*CONTROLLER

Purpose: The keyword *CONTROLLER provides capability related to the control application, such as controller design, model order reduction, etc.

*CONTROLLER_PLANT

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Purpose: Perform model order reduction for linear systems and export the reduced matrices into the state space format $\dot{X} = AX + Bu, Y = CX + Du$. Matrices A, B, C, D can be written in specified file format, such as SCILAB and MATLAB.

This feature currently works for the SMP, double precision versions. We implemented two methods for model order reduction: modal truncation and Krylov subspace method. The modal truncation method is based on the truncated modes, meaning eigenvectors, which carry more physical meaning. The Krylov subspace method matches moments of transfer functions to ensure the reduced system has a similar response to the original one. For both methods, the input deck requires necessary *CONTROL_IMPLICIT cards.

ID card. Define plant ID, specify input/output channel numbers and method.

Card 1	1	2	3	4	5	6	7	8
Variable	PLNTID	NIN	NOUT	NMODE	MTXQ	MTXR	MOPT	
Type	I	I	I	I	I	I	I	
Default	none	none	none	0	0	0	0	

File card. Specify file names in SCILAB and MATLAB format.

Card 2	1	2	3	4	5	6	7	8
Variable	FSCILAB				FMATLAB			
Type	A				A			

Input DOFs card. Specify the input node/set and its DOFs. Repeat this card if necessary.

Card 3	1	2	3	4	5	6	7	8
Variable	NODI1	DOFI1	NODI2	DOFI2	NODI3	DOFI3	NODI4	DOFI4
Type	I	I	I	I	I	I	I	I
Default	0	0	0	0	0	0	0	0

Output DOFs card. Specify the output node/set and its DOFs. Repeat this card if necessary.

Card 4	1	2	3	4	5	6	7	8
Variable	NODO1	DOFO1	NODO2	DOFO2	NODO3	DOFO3	NODO4	DOFO4
Type	I	I	I	I	I	I	I	I
Default	0	0	0	0	0	0	0	0

Settings card. Set frequency number and tolerance for the Krylov subspace method.

Card 5	1	2	3	4	5	6	7	8
Variable	NFEQ	DEFTOL						
Type	I	F						
Default	1	10^{-9}						

Mode/Frequency card. Specify the mode and frequency index. Repeat this card if necessary.

Card 6	1	2	3	4	5	6	7	8
Variable	MOD1	MOD2	MOD3	MOD4	MOD5	MOD6	MOD7	MOD8
Type	I	I	I	I	I	I	I	I
Default	0	0	0	0	0	0	0	0

VARIABLE	DESCRIPTION
PLNTID	Plant ID
NIN	Number of input DOFs, such as nodal force or voltage. If all nodes within a set share a single input variable, together they account for one DOF. For example, all nodes within a set share a single input voltage for a piezo actuator.
NOUT	Number of output DOFs, such as nodal displacement or voltage. Note that the same node velocity will be automatically exported as well.
NMODE	Number of modes for the modal truncation, or number of base vectors for the Krylov method. If zero, all active DOFs will be used (not recommended). The reduced system will have a dimension of 2NMODE for the modal truncation method, and NMODE for the Krylov method.
MTXQ	Q matrix for linear-quadratic-regular (LQR) method (unused currently)
MTXR	R matrix for linear-quadratic-regular (LQR) method (unused currently)
MOPT	Modal order reduction method (see Remark 1): EQ.0: Modal truncation method EQ.1: Krylov subspace method
FSCILAB	File name in SCILAB format .sci. If specified, the reduced matrices will be written accordingly. If left blank, no such file will be generated.

VARIABLE	DESCRIPTION
FMATLAB	File name in MATLAB format .m. If specified, the reduced matrices will be written accordingly. If left blank, no such file will be generated.
NODI*x*	Node or node set index for the input channel. GT.0: Node index LT.0: Node set index within which all nodes share the same input variable, such as force, voltage.
DOFI*x*	Degree-of-freedom for input: EQ.1: Nodal force in the x-direction, f_x EQ.2: Nodal force in the y-direction, f_y EQ.3: Nodal force in the z-direction, f_z EQ.7: Voltage if piezoelectric materials are defined. See Remark 2.
NODO*x*	Node index for output
DOFO*x*	Degree-of-freedom for output: EQ.1: Displacement along the x-direction EQ.2: Displacement along the y-direction EQ.3: Displacement along the z-direction EQ.7: Voltage output if piezoelectric materials are defined.
NFEQ	Number of shifted frequencies to generate the Krylov base vectors. In most cases, a single frequency at zero rad/s works. For the modal truncation method, just leave as it is.
DEFTOL	Deflation tolerance for the Krylov method. The default value of 10^{-9} works in most cases. For the modal truncation method, just leave as it is.
MOD*x*	List all NMODE mode indexes for the modal truncation method, or NFEQ shifting frequencies (unit: rad/s) for the Krylov method. The default setting of a single frequency at 0 rad/s works in most Krylov cases. For the modal truncation method, a negative MOD*x* triggers mode generation between MOD_{x-1} and $-MOD_x$, meaning all modes between MOD_{x-1} and $-MOD_x$ will be considered.

Remarks:

1. **MOPT.** If MOPT = 0, the modal truncation method is selected to perform the model order reduction based on the NMODE eigenvectors. Users need to define *CONTROL_IMPLICIT_GENERAL and *CONTROL_IMPLICIT_EIGENVALUE to generate the required eigenvectors, and the eigenvalue number *neig* should not be less than NMODE. If MOPT = 1, the Krylov subspace method will be selected. No eigenvalues are calculated, but *CONTROL_IMPLICIT_GENERAL is still needed to acquire the system matrices. The default setting of NFEQ = 1, DEFTOL = 10^{-9}, and 0 frequency works in most cases for the Krylov method.

2. **Voltage Input.** DOFI*x* = 7 indicates a voltage input. The material of that respective index should be piezoelectric, that is, *MAT_ADD_PZELECTRIC should be used.