OSIsoft FFT-INT

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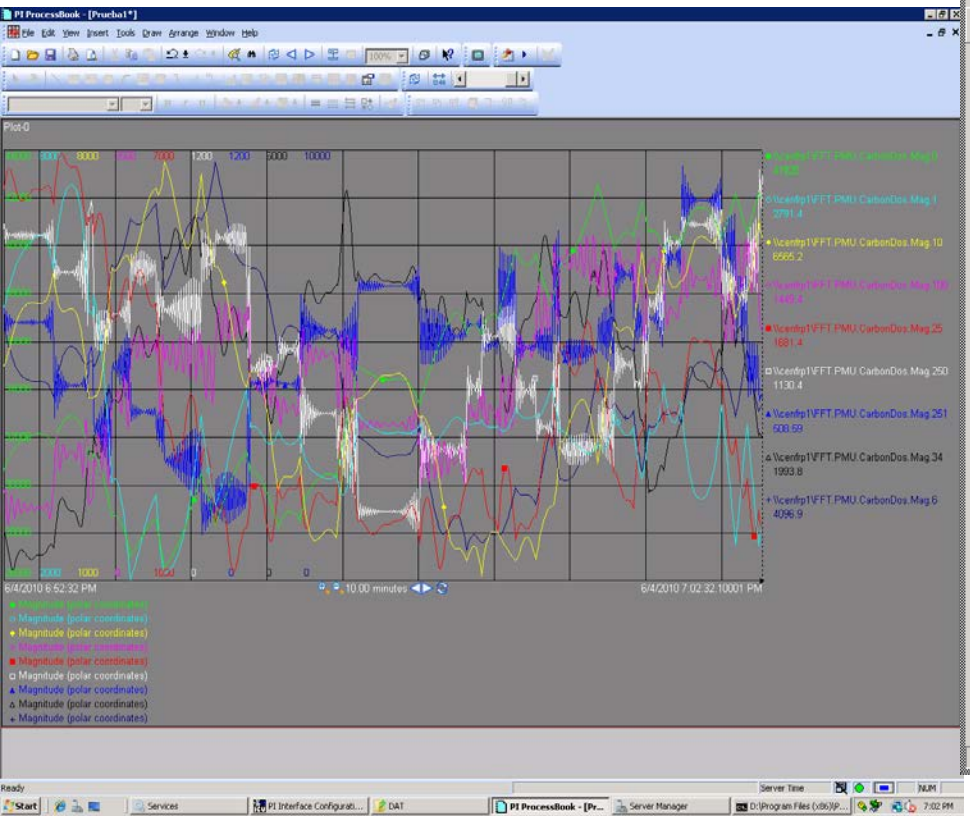
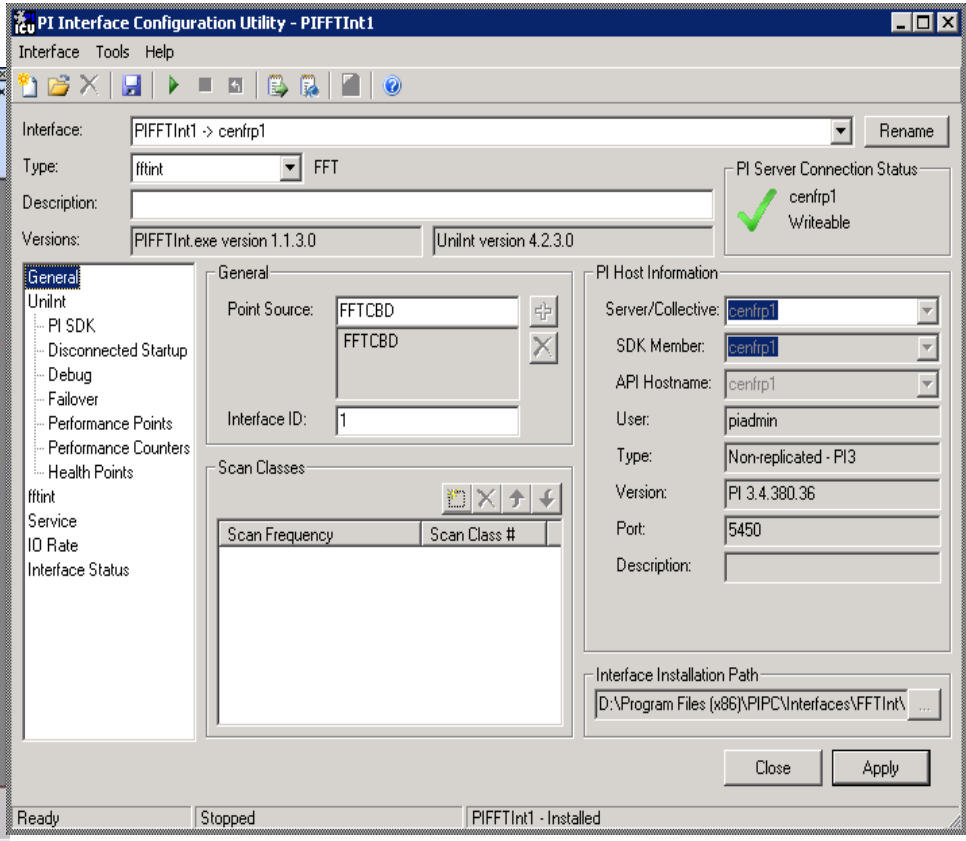
June 8th 2011

Empowering Business in Real Time.

MODICOSEN Analytics

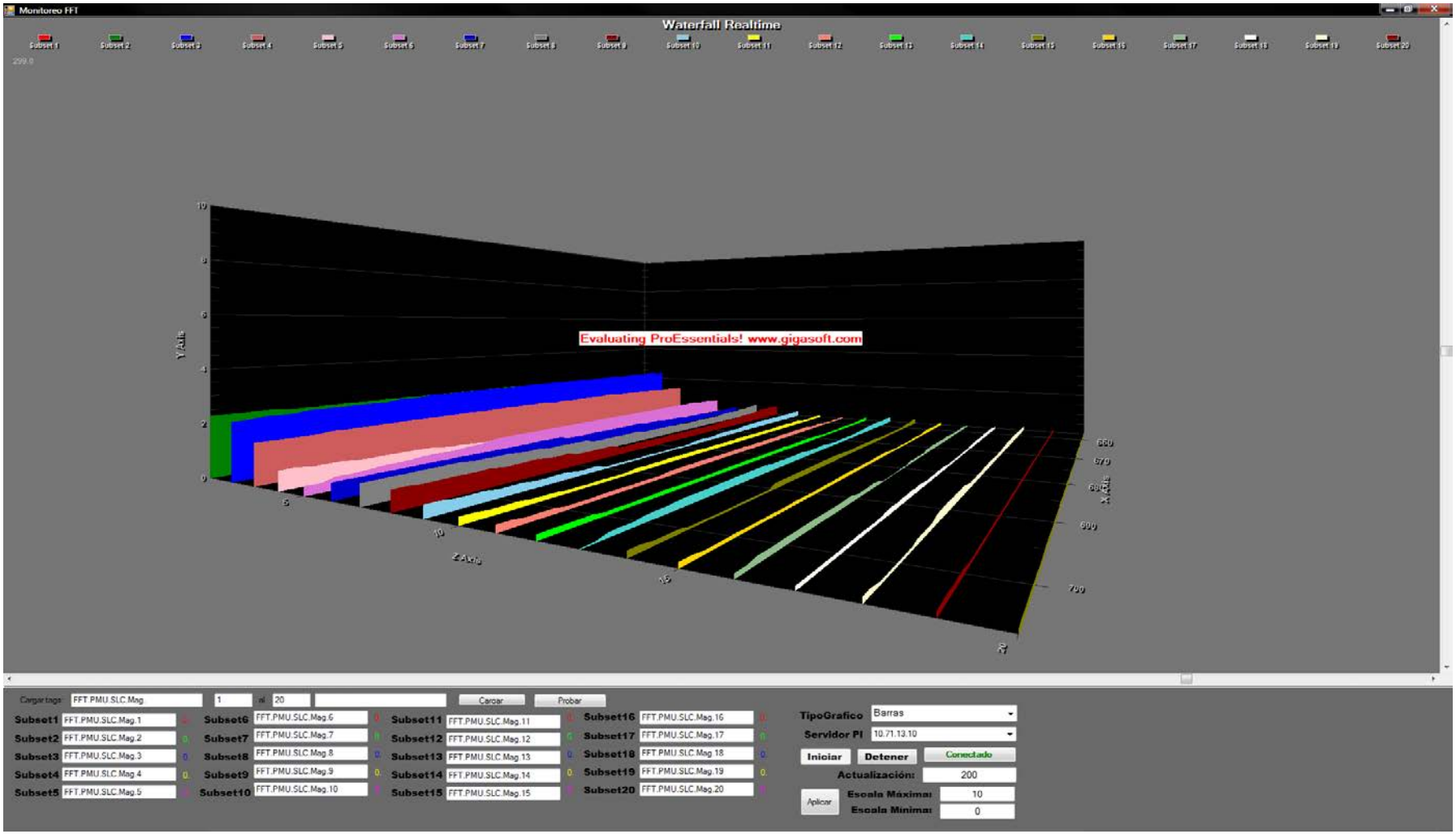
- OSIsoft PI FFT Interface (Fast Fourier Transform)
  - Calculates the modes of oscillation (Harmonics Content)
  - Polar & Rectangular Coordinates





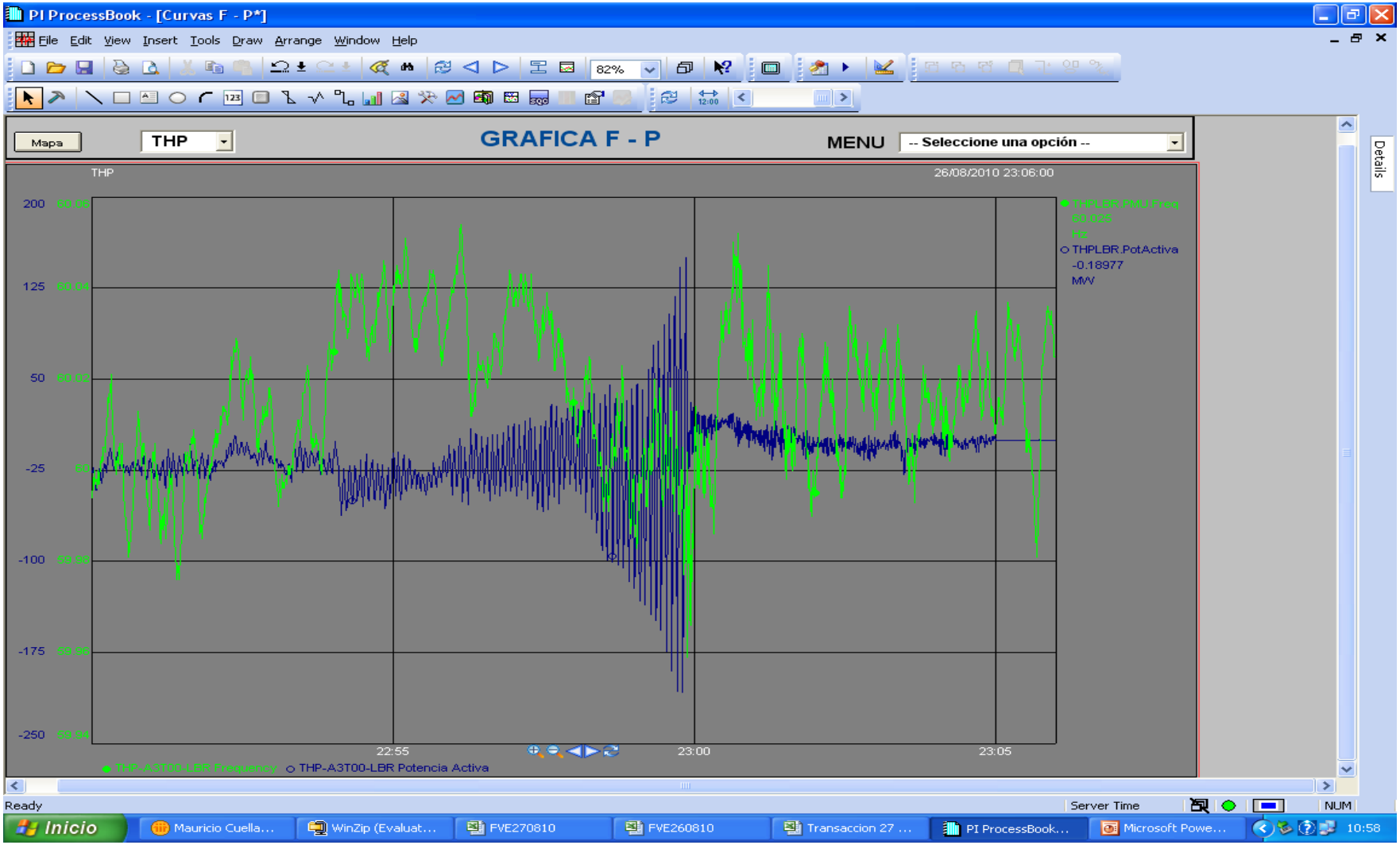
MODICOSEN Analytics

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



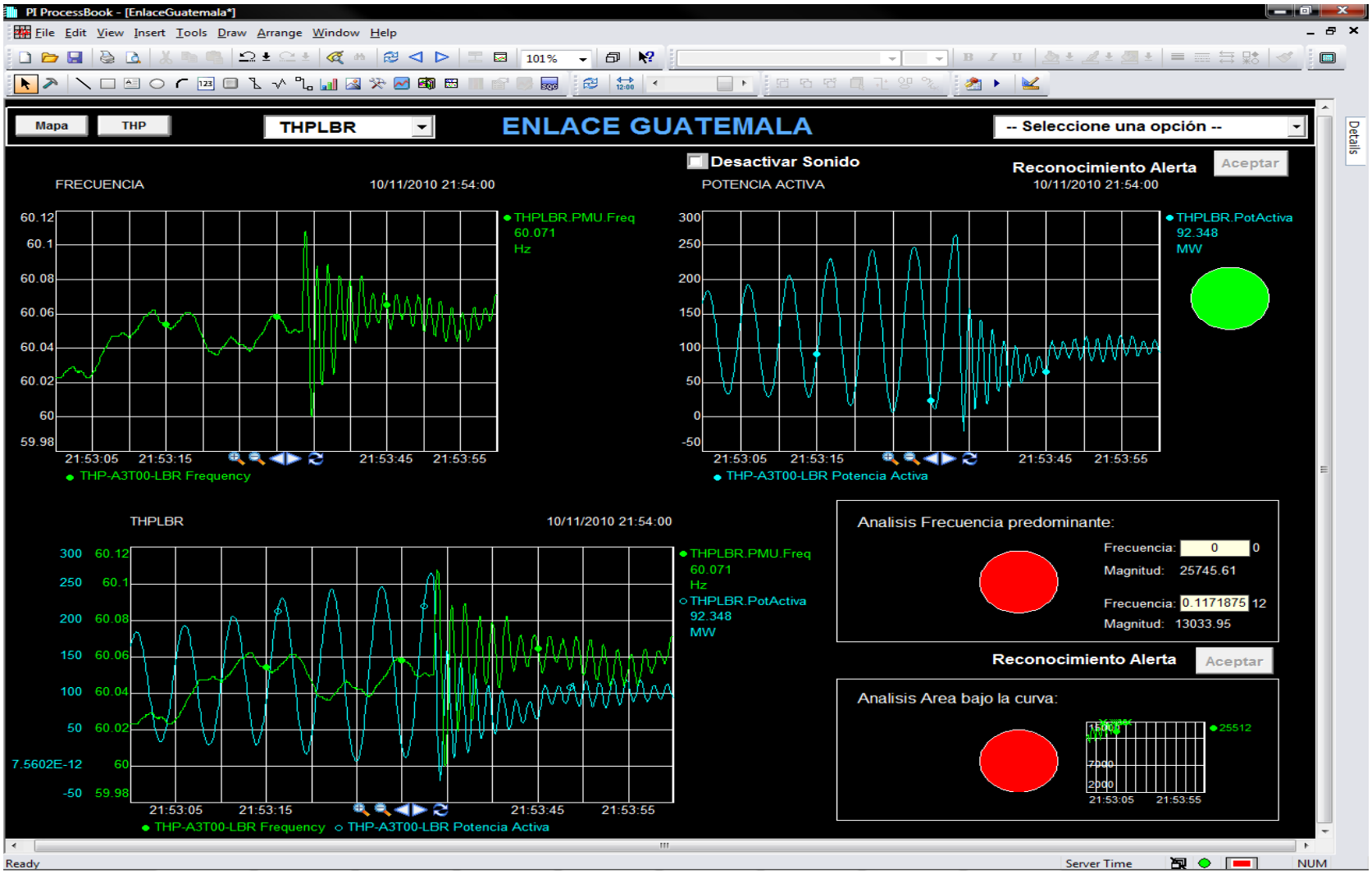
MODICOSEN Analytics

- Mexico – Guatemala Tie Line Event



MODICOSEN Analytics

- PI FFT Interface - Low Frequency Oscillations Detection and Alarming



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

OSIsoft FFT interface

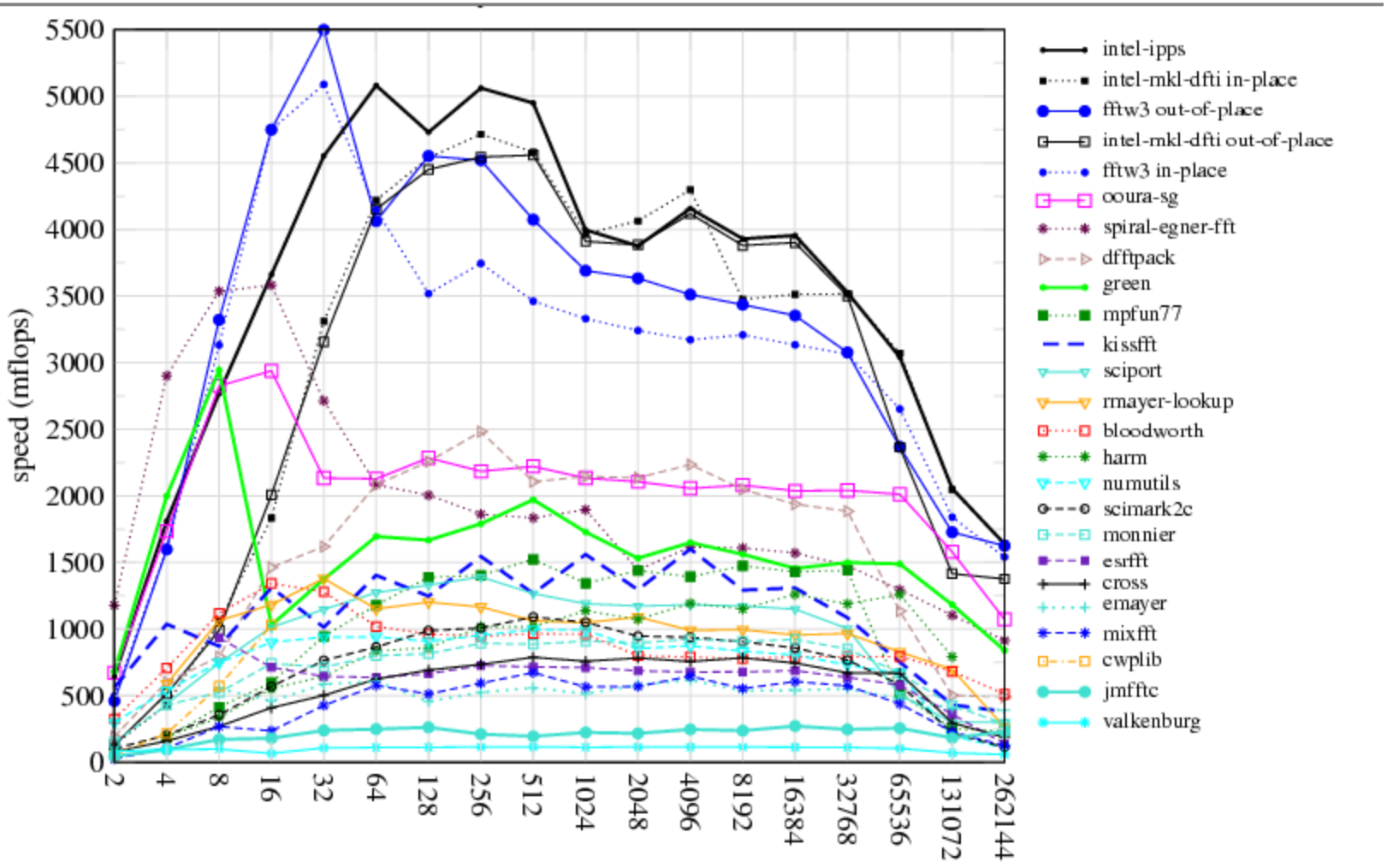
Based on Intel MKL 8.0 > 10.3

Software released in March 2005 as a standard fully supported interface:

Why Intel MKL?

Known to be the fastest FFT when more than 64 points in the window. Faster than MIT FFT-W.

Speed tests



Source:http://www.fftw.org/speed/Pentium4-3.60GHz-icc/

FFT Features

- Window width
- Execution interval
- Number of holes
- Number of missing points
- Number of peaks
- Number of peak width
- Number of peak locations
- Number of integrals under curve (AIC)
- Specific items to archive
- History recovery

Contact information and Q&A

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Thank you

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FFT-INT Manual

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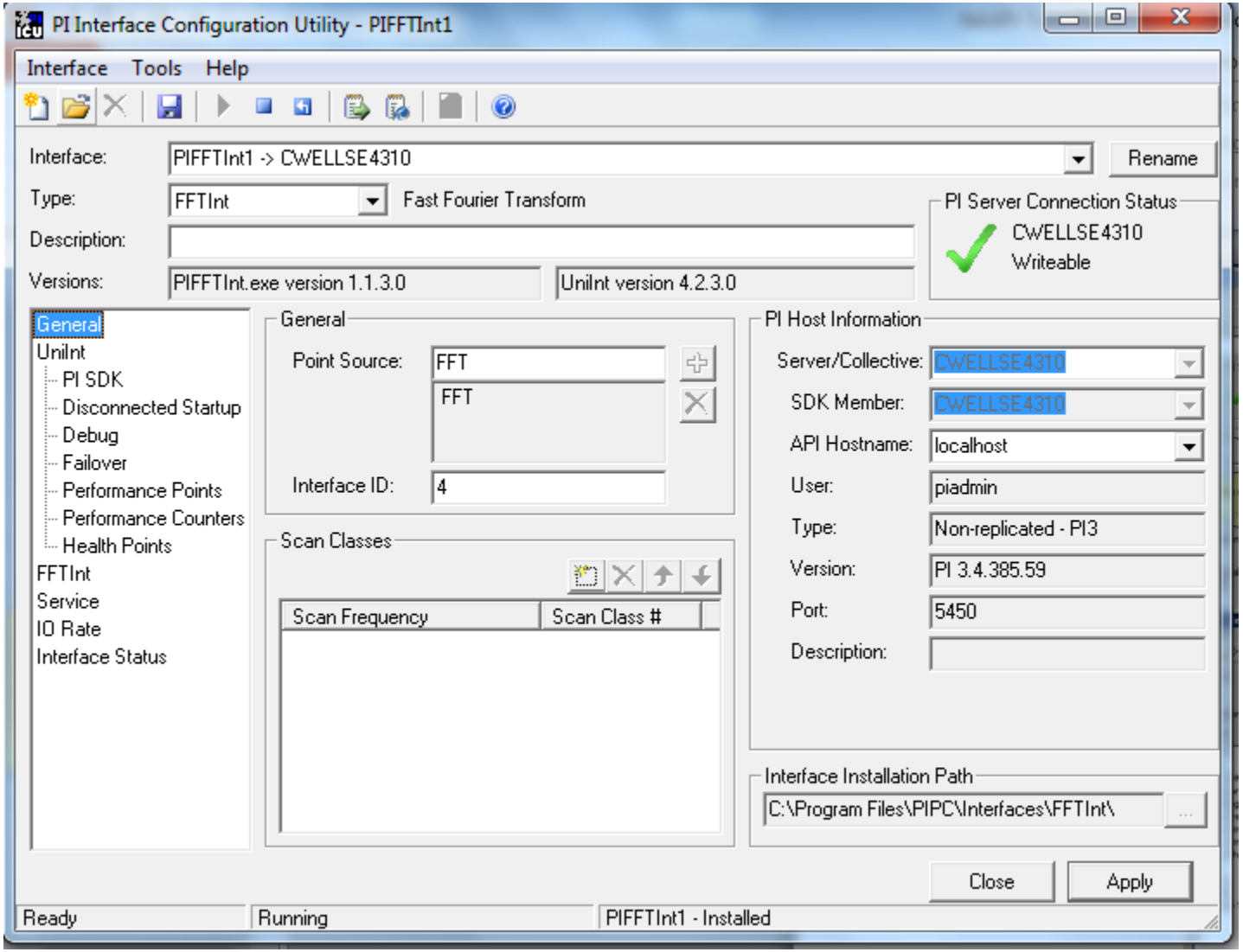
Unint Interface



FFT-INT Manual

The PI FFT interface receives exceptions from a source PI server. After enough input data has been collected, the interface calculates the FFT of the data set. The interface sends the results of the FFT calculation to the target PI server.

Input data can be real or complex. Real data is stored in floating point PI points. This can be float16, float32, or float64. The interface keeps a circular buffer of recent exceptions from the source PI server. Once the buffer is full, the FFT calculation can be performed. Every time a new value is received, the oldest value is removed. The FFT calculation is run again, and a whole new output data set is generated.

Because the output data are complex numbers, and because PI does not natively support complex numbers, outputs are sent to pairs of points. These pairs can be real/imaginary pairs (rectangular coordinates) or magnitude/angle pairs (polar coordinates). Angles can be stored as radians or degrees.

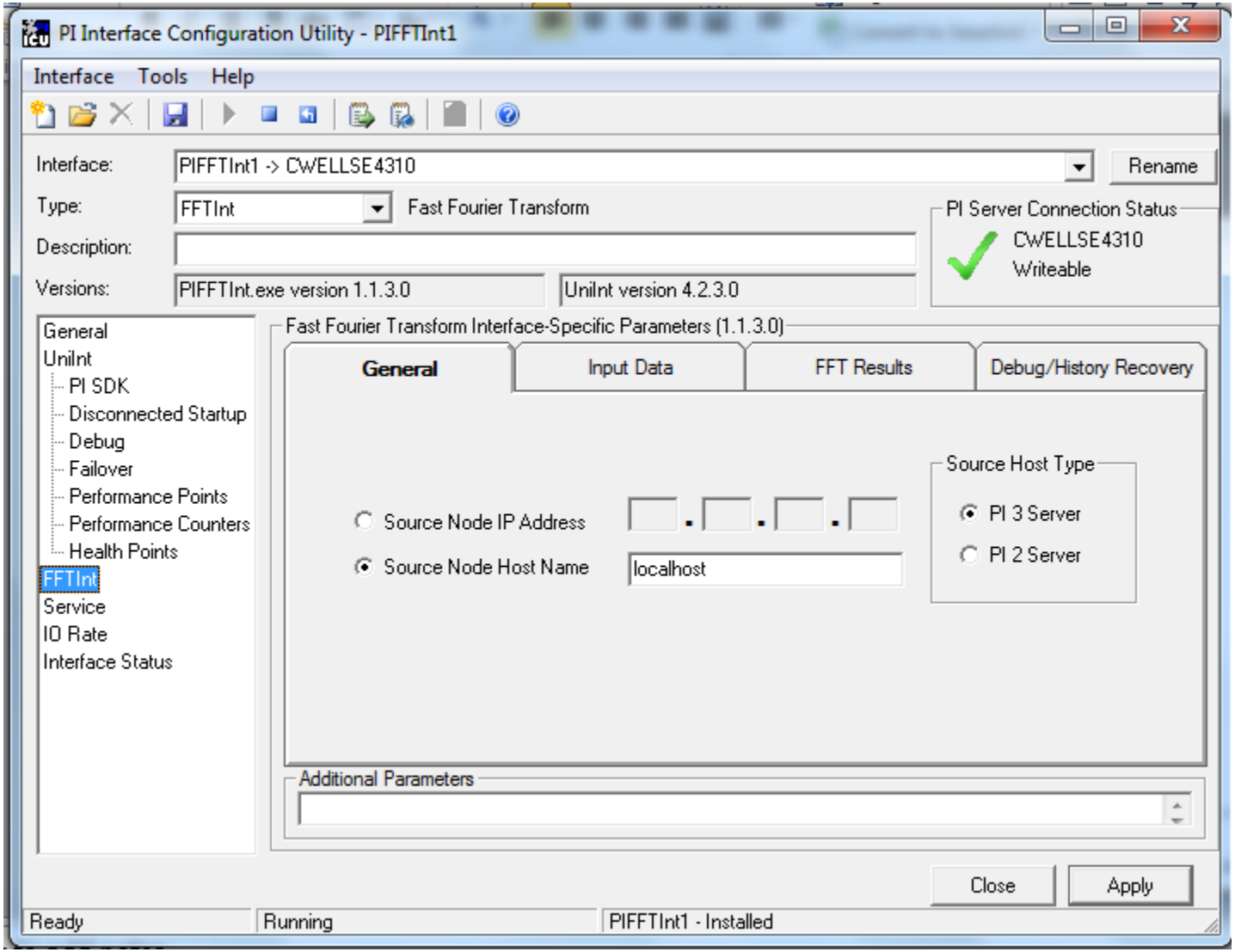
Additionally, the interface can perform several aggregation functions on the resulting FFT data. The interface can sort the FFT magnitudes and report which frequencies were the most dominant in the input signal. The interface can also calculate the area under the FFT spectrum.

There are two terms used in this document for identifying PI servers. The term host refers to the PI server where the destination points reside. The term sourcehost refers to the PI server where the points that are used as input data reside.

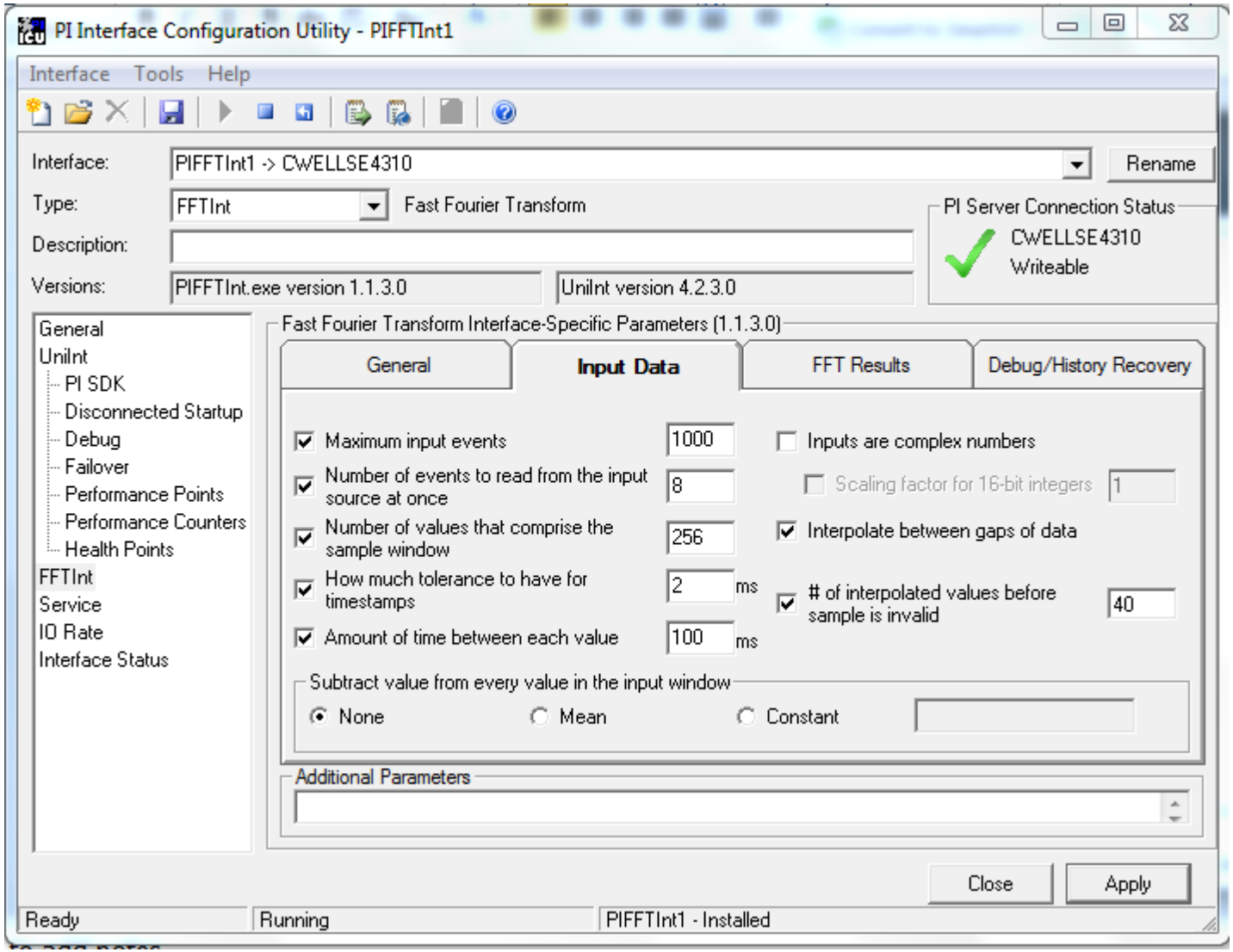
OSIsoft FFT Interface

- Standard interface
- Configured using standard ICU (Interface Configuration Utility)
- Runs in real time

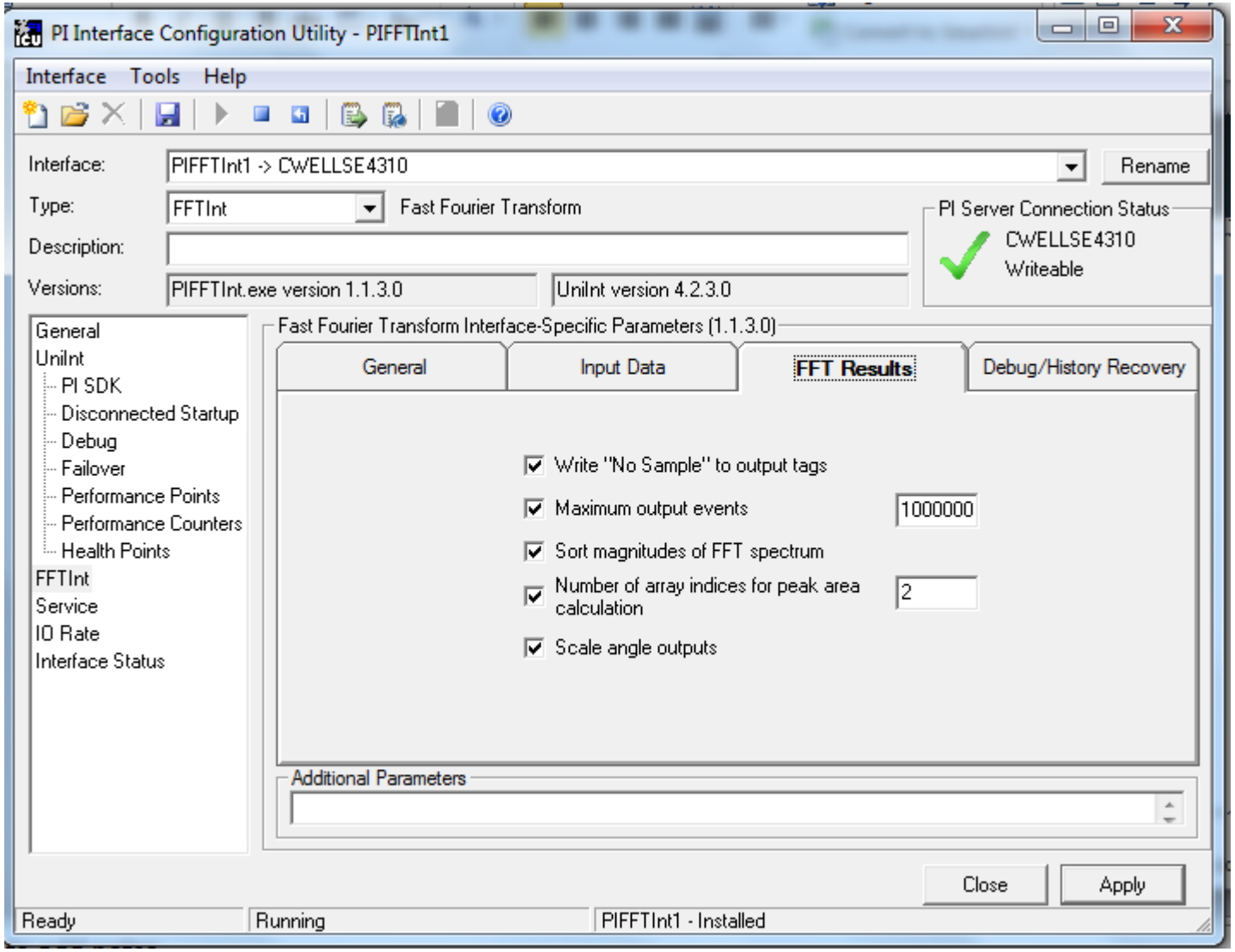
General tab



Input data tab



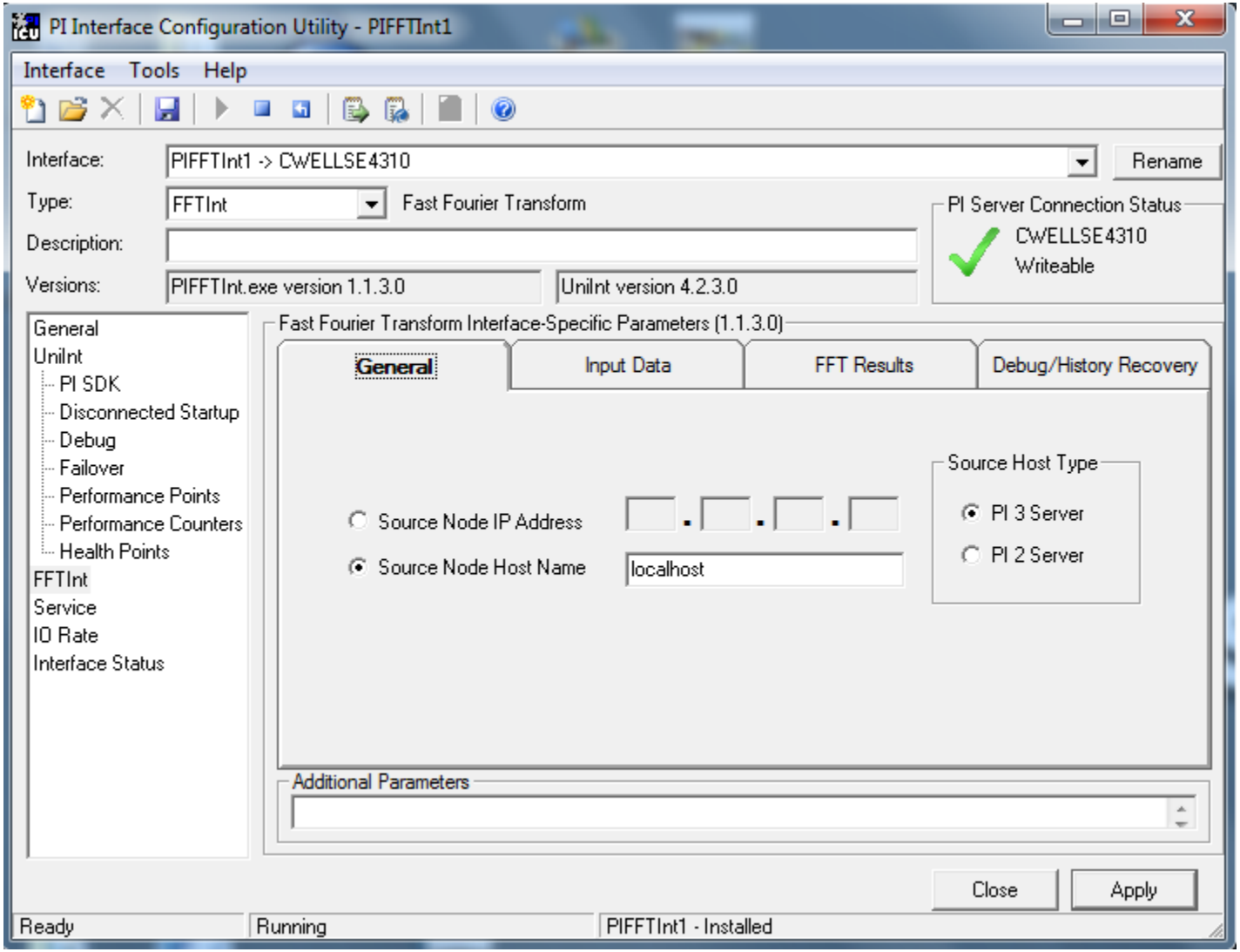
FFT results tab



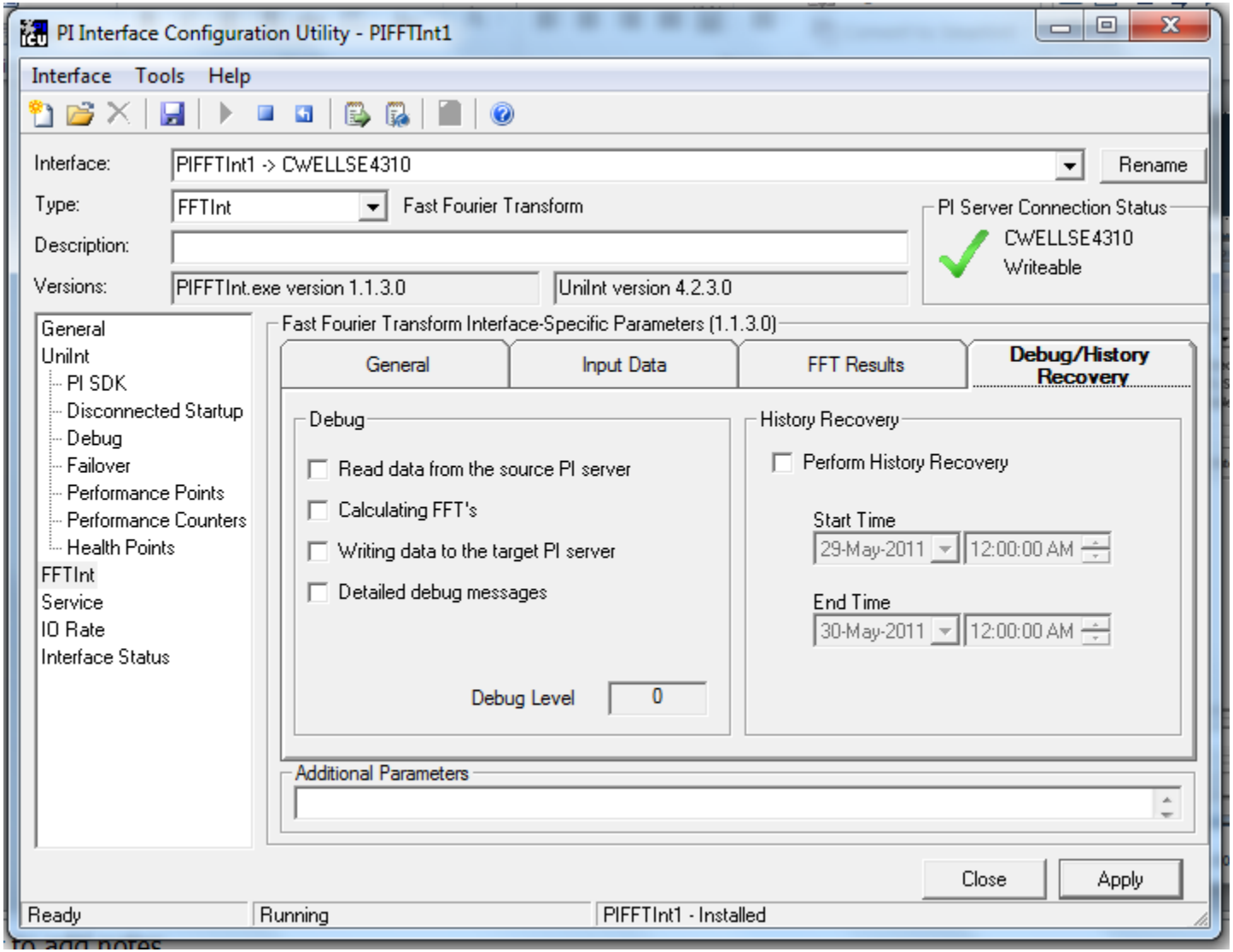
What is an FFT, what is it used for?

- Conversion of time series to its harmonic components (spectrum).
- Invented in 1965 by Cooley-Tukey (IBM)
- Theory by Fourier ~1815
- Uses of the FFT
  - Stability of systems (power networks)
  - Wear of components (rotating equipment)
  - Control of systems (Indentification)
  - Condition of equipment (Paper machines, turbines)
  - Detection of patterns (hourly, shift, daily, etc)
  - Capability of systems (paper, steel, any sheet)

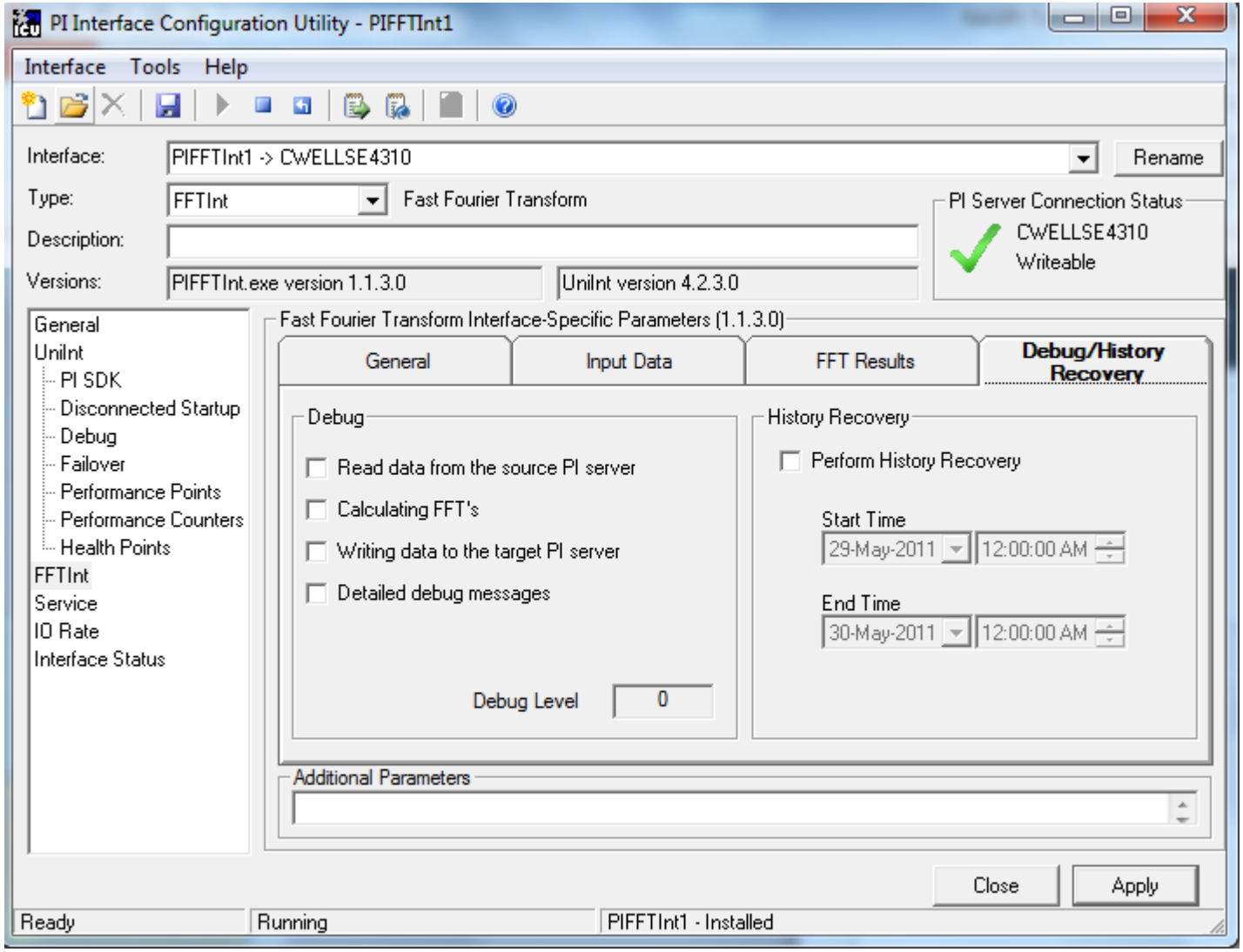
General tab



Debug/History recovery



Debug history tab



Northeast Blackout 2003

- Power grid stability

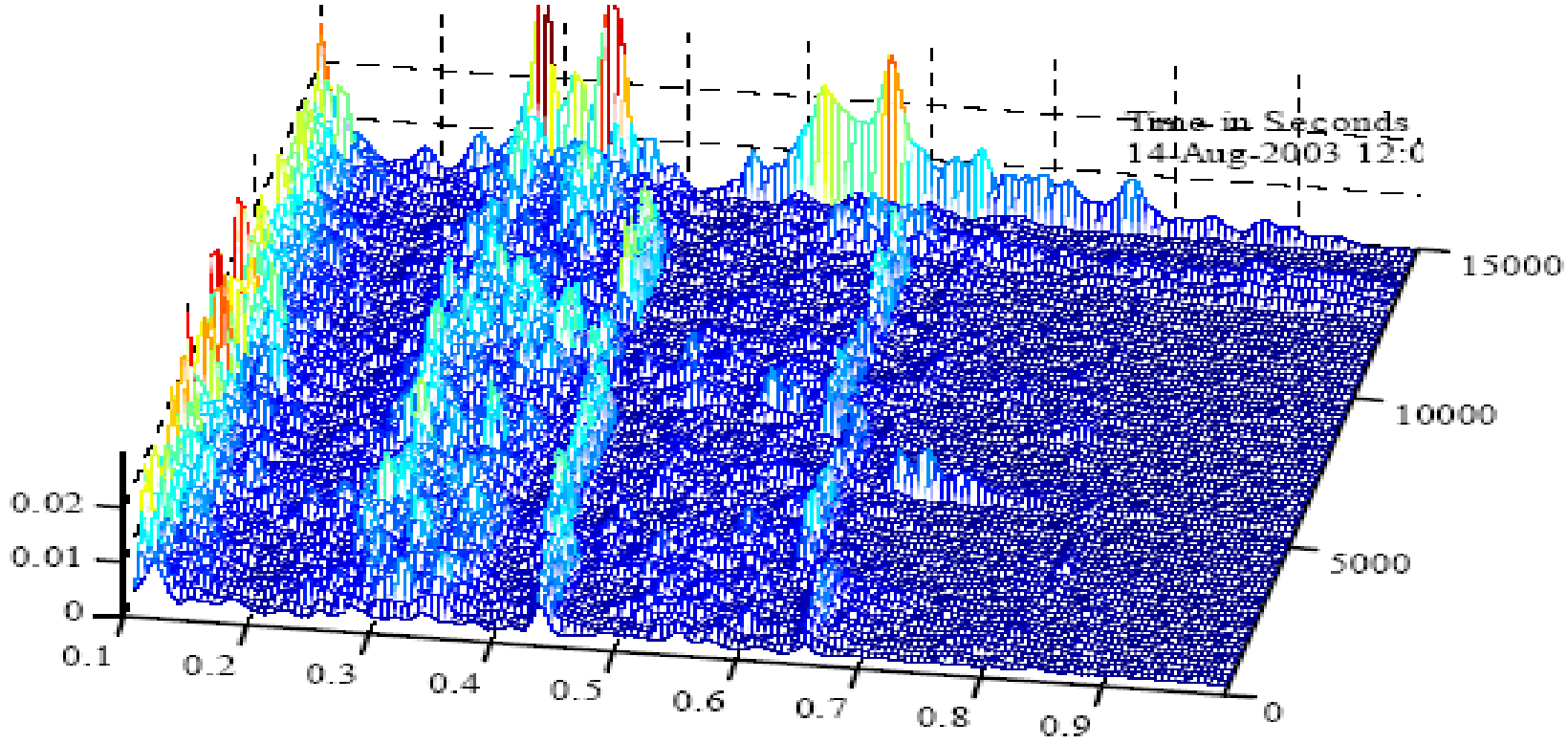


Fig. 12. Spectral history of AEP Kanawha River bus frequency for August 14 Blackout. 12:00-16:10 EDT

Northeast Blackout 2003

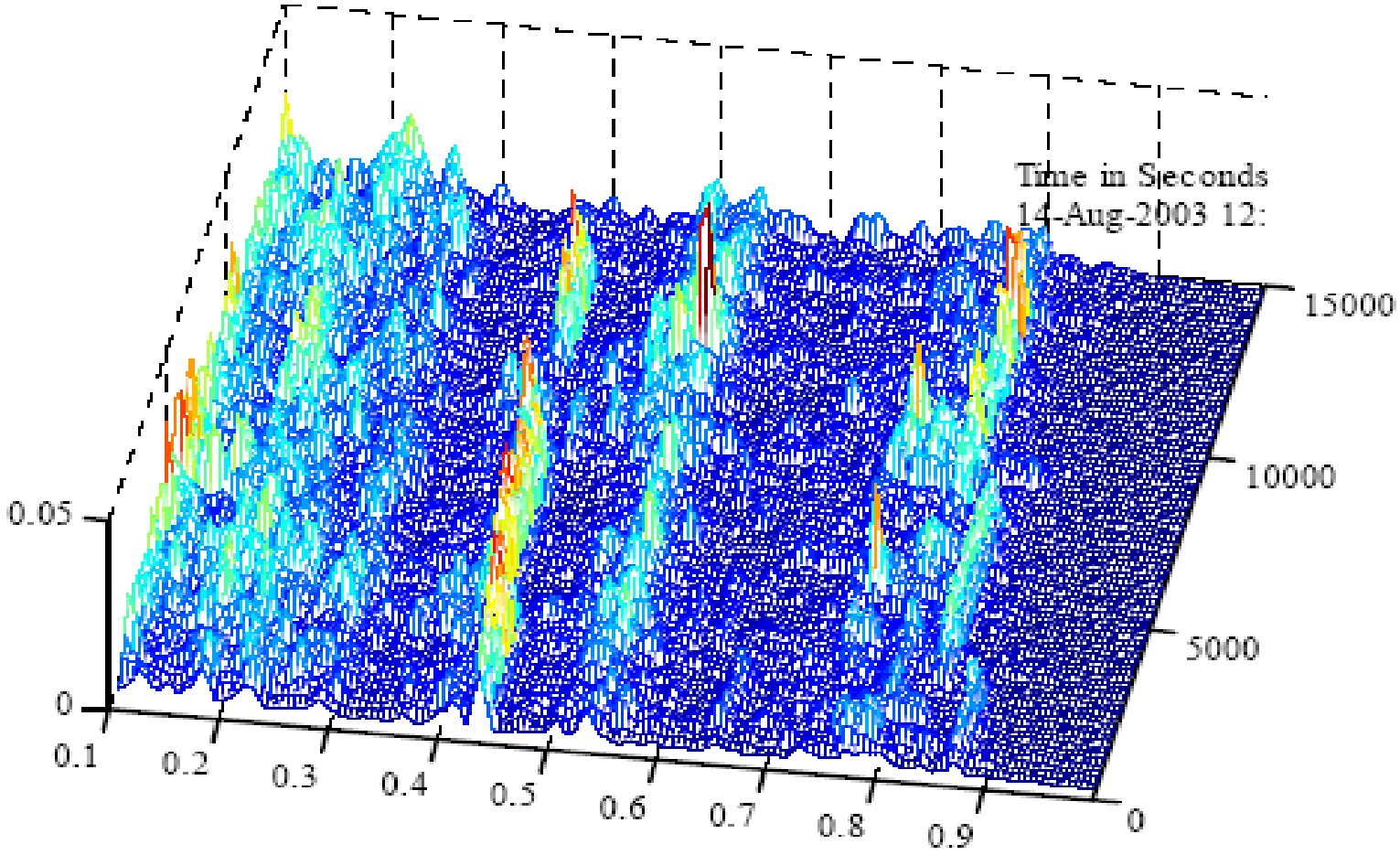
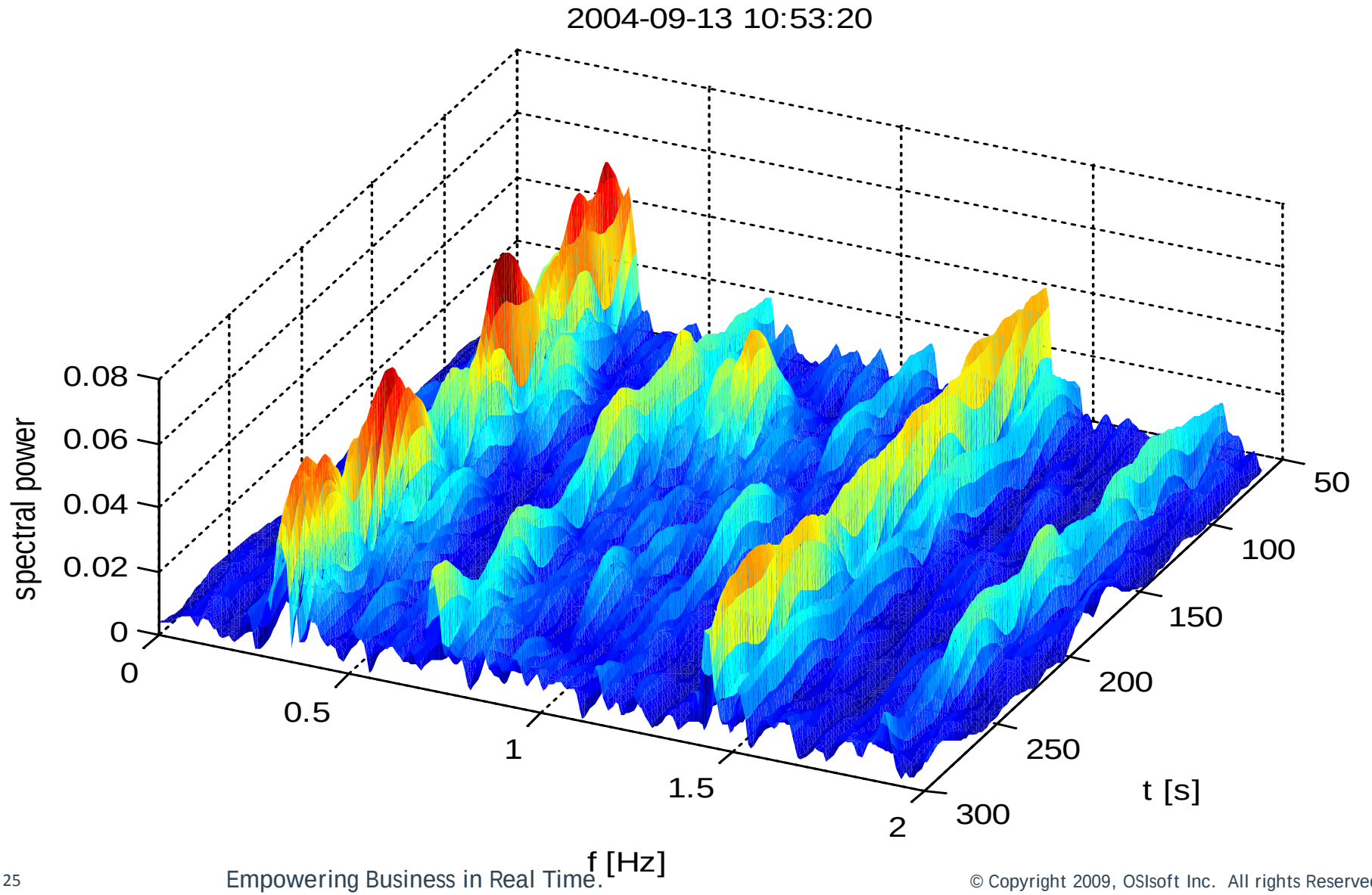
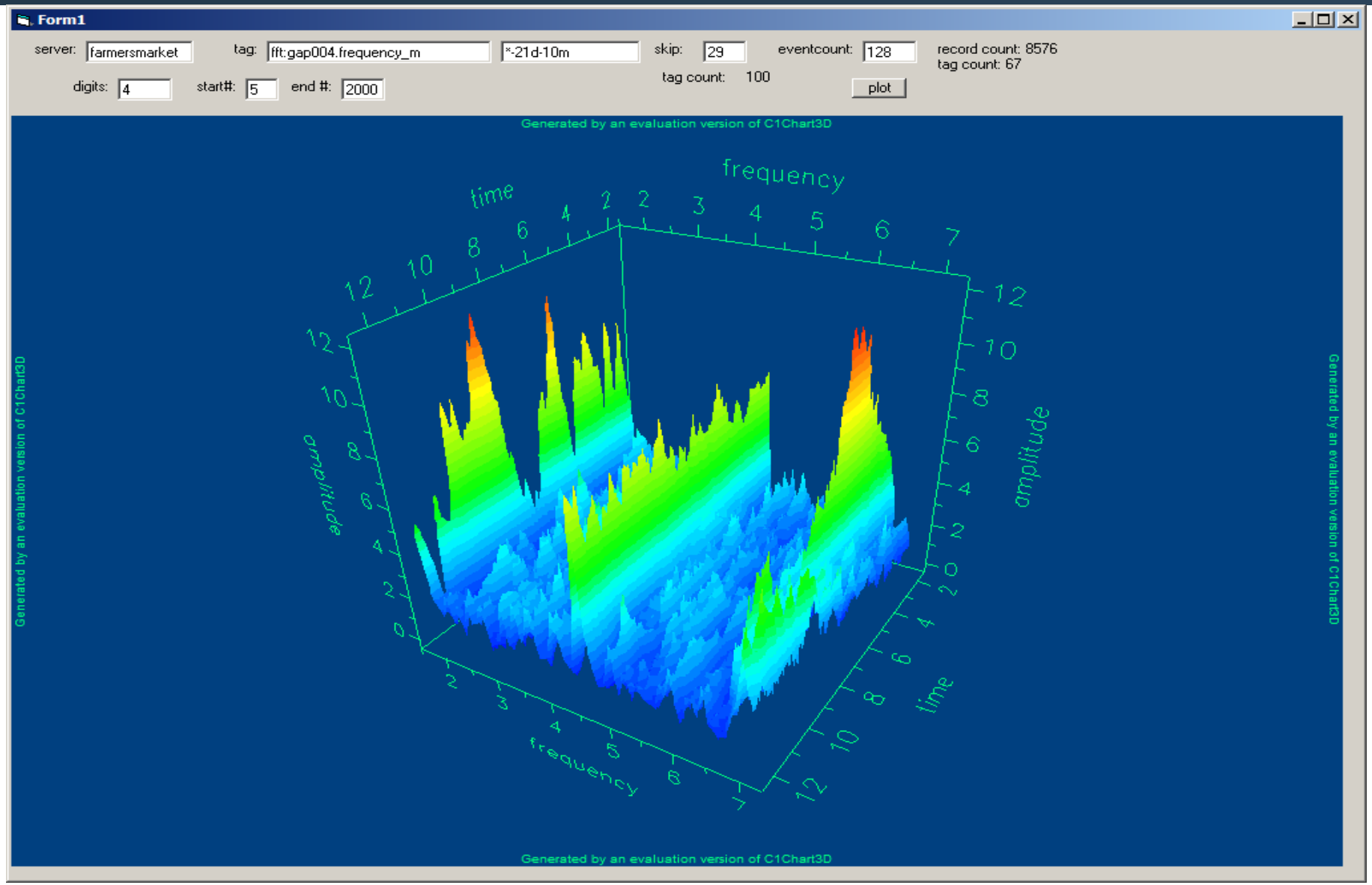


Fig. 13. Spectral history of Ameren Rush Island bus frequency for August 14 Blackout. 12:00-16:10 EDT

Swedish Blackout 2004



777 Davis Street (transformer)



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China Blackout 2006

7/1 20:00 (transmission line over load)

No action is taken

7/1 20:47 (500KV line tripped)

4 big power plants were offlined by operators

7/1 20:59 (grid network starting oscillation)

Many power plants were automatically tripped offline

Tieline was tripped

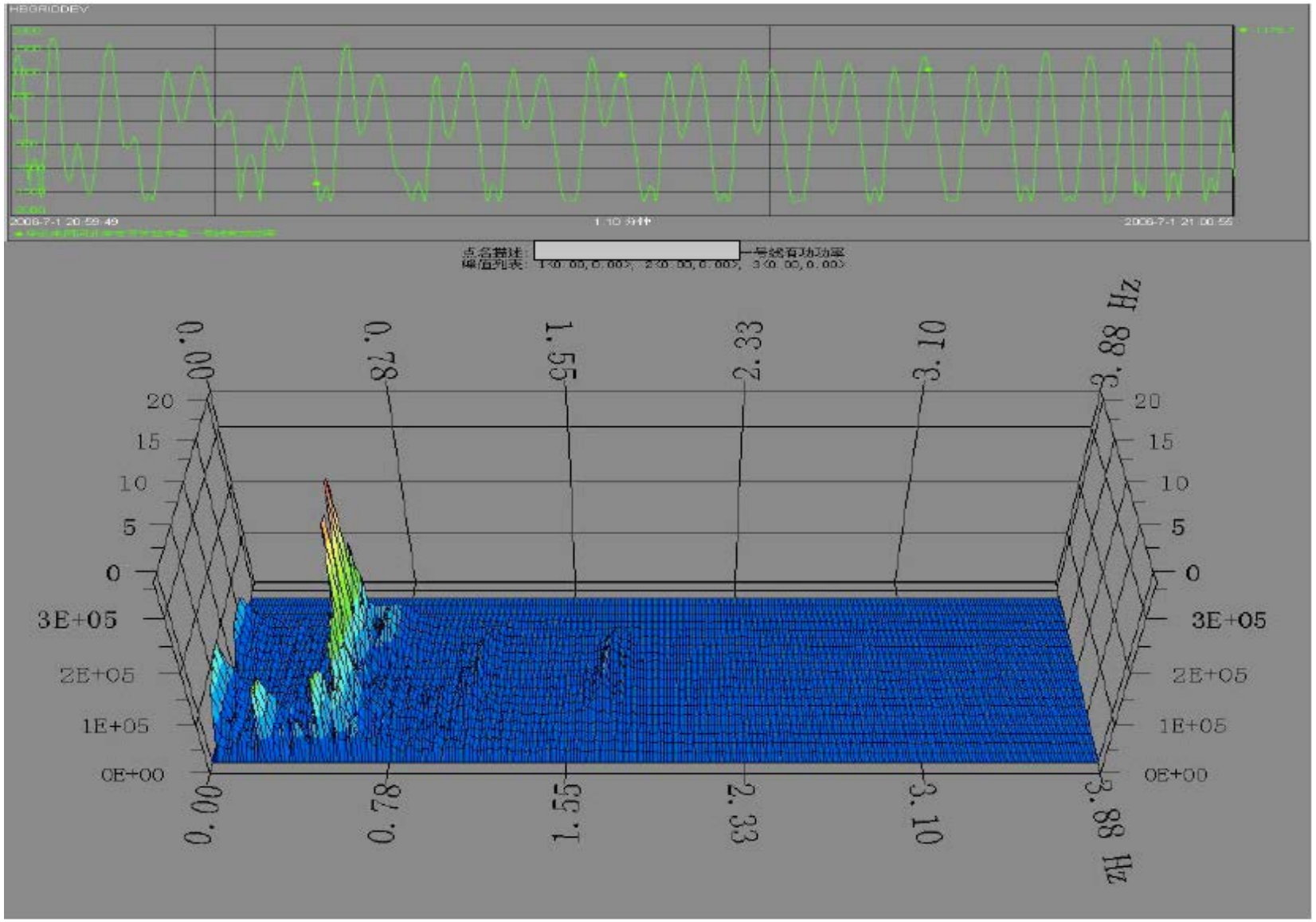
5 major cities in Henan were out of power

More than 30 million people affected

7/1 23:20

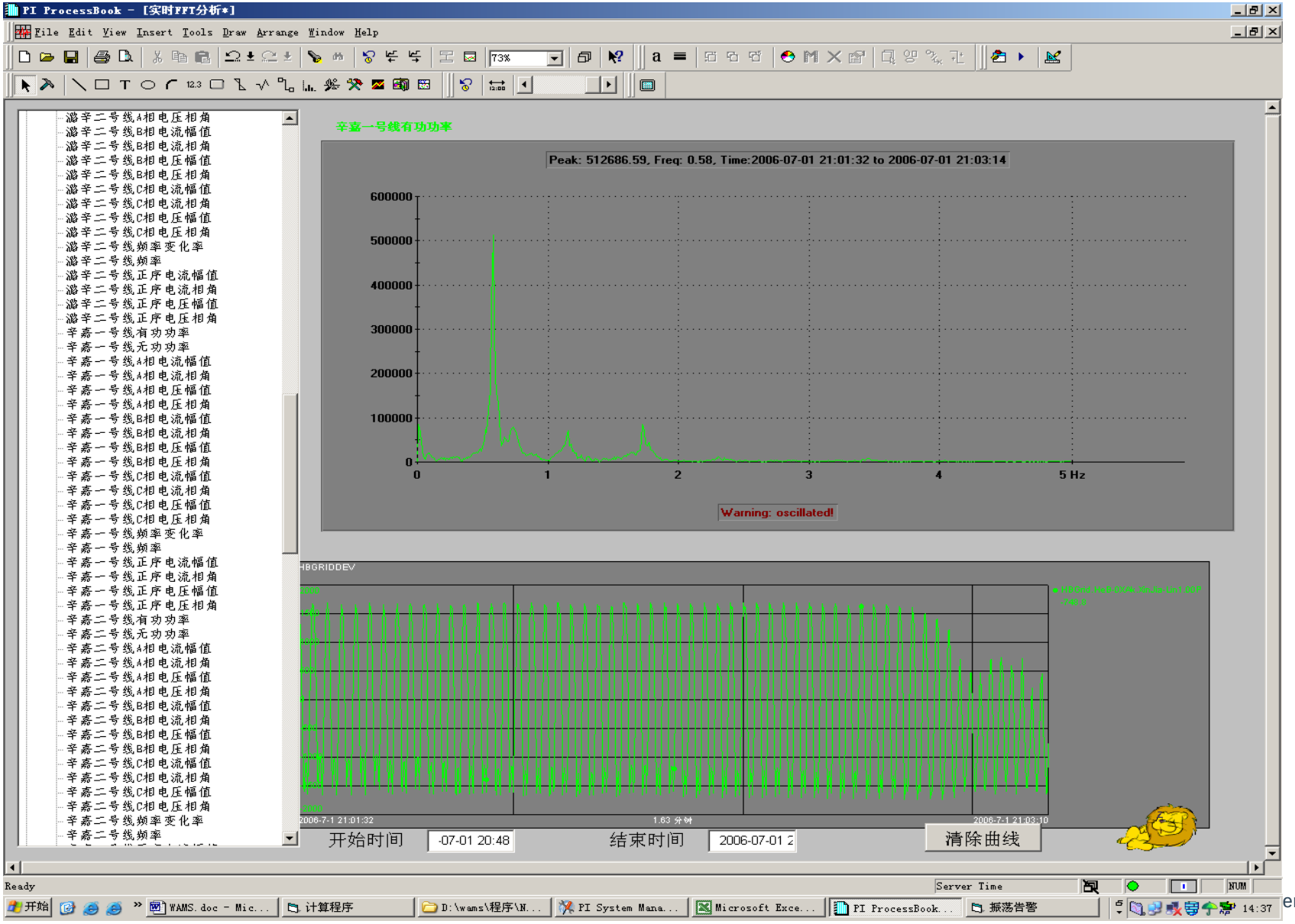
Grid network was restored

China Blackout July 1, 2006

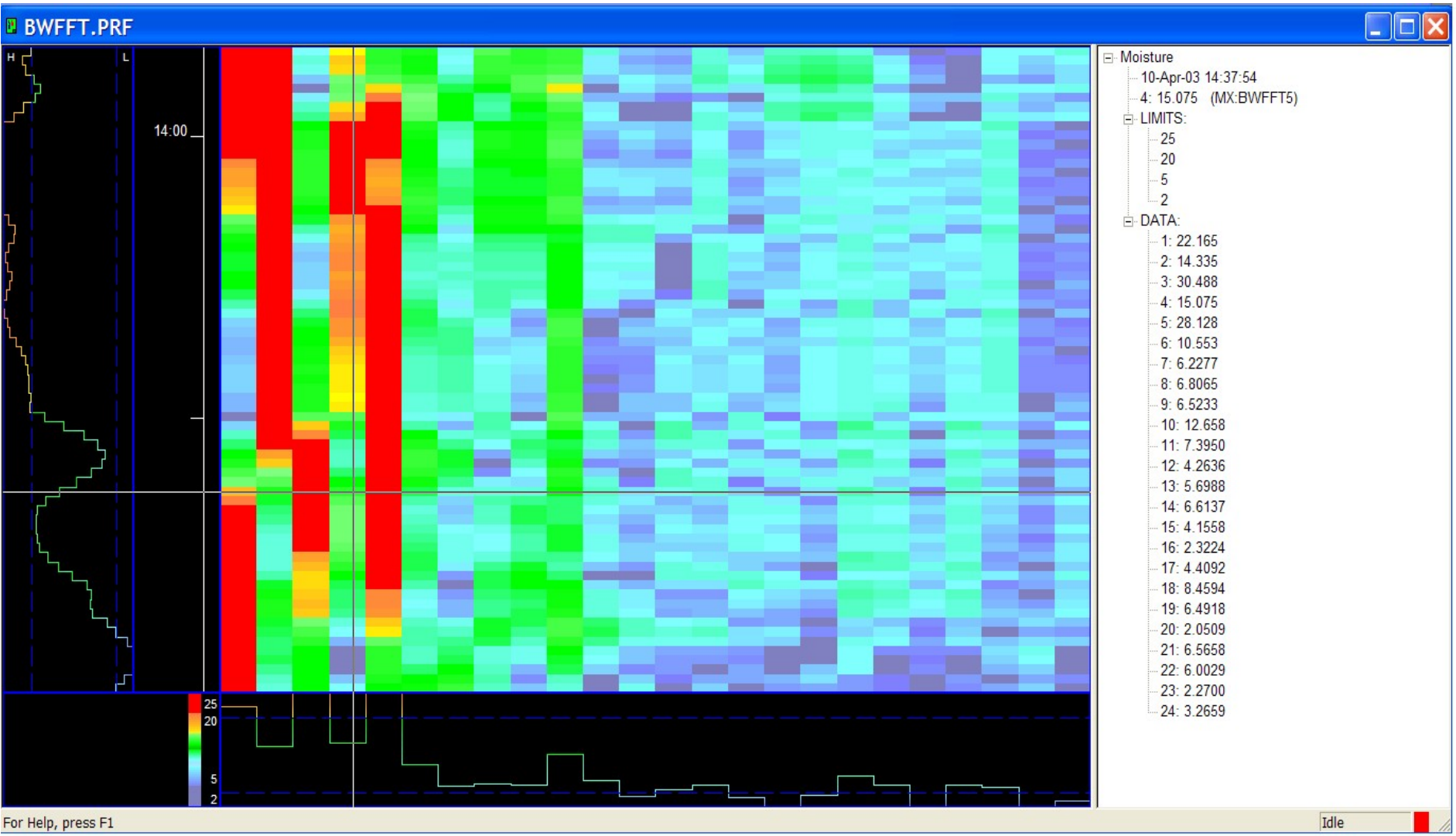


Empowering Business in Real Time.

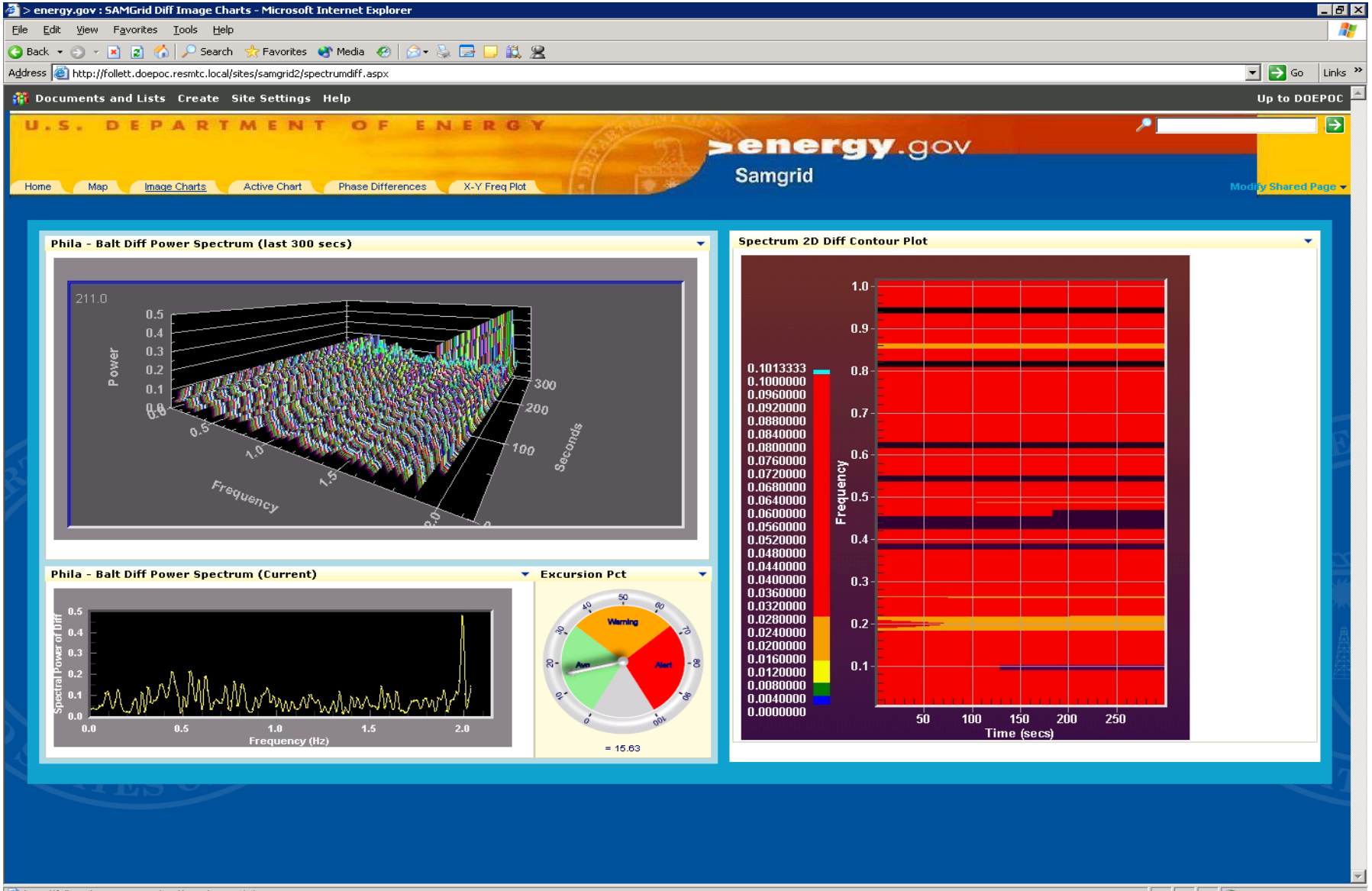
China 2006



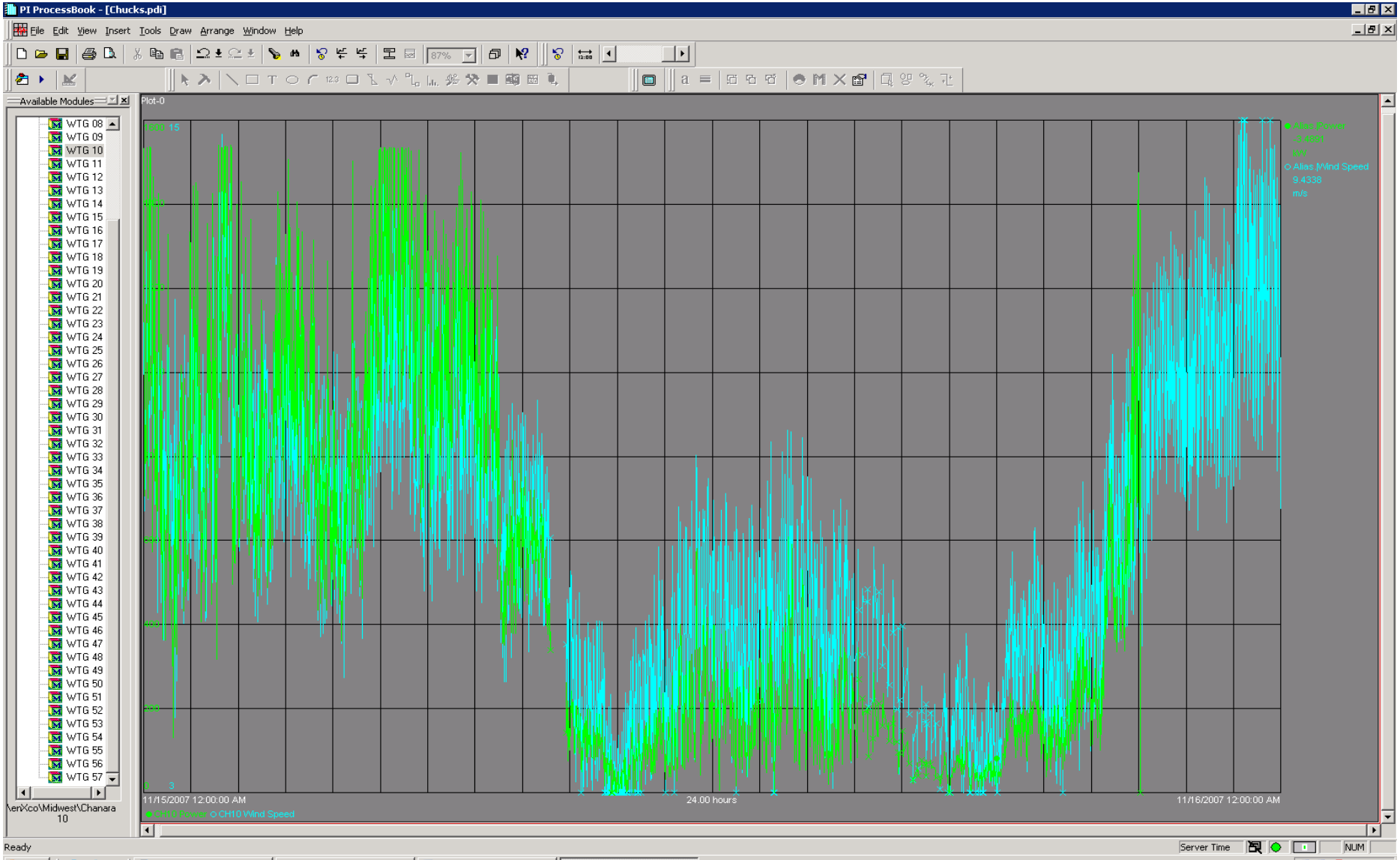
Paper machine (Inland Container)



US Eastern Interconnection (2005)



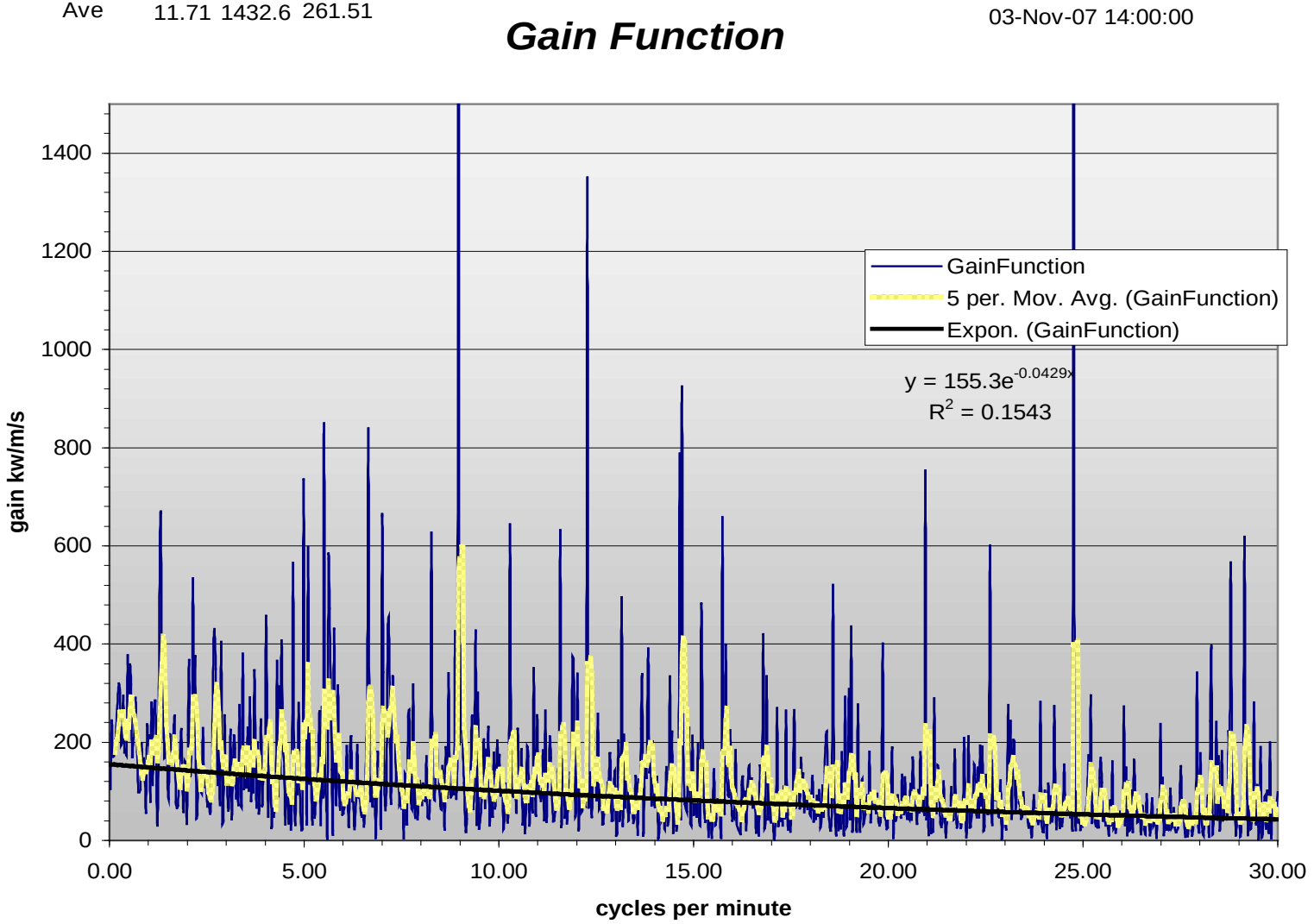
Wind Turbine



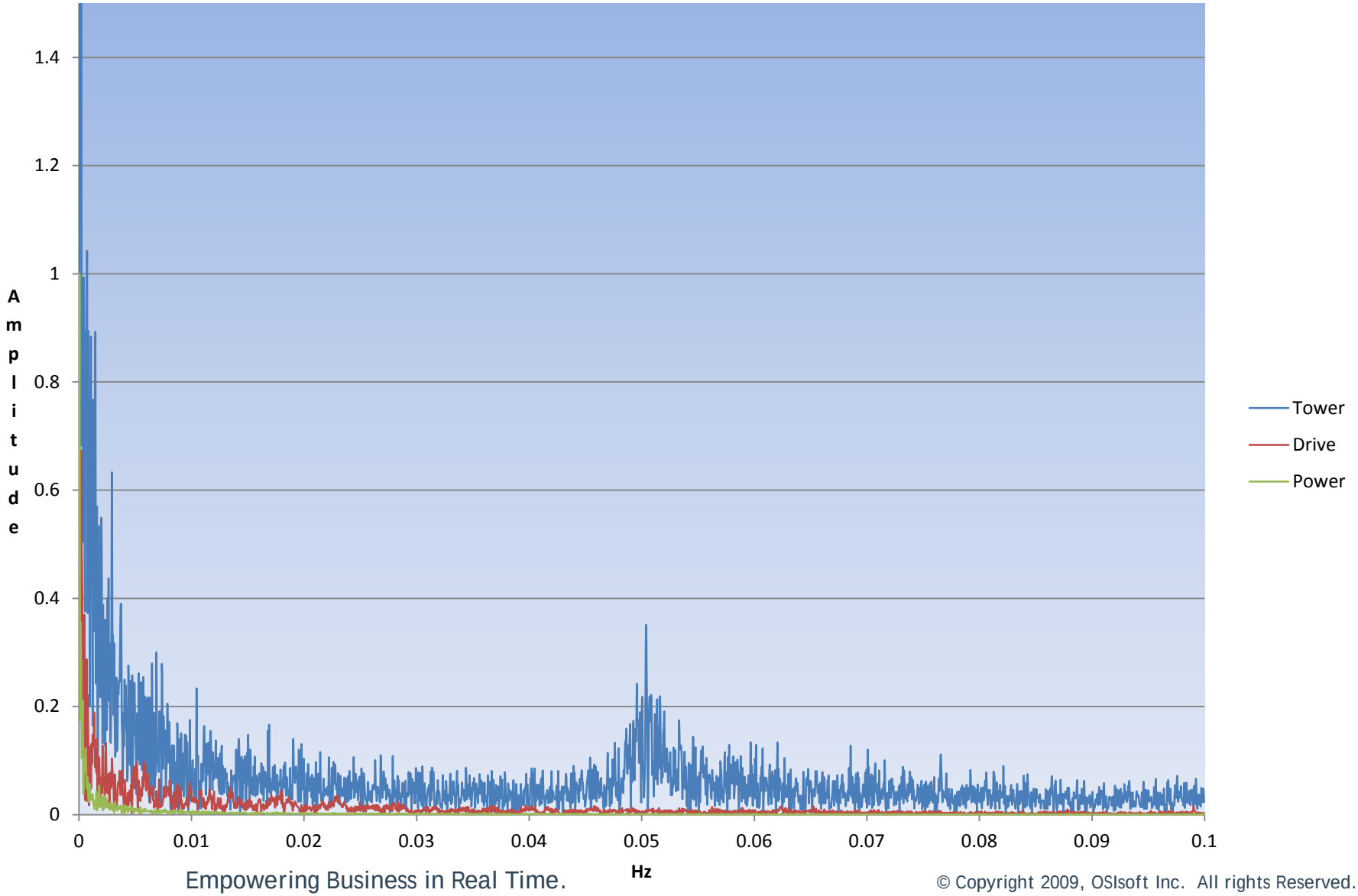
Wind Turbine FFT

	Speed	Power	Direction
Ave	11.71	1432.6	261.51

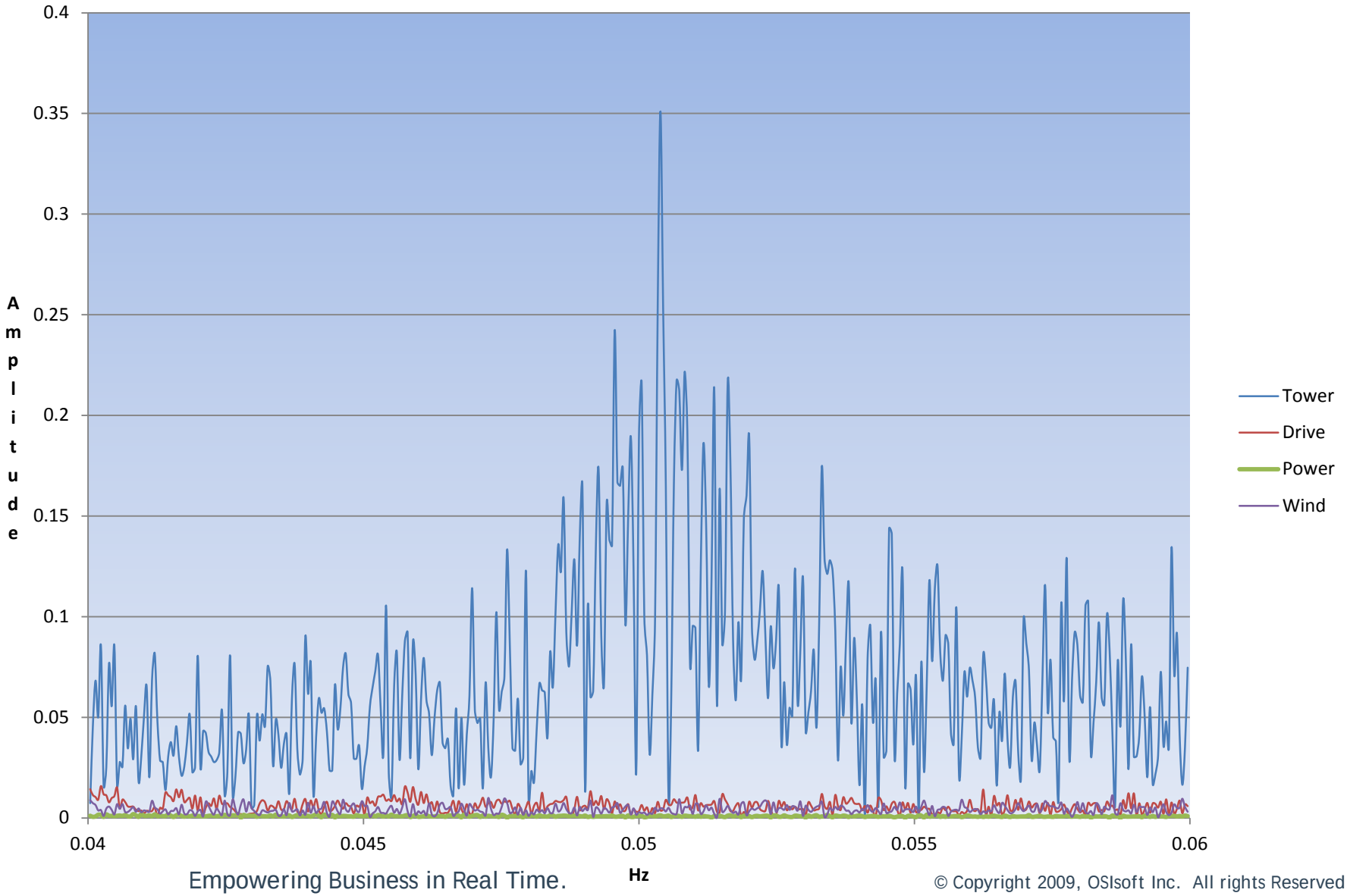
03-Nov-07 14:00:00



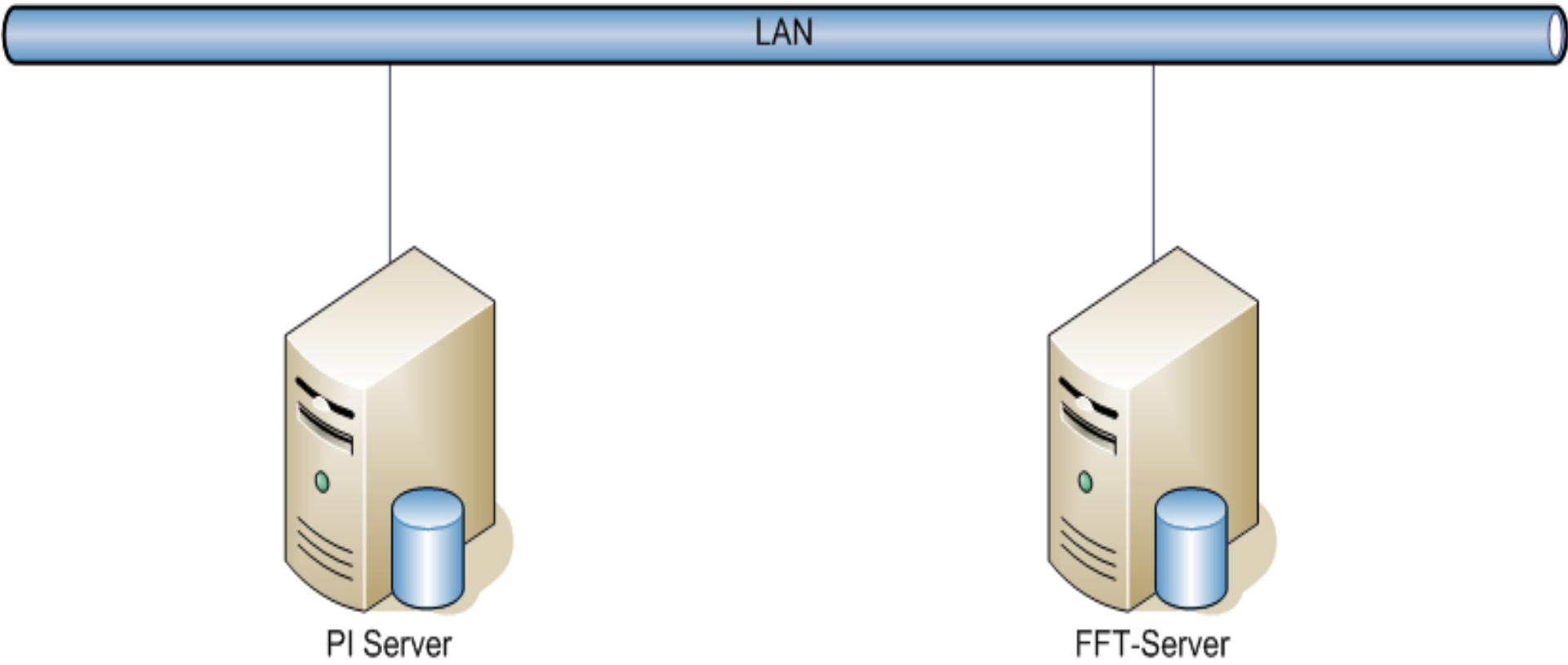
Wind turbine tower resonance



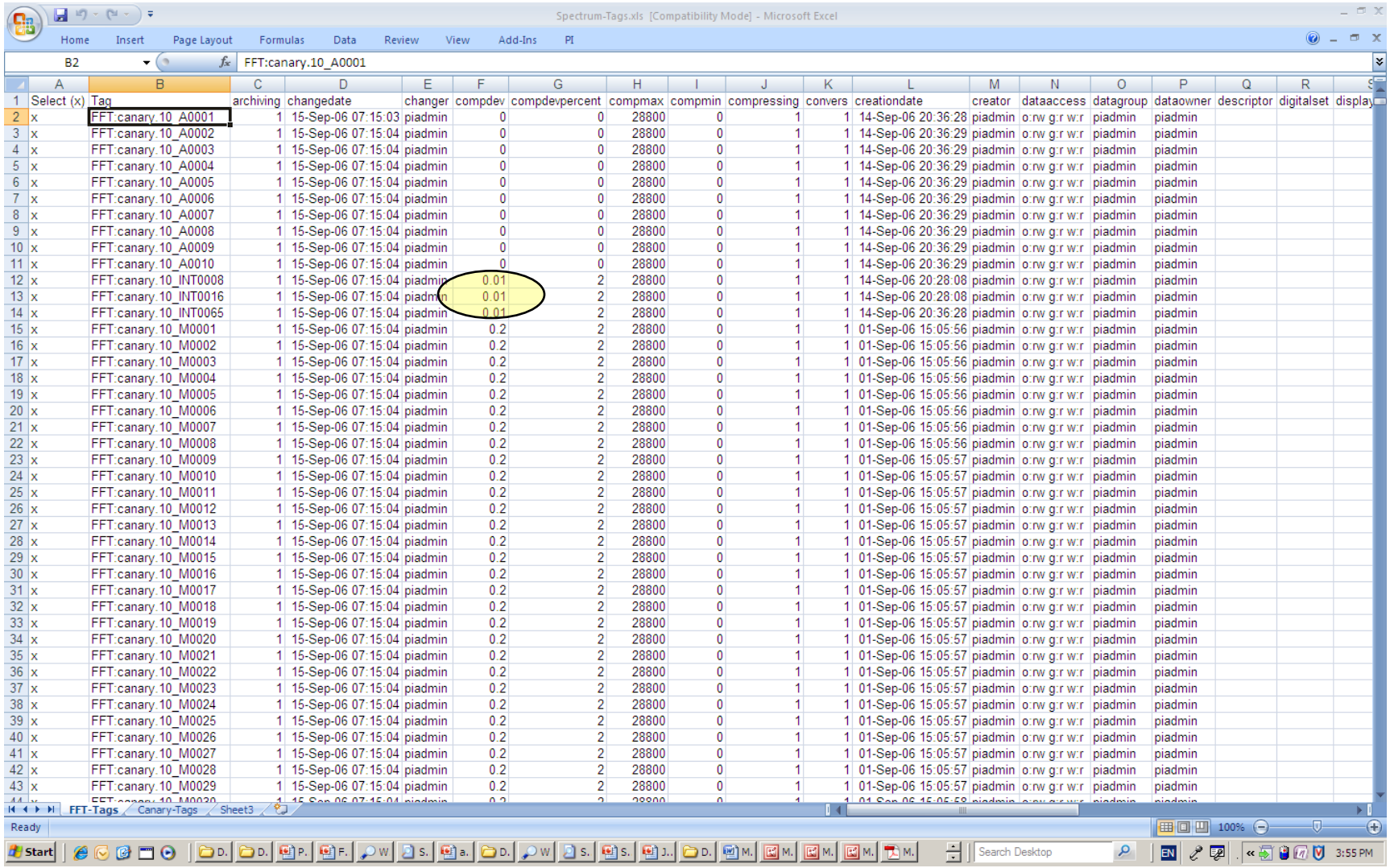
Zoom



Suggested architecture



FFT Tags



Spectrum-Tags.xls [Compatibility Mode] - Microsoft Excel

Home Insert Page Layout Formulas Data Review View Add-Ins PI

B2 FFT:canary.10_A0001

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Select (x)	Tag	archiving	changedate	changer	compdev	compdevpercent	compmax	compmin	compressing	convers	creationdate	creator	dataaccess	datagroup	dataowner	descriptor	digitalset	display
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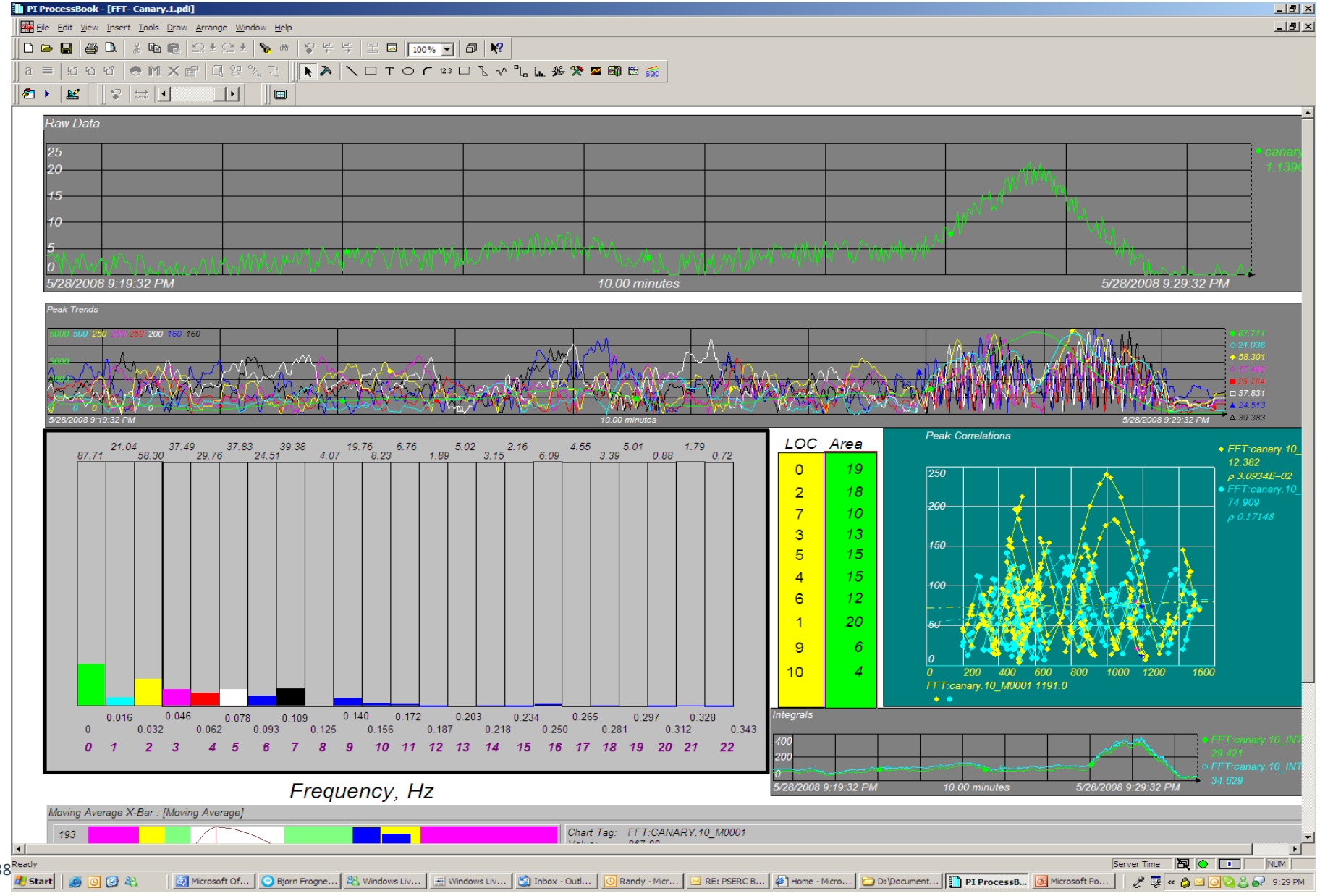
41	x	FFT:canary.10_M0027	1	15-Sep-06 07:15:04	piadmin	0.2		2	28800	0	1	1	01-Sep-06 15:05:57	piadmin	o:rw g:r w:r	piadmin	piadmin			
42	x	FFT:canary.10_M0028	1	15-Sep-06 07:15:04	piadmin	0.2		2	28800	0	1	1	01-Sep-06 15:05:57	piadmin	o:rw g:r w:r	piadmin	piadmin			
43	x	FFT:canary.10_M0029	1	15-Sep-06 07:15:04	piadmin	0.2		2	28800	0	1	1	01-Sep-06 15:05:57	piadmin	o:rw g:r w:r	piadmin	piadmin			

FFT-Tags Canary-Tags Sheet3

Ready 100%

Start Search Desktop 3:55 PM

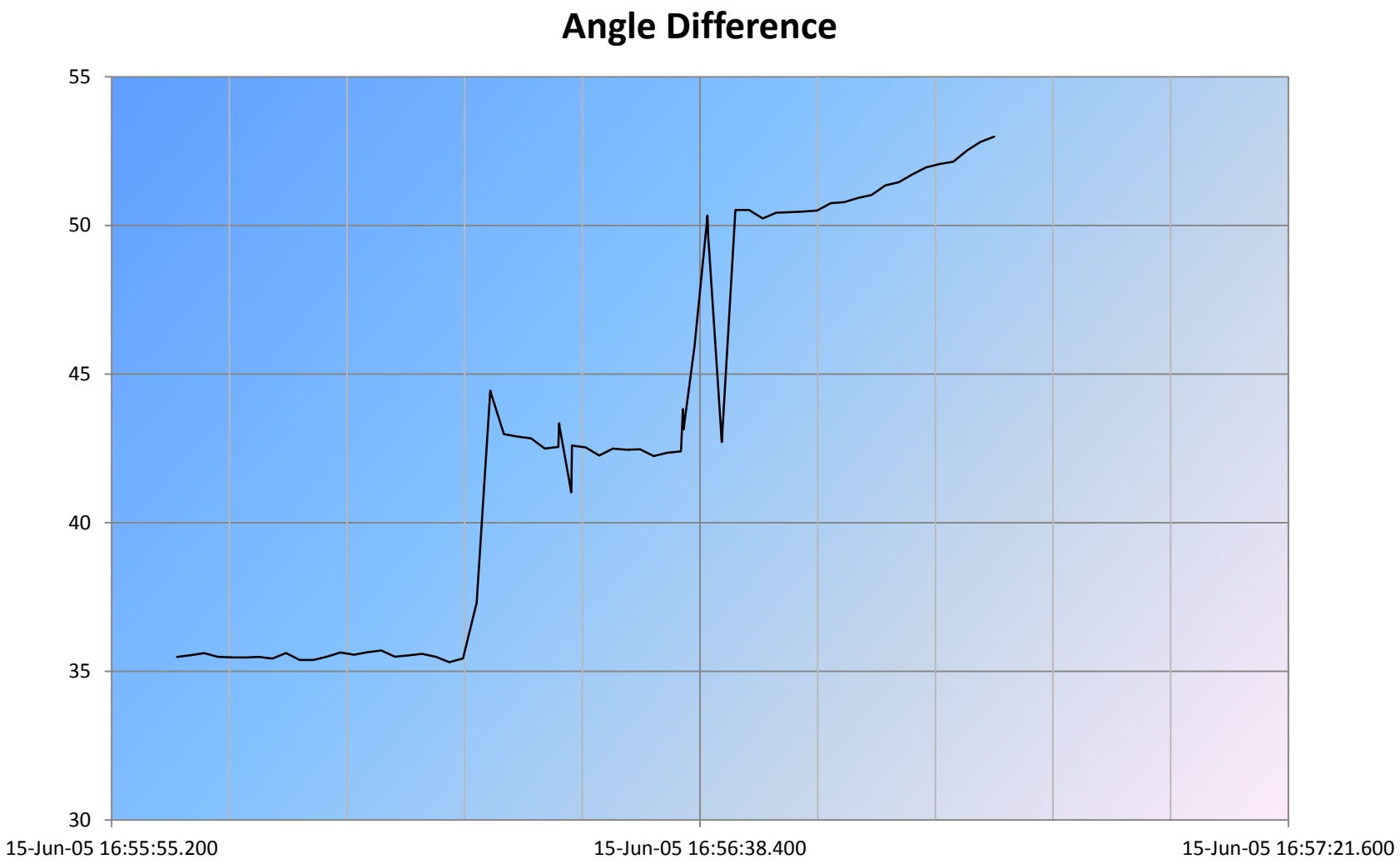
Example in ProcessBook



Summary FFT Interface

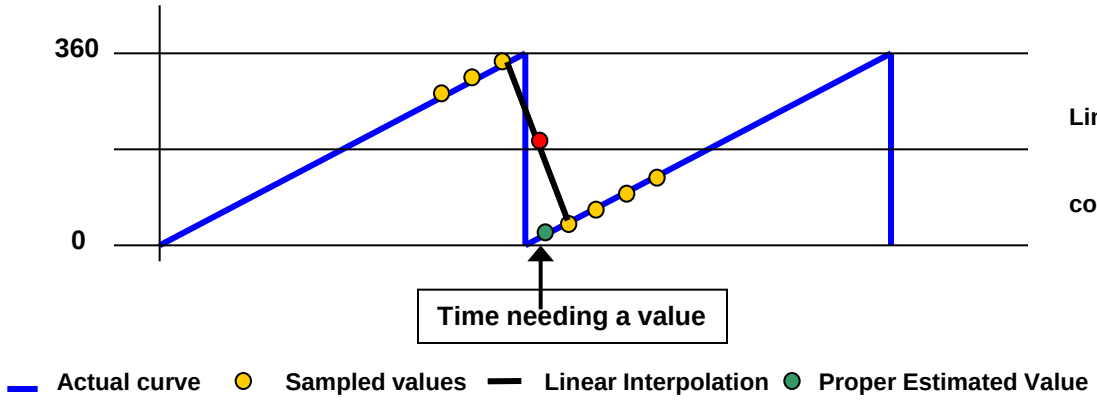
- Standard OSIsoft product
- FFT of any tag in any PI Server
- Configuration using ICU
- FFT outputs are standard PI tags
- Can process data at same speed as data arrives at the snapshot
- Standard PI tools access FFT data
  - SQC, Alarms, RtReports, WebParts, X-Y plots, Profiles

Angle jumping



Some technical tidbits: Linear Interpolation

Algorithm can't use linear interpolation at 360<->0 transition.



Linear Interpolation could yield

Interpolation is required to allow PMUs with different sampling rates to be compared.

Need to be careful of this when using DataLink as well.