AMETEK POWER INSTRUMENTS

NASPI North American SynchroPhasor Initiative

Analytics with Continuous Point-on-Wave Data - A Signal Processing Perspective

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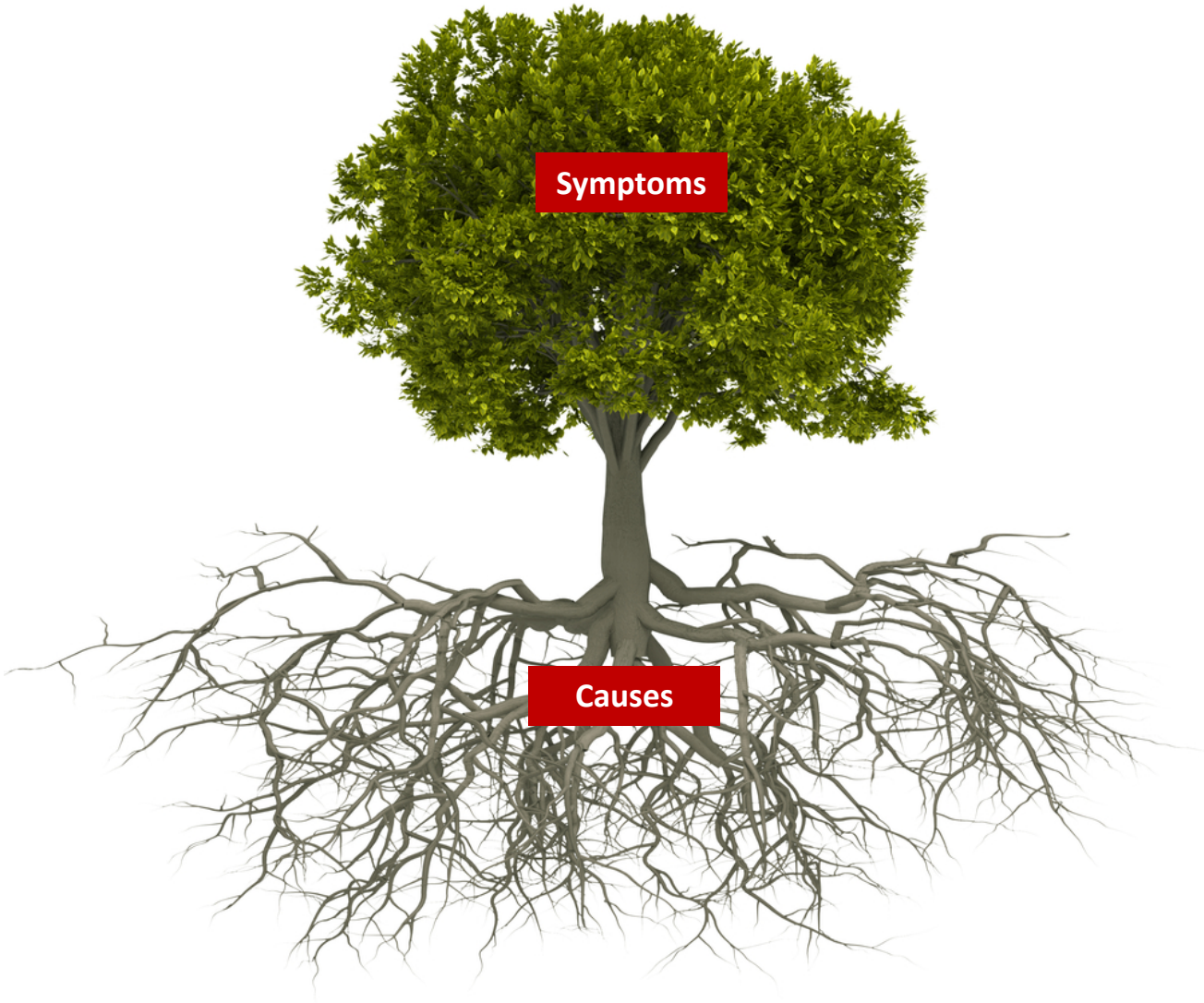
Overview

- POW Data from a signal processing perspective – Why does it matter?
- PMU vs POW
- Examples

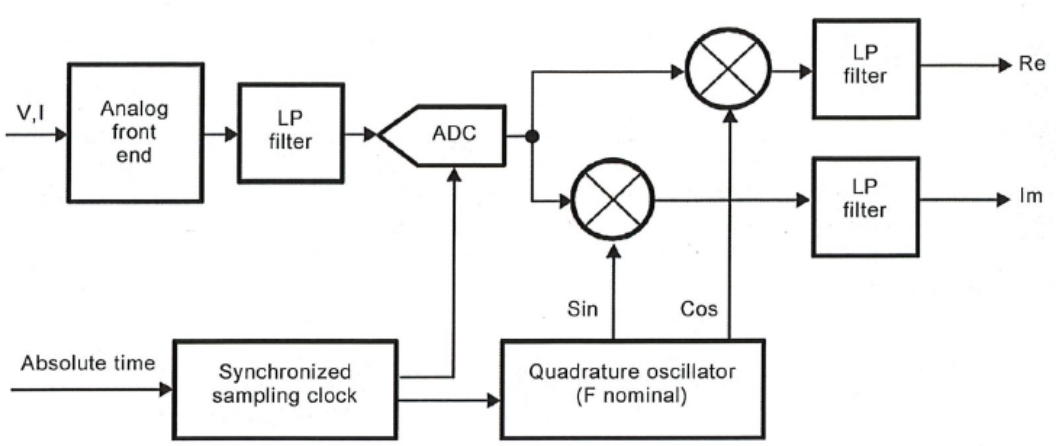
Signal Processing – Why does it matter?



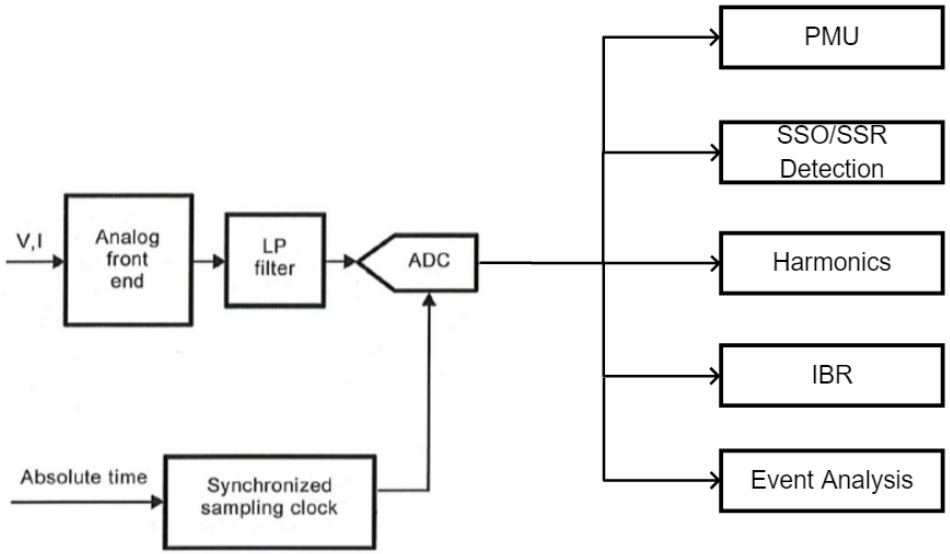
Symptoms are easily visible but don’t always reveal the ”root” cause
(Unreliable data, Inaccurate analysis, lack of detail, etc.)

Causes are below the surface and not always obvious
(Measurement algorithms, Raw data resolution, Filters, etc.)

Signal Processing - PMU vs POW



IEEE/IEC 60255-118-1 PMU reference model



Generic POW model

PMU

- Force fits to a sinusoidal representation.
- P class - Short acquisition window & minimal filtering
- Limited protection against interference signals, particularly sub-synchronous frequencies.
- Reduction to phasors implies lossy compression.

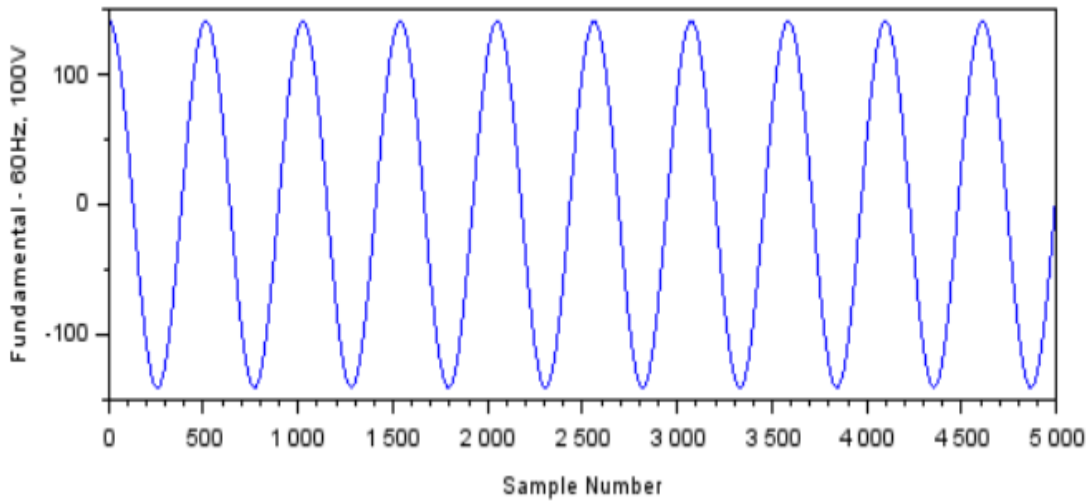
POW

- Application specific processing methods.
- Raw data for each processing module.
- Opportunity to filter according to the application. Not constrained by source data limited to a certain format.

Examples

1. Oscillations – Amplitude modulation
2. Oscillations – Phase modulation
3. Sub-harmonics

1. Oscillations – Amplitude Modulation



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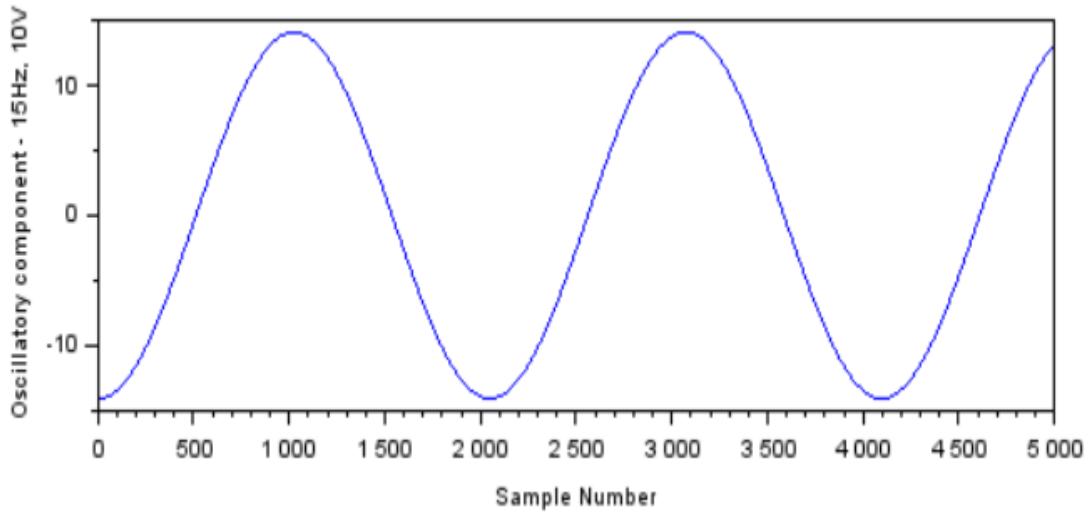
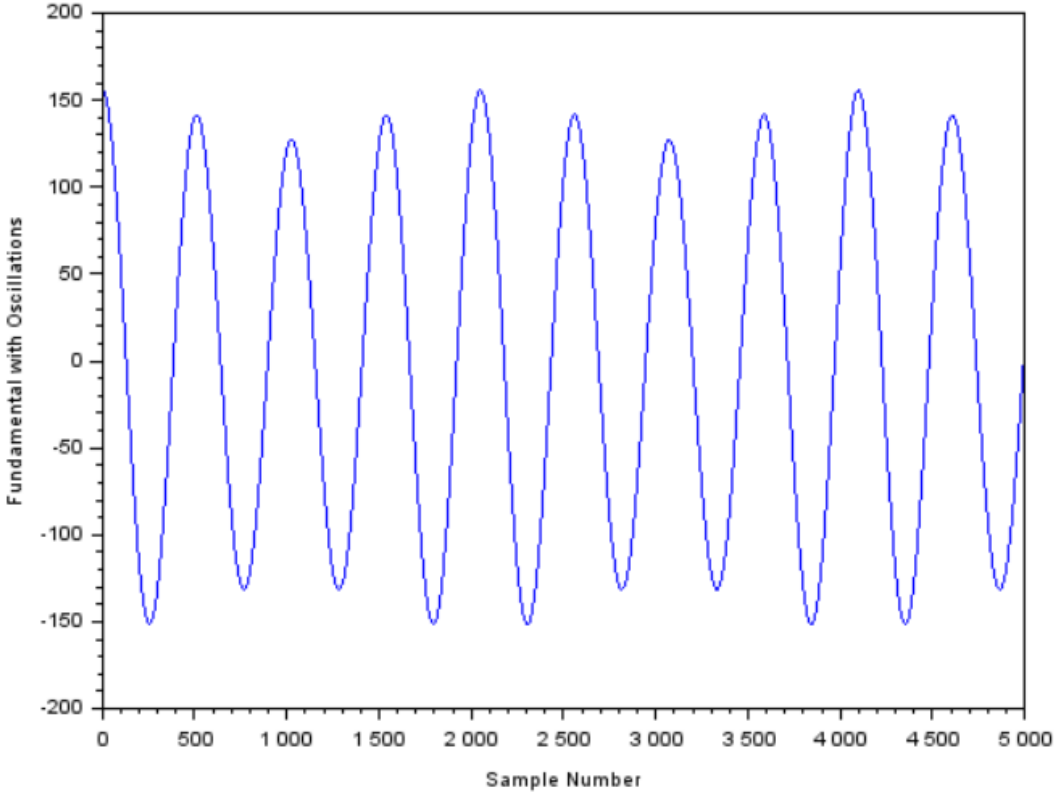
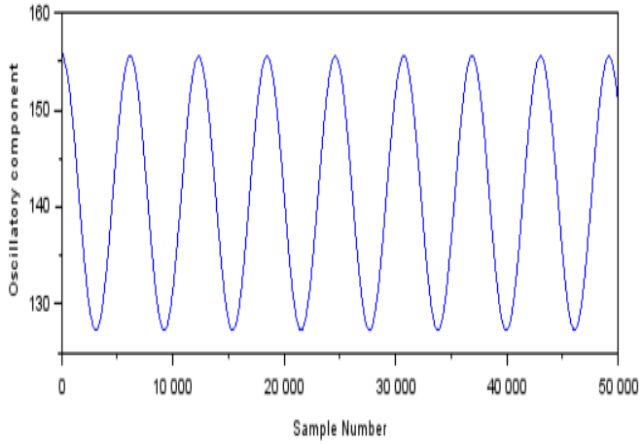


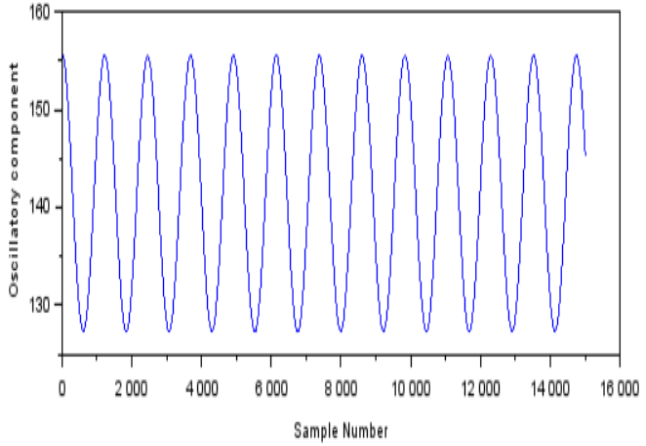


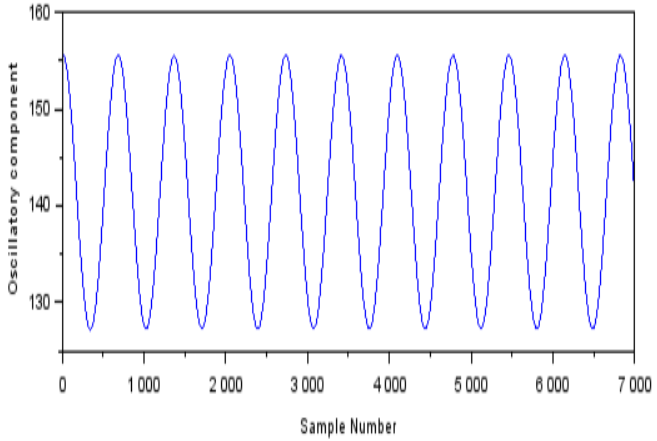
1. Oscillations – Amplitude Modulation

f = 5 Hz | **f = 25 Hz** | **f = 45 Hz**

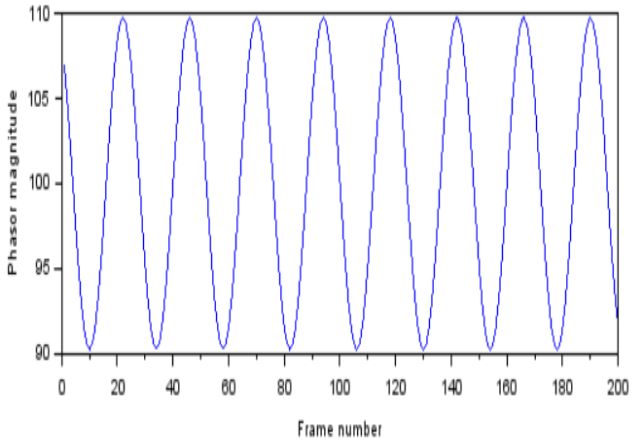
POW

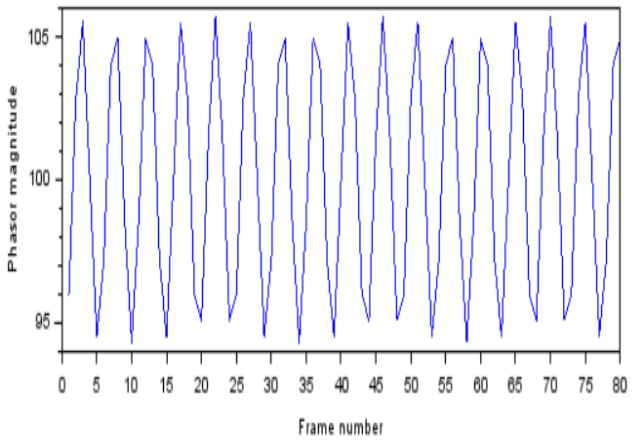


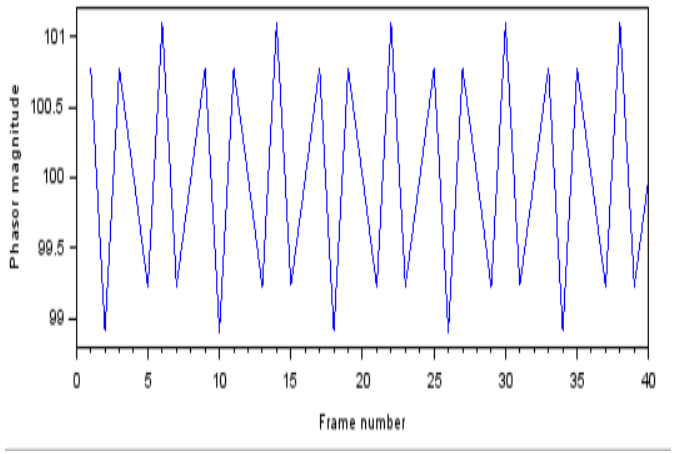




PMU



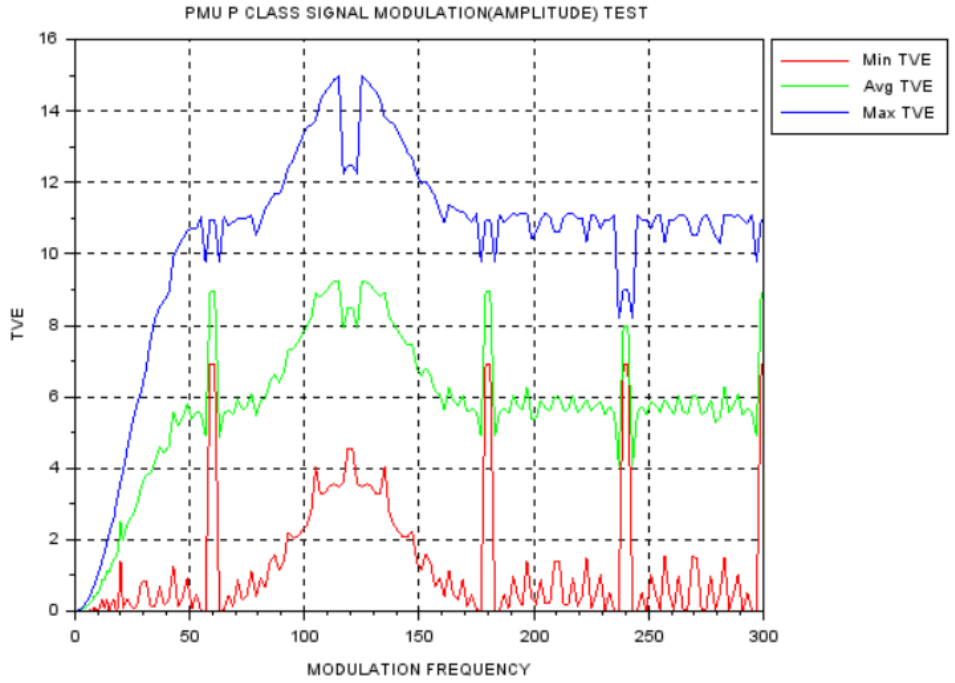




1. Oscillations – Amplitude Modulation

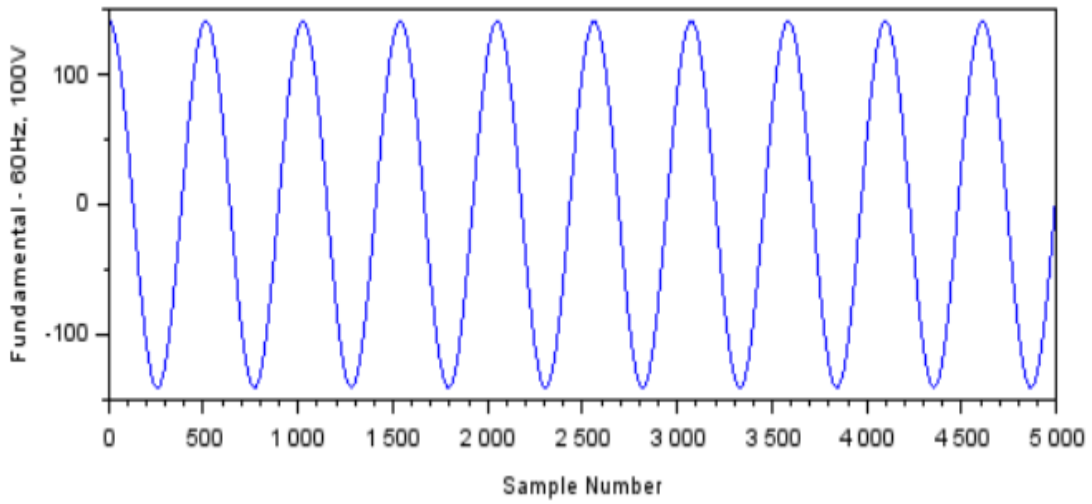
Table 4 – Synchrophasor measurement bandwidth requirements using modulated test signals

Modulation level	Reference condition	Minimum range of influence quantity over which PMU shall be within given TVE limit			
		P class		M class	
		Range	Max. TVE	Range	Max. TVE
k_x = 0,1, k_a = 0	100 % rated signal magnitude, $f_{nominal}$	Modulation frequency 0,1 to lesser of F_s/10 or 2 Hz	3 %	Modulation frequency 0,1 to lesser of F_s/5 or 5 Hz	3 %
k_x = 0, k_a = 0,1	100 % rated signal magnitude, $f_{nominal}$		3 %		3 %

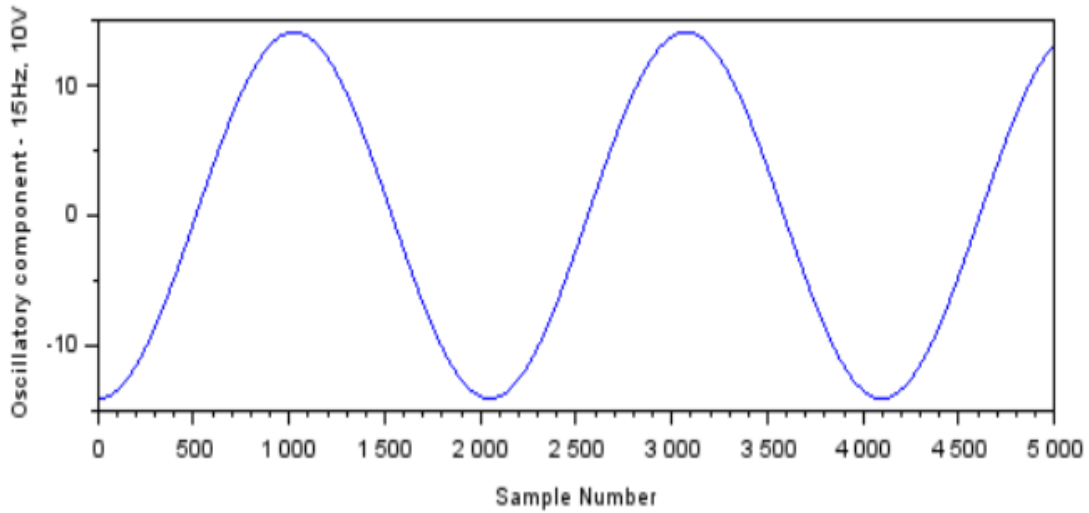


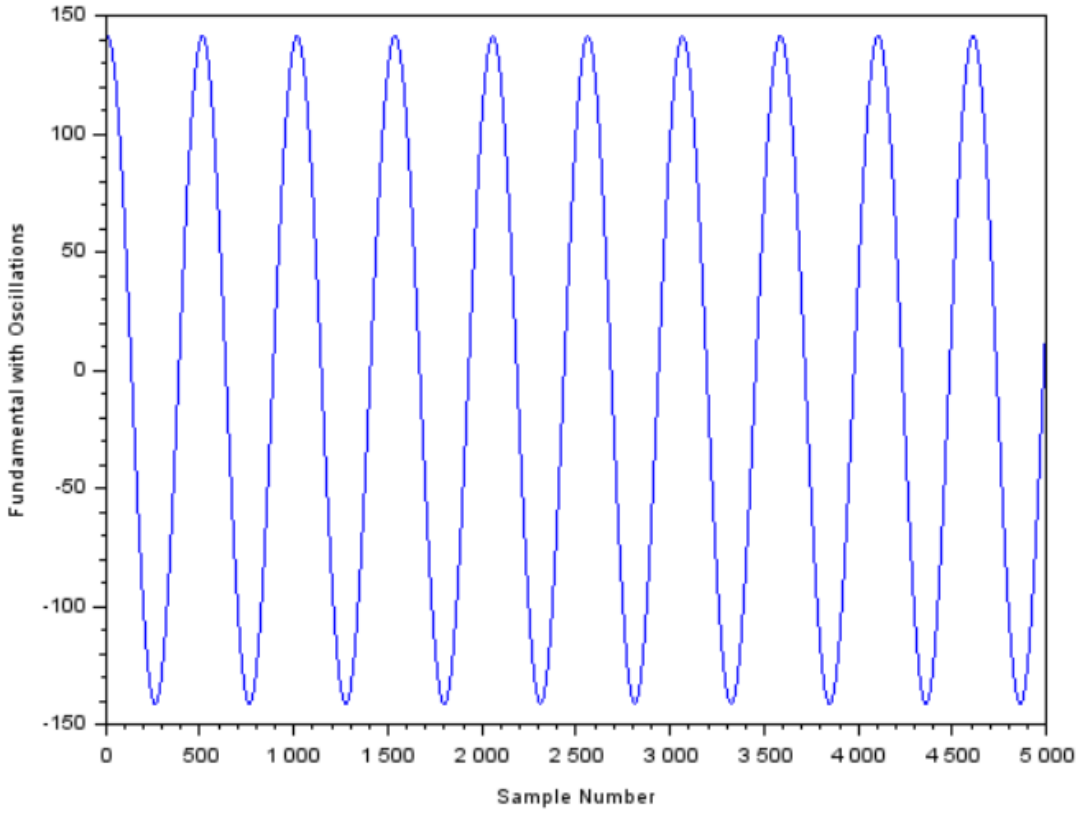
- Higher the oscillation frequency, lower the accuracy.
- Not merely an issue with low reporting rate.
- Modulating frequencies have a negative impact on the phasor measurement process.

2. Oscillations – Phase Modulation



PM





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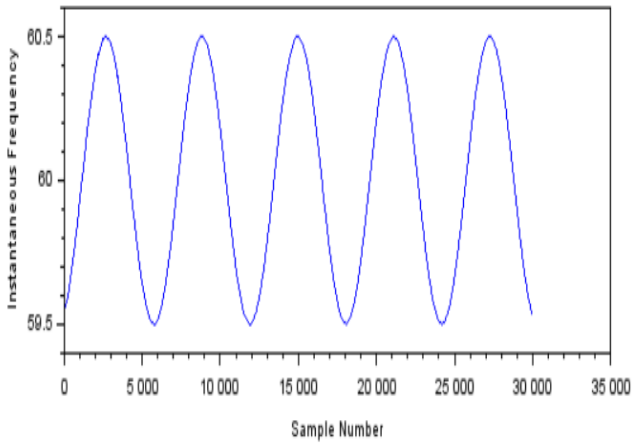
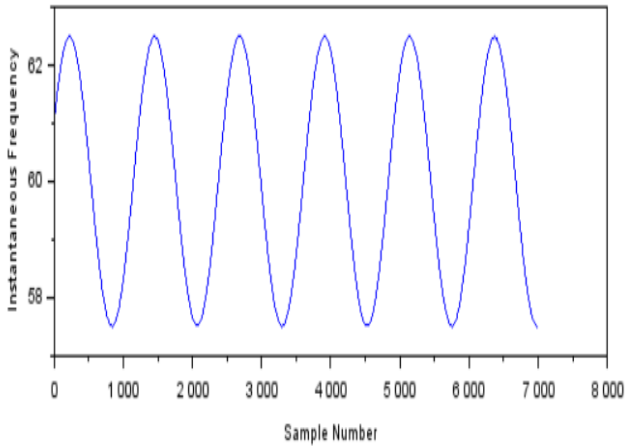
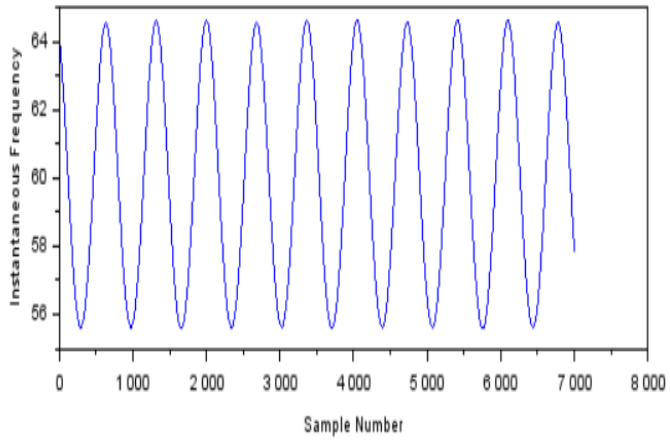
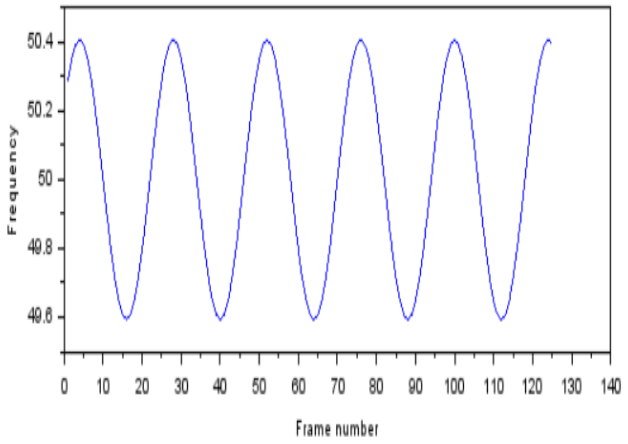
POW

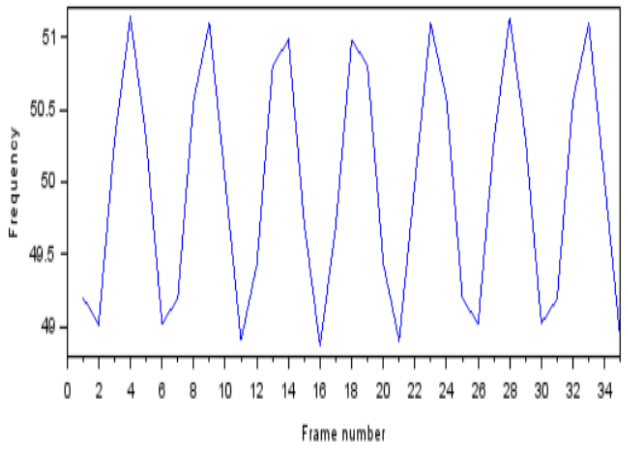


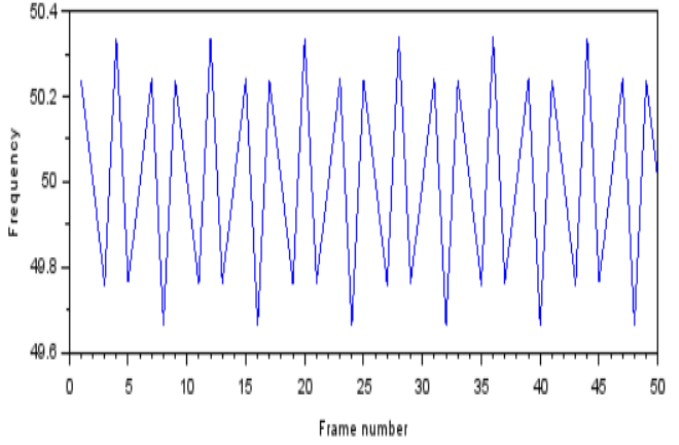




PMU







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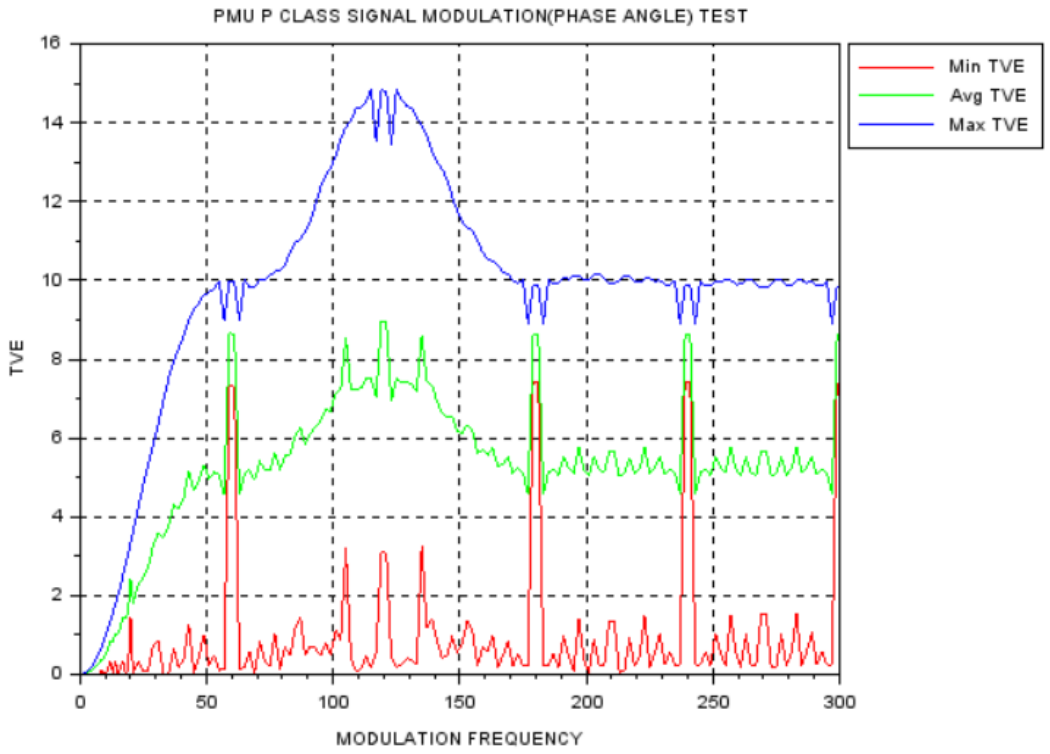
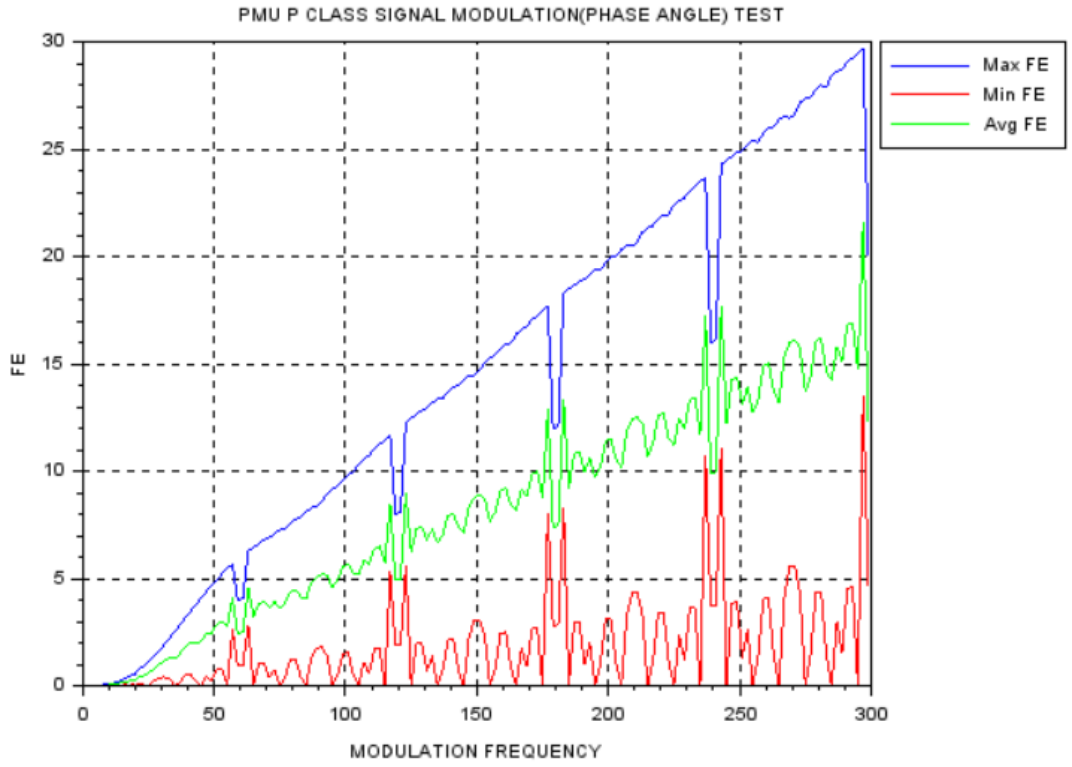
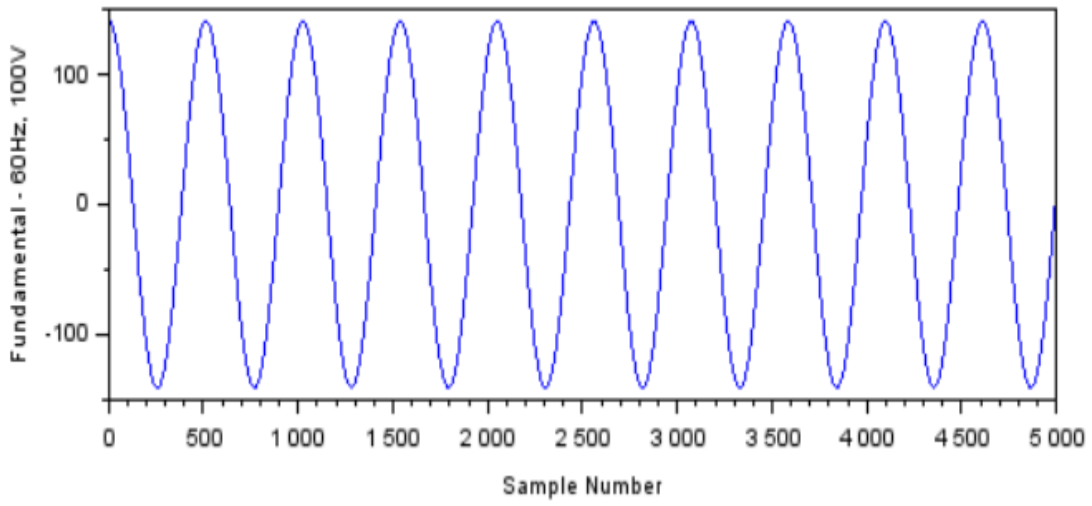




3. Sub-harmonics



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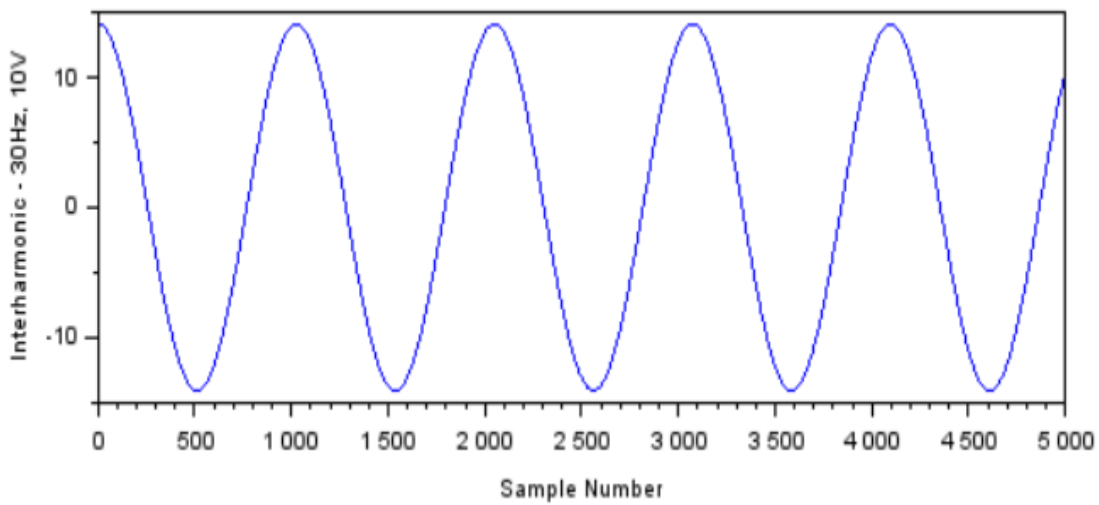

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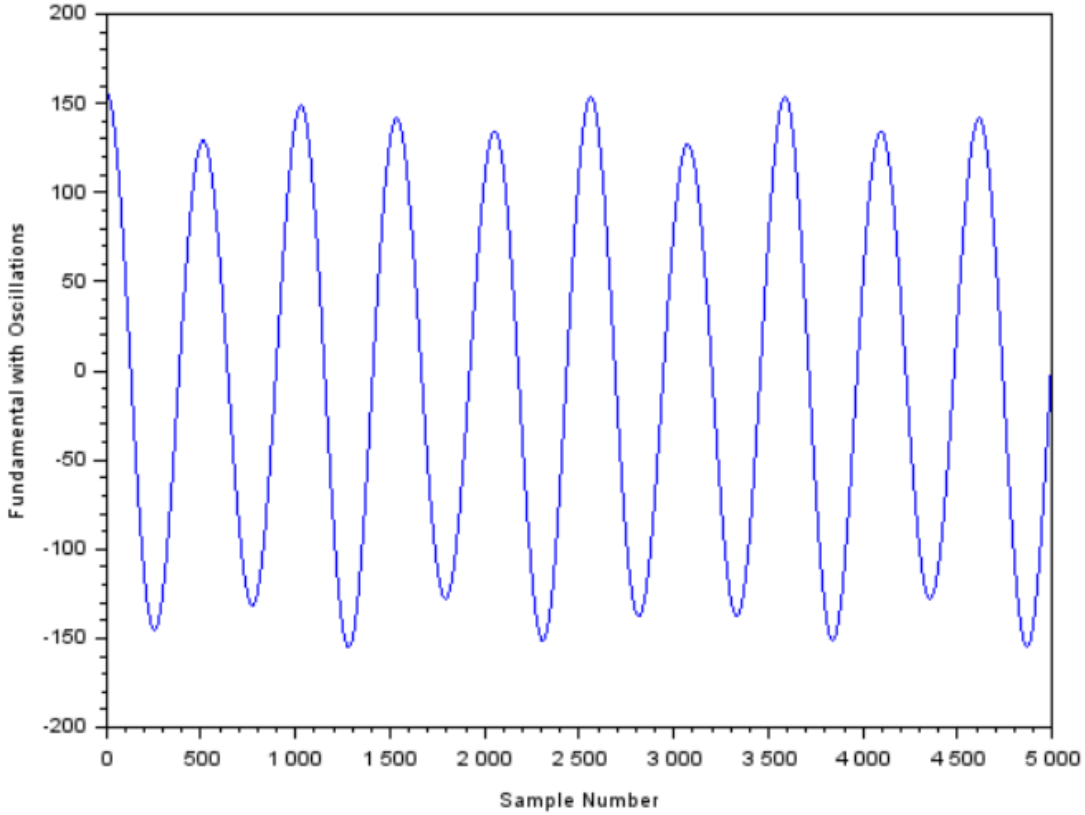

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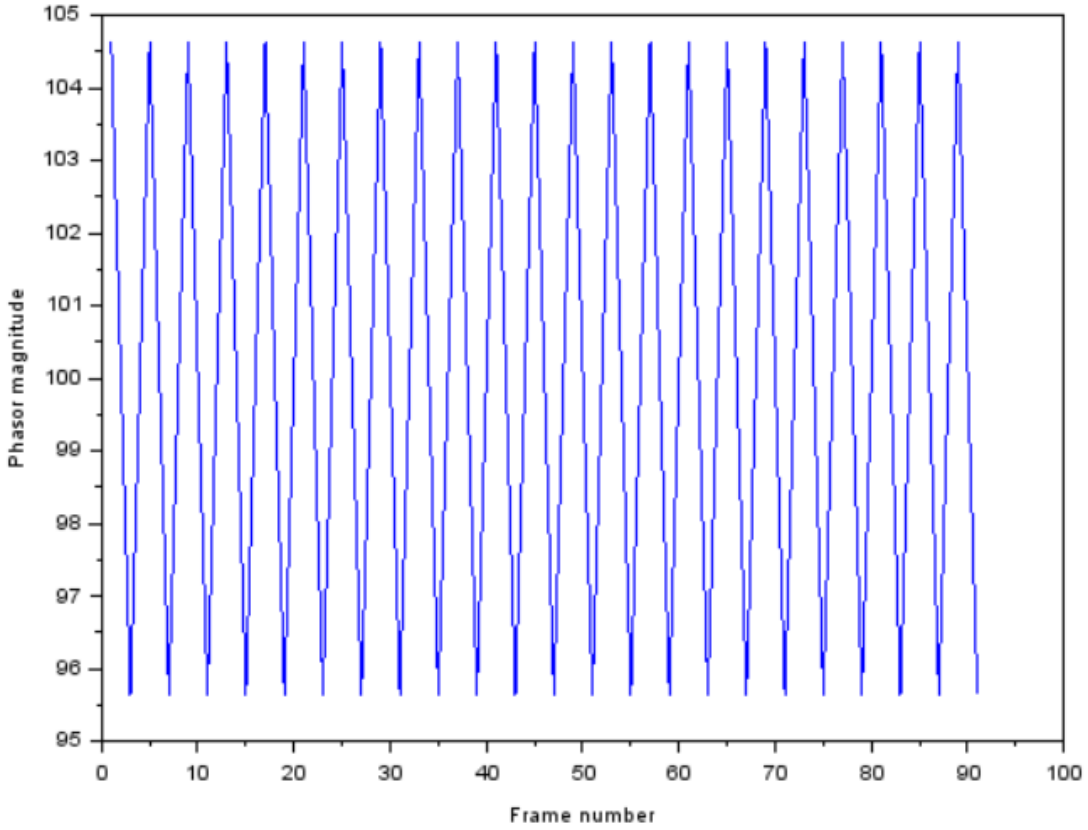
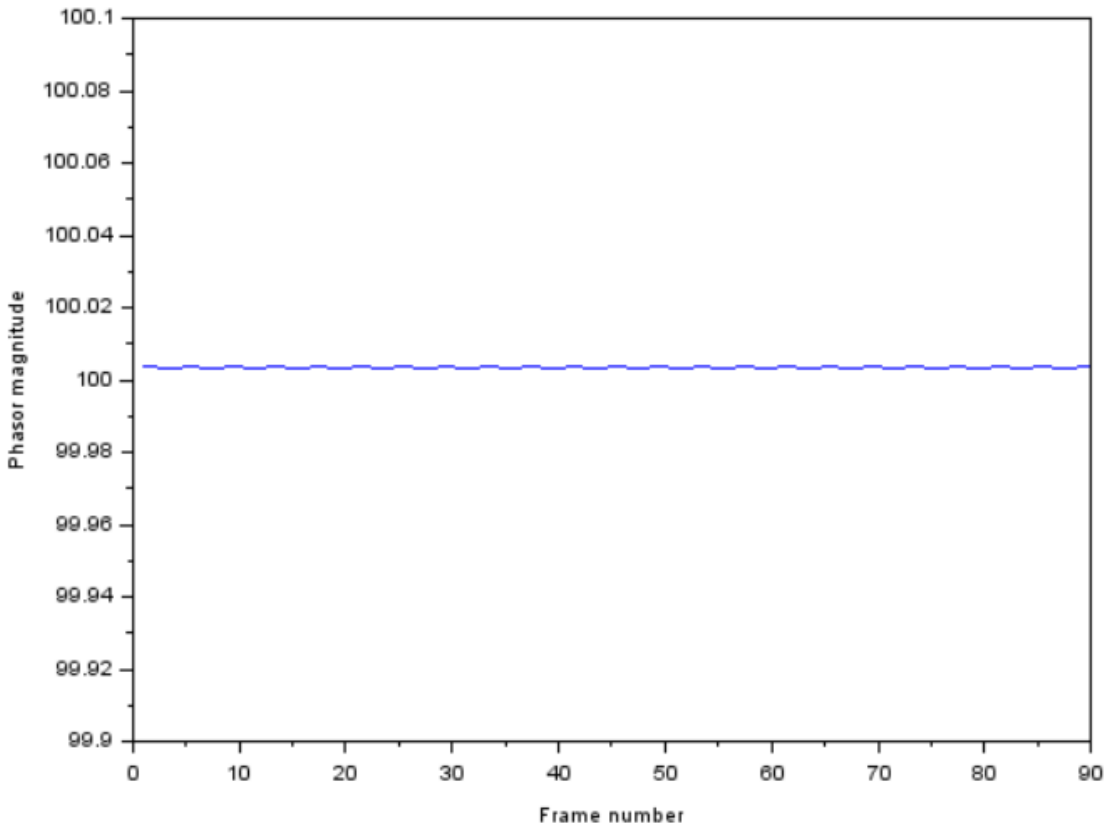


POW



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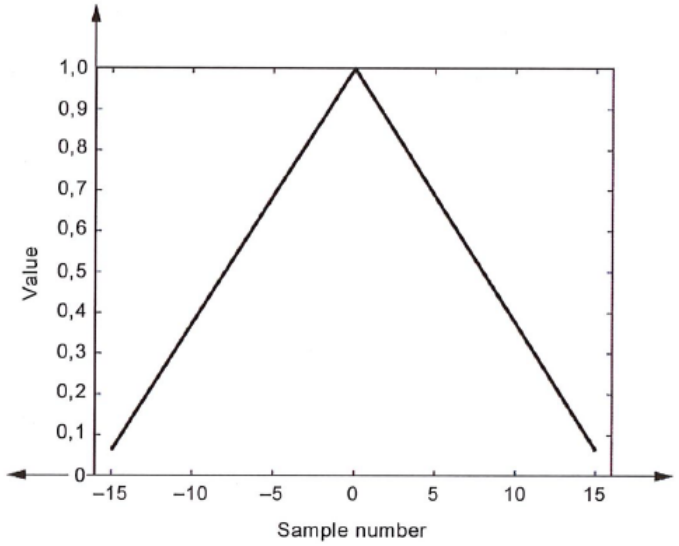
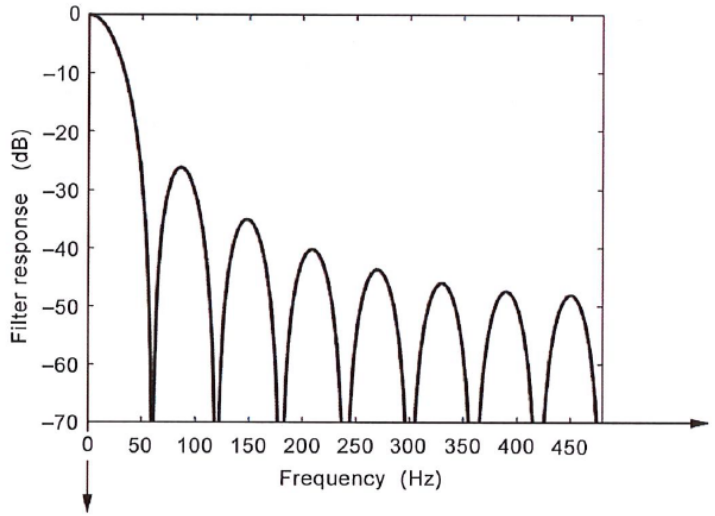


P Class filter coefficients



P Class filter response as a function of frequency

- Filter designed to attenuate harmonic components above nominal frequency.
- Fixed frequency filter (50/60 Hz) with magnitude compensation for off-nominal fundamental frequency.
- Presence of sub-harmonic frequencies has negative impact on oscillation analysis.

Conclusion

- Signal processing techniques play a vital role in the accurate & reliable analysis of power system phenomena.
- Phasors are good for certain applications & acceptable for others but not always suitable for every application.
- CPOW data coupled with application specific algorithms deliver higher quality results.
- Oscillation monitoring, especially with higher frequencies, is likely to benefit from signal processing methods dedicated for such applications rather than relying on phasor measurements alone.
- Volume of POW data has always been a concern. Hybrid architectures with local/on-device storage of CPOW data & selected streaming might address this, i.e. stream some but record all.