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The PI System based MODICOSEN (Dynamic Monitoring & Control of the National Power System) at CFE, Mexico

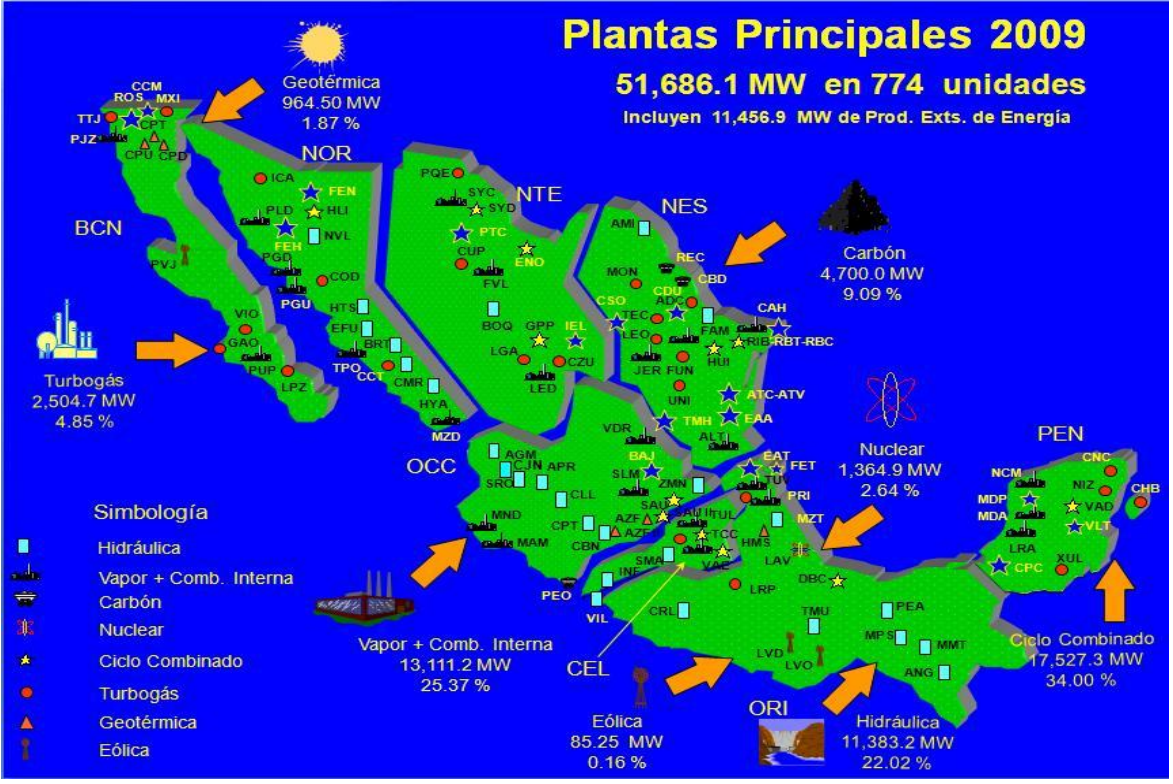
Presented by **Arturo Gonzalez, Comision Federal de Electricidad (CFE)**
Centro Nacional de Control de la Energía (CENACE)

Agenda

- **Who is CFE CENACE ?**
- **Grid Stability Issues**
- **Proposed Solution**
- **Benefits**
- **Next Steps**
- **Q & A**

CENACE (National Energy Control Center) Overview

- CFE around 70K employees, and CENACE approx. 1,200
 - 1 National Center
 - 8 Control Areas
 - 32 Control Subareas
- Total installed capacity 51 GW
- More than 700 Generators
- Max. instantaneous demand 35,434 MW



Grid Stability Issues

- **In the past, it has been difficult to prevent grid stability issues from occurring**
- **It has not been possible to monitor Phase Angles in Real-time**
- **No visibility on Network Stability**
- **Fault analysis and report generation have been difficult and labor intensive**

Sistema de Monitoreo Dinámico y Control del Sistema Eléctrico Nacional MODICOSEN

Proposed Solution:

MODICOSEN (Dynamic Monitoring & Control of the National Power System):

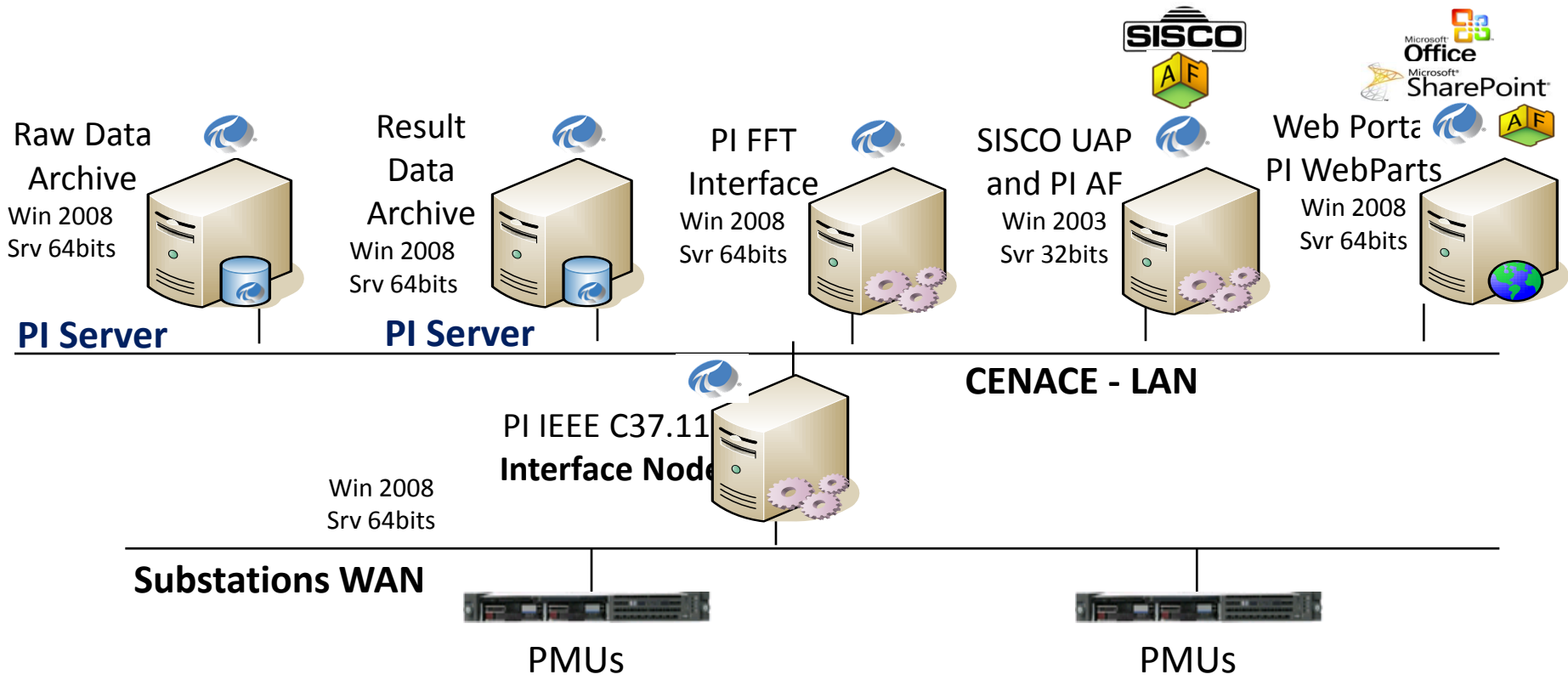
- Provide the means for **Real-Time Monitoring, Analysis**, and **Archiving** for Synchrophasor measurements from PMUs
- Present and visualize the dynamic behavior of the National Electrical Power system in a much faster real-time way, much better than what a SCADA system does

Sistema de Monitoreo Dinámico y Control del Sistema Eléctrico Nacional

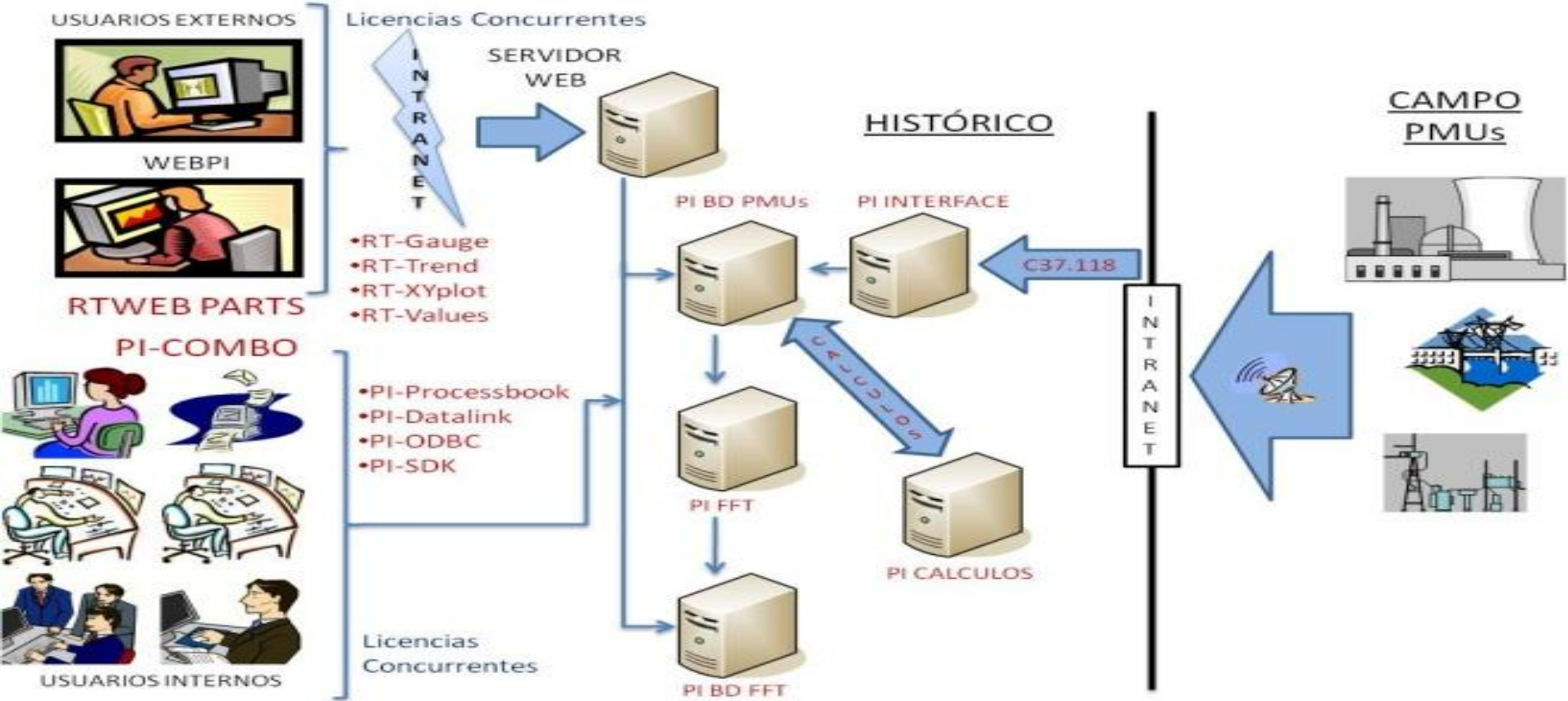
MODICOSEN

- WAMS (Wide Area Measurement System) designed to monitor the National Electrical Power System
- Prevent Future Blackouts by enabling a timely response to emerging network instabilities
- Analysis and Real Time Visualization of measurements of Voltage & Current synchrophasors, Angle Differences, and the Damping Coefficient calculations for inter-area regional low frequency oscillations
- Apply OSIsoft PI System platform and national electrical infrastructure to improve stability analysis, generate timely alarm notifications, and help identify differences in the network settings that will improve stability

MODICOSEN System Components

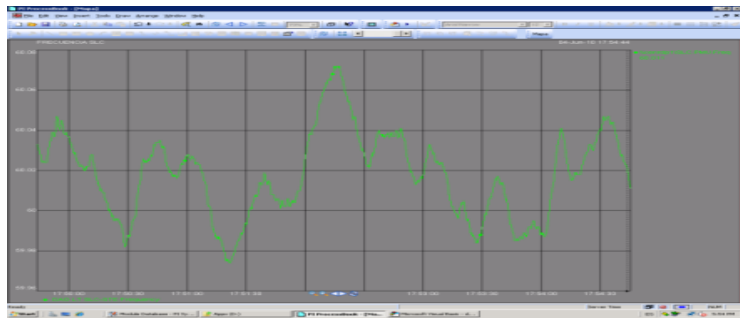


MODICOSEN System Components

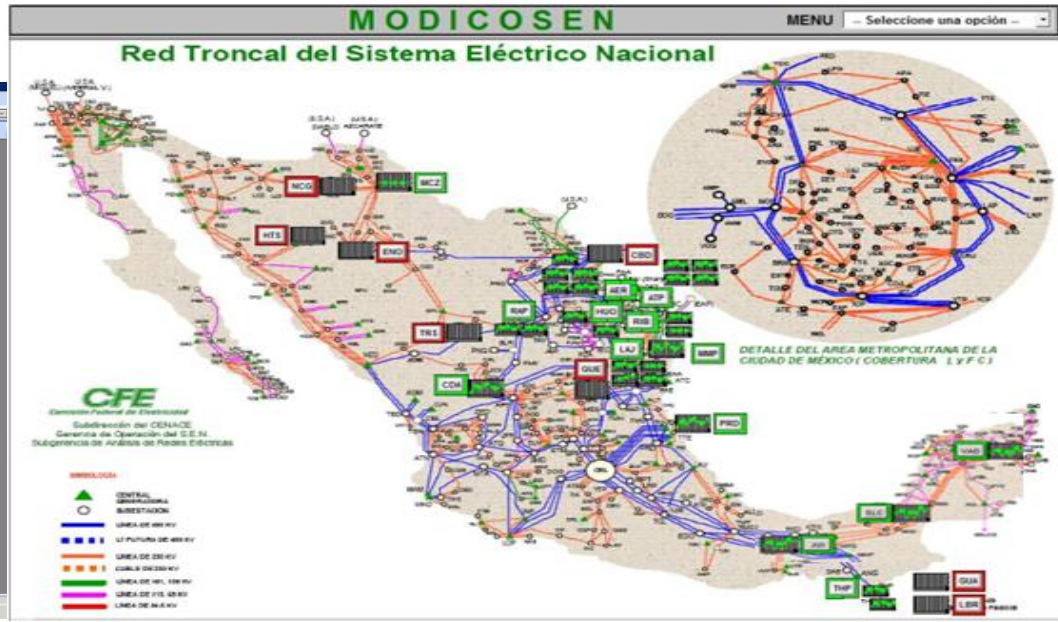


MODICOSEN Visualization

- PMU Monitoring
 - PI ProcessBook 3.2.0.0
 - 25 PMUs
 - Connection Status
 - Status Updates



A screenshot of the PI ProcessBook software interface. A window titled 'Mapa_PMU_v1.5' is open, displaying a menu with the following options: Mapa, Diferencia Angular, Cambio de Frecuencia, Información PMUs, MultiPotencias, MultiPotencias(Q), Curvas V - I, and Curvas F - P. A vertical toolbar on the right side of the window contains icons for various map functions. The main window area is currently blank.



MODICOSEN Visualization

PI ProcessBook - Resumen SLC

Diferencia Angular		Multi-Frecuencias	Multi-Potencias (P) MW	Grafica F - P
Gusano de Frecuencia		Multi-Potencias (Q) MVAR	Grafica V - Q	
NOMBRE		VALOR		
SANTA LUCIA (SLC)				
SLC.PMU.Freq 60.026				
04-Jun-10 16:44:29.75				
SLC.ConnectState	Connected			
SLC.LeapSecond	Normal			
SLC.PMU.Freq	60.02600			
SLC.DAGLTS LC-STE.DFreq	0.01000			
SLC.DAGLTS LC-STE.FreqErr	0.02600			
SLC.DAGLTS LC-STE.NomFreq	60Hz			
SLC.DAGLTS LC-STE.Latitude	-999.000			
SLC.DAGLTS LC-STE.Longitude	-999.000			
SLC.DAGLTS LC-STE.CompositeQual	Good			
SLC.DAGLTS LC-STE.ConfigChange	Normal			
SLC.DAGLTS LC-STE.DataSorting	By Time			
SLC.DAGLTS LC-STE.DataValidity	Valid			
SLC.DAGLTS LC-STE.Phasor.IHWPM.Angle	-66.176			
SLC.DAGLTS LC-STE.Phasor.IHWPM.Imag	-342.142			
SLC.DAGLTS LC-STE.Phasor.IHWPM.Mag	374.012			
SLC.DAGLTS LC-STE.Phasor.IHWPM.Real	151.076			
SLC.DAGLTS LC-STE.Phasor.V1LPM.Angle	-57.952			
SLC.DAGLTS LC-STE.Phasor.V1LPM.Imag	-117.169.141			
SLC.DAGLTS LC-STE.Phasor.V1LPM.Mag	138235.766			
SLC.DAGLTS LC-STE.Phasor.V1LPM.Real	73352.023			
SLC.DAGLTS LC-STE.PMUError	Normal			
SLC.DAGLTS LC-STE.SyncError	Normal			
SLC.DAGLTS LC-STE.TimeLock	Locked			

SLC.VoltajeLinea	239.380
SLC.PotActiva	152.439
SLC.PotReactiva	22.17897

VOLTAJES Y CORRIENTES FASORES DE VOLTAJE FASORES DE CORRIENTE

FRECUENCIA SOC

PI ProcessBook - Frecuencia SOC SLC*

Chart Tag: SLC.PMU.FREQ
 Value: 59.9880
 USL/LSL: 60.1 / 59.9
 Sigma: N/A
 Cpk: 0.80173

Mapa SLC

267

0

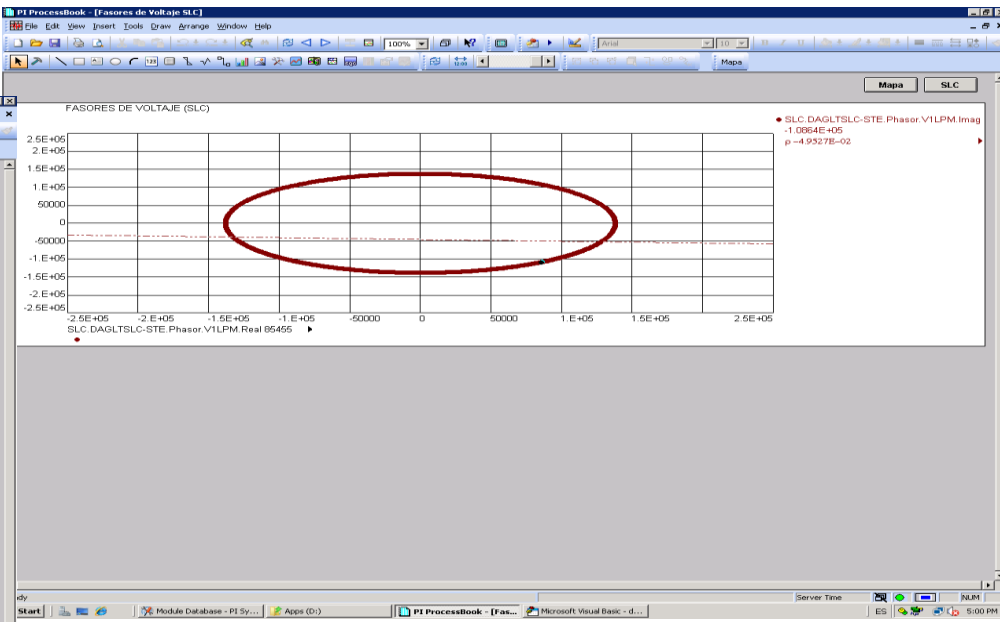
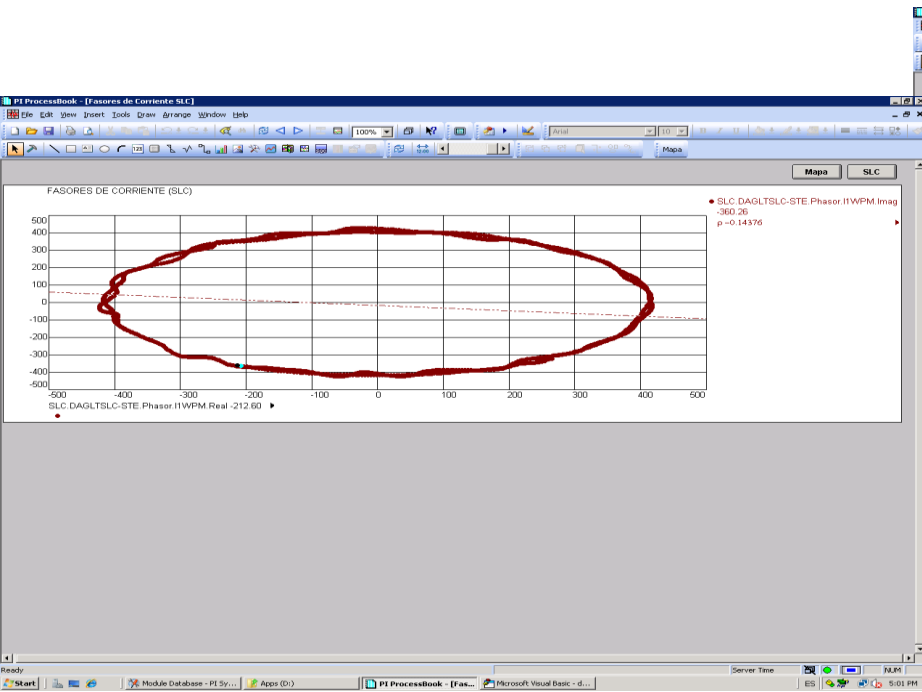
60.1
60.08
60.06
60.04
60.02
60
59.98
59.96
59.94
59.92
59.9

04-Jun-10 16:47:06.25 04-Jun-10 16:52:05.5

- PMUs Raw Data Displays

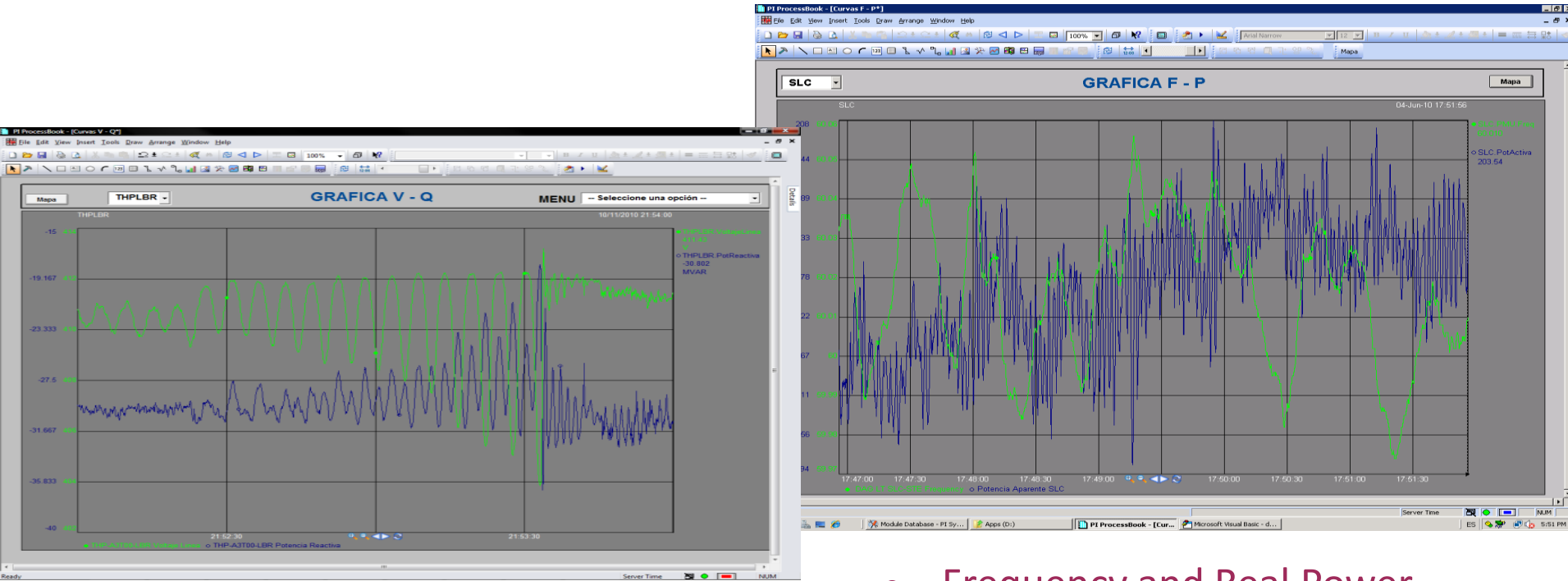
- PMUs Data Analysis Frequency using PI SQC (Statistical Quality Control)

MODICOSEN Visualization



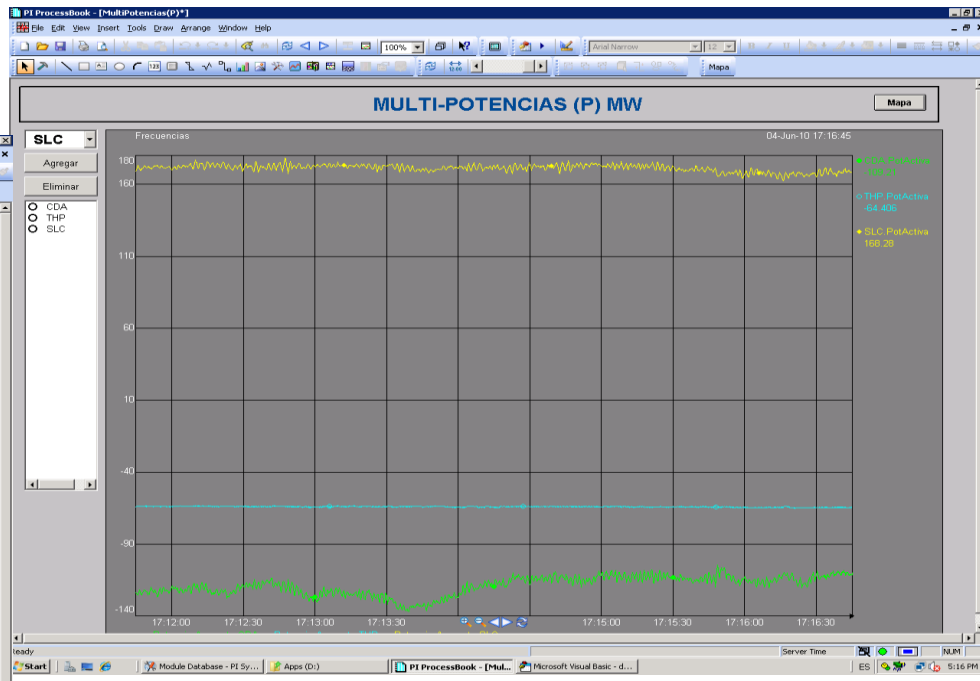
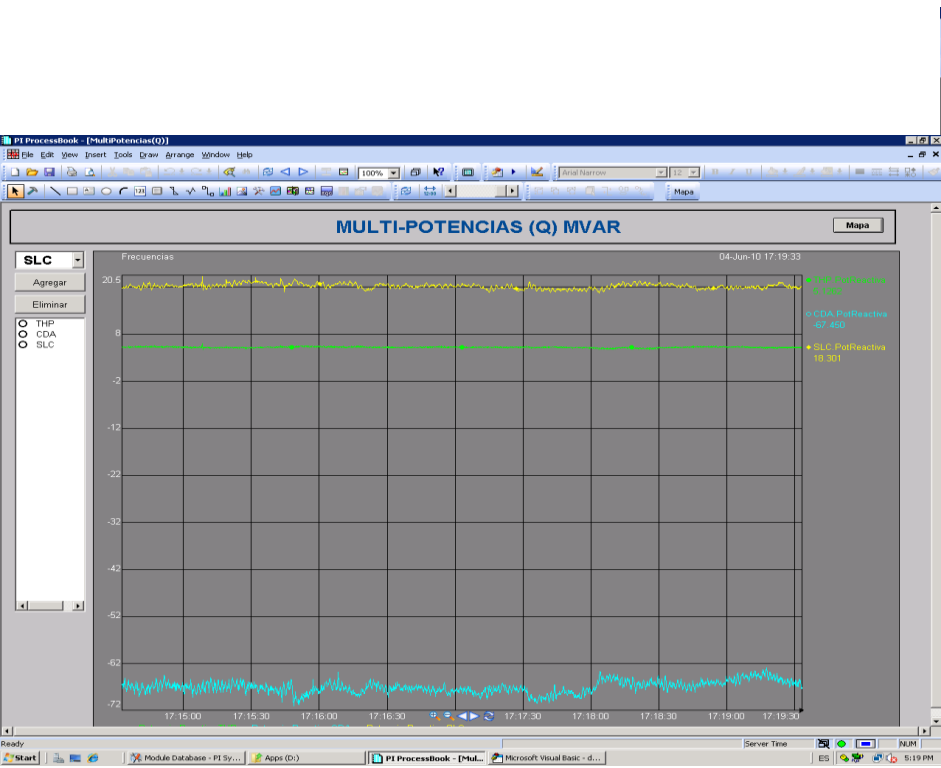
- Voltage Phasors Real & Imag Parts
- Current Phasors Real & Imag Parts

MODICOSEN Visualization



- Voltage and Reactive Power
- Frequency and Real Power

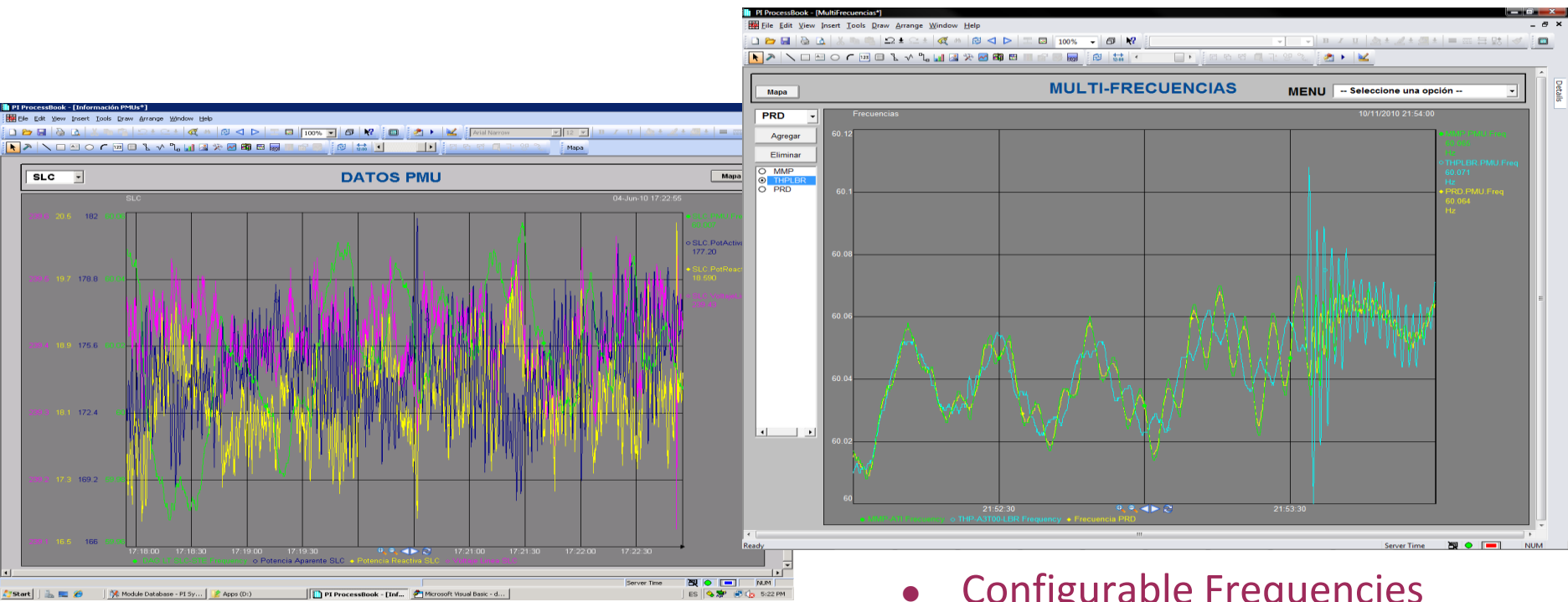
MODICOSEN Visualization



- Configurable MWs Trending

- Configurable MVARs Trending

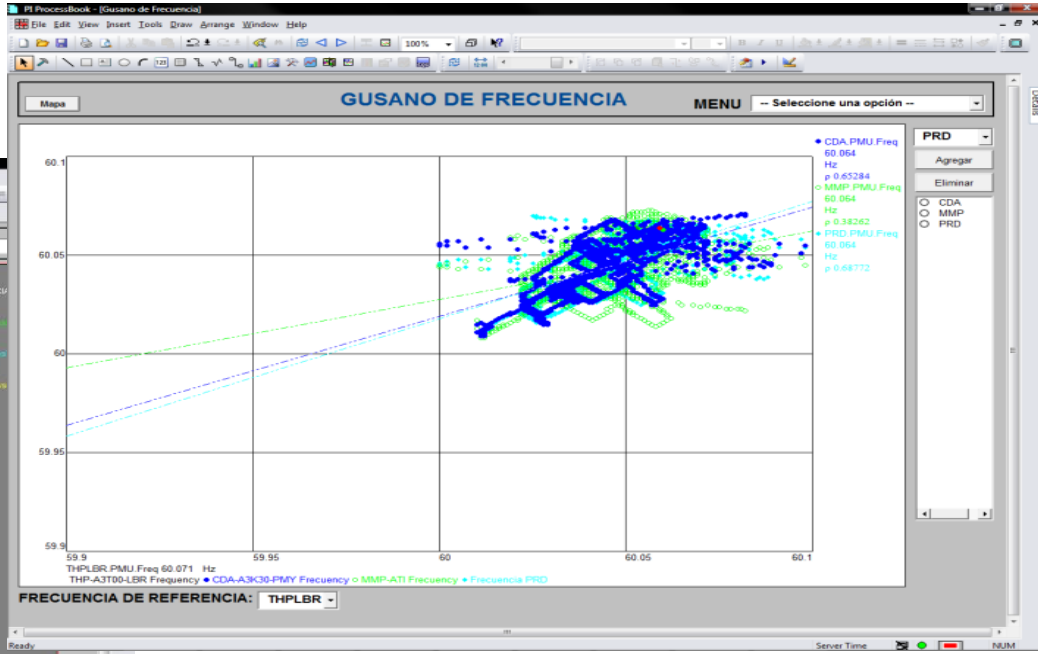
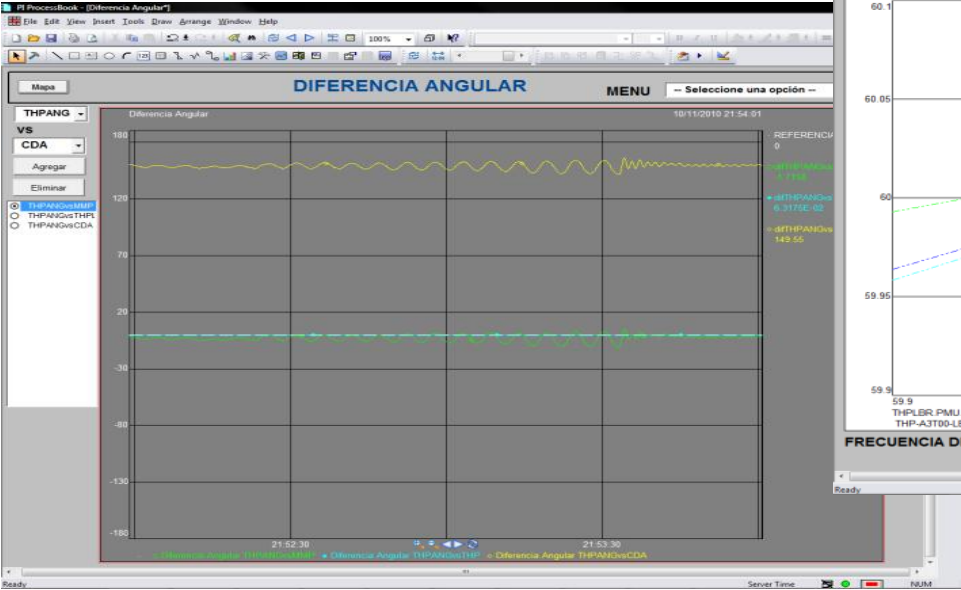
MODICOSEN Visualization



- Configurable Raw PMUs Data

- Configurable Frequencies

MODICOSEN Visualization



- Configurable Angle Differences Chart

- Configurable Frequency Worm Chart

MODICOSEN Web-based Visualization

The screenshot shows a web browser window titled "demoDLES2". The main content area displays an Excel spreadsheet with columns A through J and rows 1 through 30. The spreadsheet contains data for a time series, including tags, start times, end times, and intervals. The data is as follows:

	A	B	C	D	E	F	G	H	I	J
1										
2	Tag	bartemp.1		10:24:40 AM	23.00031					
3	StartTime	*		10:22:40 AM	23.00031					
4	EndTime	*-10m		10:20:40 AM	23.00031					
5	Interval	2m		10:18:40 AM	23.00031					
6				10:16:40 AM	23.00031					
7				10:14:40 AM	22.95907					
8										
9										
10										
11										
12										
13										
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28										
29										
30										

The screenshot shows a web browser window titled "demoPMUdata". The interface includes a tree view on the left and a line chart on the right. The tree view shows a hierarchy of data points under "PI TreeView - PI Trend & Time Series". The line chart displays a "PI Trend" over time, with a green line showing a sawtooth pattern. The x-axis is labeled "6/4/2010 6:01:36 PM" and "60 Sec(s)". The y-axis ranges from -200 to 200. Below the chart, a "PI TimeSeries" table is visible, showing a list of time and value pairs.

Time	Value
6/4/2010 6:01:36 PM	-126.67
6/4/2010 6:01:36 PM	-126.04
6/4/2010 6:01:36 PM	-125.44
6/4/2010 6:01:36 PM	-124.79
6/4/2010 6:01:36 PM	-124.19
6/4/2010 6:01:36 PM	-123.58
6/4/2010 6:01:36 PM	-123
6/4/2010 6:01:37 PM	-122.39
6/4/2010 6:01:37 PM	-121.73
6/4/2010 6:01:37 PM	-121.09

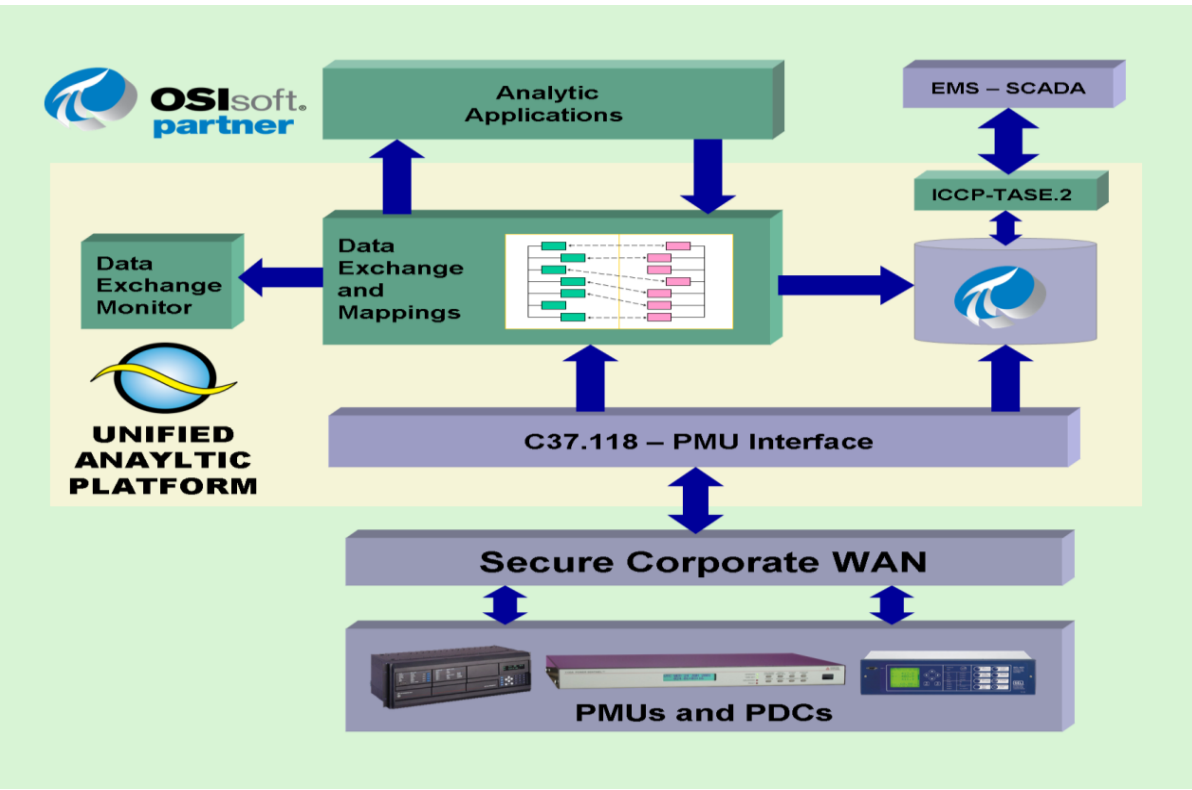
- PI DataLink Excel Services

- PI WebParts



MODICOSEN Analytics – UAP (Unified Analytic Platform)

- Real-Time Calculations performed using SISCO Unified Analytic Platform

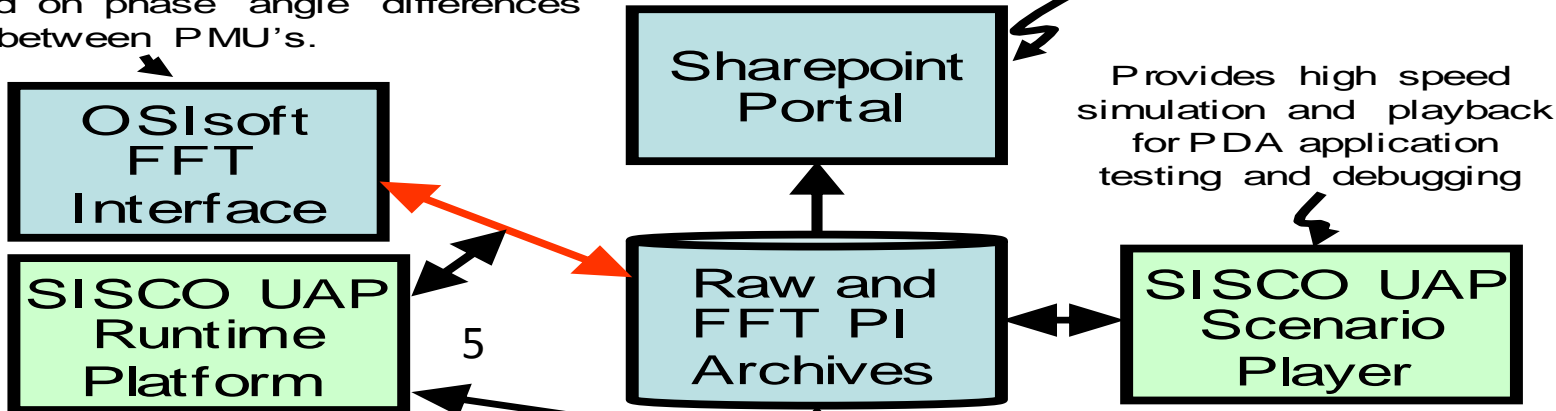


- Angle Differences, 20 times per second
- Oscillation Detection and Alarming, 5 times per second
- Damping Coefficient of Significant Harmonics, 5 times per second

MODICOSEN Analytics – PDA (Phasor Data Analyzer)

4) Calculates most significant modes of oscillation in real-time on frequencies from each PMU and on phase angle differences between PMU's.

6) Displays voltage and frequency trends as well as oscillation trends and alarms



3) Calculates the difference in phase angle between phasors and

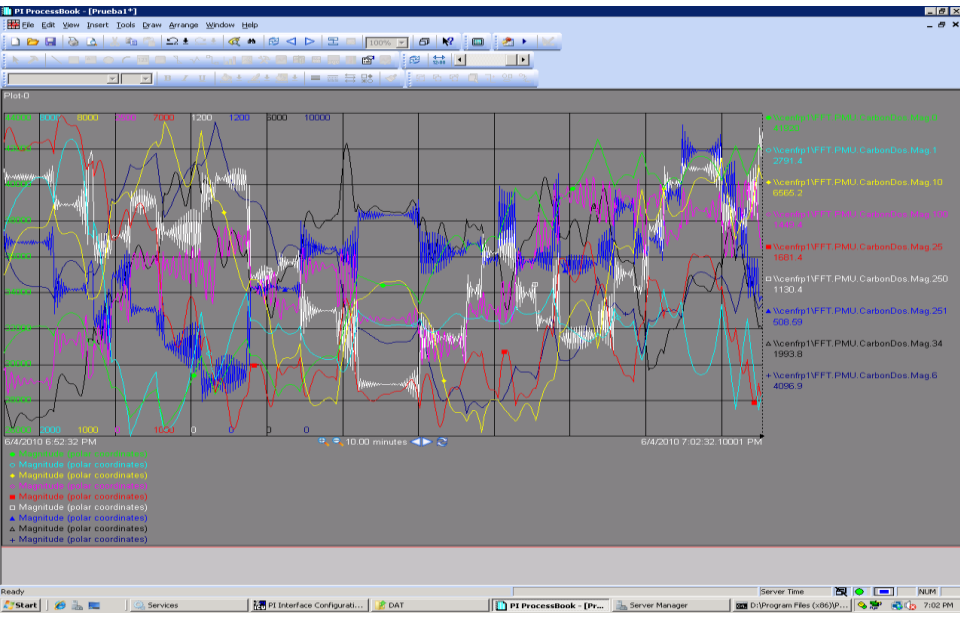
5) Calculates damping coefficients from FFT results as driven by the run rate of the FFT. Determines if the most significant modes of oscillation are increasing greater than a set point for longer than a setable time period.

2) Buffers phasor data for input into the archive

1) C37.118 Data Streams received via CEE WAN

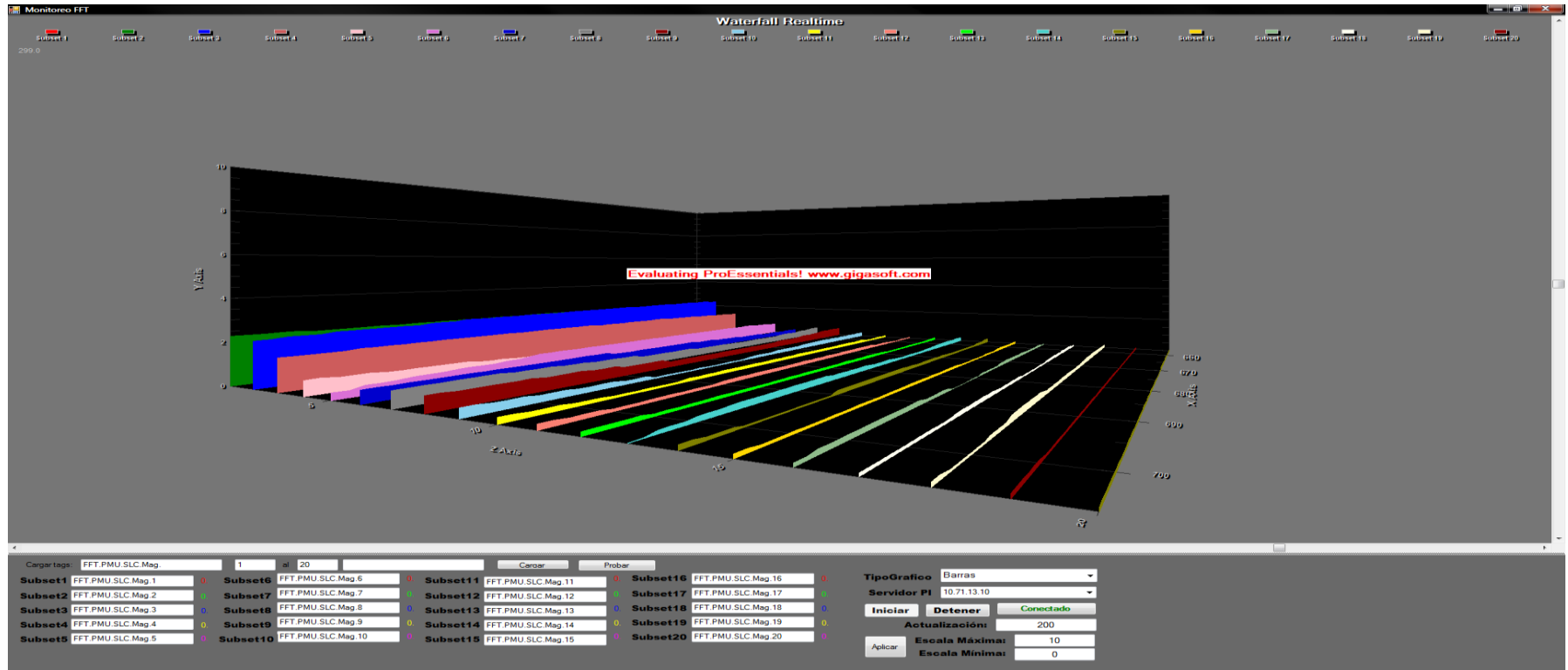
MODICOSEN Analytics

- OSisoft PI FFT Interface (Fast Fourier Transform)
 - Calculates the modes of oscillation (Harmonics Content)
 - Polar & Rectangular Coordinates



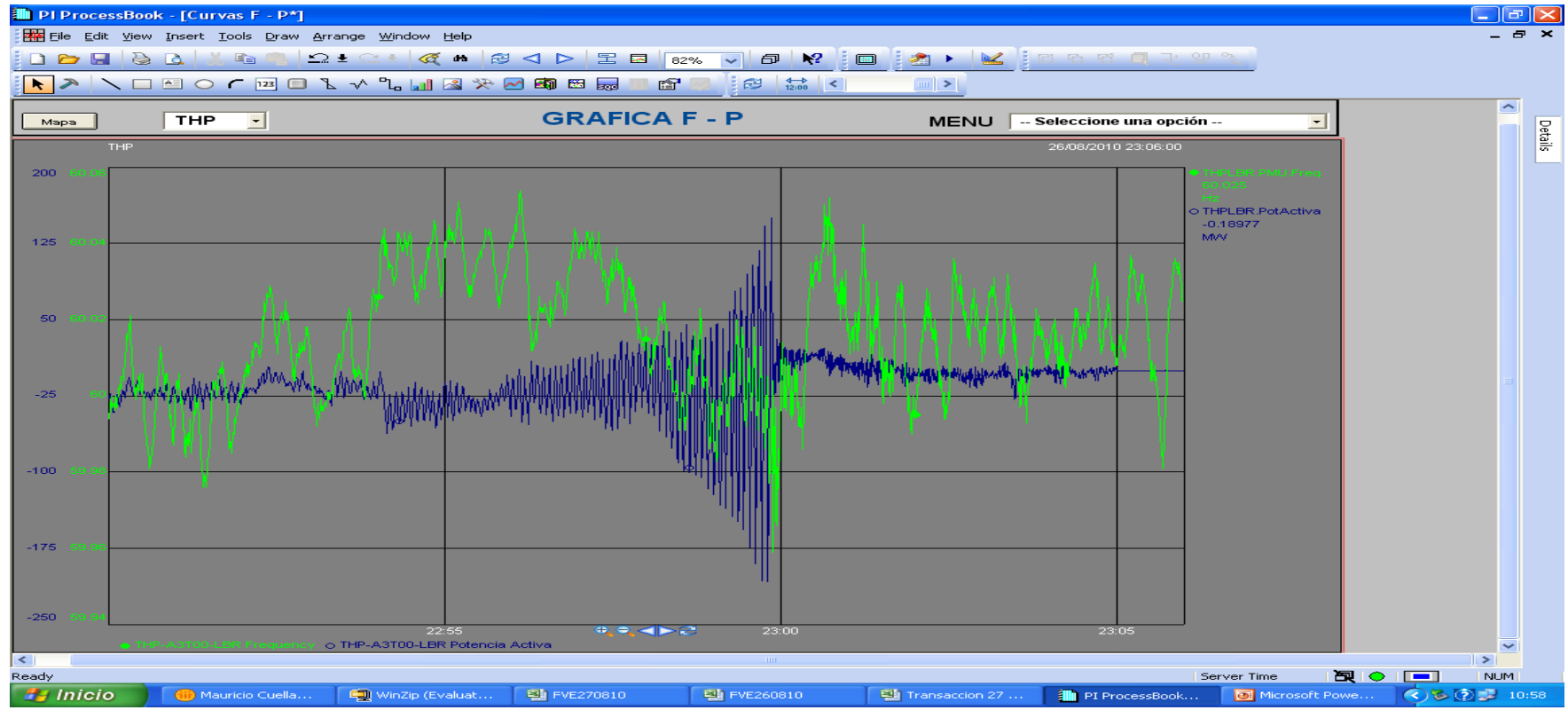
MODICOSEN Analytics

- OSIsoft PI FFT Interface (Real Time Water Fall Chart)



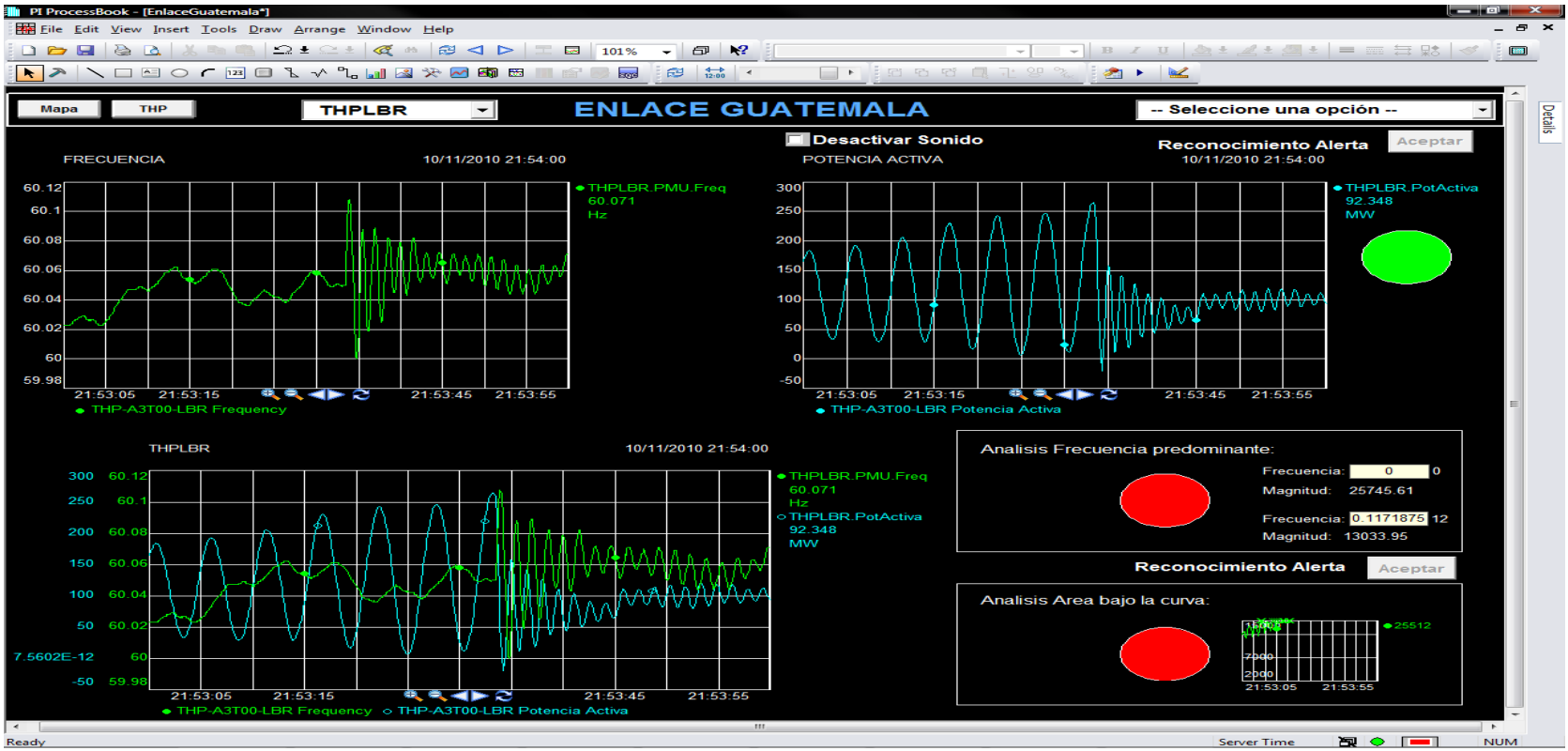
MODICOSEN Analytics

- Mexico – Guatemala Tie Line Event



MODICOSEN Analytics

- PI FFT Interface - Low Frequency Oscillations Detection and Alarming



Intangible Benefits

- Improved response times for data analysis
- Greater flexibility in searching
- Friendly tool (graphics and Excel)
- Democratization of information through Integration
- A single source of information
- Improved visualization “Look and Feel”
- Easy and fast to update the information

Tangible Benefits

- Operators can foresee instabilities in different areas of the electrical system to implement corrective or preventive actions
- Monitoring Phase Angle 20 times per second (50ms)
- The Report Generation is flexible and simple
- The Failure Analysis can be carried out in Real-time
- Monitoring the Network Stability in Real-time better than SCADA

Next Steps

- **Increase PMUs coverage and data acquisition**
- **Install more instances of PI C37.118 PMUs Interface**
- **Increase System Scalability**
- **Install PI Interface Node & PI Raw Data Server at each Substation Level**
- **Implement PI HA (High Availability) Architecture**
- **Expand MODICOSEN at each Regional Control Area Level**

MODICOSEN

Questions & Answers



Thank you

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