State-Space Representation of a Lumped Parameter Thermal Network

This document presents the state-space representation of a lumped parameter thermal network. The thermal network consists of four nodes where each node represents a thermal mass and is connected to every other node through thermal resistances. The state variables in the model are the temperatures at these nodes, and the input variables are the power inputs to the nodes.

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# Lumped Parameter Thermal Network (LPTN):

The thermal network is described by the following nodes and resistances:  
- Four thermal nodes: SY (System), SW (Southwest), ST (Start), and PM (Power Module).  
- Thermal resistances connecting each node to every other node: R\_C\_SY, R\_SY\_SW, R\_SY\_ST, R\_SW\_ST, R\_ST\_PM, R\_SW\_PM, and R\_PM\_A.  
Each node is also associated with a thermal capacitance that determines its heat capacity.

# State-Space Model Equations:

The state-space model is formulated based on the assumption that the temperatures at each node change due to thermal conduction to other nodes and due to power inputs. The equations representing the dynamics of the system are as follows:

## State Equations:

The rate of change of temperature at each node is given by the differential equations:  
T\_SY' = -(T\_SY/R\_C\_SY + T\_SY/R\_SY\_SW + T\_SY/R\_SY\_ST - T\_SW/R\_SY\_SW - T\_ST/R\_SY\_ST + P\_SY)/C\_SY  
T\_SW' = -(T\_SW/R\_SY\_SW + T\_SW/R\_SW\_ST + T\_SW/R\_SW\_PM - T\_SY/R\_SY\_SW - T\_ST/R\_SW\_ST - T\_PM/R\_SW\_PM + P\_SW)/C\_SW  
T\_ST' = -(T\_ST/R\_SY\_ST + T\_ST/R\_SW\_ST + T\_ST/R\_ST\_PM - T\_SY/R\_SY\_ST - T\_SW/R\_SW\_ST - T\_PM/R\_ST\_PM + P\_ST)/C\_ST  
T\_PM' = -(T\_PM/R\_C\_SY + T\_PM/R\_SW\_PM + T\_PM/R\_ST\_PM - T\_SY/R\_C\_SY - T\_SW/R\_SW\_PM - T\_ST/R\_ST\_PM + P\_PM)/C\_PM

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## Output Equation:

The output vector y is the temperatures at the nodes, given by the state vector x:  
y = [T\_SY, T\_SW, T\_ST, T\_PM]^T