

IEEE PES Task Force on Benchmark Systems for Stability Controls

Simplified 14-Generator Model of the South East Australian Power System:

DataPackage: AU14GenModel_StateSpaceAndEigen_Matlab_Ver04

Version 4 - 18 February 2014

Mike Gibbard & David Vowles

**Power Systems Dynamics Group
School of Electrical and Electronic Engineering
The University of Adelaide, South Australia**

Matlab [1] *.mat files containing state-space model data and eigenanalysis results created by the Mudpack small-signal analysis package [2] for study cases 1 & 6 with the PSSs in- and out-of-service are provided in the archive file AU14GenModel_StateSpaceAndEigen_Matlab_Ver04. The contents of the archive are summarized in the following table and detailed information on the contents of each type of *.mat file is provided in subsequent sections.

Table 1 Contents of “AU14GenModelData_Ver04.zip”

File	Description
Case<n>_PSSs_Off_ABCD_Rev3_Matlab.mat	Matlab *.mat file containing the state-space model of the system for cases <n>= 1 & 6; all PSSs out-of-service. The state-space models are produced by Mudpack.
Case<n>_PSSs_On_ABCD_Rev3_Matlab.mat	Matlab *.mat file containing the state-space model of the system for cases <n>= 1 & 6; all PSSs in-service with their design damping gain of $D_e = 20$ pu on machine MVA base. The state-space models are produced by Mudpack.
Case<n>_PSSs_Off_Eigs_Rev3_Matlab.mat	Matlab *.mat file containing the eigenanalysis results of the system for cases <n>= 1 & 6; all PSSs out-of-service. The eigenanalysis results are produced by Mudpack.
Case<n>_PSSs_On_Eigs_Rev3_Matlab.mat	Matlab *.mat file containing the eigenanalysis results of the system for cases <n>= 1 & 6; all PSSs in-service with their design damping gain of $D_e = 20$ pu on machine MVA base. The eigenanalysis results are produced by Mudpack.

File	Description
ConfirmEigenanalysis.m	Matlab function that can be used to confirm that eigenanalysis results produced by Matlab from the above state-space models are consistent with the corresponding eigenanalysis results produced by Mudpack.

1 Contents of the Matlab state-space model and eigenanalysis result files

State-space models and associated eigenanalysis results are provided in Matlab compatible files. The files, in *.mat format, are read into Matlab using the “load” command. Their contents is described below.

Table 2 Contents of Matlab state-space model (ABCD matrix) files.

Identifier	Description	Units
AA BB CC DD	System state-space model matrices: A (NX x NX), B (NX x NU), C (NY x NX) & D (NY x NU) NX = total number of state-variables; NY = total number of outputs-variables; NU = total number of input-variables;	
D	D(i) = Machine damping torque coefficient of the i^{th} device. (Relevant only if DEVCAT(i) = 1).	pu on MBASE
DDT	Date stamp	
DEVCAT	Device category: DEVCAT(i) is the type of the i^{th} device: = 1 for a synchronous machine; = 2 for a SVC	
H	H(i) = inertia constant of the i^{th} device on its MVA base, MBASE(i). Relevant only if DEVCAT(i) = 1.	MWs/MVA
HEADER	(ignore)	
MBASE	MBASE(i) = MVA base of the the i^{th} device	MVA
MatrixTag	(ignore)	
ModelTag	(ignore)	
NUM	NUM(1) = NX; NUM(2) = NY; NUM(3) = NU;	
PNAME	Device names: PNAME(i,1:8) is the name of the i^{th} device.	
SBASE	System MVA base (100 MVA)	MVA
TIT1	Title, line 1	
TIT2	Title, line 2	
UN	Names of input variables (see Section 2): UN(i,1:13) is the name of the i^{th} input-variable, i = 1...NU	
XN	Names of state variables (see Section 2): XN(i,1:13) is the name of the i^{th} state-variable, i = 1...NX	
YN	Names of output variables (see Section 2): YN(i,1:13) is the name of the i^{th} output-variable, i = 1...NY	

Table 3 Contents of Matlab Eigenanalysis Result Files

Identifier	Description
E	Vector of eigenvalues (length NX)
EIGHED	(ignore)
P	Participation factor matrix (NX x NX): $P(i,j)$ = participation factor of the i^{th} state-variable ($X(i,:)$) in the j^{th} eigenvalue ($E(j)$).
TIT1	Title, line 1
TIT2	Title, line 2
V	Matrix of right eigenvectors (NX x NX): $V(:,j)$ is the right-eigenvector of the j^{th} eigenvalue ($E(j)$).
W	Matrix of left eigenvectors (NX x NX) $W(:,j)$ is the left-eigenvector of the j^{th} eigenvalue ($E(j)$)
X	Names of state variables (see Section 2): $X(i,1:13)$ is the name of the i^{th} state-variable, $i = 1 \dots NX$

Note:

1. The eigenanalysis was conducted using the Mudpack package. If the user computes the eigenvalues and associated eigenvectors of the system state-matrix using the Matlab EIG function the ordering of eigenvalues is likely to be different from than that obtained by Mudpack. Consequently, a naive comparison of the eigenvalues calculated by Mudpack and Matlab, such as $\text{abs}(E - \text{eig}(AA)) < \text{tol}$, will most likely fail. Thus, to confirm consistency between the eigenanalysis results computed by Mudpack and Matlab, the Matlab mfile “ConfirmEigenanalysis.m” is provided.
2. Mudpack uses the LAPACK subroutine DGEEV to calculate the eigenvalues with the default scaling factor of $\text{SCLFAC} = 8$ in DGEBAL. The Matlab EIG function also employs this subroutine, but with a scaling factor $\text{SCLFAC} = 2$. It is likely that small discrepancies between the eigenvalues obtained by Matlab and Mudpack may arise as a result of this difference.

2 Variable naming conventions

The state, input and output variables are named in accordance with the following pattern:

VVVV.DDDDDDDD

in which **VVVV** is the four character name of a variable and **DDDDDDDD** is the eight character name of the device (i.e. one of the names in the list of device names, PNAME, in the state-space model file.)

Tables [4](#), [5](#) and [6](#) list the state-, output- and input-variable names used in the state-space model.

Table 4 State variable descriptions.

Variable Name	Description	Units
DEL	Rotor angle	rad.
W	Rotor speed	per unit of synchronous speed
Ed'	Voltage behind q-axis transient reactance	per unit
Eq'	Voltage behind d-axis transient reactance	per unit
Ed''	Voltage behind q-axis sub-transient reactance	per unit
FLkd	d-axis damper winding flux linkages	per unit
FLkq	q-axis damper winding flux linkages	per unit
EF ^a	Field voltage	per unit
VR, xnnn	State variables in AVR or PSS	per unit
B	SVC Susceptance	per unit
SV1	SVC AVR state	per unit

- a. Base field voltage(current) is that field voltage (current) required to generate one per-unit stator voltage on the airgap line with the machine open circuit and rotating steadily at synchronous speed.

Table 5 Output variable descriptions.

Name	Description	Units
DEL	Rotor angle	rad
W	Rotor speed	per unit of synchronous speed
Vt	Generator or SVC terminal voltage	per unit
Vang	Generator or SVC terminal voltage angle	rad
P	Generator electrical power output	per unit on SBASE
Q	Generator or SVC reactive power output	per unit on SBASE
If	Generator field current	per unit
EF	Generator field voltage	per unit
I	SVC current magnitude	per unit
B	SVC Susceptance	per unit
Q/Vt	For an SVC the perturbation in the ratio of reactive power output to terminal voltage is the perturbation in the SVC current.	per unit.

Table 6 Input variable descriptions.

Name	Description	Units
Vref	AVR voltage reference	per unit
Vs	Input corresponding to the point to which the PSS output will be connected.	per unit

Name	Description	Units
Pm	Generator mechanical power	per unit on MBASE

3 References

- [1] The Mathworks, Inc. (2010, 23 August 2010). MATLAB®. Available: www.mathworks.com.
- [2] Vowles, D.J. and Gibbard, M.J., “Mudpack - a software package for the analysis of the small-signal dynamic performance and control of large electric power systems”, School of Electrical & Electronic Engineering, The University of Adelaide, South Australia.