Electromechanicals Oscillation’s Detection Based On Synchrophasors

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COMISIÓN FEDERAL DE ELECTRICIDAD
CENTRO NACIONAL DE CONTROL DE ENERGÍA
ÁREA DE CONTROL NOROESTE
CFE’S WAMS PROJECT

2009 WAS THE BEGINNING 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"
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.

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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

PMU's Net

TCP / IP

UDP

PMU Server

Historic DB

TCP / IP

AUDIBLE ALARM

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.
GEN ANALYSIS
OSCILA’s ALGORITHM

SLIDING WINDOW OF $2^n$ DATA

FREQUENCY OF OSCILLATION
AMPLITUDE, DAMPING, COHERENCE

1
Samples

Frecuencia (Hz)
ID: 1953
Amplitud (MW)
17.1
Amortiguamiento

- Amortiguado
- Sostenido
- Creciente

- Amortiguamiento Cero (Sostenido)
- Amortiguamiento Positivo (Amortiguado)

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

ALARM
TIE SUPERVISION

Red eléctrica de Centroamérica
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 INTERCONNECNECTION 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 INTERCONNECED SUBSTATION.

-DISTURB: LOCAL, LOW FREQUENCY OSCILLATIONS
  MAX. AMPLITUDE: 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
OSCILLATION’S ENERGY CASE 1
UNIT’S FREQUENCY
OSCILA CASE 1

Frecuencia de Oscilación (Hz)
0.9375

Amplitud de Oscilación (MW)
79.87

Tipo de Oscilación
Oscilación Local

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)
1 100 200 300 400 500 600 700 800 900 1000

Cambiar Ajustes
PF CASE 1

The graph shows a time series of MW (megawatts) over time, with multiple lines representing different systems or processes. The x-axis represents time in minutes, starting from 14:31:46 to 14:37:18. The y-axis represents MW, ranging from 0 to 140 MW. Different lines are color-coded and labeled with abbreviations such as FP HLI U1, FP HTS U1, FP HTS U2, FP MZD U1, and others, indicating various entities or processes being monitored.
CASE 2

TAKING PSS IN SERVICE BY THE PLANT’S OPERATOR

DISTURB: LOCAL, LOW FREQUENCY OSCILLATIONS.
   MAX. AMPLITUDE: 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
UNIT’S FREQUENCY
OSCILA CASE 2
FINAL COMENTS

-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.
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Registro Público del Derecho de Autor

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AUTORES:  
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ZATARIAN MOREUA LUIS ALBERTO

TÍTULO:  
OSCILA

RAMA:  
PROGRAMAS DE COMPUTACIÓN

TITULAR:  
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México D.F., a 20 de julio de 2011

EL SUBDIRECTOR DE REGISTRO DE OBRAS Y CONTRATOS

ARTURO NOE CALDERÓN AGUILAR
THANK YOU