

Amplitude Resonance Tracking Using PLL and ESC for Nonlinear Systems

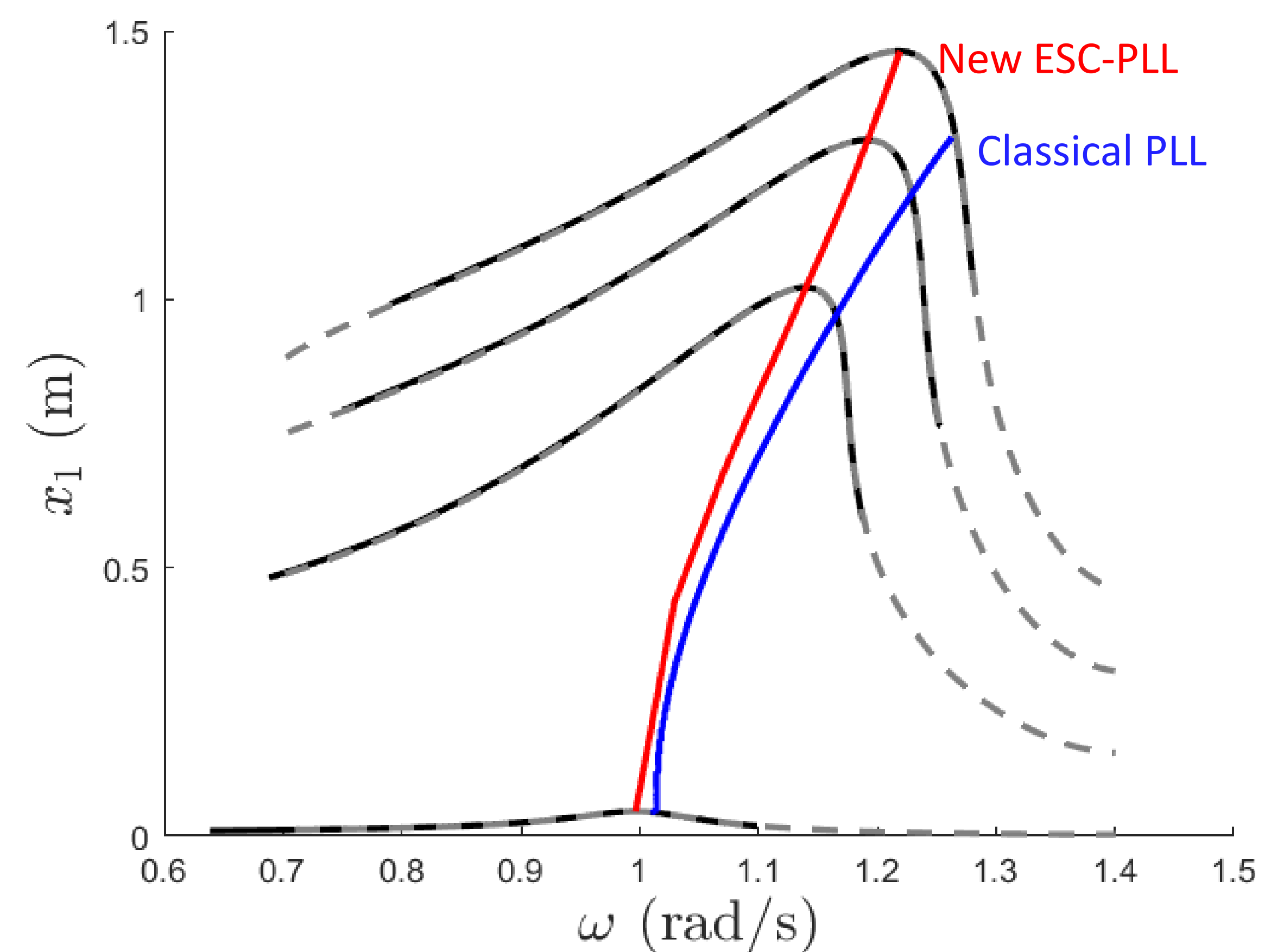
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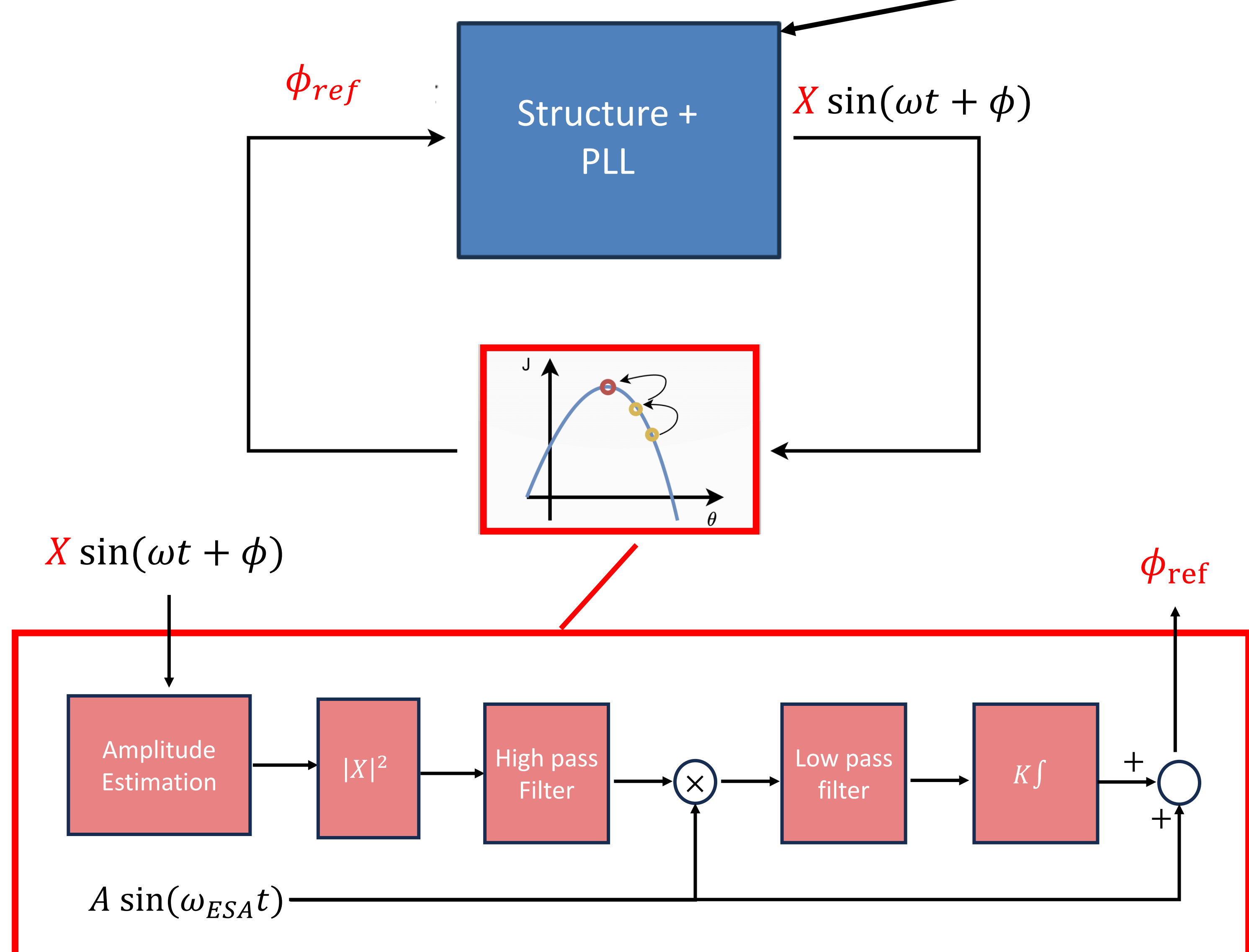
Motivation

- Tracking maximum amplitude is often required in nonlinear dynamics and fatigue testing.
- Amplitude** and **phase** resonance may diverge due to **damping** and/or **closely spaced modes**.
- Classical **Phase-Locked Loops (PLLs)** typically track **phase quadrature**, not the actual amplitude peak.
- As a result, amplitude resonance may be missed during testing.

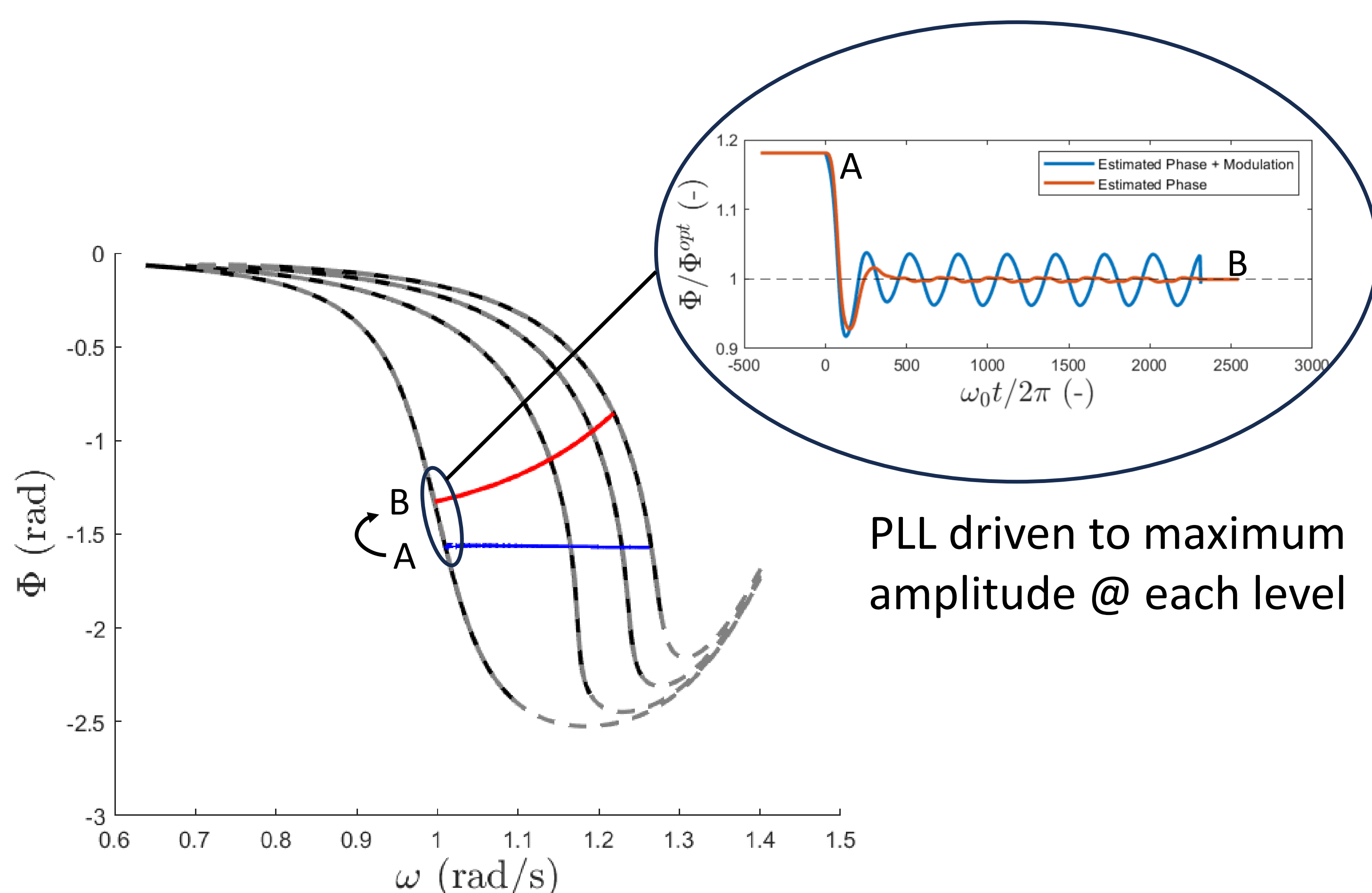


Extremum Seeking Control driven PLL (ESC-PLL)

- New, additional layer for maximum amplitude tracking.



ESC: Perturbation-based *online* response amplitude maximization

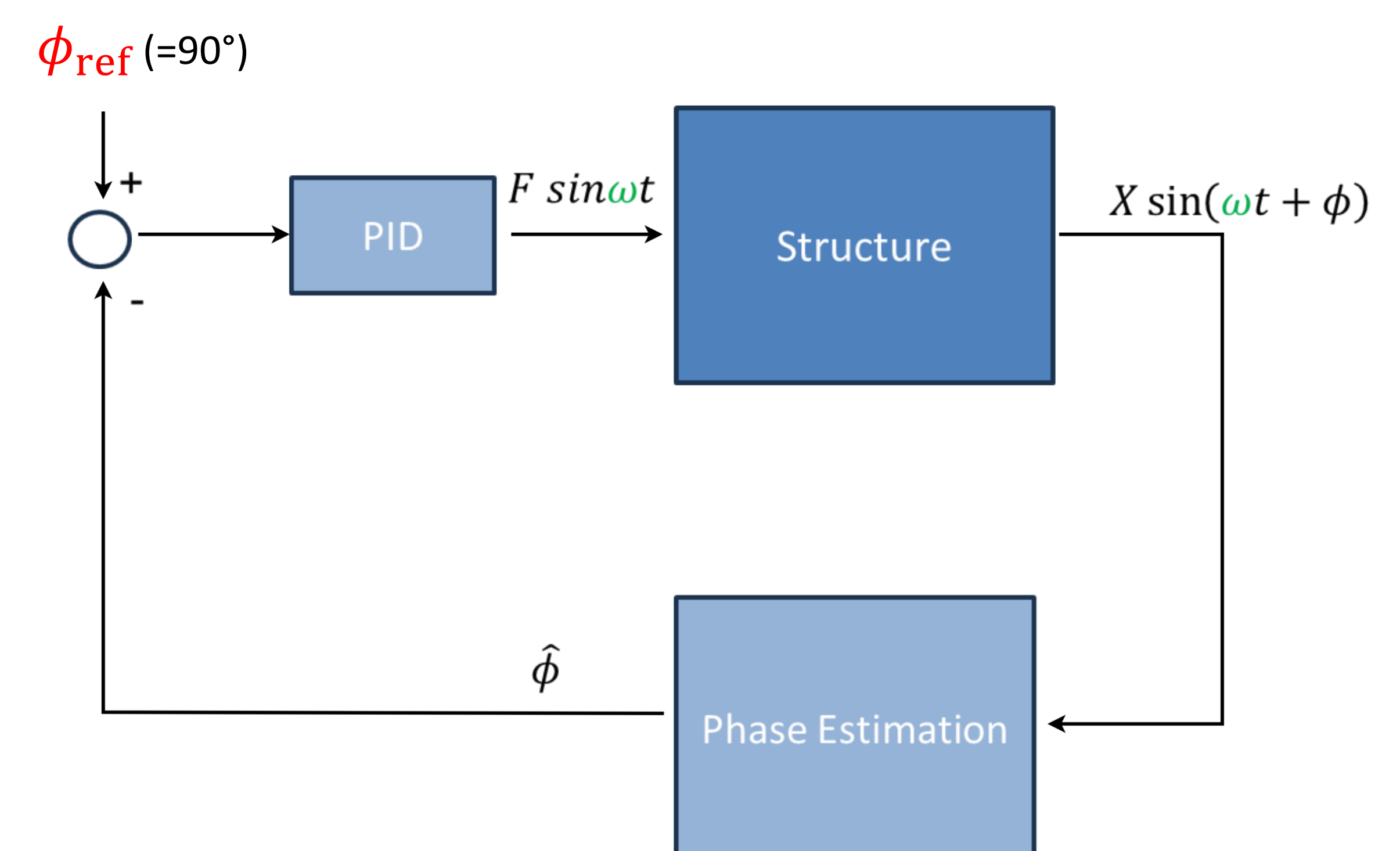


PLL driven to maximum amplitude @ each level

→ **Amplitude** backbone curve

Phase Locked Loop (PLL)

- State of the art method for resonance tracking.



- Phase quadrature enforced by PID Control.
- Backbone curve obtained by ↗ excitation level.

What's next ?

- Robust and systematic PLL-ESC control gains selection
- New optimization schemes for *faster* optimization
- Experimental validation : phase vs amplitude backbone

References

- Hippold, Patrick, Maren Scheel, Ludovic Renson, and Malte Krack. "Robust and Fast Backbone Tracking via Phase-Locked Loops." *Mechanical Systems and Signal Processing* 220 (November 1, 2024): 111670.
- T. Zhou, G. Raze, G. Kosova, and G. Kerschen. "Experimental Nonlinear Modal Analysis of an F-16 Aircraft using Phase-locked Loop Control." *Journal of Aircraft* (2025).
- Ariyur, Kartik B., and Miroslav Krstić. *Real-Time Optimization by Extremum-Seeking Control*. Hoboken, New Jersey: Wiley, 2003.

