PMU Limitations in Monitoring Fast Dynamics in Low Inertia Systems

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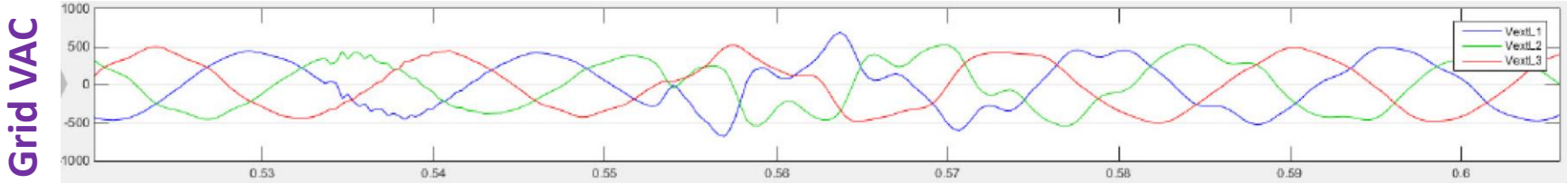
Background

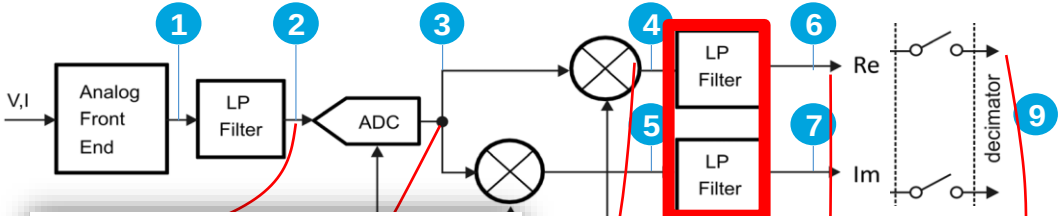
- The integration of IBRs results in unprecedented grid dynamics

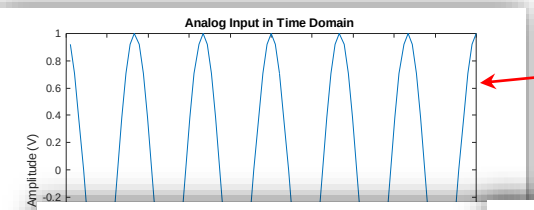


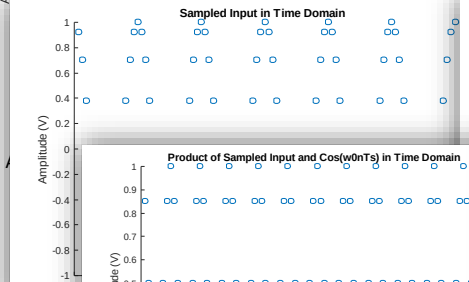
Recommended Disturbance Monitoring for Inverter-Based Resources, NERC SMS White Paper, November 2018

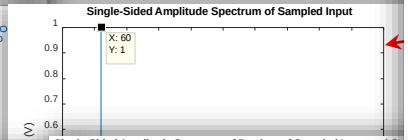
- Accurate and high-resolution monitoring of the dynamics is needed to ensure the grid reliability and security
- PMUs provide a potential solution given their high resolution
- However, there are limitations with respect to the accuracy of the output Synchrophasors, due to the PMU internal signal processing
- Therefore, the performance of the Synchrophasor-based monitoring and control applications might be compromised

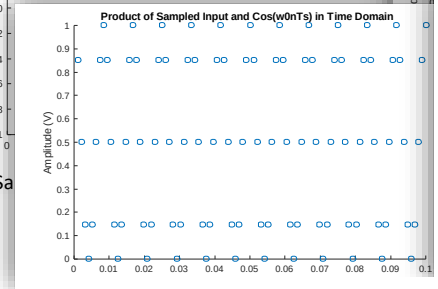
How PMU Internal Signal Processing Works (IEEE Model)?



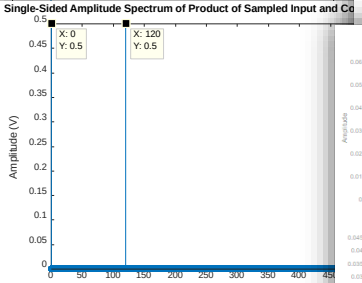




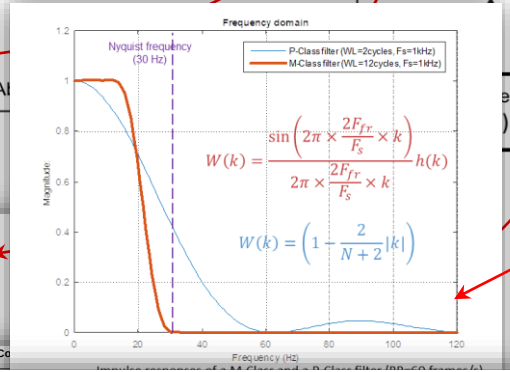


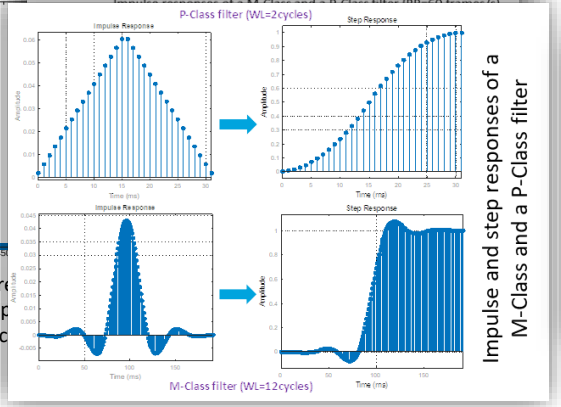


Real part of the product of the multiplicator of the sampled input signal with the nominal frequency carrier

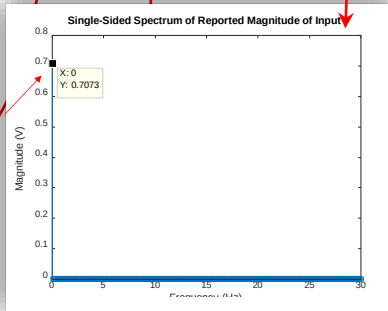


Frequency spectrum of the re multiplication of the sampled inp nominal frequency c

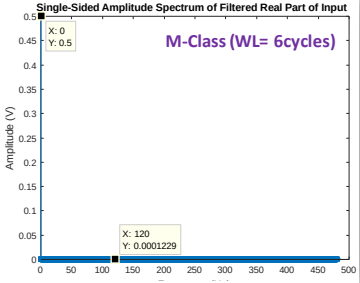




Impulse and step responses of a M-Class and a P-Class filter

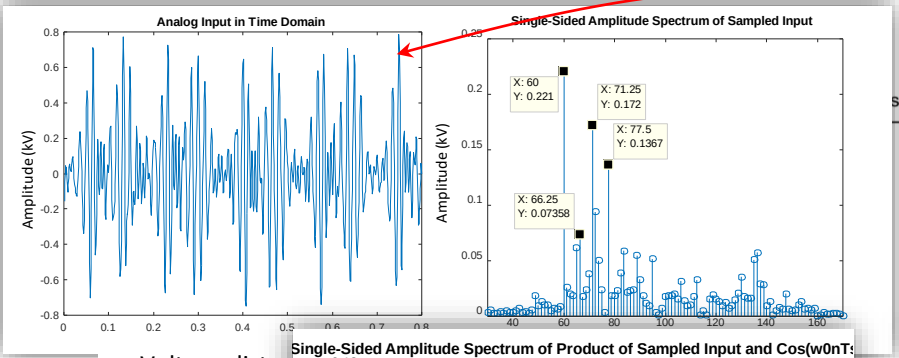


Filtered magnitude versus reported magnitude of the input signal

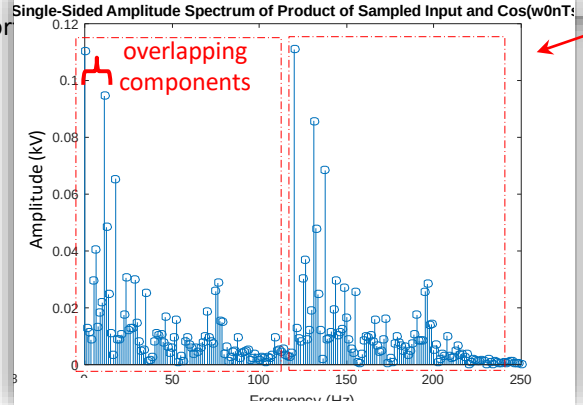


Filtered real part of the input signal

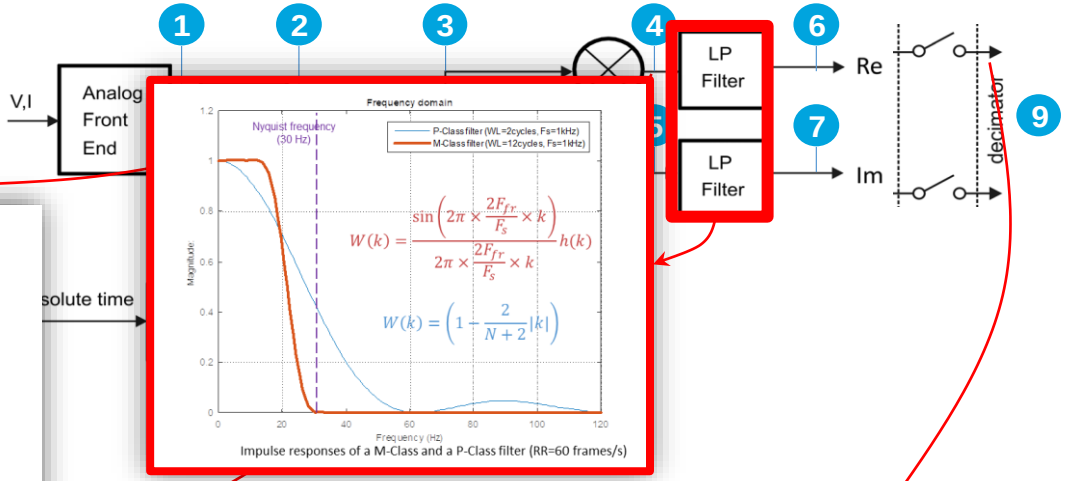
PMU (IEEE Model) Limitations in Processing a Rich Frequency Signal

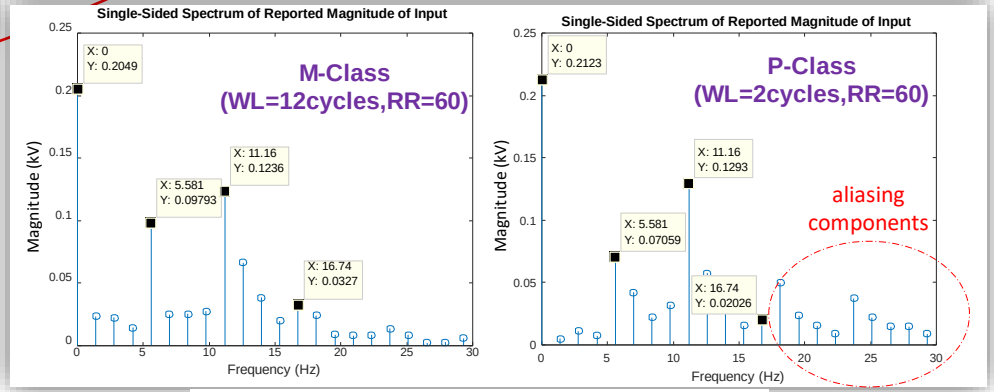


Voltage distor



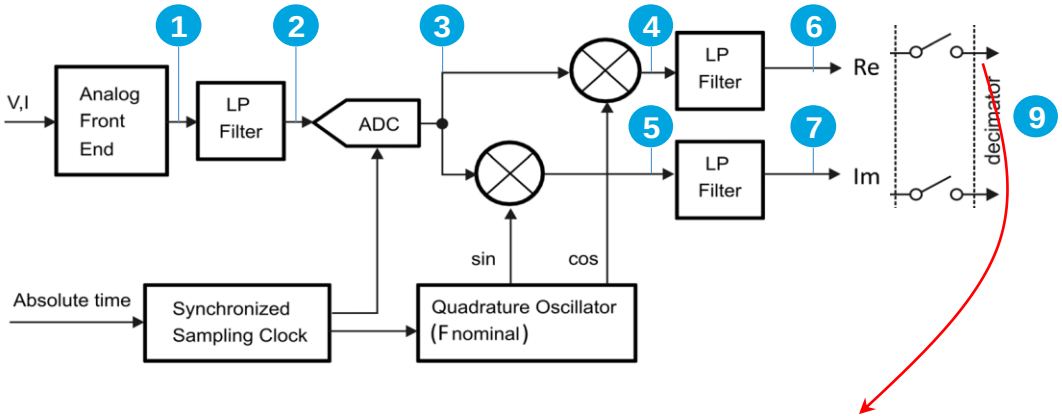
Real part of the product of the multiplication of the sampled input signal with the nominal frequency carrier

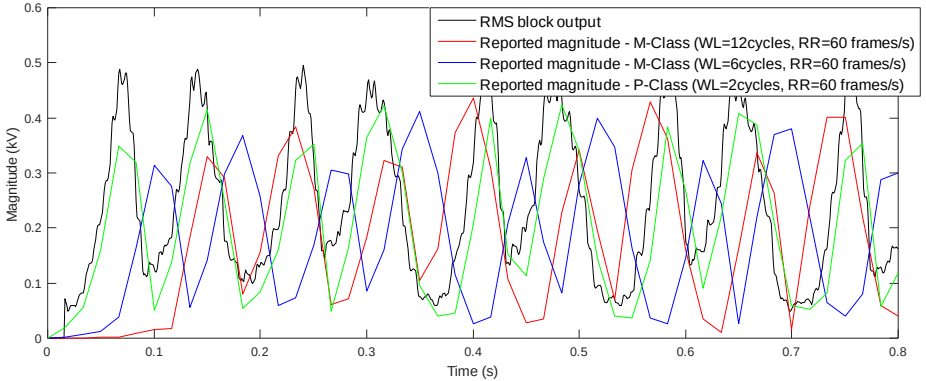




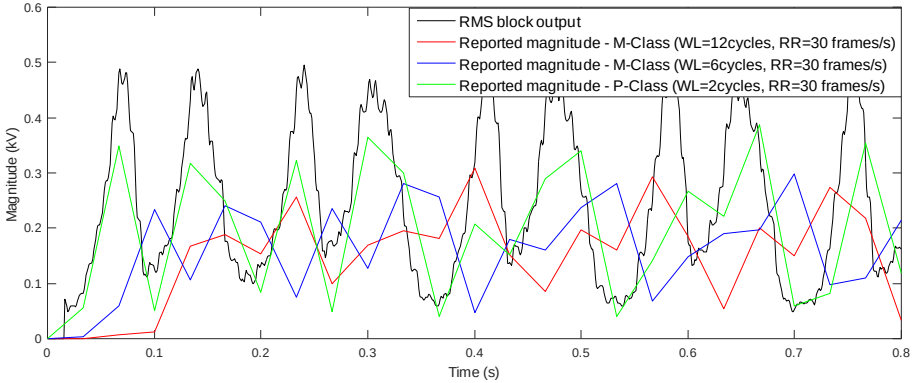
Reported magnitude of the input signal

PMU (IEEE Model) Limitations in Processing a Rich Frequency Signal





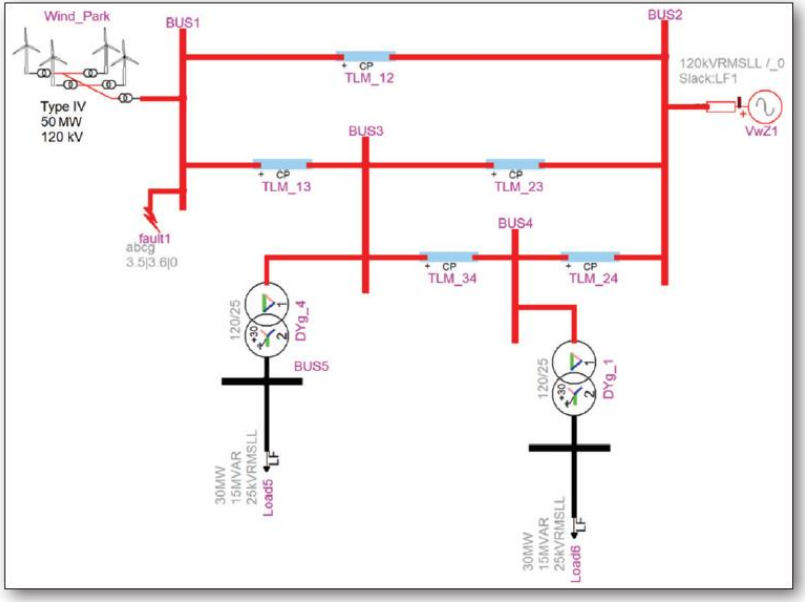
PMU reported magnitude (RR=60 frames/s) versus true RMS of input signal

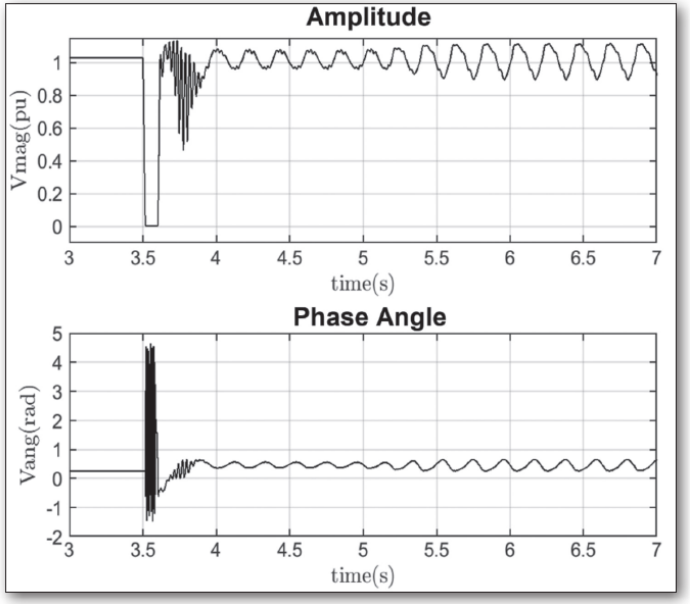


PMU reported magnitude (RR=30 frames/s) versus true RMS of input signal

PMU (IEEE Model) Limitations in Monitoring Fast Dynamics in Low Inertia Systems

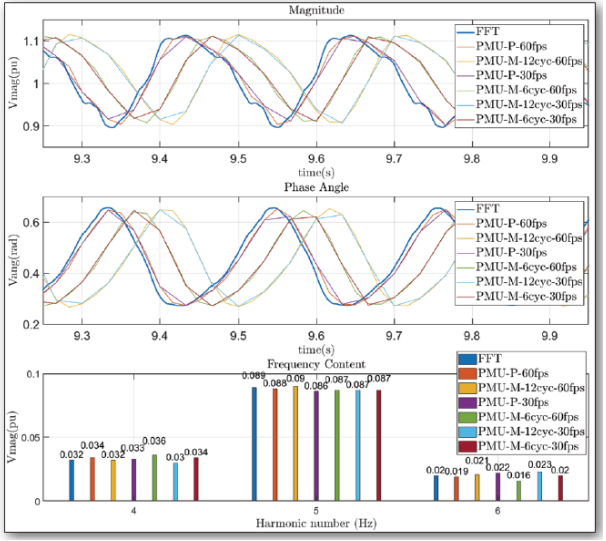
- A temporary threephase-to-ground fault on BUS1 followed by the outage of the line from BUS1 to BUS2 leads to an inverter instability manifesting itself as oscillations in the amplitude and phase angle of system voltages
- The frequency of these oscillations depends on the inverter control parameters





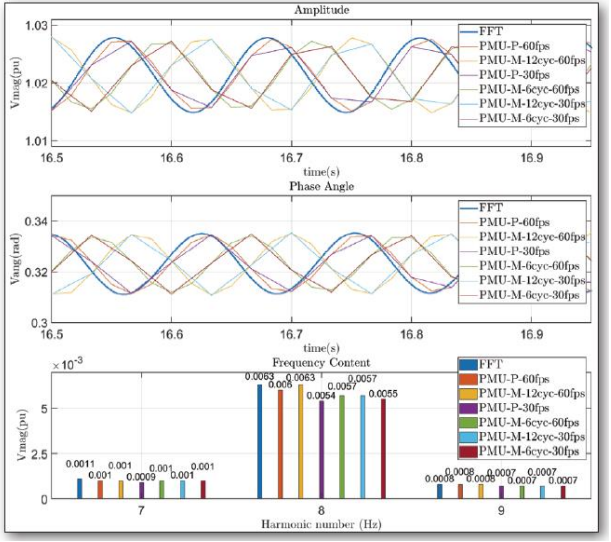
PMU (IEEE Model) Limitations in Monitoring Fast Dynamics in Low Inertia Systems

5Hz



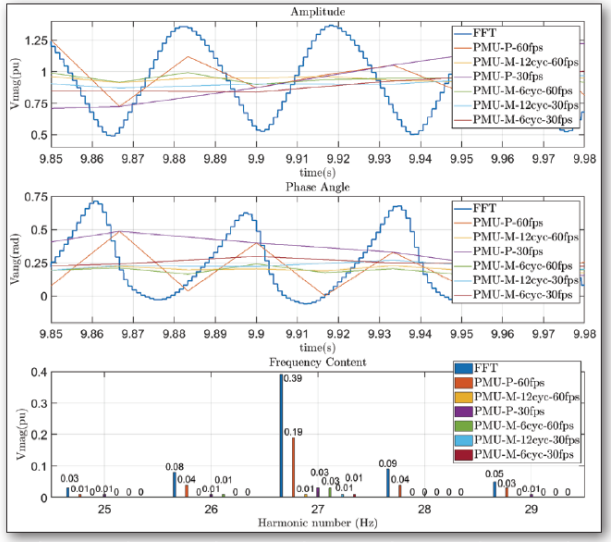
P60	P30	M60 12cyc	M60 6cyc	M30 12cyc	M30 6cyc
98%	96%	100%	97%	97%	97%

8Hz



P60	P30	M60 12cyc	M60 6cyc	M30 12cyc	M30 6cyc
95%	85%	100%	90%	90%	87%

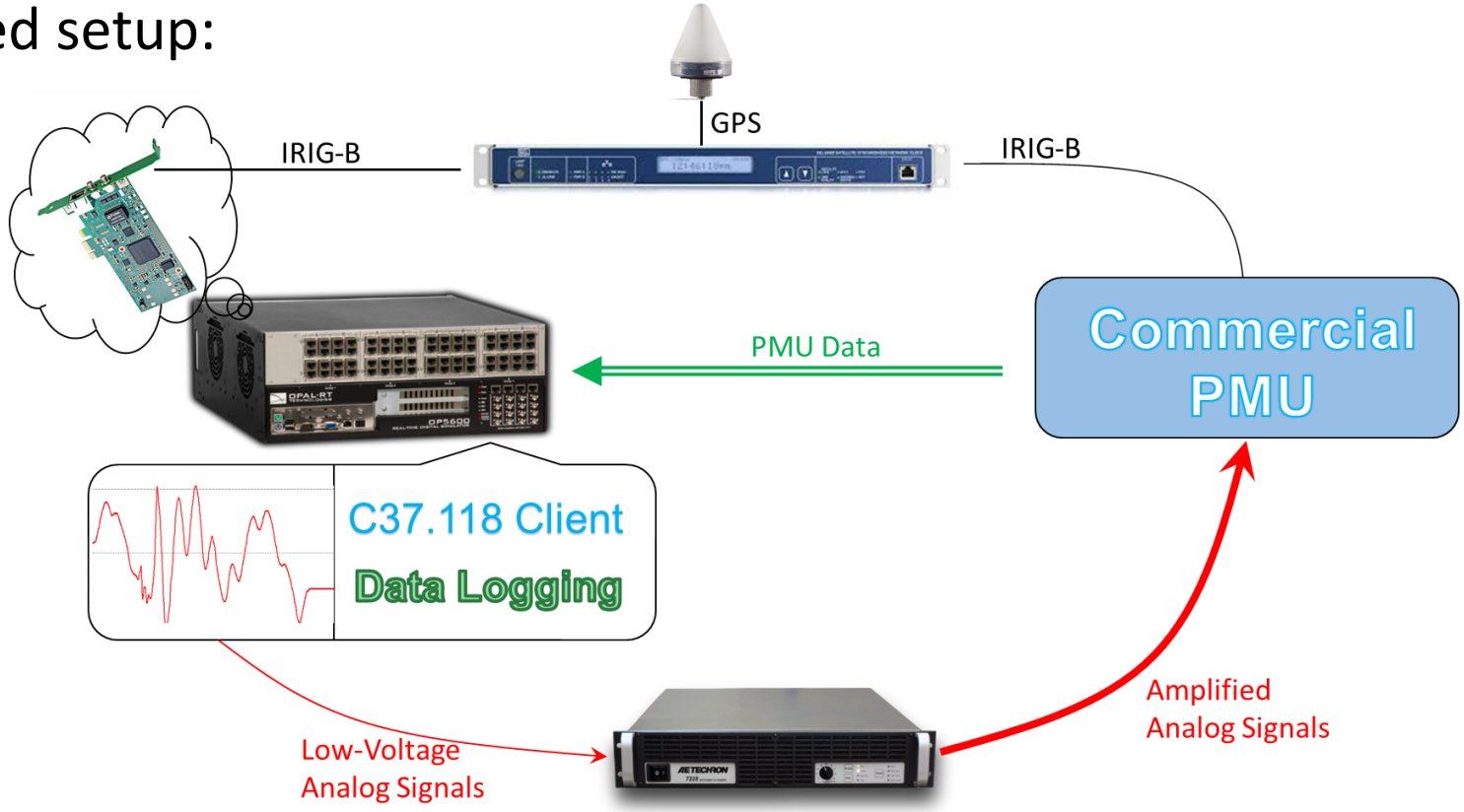
27Hz



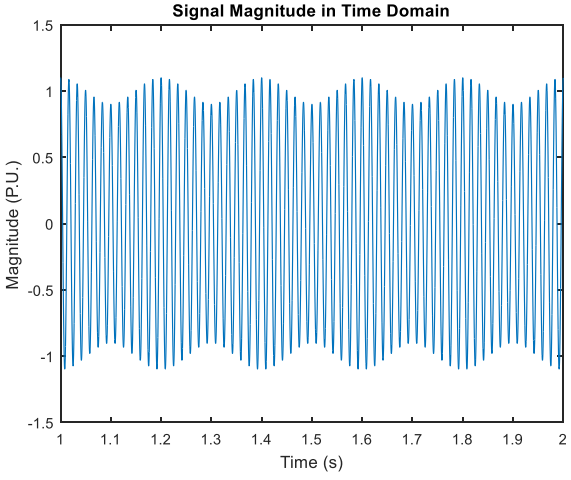
P60	P30	M60 12cyc	M60 6cyc	M30 12cyc	M30 6cyc
48%	0%	2%	2%	0%	0%

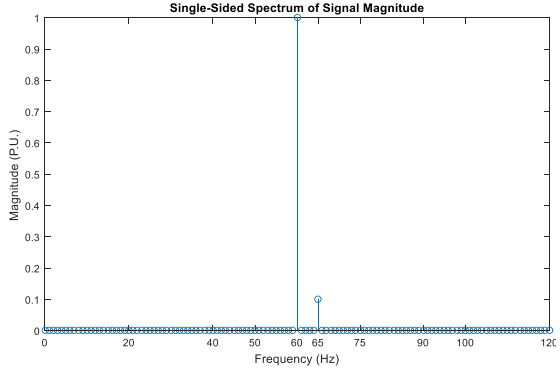
PMU (Vendor Model) Limitations in Monitoring Fast Dynamics

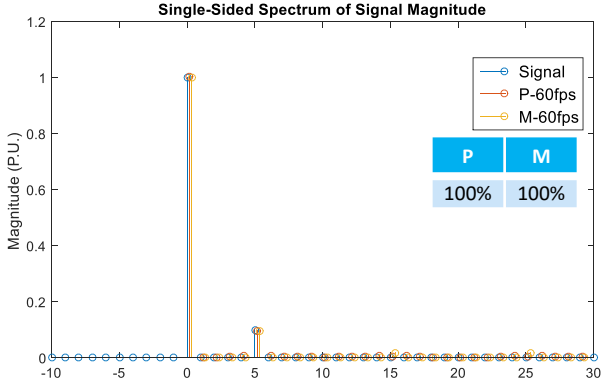
- Testbed setup:



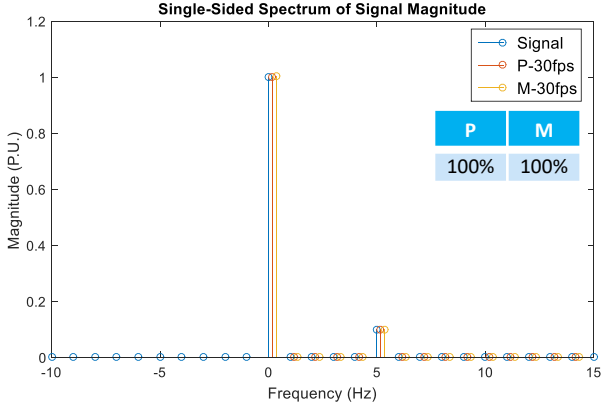
Fundamental Freq + 5 Hz



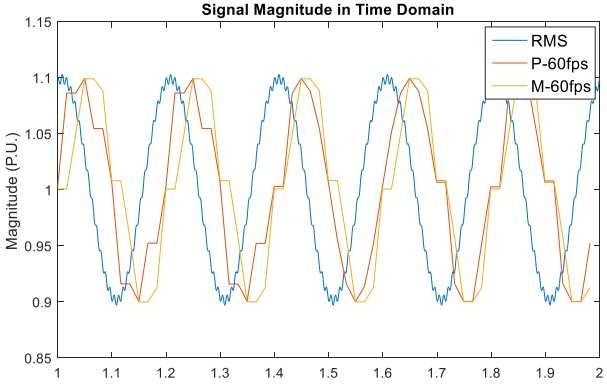


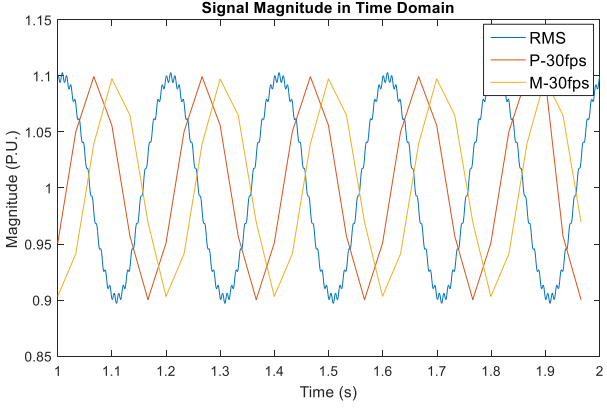


P	M
100%	100%

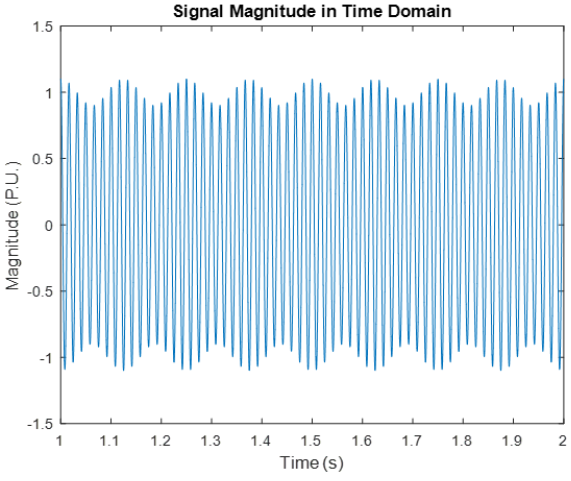


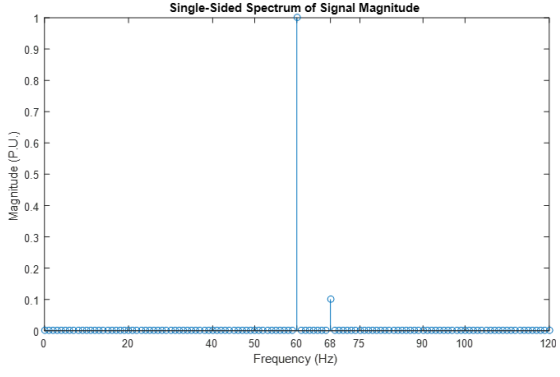
P	M
100%	100%

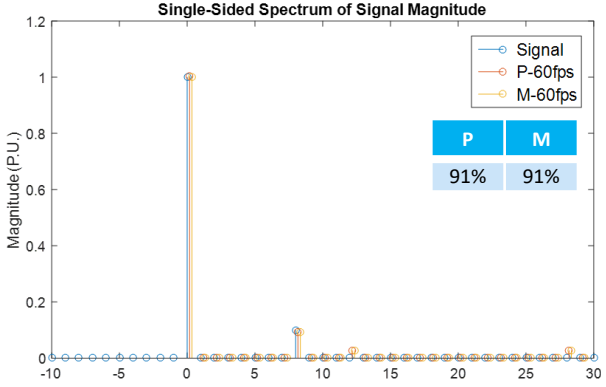




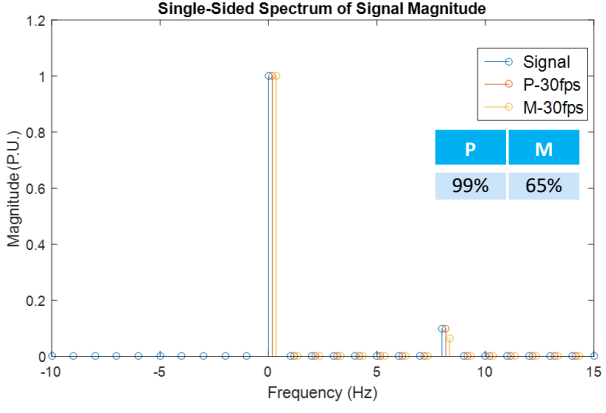
Fundamental Freq + 8 Hz



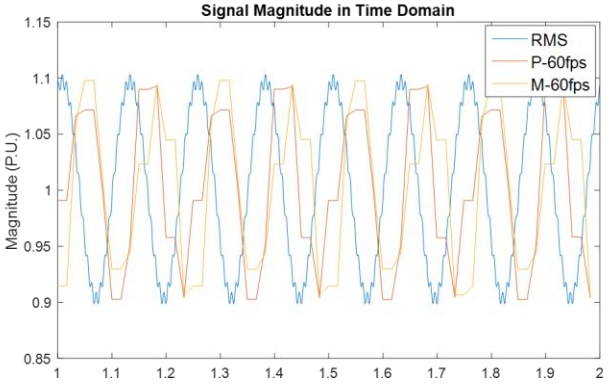


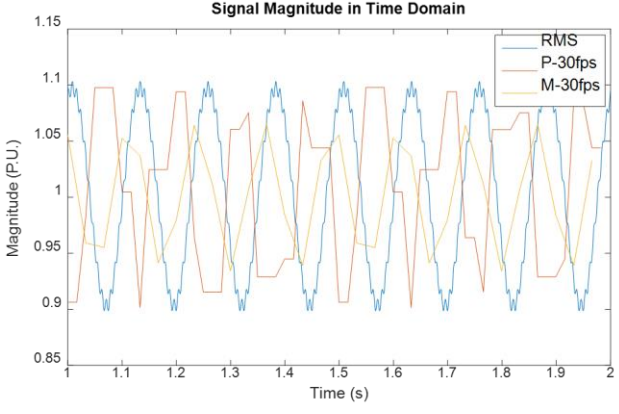


P	M
91%	91%

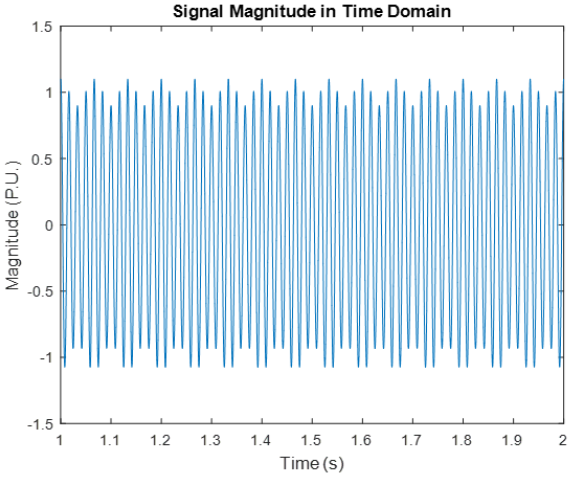


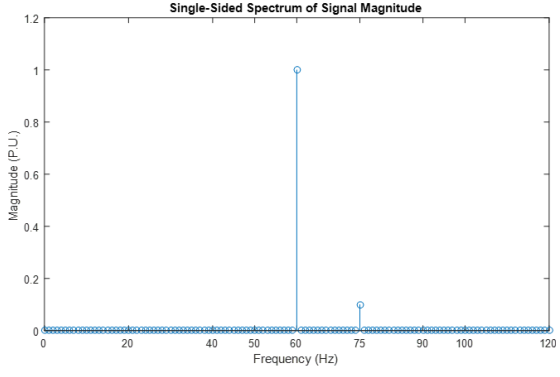
P	M
99%	65%

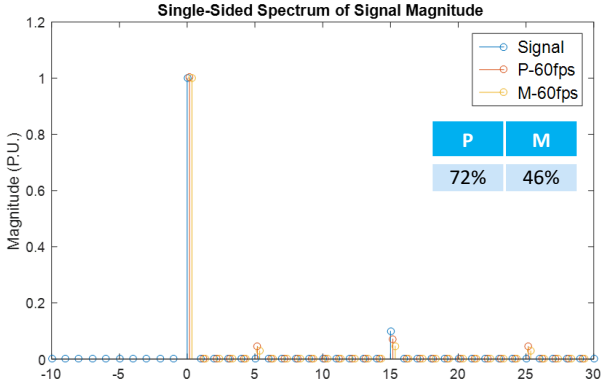




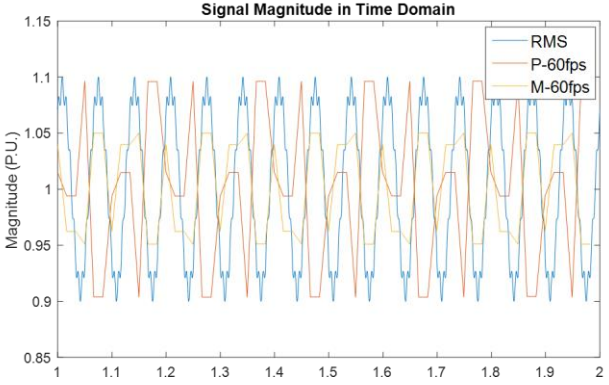
Fundamental Freq + 15 Hz

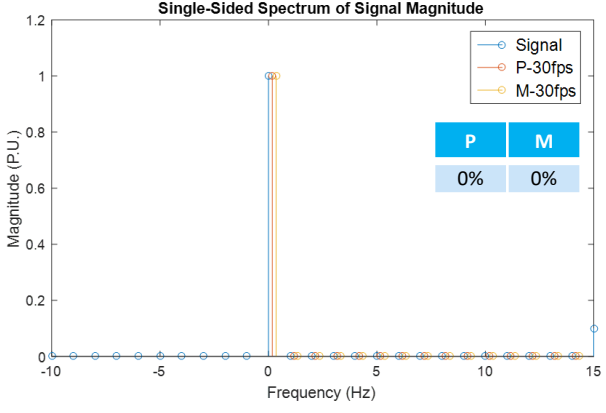




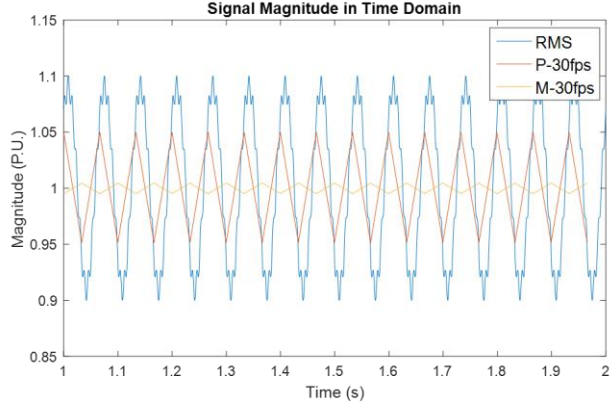


P	M
72%	46%

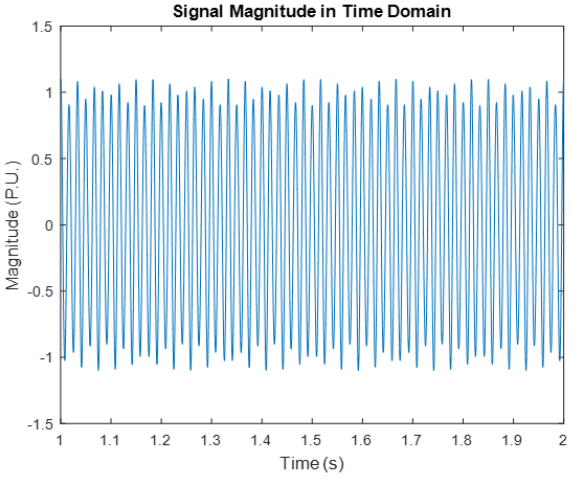


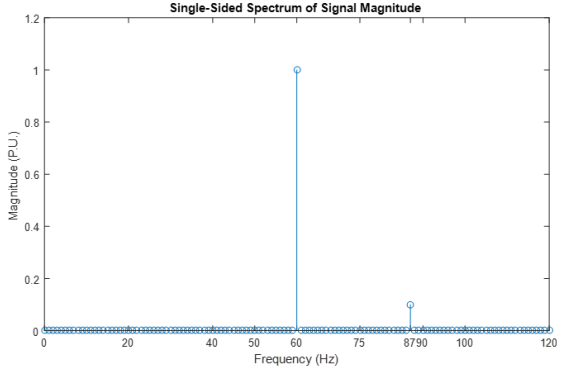


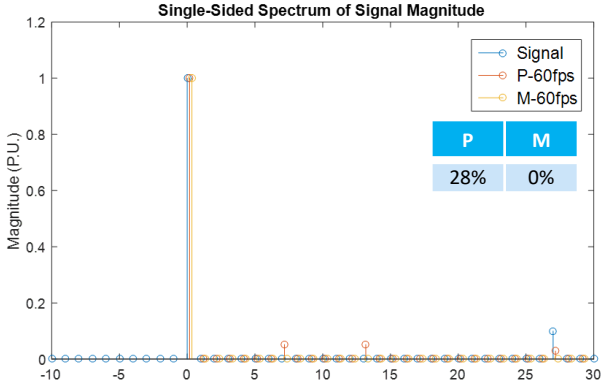
P	M
0%	0%



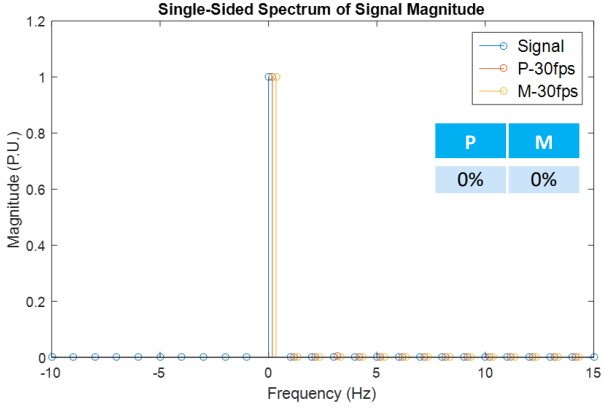
Fundamental Freq + 27 Hz



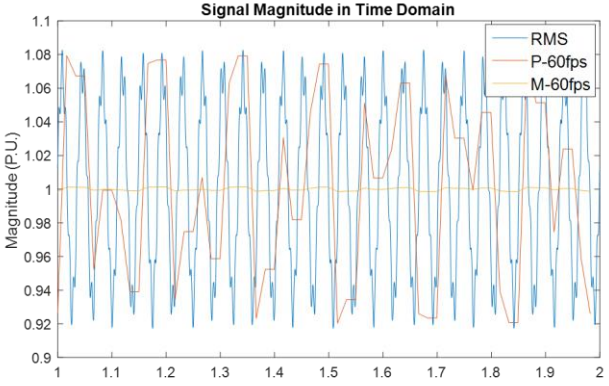


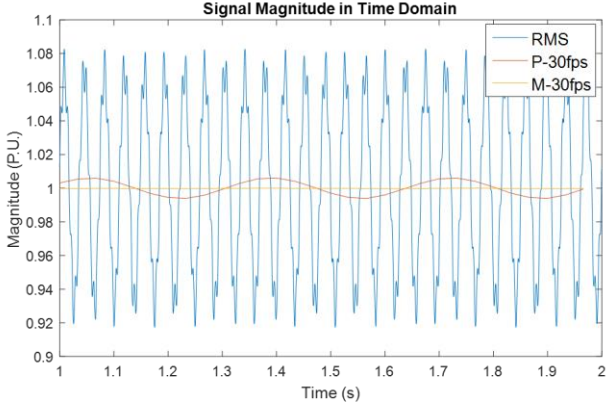


P	M
28%	0%

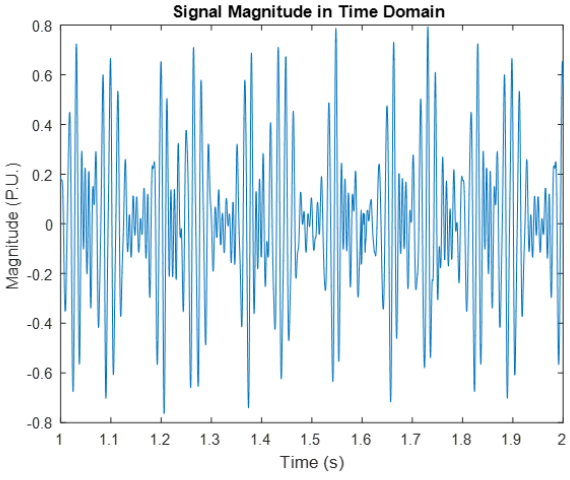


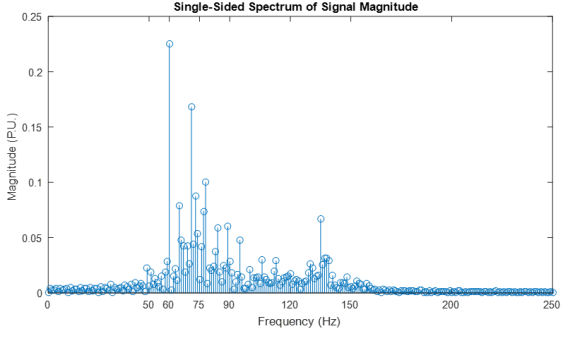
P	M
0%	0%

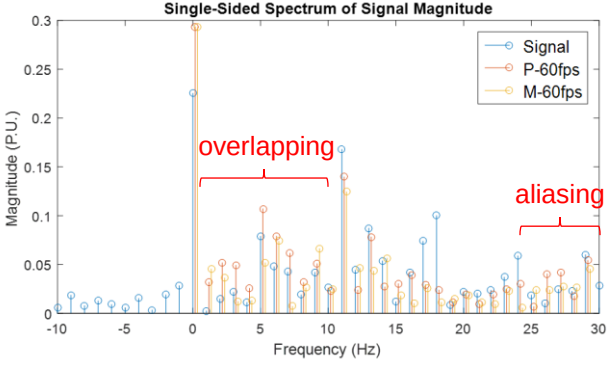


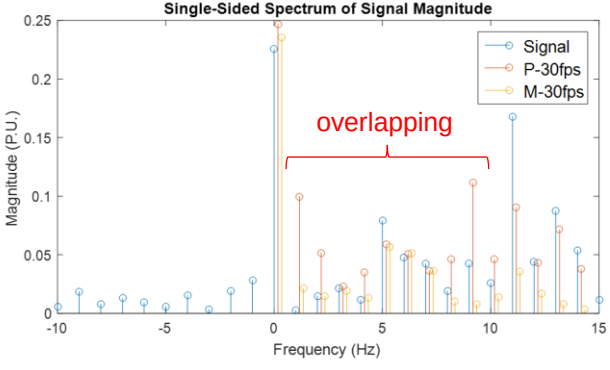


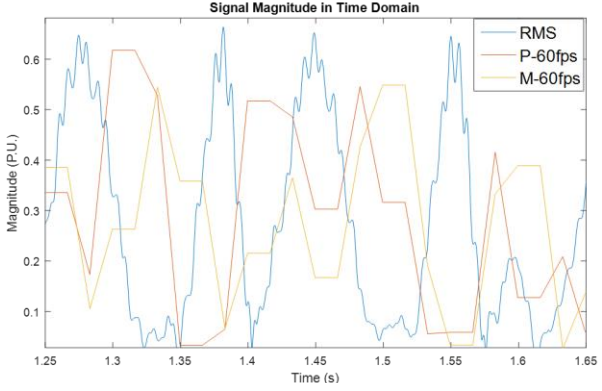
Rich Frequency Signal

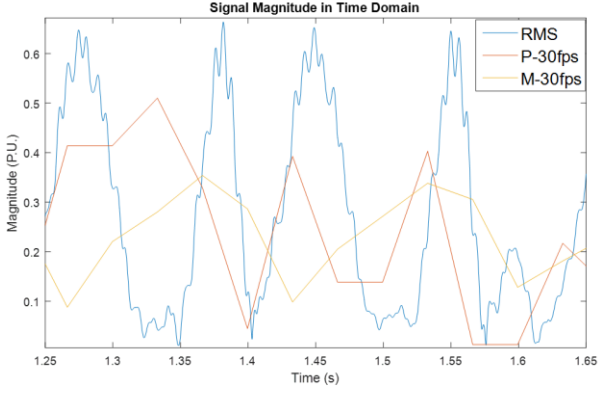






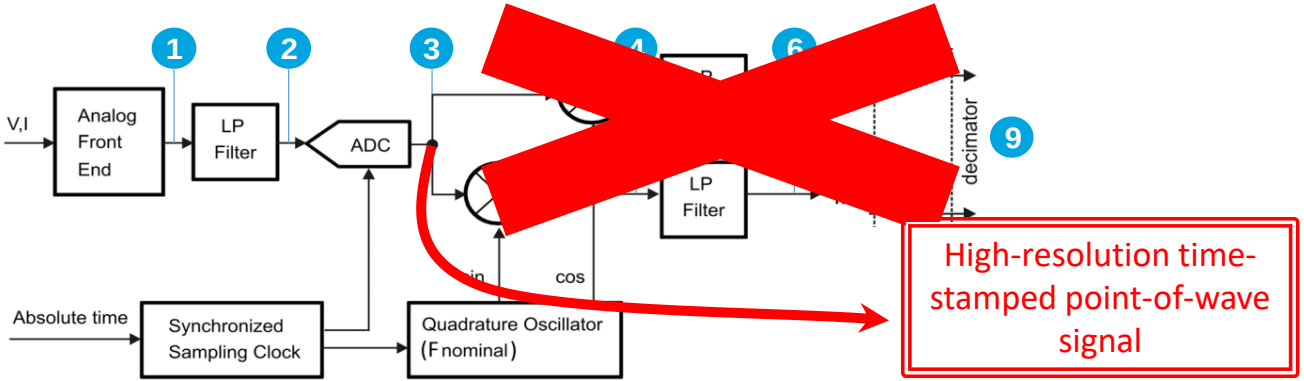






Point-on-Wave Signals for Monitoring Fast Dynamics

- PMU was originally designed to report the power system state (the phasor of the fundamental frequency)
- There exist some limitations on the range of frequencies that the PMU signal processing can handle.
- Hence, a new signal processing model is required to report the full frequency content of the input signal



Thank you!

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Together…Shaping the Future of Electricity