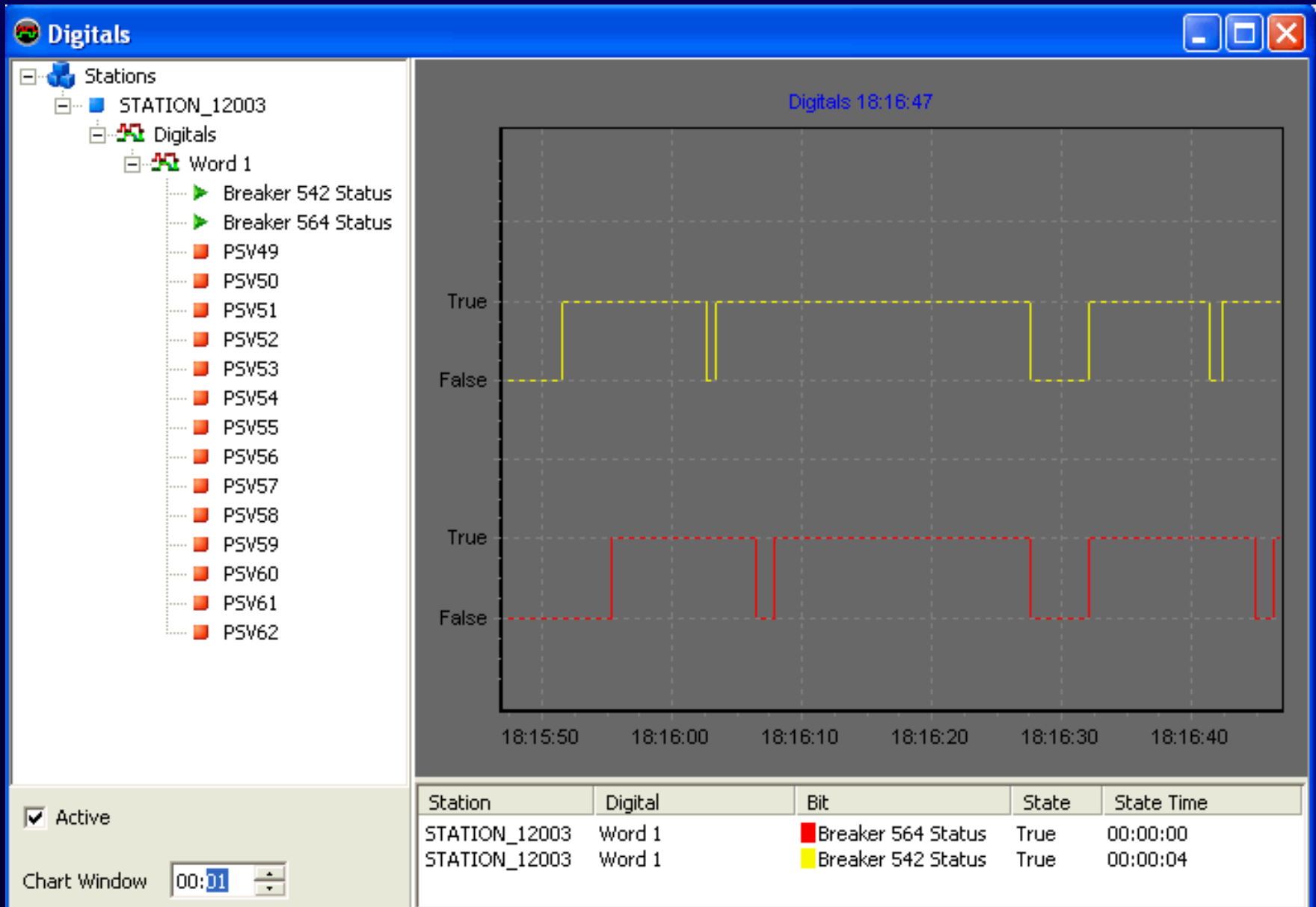


Control Requires Supervision



Qualify Inputs With Data Validity

Digitals Bring System Status Information

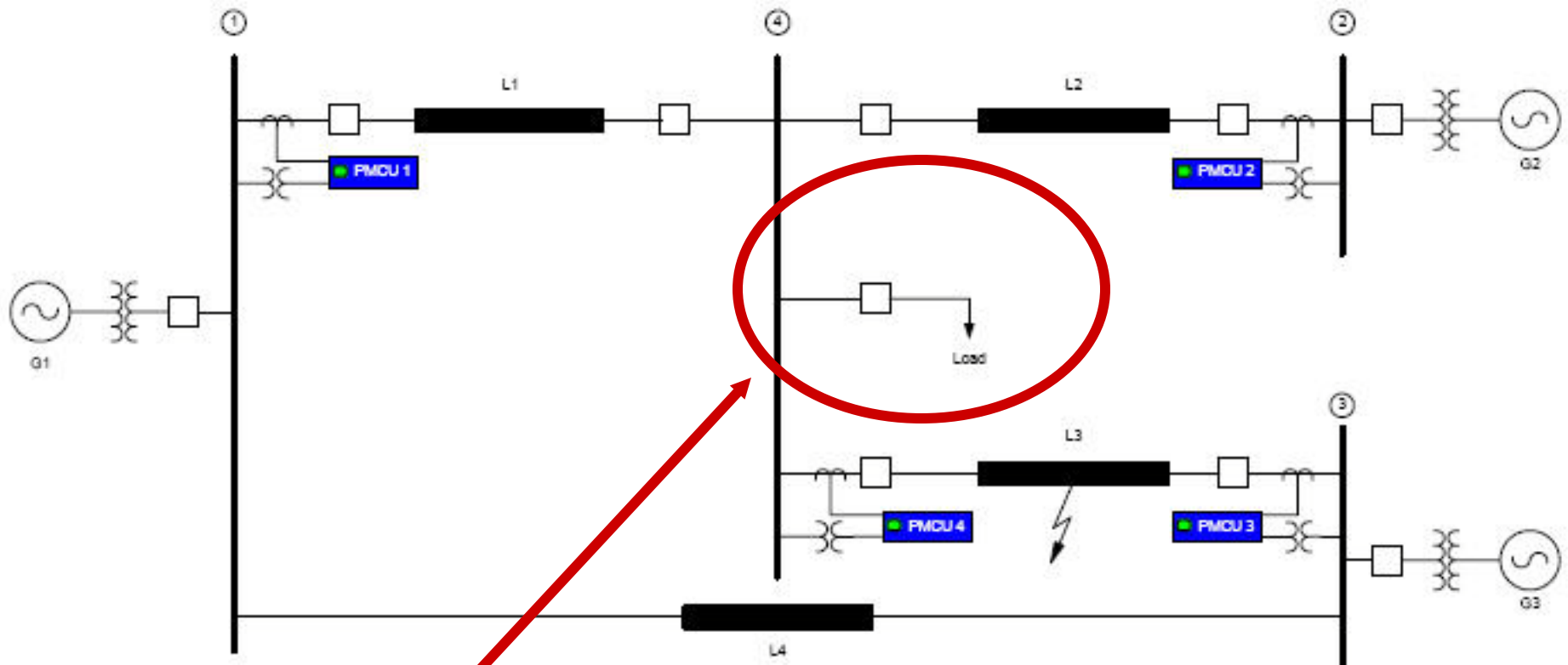


PMU Measured and Derived Quantities

- Synchrophasors to transmit information
- Local Measurements of local quantities
- Use “PMU” for non-synchronized measurements

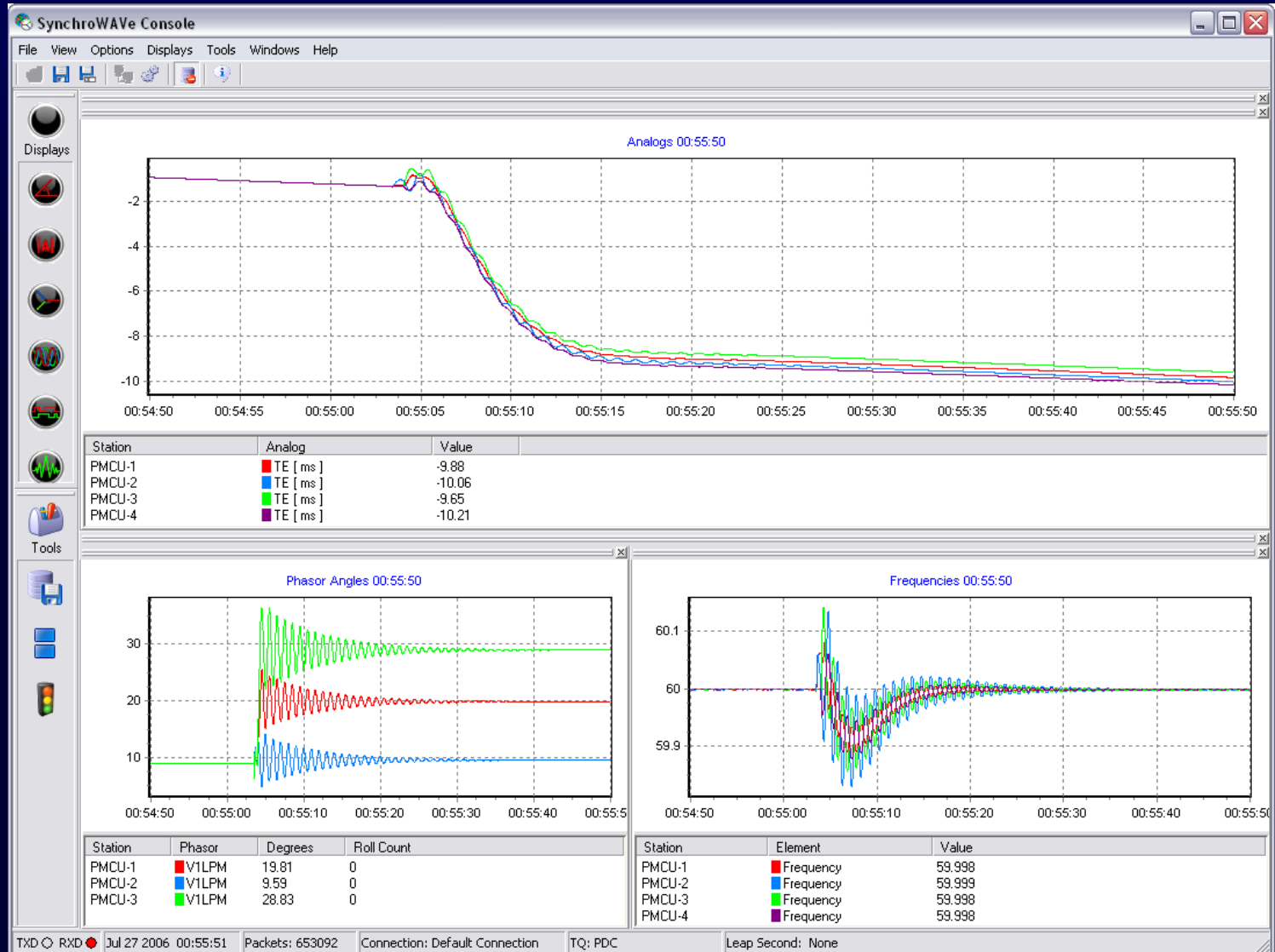


Model System

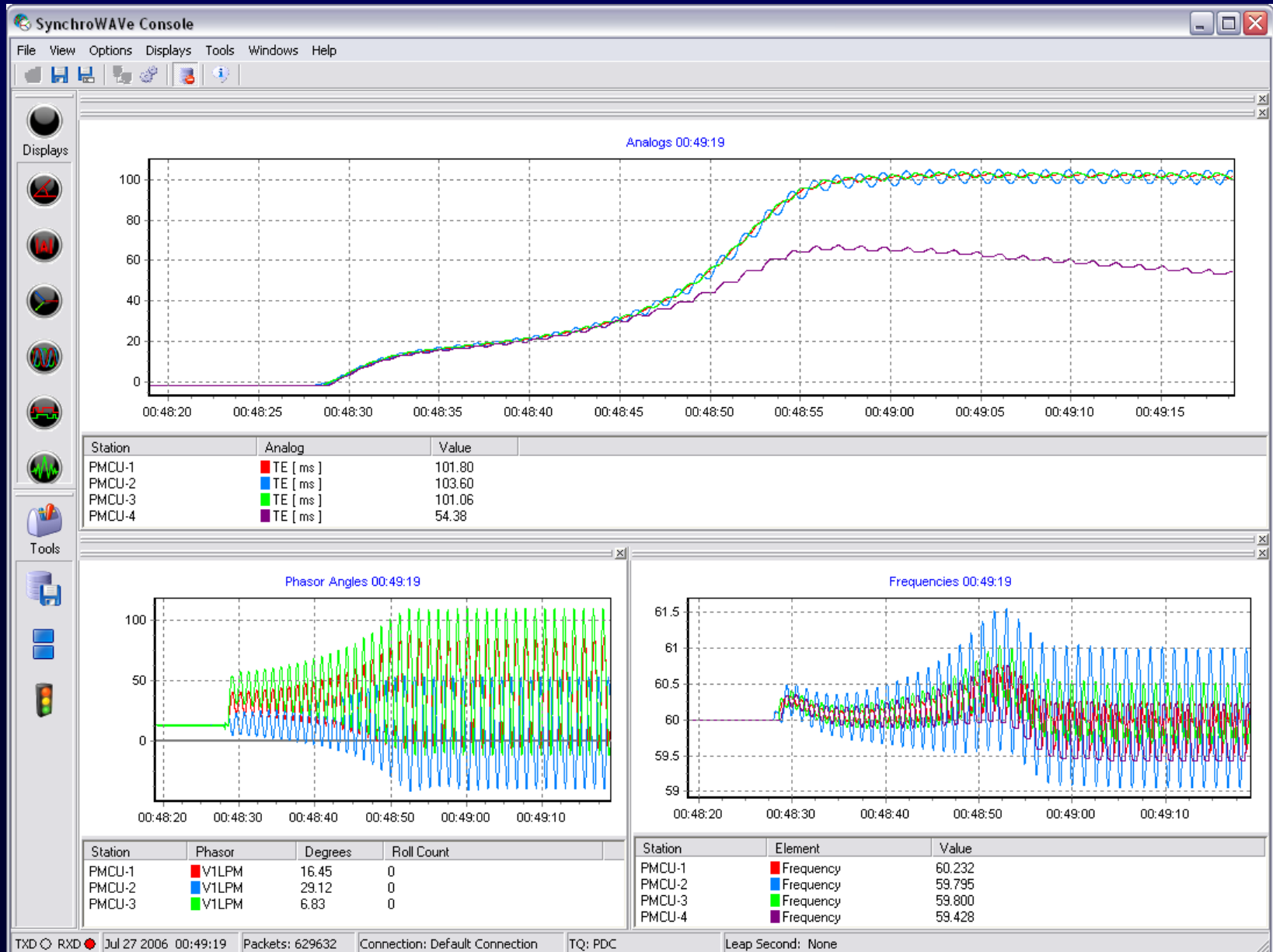


Increasing Load Decreases Stability

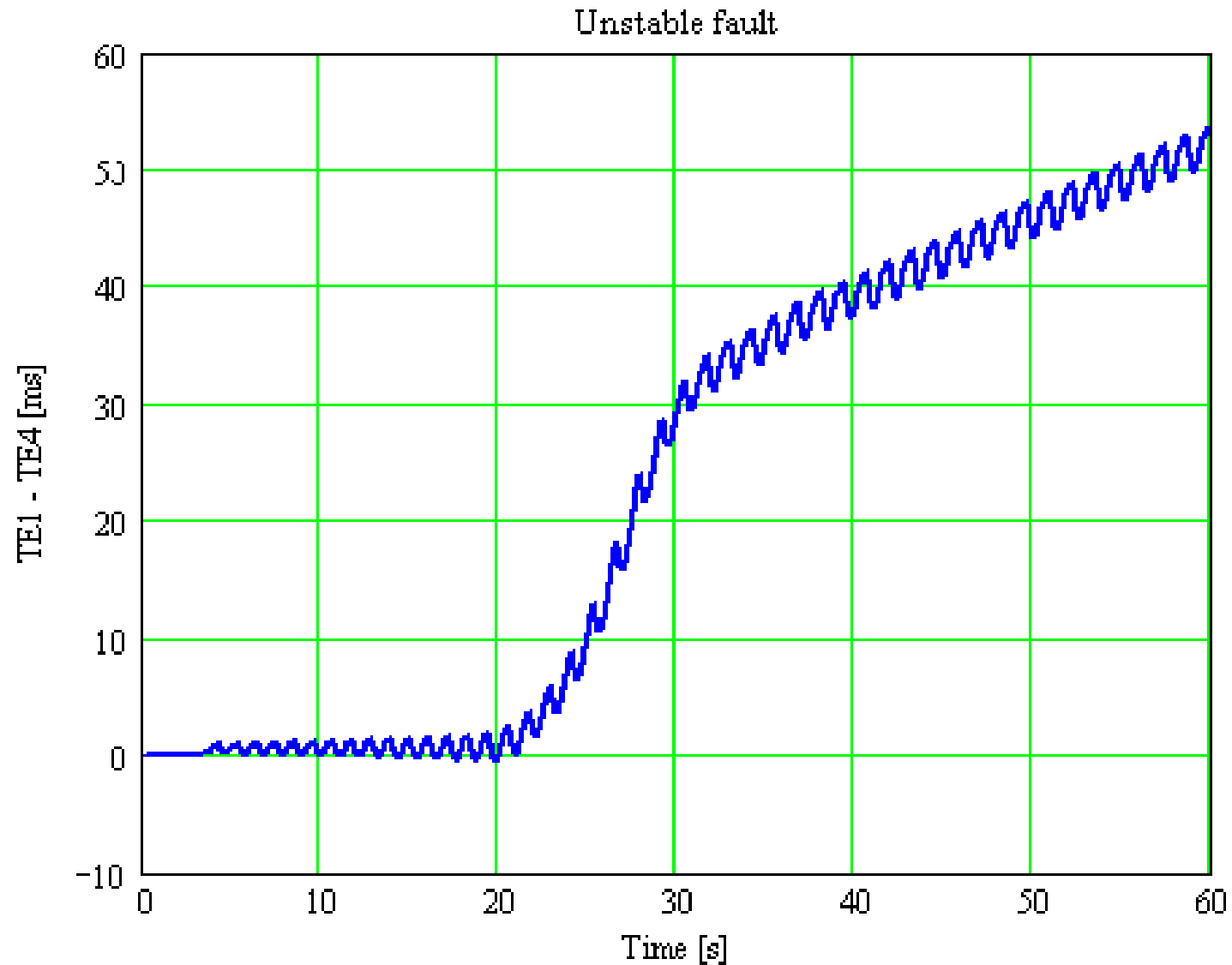
Time Error, Phase Angle and Frequency – Stable Fault



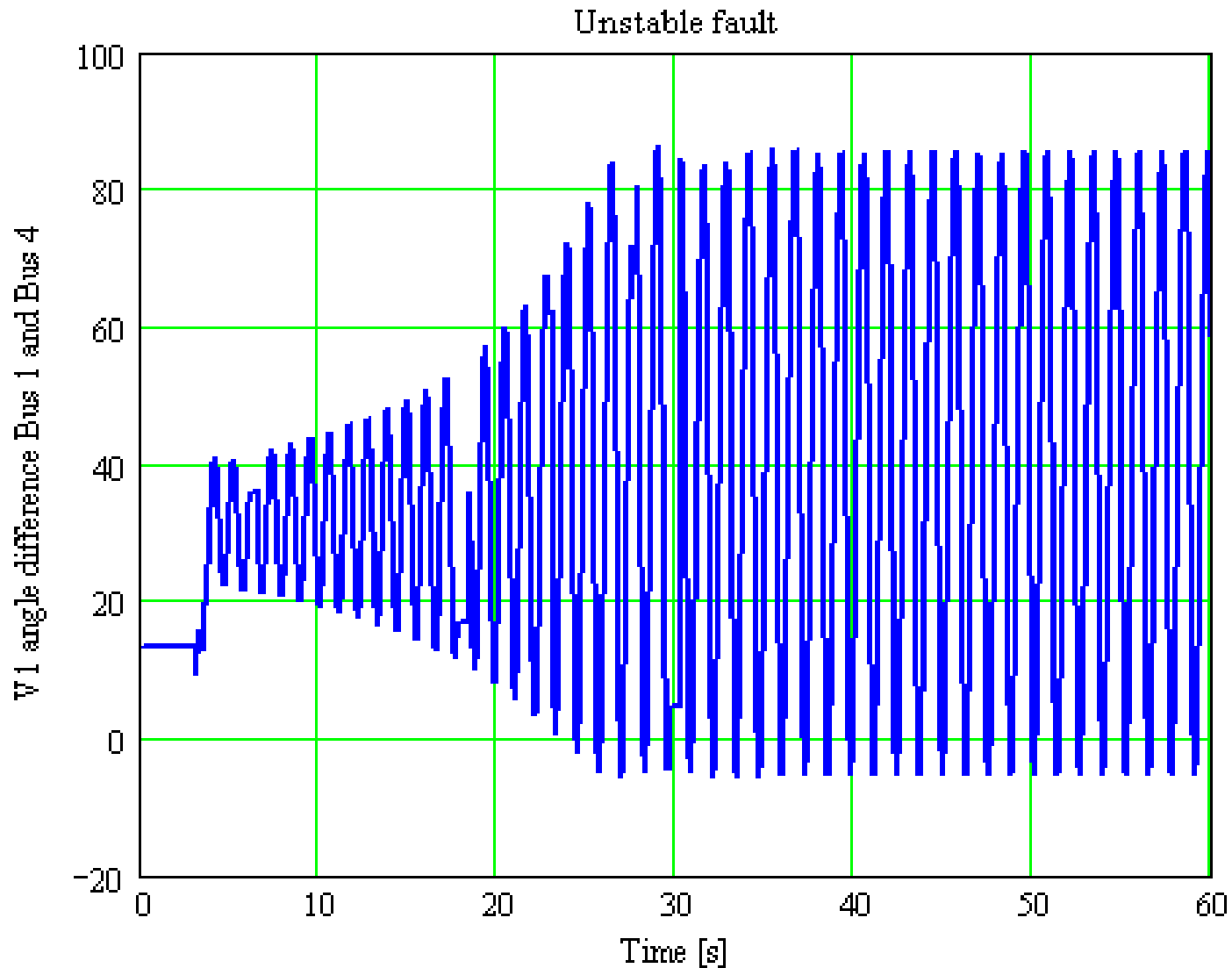
Unstable Fault



Time Error Differential



Phase Angle After Unstable Fault



Local Calculation of Line Temperature



+

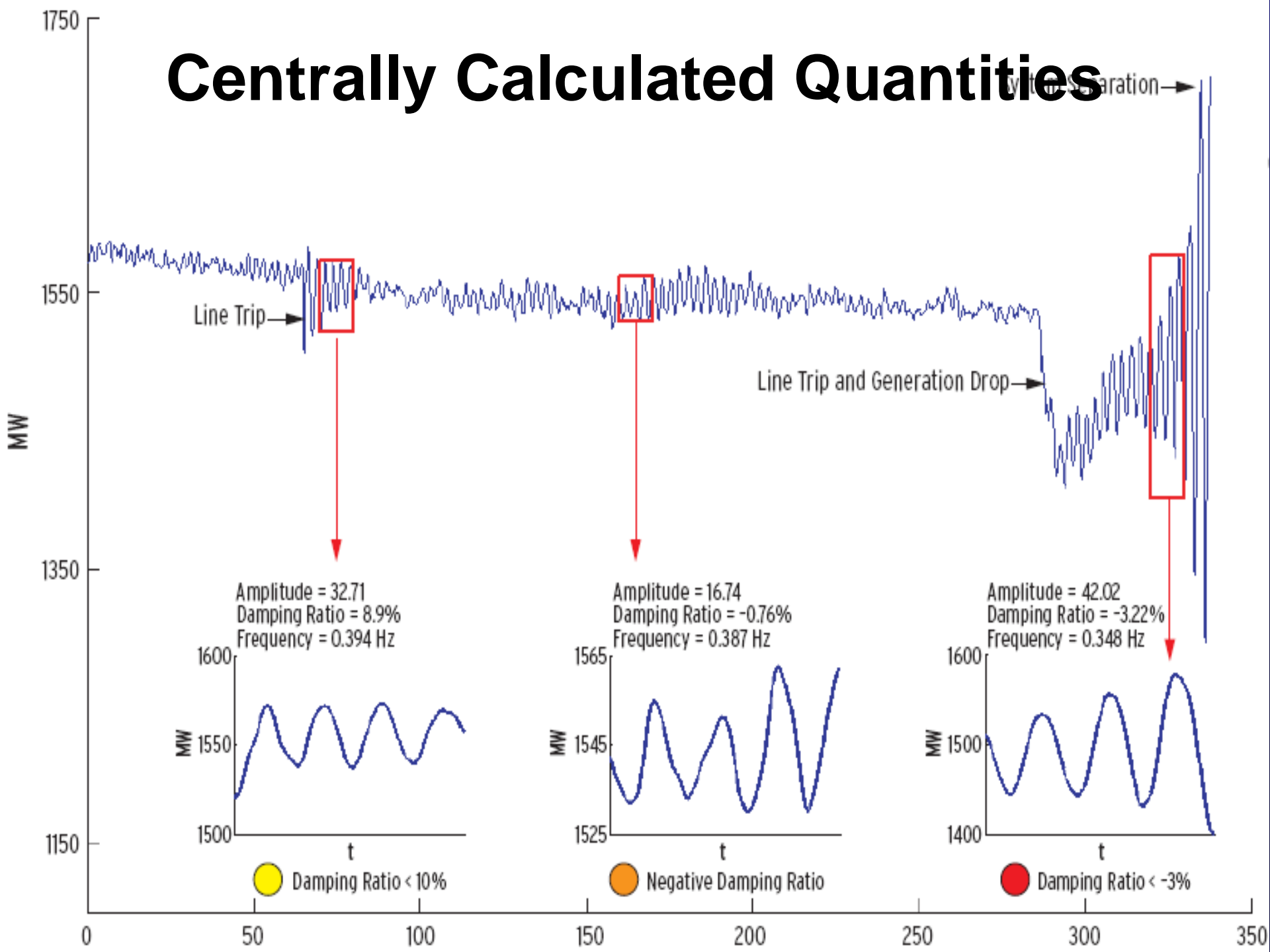


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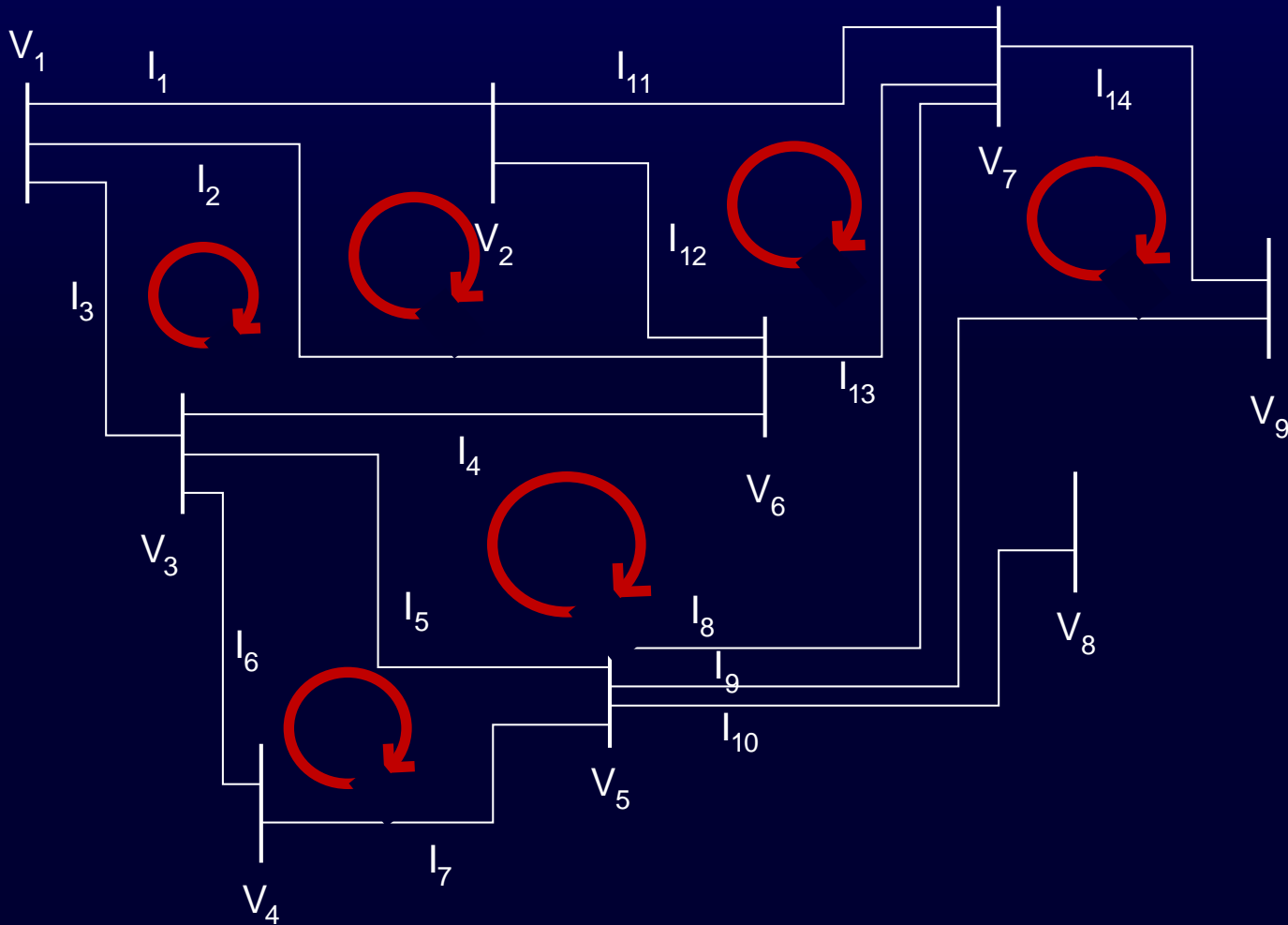


Line Temperature = f (Ambient Temp, Current, Line Orientation, Season)

Centrally Calculated Quantities



Grid Efficiency Measurement, and Control



What is Long Term Future ?



