Local rational approximation with prescribed poles for improved frequency response function identification

ERNSI 2019

ADVANCED THERMAL CONTROL CONSORTIUM

EINDHOVEN UNIVERSITY OF TECHNOLOGY

Local Rational Approximation with Prescribed Poles for Improved Frequency Response Function Identification

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Industrial Challenge [1,2]

- Accuracy deteriorated by thermally induced deformations
- Towards active thermo-mechanical control

High Fidelity Thermo-Dynamical Modeling:

- Error compensation
- Active control

Challenge in Thermal System Identification:

$$Y(k) = G(e^{i\omega_k})U(k) + \underbrace{T(e^{i\omega_k})}_{\text{transient}} + V(k)$$

Time Constants

- Mechanical: $\mathcal{O}(1\text{ s})$
- Thermal: $\mathcal{O}(1000\text{ s})$

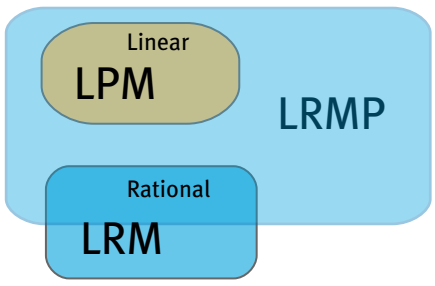
$\times\,1000$

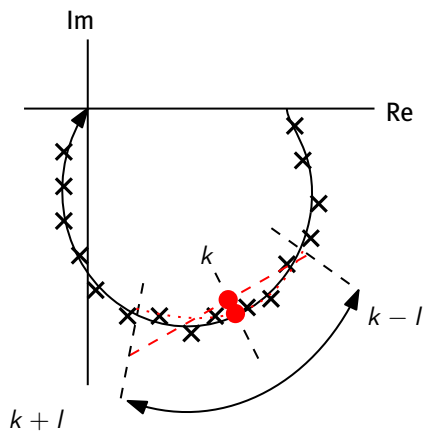
Time constant of transient $\times 1000$!

Local Method with Pre-Scribed Poles [4]

Local Parametric Modeling:

- Local Polynomial Method (LPM)
- Local Rational Method (LRM) [3]



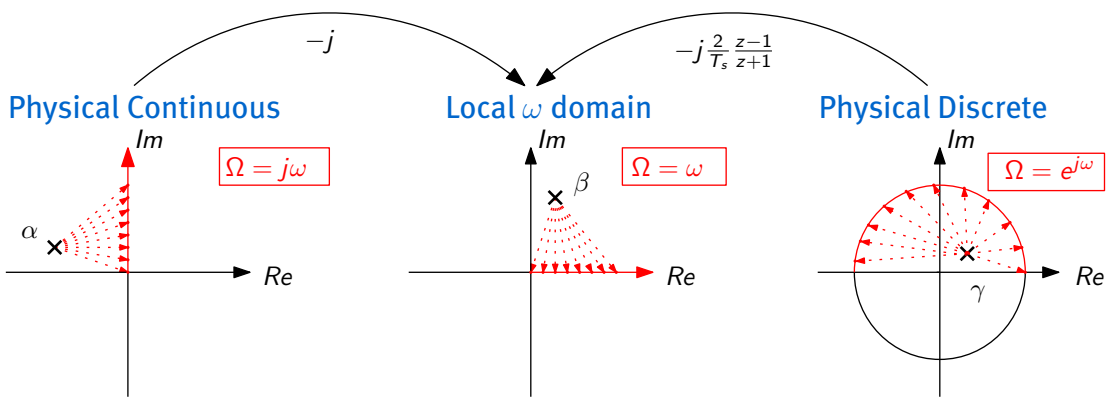


Local Rational Method with Prescribed Poles (LRMP)

$$G(\Omega_\omega) = \sum_{b=0}^{N_b} \theta_G(b,k)\Psi(b,\omega)$$
$$T(\Omega_\omega) = \sum_{b=0}^{N_b} \theta_T(b,k)\Psi(b,\omega)$$

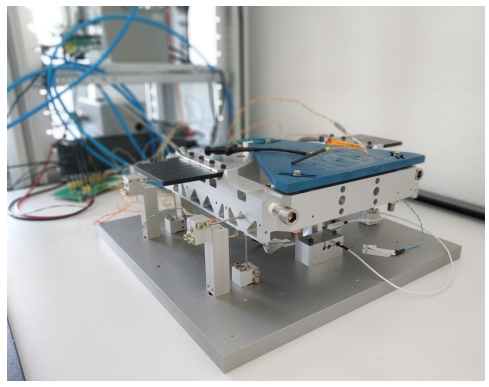
Key Mechanism: Include poles in Ψ to remain linear in the parameters

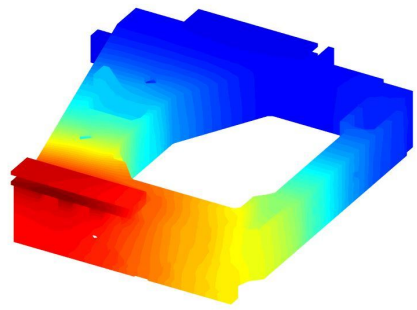
How to incorporate prior knowledge in local ω domain?



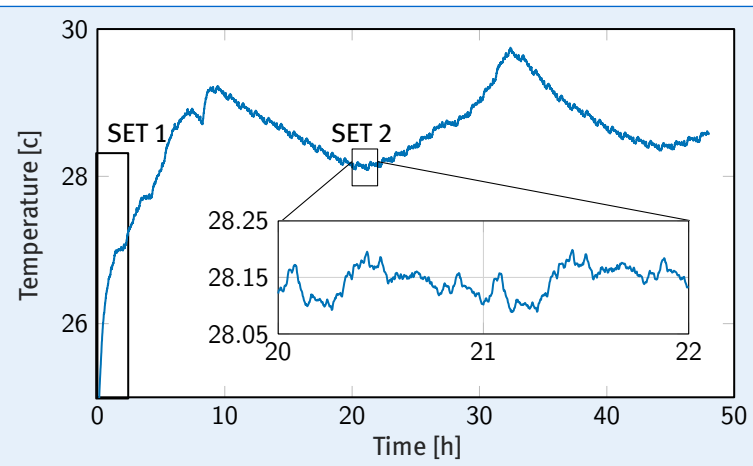
Precision stage application (PSA)

- Linear motor coil as heat source
- Multisine excitation with period of 1 hour
- Offset required, heater is positive input only

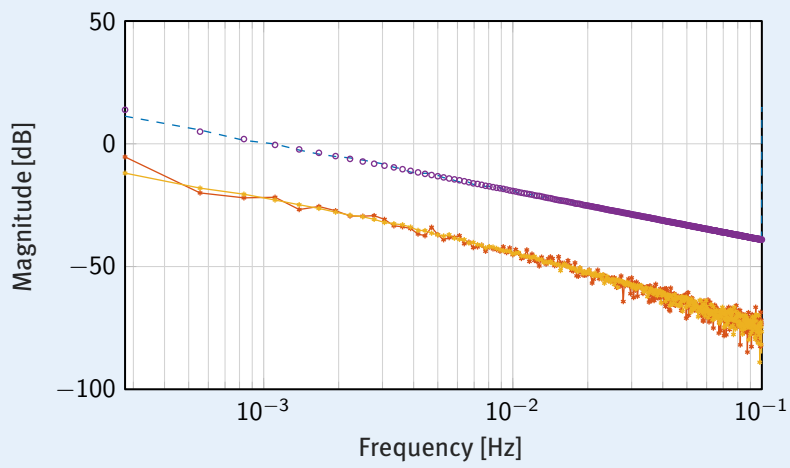




Experimental results



- Set 1 includes initial step response to offset
- Set 2 validation set, low transient after 20 hour



Fast and accurate FRF identification for advanced thermal modeling & control

References

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[3] D. Peumans, C. Busschots, G. Vandersteen, and R. Pintelon, "Improved FRF Measurements of Lightly Damped Systems Using Local Rational Models," IEEE Transactions on Instrumentation and Measurement, vol. 67, no. 7, pp. 1749–1759, Jul. 2018.
[4] E. Evers, B. de Jager, and T. Oomen, "Improved Local Rational Method by incorporating system knowledge: with application to mechanical and thermal dynamical systems," in 18th IFAC Symposium on System Identification (SYSID 2018), Stockholm, Sweden, 2018.

Acknowledgments: This work is supported by the Advanced Thermal Control consortium (ATC), and is part of the research programme VIDI with project number 15698 which is (partly) financed by the Netherlands Organisation for Scientific Research (NWO).