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Control of port-Hamiltonian systems

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**Control of Port-Hamiltonian Systems:
Observer Design and Alternate Passive
Input-Output Pairs**

The research described in this thesis was undertaken at the Johann Bernoulli Institute for Mathematics and Computer Science, University of Groningen, The Netherlands.



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The research reported in this thesis is part of the research program of the Dutch Institute of Systems and Control (DISC). The author has successfully completed the educational program of the Graduate School DISC.



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RIJKSUNIVERSITEIT GRONINGEN

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and Alternate Passive Input-Output Pairs**

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Notation

Symbol	Description	Page
∇	the partial differential operation	1
∇_x	the partial differential operation with respect to variable x	2
\mathcal{C}	a Casimir function	10
\mathcal{L}	the Lagrangian	18
C	matrix representing the Coriolis and centrifugal forces	18
H	the Hamiltonian	19
\mathcal{X}	the n -dimensional state space manifold	20
$T\mathcal{X}$	the tangent bundle	20
$T^*\mathcal{X}$	the co-tangent bundle	20
\mathcal{F}	the space of flow variables	22
\mathcal{F}^*	the space of effort variables	22
f	a flow vector	22
e	an effort vector	22
\mathcal{D}	a Dirac structure	22
\mathcal{R}	a Resistive structure	26
\circ	composition operator for Dirac and resistive structures	26
$[X, Y]$	standard Lie bracket of vector fields X and Y	35

