OSIsoft FFT-INT





Chuck Wells - Center of Excellence, OSIsoft June 8th 2011



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

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



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• Mexico - Guatemala Tie Line Event



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PLFFT Interface - Low Frequency Oscillations Detection and Alarming



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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



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- Disconnected Start	tup FFT 🔀	SDK Member: CWELLSE4310
- Debug		API Hostname: localhost
- Performance Points	s Interface ID: 4	User: piadmin
Performance Count	ters	Type: Non-replicated - PI3
FFTInt		Version: PI 3.4.385.59
Service	Scan Frequency Scan Class #	Port: 5450
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		Interface Installation Path
		C:\Program Files\PIPC\Interfaces\FFTInt\
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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 <u>sourcehost</u> refers to the PI server where the points that are used as input data reside.



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

General tab



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Input data tab



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FFT results tab



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What is an FFT, what is it used for? í oslasoft.

- 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



Interface Tools Help	🔚 PI Interface Configura	ation Utility - PIFFTInt1			- • X						
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Debug/History recovery



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Debug history tab



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Northeast Blackout 2003



• Power grid stability





Northeast Blackout 2003





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

Empowering Business in Real Time.

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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





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China 2006





29

Paper machine (Inland Container)



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US Eastern Interconnection (2005)



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Wind Turbine





Wind Turbine FFT





Wind turbine tower resonance





Zoom





Suggested architecture





FFT Tags



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21 x	FF1:canar	y.10_M0007		1 15-	Sep-06 07	:15:04	piadmin	0.2		2	28800	0	1	1	01-Sep-	06 15:05:56	piadmin	orrw gir wir	piadmin	piadmin			
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23 X	FFT:canar	y.10_W0009		1 15-	Sep-06 07	15:04	pladmin	0.2		2	28800	0	1	1	01-Sep-	06 15:05:57	pladmin	o:rw g:r w:r	pladmin	pladmin			
24 X	FFT:canar	2.10_W0010		1 15-	Sep-06-07	15:04	pladmin	0.2		2	20000	0	1	1	01-Sep-	06 15:05:57	pladmin	orw grrwr	pladmin	piadmin			
20 X	FFT:canar	2.10_W0011		1 10-	Sep-06-07	15.04	piadmin	0.2		2	20000	0	1	1	01-Sep-	06 15:05:57	piadmin	oliw gir wir	piadmin	piadmin			
20 X	FFT:canar	2.10_W0012		1 15-	Sep-06-07	15:04	piadmin	0.2		2	28800	0	1	1	01-Sep-	06 15:05:57	piadmin	oliw gir wir	piaumin	piadmin			
27 X	FET:canan	2.10_M0013		1 15-	Sep-06-07	15:04	niadmin	0.2		2	28800	0	1	1	01-Sep-	06 15:05:57	niadmin	orrwight with	piadmin	piadmin			
29 x	EET:canar	v 10_M0015		1 15.	Sen-06 07	15:04	niadmin	0.2		2	28800	0	1	1	01-Sep-	06 15:05:57	niadmin	ornwight wir	niadmin	niadmin			
30 x	EET:canar	v 10_M0016		1 15-	Sep-06-07	15.04	niadmin	0.2		2	28800	0	1	1	01-Sep-	06 15:05:57	niadmin	orrw gir wir	niadmin	niadmin			
31 x	EET:canar	v 10_M0017		1 15-	Sep-06.07	15:04	niadmin	0.2		2	28800	0	1	1	01-Sen-	06 15:05:57	niadmin	orrw gir wir	niadmin	niadmin			
32 x	EET:canar	v 10 M0018		1 15-	Sep-06 07	15:04	piadmin	0.2		2	28800	0	1	1	01-Sep-	06 15:05:57	piadmin	orrw gir wir	piadmin	piadmin			
33 x	FFT:canar	v.10 M0019		1 15-	Sep-06 07	15:04	piadmin	0.2		2	28800	0	1	1	01-Sep-	06 15:05:57	piadmin	orw ar wr	piadmin	piadmin			
34 x	FFT:canar	v.10 M0020		1 15-	Sep-06 07	:15:04	piadmin	0.2		2	28800	0	1	1	01-Sep-	06 15:05:57	piadmin	orw gir wir	piadmin	piadmin			
35 x	FFT:canar	v.10 M0021		1 15-	Sep-06 07	:15:04	piadmin	0.2	2	2	28800	0	1	1	01-Sep-	06 15:05:57	, piadmin	orrw gir wir	piadmin	piadmin			
36 x	FFT:canar	v.10 M0022		1 15-	Sep-06 07	:15:04	, piadmin	0.2	2	2	28800	0	1	1	01-Sep-	06 15:05:57	, piadmin	o:rw g:r w:r	piadmin	piadmin			
37 x	FFT:canar	y.10_M0023		1 15-	Sep-06 07	:15:04	, piadmin	0.2	2	2	28800	0	1	1	01-Sep-	06 15:05:57	piadmin	orrw gir wir	piadmin	piadmin			
38 x	FFT:canar	y.10_M0024		1 15-	Sep-06 07	:15:04	piadmin	0.2	!	2	28800	0	1	1	01-Sep-	06 15:05:57	piadmin	orw gir wir	piadmin	piadmin			
39 x	FFT:canar	y.10_M0025		1 15-	Sep-06 07	:15:04	piadmin	0.2	2	2	28800	0	1	1	01-Sep-	06 15:05:57	piadmin	orrwiger wir	piadmin	piadmin			
40 x	FFT:canar	y.10_M0026		1 15-	Sep-06 07	:15:04	piadmin	0.2	2	2	28800	0	1	1	01-Sep-	06 15:05:57	piadmin	o:rw g:r w:r	piadmin	piadmin			
41 x	FFT:canar	y.10_M0027		1 15-	Sep-06 07	:15:04	piadmin	0.2	2	2	28800	0	1	1	01-Sep-	06 15:05:57	piadmin	o:rw g:r w:r	piadmin	piadmin			
42 x	FFT:canar	y.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:canar	y.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			_
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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



Angle Difference



Empowering Business in Real Time.

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Some technical tidbits: Linear Interpolation



Algorithm can't use linear interpolation

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

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



