

Electromechanicals Oscillation's Detection Based On Synchrophasors

M.C. Alfredo Olachea Aguayo

COMISIÓN FEDERAL DE ELECTRICIDAD
CENTRO NACIONAL DE CONTROL DE ENERGÍA
ÁREA DE CONTROL NOROESTE

CFE'S WAMS PROJECT

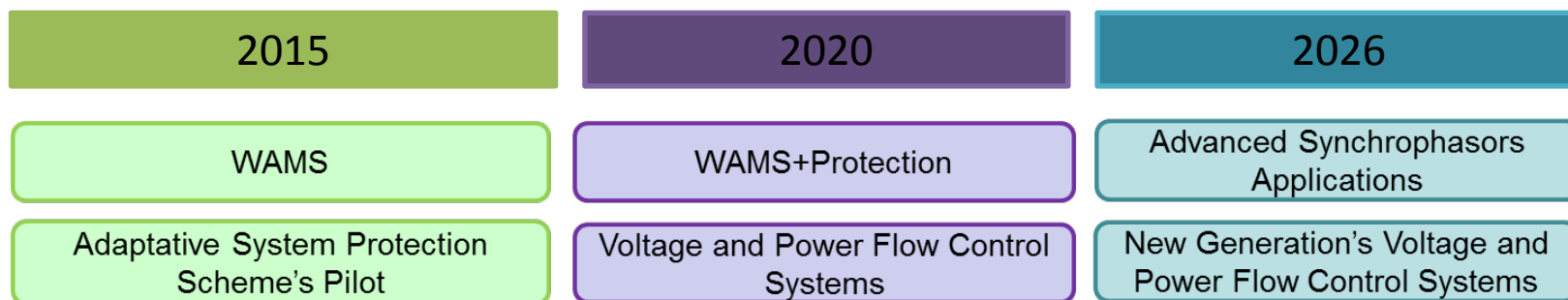
2009 WAS THE BEGINING OF A WAMS' PILOT PROJECT, RELATED WITH SUPERVISING THE NORTHWEST PART OF THE MEXICO'S POWER SYSTEM USING **PHASOR MEASUREMENTS UNITS** (PMUs).

NOW THIS PILOT HAS BECOME A NATIONAL PROJECT NAMED:

"RED INTELIGENTE"

RED INTELIGENTE

Evolve to a more reliable, secure, sustainable and efficient power system that addresses the challenges of the country, transforms the public service of electric power to satisfy the client's higher expectations and contributes to the economic and social growth of México.



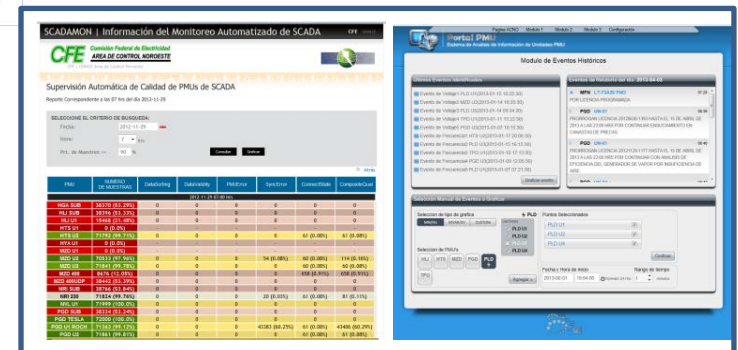
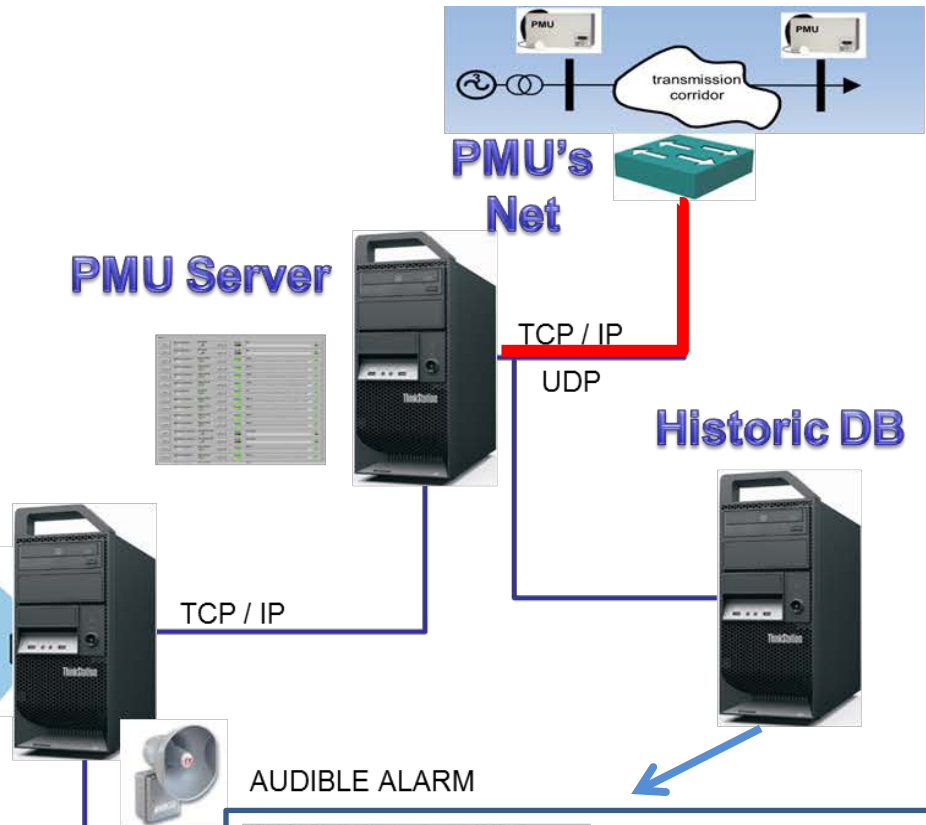
PROJECT OBJECTIVES

- TO PROVIDE THE POWER SYSTEM OPERATORS WITH **REAL TIME TOOLS** THAT HELP THEM IMPROVE THE **RELIABILITY** OF THE POWER SYSTEM
- TO ACQUIRE AND RECORD BETTER INFORMATION RELATED WITH POWER SYSTEM VARIABLES FOR **OFF-LINE ANALYSIS.**

WAMS PILOT PROJECT



LIGHT ALARM



RT APPS

PMUs:

- 17 Generators.
- 6 Substations (230 KV Net).
- 25 Substations (230 KV Net) for 2014.

Developed Applications:

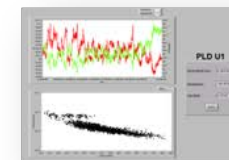
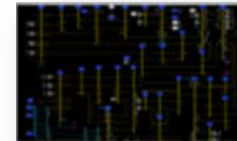
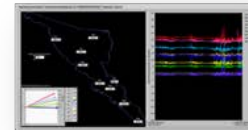
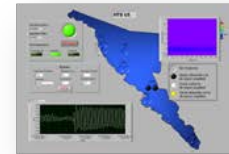
- RT Low Frequency Oscillation's Detector (Oscila).
- RT Angular Differences, Power Flow and Voltage Monitoring.
- Unit's Frequency Response Evaluation.

Under Development:

- 230 KV Net Voltage's Supervision with Contour Graphs.
- RT Unit's Operational State on Capability Curves.
- WEB Access to PMU's Historic Information

Future Developments:

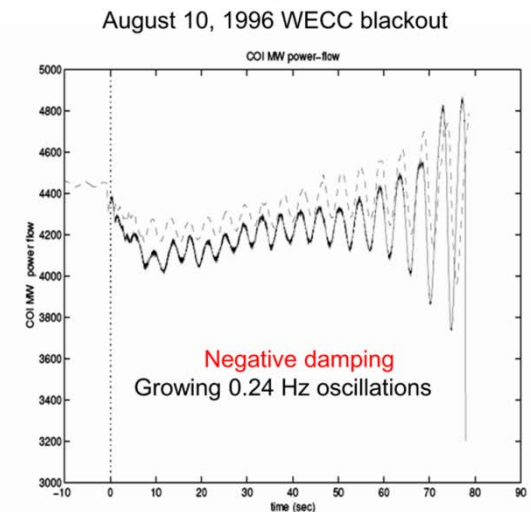
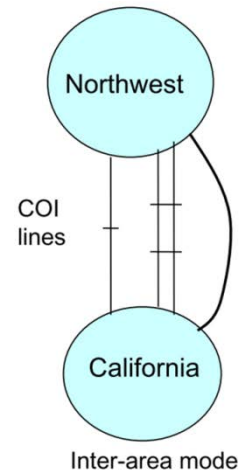
- WAMS



Oscila is a computational tool, based on **synchrophasors** and **Fast Fourier Transform (FFT)** for the detection, in **real time**, of **oscillatory patterns** in the measurement of active power from the generators.

The application consists in three modules:

- ✓ Synchrophasors acquisition.
- ✓ Oscillatory pattern detection.
- ✓ Calculus of the oscillatory pattern tendency, amplitude and oscillatory patterns correlation.



THE DETECTION OF ELECTROMECHANICAL OSCILLATIONS IN INCIPIENT STAGES CAN SAVE THE GENERATORS' SHAFTS FROM DAMAGES OR EVEN AVOID A BLACKOUT. BY NOW, THIS IS ONLY POSSIBLE IN RT, THROUGH PMUs, THANKS TO ITS SAMPLING FREQUENCY AND SYNC.

OSCILA's FP

UNIDAD CON MAYOR AMPLITUD DE OSCILACIÓN

HTS U1

Frecuencia de Oscilación (Hz)

0.9375

Amplitud de Oscilación (MW)

126.7

Tipo de Oscilación

OSCILACIÓN LOCAL

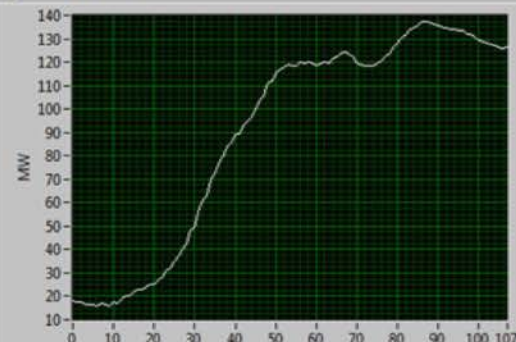
Amortiguamiento

Amortiguada

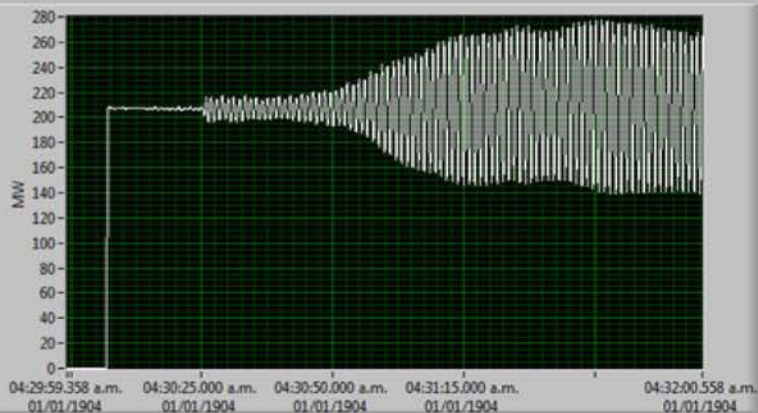
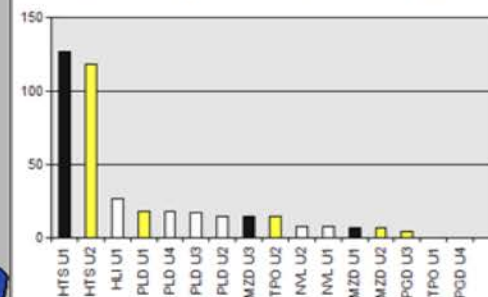
Sostenida

Creciente

Amplitud de Oscilación



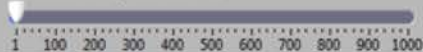
FACTORES DE PARTICIPACIÓN (MW)



Nombre de archivo histórico en reproducción

evento Mar 03 de Sep de 2013 02_37_40 p.m. - copia.xls

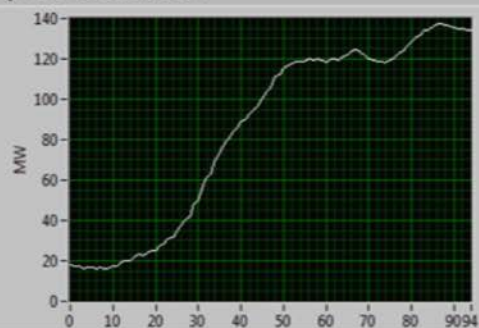
Velocidad de reproducción (ms)



Cambiar Ajustes

- ☐ Sin Oscilación
- ☒ Oscila coherente a la de mayor amplitud
- ☐ Oscila contra la de mayor amplitud
- ☒ Oscila defasada con la de mayor amplitud

Amplitud de Oscilación



Frecuencia de Oscilación (Hz)

0.9375

Amplitud de Oscilación (MW)

134.2

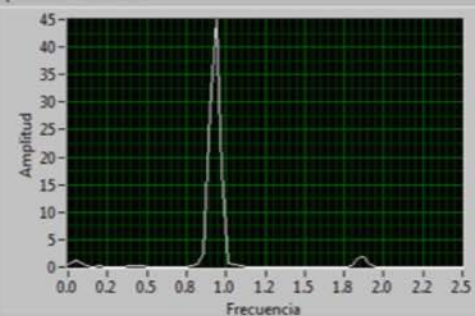
Amortiguamiento

Amortiguada

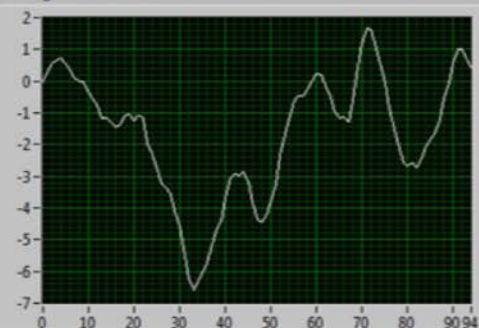
Sostenida

Creciente

Espectro Fourier



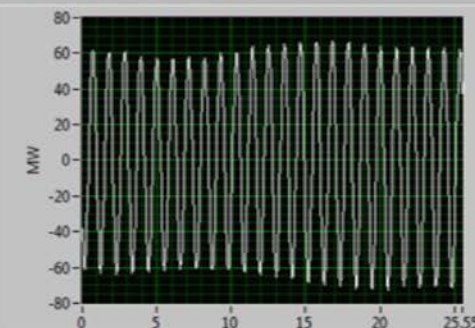
Amortiguamiento



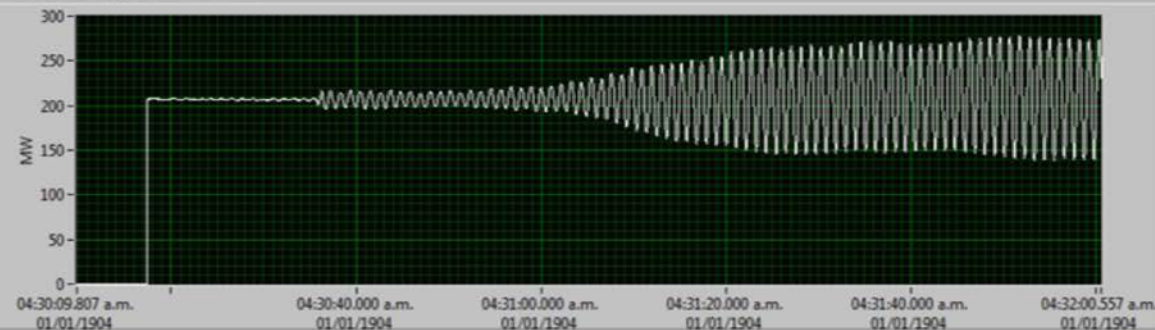
MAPA

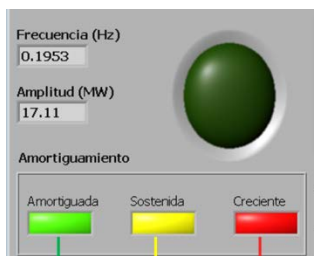
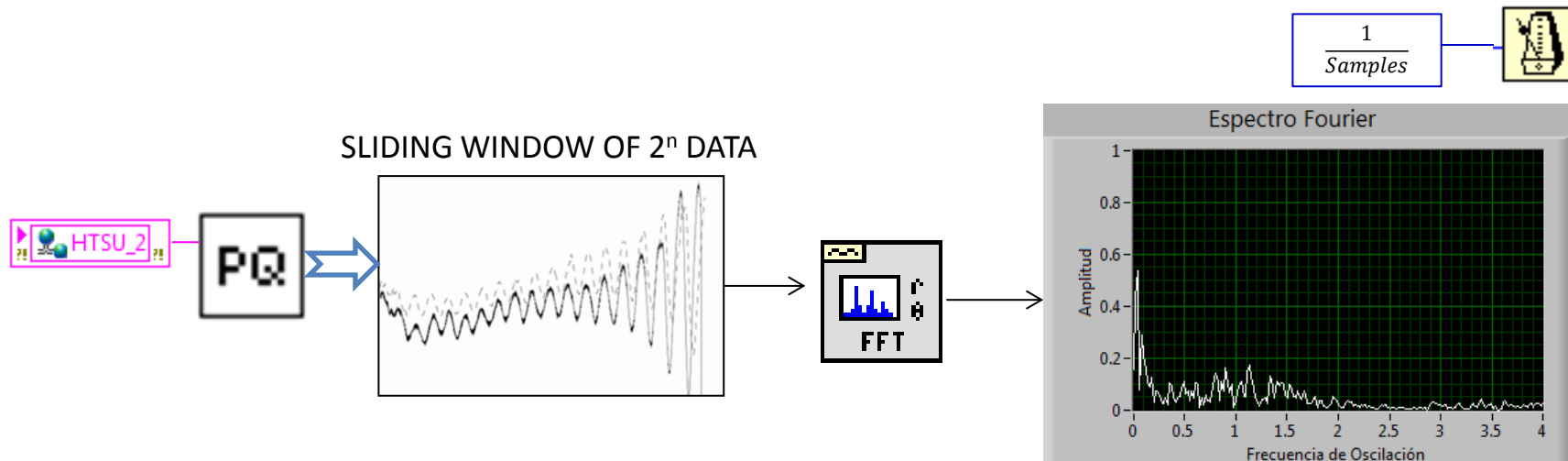
HTS U1

Desviación de Potencia

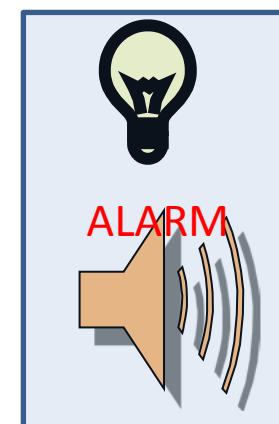
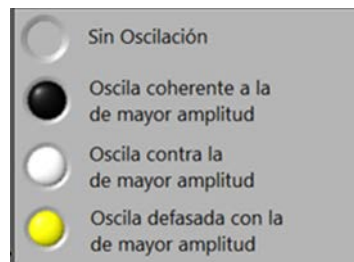
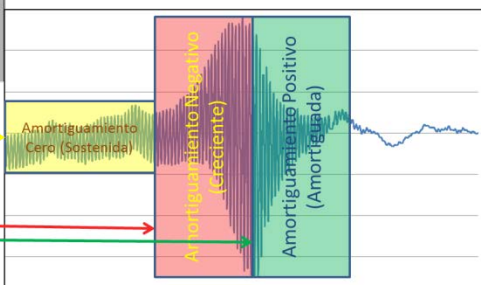


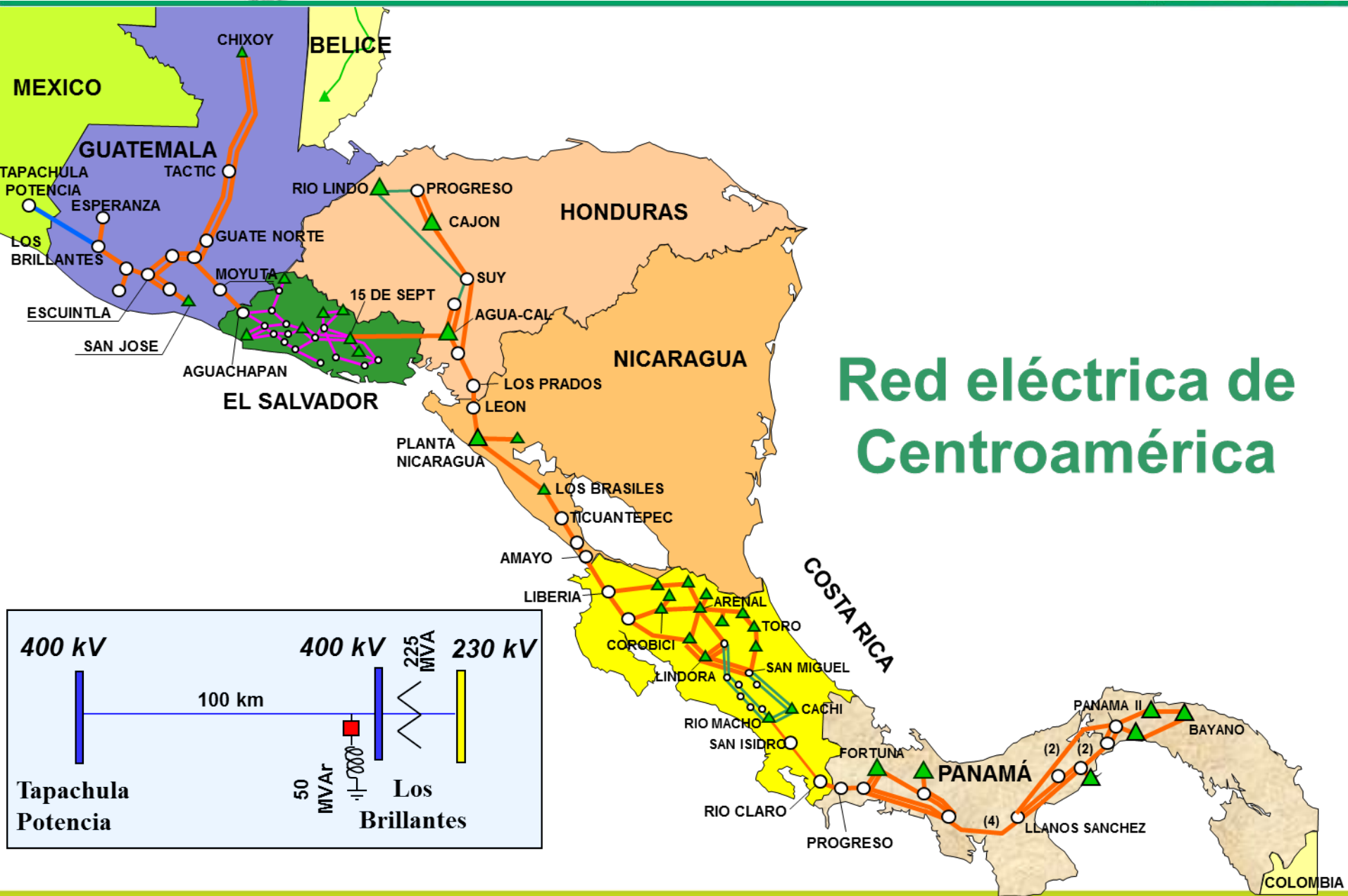
Oscilación de potencia activa





FREQUENCY OF OSCILLATION
AMPLITUD, DAMPING, COHERENCE





DETECCIÓN DE OSCILACIONES EN ENLACE

INTERCAMBIO ACTUAL

CONFIGURACIÓN

Frecuencia (Hz) 4

0

Amplitud (MW)

0

Amortiguamiento

Amortiguada

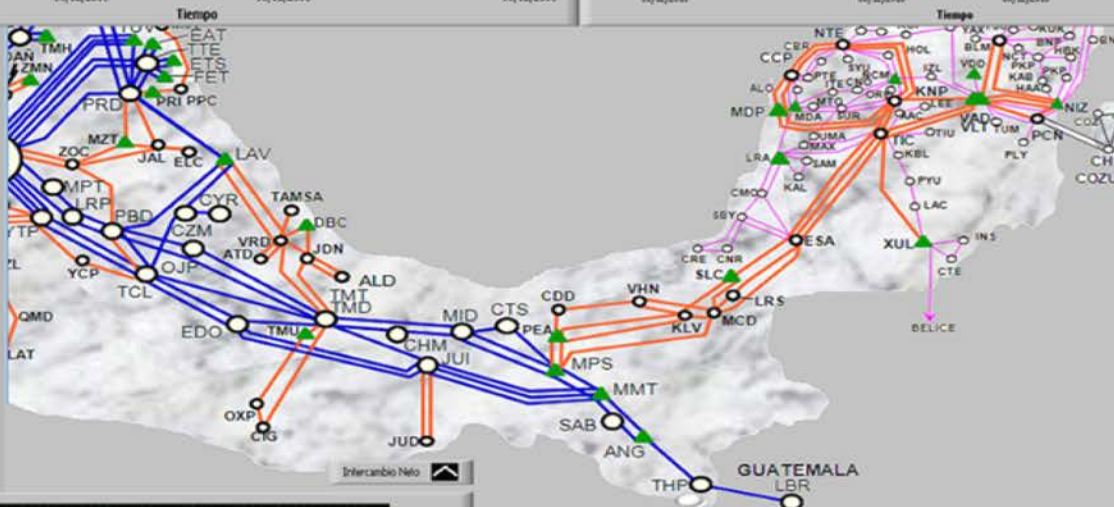
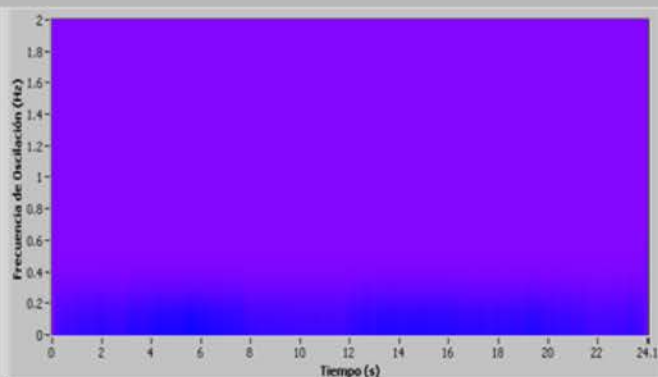
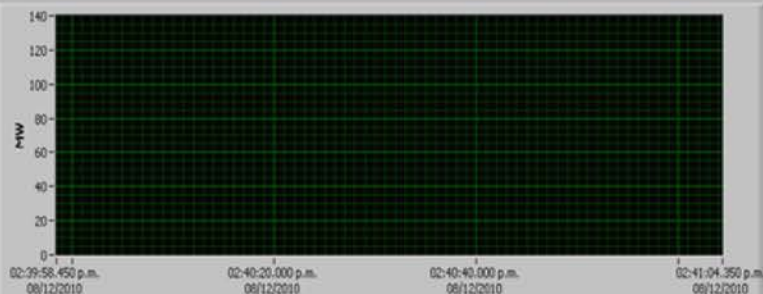
Sostenida

Creciente

Reconocer

Frecuencia de Oscilación (Hz)

Tiempo (s)



SUCCESSFUL CASES

-ONE HIDRO PLANT, TWO UNITS, 210 MW CAPACITY EACH ONE, 420 MW TOTAL.

-PLANT'S ACTIVITIES: CONTROL SYSTEM UPGRADE...

-SYSTEMS AFFECTED: AVR+PSS

-VARIABLES AFFECTED: MW'S FEEDBACK SIGNAL TO PSS, ETC.

CASE 1: LINE TRIP NEAR THE PLANT'S INTERCONNECTION SUBSTATION.

CASE 2: PLANT'S OPERATOR ACTION: PSS=ON

-DISTURB: LOCAL, LOW FREQUENCY OSCILLATIONS (MAX. AMPLITUDE: 250 MW, FREQUENCY OF OSCILLATION: 0.9 Hz).

CCA'S OPERATOR CONTROL ACTION:

RESULT: SUCCESS IN DISTURB CONTROL.

CASE 1

LINE TRIP NEAR THE PLANT'S INTERCONNECTION SUBSTATION.

-DISTURB: LOCAL, LOW FREQUENCY OSCILLATIONS

MAX. AMPLITUD: 250 MW

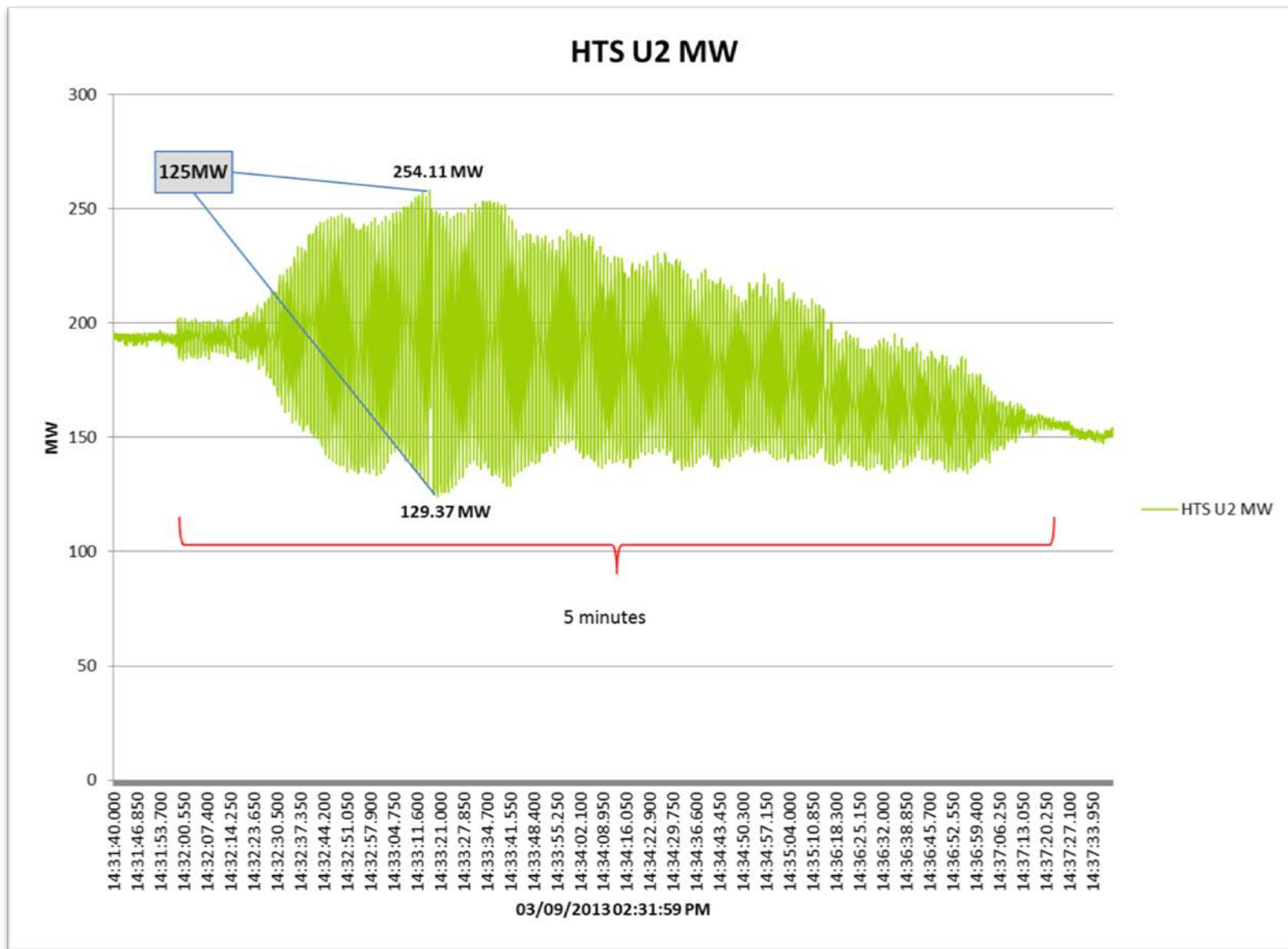
FREQUENCY OF OSCILLATION: 0.9 Hz

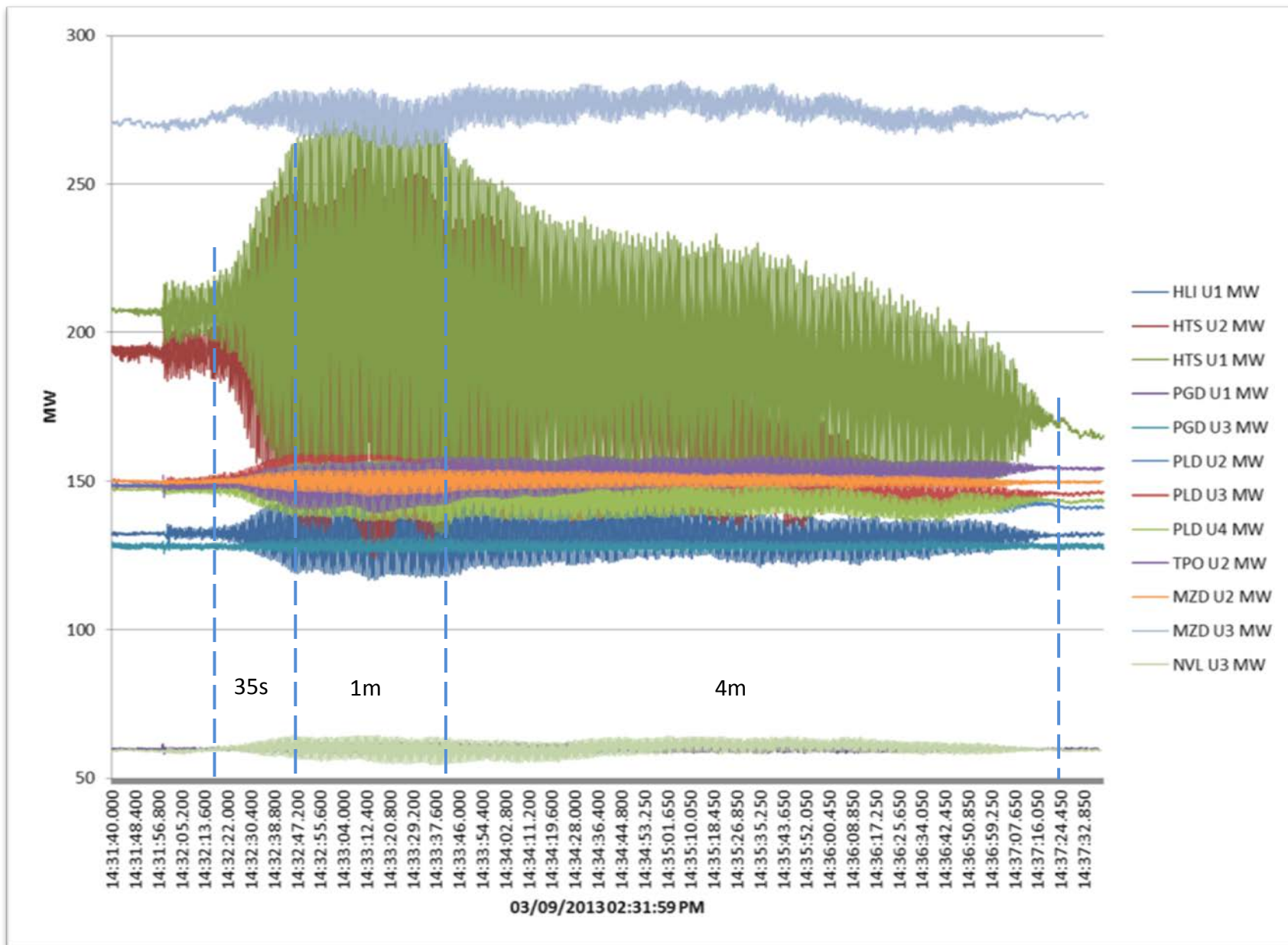
TWO UNITS OSCILLATING AGAINST THE TWELVE UNITS IN THE CCA.

CCA'S OPERATOR CONTROL ACTION: REDUCING LOAD IN UNITS MARKED, BY OSCILA, AS THOSE WITH HIGHER OSCILLATION AMPLITUDE.

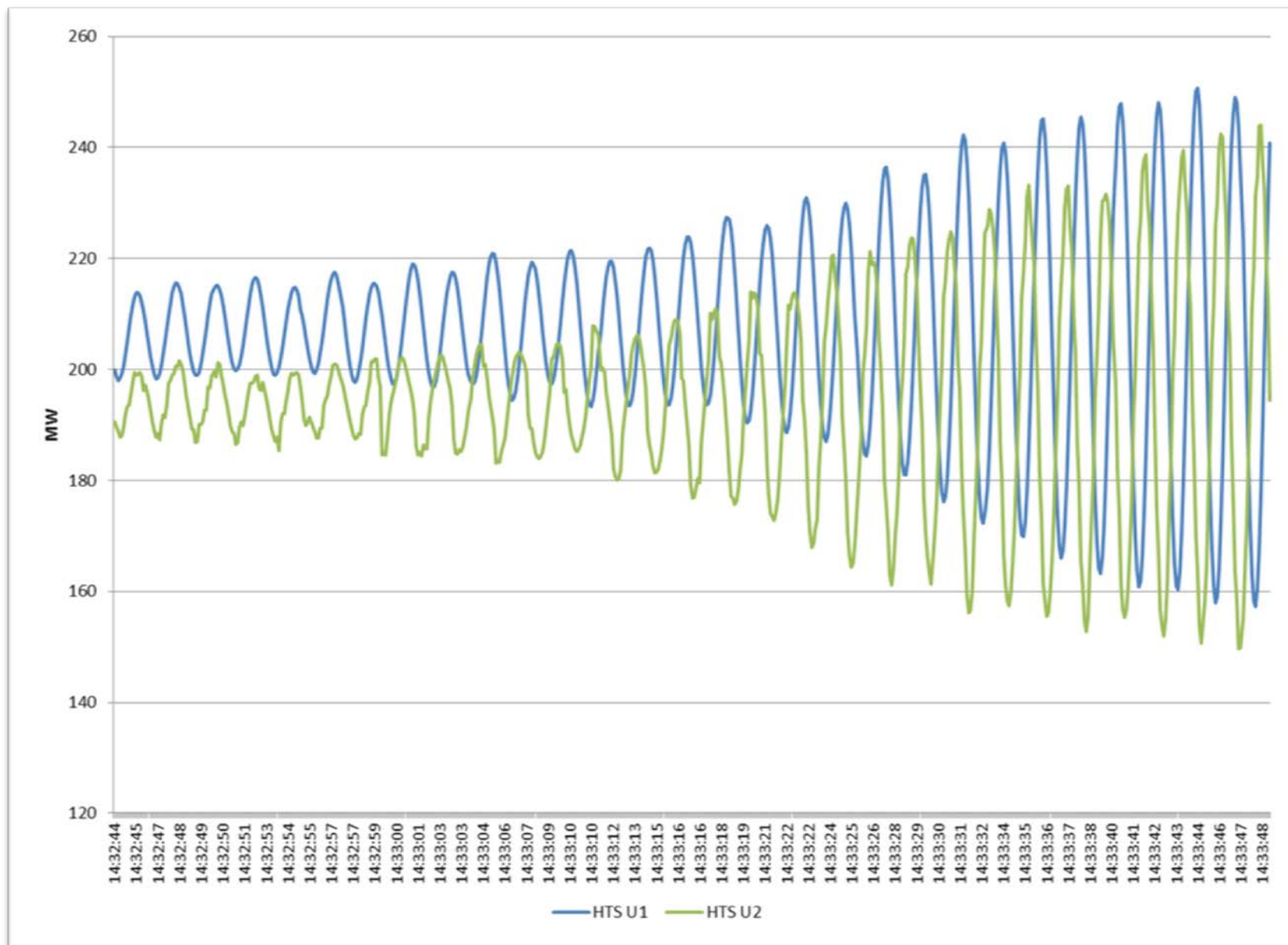
RESULT: SUCCESS IN DISTURB CONTROL.

CASE 1

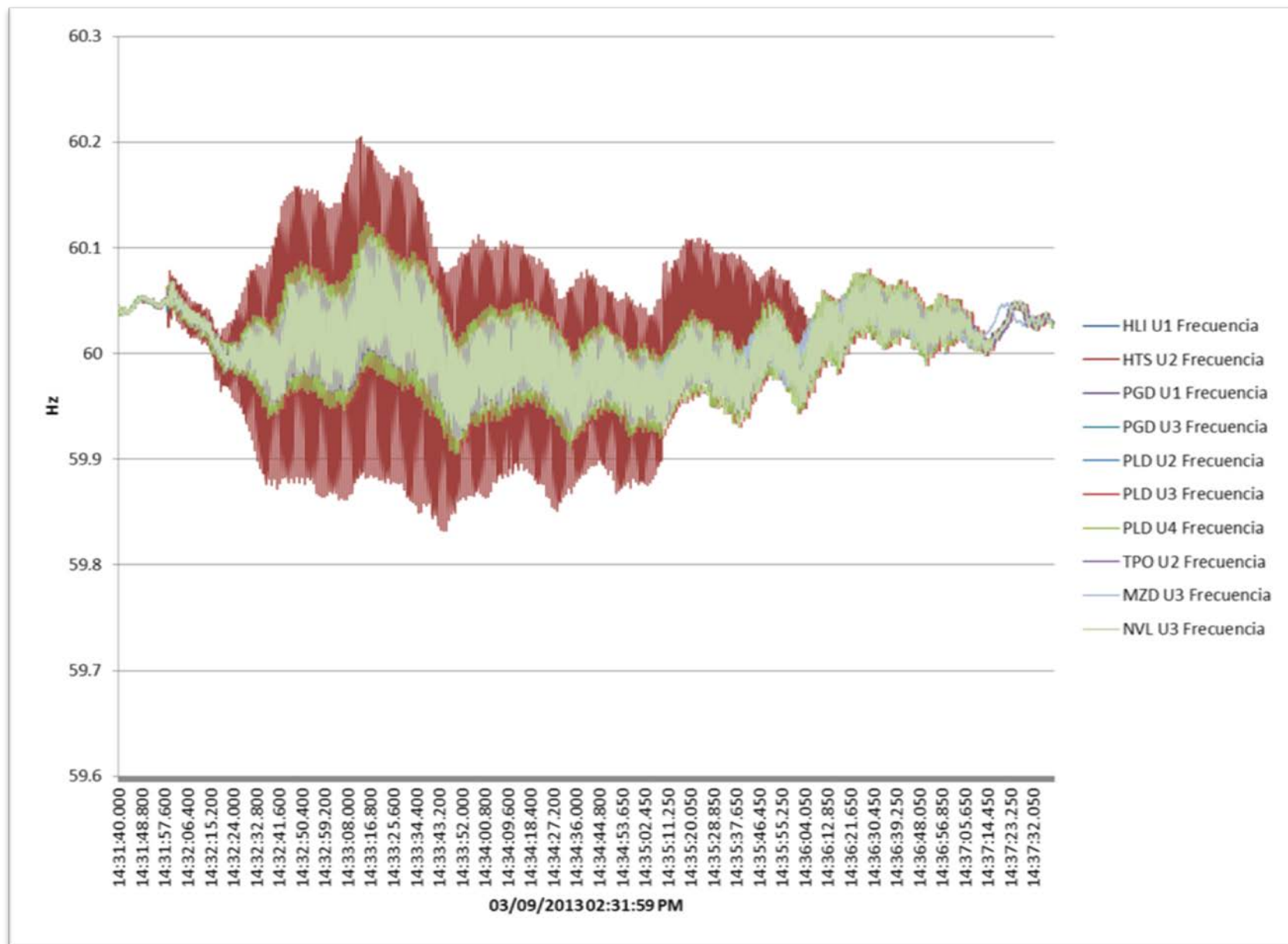




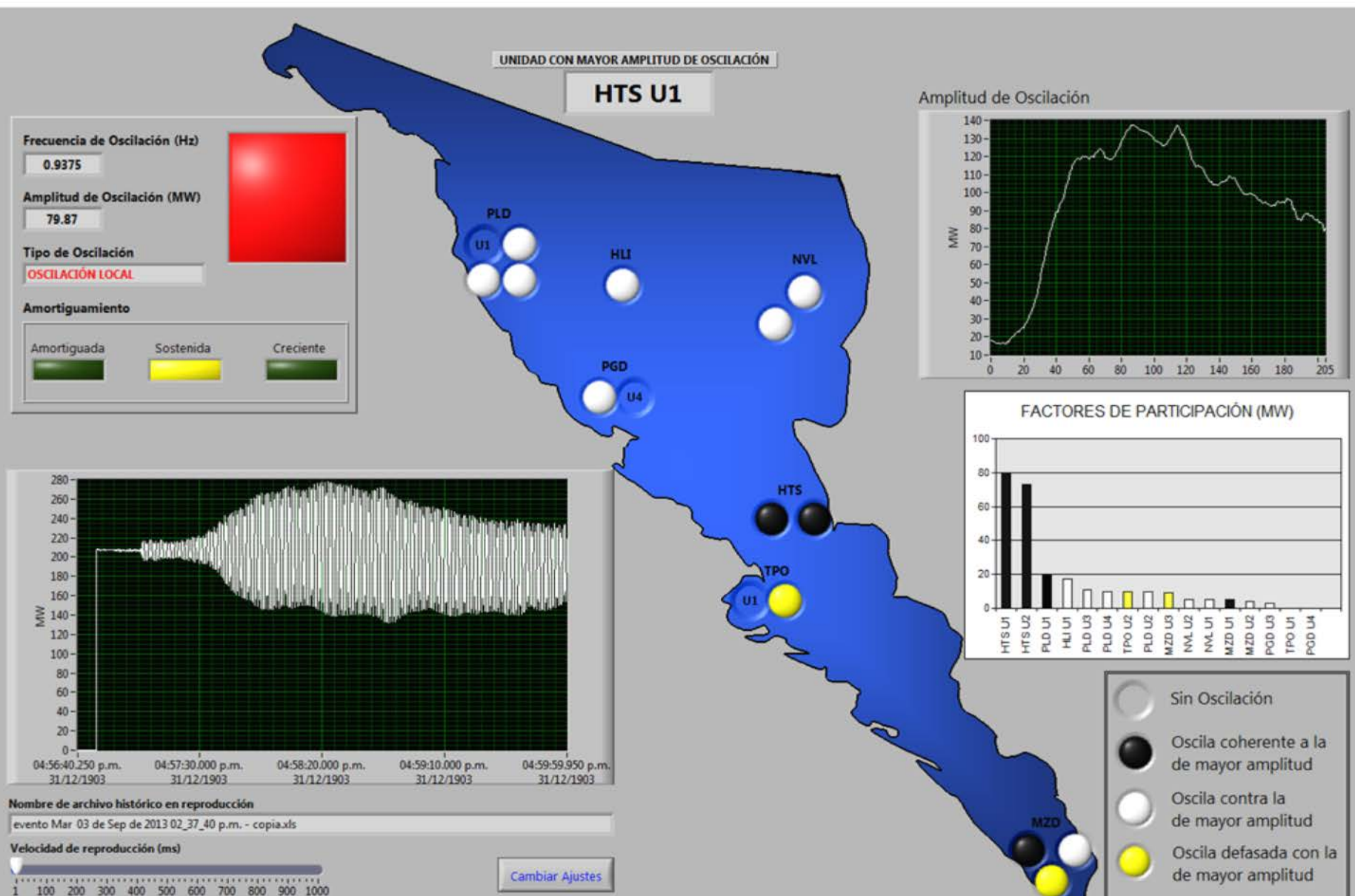
COHERENCE CASE 1



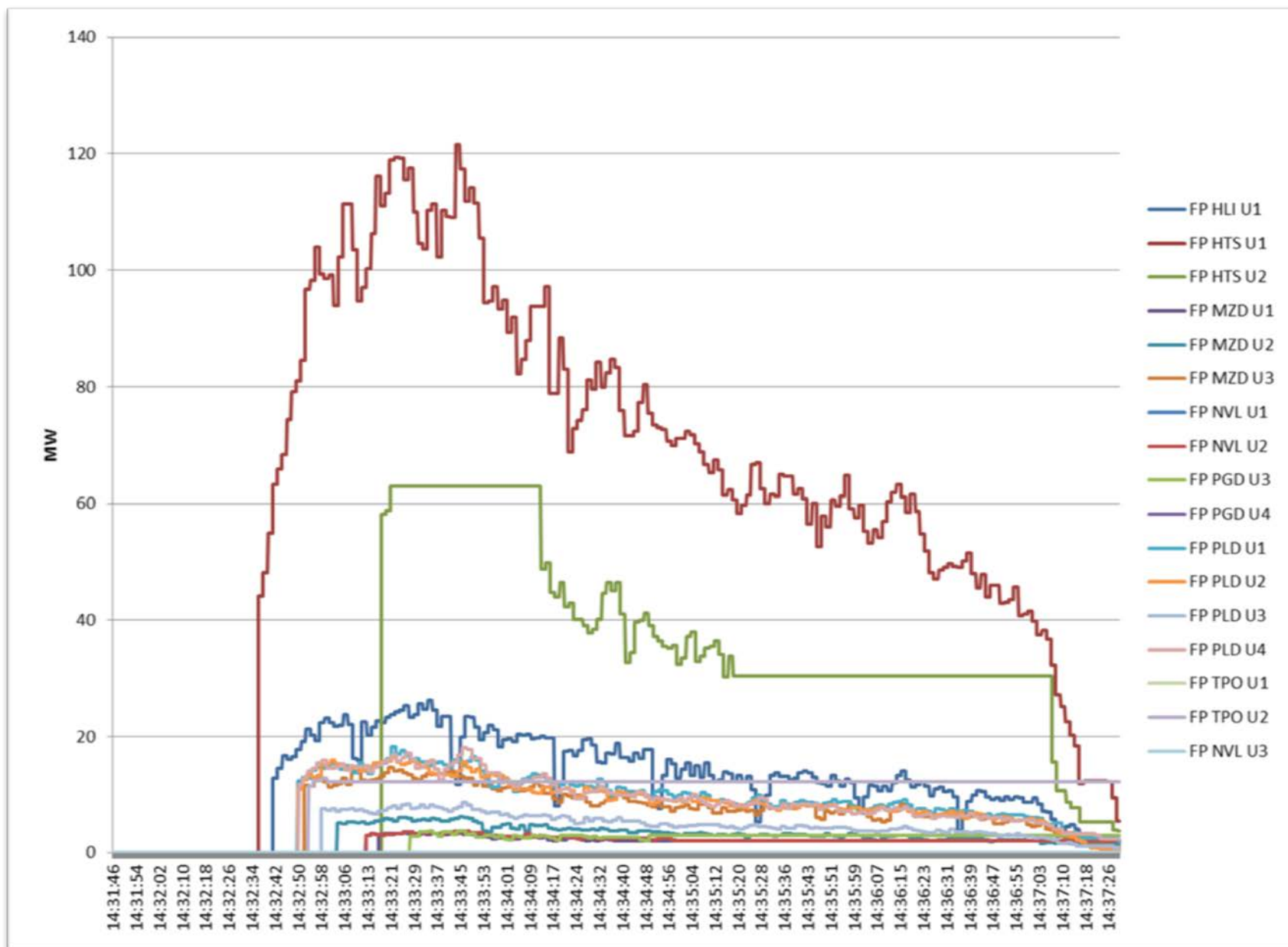
UNIT'S FREQUENCY



OSCILA CASE 1



PF CASE 1



CASE 2

TAKING PSS IN SERVICE BY THE PLANT'S OPERATOR

-DISTURB: LOCAL, LOW FREQUENCY OSCILLATIONS.

MAX. AMPLITUD: 195 MW

FREQUENCY OF OSCILLATION: 1.3 Hz.

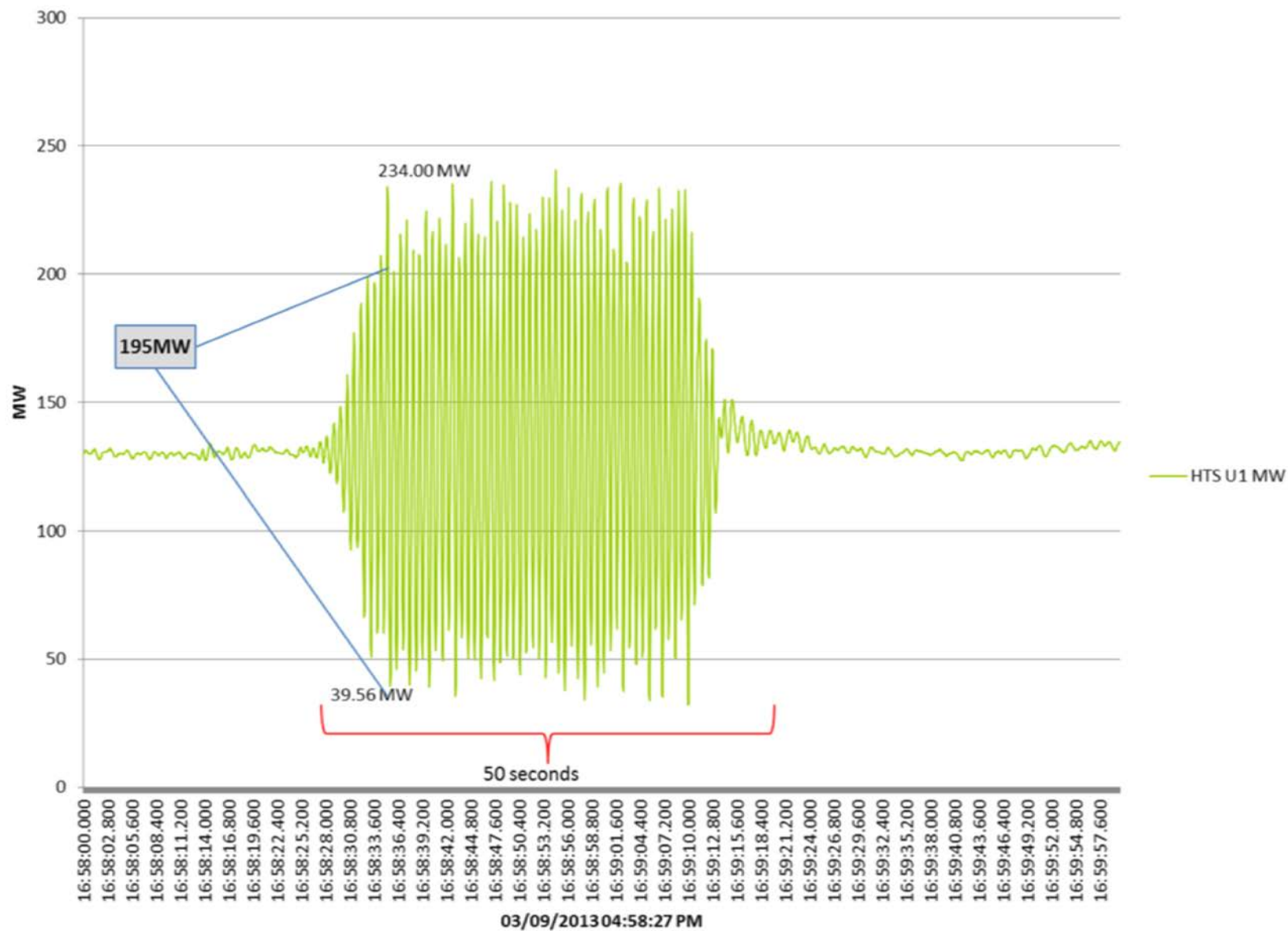
ONE UNIT OSCILLATING AGAINST THE OTHER IN THE PLANT.

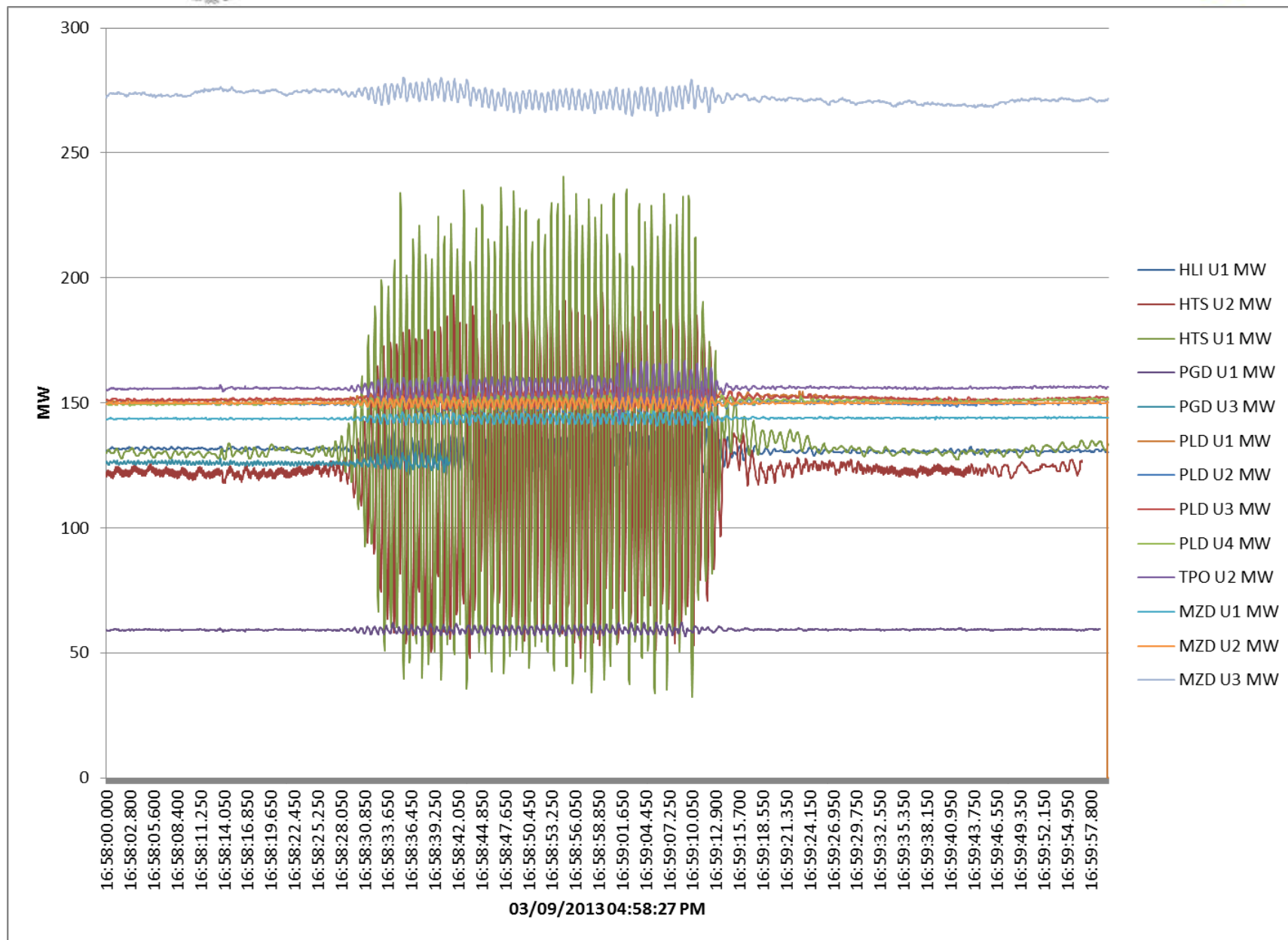
CCA'S OPERATOR CONTROL ACTION: ALERT THE PLANT OVER THE OSCILLATION EVENT, BASED ON OSCILA'S ALARM.

PLANT'S OPERATOR CONTROL ACTION: TAKE THE PSS OUT OF SERVICE.

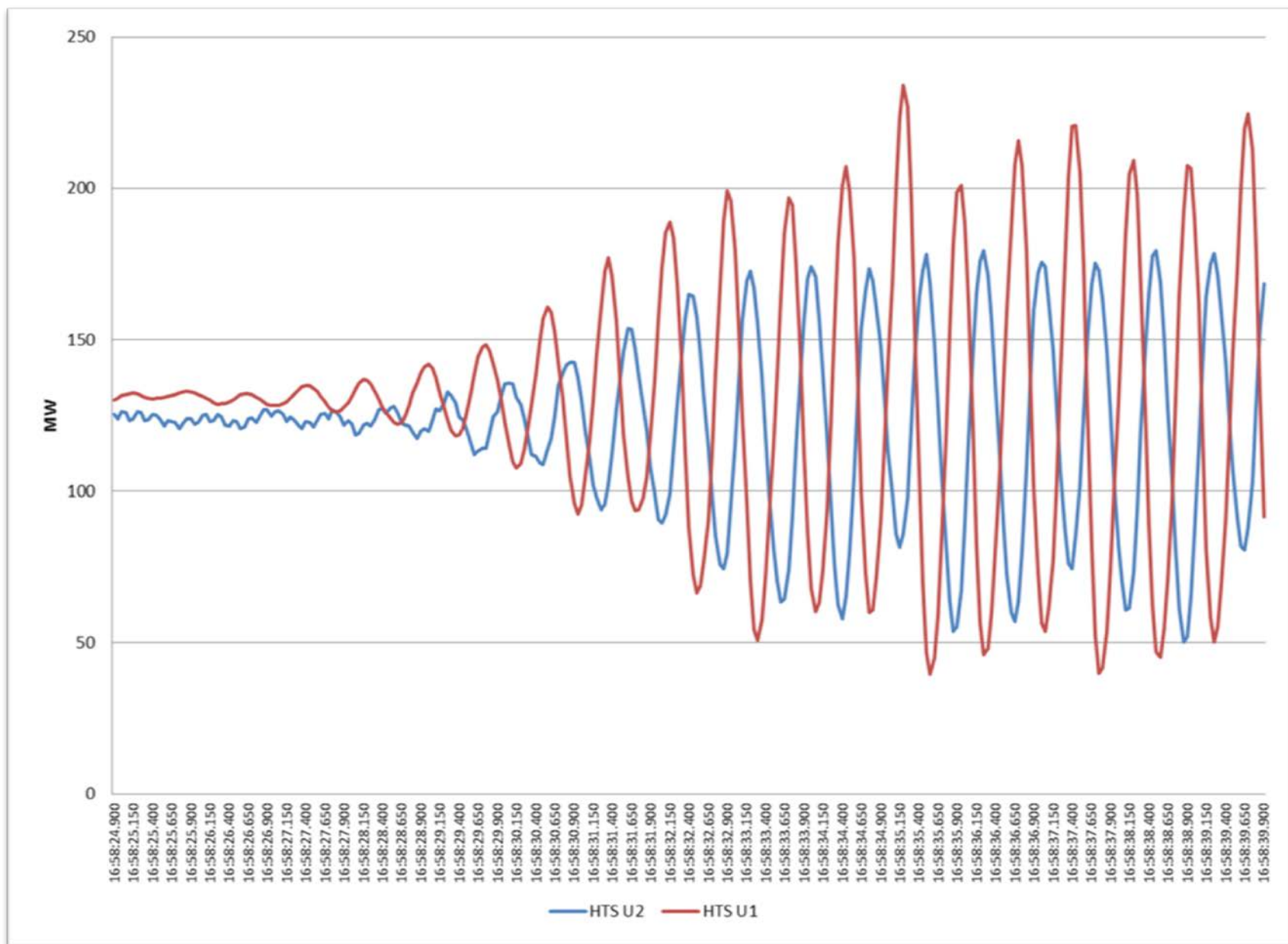
RESULT: SUCCESS IN DISTURB CONTROL.

CASE 2

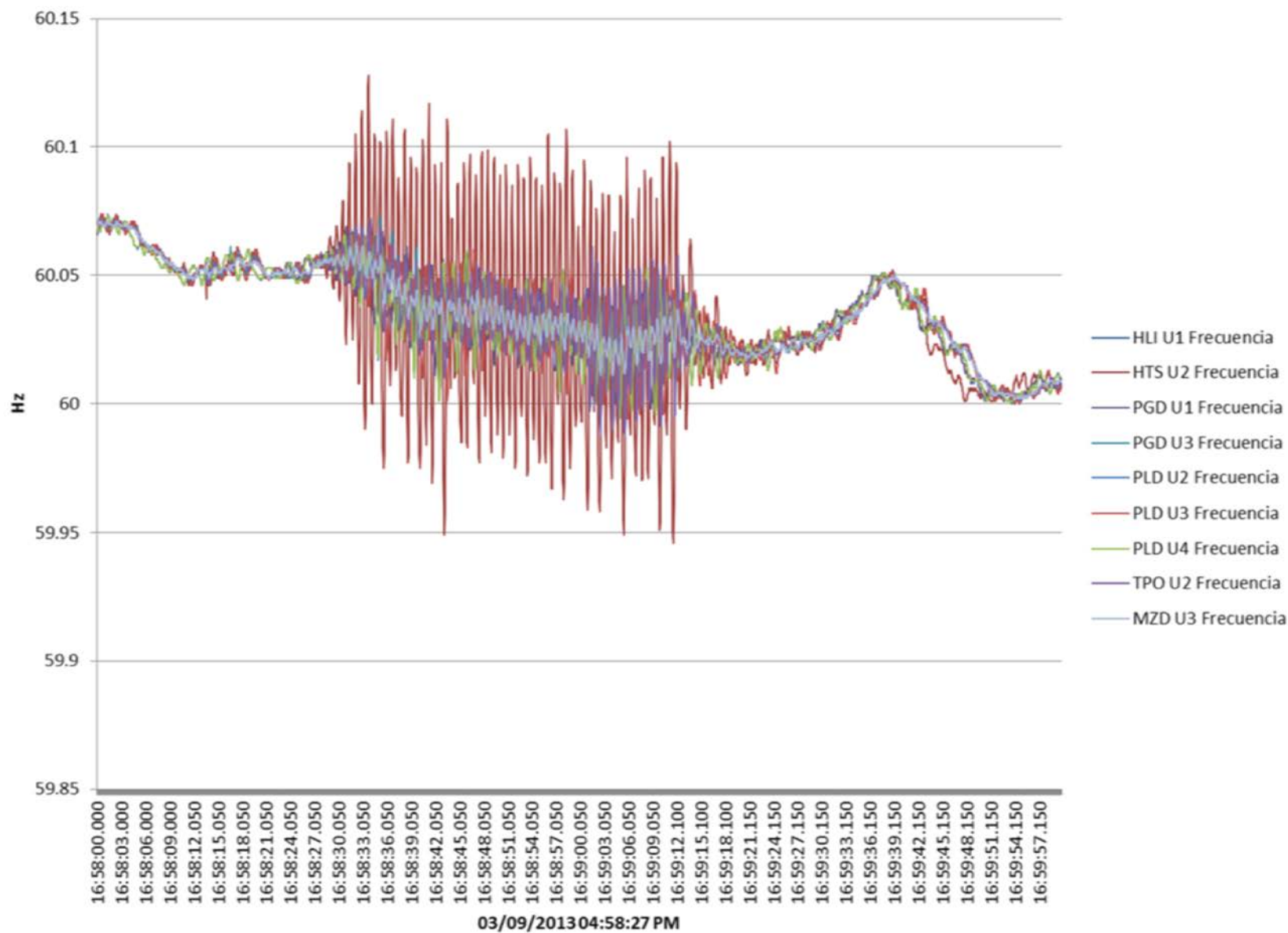




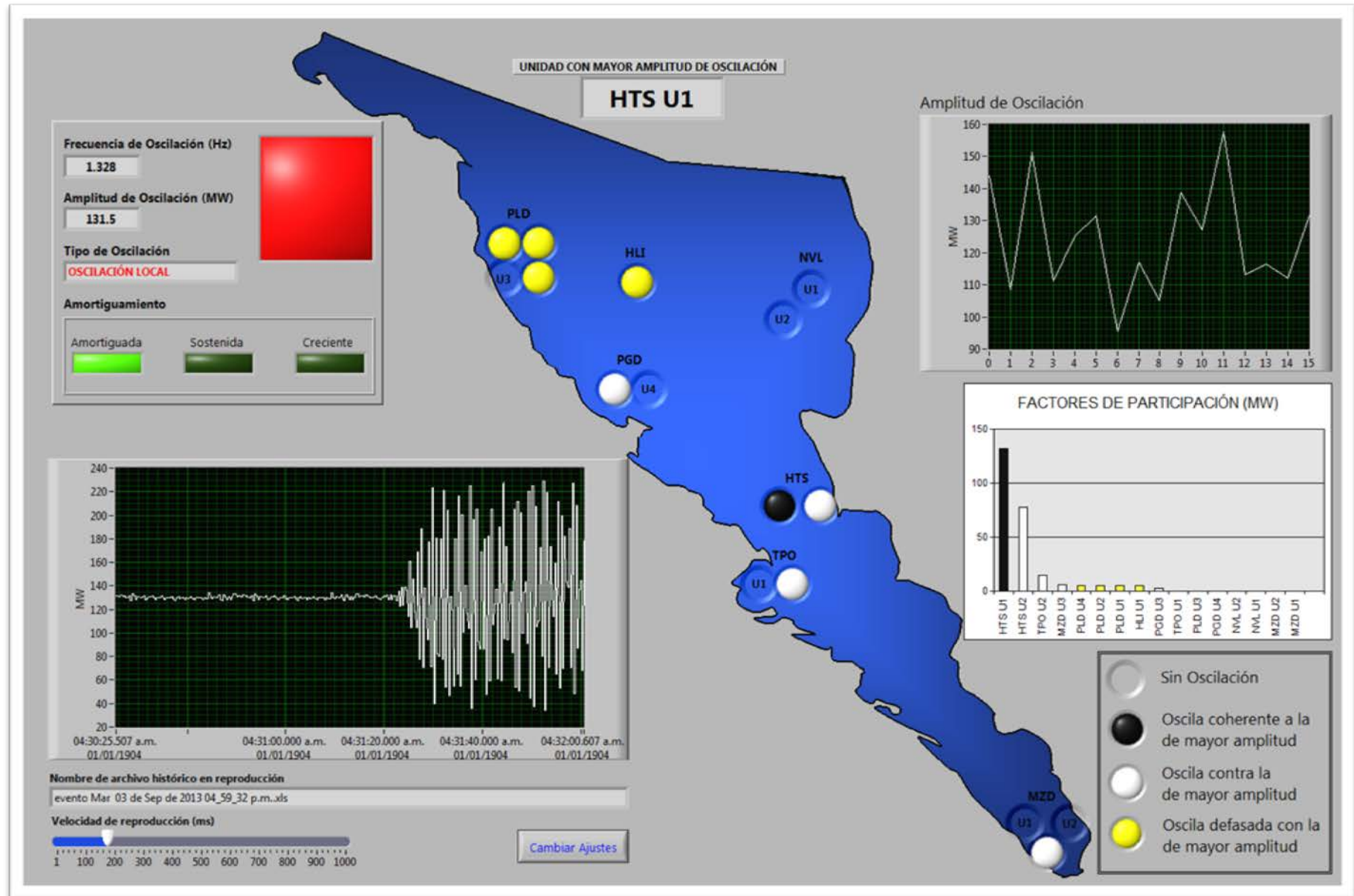
COHERENCE CASE 2



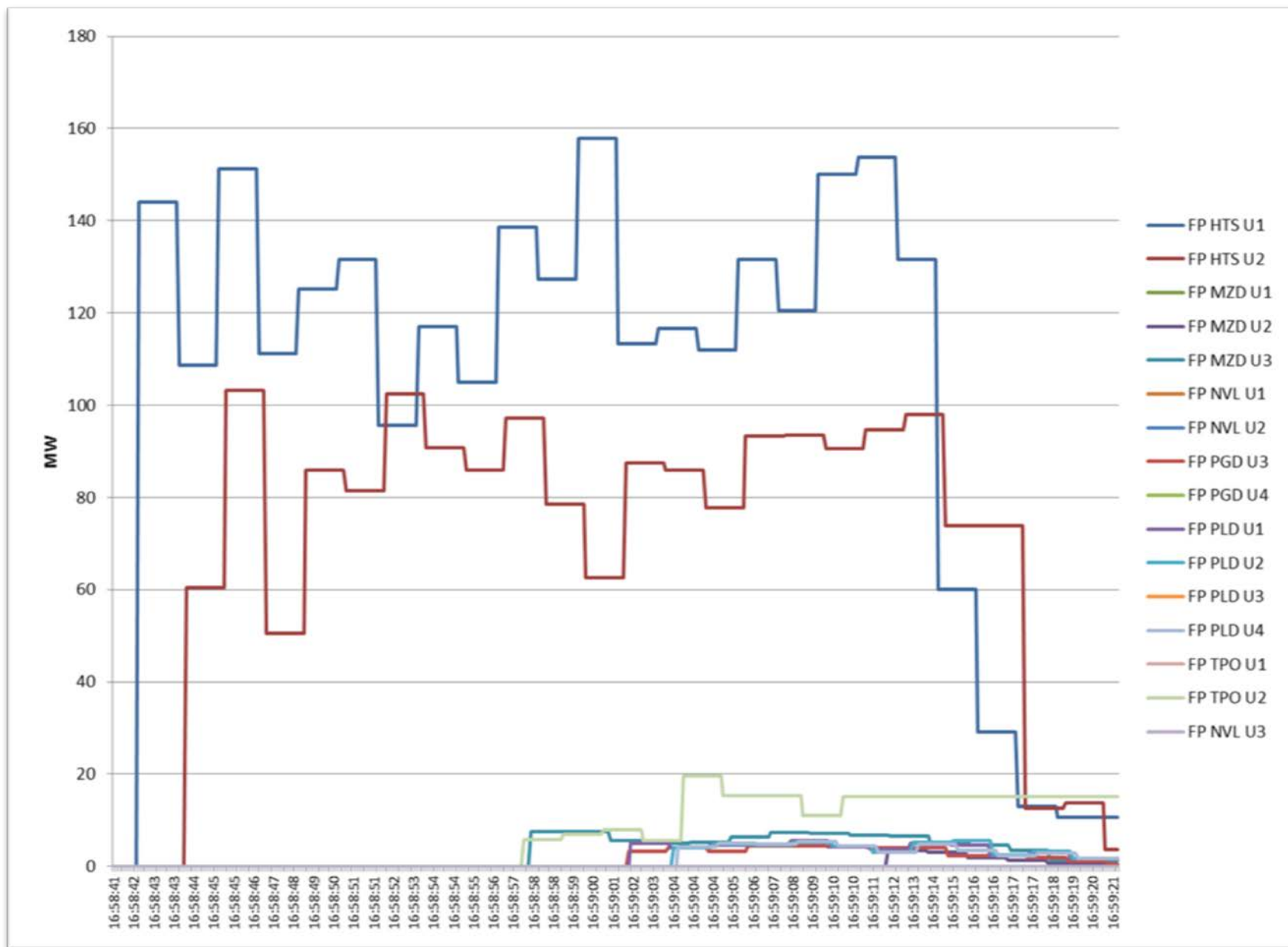
UNIT'S FREQUENCY



OSCILA CASE 2



PF CASE 2



-SUCCESSFUL SYSTEM OPERATOR'S CONTROL ACTIONS:

CASE 1: REDUCING LOAD IN UNITS MARKED, BY OSCILA, AS THOSE WITH HIGHER OSCILLATION AMPLITUDE.

CASE 2: COMMUNICATING THE SITUATION TO THE PLANT'S OPERATOR AND TAKING PSS OUT OF SERVICE.

-A TASK TEAM WAS INTEGRATED FOR SUPPORTING THE PLANT TO RESET THE CONTROLS.

-COMPLETE REVISION TO THE AVR+PSS, IT'S SIGNALS AND MODELING.




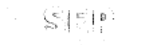



-THE MW'S TRANSDUCER WAS REPLACED.

-AVR+PSS TUNNING.

-BOTH PSS IN SERVICE AGAIN.

CONCLUSION

- The synchrophasor technology adoption entails a series of technical and technological challenges, modifications, fitness and infrastructure investment in equipment (PMUs), communication media, and information exploitation/storage systems.
- Synchrophasor technology is still in maturation process in all the aspects mentioned in the earlier point.
- With the developed applications, synchrophasors usefulness is demonstrated for supervision of the electrical power system, especially for electromechanical oscillation detection in generating units. The developed application has demonstrated its usefulness and functionality in power system critical operation situations in ACNO and for the effective supervision of Mexico-Central America link.
- This project is still being worked on in all aspects, and it is planned to keep developing tools for the supervision of the electrical power system that allow operators to anticipate emergency conditions.

CERTIFICADO Registro Público del Derecho de Autor		 GOBIERNO FEDERAL								
<p>Para los efectos de los artículos 13, 162, 163 fracción I, 164 fracción I, 168, 169, 209 fracción III y demás relativos de la Ley Federal del Derecho de Autor, se hace constar que la OBRA cuyas especificaciones aparecen a continuación, ha quedado inscrita en el Registro Público del Derecho de Autor, con los siguientes datos:</p> <table><tr><td>AUTORES:</td><td>OLACHEA AGUAYO ALFREDO ZATARAIN MORUA LUIS ALBERTO</td></tr><tr><td>TÍTULO:</td><td>OSCILA</td></tr><tr><td>RAMA:</td><td>PROGRAMAS DE COMPUTACION</td></tr><tr><td>TITULAR:</td><td>COMISION FEDERAL DE ELECTRICIDAD (CON FUNDAMENTO EN EL ART. 83 DE LA LFDA)</td></tr></table> <p>L.F.D.A.- Artículo 168.- Las inscripciones en el registro establecen la presunción de ser ciertos los hechos y actos que en ellas consten, salvo prueba en contrario. Toda inscripción deja a salvo los derechos de terceros. Si surge controversia, los efectos de la inscripción quedarán suspendidos en tanto se pronuncie resolución firme por autoridad competente.</p> <p>Número de Registro: 03-2011-062715112600-01</p> <p>México D.F., a 28 de julio de 2011</p> <p>EL SUBDIRECTOR DE REGISTRO DE OBRAS Y CONTRATOS</p> <p> ARTURO NOÉ CALDERÓN AGUILAR</p> <p> SECRETARÍA DE EDUCACIÓN PÚBLICA INSTITUTO NACIONAL DEL DERECHO DE AUTOR REGISTRO PÚBLICO</p>		AUTORES:	OLACHEA AGUAYO ALFREDO ZATARAIN MORUA LUIS ALBERTO	TÍTULO:	OSCILA	RAMA:	PROGRAMAS DE COMPUTACION	TITULAR:	COMISION FEDERAL DE ELECTRICIDAD (CON FUNDAMENTO EN EL ART. 83 DE LA LFDA)	 
AUTORES:	OLACHEA AGUAYO ALFREDO ZATARAIN MORUA LUIS ALBERTO									
TÍTULO:	OSCILA									
RAMA:	PROGRAMAS DE COMPUTACION									
TITULAR:	COMISION FEDERAL DE ELECTRICIDAD (CON FUNDAMENTO EN EL ART. 83 DE LA LFDA)									
										

THANK YOU