Temperature-Dependent Modeling of Thermoelectric Elements

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Abstract for Poster

Active thermal control is key in achieving the required accuracy and throughput in many industrial applications (Evers, de Jager, & Oomen, 2018) e.g., in the medical industry, high-power lighting industry, and semiconductor industry. In these fields, thermoelectric modules (TEMs) have received increased attention over traditional water conditioning circuits because they have compact dimensions and no moving parts. However, the thermoelectric behavior of these modules is non-affine in their inputs and state, complicating their implementation.

In view of control, and to facilitate the implementation of both accurate linearization methods and observer based control, a high fidelity model of the TEM is required. In earlier research, often a limited operating temperature for the TEM is considered, allowing the model to be simplified by using temperature-independent parameters. Here, a significantly larger operating temperature range is considered, e.g., from 5 to 80 degrees celcius, necessitating the inclusion of temperature dependent parameters.
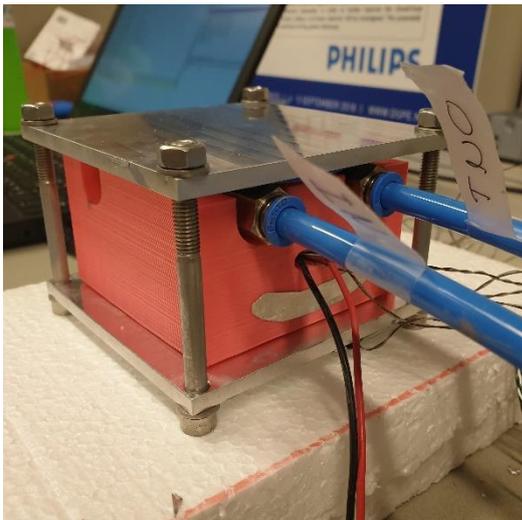
Figure 1 Experimental setup used for the calibration of temperature dependent parameters.
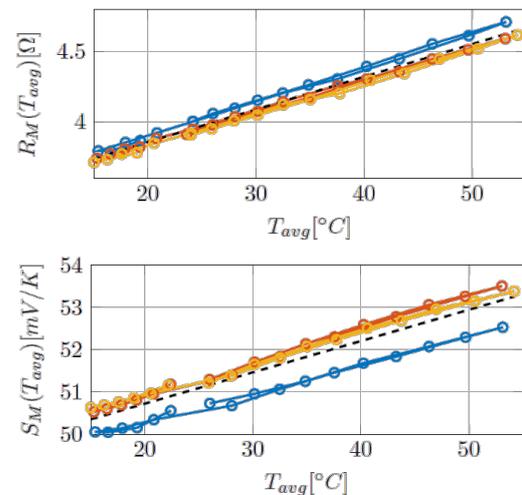

Figure 2 Experimental results of the temperature dependent parameters for different peltier modules as a function of average temperature T_{avg}

High fidelity modelling for thermoelectric elements for a wide temperature range is achieved by including temperature dependent parameters in the system model. An experimental approach (D. Mitrani, 2004) is used that exploits different timescales in the thermoelectric dynamics to uniquely determine the temperature dependent Seebeck coefficient S_M and electrical resistance R_M for different operating temperatures. The approach is applied in a dedicated experimental setup, shown in Figure 1, and yields results as shown in Figure 2 for the temperature dependency of both parameters.

Including the temperature dependent parameters in the system model facilitates the application of advanced control approaches over a wide range of temperatures. This yields improved performance for applications beyond typical steady-state operation..

Bibliografie

D. Mitrani, J. J. (2004). Methodology for extracting thermoelectric module parameters. *21st IEEE Instrumentation and Measurement Technology Conference*, (pp. 564-568). Como, Italy.

Evers, E., de Jager, B., & Oomen, T. (2018). Thermo-Mechanical Behavior in Precision Motion Control: Unified Framework for Fast and Accurate FRF Identification. *IECON 2018 - 44th Annual Conference of the IEEE Industrial Electronics Society.* Washington, DC, USA.